

**PROPOSAL FOR
RECONNAISSANCE SURVEY (G-4 STAGE) FOR IRON ORE (BLOCK A1 & A2) IN MAHAKOSHAL GROUP,
AROUND CHAKDIYA, KUSHNIAYA, JOBRA AND TUSGAON AREA, SONBHADRA DISTRICT, UTTAR PRADESH**

(18.56 Sq. Km Area)

COMMODITY: IRON ORE

**To
NATIONAL MINERAL EXPLORATION TRUST (NMET)
(Through DEPT. OF MINES & GEOLOGY,
GOVT OF UTTAR PRADESH)**

Submitted by



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INDEX
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Summary of the Block for Reconnaissance Survey (G-4 Stage)

GENERAL INFORMATION ABOUT THE BLOCK

SI No	Features	Details
I	Block ID	Block A1 – Chakdiya, Kushniaya Area Block A2 - Jobra And Tusgaon area
II	Current Exploration Agency	GeoExpOre Private Limited
III	Previous Exploration Agency	Geological Survey of India (GSI has carried out G3 stage exploration in Block GSI-A and GSI-B during FS 2017-18 and 2019-20, respectively, which is adjacent to the northern boundary of the proposed A1 block)
IV	G4/G3 stage Geological Report (Previous stage Geological Report)	Report On “Preliminary Exploration for Iron Ore in Mahakoshal Group Block B, Bharhari area, Sonbhadra” (Stage-G3) –FS 2019-20 – Report On “Preliminary Exploration for Iron Ore in Mahakoshal Group Block A, Bharhari area, Sonbhadra” (Stage-G3) –FS 2017-18 <u>-Enclosed as Annexure-1</u> Blocks C and D are being investigated by GSI during this FS, and these blocks are adjacent to the proposed A1 block boundary.
V	Commodity	Iron Ore
VI	Mineral Belt	The area is a part of the Mahakoshal belt, the host rocks of Fe mineralization, banded hematite chert/Jasper (BIF) occurs in the Agori Formation.
VII	Budget and time Schedule to complete the project	95.41 Lakhs 9 months
VIII	Objectives	1. Carry out Geological and structural mapping on a 1:12,500 scale to demarcate Iron ores. 2. Collect surface (Bedrock) samples and analyze % of Fe and associated minerals. 3. To carry out channel and trench samples collected from iron-bearing formations to demarcate mineralised zones. 4. To drill five scout angle boreholes up to 30m vertical depth to prove the strike and depth persistence of ore-bearing formation mapped in the area, which in turn will decide the future course of the

		Exploration program at the G-4 category of UNFC. 5. To estimate reconnaissance iron resources along with accessory elements as per UNFC norms and Minerals (Evidence of Mineral Contents) Rules-2015 at the G-4 level.			
IX	Whether the work will be carried out by the proposed agency or through outsourcing and details thereof. Components to be outsourced and name of the outsource agency	The Geological Mapping, trenching/pitting, sampling, core logging and report writing will be carried out by GeoExpOre Private Limited. Drilling will be done through outsourcing agencies. Drilling: GEO TECH EXPLORATION, 51, Panchdeep Nagar, Wardha Road, Nagpur – 440024. Lab Tests: PSY PSN MY# Analytical & Quality Services Pvt Ltd, Vizag. /Shiva Analytical Laboratory Bangalore. Govt labs will used whenever required (HGML, IBM, NGRI, IIMT (CSIR) & GSI).			
X	Name / Number of Geoscientists	Geologist: 01 HQ (30 days) Geologist:01 Field			
XI	Expected Field days (Geology, Geophysics, Surveyor)	90 Days (Geologists)			
1	Location	Around Chakdiya, Kushniaya, Jobra and Tusgaon Area, Sonbhadra District, Uttar Pradesh			
	Block Boundary Coordinates Latitude & Longitude	Geographic Coordinate System in Degree Decimal (WGS 1984) for Block A1			
		CARDINAL POINTS	LATITUDE	LONGITUDE	Area
		A1	N24° 32' 47.1"	E82° 51' 14.8"	7.21 sq.km
		A2	N24° 33' 07.0"	E82° 51' 15.5"	
		A3	N24° 33' 11.3"	E82° 51' 44.7"	
		A4	N24° 33' 42.8"	E82° 53' 56.9"	
		A5	N24° 34' 15.8"	E82° 56' 10.3"	
		A6	N24° 34' 13.4"	E82° 56' 24.1"	
		A7	N24° 33' 44.8"	E82° 55' 53.7"	
		A8	N24° 33' 12.3"	E82° 53' 46.3"	
		A9	N24° 32' 39.3"	E82° 51' 41.4"	

		Geographic Coordinate System in Degree Decimal (WGS 1984) for Block A2			
		CARDINAL POINTS	LATITUDE	LONGITUDE	Area
		B1	N24° 31' 13.8"	E82° 51' 14.6"	11.35 sq.km
		B2	N24° 31' 33.2"	E82° 52' 29.2"	
		B3	N24° 31' 06.0"	E82° 52' 27.6"	
		B4	N24° 31' 07.0"	E82° 52' 59.6"	
		B5	N24° 31' 03.6"	E82° 53' 10.8"	
		B6	N24° 30' 16.1"	E82° 53' 52.9"	
		B7	N24° 31' 07.5"	E82° 56' 11.0"	
		B8	N24° 31' 19.6"	E82° 56' 59.5"	
		B9	N24° 31' 0.20"	E82° 56' 57.4"	
		B10	N24° 30' 01.0"	E82° 54' 20.1"	
		B11	N24° 30' 04.4"	E82° 54' 10.0"	
		B12	N24° 30' 06.9"	E82° 52' 11.6"	
		B13	N24° 30' 46.1"	E82° 51' 11.9"	
	Villages	Chakdiya , Kushniaya, Jobra and Tusgaon			
	Tehsil/ Taluk	Sonbhadra			
	District	Sonbhadra			
	State	Uttar Pradesh			
2	Area (hectares/ square kilometres)	18.56 SQ.KM			
	Block Area	Block-A1: 7.21sq. km, Block-A2:11.35 sq. km; Total – 18.56 sq. km			
	Forest Area	Block A1 More than 95% of the area is covered by forest, and Block A2 – 50-55% of forest area.			
	Government Land Area	----			
	Private Land Area	A1 block - Less than 5% and A2 block – 45-50% of private land area.			
3	Accessibility	The proposed A1 block is located about 20 km NW of Chopan and is well connected by metalled and non-metalled roads. The A2 block is located around 17 km away from Chopan with well-connected roads. The proposed blocks run parallel to the east-flowing Son River in most parts. Jogail is the major locality near the study area and is situated about 28 km west of Chopan. The area is well connected with Allahabad, Mirzapur and Varanasi by road.			

	Nearest Rail Head	Chopan (20 km) from Block A1 and 17 km from Block A2
	Airport	Varanasi
4	Hydrography	The district area is marginally characterised by alluvium in the northern portion, and the rest of the block is a hard rock terrain. On the basis of hydrogeological information, groundwater occurs in unconfined conditions in shallow depths and confined conditions in deeper depths in alluvium. The area drains to the EW flowing Son River.
	Local Surface Drainage Pattern (Channels)	The stream exhibits a semi-dendritic drainage pattern flowing toward the north and joins the EW running Son River.
	Rivers/ Streams	Son River is the major river that flows towards the north beyond the proposed area.
5	Climate	The area experiences a sub-tropical climate, marked by moderate to severe cold seasons and very hot summers.
	Mean Annual Rainfall	The average annual rainfall is about 1250 mm.
	Temperatures (December) (Minimum)	4 °C.
	Temperatures (June) (Maximum)	48 °C.
6	Topography	The A1 block area falls in the northern fringe of Chakdiya reserved forest with rugged topography and dissected linear ridges. In the A2 block area, the south-central and NW part falls under the Jogail reserve forest with rugged topography with dissected ridges.
	Toposheet Number	63 L/14
7	Availability of baseline geoscience data	--
	Geological Map (1:50K/ 25K)	1:50,000 Scale (Source: Bhukosh)
	Geochemical Map	Not available
	Geophysical Map (Aeromagnetic, ground geophysical,	No Geophysical survey was carried out by GSI.

	Regional as well as local scale GP maps)	
8	Justification for taking Preliminary Exploration under G3	GSI carried out the preliminary exploration of the G3 stage in 2 blocks, A and B, on the northern fringe of the proposed A1 block. a) The conclusions of the preliminary exploration report on Block A on Iron ore around the Bharhari area, Sonbhadra district, U. P, consists of detailed mapping of 1.61 sq. km. on a 1:2000 scale. The report also consists of drilling of 822.7 m through 08 boreholes, 51 nos. of PTS, 10 nos. of channel samples, and 40 nos. BRS samples totalling 441 core samples. The litho-units exposed in the block include variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert/jasper (BIF), ferruginous phyllite and dolerite. The general trend of the rock types in the study area is ENE-WSW (N70°E-S70°W to N85°E-S85°W) with a dip amount of 50° to 75° towards the south. The thickness hematite band is 7 cm, and the banded hematite chert/jasper of width 8-75cm is exposed at the hill tops. The analytical results of the samples show Fe % varying between 6.9% and 52.3% in BHC/J. GSI has estimated the total resources using the cross-section method amounting to 14.89MT with an average grade of 34.73% Fe at a 30% cut-off and 8.41MT with an average grade of 38.34% Fe at a 35% cutoff. b) The conclusions of the preliminary exploration report on Block B on Iron ore around the Bharhari area, Sonbhadra district, U. P, consists of detailed mapping of 2.1 sq. km on a 1:4000 scale. The report also consists of drilling of 461.30 m through 04 boreholes, 79 nos. of PTS, 195 nos. of core samples, 23 nos. of petrological samples, 15 ore microscopy samples and 10.80 line kilometres of geophysical exploration. The litho-units exposed in the block include variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert/jasper (BIF), ferruginous phyllite and dolerite. The general trend of the rock types in the study area is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with a dip amount of 50° to 80° towards the south. The Iron ore mainly contains Hematite, Limonite, and Goethite. The ore band/body with concentrated iron ore minerals is strata-bound in between variegated phyllite with tuff and dolerite as intrusive. The exposed BIFs formed as ridge and crest of the proposed block and show continuity in the strike along ENE-WSW with varying widths of 9 to 54 m. The analytical results of Boreholes show iron content (Fe%) varying from 6.80% to 45.76%, and at 30%, the Fe cut-off weighted average of mineralized zones varies between 33.12% to 42.94% Fe. Two boreholes yielded Fe% varying between 9.55% to 43.50% and 7.69% to 58.44%, respectively. GSI estimated the total resource through the Cross-Section method at 30 % Fe is 10.77 million tonnes (MT) with an average grade of 34.50%. Goethitization and limonitization have also been observed at joint planes and fractures.

		c) GSI, during FS 2009-12, carried out a geomagnetic survey in the southern section of Toposheet 63 L/14 and reported a high gravity accompanied by strong magnetic fields. d) In F.S. 2014-15, Modak et al. (2015) carried out a large-scale mapping on a 1:12,500 scale covering parts of toposheet 63 L/14. The geologists have marked five subparallel bands of banded hematite chert. Thus, on the basis of the GSI recommendations and the occurrence of banded hematite chert formations, it is proposed to carry out the reconnaissance Survey (G4) for Iron ore (Block A1 & A2) in Mahakoshal Group around Chakdiya, Kushniaya, Jobra and Tusgaon Area” with an area of 18.56 Sq.km. Thesalie south of the GSI explored blocks. The detailed geological mapping and pitting/trenching in the proposed blocks will help to delineate the mineralized zones and associated structural features. Further, the geological mapping on 1: 12,500 scale, pitting, trenching and exploratory borehole drilling will help to identify the potential blocks, which in turn aid in assessing the grade of the mineralized zone/body.

Detailed description

1.0 Introduction

With the implementation of the New Steel Policy in 2017 and the promotion of domestic steel production, India's iron ore consumption is growing exponentially, with about 35% growth in the last five years. As per the Indian Mineral Year Book, 2021, the anticipated iron ore requirement is 437 million tonnes by the year 2030-31. Further, as the state of Uttar Pradesh is quite deficient in ferrous mineral resources, the search for iron ore, though low grade with Fe values of 35% to 45% will augment the iron resource in the mineral inventory of the state.

The current study is proposed based on the preliminary exploration carried out by GSI at the G3 stage in two blocks, A and B, during FS: 2017-18 and 2019:20 adjacent to the northern fringe of the proposed A1 block. The present study also consists of two blocks, A1 and A2, focusing on the presence of the host rocks, banded hematite chert/jasper and is a part of the toposheet 63L/14 on a 1: 50,000 scale. Block A2 lies approximately 7km south of block A1, and the area of the blocks is A1 - 7.21 sq. km and Block-A2: 11.35 sq. km, totaling 18.56 sq. km. The blocks identified are around Chakdiya, Kushniaya, Jobra and Tusgaon villages. Another two blocks, C and D, are being investigated by GSI during this FS, and these blocks are adjacent to the proposed A1 block boundary.

1.1.0 Block Summary

1.2.0 Physiography

Physiographically, more than 95% of block A1 falls in the Chakdiya reserved forest, exhibiting rugged topography and dissected linear ridges. About 50% of block A2 is covered by Jogail reserved forest and exhibits rugged topography with dissected ridges. The rest 50% of the land is covered by private land and settlements.

Both the blocks drain to the EW flowing Son River with a semi-dendritic drainage pattern. The area receives an average annual rainfall of about 1250mm, and the temperature falls to 4°C in December. The maximum temperature experienced is 48 °C in May/June. The nearest city for the proposed blocks is Chopan, which is about 20km away from both the blocks and is well connected with metalled and non-metalled roads.

1.2.1 Background Geology (Regional Geology, Geology of the Block)

1.2.2 Regional Geology

The Son Valley in parts of Sidhi and Sonbhadra districts of Madhya Pradesh and Uttar Pradesh, respectively, forms a central part of a linear, arch-shaped belt of the Mahakoshal Group. The rocks of the belt are exposed proximal to ENE-WSW to E-W trending 'Son-Narmada Lineament-Zone' (SNLZ) and extend from Palamau district, Jharkhand in the east to Narsinghpur (M.P.) in the west (Nair *et al.*, 1995) and probably further west to it (Tripathi & Mishra, 1994; Soni & Jha, 2001). These rocks are inferred to have been deposited in a rift basin environment which is separated to the north from Meso-Neoproterozoic platformal Vindhyan rocks and linear belt of gneiss-granite around Sidhi, M.P. by Son-Narmada-North-Fault (SNNF) whereas Dudhi Granitoid Complex and Gondwana sediments to the south are separated by the Narmada-South-Fault (SNSF), locally known as Dudhi-Kassar Fault. The Mahakoshal group have a WNW-ESE trending extension in the south-eastern corner, especially south of Chitrangi. East of Chitrangi, the main Mahakoshal, continuing with an ENE-WSW trend from the Narsinghpur district of Madhya Pradesh, continues within the state of Uttar Pradesh and abuts against the Son River. The Mahakoshal Supracrustal Belt (MSB), comprising metavolcanic and metasedimentary rocks, in the study area, consists of the lower Agori, middle Parsoi and upper Dudhamaniya formations and belongs to the Paleoproterozoic Mahakoshal Group. This group includes the Chitrangi, Agori and Parsoi formations in descending sequence (Nair *et al.*, 1995; Srivastava *et al.*, 2000a; Roy *et al.*, 2002). A rift basin formed during the Paleoproterozoic period in central India is the Mahakoshal Group, as described by (Roy, 2008; Srivastava, 2012,2013). The Mahakoshal Group comprise volcano-sedimentary rock sequences of Paleoproterozoic and formed between the Bundelkhand Craton in the north and the Chhotanagpur Gneissic Complex of the peninsular Indian shield in the south. The Agori formation in the eastern margin contains tuffs of metaconic lenses, dolomitic stone, BIF, quartzite, carbonate, pyroclastic, chert, BIF, Greywacke-argillite, mafic and volcanic rocks are the major types of rock (Mathur & Narain, 1981; Devarajan *et al.*, 1998; Soni & Jha, 2001).

1.2.3. Regional Stratigraphy

The Stratigraphy of the Mahakoshal Group (after Roy and Devarajan 2000) is given in Table 1, and the stratigraphy of the Mahakoshal belt, as compiled by GSI NR, in the unified legend (2011) is shown in Table 2. In the central part, the rocks of the Mahakoshal Group are broadly divided into Agori Formation, Parsoi Formation and Dudhmaniya Formation (Nair *et al.* 1995). The rocks of the Agori Formation comprise banded iron formation, chloritic phyllite, arenaceous phyllite, quartzite, greywacke, metavolcanic and tuff. The contact of Agori and Parsoi formations is gradational. Obra- Amsi-Jiawan Fault passes just near the contact of two formations. The litho units of the Parsoi Formation include variegated phyllite, chlorite-sericite quartz phyllite, greywacke, bands of quartzite, metavolcanic and tuffaceous-carbonaceous phyllite. The rocks of the Dudhmaniya Formation comprise an alternate sequence of banded hematite chert/jasper, phyllite, quartzite, shale/slate and mica schist with younger intrusives. The rocks of the Mahakoshal Group are intruded by quartz veins and basic sills/dykes. Jungel Volcanics occurs in a linear belt and consists of volcanic/ultramafic/basic rocks developed in the E-W trending valley, namely, Jungel, Garda and Bhitri valleys in U.P.

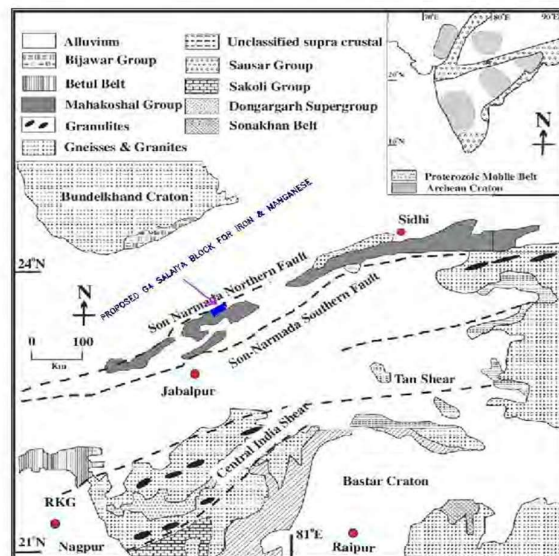


Figure 1 Map showing Proterozoic Mobile belt, Mahakoshal Group (Roy and Devrajan 2000)

Table 3: Stratigraphic sequence of Mahakoshal Group (after Roy and Devarajan 2000) (Source-GSI)

Chitrangi-Gurhar Pahar-Dudhamaniya area.		
Intrusives	Gold-bearing quartz-carbonate veins, quartz reefs, dolerite. Granite-granodiorite-intrusive plutonic belt along the southern margin. Jhirkadandi granite and equivalents. Lamprophyre and syenite in Sidhi.	
Mahakoshal Group	Dudhamaniya Formation	Alternate sequence of Banded Iron Formation (mixed oxide-sulphide-carbonate-silicate facies) and phyllite. Gradational contact
	Parsoi Formation	Dominantly phyllite with bands of greywacke, quartz arenite, and carbonaceous phyllite. -----(Amsi-Jiyawan) Fault-----
	Sleemanabad = Agori Formation	Quartz arenite and carbonate in the lower part, massive and bedded chert, BHJ, highly carbonated and fragmented metabasalt with pillows and suspected pahahoe toes, Banded hematite chert/jasper, thin argillites—ultramafic plugs.
Sidhi Gneissic Complex (basement)	Gneissic complex associated with mafic, ultramafic rocks and metasediments	

Table 4: Stratigraphic sequence of Mahakoshal Group (compiled by GSI NR, in the Unified Legend, 2011)

Mesoproterozoic	Vindhyan Supergroup		
Undifferentiated-Proterozoic	Jhirkadandi, Baghisoti-Dumar, Asnadohar and Sirpalia Granite	Two mica granite, diorite, porphyritic granite, mesocratic granite and pink leucogranite	
Palaeoproterozoic	Dudhi Granitoid Complex	Granite gneiss	
Palaeoproterozoic	Mahakoshal Group	Dudhmaniya Formation	Phyllite, quartzite, shale/ slate, mica schist with younger intrusive, Banded hematite chert/ jasper
		Parsoi Formation	Variegated phyllite, greywacke, quartzite, meta basic, doleritedykes and quartz veins
		Agori Formation	Shale, siltstone, sandstone, Bandedhematite chert/jasper, basic and ultrabasic rocks
Palaeoproterozoic to Archaean	Dudhi Gneissic Complex	Feldspathic gneiss	
		Porphyroblastic gneiss	
		Banded gneiss, migmatite and biotite gneiss	

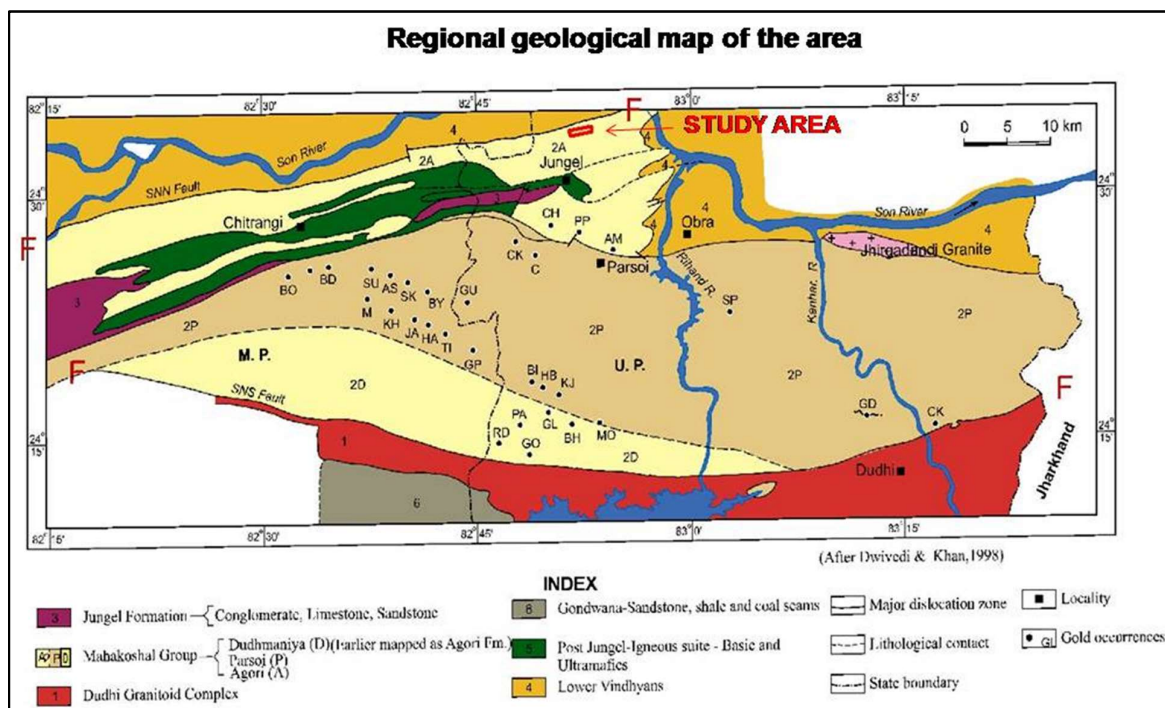


Figure 2 Regional Geological map Iron ore Block B, Bharhari area, Sonbhadra district, Uttar Pradesh (Source-GSI)

1.2.4 Structure

The Son-Narmada North Fault (SNNF) and the Son-Narmada South Fault (SNSF) separate the Mahakoshal Group, which is represented by a thick metasedimentary litho succession with significant amounts of metavolcanics.

The turbidites, which are supposedly distinctive to the WNW trending arm's Parsoi Formation, appear to be shear-generated structures, leaving footprints along the arm's length and width. In the GSI investigation areas, primary bedding (S0) is the most important primary structure that has been observed, recognized by compositional variation between ferruginous and siliceous layers manifested in the form of colour banding. Primary bedding is observed in banded hematite chert/jasper and in ferruginous phyllite. The general strike of bedding (S0) is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with moderate to steep dips from 50°-80° towards the south. Foliation (S1) is most commonly observed in the investigation area. At most places, S1 is sub-parallel to the bedding surface (S0) in phyllite, therefore showing a trend ENE-WSW (N65°E-S65°W to N85°E-S85°W) with moderate to steep dip ranging from 35° to 82° towards the south. Three sets of joints are observed in banded hematite chert/jasper and ferruginous phyllite. One set of joints (J1) trend is dominantly N10°E – S10°W to N10°W – S10°E, another set of joints (J2) trending N80°E – S80°W and the third type of joint (J3) is N30°W – S30°E to N45°W – S45°E with steep to vertical dips.

1.2.5 Geology of the Blocks

The proposed area for investigation is a narrow belt made up primarily of ENE-WSW trending hillocks and linear ridges. This region of Mahakoshal rocks stretches from Barmanghat in Narsinghpur, Madhya Pradesh, in the west to Palamau in Jharkhand, along the Narmada and Son rivers. Rocks like quartzite, phyllite, dolomite, metabasics, and banded ferruginous chert serve as examples. Banerji [2] asserted the existence of a significant shear zone in the southeast of the Mahakoshal band and regarded the WNWESE trending tract of the Agori and Parsoi Formation in the south-east as mylonites, representing his 'Dudhmania Shear Zone'. The foliation trend in the WNW-trending arm of the Mahakoshal is N80° W-S80° E in the western end, turning to N60° W-S60° E in the middle, and again swinging to N80° W-S80° E in the eastern end of the belt. The Agori Formation, or lower division of the Mahakoshal, is comprised of a sequence of basal quartzite interbedded with metabasics and overlain by dolomites with chert interbands. It is located in the western and central portions of the belt. Meta basics, banded ferruginous chert, phyllite, and meta-greywacke are the dominant minerals in the belt's eastern region, and carbonates are scarcely present.

Table 5: Lithology of the area(Source-GSI)

Group	Formation	Rocks
Mahakoshal Group	Dudhamaniya Formation	Alternate sequence of Banded Iron Formation (mixed oxide-sulphide-carbonate-silicate facies) and phyllite. Gradational contact
	Parsoi Formation	Dominantly phyllite with bands of greywacke, quartz arenite, carbonaceous phyllite. -----(Amsi-Jiyawan) Fault-----
	Sleemanabad = Agori Formation	Quartz arenite and carbonate in the lower part, massive and bedded chert, BHJ, highly carbonated and fragmented metabasalt with pillows and suspected pahoehoe toes, Banded hematite chert/jasper, thin argillites. Ultramafic plugs.

1.2.5.1 Variegated Phyllite

The phyllite exposed in the investigation area is thinly banded pale green, purple and yellow colored, at places is massive to highly jointed to splintery in nature. Mineralogically, the rock is composed of very finely-grained anhedral quartz, muscovite, biotite, and chlorite. The general strike is N60°E-S60°W to N88°E-S88°W with varying dip amounts of 38° to 82° towards the south. At some places, later quartz veins have intruded along the foliation planes of phyllite.

1.2.5.2 Ferruginous phyllite

It is one of the most widespread lithological units present in the area and runs subparallel to the BIF band; at places, it is highly enriched and shows subbands of hematite and/or jasper/chert and is marked separately within ferruginous phyllite. The ferruginous phyllite is composed of fine-grained quartz, clay minerals and iron oxide.



Figure-3 Ferruginous Phyllite, Bharhari area(Source-GSI)

1.2.5.3 Phyllite interbanded with tuff

In the central part of the Bharhari area, most of the valley portion is covered by this unit. This phyllite is interbanded with tuff having a thickness of 1mm to 5cm. It is mostly shades of colours milky white, pink, reddish and purple.

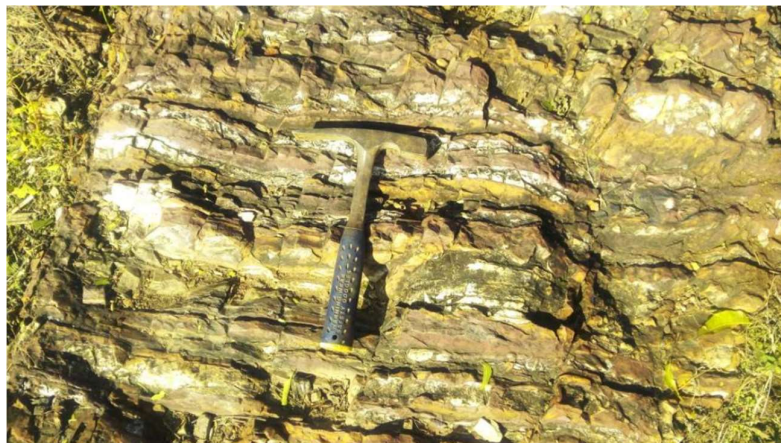


Figure-4 Phyllite interbanded with tuff, Bharhari area(Source-GSI)

1.2.5.4. Banded hematite chert/jasper:

The most significant and prevalent lithological unit having bands of hematite, chert, and/or jasper is known as banded hematite chert/jasper. It serves as the region's marker band. The enormous BIF insitu boulders have occasionally been discovered scattered across the block. These banded hematite chert/jasper bands are primarily formed where the iron ore deposits in the area are located. The ridge top is where the most persistent and continuous banded hematite chert/jasper band is visible, and its width ranges from 9 to 54 meters. Chert/Jasper meso bands typically have a thickness of 1 mm to 4 cm, whereas iron-rich meso bands have a thickness of a few mm to 8 cm. While the predominant chert bands are light grey to white, and the jasper bands are bright, deep red, the hematite is dark grey to reddish brown in colour. This unit's exposure width varies greatly depending on the slope of the hill range and the stratigraphic dip. The strike of the banded hematite jasper/chert bands ranges from N65°E-S65°W to N85°E-S85°W, while the extent of the dip towards the south varies from 50° to 80°. The band's breadth and dip rise in the eastern section, reaching a maximum width of 54 m exposed in the west, with a severe drop of 75° to 80°. In exposed chert bands, a few pyrite sulphide specks have also been observed. Under reflected light, the banded hematite chert/jasper displays alternate colours. A few scattered magnetite grains have formed in the groundmass of the Chert band due to martitization. Hematite is a mineral having fine- to medium-sized grains that are closely linked to one another, leaving tiny voids between the grains. The alternating bands include microfractures and hydroxide forms as a result of the original pre-existing minerals leaching out. A small amount of pyrite-based supplementary sulphide mineralization is observed. Hematite and chert/jasper bands alternate in this lithology when viewed under a microscope. Hematite is found as minute grains organized in a particular direction. Chert is cryptocrystalline and has cryptocrystalline elements in the interstitial spaces. It is seen that the magnetite in hematite has martitized.



Figure-5 Banded Hematite Jasper, Bharhari area(Source-GSI)

1.2.5.5 Dolerite dyke

The dolerite dyke is melanocratic, medium-grained, hard rock exposed in the southern part Bharhari area. A few impersistent bodies are also exposed in the north of part. Mineralogically, dolerite consists of plagioclase

laths and pyroxene with few sulphite specks. The general trend of dolerite in the area is ENE-WSW with a width of 17 - 150 m

1.2.5.6 Altered Basic Rock

It is light grey, hard, fine-grained and, massive and weathered in nature consists of pyroxene, chlorite and iron oxide

1.2.5.7 Quartz vein

The quartz veins are emplaced in phyllite and banded iron chert/jasper along the foliation planes and at places along the joint planes trending along N40W-S40E and N80E-S80°W. Quartz veins are white, oxidised, and show sulphide mineralisation in some places. The majority of quartz veins are emplaced in ferruginous phyllite and are sub-parallel to the strike.

1.2.6 Metamorphism

The phyllite, schistose texture is defined by subparallel arrangement of chlorite, muscovite and biotite. This suggests that rocks exposed in the mapped area are characterised by low-grade metamorphism of greenschist facies. Meta-sedimentaries of the area, namely variegated phyllite and ferruginous phyllite, are marked by the presence of fine-grained quartz, muscovite, chlorite, and biotite with few opaque. This mineral assemblage indicates the biotite zone of greenschist facies regional metamorphism. (Winkler, 1974).

1.2.7 Mineral potentiality based on geology, geophysics, ground geochemistry

GSI, during the preliminary exploration in the Bharhari A-block, carried out geological mapping as per their field observations; the iron ore bearing banded haematite chert / Jasper band has been demarcated on the hilltops (Shrivastav et al., 2021). The rolled boulders of banded hematite chert/jasper, scree material at hill slopes and hard-resistant linear bands interbanded with phyllite at ridge tops are indicators of iron ore mineralisation. The iron ore mineralization occurs in the area as a linear banded hematite chert/jasper (BIF) zone, trending N65°E – S65°W to N85°E – S85°W with moderate to steep dips of 50° to 80° due south. In banded hematite chert/jasper, the bands of chert/jasper and ferruginous layer (hematite) occur rhythmically. The thickness of individual hematite layers varies from 1 mm to 8 cm. The strike length of the banded hematite chert/jasper (BIF) band is 3.12 km, and the width is about 9 m to 54 m. The ore band/body with concentrated iron ore minerals is strata-bound in between variegated phyllite with tuff and dolerite as intrusive. The iron mineralization is in the form of banded hematite chert/jasper bands having alternating bands of chert and /or jasper and ferruginous layers (hematite). The thickness of chert/jasper bands generally ranges from 1 mm to 4 cm, while that of iron-rich bands ranges from 1 mm to 8 cm and are dark grey to reddish brown in colour. On the basis of boreholes drilled, GSI delineated five mineralized zones, with thicknesses ranging from 1.10m to 23.25m at 30% Fe cut-off, and six mineralized zones with thicknesses varying from 1.00m to 6.55m at 35% Fe have been demarcated in one borehole UPSBB-1. In UPSBB-2, two mineralized zones at 30% and 35% Fe cut-off have been established, having thickness ranging from 7.75 m to 11.0 m and 1.80 m to 3.55 m, respectively, while in UPSBB-3, three zones at 30% cut off and two zones at 35% Fe have been marked.

The preliminary exploration report on Block B on Iron ore around the Bharhari area, Sonbhadra district, U. P, consists of detailed mapping of 2.1 sq. km on a 1:4000 scale (Shrivastav & Ahmad, 2019). The report also consists of drilling of 461.30 m through 04 boreholes, 79 nos. of PTS, 195 nos. of core samples, 23 nos. of petrological samples, 15 ore microscopy samples and 10.80 line kilometres of geophysical exploration. The litho-units

exposed in the block include variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert/jasper (BIF), ferruginous phyllite and dolerite. The general trend of the rock types in the study area is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with a dip amount of 50° to 80° towards the south. The Iron ore mainly contains Hematite, Limonite, and Goethite. The ore band/body with concentrated iron ore minerals is stratabound in between variegated phyllite with tuff and dolerite as intrusive. The exposed BIFs formed as ridge and crest of the proposed block and show continuity in the strike along ENE-WSW with varying widths of 9 to 54 m. The analytical results of Boreholes show iron content (Fe%) varying from 6.80% to 45.76%, and at 30%, the Fe cut-off weighted average of mineralized zones varies between 33.12% to 42.94% Fe. Two boreholes yielded Fe% varying between 9.55% to 43.50% and 7.69% to 58.44%, respectively. GSI estimated the total resource through the Cross-Section method at 30 % Fe is 10.77 million tonnes (MT) with an average grade of 34.50%. Goethitisation and limonitization have also been observed at joint planes and fractures.

On the basis of GSI preliminary exploration for iron ore in the Bharhari area and observation of similar geological formations and occurrence of BIF, the Reconnaissance Survey for the G-4 level has been proposed for potential Iron ore demarcation in the area south of the GSI explored area.

1.2.8 Geophysical Exploration

The geophysical mapping was conducted by Bhattacharya et al., (2012) during FS 2009-10 and 2010-12 in parts of Allahabad, Mirzapur and Sonbhadra districts of Uttar Pradesh and Rewa and Sidhi districts of Madhya Pradesh. The high gravity closure of -20 meal (H1), as depicted on the Bouguer Anomaly Map in the surrounding areas of Jungel (parts of Toposheet No. 63 L/14), have been attributed to heavier litho units of Agori and Parsoi formations of Mahakoshal Group. These litho units are WNW-ESE trending banded hematite chert/jasper bands, quartz veins and reefs and are traversed by a large number of E-W dolerite dykes in these areas. The strong and wide gradient in the north and south of this high gravity (H1) outlines the boundary of the Mahakoshal rocks and separates them from the Vindhyan rocks in the north and the Dudhi Granitoid Complex in the south.

GSI carried out a geophysical investigation to assess the iron ore potential in the Bharhari area. The total length of the line laid was 2.8 km, and the magnetic (TF) survey was carried out at 10.8 L. The magnetic (TF) contours overlaid on geological maps of the area. The study region can be classified into three magnetic domains based on magnetic intensity: low, moderate, and high. The trends of Magnetic (TF) contours are in conformity with the general geological strike of the area. Magnetic (TF) contour trends are consistent with the typical geological strike of the area, which is NE-SW. Magnetic highs of varied magnitudes are well correlated with the exposed rocks. Magnetic anomaly values range from 100 to 900 nT along the strike direction of the BIF band and other rock units, with values exceeding 900 nT in the northern section. These high magnetic (TF) anomalies could be caused by magnetite and dolerite dykes in the rocks. Low magnetic anomaly levels (100 nT) are mostly recorded in southern parts over weathered dolerite/phyllite with tuff and soil cover. The wide range of magnetic (TF) anomalies in the investigated block shows the presence of many lithological units in the subsurface. Based on the results of the magnetic (TF) survey, it is recommended to conduct detailed magnetic surveys in the south-eastern and eastern portions.

1.2.9 Geochemical Exploration

The bedrock and channel sampling were carried out across the strike of the banded hematite chert/jasper (BIF) band to assess the grade of iron by GSI in both A and B blocks. The channels were excavated in the profile lines of boreholes to know the nature and mineralisation in the banded hematite chert/jasper band. The geochemical sampling of bedrock samples was carried out as per accessibility and availability of exposures. In Block A, drilling of 822.7 m through 08 boreholes, 51 nos. of PTS, 10 nos. of channel samples, and 40 nos. BRS samples totalling 441 core samples. The analytical results of the samples show Fe % varying between 6.9% and 52.3% in BHC/J (Shrivastav et al, 2021).

In Block B, a total of 80 nos. bedrock samples (including 26 nos. channel samples) and 79 nos. trench samples from five trenches were collected. Systematic sampling on a grid pattern was not possible due to narrow linear hilltop exposure of banded hematite chert/jasper and rugged and mountainous terrain conditions. The chemical results received suggested Fe values of banded hematite chert/jasper in bedrock ranging from 6.67 % to 46.39 % with an average of 26.51 %. The analytical values of 26 nos. channel samples revealed Fe values ranging from 25.20 % to 62.81 % with a weighted average of 43.28 % (Shrivastav & Ahmad, 2019).

1.3.0 Pitting/Trenching

In block A, a total of four trenches have been excavated in the field area to understand the continuity of the banded hematite chert/jasper band. A total of 51 nos. trench samples, 10 nos. channel samples, and 40 nos. bedrock samples were collected. A total of 441 nos. core samples were collected from drilled boreholes. The chemical results of the banded hematite chert/jasper in bedrock samples show Fe values from 6.9 % to 52.3 %, with an average of 28.20%. The Fe in trench samples of TR-1 varies from 31.3 % to 47.2 %, with 38.9% as an average, while in TR-2, Fe₂O₃ varies from 1.02 % to 30.86 % with an average value of 12.33 %, and Fe of TR-3 samples ranges from 12.4 % to 34.7 % averaging 25.2 %. The trench TR-4 suggests Fe₂O₃ ranging from 29.4 % to 43.2% and a weighted average of 35.4%. At 30% Fe cut-off, the mineralized iron zones have been established in six boreholes, namely SBE-2, 3, 5, 6, 7 and 8. At 35% Fe cut-off, the mineralized zones have been demarcated in SBE-5, SBE-6 and SBE-7.

In Block B, a total of five trenches were excavated to study the strike/width continuity of banded hematite chert/jasper (BIF). A total of 79 samples were extracted from BIF bands and soil with boulders of BIF that are in situ in the trenches. The sampling interval in the trenches was kept at 1 m, and homogeneous sampling was carried out. The Fe values in trench samples of trench TRB-1 vary from 12.64 % to 56.15 % with 34.39% as weighted average Fe, while in trench TRB-2, Fe values vary from 26.68 % to 45.87 % with a weighted average value of 35.53 % and Fe values of trench TRB-3 samples range from 20.21 % to 59.17 % with the weighted average of 44.33 %. The trench TRB-4 suggests Fe ranging from 42.38 % to 51.01 % and a weighted average of 45.87 %, and the trench TRB-5, Fe values ranging from 26.95 % to 62.54 % with a weighted average of 43.45 %.

1.4.0 Scope for Proposed Exploration.

The proposed area is the southern extension of the GSI preliminary exploration in the Bharhari area of two blocks, A and B. The Reconnaissance survey at the G-4 stage proposed exploration program comprises of Geological mapping of 18.56 Sq. Km area on 1:12,500 scale, Surface/ Geochemical sampling (Bedrock, soil,

stream sediment), Pitting /Trenching, drilling of 5 Nos of scout boreholes, chemical analysis, Petrological analysis and estimation of resources under G4 category and Report preparation.

1.5.0 Objectives

1. Carry out Geological and structural mapping on a 1:12,500 scale to demarcate Iron ores.
2. Collect surface (Bedrock) samples and analyze for Fe and associated minerals.
3. To carry out channel and trench samples collected from iron-bearing formations to demarcate mineralised zones.
4. To drill 5 scout angle boreholes up to 30m vertical depth to prove the strike and depth persistence of ore-bearing formation mapped in the area, which in turn will decide the future course of the Exploration program at the G-4 category of UNFC.
5. To estimate reconnaissance iron resources along with accessory elements as per UNFC norms and Minerals (Evidence of Mineral Contents) Rules-2015 at the G-4 level.

1.6.0 Observation and Recommendations of previous work.

Shrivastav and Ahmad (2019), during FS 2017-18, estimated resource for iron ores in Bharhari block 'A' as 14.89 million tonnes (MT) with an average grade of 34.73% Fe at 30% cut off and 8.41 million tonnes (MT) with an average grade of 38.34% of Fe at 35% cut off. The chemical results of core samples pertaining to borehole no. SBE-5 has an average Fe value of 36.83%. In core samples of SBE-6, the average Fe is 37.78%. Analytical results for cores from borehole SBE-7 have suggested an average Fe of 34.37%. The cores of SBE-8 have an average Fe value of 30.75%. The weighted average of all the core samples of borehole no SBE-1 to SBE-8 of the block 'A', Bharhari area at 30% Fe cut off has yielded an average grade of 34.73% Fe, and at 35% Fe cut off has yielded an average grade of 38.34% Fe.

GSI, during Field Season 2019-20 (Shrivastav et al., 2021), carried out a preliminary exploration for Iron ore in Block 'B', Bharhari area, Sonbhadra, U.P. was carried out in 2.1 sq km by detailed mapping on 1:4000 and G-3 stage drilling. The Banded Hematite Chert/Jasper bands (BIF) exposed in block 'B' is part of the 20 km long BIF zone extending from NW of Bijaura in the east to Bharhari (Bharahari) in the west, having a general trend of N65°E-S65°W to N85°E-S85°W with a dip of 50°-80° towards the south. BIF bands are the parts of the Agori Formation of the Mahakoshal Group of rocks and are closely associated with variegated phyllite; phyllite interbedded with tuff, tuff, banded hematite chert/jasper (BIF), ferruginous phyllite and mafic intrusives in the form of dolerites. Based on chemical results, the total estimated resource for iron ores in the block 'B' Bharhari area is 10.77 million tonnes (MT) with an average grade of 34.50% Fe at 30 % cut off and 5.03 million tonnes (MT) with an average grade of 39.51% of Fe at 35 % cut off. The resource has been calculated for a 1.32 km strike length only of the detailed mapping (DM) block 'B' when the total strike length of the exposed BIF is 3.12 km.

GSI recommended that as the state of Uttar Pradesh is quite deficient in ferrous mineral resources, the search for low-grade iron ore is a dire need at this point, and the discovery of potential mineral blocks with Fe value of 35% to 45% will augment the iron resource in the mineral inventory of the state. The resource in the 1.32 km strike length has been estimated, and the remaining 1.8 km strike length in the eastern part of the block may be taken up for exploration for resource estimation. Further, beneficiation studies of the bulk samples (drill core samples) are to be carried out to know the iron percentage in the beneficiated samples.

2.0 Previous Work

Iron-ore occurrence in Bargawan (24°36'00", 82°52'30") in the Mirzapur district of Uttar Pradesh was the subject of preliminary investigation work conducted by A.K. Dey (1967–68; 1968–69); the iron ore is mainly siliceous hematite, limonite and goethite with rare magnetite. Analytical results reveal that about 70% of samples contain less than 35% Fe₂O₃. Approximately 6 million tonnes of possible resource of low grade Iron-ore was estimated in an area of about 0.37 sq. km. and subsequently taken up during the F.S. 1968–69 for the purpose of evaluating the quality and quantity of the accessible reserves. Sarkar et al. performed NGCM in toposheet no. 63L/14 during F.S. 2013–2014. In the southern and northern portions of toposheets 63L/14 and 63L/15, the Mahakoshal Group rocks had higher Fe₂O₃ values than the threshold. Banded hematite quartzite and banded hematite jasper both contribute to the composite samples' high Fe₂O₃ (>14%) concentration. The work indicated anomalous values in different parts of the area with respect to Cr (>459.12 ppm), Cu (>92.50 ppm), Ni (>164.26 ppm), Pb (>117.94 ppm) and V (>386.97 ppm).

During F.S. 2009–12, geophysical mapping was carried out by GSI. The Mahakoshal Group of rocks are thought to be connected to a gravity high that is reinforced by high magnetic values ranging from 100 nT to 150 nT and shown in the southern portion of Toposheet No. 63 L/14. Modak et al. carried out large-scale mapping at a 1:12500 scale during FS 2014–15, encompassing portions of toposheet 63 L/14. From the northwest of Bijaura in the east to Bharahari in the west, five subparallel bands of banded hematite chert/jasper were identified. These banded hematite chert/jasper bands have a total strike length of around 20 km, range in width from 2 to 10 m, and have a cumulative width of 170 to 450 m. It is interbanded with khaki and reddish-brown phyllite, with a maximum width of 77 meters. Banded hematite chert/jasper is composed of brecciated chert-jasper-quartzite-banded hematite chert/jasper clast fragments embedded in a ferruginous and siliceous matrix, which manifest as linear patches with a width of up to 60 m. Banded hematite jasper (BHJ) and banded hematite chert (BHC) are found in the areas northwest of Bharahi, south of Murgidand, and northeast of Karwaniya. These rocks have exposed strike lengths of around 100 m and widths of 1 m to 2 m, and they are interbanded with phyllite, as seen on ridge tops. The value of Fe₂O₃ varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe₂O₃ in the easternmost two blocks.

Iron ore investigation through detailed mapping of 1.50 sq km, pitting/trenching of 50 cubic meters and 50 numbers of BRS along with 750 metres of drilling was taken up in block 'A' of Bharhari, Sonbhadra district, UP vide item no. M2AFGBM: MEP/NC/NR/SU-UP/2017/11767, FS 2017-18 bounded by latitude N 24°33'32" – 24°34'09" and longitude E 82°51'41" – 82°53'16" (Shrivastav and Ahmad, 2019). The strike length of banded hematite chert/jasper band is 2.62 km and width ranging from 8-75m. The Fe values in trench samples of TR-1 vary from 31.3 % to 47.2 %, with 38.95% as a weighted average, while in TR-2, Fe values vary from 1.02 % to 30.86 % with a weighted average value of 12.33% and Fe values of TR-3 samples range from 12.4 % to 34.7 % with a weighted average of 25.2 %. The trench TR-4 suggests Fe ranging from 29.4 % to 43.2% and a weighted average of 35.4%. A total of 441 core samples were submitted for chemical analysis from borehole samples from block 'A', Bharhari area, Sonbhadra. The analytical analysis shows that iron value (at 30% Fe cut-off) varies from 29.99% to 49.87%, SiO₂ varies from 24.04% to 71.71%, and Al₂O₃ varies from 0.12% to 8.51%. At 30 % Fe cut-off, the core samples of boreholes have yielded average Fe values of 29.98% and 31.58%, respectively.

GSI during 2019-20, the preliminary exploration in the Bharhari B Block area, carried geological mapping as per their field observations, the iron ore bearing banded haematite chert / Jasper band has been demarcated on

the hilltops and estimated resources through Cross Section method at 30 % Fe is 10.77 million tonnes (MT) with an average grade of 34.50% (Shrivastav et al., 2021).

3.0 Block Description

The proposed blocks A1 and A2 fall in Survey of India Toposheet No. 63L/14 and cover an area of about 7.21 sq. km and 11.35 sq. km totalling 18.56 sq. km. The villages in the area are Chakdiya, Kushniaya, Jobra and Tusgaon Villages, Sonbhadra District, Uttar Pradesh. The cardinal points of the proposed area are given in Table 4 below.

Table 6a: Proposed area boundary for block A1		
Cardinal Points	Geographic Coordinate System in Degree Decimal (WGS 1984) for Block A1	
	Latitude	Longitude
A1	N24° 32' 47.1"	E82° 51' 14.8"
A2	N24° 33' 07.0"	E82° 51' 15.5"
A3	N24° 33' 11.3"	E82° 51' 44.7"
A4	N24° 33' 42.8"	E82° 53' 56.9"
A5	N24° 34' 15.8"	E82° 56' 10.3"
A6	N24° 34' 13.4"	E82° 56' 24.1"
A7	N24° 33' 44.8"	E82° 55' 53.7"
A8	N24° 33' 12.3"	E82° 53' 46.3"
A9	N24° 32' 39.3"	E82° 51' 41.4"

Table 7b: Proposed area boundary for block A2		
Cardinal Points	Geographic Coordinate System in Degree Decimal (WGS 1984) for Block A2	
	Latitude	Longitude
B1	N24° 31' 13.8"	E82° 51' 14.6"
B2	N24° 31' 33.2"	E82° 52' 29.2"
B3	N24° 31' 06.0"	E82° 52' 27.6"
B4	N24° 31' 07.0"	E82° 52' 59.6"
B5	N24° 31' 03.6"	E82° 53' 10.8"
B6	N24° 30' 16.1"	E82° 53' 52.9"
B7	N24° 31' 07.5"	E82° 56' 11.0"
B8	N24° 31' 19.6"	E82° 56' 59.5"
B9	N24° 31' 0.20"	E82° 56' 57.4"
B10	N24° 30' 01.0"	E82° 54' 20.1"
B11	N24° 30' 04.4"	E82° 54' 10.0"
B12	N24° 30' 06.9"	E82° 52' 11.6"
B13	N24° 30' 46.1"	E82° 51' 11.9"

4.0 Planned Methodology

The Exploration programme has been proposed in accordance with the set objective for the area, and the Exploration shall be carried out as per Minerals (Evidence of Mineral Contents) Rules-2015 and Minerals (Evidence of Mineral Contents) Amendment Rules-2021. To achieve the objectives, the following different

activities are to be carried out under the G4 category. Accordingly, the following scheme of exploration is formulated in order to achieve the objectives. The details of different activities to be carried out are presented in subsequent paragraphs.

4.1.0 Geological Mapping (1: 12,500 Scale)

Geological Mapping will be done in the entire 18.56 sq. km area on a 1: 12,500 scale. Rock types, their contact, demarcation of mineral deposits and associated mineralization-bearing formations (host rock) with the structural features to identify the surface manifestations and lateral dispositions of the mineralized zones.

4.2.0 Geochemical Sampling (BedRock sampling)

Bedrock samples will all be taken from outcrops throughout the geochemical sampling process. 125 primary samples will be gathered and examined for the presence of Fe and any related mineralization.

4.3.0 Pitting/Trenching

Shallow trenching (Excavation) shall be carried out in the BIF in anomaly zones identified based on the results of geological mapping and geochemical sampling. Trenching of 100 CuM will be carried out on the surface following 1mX2mx10m dimension, and sampling will be done for 25 samples.

4.4.0 Core Drilling

Based on the results of surface exploration such as geological mapping and geochemical survey and pitting/trenching in an area of 18.56 Sq.km, 5 scout boreholes shall be drilled in targeted mineralized zones to find out the continuity of mineralized zones in strike and dip direction and to assess the attitude of the subsurface disposition of the Iron bodies for the upper level of intersection. The lower level of the intersection drilling programme shall be formulated after getting the positive intersections at the upper-level stage. The azimuth and angle of inclination of the proposed boreholes will be decided once the attitude (strike and dip) of mineralized zones (host rock) is deciphered after geological mapping.

4.5.0 Drill Core Logging

The drill core will be logged for rock types, structural features, textures, intersection of ore zones, types of mineralization and occurrence of various ore minerals.

4.6.0 Drill Core Sampling

During the geological logging of the drill core, the mineralized zone will be marked on the basis of the concentration of ore minerals and lithology. 125 Nos. of samples will be analysed for Fe and associated minerals.

4.7.0 Whole Rock Analysis

Whole Rock analysis for will be carried out on 10 Nos samples to check the rock types, their variation in chemical composition.

4.8.0 XRD Studies

Selected 10 samples shall be subjected to XRD studies to understand the mineral profiles.

4.9.0 Petrological & Mineralogical Studies

During the course of Geochemical sampling and core logging, 10 samples from various litho-units from the surface and in borehole cores will be studied for petrography in thin sections, and 10 samples from mineralized zones will be studied for the mimeography (ore mineral assemblages and their distribution, alteration, enrichment etc.) in polished sections. Ore-microscopy and Geochemistry of samples will also be studied.

4.10.0 Estimation of resources

To estimate resources as per UNFC norms and Minerals Evidence & Mineral Contents (MEMC) Rule- 2015 at the G-4 level and meet the NMET objectives.

4.11.0 Submission of reports and recommendations

Submission of reports and recommendations compliant with G4 level as per MEMC 2021 and suggestions for follow-up work to upgrade the project, if deemed necessary.

5. Nature Quantum and Target

Table 8: The nature and quantum of the proposed work are given below

DETAILS OF QUANTUM OF WORK PROPOSED										
Time Schedule (in Months) for Reconnaissance Survey (G-4 STAGE) for Iron ore (Block A1 and A2) in Mahakoshal Group										
Item of Work	1	2	3	4	R E V I E W	5	6	7	8	9
Forest Permission										
Geological Mapping, -(18.56 Sq.Km.) (1:12,500 SCALE)										
Bed Rock Sampling (BRS), 75 nos.										
Chemical Analysis of BRS										
Pitting/Trenching and sampling 5 Nos./100 cu.m, 25 Nos. samples										
Chemical Analysis of P/Ts samples										
Drilling of Scout borewells (5 Nos.), core sampling and analysis, 125 Nos. samples										
Geological Report Writing with Peer Review and submission										

5.1 Nature and Quantum of Work Proposed

The details of the particular quantum and the targets are tabulated below in Table 6.

Table 6: Quantum of proposed work (G-4) for Iron ore in Mahakosal Group around Chakdiya, Kushaniya, Jobra and Tusgaon Area, Sonbhadra District, U.P. Total Area 18.56 sq.km - Mapping 1:12,500 Scale			
Sl.No	Item of work	Unit	Qty
A	GEOLOGICAL WORK		
i	Geologist Party days H Q	Days	30
ii	Geologist Party days (1) -Field (6bmonth)	Days	90
iii	Labourers (2 Nos.) (Rs 477/day/labour)	Days	180
iv	Sampler Party days (1party)	Days	31
v	Labour for Sampling (2 Nos.)	Days	124
B	PITTING & TRENCHING		
ii	Trenching(1m x 2mx 10 m) (5 Nos)	Per Cu.M	100
C	DRILLING		
i	Surface Drilling (30 m vertical depth) 5 bhs	mts.	300
ii	Drill core preservation charges- "One complete borehole plus mineralised cores of all the BHs of the Block, all costs included	per Mts.	150
D	LABORATORY STUDIES		
	a.Chemical analyses	Nos	
	(i) Primary Samples (Bedrock/Channel/ Trench/core)	Per sample	225
	(iii) Check Samples (Bedrock/ soil/ stream) (10%)	Per sample	23
	b.Petrography studies		
	c) Preparation of thin sections	Per sample	10
	d)Complete petrographic /ore microscopic study/Mineragraphic studies (BRS)	Per sample	10
	c) Preparation of polished sections	Per sample	10
	d) Complete ore microscopic study/Mineragraphic studies	Per sample	10
E	PREPARATION OF EXPLORATION PROPOSAL (5+1 Softcopy)	Per Project	1
F	PEER REVIEW	As per the EC committee	1
G	GEOLOGICAL REPORT PREPARATION 5+5 HARD COPIES + 2 SOFTCOPY (@3%)	Per Project	1

6. Manpower deployment

The manpower requirement for initial Geological activity shall be 2 Geologists in the field and 1 Geologist in the headquarters, 1 sampling technician, and 4 labourers. Exploratory Drilling Activities shall be outsourced.

7. Break-up of expenditure

The tentative cost has been estimated based on the Schedule of Charges (SoC) of projects funded by the National Mineral Exploration Trust (NMET) w.e.f. 01/04/2020, and the total estimated cost is **Rs. 95.41** Lakhs (including GST). The details of tentative cost estimates are given in Table No. 7 below.

Estimate for Preliminary Investigation (G-4) for Iron ore in Mahakosal Group around Chakdiya, Kushaniya, Jobra and Tusgaon Area, Sonbhadra District, U.P. Total Area 18.56 sq. km - Mapping 1:12,500 Scale						
Sl.No	Item of work	Unit	NMET SoC-Item No.	NMET Rates (2020)	Qty	Amount INR
A	GEOLOGICAL WORK					
i	Geologist Party days H Q	Days	1.3	9000	30	270000
ii	Geologist Party days (1) -Field (6bmonth)	Days	1.3	11000	90	990000
iii	Labourers (2 Nos.) (Rs 477/day/labour)	Days	5.7	504	180	90720
iv	Sampler Party days (1party)	Days	1.5.2	5100	31	158100
v	Labour for Sampling (2 Nos.)	Days	5.7	504	124	62496
						1571316
	Sub Total A					1571316
B	PITTING & TRENCHING					
ii	Trenching(1m x 2mx 10 m) (5 Nos)	Per Cu.M	2.1.1	3330	100	333000
	Sub Total B					333000
C	DRILLING					
i	Surface Drilling (30 m vertical depth) 5 bhs	mts.	2.2.1.5a	12650	300	3795000
ii	Drill core preservation charges- "One complete borehole plus mineralised cores of all the BHs of the Block, all cost included	per Mts.	5.3	1590	150	238500
	SubTotal C					4033500
D	LABORATORY STUDIES					
	a.Chemical analyses	Nos				
	(i) Primary Samples (Bed rock/Channal/ Trench/core) for 5 Radicals Fe, Al ₂ O ₃ , P ₂ O ₅ & SiO ₂ , LOI	Per sample	4.1.15a	4200	225	945000
	(iii) Check Samples (Bed rock/ soil/ stream) (10%)	Per sample	4.1.15a	4200	23	96600
	b.Petrography studies					
	c) Preparation of thin sections	Per sample	4.3.1	2353	10	23530
	d)Complete petrographic /ore microscopic study/Mineragraphic studies (BRS)	Per sample	4.3.4	4232	10	42320
	c) Preparation of polished sections	Per sample	4.3.2	1549	10	15490

	d) Complete ore microscopic study/Mineragraphic studies	Per sample	4.3.4	4232	10	42320
	SubTotal D					1165260
	Total A+B+C+D					7103076
E	PREPARATION OF EXPLORATION PROPOSAL (5+1 Softcopy)	Per Project	5.1		1	142062
F	PEER REVIEW	As per EC committee				30000
G	GEOLOGICAL REPORT PREPARATION 5+5 HARD COPIES + 2 SOFTCOPY (@3%)	Per Project	5.2		1	355154
H	Tender Processing Cost	Per Project				75900
I	Operational Charges	Per Project				379500
	TOTAL A to I					8085691
	GST 18%					1455424
	Total with GST 18% (Say 95.41 lakhs)					9541116

8. References

- Bhattacharya D. et al., (2012):** Report on the ground geophysical mapping in parts of degree sheet no. 63L (TS no. 63L/1, 5, 9, 13, 14, 15 & 16) in Uttar Pradesh and Madhya Pradesh.
- Deshmukh, T., Prabhakar, N., Bhattacharya, A. & Madhavan, K. (2017).** Late Paleoproterozoic clockwise P–T history in the Mahakoshal Belt, Central Indian Tectonic Zone: Implications for Columbia supercontinent assembly. *Precambrian Research*, pp. 298, 56–78. <http://dx.doi.org/10.1016/j.precamres.2017.05.020>.
- Devrajan, M.K., Prasad, H.M., Prasad, A.V.K. & Soni, M.K. (1998).** Gold mineralisation in the Mahakoshal Greenstone belt, Central India: A preliminary study. *Journal Geological Society of India*, 52, 147-152.
- Dey A.K., (1967-68).** Report on the preliminary investigation of Iron-ore Deposit near Bargawan, District Mirzapur, U.P., *Unpub. report Geol. Surv. India*.
- Dey A.K., (1968-69):** Report on the exploratory operations carried out on the iron-ore deposit near Bargawan. Dist. Mirzapur, U.P. *Unpub. report Geol. Surv. India*.
- Dwivedi, G.N., Sharma, D.P., Prasad, M., Sinha, V.P., Tripathi, A.K., Yadav, M.L., Mishra, R., Khan, M.A. & Absar, A. (2001).** Gold Exploration at Sona Pahari, Sonbhadra District, U.P.: An Introspect. *Geol. Surv. India, Spl. Publ. No-58 P. 361–365*.
- Mathur, S.M. & Narain, K. (1981)** Geosynclinal sedimentation in the Archaeans of the Mirzapur-Sidi area. In: *Archaeans of Central India. Geological Survey of India Special Publications*, 3, 31–37.
- Misra, P.S., Pandit, D., Murmu, A., Saleesh, P.N. & Salu, S., (2022).** Bismuth–Telluride–Gold mineralisation from Parsoi area in Eastern Mahakoshal belt, Sonbhadra District, UP, India. *Journal Geological Society of India*, 98, 198-202. <https://doi.org/10.1007/s12594-022-1959-4>.
- Modak, A, Arvind, Chaki. P. and Nag, R., (2015):** Report on resource evaluation of potentiality of iron in Mahakoshal Group, Bharhari area, Sonbhadra district, Uttar Pradesh., *Unpub. report Geol. Surv. India, FS: 2014-15*.

- Nair, K.K.K., Jain, S.C. and Yedekar, D.B. (1995).** Stratigraphy, Structure and geochemistry of Mahakoshal Greenstone Belt. *Mem. Geol. Soc. Ind.* 31: 405–432.
- Roy A. and Devarajan M. K. (2000).** Reappraisal of stratigraphy of Mahakoshal Group, Cambrian crust in eastern and central India, proceeding on international seminar, UNSCO- IUGS-IGCP-368. *Geol. Surv. Ind. Spl. Pub. No. 57.*
- Roy, A. & Prasad, M.H. (2003).** Tectonothermal events in Central Indian Tectonic Zone (CITZ) and its implications in Rodinian crustal assembly. *Journal of Asian Earth Sciences*, 22, 115–129.
- Roy, A. & Bandyopadhyay, B.K. (1990).** Tectonic and structural pattern of the Mahakoshal belt of Central India: a discussion. Geological Survey of India Special Publication, pp. 28, 226–240.
- Roy, A., Prasad, M.H. & Devarajan, M.K. (2002).** Low-pressure metamorphism, deformation and syntectonic granite emplacement in the Palaeoproterozoic Mahakoshal supracrustal belt, Central India. *Gondwana Research*, 5, 489-500.
- Sarkar, Abhijit, Gupta, Sangeeta, Sangeeta and Pramanik Suhrit (2014).** Interim Report on the geochemical mapping of Vindhyan basin and Mahakoshal Belt in toposheet nos. 63L/13, 14 and 15 (NW/NE) covering parts of Mirzapur and Sonbhadra districts of U.P. and Sidhi district of M.P. *Unpub. report Geol. Surv. India, FS:2013-2014.*
- Sharma, D.P., Sinha, V.P., Kannadasan, T., Khan, M.A., Mehrotra, R. D., Dwivedi, G.N., Yadav, M.L., Dhir, N.K., Prasad, M. & Trpathi, A.K. (2000).** Gold mineralisation in Eastern Part of Son Valley Greenstone Belt, Sidhi and Sonbhadra districts, M.P. and U.P. In *Precambrian Crust in Eastern and Central India*. Geological Survey of India Special Publication, 57, 271–278.
- Shrivastav, M. R., Ahmad, S. (2019).** Preliminary exploration for iron ore in Mahakoshal Group Block 'A' Bharhari area, Sonbhadra district, Uttar Pradesh, FS 2017-18.
- Shukla, S., Chauhan, H., Yousuf, I. & Ahmad, T. (2021).** Bulk rock and mineral chemistry of meta-sediments from Mahakoshal Supracrustal Belt, Central Indian Tectonic Zone: Constraints on weathering, provenance, paleoclimate and metamorphism. *Journal of Sedimentary Environments*, 6, 621–645. <https://doi.org/10.1007/s43217-021-00074-3>.
- Soni, M.K. & Jha, D.K. (2001).** Mahakoshal Greenstone belt and associated gold mineralisation. *Geol. Surv. Ind., Spl. Pub. No. 64*, pp. 317- 326.
- Srivastava, R.K. (2012).** Petrological and geochemical studies of Paleoproterozoic mafic dykes from the Chitrangi region, Mahakoshalupracrustal belt, Central Indian Tectonic Zone: petrogenetic and tectonic significance. *Journal Geological Society of India*, 80, 369-381.
- Srivastava, R.K. (2013).** Petrological and geochemical characteristics of Paleoproterozoic ultramafic lamprophyres and carbonates from the Chitrangi region, Mahakoshalupracrustal belt, central India. *Journal of Earth System Science*, 122, 759-776.
- Talusani, V.R.R. (2001).** Possible Carlin-type disseminated gold mineralization in the Mahakoshal fold belt, central India. *OreGeology Reviews*, 17, 241-247.

Tripathi, S.C. & Mishra, M.N. (1994). Cyclic volcanism and sedimentation in the Mahakoshal Greenstone Belt, district Sidhi, Madhya Pradesh. *Jour. Geol. Soc. India, Vol. XLIV, p 167 – 173.*

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भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण
उत्तरी क्षेत्र, लखनऊ

**GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA
NORTHERN REGION, LUCKNOW**



राज्य इकाई : उत्तर प्रदेश
परियोजना : लौह खनिज
**STATE UNIT : UTTAR PRADESH
PROJECT : FERROUS MINERALS**

उत्तर प्रदेश के सोनभद्र जिले के भरहारी क्षेत्र के ब्लॉक 'ए' में लौह अयस्क के प्राथमिक अन्वेषण पर प्रतिवेदन
(जी-3 चरण)

टोपोशीट सं.: 63 एल / 14

कार्यसत्र : 2017-18

कार्यक्रम मद सं.: एम2एएफजीबीएम-एमईपी/एनसी/एनआर/एसयू-यूपी/2017/11767

**PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL
GROUP BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT,
UTTAR PRADESH. (Stage - G3)**

Toposheet No. : 63 L/14

Field Season: 2017-18

Item code: M2AFGBM-MEP/NC/NR/SU-UP/2017/11767

मुकेशकुमार राजकुमार श्रीवास्तव, वरिष्ठ भूवैज्ञानिक
एवं

शमीउद्दीन अहमद, सहायक भूवैज्ञानिक

Mukeshkumar Rajkumar Shrivastav, Senior Geologist
And

Shamiuddin Ahmad, Assistant Geologist

लखनऊ / Lucknow

2019

पूर्वानुमति के बिना पूर्ण अथवा आंशिक खंडाश किसी भी रूप में उद्धरित न किया जाए। प्रतिवेदन की सॉफ्ट प्रति एवं आंकिक आंकड़े महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण, कोलकाता-700016 की अनुमति से प्राप्त किए जा सकते हैं।
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Director General, Geological Survey of India, Kolkata-700 016.

**PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP
BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT,
UTTAR PRADESH. (STAGE - G3)**

(T.S. 63 L/14)

**(Field item no.: M2AFGBM-MEP/NC/NR/SU-UP/2017/11767)
(Field Season: 2017-18)**

By

Mukeshkumar Rajkumar Shrivastav, Senior Geologist and Shamiuddin Ahmad, Assistant Geologist
Geological Survey of India

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उत्तर प्रदेश के सोनभद्र जिले के भरहरी क्षेत्र के ब्लॉक 'ए' में लौह अयस्क के प्राथमिक अन्वेषण पर प्रतिवेदन

(चरण – जी 3)

(क्षेत्रावधि 2017-18)

भूमानचित्र भाग संख्या : 63 एल /14

मद कोड : एम2एएफजीबीएम-एमईपी/एनसी/एनआर/एसयू – यूपी/2017/11767

द्वारा

मुकेशकुमार राजकुमार श्रीवास्तव, वरिष्ठ भूवैज्ञानिक

एवं

शमीउद्दीन अहमद, सहायक भूवैज्ञानिक

भारतीय भूवैज्ञानिक सर्वेक्षण

सारांश

कार्य सत्र 2017-18 में मद कोड - एम2ए एफजीबीएम-एमईपी/एनसी/एनआर/एसयू-

यूपी/2017/11767 के अनुपालन में भरहरी क्षेत्र के विस्तारित ब्लॉक 'ए' में लौह अयस्क के प्राथमिक अन्वेषण के लिये 1:2,000 के पैमाने पर 1.61 वर्ग किमी क्षेत्र में विस्तृत मैपिंग तथा जी- 3 चरण का वेधन कार्य किया गया। अन्वेषण क्षेत्र N 24°33'32 "- 24°34'09" और E 82°51'41 "- 82°53'16" के बीच स्थित है जो की भारतीय सर्वेक्षण विभाग की टोपोशीट सं 63 L / 14 के अंतर्गत आता है। यह विस्तारित क्षेत्र भरहरी गांव के पूर्व में स्थित है। विस्तारित ब्लॉक 'ए' में महाकौशल संघ के अगोरी शैल समूह की शबलित फिलाइट, फेल्सिक टफ, पट्टित हेमाटाइट चर्ट/जैस्पर , लौहयुक्त फिलाइट उपस्थित हैं एवं डोलेराइट भित्ति इंड्रिसव के रूप में है। पट्टित हेमाटाइट चर्ट/जैस्पर पट्टि का नतिलम्ब २.६२ किमी है। अध्ययन क्षेत्र में चट्टानों की सामान्य प्रवृत्ति ENE-WSW (N70°E-S70°W से N85°E-S85°W) है और इसका नमन दक्षिण दिशा में है जो कि 50°-75° के बीच बदलता है। पट्टित हेमाटाइट चर्ट/जैस्पर में संस्तर (S₀) क्षेत्र में देखी गई प्राथमिक संरचना है।

पट्टित हेमाटाइट चर्ट/जैस्पर, लौह ऑक्साइड तथा चर्ट अथवा जैस्पर युक्त पट्टियों से बनी हुई एक अलग शैल इकाई है। लौह ऑक्साइड गहरे धूसर से गहरे भुरे रंग के तथा चर्ट पट्टियां हल्के धूसर रंग जबकि जैस्पर पट्टियां लाल रंग की हैं। हेमाटाइट बैंड की मोटाई कुछ मिलीमीटर से 7 सेमी तक बदलती है। पट्टित हेमाटाइट चर्ट/जैस्पर पट्टि पहाड़ी की चोटी पर उजागर होता है और इसकी चौड़ाई 8- 75 मीटर है। पट्टित हेमाटाइट चर्ट/जैस्पर पट्टि की उप-सतह निरंतरता को समझने के लिए कुल आठ वेध छिद्र किये गये। वेध छिद्र एसबीई-1, एसबीई-2, एसबीई-3, एसबीई-4 तथा एसबीई-5, एसबीई-6, एसबीई-7 तथा एसबीई-8 के वेधन द्वारा कुल 822.70 मी. वेधन लक्ष्य प्राप्त किया गया। उजागर आधार शैल खड़ी नमन की होने के कारण सभी वेध छिद्र झुके हुए हैं। वेध छिद्रों की गहराई 59.0 मी. से लेकर 160.05 मी. तक है तथा प्रतिछेदित खनिज क्षेत्र की संचर्च मोटाई 30% Fe के कट ऑफ पर 1.5 मी to 34 मी के बीच बदलती है एवं औसत Fe 30.00% to 37.78% है।

वेध छिद्र एसबीई-2 में 41.5 से 42 मी (0.5 मी) गहराई तक पट्टित हेमाटाइट चर्ट/जैस्पर तथा 86.10 से 94.05 मी (7.95 मी) तक विभंग लिमोनाइट/गोयथाइट युक्त पट्टित हेमाटाइट चर्ट/जैस्पर की उपस्थिति प्रदर्शित करता है। वेध छिद्र एसबीई-3 में पट्टित हेमाटाइट चर्ट/जैस्पर 70 मी से 89 मी (19 मी) पर प्रतिच्छेदित हुआ है। एसबीई-5 में 18.20 मी मोटाई का पट्टित हेमाटाइट चर्ट/जैस्पर 40.80 मी to 59.0 मी पर प्रतिच्छेदित हुआ है। एसबीई- 6 में 62.55 मी मोटाई का बिआइएफ़ 90.75 मी के गहराई पर प्रतिच्छेदित हुआ जो की 153.30 मी तक चलता है। एसबीई-7 में पट्टित हेमाटाइट चर्ट/जैस्पर 48.80 मी पर प्रतिच्छेदित होकर 133.90मी तक लगातार चलता है एवं कुल मोटाई 85.10 मी है। एसबीई-8 में पट्टित हेमाटाइट चर्ट/जैस्पर के रूप में 34.05 मी मोटाई का जोन 43.25 मी से 77.30 मी के बीच प्रतिच्छेदित होता है।

पट्टित हेमाटाइट चर्ट/जैस्पर की निरंतरता को प्रकट करने/ अध्ययन करने के लिए क्षेत्र में चार ट्रेंचों का उत्खनन किया गया है। कुल 51 ट्रेंच के नमूने , 10 चैनल नमूने और 40 आधार शैल नमूने एकत्र किए गए। वेधित छिद्रों से कुल 441 कोर नमूने लिए गए।

आधार शैलों में पट्टित हेमाटाइट चर्ट/जैस्पर के रासायनिक नतीजों में Fe का मान 28.20 % के औसत के साथ 6.9 % to 52.3 % की सीमा तक है। ट्रेंच टीआर-1 के नमूनों में Fe का मान 38.9% के औसत के साथ 31.3 % to 47.2 % के बीच बदलता है, जबकि ट्रेंच टीआर-2 में Fe 12.33 % औसत के साथ 1.02 % to 30.86 % के बीच है तथा ट्रेंच टीआर-3 के नमूनों में Fe 25.2 % औसत के साथ 12.4 % to 34.7 % के बीच बदलता है। ट्रेंच टीआर-4 में Fe 35.4% औसत के साथ 29.4 % to 43.2% % के बीच है। छह वेधन छिद्रों एसबीई -2, एसबीई -3, एसबीई -5, एसबीई -6, एसबीई -7 एवं एसबीई -8 में लौह खनिजीकरण जोन Fe > 30% कट ऑफ पर चिन्हित किया गया है। एसबीई -5, एसबीई -6 और एसबीई -7 में लौह खनिजीकरण जोन Fe > 35% कट ऑफ पर चिन्हित किया गया है।

लौह 30% कट ऑफ पर अनुमानित संसाधन 14.89 मिलियन टन है जिसका औसत ग्रेड 34.73% Fe है और 35% लौह कट ऑफ पर अनुमानित संसाधन 8.41 मिलियन टन है जिसका औसत ग्रेड 38.34% Fe है यह यूएनएफसी के 333 वर्ग के अंतर्गत आता है।

**PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP
BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT,
UTTAR PRADESH. (Stage - G3)**

(Field Season: 2017-18)

Toposheet Nos.: 63 L/14

Item code M2AFGBM-MEP/NC/NR/SU-UP/2017/11767

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ABSTRACT

In pursuance of item code M2AFGBM-MEP/NC/NR/SU-UP/2017/11767, field season 2017-18, preliminary exploration for iron ore in extended Block 'A', Bharhari area was carried out by Detailed Mapping of 1.61 sq km on 1:2000 scale and drilling under G-3 stage. The block area of investigation lies between N 24°33'32" - 24°34'09" and E 82°51'41" - 82°53'16" and falls under Survey of India toposheet no. 63L/14. It is situated in the east of the Bharhari village. The litho units exposed in extended Block 'A' are variegated phyllite, felsic tuff, banded hematite chert / jasper and ferruginous phyllite of Agori Formation of Mahakoshal Group and dolerite dyke and quartz vein as intrusives. The strike length of banded hematite chert / jasper band is 2.62 km. The general trend of the rock types in the study area is ENE-WSW (N70°E-S70°W to N85°E-S85°W) and its dip amount varies from 50°-75° due south. Bedding (S₀) in banded hematite chert / jasper is the primary structure observed in the area.

The banded hematite chert / jasper is a distinct rock unit with bands of iron oxide, chert and/or jasper. The iron oxide is dark grey to reddish brown and chert bands are light grey while the jasper bands are brilliant vermillion red in colour. The thickness of the individual hematite bands varies from a few millimetres to 7cm. The banded hematite chert / jasper band is exposed at the hilltop and has width of 8-75m. A total of eight boreholes have been drilled to understand the subsurface continuity of exposed banded hematite chert / jasper bands. A total of 822.70 m drilling has been achieved by the drilling of eight boreholes namely SBE-1, SBE-2, SBE-3, SBE-4 and SBE-5, SBE-6, SBE-7 and SBE-8. All the boreholes are inclined as the exposed bed rocks have the steep dip. The boreholes have depth varying from 59.0 m to 160.05m and cumulative

thickness of mineralized zone intersected at 30% Fe cut off varies from 1.5m to 34m having average iron content from 30.00% to 37.78% Fe.

The borehole SBE-2 revealed the presence of banded hematite chert / jasper at the depth of 41.5 to 42 m (0.5m) and fractured banded hematite chert / jasper with limonite/goethite and chert bands at 86.1 to 94.05m (7.95m). The SBE-3 has been intersected banded hematite chert/jasper from 70m to 89m (19 m). In SBE-5, 18.20m thick banded hematite chert / jasper was intersected from 40.80 m to 59.0m. The SBE-6, 62.55 m thick BIF was intersected at 90.75m depth and continued to the depth of 153.30m. The banded hematite chert/jasper was intersected in SBE-7 from 48.80 m to 133.90m (85.10m). In SBE-8, banded hematite chert/jasper has thickness of 34.05m intersected from 43.25 m to 77.30m of depth.

Four trenches have been excavated in the field area to expose / to study the continuity of banded hematite chert / jasper band. Total 51 nos. trench samples, 10 nos. channel samples and 40 nos. bed rock samples were collected. A total of 441 nos. core samples were collected from drilled boreholes.

The chemical results of the banded hematite chert / jasper in bed rock samples show Fe values from 6.9 % to 52.3 % with an average of 28.20%. The Fe in trench samples of TR-1 varies from 31.3 % to 47.2 % with 38.9% as an average; while in TR-2, Fe_2O_3 varies from 1.02 % to 30.86 % with an average value of 12.33 % and Fe of TR-3 samples ranges from 12.4 % to 34.7 % averaging 25.2 %. The trench TR-4 suggests Fe_2O_3 ranging from 29.4 % to 43.2% and weighted average of 35.4%. At 30% Fe cut off, the mineralized iron zones have been established in six boreholes namely SBE-2, 3, 5, 6, 7 and 8. At 35% Fe cut off, the mineralized zones have been demarcated in SBE-5, SBE-6 and SBE-7.

The estimated resource of 14.89 million tonnes (MT) with average grade of 34.73% Fe at 30 % cut off and 8.41 million tonnes (MT) with average grade of 38.34% of Fe at 35 % cut off fulfils the 333 category of UNFC classification.

2. INTRODUCTION

In pursuance of Annual Programme 2017-18, the preliminary exploration for iron ore was taken up by Geological Survey of India, Northern Region, Lucknow vide item code no. M2AFGBM-MEP/NC/NR/SU-UP/2017/11767 in Bharhari area, Sonbhadra district, U.P. The area falls in Survey of India toposheet no. 63L/14.

Objective:

The investigation was taken up with an objective to assess the economic potentiality of iron ore occurrence in the area.

Basis of taking the investigation:

The NGCM was carried out by Sarkar *et. al.* during F.S. 2013-14 in toposheet no 63L/14 and shows high Fe_2O_3 (>14%) value in the composite samples. The anomalous Fe_2O_3 is contributed by banded hematite quartzite and banded hematite jasper bands of the area. Geophysical mapping carried out during F.S. 2009-2012 has also revealed a gravity high supplemented with high magnetic values in the southern part of the Toposheet No. 63 L/14. Modak *et. al.* carried out large scale mapping on 1:12500 scale covering parts of toposheet 63 L/14 during FS 2014-15. He marked five subparallel bands of banded hematite chert / jasper extending from NW of Bijaura in east to Bharahari in west. The total strike length of these banded hematite chert / jasper bands is around 20 kms and width varies from 2m to 10m with cumulative width of 170 m to 450 m. The value of Fe_2O_3 varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe_2O_3 in two eastern most blocks. On the basis of the outcomes and recommendations, the project was taken up during FS 2017-2018.

Present work:

Work started in the proposed block and detailed mapping of 0.11 sq. km. was completed. The profiling of the proposed borehole BBA-1 was carried out and its approval was granted by Deputy Director General & Regional Mission Head, Mission – II, NR. However, the drilling unit (DU 467) showed its inability to reach to the given borehole point of BBA-1 due to inaccessibility of the terrain and approach road. Thereafter, the proposed block was shifted westward and named as “extended Block A”. A Detailed Mapping of 1.61 sq. km. on 1: 2,000 scale, drilling of 822.70 m through 8 boreholes, 51 nos of PTS, 441 nos of core samples, 20 nos of petrological samples and 10 line kilometres of geophysical studies were carried out during the course of investigation. The investigation area falls in the northern fringes of Chakdiya Reserved Forest having rugged topography with dissected linear ridges, which causes difficulties in fixing borehole locations as

well as hindrances in drilling operations due to paucity of water. The inaccessibility and ruggedness of the terrain leads to this investigation to continue the drilling up to 28 February 2019 and based on field and laboratory data synthesis, the resource has been estimated

The achievements vis-à-vis envisaged targets are mentioned in Table 2.1.

Table 2.1: The nature and quantum of work

Nature of Work	Target for F.S. 2017-18	Achievements for F.S. 2017-18
1. Detailed mapping (1:2,000)	1.5 sq km	1.61 sq. km. [#]
2. Pitting/Trenching (cu m)	50 cu m	51 cu m
3. Drilling (unit no. 467)	750 m	822.70 m
4. Sampling (nos.)		
(i) BRS (Groove samples)	50 nos.	50 nos.
(ii) PTS	50 nos.	51 nos.
(iii) CS	350 nos.	441 nos.
(iv) PS	20 nos.	20 nos.
(v) Ore Microscopy	10 nos.	10 nos.
4. Chemical Analysis		
(i) PTS	50 nos.	51 nos.
(ii) BRS	50 nos.	50 nos.
(iii) CS	350 nos.	441 nos.
5. Geophysical Survey (IP, SP, Magnetic & Resistivity)	10 L. Km	10 L.Km

[#] 0.11 sq. km. mapping was covered in earlier approved block.

The details of the officers engaged in the investigation with number of field days are given below in Table 2.2:

Table 2.2: Details of officers with number of field days

Sl.No.	Name of Officer	Days spent in field
1	Mukeshkumar R. Shrivastav, Senior Geologist	160
2	Shamiuddin Ahmad, Assistant Geologist	152
3	Shri. Ram Sahay Prasad, Senior Surveyor	143
Supervisory officer		
1	Shri. Pushpesh Narayan, Director	26

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3. PROPERTY DESCRIPTION

1. Title of Ownership: Most of the study area falls under Chakdiya reserved forest and northern part is occupied by revenue/agricultural land.

2. Details of the area:

I. Village name, District, State:

Kurcha, Chatarwar, Bargawan and Marauli are the villages situated in northern side of study area while Kusahniya is situated at south. Jogail is the main locality situated 4.4 km towards SW whereas Bharhari (Bharahari) is situated approx 20 km towards west from the extended block. These localities are situated in Sonbhadra district, Uttar Pradesh.

II. Survey of India Toposheet No.:

The present area of investigation falls in Survey of India Toposheet nos. 63 L/14.

III. Geo-coordinates of all corner points of the Investigated Block:

The geo-coordinates of all corner points of investigated block were recorded with the aid of DGPS. The geo-coordinates of all four corner points are given in following Table.

Table – 3.1: Geo-coordinates of four corner of investigated block

STATION	LATITUDE	LONGITUDE	ELEVATION
BHARHARI_NW	24° 33' 54.05465" N	82° 51' 41.06067" E	241.4047 m
BHARHARI_NE	24° 34' 08.71223" N	82° 53' 12.09938" E	244.9216 m
BHARHARI_SW	24° 33' 31.91441" N	82° 51' 44.30233" E	368.9779 m
BHARHARI_SE	24° 33' 47.39789" N	82° 53' 15.70808" E	382.8358 m

IV. Cadastral details of the area with land use:

The area of investigation falls under Chakdiya Reserved Forest covered with fairly dense jungle. Agriculture practice is common on favourable hill slope but difficult due to scarcity of water. The study area in general is backward in development. People living in the study area, depend on agriculture and daily wages for their livelihood.

V. Freehold/Leasehold: The study area is covered by forest land with few revenue lands.

VI. Location and accessibility:

The given block is located about 12 km north - west of Chopan and is connected by metalled road which runs parallel to the east flowing Son river in most part. Chopan is the nearest town well connected by both rail and metalled road with Robertsganj, district headquarter, Sonbhadra, Uttar Pradesh. Jogail is the major locality near study area and is situated around 28 km west of Chopan and well connected by metalled road. The area is well connected

with Allahabad, Mirzapur and Varanasi by roads. The nearest railway station is Chopan and nearest airport is Varanasi and Muirpur (Plate – I).

VII. Climate:

The area experiences sub-tropical climate, marked by moderate to severe cold season and very hot summer. Cold is experienced during the month of December and January while extreme hot weather prevails from March to June. During May to mid-June the temperature goes as high as 48°C. It is followed by monsoon rainy season from mid-June to September with about 125 cm of average rainfall. Winter is equally cold when the temperature drops down to 4°C in December.

VIII. Flora and fauna

The area supports a tropical mixed monsoon forest and the main species of trees and shrubs include *Boswellia Serrate* (Salai), *Diospyros metonoxylon* (Tendu), *Zizphus mountain* (Ber), *Mudhuca indica* (Mahuwa) and thorny shrubs.

The forest is shelter for wild life such as fox, bear, deer, wild rabbits, wild pigs, different varieties of birds and a number of reptiles, mainly snakes.

3. Infrastructure & environment:

The nearest town Chopan has facilities for hospitals, police station, schools, etc. Agori fort is located 8 km south east of the study area at Agori Khas village. The Indian railways has large setup at Chopan and Chopan is main junction for this area. The villages and interior are well connected with metalled roads and tracks. The roads and tracks are suitable to reach study area but the hilly terrains and interior small villages are accessible by foot tracks only. The river terrace, plains and hilly slopes are cultivated lands. Main crops are wheat, tur, maize and rice.

4. Previous exploration / Work

I. Details of previous exploration / investigation carried by other agencies / parties:

A.K. Dey (1967-68; 1968-69) carried out a preliminary investigation work on Iron-ore occurrence near Bargawan (24°36'00", 82°52'30") Mirzapur district, U.P and it was subsequently taken up during the F.S. 1968-69 for making an appraisal of the quality and quantity of the available reserves. He observed iron ore in banded siliceous hematite-quartzite-jasper. The iron ore are mainly siliceous hematite, limonite and goethite with rare magnetite. Analytical results reveal that about 70% samples contain less than 35% Fe₂O₃. Approximately 6 million tonnes of possible resource of low grade Iron-ore was estimated in an area of about 0.37 sq. km.

NGCM was carried out by Sarkar *et. al.* during F.S. 2013-14 in toposheet no 63L/14. The higher Fe₂O₃ values above threshold were observed over the rocks of Mahakoshal Group in southern part of toposheet 63L/14 and north-western part of toposheet 63L/15. The high Fe₂O₃ (>14%) content in the composite samples is contributed by banded hematite quartzite and banded hematite jasper. The work indicated anomalous values in different parts of the area with respect to Cr (>459.12 ppm), Cu (>92.50 ppm) Ni (>164.26 ppm) Pb (>117.94 ppm) and V (>386.97 ppm).

Geophysical mapping was carried out during F.S. 2009-12. A gravity high supplemented with high magnetic values, observed in the southern part of the Toposheet No. 63 L/14 is interpreted to be associated with the Mahakoshal Group of rocks.

Many workers have worked for different commodities in Mahakoshal Group of rocks. Some important work is described here -

Gold mineralisation: Gold exploration was carried out by Dwivedi, *et.al.* in Proterozoic rocks of Sonapahari area, Sonbhadra district, U.P., during the field season 1998-99 and 1999-2000. The exploration involved both surface trenching and sub-surface drilling to prove lateral and depth continuity of the zones in order to evaluate the potentiality of gold mineralization. The rocks exposed in the area are represented by phyllite-quartzite-tuff sequence with greywacke belonging to Parsoi Formation of the Early Proterozoic Mahakoshal Group. These are intruded by quartz/quartz-carbonate veins and a few basic bodies. The mineralisation in the area is controlled by shears, fold closures and at places by lithology.

Base metal mineralisation: Sporadic lead mineralisations in the form of dissemination of galena in clalcerous chlorite schist have been noticed near Arangi. Galena quartz vein is found in the Parsoi phyllites. The presence of disseminations of pyrite, chalcopyrite and pyrrhotite in association with quartz veins and basic intrusives and geochemical anomalies with values upto 4,000 p.p.m. Cu. have been reported (Radhakrishnan and Vishwanathan, 1962) from the western

extensions of the same belt of rocks in the sidhi district of Madhya Pradesh. Vredenburg (1901) also mentioned the presence of an old working for copper about half a mile north east of Charka.

Calcite blocks with good cleavage are seen in the localized area of Chulia hill. Ochreous pale pinkish to reddish and sometimes white clays were located near a foot-path 300 m west of the occurrence of calcite in Chulia hills. White clays were also seen in the hills towards N.E. of Parsoi and near Arangi. Gossan zones consisting generally of massive limonitic rocks occasionally showing a sponge or box-work structure are commonly present as capping rock. Iron ore occurs in the banded hematite and magnetite bearing quartzite of the Parsoi Formation. Manganese in the form of pyrolusite could be seen locally in cap rock on the brecciated quartzite as towards N.E. of Parsoi.

During FS 2014-15, Modak *et. al.*, carried out large scale mapping on 1:12500 scale covering parts of toposheet 63 L/14. Five subparallel bands of Banded hematite chert / jasper bands were delineated from NW of Bijaura in east to Bharahari in west. The total strike length of these Banded hematite chert / jasper bands is around 20 kms and width varies from 2m to 10m with cumulative width varying from 170 m to 450 m. It is interbanded with reddish brown, khaki phyllite with width up to 77m. Fragments of brecciated chert-jasper-quartzite-Banded hematite chert / jasper clasts embedded in ferruginous and siliceous matrix occurs as linear patches having width up to 60 m within Banded hematite chert / jasper. Banded hematite jasper (BHJ), banded hematite chert (BHC) are observed NW of Bharahi, south of Murgidand and NE of Karwaniya, having exposed strike length of around 100 m and width 1m-2 m which are interbanded with phyllite as exposed on ridge top. The value of Fe_2O_3 varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe_2O_3 in the eastern most two blocks.

II. Details of aero-geophysical and Geophysical mapping, if any:

The geophysical mapping was conducted by Bhattacharya *et. al.*, during FS 2009-10 & 2010-12 in parts of Allahabad, Mirzapur and Sonbhadra districts of Uttar Pradesh and Rewa and Sidhi districts of Madhya Pradesh. The high gravity closure of -20 mgal (H1) as depicted on Bouguer Anomaly Map in the surrounding areas of Jungel (parts of Toposheet No. 63 L/14) have been attributed to heavier lithounits of Agori and Parsoi formations of Mahakoshal Group. These lithounits are WNW-ESE trending Banded hematite chert / jasper bands, quartz veins and reefs and are traversed by a large number of E-W dolerite dykes in these areas. The strong and wide gradient in north and south of this high gravity (H1) outlines the boundary of the Mahakoshal rocks and separates it from Vindhyan rocks in the north and Dudhi Granitoid Complex in the south.

The variation in magnetic total field anomaly (MA) is gentle and small having widely-spaced contours in the entire study area except in the southern part of Toposheet No. 63 L /14. The gradients of Bouguer Anomaly observed on map are also observed on magnetic total field anomaly and are corroborated one to one. The strong gravity gradients observed north and south of Jogail, at west of Obra are strongly replicated on magnetic map also. Geologically, this area is highly disturbed as a large number of contact zones are passing through this place besides presence of basic dykes traversing through the area.

III. Details of the part of the area covered earlier by exploration:

Large scale mapping in the present study area was carried out by Modak, *et.al.* in FS 2014-15 under the project entitled “Resource evaluation of potentiality of iron in Mahakoshal Group, Bharhari area, Sonbhadra district, Uttar Pradesh”. The investigated area falls in the Survey of India Toposheet nos. 63L/14 & 15. An area of 138 sq. km. was covered on 1:12,500 scale by large scale mapping. A total of 327 nos of bed rock samples were analyzed and a total of 26 cu. m. of excavation were done in 4 numbers of trenches. The chemical analysis of the bed rock samples collected from Banded hematite chert / jasper zone yielded Fe_2O_3 values ranging from 13.07 to 82.15% with an average of 40.64%.

5. Geoscience investigation

A. Regional Geology

I. Aerial Reconnaissance

Remote sensing LISS –III satellite data of pre-monsoon season (13 Mar 2013) and post monsoon season (26 Oct 2011) having 23.5 m spatial resolution has been downloaded from bhuvan.nrsc.gov.in and location of “the investigation block ‘A’, Bharhari area” has been marked. In pre monsoon data of 13Mar 2013, area is showing less vegetation and ENE-WSW trending ridge is totally barren whereas in post monsoon data of 26 Oct 2011, it is showing dense vegetation. Lineament map as available on bhuvan.nrsc.gov.in website has been used and in the investigation block ‘A’. 3D visualization of area has been shown by ASTER DEM data and LISS III data. Relief map generated from ASTER DEM data shows ENE-WSW trending Banded hematite chert / jasper ridge is almost steeply dipping towards south.

II. Regional geology outlining the broad geological and structural framework:

The Son valley in parts of Sidhi and Sonbhadra districts of Madhya Pradesh and Uttar Pradesh respectively forms central part of linear, arch-shaped belt of Mahakoshal Group. The rocks of the belt are exposed proximal to ENE-WSW to E-W trending ‘Son-Narmada-Lineament-Zone’ (SNLZ) and extend from Palamau district, Jharkhand in the east to Narsinghpur (M.P.) in the west (Nair *et al.* 1995) and probably further west to it (Tripathi and Mishra 1994; Soni and Jha, 2001). These rocks are inferred to have been deposited in rift basin environment which are separated to the north from Mesoproterozoic platformal Vindhyan rocks and linear belt of gneiss-granite around Sidhi, M.P. by Son-Narmada-North-Fault (SNNF) whereas Dudhi Granitoid Complex and Gondwana sediments to the south are separated by the Son- Narmada-South-Fault (SNSF), locally known as Dudhi-Kassar Fault. The rocks of Mahakoshal Group show lot of variation in lithology from west to east. The western part is dominated by carbonate and chemical precipitates over clastics, whereas in the eastern part, rocks are predominantly meta-volcanics associated with metasediments and chemogenic sediments (Banded Iron Formation).

The stratigraphy of the Mahakoshal belt, as compiled by GSI NR, in the unified legend, (2011) is shown in Table-5.2. In the central part, the rocks of the Mahakoshal Group are broadly divided into Agori Formation, Parsoi Formation and Dudhmaniya Formation (Nair *et al.* 1995). The rocks of Agori Formation comprise banded iron formation, chloritic phyllite, arenaceous phyllite, quartzite, greywacke, metavolcanics and tuff. The contact of Agori and Parsoi formations is gradational. Odra- Amsi-Jiawan Fault is passing just near the contact of two the

formations. The Parsoi Formation includes variegated phyllite, chlorite-sericite-quartz phyllite, greywacke, bands of quartzite, metavolcanics and tuffaceous-carbonaceous phyllite. The rocks of Dudhamaniya Formation comprise alternate sequence of Banded hematite chert / jasper, phyllite, quartzite, shale / slate and mica schist with younger intrusives. It has large spread in the area and shows sinuous structure with foliation trending WNW-ESE in the west to E-W in the east. In the northern part of the area, Jungel Volcanics occurs in a linear belt and consists of volcanics/ultramafic/basic rocks developed in the E-W trending valley, namely, Jungel, Garda and Bhitri valleys in U.P. These rocks further extend towards west in M.P. The rocks of Mahakoshal Group are intruded by quartz veins and basic sills/dykes (Plate – II).

III. Regional stratigraphy

The generalised stratigraphic succession of the area is given in Table – 3.

**Table- 5.1: Stratigraphic sequence of Mahakoshal Group
(after Roy and Devarajan 2000)**

Chitrangi-Gurhar Pahar-Dudhamaniya area.		
Intrusives	Gold bearing quartz-carbonate veins, quartz reefs, dolerite. Granite-granodiorite-intrusive plutonic belt along the southern margin. Jhirkadandi granite and equivalents. Lamprophyre and syenite in Sidhi.	
Mahakoshal Group	Dudhamaniya Formation	Alternate sequence of Banded Iron Formation (mixed oxide-sulphide-carbonate-silicate facies) and phyllite. -----Gradational contact-----
	Parsoi Formation	Dominantly phyllite with bands of greywacke, quartz arenite, carbonaceous phyllite. ----- (Amsi-Jiyawan) Fault -----
	Sleemanabad = Agori Formation	Quartz arenite and carbonate in the lower part, massive and bedded chert, BHJ, highly carbonated and fragmented metabasalt with pillows and suspected pahahoe toes, Banded hematite chert / jasper, thin argillites. Ultramafic plugs.
Sidhi Gneissic Complex (basement)	Gneissic complex associated with mafic, ultramafic rocks and metasediments	

**Table – 5.2: Stratigraphic sequence of Mahakoshal Group
(compiled by GSI NR, in the Unified Legend, 2011)**

Mesoproterozoic	Vindhyan Supergroup		
Undifferentiated-Proterozoic	Jhirkadandi, Baghisoti-Dumar, Asnadohar and Sirpalia Granite	Two mica granite, diorite, porphyritic granite, mesocratic granite and pink leucogranite	
Palaeoproterozoic	Dudhi Granitoid Complex	Granite gneiss	
Palaeoproterozoic	Mahakoshal Group	Dudhmaniya Formation	Phyllite, quartzite, shale/ slate, mica schist with younger intrusive, Banded hematite chert / jasper
		Parsoi Formation	Variegated phyllite, greywacke, quartzite, metabasic, dolerite dykes and quartz veins
		Agori Formation	Shale, siltstone, sandstone, Banded hematite chert / jasper, basic and ultrabasic rocks
Palaeoproterozoic to Archaean	Dudhi Gneissic Complex	Feldspathic gneiss	
		Porphyroblastic gneiss	
		Banded gneiss, migmatite and biotite gneiss	

B. Detailed geological exploration

I. Detailed mapping on 1:2000 scale:

A total of 1.61 sq. km. area was mapped on 1:2000 scale that bounded by NW 24° 33' 54.05" 82° 51' 41.06"; NE 24° 34' 08.71" 82° 53' 12.099"; SW 24° 33' 31.91" 82° 51' 44.30" and SE 24° 33' 47.398" 82° 53' 15.71" and falls under SOI toposheet no. 63L/14. The litho-units exposed in the block are variegated phyllite, felsic tuff, banded hematite chert / jasper, ferruginous phyllite and dolerite dykes. The sample locations, data collections point and contour heights were measured with the Total Station survey instrument. The banded hematite chert / jasper band forms a continuous band at the hill top with a strike length of 2.62 km and width ranging from 8m to 75m. The general trend of the rock types in the study area is ENE-WSW (N70°E-S70°W to N85°E-S85°W) with dip amount of 50° to 75° towards south.

II. Outcrop map on 1:2000 scale:

The geological map shows the disposition of different lithologies in the mapped area as well as structural data recorded in the rocks of the investigated area. A considerable portion of the area is rugged and is covered with dense vegetation. The rock exposures are outlined along the traverse lines, hill slopes, plains and *nala* sections. The geological map on 1:2000 scale has been prepared by plotting the lithological outcrops, structural data and litho-contacts. (Plate–III).

III. Description of Rock types

The mapped area comprises the rocks of Agori Formation of Mahakoshal Group. A brief description of stratigraphy of the investigated area is given in Table 5.3:

Table – 5.3: Lithological succession of the investigated area

Age	Group	Formation	Lithounits
	Intrusives		Dolerite/Quartz veins
Palaeo-Proterozoic	Mahakoshal Group	Agori Formation	Felsic tuff Variegated phyllite, banded hematite chert / jasper, ferruginous phyllite
Basement is not exposed			

A brief discussion of the rock types observed during mapping of the investigation area is given below:

a) Variegated Phyllite:

The variegated phyllite is an important lithological unit present in most of the study area. The phyllite exposed in the study area is thinly banded and has variant of colours namely pale green, purple and yellow. The colours of rock are not persistent and grade into each other with dominant shades of grey, pink/red, buff to khaki (Fig. 5.1 and 5.2). In the southernmost part of the detailed mapped area, the variegated phyllite is intruded by mafic intrusive i.e. dolerite. At some places, later quartz veins have intruded along the foliation planes of phyllite. The phyllite at places is massive to highly jointed to splintery in nature. The phyllite is intermixed with tuff at places and appear as single unit. Mineralogically, the rock is composed of fine grained quartz, muscovite, biotite and chlorite. The phyllite occurring in the nala section is generally hard and indurated but that associated with tuff is somewhat soft and easily breakable. The general strike is N70°E-S70°W to N85°E-S85°W with dip amount varies from 40° to 75° towards south.



Fig. 5.1 Variegated Phyllite exposed in northern flank of the marker BIF band



Fig. 5.2 Buff coloured variegated Phyllite exposed north of borehole SBE-8

b) Ferruginous phyllite:

It is one of the most widespread lithological unit present in the area and runs subparallel to BIF in down dip direction. It is characterised by ferruginous bands (Fig. 5.3). This lithology is generally reddish in colour and soils fingers when held in hand. This hard, massive rock type is present on down dip as well as up dip sides of the ridge. The ferruginous phyllite is composed of fine grained quartz, clay minerals and iron oxide. The Fe_2O_3 values ranges from 9.53% to 44.68% averaging 24.35%. At places, iron oxide banding is missing and massive brick red phyllite is exposed. The ferruginous phyllite has peculiar feature of having chert nodules on the bedding planes (Fig.5.4). These chert nodules have sub-rounded to sub-oval outlines in third dimension.



Fig. 5.3 Ferruginous phyllite with bands of iron oxide south of SBE-4



Fig. 5.4 Ferruginous phyllite with bands of iron oxide and elongated chert nodules near SBE-2

c) Felsic Tuff:

The felsic tuffs are laminated, white, purple to reddish in colour due to its proximity with ferruginous bands namely banded hematite chert / jasper. The individual grains are not identifiable under unaided eyes but felsic in constitutions. The fresh surface shows vitreous lustre and conchoidal fracture, whereas their weathered surface shows waxy luster. The tuff is exposed dominantly in south of banded hematite chert / jasper all along its strike length and in form of lenses in the north of BIF band. The tuff at places gets eroded and soil is exposed in the north of borehole SBE-2. These tuffs have originated from volcanic sources and constitute the uppermost part of the iron sequences.

d) Banded hematite chert / jasper:

The banded hematite chert / jasper is the most important and wide spread lithological unit with bands of hematite, chert and/or jasper. It is the marker band of the area. The insitu boulders of massive BIF have been found to be dispersed on the ridge crest of the assigned block. The iron ore resources in the area are mainly hosted with these banded hematite chert / jasper bands. The thickness of chert/jasper meso bands generally ranges from 4-5mm to 4 cm, while that of

iron rich meso bands ranges from few mm to 7 cm (Fig. 5.5). The hematite is dark grey to reddish brown in colour while dominant chert bands are light grey to white and the jasper bands are brilliant deep red in colour (Fig. 5.6). The exposure width of this unit varies widely depending upon the dip of strata and slope of hill range. Maximum width of outcrop is 75 m and is exposed in north of borehole no. SBE-6. The banded hematite jasper/chert bands has N70°E-S70°W to N85°E-S85°W strike and its dip amount varies from 50° to 75° towards south. In north of SBE-4 and NW of SBE-7, the dip is so steep that it makes vertical scarp sections (Fig. 5.7). The banded hematite chert / jasper bands, generally exposed at the ridge top, its width ranges from 8 m to 75 m. Few sulphide specks as pyrite are present in the chert bands.

The hematite is altered at places and given rise to its hydroxides i.e. Goethite and Limonite (Fig. 5.8). The goethite exhibits in colloform bands flanking the solution cavities. Sometimes, streaks and anhedral patches of goethite are also found. It has shades of brown, reddish to pinkish brown. Limonite occurs with goethite and as stains in the microcavities of hematite bands. It is dull yellowish to pale brownish in colour.



Fig. 5.5 Banded hematite chert, East of trench TR-4



Fig. 5.6 Banded hematite jasper, East of trench TR-1



Fig. 5.7 Massive Banded hematite chert, North of borehole SBE-4



Fig. 5.8 Limonitized BIF in north of borehole SBE-3

e) Dolerite dyke:

The dolerite dyke is melanocratic, medium grained hard rock exposed in the southernmost part of study area. It is also exposed in the north of ridge in the north western part

of map and show intrusive nature as seen in south-west of borehole SBE-4. The dyke is massive as well as weathered to crudely foliated and characterised by spheroidal weathering. The dolerite consists of plagioclase laths and pyroxene with few sulphide specks. The general trend of dolerite bodies is ENE-WSW with a width of 30-70 m.

f) Quartz vein:

The quartz veins are emplaced in phyllite along the foliation planes and at places along the joint planes trending along N70°W – S70°E and N75°E – S75°W. Quartz grains are white, oxidised and show sulphide mineralisation at places. The majority of quartz veins emplaced within ferruginous phyllite are sub-parallel to the strike. The quartz veins have thickness of 1mm to 1cm and its exposed length extends up to 5m.

I) Petrological and petrochemical studies:

The petrographic studies of thin sections were done and the descriptions are as follows:

a) Variegated Phyllite:

Under microscope, phyllite is fine to medium grained and comprises of quartz, muscovite, chlorite and biotite. It shows the sub-parallel arrangement of flaky minerals like chlorite, muscovite and biotite. The quartz shows anhedral to subhedral, fine to medium grained exhibits first order grey interference colour and exhibits typical undulose extinction under cross nicols. Few opaque minerals like magnetite has also been observed in reflected light (Fig. 5.9). The crenulation cleavages also show its presence. The quartz grains are surrounded by several recrystallised quartz. The ferruginous phyllite is generally medium grained, consisting of quartz, muscovite, chlorite and biotite. It is similar to phyllite but has presence of iron oxide bands (Fig. 5.10).

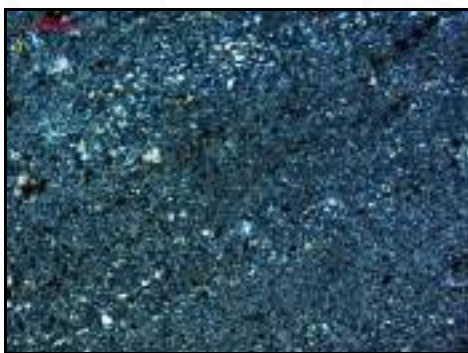


Fig. 5.9 Photomicrograph of phyllite with fine constituent of quartz, muscovite and sericite with few opaques of magnetite
Sample:PS-4, Loc: 24°34'1.5" 82°54'7.2"



Fig. 5.10 Photomicrograph of ferruginous phyllite showing bands of phyllite and iron oxide. Sample:SBE-2/29.60, Loc: 24°33'41.8" 82°52'7.0"

b) Felsic Tuff:

Under microscope, tuff consists of anhedral quartz, feldspar laths and sericite mica – lithic fragments in glassy groundmass (Fig. 5.11). The irregularly shaped glass shards and phenocrysts of feldspar have been noticed. The quartz grains are represented by broken anhedral sub-rectangular grains often showing embayment. The lath shaped feldspar in form of plagioclase showing polysynthetic twinning (Fig. 5.12).



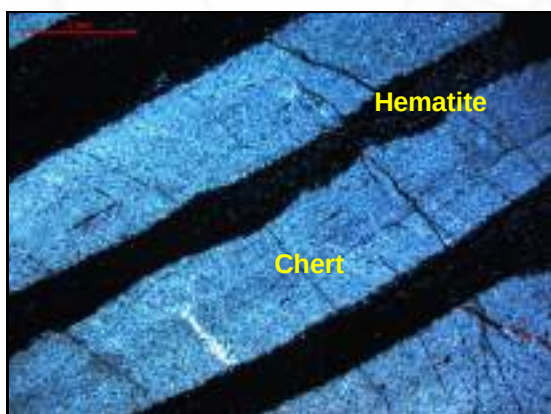
Fig. 5.11 Photomicrograph of felsic tuff in PPL
Sample:PS-15, Loc: 24°33'39.4" 82°52'7.7"



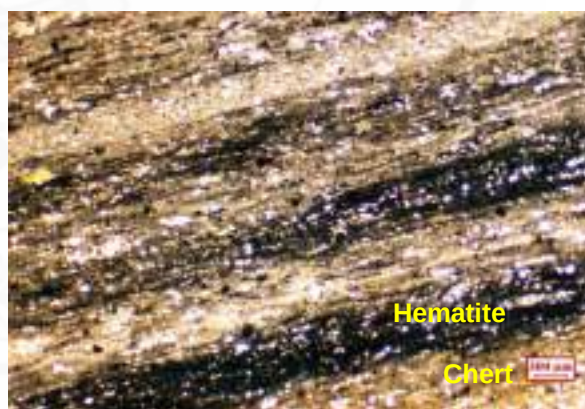
Fig. 5.12 Photomicrograph of felsic tuff in
10X optical lens under cross nicols
Sample:PS-15, Loc: 24°33'39.4" 82°52'7.7"

c) Banded hematite chert / jasper:

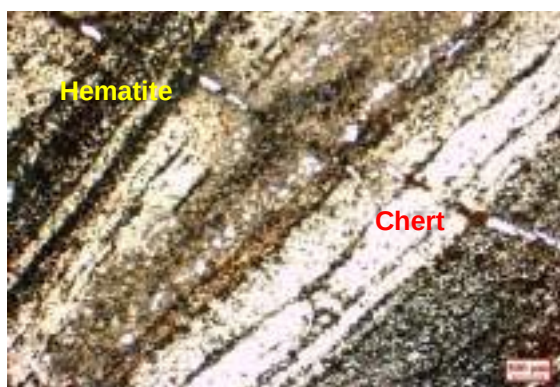
Under microscope, hematite and chert bands are found in abundance. The hematite occurs as tiny grains arranged in a preferred orientation. The chert has its cryptocrystalline nature and also present in the interstitial spaces. The martitisation of magnetite in hematite is noticed. A few scattered opaque minerals identified as magnetite and sulphides in form of pyrite. Chlorite is present in subordinate amount (Fig. 5.13a to 5.13d).



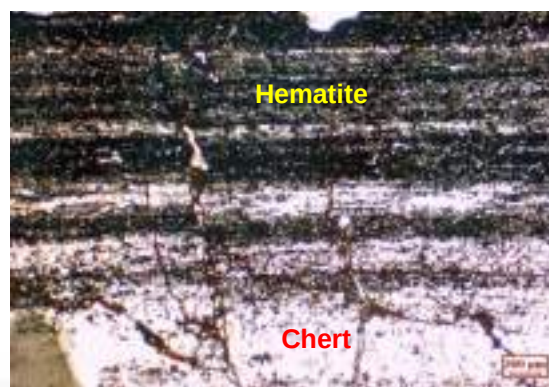
5.13a



5.13b



5.13c



5.13d

Fig. 5.13 Chert and hematite bands in Banded Hematite Chert

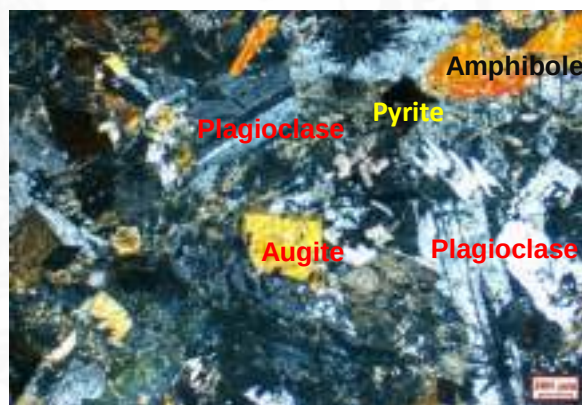
a. Sample:PS-6, Loc: 24°34'4.3" 82°54'1.1"; b. Sample:PS-5, Loc: 24°34'1.5" 82°54'7.3";
c and d. Sample:PS-12, Loc: 24°33'43.1" 82°51'58.7"

d) Dolerite dyke:

Under microscope, the rock is holocrystalline composed of plagioclase, clinopyroxene-augite, amphibole, and sericite with pyrite. The rock shows sub-ophitic intersertal texture, as the laths of plagioclase lie in a matrix of coarse subhedral augite minerals. The plagioclase grains appear to be partially or entirely enclosed in pyroxene (Fig. 5.14a and 5.14b).



5.14 a



5.14b

Fig. 5.14: Photomicrograph of dolerite showing laths of plagioclase and mafic minerals

Ore Microscopic studies:

a) Variegated Phyllite:

Under reflected light, the rock shows few opaque minerals which are identified as magnetite and sulphide grains. The groundmass is mainly composed of fine to medium grained quartz, muscovite, chlorite and biotite minerals. It also shows few fine grained dispersed opaque minerals (Fig. 5.15). The ferruginous phyllite under reflected light shows the bandings of phyllite and iron oxide bands. Few accessory opaque minerals are seen mainly of magnetite and sulphide minerals (Fig. 5.16).



Fig. 5.15 Sulphide specks in the phyllite in reflected light under 10X optical lens
Sample: SBE-1/21 Loc. 24°33'39.5" 82°52'7.8"



Fig. 5.16 Banding of phyllite and iron oxide bands with few accessory magnetite in reflected light under 5X optical lens
Sample: PS-8 Loc. 24°34'5.7" 82°53'3.8"

b) Banded hematite chert / jasper:

The banded hematite chert / jasper under reflected light shows hematite and chert/jasper bands are found in abundance. The light grey groundmass of hematite has a few sporadic magnetite grains (Fig. 5.17). Fine-to-medium grained grains of hematite are intricately associated with each other leaving fine intergranular micro pore spaces. Micro fractures are present in the alternating bands and hydroxide from leaching out of original pre-existing minerals (Fig. 5.18). Few accessory sulphide mineralisation in form of pyrite is present.



Fig. 5.17 Sporadic magnetite in hematite groundmass in BIF under 5X optical lens
Sample: SBE-1/PS-17 Loc. 24°33'39.5" 82°52'7.8"



Fig. 5.18 Bands of iron oxide and silica in BIF under 5X optical lens
Sample: PS-6 Loc. 24°34'4.3" 82°54'1.1"

XRD studies:

Total 5 samples from banded hematite chert/jasper, ferruginous phyllite, grey phyllite and tuff were submitted for XRD analysis. The chlorite in minor amount is found present in banded hematite chert/jasper, grey phyllite and tuff. The iron ore is in the form of hematite but minor amount of iron carbonates in form of siderite and hydroxides in form of goethite and

limonite are also observed. The mineral Anatase (polymorph of rutile) and Titano-magnetite also shows their present in trace amounts. Few minute specks of sulphide mineralisation were analysed as pyrite in phyllite. The felsic tuff has chlorite, quartz and orthoclase as main contributing minerals and anatase and ilmenite in traces. The ferruginous phyllite has quartz as major constituent while hematite and kaolinite in minor or small amounts. The XRD analytical results of samples are described in the following table 5.4.

Table 5.4: X- ray diffraction analysis of samples

Sr. No.	Sample No.	Lithology	Constituents detected in semi-quantitative analysis of crystalline portion of samples by RIR values					
			Major	Minor	Good Amount	Small Amount	Trace Amount	Likely trace
1	BBA-7/68m	Banded hematite chert / jasper	Quartz	Chlorite	Microcline	Siderite, Goethite, Titano-magnetite	Chamosite, Muscovite	X
2	BBA-7/96.8m	Grey phyllite with sulphide specks	Quartz	Chlorite	Orthoclase	Pyrite	Muscovite	X
3	BBA-7/117m	Felsic Tuff	Chlorite	Quartz	Orthoclase, Siderite	X	Anatase, Ilmenite	X
4	PS-24	Ferruginous phyllite $\pm$ iron oxide	Quartz	X	Hematite	X	Kaolinite	X
5	BRS-34	Ferruginous phyllite $\pm$ iron oxide	Quartz	Kaolinite	X	Hematite	Anatase	X

V. Structure

Both non-diastrophic and diastrophic structures are noticed in the area which are discussed below:

Non-diastrophic Structure

(a) Primary bedding (S_0): Bedding is the most important primary structure observed in the investigated area, recognized by compositional variation between ferruginous and siliceous layers manifested in the form of colour banding. Primary bedding is observed in banded hematite chert/jasper and in ferruginous phyllite and it is defined by composition and color banding. In banded hematite chert / jasper, alternate bands of hematite and chert/jasper define the S_0 . The thickness of the individual hematite bands varies from a few millimeters to 5 cm. Similarly in ferruginous phyllite, ferruginous and siliceous layers often masked by deep brown colors define compositional banding. The general strike of bedding (S_0) is ENE-WSW (N70°E-S70°W to N85°E-S85°W) with moderate to steep dips from 50°-75° towards south.

Diastrophic Structure

(a) Foliation: Penetrative axial planar fabric, S_1 , is most commonly observed in the investigation area. At most places, S_1 is sub-parallel to the bedding surface (S_0) in phyllite therefore showing trend ENE-WSW ($N70^\circ E-S70^\circ W$ to $N85^\circ E-S85^\circ W$) with moderate to steep dip towards south.

(b) Joints: Two sets of joints are observed in banded hematite chert / jasper and ferruginous phyllite. One set of joint (J_1) trend is dominantly $N70^\circ W - S70^\circ E$ and other (J_2) is $N75^\circ E - S75^\circ W$ with steep to vertical dips, whereas few joint having N-S trend are also present in the area.

VI. Metamorphism

In thin section studies of phyllite, schistose texture is defined by parallel arrangement of quartz, chlorite, muscovite and biotite. This suggests the rocks exposed in the mapped area are characterised by low-grade metamorphism of greenschist facies. Metasedimentaries of the area namely variegated phyllite and ferruginous phyllite are marked by the presence of fine grained quartz, muscovite, chlorite, biotite with few opaque. This mineral assemblage indicates the biotite zone of greenschist facies regional metamorphism. (Winkler, 1974).

VII. Mineralogy of the ore zone and ore textures:

The banded iron formation exhibits hematite and chert bands in majority. At places, jasper is present with chert. The hematite band has thickness ranging from few millimetres to 5 centimeters. Disseminated specks / veins of pyrite and arsenopyrite are hosted by variegated (grey, massive) phyllite, banded hematite chert / jasper and small amount in felsic tuff.

VIII. Pitting and Trenching

Total four trenches were excavated in the area during the course of the present investigation to study the strike / width continuity of banded hematite chert / jasper. The trenches were cut across the trend of the banded hematite chert / jasper wherever it is not exposed and 51 nos. of samples were collected from them. The samples were withdrawn from BIF bands and the boulders of BIF that are *insitu* in the trench. The sampling interval in the trenches was kept at 1 m and homogeneous sampling was carried out.

Table 5.5: Details of trenches

Sr. No.	Trench No.	Fe Band	Latitude / Longitude	Orientation of the trench	Area in cu.m. (l x w x d)	Width of the iron ore zone	No. of samples including ore zone	Wt avg of Fe% / width (m)
1	TR-1	1	24° 33' 55.3" 82° 53' 04.5"	N05°W–S05°E	18x1x1=18	18m	18	38.91/18m
2	TR-2	1	24° 33' 43.0" 82° 51' 55.4"	N18°W–S18°E	13x1x1=13	3m	13	30.42/3m
3	TR-3	1	24° 33' 52.3" 82° 52' 50.1"	N10°W–S10°E	10x1x1=10	2m	10	34.30/2m
4	TR-4	1	24° 33' 52.1" 82° 52' 37.2"	N05°W–S05°E	10x1x1=10	10m	10	35.37/10m

The trench TR-1 was excavated in the profile line of proposed borehole SBE-7 (erstwhile BBA-2) across the banded hematite chert / jasper band to expose the true width of the band. The trench TR-1 is 18 m long X 1m wide X 1 m deep and samples were collected from 1m interval all along the floor of trench. The trench TR-2 excavated along the profile line of borehole SBE-3 is 13 m long X 1m wide X 1m deep. A total of 13 samples were withdrawn keeping sample length to 1m. Trench TR-3, 10 m long X 1m wide X 1m deep, was excavated to the east of profile line of proposed borehole SBE-6 for exposing the banded hematite chert / jasper band. The fourth trench TR-4 was excavated in the middle of profile lines of boreholes SBE-5 and SBE-6 to expose the width of hematite bearing zone. All trenches are systematically logged and trench logs are prepared. (Plate – XV to XVIII). The details of all four trenches with analytical results are given in annexure – III.

IX. Sampling

Bed rock sampling was carried out during the course of investigation. Most of the bed rock samples were collected from banded hematite chert / jasper and ferruginous phyllite with few samples from phyllite, tuff, quartz veins and dolerite. A total of 50 bed rock samples were collected and submitted to chemical division for analysis. The bed rock samples were collected by removing the oxidised / weathered top portion of bed rock and collecting the fresh part. The bed rock samples were kept in the fresh polythene bags and labelled. One channel of 10m length was put across the strike of banded hematite chert/jasper band and 10 samples of 1m length were withdrawn. The details of channel cut in the area is summarised in the table 5.4.

Table 5.4: Details of channel no. CH-1

CHANNEL - CH-1						
Sr. No.	Sample No.	From (m)	To (m)	Sample Length (m)	Lithology	Fe %
1	CH-1/1	0	1	1	Banded Hematite Chert / Jasper	30.21
2	CH-1/2	1	2	1	Banded Hematite Chert / Jasper	29.35

3	CH-1/3	2	3	1	Banded Hematite Chert / Jasper	30.93
4	CH-1/4	3	4	1	Banded Hematite Chert / Jasper	20.92
5	CH-1/5	4	5	1	Banded Hematite Chert / Jasper	29.96
6	CH-1/6	5	6	1	Banded Hematite Chert / Jasper	26.81
7	CH-1/7	6	7	1	Banded Hematite Chert / Jasper	23.96
8	CH-1/8	7	8	1	Banded Hematite Chert / Jasper	26.19
9	CH-1/9	8	9	1	Banded Hematite Chert / Jasper	18.83
10	CH-1/10	9	10	1	Banded Hematite Chert / Jasper	25.15
Weighted average						26.23/10m

X. Discussion of results of chemical analysis of samples

A total of 50 nos. bed rock samples (including 10 nos. of channel samples), 51 nos. trench samples from four trenches and 441 nos. core samples from eight boreholes were collected. The chemical results suggested Fe values of banded hematite chert / jasper in bed rock ranging from 6.9 % to 52.3 % with an average of 29.5 %. The analytical values of ten channel samples revealed Fe values ranging from 18.8 % to 30.9 % with weighted average of 26.23%. The analytical results of bed rock samples and channel samples are given in the Annexure – I.

The Fe values in trench samples of TR-1 varies from 31.3 % to 47.2 % with 38.95% as weighted average; while in TR-2, Fe values vary from 1.02 % to 30.86 % with weighted average value of 12.33% and Fe values of TR-3 samples range from 12.4 % to 34.7 % with weighted average of 25.2 %. The trench TR-4 suggests Fe ranging from 29.4 % to 43.2% and weighted average of 35.4%. The analytical values of 51 nos. trench samples are summarised in Annexure – III.

A total of 441 core samples were submitted for chemical analysis from borehole nos. SBE-1 to SGB- 8 from extended block 'A', Bbharhari area, Sonbhadra. The samples processed from drill cores were analysed for Fe₂O₃, Al₂O₃, SiO₂, CaO and LOI content. The analytical analysis shows iron content (at 30% Fe cut off) to vary from 29.99% to 49.87%, SiO₂ varies from 24.04% to 71.71% and Al₂O₃ varies from 0.12% to 8.51%. At 30 % Fe cut off, the core samples of boreholes SBE-2 and SBE-3 have yielded average Fe value of 29.98% and 31.58% respectively. The chemical results of core samples pertaining to boreholes SBE-5 has average Fe value of 36.83%. In core samples of SBE-6, average Fe is 37.78%. Analytical results for cores from borehole SBE-7 have suggested average Fe of 34.37%. The cores of SBE-8 have average Fe value as 30.75%. The weighted average of all the core samples of borehole no SBE-1 to SGB-8 of the extended block 'A', Bharhari area at 30% Fe cut off has yielded an average grade of 34.46% Fe and at 35% Fe cut off has yielded an average grade of 38.29% Fe. The analysis of drill core samples is given in the Annexure-II.

XI. Details of interpreted ore zones on the basis of geological investigation:

The iron ore mineralization occurs in the area as a linear banded hematite chert / jasper zone, trending N70°E-S70°W to N85°E-S85°W, with moderate to steep dips of 50° to 75° due south. In banded hematite chert / jasper, the bands of siliceous layer (chert & jasper) and ferruginous layer (hematite) occurs rhythmically. The thickness of individual hematite layer varies from 1 mm to 7 cm. The strike length of banded hematite chert / jasper band is 2.62 km and width about 8 m to 75 m.

C. Geophysical Exploration

I. Methodology of geophysical exploration:

Geophysical survey of 10-line km was carried out by Geophysics Division, GSI, NR, Lucknow. The geophysical methodologies adopted were Induced Potential, Self Potential, Magnetic & Resistivity methods. The base line was laid trending N75°E – S75°W parallel to the general strike of the area and the traverse lines were laid perpendicular to the baseline. The traverses were laid at regular interval of 200m, with station interval 20m. Total length of base line laid is 1.8 km and the area covered with geophysical surveys is 1.8 sq. km. Total 10 traverses having 1 L.km. length have been laid and SP, Magnetic, IP/Resistivity have been carried out over these traverses.

II. Criteria for selection of method for geophysical exploration:

The iron ore exploration demands the induced potential, self potential, magnetic & resistivity methods to prove or identify iron bands existence beneath the surface. Magnetic (VF), SP & IP/Resistivity surveys were carried out to assess the iron ore potential in Bharhari area, block 'A', Sonbhadra district, U.P. The magnetic data was reduced to the magnetic base established outside of the area under surveys. The SP data collected are reduced to base established within the block area (in non-anomalous zone). IP/Resistivity surveys were carried out using dipole-dipole configuration.

III. Scale of mapping:

Geophysical survey was done on 1:5000 scale.

IV. Interpretation of geophysical maps:

The moderate uneven magnetic fluctuations indicate the variation in the concentration of ferruginous material within the litho unit. Analytical signal map of magnetic data shows a steep variation along the baseline and continued up to all traverses. This signal clearly indicates the presence of magnetic causative body at shallower level. The causative source of these magnetic anomalies may be due to the presence of BIF bands in the formation in the study block.

V. Identification of anomalies:

The magnetic data depict strong evidence for the presence of magnetic causative body at shallower level. These causative sources delineated over traverses E400, E600, E800, E1000 & W200 may be due to the presence of banded hematite chert / jasper bands in the study block. The analytic signal map shows the presence of a causative source having appreciable magnitude of magnetic anomaly extending between E600 to W200 trending almost in strike direction. Another magnetic anomaly axis is demarcated over analytic signal map in western portion of the block extending between W200 to W600 but in small patches (Annexure –XVI).

SP survey, in general has not indicated any significant response from mineralization point of view. The broad nature of SP anomaly is due to effect of topography /terrain in the area. Some isolated IP/Resistivity anomalies have been observed in the study area. These anomalies are not corroborating with S.P. and magnetic (VF) responses.

D. Geochemical Exploration

I. Selection of Geochemical exploration type: Bed rock sampling / pedogeochemical sampling on grid pattern

Channel sampling was carried out across strike of the banded hematite chert / jasper band to assess the grade of iron. One channel was excavated in the profile line of SBE-2 to know the nature and mineralisation in the banded hematite chert / jasper band. This channel has yielded weighted average Fe as 26.23%. The geochemical sampling of bed rock samples was carried out as per accessibility and availability of exposures.

II. Methodology of geochemical exploration

The samples were pulverised and sieved to -120 mesh. Coning and quartering of the samples were done and two sets of samples were prepared. The original samples about 250 gm were sent for analysis and duplicate were retained for future reference. The samples were analysed by XRF analysis for major oxides and at Chemical division, Geological Survey of India, Northern Region, Lucknow.

III. Grid of Geochemical sampling

Samples were collected as per accessibility and availability of exposures. Systematic sampling on grid pattern was not possible due to narrow linear hilltop exposure of banded hematite chert / jasper, rugged and mountainous terrain conditions.

IV. Statistical analysis of geochemical data and its interpretation of anomalous zones

The weighted average of Fe for banded hematite chert / jasper samples in trench and boreholes with their thickness are summarised in the table below:

Table 5.9: Minimum, Maximum, Average of Fe₂O₃ values and weighted average Fe for banded hematite chert / jasper samples

Trench/Borehole No. (No. of Samples)	From (m)	To (m)	Thickness (m)	Weighted Fe %
TR-1 (18 samples)	0	18	18	38.91/18m
TR-2 (13 samples)	0	13	13	12.31/13m
TR-2 (4 banded hematite chert / jasper samples where Fe ₂ O ₃ >35%)	0	3	3	30.42/3m
TR-3 (10 samples)	0	10	10	21.35/10m
TR-3 (4 banded hematite chert / jasper samples where Fe ₂ O ₃ >35%)	7	10	3	32.37/3m
TR-4 (10 samples)	0	10	10	35.37/10m
SBE-2 (56 samples)	16.20	93.35	77.15	18.27/28.25m
SBE-3 (64 samples)	12.30	87.50	75.20	20.78/34.35m
SBE-4 (10 samples)	12.40	20.10	7.70	19.26/5.50m
SBE-5 (40 samples)	3.00	59.00	56.00	25.97/22.80m
SBE-5 (17 samples where Fe ₂ O ₃ >35%)	49.00	59.00	10.00	36.91/9.60m
SBE-6	41.00	160.05	119.05	24.99/119.05m
SBE-6 (15 samples where Fe ₂ O ₃ >35%)	107.55	115.20	7.65	38.20/7.65m
SBE-6 (17 samples where Fe ₂ O ₃ >35%)	117.30	125.65	8.35	35.14/8.35m
SBE-6 (18 samples where Fe ₂ O ₃ >35%)	143.80	153.25	9.45	38.43/9.45m
SBE-6 (12 samples where Fe ₂ O ₃ >35%)	153.75	160.05	6.30	34.31/6.30m
SBE-7	48.8	134.00	85.20	28.63/85.20m
SBE-7 (33 samples where Fe ₂ O ₃ >35%)	60.00	93.00	33.00	35.06/33.0m
SBE-8	43.25	77.5	34.25	27.01/34.25m
SBE-8 (19 samples where Fe ₂ O ₃ >35%)	50.4	68.5	18.10	30.10/18.10m
SBE-8 (5 samples where Fe ₂ O ₃ >35%)	70.5	75.2	4.70	30.35/4.70m

V. Identification of anomalous zones with strike length and width

The banded hematite chert / jasper are exposed on the top surface of the linear East - West ridge running parallel to the Son River with thickness varying from of 8.0 m to 75 m. The banded hematite chert / jasper has a general strike of N70°E – S70°W to N85°E – S85°W and dips 50°-75° due south. The mineralized zones with 30% Fe cut off have been established in six boreholes namely SBE - 2, SBE -3, SBE -5, SBE -6, SBE- 7 and SBE -8. While the mineralized zones with 35% Fe cut off has been demarcated in boreholes namely SBE-5, SBE-6 and SBE-7. These zones are confined to central and eastern part of the mapped area.

6. Integration of Geological, Geochemical and Geophysical exploration data and interpretation thereof

I. Creation of Geophysical, Geochemical, Geological (Lithological & Structural) and Outcrop maps on true scales

Detailed mapping on 1:2000 scale was carried out in the investigated area and a geological map has been prepared depicting the different lithologies observed in the area (Plate – III & VII). Bed rocks and channel samples were collected during the course of investigation and have been shown in the sample location map (Plate-VI). Chemical analyses results reveal the low grade iron ore in the area. Geophysical survey for SP, IP, magnetic and resistivity was done.

II. Overlay studies in GIS (Geological, Geochemical and Geophysical maps)

The overlay studies of geological and geochemical results are done and prepared in GIS (Plate-VI).

III. Semitransparent overlay maps

Semitransparent overlay maps are prepared in GIS which are attached herewith as plate nos Plate-III, VI & VII.

7. Mineral Prospect

I. Surface indication of mineralisation

As per field observations during mapping of the investigated area, the iron ore bearing banded haematite chert / Jasper band has been demarcated on the hilltops. The rolled boulders of banded hematite chert / jasper, scree material at hill slopes and hard resistant linear bands inter banded with phyllite at ridge tops are indicators of iron ore mineralisation.

II. Mode of occurrence

Iron ore mineralization occurs in the area as a linear banded hematite chert / jasper zone, trending N70°E – S70°W to N85°E – S85°W, with moderate to steep dips 50°-75° towards south

III. Nature of Mineralisation

The iron mineralization in the assigned block is in form of banded hematite chert / jasper bands having alternating bands of siliceous (chert & jasper) and ferruginous layers (hematite). Thickness of hematite layers varies from 1 mm to 5 cm.

IV. Details of Mineralised Zones: Strike length and width of anomalies identified on the basis of geology, geophysical and geochemical exploration

The linear banded hematite chert / jasper trending N70°-85°E was observed in the area at top of the ridge as wall like structure. The strike length of banded hematite chert / jasper band is 2.62 km and width ranges from 8 m to 75 m.

V. Alteration zones and its relevance with mineralization.

Goethitisation and limonitization have also been observed at joint planes and fractures. The iron hydroxides are developed due to oxidation of iron oxides. The presence of iron hydroxides in form of Limonite/ lepidochrocite leads to lowering of Fe % in the mineralized zones. In excavated trenches of TR-2 and TR-3, it has been found to be associated with felsic tuffs. Such zones in the subsurface have led to the partings in the mineralized zones of SBE-6 and SBE-7.

8. Exploration by drilling

Drilling commenced on 21.10.2017 and completed on 28.02.2019 by GSI drill unit 467. A total of 822.70 m drilling in 8 boreholes was completed. The details of boreholes are described in the table given below:

Table 8.1: Details of boreholes drilled in Bharhari, modified block 'A', Sonbhadra, U.P.

Borehole No.	Coordinates	Azimuth	BH Angle	Collar RL (m)	Depth RL (m)	Date of Commencement	Date of closing	Total Drilled depth (m)
SBE-1	24°33'39.5" 82°52'07.8"	N20°W	45°	346	265.5	21.10.2017	12.12.2017	120.10
SBE-2	24°33'41.8" 82°52'08.4"	N20°W	45°	388	324	26.12.2017	29.01.2018	94.05
SBE-3	24°33'41.1" 82°51'59.1"	N18°W	45°	390	323.5	16.02.2018	28.03.2018	93.10
SBE-4	24°33'44.2" 82°52'24.2"	N04°W	45°	317	267	23.04.2018	20.05.2018	71.10
SBE-5	24°33'47.1" 82°52'34.1"	N10°W	45°	366	324.5	13.06.2018	23.07.2018	59.00
SBE-6	24°33'47.3" 82°52'45.2"	N10°W	40°	402	297.5	03.10.2018	03.12.2018	160.05
SBE-7	24°33'51.4" 82°53'3.4"	N05°W	45°	390	296.5	10.12.2018	28.02.2019	138.80
SBE-8	24°33'46.9" 82°52'28.1"	N09°W	45°	368	310	18.11.2018	03.01.2019	86.50
Total								822.70

I. Stage of exploration as per mineral content Rule

The stage of exploration is G-3 of UNFC as per mineral content rule.

II. Methodology of drilling with the details of type of drilling i.e. core drilling, auger, reverse circulation, etc.

The core drilling with reverse circulation technology at an inclination of 45° was done by GSI, NR, Lucknow.

III. Boreholes planning: Spacing of boreholes and level of intersection of ore zones as per mineral content rule

A total of eight boreholes were planned for drilling to intersect the banded hematite chert / jasper to understand the subsurface continuity of exposed bands. The drilling was planned on the basis of banded hematite chert / jasper disposition. The boreholes were planned to be drilled at an interval of 400 m. The targets were to intersect banded hematite chert / jasper zone at 30 m vertical depths from 370m datum line. Total eight boreholes viz. SBE-1 (erstwhile BBA-7), SBE-2 (erstwhile BBA-6), SBE-3, SBE-4, SBE-5, SBE-6, SBE-7 and SBE-8 were drilled. Due

to rugged terrain conditions, all boreholes except SBE-6, SBE-7 and SBE-8 were shifted from original planned locations to nearer points where it was suitable for drilling/ drill rig installation.

The boreholes have depth varying from 59.0 m to 160.05m and cumulative thickness of mineralized zone intersected at 30% Fe cut off varies from 1.5m to 34m having average iron content from 30.00% to 37.78% Fe. The borehole SBE-1 drilled upto 120.10 m and logging of cores revealed the reddish buff phyllite, ferruginous phyllite $\pm$ chert nodules, grey phyllite with chert nodules, banded hematite chert / jasper and felsic tuff as rock types. SBE-2 borehole was drilled to depth of 94.05 m and revealed the presence of banded iron formation (banded hematite chert / jasper) at the depth of 41.5 to 42 m (0.5m) and fractured banded hematite chert / jasper with limonite/goethite and chert bands at 86.1 to 94.05m (7.95m). The SBE-3 borehole was drilled to the depth of 93.10 m in which banded hematite chert / jasper has been intersected from 70m to 89m (19 m). Sulphide specks in form of pyrite have also been recorded in drilled cores of SBE-1 and SBE-4 in chert and phyllite bands. In SBE-5, the intersected rock types were ferruginous phyllite, felsic tuff and banded hematite chert/jasper. A 18.20m thick banded hematite chert / jasper was intersected from 40.80 m to 59.0m. The SBE-6 was encountered with lithologies of variegated phyllite, ferruginous phyllite, banded hematite chert/jasper, tuff and dolerite. The 62.55 m thick zone of BIF was intersected at 90.75m depth and continued to the depth of 153.30m. The lithologies intersected in SBE-7 were tuff, dolerite and banded hematite chert/jasper. The banded hematite chert/jasper was intersected at the drilling depth of 48.80 m and continued to 133.90m with total thickness of 85.10m. In SBE-8 the lithologies intersected were tuff, dolerite, banded hematite chert/jasper and variegated phyllite. The banded hematite chert/jasper 34.05m thickness was intersected from 43.25 m to 77.30m of depth.

IV. Borehole logging

The cores of boreholes were logged in detail for their core recovery, lithology, mineralisation and structures, if any. It was done run wise and the data were recorded in register for each drill hole. On the basis of these data summarized lithologs of boreholes were prepared. (Annexure: IV – XI).

V. Core recovery percentage

Core recovery was satisfactory in the hard non-mineralized portion of drill cores. The core recovery in the mineralised zone was low because of presence of fracture zone at this level. In borehole no's SBE-2 and SBE-3, at the intersection of the mineralized zone, there was 100% water loss and recovery of the drilled cores was matter of concern (very poor). The overall average core recovery percentage can be stated about 70 – 85 %.

VI. Geophysical logging of borehole and correlation with borehole Geology

Geophysical logging was carried out for boreholes in extended block 'A', Bharhari area by Geophysics division, GSI, NR, Lucknow (Annexure – XVII). The geophysical logs of boreholes SBE-1 suggest conductive zones at the depth interval of 66.40 to 76.40, 89.60 to 100 and 102.2 to 114m however the magnetic susceptibility log does not reflect any significant responses which indicate the absence of magnetic minerals in the formation. Geologically, the above borehole has not given any mineralized zone at 30 % Fe.

The geophysical log of SBE-2 suggests five conductive zones at the depth interval of 32.70 to 35, 56.50 to 58.90, 70.30 to 74.40, 75.10 to 79.20 and 79.80 to 81.40m. These zones are characterized by low values of SP, SPR, short normal & long normal resistivity's and low values of natural gamma counts. the magnetic susceptibility log shows the absence of magnetic minerals in the formation intersected in the borehole. As the borehole was logged to the depth of 88.60m only, it could not reveal the mineralized zones at the depth interval of 86.55 to 88.12m at 30% Fe cut off. The borehole was drilled to the depth of 92.50m and thereafter it was abandoned due to very poor core recovery and complete water loss in the bore hole.

In borehole SBE-3, moderate to high magnetic susceptibility response was recorded at two depth zones namely zone-I from 73.90 to 74.40m and zone –II from 79.20 to 83.80m. At these depth zones, the presence of magnetic material in the formation has been inferred. The borehole was geophysically logged to the depth of 84m and borehole was drilled to the depth of 87.50m. Geologically, the mineralized zone at 30 % Fe cut off has been established from 78.10 to 87.50m (7.50m). Zone-1 of the geophysical log is not correlatable with the established mineralized zone while zone-II has been well picked up and is part of the established mineralized zone of the SBE-3.

In the borehole SBE-4 magnetic susceptibility log does not reflect any significant responses which indicate the absence of magnetic minerals in the formation. The log is correlatable with the lithological log and no iron mineralisation is found in the borehole. Natural gamma log reflects lithological changes depending upon the variation of sand and shale content in the rock units. Low gamma count indicates the presence of sand content whereas high gamma represents the presence of clay/radioactive mineral in the formation.

The borehole SBE-6 was logged upto 128.0m. Moderate to High Magnetic susceptibility values (Zone-I, II, III, IV & V) have been recorded at the depths range from 115.0 – 115.3m, 126.0 – 126.2m, 126.5 – 127.0m, 127.4 -127.8m & 102.0 – 107.5m, it indicates the presence of

magnetic minerals in the formation at that depths. The geological lithological log also confirms the iron mineralisation in these depths. The Temperature log shows the normal gradient along the borehole.

The geophysical studies of borehole SBE-7 reveals moderate magnetic susceptibility response (Zone-I to XXI) has been recorded. The depth of these zones ranges from 60.1m to 121.20m. The presence of magnetic minerals in the formation and zones I & XI are characterized by high values of magnetic susceptibility within the formation from 60.1-60.8m & 82.4-83.1m depths. Conductive zones associated with low SP and low natural gamma counts, indicates the presence of Sulphide mineralization within the formation from 46.7-47.2m depth. These depth zones are well correlated with geological lithological log and chemical analytical data. The mineralised zone-I from 63.80m to 97.10m, mineralised zone-II from 100.6m to 103.6m and mineralised zone-III from 100.6m to 116.6m is very well correlated with the geophysical zones. The mineralised zone-IV is however, was not identified in the geophysical log.

The geophysical logs of borehole SBE-8, suggests two conductive zones I & II for depths from 74.2m to 82.4m characterized by low values of SPR, short normal & long normal resistivities. Moderate to High Magnetic susceptibility response (Zone-I, II, III, IV, V, VI, VII & VIII) for depth range from 50.7m to 71.45m has been recorded and it indicates the presence of magnetic minerals in the formation. Conductive zone associated with low SP and low natural gamma counts, indicates the presence of Sulphide mineralization within the formation from 76.8 – 77.2m depth. Geologically and chemically, the mineralised zones were identified as mineralised zone-I from 53.30m to 66.60m and mineralised zone-II from 71.50m to 77.50m. the mineralised zone-I is very well correlatable but zone-II was not recognisable in the geophysical log.

VII. Mineralogy of the ore zone

The iron ore mineralization has been observed in banded hematite chert / jasper. The alternate iron oxide and siliceous bands are present. The individual iron oxide band has a thickness of 1mm to 5 cm. The siliceous bands are mostly chert and few jasper bands. In drill cores, the quartz/chert vein shows presence of pyrite, arsenopyrite at various levels in disseminated nature.

VIII. Borehole deviation test and methodology

Borehole deviation test was performed in each borehole. Deviation of drill holes at regular interval of about 30-40 m was carried out by etch method using 10% hydrofluoric acid. Correction method had been applied to minimize the deviation.

Table 8.2: Details of deviation and correction of borehole angle

Sl. No.	BH No.	Inclination	Depth (m)	Calculated angle by Etch Method	Difference (Deviation angle)
1	SBE - 1	45°	30	42°	3°
			70	41°	4°
			100	40.5°	4.5°
2	SBE - 2	45°	30	44°	1°
			60	44°	1°
			90	40.5°	4.5°
3	SBE - 3	45°	20	45°	0°
			50	46.5°	1.5°
			80	46°	1°
4	SBE - 4	45°	15	42°	3°
			40	41.5°	3.5°
			60	41.5°	3.5°
5	SBE-6	40°	50	40.5°	0.5°
			100	41°	1°
			150	44°	4°
6	SBE-7	45°	40	41.5°	3.5°
			80	40.5°	4.5°
			120	41°	4°
7	SBE-8	45°	20	42°	3°
			40	40.5°	4.5°
			60	41°	4°

IX. Methodology of ore zone sampling

Sampling in all the boreholes was carried out in a systematic way in mineralized zone of intersected banded hematite chert / jasper. Few samples were also drawn from sulphide show zones. The sample length was tried to be kept at 1 m without mixing of run.

X. Sample preparation, chemical analysis and laboratory procedures

A total of 441 samples from eight boreholes were collected and sent for chemical analysis. The samples were collected after thorough proper logging of cores. Initially, sample length of 50 cm interval was taken, as the intersected width of BIF was minimal. Later on, the sample length interval was maintained at 1.0 m. The cores were splitted into two equal halves longitudinally. One half was pulverized to -120 mesh size and after coning and quartering submitted for chemical analysis and other half was kept in the core box.

XI. Check samples

A total 05 drill core samples were sent for check analysis and no significant variation is observed.

XII. Details of intersected ore zones of the drill holes drilled and their correlation

Considering cut off for Fe is as 30%, the ore zones in each borehole were demarcated. The boreholes SBE-1 and SBE-4 does not have any significant values. The geological sections along with intersected ore zones of the drill holes has been drawn and appended in plates VIII to XIV. The ore zones established in each borehole is summarised in the following table.

Table 8.3: Details of intersected ore zones in drilled boreholes

At 30% Fe Cut Off					
Borehole No.	Zone	From (m)	To (m)	Thickness (m)	Weighted Average Fe%
SBE-2	I	86.55	88.12	1.57	28.73/1.57m
SBE-3	I	78.10	87.50	7.50	31.58/7.50m
SBE-5	I	47.85	59.00	10.25	36.83/10.25m
SBE-6	I	93.10	95.05	1.95	41.93/1.95m
	II	108.10	115.20	7.10	39.14/7.10m
	III	118.20	125.65	7.45	36.04/7.45m
	IV	143.80	160.05	16.25	36.30/16.25m
SBE-7	I	63.80	97.10	33.30	34.79/33.30m
	II	100.60	103.60	3.00	32.74/3.0m
	III	106.60	116.60	10.00	31.10/10.0m
	IV	131.60	133.60	2.00	34.16/2.0m
SBE-8	I	53.30	66.60	13.30	31.10/13.30m
	II	71.50	77.50	6.00	30.22/6.0m
At 35% Fe Cut Off					
SBE-5	I	47.85	59.00	10.25	36.83/10.25m
SBE-6	I	93.55	95.05	1.50	45.30/1.50m
	II	108.10	115.20	7.10	39.14/7.10m
	III	121.60	125.65	4.05	39.44/4.05m
	IV	146.55	153.25	6.70	40.82/6.70m
	V	157.25	160.05	2.80	39.18/2.80m
SBE-7	I	63.80	75.45	11.65	35.58/11.65m
	II	77.00	89.85	12.85	38.07/12.85m

9. Resource Estimation

I. Introduction

In the extended block 'A', Bharhari, Sonbhadra, U.P. a total of 822.70m of drilling was carried out through eight boreholes with an objective assess the economic potentiality of iron ore occurrence in the area. The borehole was drilled at the interval of 400m in general and all the boreholes were drilled at an angle of 45° except SBE-6 which was drilled at 40°. The subsurface iron ore mineralization in the area was targeted at 30m vertical depth (1st Level) from 370m datum line. The mineralized zones have demarcated based on the chemical analysis with Fe cut off $\geq$ 30% and 35%. At 30% Fe cut off, the mineralized iron zones have been established in six boreholes namely SBE-2, 3, 5, 6, 7 and 8. At 35% Fe cut off, the mineralized zones have been demarcated in SBE-5, SBE-6 and SBE-7. The grade of mineralization in drilled boreholes at 30 % Fe varies from 30% to 37.26% with average grade of the explored block being 34.46%.

Assumptions of resource estimations:

- The mineralized zones intersected in each borehole have been considered as a continuous single body.
- The exposed BIF shows strike continuity all along the ridge crest in the extended block 'A', however, it is cut across by two northerly flowing nalas in the block. One nala flows between SBE-2 and SBE-4 and other nala flows between SBE-6 and SBE-7 (Plate - III). These northerly flowing nalas possess great challenges to puncture the planned boreholes at 400m interval.
- The Fe% is calculated by the molecular formula of Fe_2O_3 i.e. $\text{Fe}_2\text{O}_3\%$ is multiplied by factor of 0.6994.
- Strike influence of the mineralized zone has been taken as half the distance between two adjacent boreholes while the strike influence of the end boreholes namely SBE-3 and SBE-7 has been taken as half of the distance of its adjoining boreholes which have intersected the iron ore mineralization.
- As per the norm of G-3 stage investigation, the maximum distance between two adjacent boreholes is 400m however the distance between SBE-6 and SBE-7 is 527m due to the northerly flowing nala in its vicinity and non-drilling of the SBE-6 at the given point due to the steep dip slope of the outcrop. The strike influence for the borehole SBE-7 has been taken as 400m while the strike influence for SBE-2 has been recalculated as 363m as SBE-4 went barren.
- The mineralized zones have been assumed to continue right from the outcrop surface as weighted average Fe% in the TR-1, TR-2, TR-3 and TR-4 have been found to be

38.9/18m, 30.42/3m, 34.30/2m and 35.37/10m respectively. The weighted average Fe% of the channel samples (10 nos.) is 26.23/10m.

- In the explored extended block – ‘A’, the resource has been calculated by cross sectional method and longitudinal vertical section method (LVS method) at 30% and 35% cut off Fe%. For cross section method, the dip influence of mineralized zone has been considered to be continuous from the surface to the 10m below the lower RL of the intersected mineralized zone.
- True thickness of the zones has been calculated by the trigonometrical method. The horizontal thickness of the mineralized zones has been calculated by dividing the true thickness with $\sin \theta$ where θ is dip angle of mineralized zones.
- The bed rock samples weighing upto two kilograms of exposed banded hematite chert/jaspers was sent for determination of bulk density and its average has been taken for estimation of the resource.
- The minimum stoping width has been taken as one and half metres.

I. Resource estimation by cross sectional method (taking true thickness):

In this method, the volume of the mineralized zone has been calculated by the multiplying the true thickness of the mineralized zones with its strike influence and dip influence. The total resource has been calculated at two cut offs i.e. at 30% and 35% Fe. The total resource has been calculated by following formulae:

$$\text{Total Resource} = \text{True thickness} \times \text{Dip influence} \times \text{Strike influence} \times \text{Bulk density}$$

Table 9.1: Total resource at Fe $\geq$ 30% calculated by the cross sectional method

S. NO.	Borehole No.	Mineralized Zone thickness intersected in borehole (t in m)	Core Angle (β)	$\sin(\beta)$	True Thickness ($\sin(\beta) \times t$) (m)	Strike Influence (m)	Dip Influence (m)	Bulk Density	Resources (Tonnes)	Avg. grade (%)
1	SBE-2	1.57	71°	0.94552	1.48	363	95	3.2	163320.96	34.73 %
2	SBE-3	7.50	84°	0.99452	7.40	258	112	3.2	684257.28	
3	SBE-5	10.25	74°	0.96126	9.85	241	121	3.2	919154.72	
4	SBE-6- Zone I	1.95	86°	0.99760	1.95	333	113.5	3.2	235843.92	
5	SBE-6 - Zone II	7.10	80°	0.98480	7.01	333	118.5	3.2	885177.94	
6	SBE-6- Zone III	7.45	80°	0.98480	7.36	333	120	3.2	941137.92	
7	SBE-6 - Zone IV	16.25	70°	0.93969	15.30	333	132.5	3.2	2160237.60	
8	SBE-7 - Zone I	33.30	66°	0.91350	30.40	400	142	3.2	5525504.00	
9	SBE-7 - Zone II	3.00	66°	0.91350	2.70	400	136	3.2	470016.00	

10	SBE-7 - Zone III	10.00	66°	0.91350	9.10	400	135	3.2	1572480.00
11	SBE-7 - Zone IV	2.00	61°	0.87460	1.60	400	129	3.2	264192.00
12	SBE-8 - Zone I	13.30	65°	0.90631	12.05	169	116	3.2	755930.24
13	SBE-8 - Zone II	6.00	62°	0.88295	5.30	169	110	3.2	315286.40
Total Resource $\sum T$ (in Tonnes)=									14892538.98
Total Resource : 14.89 MT									

Table 9.2: Total resource at Fe $\geq$ 35% calculated by the cross sectional method

S. NO.	Borehole No.	Mineralized Zone thickness intersected in borehole (t in m)	Core Angle (β)	Sin(β)	True Thickness (Sin(β)xt) (m)	Strike Influence (m)	Dip Influence (m)	Bulk Density	Resources (Tonnes)	Avg. grade (%)
1	SBE-5	10.25	74°	0.96126	9.85	241	121	3.2	919154.72	38.34 %
2	SBE-6 - Zone I	1.50	86°	0.99760	1.20	333	178	3.2	227612.16	
3	SBE-6 - Zone II	7.10	81°	0.98770	7.01	333	167	3.2	1247465.95	
4	SBE-6 - Zone III	4.05	81°	0.98770	4.00	333	160	3.2	681984.00	
5	SBE-6 - Zone IV	6.70	70°	0.93969	6.30	333	147	3.2	986852.16	
6	SBE-6 - Zone V	2.80	68°	0.92718	2.60	333	143	3.2	396190.08	
7	SBE-7 - Zone I	11.65	66°	0.91350	10.60	400	137	3.2	1858816.00	
8	SBE-7 - Zone II	12.85	66°	0.91350	11.70	400	140	3.2	2096640.00	
Total Resource $\sum T$ (in Tonnes)=									8414715.072	
Total Resource : 8.41 MT										

II. Resource estimation by longitudinal vertical section(LVS)method:

In this method, the volume of the mineralized zone has been calculated by the multiplying the strike influence with differences in dip RL along with horizontal thickness. The differences in dip RL has been calculated by deducting the upper RL (URL) with RL of 10m below the lower RL of the intersected mineralized zone. Horizontal thickness has been determined by the trigonometric method. The total resource has been calculated at two cut offs i.e. at 30% and 35 % Fe (Plate – XIX). The total resource has been calculated by following formulae:

$$\text{Total Resource} = \text{Strike influence} \times \text{Difference in Dip RL} \times \text{Horizontal Thickness} \times \text{Bulk Density}$$

Table 9.3: Total resource at Fe ≥ 30% calculated by LVS method

S. No.	Borehole No.	Mineralized Zone thickness intersected in borehole (m)	True Thickne ss (t in m)	Min. Zone dip angle (θ)	Sinθ	Horizontal Thickness (m)	Dip Length RL (m)		Differe nce in Dip RL (m)	Strike Influen ce (m)	Bulk Densit y	Resources (T) (Tonnes)	Avg. grade of borehol e (g) (Fe %)	Tonnage x Avg. grade (T)x (g)	Avg. grad e (%) $\sum (T \times g) / \sum T$
			1			(t / Sinθ) 2	Upper RL 3	Lowe r RL 4	5	6	7	6x5x2x7			
1	SBE-2	1.57	1.48	50°	0.76600	1.9	404	314	90	363	3.2	198633.6	30	5959008.00	34.8 5%
2	SBE-3	7.50	7.4	48°	0.74314	9.6	402	321	81	258	3.2	641986.56	31.58	20273935.56	
3	SBE-5	10.25	9.85	61°	0.87461	11.3	419	314	105	241	3.2	915028.8	36.83	33700510.70	
4	SBE-6- Zone I	1.95	1.95	50°	0.76604	2.5	430.5	288.5	142	333	3.2	378288	41.93	15861615.84	
5	SBE-6 - Zone II	7.10	7.01	58°	0.84804	8.3	431	288.5	142.5	333	3.2	1260338.4	39.14	49329644.98	
6	SBE-6- Zone III	7.45	7.36	58°	0.84804	8.7	424.5	288.5	136	333	3.2	1260817.92	36.04	45439877.84	
7	SBE-6 - Zone IV	16.25	15.3	67°	0.92050	16.6	423.5	288.5	135	333	3.2	2388009.6	36.3	86684748.48	
8	SBE-7 - Zone I	33.30	30.4	63°	0.89100	34	420.5	289.5	131	400	3.2	5701120	34.79	198341964.8	
9	SBE-7 - Zone II	3.00	2.7	72°	0.95105	2.8	419	289.5	129.5	400	3.2	464128	32.74	15195550.72	
10	SBE-7 - Zone III	10.00	9.1	72°	0.95105	9.6	418.5	289.5	129	400	3.2	1585152	31.1	49298227.20	
11	SBE-7 - Zone IV	2.00	1.6	72°	0.95105	1.7	416.5	289.5	127	400	3.2	276352	34.16	9440184.32	
12	SBE-8 - Zone I	13.30	12.05	74°	0.96126	12.5	418.5	305.5	113	169	3.2	763880	31.1	23756668.00	
13	SBE-8 - Zone II	6.00	5.3	74°	0.96126	5.5	415	305.5	109.5	169	3.2	325696.8	30.22	9842557.30	
Total Resource $\sum$ (T) (in Tonnes)=												16159431.68	$\sum$ (Txg)	563124493.7	
Total Resource = 16.16 MT															

The total estimated resource through LVS method at 30 % Fe is **16.16 million tonnes (MT)** with average **grade of 34.85%**.

Table 9.4: Total resource at Fe ≥ 35% calculated by LVS method

S. No	Borehole No.	Mineralized Zone thickness intersected in borehole (m)	True Thickne ss (t in m)	Mine ralize d Zone dip angle (θ)	Sinθ	Horizontal Thickness (m)	Dip Length RL (m)		Differ ence in Dip RL (m)	Strike Influen ce (m)	Bulk Densit y	Resources (T) (Tonnes)	Avg. grade of borehol e (g) (Fe %)	Tonnage x Avg. grade (T)x (g)	Avg. grad e (%) $\sum (T \times g) / \sum T$
			1			(t / Sinθ) 2	Upper RL 3	Lowe r RL 4	5	6	7	6 x 5 x 2 x 7			
1	SBE-5	10.25	9.85	61°	0.87461	11.3	419	314	105	241	3.2	915028.8	36.83	33700510.70	38.21%
2	SBE-6 - Zone I	1.50	1.2	53°	0.79863	1.5	430.5	288.5	142	333	3.2	226972.8	45.3	10281867.84	
3	SBE-6 - Zone II	7.10	7.01	57°	0.83867	8.4	431	288.5	142.5	333	3.2	1275523.2	39.14	49923978.05	
4	SBE-6 - Zone III	4.05	4	57°	0.83867	4.8	424	288.5	135.5	333	3.2	693066.24	39.44	27334532.51	
5	SBE-6 - Zone IV	6.70	6.3	68°	0.92718	6.8	423	288.5	134.5	333	3.2	974597.76	40.82	39783080.56	
6	SBE-6 - Zone V	2.80	2.6	68°	0.92718	2.8	420.5	288.5	132	333	3.2	393845.76	39.18	15430876.88	
7	SBE-7 - Zone I	11.65	10.6	63°	0.89100	11.8	416	289.5	126.5	400	3.2	1910656	35.59	68000247.04	
8	SBE-7 - Zone II	12.85	11.7	63°	0.89100	13.1	420.5	289.5	131	400	3.2	2196608	38.07	83624866.56	
Total Resource $\sum (T)$ (in Tonnes)=												8586298.56	$\sum (T \times g)$ =	328079960.14	
Total Resource = 8.50 MT															

The total estimated resource through LVS method at 35 % Fe is **8.50 million tonnes (MT)** with average **grade of 38.21%**.

Table 9.5: Comparative study of the estimated resources

SR. No.	METHOD	at 30% Fe	at 35%Fe
I	Resource estimation by cross sectional method (taking true thickness)	14.89 MT	8.41 MT
II	Resource estimation by longitudinal vertical section (LVS) method	16.16 MT	8.50 MT

The resource has been estimated by cross sectional method and longitudinal vertical section methods for the extended block 'A', Bharhari, Sonbhadra, U.P. From the comparative study of the estimated resources, it can be inferred that the resource estimated by cross sectional method has given the total tonnage of 14.89 million tonnes with average grade of 34.73% Fe at 30% Fe cut off. The total estimated resource at 35% Fe cut off is 8.41 million tonnes with average grade of 38.34 %. This method of resource estimation has been considered as the best fit method as per the prevailing nature of the different mineralized zones in drilled boreholes of the area has the highest confidence for volume calculation and resource estimation of the explored block.

Category of the resource as per UNFC classification:

Detailed geological mapping was carried out on 1:2000 scale over an area of 1.61 sq. km. with triangulation stations depicting all geological details with contour interval of 5m. Surface investigation in the DM block was carried out through collection of 50 nos. of BRS and 51 nos. of PTS. Subsurface investigation in the area was carried out through 8 nos. of boreholes and all the boreholes were put through geophysical logging. Within the assigned block geophysical survey was also carried out by SP, IP, resistivity and magnetic survey. The estimated resource of 14.89 million tonnes (MT) with average grade of 34.73% Fe at 30% cut off and 8.41 million tonnes (MT) with average grade of 38.34% of Fe at 35% cut off fulfils the 333 category of UNFC classification.

10. Conclusion

The Banded Hematite Chert/Jasper bands (BIF) exposed in the extended block 'A' is the part of the 20 km long BIF zone extending from NW of Bijaura in east to Bhahari (Bharahari) in west, having general trend of N70°E-S70°W with dip of 50°-60° towards south. These bands are located in the northern most flank of the Mahakoshal ridge at the south of the Son-Narmada north fault. These BIF bands are the parts of the Agori Formation of the Mahakoshal Group of rocks and are closely associated with variegated phyllite, felsic tuff, ferruginous phyllite and mafic intrusives in form of dolerites.

The banded hematite chert / jasper is exposed on the top surface of the Mahakoshal ridge with variable thickness. The general trend of BIF bands in the extended block 'A', Bhahari is ENE- WSW with steep dip of 45° to 70° due south. The thickness of the individual hematite band varies from 1mm to 7 cm while the thickness of chert bands ranges from few cm to 8 cm in the drilled cores of SBE-5/ SBE-6. The channels cut across the banded hematite chert / jasper (BIF) has shown low Fe value of 30%. According to chemical analysis of samples, the iron ore present in the area is of low grade. From the study of the geological sections, it has been found that maximum depth (Lower RL) of banded hematite chert / jasper is 296 m.

Based on chemical results, total estimated resource for iron ores in the extended block 'A' is 14.89 million tonnes (MT) with average grade of 34.73% Fe at 30 % cut off and 8.41 million tonnes (MT) with average grade of 38.34% of Fe at 35 % cut off. Since iron ore bands are of low grade only hence it has its limitations for steel industry usage in present time. However, such occurrences would be of useful in future when the advancement in beneficiation techniques and rise in demand for the commodity. The iron from banded hematite chert /jasper may be concentrated with weight recovery commensurate with the available hematite after crushing and elimination of silica, which needs a better beneficiation plant. It can be used with very high grade iron ore for blending purpose.

11. Recommendation

The World's Iron & Steel industry is based almost exclusively on iron ores associated with banded iron formation. Commercial extraction of high grade iron ore from banded iron formation is the need of the hour. As the state of Uttar Pradesh is quite deficient in ferrous mineral resources, therefore, search for low grade iron ore is the need of hour and the discovery of potential mineral blocks with Fe value of 35% to 45% will help in augmenting the iron resource in the mineral inventory of the state.

- Since the sub surface exploration of the present block was taken based on outcome of the large scale mapping of the Bharhari area by Modak *et.al.* (FS 2014-15) hence other blocks with BIF of considerable strike length, width and grade should also be explored to estimate the mineral potential of the area.
- It is also recommended to explore all the BIF bands of Agori Formation of Mahakoshal Group to know its potentialities.
- The intimate association of felsic tuffs in the down dip side of the BIF poses a great challenge for drilling, therefore, in such zones better and advanced techniques of drilling should be adopted as it would facilitate in better core recovery and knowing the exact thickness of the mineralized zones for all boreholes. It would also help in timely completion of drilling targets without overshooting the budgeted expenditure.

LOCALITY INDEX

LOCALITY	LATTITUDE			LONGITUDE		
	DEG	MIN	SEC	DEG	MIN	SEC
Agori Khas	24	32	49.2	82	57	53.2
Allahabad	25	26	41.2	81	52	35.6
Baghmanva Pahar	24	34	07.0	82	54	10.7
Bargawan	24	35	35.7	82	54	34.2
Bharhari	24	32	30.0	82	45	0
Bijaura	24	34	18.1	82	56	53.1
Chakdiya (Chakdahi)	24	32	32.0	82	51	36.8
Chatarwar	24	35	44.2	82	53	38.0
Chaura	24	33	25.8	82	57	05.3
Chopan	24	30	50.5	83	01	33.0
Jogail	24	30	45.0	82	51	00
Karwaniya	24	31	54.1	82	53	40.7
Kurchha	24	34	15.5	82	53	05.4
Kushaniya (Sisauniya)	24	33	24.2	82	52	03.8
Marauli	24	34	15.2	82	52	07.7
Mirzapur	25	08	41.6	82	33	55.2
Muirpur	24	07	33.0	83	02	36.0
Murgidand	24	32	20.5	82	52	53.7
Robertsganj	24	41	19.0	83	04	04.2
Varanasi	25	19	0	83	0	37.5

REFERENCES

Bhattacharya D. et al., (2012): Report on the ground geophysical mapping in parts of degree sheet no. 63L (TS no. 63L/1, 5, 9, 13, 14, 15 & 16) in Uttar Pradesh and Madhya Pradesh.

Dey A.K., (1967-68): Report on the preliminary investigation of Iron-ore Deposit near Bargawan, District Mirzapur, U.P., *Unpub. report Geol. Surv. India.*

Dey A.K., (1968-69): Report on the exploratory operations carried out on the iron-ore deposit near Bargawan. Dist. Mirzapur, U.P. *Unpub. report Geol. Surv. India.*

Dwivedi, G.N., Sharma, D.P., Prasad, M., Sinha, V.P., Tripathi, A.K., Yadav, M.L., Mishra, R., Khan, M.A. and Absar, A. (2001): Gold Exploration at Sona Pahari, Sonbhadra District, U.P.: An Introspect. *Geol. Surv. India, Spl. Publ. No-58 P. 361-365.*

Modak, A, Arvind, Chaki. P. and Nag, R., (2015): Report on resource evaluation of potentiality of iron in Mahakoshal Group, Bharhari area, Sonbhadra district, Uttar Pradesh., *Unpub. report Geol. Surv. India.*

Nair, K.K.K., Jain, S.C. and Yedekar, D.B. (1995): Stratigraphy, Structure and geochemistry of Mahakoshal Greenstone Belt. *Mem. Geol. Soc. Ind. 31: 405-432.*

Roy A. and Devarajan M. K. (2000): Reappraisal of stratigraphy of Mahakoshal Group, Cambrian crust in eastern and central India, proceeding on international seminar, UNSCO-IUGS-IGCP-368. *Geol. Surv. Ind. Spl. Pub. No. 57.*

Sarkar, Abhijit, Gupta, Sangeeta, Sangeeta and Pramanik Suhrit (2014): Interim Report on geochemical mapping of Vindhyan basin and Mahakoshal Belt in toposheet nos. 63L/13, 14 and 15 (NW/NE) covering parts of Mirzapur and Sonbhadra districts of U.P. and Sidhi district of M.P. *Unpub. report Geol. Surv. India.*

Soni, M.K. and Jha, D.K. (2001): Mahakoshal Greenstone belt and associated gold mineralisation. *Geol. Surv. Ind., Spl. Pub. No. 64, pp. 317- 326.*

Tripathi, S.C. and Mishra, M.N. (1994): Cyclic volcanism and sedimentation in the Mahakoshal Greenstone Belt, district Sidhi, Madhya Pradesh. *Jour. Geol. Soc. India, Vol. XLIV, p 167 – 173.*

Vredenburg, E. (1901): Geology of Son Valley in Rewa state and parts of Jabalpur and Mirzapur. *Mem. Geol. Surv. India Vol . 33.*

Winkler H.G.F., (1974): Petrogenesis of metamorphic rocks, 3rd ed. Springer, Berlin, 320p.



Analytical results of Major Oxides of Bed rock samples from extended Block - 'A', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	Latitude	Longitude	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
1	BBA/BRS-1	24°34'05.4"	82°54'10.4"	Banded Hematite Chert	16.08	0.45	74.83	0.24	<0.1	<0.1	<0.1	0.36	0.02	0.28	52.34
2	BBA/BRS-2	24°34'09.4"	82°53'51.2"	Banded Iron Formation / Phyllite banding	72.56	12.18	9.87	0.14	0.15	<0.1	<0.1	0.01	0.47	0.07	6.90
3	BBA/BRS-3	24°34'04.3"	82°53'51.2"	Banded Hematite Chert	34.12	0.85	56.06	<0.1	<0.1	<0.1	<0.1	<0.003	0.03	0.19	39.21
4	BBA/BRS-4	24°34'10.0"	82°54'03.2"	Banded Hematite Chert / Jasper	50.75	12.49	25.15	<0.1	0.52	<0.1	0.17	<0.003	0.38	0.07	17.59
5	BBA/BRS-5	24°34'17.8"	82°54'07.2"	Grey Phyllite	57.25	16.57	16.1	0.45	1.67	0.517	2.4	0.22	0.62	0.07	11.26
6	BBA/BRS-6	24°34'01.5"	82°54'07.3"	Banded Iron Formation / Phyllite banding	58.88	9.78	28.28	<0.1	0.14	<0.1	<0.1	<0.003	0.29	0.07	19.78
7	BBA/BRS-7	24°34'04.3"	82°54'01.1"	Banded Hematite Chert / Jasper	44.07	0.43	54.42	<0.1	<0.1	<0.1	<0.1	<0.003	0.02	0.1	38.06
8	BBA/BRS-8	24°34'10.3"	82°54'00.3"	Reddish Phyllite	48.48	14.93	24.91	<0.1	0.32	<0.1	<0.1	<0.003	0.55	0.04	17.42
9	BBA/BRS-9	24°33'41.3"	82°51'47.9"	Banded Hematite Chert / Jasper	54.18	1.97	37.45	0.21	<0.1	<0.1	<0.1	<0.003	0.02	0.13	26.19
10	BBA/BRS-10	24°33'41.1"	82°51'43.4"	Banded Hematite Chert / Jasper	59.83	1.39	33.26	<0.1	<0.1	<0.1	<0.1	<0.003	0.03	0.07	23.26
11	BBA/BRS-11	24°34'05.7"	82°53'03.8"	Reddish Ferruginous Phyllite ± iron oxide	53.14	15.07	21.48	0.34	0.91	0.358	2.58	0.35	0.51	0.12	15.02
12	BBA/BRS-12	24°33'42.6"	82°52'06.8"	Reddish Ferruginous Phyllite ± iron oxide	64.16	13.28	15.47	0.21	0.12	<0.1	<0.1	<0.003	0.58	0.05	10.82
13	BBA/BRS-13	24°33'43.5"	82°52'00.4"	Banded Hematite Jasper (brecciated)	33.97	3.41	54.32	0.33	<0.1	<0.1	<0.1	<0.003	0.13	0.12	37.99
14	BBA/BRS-14	24°33'46.0"	82°52'00.0"	Banded Hematite Chert / Jasper	31.49	0.73	64.26	0.24	<0.1	<0.1	<0.1	<0.003	0.03	0.26	44.94
15	BBA/BRS-15	24°33'43.1"	82°51'58.7"	Banded Hematite Chert / Jasper	58.97	1.2	34.2	0.25	<0.1	<0.1	<0.1	<0.003	0.03	0.1	23.92
16	BBA/BRS-16	24°33'44.0"	82°52'02.1"	Reddish Tuff	57.09	17.58	18.59	0.14	1.03	<0.1	0.28	<0.003	1.68	0.08	13.00
17	BBA/BRS-17	24°33'44.4"	82°52'24.3"	Quartz / Chert vein	84.44	1.21	7.53	0.14	0.55	<0.1	<0.1	0.04	0.11	0.05	5.27
18	BBA/BRS-18	24°33'44.3"	82°52'24.3"	Reddish Ferruginous Phyllite ± iron oxide	53.36	7.19	27.69	0.31	1.29	<0.1	0.86	0.08	0.39	0.13	19.37
19	BBA/BRS-19	24°33'51.4"	82°52'42.8"	Banded Hematite Chert / Jasper	52.71	0.68	41.87	0.22	0.1	<0.1	<0.1	<0.003	0.02	0.17	29.28
20	BBA/BRS-20	24°33'47.7"	82°52'57.1"	Reddish Ferruginous Phyllite ± iron oxide	54.85	7.58	28.67	0.22	1.09	<0.1	0.41	0.18	0.35	0.06	20.05
21	BBA/BRS-21	24°33'47.7"	82°52'57.2"	Reddish Ferruginous Phyllite ± iron oxide	86.19	0.82	8.37	0.19	0.13	<0.1	<0.1	0.02	0.05	0.03	5.85
22	BBA/BRS-22	24°33'57.7"	82°52'53.8"	Reddish Ferruginous Phyllite ± iron oxide	42.07	11.71	34.09	0.9	1.5	<0.1	0.4	0.08	0.37	0.06	23.84
23	BBA/BRS-23	24°33'48.3"	82°53'06.8"	Reddish Phyllite / Tuff	73.45	16.14	2.89	0.19	1.01	<0.1	2.33	0.01	0.01	0.01	2.02
24	BBA/BRS-24	24°33'48.8"	82°53'15.4"	Dolerite	44.91	21	19.74	0.14	1.15	0.744	2.98	-0.01	2.31	0.15	13.81
25	BBA/BRS-25	24°33'54.6"	82°53'13.6"	Banded Hematite Chert / Jasper	41.68	0.29	49.63	<0.1	<0.1	<0.1	<0.1	<0.003	0.05	0.18	34.71
26	BBA/BRS-26	24°33'56.8"	82°53'04.3"	Banded Hematite Chert / Jasper	50.76	0.7	40.44	<0.1	<0.1	<0.1	<0.1	<0.003	0.03	0.12	28.28
27	BBA/BRS-27	24°33'45.4"	82°52'17.7"	Sheared Banded Hematite Chert / Jasper	78.16	0.99	15.66	0.1	0.13	<0.1	<0.1	0.03	0.02	0.1	10.95
28	BBA/BRS-28	24°34'00.9"	82°53'06.0"	Reddish Ferruginous Phyllite ± iron oxide	48.81	10.16	31.88	<0.1	0.13	<0.1	<0.1	<0.003	0.36	0.08	22.30
29	BBA/BRS-29	24°33'54.6"	82°52'46.6"	Reddish Ferruginous Phyllite ± iron oxide	39.3	0.5	49.08	<0.1	0.11	<0.1	<0.1	0.43	0.02	0.07	34.33
30	BBA/BRS-30	24°33'58.0"	82°52'44.9"	Buff Phyllite with iron oxide bandings	50.69	3.94	37.74	<0.1	0.37	<0.1	0.23	<0.003	0.16	0.15	26.40

Sr. No.	Sample No	Latitude	Longitude	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
31	BBA/BRS-31	24°33'58.7"	82°52'40.7"	Reddish Ferruginous Phyllite ± iron oxide	50.02	10.06	35.02	0.11	0.24	0.1	0.16	0.03	0.36	0.12	24.49
32	BBA/BRS-32	24°33'50.7"	82°52'35.9"	Banded Hematite Chert / Jasper	40.52	0.72	54.49	<0.1	0.2	0.1	<0.1	<0.003	0.04	0.08	38.11
33	BBA/BRS-33	24°33'55.2"	82°52'28.7"	Reddish Ferruginous Phyllite ± iron oxide	59.43	10.47	25.79	0.12	0.88	0.1	0.32	0.03	0.53	0.09	18.04
34	BBA/BRS-34	24°33'46.1"	82°51'45.3"	Reddish Ferruginous Phyllite ± iron oxide	55.74	12.93	27.35	0.35	2.04	0.1	0.14	0.12	0.6	0.04	19.13
35	BBA/BRS-35	24°33'41.1"	82°51'50.3"	Reddish Ferruginous Phyllite ± iron oxide	71.91	8.86	19.12	<0.1	0.37	0.1	0.11	0.01	0.36	0.07	13.37
36	BBA/BRS-36	24°33'42.6"	82°52'23.4"	Dolerite	43.33	7.26	17.15	5.63	23.27	0.1	<0.1	0.18	1.05	0.16	11.99
37	BBA/BRS-37	24°34'02.3"	82°52'52.9"	Grey phyllite iron bands & chert nodules	56.62	13.14	20.35	1.73	3.09	0.69	1.94	0.1	0.53	0.07	14.23
38	BBA/BRS-38	24°33'43.3"	82°52'00.4"	Reddish Tuff	47.92	19.87	18.98	0.36	0.91	0.2	0.56	0.04	2.13	0.15	13.27
39	BBA/BRS-39	24°33'59.4"	82°52'19.6"	Grey phyllite	48.09	12.54	27.48	0.33	3.81	0.15	0.94	0.06	0.28	0.1	19.22
40	BBA/BRS-40	24°33'47.5"	82°52'15.8"	Grey phyllite iron bands & chert nodules	50.5	18.49	15.49	1.21	1.7	0.91	4.95	0.39	0.76	0.27	10.83
41	CH-1/1	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	48.94	1.24	43.2	0.16	<0.1	<0.1	0.15	0.27	0.01	0	30.21
42	CH-1/2	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	49.23	1.57	41.97	0.25	<0.1	<0.1	0.1	0.24	0.02	0.09	29.35
43	CH-1/3	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	46.96	2.38	44.22	0.44	<0.1	<0.1	0.3	0.22	0.02	0.09	30.93
44	CH-1/4	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	63.26	1.61	29.91	0.15	0.1	<0.1	0.25	0.27	0.02	0.07	20.92
45	CH-1/5	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	48.35	1.43	42.83	0.24	<0.1	<0.1	0.17	0.2	0.02	0.12	29.96
46	CH-1/6	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	51.39	1.45	38.33	0.42	<0.1	<0.1	0.18	0.35	0.02	0.14	26.81
47	CH-1/7	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	57.49	1.53	34.26	0.25	<0.1	<0.1	0.16	0.26	0.03	0.13	23.96
48	CH-1/8	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	55.86	1.9	37.44	0.15	<0.1	<0.1	<0.1	0.29	0.07	0.14	26.19
49	CH-1/9	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	66.69	1.02	26.92	0.12	<0.1	<0.1	<0.1	0.28	0.04	0.1	18.83
50	CH-1/10	24°33'45.0"	82°52'05.8"	Banded Hematite Chert / Jasper	56.81	1.51	35.96	0.28	<0.1	<0.1	<0.1	0.27	0.03	0.1	25.15

Analytical results of Major Oxides of drill core samples from extended Block - 'A', Bharhari area, Sonbhadra district, Uttar Pradesh																
Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Borehole No. SBE-1 (erstwhile BBA-7) 24° 33' 39.5" 82° 52' 07.8"																
1	SBE-1/1	14.00	14.50	0.50	Banded Ferruginous Chert	61.66	13.02	13.07	0.45	2.34	<0.1	0.87	0.37	0.94	0.04	9.14
2	SBE-1/2	14.50	15.00	0.50	Banded Ferruginous Phyllite	61.68	13.95	13.46	0.32	1.92	<0.1	1.18	0.31	0.39	0.04	9.41
3	SBE-1/3	15.00	15.60	0.60	Banded Ferruginous Phyllite	61.6	13.68	16.09	0.37	1.92	<0.1	1.01	0.44	0.35	0.03	11.25
4	SBE-1/4	15.60	16.20	0.60	Banded Ferruginous Phyllite	60.99	9.76	16.13	0.42	2.95	<0.1	0.34	0.4	0.67	0.06	11.28
5	SBE-1/5	16.20	16.80	0.60	Banded Ferruginous Phyllite	47.34	16.77	24.63	0.31	1.78	<0.1	<0.1	0.31	1.16	0.09	17.23
6	SBE-1/6	16.80	17.20	0.40	Banded Ferruginous Phyllite	60.91	11.03	18.26	0.18	1.45	<0.1	<0.1	0.3	0.28	0.05	12.77
7	SBE-1/7	17.20	17.55	0.35	Banded Ferruginous Phyllite	48.95	11.74	29.17	0.29	1.52	<0.1	0.1	0.62	0.25	0.06	20.40
8	SBE-1/8	17.55	18.05	0.50	Banded Ferruginous Phyllite	59.67	8.93	22.99	0.15	0.86	<0.1	0.17	0.27	0.22	0.05	16.08
9	SBE-1/9	18.05	18.60	0.55	Banded Ferruginous Phyllite	56.02	7.42	26.11	0.16	0.73	<0.1	0.2	0.61	0.17	0.05	18.26
10	SBE-1/10	26.90	27.20	0.30	Grey chert with sulphide	91.11	1.47	6.68	<0.1	0.5	<0.1	<0.1	0.24	0.05	0.02	4.67
11	SBE-1/11	28.25	28.75	0.50	Banded Ferruginous Phyllite	55.53	14.08	17.82	0.11	1.45	<0.1	1.4	0.38	0.47	0.05	12.46
12	SBE-1/12	28.75	29.25	0.50	Banded Ferruginous Phyllite	56.82	13.03	17.96	<0.1	1.61	<0.1	1.56	0.41	0.37	0.04	12.56
13	SBE-1/13	29.25	29.65	0.40	Banded Ferruginous Phyllite	57.14	12.59	18.43	<0.1	1.89	<0.1	1.3	0.6	0.36	0.04	12.89
14	SBE-1/14	30.60	31.00	0.40	Banded Ferruginous Phyllite	58.48	11.73	18.43	0.12	1.58	<0.1	0.61	0.34	0.42	0.05	12.89
15	SBE-1/15	31.00	31.40	0.40	Banded Ferruginous Phyllite	58.96	9.71	19.96	<0.1	1.44	<0.1	0.6	0.77	0.31	0.04	13.96
16	SBE-1/16	31.40	31.90	0.50	Banded Ferruginous Phyllite	57.93	11.15	19.83	<0.1	1.36	<0.1	0.71	0.26	0.37	0.04	13.87
17	SBE-1/17	67.90	68.30	0.40	Grey phyllite with BIF	38.27	6.41	27.5	0.43	1.1	<0.1	1.05	0.65	0.21	0.3	19.23
18	SBE-1/18	68.30	68.70	0.40	Grey phyllite with BIF	42.1	4.37	33.29	1.05	1.09	<0.1	0.67	0.68	0.16	0.67	23.28
19	SBE-1/19	68.70	69.10	0.40	Grey phyllite with BIF	62.77	4.6	20.48	0.37	1.17	<0.1	0.62	0.47	0.2	0.18	14.32
20	SBE-1/20	74.60	75.00	0.40	Grey phyllite with BIF	49.89	6.95	25.96	0.26	1.51	<0.1	2.3	0.37	0.4	0.14	18.16
21	SBE-1/21	84.30	84.70	0.40	Phyllite with chert and sulphides	54.32	15	16.09	<0.1	2.06	<0.1	2.71	0.21	0.55	0.09	11.25
22	SBE-1/22	96.70	97.20	0.50	Phyllite with chert and sulphides	56.06	17.19	13.44	<0.1	1.99	<0.1	3.26	0.19	0.62	0.09	9.40

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Borehole No. SBE-2 (erstwhile BBA-8) 24° 33' 41.8" 82° 52' 08.4"																
23	SBE-2/1	16.20	16.70	0.50	Banded Ferr. Phyllite with Chert nodules	43.26	4.74	44.68	0.17	0.43	0.17	0.25	0.53	0.3	0.14	31.249
24	SBE-2/2	18.50	19.00	0.50	Banded Ferr. Phyllite with Chert nodules	57.29	4.82	34.78	0.1	0.33	0.18	0.16	0.19	0.27	0.04	24.325
25	SBE-2/3	21.50	22.00	0.50	Banded Ferr. Phyllite with Chert nodules	53.77	12.71	27.7	0.1	0.33	0.19	0.3	0.08	0.44	0.06	19.373
26	SBE-2/4	22.00	22.50	0.50	Banded Ferr. Phyllite with Chert nodules	55.54	10.64	28.42	0.1	0.27	0.18	0.12	<0.003	0.34	0.05	19.877
27	SBE-2/5	22.50	23.00	0.50	Banded Ferr. Phyllite with Chert nodules	51.65	13.61	26.66	0.12	0.31	0.19	0.17	<0.003	0.43	0.05	18.646
28	SBE-2/6	23.00	23.50	0.50	Banded Ferr. Phyllite with Chert nodules	53.8	9.47	29.96	0.14	0.42	0.18	0.18	<0.003	0.37	0.05	20.954
29	SBE-2/7	23.50	24.00	0.50	Banded Ferr. Phyllite with Chert nodules	65.52	9.28	22.53	0.11	0.41	0.19	0.15	<0.003	0.38	0.04	15.757
30	SBE-2/8	24.00	24.50	0.50	Banded Ferr. Phyllite with Chert nodules	65.52	7.4	22.91	<0.1	0.36	0.19	0.14	<0.003	0.32	0.05	16.023
31	SBE-2/9	24.50	25.00	0.50	Banded Ferr. Phyllite with Chert nodules	59.74	9.48	25.23	0.11	0.36	0.19	0.15	<0.003	0.41	0.05	17.646
32	SBE-2/10	25.00	25.50	0.50	Banded Ferr. Phyllite with Chert nodules	68.57	7.45	17.2	0.26	0.98	0.16	0.22	0.02	0.46	0.04	12.03
33	SBE-2/11	25.50	26.00	0.50	Banded Ferr. Phyllite with Chert nodules	69.05	7.95	20.23	0.11	0.49	0.19	0.17	<0.003	0.4	0.04	14.149
34	SBE-2/12	26.10	26.60	0.50	Banded Ferr. Phyllite with Chert nodules	56.58	8.78	27.85	0.18	0.46	0.19	0.83	0.03	0.36	0.07	19.478
35	SBE-2/13	26.60	27.10	0.50	Banded Ferr. Phyllite with Chert nodules	51.7	8.69	30.89	0.12	0.45	0.18	0.31	0.03	0.32	0.06	21.604
36	SBE-2/14	27.10	27.60	0.50	Banded Ferr. Phyllite with Chert nodules	55.68	11.74	26.86	0.14	0.33	0.19	1.24	<0.003	0.43	0.05	18.786
37	SBE-2/15	27.60	28.10	0.50	Banded Ferr. Phyllite with Chert nodules	52.32	10.62	27.64	0.1	0.57	0.19	0.65	<0.003	0.4	0.05	19.331
38	SBE-2/16	28.10	28.60	0.50	Banded Ferr. Phyllite with Chert nodules	53.22	12.22	24.88	0.17	1	0.2	1.17	0.01	0.42	0.06	17.401
39	SBE-2/17	28.90	29.40	0.50	Banded Ferr. Phyllite with Chert nodules	54.37	8.21	31.32	0.19	0.88	0.18	0.44	0.11	0.35	0.08	21.905
40	SBE-2/18	29.40	30.00	0.60	Banded Ferr. Phyllite with Chert nodules	51.82	9.11	29.88	0.19	0.92	0.18	0.59	0.05	0.37	0.07	20.898
41	SBE-2/19	30.00	30.50	0.50	Banded Ferr. Phyllite with Chert nodules	56.73	8.35	27.74	0.19	0.84	0.18	0.56	0.01	0.32	0.07	19.401
42	SBE-2/20	30.50	31.00	0.50	Banded Ferr. Phyllite with Chert nodules	60.11	11.05	21.71	0.17	0.75	0.2	1.58	0.07	0.45	0.07	15.184
43	SBE-2/21	31.00	31.50	0.50	Banded Ferr. Phyllite with Chert nodules	49.88	8.14	32.1	0.19	0.88	0.18	1.13	0.14	0.45	0.11	22.451
44	SBE-2/22	32.20	32.70	0.50	Banded Ferr. Phyllite with Chert nodules	56.75	12.48	21.46	0.14	0.64	0.2	3.05	0.05	1.01	0.08	15.009
45	SBE-2/23	32.70	33.30	0.60	Banded Ferr. Phyllite with Chert nodules	54.41	15.5	18.52	0.13	0.68	0.23	4.72	<0.003	1.18	0.11	12.953
46	SBE-2/24	35.35	35.90	0.55	Banded Ferr. Phyllite with Chert nodules	60.07	18.63	9.91	<0.1	0.37	0.22	4.96	<0.003	0.77	0.05	6.9311
47	SBE-2/25	35.90	36.40	0.50	Banded Ferr. Phyllite with Chert nodules	51	12.93	25.64	0.1	0.61	0.2	3.09	0.11	0.58	0.05	17.933
48	SBE-2/26	36.40	37.00	0.60	Banded Ferr. Phyllite with Chert nodules	50.95	12.49	26.29	0.2	1.01	0.2	2.56	0.2	0.55	0.05	18.387
49	SBE-2/27	37.00	37.60	0.60	Banded Ferr. Phyllite with Chert nodules	57.02	15.8	20.49	0.15	0.87	0.2	3.09	0.04	0.59	0.05	14.331
50	SBE-2/28	37.60	38.20	0.60	Banded Ferr. Phyllite with Chert nodules	53.4	14.15	21.46	0.19	1.05	0.2	2.48	<0.003	0.85	0.04	15.009
51	SBE-2/29	38.20	38.70	0.50	Banded Ferr. Phyllite with Chert nodules	57.41	9.36	21.36	0.41	1.94	0.17	2	0.27	0.47	0.03	14.939
52	SBE-2/30	38.70	39.20	0.50	Banded Ferr. Phyllite with Chert nodules	48.18	10.54	30.71	0.23	0.99	0.19	0.84	0.44	0.6	0.04	21.479

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
53	SBE-2/31	39.20	39.70	0.50	Banded Ferr. Phyllite with Chert nodules	60.82	10.74	20.89	0.15	0.7	0.19	0.61	0.07	0.55	0.04	14.61
54	SBE-2/32	39.70	40.20	0.50	Banded Ferr. Phyllite with Chert nodules	46	11.11	29.54	0.21	0.77	0.19	0.51	0.26	0.54	0.05	20.66
55	SBE-2/33	40.20	40.65	0.45	Banded Ferr. Phyllite with Chert nodules	58.41	6.69	26.96	0.2	0.47	0.18	0.26	0.21	0.33	0.04	18.856
56	SBE-2/34	40.65	41.10	0.45	Banded Ferr. Phyllite with Chert nodules	49.31	11.09	31.93	0.18	0.3	0.18	0.29	0.79	0.54	0.05	22.332
57	SBE-2/35	41.10	41.50	0.40	Banded Ferr. Phyllite with Chert nodules	49.35	10.56	31.73	0.16	0.28	0.18	0.69	0.3	0.47	0.05	22.192
58	SBE-2/36	41.50	42.00	0.50	Banded Hematite Chert	55.95	2.44	32.78	0.11	0.22	0.18	0.26	0.44	0.11	0.04	22.926
59	SBE-2/37	42.50	43.00	0.50	Banded Ferr. Phyllite	54.22	17.01	17.74	0.15	0.5	0.22	3.93	<0.003	1.03	0.05	12.407
60	SBE-2/38	43.00	43.50	0.50	Banded Phyllite with tuff	58.98	17.91	16.59	0.14	0.28	0.22	4.32	<0.003	1.32	0.06	11.603
61	SBE-2/39	43.50	44.00	0.50	Banded Phyllite with tuff	55.42	16.28	19.99	0.14	0.18	0.2	3.12	<0.003	1.4	0.06	13.981
62	SBE-2/40	48.00	48.50	0.50	Banded Ferr. Phyllite	61.81	13.96	9.53	0.24	0.32	0.2	6.17	0.01	0.5	0.05	6.6653
63	SBE-2/41	49.30	49.80	0.50	Banded Ferr. Phyllite	63.98	13.84	18.52	0.15	0.36	0.2	0.88	0.1	0.55	0.04	12.953
64	SBE-2/42	51.20	51.70	0.50	Banded Ferr. Phyllite	44.88	19.35	24.57	0.33	1.47	0.21	0.26	0.01	2.92	0.07	17.184
65	SBE-2/43	51.70	52.20	0.50	Banded Ferr. Phyllite	44.77	17.91	24.08	0.41	1.83	0.21	0.34	0.02	3.27	0.07	16.842
66	SBE-2/44	55.20	55.70	0.50	Tuff / Dolerite	37.53	14.74	30.94	0.37	2.22	0.19	0.11	0.39	2.48	0.07	21.639
67	SBE-2/45	55.70	56.20	0.50	Tuff / Dolerite	42.66	17.42	24.93	0.37	4.71	0.2	<0.1	0.04	2.33	0.06	17.436
68	SBE-2/46	62.85	63.30	0.45	Banded Ferr. Phyllite	43.97	14.43	31.92	0.18	0.22	0.18	0.15	<0.003	0.74	0.05	22.325
69	SBE-2/47	63.30	63.80	0.50	Reddish Tuff with quartz vein	40.61	19.18	25.45	0.56	5.9	0.16	<0.1	0.14	2.81	0.05	17.8
70	SBE-2/48	73.60	74.10	0.50	Dolerite with quartz vein	42.16	17.14	20.28	1.15	7.95	0.16	0.75	0.17	1.87	0.17	14.184
71	SBE-2/49	85.60	86.10	0.50	Reddish Phyllite + Tuff with iron oxide	58.15	12.87	15.91	0.36	3.76	0.17	2.25	0.05	1.09	0.04	11.127
72	SBE-2/50	86.10	86.55	0.45	Sheared banded hematite chert	47.69	12.86	28.53	0.3	2.41	0.14	<0.1	0.03	0.68	0.03	19.954
73	SBE-2/51	86.55	87.00	0.45	Sheared banded hematite chert	37.57	8.51	45.65	0.21	0.38	0.17	0.2	0.65	0.34	0.06	31.928
74	SBE-2/52	87.00	87.56	0.56	Sheared banded hematite chert	42.59	5.49	38.64	0.63	0.76	0.18	<0.1	0.47	0.29	0.05	27.025
75	SBE-2/53	87.56	88.12	0.56	Sheared banded hematite chert	43.22	4.97	39.86	0.9	0.51	0.18	<0.1	0.18	0.2	0.05	27.878
76	SBE-2/54	88.12	88.70	0.58	Sheared banded hematite chert	50.28	2.66	38.15	0.2	0.24	0.18	<0.1	0.15	0.07	0.05	26.682
77	SBE-2/55	92.50	92.92	0.42	Goethitic / limonitic banded hematite chert	65.44	1.74	24.78	0.14	0.31	0.18	<0.1	0.02	0.06	0.03	17.331
78	SBE-2/56	92.92	93.35	0.43	Goethitic / limonitic banded hematite chert	69.05	2.25	18.84	0.24	0.77	0.15	<0.1	0.07	0.1	0.02	13.177

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Borehole No. SBE-3 24° 33' 41.1" 82° 51' 59.1"																
79	SBE-3/1	12.30	12.80	0.50	Ferr. Tuff / Phyllite with chert bands	64.7	8.8	23.14	0.16	0.17	0.11	<0.1	0.01	0.4	0.13	16.184
80	SBE-3/2	14.50	15.00	0.50	Ferr. Tuff / Phyllite with chert bands	66.31	9.7	18.72	0.15	0.15	0.11	0.1	0.01	0.36	0.15	13.093
81	SBE-3/3	15.00	15.50	0.50	Banded ferruginous phyllite	65.37	9.24	20.15	0.14	0.18	<0.1	0.12	0.02	0.35	0.1	14.093
82	SBE-3/4	15.50	16.00	0.50	Banded ferruginous phyllite with chert	58.88	12.84	22.34	0.17	0.24	<0.1	<0.1	0.05	0.48	0.06	15.625
83	SBE-3/5	16.00	16.50	0.50	Banded ferruginous phyllite with chert	58.85	9.19	29.36	0.19	0.4	0.24	<0.1	0.03	0.37	0.06	20.534
84	SBE-3/6	16.50	17.00	0.50	Banded ferruginous phyllite with chert	62.12	9.54	25.78	0.17	0.33	0.19	0.11	0.04	0.46	0.05	18.031
85	SBE-3/7	17.00	17.60	0.60	Banded ferruginous phyllite with chert	55.97	9.87	28.6	0.19	0.57	<0.1	0.13	0.02	0.41	0.07	20.003
86	SBE-3/8	17.60	18.10	0.50	Banded ferruginous phyllite with chert	61.19	8.71	25.85	0.14	0.45	0.1	<0.1	0.02	0.35	0.06	18.079
87	SBE-3/9	18.10	18.60	0.50	Banded ferruginous phyllite with chert	59.67	9.9	25.56	0.16	0.39	<0.1	<0.1	0.04	0.44	0.07	17.877
88	SBE-3/10	18.60	19.00	0.40	Banded ferruginous phyllite with chert	53.7	13.13	26.27	0.24	0.55	<0.1	0.15	0.03	0.77	0.04	18.373
89	SBE-3/11	19.00	19.50	0.50	Banded ferruginous phyllite with chert	55.56	12.1	23.93	0.22	0.49	<0.1	0.15	0.02	0.61	0.06	16.737
90	SBE-3/12	19.50	20.00	0.50	Banded ferruginous phyllite with chert	55.62	11.84	23.82	0.18	0.42	0.22	0.14	0.03	0.54	0.09	16.66
91	SBE-3/13	20.00	20.40	0.40	Banded ferruginous phyllite with chert	57.38	12.2	25.09	0.16	0.32	0.28	0.11	0.04	0.53	0.09	17.548
92	SBE-3/14	20.40	20.80	0.40	Banded ferruginous phyllite with chert	57.24	11.25	26.99	0.15	0.3	<0.1	0.21	0.07	0.55	0.06	18.877
93	SBE-3/15	20.80	21.40	0.60	Banded ferruginous phyllite with chert	62.99	9.81	20.68	0.12	0.32	0.1	0.1	0.04	0.4	0.05	14.464
94	SBE-3/16	21.40	22.00	0.60	Banded ferruginous phyllite with chert	62.78	10.01	21.08	0.11	0.27	0.2	0.15	0.05	0.38	0.04	14.743
95	SBE-3/17	22.00	22.60	0.60	Banded ferruginous phyllite with chert	61.98	10.2	20.51	0.15	0.68	0.14	0.23	0.02	0.39	0.04	14.345
96	SBE-3/18	22.60	23.20	0.60	Banded ferruginous phyllite with chert	54.54	12.94	26.08	0.17	0.36	0.12	0.1	0.03	0.45	0.04	18.24
97	SBE-3/19	23.20	23.70	0.50	Banded ferruginous phyllite with chert	56.18	12.28	24.49	0.16	0.43	0.11	0.11	0.03	0.41	0.04	17.128
98	SBE-3/20	23.70	24.20	0.50	Banded ferruginous phyllite with chert	65.15	10.11	18.13	0.12	0.22	<0.1	0.17	0.01	0.37	0.06	12.68
99	SBE-3/21	24.20	24.80	0.60	Banded ferruginous phyllite with chert	53.04	13.4	28.02	0.16	0.34	0.12	<0.1	0.02	1.18	0.05	19.597
100	SBE-3/22	24.80	25.40	0.60	Banded ferruginous phyllite with chert	57.61	13.5	24.38	0.14	0.24	0.14	0.12	0.01	1.1	0.08	17.051
101	SBE-3/23	25.40	26.00	0.60	Banded ferruginous phyllite with chert	65.17	10.99	21.02	0.1	0.14	<0.1	0.1	0.01	0.41	0.07	14.701
102	SBE-3/24	26.00	26.50	0.50	Banded ferruginous phyllite with chert	62.12	14.19	19.42	0.11	0.15	0.13	0.2	0.01	0.78	0.07	13.582
103	SBE-3/25	26.50	27.00	0.50	Banded ferruginous phyllite with chert	66.22	11.64	18.61	<0.1	0.15	0.13	0.12	<0.003	0.44	0.07	13.016
104	SBE-3/26	27.80	28.30	0.50	Banded ferruginous phyllite with chert	51.6	18.38	20.99	0.13	0.14	0.13	0.15	0.01	2.08	0.1	14.68
105	SBE-3/27	28.30	28.80	0.50	Banded ferruginous phyllite with chert	54.88	17.62	18.18	0.12	0.15	0.13	0.56	0.01	1.05	0.08	12.715
106	SBE-3/28	28.80	29.30	0.50	Banded ferruginous phyllite with chert	44.52	21	24.79	0.19	0.66	0.14	1.6	0.01	0.5	0.05	17.338
107	SBE-3/29	29.60	30.10	0.50	Banded ferruginous phyllite with chert	42.17	18.64	28.24	0.14	0.22	0.13	2.1	0.01	0.54	0.05	19.751
108	SBE-3/30	30.10	30.60	0.50	Banded ferruginous phyllite with chert	54.82	19.35	13.71	0.12	0.25	0.14	3.59	<0.003	0.99	0.07	9.5888
109	SBE-3/31	30.60	31.10	0.50	Banded ferruginous phyllite with chert	47.42	19.74	20.71	0.17	0.27	0.13	1.7	<0.003	0.83	0.14	14.485
110	SBE-3/32	31.10	31.60	0.50	Banded ferruginous phyllite with chert	50.57	21.92	16.75	0.13	0.25	0.13	0.59	<0.003	0.81	0.1	11.715
111	SBE-3/33	31.60	32.15	0.55	Banded ferruginous phyllite with chert	54.26	15.61	21.36	0.17	0.34	0.13	0.29	<0.003	0.53	0.05	14.939
112	SBE-3/34	32.15	32.65	0.50	Banded ferruginous phyllite with chert	54.01	15.28	23.03	0.14	0.2	0.12	0.11	<0.003	0.71	0.07	16.107
113	SBE-3/35	33.00	33.50	0.50	Banded ferruginous phyllite with chert	55.4	12.92	26.9	0.13	0.21	0.12	<0.1	0.01	0.57	0.06	18.814
114	SBE-3/36	33.50	34.00	0.50	Banded ferruginous phyllite with chert	61.28	11.88	22.02	0.15	0.27	0.13	0.1	<0.003	0.38	0.04	15.401
115	SBE-3/37	36.10	36.60	0.50	Banded ferruginous phyllite with chert	62.24	11.85	22.51	0.16	0.27	0.13	0.1	0.01	0.32	0.09	15.743
116	SBE-3/38	36.60	37.10	0.50	Banded ferruginous phyllite with chert	63.56	7.74	27.05	0.17	0.58	0.13	0.12	0.01	0.27	0.08	18.919

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117	SBE-3/39	37.20	37.70	0.50	Banded ferruginous phyllite with chert	56.31	9.09	29.89	0.21	0.77	0.13	0.1	0.02	0.23	0.07	20.905
118	SBE-3/40	39.70	40.20	0.50	Banded ferruginous phyllite with chert	45.9	16.41	26.79	0.47	2.07	0.15	0.4	0.04	1.32	0.07	18.737
119	SBE-3/41	47.00	47.60	0.60	Iron oxide / phyllite / tuff bandings	43.98	14.97	26.81	0.66	4.59	0.15	0.89	0.02	1.53	0.05	18.751
120	SBE-3/42	52.40	52.90	0.50	Tuff with quartz veins	38.71	18.17	27.15	0.45	5.72	0.15	0.29	0.11	1.5	0.05	18.989
121	SBE-3/43	52.90	53.40	0.50	Tuff with quartz veins	39.28	20.05	25.96	0.41	5.81	0.15	0.27	0.13	1.58	0.04	18.156
122	SBE-3/44	69.30	70.00	0.70	Dolerite dyke / Tuff	44.72	15.46	22.19	0.27	6.32	0.13	0.66	0.09	1.95	0.06	15.52
123	SBE-3/45	74.00	74.50	0.50	Banded Hematite Chert	75.53	1.17	18.2	0.1	0.25	0.12	0.1	0.03	0.04	0.1	12.729
124	SBE-3/46	74.60	75.10	0.50	Banded Hematite Chert	57.59	0.53	38.41	<0.1	<0.1	0.12	0.12	0.01	0.01	0.31	26.864
125	SBE-3/47	75.10	75.60	0.50	Banded Hematite Chert	55.07	0.69	45.46	0.12	<0.1	0.11	0.22	0.01	0.01	0.33	31.795
126	SBE-3/48	75.60	76.10	0.50	Banded Hematite Chert	65.85	0.61	33.24	0.14	0.2	0.12	0.15	0.01	0.02	0.29	23.248
127	SBE-3/49	76.10	77.10	1.00	Banded Hematite Chert	52.17	0.8	46.49	0.16	0.14	0.14	0.24	0.01	0.01	0.3	32.515
128	SBE-3/50	77.10	77.60	0.50	Banded Hematite Chert	63.24	0.8	33.09	0.21	0.19	0.12	0.14	0.01	0.01	0.27	23.143
129	SBE-3/51	77.60	78.10	0.50	Banded Hematite Chert	64.36	1.39	30.85	0.15	0.16	0.17	<0.1	0.01	0.01	0.29	21.576
130	SBE-3/52	78.10	78.60	0.50	Banded Hematite Chert	44.37	0.46	55.99	0.1	0.1	0.18	<0.1	0.01	0.01	0.33	39.159
131	SBE-3/53	78.60	79.10	0.50	Banded Hematite Chert	63.8	0.48	32.13	0.1	0.12	0.1	<0.1	0.01	0.01	0.25	22.472
132	SBE-3/54	80.10	80.60	0.50	Banded Hematite Chert	49.67	1.32	48.86	0.1	0.32	0.19	0.2	0.01	0.01	0.26	34.173
133	SBE-3/55	81.00	81.50	0.50	Banded Hematite Chert	52.12	1.02	48.04	0.17	0.31	0.21	0.1	0.01	0.01	0.2	33.599
134	SBE-3/56	82.00	82.70	0.70	Banded Hematite Jasper	58.81	0.54	39.56	0.25	0.1	0.11	0.2	0.01	<0.01	0.22	27.668
135	SBE-3/57	82.70	83.20	0.50	Banded Hematite Jasper	63.64	0.66	34.1	0.24	0.12	0.18	<0.1	<0.003	0.01	0.19	23.85
136	SBE-3/58	83.20	84.20	1.00	Banded Hematite Jasper	57.88	0.58	41.86	0.1	0.24	0.2	<0.1	0.01	0.01	0.18	29.277
137	SBE-3/59	84.20	85.00	0.80	Banded Hematite Jasper	47.92	0.72	52.06	<0.1	0.14	0.1	0.12	0.02	0.03	0.16	36.411
138	SBE-3/60	85.00	85.35	0.35	Banded Hematite Jasper	50.12	0.5	48.47	0.11	0.1	0.22	0.24	0.01	0.01	0.15	33.9
139	SBE-3/61	85.35	85.70	0.35	Banded Hematite Jasper	61.32	0.42	37.45	<0.1	0.1	0.12	<0.1	0.01	<0.01	0.1	26.193
140	SBE-3/62	85.70	86.30	0.60	Banded Hematite Jasper	45.36	0.56	55.21	0.1	0.1	0.17	<0.1	0.01	0.01	0.1	38.614
141	SBE-3/63	86.30	86.90	0.60	Banded Hematite Jasper	52.05	0.54	48.64	0.1	<0.1	0.15	<0.1	0.01	0.01	0.12	34.019
142	SBE-3/64	86.90	87.50	0.60	Banded Hematite Jasper	56.25	0.45	42.47	0.1	<0.1	0.1	<0.1	<0.003	0.04	0.04	29.704

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Borehole No. SBE-4 24° 33' 44.2" 82° 52' 24.2"																
143	SBE-4/1	14.60	15.40	0.80	Banded Ferruginous Phyllite	64.97	3.87	25.12	0.27	1.83	<0.1	<0.1	0.2	0.21	0.15	17.569
144	SBE-4/2	15.40	16.00	0.60	Banded Ferruginous Phyllite	54.2	5.76	34.01	0.31	1.23	<0.1	1.12	0.24	0.26	0.15	23.787
145	SBE-4/3	16.50	17.00	0.50	Banded Ferruginous Phyllite	61.04	4.94	25.71	0.37	1.25	<0.1	<0.1	0.13	0.29	0.15	17.982
146	SBE-4/4	17.00	17.50	0.50	Banded Ferruginous Phyllite	56.93	5.78	28.8	0.82	2.36	<0.1	<0.1	0.08	0.28	0.33	20.143
147	SBE-4/5	17.50	18.00	0.50	Banded Ferruginous Phyllite	51.26	7.65	31.63	0.42	3.89	<0.1	0.12	0.21	0.37	0.17	22.122
148	SBE-4/6	18.00	18.50	0.50	Banded Ferruginous Phyllite	55.59	7.4	26.5	0.39	3.58	<0.1	<0.1	0.13	0.41	0.17	18.534
149	SBE-4/7	18.50	19.00	0.50	Banded Ferruginous Phyllite	53.69	7.97	28.85	0.84	3.9	<0.1	<0.1	0.07	0.34	0.34	20.178
150	SBE-4/8	19.00	19.50	0.50	Banded Ferruginous Phyllite	57.25	7.43	26.69	0.42	3.68	<0.1	<0.1	0.07	0.37	0.16	18.667
151	SBE-4/9	19.50	20.10	0.60	Banded Ferruginous Phyllite	63.77	6.14	21.85	0.57	2.66	<0.1	<0.1	0.09	0.31	0.34	15.282
152	SBE-4/10	12.40	12.90	0.50	Grey Phyllite	58.47	6.83	27.44	0.58	2.68	<0.1	0.14	0.06	0.34	0.13	19.192

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Borehole No. SBE-5 24° 33' 47.1" 82° 52' 34.1"																
153	SBE-5/1	3.00	3.50	0.50	Banded Ferruginous Phyllite with chert	51.27	8.84	28.05	0.36	1.84	<0.1	0.41	0.09	0.26	0.11	19.618
154	SBE-5/2	3.50	4.00	0.50	Banded Ferruginous Phyllite with chert	54.14	8.55	26.16	0.35	1.74	<0.1	0.36	0.07	0.3	0.11	18.296
155	SBE-5/3	4.00	4.50	0.50	Banded Ferruginous Phyllite with chert	54	8.09	24.66	0.43	2	<0.1	0.34	0.1	0.27	0.06	17.247
156	SBE-5/4	4.50	5.00	0.50	Banded Ferruginous Phyllite with chert	52.27	8.18	27.51	0.49	2.02	<0.1	0.44	0.14	0.27	0.08	19.24
157	SBE-5/5	5.00	5.50	0.50	Banded Ferruginous Phyllite with chert	53.99	8.76	24.56	0.6	2.09	<0.1	0.88	0.16	0.29	0.1	17.177
158	SBE-5/6	6.50	7.00	0.50	Banded Ferruginous Phyllite with chert	56.29	7.75	26.5	0.48	2.07	<0.1	0.35	0.16	0.25	0.1	18.534
159	SBE-5/7	7.00	7.50	0.50	Banded Ferruginous Phyllite with chert	52.75	7.46	28.12	0.45	1.88	<0.1	0.26	0.23	0.28	0.06	19.667
160	SBE-5/8	7.50	8.00	0.50	Banded Ferruginous Phyllite with chert	53.5	8.45	26.76	0.47	2	<0.1	0.31	0.15	0.32	0.06	18.716
161	SBE-5/9	8.30	9.00	0.70	Banded Ferruginous Phyllite with chert	51.39	9.46	27.71	0.4	1.88	<0.1	1.06	0.26	0.33	0.08	19.38
162	SBE-5/10	9.00	10.00	1.00	Banded Ferruginous Phyllite with chert	51.99	11.24	25.66	0.37	2.18	<0.1	1.35	0.05	0.41	0.06	17.947
163	SBE-5/11	40.80	41.40	0.60	Banded Hematite chert / jasper	52.93	16.4	16.56	0.21	1.23	<0.1	3.59	0.01	0.58	0.07	11.582
164	SBE-5/12	41.90	42.65	0.75	Banded Hematite chert / jasper	56.26	14.3	16.07	0.19	0.84	<0.1	3.49	0.03	0.73	0.11	11.239
165	SBE-5/13	42.65	43.40	0.75	Banded Hematite chert / jasper	48.22	16.65	15.64	0.28	1.09	<0.1	5.4	0.07	2.57	0.32	10.939
166	SBE-5/14	43.40	44.00	0.60	Banded Hematite chert / jasper	62.1	6.53	21.72	1.56	0.94	<0.1	1.54	0.11	0.31	0.11	15.191
167	SBE-5/15	44.05	44.55	0.50	Banded Hematite chert / jasper	47.4	4.86	33.08	1.68	2.53	<0.1	0.99	0.21	0.18	0.14	23.136
168	SBE-5/16	44.55	45.05	0.50	Banded Hematite chert / jasper	50.53	8.17	23.84	0.64	2.44	0.1	2.61	0.15	0.32	0.15	16.674
169	SBE-5/17	45.05	45.55	0.50	Banded Hematite chert / jasper	51.42	12.43	18.1	0.17	0.72	0.1	4.71	0.01	0.94	0.19	12.659
170	SBE-5/18	45.55	46.05	0.50	Banded Hematite chert / jasper	56.06	8.04	26.66	0.17	0.71	<0.1	2.33	0.03	0.3	0.17	18.646
171	SBE-5/19	46.20	46.70	0.50	Banded Hematite chert / jasper	56.65	11.41	18.77	0.14	0.78	<0.1	2.28	0.02	0.3	0.22	13.128
172	SBE-5/20	46.70	47.20	0.50	Banded Hematite chert / jasper	50.33	18.94	13.09	<0.1	0.83	<0.1	4.34	<0.003	0.51	0.1	9.1551

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173	SBE-5/21	47.20	47.85	0.65	Banded Hematite chert / jasper	34.18	6.68	40.51	1.9	2.68	<0.1	0.86	0.66	0.16	0.63	28.333
174	SBE-5/22	47.85	48.50	0.65	Banded Hematite chert / jasper	24.04	6.27	50.85	2.58	4.2	<0.1	<0.1	0.24	0.14	0.7	35.564
175	SBE-5/23	48.50	49.00	0.50	Banded Hematite chert / jasper	50.16	6.78	31.81	0.49	3.04	<0.1	0.11	0.18	0.17	0.32	22.248
176	SBE-5/24	49.00	49.50	0.50	Banded Hematite chert / jasper	35.08	1.58	52.46	0.64	0.61	<0.1	<0.1	0.54	0.02	0.29	36.691
177	SBE-5/25	49.50	50.15	0.65	Banded Hematite chert / jasper	32.03	1.43	62.15	1.47	0.39	<0.1	<0.1	0.09	0.01	0.64	43.468
178	SBE-5/26	50.15	50.65	0.50	Banded Hematite chert / jasper	38.8	1.31	54.05	1.01	0.77	<0.1	<0.1	0.24	0.01	0.38	37.803
179	SBE-5/27	51.00	51.50	0.50	Banded Hematite chert / jasper	30.45	0.76	61.7	1.5	1.1	<0.1	<0.1	0.06	0.01	0.63	43.153
180	SBE-5/28	51.50	52.00	0.50	Banded Hematite chert / jasper	32.95	1.08	62.66	2.09	0.56	0.1	<0.1	0.09	<0.01	0.66	43.824
181	SBE-5/29	52.00	52.45	0.45	Banded Hematite chert / jasper	46	2.16	44.64	0.7	0.4	<0.1	<0.1	0.15	0.06	0.35	31.221
182	SBE-5/30	52.45	53.00	0.55	Banded Hematite chert / jasper	39.89	1.02	50.69	1.82	1.84	<0.1	<0.1	0.11	0.02	0.76	35.453
183	SBE-5/31	53.00	53.55	0.55	Banded Hematite chert / jasper	42.36	1	52.38	1.26	0.53	<0.1	<0.1	0.07	0.03	0.54	36.635
184	SBE-5/32	53.55	54.15	0.60	Banded Hematite chert / jasper	34.12	0.43	62.39	1.71	0.36	<0.1	<0.1	0.06	<0.01	0.71	43.636
185	SBE-5/33	54.15	54.75	0.60	Banded Hematite chert / jasper	39.25	0.93	54.14	0.95	0.58	<0.1	<0.1	0.12	0.01	0.37	37.866
186	SBE-5/34	54.75	55.40	0.65	Banded Hematite chert / jasper	52.24	1.21	41.46	0.13	0.25	<0.1	<0.1	0.11	0.03	0.04	28.997
187	SBE-5/35	55.40	55.90	0.50	Banded Hematite chert / jasper	46.03	1.2	48.39	0.1	0.18	<0.1	<0.1	0.05	0.01	0.03	33.844
188	SBE-5/36	55.90	56.45	0.55	Banded Hematite chert / jasper	47.08	0.43	51.01	0.17	<0.1	<0.1	<0.1	0.01	0.01	0.06	35.676
189	SBE-5/37	56.45	57.05	0.60	Banded Hematite chert / jasper	53.49	0.36	45.09	0.1	<0.1	<0.1	<0.1	0.02	0.01	0.04	31.536
190	SBE-5/38	57.05	57.75	0.70	Banded Hematite chert / jasper	48.01	0.41	49.16	0.13	<0.1	<0.1	<0.1	0.03	0.01	0.05	34.383
191	SBE-5/39	57.75	57.95	0.20	Banded Hematite chert / jasper	43.43	0.25	53.52	0.11	<0.1	<0.1	<0.1	0.01	0.01	0.05	37.432
192	SBE-5/40	58.00	59.00	1.00	Banded Hematite chert / jasper	43.51	0.15	52.81	<0.1	<0.1	<0.1	<0.1	0.01	<0.01	0.04	36.935

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Borehole No. SBE-6 24° 33' 47.3" 82° 52' 45.2"																
193	SBE-6/1	41	41.5	0.50	Ferruginous phyllite	57.95	6.51	28.89	0.47	2.41	0.10	1.11	0.17	0.41	0.20	20.206
194	SBE-6/2	41.5	92.65	51.15	Ferruginous phyllite	56.86	8.31	28.92	0.66	2.99	0.41	0.80	0.08	0.34	0.23	20.227
195	SBE-6/3	92.65	93.1	0.45	Banded hematite chert/jasper	53.71	7.79	33.63	0.46	0.58	0.51	1.66	0.28	0.27	0.32	23.521
196	SBE-6/4	93.1	93.55	0.45	Banded hematite chert/jasper	49.69	1.74	43.91	0.79	0.37	0.12	0.57	0.22	0.07	0.50	30.711
197	SBE-6/5	93.55	94.05	0.50	Banded hematite chert/jasper	30.17	0.66	62.80	1.29	0.93	0.11	0.10	0.50	0.03	0.46	43.922
198	SBE-6/6	94.05	94.55	0.50	Banded hematite chert/jasper	24.14	0.27	71.31	0.91	0.32	0.21	<0.1	0.18	0.04	0.49	49.874
199	SBE-6/7	94.55	95.05	0.50	Banded hematite chert/jasper	31.18	3.05	60.19	1.45	0.50	0.10	0.43	0.13	0.11	0.67	42.097
200	SBE-6/8	95.05	95.55	0.50	Banded hematite chert/jasper	57.16	4.31	31.88	0.38	0.40	0.28	1.30	0.13	0.55	0.27	22.297
201	SBE-6/9	95.55	96.15	0.60	Banded hematite chert/jasper	63.40	2.78	29.79	0.39	0.51	0.32	0.57	0.16	0.06	0.25	20.835
202	SBE-6/10	96.15	96.75	0.60	Banded hematite chert/jasper	35.55	4.40	53.68	0.48	0.45	0.10	1.51	0.29	0.33	0.33	37.544
203	SBE-6/11	96.75	97.35	0.60	Banded hematite chert/jasper	49.22	5.41	40.88	0.21	0.82	0.15	0.68	0.15	0.40	0.12	28.591
204	SBE-6/12	97.35	97.85	0.50	Banded hematite chert/jasper	53.28	9.94	30.37	0.40	1.40	0.12	1.01	0.23	0.38	0.07	21.241
205	SBE-6/13	97.85	98.35	0.50	Banded hematite chert/jasper	63.49	9.74	21.49	0.18	0.47	0.14	0.85	0.47	0.41	0.06	15.03
206	SBE-6/14	98.35	99.35	1.00	Banded hematite chert/jasper	71.86	4.39	18.53	0.17	0.32	0.23	0.46	0.07	0.21	0.07	12.96
207	SBE-6/15	99.35	100.35	1.00	Banded hematite chert/jasper	57.90	5.28	34.72	0.29	0.54	0.15	0.61	0.07	0.21	0.09	24.283
208	SBE-6/16	100.35	101.35	1.00	Banded hematite chert/jasper	58.44	7.10	31.56	0.28	0.61	0.14	0.75	0.03	0.21	0.09	22.073
209	SBE-6/17	101.35	102.1	0.75	Banded hematite chert/jasper	43.29	6.56	45.67	0.11	0.29	0.24	1.67	0.18	0.24	0.12	31.942
210	SBE-6/18	102.1	102.95	0.85	Banded hematite chert/jasper	58.80	0.81	38.82	0.12	0.11	0.16	0.10	0.06	0.02	0.08	27.151
211	SBE-6/19	102.95	103.85	0.90	Banded hematite chert/jasper	61.29	0.67	35.86	0.12	0.17	0.18	0.10	0.33	0.02	0.07	25.08
212	SBE-6/20	103.85	104.35	0.50	Banded hematite chert/jasper	84.59	2.09	10.33	0.10	0.18	0.34	0.12	0.03	0.07	0.10	7.2248
213	SBE-6/21	104.35	104.9	0.55	Banded hematite chert/jasper	44.18	0.39	53.96	0.17	0.10	0.22	0.18	0.02	0.05	0.08	37.74
214	SBE-6/22	104.9	105.45	0.55	Banded hematite chert/jasper	79.52	1.72	16.54	0.21	0.10	0.19	0.13	0.01	0.07	0.05	11.568
215	SBE-6/23	105.45	106.35	0.90	Banded hematite chert/jasper	38.54	0.12	58.35	0.18	<0.1	<0.1	0.10	0.03	0.01	0.04	40.81
216	SBE-6/24	106.35	106.95	0.60	Banded hematite chert/jasper	63.59	0.40	32.82	0.20	<0.1	0.20	0.22	0.03	0.01	0.04	22.954
217	SBE-6/25	106.95	107.55	0.60	Banded hematite chert/jasper	71.65	0.73	24.41	0.20	0.20	0.19	<0.1	0.01	0.01	0.05	17.072
218	SBE-6/26	107.55	108.1	0.55	Banded hematite chert/jasper	59.35	0.42	37.45	0.20	0.10	0.17	0.24	0.02	0.01	0.05	26.193
219	SBE-6/27	108.1	108.65	0.55	Banded hematite chert/jasper	43.44	0.44	55.25	<0.1	0.10	0.10	0.10	0.02	0.02	0.07	38.642
220	SBE-6/28	108.65	109.2	0.55	Banded hematite chert/jasper	38.55	0.39	58.82	<0.1	0.12	0.10	0.12	0.01	0.01	0.11	41.139
221	SBE-6/29	109.2	109.8	0.60	Banded hematite chert/jasper	40.73	0.34	56.71	0.17	0.19	<0.1	0.15	0.02	0.02	0.09	39.663
222	SBE-6/30	109.8	110.25	0.45	Banded hematite chert	40.85	0.31	58.44	0.17	0.20	0.10	0.15	0.02	0.01	0.12	40.873

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223	SBE-6/31	110.25	110.7	0.45	Banded hematite chert	38.36	0.82	57.73	0.23	0.19	0.12	<0.1	<0.003	0.02	0.08	40.376
224	SBE-6/32	110.7	111.15	0.45	Banded hematite chert	44.88	0.60	55.80	<0.1	<0.1	0.17	<0.1	0.01	0.02	0.17	39.027
225	SBE-6/33	111.15	111.65	0.50	Banded hematite chert	50.23	0.49	48.63	<0.1	<0.1	0.20	<0.1	0.01	0.01	0.18	34.012
226	SBE-6/34	111.65	112.15	0.50	Banded hematite chert	55.72	0.40	44.05	0.20	<0.1	<0.1	<0.1	0.01	0.02	0.16	30.809
227	SBE-6/35	112.15	112.65	0.50	Banded hematite chert	45.05	0.38	53.21	0.19	<0.1	0.11	0.10	0.01	0.02	0.11	37.215
228	SBE-6/36	112.65	113.15	0.50	Banded hematite chert	40.24	0.19	55.87	0.19	<0.1	0.19	0.12	<0.003	0.02	0.07	39.075
229	SBE-6/37	113.15	113.65	0.50	Banded hematite chert	39.61	0.48	57.51	0.20	0.24	<0.1	0.12	0.01	0.04	0.10	40.222
230	SBE-6/38	113.65	114.05	0.40	Banded hematite chert	45.32	0.40	52.69	0.15	0.10	0.23	<0.1	0.02	0.01	0.13	36.851
231	SBE-6/39	114.05	114.5	0.45	Banded hematite chert	34.81	0.12	64.12	0.15	0.12	0.20	<0.1	0.03	0.01	0.13	44.846
232	SBE-6/40	114.5	115.2	0.70	Banded hematite chert	35.03	0.86	62.32	<0.1	0.18	0.19	<0.1	0.01	0.04	0.16	43.587
233	SBE-6/41	115.2	115.9	0.70	Banded hematite chert	70.14	0.73	25.39	<0.1	0.15	0.10	<0.1	<0.003	0.02	0.13	17.758
234	SBE-6/42	115.9	116.6	0.70	Banded hematite chert	90.78	0.42	7.34	<0.1	0.22	0.29	0.11	<0.003	0.01	0.09	5.1336
235	SBE-6/43	116.6	117.3	0.70	Banded hematite chert	86.98	0.57	8.95	<0.1	0.20	0.24	0.15	0.01	0.01	0.05	6.2596
236	SBE-6/44	117.3	117.75	0.45	Banded hematite chert	58.26	0.49	40.80	0.29	0.19	0.15	0.11	<0.003	0.03	0.08	28.536
237	SBE-6/45	117.75	118.2	0.45	Banded hematite chert	58.08	0.82	38.68	0.23	0.22	0.23	0.12	<0.003	0.02	0.08	27.053
238	SBE-6/46	118.2	118.65	0.45	Banded hematite chert	52.97	0.61	44.61	0.36	0.10	<0.1	0.20	<0.003	0.02	0.12	31.2
239	SBE-6/47	118.65	119.1	0.45	Banded hematite chert/jasper	50.48	0.68	45.32	0.15	0.29	0.18	0.10	<0.003	0.03	0.11	31.697
240	SBE-6/48	119.1	119.55	0.45	Banded hematite chert/jasper	32.24	0.37	64.68	0.10	0.23	0.23	<0.1	0.01	0.02	0.15	45.237
241	SBE-6/49	119.55	120	0.45	Banded hematite chert/jasper	52.17	0.58	47.93	0.10	0.19	<0.1	0.10	0.01	0.03	0.12	33.522
242	SBE-6/50	120	120.6	0.60	Banded hematite chert/jasper	61.43	1.05	35.13	0.10	0.19	0.10	0.10	<0.003	0.03	0.10	24.57
243	SBE-6/51	120.6	121.1	0.50	Banded hematite chert/jasper	58.82	0.37	38.13	0.10	<0.1	<0.1	0.10	0.01	0.02	0.15	26.668
244	SBE-6/52	121.1	121.6	0.50	Banded hematite chert/jasper	50.08	0.93	48.38	0.19	<0.1	0.20	0.10	<0.003	0.03	0.09	33.837
245	SBE-6/53	121.6	122.15	0.55	Banded hematite chert	42.92	0.48	54.15	0.15	<0.1	<0.1	0.22	0.03	0.02	0.05	37.873
246	SBE-6/54	122.15	122.65	0.50	Banded hematite chert	45.24	1.12	52.15	0.14	<0.1	<0.1	0.19	0.02	0.04	0.11	36.474
247	SBE-6/55	122.65	123.1	0.45	Banded hematite chert	62.83	0.58	35.08	0.10	0.23	<0.1	0.19	<0.003	0.02	0.07	24.535
248	SBE-6/56	123.1	123.55	0.45	Banded hematite chert	40.17	0.26	57.88	0.20	0.10	0.23	0.15	0.01	0.01	0.13	40.481
249	SBE-6/57	123.55	124.15	0.60	Banded hematite chert	37.32	0.22	58.63	0.19	0.23	0.10	0.10	0.01	0.01	0.05	41.006
250	SBE-6/58	124.15	124.65	0.50	Banded hematite chert	36.64	0.38	64.47	0.19	0.17	0.10	<0.1	0.01	0.01	0.06	45.09
251	SBE-6/59	124.65	125.15	0.50	Banded hematite chert	41.65	0.52	59.17	0.15	0.20	0.10	0.13	0.01	0.02	0.08	41.383
252	SBE-6/60	125.15	125.65	0.50	Banded hematite chert/jasper	31.26	0.58	67.37	<0.1	<0.1	<0.1	0.19	0.01	0.03	0.10	47.119

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
253	SBE-6/61	125.65	126.15	0.50	Banded hematite chert/jasper	74.24	0.32	24.76	<0.1	0.19	0.23	0.20	<0.003	0.01	0.10	17.317
254	SBE-6/62	126.15	126.7	0.55	Banded hematite chert/jasper	58.83	0.63	36.79	<0.1	0.19	<0.1	0.20	<0.003	0.02	0.09	25.731
255	SBE-6/63	126.7	127.1	0.40	Banded hematite chert/jasper	74.09	0.93	22.53	0.24	0.25	0.29	0.20	<0.003	0.03	0.06	15.757
256	SBE-6/64	127.1	127.55	0.45	Banded hematite chert/jasper	75.07	1.00	19.80	0.19	0.17	0.20	0.11	0.01	0.05	0.15	13.848
257	SBE-6/65	127.55	128.1	0.55	Banded hematite chert/jasper	78.55	0.79	18.40	0.10	0.22	0.17	0.19	<0.003	0.03	0.07	12.869
258	SBE-6/66	128.1	128.65	0.55	Banded hematite chert/jasper	73.65	1.17	21.00	<0.1	0.17	0.15	0.25	<0.003	0.03	0.07	14.687
259	SBE-6/67	128.65	129.2	0.55	Banded hematite chert/jasper	54.55	0.60	42.54	0.10	0.17	0.10	0.15	0.01	0.02	0.19	29.752
260	SBE-6/68	129.2	130.1	0.90	Banded hematite chert/jasper	60.30	0.72	39.11	0.11	<0.1	<0.1	0.21	<0.003	0.03	0.04	27.354
261	SBE-6/69	130.1	133.65	3.55	Banded hematite chert/jasper	84.66	1.23	10.35	0.10	<0.1	<0.1	0.10	<0.003	0.04	0.05	7.2388
262	SBE-6/70	133.65	134.4	0.75	Banded hematite chert/jasper	70.01	6.34	19.10	0.19	0.23	0.10	0.11	0.02	0.19	0.05	13.359
263	SBE-6/71	134.4	135	0.60	Banded hematite chert/jasper	77.30	2.06	17.10	0.21	0.19	<0.1	0.25	0.03	0.07	0.04	11.96
264	SBE-6/72	135	135.6	0.60	Banded hematite chert/jasper	53.17	2.38	41.60	<0.1	0.16	<0.1	0.13	0.06	0.09	0.03	29.095
265	SBE-6/73	135.6	136.2	0.60	Banded hematite chert/jasper	59.88	2.38	36.61	<0.1	0.10	<0.1	0.44	0.03	0.08	0.07	25.605
266	SBE-6/74	136.2	136.8	0.60	Banded hematite chert/jasper	60.52	2.31	35.03	<0.1	0.11	<0.1	0.11	0.03	0.08	0.03	24.5
267	SBE-6/75	136.8	137.3	0.50	Banded hematite chert/jasper	55.01	1.59	39.49	<0.1	0.12	<0.1	0.29	0.05	0.07	0.02	27.619
268	SBE-6/76	137.3	137.8	0.50	Banded hematite chert/jasper	56.18	2.01	39.86	0.10	0.19	0.15	0.19	0.03	0.08	0.12	27.878
269	SBE-6/77	137.8	138.3	0.50	Banded hematite chert/jasper	71.98	1.44	22.56	0.20	0.19	0.20	0.15	0.01	0.05	0.03	15.778
270	SBE-6/78	138.3	138.8	0.50	Banded hematite chert/jasper	54.68	2.12	42.27	0.20	0.19	0.17	0.22	0.05	0.07	0.05	29.564
271	SBE-6/79	138.8	139.3	0.50	Banded hematite chert/jasper	74.02	1.79	20.13	<0.1	0.17	<0.1	0.14	0.06	0.06	0.04	14.079
272	SBE-6/80	139.3	139.8	0.50	Banded hematite chert/jasper	56.59	3.38	36.17	<0.1	0.13	<0.1	<0.1	0.10	0.12	0.03	25.297
273	SBE-6/81	139.8	140.3	0.50	Banded hematite chert/jasper	52.17	4.33	40.30	0.10	0.11	<0.1	0.10	0.10	0.14	0.04	28.186
274	SBE-6/82	140.3	140.7	0.40	Banded hematite chert/jasper	56.63	5.45	34.78	0.25	0.26	0.17	0.19	0.15	0.27	0.05	24.325
275	SBE-6/83	140.7	141.1	0.40	Banded hematite chert/jasper	65.75	4.03	26.53	0.15	0.31	<0.1	0.10	0.02	0.16	0.05	18.555
276	SBE-6/84	141.1	141.5	0.40	Banded hematite chert/jasper	56.16	3.68	36.83	0.10	0.12	<0.1	0.33	0.04	0.13	0.04	25.759
277	SBE-6/85	141.5	142.1	0.60	Banded hematite chert/jasper	58.35	3.17	36.40	0.14	0.13	0.20	<0.1	0.05	0.16	0.05	25.458
278	SBE-6/86	142.1	142.7	0.60	Banded hematite chert/jasper	63.93	4.87	28.18	0.11	0.15	0.10	<0.1	0.09	0.17	0.07	19.709
279	SBE-6/87	142.7	143.3	0.60	Banded hematite chert/jasper	60.04	6.96	30.07	0.18	0.10	0.10	<0.1	0.42	0.29	0.07	21.031
280	SBE-6/88	143.3	143.8	0.50	Banded hematite chert/jasper	74.70	2.83	18.81	0.10	0.17	<0.1	<0.1	0.10	0.11	0.10	13.156
281	SBE-6/89	143.8	144.3	0.50	Banded hematite chert/jasper	52.57	2.53	42.97	0.10	0.20	0.14	0.22	0.12	0.08	0.06	30.053
282	SBE-6/90	144.3	145	0.70	Banded hematite chert/jasper	44.32	1.83	48.79	0.10	0.20	<0.1	0.10	0.21	0.06	0.06	34.124

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283	SBE-6/91	145	145.55	0.55	Banded hematite chert/jasper	39.50	0.95	57.88	0.31	0.14	0.21	0.15	0.26	0.03	0.28	40.481
284	SBE-6/92	145.55	146.1	0.55	Banded hematite chert/jasper	52.32	1.18	41.79	0.81	0.18	0.10	0.18	0.13	0.04	0.54	29.228
285	SBE-6/93	146.1	146.55	0.45	Banded hematite chert/jasper	56.04	2.91	39.52	0.11	0.17	0.11	0.10	0.09	0.07	0.09	27.64
286	SBE-6/94	146.55	147.3	0.75	Banded hematite chert/jasper	37.70	2.58	59.89	0.11	0.18	0.24	0.10	0.08	0.05	0.09	41.887
287	SBE-6/95	147.3	147.7	0.40	Banded hematite chert/jasper	37.61	1.78	60.79	0.15	0.16	<0.1	0.24	0.28	0.06	0.10	42.517
288	SBE-6/96	147.7	148.15	0.45	Banded hematite chert/jasper	41.73	1.59	53.05	0.37	0.21	0.20	0.28	0.06	0.04	0.29	37.103
289	SBE-6/97	148.15	148.75	0.60	Banded hematite chert/jasper	42.43	2.57	56.51	0.13	0.10	<0.1	<0.1	0.06	0.05	0.07	39.523
290	SBE-6/98	148.75	149.15	0.40	Banded hematite chert/jasper	38.84	0.21	59.88	0.15	0.18	<0.1	0.15	0.08	0.01	0.07	41.88
291	SBE-6/99	149.15	149.55	0.40	Banded hematite chert/jasper	32.48	1.09	60.19	1.26	0.28	<0.1	0.24	0.12	0.02	0.78	42.097
292	SBE-6/100	149.55	150.05	0.50	Banded hematite chert/jasper	31.81	2.44	62.91	0.33	0.10	0.20	0.17	0.12	0.05	0.21	43.999
293	SBE-6/101	150.05	150.55	0.50	Banded hematite chert/jasper	36.35	0.69	60.32	0.11	0.20	0.10	<0.1	0.22	0.02	0.09	42.188
294	SBE-6/102	150.55	151.1	0.55	Banded hematite chert/jasper	38.05	0.81	58.13	0.24	0.10	<0.1	<0.1	0.01	0.03	0.05	40.656
295	SBE-6/103	151.1	151.65	0.55	Banded hematite chert/jasper	40.19	1.92	55.12	0.21	0.29	<0.1	0.19	0.05	0.15	0.08	38.551
296	SBE-6/104	151.65	152.2	0.55	Banded hematite chert/jasper	43.75	1.80	52.47	0.16	0.27	<0.1	<0.1	0.15	0.20	0.09	36.698
297	SBE-6/105	152.2	152.75	0.55	Banded hematite chert/jasper	40.51	1.13	58.94	0.19	0.13	0.20	0.10	0.07	0.03	0.06	41.223
298	SBE-6/106	152.75	153.25	0.50	Banded hematite chert/jasper	36.44	0.98	61.64	0.21	0.10	<0.1	0.20	0.05	0.03	0.07	43.111
299	SBE-6/107	153.25	153.75	0.50	Banded hematite jasper with phyllite	51.59	8.35	29.89	0.40	8.53	<0.1	0.15	0.04	0.14	0.19	20.905
300	SBE-6/108	153.75	154.25	0.50	Banded hematite chert/jasper	47.84	1.43	50.32	0.26	0.16	0.12	0.17	0.15	0.04	0.19	35.194
301	SBE-6/109	154.25	154.75	0.50	Banded hematite chert/jasper	54.05	1.26	42.63	0.25	0.16	<0.1	0.26	0.06	0.04	0.21	29.815
302	SBE-6/110	154.75	155.25	0.50	Banded hematite chert/jasper	52.53	1.56	40.19	0.49	0.79	<0.1	0.11	0.17	0.05	0.19	28.109
303	SBE-6/111	155.25	155.75	0.50	Banded hematite chert/jasper	50.37	1.63	46.47	0.92	0.43	0.10	0.12	0.30	0.12	0.58	32.501
304	SBE-6/112	155.75	156.25	0.50	Banded hematite chert/jasper	52.14	0.97	43.73	0.67	0.37	0.29	0.11	0.15	0.02	0.47	30.585
305	SBE-6/113	156.25	156.75	0.50	Banded hematite chert/jasper	51.92	1.37	41.55	0.96	0.43	0.10	0.27	0.15	0.04	0.68	29.06
306	SBE-6/114	156.75	157.25	0.50	Banded hematite chert/jasper	55.12	1.27	39.56	0.48	0.15	<0.1	0.10	0.27	0.05	0.36	27.668
307	SBE-6/115	157.25	157.7	0.45	Banded hematite chert/jasper	39.89	0.84	58.30	0.86	0.14	0.17	0.10	0.12	0.02	0.56	40.775
308	SBE-6/116	157.7	158.1	0.40	Banded hematite chert/jasper	39.87	0.54	56.61	0.89	0.13	0.27	0.19	0.11	0.02	0.60	39.593
309	SBE-6/117	158.1	158.75	0.65	Banded hematite chert/jasper	35.92	0.67	61.36	1.03	0.25	0.18	0.19	0.14	0.02	0.67	42.915
310	SBE-6/118	158.75	159.4	0.65	Banded hematite jasper/phyllite	40.73	1.13	54.06	1.33	0.31	0.11	0.10	0.21	0.02	0.83	37.81
311	SBE-6/119	159.4	160.05	0.65	Banded hematite jasper/phyllite	45.01	1.35	50.72	0.81	0.44	0.17	0.20	0.15	0.04	0.51	35.474

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Borehole No. SBE-7 24° 33' 51.4" 82° 53' 3.4"																
312	SBE-7/1	48.8	49.3	0.50	Banded hematite chert	43.69	5.27	46.90	0.14	0.14	0.24	0.49	0.02	0.27	0.21	32.802
313	SBE-7/2	49.3	49.8	0.50	Banded hematite chert with tuff	41.46	14.68	40.27	0.16	0.22	<0.1	0.52	0.01	0.22	0.23	28.165
314	SBE-7/3	49.8	50.3	0.50	Banded hematite chert with tuff	64.81	11.42	19.96	0.23	0.66	<0.1	0.90	<0.003	0.61	0.30	13.96
315	SBE-7/4	50.3	50.8	0.50	Banded hematite chert with tuff	68.24	8.94	17.53	0.13	0.15	<0.1	0.50	<0.003	0.47	0.22	12.26
316	SBE-7/5	50.8	51.2	0.40	Banded hematite chert with tuff	66.35	13.62	17.28	0.12	0.13	0.15	0.38	<0.003	0.34	0.14	12.086
317	SBE-7/6	51.2	51.7	0.50	Banded hematite chert with tuff	50.63	10.34	35.44	0.15	0.26	0.1	1.15	<0.003	0.31	0.11	24.787
318	SBE-7/7	51.7	52.1	0.40	Banded hematite chert	69.19	5.00	22.63	0.10	0.16	0.11	0.67	<0.003	0.16	0.11	15.827
319	SBE-7/8	52.1	52.5	0.40	Banded hematite chert	44.61	4.32	47.11	0.12	0.22	0.18	0.76	0.01	0.15	0.12	32.949
320	SBE-7/9	52.5	52.9	0.40	Banded hematite chert	53.04	3.84	37.99	0.10	0.25	<0.1	0.80	0.01	0.11	0.18	26.57
321	SBE-7/10	52.9	53.3	0.40	Banded hematite chert	56.73	4.48	34.94	<0.1	0.18	0.2	0.89	<0.003	0.17	0.14	24.437
322	SBE-7/11	53.3	53.8	0.50	Banded hematite chert with tuff	50.13	10.25	33.13	0.11	0.37	<0.1	2.24	<0.003	0.30	0.17	23.171
323	SBE-7/12	53.8	54.3	0.50	Banded hematite chert (chert dominant)	77.72	2.71	15.10	<0.1	0.10	<0.1	0.58	<0.003	0.08	0.13	10.561
324	SBE-7/13	54.3	54.8	0.50	Banded hematite chert with tuff	71.69	10.01	14.63	<0.1	0.33	0.2	2.43	<0.003	0.25	0.09	10.232
325	SBE-7/14	54.8	55.4	0.60	Banded hematite chert (chert dominant)	54.11	3.75	37.46	<0.1	0.16	<0.1	0.71	0.01	0.09	0.16	26.2
326	SBE-7/15	55.4	55.8	0.40	Banded hematite chert with tuff	42.47	7.10	45.02	<0.1	0.27	0.1	1.81	0.03	0.28	0.29	31.487
327	SBE-7/16M	55.80	56.20	0.40	Banded hematite chert with tuff	44.58	10.02	38.27	0.15	0.47	0.14	1.25	0.08	0.32	0.15	26.766
328	SBE-7/17M	56.20	57.30	1.10	Banded hematite chert/jasper	50.02	2.57	39.3	0.13	0.2	0.12	0.36	0.08	0.05	0.28	27.486
329	SBE-7/18M	57.30	58.30	1.00	Banded hematite chert/jasper	59.24	2.82	34.1	0.12	0.17	0.12	0.216	0.09	0.09	0.23	23.85
330	SBE-7/19M	58.30	59.10	0.80	Banded hematite chert/jasper	64.01	1.35	31.18	0.11	0.12	0.1	<0.1	0.08	0.02	0.24	21.807
331	SBE-7/20M	59.10	60.00	0.90	Banded hematite chert/jasper	71.67	0.71	23.34	0.1	0.12	0.11	0.12	0.09	0.02	0.24	16.324
332	SBE-7/21M	60.00	60.80	0.80	Banded hematite chert/jasper	41.49	0.32	53.8	0.1	0.11	0.1	<0.1	0.1	0.01	0.28	37.628
333	SBE-7/22M	60.80	61.80	1.00	Banded hematite chert/jasper	54.16	0.86	41.43	0.11	0.12	0.1	0.1	0.1	0.03	0.31	28.976
334	SBE-7/23M	61.80	62.80	1.00	Banded hematite chert/jasper	56.07	0.25	39.13	0.11	0.1	0.17	0.5	0.1	0.01	0.31	27.368
335	SBE-7/24M	62.80	63.80	1.00	Banded hematite chert/jasper	58.52	0.55	37.44	0.27	0.1	0.1	0.54	0.1	0.01	0.23	26.186
336	SBE-7/25M	63.80	64.50	0.70	Banded hematite chert/jasper	44.42	0.34	51.06	0.68	0.12	<0.1	0.41	0.09	0.01	0.18	35.711
337	SBE-7/26M	64.50	65.50	1.00	Banded hematite chert/jasper	43.56	0.52	51.81	<0.1	0.14	0.1	0.33	0.1	0.02	0.3	36.236
338	SBE-7/27M	65.50	66.60	1.10	Banded hematite chert/jasper	44.91	0.36	51.09	0.12	0.17	0.1	0.11	0.1	0.01	0.33	35.732
339	SBE-7/28M	66.60	67.60	1.00	Banded hematite chert/jasper	43.52	0.29	50.27	0.69	0.12	<0.1	0.24	0.1	0.02	0.2	35.159
340	SBE-7/29M	67.60	68.40	0.80	Banded hematite chert/jasper	40.63	0.39	54.9	<0.1	0.11	0.11	0.18	0.12	0.01	0.23	38.397
341	SBE-7/30M	68.40	69.50	1.10	Banded hematite chert/jasper	41.5	0.35	52.27	<0.1	0.1	0.11	0.14	0.12	0.01	0.19	36.558
342	SBE-7/31M	69.50	70.40	0.90	Banded hematite chert/jasper	37.88	0.28	58.4	<0.1	0.1	0.1	<0.1	0.11	0.17	0.14	40.845
343	SBE-7/32M	70.40	71.25	0.85	Banded hematite chert/jasper	45.11	0.78	47.86	0.7	0.19	0.11	0.12	0.11	0.02	0.29	33.473
344	SBE-7/33M	71.25	72.10	0.85	Banded hematite chert/jasper	42.99	1.36	48.81	0.11	0.12	0.1	0.15	0.1	0.04	0.33	34.138
345	SBE-7/34M	72.10	73.30	1.20	Banded hematite chert/jasper	44.96	2.78	46.47	0.13	<0.1	0.1	0.17	0.09	0.09	0.31	32.501

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
346	SBE-7/35M	73.30	74.50	1.20	Banded hematite chert/jasper	45.43	0.64	49.72	<0.1	0.1	0.1	0.14	0.1	0.01	0.24	34.774
347	SBE-7/36M	74.50	75.45	0.95	Banded hematite chert/jasper	45.98	0.57	49.65	0.1	0.16	0.11	0.11	0.09	0.01	0.23	34.725
348	SBE-7/37M	75.45	76.40	0.95	Banded hematite chert/jasper	46.5	1.7	46.59	<0.1	0.11	0.1	0.12	0.09	0.04	0.28	32.585
349	SBE-7/38M	76.40	77.00	0.60	Banded hematite chert/jasper	58.64	0.75	35.5	0.12	<0.1	0.1	0.1	0.09	0.02	0.38	24.829
350	SBE-7/39M	77.00	78.10	1.10	Banded hematite chert/jasper	38.8	0.64	53.62	<0.1	0.11	0.1	0.13	0.1	0.01	0.29	37.502
351	SBE-7/40M	78.10	79.10	1.00	Banded hematite chert/jasper	36.81	0.94	57.97	0.1	0.11	0.1	0.5	0.1	0.02	0.32	40.544
352	SBE-7/41M	79.10	80.05	0.95	Banded hematite chert/jasper	42.01	0.76	54.28	<0.1	0.11	0.10	0.12	0.10	0.01	0.26	37.963
353	SBE-7/42M	80.05	81.00	0.95	Banded hematite chert/jasper	34.21	0.50	62.21	<0.1	0.11	0.10	0.17	0.09	0.01	0.13	43.51
354	SBE-7/43M	81.00	82.00	1.00	Banded hematite chert/jasper	38.66	0.87	59.54	0.11	0.15	0.11	0.12	0.10	0.01	0.12	41.642
355	SBE-7/44M	82.00	83.20	1.20	Banded hematite chert/jasper	45.31	0.57	53.11	0.11	0.10	0.11	0.10	0.09	0.01	0.20	37.145
356	SBE-7/45M	83.20	84.20	1.00	Banded hematite chert/jasper	44.80	2.07	47.57	0.10	0.10	0.10	0.17	0.09	0.05	0.30	33.27
357	SBE-7/46M	84.20	85.40	1.20	Banded hematite chert/jasper	44.45	1.72	49.71	0.10	0.16	0.10	<0.1	0.10	0.04	0.28	34.767
358	SBE-7/47M	85.40	86.50	1.10	Banded hematite chert/jasper	36.38	2.23	54.28	0.11	0.17	0.10	<0.1	0.09	0.03	0.34	37.963
359	SBE-7/48M	86.50	87.80	1.30	Banded hematite chert/jasper	44.37	2.11	50.50	0.15	0.10	0.10	<0.1	0.10	0.04	0.17	35.32
360	SBE-7/49M	87.80	88.80	1.00	Banded hematite chert/jasper	32.05	3.43	59.82	0.18	0.15	0.10	0.10	0.11	0.08	0.24	41.838
361	SBE-7/50M	88.80	89.85	1.05	Banded hematite chert/jasper	36.89	4.21	53.54	0.20	0.11	0.12	0.10	0.09	0.12	0.20	37.446
362	SBE-7/51M	89.85	90.80	0.95	Banded hematite chert/jasper	54.81	4.09	37.82	0.17	<0.1	0.10	<0.1	0.08	0.12	0.15	26.451
363	SBE-7/52M	90.80	92.00	1.20	Oxidised banded hematite chert	46.60	7.20	41.90	0.16	<0.1	0.10	0.11	0.08	0.20	0.22	29.305
364	SBE-7/53M	92.00	93.00	1.00	Oxidised banded hematite chert	42.38	3.17	49.33	0.15	<0.1	0.10	0.11	0.08	0.07	0.28	34.501
365	SBE-7/54M	93.00	94.00	1.00	Banded hematite chert (chert dominant)	71.71	1.63	24.57	<0.1	<0.1	0.10	<0.1	0.07	0.05	0.14	17.184
366	SBE-7/55M	94.00	95.00	1.00	Banded hematite chert (chert dominant)	61.55	1.93	32.73	0.12	<0.1	0.10	<0.1	0.07	0.05	0.16	22.891
367	SBE-7/56M	95.00	96.00	1.00	Limonitized banded hematite chert	35.37	2.07	55.83	0.11	<0.1	0.12	0.11	0.09	0.05	0.48	39.048
368	SBE-7/57M	96.00	97.10	1.10	Limonitized banded hematite chert	48.93	1.41	45.28	<0.1	<0.1	0.10	0.17	0.09	0.03	0.39	31.669
369	SBE-7/58M	97.10	98.00	0.90	Banded hematite chert (chert dominant)	54.41	1.63	38.36	<0.1	<0.1	0.10	0.13	0.08	0.04	0.19	26.829
370	SBE-7/59M	98.00	99.00	1.00	Banded hematite chert (chert dominant)	62.34	1.68	31.50	<0.1	0.12	0.10	0.12	0.08	0.05	0.18	22.031
371	SBE-7/60M	99.00	99.60	0.60	Banded hematite chert	55.08	1.61	37.40	0.10	0.12	0.10	0.17	0.08	0.05	0.22	26.158
372	SBE-7/61M	99.60	100.60	1.00	Limonitised banded hematite chert	61.73	0.99	34.43	0.11	0.12	<0.1	0.16	0.08	0.02	0.12	24.08
373	SBE-7/62M	100.60	101.60	1.00	Limonitised banded hematite chert	52.13	0.94	42.88	0.12	0.10	0.10	<0.1	0.08	0.02	0.25	29.99
374	SBE-7/63M	101.60	102.60	1.00	Banded hematite jasper	48.09	0.59	48.80	0.12	<0.1	0.10	<0.1	0.09	0.01	0.13	34.131
375	SBE-7/64M	102.60	103.60	1.00	Banded hematite jasper	45.93	1.72	48.75	0.10	<0.1	0.10	0.10	0.09	0.02	0.16	34.096
376	SBE-7/65M	103.60	104.60	1.00	Limonitised banded hematite jasper	82.37	0.81	13.14	0.11	<0.1	0.12	0.40	0.12	0.03	0.07	9.1901
377	SBE-7/66M	104.60	105.60	1.00	Banded hematite chert/jasper	62.68	1.14	32.36	0.15	<0.1	0.10	0.17	0.08	0.03	0.14	22.633
378	SBE-7/67M	105.60	106.60	1.00	Banded hematite chert/jasper	48.48	0.79	48.53	0.24	<0.1	0.10	0.10	0.09	0.02	0.15	33.942
379	SBE-7/68M	106.60	107.60	1.00	Banded hematite chert/jasper	42.40	0.65	54.53	0.17	0.15	0.10	<0.1	0.09	0.01	0.14	38.138

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
380	SBE-7/69M	107.60	108.60	1.00	Banded hematite chert/jasper	62.38	0.98	32.71	<0.1	0.15	0.10	<0.1	0.08	0.02	0.16	22.877
381	SBE-7/70M	108.60	109.60	1.00	Banded hematite chert/jasper	56.11	1.27	40.64	<0.1	<0.1	0.10	<0.1	0.09	0.02	0.17	28.424
382	SBE-7/71M	109.60	110.60	1.00	Banded hematite chert/jasper	47.01	1.14	49.34	0.17	0.40	0.10	<0.1	0.10	0.02	0.22	34.508
383	SBE-7/72M	110.60	111.60	1.00	Banded hematite chert/jasper	62.16	2.85	26.88	0.12	0.10	0.10	0.11	0.09	0.72	0.21	18.8
384	SBE-7/73M	111.60	112.60	1.00	Banded hematite chert/jasper	48.62	0.59	50.03	0.15	<0.1	0.10	<0.1	0.10	0.01	0.15	34.991
385	SBE-7/74M	112.60	113.60	1.00	Banded hematite chert/jasper	47.85	1.20	48.09	0.29	0.28	0.14	0.16	0.10	0.05	0.23	33.634
386	SBE-7/75M	113.60	114.60	1.00	Banded hematite chert/jasper	47.85	1.15	49.19	0.12	0.12	0.11	0.12	0.10	0.03	0.18	34.403
387	SBE-7/76M	114.60	115.60	1.00	Banded hematite chert/jasper	46.10	2.03	48.70	0.22	0.19	0.13	0.16	0.10	0.06	0.25	34.061
388	SBE-7/77M	115.60	116.60	1.00	Banded hematite chert/jasper	50.05	1.88	44.53	0.12	0.11	0.10	0.17	0.10	0.05	0.18	31.144
389	SBE-7/78M	116.60	117.60	1.00	Banded hematite chert (chert dominant)	84.66	1.48	10.32	0.12	0.10	0.10	0.12	0.07	0.05	0.08	7.2178
390	SBE-7/79M	117.60	118.60	1.00	Banded hematite chert (chert dominant)	78.35	2.17	15.82	0.11	<0.1	0.10	0.11	0.08	0.07	0.09	11.065
391	SBE-7/80M	118.60	119.60	1.00	Banded hematite chert (chert dominant)	71.76	0.86	23.62	0.17	<0.1	0.10	0.10	0.08	0.02	0.15	16.52
392	SBE-7/81M	119.60	120.60	1.00	Banded hematite chert	60.03	1.20	34.01	0.23	0.25	0.13	0.17	0.09	0.05	0.15	23.787
393	SBE-7/82M	120.60	121.60	1.00	Banded hematite chert	72.76	2.30	16.51	0.14	0.10	0.10	0.11	0.08	0.07	0.08	11.547
394	SBE-7/83M	121.60	122.60	1.00	Banded hematite chert	47.36	0.68	49.24	<0.1	<0.1	0.10	<0.1	0.08	0.01	0.13	34.438
395	SBE-7/84M	122.60	123.60	1.00	Banded hematite chert	70.97	1.63	23.94	<0.1	<0.1	0.10	<0.1	0.09	0.06	0.12	16.744
396	SBE-7/85M	123.60	124.60	1.00	Banded hematite chert	51.82	1.87	40.59	0.12	0.10	0.10	0.11	0.08	0.05	0.14	28.389
397	SBE-7/86M	124.60	125.60	1.00	Banded hematite chert	48.26	0.79	49.86	0.11	0.14	0.10	<0.1	0.09	0.01	0.15	34.872
398	SBE-7/87M	125.60	126.60	1.00	Banded hematite chert	77.18	2.40	17.06	0.16	0.14	0.12	0.11	0.08	0.10	0.09	11.932
399	SBE-7/88M	126.60	127.60	1.00	Banded hematite chert	78.21	0.71	16.80	0.10	<0.1	0.10	0.11	0.08	0.02	0.13	11.75
400	SBE-7/89M	127.60	128.60	1.00	Banded hematite chert	70.65	1.36	25.63	0.18	0.12	0.11	0.11	0.08	0.06	0.10	17.926
401	SBE-7/90M	128.60	129.60	1.00	Banded hematite chert (chert dominant)	43.36	1.89	48.94	0.35	0.31	0.15	0.16	0.12	0.08	0.24	34.229
402	SBE-7/91M	129.60	130.60	1.00	Banded hematite chert	75.75	2.86	17.32	<0.1	<0.1	0.10	<0.1	0.07	0.07	0.15	12.114
403	SBE-7/92M	130.60	131.60	1.00	Banded hematite chert + chert nodules	82.09	0.54	16.55	<0.14	<0.11	0.10	<0.1	0.07	0.01	0.10	11.575
404	SBE-7/93M	131.60	132.60	1.00	Banded hematite chert	40.97	1.01	55.10	0.27	0.26	0.12	0.17	0.10	0.03	0.24	38.537
405	SBE-7/94M	132.60	133.60	1.00	Banded hematite chert (chert dominant)	54.05	0.99	42.57	<0.1	<0.1	0.10	0.12	0.10	0.02	0.19	29.773
406	SBE-7/95M	133.60	134.00	0.40	Limonitised Banded hematite chert	67.62	2.76	25.60	0.12	0.14	0.10	0.18	0.08	0.06	0.17	17.905

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Borehole No. SBE-8 24° 33' 46.9" 82° 52' 28.1"																
407	SBE-8/1M	43.25	44.45	1.20	Silicified banded hematite chert	63.80	1.64	27.73	0.10	0.29	0.11	0.38	0.19	0.05	0.05	19.394
408	SBE-8/2M	44.45	45.55	1.10	Silicified banded hematite chert	79.98	2.16	12.77	0.12	0.32	0.17	1.05	0.14	0.05	0.05	8.9313
409	SBE-8/3M	45.55	46.55	1.00	Banded hematite chert	50.43	0.50	43.75	0.11	<0.1	0.10	<0.1	0.09	0.01	0.26	30.599
410	SBE-8/4M	46.55	47.5	0.95	Banded hematite chert	76.67	2.25	16.95	<0.1	0.15	0.11	0.16	0.12	0.05	0.07	11.855
411	SBE-8/5M	47.5	48.6	1.10	Silicified banded hematite chert	52.46	6.11	35.08	0.15	0.24	0.12	0.17	0.33	0.13	0.10	24.535
412	SBE-8/6M	48.6	49.7	1.10	Silicified banded hematite chert	60.17	5.05	27.45	0.17	0.10	0.11	0.11	0.09	0.15	0.07	19.199
413	SBE-8/7M	49.7	50.4	0.70	Silicified banded hematite chert	70.72	2.23	22.96	0.14	<0.1	0.11	0.17	0.39	0.04	0.04	16.058
414	SBE-8/8M	50.4	51.45	1.05	Silicified banded hematite chert	49.33	1.92	42.41	0.12	0.24	0.11	0.10	0.38	0.05	0.03	29.662
415	SBE-8/9M	51.45	52.5	1.05	Banded hematite chert	50.24	2.05	39.57	0.10	0.43	0.11	0.14	0.30	0.05	0.04	27.675
416	SBE-8/10M	52.5	53.3	0.80	Banded hematite chert/jasper	57.27	1.65	36.96	0.10	0.18	0.12	<0.1	0.28	0.03	0.04	25.85
417	SBE-8/11M	53.3	54.35	1.05	Banded hematite chert/jasper	50.92	1.64	44.62	0.12	0.16	0.12	0.11	0.28	0.03	0.05	31.207
418	SBE-8/12M	54.35	55.35	1.00	Banded hematite chert/jasper	52.13	1.35	42.94	0.10	0.13	0.11	0.11	0.14	0.02	0.04	30.032
419	SBE-8/13M	55.35	56.05	0.70	Banded hematite chert/jasper	50.88	2.10	44.80	0.10	0.13	0.11	0.11	0.14	0.04	0.08	31.333
420	SBE-8/14M	56.05	57	0.95	Banded hematite chert/jasper	42.26	0.48	53.18	0.10	0.11	0.14	0.15	0.14	0.01	0.05	37.194
421	SBE-8/15M	57	58.05	1.05	Banded hematite chert/jasper	54.95	1.44	41.19	0.12	0.14	0.10	0.10	0.13	0.02	0.06	28.808
422	SBE-8/16M	58.05	58.95	0.90	Banded hematite chert/jasper	50.41	0.96	45.45	0.13	0.10	0.10	0.10	0.09	0.01	0.08	31.788
423	SBE-8/17M	58.95	59.85	0.90	Banded hematite jasper	50.14	1.69	45.94	0.13	0.31	0.10	0.10	0.19	0.03	0.06	32.13
424	SBE-8/18M	59.85	60.65	0.80	Banded hematite jasper	52.13	1.14	44.63	0.13	0.23	0.10	0.18	0.12	0.02	0.06	31.214
425	SBE-8/19M	60.65	61.55	0.90	Banded hematite chert/jasper	47.76	1.45	48.89	0.11	0.32	0.10	0.14	0.10	0.02	0.05	34.194
426	SBE-8/20M	61.55	62.60	1.05	Banded hematite chert/jasper +Tuff	56.48	2.06	39.35	0.12	0.19	0.10	0.11	0.10	0.03	0.06	27.521
427	SBE-8/21M	62.6	63.5	0.90	Banded hematite chert/jasper	55.44	1.55	40.87	0.11	0.14	0.10	0.12	0.15	0.03	0.04	28.584
428	SBE-8/22M	63.5	64.45	0.95	Banded hematite chert/jasper	49.96	1.49	45.97	0.10	0.14	0.10	0.14	0.16	0.03	0.04	32.151
429	SBE-8/23M	64.45	65.5	1.05	Banded hematite chert/jasper	50.23	2.00	43.74	0.10	0.21	0.10	0.10	0.23	0.04	0.05	30.592
430	SBE-8/24M	65.5	66.6	1.10	Banded hematite chert/jasper	50.07	1.97	42.62	0.28	0.40	0.10	0.10	0.17	0.05	0.13	29.808
431	SBE-8/25M	66.6	67.6	1.00	Banded hematite chert/jasper	52.42	2.61	39.86	0.10	0.14	0.10	0.17	0.14	0.06	0.05	27.878
432	SBE-8/26M	67.6	68.5	0.90	Banded hematite chert/jasper	56.31	2.86	35.79	0.10	0.16	0.10	0.11	0.12	0.12	0.05	25.032
433	SBE-8/27M	68.5	69.5	1.00	Banded hematite chert/jasper	61.15	3.40	28.10	0.10	0.21	0.10	0.16	0.12	0.11	0.05	19.653
434	SBE-8/28M	69.5	70.5	1.00	Banded hematite chert/jasper	59.53	3.55	30.62	0.25	0.22	0.10	0.16	0.14	0.09	0.04	21.416
435	SBE-8/29M	70.5	71.5	1.00	Banded hematite chert/jasper	51.96	2.07	40.37	<0.1	0.27	0.10	<0.1	0.17	0.06	0.04	28.235
436	SBE-8/30M	71.5	72.5	1.00	Banded hematite chert	38.07	0.80	52.85	0.10	0.28	0.10	<0.1	0.14	0.01	0.08	36.963
437	SBE-8/31M	72.5	73.5	1.00	Banded hematite chert	53.74	1.94	38.25	0.11	0.41	0.10	0.11	0.13	0.05	0.06	26.752
438	SBE-8/32M	73.5	74.4	0.90	Banded hematite chert	52.28	0.97	41.47	0.10	0.29	0.10	0.22	0.13	0.02	0.05	29.004
439	SBE-8/33M	74.4	75.2	0.80	Banded hematite chert	47.64	1.85	43.91	0.11	0.44	0.10	0.11	0.16	0.05	0.09	30.711
440	SBE-8/34M	75.2	76.35	1.15	Limonitized banded hematite chert	55.10	3.96	34.60	0.26	0.50	0.11	0.71	0.13	0.13	0.19	24.199
441	SBE-8/35M	76.35	77.5	1.15	Limonitized banded hematite chert	44.18	4.03	42.87	<0.1	0.62	0.12	2.12	0.10	0.10	0.04	29.983

Analytical results of Major Oxides of Trench samples from extended Block - 'A', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	From (m)	To (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Trench TR-1 24° 33' 55.3" 82° 53' 04.5"															
1	TR-1/1	0	1	Banded Hematite Jasper / Chert	39.8	0.31	59.96	0.87	<0.1	<0.1	<0.1	<0.003	0.01	0.08	41.94
2	TR-1/2	1	2	Banded Hematite Jasper / Chert	43.88	0.24	54.9	0.75	<0.1	<0.1	<0.1	<0.003	0.02	0.09	38.40
3	TR-1/3	2	3	Banded Hematite Jasper / Chert	42.35	0.31	53.81	0.64	<0.1	<0.1	<0.1	<0.003	0.02	0.11	37.63
4	TR-1/4	3	4	Banded Hematite Jasper / Chert	27.57	0.28	66.8	0.91	<0.1	<0.1	<0.1	<0.003	0.02	0.17	46.72
5	TR-1/5	4	5	Banded Hematite Jasper / Chert	38.22	0.2	58.57	0.21	<0.1	<0.1	<0.1	<0.003	0.02	0.12	40.96
6	TR-1/6	5	6	Banded Hematite Jasper boulders in red soil	29.63	0.25	65.02	0.36	<0.1	<0.1	<0.1	<0.003	0.01	0.16	45.47
7	TR-1/7	6	7	Banded Hematite Jasper boulders in red soil	49.16	0.39	45.66	0.44	<0.1	<0.1	<0.1	<0.003	0.02	0.11	31.93
8	TR-1/8	7	8	Banded Hematite Jasper boulders in red soil	34.48	0.29	60.15	0.53	<0.1	<0.1	<0.1	<0.003	0.02	0.15	42.07
9	TR-1/9	8	9	Banded Hematite Jasper boulders in red soil	42.87	0.28	52.66	0.9	<0.1	<0.1	<0.1	<0.003	0.02	0.12	36.83
10	TR-1/10	9	10	Banded Hematite Jasper boulders in red soil	53.65	0.3	44.69	0.8	<0.1	<0.1	<0.1	<0.003	0.02	0.1	31.26
11	TR-1/11	10	11	Banded Hematite Jasper boulders in red soil	26.46	0.18	67.49	0.26	<0.1	<0.1	<0.1	<0.003	0.02	0.21	47.20
12	TR-1/12	11	12	Banded Hematite Jasper boulders in red soil	35.74	0.36	55.02	0.12	<0.1	<0.1	<0.1	<0.003	0.02	0.22	38.48
13	TR-1/13	12	13	Banded Hematite Jasper boulders in red soil	38.29	0.39	57.05	0.33	<0.1	<0.1	<0.1	<0.003	0.02	0.13	39.90
14	TR-1/14	13	14	Banded Hematite Jasper boulders in red soil	48.01	0.84	47.1	0.5	<0.1	<0.1	<0.1	<0.003	0.02	0.1	32.94
15	TR-1/15	14	15	Banded Hematite Jasper boulders in red soil	34.28	0.21	59.91	0.36	<0.1	<0.1	<0.1	<0.003	0.02	0.15	41.90
16	TR-1/16	15	16	Banded Hematite Jasper	46.96	0.41	46.89	0.59	<0.1	<0.1	<0.1	<0.003	0.02	0.11	32.79
17	TR-1/17	16	17	Banded Hematite Jasper + Limonite	48.69	0.39	46.49	0.85	<0.1	<0.1	<0.1	<0.003	0.02	0.11	32.52
18	TR-1/18	17	18	Banded Hematite Jasper + Limonite	36.72	0.39	59.3	0.1	<0.1	<0.1	<0.1	<0.003	0.02	0.14	41.47
Trench TR-2 24° 33' 43.0" 82° 51' 55.4"															
19	TR-2/1	0	1	BIF + Chert boulders in red soil	44.57	3.77	42.84	0.68	<0.1	<0.1	<0.1	0.24	0.2	0.08	29.96
20	TR-2/2	1	2	BIF + Chert boulders in red soil	43.83	3.69	44.13	0.21	<0.1	<0.1	0.18	0.2	0.13	0.08	30.86
21	TR-2/3	2	3	BIF + Chert boulders in red soil	44.88	3.52	43.51	0.28	<0.1	<0.1	<0.1	0.2	0.14	0.09	30.43
22	TR-2/4	3	4	BIF + Chert boulders in red soil	53.97	4.24	35.31	0.24	0.1	<0.1	0.2	0.2	0.11	0.07	24.70
23	TR-2/5	4	5	Chert boulders in red soil	92.2	2.38	2.85	0.54	0.25	<0.1	<0.1	0.26	0.05	0.04	1.99
24	TR-2/6	5	6	Phyllite + Chert boulders in red soil	81.04	8.04	3.05	0.52	0.18	<0.1	0.18	0.19	0.4	0.04	2.13
25	TR-2/7	6	7	Chert and quartz boulders in red soil	92.57	3.08	1.78	0.28	0.23	<0.1	0.11	0.26	0.07	0.03	1.24
26	TR-2/8	7	8	Chert and iron oxide boulders in red soil	80.41	5.92	9.99	0.51	0.24	<0.1	<0.1	0.26	0.23	0.05	6.99
27	TR-2/9	8	9	Chert boulders in red soil	95.26	2.05	1.46	0.71	0.22	<0.1	<0.1	0.26	0.03	0.03	1.02
28	TR-2/10	9	10	Chert boulders in red soil	74.41	8.57	11.61	0.71	0.23	<0.1	0.37	0.27	0.27	0.1	8.12
29	TR-2/11	10	11	Tuff + Chert boulders in red soil	80.02	11.07	4.58	0.29	0.14	<0.1	<0.1	0.26	1.39	0.11	3.20
30	TR-2/12	11	11.55	Banded Hematite Chert boulders in red soil	71.96	2.18	20.7	0.19	<0.1	<0.1	<0.1	0.26	0.31	0.14	14.48
31	TR-2/13	12.1	13	Chert and iron oxide boulders in red soil	84.5	4.4	7.4	0.31	0.12	<0.1	0.11	0.18	0.18	0.04	5.18

Sr. No.	Sample No	From (m)	To (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Trench TR-3 24° 33' 52.3" 82° 52' 50.1"															
32	TR-3/1	0	1	Banded Hematite Chert with phyllite banding	83.47	0.56	17.68	<0.1	0.16	<0.1	<0.1	0.02	0.03	0.05	12.37
33	TR-3/2	1	2	Banded Hematite Chert with phyllite banding	61.89	2.49	29.64	<0.1	0.12	<0.1	<0.1	0.03	0.08	0.06	20.73
34	TR-3/3	2	3	Banded Hematite Chert and Chert boulders	61.55	3.28	31.2	<0.1	<0.1	<0.1	<0.1	0.02	0.08	0.04	21.82
35	TR-3/4	3	4	Phyllite + Chert boulders	85.32	0.5	14.88	<0.1	0.11	<0.1	<0.1	0.02	0.02	0.04	10.41
36	TR-3/5	4	5	Chert and Jasper boulders in red soil	78.07	1.82	17.65	<0.1	0.16	<0.1	<0.1	0.02	0.04	0.03	12.34
37	TR-3/6	5	6	Chert, jasper and iron oxide boulders in red soil + limonitic material	74.13	0.64	20.53	<0.1	0.1	<0.1	<0.1	0.02	0.03	0.03	14.36
38	TR-3/7	6	7	Banded Hematite Jasper in black soil	62.8	1.08	34.84	<0.1	0.11	<0.1	<0.1	<0.003	0.03	0.04	24.37
39	TR-3/8	7	8	Banded Hematite jasper boulders in black soil	52.83	0.74	40.78	<0.1	<0.1	<0.1	<0.1	<0.003	0.03	0.04	28.52
40	TR-3/9	8	9	Banded Hematite jasper boulders in black soil	48.52	0.4	49.67	<0.1	<0.1	<0.1	<0.1	<0.003	0.02	0.05	34.74
41	TR-3/10	9	10	Banded Hematite jasper boulders in black soil	47.21	1.08	48.4	<0.1	0.1	<0.1	<0.1	<0.003	0.03	0.06	33.85
Trench TR-4 24° 33' 52.1" 82° 52' 37.2"															
42	TR-4/1	0	1	Banded Hematite Chert (limonitic) boulders in reddish brown soil	36.55	1.53	57.62	0.15	0.12	<0.1	<0.1	<0.003	0.08	0.33	40.30
43	TR-4/2	1	2	Banded Hematite Chert boulders in reddish brown soil	36.57	0.67	58.156	<0.1	0.16	<0.1	<0.1	<0.003	0.06	0.17	40.67
44	TR-4/3	2	3	Banded Hematite Chert boulders in reddish brown soil	34.82	0.3	61.782	<0.1	<0.1	<0.1	<0.1	<0.003	0.02	0.14	43.21
45	TR-4/4	3	4	Banded Hematite Chert boulders in reddish brown soil	39.46	0.56	54.796	<0.1	<0.1	<0.1	<0.1	<0.003	0.03	0.09	38.32
46	TR-4/5	4	5	Goethitic Banded Hematite Chert boulders in reddish brown soil	51.55	0.79	42.966	<0.1	0.1	<0.1	<0.1	<0.003	0.05	0.13	30.05
47	TR-4/6	5	6	Banded Hematite Chert boulders in reddish brown soil	49.82	0.3	45.584	<0.1	0.1	<0.1	<0.1	<0.003	0.02	0.12	31.88
48	TR-4/7	6	7	Banded Hematite Chert boulders in reddish brown soil	52.72	0.39	43.02	<0.1	0.25	<0.1	<0.1	0.01	0.01	0.22	30.09
49	TR-4/8	7	8	Banded Hematite Chert boulders in reddish brown soil	52.81	0.76	41.98	<0.1	0.2	<0.1	<0.1	0.01	0.03	0.27	29.36
50	TR-4/9	8	9	Banded Hematite Chert boulders in reddish brown soil	49.02	0.61	47.42	0.1	0.12	<0.1	<0.1	0.01	0.01	0.28	33.17
51	TR-4/10	9	10	Banded Hematite Chert / Jasper boulders in reddish brown soil	43.61	0.37	52.36	0.15	0.11	<0.1	<0.1	<0.003	0.03	0.1	36.62

Litholog of borehole SBE-1, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'39.5"
 Longitude - 82°52'07.8"
 R.L. - 346 m
 Bearing - 340°

Commenced on - 21/10/17
 Closed on - 12/12/17
 Inclination - 45°
 Depth drilled - 120.10 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0	14	14	Reddish, grey, buff, fine grained phyllite rock chips (1mm – 5mm) in loose soil
2	14	24.4	10.4	Reddish ferruginous phyllite
3	24.4	67.9	43.5	Grey massive variegated phyllite
4	67.9	68.7	0.8	Fractured BIF
5	68.7	89.05	20.35	Massive variegated phyllite with chert nodules
6	89.05	90.9	1.85	Greyish white, fine grained Felsic Tuff
7	90.9	108.15	17.25	Grey massive variegated phyllite
8	108.15	108.7	0.55	Greyish white, Felsic Tuff
9	108.7	116.1	7.4	Dark grey fine grained, variegated phyllite
10	116.1	120.1	4	Greyish white, Felsic Tuff

\$ The borehole was abandoned.

Litholog of borehole SBE-2, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'41.8"
 Longitude - 82°52'08.4"
 R.L. - 388 m
 Bearing - 340°

Commenced on - 26/12/17
 Closed on - 29/01/18
 Inclination - 45°
 Depth drilled - 94.05 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0	16.2	16.2	Buff color fine to medium grain soil mixed with small fragments of buff and reddish color phyllite and chert
3	16.2	32.8	16.6	Ferruginous phyllite with elongated chert nodules
4	32.8	35.4	2.6	Variegated phyllite with white platy tuff banding
5	35.4	41.5	6.1	Reddish phyllite with elongated chert nodules
6	41.5	42	0.5	BIF
7	42	52.2	10.2	Variegated Phyllite interbanded with ash color or dirty white tuff band
8	52.2	63.3	11.1	Reddish green dolerite with green mafic minerals mixed with tuffaceous content
9	63.3	72.7	9.4	Reddish, ash color or greyish white tuff
10	72.7	83.4	10.7	Green to dark greyish green dolerite
11	83.4	86.1	2.7	Variegated Phyllite interbanded with white tuff band
12	86.1	94.05	7.95	Brecciated, sheared, limonitized BIF (very poor core recovery and 100% water loss after 89.50m)

\$ The borehole was abandoned.

Litholog of borehole SBE-3, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'41.1"
 Longitude - 82°51'59.1"
 R.L. - 390 m
 Bearing - 342°

Commenced on - 16/02/18
 Closed on - 28/03/18
 Inclination - 45°
 Depth drilled - 93.10 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0	6.5	6.5	Sludge of buff color mixed with fragments of chert, quartz and buff phyllite
2	6.5	12.5	6	Whitish purple (ash color) tuff soil with grey chert fragments (15cm) in start and ferruginous phyllite fragments (20 cm) in last.
3	12.5	40.2	27.7	Ferruginous phyllite having reddish white tuff soil/sludge in between (randomly) with chert nodules
4	40.2	70	29.8	Reddish/Pinkish white tuff (somewhere reddish green, violet in color) with 2mm-2cm thick chert vein at places.
5	70	74.5	4.5	Fault breccia type banded hematite chert (angular fragments of chert and iron oxide) intercalated with white tuff (water loss starts here)
6	74.5	89	14.5	Banded hematite jasper/chert (poor core recovery and 100% water loss).
7	89	90.2	1.2	No core recovery, 100% water loss
8	90.2	91.2	1	5 cm BHC/J small fragments followed by 35 cm reddish/greyish/whitish weathered tuff core
9	91.2	91.9	0.7	No core recovery, 100% water loss
10	91.9	93.1	1.2	No core recovery, 100% water loss

\$ The borehole was abandoned.

Litholog of borehole SBE-4, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'44.2"
 Longitude - 82°52'24.2"
 R.L. - 317 m
 Bearing - 356°

Commenced on - 23/04/18
 Closed on - 20/05/18
 Inclination - 45°
 Depth drilled -71.10 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0	3	3	Reddish buff fragmentary soil
2	3	6.2	3.2	Greyish buff phyllite mixed with ferruginous phyllite having chert nodules
3	6.2	9.2	3	Greyish buff phyllite with chert nodules
4	9.2	14.6	5.4	Grey phyllite core with chert banding, also mixed grey soil and variegated phyllite
5	14.6	19.65	5.05	Ferruginous phyllite with chert nodules (in between grey quartzite of 40 cm with sulphide specks are also observed).
6	19.65	45.75	26.1	Grey phyllite with chert nodules and bands. Highly enriched in sulphide veins and specks. Massive grey chert is also at places.
7	45.75	47.5	1.75	Massive grey chert having few pyrite veins
8	47.5	51.25	3.75	Grey phyllite intruded by thin quartz veins, sulphide specks also observed at places
9	51.25	55.5	4.25	Felsic tuff
10	55.5	66.2	10.7	Dark grey dolerite with thin quartz vein intrusion and presence of sulphide at places.
11	66.2	68.25	2.05	Light grey tuff with quartz vein intrusion.
12	68.25	71.1	2.85	Light grey, fine grained hard, massive meta basic.

Litholog of borehole SBE-5, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'47"
 Longitude - 82°52'34"
 R.L. - 366 m
 Bearing - 350°

Commenced on - 13/06/18
 Closed on - 23/07/18
 Inclination - 45°
 Depth drilled - 59.0 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	1.50	1.5	Buff, fine grained, soil
2	1.50	10.00	8.5	Ferruginous phyllite core having chert nodules with core fragments having hematite banding of 2 mm to 1 cm.
3	10.00	15.85	5.85	Purple felsic tuff
4	15.85	20.15	4.3	Ferruginous phyllite with fine grained white tuff fragments
5	20.15	29.95	9.8	Reddish, purple tuff with fine grained white tuffaceous phyllite fragments
6	29.95	40.80	10.85	Greenish grey, fine to medium grained dolerite intermixed with tuff
7	40.80	59.00	18.2	Banded Hematite chert/jasper (silica dominant)

\$ The borehole was abandoned.

Litholog of borehole SBE-6, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'47.3"
 Longitude - 82°52'45.2"
 R.L. - 402 m
 Bearing - 350°

Commenced on - 03/10/2018
 Closed on - 03/12/2018
 Inclination - 40°
 Depth drilled - 160.05 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	26.10	26.10	Reddish phyllite with black chert band of 55 cm. Also mixed with buff phyllite core and chert nodules with sludge.
2	26.10	47.00	20.90	Ferruginous phyllite and chert nodules and occasionally thin (1mm) to thick (8 cm) dark grey chert bands.
3	47.00	57.65	10.65	Dark grey fine grained phyllite having chert nodules interbanded with ash color tuff. Sulphide veins and specks occur in grey phyllite and also
4	57.65	61.40	3.75	Greenish grey dolerite
5	61.40	65.00	3.60	Variegated phyllite with chert nodules, also sulphide specks.
6	65.00	66.25	1.25	Ash color tuff interbanded with grey phyllite in between.
7	66.25	90.75	24.50	Greenish grey colored medium grained dolerite
8	90.75	153.3	62.55	Banded hematite jasper/chert, jasper is dominant with occasionally elongated chert nodules.
9	153.3	158.74	5.44	Silica dominant Banded hematite jasper/chert (jasper dominant) interbanded with greenish chloritic phyllite banding at places.
10	158.74	160.05	1.31	Variegated phyllite

Litholog of borehole SBE-7, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'51.4"

Commenced on - 10/12/2018

Longitude - 82°53'3.4"

Closed on - 28/02/2019

R.L. - 390 m

Inclination - 45°

Bearing - 355°

Depth drilled - 138.80 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	8.90	8.90	Fragments and broken pieces of white to ash colored tuff.
2	8.90	25.80	16.90	Reddish phyllite with purple to reddish tuff and sludge
3	25.80	45.90	20.10	Greenish grey to dark grey dolerite.
4	45.90	48.20	2.30	Reddish to purple tuff core fragments, also purple sludge of tuff.
5	48.20	48.60	0.40	Light grey dolerite
6	48.60	48.80	0.20	Dark grey chert core
7	48.80	133.90	85.10	Banded haematite chert/Jasper , haematite banding is 1mm to 5 cm, leached and limonitized at places. Jasper banding of 2-3 mm thick is present after 61.30m onwards. Chert is present in banded and rounded to elongated nodular forms.
8	133.9	135.2	1.30	Reddish to white tuff
9	135.2	138.8	3.60	Weathered to fresh greenish dolerite

Litholog of borehole SBE-8, extended Block – ‘A’, Bharhari area, Sonbhadra district, Uttar Pradesh

Latitude - 24°33'46.9"
 Longitude - 82°52'28.1"
 R.L. - 368 m
 Bearing - 351°

Commenced on - 18/11/2018
 Closed on - 03/01/2019
 Inclination - 45°
 Depth drilled - 86.50 m

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	2.25	2.25	Fragments of reddish tuff
2	2.25	41.55	39.30	Greenish to reddish colored dolerite core mixed with fragments, also intrusion of quartz vein at places.
3	41.55	42.10	0.55	Oxidised banded hematite chert
4	42.10	43.25	1.15	Greyish / green dolerite
5	43.25	77.30	34.05	Banded hematite chert/Jasper , Initially BHC is oxidised and leached somewhere limonitized. Hematite bands are 2 mm to 7 cm thick, at a place it is 13 cm thick, chert is present as bands (2mm-6cm) and elongated nodular forms.
6	77.3	80.4	3.10	Dark grey phyllite having sulphide veins (1-2mm) and dissemination with elongated chert nodules randomly. Also intermixed with low grade BHC/J in between at places.
7	80.4	83.7	3.30	Off white tuff (initially intermixed with randomly grey phyllite having elongated/rounded chert nodules and sulphide disseminations).
8	83.7	86.5	2.80	Dark grey dolerite.

**DETERMINATION OF BULK DENSITY OF BANDED IRON FORMATION IN EXTENDED BLOCK 'A',
BHARHARI, SONBHADRA DISTRICT, UTTAR PRADESH**

Sl. No.	Sample No	Sample Type	Latitude	Longitude	Remarks	Bulk Density
1	SBE/GS-1	Banded Iron Formation	24° 33' 51.6"	82° 52' 42.1"	BRS	3.51
2	SBE/GS-2	Banded Iron Formation	24° 33' 54.6"	82° 53' 13.6"	BRS	3.24
3	SBE/GS-3	Banded Iron Formation	24° 33' 43.1"	82° 51' 58.7"	BRS	3.27
4	SBE/GS-4	Banded Iron Formation	24° 33' 44.2"	82° 52' 24.2"	BRS	3.19
5	SBE/GS-5	Banded Iron Formation	24° 33' 41.1"	82° 51' 59.1"	BRS	2.9
6	SBE/GS-6	Banded Iron Formation	24° 33' 47.1"	82° 52' 34.1"	BRS	3.05
					Average	3.20

**CALCULATION OF AVERAGE GRADE OF Fe FOR EXTENDED BLOCK 'A',
BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH**

Fe content $\geq 30\%$					
B.H. No.	Sectional area (sq.m)	Strike Influence (m)	Ore volume (v) (in cu.m)	Avg. grade (g) (in Fe %)	Volume x Avg. grade (v x g)
SBE-2	140	363	50820	30	1524600
SBE-3	937	258	241746	31.58	7634338.68
SBE-5	1037	241	249917	36.83	9204443.11
SBE-6-Zone I	267	333	88911	41.93	3728038.23
SBE-6 -Zone II	1083	333	360639	39.14	14115410.46
SBE-6-Zone III	1123	333	373959	36.04	13477482.36
SBE-6 -Zone IV	1984	333	660672	36.3	23982393.6
SBE-7 -Zone I	3886	400	1554400	34.79	54077576
SBE-7 -Zone II	408	400	163200	32.74	5343168
SBE-7 -Zone III	1208	400	483200	31.1	15027520
SBE-7 -Zone IV	228	400	91200	34.16	3115392
SBE-8 -Zone I	1320	169	223080	31.1	6937788
SBE-8 -Zone II	564	169	95316	30.22	2880449.52
		$\sum v =$	4637060	$\sum (v \times g) =$	161048600
Avg. grade i.e. $\sum (v \times g) / \sum v = 34.73 \%$					

Fe content $\geq 35\%$					
B.H. No.	Sectional area (sq.m)	Strike Influence (m)	Ore volume (v) (cu.m)	Avg. grade (g) (Fe %)	Volume x Avg. grade (v x g)
SBE-5	1037	241	249917	36.83	9204443.11
SBE-6 -Zone I	270	333	89910	45.3	4072923
SBE-6 -Zone II	1083	333	360639	39.14	14115410.46
SBE-6 -Zone III	636	333	211788	39.44	8352918.72
SBE-6 -Zone IV	827	333	275391	40.82	11241460.62
SBE-6 -Zone V	346	333	115218	39.18	4514241.24
SBE-7 -Zone I	1249	400	499600	35.59	17780764
SBE-7 -Zone II	1652	400	660800	38.07	25156656
		$\sum v =$	2463263	$\sum (v \times g) =$	94438817.15
Avg. grade i.e. $\sum (v \times g) / \sum v = 38.34 \%$					

**CALCULATION OF ZONE ON AVERAGE Fe>30% CUT OFF IN BANDED HEMATITE CHERT/JASPER
ZONE INTERSECTED IN BOREHOLES, EXTENDED BLOCK 'A', BHARHARI AREA, SONBHADRA
DISTRICT, UTTAR PRADESH**

BH NO : SBE-2

Fe content $\geq$ 30%

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-2/51	86.55	87.00	0.45	45.65	31.9276	14.367
2	SBE-2/52	87.00	87.56	0.56	43.64	30.5218	17.092
3	SBE-2/53	87.56	88.12	0.56	39.86	27.8781	15.612
Total length $\sum L =$				1.57	Total L x G =		47.071
Avg. grade i.e. $\sum L \times G / \sum L =$					29.98 %		

BH NO : SBE-3

Fe content $\geq$ 30%

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-3/52	78.10	78.60	0.5	55.99	39.16	19.58
2	SBE-3/53	78.60	79.10	0.5	32.13	22.47	11.24
3	SBE-3/54	80.10	80.60	0.5	48.86	34.17	17.09
4	SBE-3/55	81.00	81.50	0.5	48.04	33.60	16.80
5	SBE-3/56	82.00	82.70	0.7	39.56	27.67	19.37
6	SBE-3/57	82.70	83.20	0.5	34.1	23.85	11.92
7	SBE-3/58	83.20	84.20	1	41.86	29.28	29.28
8	SBE-3/59	84.20	85.00	0.8	52.06	36.41	29.13
9	SBE-3/60	85.00	85.35	0.35	48.47	33.90	11.86
10	SBE-3/61	85.35	85.70	0.35	37.45	26.19	9.17
11	SBE-3/62	85.70	86.30	0.6	55.21	38.61	23.17
12	SBE-3/63	86.30	86.90	0.6	48.64	34.02	20.41
13	SBE-3/64	86.90	87.50	0.6	42.47	29.70	17.82
Total length $\sum L =$				7.50	Total L x G =		236.83
Avg. grade i.e. $\sum L \times G / \sum L =$					31.58 %		

BH NO : SBE-5

Fe content $\geq$ 30%

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-5/22	47.85	48.50	0.65	50.85	35.56	23.117
2	SBE-5/24	49.00	49.50	0.50	52.46	36.69	18.345
3	SBE-5/25	49.50	50.15	0.65	62.15	43.47	28.254
4	SBE-5/26	50.15	50.65	0.50	54.05	37.80	18.901
5	SBE-5/27	51.00	51.50	0.50	61.7	43.15	21.576
6	SBE-5/28	51.50	52.00	0.50	62.66	43.82	21.912
7	SBE-5/29	52.00	52.45	0.45	44.64	31.22	14.050
8	SBE-5/30	52.45	53.00	0.55	50.69	35.45	19.499
9	SBE-5/31	53.00	53.55	0.55	52.38	36.63	20.149
10	SBE-5/32	53.55	54.15	0.60	62.39	43.64	26.181
11	SBE-5/33	54.15	54.75	0.60	54.14	37.87	22.719
12	SBE-5/34	54.75	55.40	0.65	41.46	29.00	18.848
13	SBE-5/35	55.40	55.90	0.50	48.39	33.84	16.922
14	SBE-5/36	55.90	56.45	0.55	51.01	35.68	19.622
15	SBE-5/37	56.45	57.05	0.60	45.09	31.54	18.922
16	SBE-5/38	57.05	57.75	0.70	49.16	34.38	24.068
17	SBE-5/39	57.75	57.95	0.20	53.52	37.43	7.486
18	SBE-5/40	58.00	59.00	1.00	52.81	36.94	36.935
Total length $\sum L =$				10.25	Total L x G =		377.507
Avg. grade i.e. $\sum L \times G / \sum L =$					36.83 %		

BH NO : SBE-6

ZONE-I Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/4	93.1	93.55	0.45	43.91	30.71	13.8197943
2	SBE-6/5	93.55	94.05	0.5	62.80	43.92	21.96116
3	SBE-6/6	94.05	94.55	0.5	71.31	49.87	24.937107
4	SBE-6/7	94.55	95.05	0.5	60.19	42.10	21.048443
Total length $\sum L =$				1.95	Total L x G =		81.7665043
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$				41.93 %			

ZONE-II Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/27	108.1	108.65	0.55	55.25	38.64	21.2530175
2	SBE-6/28	108.65	109.2	0.55	58.82	41.14	22.6262894
3	SBE-6/29	109.2	109.8	0.6	56.71	39.66	23.7977844
4	SBE-6/30	109.8	110.25	0.45	58.44	40.87	18.3928212
5	SBE-6/31	110.25	110.7	0.45	57.73	40.38	18.1693629
6	SBE-6/32	110.7	111.15	0.45	55.80	39.03	17.561934
7	SBE-6/33	111.15	111.65	0.5	48.63	34.01	17.005911
8	SBE-6/34	111.65	112.15	0.5	44.05	30.81	15.404285
9	SBE-6/35	112.15	112.65	0.5	53.21	37.22	18.607537
10	SBE-6/36	112.65	113.15	0.5	55.87	39.08	19.537739
11	SBE-6/37	113.15	113.65	0.5	57.51	40.22	20.111247
12	SBE-6/38	113.65	114.05	0.4	52.69	36.85	14.7405544
13	SBE-6/39	114.05	114.5	0.45	64.12	44.85	20.1804876
14	SBE-6/40	114.5	115.2	0.7	62.32	43.59	30.5106256
Total length $\sum L =$				7.10	Total L x G =		277.899596
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$				39.14 %			

ZONE-III Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/46	118.2	118.65	0.45	44.61	31.20	14.0401053
2	SBE-6/47	118.65	119.1	0.45	45.32	31.70	14.2635636
3	SBE-6/48	119.1	119.55	0.45	64.68	45.24	20.3567364
4	SBE-6/49	119.55	120	0.45	47.93	33.52	15.0850089
5	SBE-6/50	120	120.6	0.6	35.13	24.57	14.7419532
6	SBE-6/51	120.6	121.1	0.5	38.13	26.67	13.334061
7	SBE-6/52	121.1	121.6	0.5	48.38	33.84	16.918486
8	SBE-6/53	121.6	122.15	0.55	54.15	37.87	20.8298805
9	SBE-6/54	122.15	122.65	0.5	52.15	36.47	18.236855
10	SBE-6/55	122.65	123.1	0.45	35.08	24.53	11.0407284
11	SBE-6/56	123.1	123.55	0.45	57.88	40.48	18.2165724
12	SBE-6/57	123.55	124.15	0.6	58.63	41.01	24.6034932
13	SBE-6/58	124.15	124.65	0.5	64.47	45.09	22.545159
14	SBE-6/59	124.65	125.15	0.5	59.17	41.38	20.691749
15	SBE-6/60	125.15	125.65	0.5	67.37	47.12	23.559289
Total length $\sum L =$				7.45	Total L x G =		268.4636409
Zone -III Avg. grade i.e. $\sum L \times G / \sum L =$				36.04 %			

ZONE-IV Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/89	143.8	144.3	0.5	42.97	30.05	15.026609
2	SBE-6/90	144.3	145	0.7	48.79	34.12	23.8866082
3	SBE-6/91	145	145.55	0.55	57.88	40.48	22.2646996
4	SBE-6/92	145.55	146.1	0.55	41.79	29.23	16.0753593
5	SBE-6/93	146.1	146.55	0.45	39.52	27.64	12.4381296
6	SBE-6/94	146.55	147.3	0.75	59.89	41.89	31.4152995
7	SBE-6/95	147.3	147.7	0.4	60.79	42.52	17.0066104
8	SBE-6/96	147.7	148.15	0.45	53.05	37.10	16.6964265
9	SBE-6/97	148.15	148.75	0.6	56.51	39.52	23.7138564
10	SBE-6/98	148.75	149.15	0.4	59.88	41.88	16.7520288
11	SBE-6/99	149.15	149.55	0.4	60.19	42.10	16.8387544
12	SBE-6/100	149.55	150.05	0.5	62.91	44.00	21.999627
13	SBE-6/101	150.05	150.55	0.5	60.32	42.19	21.093904
14	SBE-6/102	150.55	151.1	0.55	58.13	40.66	22.3608671
15	SBE-6/103	151.1	151.65	0.55	55.12	38.55	21.2030104
16	SBE-6/104	151.65	152.2	0.55	52.47	36.70	20.1836349
17	SBE-6/105	152.2	152.75	0.55	58.94	41.22	22.6724498
18	SBE-6/106	152.75	153.25	0.5	61.64	43.11	21.555508
19	SBE-6/107	153.25	153.75	0.5	29.89	20.91	10.452533
20	SBE-6/108	153.75	154.25	0.5	50.32	35.19	17.596904
21	SBE-6/109	154.25	154.75	0.5	42.63	29.82	14.907711
22	SBE-6/110	154.75	155.25	0.5	40.19	28.11	14.054443
23	SBE-6/111	155.25	155.75	0.5	46.47	32.50	16.250559
24	SBE-6/112	155.75	156.25	0.5	43.73	30.58	15.292381
25	SBE-6/113	156.25	156.75	0.5	41.55	29.06	14.530035
26	SBE-6/114	156.75	157.25	0.5	39.56	27.67	13.834132
27	SBE-6/115	157.25	157.7	0.45	58.30	40.78	18.348759
28	SBE-6/116	157.7	158.1	0.4	56.61	39.59	15.8372136
29	SBE-6/117	158.1	158.75	0.65	61.36	42.92	27.8948696
30	SBE-6/118	158.75	159.4	0.65	54.06	37.81	24.5762166
31	SBE-6/119	159.4	160.05	0.65	50.72	35.47	23.0578192
Total length $\sum$ L =				16.25	Total L x G =		589.8169589
Zone -IV Avg. grade i.e. $\sum$ L x G / $\sum$ L =						36.30 %	

BH NO : SBE-7

ZONE-I Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-7/25M	63.80	64.50	0.7	51.06	35.71	24.9979548
2	SBE-7/26M	64.50	65.50	1	51.81	36.24	36.235914
3	SBE-7/27M	65.50	66.60	1.1	51.09	35.73	39.3055806
4	SBE-7/28M	66.60	67.60	1	50.27	35.16	35.158838
5	SBE-7/29M	67.60	68.40	0.8	54.9	38.40	30.717648
6	SBE-7/30M	68.40	69.50	1.1	52.27	36.56	40.2134018
7	SBE-7/31M	69.50	70.40	0.9	58.4	40.84	36.760464
8	SBE-7/32M	70.40	71.25	0.85	47.86	33.47	28.4522914
9	SBE-7/33M	71.25	72.10	0.85	48.81	34.14	29.0170569
10	SBE-7/34M	72.10	73.30	1.2	46.47	32.50	39.0013416
11	SBE-7/35M	73.30	74.50	1.2	49.72	34.77	41.7290016
12	SBE-7/36M	74.50	75.45	0.95	49.65	34.73	32.9889495
13	SBE-7/37M	75.45	76.40	0.95	46.59	32.59	30.9557937
14	SBE-7/38M	76.40	77.00	0.6	35.5	24.83	14.89722
15	SBE-7/39M	77.00	78.10	1.1	53.62	37.50	41.2520108
16	SBE-7/40M	78.10	79.10	1	57.97	40.54	40.544218
17	SBE-7/41M	79.10	80.05	0.95	54.28	37.96	36.0652604
18	SBE-7/42M	80.05	81.00	0.95	62.21	43.51	41.3341903
19	SBE-7/43M	81.00	82.00	1	59.54	41.64	41.642276
20	SBE-7/44M	82.00	83.20	1.2	53.11	37.15	44.5741608
21	SBE-7/45M	83.20	84.20	1	47.57	33.27	33.270458
22	SBE-7/46M	84.20	85.40	1.2	49.71	34.77	41.7206088
23	SBE-7/47M	85.40	86.50	1.1	54.28	37.96	41.7597752
24	SBE-7/48M	86.50	87.80	1.3	50.50	35.32	45.91561
25	SBE-7/49M	87.80	88.80	1	59.82	41.84	41.838108
26	SBE-7/50M	88.80	89.85	1.05	53.54	37.45	39.3181698
27	SBE-7/51M	89.85	90.80	0.95	37.82	26.45	25.1287426
28	SBE-7/52M	90.80	92.00	1.2	41.90	29.30	35.165832
29	SBE-7/53M	92.00	93.00	1	49.33	34.50	34.501402
30	SBE-7/54M	93.00	94.00	1	24.57	17.18	17.184258
31	SBE-7/55M	94.00	95.00	1	32.73	22.89	22.891362
32	SBE-7/56M	95.00	96.00	1	55.83	39.05	39.047502
33	SBE-7/57M	96.00	97.10	1.1	45.28	31.67	34.8357152
Total length $\sum L =$				33.30	Total L x G =		1158.421116
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$						34.79%	

ZONE-II Fe content $\geq 30\%$

ZONE-II Fe content = 56.7%							
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-7/62M	100.60	101.60	1	42.88	29.99	29.990272
2	SBE-7/63M	101.60	102.60	1	48.80	34.13	34.13072
3	SBE-7/64M	102.60	103.60	1	48.75	34.10	34.09575
Total length $\sum L =$				3.00	Total L x G =		98.216742
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$ 32.74%							

ZONE-III Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-7/68M	106.60	107.60	1	54.53	38.14	38.138282
2	SBE-7/69M	107.60	108.60	1	32.71	22.88	22.877374
3	SBE-7/70M	108.60	109.60	1	40.64	28.42	28.423616
4	SBE-7/71M	109.60	110.60	1	49.34	34.51	34.508396
5	SBE-7/72M	110.60	111.60	1	26.88	18.80	18.799872
6	SBE-7/73M	111.60	112.60	1	50.03	34.99	34.990982
7	SBE-7/74M	112.60	113.60	1	48.09	33.63	33.634146
8	SBE-7/75M	113.60	114.60	1	49.19	34.40	34.403486
9	SBE-7/76M	114.60	115.60	1	48.70	34.06	34.06078
10	SBE-7/77M	115.60	116.60	1	44.53	31.14	31.144282
Total length $\sum L =$				10.00	Total L x G =		310.981216
Zone -III Avg. grade i.e. $\sum L \times G / \sum L =$ 31.10 %							

ZONE-IV Fe content $\geq 30\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-7/93M	131.60	132.60	1	55.10	38.54	38.53694
2	SBE-7/94M	132.60	133.60	1	42.57	29.77	29.773458
Total length $\sum L =$				2.00	Total L x G =		68.310398
Zone -IV Avg. grade i.e. $\sum L \times G / \sum L = 34.16\%$							

BH NO : SBE-8

ZONE-I Fe content $\geq 30\%$

ZONE-I Fe content $\geq 50\%$							
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-8/11M	53.3	54.35	1.05	44.62	31.21	32.7675894
2	SBE-8/12M	54.35	55.35	1	42.94	30.03	30.032236
3	SBE-8/13M	55.35	56.05	0.7	44.80	31.33	21.933184
4	SBE-8/14M	56.05	57	0.95	53.18	37.19	35.3343874
5	SBE-8/15M	57	58.05	1.05	41.19	28.81	30.2487003
6	SBE-8/16M	58.05	58.95	0.9	45.45	31.79	28.608957
7	SBE-8/17M	58.95	59.85	0.9	45.94	32.13	28.9173924
8	SBE-8/18M	59.85	60.65	0.8	44.63	31.21	24.9713776
9	SBE-8/19M	60.65	61.55	0.9	48.89	34.19	30.7742994
10	SBE-8/20M	61.55	62.60	1.05	39.35	27.52	28.8974595
11	SBE-8/21M	62.6	63.5	0.9	40.87	28.58	25.7260302
12	SBE-8/22M	63.5	64.45	0.95	45.97	32.15	30.5438471
13	SBE-8/23M	64.45	65.5	1.05	43.74	30.59	32.1213438
14	SBE-8/24M	65.5	66.6	1.1	42.62	29.81	32.7892708
Total length $\sum L =$				13.30	Total L x G =		413.6660749
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$						31.10 %	

BH NO : SBE-8

ZONE-II Fe content $\geq 30\%$

ZONE-II Fe content $\geq 50\%$							
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-8/30M	71.5	72.5	1	52.85	36.96	36.96329
2	SBE-8/31M	72.5	73.5	1	38.25	26.75	26.75205
3	SBE-8/32M	73.5	74.4	0.9	41.47	29.00	26.1037062
4	SBE-8/33M	74.4	75.2	0.8	43.91	30.71	24.5685232
5	SBE-8/34M	75.2	76.35	1.15	34.60	28.20	32.429126
6	SBE-8/35M	76.35	77.5	1.15	42.87	29.98	34.4807697
Total length $\sum L =$				6.00	Total L x G =		181.2974651
Zone -II Avg. grade i.e. $\sum L \times G / \sum L = 30.22\%$							

**CALCULATION OF ZONE ON AVERAGE Fe>35% CUT OFF IN BANDED HEMATITE
CHERT/JASPER ZONE INTERSECTED IN BOREHOLES, EXTENDED BLOCK 'A', BHARHARI
AREA, SONBHADRA DISTRICT, UTTAR PRADESH**

BH NO : SBE-5

Fe content $\geq$ 35%

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-5/22	47.85	48.50	0.65	50.85	35.56	23.117
2	SBE-5/24	49.00	49.50	0.50	52.46	36.69	18.345
3	SBE-5/25	49.50	50.15	0.65	62.15	43.47	28.254
4	SBE-5/26	50.15	50.65	0.50	54.05	37.80	18.901
5	SBE-5/27	51.00	51.50	0.50	61.7	43.15	21.576
6	SBE-5/28	51.50	52.00	0.50	62.66	43.82	21.912
7	SBE-5/29	52.00	52.45	0.45	44.64	31.22	14.050
8	SBE-5/30	52.45	53.00	0.55	50.69	35.45	19.499
9	SBE-5/31	53.00	53.55	0.55	52.38	36.63	20.149
10	SBE-5/32	53.55	54.15	0.60	62.39	43.64	26.181
11	SBE-5/33	54.15	54.75	0.60	54.14	37.87	22.719
12	SBE-5/34	54.75	55.40	0.65	41.46	29.00	18.848
13	SBE-5/35	55.40	55.90	0.50	48.39	33.84	16.922
14	SBE-5/36	55.90	56.45	0.55	51.01	35.68	19.622
15	SBE-5/37	56.45	57.05	0.60	45.09	31.54	18.922
16	SBE-5/38	57.05	57.75	0.70	49.16	34.38	24.068
17	SBE-5/39	57.75	57.95	0.20	53.52	37.43	7.486
18	SBE-5/40	58.00	59.00	1.00	52.81	36.94	36.935
Total length $\sum L =$				10.25	Total L x G =		377.507
Avg. grade i.e. $\sum L \times G / \sum L =$						36.83 %	

BH NO : SBE-6

ZONE-I

Fe content $\geq$ 35%

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/5	93.55	94.05	0.5	62.80	43.92	21.96116
2	SBE-6/6	94.05	94.55	0.5	71.31	49.87	24.937107
3	SBE-6/7	94.55	95.05	0.5	60.19	42.10	21.048443
Total length $\sum L =$				1.50	Total L x G =		67.94671
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$						45.30 %	

ZONE-II Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/27	108.1	108.65	0.55	55.25	38.64	21.2530175
2	SBE-6/28	108.65	109.2	0.55	58.82	41.14	22.6262894
3	SBE-6/29	109.2	109.8	0.6	56.71	39.66	23.7977844
4	SBE-6/30	109.8	110.25	0.45	58.44	40.87	18.3928212
5	SBE-6/31	110.25	110.7	0.45	57.73	40.38	18.1693629
6	SBE-6/32	110.7	111.15	0.45	55.80	39.03	17.561934
7	SBE-6/33	111.15	111.65	0.5	48.63	34.01	17.005911
8	SBE-6/34	111.65	112.15	0.5	44.05	30.81	15.404285
9	SBE-6/35	112.15	112.65	0.5	53.21	37.22	18.607537
10	SBE-6/36	112.65	113.15	0.5	55.87	39.08	19.537739
11	SBE-6/37	113.15	113.65	0.5	57.51	40.22	20.111247
12	SBE-6/38	113.65	114.05	0.4	52.69	36.85	14.7405544
13	SBE-6/39	114.05	114.5	0.45	64.12	44.85	20.1804876
14	SBE-6/40	114.5	115.2	0.7	62.32	43.59	30.5106256
Total length $\sum L =$				7.10	Total L x G =		277.899596
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$						39.14 %	

ZONE-III Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/53	121.6	122.15	0.55	54.15	37.87	20.8298805
2	SBE-6/54	122.15	122.65	0.5	52.15	36.47	18.236855
3	SBE-6/55	122.65	123.1	0.45	35.08	24.53	11.0407284
4	SBE-6/56	123.1	123.55	0.45	57.88	40.48	18.2165724
5	SBE-6/57	123.55	124.15	0.6	58.63	41.01	24.6034932
6	SBE-6/58	124.15	124.65	0.5	64.47	45.09	22.545159
7	SBE-6/59	124.65	125.15	0.5	59.17	41.38	20.691749
8	SBE-6/60	125.15	125.65	0.5	67.37	47.12	23.559289
				4.05	Total L x G =		159.7237265
Zone -III Avg. grade i.e. $\sum L \times G / \sum L =$						39.44 %	

ZONE-IV Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/94	146.55	147.3	0.75	59.89	41.89	31.4152995
2	SBE-6/95	147.3	147.7	0.4	60.79	42.52	17.0066104
3	SBE-6/96	147.7	148.15	0.45	53.05	37.10	16.6964265
4	SBE-6/97	148.15	148.75	0.6	56.51	39.52	23.7138564
5	SBE-6/98	148.75	149.15	0.4	59.88	41.88	16.7520288
6	SBE-6/99	149.15	149.55	0.4	60.19	42.10	16.8387544
7	SBE-6/100	149.55	150.05	0.5	62.91	44.00	21.999627
8	SBE-6/101	150.05	150.55	0.5	60.32	42.19	21.093904
9	SBE-6/102	150.55	151.1	0.55	58.13	40.66	22.3608671
10	SBE-6/103	151.1	151.65	0.55	55.12	38.55	21.2030104
11	SBE-6/104	151.65	152.2	0.55	52.47	36.70	20.1836349
12	SBE-6/105	152.2	152.75	0.55	58.94	41.22	22.6724498
13	SBE-6/106	152.75	153.25	0.5	61.64	43.11	21.555508
Total length $\sum L =$				6.70	Total L x G =		273.4919772
Zone -IV Avg. grade i.e. $\sum L \times G / \sum L =$						40.82 %	

ZONE-V Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-6/115	157.25	157.7	0.45	58.30	40.78	18.348759
2	SBE-6/116	157.7	158.1	0.4	56.61	39.59	15.8372136
3	SBE-6/117	158.1	158.75	0.65	61.36	42.92	27.8948696
4	SBE-6/118	158.75	159.4	0.65	54.06	37.81	24.5762166
5	SBE-6/119	159.4	160.05	0.65	50.72	35.47	23.0578192
Total length $\sum L =$				2.80	Total L x G =		109.714878
Zone -V Avg. grade i.e. $\sum L \times G / \sum L =$						39.18 %	

BH NO : SBE-7

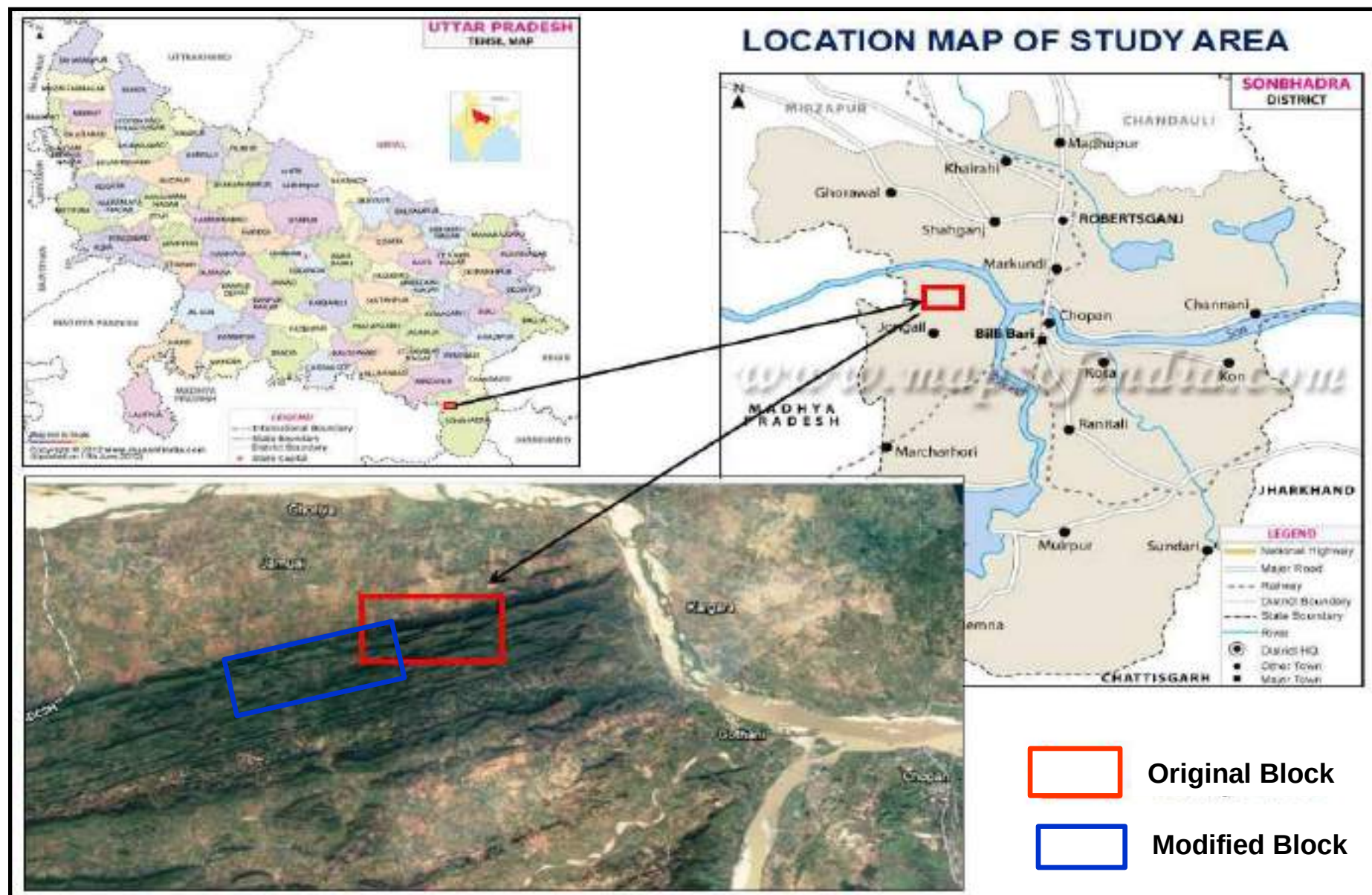
ZONE-I Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-7/25M	63.80	64.50	0.7	51.06	35.71	24.9979548
2	SBE-7/26M	64.50	65.50	1	51.81	36.24	36.235914
3	SBE-7/27M	65.50	66.60	1.1	51.09	35.73	39.3055806
4	SBE-7/28M	66.60	67.60	1	50.27	35.16	35.158838
5	SBE-7/29M	67.60	68.40	0.8	54.9	38.40	30.717648
6	SBE-7/30M	68.40	69.50	1.1	52.27	36.56	40.2134018
7	SBE-7/31M	69.50	70.40	0.9	58.4	40.84	36.760464
8	SBE-7/32M	70.40	71.25	0.85	47.86	33.47	28.4522914
9	SBE-7/33M	71.25	72.10	0.85	48.81	34.14	29.0170569
10	SBE-7/34M	72.10	73.30	1.2	46.47	32.50	39.0013416
11	SBE-7/35M	73.30	74.50	1.2	49.72	34.77	41.7290016
12	SBE-7/36M	74.50	75.45	0.95	49.65	34.73	32.9889495
Total length $\sum L =$				11.65	Total L x G =		414.5784422
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$						35.59 %	

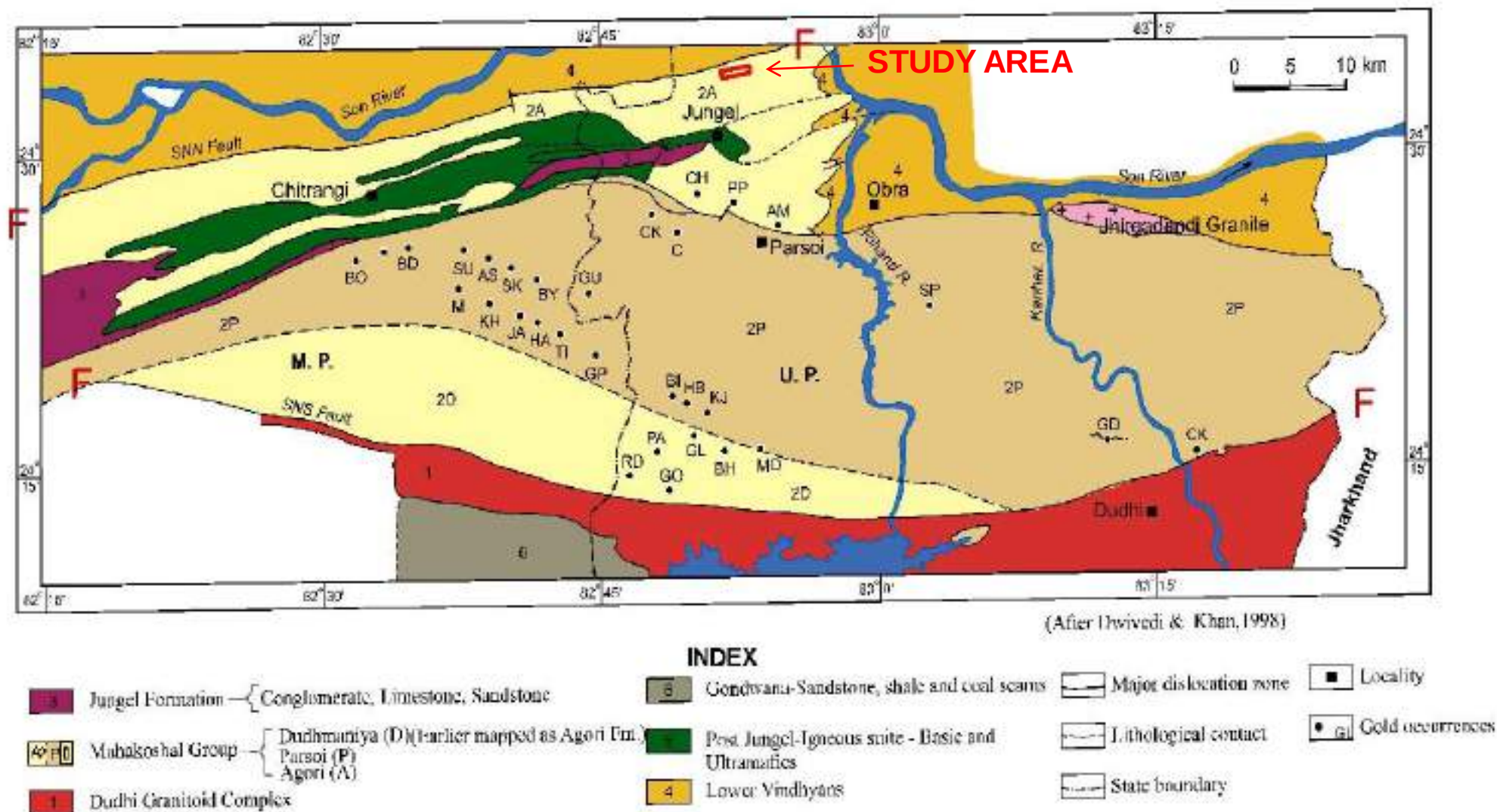
ZONE-II Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	SBE-7/39M	77.00	78.10	1.1	53.62	37.50	41.2520108
2	SBE-7/40M	78.10	79.10	1	57.97	40.54	40.544218
3	SBE-7/41M	79.10	80.05	0.95	54.28	37.96	36.0652604
4	SBE-7/42M	80.05	81.00	0.95	62.21	43.51	41.3341903
5	SBE-7/43M	81.00	82.00	1	59.54	41.64	41.642276
6	SBE-7/44M	82.00	83.20	1.2	53.11	37.15	44.5741608
7	SBE-7/45M	83.20	84.20	1	47.57	33.27	33.270458
8	SBE-7/46M	84.20	85.40	1.2	49.71	34.77	41.7206088
9	SBE-7/47M	85.40	86.50	1.1	54.28	37.96	41.7597752
10	SBE-7/48M	86.50	87.80	1.3	50.50	35.32	45.91561
11	SBE-7/49M	87.80	88.80	1	59.82	41.84	41.838108
12	SBE-7/50M	88.80	89.85	1.05	53.54	37.45	39.3181698
Total length $\sum L =$				12.85	Total L x G =		489.2348461
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$						38.07%	

Location Map of the investigated area

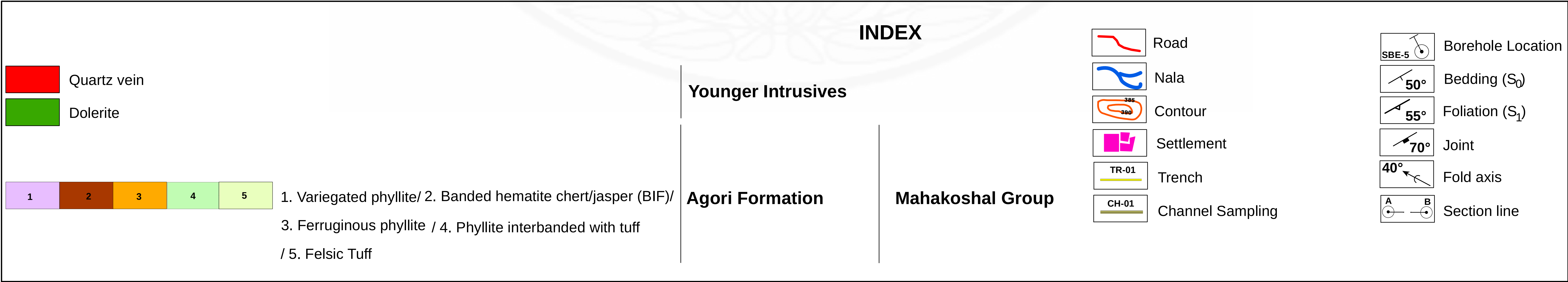
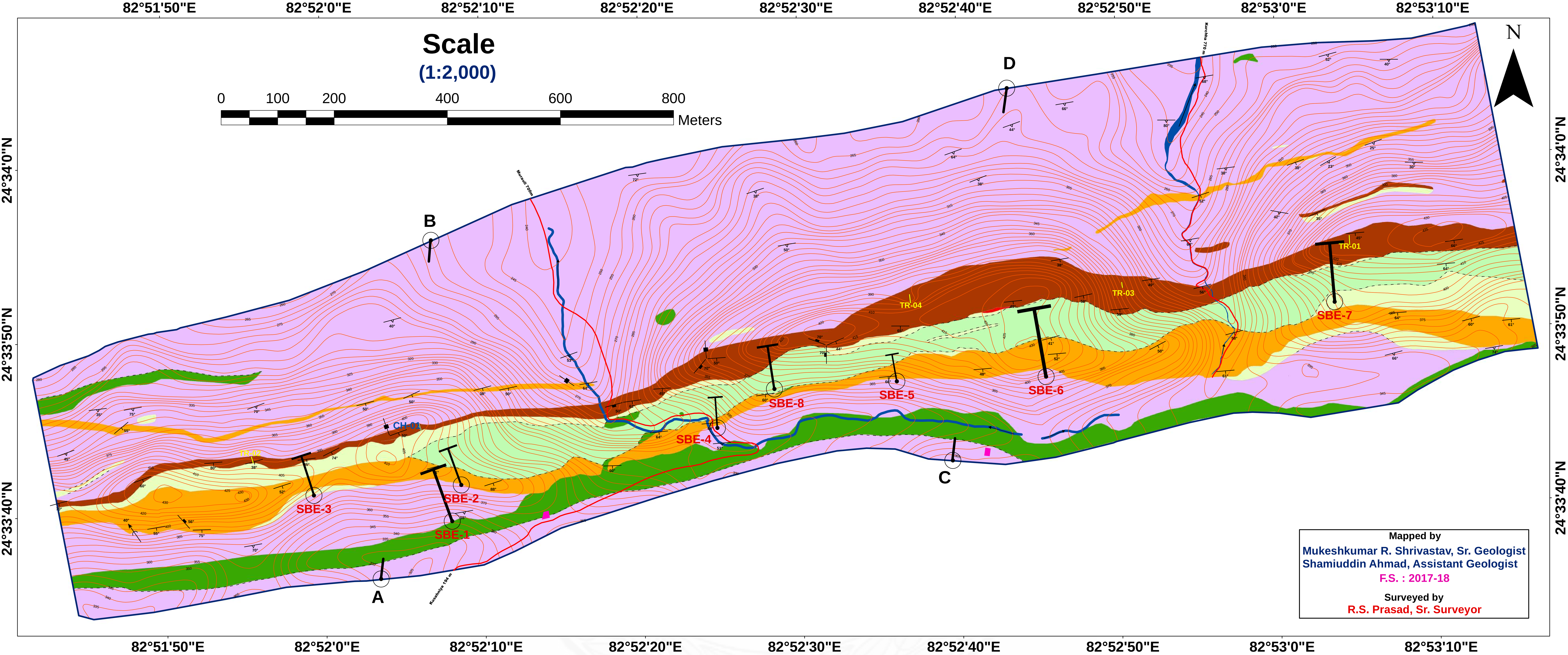


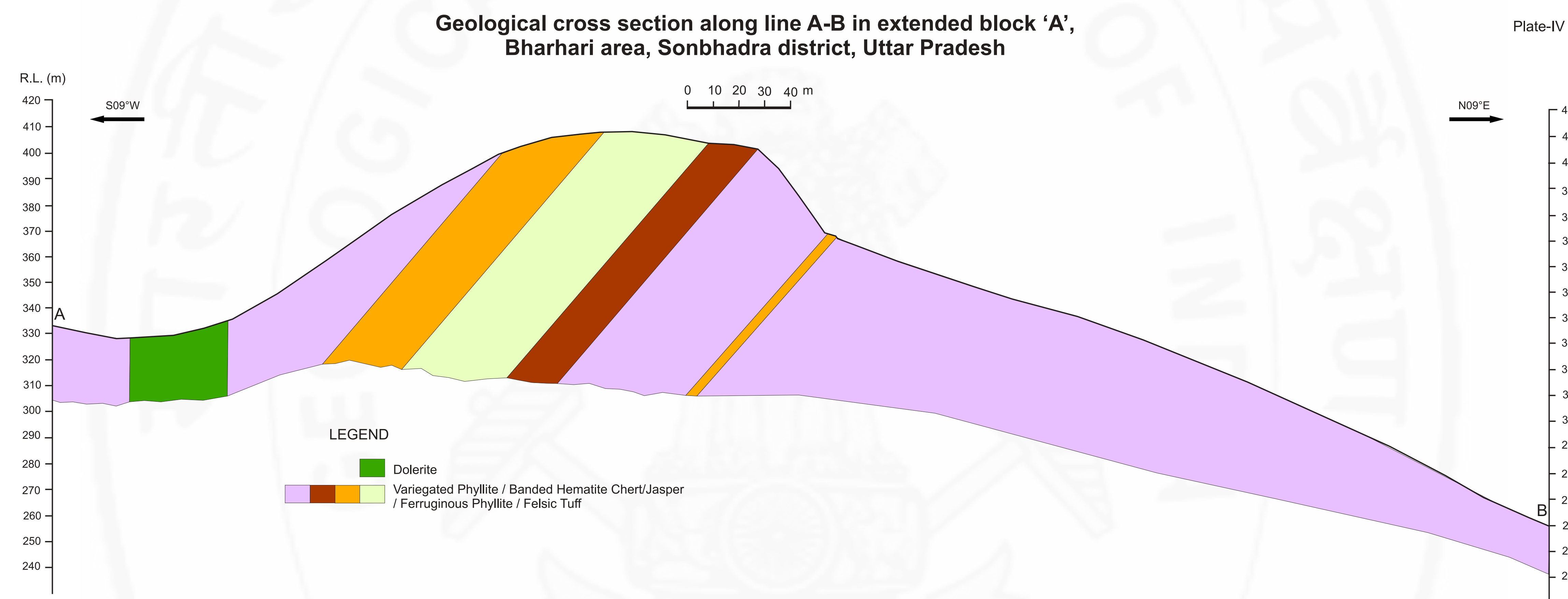
Regional geological map of the area



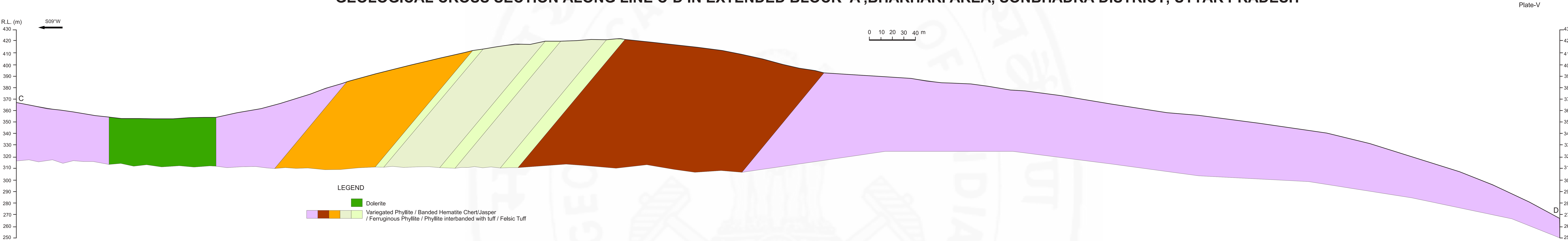
DETAILED GEOLOGICAL MAP OF EXTENDED BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH

(Part of Toposheet No. 63L/14)

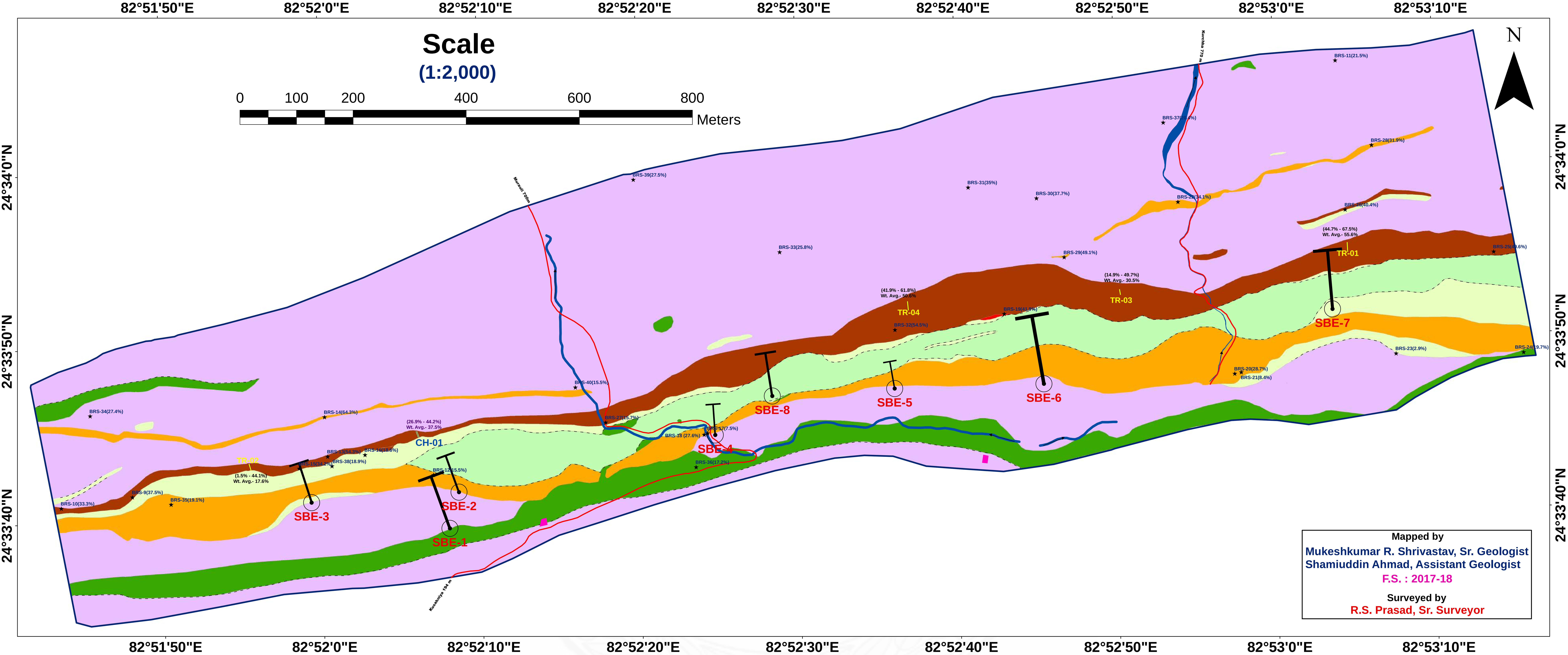




GEOLOGICAL CROSS SECTION ALONG LINE C-D IN EXTENDED BLOCK ‘A’,BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH

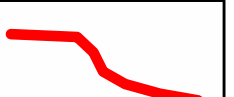
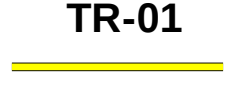
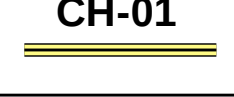
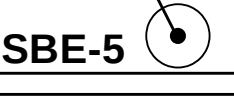


SAMPLE LOCATIONS WITH Fe₂O₃% OF EXTENDED BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH
(Part of Toposheet No. 63L/14)



Mapped by
Mukeshkumar R. Shrivastav, Sr. Geologist
Shamiuddin Ahmad, Assistant Geologist
F.S. : 2017-18
Surveyed by
R.S. Prasad, Sr. Surveyor

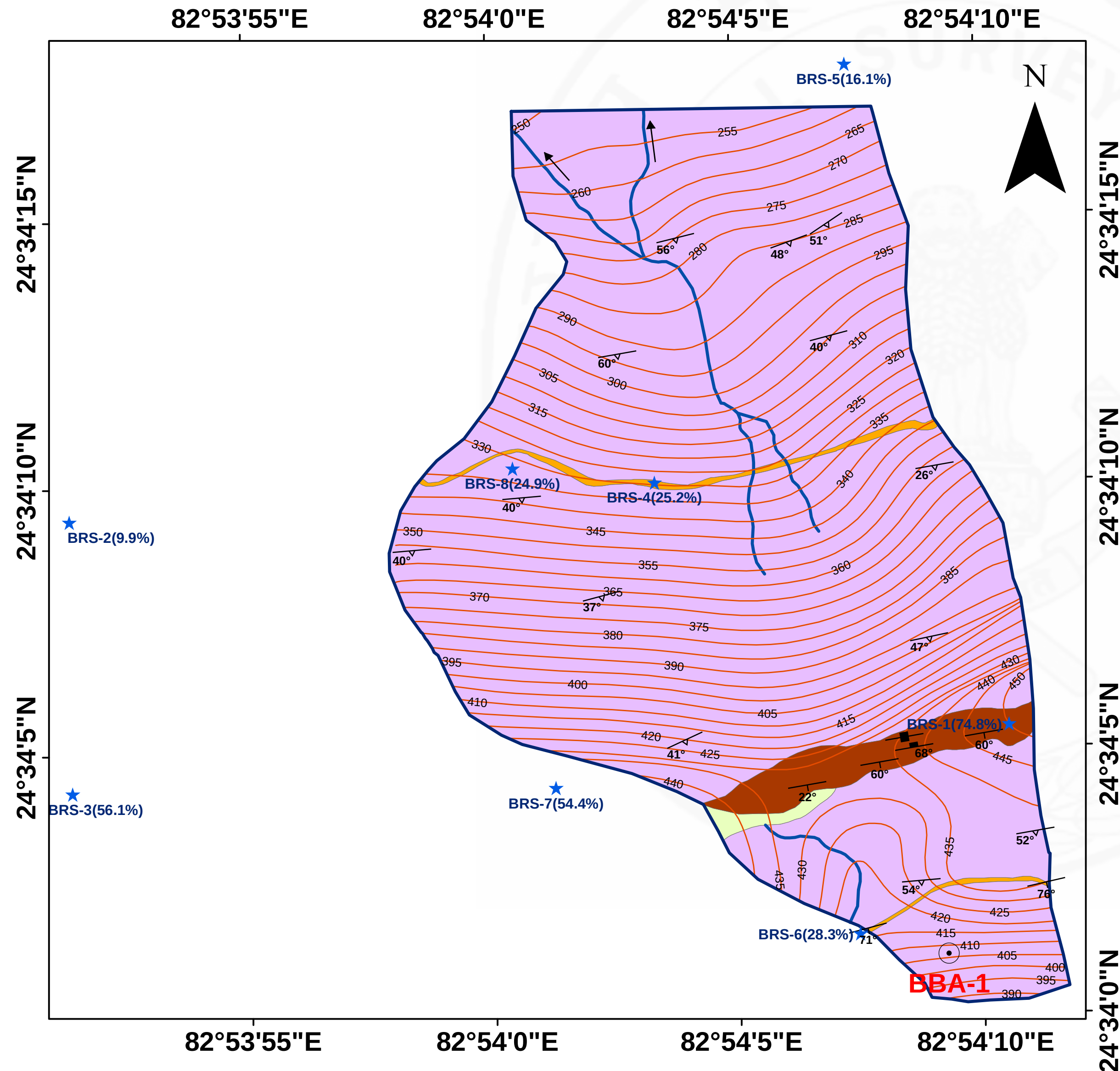
INDEX					
	Quartz vein				
	Dolerite				
	1. Variegated phyllite/		2. Banded hematite chert/jasper (BIF)/	Younger Intrusives	
	3. Ferruginous phyllite / 4. Phyllite interbanded with tuff		5. Felsic Tuff		Agori Formation
					

	Road
	Nala
	Settlement
	Trench with Fe ₂ O ₃ %
	Channel Sampling with Fe ₂ O ₃ %
	Borehole Location
	Sample Location with Fe ₂ O ₃ %

DETAILED GEOLOGICAL MAP (Part) OF PROPOSED BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT, U.P.

(Part of Toposheet No. 63L/14)

Scale
(Scale 1:2,000)



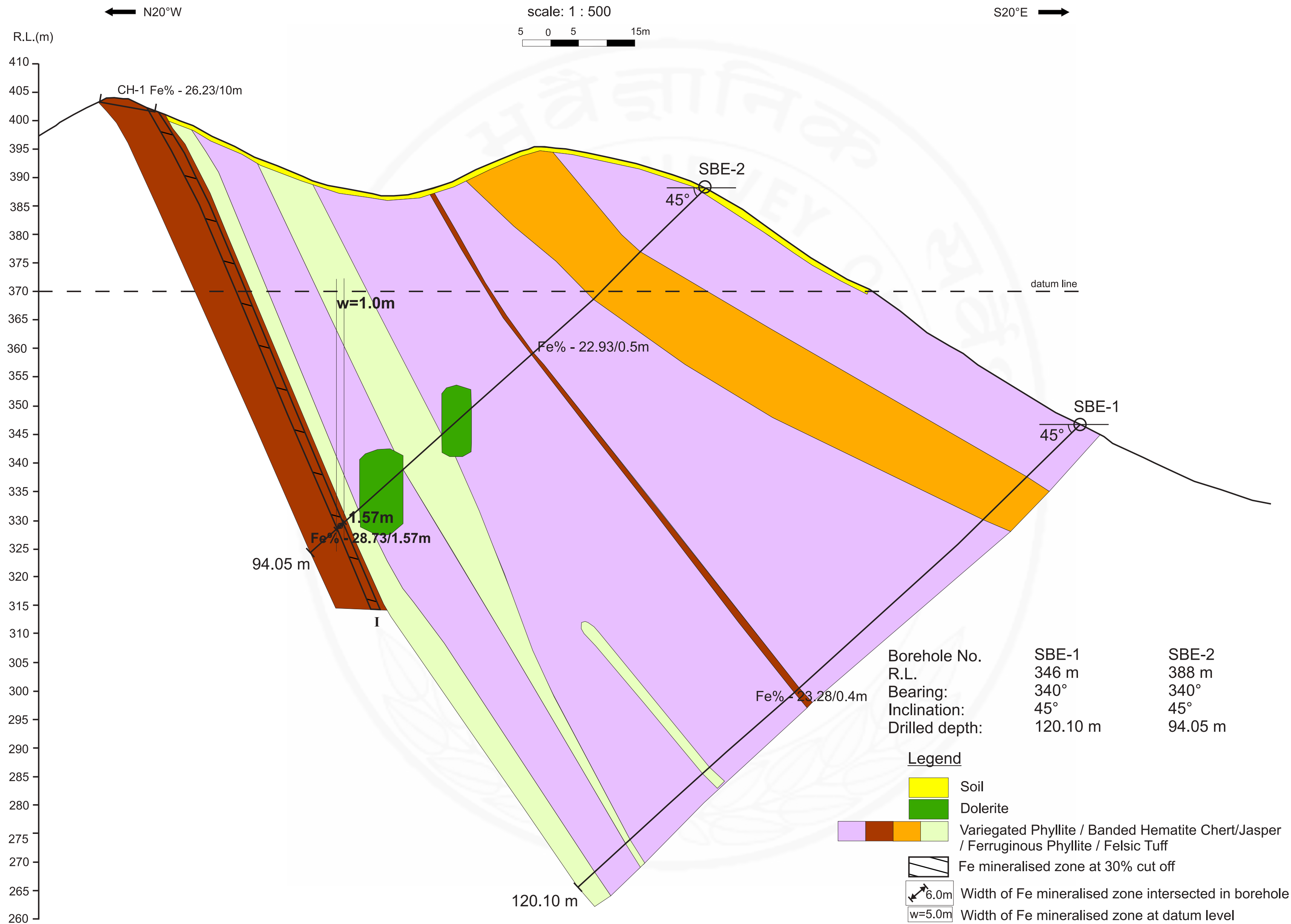
INDEX

	Variegated phyllite
	Banded hematite chert/jasper
	Ferruginous phyllite
	Felsic Tuff
	Nala
	Contour
	Borehole (not drilled)
	Bedding (S_0)
	Foliation (S_1)
	Joint
	Sample Location with $Fe_2O_3\%$

Mapped by
Mukeshkumar R. Shrivastav, Sr. Geologist
Shamiuddin Ahmad, Assistant Geologist
F.S. : 2017-18
Surveyed by
R.S. Prasad, Sr. Surveyor

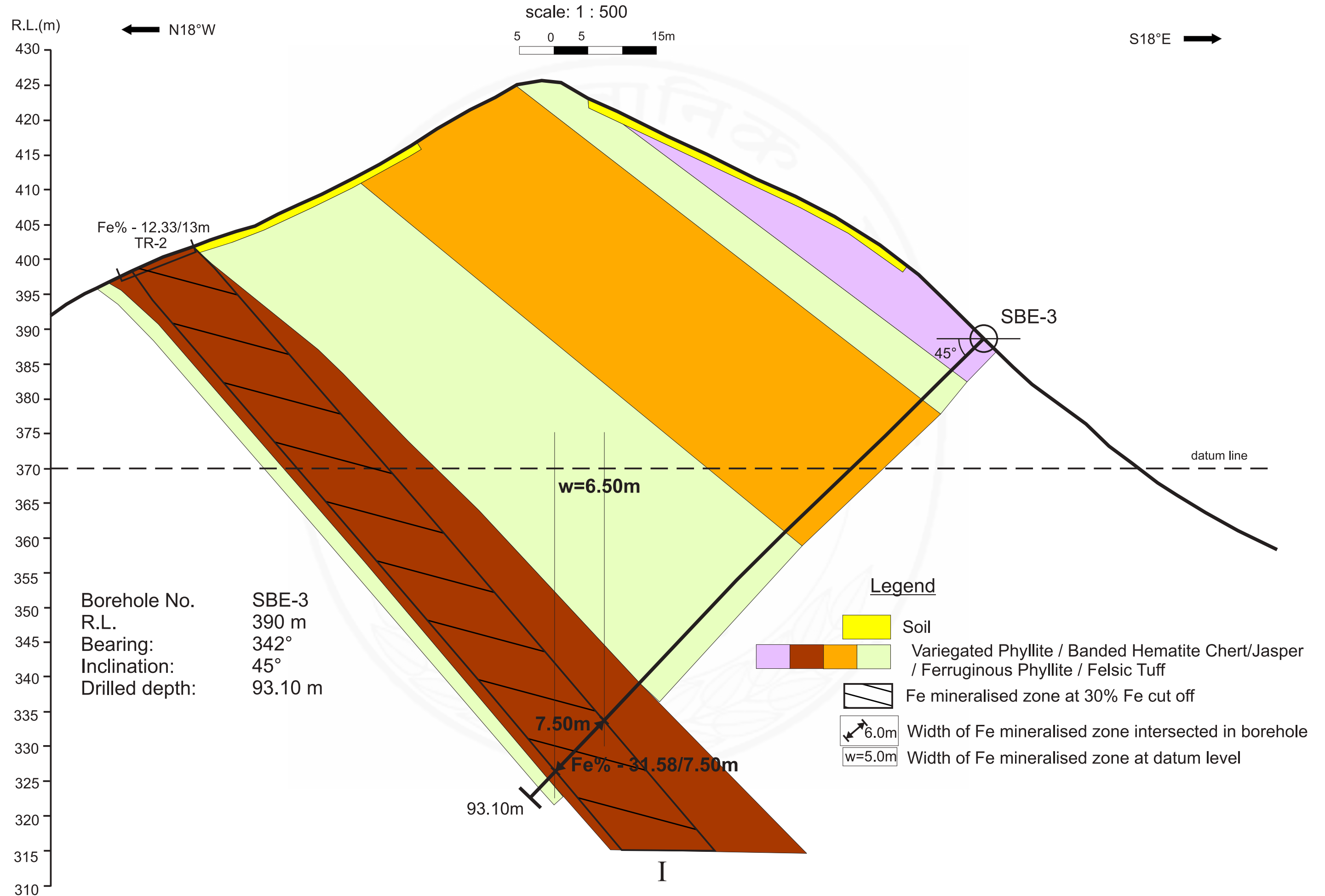
Geological section along boreholes SBE-1 and SBE-2,
extended block 'A', Bharhari area, Sonbhadra district, Uttar Pradesh.

Plate-VIII



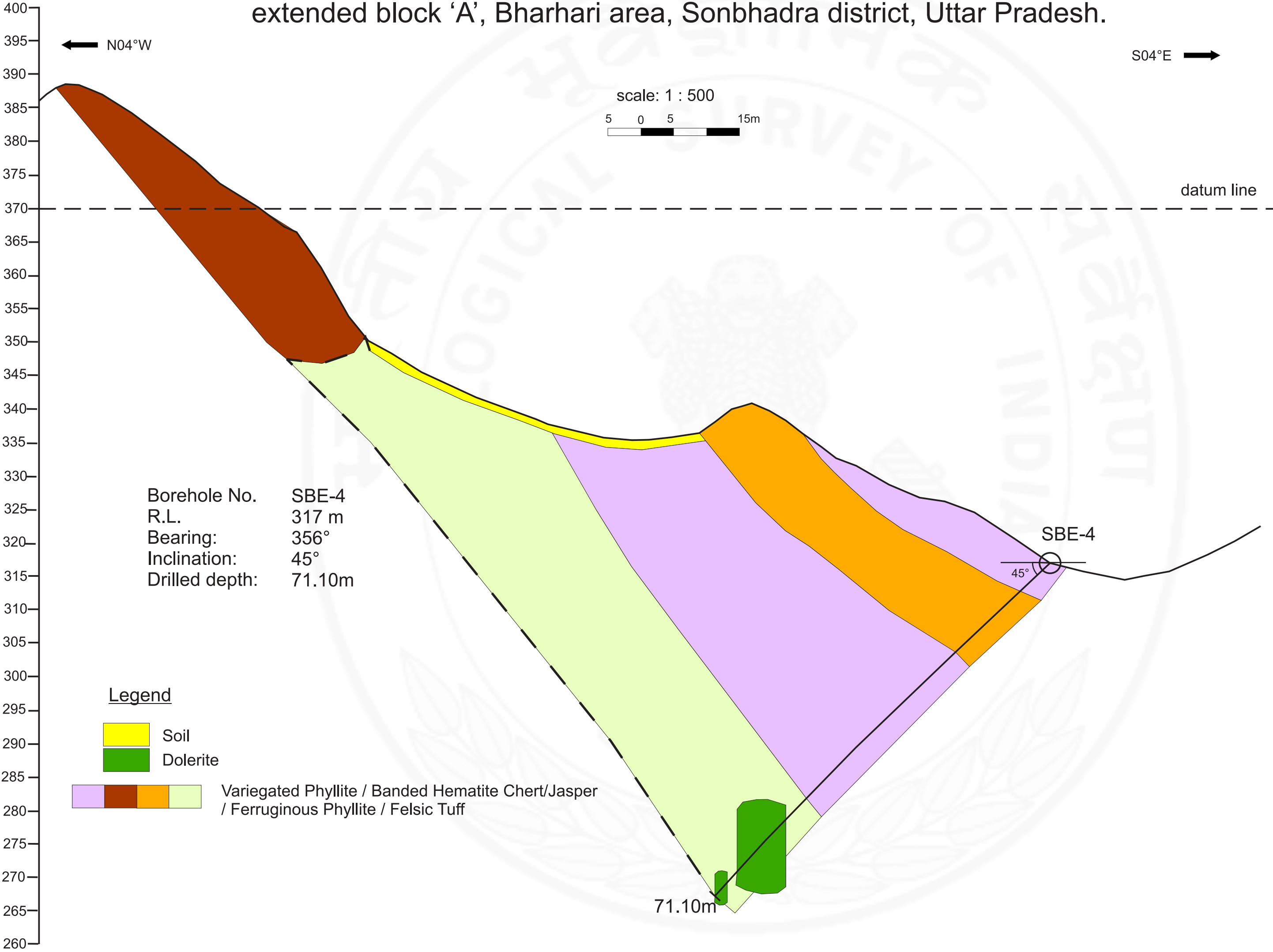
Geological section along borehole SBE-3, extended block 'A', Bharhari area, Sonbhadra district, Uttar Pradesh.

Plate-IX

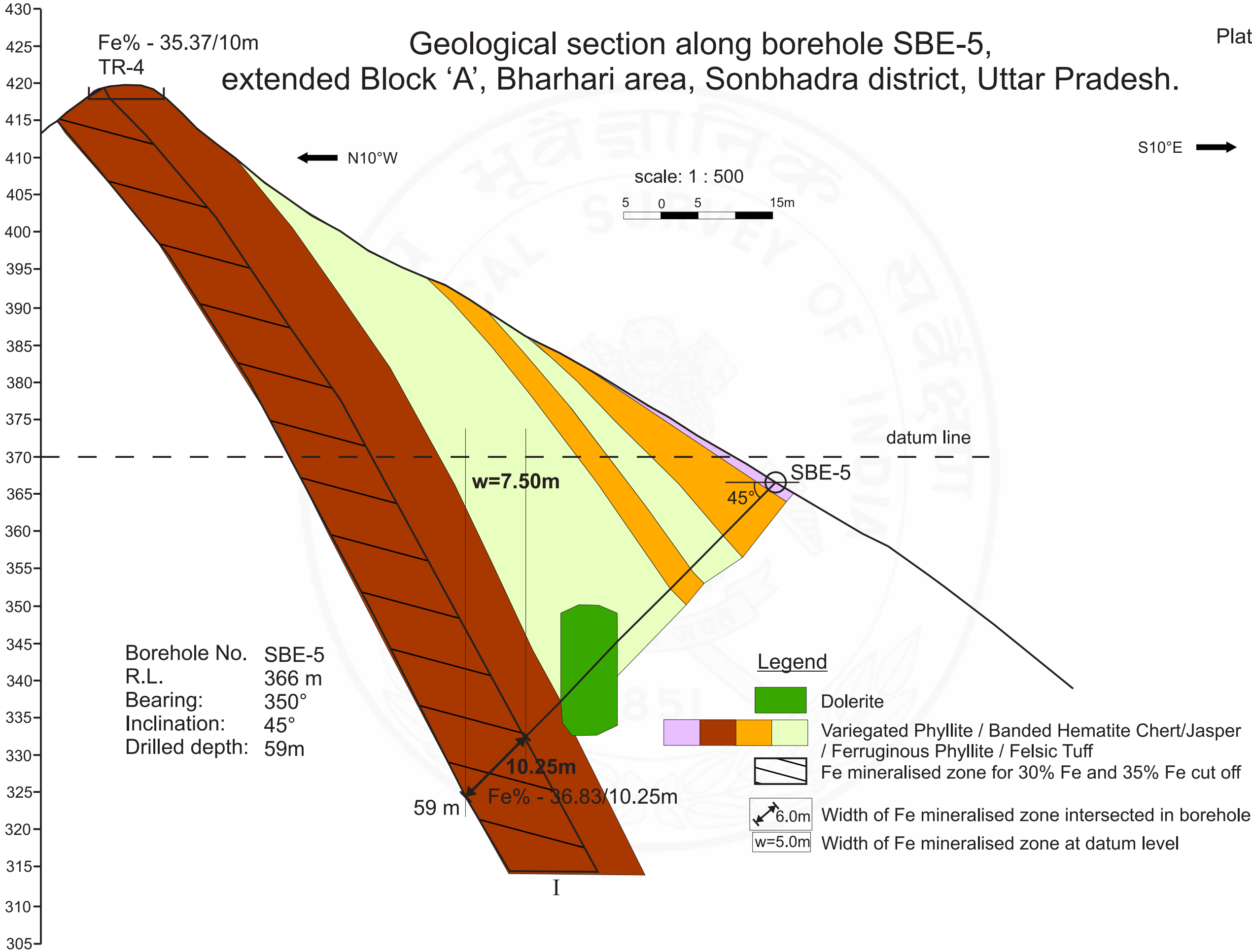


Geological section along borehole SBE-4,
extended block 'A', Bharhari area, Sonbhadra district, Uttar Pradesh.

Plate-X

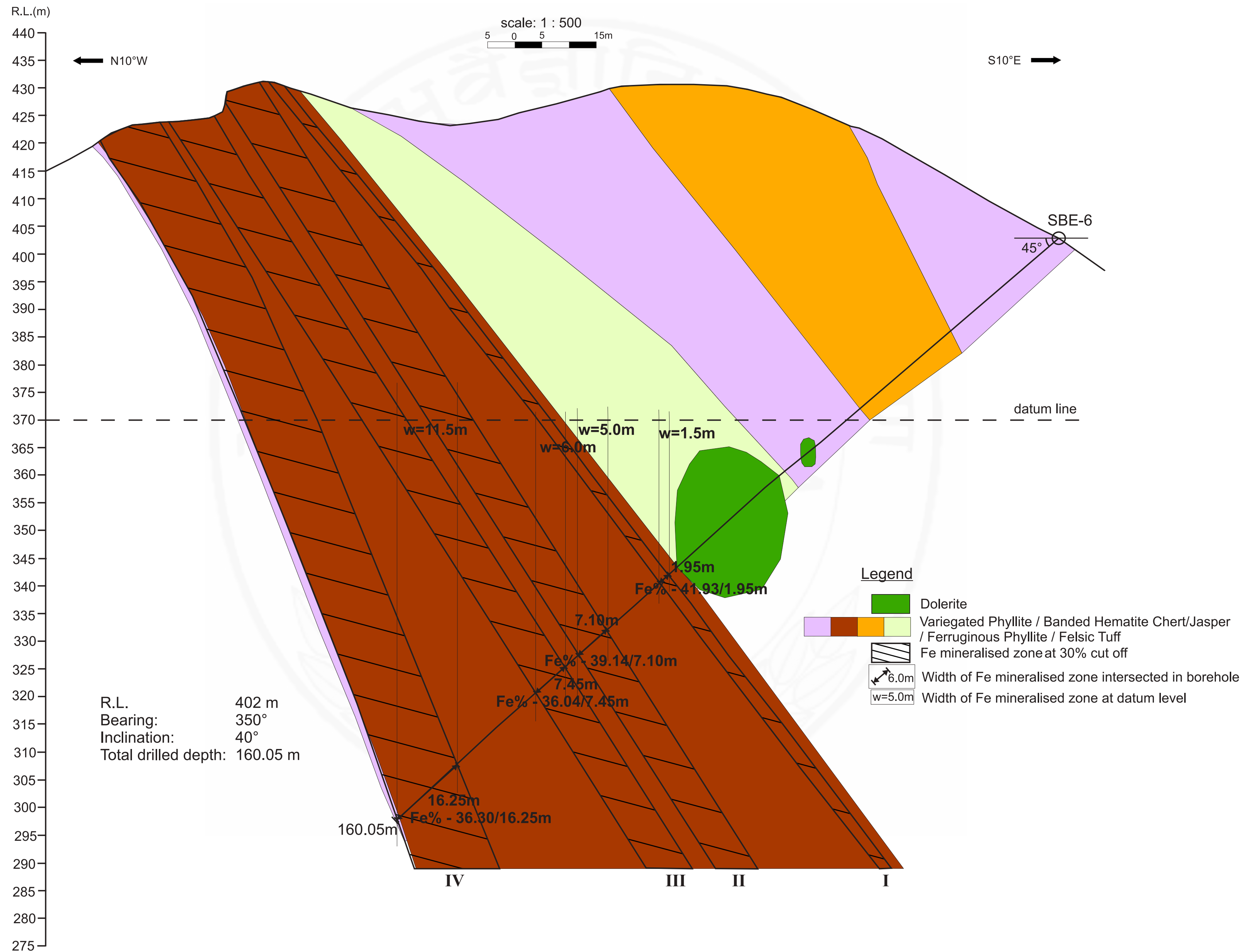


Geological section along borehole SBE-5,
extended Block 'A', Bharhari area, Sonbhadra district, Uttar Pradesh.



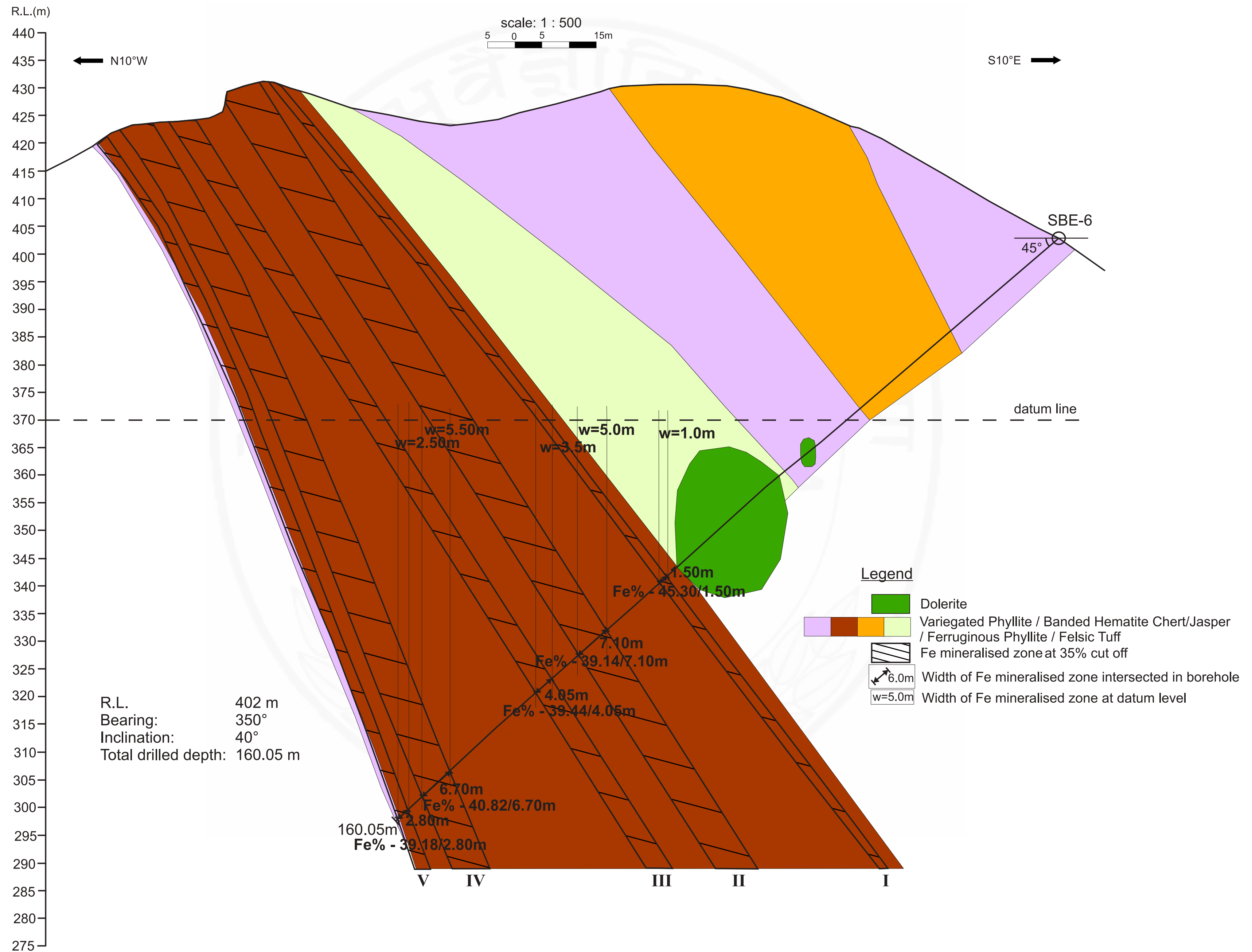
Geological section along borehole SBE-6 in extended block 'A', Bharhari area, Sonbhadra district, Uttar Pradesh. (at Fe - 30% cut off)

Plate-XII-A



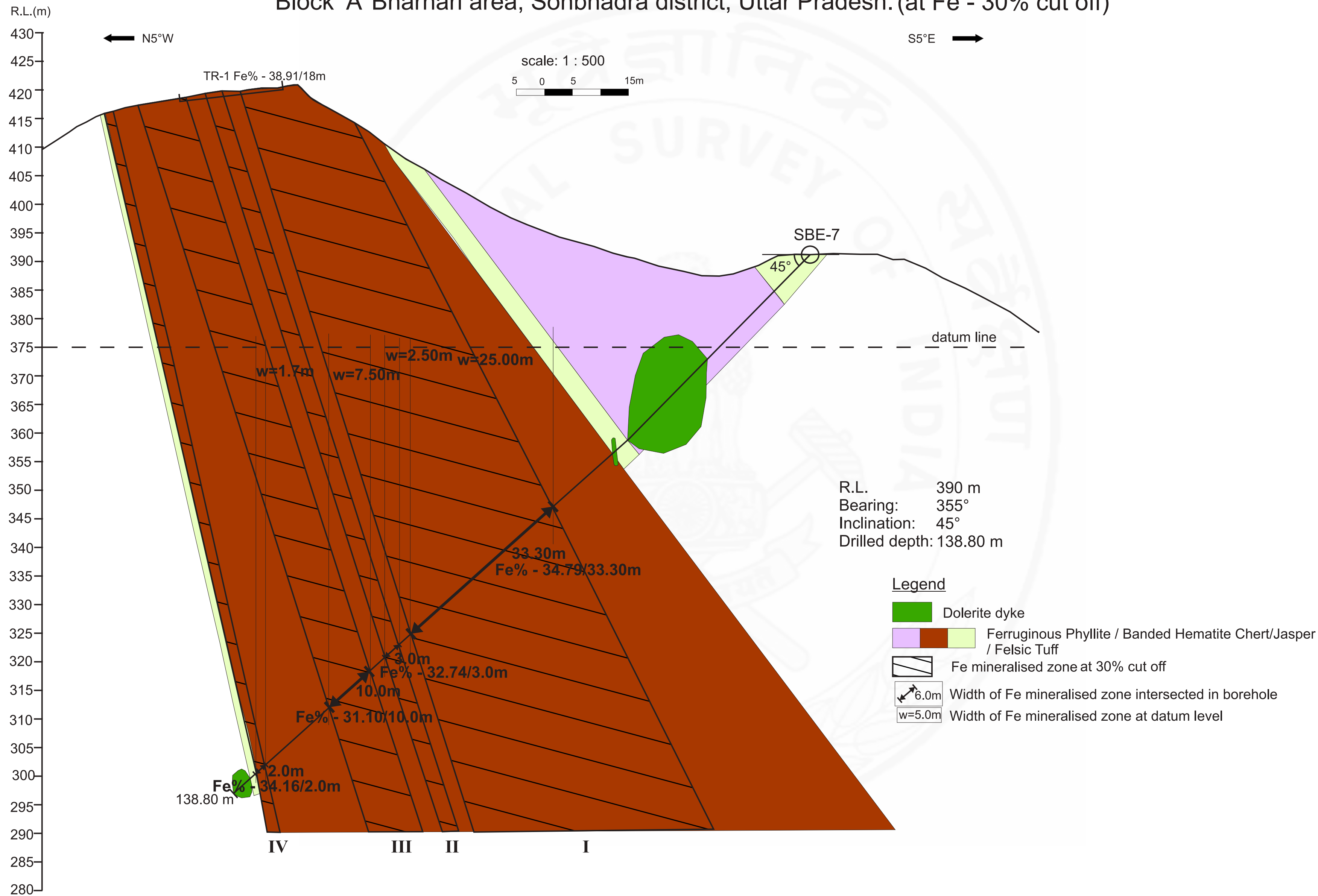
Geological section along borehole SBE-6 in extended block 'A', Bharhari area, Sonbhadra district, Uttar Pradesh. (at Fe - 35% cut off)

Plate-XII-B



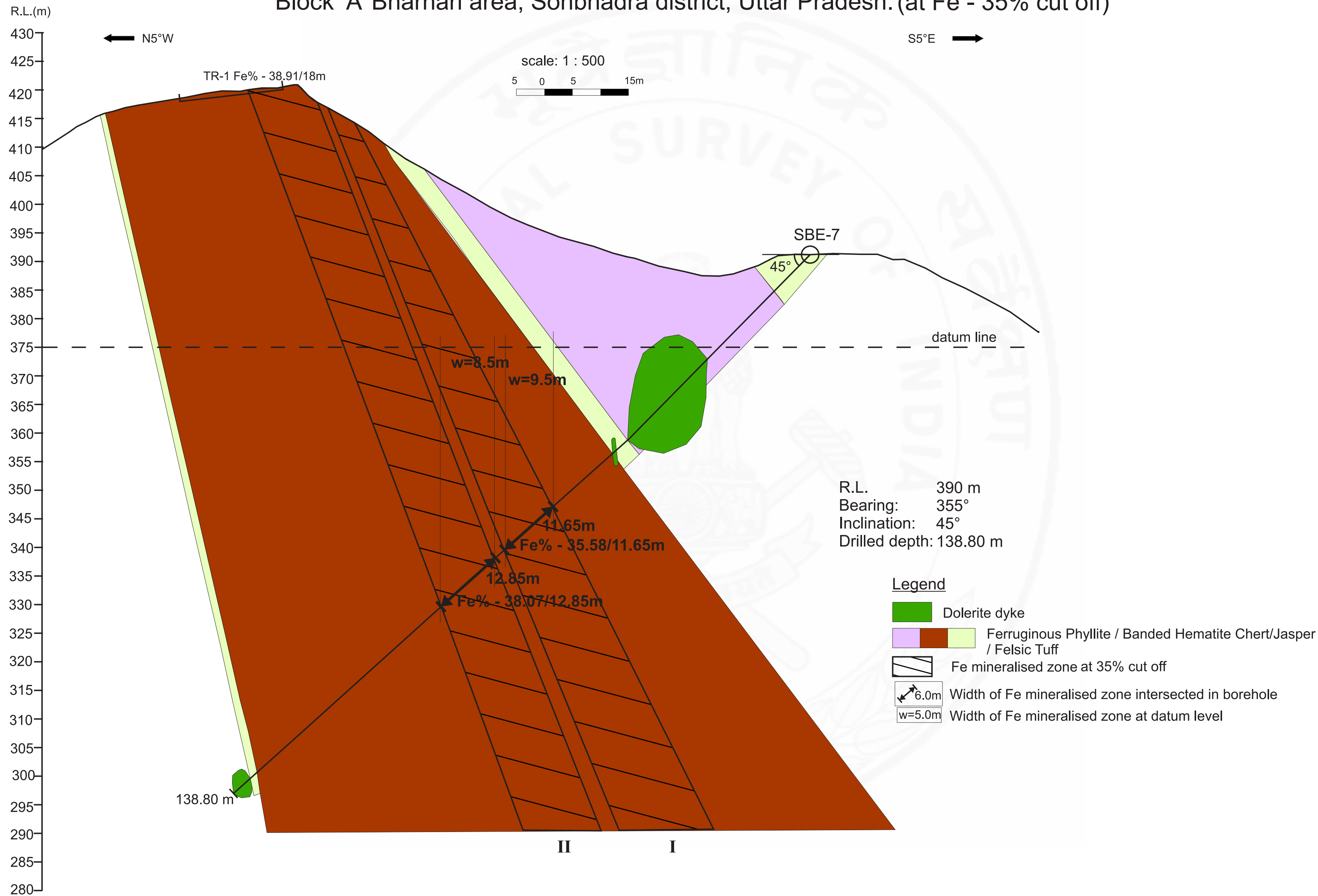
Geological section along borehole SBE-7 in extended Block 'A' Bharhari area, Sonbhadra district, Uttar Pradesh. (at Fe - 30% cut off)

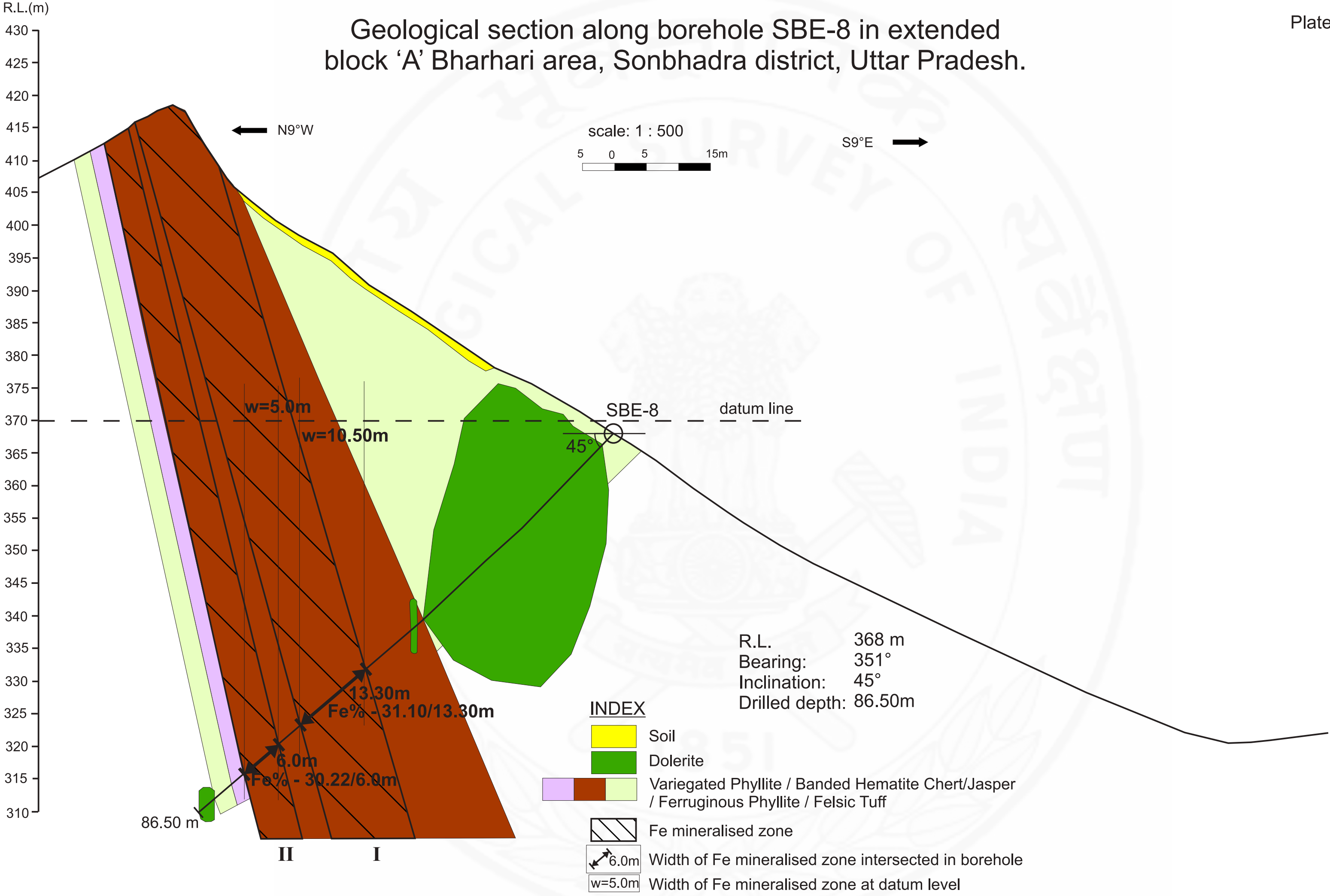
Plate-XIII-A



Geological section along borehole SBE-7 in extended Block 'A' Bharhari area, Sonbhadra district, Uttar Pradesh. (at Fe - 35% cut off)

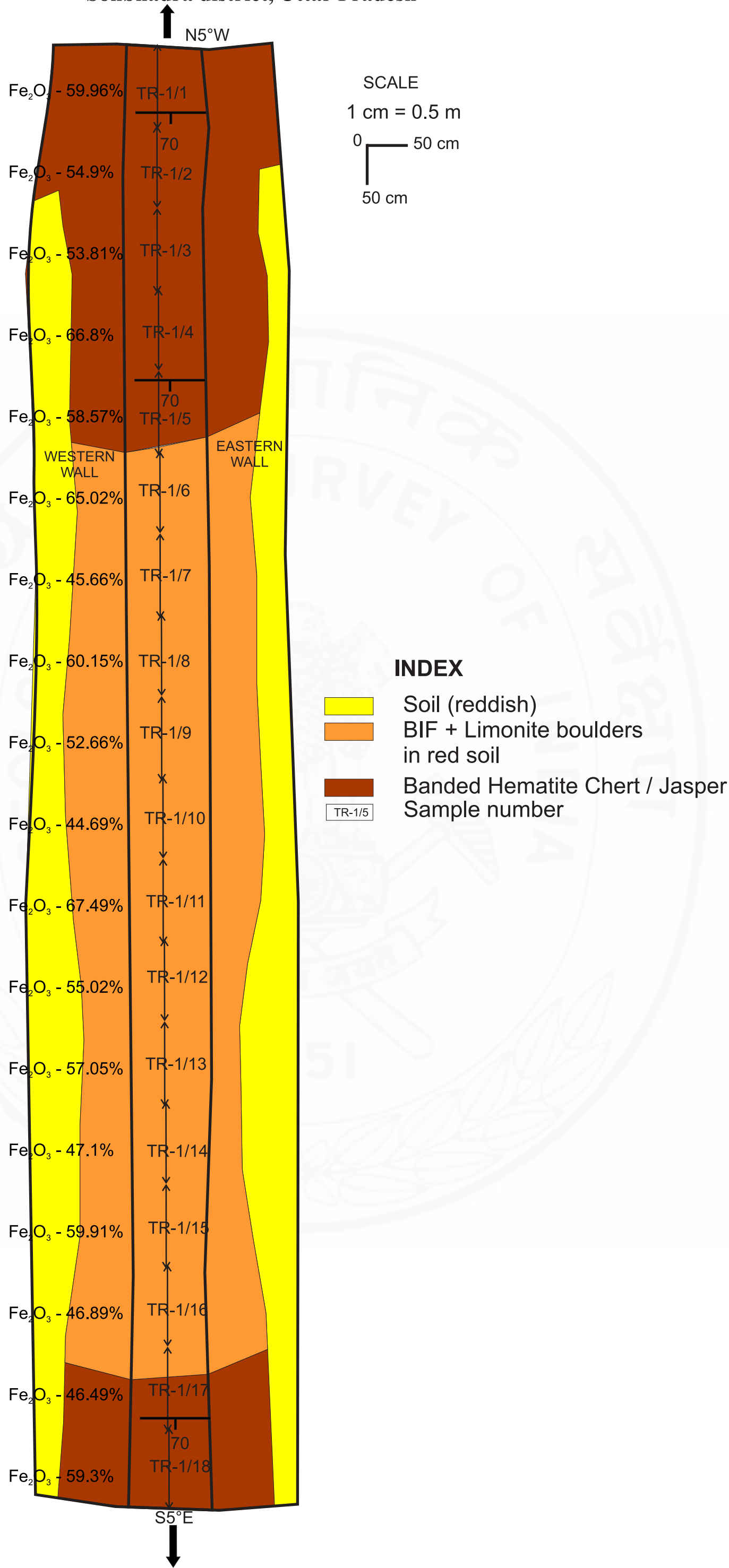
Plate-XIII-B





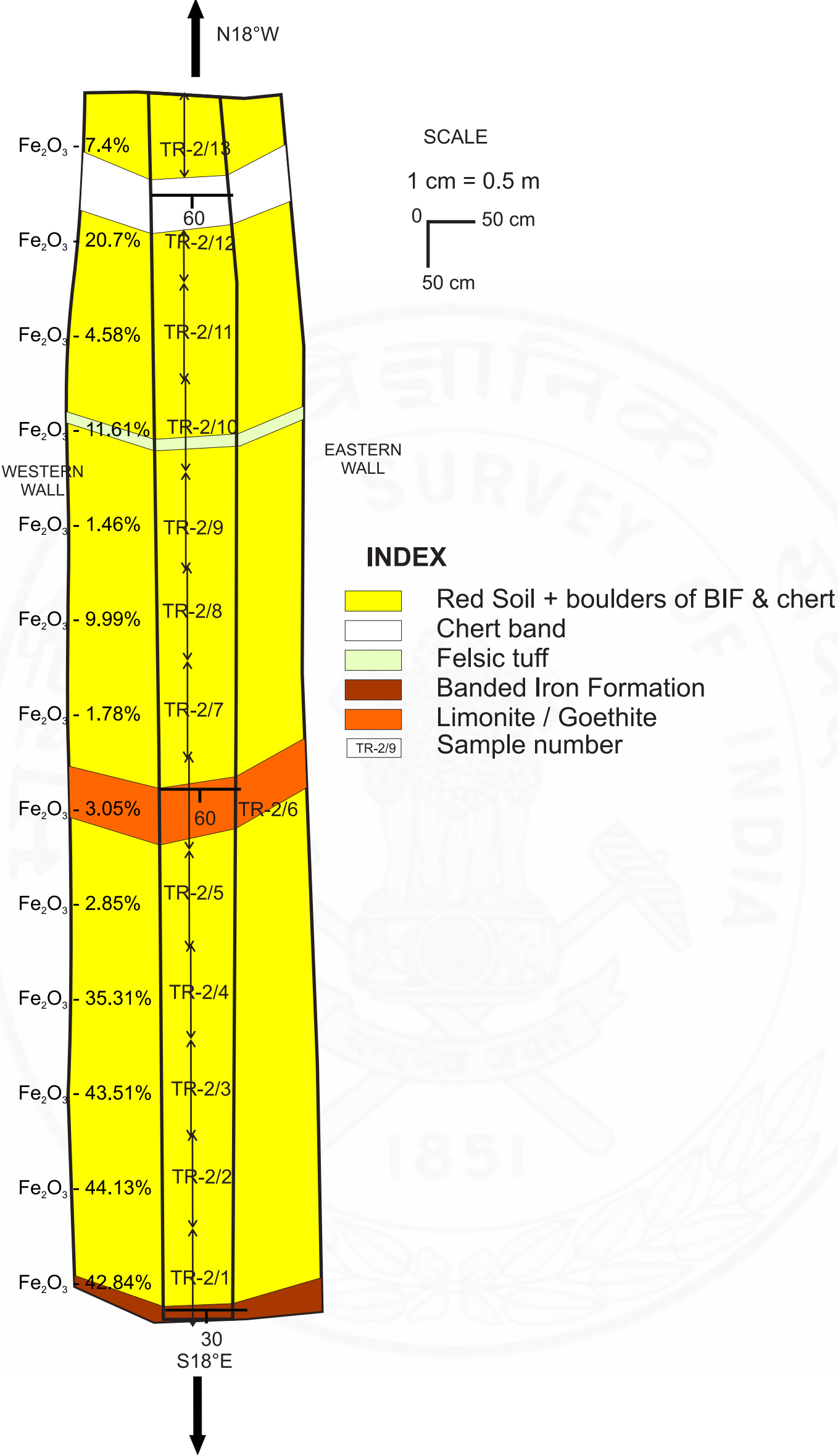
Trench log of TR-1 block – 'A', Bharhari area,
Sonbhadra district, Uttar Pradesh

PLATE - XV



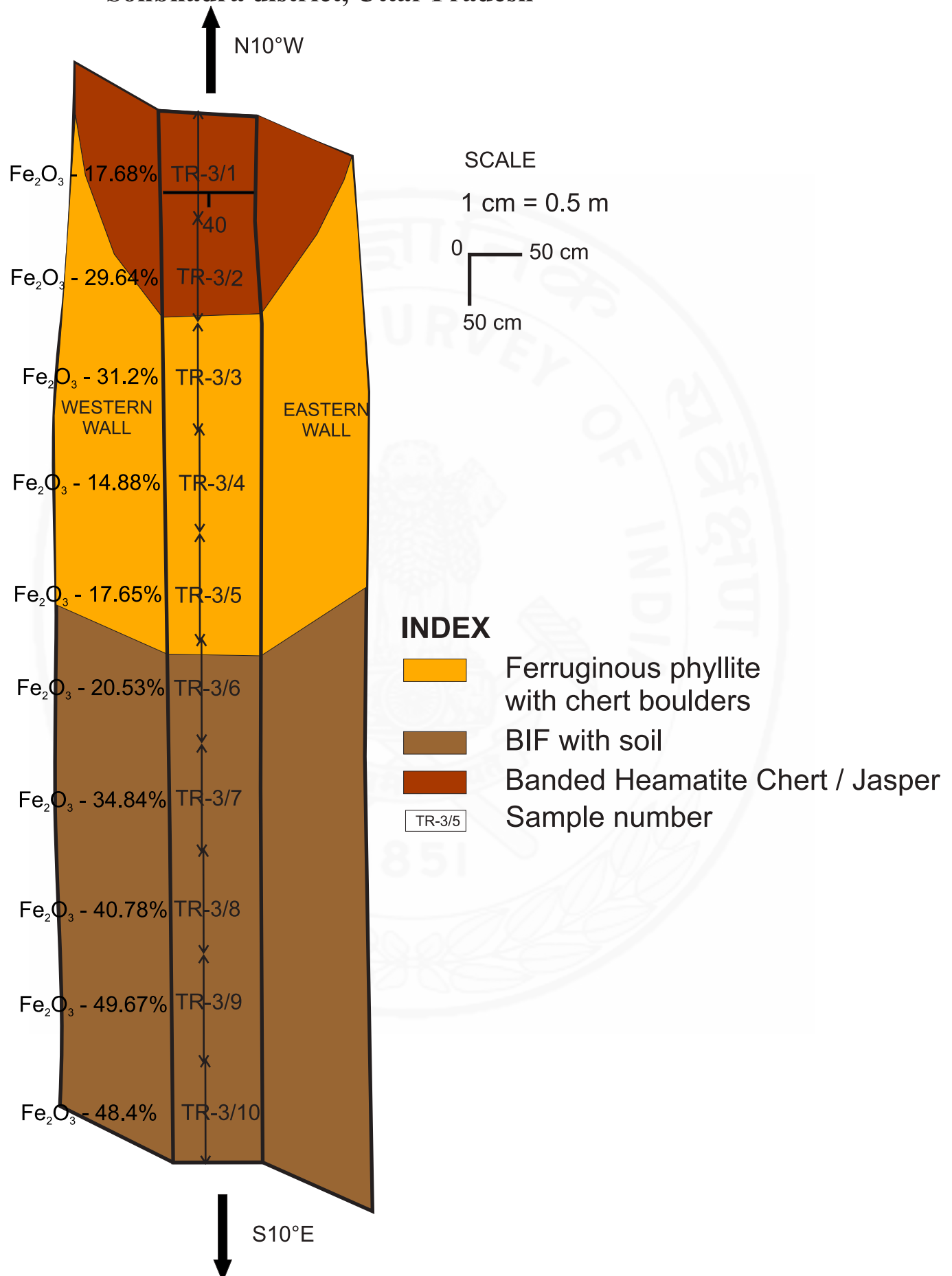
Trench log of TR-2 block – 'A', Bharhari area,
Sonbhadra district, Uttar Pradesh

PLATE - XVI



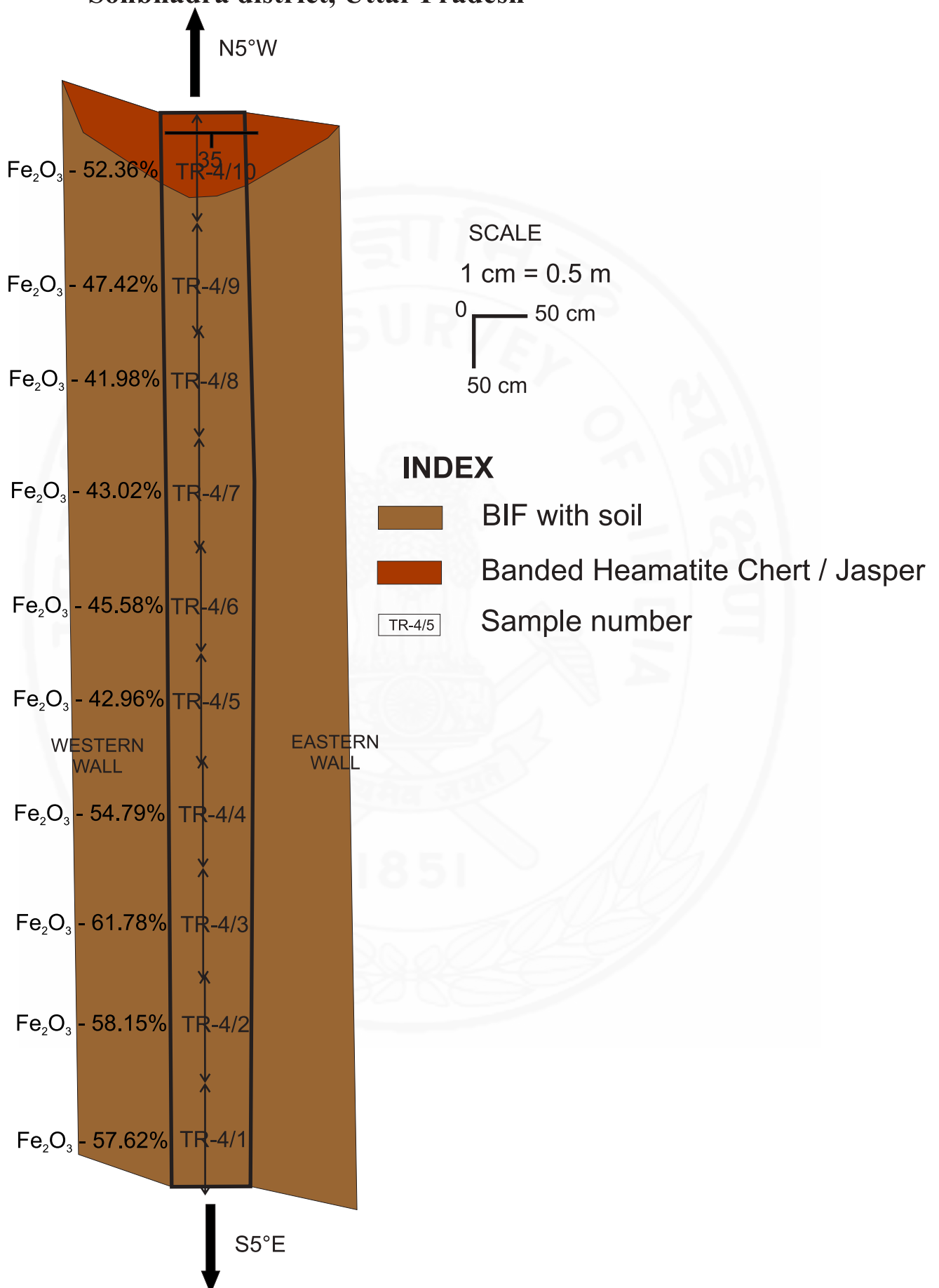
Trench log of TR-3 block – 'A', Bharhari area, Sonbhadra district, Uttar Pradesh

PLATE - XVII

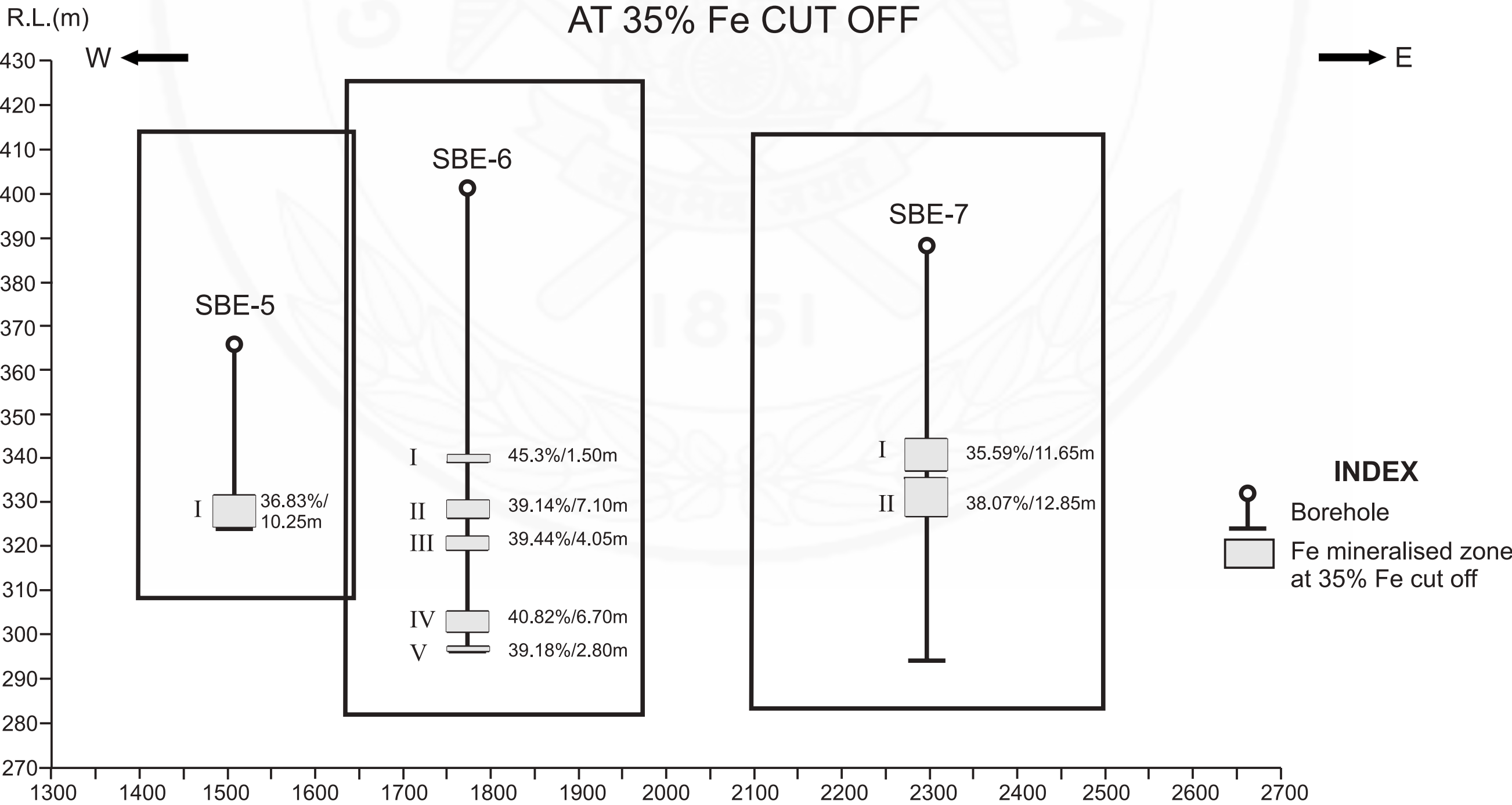
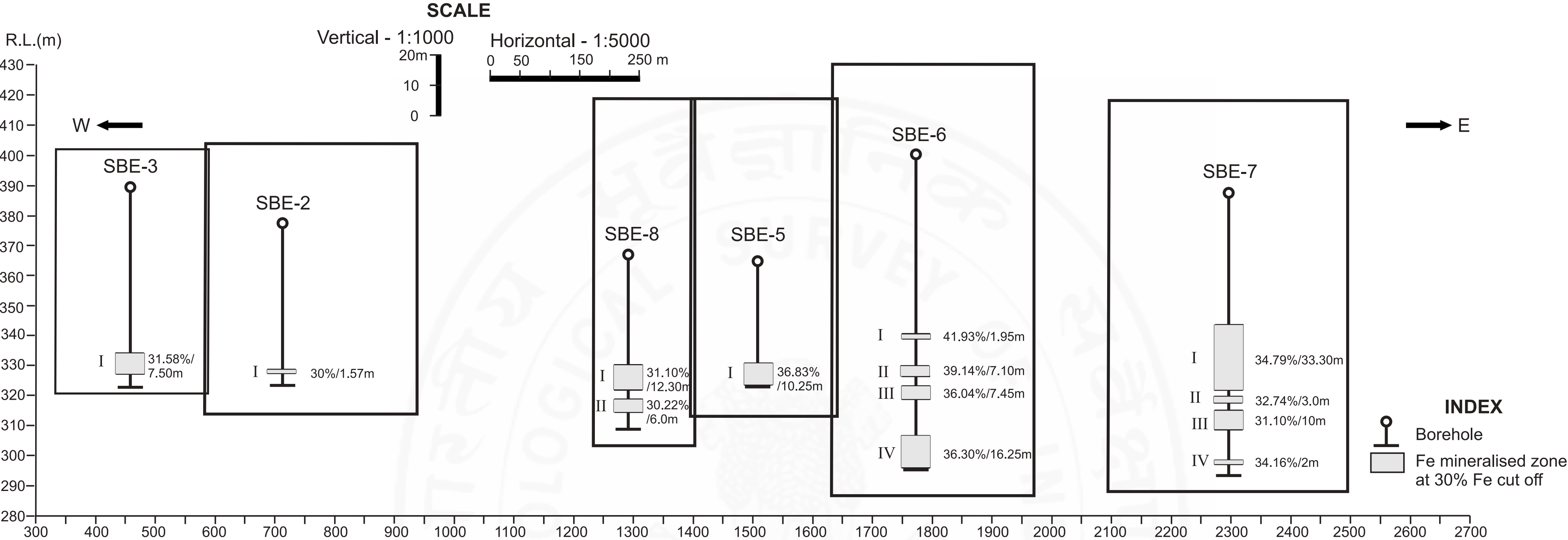


**Trench log of TR-4 block – 'A', Bharhari area,
Sonbhadra district, Uttar Pradesh**

PLATE - XVIII



LONGITUDINAL VERTICAL SECTION OF BOREHOLES AT 30% Fe CUT OFF,
BLOCK 'A', BHARHARI AREA, SONBHADRA, UTTAR PRADESH



FIVE POINT PROFORMA

Title of the report:

PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH. (Stage - G3)

Authors:

Mukeshkumar Rajkumar Shrivastav, Senior Geologist,
Shamiuddin Ahmad, Asstt. Geologist

1. Background of information i.e. whose instance or with what particular objective in view the investigation was undertaken

The NGCM was carried out by Sarkar et. al. during F.S. 2013-14 in toposheet no 63L/14 and shows high Fe_2O_3 (>14%) value in the composite samples. Geophysical mapping carried out during F.S. 2009-2012 has also revealed a gravity high supplemented with high magnetic values in the southern part of the Toposheet No. 63 L/14. Shri Modak et. al. carried out large scale mapping on 1:12500 scale covering parts of toposheet 63 L/14 during FS 2014-15. The total strike length of these Banded hematite chert / jasper bands is around 20 kms and width varies from 2m to 10m with cumulative width of 170 m to 450 m. The value of Fe_2O_3 varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe_2O_3 in two eastern most blocks.

2. Whether the item of investigation was included in approved programme for the year concerned, if so particulars such as item No., page etc. may be given.

YES
Item no. M2AFGBM-MEP/NC/NR/SU-UP/2017/11767

3. Date of commencement of the investigation with month, year and exact number of days spent in the field in connection with the investigation.

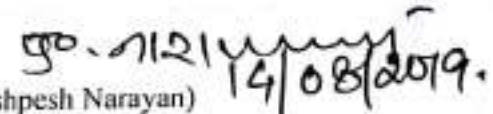
09-07-2017 to 28-02-2019
Number of field days:
Mukeshkumar Rajkumar Shrivastav, Geologist – 160 days
Shamiuddin Ahmad, Asstt. Geologist – 152 dyas

4. Brief account by you on the conclusions and recommendations made by the author with suggestions for implementing the same.

I agree with the conclusion and recommendation made by the authors.

5. Please state specifically how the results of investigation compare with the objective for which it was undertaken.

Results of the investigation fulfill the objective for which the investigation was undertaken.

50.1121 
(Pushpesh Narayan) 14/08/2019.
Director
Proj: Mineral Investigation
SU: UP, GSI, NR, Lucknow

FORMAT OF REPORT ON MINERAL EXPLORATION IN TERMS OF UNFC COMPLIANCE

TITLE OF REPORT: PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH. (Stage - G3)

STAGE G-4	NATURE OF COMPLIANCE REQUIRED	COMPLIED (PAGE NO) /NOT COMPLIED	REMARKS
I Summary	(1) Factual Data - (2) Recommendations (3) Cost estimation	- 8 - 45 - NA	
II. Introduction	(4) Scope & Purpose (5) Authority (6) Current/Past Property Examination (BGI) (7) Principal Sources of Information (8) Acknowledgement	- 5 - 5 - 8 - 8 - 6-7	
III. Property Description	(9) Size, Continuity, shape, surface rights (10) Third party issue (11) Claims/rights with dates (12) Land Title Officer (13) Lat/Long/village/town/district/mine site (14) Accessibility/infrastructure (15) Land nature/water/timber/power/gas/ agriculture/ manpower - 8 (16) Environmental issues/plan act/park/preservation - 9 (17) Climate/topography (18) Impact on landscape on mining (19) Map of area/ Block with roads/accessibility - Plate - I	- 8-9 - NA - NA - 8 - 8 - 9 - 9 - NA - Plate - I	
IV. History	(20) Previous work highlights (21) Attachment of previous maps/sections/tables- Plate - II (22) Previous Mining History (23) Reasons for closure (24) Earlier production data (25) Data on nearby Mines	- - Plate - II - NA - NA - NA - NA	
V. Geoscience Investigation			
(i) Geology	(26) Stratigraphy (27) Lithology (28) Structure (with maps/profiles) (29) Alteration Zones (30) Geotechnical (31) Adequacy of data density (32) Reliability (quality & quantity)	- 14-15 - 16-22 - 23-24 - 31 - NA - Yes - Yes	
(33) Geological Model			
(ii) Investigation Methods	(34) Instrument & Technique (35) Geology (Map with Scale) (36) Geophysical (with Map & Scale) (36) Geochemical (with Map & Scale) (37) data density of above	- 26 - Plate III - NA - Plate VI - Adequate	

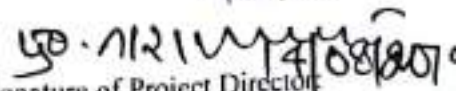
	(38) Size & style of Mineralised Zone	- NA
	(39) Diagrams	- NA
	(40) Metallurgical Tests	- NA
	(41) Deleterious/Contamination source	- NA
VI. Mineral Deposits		
(i) Features of deposit	(42) Type of mineralisation	- 31
	(43) Mode of occurrence	- 31
	(44) nature of Mineralisation (gossan/alteration/ structure)-	- 31
	(45) Reflectance of Mineralisation on geology/ gp/gc - 31	- 31
	(46) Maps given	- Plate III, VI, VII
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	(48) Reliability on resource estimation	- Adequate
	(49) Nature of Sampling Bed rock/grab/channel	- 25
	(50) Sampling Method	- 25
	(51) Introduction of Duplicates in Analysis	- 37
(iii) Analysis Details	(52) Laboratory	- 25
	(53) Analytical Methods	- 25
	(54) Precision & Accuracy	- NA
	(55) Cross Check analysis details	- 36
(iv) Quality/Grade	(56) Statistical data processing	- 37
	(57) Cut Off grade	- 37
	(58) Assumptions	- 38-39
(v) Resource Estimation	(59) Geological Interpretation	- 43
	(60) Statement of tonnage & grade	- 43
	(61) Geometry of Mineralisation assumed	- 38
	(62) Method adopted to arrive estimation	- 40-43
	(63) Estimation	- 40-43
(vi) Economic viability	(64) Rough estimation of Economic viability	- NA
	(65) Intrinsic economic interest	- NA
	(66) Eventual Economic exploitation.	- NA

CERTIFICATE: Certified that this REPORT is in compliance with UNFC 333 Stage of Mineral Investigation.

PLACE: Lucknow

DATE:

Signature of Author(s):

M.R. Shrivastava
14/08/19
Signature of Project Director:

14/08/19

REPORT DATA

1. Title: **PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP BLOCK 'A', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH. (Stage - G3)**
2. Author(s): Mukeshkumar Rajkumar Shrivastav, Senior Geologist and Shamiuddin Ahmad, Assistant Geologist
3. Field season: 2017-18
4. Year (s) (in case item continues from an earlier FSP): 1 year
5. FSP Code No.: M2AFGBM-MEP/NC/NR/SU-UP/2017/11767
6. Theme: Mineral Investigation
7. Subtheme: To assess the economic potentiality of iron ore occurrence in the area.
8. Status: Limited circulation report.
9. State: Uttar Pradesh.
10. District: Sonbhadra
11. Toposheet: 63 L/14
12. Key Locations: Bharhari, Bargawan, Jogail, Chopan
13. **Short Abstract:**

In pursuance of item code M2AFGBM-MEP/NC/NR/SU-UP/2017/11767, field season 2017-18, preliminary exploration for iron ore in extended Block 'A', Bharhari area was carried out by detailed mapping of 1.61 sq km on 1:2000 scale and drilling under G-3 stage. The block area of investigation lies between N 24°33'32" - 24°34'09" and E 82°51'41" - 82°53'16" and falls under Survey of India toposheet no. 63L/14. It is situated in the east of the Bharhari village. The litho units exposed in extended Block 'A' are variegated phyllite, felsic tuff, banded hematite chert / jasper and ferruginous phyllite of Agori Formation of Mahakoshal Group and dolerite dyke and quartz vein as intrusives. The strike length of banded hematite chert / jasper band is 2.62 km. The general trend of the rock types in the study area is ENE-WSW (N70°E-S70°W to N85°E-S85°W) and its dip amount varies from 50°-75° due south. Bedding (S0) in banded hematite chert / jasper is the primary structure observed in the area.

The banded hematite chert / jasper is a distinct rock unit with bands of iron oxide, chert and/or jasper. The iron oxide is dark grey to reddish brown and chert bands are light grey while the jasper bands are brilliant vermilion red in colour. The thickness of the individual hematite bands varies from a few millimetres to 7cm. The banded hematite chert / jasper band is exposed at the hilltop and has width of 8-75m. A total of eight boreholes have

been drilled to understand the subsurface continuity of exposed banded hematite chert / jasper bands. A total of 822.70 m drilling has been achieved by the drilling of eight boreholes namely SBE-1, SBE-2, SBE-3, SBE-4 and SBE-5, SBE-6, SBE-7 and SBE-8. All the boreholes are inclined as the exposed bed rocks have the steep dip. The boreholes have depth varying from 59.0 m to 160.05m and cumulative thickness of mineralized zone intersected at 30% Fe cut off varies from 1.5m to 34m having average iron content from 30.00% to 37.78% Fe.

The borehole SBE-2 revealed the presence of banded hematite chert / jasper at the depth of 41.5 to 42 m (0.5m) and fractured banded hematite chert / jasper with limonite/goethite and chert bands at 86.1 to 94.05m (7.95m). The SBE-3 has been intersected banded hematite chert/jasper from 70m to 89m (19 m). In SBE-5, 18.20m thick banded hematite chert / jasper was intersected from 40.80 m to 59.0m. The SBE-6, 62.55 m thick BIF was intersected at 90.75m depth and continued to the depth of 153.30m. The banded hematite chert/jasper was intersected in SBE-7 from 48.80 m to 133.90m (85.10m). In SBE-8, banded hematite chert/jasper has thickness of 34.05m intersected from 43.25 m to 77.30m of depth.

Four trenches have been excavated in the field area to expose / to study the continuity of banded hematite chert / jasper band. Total 51 nos. trench samples, 10 nos. channel samples and 40 nos. bed rock samples were collected. A total of 441 nos. core samples were collected from drilled boreholes.

The chemical results of the banded hematite chert / jasper in bed rock samples show Fe values from 6.9 % to 52.3 % with an average of 28.20%. The Fe in trench samples of TR-1 varies from 31.3 % to 47.2 % with 38.9% as an average; while in TR-2, Fe₂O₃ varies from 1.02 % to 30.86 % with an average value of 12.33 % and Fe of TR-3 samples ranges from 12.4 % to 34.7 % averaging 25.2 %. The trench TR-4 suggests Fe₂O₃ ranging from 29.4 % to 43.2% and weighted average of 35.4%. At 30% Fe cut off, the mineralized iron zones have been established in six boreholes namely SBE-2, 3, 5, 6, 7 and 8. At 35% Fe cut off, the mineralized zones have been demarcated in SBE-5, SBE-6 and SBE-7.

The estimated resource of 14.89 million tonnes (MT) with average grade of 34.73% Fe at 30 % cut off and 8.41 million tonnes (MT) with average grade of 38.34% of Fe at 35 % cut off fulfils the 333 category of UNFC classification.



Geological Survey of India

Data sheet on report movement in connection with its scrutiny

Project/Division Mineral Investigation FSP No M2AFGBM-MEP/NC/NR/SU-UP/2017/11767 Mission - II
 Title of the report Preliminary exploration for iron ore in Mahakoshal Group Block 'A', Bharhari area,
 Sonbhadra district, Uttar Pradesh. (Stage - G3)

Name of author(s) 1. Mukeshkumar R. Shrivastav Senior Geologist 2. Shamiuddin Ahmad Assistant Geologist	Date of submission of report to the Supervisory Officer 29-06-2018 Signature of the senior most author [Signature]
Name of Supervisory Officer Sh. Pushpesh Narayan, Director	Date of receipt of report 02/07/2018 Date of completion of scrutiny 27/07/18 Date of handing over report to the author after scrutiny 30/07/18 Signature [Signature]
Name of author(s) To whom the report has been handed over by the Supervisory Officer M.R. Shrivastav, Jr. Geol.	Date of receipt after scrutiny 31/07/18 Signature [Signature] Date of resubmission 21/08/2018 Signature [Signature]
Supervisory Officer Sh. Pushpesh Narayan, Director	Date of receipt after modification 21/08/2018 Date of handing over report to the Regional Mission Head 21/08/2018 Signature [Signature]
Name of Regional Mission Head Dr. J. S. Mehta	Date of receipt of report 21.08.2018 Date of handing over the report after peer review to the Project Director 19.9.2018 Signature [Signature]
Name of Supervisory Officer Pushpesh Narayan Director	Date of receipt from the Regional Mission Head after peer review 20/09/2018 Date of handing over to author(s) 24/09/2018 Signature [Signature]
Name of author(s) M.R. Shrivastav, Jr. Geol.	Date of receipt of report from Supervisory Officer 24-09-2018 Date of handing over report after modification to Supervisory Officer 21-06-2019 Signature [Signature]
Name of Supervisory Officer	Date of receipt of report after 21/06/19

Sh. Pushpesh Narayan, Director.	modification from the author(s) 21/06/2019. Date of handing over report to Regional Mission Head 21/06/2019. Signature..... <u>[Signature]</u>
Name of Regional Mission Head Shri. RAKESH KUMAR DDG & RMH-II, NR.	Date of receipt after modification from the Project Director... 21-06-19... Date of handing over the report to the HoD of the Region for approval 14-08-19 Signature..... <u>[Signature]</u>
Name of the HoD of the Region Santosh Chandel Additional Director General & HOD, NR.	Date of receipt of report for approval 14-08-19 Date of approval... 14-08-19 Date of sending back report to Project Director... 14-8-19 Signature of the HoD..... <u>[Signature]</u>
Name of the Project Director Sh. Pushpesh Narayan	Date of receipt of report after approval of HoD... 14/08/2019. Date of circulation of report..... Signature..... <u>[Signature]</u>

[Signature]
21/6/19 for DDG & RMH-II

[Signature] for DDG & RMH-II

- The report was sent to NMH-II on 21.06.2019 for vetting.
- Report was received at RMH-II, NR office on 16-07-19
- Report sent to DDG, SU:UP on 16/7/19
- Report was received to M.R. Shrivastava, Sr. Asst on 16-07-19 in afternoon. [Signature]
- Report handed over to Director, NM-II, Nagpur by hand on 05-08-19 and the same was received back by hand on 09-08-19 evening. [Signature]
- Report handed over to Director, MUP by hand on 14-08-19. [Signature]
- Report was received at RMH-II, NR office on 14-08-2019 [Signature]
14/8/19



Geological Survey of India

Certificate of Quality of the report

Project/Division Mineral Investigation FSP No M2AFGBM-MEP/NC/NR/SU-UP/2017/11767 Mission - II
 Title of the report Preliminary exploration for iron ore in Mahakoshal Group Block 'A', Bharhari area,
 Sonbhadra district, Uttar Pradesh. (Stage - G3)

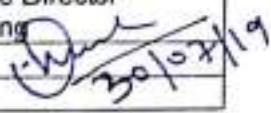
Part-A

This is to certify that the following officer(s) have carried out the above mentioned FSP, and are responsible for collection of field data, carrying out the required laboratory analysis, compilation and synthesis of field data, coalition of the data and writing of the report as per the approved guidelines. The duration of field stay of each officer(s) is as against his/her name.

Name(s)/Designation of the Field Officer	Total field stay during the FSP (no. of days)	Signature with date
1. Mukeshkumar R. Shrivastav, Sr Geologist	160	 21/06/19
2. Shamiuddin Ahmad, Assistant Geologist	152	 05/06/19

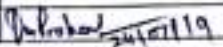
Part-B

This is to certify that drilling has been carried out and completed as per the table given below:

Drilling Unit No	Date of commencement of drilling	Date of completion of drilling	Name and Signature of the Director Drilling
1. 467	21-10-2017	28-02-2019	 30/07/19
2.			

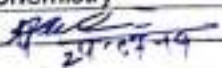
Part-C

This is to certify that geophysical component of the item has been carried out as per the table given below:

Name(s)/Designation of Geophysist	Date of commencement of work	Date of completion of work	Signature with date of the Geophysist
1. KALPANA KUMARI	15-03-2018	07-06-2018	Kalpana Kumari 24.04.19
2.			
Name and signature with date of the Director (Geophysics)			 24/04/19

Part-D

This is to certify that the chemical analysis of the geological samples has been carried out as per the table given below:

Name of Director in charge of the Chemical Lab	Dates of receipt of samples from the field officer/party	Date of providing complete analytical results to the field officer	Signature with date of the Director Chemistry
U.C. Gaur	29-11-2017	31-05-2018	 24/04/19
Director (Chem)	to	to	
	27-03-2019	22-05-2019	

Part-E

This is to certify that the below mentioned Supervisory Officer(s) have supervised the above item and have provided guidance to the Field Officer(s). The number of inspection visits and total duration of field visits is as per the below table. It is also certified that the work carried out

under the project is of high standards, the norms of field work, lab work etc. have been followed. It is also certified that thorough scrutiny of the report for maintaining the scientific contents and its Quality has been overseen.

Name(s)/Designation of the Supervisory Officer	No. of inspection visits made to the field area	Total no. of days spent on inspection visit	Signature with date
Pushpesh Narayan Director	14	28 days	50 1121mm 20/08/2019.

Part-F

This is to certify that the report has been thoroughly scrutinized at the Regional Mission Head level. The scientific contents and the Quality of the report are certified. The report has been peer reviewed and the needful corrections have been attended to.

Name(s)/Designation of the Regional Mission Head	Signature with date
Sh. Pakesh Kumar, Dy. Dir.	<i>[Signature]</i> 14/8/19

Part-G

This is to certify that the above report has been scrutinized at various levels and has also been peer reviewed. On being satisfied regarding the scientific contents and the Quality of the report, the undersigned has accorded approval for its circulation.

Name(s)/Designation of the Regional HoD	Signature with date
Sh. S. N. Chandel, A.D.G.	<i>[Signature]</i> 14/8/19

& HoD, N.E.



भारत सरकार
Government of India
भारतीय भूवैज्ञानिक सर्वेक्षण
Geological Survey of India

**उत्तर प्रदेश के सोनभद्र जिले के महाकौशल संघ में भरहरी क्षेत्र के ब्लॉक 'ब' में लौह
अयस्क के लिए प्राथमिक अन्वेषण पर प्रतिवेदन (चरण: जी-३)**

**REPORT ON "PRELIMINARY EXPLORATION FOR IRON ORE IN
MAHAKOSHAL GROUP BLOCK 'B', BHARHARI AREA, SONBHADRA
DISTRICT, UTTAR PRADESH" (STAGE : G-3)**

टोपोशीट सं: 63L/14 / Toposheet No.: 63L/14

मद संख्या: एम२एएफजीबीएम-एमईपी/एनसी/एनआर/एसयू-यूपी/2019/26399

Item no.: M2AFGBM-MEP/NC/NR/SU-UP/2019/26399

कार्यसत्र 2019-20 का अंतिम प्रतिवेदन
Final report for field season 2019-20

मुकेशकुमार राजकुमार श्रीवास्तव, वरिष्ठ भूवैज्ञानिक Mukeshkumar Rajkumar Shrivastav, Sr. Geologist
शमीउद्दीन अहमद, सहायक भूवैज्ञानिक Shamiuddin Ahmad, Assistant Geologist
उदय नारायण, वरिष्ठ भूवैज्ञानिक Uday Narayan, Senior Geologist (additional charge)

मिशन-II
MISSION-II

राज्य इकाई: उत्तर प्रदेश /State Unit: Uttar Pradesh
उत्तरी क्षेत्र/Northern Region
लखनऊ/Lucknow

जनवरी, 2021
January, 2021

भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण
उत्तरी क्षेत्र, लखनऊ

**GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA
NORTHERN REGION, LUCKNOW**



राज्य इकाई : उत्तर प्रदेश
परियोजना : लौह खनिज
**STATE UNIT: UTTAR PRADESH
PROJECT: FERROUS MINERALS**

उत्तर प्रदेश के सोनभद्र जिले के महाकौशल संघ में भरहरी क्षेत्र के ब्लॉक 'ब' में लौह अयस्क के प्राथमिक अन्वेषण
पर प्रतिवेदन

(चरण: जी-3)

टोपोशीट सं.: 63 एल / 14

कार्यसत्र : 2019-20

कार्यक्रम मद सं.: एम2एएफजीबीएम-एमईपी/एनसी/एनआर/एसयू-यूपी/2019/26399

**PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL
GROUP BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT,
UTTAR PRADESH (Stage: G-3)**

Toposheet No. : 63 L/14

Field Season: 2019-20

Item code: M2AFGBM-MEP/NC/NR/SU-UP/2019/26399

मुकेशकुमार राजकुमार श्रीवास्तव, वरिष्ठ भूवैज्ञानिक

शमीउद्दीन अहमद, सहायक भूवैज्ञानिक

एवं

उदय नारायण, वरिष्ठ भूवैज्ञानिक (अतिरिक्त प्रभार)

Mukeshkumar Rajkumar Shrivastav, Senior Geologist

Shamiuddin Ahmad, Assistant Geologist

and

Uday Narayan, Senior Geologist (additional charge)

लखनऊ / Lucknow

2021

पूर्वानुमति के बिना पूर्ण अथवा आंशिक खंडांश किसी भी रूप में उद्धरित न किया जाए। प्रतिवेदन की सॉफ्ट प्रति एवं आंकिक आंकड़े
महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण, कोलकाता-700016 की अनुमति से प्राप्त किए जा सकते हैं।

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General, Geological Survey of India, Kolkata-700 016

**PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP
BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT,
UTTAR PRADESH. (STAGE - G3)**

(T.S. 63 L/14)

**(Field item no.: M2AFGBM-MEP/NC/NR/SU-UP/2019/26399)
(Field Season: 2019-20)**

By

Mukeshkumar Rajkumar Shrivastav, Senior Geologist, Shamiuddin Ahmad, Assistant Geologist and
Uday Narayan, Senior Geologist (additional charge)

Geological Survey of India

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उत्तर प्रदेश के सोनभद्र जिले के महाकौशल संघ में भरहारी क्षेत्र के ब्लॉक 'ब' में लौह अयस्क के प्राथमिक अन्वेषण पर प्रतिवेदन (चरण : जी - 3)

(क्षेत्रावधि 2019-20)

भूमानचित्र भाग संख्या : 63 एल /14

मद कोड : एम2एएफजीबीएम -एमईपी/एनसी/एनआर/एसयू - यूपी/2019/26399

द्वारा

मुकेशकुमार राजकुमार श्रीवास्तव, वरिष्ठ भूवैज्ञानिक

शमीउद्दीन अहमद, सहायक भूवैज्ञानिक

एवं

उदय नारायण, वरिष्ठ भूवैज्ञानिक (अतिरिक्त प्रभार)

भारतीय भूवैज्ञानिक सर्वेक्षण

सारांश

सोनभद्र जनपद के भरहारी क्षेत्र के ब्लॉक 'ब' में लौह अयस्क के प्राथमिक अन्वेषण के लिए 1:4000 के पैमाने पर विस्तृत मानचित्रण एवं जी-3 चरण का वेधन कार्य किया गया। अन्वेषण ब्लॉक का क्षेत्र उत्तर-पूर्व में $24^{\circ} 34' 29.68''$ $82^{\circ} 54' 49.66''$; उत्तरपश्चिम में $24^{\circ} 34' 04.39''$, $82^{\circ} 53' 09.93''$; दक्षिण-पश्चिम में $24^{\circ} 33' 44.04''$, $82^{\circ} 53' 12.07''$ एवं दक्षिणपूर्व में $24^{\circ} 33' 59.71''$ $82^{\circ} 55' 09.83''$ के मध्य में तथा भारतीय सर्वेक्षण विभाग की टोपोशीट सं. 63L/14 में आता है। यह भरहारी गाँव के पूर्व में स्थित है। इस ब्लॉक में महाकौशल संघ के अगोरी शैल समूह की शबलित फिलाइट, फिलाइट अंतर्भेदित टूफ, टूफ, पट्टित हेमाटाइट चर्ट/जैस्पर (बी.आई.एफ.), लौहयुक्त फिलाइट उपस्थित हैं एवं डोलेराइट भित्ति और क्वार्ट्ज शिरायें इंड्रिसव के रूप में हैं। पट्टित हेमाटाइट चर्ट/जैस्पर पट्टि का नतिलम्ब 3.12 किमी है, चौड़ाई 9 मी से 54 मी तक है तथा यह लगातार बैंड के रूप में पहाड़ी के उपरी हिस्सों में मौजूद है। अध्ययन क्षेत्र में चट्टानों की सामान्य प्रवृत्ति ENE-WSW ($N65^{\circ}E-S65^{\circ}W$ से $N85^{\circ}E-S85^{\circ}W$) है और इसका नमन दक्षिण दिशा में है जो कि 50° - 80° के बीच बदलता है।

पट्टित हेमाटाइट चर्ट/जैस्पर, लौह ऑक्साइड तथा चर्ट अथवा जैस्पर युक्त पट्टियों से बनी हुई एक अलग शैल इकाई है। लौह ऑक्साइड गहरे धूसर से गहरे भुरे रंग के तथा चर्ट पट्टियाँ हल्के धूसर रंग जबकि जैस्पर पट्टियाँ लाल रंग की हैं। हेमाटाइट बैंड की मोटाई 1 मिलीमीटर से 8 सेमी तक बदलती है जबकि चर्ट/जैस्पर बैंड की मोटाई प्रायः 1 मिलीमीटर से 4 सेमी है। आधार शैलों से कुल 80 नमूने (26 चैनल नमूने सहित) 79 ट्रेन्च नमूने पांच ट्रेन्चों से एवं 4 वेधन छिद्रों से कुल 195 कोर नमूने (6 चेक नमूने सहित) लिए गए। आधार शैलों के रासायनिक नतीजें पट्टित हेमाटाइट चर्ट/जैस्पर में लौह की मात्रा 6.67% से 46.39% तक दर्शाते हैं। 26 चैनल नमूने के विश्लेषणात्मक परिणाम लौह की मात्रा 25.20% से 62.81% तक औसतन 43.28% दर्शाते हैं।

अन्वेषण के दौरान क्षेत्र में कुल 5 ट्रेन्चों का उत्खनन पट्टित हेमाटाइट चर्ट/जैस्पर की लम्बाई / चौड़ाई का अध्ययन करने हेतु किया गया। ट्रेन्चों को पट्टित हेमाटाइट चर्ट/जैस्पर की लम्बाई के पार में जहाँ पट्टित हेमाटाइट चर्ट/जैस्पर चट्टान मौजूद नहीं थी, उत्खनन किया गया एवं 79 नमूने लिए गए। ट्रेन्च TRB-1 में लौह की मात्रा 12.64 % से 56.15 % तक औसतन 34.39% है जबकि TRB-2 में 26.68 % से 45.87 % तक औसतन 35.53 % है एवं TRB-3 के नमूनों में 20.21 % से 59.17 % तक औसतन 44.33 % है। ट्रेन्च TRB-4, लौह की मात्रा 42.38 % से 51.01 % तक औसतन 45.87% इंगित करता है। ट्रेन्च TRB-5 में लौह की मात्रा 26.95 % से 62.54 % के बीच बदलती है एवं औसतन 43.45 % है।

चार वेधन छिद्रों में कुल 461.30 मी वेधन किया गया। मौजूद पट्टित हेमाटाइट चर्ट/जैस्पर की आंतरिक गहराई का पता लगाने के लिए वेधन की योजना बनाई गयी। वेधन छिद्रों की दूरी को 400 मी की दूरी पर नियोजित किया गया। वेधन कार्य का ध्येय पट्टित हेमाटाइट चर्ट/जैस्पर को 400 मी डेटम से 30 मी की खड़ी गहराई पर भेदना था। कुल चार वेधन छिद्रों क्रमशः UPSBB-1, UPSBB-2, UPSBB-3 एवं UPSBB-4 में वेधन कार्य किया गया। विषम भूखंड परिस्थितियों की वजह से वेधन कार्य चुनौतीपूर्ण था।

वेधन छिद्र UPSBB-1 में कुल 72.30 मी मोटाई का बीआईएफ बैंड (खनिजिकरण जोन) 22.50 से 61.50 मी, 72.90 से 96.10 मी तथा 100.20 से 106.10 मी तक की गहराई में प्रतिच्छेदित हुआ। वेधन छिद्र UPSBB-2 में प्रतिच्छेदित बीआईएफ बैंड की कुल मोटाई 28.75 मी है, आदर्श बीआईएफ बैंड 131 से 156.25 मी की गहराई में प्रतिच्छेदित हुआ। वेधन छिद्र UPSBB-3 में कुल 33.45 मी मोटा बीआईएफ बैंड 94.00 मी से 127.45 मी की गहराई में प्रतिच्छेदित हुआ। वेधन छिद्र UPSBB-4, 43.50 मी तक ही वेधित हुआ। वेधन छिद्र जल्दी बंद होने के कारण (43.50 मी पर) इसमें बीआईएफ प्रतिच्छेदित ना हो सका। बोरहोल की आगे की ड्रिलिंग को पत्र क्रमांक ____ /45A/FS 2019-20/Mod/PSS:P&M-2/2020 दिनांक 29/05/2020 के अनुसार रोक दिया गया। वेधन छिद्र UPSBB-1, UPSBB-2, UPSBB-3 एवं UPSBB-4 से कुल 195 कोर नमूने रासायनिक विश्लेषण हेतु जमा किए गए थे। वेधन छिद्र UPSBB-1, UPSBB-2 एवं UPSBB-3 में 30% एवं 35% कट ऑफ पर खनिजिकरण जोन बनाए गए। लौह 30% कट ऑफ पर वेधन छिद्र UPSBB-1 में अधिकतम ग्रेड 42.94% Fe स्थापित किया गया जिसकी मोटाई 1.70 मी है जबकि 35% लौह कट ऑफ पर वेधन छिद्र UPSBB-3 में अधिकतम 8.05 मी मोटाई का जिसका औसत ग्रेड 39.35% Fe है पाया गया। अन्वेषित ब्लॉक में लौह का अधिकतम ग्रेड 43.64% कुल मोटाई 1.20मी है। सोनभद्र के ब्लॉक 'B' भरहरी क्षेत्र में लौह 30% कट ऑफ पर कुल अनुमानित संसाधन 10.77 मिलियन टन है जिसका औसत ग्रेड 34.50% Fe है और 35% लौह कट ऑफ पर अनुमानित संसाधन 5.03 मिलियन टन है जिसका औसत ग्रेड 39.51% Fe है यह यूएनएफसी के 333 वर्ग के अंतर्गत आता है।

**PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP
BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT,
UTTAR PRADESH. (Stage : G-3)**

(Field Season: 2019-20)

Toposheet No.: 63 L/14

Item code M2AFGBM-MEP/NC/NR/SU-UP/2019/26399

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ABSTRACT

The preliminary exploration for Iron ore in Block 'B', Bharhari area, Sonbhadra, U.P. was carried out in 2.1 sq km by detailed mapping on 1:4000 and G-3 stage drilling. The block area of investigation lies between NE 24° 34' 29.68", 82° 54' 49.66"; NW 24° 34' 04.39", 82° 53' 09.93"; SW 24° 33' 44.04", 82° 53' 12.07" and SE 24° 33' 59.71", 82° 55' 09.83" and falls under SOI toposheet no. 63L/14. It is situated in the east of the Bharhari village. The litho-units exposed in the block are variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert / jasper (BIF), ferruginous phyllite of Agori Formation of Mahakoshal Group and dolerite dyke and quartz vein as intrusives. The banded hematite chert / jasper is exposed at the hill top with a strike length of 3.12 km and width ranging from 9m to 54m. The general trend of the rock types in the study area is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with dip amount of 50° to 80° towards south.

The banded hematite chert / jasper is a distinct rock unit with bands of iron oxide, chert and/or jasper. The iron oxide is dark grey to reddish brown and chert bands are light grey while the jasper bands are brilliant vermilion red in colour. The thickness of the individual hematite bands varies from a 1mm to 8cm while chert/jasper bands generally having thickness of 1mm to 4cm.

A total of 80 nos. bed rock samples (including 26 nos. channel samples), 79 nos. trench samples from five trenches and 195 nos. core samples (including 6 nos. check samples) from four boreholes were collected. The chemical results suggested Fe values of banded hematite

chert / jasper in bed rock samples vary from 6.67 % to 46.39 % with an average of 26.51 %. The analytical values of 26 nos. channel samples have revealed the Fe values ranging from 25.20 % to 62.81 % with weighted average of 43.28 % Fe.

Total five trenches were excavated in the area during the course of the present investigation to study the strike / width continuity of banded hematite chert / jasper. The trenches were cut across the trend of the banded hematite chert / jasper wherever it is not exposed and 79 samples were collected. The Fe values in trench samples of TRB-1 varies from 12.64 % to 56.15 % with 34.39% Fe as weighted average, while in TRB-2, Fe values vary from 26.68 % to 45.87 % with weighted average value of 35.53 % and Fe values of TRB-3 samples range from 20.21 % to 59.17 % with weighted average of 44.33 %. The trench TRB-4 suggests Fe ranging from 42.38 % to 51.01 % and weighted average of 45.87 %. In trench TRB-5, Fe values ranges from 26.95 % to 62.54 % with weighted average of 43.45 %.

A total of 461.30m of drilling was carried out through four boreholes. The drilling was planned to intersect the banded hematite chert / jasper to understand the subsurface continuity of exposed bands. At the sub-surface, the exposed BIF were planned to intersect at 30 m vertical depth from 400m datum line. A total of four boreholes viz. UPSBB-1, UPSBB-2, UPSBB-3 and UPSBB-4 were drilled at an interval of 400m each. Due to rugged terrain conditions, the drilling was a challenging task.

In the borehole no. UPSBB-1, a total 72.30 m thick banded hematite chert / jasper band was intersected at the depth interval of 22.50 to 61.50m, 63.30 to 67.50m, 72.90 to 96.10 and 100.20 to 106.10m. In the drilled borehole of UPSBB-2, total BIF thickness is 28.75 m, in which the typical BIF was intersected at the depth interval of 131.0 to 156.25m. In the borehole UPSBB-3, the BIF intersected from 94.00m to 127.45m having total thickness of 33.45 m. The borehole UPSBB-4 was drilled only to the depth of 43.50m, the BIF could not be intersected due to early closing of borehole (at 43.50m depth). The further drilling of borehole was stopped as per the letter vide order no.____/45A/FS 2019-20/Mod/PSS:P&M-2/2020 dated 29/05/2020. A total of 195 core samples were submitted for chemical analysis from borehole nos UPSBB-1, UPSBB-2, UPSBB-3 and UPSBB-4. Mineralized zones have been demarcated at 30% and 35% Fe cut off for borehole no. UPSBB-1, UPSBB-2 & UPSBB-3. At 30 % Fe cut off, the maximum grade of 42.94% Fe has been established for a total thickness of 1.70m in UPSBB-1 while at 35% Fe cut off, the maximum thickness of 8.05m has been brought out with an average grade of

39.35% Fe in borehole UPSBB-3. The highest grade of Fe mineralization is 43.64% with total thickness of 1.20m in the investigated block.

A total resource of 10.77 million tonnes (MT) with average grade of 34.50% Fe at 30% cut off and 5.03 million tonnes (MT) with average grade of 39.51% of Fe at 35 % cut off have been estimated in block-‘B’ of the Bharhari area, Sonbhadra. The investigation fulfils 333 category of UNFC classification.

2. INTRODUCTION

In pursuance of Annual Programme 2019-20, the preliminary exploration for iron ore was taken up by Geological Survey of India, Northern Region, Lucknow vide item code no. M2AFGBM-MEP/NC/NR/SU-UP/2019/26399 in Block 'B', Bharhari area, Sonbhadra district, U.P. The area falls in Survey of India toposheet no. 63L/14.

Objective:

The investigation was taken up with an objective to assess the economic potentiality of iron ore occurrence in the area.

Basis of taking the investigation:

A.K. Dey (1967-68) carried out a preliminary investigation work on Iron-ore occurrence near Bargawan (24°36'00", 82°52'30") Mirzapur district, U.P. The iron ore are mainly siliceous hematite, limonite and goethite with rare magnetite. Analytical results reveal that about 70% samples contain less than 35% Fe₂O₃. Approximately 6 million tonnes of possible resource of low-grade Iron-ore was estimated in an area of about 0.37 sq. km.

The NGCM was carried out by Sarkar *et. al.* during F.S. 2013-14 in toposheet no 63L/14 and shows high Fe₂O₃ (>14%) value in the composite samples. The anomalous Fe₂O₃ is contributed by banded hematite quartzite and banded hematite jasper bands of the area. Geophysical mapping carried out during F.S. 2009-2012 has also revealed gravity high supplemented with high magnetic values in the southern part of the Toposheet No. 63 L/14. Modak *et. al.* (2015) carried out large scale mapping on 1:12,500 scale covering parts of toposheet 63 L/14 during FS 2014-15. He marked five subparallel bands of banded hematite chert / jasper extending from NW of Bijaura in east to Bharahari in west. The total strike length of these banded hematite chert / jasper bands is around 20 kms and width varies from 2m to 10m with cumulative width of 170 m to 450 m. The value of Fe₂O₃ varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe₂O₃ in two eastern most blocks. Shrivastav, M.R. and Ahmad, S during FS 2017-18 estimated resource for iron ores in block 'A' as 14.89 million tonnes (MT) with average grade of 34.73% Fe at 30% cut off and 8.41 million tonnes (MT) with average grade of 38.34% of Fe at 35% cut off. On the basis of the outcomes and recommendations, the project was taken up during FS 2019-2020.

Present work:

During the FS 2019-20, detailed mapping of 2.1 sq. km. on 1:4,000 scale, drilling of 461.30 m through 04 boreholes, 79 nos of PTS, 195 nos of core samples, 23 nos of petrological

samples, 15 ore microscopy samples and 10.80 line kilometres of geophysical studies were carried out during the course of investigation. The investigation area falls in the northern fringes of Chakdiya Reserved Forest having rugged topography with dissected linear ridges, which causes difficulties in fixing borehole locations as well as hindrances in drilling operations due to paucity of water.

The achievements vis-à-vis envisaged targets are mentioned in Table 2.1.

Table 2.1: The nature and quantum of work

Nature of Work	Target for F.S. 2019-20	Achievements for F.S. 2019-20
A. Geological Survey i) DM (1:4000)	2.0 sq km	2.1 sq km
B. Technological Survey a. Surface exploration i) Pitting / Trenching b. Subsurface exploration ii) Drilling (DU – 467)	75 cu m 550 m	79 cu m 461.30 m
C. Geophysical survey i) Magnetic	10 Line km	10.80 Line km
D. Samples (Nos.) i) BRS (Groove samples) ii) PTS iii) CS iv) PS v) Ore Microscopy	75 nos 75 nos 300 nos 20 nos 15 nos	80 nos 79 nos 195 nos 23 nos 15 nos
E. Chemical Analysis (ICPMS/NAA) i) BRS ii) PTS iii) CS	75 nos 75 nos 300 nos	80 nos 79 nos 195 nos

The details of the officers engaged in the investigation with number of field days are given below in Table 2.2:

Table 2.2: Details of officers with number of field days

Sl.No.	Name of Officer	Days spent in field
1	Mukeshkumar R. Shrivastav, Senior Geologist	131
2	Shamiuddin Ahmad, Assistant Geologist	67
3	Shri. Uday Narayan, Senior Geologist (additional Charge)	56
Surveyor		
1	Shri. Ramashray Ram, Senior Surveyor	129

2	Shri. Ravindra Kumar Saxena, Senior Surveyor	20
Supervisory officer		
1	Shri. Pushpesh Narayan, Director	12

Acknowledgement:

The authors would like to express their heartfelt thanks to Smt. Varsha A. Aglawe, Dy. Director General and HOD, Shri S.N. Chandel, then Addl. Director General & HOD, Northern Region and Shri P.S. Gill, Dy. Director General, State Unit: Uttar Pradesh for extending necessary facilities for carrying out the given assignment. The technical inputs and suggestions given by Sri. Supriya Kumar Saha, Dy. Director General & RMH-II, along with Sri. P.S. Misra, Director, RMH-II, NR were of immense value and are worthy of special thanks from us. The authors would like to express their sincere gratitude to Shri Pushpesh Narayan, Director for his kind supervision and guidance during the course of the work. Sincere thanks are also conveyed to the officers and staff of Drilling Division, Chemical Division and Petrology Division GSI, NR, Lucknow for their active co-operation during the course of the study.

3. PROPERTY DESCRIPTION

1. Title of Ownership: Most of the study area falls under Chakdiya reserved forest and northern part is occupied by revenue/agricultural land.

2. Details of the area:

I. Village name, District, State:

Kurcha, Chatarwar, Bargawan and Murauli are the villages situated in northern side of study area while Kusahniya is situated at south. Jogail is the main locality situated 4.4 km towards SW whereas Bharhari (Bharahari) is situated approx 20 km towards west from the present block. These localities are situated in Sonbhadra district, Uttar Pradesh.

II. Survey of India Toposheet No.:

The present area of investigation falls in Survey of India Toposheet nos. 63 L/14.

III. Geo-coordinates of all corner points of the Investigated Block:

The geo-coordinates of all corner points of investigated block were recorded with the aid of DGPS. The geo-coordinates of all four corner points are given in following Table.

Table – 3.1: Geo-coordinates of four corner of investigated block

STATION	LATITUDE	LONGITUDE	ELEVATION (m)
BHARHARI_NE	24° 34' 29.68" N	82° 54' 49.66" E	222.6562
BHARHARI_NW	24° 34' 04.39" N	82° 53' 09.93" E	275.324
BHARHARI_SW	24° 33' 44.04" N	82° 53' 12.07" E	379.6115
BHARHARI_SE	24° 33' 59.71" N	82° 55' 09.83" E	331.2504

IV. Cadastral details of the area with land use:

The area of investigation falls under Chakdiya Reserved Forest covered with fairly dense jungle. Agriculture practice is common on favourable hill slope but difficult due to scarcity of water. The study area in general is backward in development. People living in the study area, depend on agriculture and daily wages for their livelihood.

V. Freehold/Leasehold: The study area is covered by forest land with few revenue lands.

VI. Location and accessibility:

The given block is located about 12 km north - west of Chopan and is connected by metalled road which runs parallel to the east flowing Son river in most part. Chopan is the nearest town well connected by both rail and metalled road with Robertsganj, district headquarter, Sonbhadra, Uttar Pradesh. Jogail is the major locality near study area and is situated around 28 km west of Chopan and well connected by metalled road. The area is well connected

with Allahabad, Mirzapur and Varanasi by roads. The nearest railway station is Chopan and nearest airport is Varanasi and Muirpur (Plate – I).

VII. Climate:

The area experiences sub-tropical climate, marked by moderate to severe cold season and very hot summer. Cold is experienced during the month of December and January while extreme hot weather prevails from March to June. During May to mid-June the temperature goes as high as 48°C. It is followed by monsoon rainy season from mid-June to September with about 125 cm of average rainfall. Winter is equally cold when the temperature drops down to 4°C in December.

VIII. Flora and fauna

The area supports a tropical mixed monsoon forest and the main species of trees and shrubs include *Boswellia Serrate* (Salai), *Diospyros metonoxylon* (Tendu), *Zizphus mountain* (Ber), *Mudhuca indica* (Mahuwa) and thorny shrubs.

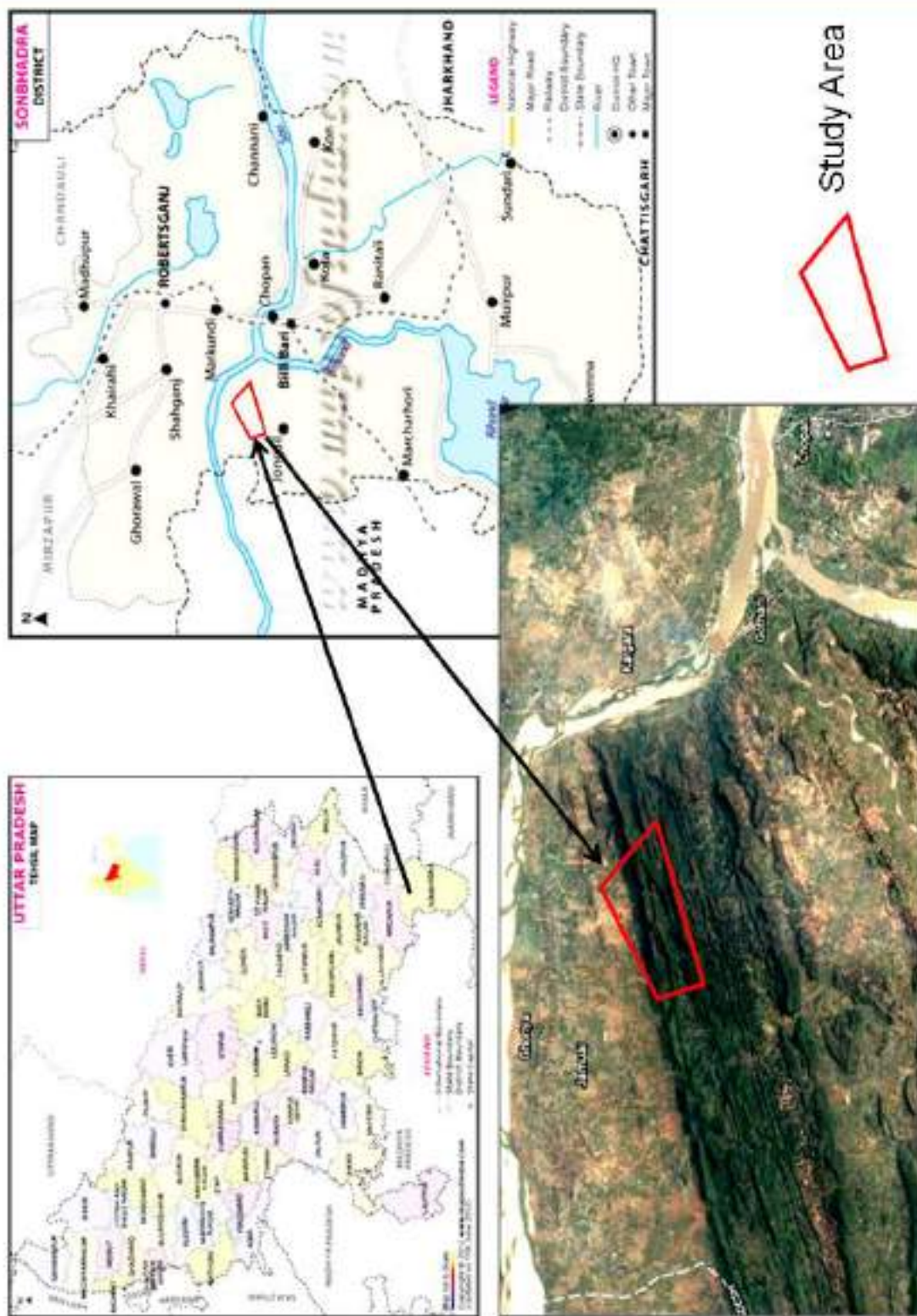
The forest is shelter for wild life such as fox, bear, dear, wild rabbits, wild pigs, different varieties of birds and a number of reptiles, mainly snakes.

3. Infrastructure & environment:

The nearest town Chopan has facilities for hospitals, police station, schools, etc. Agori fort is located 8 km south east of the study area at Agori Khas village. The Indian railways has large setup at Chopan and Chopan is main junction for this area. The villages are well connected with metalled roads and tracks. The roads and tracks are suitable to reach study area but the hilly terrains and interior small villages are accessible by foot tracks only. The river terrace, plains and hilly slopes are cultivated lands. Main crops are wheat, tur, maize and rice.

PLATE-I

LOCATION MAP OF IRON ORE BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH



Study Area

4. PREVIOUS EXPLORATION / WORK

I. Details of previous exploration / investigation carried by other agencies / parties:

A.K. Dey (1967-68; 1968-69) carried out a preliminary investigation work on Iron-ore occurrence near Bargawan (24°36'00", 82°52'30") Mirzapur district, U.P and it was subsequently taken up during the F.S. 1968-69 for making an appraisal of the quality and quantity of the available reserves. He observed iron ore in banded siliceous hematite-quartzite-jasper. The iron ore are mainly siliceous hematite, limonite and goethite with rare magnetite. Analytical results reveal that about 70% samples contain less than 35% Fe₂O₃. Approximately 6 million tonnes of possible resource of low grade Iron-ore was estimated in an area of about 0.37 sq. km.

NGCM was carried out by Sarkar *et. al.* during F.S. 2013-14 in toposheet no 63L/14. The higher Fe₂O₃ values above threshold were observed over the rocks of Mahakoshal Group in southern part of toposheet 63L/14 and north-western part of toposheet 63L/15. The high Fe₂O₃ (>14%) content in the composite samples is contributed by banded hematite quartzite and banded hematite jasper. The work indicated anomalous values in different parts of the area with respect to Cr (>459.12 ppm), Cu (>92.50 ppm) Ni (>164.26 ppm) Pb (>117.94 ppm) and V (>386.97 ppm).

Geophysical mapping was carried out during F.S. 2009-12. A gravity high supplemented with high magnetic values ranging from 100 nT to -150 nT, observed in the southern part of the Toposheet No. 63 L/14 is interpreted to be associated with the Mahakoshal Group of rocks.

Many workers have worked for different commodities in Mahakoshal Group of rocks. Some important work is described here -

Gold mineralisation: Gold exploration was carried out by Dwivedi, *et.al.* (2001) in Proterozoic rocks of Sonapahari area, Sonbhadra district, U.P., during the field season 1998-99 and 1999-2000. The exploration involved both surface trenching and sub-surface drilling to prove lateral and depth continuity of the zones in order to evaluate the potentiality of gold mineralization. The rocks exposed in the area are represented by phyllite-quartzite-tuff sequence with greywacke belonging to Parsoi Formation of the Early Proterozoic Mahakoshal Group. These are intruded by quartz/quartz-carbonate veins and a few basic bodies. The mineralisation in the area is controlled by shears, fold closures and at places by lithology.

Base metal mineralisation: Sporadic lead mineralisations in the form of dissemination of galena in calcareous chlorite schist have been noticed near Arangi. Galena in quartz vein is found in the Parsoi phyllites. The presence of disseminations of pyrite, chalcopyrite and pyrrhotite in

association with quartz veins and basic intrusives and geochemical anomalies with values upto 4,000 ppm Cu have been reported (Radhakrishnan and Vishwanathan, 1962) from the western extensions of the same belt of rocks in the sidhi district of Madhya Pradesh. Vredenburg (1901) also mentioned the presence of an old working for copper about half a mile north east of Charka.

Calcite blocks with good cleavage are seen in the localized area of Chulia hill. Ochreous pale pinkish to reddish and sometimes white clays were located near a foot-path 300 m west of the occurrence of calcite in Chulia hills. White clays were also seen in the hills towards N.E. of Parsoi and near Arangi. Gossan zones consisting of massive limonitic rocks occasionally showing a sponge or box-work structure are commonly present as capping rock. Iron ore occurs in the banded hematite and magnetite bearing quartzite of the Parsoi Formation. Manganese in the form of pyrolusite could be seen locally in cap rock on the brecciated quartzite as towards N.E. of Parsoi.

During FS 2014-15, Modak *et. al.*, carried out large scale mapping on 1:12500 scale covering parts of toposheet 63 L/14. Five subparallel bands of banded hematite chert / jasper were delineated from NW of Bijaura in east to Bharahari in west. The total strike length of these banded hematite chert / jasper bands is around 20 kms and width varies from 2m to 10m with cumulative width varying from 170 m to 450 m. It is interbanded with reddish brown, khaki phyllite with width up to 77m. Fragments of brecciated chert-jasper-quartzite-banded hematite chert / jasper clasts embedded in ferruginous and siliceous matrix occurs as linear patches having width up to 60 m within Banded hematite chert / jasper. Banded hematite jasper (BHJ), banded hematite chert (BHC) are observed NW of Bharahi, south of Murgidand and NE of Karwaniya, having exposed strike length of around 100 m and width 1m-2 m which are interbanded with phyllite as exposed on ridge top. The value of Fe_2O_3 varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe_2O_3 in the eastern most two blocks.

Iron ore investigation through detailed mapping of 1.50 sq km, pitting / trenching of 50 cubic meters and 50 numbers of BRS along with 750 metres of drilling was taken up in block 'A' of Bharhari, Sonbhadra district, UP vide item no. M2AFGBM:MEP/NC/NR/SU-UP/2017/11767, FS 2017-18 bounded by latitude N 24°33'32" – 24°34'09" and longitude E 82°51'41" – 82°53'16" by Shrivastav, M.R. and Ahmad S. The strike length of banded hematite chert / jasper band is 2.62 km and width ranging from 8-75m. The Fe values in trench samples of TR-1 varies from 31.3 % to 47.2 % with 38.95% as weighted average; while in TR-2, Fe values vary from 1.02 % to 30.86 % with weighted average value of 12.33% and Fe values of TR-3 samples range

from 12.4 % to 34.7 % with weighted average of 25.2 %. The trench TR-4 suggests Fe ranging from 29.4 % to 43.2% and weighted average of 35.4%. A total of 441 core samples were submitted for chemical analysis from borehole nos. SBE-1 to SBE- 8 from block 'A', Bharhari area, Sonbhadra. The analytical analysis shows that iron value (at 30% Fe cut off) varies from 29.99% to 49.87%, SiO₂ varies from 24.04% to 71.71% and Al₂O₃ varies from 0.12% to 8.51%. At 30 % Fe cut off, the core samples of boreholes SBE-2 and SBE-3 have yielded average Fe value of 29.98% and 31.58% respectively. The chemical results of core samples pertaining to borehole no. SBE-5 has average Fe value of 36.83%. In core samples of SBE-6, average Fe is 37.78%. Analytical results for cores from borehole SBE-7 have suggested average Fe of 34.37%. The cores of SBE-8 have average Fe value as 30.75%. The weighted average of all the core samples of borehole no SBE-1 to SBE-8 of the block 'A', Bharhari area at 30% Fe cut off has yielded an average grade of 34.73% Fe and at 35% Fe cut off has yielded an average grade of 38.34% Fe. The estimated resource at 30% cut off is 14.89 million tonnes (MT) and 8.41 million tonnes (MT) at 35% Fe cut off.

II. Details of aero-geophysical and Geophysical mapping, if any:

The geophysical mapping was conducted by Bhattacharya *et. al.*, during FS 2009-10 & 2010-12 in parts of Allahabad, Mirzapur and Sonbhadra districts of Uttar Pradesh and Rewa and Sidhi districts of Madhya Pradesh. The high gravity closure of -20 mgal (H1) as depicted on Bouguer Anomaly Map in the surrounding areas of Jungel (parts of Toposheet No. 63 L/14) have been attributed to heavier lithounits of Agori and Parsoi formations of Mahakoshal Group. These lithounits are WNW-ESE trending banded hematite chert / jasper bands, quartz veins and reefs and are traversed by a large number of E-W dolerite dykes in these areas. The strong and wide gradient in north and south of this high gravity (H1) outlines the boundary of the Mahakoshal rocks and separates it from Vindhyan rocks in the north and Dudhi Granitoid Complex in the south.

The variation in magnetic total field anomaly (MA) is gentle and small having widely-spaced contours in the entire study area except in the southern part of Toposheet No. 63 L /14. The gradients of Bouguer Anomaly observed on map are also observed on magnetic total field anomaly and are corroborated one to one. The strong gravity gradients observed north and south of Jogail, at west of Obra are strongly replicated on magnetic map also. Geologically, this area is

highly disturbed as a large number of contact zones are passing through this place besides presence of basic dykes traversing through the area.

III. Details of the part of the area covered earlier by exploration:

Large scale mapping in the present study area was carried out by Modak, *et.al.* in FS 2014-15 under the project entitled “Resource evaluation of potentiality of iron in Mahakoshal Group, Bharhari area, Sonbhadra district, Uttar Pradesh”. The investigated area falls in the Survey of India Toposheet nos. 63L/14 & 15. An area of 138 sq. km. was covered on 1:12,500 scale by large scale mapping. A total of 327 nos of bed rock samples were analyzed and a total of 26 cu. m. of excavation were done in 4 numbers of trenches. The chemical analysis of the bed rock samples collected from banded hematite chert / jasper zone yielded Fe_2O_3 values ranging from 13.07 to 82.15% with an average of 40.64%.

5. GEOSCIENCE INVESTIGATION

A. Regional Geology

I. Aerial Reconnaissance

Remote sensing LISS –III satellite data of pre-monsoon season (13th Mar 2013) and post monsoon season (26th Oct 2011) having 23.5 m spatial resolution has been downloaded from bhuvan.nrsc.gov.in and location of the investigation “Block ‘B’, Bharhari area” has been marked. In pre monsoon data of 13th Mar 2013, area is showing less vegetation and ENE-WSW trending ridge is totally barren whereas in post monsoon data of 26th Oct 2011, it is showing dense vegetation. Lineament map as available on bhuvan.nrsc.gov.in website has been used in the investigation block ‘B’. 3D visualization of area has been shown by ASTER DEM data and LISS III data. Relief map generated from ASTER DEM data shows ENE-WSW trending Banded hematite chert / jasper ridge is almost steeply dipping towards south (Plate: III).

II. Regional geology outlining the broad geological and structural framework:

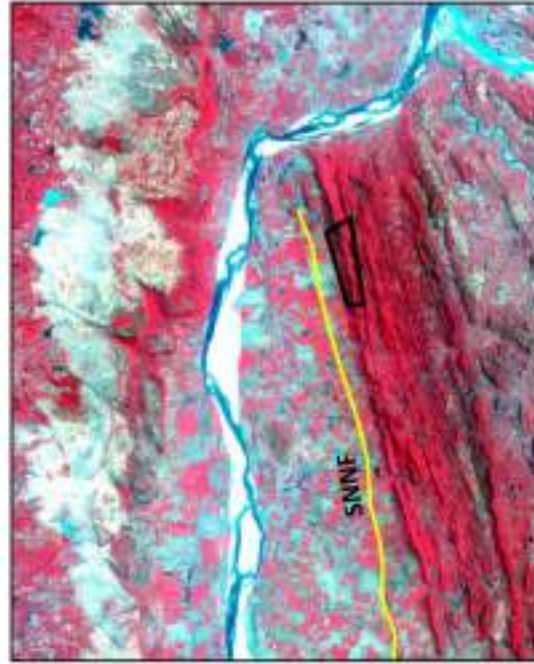
The Son valley in parts of Sidhi and Sonbhadra districts of Madhya Pradesh and Uttar Pradesh respectively forms central part of linear, arch-shaped belt of Mahakoshal Group. The rocks of the belt are exposed proximal to ENE-WSW to E-W trending ‘Son-Narmada-Lineament-Zone’ (SNLZ) and extend from Palamau district, Jharkhand in the east to Narsinghpur (M.P.) in the west (Nair *et al.* 1995) and probably further west to it (Tripathi and Mishra 1994; Soni and Jha, 2001). These rocks are inferred to have been deposited in rift basin environment which are separated to the north from Meso-Neoproterozoic platformal Vindhyan rocks and linear belt of gneiss-granite around Sidhi, M.P. by Son-Narmada-North-Fault (SNNF) whereas Dudhi Granitoid Complex and Gondwana sediments to the south are separated by the Son- Narmada-South-Fault (SNSF), locally known as Dudhi-Kassar Fault. The rocks of Mahakoshal Group show lot of variation in lithology from west to east. The western part is dominated by carbonate and chemical precipitates over clastics, whereas in the eastern part, rocks are predominantly meta-volcanics associated with metasediments and chemogenic sediments (Banded Iron Formation).

The stratigraphy of the Mahakoshal belt, as compiled by GSI NR, in the unified legend, (2011) is shown in Table-5.2. In the central part, the rocks of the Mahakoshal Group are broadly divided into Agori Formation, Parsoi Formation and Dudhmaniya Formation (Nair *et al.* 1995). The rocks of Agori Formation comprise of banded iron formation, chloritic phyllite, arenaceous

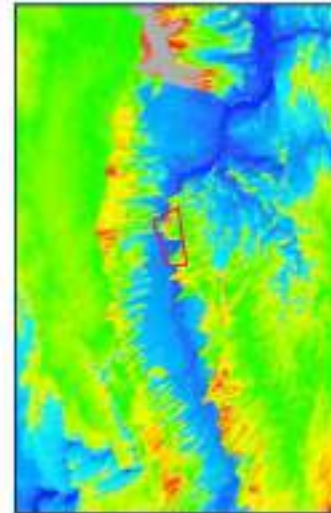
PLATE III



LISS III satellite view (13th March 2013) of Study Area



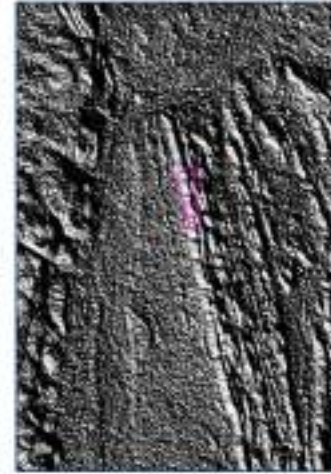
LISS III satellite view (26th October 2011) of Study Area



3D Visualization (front view) of area through
ASTER DEM data



3D Visualization (side view) of area
through LISS-III data



Relief map through ASTER DEM data

phyllite, quartzite, greywacke, metavolcanics and tuff. The contact of Agori and Parsoi formations is gradational. Obra- Amsi-Jiawan Fault is passing just near the contact of two the formations. The lithounits of Parsoi Formation includes variegated phyllite, chlorite-sericite-quartz phyllite, greywacke, bands of quartzite, metavolcanics and tuffaceous-carbonaceous phyllite. The rocks of Dudhmaniya Formation comprise of alternate sequence of banded hematite chert / jasper, phyllite, quartzite, shale / slate and mica schist with younger intrusives. It has large spread in the area and shows sinuous structure with foliation trending WNW-ESE in the west to E-W in the east. In the northern part of the area, Jungel Volcanics occurs in a linear belt and consists of volcanics/ultramafic/basic rocks developed in the E-W trending valley, namely, Jungel, Garda and Bhitri valleys in U.P. These rocks further extend towards west in M.P. The rocks of Mahakoshal Group are intruded by quartz veins and basic sills/dykes (Plate – II).

III. Regional stratigraphy

The generalised stratigraphic succession of the area is given in Table – 3.

**Table- 5.1: Stratigraphic sequence of Mahakoshal Group
(after Roy and Devarajan 2000)**

Chitrangi-Gurhar Pahar-Dudhamaniya area.		
Intrusives	Gold bearing quartz-carbonate veins, quartz reefs, dolerite. Granite-granodiorite-intrusive plutonic belt along the southern margin. Jhirkadandi granite and equivalents. Lamprophyre and syenite in Sidhi.	
Mahakoshal Group	Dudhamaniya Formation	Alternate sequence of Banded Iron Formation (mixed oxide-sulphide-carbonate-silicate facies) and phyllite. -----Gradational contact-----
	Parsoi Formation	Dominantly phyllite with bands of greywacke, quartz arenite, carbonaceous phyllite. ----- (Amsi-Jiyawan) Fault -----
	Sleemanabad = Agori Formation	Quartz arenite and carbonate in the lower part, massive and bedded chert, BHJ, highly carbonated and fragmented metabasalt with pillows and suspected pahahoe toes, Banded hematite chert / jasper, thin argillites. Ultramafic plugs.
Sidhi Gneissic Complex (basement)	Gneissic complex associated with mafic, ultramafic rocks and metasediments	

PLATE-II

Regional geological map of the area

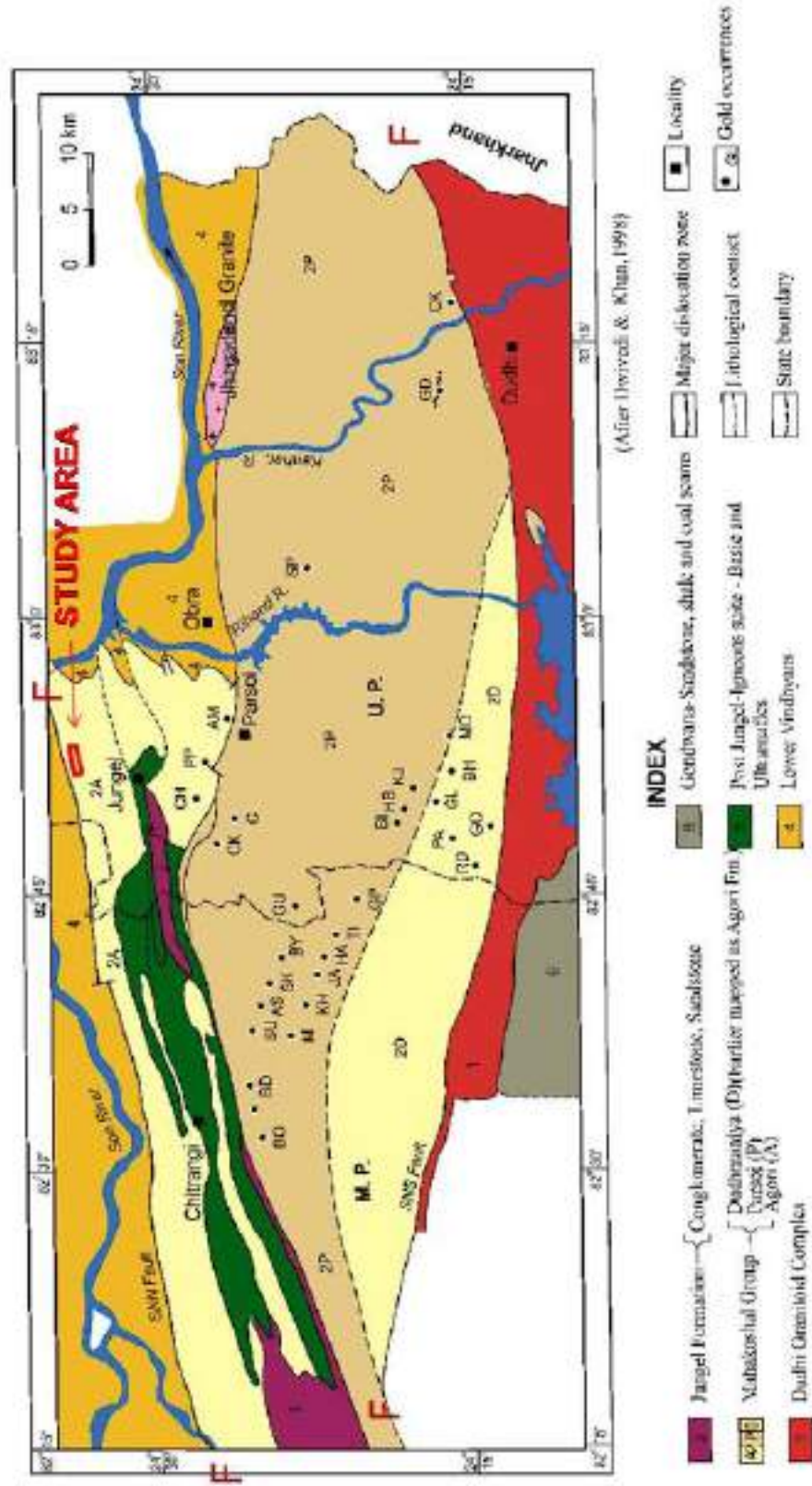


**Table – 5.2: Stratigraphic sequence of Mahakoshal Group
(compiled by GSI NR, in the Unified Legend, 2011)**

Mesoproterozoic	Vindhyan Supergroup		
Undifferentiated-Proterozoic	Jhirkadandi, Baghisoti-Dumar, Asnadohar and Sirpalia Granite	Two mica granite, diorite, porphyritic granite, mesocratic granite and pink leucogranite	
Palaeoproterozoic	Dudhi Granitoid Complex	Granite gneiss	
Palaeoproterozoic	Mahakoshal Group	Dudhmaniya Formation	Phyllite, quartzite, shale/ slate, mica schist with younger intrusive, Banded hematite chert / jasper
		Parsoi Formation	Variegated phyllite, greywacke, quartzite, metabasic, dolerite dykes and quartz veins
		Agori Formation	Shale, siltstone, sandstone, Banded hematite chert / jasper, basic and ultrabasic rocks
Palaeoproterozoic to Archaean	Dudhi Gneissic Complex	Feldspathic gneiss	
		Porphyroblastic gneiss	
		Banded gneiss, migmatite and biotite gneiss	

B. Detailed geological exploration

I. Detailed mapping on 1:4000 scale:

A total of 2.1 sq. km. area was mapped on 1:4000 scale and is bounded by NE 24° 34' 29.68" 82° 54' 49.66"; NW 24° 34' 04.39" 82° 53' 09.93"; SW 24° 33' 44.04" 82° 53' 12.07" and SE 24° 33' 59.71" 82° 55' 09.83" and falls under SOI toposheet no. 63L/14. The litho-units exposed in the block are variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert / jasper (BIF), ferruginous phyllite and dolerite. The sample locations, data collections point and contour heights were measured with the Total Station survey instrument. The banded hematite chert / jasper band forms a continuous band at the hill top with a strike length of 3.12 km and width ranging from 9m to 54m. The general trend of the rock types in the study area is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with dip amount of 50° to 80° towards south.

II. Outcrop map on 1:4000 scale:

The geological map shows the disposition of different lithologies in the mapped area as well as structural data recorded in the rocks of the investigated area. A considerable portion of the area is rugged and is covered with dense vegetation. The rock exposures have been outlined along the traverse lines, hill slopes, plains and nala sections. The geological map on 1:4000 scale

has been prepared by plotting the lithological outcrops, structural data and litho-contacts. (Plate–IV).

III. Description of Rock types

The mapped area comprises of the rocks of Agori Formation of Mahakoshal Group. A brief description of stratigraphy of the investigated area is given in Table 5.3:

Table – 5.3: Lithological succession of the investigated area

Age	Group	Formation	Lithounits
	Intrusives		Dolerite/Quartz veins
Palaeo-Proterozoic	Mahakoshal Group	Agori Formation	Tuff Phyllite interbanded with tuff Variegated phyllite, Banded hematite chert / jasper (BIF), Ferruginous phyllite
Basement is not exposed			

A brief discussion of the rock types observed during mapping of the investigation area is given below:

a) Variegated Phyllite:

The variegated phyllite is an important lithological unit present in most of the study area. The phyllite exposed in the study area is thinly banded (1mm-2cm) and has variant of colours namely pale green, purple and yellow. The colours of rock are not persistent and grade into each other with dominant shades of grey, pink/red, buff to khaki (Fig. 5.1 and 5.2). The phyllite at places is massive to highly jointed to splintery in nature. It is present dominantly in northern part of main BIF band and also in south-eastern boundary of area. The phyllite is interbanded with tuff at places and appears as a single unit. Mineralogically, the rock is composed of very fine grained anhedral quartz, muscovite, biotite and chlorite. The general strike is N60°E-S60°W to N88°E-S88°W with varying dip amount of 38° to 82° towards south. The phyllite exposed in SE boundary shows very high dip. At some places, later quartz veins have intruded along the foliation planes of phyllite. The phyllite occurring in the nala section is generally hard and indurated but that associated with tuff is comparatively soft and easily breakable.



Fig. 5.1 Variegated Phyllite, 228m south of borehole UPSBB-4, block-B, Bharhari



Fig. 5.2 Variegated Phyllite, NE of Δ 471, block-B, Bharhari.

b) Ferruginous phyllite:

It is one of the most widespread lithological unit present in the area and runs subparallel to the BIF band. This hard, massive rock type is present on down dip as well as up dip sides of the ridge. In down dip direction, these ferruginous phyllite are present as subparallel, discontinuous bands having an average width of 08-10m (slightly thicker at few places) traversing the area. Near eastern part of the block, these bands increase in width to 30m while in northern part (updip side) only one band is present. It is characterised by ferruginous bands (Fig. 5.3). These bands, at places, are highly enriched and shows subbands of hematite and/or jasper/chert and are marked separately within ferruginous phyllite. This lithology is generally light to dark reddish in colour. This is also intermixed with tuff parting of 1mm to 3cm. The ferruginous phyllite is composed of fine grained quartz, clay minerals and iron oxide. The ferruginous phyllite has peculiar feature of having chert nodules on the bedding planes (Fig.5.4). These chert nodules have sub-rounded to sub-oval outlines on the outcrop surface.



Fig. 5.3 Ferruginous Phyllite, 168m North of TRB-4, block-B, Bharhari



Fig. 5.4 Ferruginous Phyllite, near eastern boundary of block-B, Bharhari

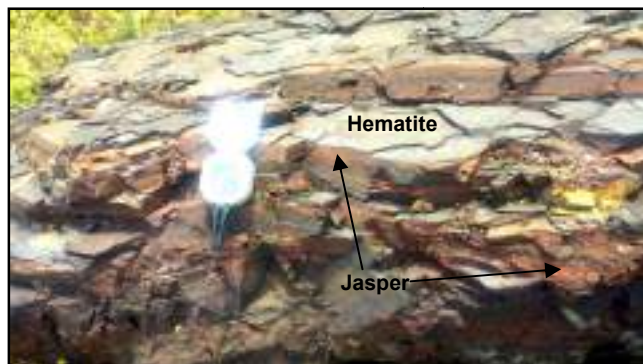


Fig 5.5 Ferruginous phyllite cum Banded hematite jasper/chert, south of UPSBB-3, block-B, Bharhari

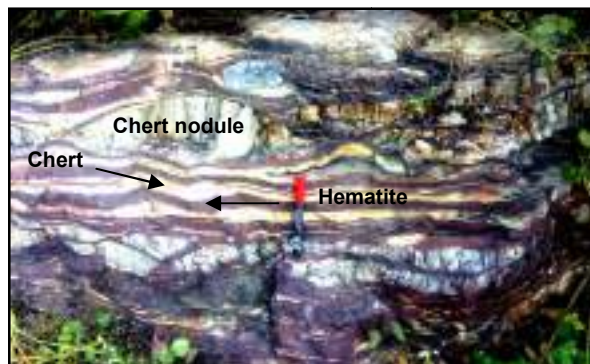


Fig 5.6 Ferruginous phyllite showing chert nodules at the south east of UPSBB-1(the west boundary), block-B, Bharhari.

c) Tuff:

The creamish/dirty white (off-white), purple to reddish colored tuffs are often laminated (also lumpy) and show laminations of 3 to 5 mm on freshly broken surface. The reddish color is due to its proximity with ferruginous bands namely banded hematite chert / jasper. The individual grains are not identifiable under unaided eyes but felsic in constitutions. The fresh surface shows vitreous lustre and conchoidal fracture, whereas their weathered surface shows waxy luster. The tuff is exposed dominantly in south of banded hematite chert / jasper along its strike length as isolated patches and in form of lenses in the north of BIF band. These tuffs have originated from volcanic sources and constitute the uppermost part of the iron sequences. These often occur as low mounds in the valley portion of DM block.



Fig. 5.7 Tuff, 44m north of UPSBB-4, block-B, Bharhari.

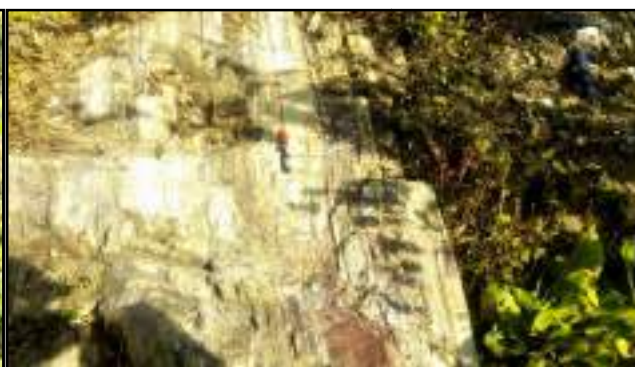


Fig. 5.8 Tuff, near western Boundary of block-B, Bharhari.

d) Phyllite interbanded with tuff:

This unit constitute the major part of area and present in south of major BIF band all along its strike. In central part most of the valley part is covered by this unit. The phyllite is interbanded with tuff having thickness of 1mm to 5cm. This lithology has various shades of colors milky white, pink, reddish and purple. The tuff gets silicified, hardens and loose its original soft nature. This lithology is widely exposed at the northern flank from north of borehole UPSBB-2 to UPSBB-4.



Fig. 5.9 Phyllite interbanded with tuff, 70m south of borehole UPSBB-4, block-B, Bharhari.



Fig. 5.10 Phyllite interbanded with tuff, east of trench TRB-3, block-B, Bharhari.

e) Banded hematite chert / jasper:

The banded hematite chert / jasper is the most important and wide spread lithological unit with bands of hematite, chert and/or jasper. It is the marker band of the area. At places, the insitu boulders of massive BIF have been found to be dispersed on the ridge crest of the assigned block. The iron ore resources in the area are mainly hosted with these banded hematite chert / jasper bands. The most persistent and continuous banded hematite chert / jasper band is exposed at the ridge top and its width varies from 9 m to 54 m. The thickness of chert/jasper meso bands generally ranges from 1 mm to 4 cm, while that of iron rich meso bands ranges from few mm to 8 cm. The hematite is dark grey to reddish brown in colour while dominant chert bands are light grey to white and the jasper bands are brilliant deep red in colour. The exposure width of this unit varies widely depending upon the dip of strata and slope of hill range. The banded hematite jasper/chert bands has N65°E-S65°W to N85°E-S85°W strike and its dip amount varies from 50° to 80° towards south. In eastern part of trench TRB-3 the width of the band and dip increases and attains maximum width of 54 m exposed in west of trench TRB-5 and has steep dip of 75° to 80°. Few sulphide specks in form of pyrite have also been noticed in exposed chert bands.

The hematite is altered at places and has given rise to its hydroxides i.e. Goethite and Limonite. Goethite has shades of brown, reddish to pinkish brown. Limonite occurs with goethite and as stains in the microcavities of hematite bands. It is dull yellowish to pale brownish in colour.



Fig. 5.11 Banded hematite jasper, 5m South of trench TRB-2

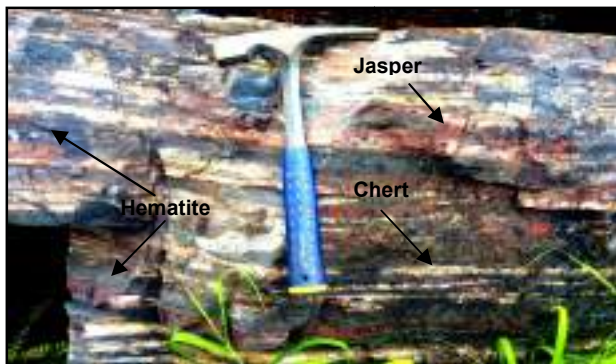


Fig. 5.12 Banded hematite chert/jasper, 156m NE of borehole UPSBB-1



Fig. 5.13 Banded hematite chert/jasper, 140m NE of borehole UPSBB-1.



Fig. 5.14 Banded hematite chert, East of Δ 471.

f) Dolerite dyke:

The dolerite dyke is melanocratic, medium grained hard rock exposed in the southern part started from western boundary to near borehole no. UPSBB-4, few outcrops are found near south-east boundary of study area. A few impersistent bodies are also exposed in the north of ridge in the form of impersistent lenses. These dolerite dykes are weathered in the south-western part of the area, however, at central part (i.e. ~200 m south-east of UPSBB-4), it is massive and show crude foliation. Mineralogically, the dolerite consists of plagioclase laths and pyroxene with few sulphide specks. The general trend of dolerite bodies is ENE-WSW with a width of 17-150 m. In South-West of UPSBB-1, it is showing spheroidal weathering. (Fig. 5.15)

g) Altered Basic Rock:

This lithounit is light greenish grey, hard, fine grained and massive as well as weathered in nature. It is exposed in south of TRB-4 near southern boundary along nala and disposed along foliation direction in continuation of dolerite/weathered dolerite. It consist of pyroxenes, chlorite (altered pyroxene) and iron oxides (Fig. 5.16).



Fig. 5.15 Dolerite showing spheroidal weathering



Fig. 5.16 Altered basic rock

h) Quartz vein:

The quartz veins are emplaced in phyllite and banded iron chert / jasper along the foliation planes and at places along the joint planes trending along N40°W – S40°E and N80°E – S80°W. Quartz veins are white, oxidised and show sulphide mineralisation at places. The majority of quartz veins are emplaced in ferruginous phyllite and are sub-parallel to the strike. The quartz veins have thickness of 1mm to 2m and its length extends up to 118m in east of borehole no. UPSBB-1.

I) Petrological and petrochemical studies:

The petrographic studies of thin sections were done and the descriptions are as follows:

a) Variegated Phyllite/Ferruginous Phyllite:

The phyllite studied under microscope is composed of fine to medium grained quartz, muscovite, chlorite and biotite. It shows the sub-parallel arrangement of flaky minerals like chlorite, muscovite and biotite. The anhedral to subhedral quartz grains are fine to medium grained, show first order grey interference colour and exhibits typical undulose extinction under cross nicols. Few opaque minerals like magnetite has also been observed in reflected light (Fig. 5.17). The crenulation cleavages have also been observed in the flaky minerals like muscovite and biotite. At places, the iron oxide is present as bands within the phyllite. The chert grains show preferred orientation and are surrounded by platy and flaky minerals. (Fig.

5.18 & Fig. 5.19). At places, the phyllite has alternate bands of iron oxide and chert/jasper. The ferruginous phyllite is generally medium grained, consisting subhedral to anhedral quartz, muscovite, chlorite and biotite. It is similar to phyllite but with marked presence of iron oxide bands. (Fig. 5.20).

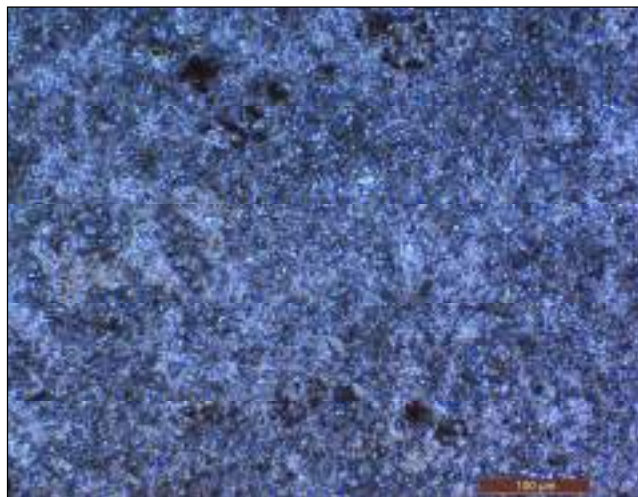


Fig. 5.17 Photomicrograph of phyllite with fine grained anhedral quartz, muscovite and sericite with few opaque of magnetite (Sample:PS-16)



Fig. 5.18 Photomicrograph of ferruginous phyllite showing bands of phyllite and iron oxide. (Sample:PS-5)



Fig. 5.19 Chert nodule surrounded by platy and flaky minerals in ferruginous phyllite (Sample: PS-8)

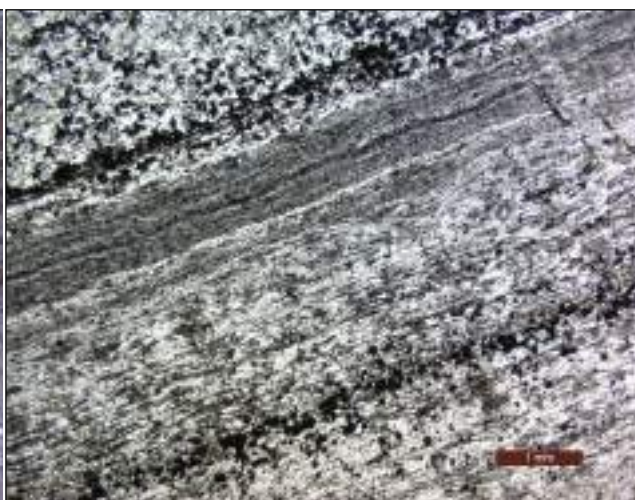


Fig. 5.20 Alternate bands of iron oxide (greyish black) and chert/jasper within ferruginous phyllite (Sample: PS-11)

b) Tuff:

Under microscope, tuff consists of anhedral quartz, sericite mica – lithic fragments in glassy groundmass along with devitrified quartz veins and opaque. The irregularly shaped glass shards have also been noticed. The quartz grains are represented by broken anhedral sub-rectangular grains often showing embayment. (Fig. 5.21 & 5.22).



Fig. 5.21 Photomicrograph of tuff in PPL
(Sample:PS-4)

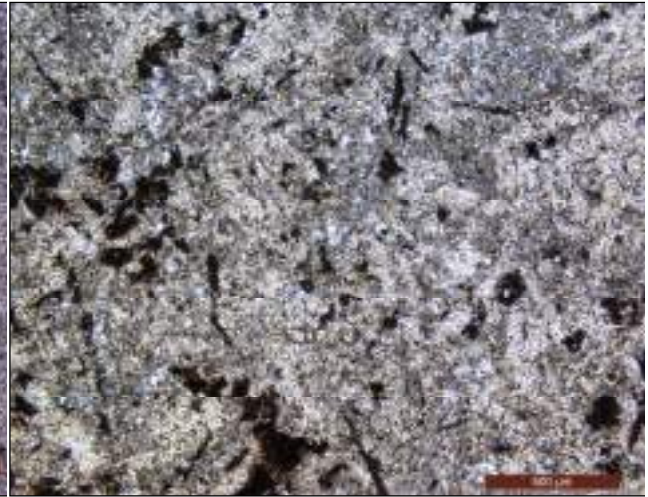


Fig. 5.22 Photomicrograph of tuff in PPL
(Sample:PS-31)

c) Banded hematite chert / jasper (BIF):

This lithology when studied under microscope has alternate bands of hematite and chert/jasper bands. The hematite occurs as tiny grains arranged in a preferred orientation (Fig. 5.23, Fig. 5.26) The chert has its cryptocrystalline nature and also present in the interstitial spaces. The martitisation of magnetite in hematite is noticed. A few scattered opaque minerals identified as magnetite and sulphides in form of pyrite (Fig. 5.24). Chlorite is present in subordinate amount (Fig. 5.25).

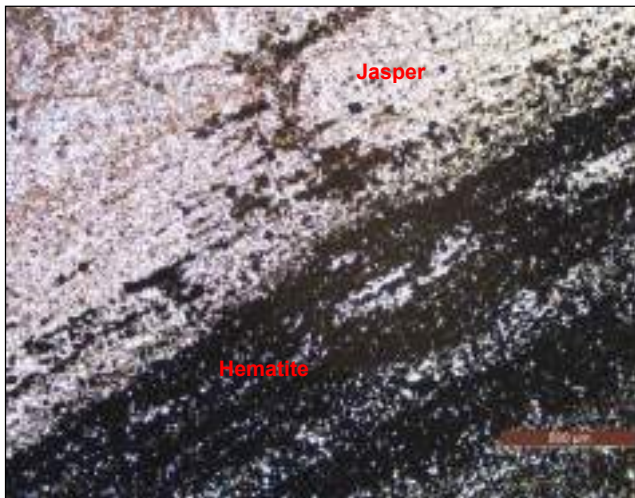


Fig. 5.23 Alternate bands of hematite and jasper (BIF),
(Sample:PS-1)

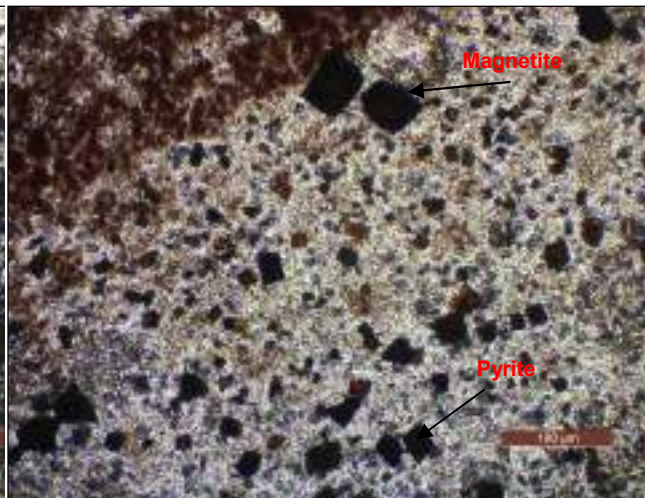


Fig. 5.24 Pyrite and Magnetite grains in banded hematite
jasper (Sample: PS-1)

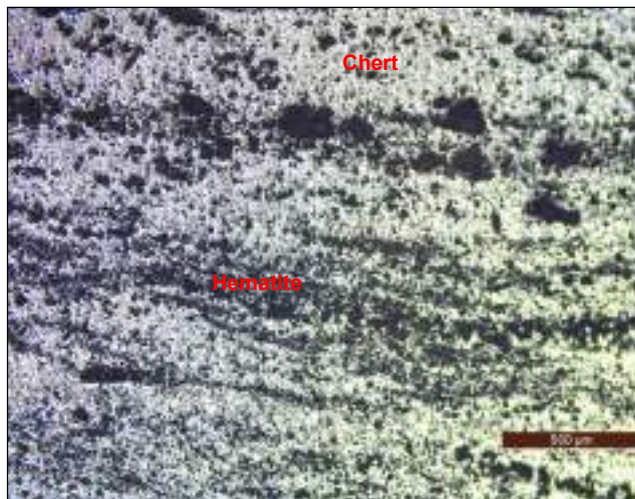


Fig. 5.25 Photomicrograph of banded hematite chert/jasper, (Sample: SBB-2/138)

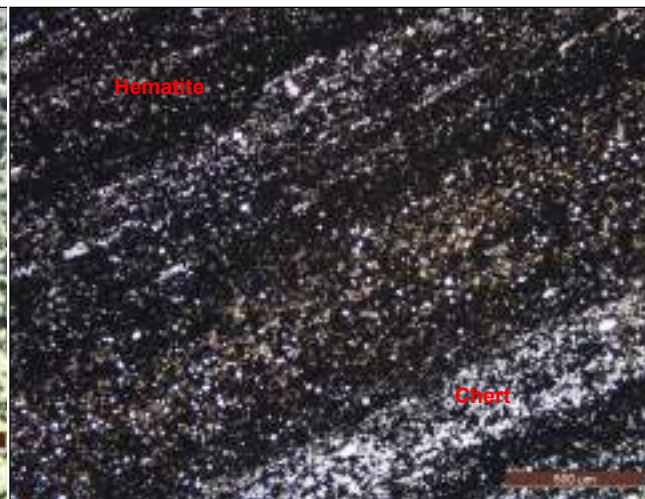


Fig 5.26 Photomicrograph of banded hematite chert/jasper, (Sample: SBB-1/31.5)

d) Dolerite dyke:

Under microscope, the rock is holocrystalline composed of plagioclase, clinopyroxene-augite, amphibole, and sericite with pyrite. The rock shows sub-ophitic intersertal texture, as the laths of plagioclase lie in a matrix of coarse subhedral augite minerals. The plagioclase grains appear to be partially or entirely enclosed in pyroxene (Fig. 5.27 and 5.28). Sericite is observed within the plagioclase grain.

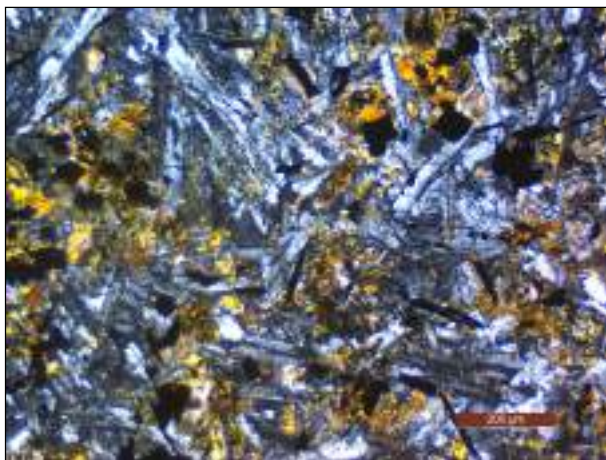


Fig. 5.27 Photomicrograph of Dolerite showing laths of plagioclase and augite (Sample: SBB-2/124.35)

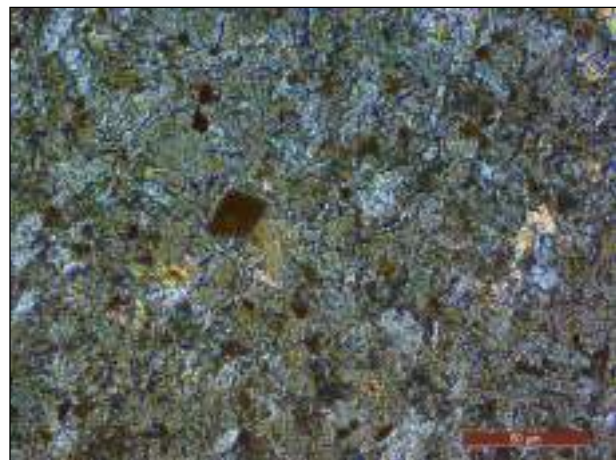


Fig. 5.28 Photomicrograph of Dolerite (Sample: PS-19)

Ore Microscopic studies:

a) Ferruginous Phyllite:

In ferruginous phyllite, the alternate bands of phyllite and iron oxide is present. The rock when studied under reflected light shows very fine grained nature. It is composed of fine to medium grained quartz, muscovite, chlorite and biotite minerals. The rock shows crenulations developed due to preferred orientation of platy and flaky minerals. It also shows few fine grained dispersed few opaque minerals which are identified as magnetite and sulphide grains. (Fig. 5.29 and Fig. 5.30).

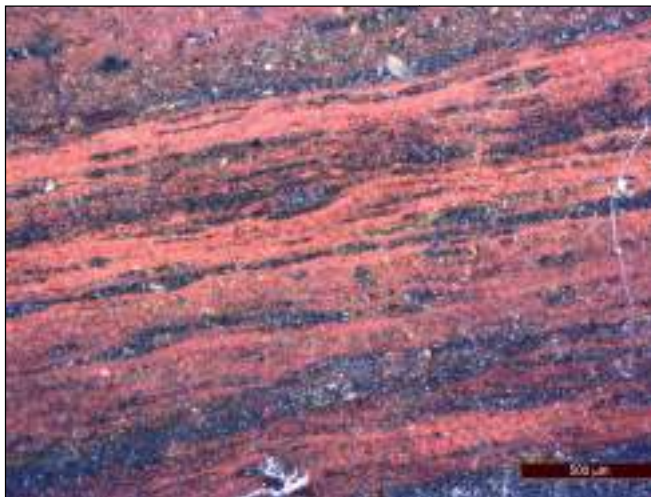


Fig. 5.29 Photomicrograph of ferruginous phyllite showing crenulations of platy and flaky minerals (Sample:PS-5)

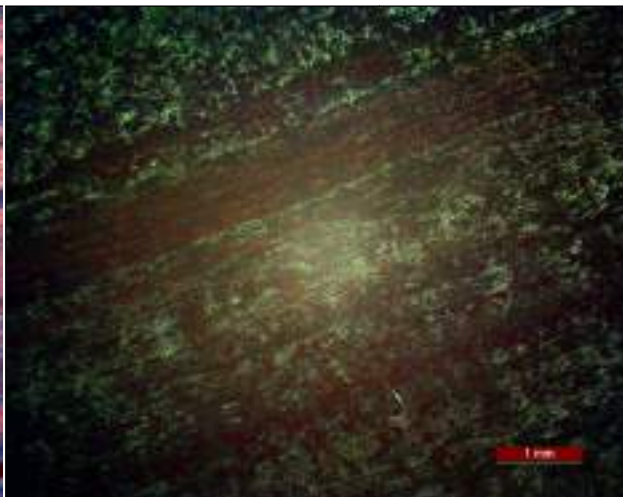


Fig. 5.30 Photomicrograph of ferruginous phyllite showing alternate bands of phyllite and iron oxide, Sample: PS-11

b) Banded hematite chert / jasper (BIF):

The banded hematite chert / jasper under reflected light shows alternate bands of hematite and chert/jasper (Fig. 5.31, 5.32 and 5.33). Chert band groundmass has a few sporadic magnetite grains formed due to martitisation (Fig. 5.34). Fine-to-medium grained grains of hematite are intricately associated with each other leaving fine intergranular micro pore spaces. Micro fractures are present in the alternating bands and hydroxide occur due to leaching out of original pre-existing minerals (Fig. 5.32, 5.33). Few accessory sulphide mineralisation in form of pyrite is present.



Fig. 5.31 Photomicrograph of banded hematite chert showing bands of hematite and chert (Sample: PS-6)



Fig. 5.32 Photomicrograph of banded hematite chert/jasper showing alternate bands of hematite and chert (Sample: SBB/2-139.50m)

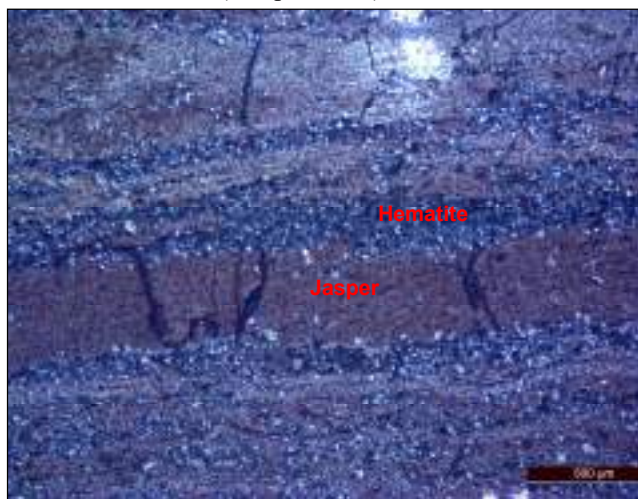


Fig. 5.33 Photomicrograph of banded hematite chert/jasper showing alternate bands of hematite and jasper (Sample: PS-12)

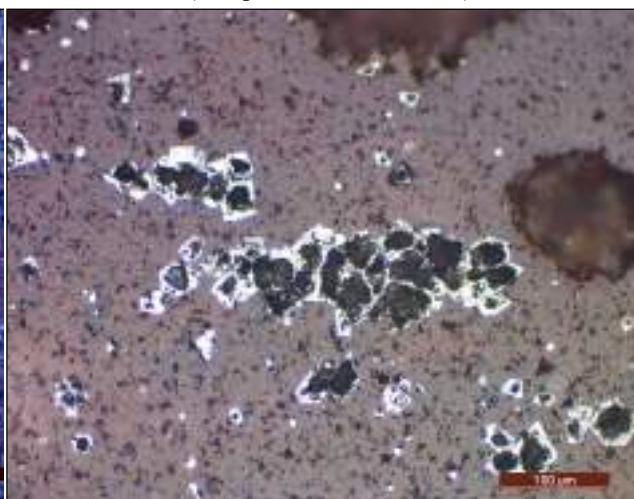


Fig. 5.34 Sporadic magnetite in jasper groundmass in Banded hematite chert/jasper (Sample: PS-6)

XRD studies:

Two samples from Tuff and Phyllite interbanded with tuff were analysed with X-Ray Diffraction. The quartz and clay (kaolinite) are present in the tuff with minor amount of anatase (polymorph of rutile). The hematite shows its presence in good amount because tuff is in close proximity of BIF. The Phyllite interbanded with tuff has quartz as major constituent and clay (Kaolinite) in trace amount. In this sample also small amount of hematite shows its presence due to proximity with BIF. The XRD analytical results of samples are described in the following table 5.4.

Table 5.4: X- ray diffraction analysis of samples

Sr. No.	Sample No.	Lithology	Constituents detected in semi-quantitative analysis of crystalline portion of samples by RIR values					
			Major	Minor	Good Amount	Small Amount	Trace Amount	Likely trace
1	PS-7	White Tuff	Quartz	Kaolinite	Hematite	X	Anatase	X
2	PS-8	Phyllite interbanded with tuff	Quartz	X	X	Hematite	Kaolinite	X

V. Structure

Both non-diastrophic and diastrophic structures are noticed in the area which are discussed below:

Non-diastrophic Structure

(a) Primary bedding (S_0): Bedding is the most important primary structure observed in the investigated area, recognized by compositional variation between ferruginous and siliceous layers manifested in the form of colour banding. Primary bedding is observed in banded hematite chert/jasper and in ferruginous phyllite, it is defined by composition and color banding. In banded hematite chert / jasper, alternate bands of hematite and chert/jasper define the S_0 . The thickness of the individual hematite bands varies from a few millimeters to 8 cm. Similarly, in ferruginous phyllite, ferruginous and siliceous layers are often masked by deep brown colors and define compositional banding. The general strike of bedding (S_0) is ENE-WSW ($N65^\circ E-S65^\circ W$ to $N85^\circ E-S85^\circ W$) with moderate to steep dips from 50° - 80° towards south.

Diastrophic Structure

(a) Foliation: Penetrative axial planar fabric, S_1 , is most commonly observed in the investigation area. At most places, S_1 is sub-parallel to the bedding surface (S_0) in phyllite therefore showing trend ENE-WSW ($N65^\circ E-S65^\circ W$ to $N85^\circ E-S85^\circ W$) with moderate to steep dip ranging from 35° to 82° towards south.

(b) Joints: Three sets of joints are observed in banded hematite chert / jasper and ferruginous phyllite. One set of joint (J_1) trend is dominantly $N10^\circ E - S10^\circ W$ to $N10^\circ W - S10^\circ E$, other set of joint (J_2) trending $N80^\circ E - S80^\circ W$ and third type of joint (J_3) is $N30^\circ W - S30^\circ E$ to $N45^\circ W - S45^\circ E$ with steep to vertical dips.

VI. Metamorphism

In thin section studies of phyllite, schistose texture is defined by subparallel arrangement of chlorite, muscovite and biotite. This suggests that rocks exposed in the mapped area are characterised by low-grade metamorphism of greenschist facies. Metasedimentaries of the area namely variegated phyllite and ferruginous phyllite are marked by the presence of fine grained quartz, muscovite, chlorite, biotite with few opaque. This mineral assemblage indicates the biotite zone of greenschist facies regional metamorphism. (Winkler, 1974).

VII. Mineralogy of the ore zone and ore textures:

The banded iron formation exhibits hematite and chert bands in majority. At places, jasper band is also present. The hematite band has thickness ranging from 1mm to 8 cm. Disseminated specks / veins of pyrite and arsenopyrite are hosted by variegated (grey, massive) phyllite, banded hematite chert / jasper and small amount in tuff.

VIII. Pitting and Trenching

Total five trenches were excavated in the area during the course of the present investigation to study the strike / width continuity of banded hematite chert / jasper (BIF). The trenches were cut across the trend of the banded hematite chert / jasper wherever it is not exposed and 79 nos. of samples were collected from them. The samples were withdrawn from BIF bands and soil with boulders of BIF that are *insitu* in the trenches. The sampling interval in the trenches was kept at 1 m and homogeneous sampling was carried out.

Table 5.5: Details of trenches

Sr. No.	Trench No.	Fe Band	Latitude / Longitude	Orientation of the trench	Area in cu.m. (l x w x d)	Width of the iron ore zone	No. of samples including ore zone	Wt avg of Fe%
1	TRB-1	1	24° 33' 57.7" 82° 53' 25.8"	N10°W-S10°E	16x1x1=16	16m	16	34.39
2	TRB-2	1	24° 34' 03.9" 82° 53' 58.7"	N-S	22x1x1=22	11m	22	35.53
3	TRB-3	1	24° 34' 08.9" 82° 54' 28.1"	N-S	20x1x1=20	13m	20	44.33
4	TRB-4	-	24° 34' 04.7" 82° 54' 13.2"	N10°W-S10°E	6x1x1=6	0m	6	45.87
5	TRB-5	-	24° 34' 14.2" 82° 54' 52.6"	N-S	15x1x1=15	0m	15	43.45

The trench TRB-1 was excavated in the profile line of borehole UPSBB-1 across the banded hematite chert / jasper band to expose the true width of the band. The trench TRB-1 is 16

m long X 1m wide X 1 m deep and samples were collected from 1m interval all along the floor of trench. In TRB-1, the thickness of BHC/J (BIF) is 13m with Fe% varies from 23.81% to 45.13%. The trench TRB-2 excavated in between borehole UPSBB-3 and UPSBB-4 in soil cover of 22 m long X 1m wide X 1m deep. A total of 22 samples were withdrawn keeping sample length to 1m. Trench TRB-3, 20 m long X 1m wide X 1m deep, was excavated in the soil cover for exposing the banded hematite chert / jasper band. The trench TRB-4 was excavated at 250 m in east of borehole UPSBB-4 to expose the width of banded hematite chert/jasper bearing zone. The last trench TRB-5 was excavated at the eastern part of mapped area for exposing the width continuity of banded hematite chert / jasper. All trenches are systematically logged and trench logs are prepared. (Plate – VI to X). The details of all five trenches with analytical results are given in annexure – III.

IX. Sampling

Bed rock sampling was carried out during the course of investigation. Most of the bed rock samples were collected from banded hematite chert / jasper and ferruginous phyllite with few samples from phyllite, tuff, quartz veins and dolerite. A total of 54 bed rock samples and 26 channel samples were collected and submitted to chemical division for analysis. The bed rock samples were collected by removing the oxidised / weathered top portion of bed rock and collecting the fresh part. The bed rock samples were kept in the fresh polythene bags and labelled. Three channels were cut across the BIF in the profile lines of boreholes. The channel SBB/CH-1 of 6m length was cut across banded hematite chert/jasper band in the profile line of borehole UPSBB-2 and 6 samples of 2m length were withdrawn. The channel SBB/CH-2 of 8m length cut across banded hematite chert/jasper band in the profile line borehole UPSBB-3 and 8 samples of 2m length were withdrawn. The channel SBB/CH-3 of 12m length was cut across banded hematite chert/jasper band in the profile line of borehole UPSBB-4 and 12 samples of 1m length were withdrawn (Plate – XI).

The detail of channels cut in the area are summarised in the table 5.6.

Table 5.6: Detail of channels

CHANNEL – SBB/CH-1						
Sr. No.	Sample No.	From (m)	To (m)	Sample Length (m)	Lithology	Fe %
1	SBB/CH-1/1	0	2	2	Banded Hematite Chert / Jasper	25.20
2	SBB/CH-1/2	2	4	2	Banded Hematite Chert / Jasper	28.42
3	SBB/CH-1/3	4	6	2	Banded Hematite Chert / Jasper	51.01

4	SBB/CH-1/4	6	8	2	Banded Hematite Chert / Jasper	45.17
5	SBB/CH-1/5	8	10	2	Banded Hematite Chert / Jasper	39.12
6	SBB/CH-1/6	10	12	2	Banded Hematite Chert / Jasper	31.85
Weighted average						36.80
CHANNEL – SBB/CH-2						
7	SBB/CH-2/1	0	2	2	Banded Hematite Chert / Jasper	38.43
8	SBB/CH-2/2	2	4	2	Banded Hematite Chert / Jasper	37.89
9	SBB/CH-2/3	4	6	2	Banded Hematite Chert / Jasper	28.74
10	SBB/CH-2/4	6	8	2	Banded Hematite Chert / Jasper	30.63
11	SBB/CH-2/5	8	10	2	Banded Hematite Chert / Jasper	39.25
12	SBB/CH-2/6	10	12	2	Banded Hematite Chert / Jasper	35.89
13	SBB/CH-2/7	12	14	2	Banded Hematite Chert / Jasper	39.50
14	SBB/CH-2/8	14	16	2	Banded Hematite Chert / Jasper	29.53
Weighted average						34.98
CHANNEL – SBB/CH-3						
15	SBB/CH-3/1	0	1	1	Banded Hematite Chert / Jasper	42.26
16	SBB/CH-3/2	1	2	1	Banded Hematite Chert / Jasper	41.60
17	SBB/CH-3/3	2	3	1	Banded Hematite Chert / Jasper	46.22
18	SBB/CH-3/4	3	4	1	Banded Hematite Chert / Jasper	31.69
19	SBB/CH-3/5	4	5	1	Banded Hematite Chert / Jasper	55.98
20	SBB/CH-3/6	5	6	1	Banded Hematite Chert / Jasper	56.58
21	SBB/CH-3/7	6	7	1	Banded Hematite Chert / Jasper	56.86
22	SBB/CH-3/8	7	8	1	Banded Hematite Chert / Jasper	62.62
23	SBB/CH-3/9	8	9	1	Banded Hematite Chert / Jasper	52.39
24	SBB/CH-3/10	9	10	1	Banded Hematite Chert / Jasper	57.11
25	SBB/CH-3/11	10	11	1	Banded Hematite Chert / Jasper	58.54
26	SBB/CH-3/12	11	12	1	Banded Hematite Chert / Jasper	62.81
Weighted average						52.05

X. Discussion of results of chemical analysis of samples

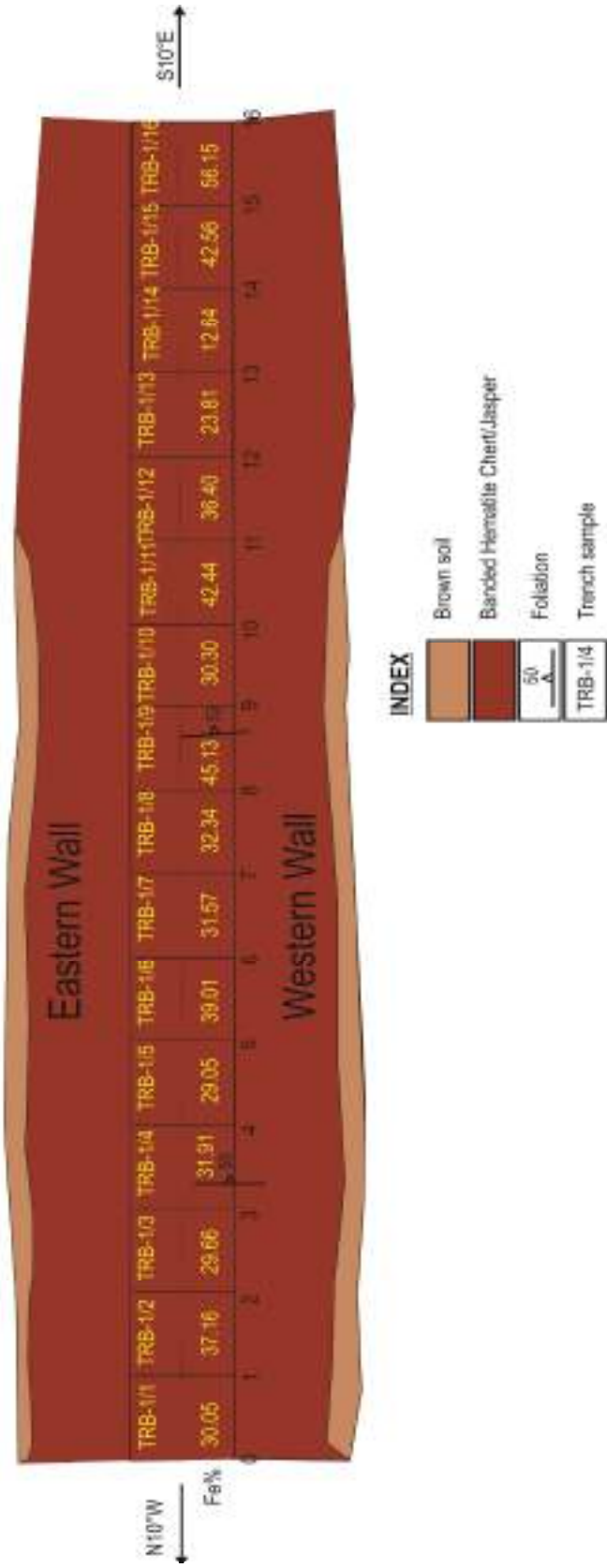
A total of 80 nos. bed rock samples (including 26 nos. channel samples), 79 nos. trench samples from five trenches and 195 nos. core samples from four boreholes were collected. The chemical results received suggested Fe values of banded hematite chert / jasper in bed rock ranging from 6.67 % to 46.39 % with an average of 26.51 %. The analytical values of 26 nos. channel samples revealed Fe values ranging from 25.20 % to 62.81 % with weighted average of 43.28 %. The analytical results of bed rock samples and channel samples are given in the Annexure – I.

The Fe values in trench samples of TRB-1 varies from 12.64 % to 56.15 % with 34.39% as weighted average Fe, while in TRB-2, Fe values vary from 26.68 % to 45.87 % with weighted average value of 35.53 % and Fe values of TRB-3 samples range from 20.21 % to 59.17 % with

Trench log of TRB-1 at Block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

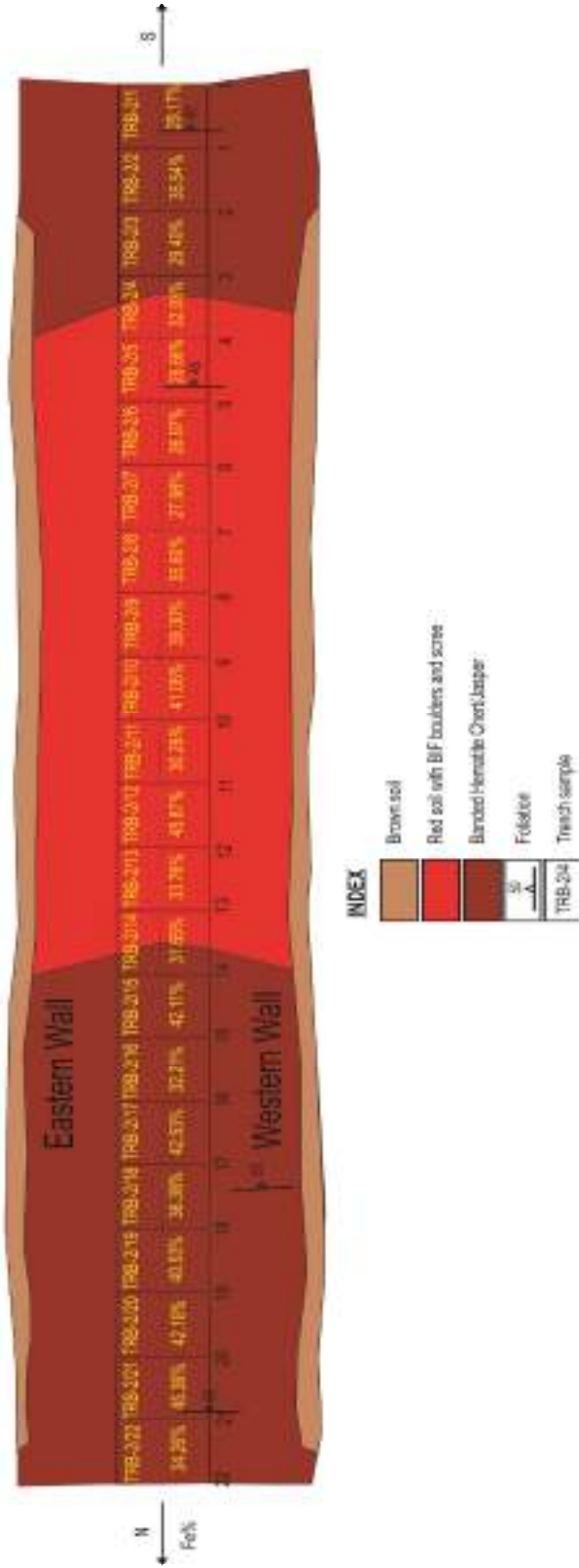
Plate - VI

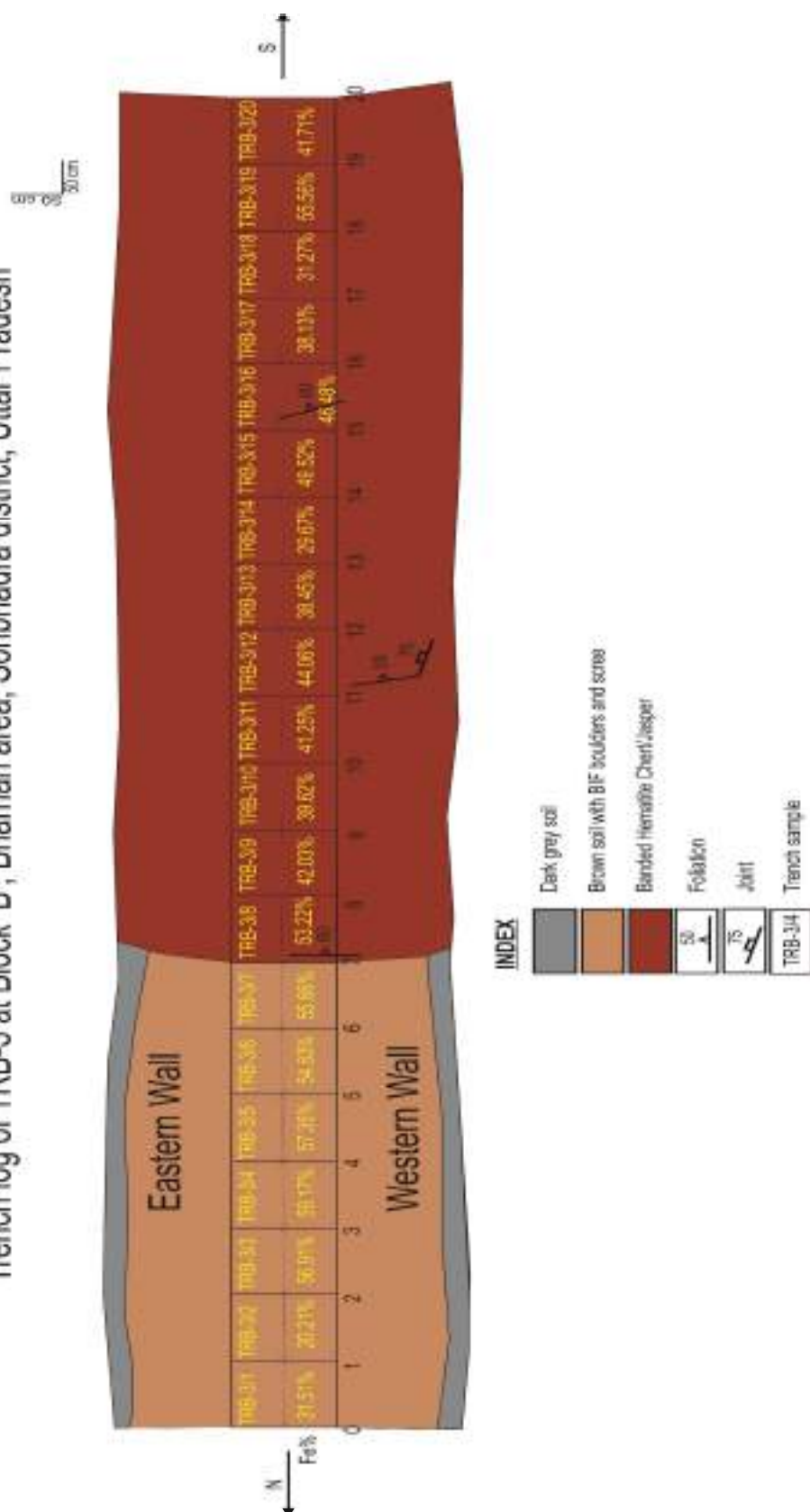
0 20 40 cm



Trench log of TRB-2 at Block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

00 cm
50 cm

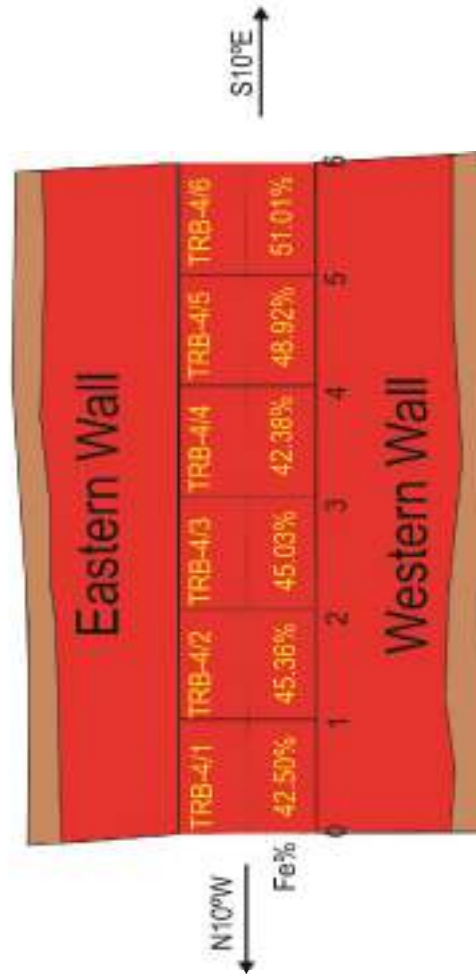




Trench log of TRB-4 at Block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Plate - IX

50 cm
50 cm



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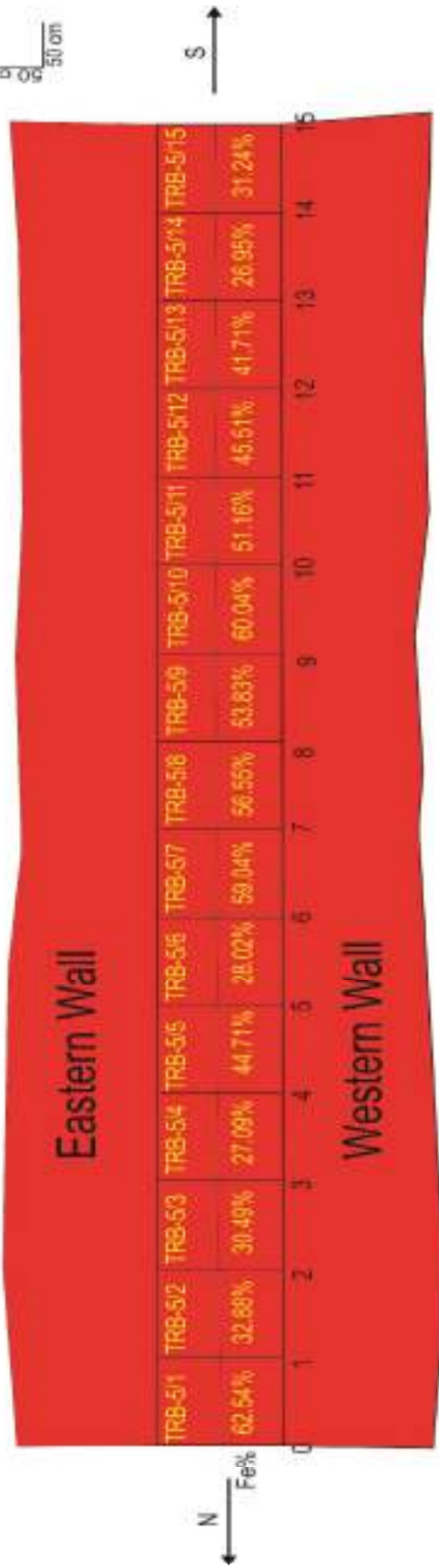
Brown soil

Red soil with BIF boulders and scree

TRB-4/2
Trench sample

Trench log of TRB-5 at Block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

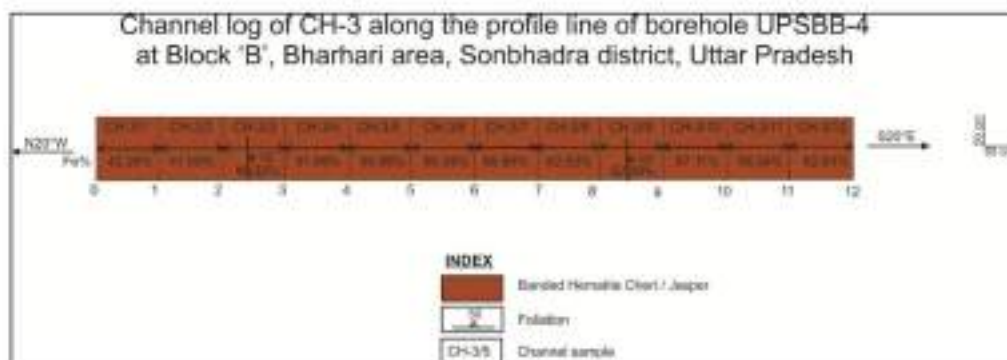
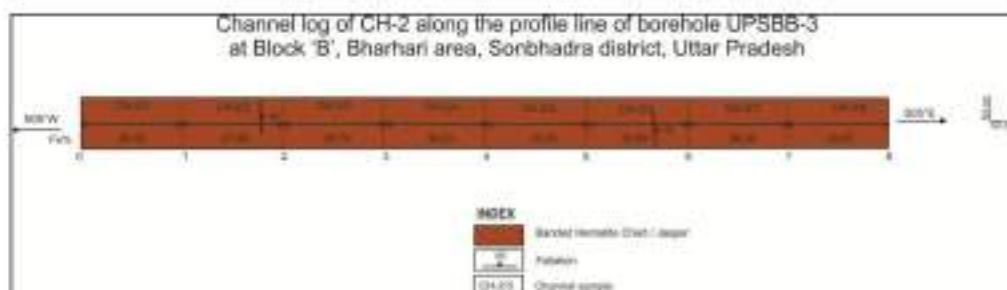
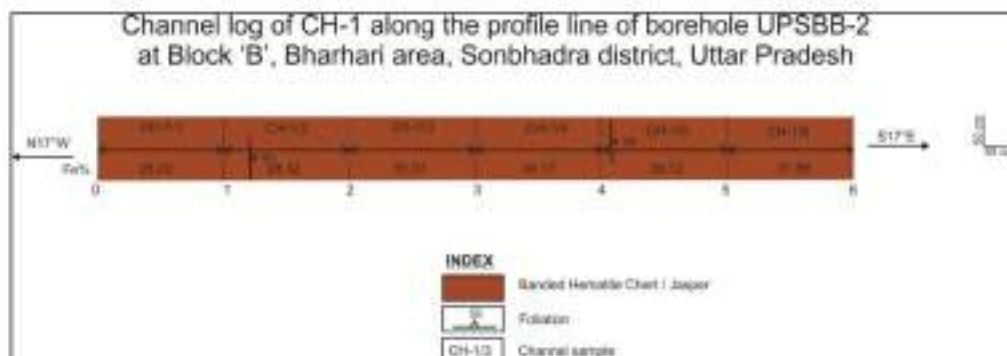
Plate - X



INDEX

- Reddish soil with BIF boulders and scree
- Foliation
- Trench sample

Channel log of Block- 'B', Bharhari Area, Sonbhadra district, Uttar Pradesh



weighted average of 44.33 %. The trench TRB-4 suggests Fe ranging from 42.38 % to 51.01 % and weighted average of 45.87 %. In trench TRB-5, Fe values ranging from 26.95 % to 62.54 % with weighted average of 43.45 %. The analytical values of trench samples are summarised in Annexure – III.

A total of 195 nos. core samples (including 6 nos. of check samples) were submitted for chemical analysis from borehole nos. UPSBB-1 to UPSBB-4 from block 'B', Bharhari area, Sonbhadra. The analytical results of UPSBB-1 shows iron content (Fe%) varying from 6.80% to 45.76% and at 30% Fe cut-off weighted average of mineralized zones vary between 33.12% to 42.94% Fe. The core samples of boreholes UPSBB-2 and UPSBB-3 have yielded Fe% varies between 9.55% to 43.50% and 7.69% to 58.44% respectively.

The weighted average of all the core samples of borehole no UPSBB-1 to UPSBB-3 of block 'B', Bharhari area at 30% Fe cut off has yielded an average grade of 34.34% Fe and at 35% Fe cut off has yielded an average grade of 39.47% Fe. The analysis of drill core samples is given in the Annexure-II.

The chemical plot of Fe% and SiO₂% of all BIF surface samples (Channel & Trench) and subsurface samples from core for UPSBB-1 to UPSBB-3 at 30% and 35% Fe cut-off shows inverse relationship (Fig. 5.35, Fig. 5.36 & Fig. 5.37).

Analysis for Vanadium from drill core samples show values ranging between 20 mg/kg to 1530 mg/kg.

Analysis for 91 nos. samples of base metal shows Cu values ranging from 13ppm to 3176ppm, this higher value is found in Ferruginous phyllite with chert nodules having malachite dissemination from borehole no. UPSBB-3. While for Pb, Zn, Ni and Co max values are 479ppm, 664ppm, 456ppm and 159ppm respectively. The analysis of samples is given in the Annexure-IV.

Banded hematite chert/jasper samples and tuff samples analysed for gold showing <50 ppb for all samples (Annexure-V).

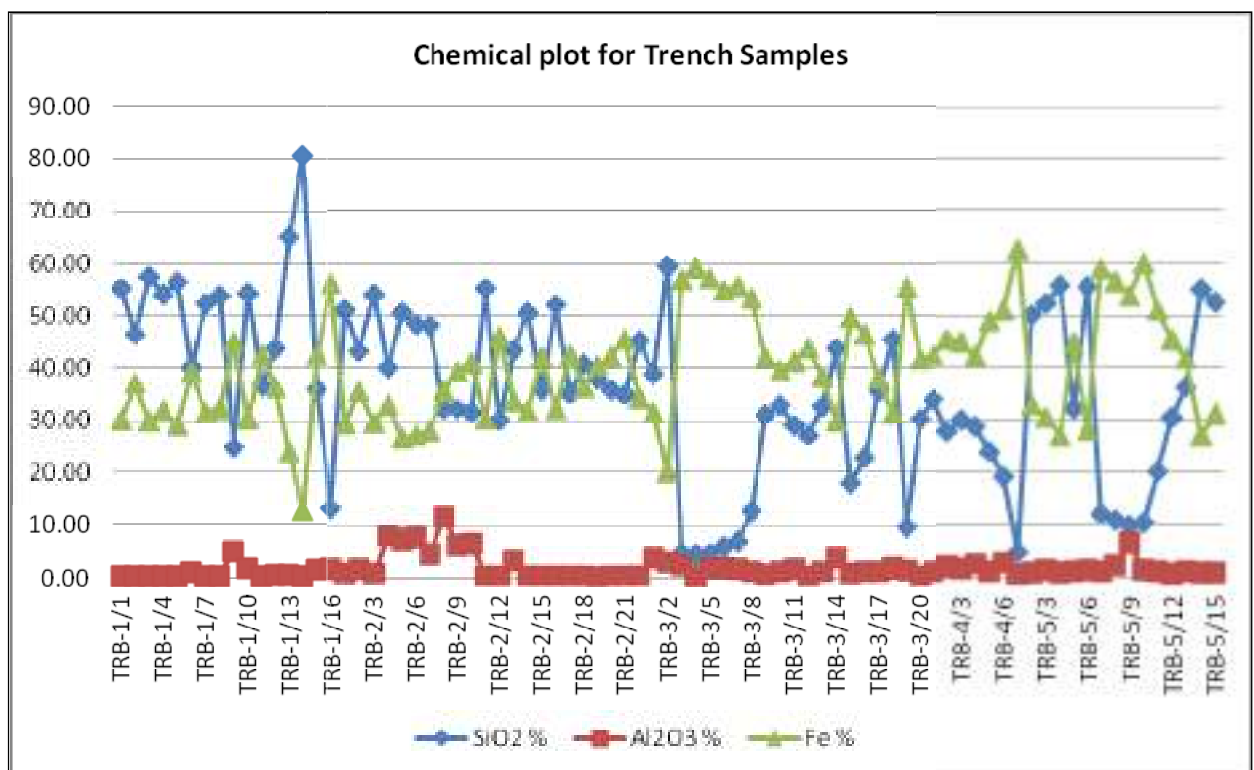
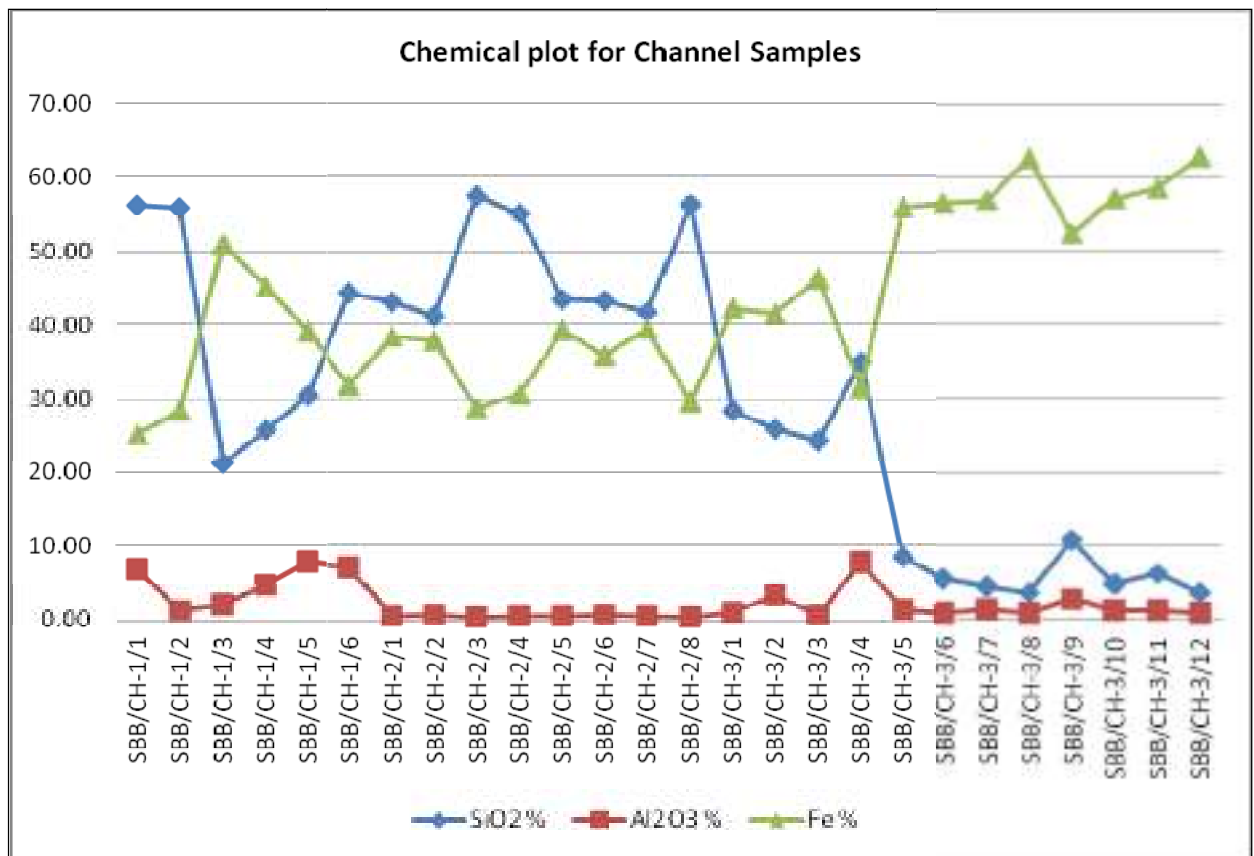


Fig 5.35: Chemical Plot for Surface Samples

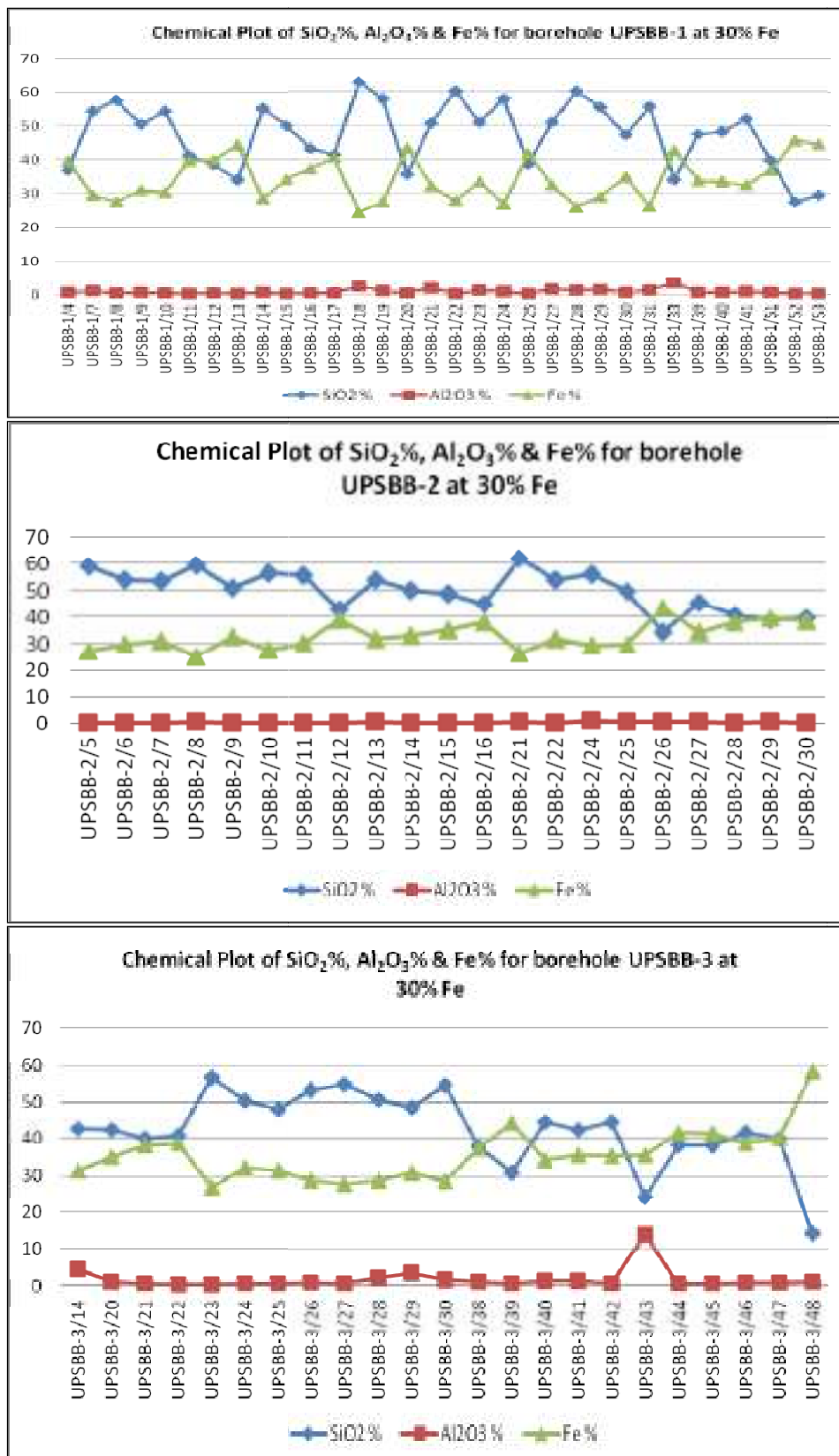


Fig 5.36: Chemical Plot for subsurface samples from core at 30% Fe cut-off

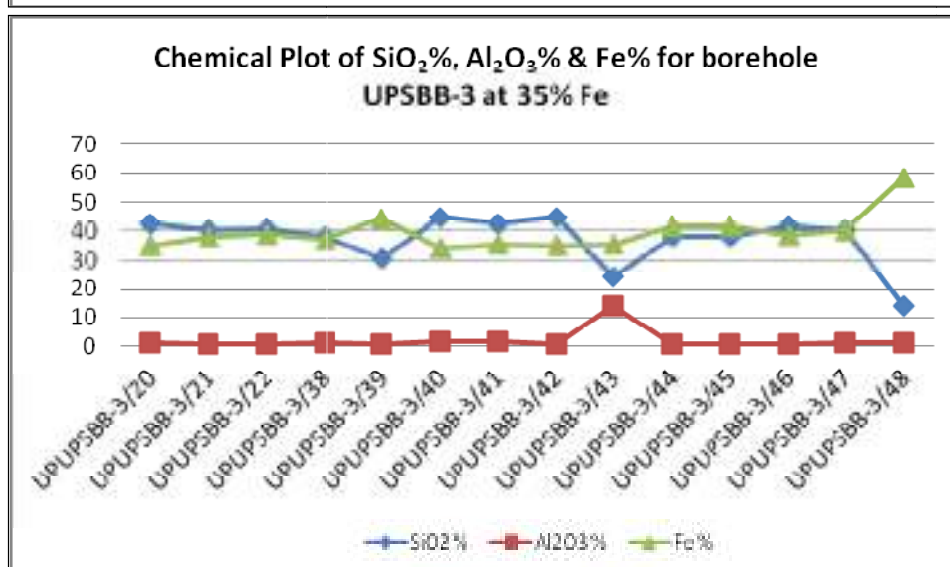
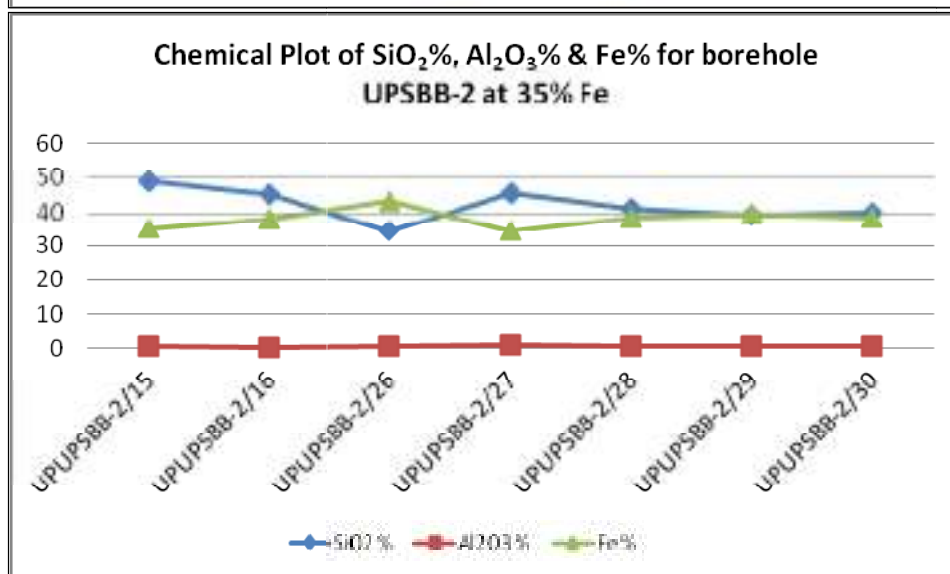
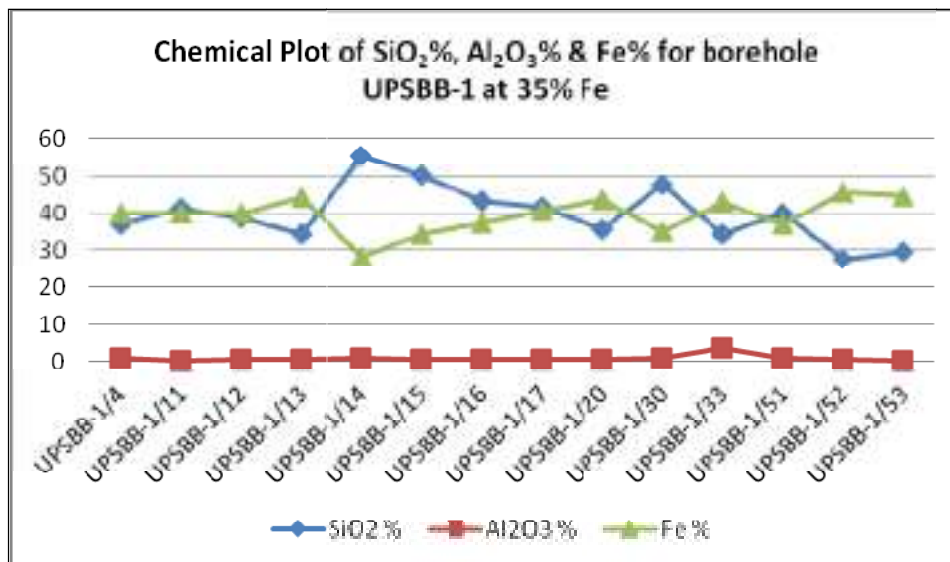


Fig 5.37: Chemical Plot for subsurface samples from core at 35% Fe cut-off

Statistical comparison (minimum, average and maximum values) of chemical results for BHC/J major oxides analysed from both surface and core samples are summarised below-

Table 5.7: Statistical comparison of chemical analyses results for channel, trench and core samples

Sample Type		SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Channel	Minimum	3.69	0.33	36.03	0.13	0.10	0.02	0.10	0.01	0.01	0.01	25.20
	Average	29.89	2.22	61.88	0.26	0.20	0.10	0.14	0.03	0.10	0.21	43.28
	Maximum	57.56	7.78	89.80	0.57	0.81	0.20	0.20	0.06	1.05	0.81	62.81

Sample Type		SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Trench	Minimum	4.47	0.22	18.07	0.09	0.08	0.10	0.04	0.01	0.01	0.01	12.64
	Average	36.04	1.95	56.93	0.15	0.21	0.12	0.16	0.05	0.08	0.17	39.82
	Maximum	80.45	11.47	89.42	0.32	0.70	0.16	0.90	0.44	0.99	0.74	62.54

Sample Type		SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Core	Minimum	14.17	0.26	9.72	0.09	0.05	0.10	0.10	0.01	0.01	0.05	6.80
	Average	53.81	1.52	41.57	0.13	0.15	0.12	0.14	0.02	0.07	0.12	29.07
	Maximum	84.48	13.88	83.56	0.49	0.69	0.19	0.76	0.11	1.53	0.36	58.44

XI. Details of interpreted ore zones on the basis of geological investigation:

The iron ore mineralization occurs in the area as a linear banded hematite chert / jasper (BIF) zone, trending N65°E – S65°W to N85°E – S85°W with moderate to steep dips of 50° to 80° due south. In banded hematite chert / jasper, the bands of chert/jasper and ferruginous layer (hematite) occur rhythmically. The thickness of individual hematite layer varies from 1 mm to 8 cm. The strike length of banded hematite chert / jasper (BIF) band is 3.12 km and width about 9 m to 54 m.

C. Geophysical Exploration

I. Methodology of geophysical exploration:

Geophysical survey of 10.80-line km was carried out by Geophysics Division, GSI, NR, Lucknow. The Magnetic (TF) method of geophysics was adopted. The reference point was fixed at (24°34'01.8"N, 82°53'51.7"E) and the base line was laid E-W direction and the traverses were laid perpendicular to the baseline i.e. N-S direction. The traverses were laid at regular interval of 200m, with station interval 20m. Total length of base line laid was 2.8 km and the magnetic (TF) survey was carried out at 10.8 L. Km. Total fourteen traverses of length varying from 700m to 1km. was laid to cover 10.8 L. Km. by magnetic survey (Annexure XIV).

II. Criteria for selection of method for geophysical exploration:

The iron ore exploration demands magnetic method to prove or identify iron bands existence beneath the surface. Magnetic (TF) survey was carried out to assess the iron ore potential in block 'B', Bharhari area, Sonbhadra district, U.P. The magnetic data was reduced to the magnetic base established outside of the area under surveys.

III. Scale of mapping:

Geophysical survey was done on 1:10,000 scale.

IV. Interpretation of geophysical maps:

The overall total magnetic field anomaly (TF) in Block 'B', Bharhari area varies from 100 to 900nT along the strike of BIF band as well as other litho-units in the area. It has also been inferred from residual magnetic anomaly map that the anomalies are bipolar in nature all along the strike and in southern portion it trends NE-SW. Such nature of anomalies indicate shallow nature of causative sources. The surface magnetic survey has shown that average depth to the top of the causative bodies as estimated from Euler 3D deconvolution radially averaged power spectrum, P- depth sections, Peter's half slope method and 2D magnetic models, ranges from 20 to 80m and maximum depth extension of shallow causative bodies may be upto 150m say for BIF bodies. However, the depth is extended to about 400m in case of few deeper bodies lying in northern and southeastern parts of the block.

V. Identification of anomalies:

The magnetic (TF) contour map shows a wide range of magnetic variation from -5391.8 nT (observed in the southern portion over traverses 'W400' to 'E800 (western portion)') to

6369nT (observed in the southern portion over traverses 'E800 (eastern portion)' to 'E1800') in the study area.

The total strike length of study area is 3.12km. High magnetic gradients running in NE-SW and E-W direction in the Block indicate the lithological contacts/fault. Residual map of Magnetic (TF) anomaly shows various high magnetic anomaly zones (RH1 to RH7) with values ranging from 150 to 350 nT indicating bipolar nature of the bodies lying at shallower level in subsurface. The causative sources delineated over northern part over traverses E200, E400, 'E800' and 'E1000' in Magnetic (TF) anomaly contour map may be due to the presence of BIF bands/ferruginous rocks in the study block. From western boundary to borehole no. UPSBB-3, i.e. strike length is 1144m is explored by drilling and BIF body intersected. In north-south of these boreholes, no any anomalous value is seen in geophysical magnetic anomaly map. But in north of borehole no. UPSBB-4 which was closed earlier due to NMH II letter and COVID 19, a very strong anomaly is showing between E200 to E400 traverse line. Further towards east started from E800 to E1800 area is showing anomalous value in north and south portion. Here in detailed map major BIF band thickness increases and goes upto 54 m (near traverse E1400) also no of bands increases. Besides this major BIF band, there are three continuous bands having an average thickness of 6-8m traversing the area and two lenses (600-700m length) occur in the form of banded ferruginous phyllite which are enriched in between in iron oxide and showing jasper banding and phyllite parting.

In magnetic anomaly map in SE portion there are two isolated patches (RH8, RH9) showing very strong anomalous value of 350nT may indicate the dominance of ferromagnetic material (magnetite) in the subsurface rock. This area exists in south and is outside of defined block, therefore not mapped.

The magnetic anomaly values vary from 100-900 nT along the strike direction over BIF band and other lithological units while the values are lying more than 900 nT in northern part between stations N100 to N300 at all traverses and south-eastern part between station N50 to S300 from traverses E800 to E1400 of the block. The veriegated phyllites/phyllites shows magnetic anomaly values in the range of 300 to 600 nT. The low magnetic anomaly values (<100 nT) is recorded mostly in southern part (from traverses W800 to E800) over weathered dolerite/phyllites with tuffs and soil covered area. The large variation in magnetic (TF)

anomalies indicates the presence of different lithological units in subsurface. The shape of magnetic anomalies is elliptical with NE-SW strike and lies over the BIF/ferruginous body.

D. Geochemical Exploration

I. Selection of Geochemical exploration type: Bed rock sampling / pedogeochemical sampling on grid pattern

The bed rock and channel sampling were carried out across strike of the banded hematite chert / jasper (BIF) band to assess the grade of iron. The channels were excavated in the profile lines of boreholes to know the nature and mineralisation in the banded hematite chert / jasper band. The geochemical sampling of bed rock samples was carried out as per accessibility and availability of exposures.

II. Methodology of geochemical exploration

The samples were pulverised and sieved to -120 mesh. Coning and quartering of the samples were done and two sets of samples were prepared. The original samples about 250 gm were sent for analysis and duplicate were retained for future reference. The samples were analysed by XRF analysis for major oxides and trace elements at Chemical division, Geological Survey of India, Northern Region, Lucknow.

III. Grid of Geochemical sampling

Samples were collected as per accessibility and availability of exposures. Systematic sampling on grid pattern was not possible due to narrow linear hilltop exposure of banded hematite chert / jasper, rugged and mountainous terrain conditions.

IV. Statistical analysis of geochemical data and its interpretation of anomalous zones

Statistical analyses of chemical analyses results of BHC/J from channel (SBB/CH-1,2 &3), Trench (TRB-1 to TRB-5) and core samples (UPSBB-1, UPSBB-2 and UPSBB-3) is calculated and presented below:-

Table 5.8: Statistical analyses of chemical results of Channel samples, Block ‘B’, Bharhari area, Sonbhadra Distt., U.P.

Statistical parameter	SiO₂ %	Al₂O₃ %	Fe₂O₃ %	CaO %	MgO %	Na₂O %	K₂O %	MnO %	TiO₂ %	P₂O₅ %	Total Fe %
Mean	29.89	2.22	61.88	0.26	0.20	0.10	0.10	0.03	0.10	0.21	43.28
Standard Error	3.77	0.48	3.26	0.02	0.03	0.01	0.01	0.00	0.04	0.05	2.28

Median	29.42	1.14	57.98	0.26	0.16	0.10	0.11	0.01	0.04	0.13	40.55
Mode	0.00	0.00	0.00	0.27	0.16	0.10	0.11	0.01	0.01	0.01	0.00
Standard Deviation	19.24	2.47	16.65	0.11	0.15	0.03	0.06	0.02	0.22	0.25	11.64
Sample Variance	370.06	6.09	277.13	0.01	0.02	0.00	0.00	0.00	0.05	0.06	135.56
Kurtosis	-1.42	0.85	-1.24	1.39	9.63	0.87	-1.14	-1.89	16.76	0.98	-1.24
Skewness	-0.05	1.52	0.23	1.08	2.95	-1.27	0.03	0.31	3.99	1.42	0.23
Range	53.87	7.45	53.77	0.44	0.71	0.10	0.18	0.05	1.04	0.80	37.61
Minimum	3.69	0.33	36.03	0.13	0.10	0.03	0.02	0.01	0.01	0.01	25.20
Maximum	57.56	7.78	89.80	0.57	0.81	0.13	0.20	0.06	1.05	0.81	62.81
Sum	777.01	57.67	1608.95	6.67	5.30	2.50	2.59	0.78	2.52	5.46	1125.30
Count	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
Confidence Level(95.0%)	7.77	1.00	6.72	0.04	0.06	0.01	0.02	0.01	0.09	0.10	4.70

**Table 5.9: Statistical analyses of chemical results of Trench samples (TRB-1 to TR-5)
Block 'B', Bharhari area, Sonbhadra Distt., U.P.**

Statistical parameter	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %
Mean	36.04	1.95	56.93	0.15	0.20	0.12	0.15	0.05	0.08	0.17	39.82
Standard Error	1.89	0.24	1.70	0.01	0.01	0.00	0.02	0.01	0.02	0.02	1.19
Median	35.88	1.28	56.65	0.13	0.17	0.11	0.10	0.04	0.02	0.10	39.62
Mode	35.88	0.37	59.64	0.13	0.12	0.10	0.10	0.03	0.01	0.09	41.71
Standard Deviation	16.80	2.11	15.08	0.05	0.12	0.02	0.14	0.06	0.17	0.15	10.55
Sample Variance	282.22	4.46	227.36	0.00	0.02	0.00	0.02	0.00	0.03	0.02	111.21
Kurtosis	-0.45	5.93	-0.45	2.84	5.63	-0.39	17.80	29.13	12.59	3.23	-0.45
Skewness	-0.18	2.34	0.20	1.52	2.18	0.72	4.01	4.92	3.41	1.68	0.20
Range	75.98	11.25	71.35	0.23	0.62	0.06	0.86	0.43	0.98	0.73	49.90
Minimum	4.47	0.22	18.07	0.09	0.08	0.10	0.04	0.01	0.01	0.01	12.64
Maximum	80.45	11.47	89.42	0.32	0.70	0.16	0.90	0.44	0.99	0.74	62.54
Sum	2847.50	153.87	4497.40	11.77	16.10	9.10	11.94	3.90	6.68	13.32	3145.48
Count	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00	79.00
Confidence Level(95.0%)	3.76	0.47	3.38	0.01	0.03	0.00	0.03	0.01	0.04	0.03	2.36

Table 5.10: Statistical analyses of chemical results of Core samples (UPSBB-1 to UPSBB-3), Block ‘B’, Bharhari area, Sonbhadra Distt., U.P.

Statistical parameter	SiO₂ %	Al₂O₃ %	Fe₂O₃ %	CaO %	MgO %	Na₂O %	K₂O %	MnO %	TiO₂ %	P₂O₅ %	Total Fe %
Mean	53.81	1.52	41.57	0.13	0.15	0.11	0.13	0.02	0.07	0.12	29.07
Standard Error	1.22	0.18	1.28	0.00	0.01	0.00	0.01	0.00	0.02	0.01	0.89
Median	54.45	0.83	42.15	0.12	0.11	0.10	0.10	0.01	0.02	0.09	29.48
Mode	60.47	1.45	37.56	0.12	0.10	0.10	0.10	0.01	0.01	0.09	26.27
Standard Deviation	13.24	1.98	13.82	0.05	0.10	0.02	0.07	0.02	0.17	0.06	9.66
Sample Variance	175.33	3.93	190.89	0.00	0.01	0.00	0.01	0.00	0.03	0.00	93.38
Kurtosis	0.04	16.77	0.05	27.56	13.09	1.53	48.55	6.76	46.54	2.81	0.05
Skewness	-0.05	3.65	-0.18	4.67	3.35	1.57	6.20	2.26	6.18	1.70	-0.18
Range	70.31	13.62	73.84	0.40	0.64	0.09	0.66	0.11	1.52	0.31	51.64
Minimum	14.17	0.26	9.72	0.09	0.05	0.10	0.10	0.00	0.01	0.05	6.80
Maximum	84.48	13.88	83.56	0.49	0.69	0.19	0.76	0.11	1.53	0.36	58.44
Sum	6295.68	178.04	4863.31	15.40	17.08	13.41	15.03	2.43	8.50	14.27	3401.40
Count	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.00
Confidence Level(95.0%)	2.42	0.36	2.53	0.01	0.02	0.00	0.01	0.00	0.03	0.01	1.77

V. Identification of anomalous zones with strike length and width

The banded hematite chert / jasper (BIF) are exposed on the top surface of the linear East - West ridge running parallel to the Son river with outcrop width varying from of 9.0 m to 54 m. The banded hematite chert / jasper has a general strike of N65°E – S65°W to N85°E – S85°W and dips 50°- 80° due south. The mineralized zones with 30% Fe cut off and 35% cut off have been established in borehole UPSBB-1, UPSBB-2 and UPSBB-3.

6. INTEGRATION OF GEOLOGICAL, GEOCHEMICAL AND GEOPHYSICAL EXPLORATION DATA AND INTERPRETATION THEREOF

I. Creation of Geophysical, Geochemical, Geological (Lithological & Structural) and

Outcrop maps on true scales

Detailed mapping on 1:4,000 scale was carried out in the investigated area and a geological map has been prepared depicting the different lithologies observed in the area (Plate – IV). Bed rocks and channel samples were collected during the course of investigation and have been shown in the sample location map (Plate-V). Chemical analyses results reveal the low grade iron ore in the area. Geophysical survey for magnetic method was done.

II. Overlay studies in GIS (Geological, Geochemical and Geophysical maps)

The overlay studies of geological and geochemical results are done and prepared in GIS (Plate-V).

III. Sem-transparent overlay maps

Semitransparent overlay maps are prepared by overlaying geological map on geophysical anomaly map.

7. MINERAL PROSPECT

I. Surface indication of mineralisation

As per field observations during mapping of the investigated area, the iron ore bearing banded haematite chert / Jasper band has been demarcated on the hilltops. The rolled boulders of banded hematite chert / jasper, scree material at hill slopes and hard resistant linear bands inter banded with phyllite at ridge tops are indicators of iron ore mineralisation.

II. Mode of occurrence

Iron ore occurs as conformable band/body with varying thickness of 9m to 54m along the strike. The ore-band/body with concentrated iron ore minerals is strata-bound in between variegated phyllite with tuff and dolerite as intrusive. Low grade iron ore occurs in the area as a linear banded hematite chert / jasper body with general trend of N65°E-S65°W to N85°E-S85°W with moderate to steep dip amount of 50° to 80° towards south.

III. Nature of Mineralisation

The iron mineralization in the assigned block is in the form of banded hematite chert / jasper bands having alternating bands of chert and /or jasper and ferruginous layers (hematite). The thickness of chert/jasper meso bands generally ranges from 1 mm to 4 cm, while that of iron rich meso bands ranges from 1 mm to 8 cm and are dark grey to reddish brown in color.

IV. Details of Mineralised Zones: Strike length and width of anomalies identified on the basis of geology, geophysical and geochemical exploration

The linear banded hematite chert / jasper trending N70°E to N85°E was observed in the area at top of the ridge as wall like structure. The strike length of banded hematite chert / jasper band is 3.12 km and its width ranges from 9 m to 54 m. On the basis of analytical results of UPSBB-1, five mineralized zones with thickness ranging from 1.10m to 23.25m at 30% Fe cut off and six mineralized zones with thickness varying from 1.00m to 6.55m at 35% Fe have been demarcated. In UPSBB-2, two mineralized zones at 30% and 35% Fe cut off have been established, having thickness ranging from 7.75 m to 11.0 m and 1.80 m to 3.55 m respectively while in UPSBB-3, three zones at 30% cut off and two zones at 35% Fe have been marked (Table 8.4).

V. Alteration zones and its relevance with mineralization.

Goethitisation and limonitization have also been observed at joint planes and fractures. The iron hydroxides are developed due to oxidation of iron oxides. The presence of iron hydroxides in the form of Limonite/ Goethite leads to lowering of Fe % in the mineralized zones. In excavated trenches of TRB-2 and TRB-3, it has been found to be associated with tuffs. Such zones in the subsurface have led to the partings in the mineralized zones of UPSBB-2 and UPSBB-3.

8. EXPLORATION BY DRILLING

Drilling commenced on 24.05.2019 and continued upto 24.03.2020 by GSI drill unit 467 and thereafter stopped as well as per the letter no. ____/45A/FS 2019-20/Mod/PSS:P&M-2/2020 dated 29/05/2020 from NMH-II, Nagpur. A total of 461.30 m drilling in 4 boreholes was completed. The details of boreholes are described in the table given below:

Table 8.1: Details of boreholes drilled in Bharhari, Block 'B', Sonbhadra, U.P.

Borehole No.	Coordinates	Azimuth	BH Angle	Collar RL (m)	Bottom RL (m)	Date of Commencement	Date of closing	Total Drilled depth (m)
UPSBB-1	24°33'55.2" 82°53'25.2"	N10°W	45°	399	307	24.05.2019	24.08.2019	127.10
UPSBB-2	24°33'55.0" 82°53'37.8"	N17°W	47°	450	335	02.09.2019	10.12.2019	160.45
UPSBB-3	24°33'58.0" 82°53'51.5"	N5°W	45°	407.5	318.5	25.12.2019	04.03.2020	130.25
UPSBB-4	24°34'01.8" 82°54'03.7"	N20°W	45°	429.5	397	15.03.2020	24.03.2020	43.50
Total								461.30

I. Stage of exploration as per mineral content Rule

The stage of exploration is G-3 of UNFC as per mineral content rule.

II. Methodology of drilling with the details of type of drilling i.e. core drilling, auger, reverse circulation, etc.

The core drilling with reverse circulation technology at an inclination of 45° was done by GSI, NR, Lucknow.

III. Boreholes planning: Spacing of boreholes and level of intersection of ore zones as per mineral content rule

A total of four boreholes were planned for drilling to intersect the banded hematite chert / jasper to understand the subsurface continuity of exposed bands. The drilling was planned on the basis of banded hematite chert / jasper (BIF) disposition. The boreholes were planned to be drilled at an interval of 400 m. The targets were to intersect banded hematite chert / jasper zone at 30 m vertical depths from 400m datum line. Total four boreholes viz. UPSBB-1, UPSBB-2, UPSBB-3 and UPSBB-4 were drilled. Due to rugged terrain conditions, the drilling was a challenging task.

Borehole UPSBB-1:

The borehole UPSBB-1 was the first borehole started on 24-05-2019 and closed on 24-08-2019. The borehole was drilled to a depth of 127.10m. In the drilled borehole of UPSBB-1, the BIF was intersected from 22.50m to 106.10m with tuff and dolerite in between. The mineralized zones were intersected at the depth of 22.50 to 61.50m, 63.30 to 67.50m, 72.90 to 96.10 and 100.20 to 106.10m. The borehole section was prepared and lithologies were plotted and mineralised zones at 30% and 35% Fe cut-off were shown (Fig. 8.1 and Fig. 8.2).

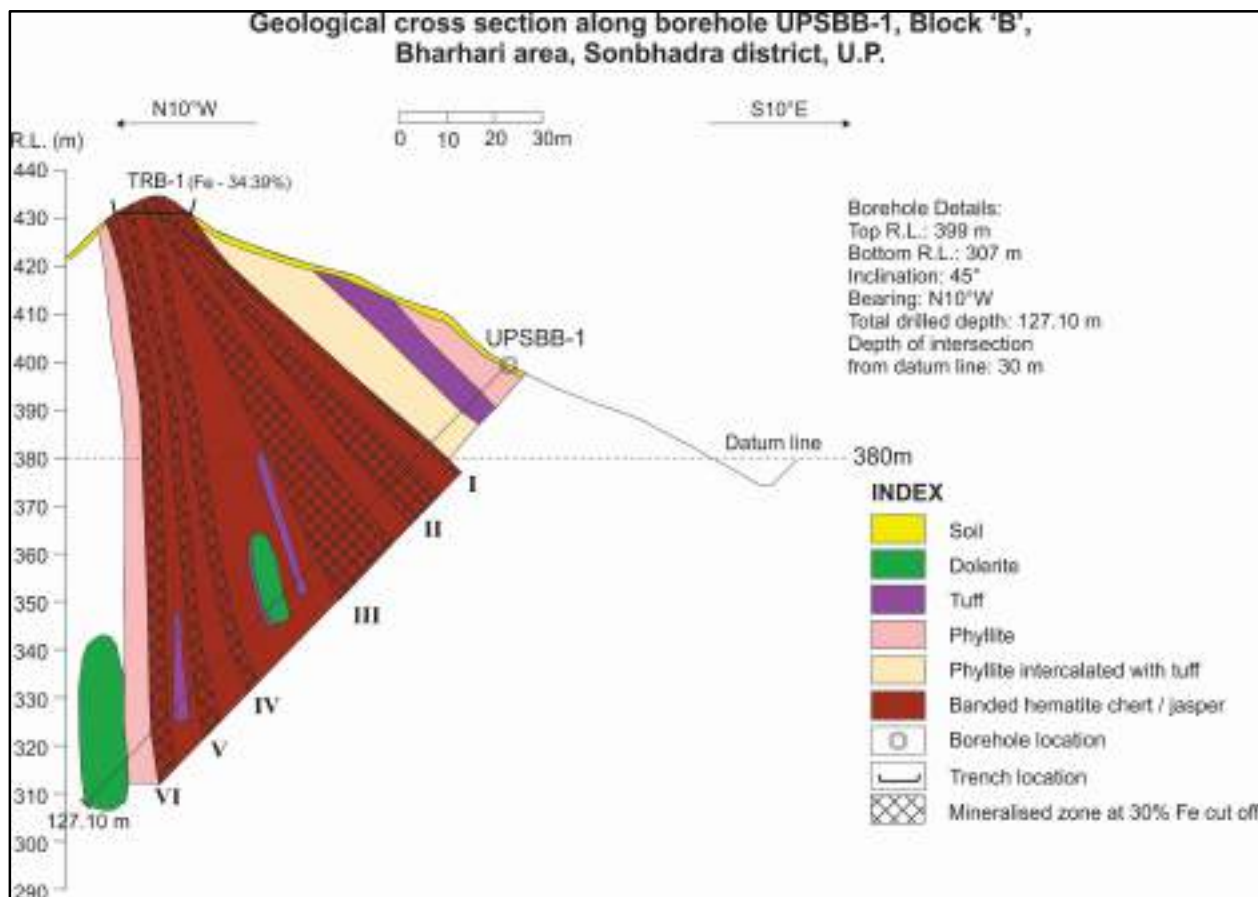


Fig. 8.1 Geological cross section of UPSBB-1 with mineralised zone on 30% Fe cut off

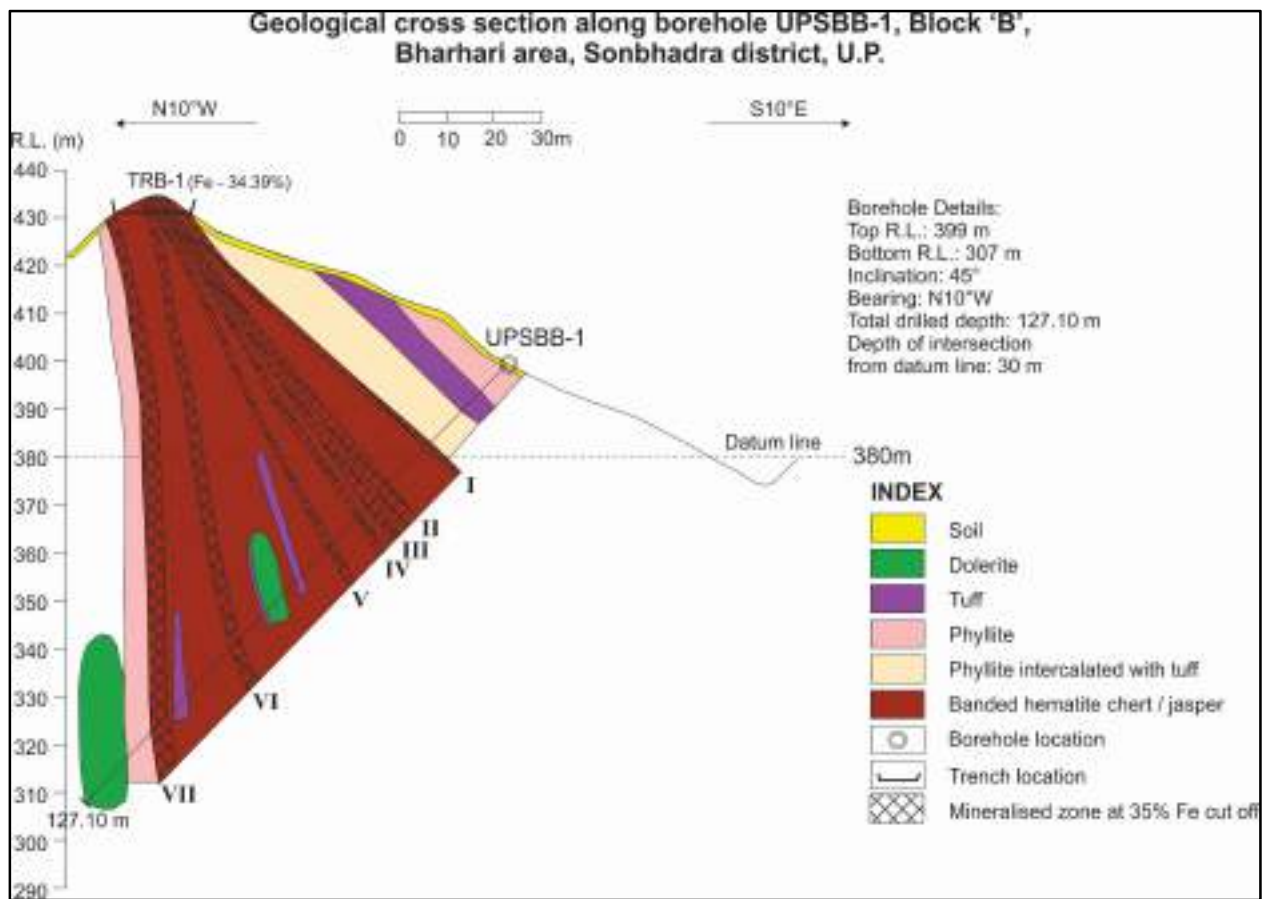


Fig. 8.2 Geological cross section of UPSBB-1 with mineralised zone on 35% Fe cut off

Borehole UPSBB-2:

The second borehole UPSBB-2 was planned at about 403 m east of borehole UPSBB-1. The borehole UPSBB-2 initiated on 02-09-2019 and concluded on 10-12-2019 and it was drilled for a depth of 160.45m. In borehole UPSBB-2, weathered, silica dominant BHC/J of 3.50m thickness was intersected at 120m depth and typical BHC/J of 25.25m thickness was intersected at the depth interval of 131.0 to 156.25m. The borehole section was prepared and lithologies along with mineralised zones at 30% and 35% Fe cut-off were plotted (Fig. 8.3 and Fig. 8.4).

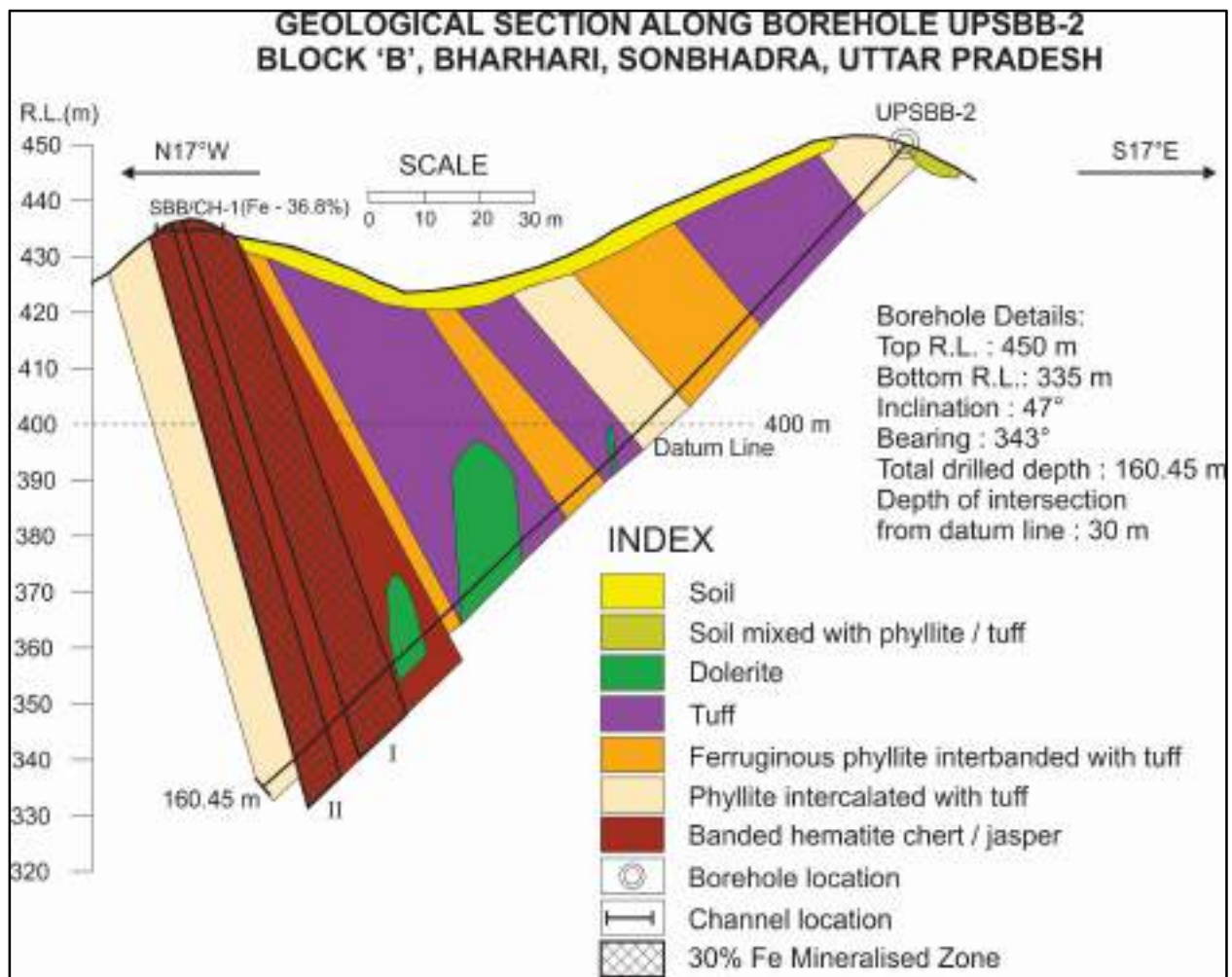


Fig. 8.3 Geological cross section of UPSBB-2 with mineralised zone on 30% Fe cut off

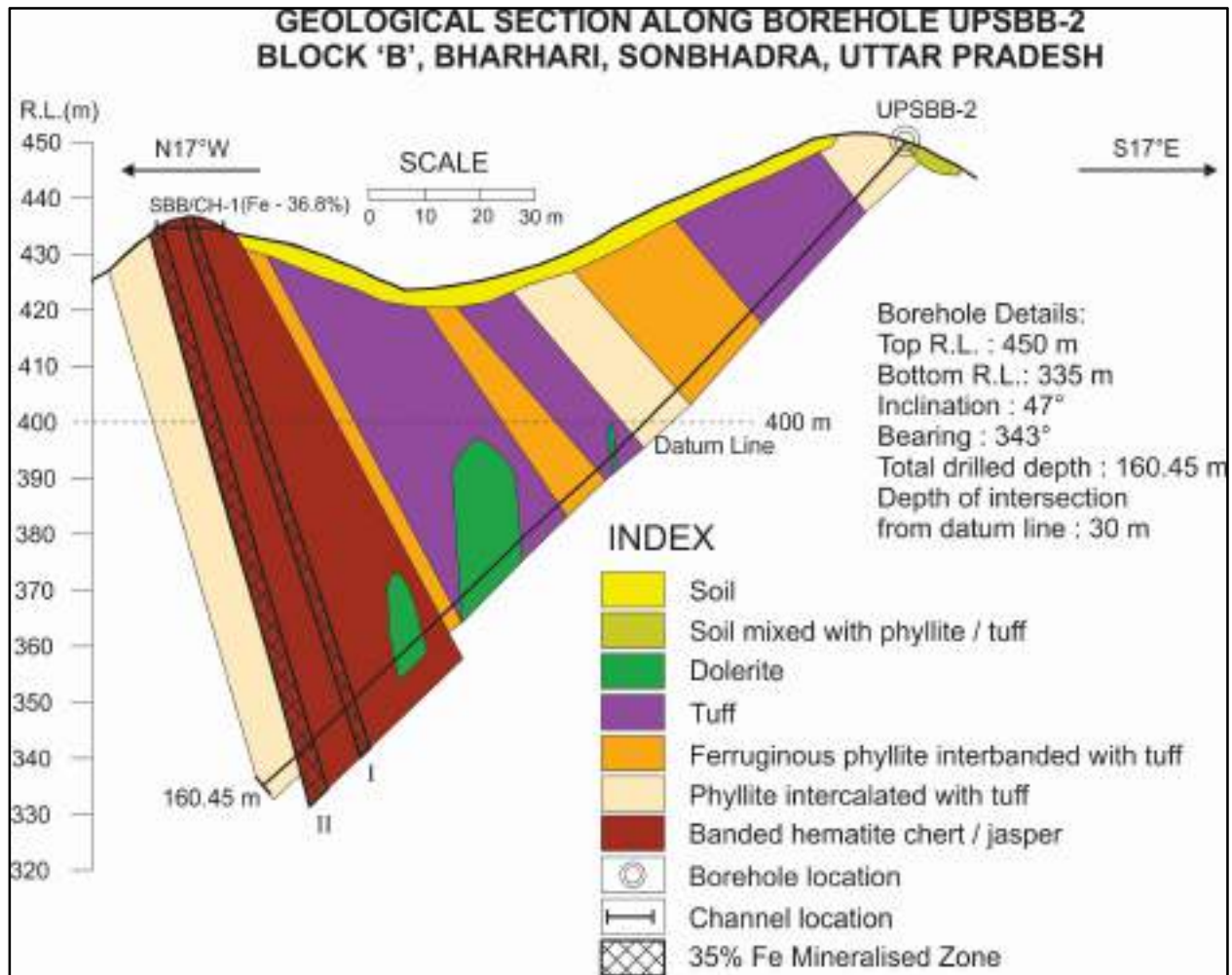


Fig. 8.4 Geological cross section of UPSBB-2 with mineralised zone on 35% Fe cut off

Borehole UPSBB-3:

The third borehole UPSBB-3 was planned at 395 m east of borehole UPSBB-2. It was drilled for a depth of 130.25m and 33.45m thick BHC/J intersected from 95.15m to 127.45m. The borehole section was prepared and lithologies and mineralised zones at 30% and 35% Fe cut-off were shown (Fig. 8.5 and Fig. 8.6).

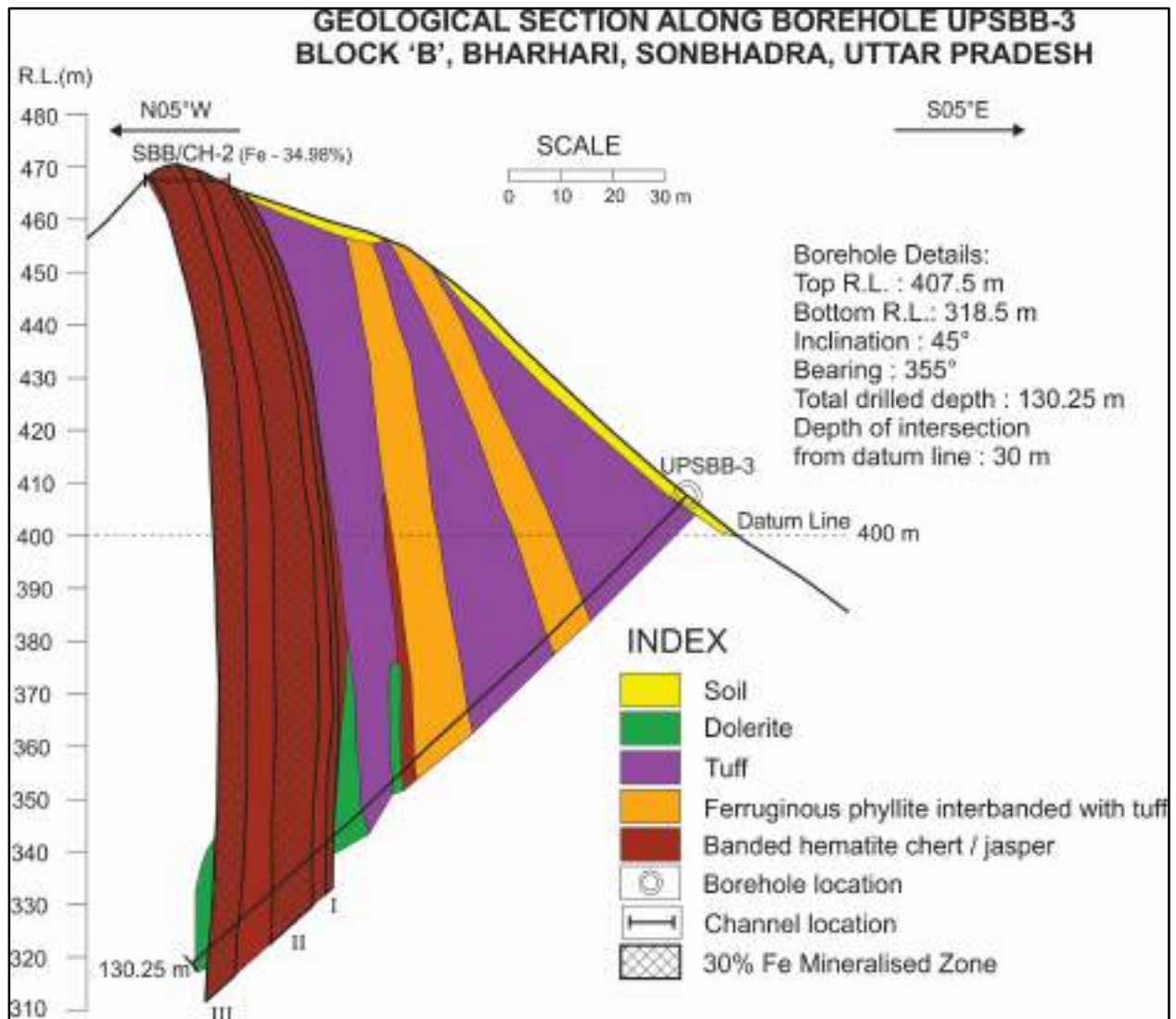


Fig. 8.5 Geological cross section of UPSBB-3 with mineralised zone on 30% Fe cut off

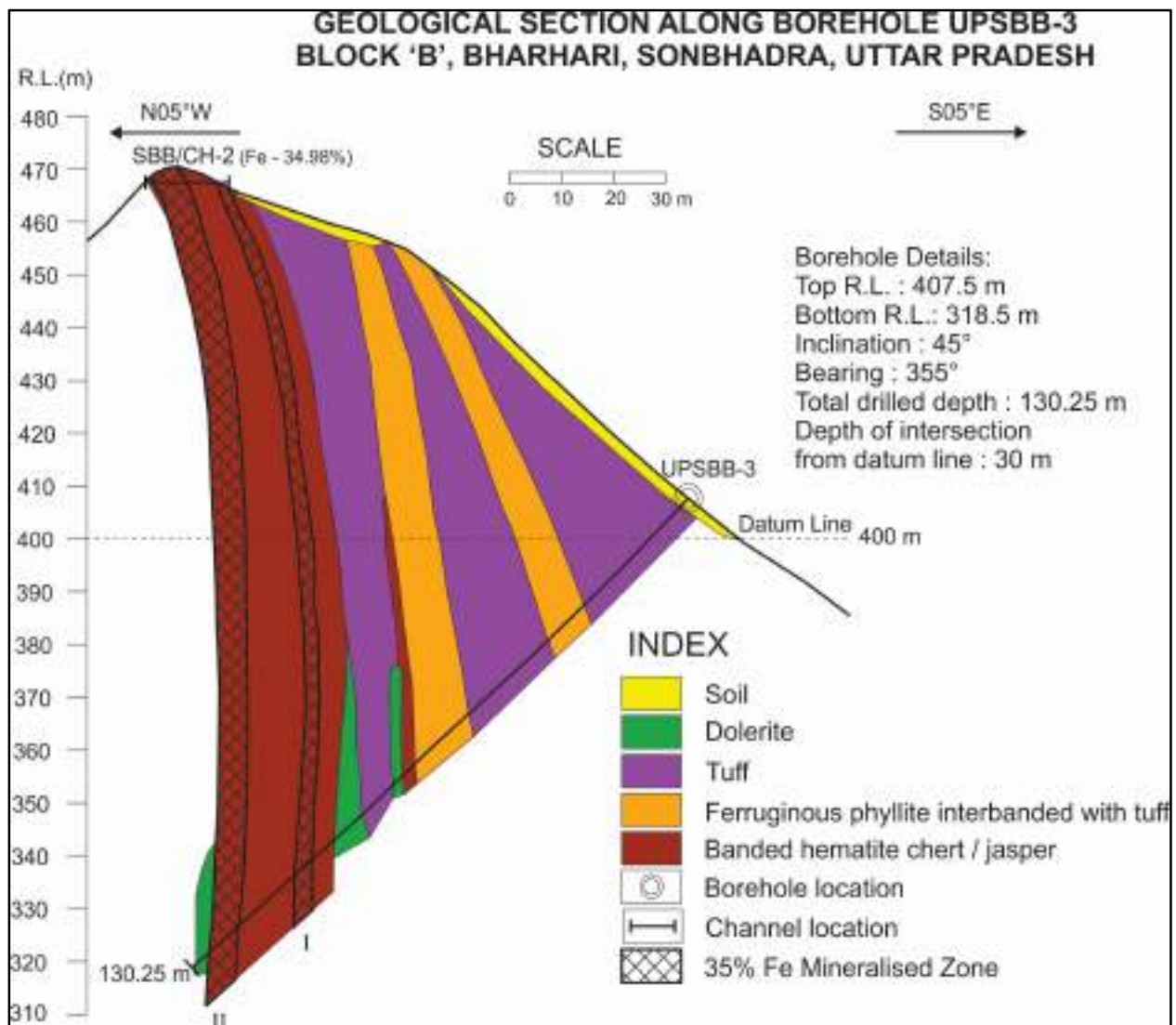


Fig. 8.6 Geological cross section of UPSBB-3 with mineralised zone on 35% Fe cut off

Borehole UPSBB-4:

The fourth and last borehole UPSBB-4 was planned at 391 m east of borehole UPSBB-3. The borehole UPSBB-4 was drilled upto 43.50m. Upto this depth, mainly sludge, broken pieces of tuff/chert and weathered dolerite have been intersected and BIF could not be intersected. The borehole was abandoned due to the lockdown in the country in view of COVID-19 pandemic (Fig. 8.7).

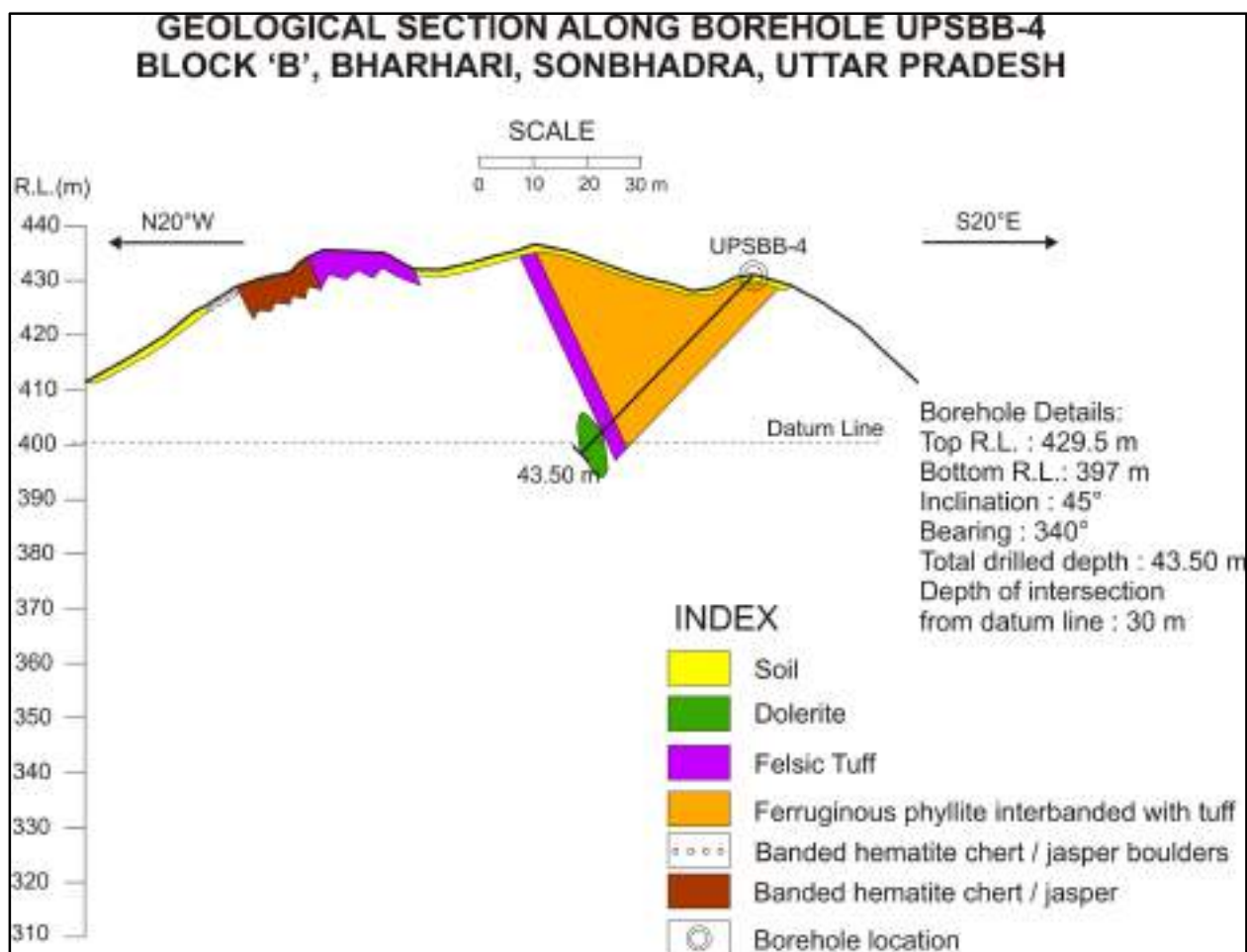


Fig. 8.7 Geological cross section of UPSBB-4

IV. Borehole logging

The cores of boreholes were logged in detail for their core recovery, lithology, mineralisation and structures, if any. It was done run wise and the data were recorded in register for each drill hole. On the basis of these data summarized litho logs of boreholes were prepared. (Annexure: VI – IX).

V. Core recovery percentage

Core recovery was satisfactory in the hard non-mineralized portion of drill cores. The core recovery in the mineralised zone was low because of presence of fracture zone at this level. In borehole nos. UPSBB-2 and UPSBB-3, at the intersection of the mineralized zone, there was 100% water loss and recovery of the drilled cores was matter of concern. The overall average core recovery percentage can be stated about 70 – 85 %. Few core photos are shown in Fig. 8.8 to 8.10.



Fig. 8.8 CORE PHOTOGRAPHS OF BOREHOLE NO. UPSBB-1



Fig. 8.9 CORE PHOTOGRAPHS OF BOREHOLE NO. UPSBB-2



Fig. 8.10 CORE PHOTOGRAPHS OF BOREHOLE NO. UPSBB-3

VI. Geophysical logging of borehole and correlation with borehole Geology

Geophysical logging was carried out for two boreholes i.e. UPSBB-1 and UPSBB-2 in block 'B', Bharhari area by Geophysics division, GSI, NR, Lucknow. (Annexure – XIII).

Borehole UPSBB-1: The borehole was logged up to 113m depth by using RG Portable Micrologger. Resistivities (SHN & LONG) Single point resistance (SPR), Temperature and Chargeability parameters were recorded by using ELTG, Magnetic Susceptibility & INPS probes. Based on Geophysical log, four conductive zones characterized by low values of SPR, Short normal & Long normal resistivity have been recorded. Moderate to High Magnetic susceptibility response zones have been recorded at the depth range from 28.4-28.8m, 46.4-46.6m, 48.2-48.4m and 52.1-52.5m, it indicates the presence of magnetic minerals in the formation. The temperature log shows normal gradient along the borehole. The geophysical log of borehole UPSBB-1 is shown below in Figure 8.11.

Borehole UPSBB-2: The borehole was logged up to 151.2m depth by using RG Portable Micrologger. Based on Geophysical log, two conductive zones characterised by low values of SPR, Short normal resistivity & Long normal resistivity are inferred. From IP, Magnetic

susceptibility and SP logs, no anomalous zone have been recovered. The temperature log shows normal gradient along the borehole. The geophysical log of borehole UPSBB-1 is shown below in Figure 8.12.

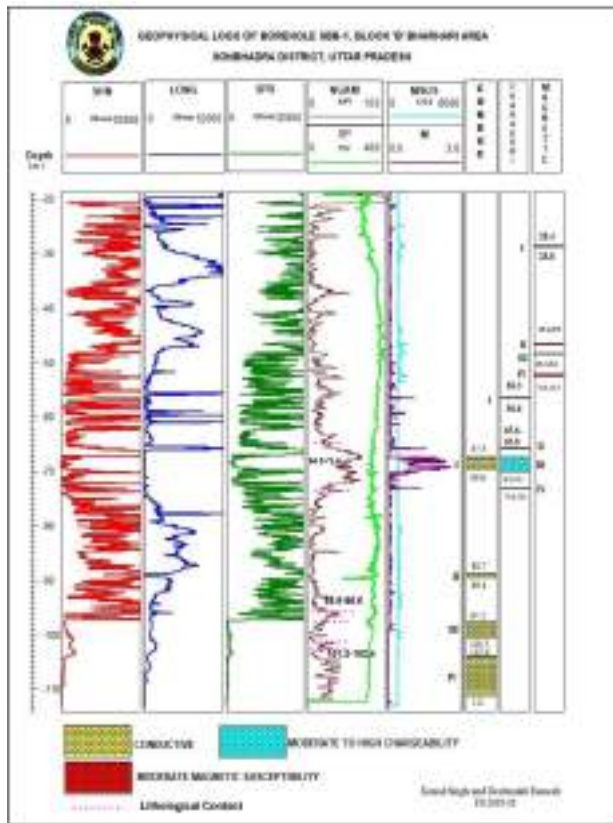


Figure 8.11 Geophysical log of borehole UPSBB-1

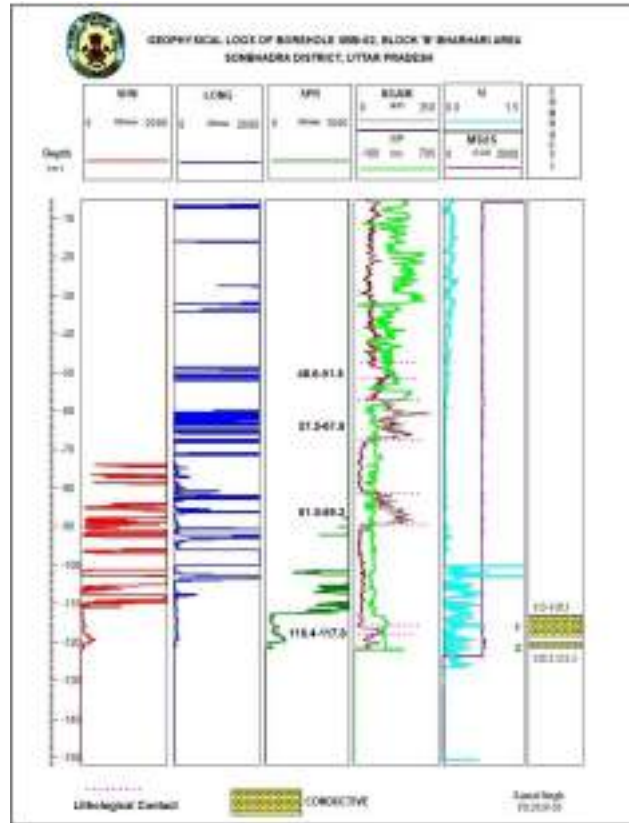


Figure 8.12 Geophysical log of borehole UPSBB-2

VII. Mineralogy of the ore zone

The iron ore mineralization has been observed in banded hematite chert / jasper. The alternate iron oxide and siliceous bands are present. The individual iron oxide band has a thickness of 1mm to 8 cm. The siliceous bands are mostly chert and few jasper bands. In drill cores, the quartz/chert vein shows presence of pyrite, arsenopyrite at various levels in disseminated nature.

VIII. Borehole deviation test and methodology

Borehole deviation test was performed in the boreholes UPSBB-1, UPSBB-2 and UPSBB-3. Deviation of drill holes at regular interval of about 30-50 m was carried out by etch method using 10% hydrofluoric acid. Correction method had been applied to minimize the deviation. The details of deviation and corrections of borehole angle are given in table 8.2.

Table 8.2: Details of deviation and correction of borehole angle

Sl. No.	BH No.	Inclination	Depth (m)	Calculated angle by Etch Method	Difference (Deviation angle)
1	UPSBB - 1	45°	45	46°	1°
			90	47.5°	2.5°
2	UPSBB - 2	47°	50	43.5°	3.5°
			100	44°	3°
			150	43.5°	3.5°
3	UPSBB - 3	45°	30	44°	1°
			70	44°	1°
			93	43.5°	1.5°

IX. Methodology of ore zone sampling

Sampling in all the boreholes was carried out in a systematic way in mineralized zone of intersected banded hematite chert / jasper. Few samples were also drawn from ferruginous phyllite show zones. The sample length was tried to be kept at 1 m without mixing of run.

X. Sample preparation, chemical analysis and laboratory procedures

A total of 195 core samples from four boreholes were collected and sent for chemical analysis. The samples were collected after thorough proper logging of cores. The sample length interval was maintained at 1.0 m. The cores were splitted into two equal halves longitudinally. One half was pulverized to -120 mesh size and after coning and quartering submitted for chemical analysis and other half was kept in the core box.

XI. Check samples

A total 06 drill core samples were sent for check analysis of major oxide and trace elements, analytical results showing not much variation (Annexure X and Table 8.3). Check sample results of Fe₂O₃ for bore hole no. UPSBB-1 is 50.33% (actual 46.14%) and 49.14% (actual 47.81%) and for UPSBB-3, Fe₂O₃ values are 59.70% (actual 63.37%) & 51.38% (actual 55.32%). For gold analysis showing results of <50 ppb.

Table 8.3: Analytical results of Base Metals from check samples

Sr. No.	Sample No	Lithology	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Ag (ppm)	Mn (ppm)
1	SBB/DP-2/1	Weathered tuff	<10	45	41	35	<20	26	<5	<5	<5
2	SBB/DP-2/2	Reddish ferruginous phyllite with tuff	<10	53	206	<10	35	22	<5	<5	<5

XII. Details of intersected ore zones of the drill holes drilled and their correlation

Considering cut off for Fe as 30% and 35%, the ore zones in boreholes UPSBB-1, UPSBB-2 and UPSBB-3 have been demarcated (Fig 8.1 to 8.6) and tabulated in table 8.4. The ore zones established in each borehole is summarised in the following table.

Table 8.4: Details of intersected ore zones in drilled boreholes

At 30% Fe Cut Off					
Borehole No.	Mineralized zone	Drilled Depth		Total thickness (m)	Weighted Avg. Grade Fe%
		From (m)	To (m)		
UPSBB-1	Zone I	26.10	27.20	1.10	39.78%
	Zone II	29.00	37.00	8.00	35.22%
	Zone III	39.00	55.45	15.25	32.01%
	Zone IV	80.80	82.50	1.70	42.94%
	Zone V	90.10	92.80	2.70	33.44%
	Zone VI	102.10	106.10	4.00	42.49%
UPSBB-2	Zone I	133.00	144.00	11.00	31.50%
	Zone II	147.50	156.25	7.75	33.87%
UPSBB-3	Zone I	94.00	95.15	1.15	31.42%
	Zone II	99.50	110.15	10.65	31.70%
	Zone III	119.40	127.45	8.05	39.35%
At 35% Fe Cut Off					
UPSBB-1	Zone I	26.10	27.20	1.10	39.78%
	Zone II	33.25	37.00	3.75	41.44%
	Zone III	39.00	41.80	2.80	35.10%
	Zone IV	43.80	45.00	1.20	43.64%
	Zone V	53.15	54.15	1.00	35.01%
	Zone VI	80.80	82.50	1.70	42.94%
	Zone VII	102.10	106.10	4.00	42.49%
UPSBB-2	Zone I	142.20	144.00	1.80	36.99%
	Zone II	152.70	156.25	3.55	38.89%
UPSBB-3	Zone I	99.50	102.70	3.20	37.26%
	Zone II	119.40	127.45	8.05	39.35%

9. RESOURCE ESTIMATION

I. Introduction

In the block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh, a total of 461.30 m of drilling was carried out through four boreholes with an objective assess the economic potentiality of iron ore occurrence in the area. The borehole was drilled at the interval of 400m in general and all three boreholes UPSBB-1, UPSBB-3 & UPSBB-4 were drilled at an angle of 45° except UPSBB-2 which was drilled at 47°. The subsurface iron ore mineralization in the area was targeted at 30m vertical depth (Ist Level) from 400m datum line. Borehole no. UPSBB-1 has been planned by taking 380m datum line. The mineralized zones have demarcated based on the chemical analysis with Fe cut off $\geq 30\%$ and 35%. The mineralized iron zones have been established in all three boreholes namely UPSBB-1, UPSBB-2 & UPSBB-3. Borehole no. UPSBB-4 was closed earlier by the permission of NMH-II during COVID 19 pandemic and could not reach upto the depth of intersection of BIF. The grade of mineralization in drilled boreholes at 30% Fe varies from 31.42% to 42.94% with average grade of the explored block being 34.34%. Whereas the grade of mineralization at 35 % Fe varies from 35.01% to 43.64% with average grade of 39.47%.

Assumptions of resource estimations:

- The exposed BIF shows strike continuity all along the ridge crest in the investigated block with variable width of 9 to 54 m.
- As per the norm of G-3 stage investigation, the maximum distance between two adjacent boreholes is ~400m.
- The mineralized zones intersected in each borehole have been considered as a continuous single body.
- The Fe% is calculated from the molecular formula of Fe_2O_3 by multiplying the $\text{Fe}_2\text{O}_3\%$ by a factor of 0.6994.
- Since the BIF of present block 'B' is a continuation of BIF band of block 'A' explored in FS 2017-18, therefore, the average bulk density of 3.2 determined during FS 2017-18 has been taken for estimation of the resource.
- Strike influence of the mineralized zone has been taken as half the distance between two adjacent boreholes. In the east of borehole no. UPSBB-3, strike influence has been taken as 200m while for borehole no. UPSBB-1, the strike influence (western part) has been taken as 285m (half the distance of UPSBB-1 and SBE-7) as borehole SBE-7 has two

mineralized zones of 11.65m and 12.85m thickness with max dip influence of 140m at 35% Fe in Block 'A', Bharhari area, FS 2017-18.

- True thickness of the zones has been calculated by the trigonometrical method. The horizontal thickness of the mineralized zones has been calculated by dividing the true thickness with sine where θ is dip angle of mineralized zones.
- The minimum stopping width has been taken one metre.
- In the calculation of grade of mineralized zones at 30% and 35% Fe cut off, values of Fe approaching 30% & 35% have also taken into account and as their cumulative value is satisfying our cut off grade.
- The mineralized zones have been assumed to continue right from the outcrop surface as weighted average Fe% in the TRB-1, TRB-2, TRB-3, TRB-4 and TRB-5 have been found to be 34.39/16m, 35.53/22m, 44.33/20m, 45.87/6m and 43.45/15m respectively. The weighted average Fe% of the channel samples SBB/CH-1, SBB/CH-2 and SBB/CH-3 are 36.80/12m, 34.98/16m and 52.05/12m respectively. Trench TRB-1 is in profile line of borehole no. UPSBB-1 whereas channel SBB/CH-1 and SBB/CH-2 are in profile line of borehole no. UPSBB-2 & UPSBB-3 respectively.
- In the explored Block – 'B', Bharhari, the resource has been calculated by cross sectional method and longitudinal vertical section method (LVS method) at 30% and 35% Fe cut off. For cross section method, the dip influence of mineralized zone has been considered to be continuous from the surface to the 10m below the lower RL of the each intersected mineralized zone.

The resource has been estimated by cross sectional method and longitudinal vertical section methods for the Block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh.

I. Resource estimation by cross sectional method (taking true thickness):

In this method, the volume of the mineralized zone has been calculated by the multiplying the true thickness of the mineralized zones with its strike influence and dip influence. The total resource has been calculated at two cut offs i.e. at 30% and 35% Fe. The total resource has been calculated by following formulae:

$$\text{Total Resource} = \text{True thickness} \times \text{Dip influence} \times \text{Strike influence} \times \text{Bulk density}$$

Table 9.1: Total resource at Fe ≥ 30% calculated by the cross-sectional method

S. No.	Borehole No.	Mineralized Zone thickness intersected in borehole (t in m)	Core Angle (β)	Sin(β)	True Thickness (Sin(β)xt) (m)	Strike Influence (m)	Dip Influence (m)	Bulk Density	Resources (T) (Tonnes)	Avg. grade of borehole (g) (Fe %)	Tonnage x Avg. grade (T)x (g)	Avg. grade (%) $\frac{\sum (T \times g)}{\sum T}$
1	UPSBB-1-Zone I	1.10	85°	0.99619	1.10	485	84	3.2	142858.43	39.78	5682908.25	34.50%
2	UPSBB-1-Zone II	8.00	80°	0.98481	7.88	485	89	3.2	1088238.69	35.22	38327766.50	
3	UPSBB-1-Zone III	15.25	80°	0.98481	15.02	485	96	3.2	2237614.38	32.01	71626036.17	
4	UPSBB-1-Zone IV	1.70	70°	0.93969	1.60	485	106	3.2	262803.48	42.94	11284781.35	
5	UPSBB-1-Zone V	2.70	75°	0.96593	2.61	485	112	3.2	453334.90	33.44	15159519.19	
6	UPSBB-1-Zone VI	4.00	67°	0.92050	3.68	485	119	3.2	680021.22	42.49	28894101.47	
7	UPSBB-2-Zone I	11.00	70°	0.93969	10.34	401	104	3.2	1379446.88	31.5	43452576.66	
8	UPSBB-2-Zone II	7.75	72°	0.95106	7.37	401	110	3.2	1040391.16	33.87	35238048.71	
9	UPSBB-3-Zone I	1.15	70°	0.93969	1.08	397	140	3.2	192198.93	31.42	6038890.39	
10	UPSBB-3-Zone II	10.65	60°	0.86603	9.22	397	153	3.2	1792728.24	31.7	56829485.27	
11	UPSBB-3 -Zone III	8.05	65°	0.90631	7.30	397	162	3.2	1501509.73	39.35	59084408.02	
Total Resource $\sum T$ (in Tonnes)=									10771146.03	$\sum (T \times g)$=	371618521.99	
Total Resource : 10.77 MT												

The total estimated resource through Cross Section method at 30 % Fe is **10.77 million tonnes (MT)** with average **grade of 34.50%**.

Table 9.2: Total resource at Fe ≥ 35% calculated by the cross sectional method

S. No.	Borehole No.	Mineralized Zone thickness intersected in borehole (t in m)	Core Angle (β)	Sin(β)	True Thickness (Sin(β)x t) (m)	Strike Influence (m)	Dip Influence (m)	Bulk Density	Resources (T) (Tonnes)	Avg. grade of borehole (g) (Fe %)	Tonnage x Avg. grade (T)x (g)	Avg. grade (%) $\frac{\sum (T \times g)}{\sum T}$
1	UPSBB-1-Zone I	1.10	85°	0.99619	1.10	485	84	3.2	142858.43	39.78	5682908.25	39.51%
2	UPSBB-1-Zone II	3.75	85°	0.99619	3.74	485	89	3.2	516006.50	41.44	21383309.20	
3	UPSBB-1-Zone III	2.80	85°	0.99619	2.79	485	91	3.2	393942.94	35.1	13827397.09	
4	UPSBB-1-Zone IV	1.20	78°	0.97815	1.17	485	93	3.2	169418.71	43.64	7393432.51	
5	UPSBB-1-Zone V	1.00	73°	0.95630	0.96	485	94	3.2	139512.69	35.01	4884339.43	
6	UPSBB-1-Zone VI	1.70	70°	0.93969	1.60	485	106	3.2	262803.48	42.94	11284781.35	
7	UPSBB-1-Zone VII	4.00	67°	0.92050	3.68	485	119	3.2	680021.22	42.49	28894101.47	
8	UPSBB-2-Zone I	1.80	72°	0.95106	1.71	401	104	3.2	228458.92	36.99	8450695.30	
9	UPSBB-2-Zone II	3.55	72°	0.95106	3.38	401	110	3.2	476566.27	38.89	18533662.43	
10	UPSBB-3-Zone I	3.20	60°	0.86603	2.77	397	148	3.2	521056.86	37.26	19414578.49	
11	UPSBB-3 -Zone II	8.05	65°	0.90631	7.30	397	162	3.2	1501509.73	39.35	59084408.02	
Total Resource $\sum T$ (in Tonnes)=									5032155.741	$\sum (T \times g)$ =	198833613.55	
Total Resource : 5.03 MT												

The total estimated resource through Cross Section method at 35 % Fe is **5.03 million tonnes (MT)** with average **grade of 39.51%**.

II. Resource estimation by longitudinal vertical section (LVS) method:

In this method, the volume of the mineralized zone has been calculated by the multiplying the strike influence with differences in dip RL along with horizontal thickness. The differences in dip RL has been calculated by deducting the upper RL (URL) with RL of 10m below the lower RL of the intersected mineralized zone. Horizontal thickness has been determined by the trigonometric method. The total resource has been calculated at two cut offs i.e. at 30% and 35 % Fe content. The total resource has been calculated by fallowing formulae:

$$\text{Total Resource} = \text{Strike influence} \times \text{Difference in Dip RL} \times \text{Horizontal Thickness} \times \text{Bulk Density}$$

Table 9.3: Total resource at Fe ≥ 30% calculated by LVS method

S. No	Borehole No.	Mineralized Zone thickness intersected in borehole (m)	True Thickness (m)	Min. Zone dip angle (θ)	Sinθ	Horizontal Thickness (m)	Dip Length RL (m)		Difference in Dip RL (m)	Strike Influence (m)	Bulk Density	Resources (T) (Tonnes)	Avg. grade of borehole (g) (Fe %)	Tonnage x Avg. grade (T)x (g)	Avg. grade (%) $\sum (T \times g) / \sum T$
			1			(True T/ Sinθ) 2	Upper RL 3	Lower RL 4							
1	UPSBB-1-Zone I	1.10	1.10	42°	0.66913	1.63766	432	374	58	485	3.2	147415.81	39.78	5864201.04	34.55 %
2	UPSBB-1-Zone II	8.00	7.88	50°	0.76604	10.28667	434.5	364	70.5	485	3.2	1125526.19	35.22	39641032.29	
3	UPSBB-1-Zone III	15.25	15.02	57°	0.83867	17.90931	434	350.5	83.5	485	3.2	2320903.14	32.01	74292109.65	
4	UPSBB-1-Zone IV	1.70	1.60	67°	0.92050	1.73544	434	330.5	103.5	485	3.2	278767.28	42.94	11970267.08	
5	UPSBB-1-Zone V	2.70	2.61	72°	0.95106	2.74222	432	322	110	485	3.2	468150.95	33.44	15654967.61	
6	UPSBB-1-Zone VI	4.00	3.68	72°	0.95106	3.87147	431	312.5	118.5	485	3.2	712009.74	42.49	30253293.88	
7	UPSBB-2-Zone I	11.00	10.34	70°	0.93969	11.00000	437	339	98	401	3.2	1383289.60	31.5	43573622.40	
8	UPSBB-2-Zone II	7.75	7.37	74°	0.96126	7.66776	436	331	105	401	3.2	1033123.88	33.87	34991905.65	
9	UPSBB-3-Zone I	1.15	1.08	67°	0.92050	1.17397	466	331	135	397	3.2	201341.32	31.42	6326144.20	
10	UPSBB-3-Zone II	10.65	9.22	77°	0.97437	9.46583	469	321	148	397	3.2	1779757.54	31.7	56418313.94	
11	UPSBB-3 - Zone III	8.05	7.30	72°	0.95106	7.67123	471	311	160	397	3.2	1559283.93	39.35	61357822.73	
Total Resource $\sum (T)$ (in Tonnes)=												11009569.37	$\sum (T \times g)$=	380343680.47	
Total Resource = 11.01 MT															

The total estimated resource through LVS method at 30 % Fe is **11.01 million tonnes (MT)** with average **grade of 34.55%.**

Table 9.4: Total resource at Fe ≥ 35% calculated by LVS method

S. No.	Borehole No.	Mineralized Zone thickness intersected in borehole (m)	True Thickness (m)	Min. Zone dip angle (θ)	Sinθ	Horizontal Thickness (m)	Dip Length RL (m)		Difference in Dip RL (m)	Strike Influence (m)	Bulk Density	Resources (T) (Tonnes)	Avg. grade of borehole (g) (Fe %)	Tonnage x Avg. grade (T)x (g)	Avg. grade (%) $\frac{\sum (T \times g)}{\sum T}$
			1			(True T/ Sinθ) 2	Upper RL 3	Lower RL 4							
1	UPSBB-1-Zone I	1.10	1.10	42°	0.66913	1.63766	432	374	58	485	3.2	147415.81	39.78	5864201.04	39.56 %
2	UPSBB-1-Zone II	3.75	3.74	54°	0.80901	4.62293	433	364	69	485	3.2	495060.78	41.44	20515318.64	
3	UPSBB-1-Zone III	2.80	2.79	55°	0.81915	3.40597	433.5	361	72.5	485	3.2	383239.70	35.1	13451713.46	
4	UPSBB-1-Zone IV	1.20	1.17	56°	0.82904	1.41583	434.5	358	76.5	485	3.2	168098.71	43.64	7335827.56	
5	UPSBB-1-Zone V	1.00	0.96	60°	0.86603	1.10423	434	351	83	485	3.2	142243.04	35.01	4979928.87	
6	UPSBB-1-Zone VI	1.70	1.60	56°	0.82904	1.92689	434	330.5	103.5	485	3.2	309520.99	42.94	13290831.38	
7	UPSBB-1-Zone VII	4.00	3.68	72°	0.95106	3.87147	431	312.5	118.5	485	3.2	712009.74	42.49	30253293.88	
8	UPSBB-2-Zone I	1.80	1.71	71°	0.94552	1.81055	437	339	98	401	3.2	227682.75	36.99	8421984.93	
9	UPSBB-2-Zone II	3.55	3.38	74°	0.96126	3.51233	435	331	104	401	3.2	468730.37	38.89	18228923.90	
10	UPSBB-3-Zone I	3.20	2.77	77°	0.97437	2.84419	468	325	143	397	3.2	516696.52	37.26	19252112.20	
11	UPSBB-3 - Zone II	8.05	7.30	72°	0.95106	7.67123	471	311	160	397	3.2	1559283.93	39.35	61357822.73	
Total Resource $\sum (T)$ (in Tonnes)=												5129982.33	$\sum (T \times g)$ =	202951958.59	
Total Resource = 5.13 MT															

The total estimated resource through LVS method at 35 % Fe is **5.13 million tonnes (MT)** with average **grade of 39.56%.**

Table 9.5: Comparative study of the estimated resources

SR. No.	METHOD	at 30% Fe	at 35%Fe
I	Resource estimation by cross sectional method (taking true thickness)	10.77 MT	5.03 MT
II	Resource estimation by longitudinal vertical section (LVS) method	11.01 MT	5.13 MT

From the comparative study of the estimated resources, it can be inferred that the resource estimated by cross section method and LVS method given almost same tonnage at 30% and 35% Fe cut off. But resource estimation by cross section method has been considered as the best fit method as per the prevailing nature of the different mineralized zones in drilled boreholes of the area has the highest confidence for volume calculation and resource estimation of the explored block.

Category of the resource as per UNFC classification:

Detailed geological mapping was carried out on 1:4000 scale over an area of 2.1 sq. km. with triangulation stations depicting all geological details with contour interval of 10m. Surface investigation in the DM block was carried out through collection of 80 nos. of BRS and 79 nos. of PTS. Subsurface investigation in the area was carried out through 4 nos. of boreholes and borehole no. UPSBB-1 & UPSBB-2 were put through geophysical logging. Within the assigned block geophysical survey was also carried out by magnetic (TF) survey. A total resource of 10.77 million tonnes (MT) with average grade of 34.50% Fe at 30 % cut off and 5.03 million tonnes (MT) with average grade of 39.51% of Fe at 35 % cut off have been estimated in block- 'B' of the Bharhari area, Sonbhadra and fulfils the 333 category of UNFC classification.

10. CONCLUSION

The Banded Hematite Chert/Jasper bands (BIF) exposed in the block 'B' is the part of the 20 km long BIF zone extending from NW of Bijaura in east to Bharhari (Bharahari) in west, having general trend of N65°E-S65°W to N85°E-S85°W with dip of 50°-80° towards south. These bands are located in the northern most flank of the Mahakoshal ridge at the south of the Son-Narmada north fault. These BIF bands are the parts of the Agori Formation of the Mahakoshal Group of rocks and are closely associated with variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert / jasper (BIF), ferruginous phyllite and mafic intrusives in form of dolerites.

The most persistent and continuous banded hematite chert / jasper band is exposed at the ridge top and its width varies from 9 m to 54 m. The thickness of chert/jasper meso bands generally ranges from 1 mm to 4 cm, while that of iron rich meso bands ranges from 1 mm to 8 cm. The channels cut across the banded hematite chert / jasper (BIF) has shown Fe grade ranging from 34.98% to 52.05%. According to chemical analysis of samples, the iron ore present in the area is of low grade. From the study of the geological sections, it has been found that maximum depth (Lower RL) of banded hematite chert / jasper is 311 m in first level of intersection at 30m vertical from datum.

Based on chemical results, total estimated resource for iron ores in the block 'B' Bharhari area is 10.77 million tonnes (MT) with average grade of 34.50% Fe at 30 % cut off and 5.03 million tonnes (MT) with average grade of 39.51% of Fe at 35 % cut off. Resource has been calculated for 1.32 km strike length only of the detailed mapping (DM) block 'B' when the total strike length of the exposed BIF is 3.12 km. The preliminary investigation was confined in the western half of the block 'B'. The iron from banded hematite chert /jasper may be concentrated with weight recovery commensurate with the available hematite after crushing and elimination of silica, which needs a better beneficiation plant. It can also be used with very high-grade iron ore for blending purpose.

11. RECOMMENDATION

The World's Iron & Steel industry is based almost exclusively on iron ores associated with banded iron formation. Commercial extraction of high-grade iron ore from banded iron formation is the need of the hour. As the state of Uttar Pradesh is quite deficient in ferrous mineral resources, therefore, search for low grade iron ore is the need of hour and the discovery of potential mineral blocks with Fe value of 35% to 45% will augment the iron resource in the mineral inventory of the state.

- Since the sub surface exploration of the present block was taken based on outcome of the large-scale mapping of the Bharhari area by Modak *et.al.* (FS 2014-15), therefore, the remaining high potential blocks having iron values greater than or equal to 45% to be explored to estimate the iron resources as low grade iron ore.
- Before initiating the full-fledged G-3 stage investigation followed by G-2 stage in the remaining high potential blocks having iron values greater than or equal to 45%, the blocks must be explored through ground geophysical survey (Magnetic survey) to know the possible depth and spacing of the boreholes for iron mineralization.
- As the total strike of block is 3.12 km and resource has been estimated for 1.3 km of strike length on the basis of sub surface investigations. The remaining 1.8 km strike length in the eastern part of block may be drilled and resource can be calculated.
- The intimate association of tuffs in the down dip side of the BIF poses a great challenge for drilling, therefore, in such zones better and advanced techniques of drilling as well as latest high capacity drilling machinery should be used, as it would facilitate in better core recovery and knowing the exact thickness of the mineralized zones for all boreholes. It would also help in timely completion of drilling targets without overshooting the budgeted expenditure.
- Beneficiation studies of the bulk samples (drill core samples) to be carried out to know the iron percentage in the beneficiated samples.

LOCALITY INDEX

LOCALITY	LATTITUDE			LONGITUDE		
	DEG	MIN	SEC	DEG	MIN	SEC
Agori Khas	24	32	49.2	82	57	53.2
Allahabad	25	26	41.2	81	52	35.6
Baghmanva Pahar	24	34	07.0	82	54	10.7
Bargawan	24	35	35.7	82	54	34.2
Bharhari	24	32	30.0	82	45	0
Bijaura	24	34	18.1	82	56	53.1
Chakdiya (Chakdahi)	24	32	32.0	82	51	36.8
Chatarwar	24	35	44.2	82	53	38.0
Chaura	24	33	25.8	82	57	05.3
Chopan	24	30	50.5	83	01	33.0
Jogail	24	30	45.0	82	51	00
Karwaniya	24	31	54.1	82	53	40.7
Kurchha	24	34	15.5	82	53	05.4
Kushaniya (Sisauniya)	24	33	24.2	82	52	03.8
Marauli	24	34	15.2	82	52	07.7
Mirzapur	25	08	41.6	82	33	55.2
Muirpur	24	07	33.0	83	02	36.0
Murgidand	24	32	20.5	82	52	53.7
Robertsganj	24	41	19.0	83	04	04.2
Varanasi	25	19	0	83	0	37.5

REFERENCES

- Bhattacharya D. et al., (2012):** Report on the ground geophysical mapping in parts of degree sheet no. 63L (TS no. 63L/1, 5, 9, 13, 14, 15 & 16) in Uttar Pradesh and Madhya Pradesh.
- Dey A.K., (1967-68):** Report on the preliminary investigation of Iron-ore Deposit near Bargawan, District Mirzapur, U.P., *Unpub. report Geol. Surv. India*.
- Dey A.K., (1968-69):** Report on the exploratory operations carried out on the iron-ore deposit near Bargawan. Dist. Mirzapur, U.P. *Unpub. report Geol. Surv. India*.
- Dwivedi, G.N., Sharma, D.P., Prasad, M., Sinha, V.P., Tripathi, A.K., Yadav, M.L., Mishra, R., Khan, M.A. and Absar, A. (2001):** Gold Exploration at Sona Pahari, Sonbhadra District, U.P.: An Introspect. *Geol. Surv. India, Spl. Publ. No-58 P. 361-365*.
- Modak, A, Arvind, Chaki. P. and Nag, R., (2015):** Report on resource evaluation of potentiality of iron in Mahakoshal Group, Bharhari area, Sonbhadra district, Uttar Pradesh., *Unpub. report Geol. Surv. India, FS: 2014-15*.
- Shrivastav, Mukeshkumar R., Ahmad, Shamiuddin (2019):** Preliminary exploration for iron ore in Mahakoshal Group Block 'A' Bharhari area, Sonbhadra district, Uttar Pradesh, FS 2017-18.
- Nair, K.K.K., Jain, S.C. and Yedekar, D.B. (1995):** Stratigraphy, Structure and geochemistry of Mahakoshal Greenstone Belt. *Mem. Geol. Soc. Ind. 31: 405-432*.
- Roy A. and Devarajan M. K. (2000):** Reappraisal of stratigraphy of Mahakoshal Group, Cambrian crust in eastern and central India, proceeding on international seminar, UNSCO-IUGS-IGCP-368. *Geol. Surv. Ind. Spl. Pub. No. 57*.
- Sarkar, Abhijit, Gupta, Sangeeta, Sangeeta and Pramanik Suhrit (2014):** Interim Report on geochemical mapping of Vindhyan basin and Mahakoshal Belt in toposheet nos. 63L/13, 14 and 15 (NW/NE) covering parts of Mirzapur and Sonbhadra districts of U.P. and Sidhi district of M.P. *Unpub. report Geol. Surv. India, FS:2013-2014*
- Soni, M.K. and Jha, D.K. (2001):** Mahakoshal Greenstone belt and associated gold mineralisation. *Geol. Surv. Ind., Spl. Pub. No. 64, pp. 317- 326*.

Tripathi, S.C. and Mishra, M.N. (1994): Cyclic volcanism and sedimentation in the Mahakoshal Greenstone Belt, district Sidhi, Madhya Pradesh. *Jour. Geol. Soc. India, Vol. XLIV, p 167 – 173.*

Vredenburg, E. (1901): Geology of Son Valley in Rewa state and parts of Jabalpur and Mirzapur. *Mem. Geol. Surv. India Vol . 33.*

Winkler H.G.F., (1974): Petrogenesis of metamorphic rocks, 3rd ed. Springer, Berlin, 320p.

Analytical results of Major Oxides and Trace Elements of Bed rock samples from Block - 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	Latitude	Longitude	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)	LOI %
1	SBB/BR5-1	24°34'0.4"	82°53'43.0"	Banded Hematite Jasper	46.7	0.43	49.25	0.1	<0.1	0.11	<0.1	0.01	0.1	0.13	34.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	SBB/BR5-2	24°33'56.4"	82°53'43.4"	Ferruginous phyllite interbanded with tuff	25.34	12.22	48.51	0.19	0.15	<0.1	<0.1	0.01	2.04	1.09	33.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	SBB/BR5-3	24°33'56.5"	82°53'19.2"	Banded Hematite Jasper	33.05	0.47	66.33	0.17	0.3	0.12	0.11	0.01	0.07	0.25	46.39	581	62	52	10	8	9	34	7	24	34	44	10	77	27	35	22	-
4	SBB/BR5-4	24°33'55.2"	82°53'12.8"	Banded Hematite Jasper/Chert	55.69	0.57	42.13	0.19	0.6	<0.1	0.19	0.01	0.03	0.24	29.47	300	48	41	50	9	7	61	11	12	22	19	7	40	28	91	26	-
5	SBB/BR5-5	24°33'53.3"	82°53'46.0"	Bedded Tuff	78.69	16.41	0.86	0.11	0.4	0.1	0.14	0.03	1.11	0.1	0.60	77	22	127	12	14	22	39	8	7	20	43	6	105	26	16	135	-
6	SBB/BR5-6	24°33'53.3"	82°53'46.0"	Banded Hematite Chert	55.25	0.47	41.54	0.2	0.2	<0.1	0.17	0.02	0.01	0.29	29.05	305	53	35	37	6	7	64	6	13	20	16	9	31	21	94	19	-
7	SBB/BR5-7	24°33'52.4"	82°53'23.4"	Banded Hematite Chert with chert nodules	51.36	9.27	35.97	0.27	0.11	<0.1	0.15	0.03	0.15	0.32	25.16	280	43	92	82	11	11	54	101	11	31	29	5	157	38	59	80	-
8	SBB/BR5-8	24°34'03.7"	82°54'04.4"	Reddish white altered tuff	54.86	26.84	7.74	0.13	0.17	0.12	0.4	0.02	3.12	0.12	5.41	227	14	186	75	16	27	11	7	10	49	32	6	411	10	16	145	-
9	SBB/BR5-9	24°34'04.0"	82°54'04.5"	Banded Hematite Chert	65.63	4.04	30.48	0.1	0.25	0.1	0.11	0.03	0.18	0.21	21.32	250	25	59	37	5	9	37	6	8	20	21	8	124	20	37	49	-
10	SBB/BR5-10	24°34'06.0"	82°54'12.3"	Banded Hematite Jasper	53.93	8.5	32.03	0.2	0.35	0.1	0.14	0.01	0.79	0.42	22.40	419	30	157	25	7	13	22	23	10	35	27	7	329	20	31	72	-
11	SBB/BR5-11	24°34'03.4"	82°54'15.6"	Ferruginous phyllite ± chert nodules,tuff bands	71.7	6.41	20.54	0.13	0.2	<0.1	0.16	0.02	0.27	0.11	14.37	173	26	65	31	7	11	70	7	5	16	19	8	65	15	42	53	-
12	SBB/BR5-12	24°33'54.0"	82°54'01.8"	Ferruginous phyllite with Hematite & Jasper	71.88	5.49	21.88	0.14	0.15	0.11	0.18	0.04	0.11	0.27	15.30	1443	34	38	32	9	10	17	5	7	16	63	6	58	23	35	52	-
13	SBB/BR5-13	24°33'49.0"	82°53'33.9"	Banded Hematite Chert/Jasper	63.69	0.69	34.95	0.11	0.22	<0.1	0.1	0.03	0.01	0.24	24.44	420	40	33	67	6	7	16	6	7	19	56	5	26	20	23	20	-
14	SBB/BR5-14	24°33'45.5"	82°53'20.2"	Banded Hematite Jasper	60.57	1.43	36.84	0.18	0.14	0.12	0.17	0.01	0.02	0.26	25.77	525	38	45	25	7	7	34	8	9	22	105	8	31	27	34	23	-
15	SBB/BR5-15	24°34'07.5"	82°54'23.3"	Silicified Banded Hematite Chert	52.20	1.80	37.54	0.22	1.06	0.15	0.14	0.27	0.03	0.29	26.26	873	-	-	-	13	-	-	6	74	46	72	<5	87	66	-	67	-
16	SBB/BR5-16	24°34'03.4"	82°54'16.5"	Quartz vein in Banded Hematite Chert	83.35	2.11	11.37	0.15	0.51	0.12	0.12	0.02	0.11	0.09	7.95	191	-	-	-	8	-	-	7	54	19	71	6	37	41	-	69	-
17	SBB/BR5-17	24°34'03.5"	82°54'18.9"	Banded Hematite Chert	70.07	7.00	18.62	0.17	0.46	0.13	0.12	0.02	0.29	0.07	13.02	394	-	-	-	15	-	-	11	58	44	85	<5	168	52	-	111	-
18	SBB/BR5-18	24°34'04.3"	82°54'24.0"	Ferruginous phyllite with tuff	60.91	6.84	27.26	0.25	0.46	0.12	0.12	0.03	0.28	0.08	19.07	519	-	-	-	13	-	-	9	61	44	114	8	96	57	-	104	-
19	SBB/BR5-19	24°34'08.7"	82°53'36.0"	Buff phyllite	56.69	8.01	23.03	0.28	1.48	0.12	0.92	0.04	0.42	0.01	16.11	370	-	-	-	20	11	-	-	-	29	72	-	89	44	-	93	-
20	SBB/BR5-20	24°34'06.4"	82°53'39.3"	White tuff with ferruginous phyllite	66.95	18.76	2.94	0.10	0.68	0.10	2.37	0.01	0.78	0.01	2.06	179	-	-	-	22	13	-	-	-	18	44	-	76	16	-	94	-
21	SBB/BR5-21	24°34'08.2"	82°54'26.2"	Banded Hematite Jasper/Chert	37.05	0.58	58.31	0.17	0.12	0.10	0.03	0.03	0.01	0.01	40.78	601	-	-	-	9	8	-	-	-	40	48	-	24	58	-	47	-
22	SBB/BR5-22	24°34'06.1"	82°54'25.8"	Ferruginous phyllite with chert nodules and tuff	73.50	5.96	12.64	0.11	0.12	0.04	0.06	0.01	0.49	0.01	8.84	237	-	-	-	12	11	-	-	-	19	53	-	75	29	-	98	-
23	SBB/BR5-23	24°34'13.0"	82°53'46.1"	Grey phyllite	57.45	8.43	21.44	1.24	1.99	0.97	1.55	0.18	0.46	0.01	15.00	491	-	-	-	21	11	-	-	-	26	141	-	97	32	-	109	-
24	SBB/BR5-24	24°34'10.5"	82°54'38.6"	Banded Hematite Chert/Jasper	52.74	0.52	40.98	0.11	0.12	0.05	0.04	0.03	0.01	0.01	28.66	517	-	-	-	13	8	-	-	-	38	50	-	23	58	-	50	-
25	SBB/BR5-25	24°34'08.4"	82°54'38.3"	Ferruginous phyllite with tuff	51.64	10.15	26.32	0.28	0.27	0.04	0.07	0.03	1.57	0.01	18.41	479	-	-	-	21	20	-	-	-	40	75	-	338	57	-	186	-
26	SBB/BR5-26	24°33'59.5"	82°54'11.3"	Meta basic	31.94	14.63	33.54	0.60	1.90	0.10	1.49	0.07	2.25	0.01	23.46	489	-	-	-	28	27	-	-	-	49	54	-	459	40	-	197	-
27	SBB/BR5-27	24°34'09.1"	82°54'48.2"	Ferruginous phyllite with tuff	64.97	7.47	19.35	0.18	0.20	0.04	0.12	0.07	0.43	0.01	13.53	274	-	-	-	16	11	-	-	-	20	48	-	45	43	-	117	-
28	SBB/BR5-28	24°34'04.4"	82°54'45.3"	Ferruginous phyllite ± iron oxide	56.27	5.99	29.79	0.17	0.10	0.04	0.04	0.03	0.35	0.01	20.84	401	-	-	-	14	12	-	-	-	29	65	-	105	69	-	127	-
29	SBB/BR5-29	24°34'04.8"	82°53'32.3"	Ferruginous phyllite ± iron oxide, tuff banding	65.04	9.15	16.35	0.10	0.10	0.03	0.03	0.01	0.59	0.01	11.44	215	-	-	-	18	12	-	-	-	23	54	-	106	36	-	98	-
30	SBB/BR5-53	24°33'55.4"	82°54'15.6"	Banded Hematite Jasper with thin tuff banding	45.33	1.56	42.93	2.20	0.40	<0.1	0.12	0.08	0.06	0.01	30.03	491	-	-	-	11	7	-	-	-	45	164	-	35	49	-	39	-
31	SBB/BR5-54	24°33'53.7"	82°54'25.5"	Ferruginous phyllite ± iron oxide, jasper/chert	42.97	5.76	40.41	0.14	0.12	0.10	0.10	0.01	0.51	0.01	28.26	261	-	-	-	13	19	-	-	-	34	47	-	119	40	-	100	-
32	SBB/BR5-55	24°33'57.4"	82°54'31.7"	Ferruginous phyllite ± iron oxide, chert nodules	46.93	7.91	32.99	0.14	0.12	0.10	0.11	0.09	0.54	0.01	23.07	292	-	-	-	15	16	-	-	-	38	40	-	111	34	-	102	-
33	SBB/BR5-56	24°33'58.8"	82°54'15.2"	Dark grey, hard meta basic	36.80	14.28	28.98	0.58	2.01	0.63	2.88	0.11	2.58	0.01	20.27	430	-	-	-	29	35	-	-	-	50	48	-	456	29	-	232	-
34	SBB/BR5-57	24°33'47.4"	82°53'17.5"	Weathered buff dolerite	34.98	8.73	24.10	3.51	11.25	0.15	0.15	0.11	1.39	0.02	16.86	342	-	-	-	14	14	-	-	-	51	38	-	201	20	-	79	-
35	SBB/BR5-58	24°33'59.3"	82°54'34.1"	Brecciated Banded Hematite Chert	53.46	4.17	36.77	0.52	0.22	0.1	0.1	0.03	0.48	0.01	25.72	539	-	-	-	13	10	-	-	44	54	53	7	212	53	-	95	-
36	SBB/BR5-59	24°34'05.9"	82°54'50.1"	Banded Hematite Chert	55	6.11	31.64	0.37	0.46	0.11	0.1	0.03	0.4	0.01	22.13	479	-	-	-	14	11	-	-	40	41	51	12	157	54	-	108	-
37	SBB/BR5-60	24°34'06.8"	82°54'53.5"	Banded Hematite Chert	63.84	6.6	24.98	0.21	0.19	0.1	0.1	0.06	0.48	0.01	17.47	495	-	-	-	14	10	-	-	31	32	55	7	117	47	-	108	-
38	SBB/BR5-61	24°34'04.6"	82°54'50.6"	Weathered tuff (dolerite)	44.17	0.79	51.25	0.26	0.12	0.14	0.1	0.06	0.03	0.01	35.84	611	-	-	-	8	7	-	-	49	43	53	6	71	68	-	52	-
39	SBB/BR5-62	24°34'13.3"	82°54'50.5"	Banded Hematite Chert/Jasper	49.93	12.28	23.04	0.18	0.21	0.1	<0.1	0.02	1.72	0.01	16.11	327	-	-	-	22	18	-	-	37	52	49	15	343	39	-	146	-
40	SBB/BR5-63	24°34'15.1"	82°54'53.5"	Banded Hematite Jasper/Chert	46.46	1.02	50.06	0.15	0.13	0.13	<0.1	0.03	0.02	0.01	35.01	690	-	-	-	11	7	-	-	59	46	62	12	56	60	-	53	-

Sr. No.	Sample No	Latitude	Longitude	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)	LOI %
41	SBB/BRS-64	24°34'15.1"	82°54'57.3"	Banded Hematite Jasper/Chert	42.41	0.83	51.54	0.22	0.14	0.1	<0.1	0.04	0.05	0.02	36.05	588	-	-	-	9	7	-	-	58	39	65	9	37	54	-	55	-
42	SBB/BRS-65	24°34'15.0"	82°55'06.0"	Reddish Tuff	55.78	16.98	6.48	0.16	0.22	0.1	0.12	0.01	4.09	0.03	4.53	319	-	-	-	23	24	-	-	33	38	73	<5	247	49	-	210	-
43	SBB/BRS-66	24°34'15.0"	82°55'06.0"	Ferruginous phyllite ± iron oxide, chert nodules	55.98	4.91	31.04	0.16	0.1	<0.1	<0.1	0.01	0.44	0.01	21.71	378	-	-	-	19	11	-	-	43	34	88	14	204	47	-	108	-
44	SBB/BRS-67	24°34'17.5"	82°54'09.7"	Grey phyllite	49.55	10.42	23.93	2.21	3.82	0.55	1.09	0.12	0.52	0.09	16.74	406	-	-	-	18	13	-	-	88	28	65	9	128	41	-	110	-
45	SBB/BRS-68	24°34'09.7"	82°53'57.0"	Reddish brown, also pinkish phyllite	56.05	19.03	10.96	0.12	1.1	0.14	3.97	0.01	0.98	0.09	7.67	353	-	-	-	22	14	-	-	231	17	55	8	158	16	-	116	-
46	SBB/BRS-69	24°34'10.8"	82°54'07.0"	Ash colour phyllite with ferruginous bands	53.05	10.04	28.34	0.22	0.54	0.17	0.11	0.01	0.43	0.09	19.82	397	-	-	-	13	11	-	-	42	26	64	7	115	41	-	80	-
47	SBB/BRS-70	24°34'15.3"	82°54'22.9"	Chloritic phyllite ± reddish ferruginous bands	48.75	8.31	32.38	0.4	2.22	0.15	0.34	0.03	0.48	0.1	22.65	407	-	-	-	17	11	-	-	49	29	69	9	128	41	-	94	-
48	SBB/BRS-71	24°34'18.1"	82°54'30.7"	Reddish and greenish phyllite	49.05	9.04	32.02	0.65	2.22	0.12	1.35	0.03	0.32	0.09	22.39	625	-	-	-	16	11	-	-	127	29	78	9	125	36	-	69	-
49	SBB/BRS-72	24°34'22.6"	82°54'39.9"	Reddish buff phyllite	49.18	10.93	27.27	0.47	2.37	0.1	1.39	0.06	0.44	0.09	19.07	498	-	-	-	14	10	-	-	84	33	52	10	126	39	-	85	-
50	SBB/BRS-73	24°34'22.6"	82°54'52.7"	Khakhi buff phyllite	65.93	18.51	3.42	0.1	0.75	0.11	3.15	0.01	1.12	0.09	2.39	181	-	-	-	17	11	-	-	126	17	41	7	95	15	-	91	-
51	SBB/BRS-74	24°34'19.0"	82°54'57.6"	Ferruginous phyllite ± iron oxide/tuff/chert nodules	56.24	10.81	25.15	0.13	0.27	0.1	0.24	0.01	0.47	0.09	17.59	331	-	-	-	20	11	-	-	44	22	109	7	255	41	-	117	-
52	SBB/BRS-75	24°34'19.6"	82°54'48.8"	Banded Hematite Chert	50.08	0.56	43.66	0.14	0.1	0.11	0.1	0.03	0.02	0.09	30.54	478	-	-	-	9	7	-	-	51	31	65	7	23	44	-	45	-
53	SBB/BRS-76	24°33'57.7"	82°54'51.2"	Banded Hematite Chert	87.67	0.41	9.54	0.16	0.1	0.12	0.1	0.03	0.02	0.11	6.67	133	-	-	-	8	7	-	-	31	10	40	<5	20	37	-	41	-
54	SBB/BRS-77	24°33'01.3"	82°55'07.5"	Banded Hematite Chert	58.39	3.38	32.74	0.19	0.17	0.15	0.1	0.02	0.28	0.1	22.90	571	-	-	-	13	8	-	-	42	30	52	5	88	45	-	76	-
55	SBB/CH-1/1	24°33'58.8"	82°53'36.9"	Silicified Banded Hematite Chert	56.18	6.80	36.03	0.17	0.20	0.11	0.12	0.01	0.07	0.35	25.20	425	61	77	264	9	10	41	397	10	39	22	7	401	20	69	38	-
56	SBB/CH-1/2	24°33'58.8"	82°53'36.9"	Silicified Banded Hematite Chert	55.75	1.23	40.64	0.14	0.30	<0.1	0.11	0.01	0.05	0.48	28.42	295	48	63	21	7	7	33	279	10	24	9	5	55	14	103	27	-
57	SBB/CH-1/3	24°33'58.8"	82°53'36.9"	Massive Banded Hematite Chert	21.19	2.18	72.94	0.20	0.16	0.12	0.14	0.01	0.04	0.58	51.01	653	64	94	24	5	8	53	362	20	48	12	8	169	26	168	31	-
58	SBB/CH-1/4	24°33'58.8"	82°53'36.9"	Massive Banded Hematite Chert/Jasper	25.70	4.77	64.58	0.27	0.21	0.10	0.16	0.01	0.09	0.63	45.17	718	65	134	50	7	10	56	712	22	40	25	<5	221	29	176	50	-
59	SBB/CH-1/5	24°33'58.8"	82°53'36.9"	Silicified/limonitized Banded Hematite Jasper	30.47	7.78	55.94	0.43	0.21	0.13	0.12	0.01	0.14	0.81	39.12	549	54	174	44	13	11	66	683	20	45	24	<5	390	31	204	69	-
60	SBB/CH-1/6	24°33'58.8"	82°53'36.9"	Limonitic Banded Hematite Chert	44.30	7.21	45.54	0.37	0.18	0.10	0.15	0.01	0.48	0.80	31.85	575	48	105	54	9	12	58	941	21	42	44	<5	390	39	205	123	-
61	SBB/CH-2/1	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	43.04	0.48	54.95	0.35	0.11	<0.1	0.19	0.01	0.05	0.18	38.43	461	60	42	17	5	7	38	39	16	30	27	7	43	42	43	20	-
62	SBB/CH-2/2	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	41.18	0.63	54.18	0.41	0.16	<0.1	0.17	0.01	0.07	0.22	37.89	530	48	42	12	8	7	17	61	13	23	22	6	69	28	32	20	-
63	SBB/CH-2/3	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	57.56	0.33	41.09	0.29	0.12	0.10	0.15	0.01	0.04	0.16	28.74	299	45	39	16	6	8	26	44	15	22	19	8	22	27	45	20	-
64	SBB/CH-2/4	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	55.06	0.55	43.79	0.19	0.11	<0.1	0.14	0.01	0.06	0.25	30.63	313	45	35	13	9	7	27	417	7	18	16	<5	36	30	55	20	-
65	SBB/CH-2/5	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	43.54	0.47	56.12	0.15	0.40	<0.1	0.11	0.01	0.05	0.13	39.25	424	52	39	15	5	8	31	192	14	29	16	6	49	28	47	20	-
66	SBB/CH-2/6	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	43.29	0.76	51.32	0.57	0.81	0.11	0.10	0.01	0.04	0.12	35.89	439	53	44	28	7	8	35	137	15	30	21	5	61	31	41	27	-
67	SBB/CH-2/7	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	41.82	0.59	56.48	0.14	0.10	0.13	0.13	0.01	0.01	0.16	39.50	458	55	45	18	6	7	30	261	17	32	29	7	47	33	64	23	-
68	SBB/CH-2/8	24°34'01.3"	82°53'51.3"	Banded Hematite Jasper	56.33	0.36	42.22	0.13	0.50	0.10	0.20	0.01	0.03	0.20	29.53	340	45	37	16	5	6	24	256	11	21	60	5	44	28	45	20	-
69	SBB/CH-3/1	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	28.37	1.09	60.42	0.16	0.11	0.04	0.03	0.06	0.02	0.01	42.26	698	-	-	-	11	6	-	-	-	49	51	-	124	80	-	56	-
70	SBB/CH-3/2	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	25.97	3.40	59.48	0.28	0.19	0.03	0.11	0.06	0.09	0.01	41.60	686	-	-	-	16	8	-	-	-	47	51	-	177	78	-	83	-
71	SBB/CH-3/3	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	24.35	0.67	66.09	0.17	0.15	0.04	0.02	0.06	0.01	0.01	46.22	731	-	-	-	12	7	-	-	-	48	52	-	47	62	-	48	-
72	SBB/CH-3/4	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	34.92	7.76	45.31	0.26	0.16	0.10	0.08	0.05	1.05	0.01	31.69	734	-	-	-	18	16	-	-	-	52	95	-	443	82	-	150	-
73	SBB/CH-3/5	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	8.51	1.37	80.04	0.27	0.11	0.10	0.03	0.05	0.06	0.01	55.98	905	-	-	-	13	6	-	-	-	67	56	-	132	80	-	62	-
74	SBB/CH-3/6	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	5.52	0.94	80.90	0.24	0.12	0.06	0.03	0.06	0.01	0.01	56.58	975	-	-	-	9	7	-	-	-	72	53	-	120	85	-	52	-
75	SBB/CH-3/7	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	4.48	1.38	81.30	0.19	0.14	0.10	0.02	0.05	0.01	0.01	56.86	1023	-	-	-	12	6	-	-	-	74	66	-	78	93	-	63	-
76	SBB/CH-3/8	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	3.69	0.84	89.54	0.13	0.11	0.06	0.06	0.04	0.01	0.01	62.62	1010	-	-	-	8	6	-	-	-	67	57	-	76	82	-	49	-
77	SBB/CH-3/9	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	10.79	2.72	74.90	0.27	0.19	0.12	0.09	0.06	0.01	0.08	52.39	975	-	-	-	6	7	-	-	-	79	42	-	119	85	-	47	-
78	SBB/CH-3/10	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	4.97	1.20	81.65	0.31	0.13	0.12	0.04	0.06	0.01	0.08	57.11	1026	-	-	-	6	6	-	-	-	72	43	-	116	81	-	49	-
79	SBB/CH-3/11	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	6.32	1.19	83.70	0.32	0.16	0.12	0.05	0.04	0.01	0.08	58.54	1054	-	-	-	7	7	-	-	-	67	49	-	125	76	-	51	-
80	SBB/CH-3/12	24°34'04.3"	82°54'02.7"	Banded Hematite Chert/Jasper	3.71	0.97	89.80	0.26	0.16	0.11	0.04	0.05	0.01	0.07	62.81	1125	-	-	-	7	6	-	-	-	75	58	-	126	73	-	49	-

Analytical results of Major Oxides and Trace Elements of drill core samples from Block - 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)	LOI %
Borehole No. UPSBB-1 24' 33' 55.2" 82' 53' 25.2" 88																																	
1	UPSBB-1/1	23.60	24.60	1.00	Banded Hematite Chert	84.4	0.91	9.72	0.13	0.2	0.11	0.18	0.01	0.02	0.09	6.798	52	11	69	143	6	7	22	27	9	12	13	<5	49	8	45	21	1.72
2	UPSBB-1/2	24.60	25.10	0.50	Banded Hematite Chert	60.5	1.31	32.6	0.18	0.17	0.13	0.2	0.01	0.03	0.23	22.800	202	32	67	168	5	6	48	22	15	17	11	10	46	21	124	38	3.94
3	UPSBB-1/3	25.10	26.10	1.00	Banded Hematite Chert	45.2	0.72	50	0.13	0.16	0.11	0.11	0.01	0.01	0.21	34.970	426	51	55	47	8	6	14	<5	10	27	13	8	40	21	39	19	2.1
4	UPSBB-1/4	26.10	27.20	1.10	Banded Hematite Chert	36.9	0.85	56.88	0.13	0.11	0.1	0.1	0.01	0.04	0.31	39.782	415	45	51	136	<5	8	27	13	17	26	13	9	43	28	57	30	3.73
5	UPSBB-1/5	27.20	28.00	0.80	Banded Hematite Chert	61.2	0.72	36.19	0.12	0.1	0.1	0.11	<0.003	0.01	0.18	25.311	359	42	36	30	<5	6	9	10	10	22	15	5	36	27	28	20	1.43
6	UPSBB-1/6	28.00	29.00	1.00	Banded Hematite Chert	61.3	0.84	33.45	0.13	0.12	0.11	0.11	<0.003	0.02	0.24	23.395	274	38	63	85	9	7	21	15	11	14	11	5	34	18	43	26	2.24
7	UPSBB-1/7	29.00	30.10	1.10	Banded Hematite Chert/Jasper	54.5	1.11	42.15	0.14	0.13	0.1	0.1	0.01	0.04	0.11	29.480	562	50	49	17	5	6	23	5	14	24	39	11	56	26	30	26	0.21
8	UPSBB-1/8	30.10	31.00	0.90	Banded Hematite Chert/Jasper	57.7	0.61	39.42	0.16	0.11	0.1	0.1	0.01	0.01	0.11	27.570	353	38	54	21	6	6	21	6	14	21	29	8	26	37	27	20	0.3
9	UPSBB-1/9	31.00	32.20	1.20	Banded Hematite Chert/Jasper	50.7	0.86	44.53	0.15	0.11	0.1	0.1	0.01	0.02	0.2	31.144	313	32	66	26	8	7	23	16	11	19	21	6	47	24	34	23	0.86
10	UPSBB-1/10	32.20	33.25	1.05	Banded Hematite Chert/Jasper	54.4	0.54	43.27	0.21	0.11	<0.1	0.1	0.01	0.01	0.19	30.263	354	39	61	51	<5	7	26	18	13	20	28	<5	49	37	38	22	1.22
11	UPSBB-1/11	33.25	34.45	1.20	Banded Hematite Chert/Jasper	41.1	0.36	56.89	0.14	0.13	0.1	0.1	0.01	0.01	0.14	39.789	461	46	64	23	5	6	30	14	12	23	23	13	57	30	27	20	0.46
12	UPSBB-1/12	34.45	35.70	1.25	Banded Hematite Chert/Jasper	38.5	0.51	57.13	0.12	0.12	0.1	0.1	0.01	0.01	0.09	39.957	433	55	50	21	8	6	18	9	15	27	23	9	36	29	24	21	1.05
13	UPSBB-1/13	35.70	37.00	1.30	Banded Hematite Chert/Jasper with tuff banding	34.1	0.41	63.45	0.12	0.12	0.11	0.1	0.01	0.01	0.06	44.377	455	58	73	23	<5	6	25	5	15	29	14	10	30	19	25	18	0.5
14	UPSBB-1/14	39.00	39.70	0.70	Banded Hematite Chert with tuff and chert	55.2	0.73	40.62	0.12	0.1	0.1	0.11	0.01	0.02	0.19	28.410	523	50	62	78	7	6	23	11	14	56	11	9	50	13	35	24	1.59
15	UPSBB-1/15	39.70	40.40	0.70	Banded Hematite Chert/Jasper	50.1	0.44	49.01	0.12	0.1	0.1	0.1	0.01	0.01	0.16	34.278	656	66	48	98	10	6	28	19	16	57	13	<5	41	21	33	23	0.98
16	UPSBB-1/16	40.40	41.20	0.80	Banded Hematite Chert/Jasper	43.3	0.52	53.51	0.13	0.12	0.11	0.1	0.01	0.01	0.09	37.425	706	80	68	31	6	7	32	13	17	49	16	5	40	17	30	21	1.04
17	UPSBB-1/17	41.20	41.80	0.60	Banded Hematite Chert/Jasper	41.5	0.49	58.28	0.16	0.17	0.12	0.11	0.01	0.01	0.12	40.761	750	88	59	33	8	8	35	8	19	47	27	10	49	23	26	22	1.12
18	UPSBB-1/18	41.80	43.00	1.20	Chert+tuff+iron hydroxide	63	2.52	34.87	0.12	0.14	0.1	0.1	0.01	0.07	0.17	24.388	363	57	59	73	5	8	16	17	11	31	13	<5	99	22	23	40	1
19	UPSBB-1/19	43.00	43.80	0.80	Banded Hematite Chert/Jasper with Tuff	58	1.18	39.24	0.1	0.12	0.1	0.1	0.01	0.03	0.14	27.444	379	51	54	31	6	7	16	5	12	25	9	9	51	13	21	25	0.98
20	UPSBB-1/20	43.80	45.00	1.20	Banded Hematite Chert+tuff+chert	35.7	0.51	62.39	0.13	0.13	0.1	<0.1	0.01	0.01	0.12	43.636	591	80	70	40	6	5	41	7	14	41	28	11	23	33	41	23	1.01
21	UPSBB-1/21	45.00	45.90	0.90	Banded Hematite Chert/Jasper with Tuff	51.1	2.08	46.14	0.11	0.11	0.1	0.1	0.01	0.03	0.11	32.270	412	56	82	25	6	8	27	6	16	29	21	10	67	27	24	31	1.01
22	UPSBB-1/22	45.90	46.70	0.80	Banded Hematite Chert/Jasper with Tuff	60.3	0.43	39.75	0.14	0.1	0.1	0.1	0.01	0.01	0.09	27.801	372	58	50	12	6	7	23	8	10	23	45	8	26	32	28	21	1.03
23	UPSBB-1/23	46.70	47.45	0.75	Banded Hematite Chert/Jasper+iron hydroxide (limonite/goethite)	51.1	1.38	47.81	0.12	0.1	0.1	0.1	0.01	0.02	0.09	33.438	381	62	53	28	6	6	22	13	12	24	14	6	35	14	22	25	1.01
24	UPSBB-1/24	47.45	48.45	1.00	Banded Hematite Chert/Jasper with tuffaceous banding	58.1	1	38.47	0.11	0.1	0.1	0.1	0.01	0.02	0.1	26.906	267	40	44	26	8	7	26	6	10	18	28	10	44	19	34	21	0.99
25	UPSBB-1/25	48.45	49.15	0.70	Banded Hematite Chert/Jasper with tuffaceous banding	38.7	0.27	59.97	0.13	0.12	0.15	<0.1	0.01	0.01	0.09	41.943	528	67	55	27	6	5	19	<5	16	29	18	17	32	23	20	19	1.01
26	UPSBB-1/26	49.15	50.35	1.20	Banded Hematite Chert/Jasper with Tuff	70.3	1.56	26.73	0.1	<0.1	<0.1	<0.1	0.01	0.05	0.09	18.695	215	32	44	17	9	8	20	6	10	13	13	8	52	15	23	32	0.96
27	UPSBB-1/27	50.35	51.65	1.30	Banded Hematite Chert	51.3	1.67	46.59	0.11	<0.1	0.1	<0.1	0.01	0.02	0.1	32.585	507	53	53	29	6	7	26	10	12	27	22	6	48	28	21	29	0.99
28	UPSBB-1/28	51.65	52.15	0.50	Banded Hematite Chert/Jasper	60.2	1.45	37.41	0.12	<0.1	<0.1	<0.1	0.01	0.03	0.18	26.165	656	48	41	24	5	6	24	16	11	23	24	6	36	23	29	29	0.99
29	UPSBB-1/29	52.15	53.15	1.00	Banded Hematite Chert/Jasper	55.7	1.49	41.59	0.12	<0.1	<0.1	<0.1	0.01	0.03	0.15	29.088	593	45	38	18	6	7	16	12	11	20	23	10	43	19	20	25	0.99
30	UPSBB-1/30	53.15	54.15	1.00	Banded Hematite Chert/Jasper with tuff and chert	47.5	0.76	50.06	0.11	<0.1	<0.1	<0.1	0.01	0.01	0.13	35.012	626	53	59	25	5	6	19	12	13	29	22	5	47	22	23	20	0.98
31	UPSBB-1/31	54.15	55.45	1.30	Banded Hematite Chert+tuff	55.8	1.45	37.56	0.16	<0.1	<0.1	0.11	0.01	0.04	0.25	26.269	388	38	49	19	9	8	16	9	9	20	17	9	63	26	32	30	4.17
32	UPSBB-1/32	79.40	80.80	1.40	Banded Hematite Chert/Jasper	77.3	0.46	20.29	0.1	<0.1	<0.1	0.1	0.01	0.01	0.05	14.191	92	22	46	30	5	7	11	7	9	8	10	<5	22	9	18	20	1.24
33	UPSBB-1/33	80.80	82.50	1.70	Banded Hematite Chert/Jasper	34.1	3.63	61.39	0.15	0.12	0.1	<0.1	0.01	0.04	0.08	42.936	464	51	65	31	5	7	24	<5	15	28	22	6	66	36	26	46	1.24
34	UPSBB-1/34	82.50	84.50	2.00	Banded Hematite Chert/Jasper	61.3	0.9	35.75	0.11	0.1	<0.1	<0.1	0.01	0																			

50	UPSBB-1/50	100.80	102.10	1.30	Banded Hematite Chert/Jasper	70.7	0.54	26.23	0.12	<0.1	<0.1	<0.1	0.02	0.01	0.14	18.345	242	31	35	25	<5	6	21	8	5	16	13	7	24	18	51	20	2.56
51	UPSBB-1/51	102.10	103.40	1.30	Banded Hematite Chert/Jasper	40	0.83	52.79	0.12	<0.1	<0.1	<0.1	0.01	0.03	0.18	36.921	398	50	78	31	5	7	32	9	10	40	12	9	183	24	54	22	4.83
52	UPSBB-1/52	103.40	104.75	1.35	Banded Hematite Chert/Jasper	27.5	0.4	65.43	0.13	0.1	<0.1	<0.1	0.01	0.01	0.25	45.762	586	71	57	50	8	6	54	13	13	39	6	7	59	21	84	22	5.62
53	UPSBB-1/53	104.75	106.10	1.35	Banded Hematite Chert/Jasper	29.4	0.32	63.73	0.11	0.12	<0.1	0.1	0.01	0.01	0.18	44.573	503	67	46	26	6	8	45	15	13	37	7	13	49	28	65	18	6.04
54	UPSBB-1/54	106.10	108.70	2.60	Sludge +Banded Hematite Chert/Jasper+chert	70.6	6.56	18.15	0.49	0.41	0.14	0.4	0.03	0.45	0.15	12.694	256	44	103	137	9	12	44	29	21	23	29	9	132	24	121	89	1.99
55	UPSBB-1/55	108.70	109.85	1.15	Sludge and Chert	65	7.24	19.09	0.27	0.33	0.147	0.32	0.03	0.45	0.08	13.352	251	43	98	138	8	12	48	30	20	16	28	7	139	25	24	90	8.59
56	UPSBB-1/56	109.85	111.00	1.15	Sludge and Chert	96.1	0.19	1.65	0.1	0.22	0.1	0.1	0.01	0.01	0.04	1.154	<50	10	16	24	6	7	6	7	6	<5	7	<5	22	<5	10	16	1.01
57	UPSBB-1/57	111.00	113.00	2.00	Sludge + Banded Hematite Chert/Jasper	70.1	5.74	13.22	0.25	0.43	0.12	0.25	0.02	0.78	0.15	9.246	302	36	157	185	8	15	43	18	14	17	37	5	137	14	86	98	7.21
58	UPSBB-1/58	113.00	114.00	1.00	Dolerite	38.2	13.72	22.28	0.39	8.17	0.11	1.23	0.19	4.02	0.11	15.583	1004	-	-	-	24	36	-	-	-	44	98	-	549	62	-	316	-
59	UPSBB-1/59	114.00	115.00	1.00	Dolerite	33.4	9.9	33.12	0.69	7.01	0.1	0.09	0.17	2.04	0.01	23.164	539	-	-	-	22	30	-	-	-	46	91	-	360	74	-	294	-
60	UPSBB-1/60	116.00	117.00	1.00	Dolerite	37.9	6.2	20.07	2.79	17.78	0.12	0.19	0.15	1.57	0.01	14.037	229	-	-	-	20	28	-	-	-	10	76	-	130	43	-	223	-
61	UPSBB-1/61	125.20	127.10	1.90	Dolerite	44.5	9.57	18.87	0.58	10.69	0.1	0.1	0.11	3.57	0.01	13.198	418	-	-	-	28	43	-	-	-	28	98	-	285	63	-	352	-
Borehole No. UPSBB-2 24° 33' 55.0" 82° 53' 37.8" 卐																																	
62	UPSBB-2/1	120.00	121.50	1.50	Banded Hematite Chert with phyllite	69.3	7.09	19.99	0.21	0.69	0.12	0.19	0.11	0.31	0.08	13.98	229	69	155	41	6	10	77	134	10	23	13	5	134	10	195	47	-
63	UPSBB-2/2	121.50	123.70	2.20	Weathered leached Banded Hematite Chert	61.9	5.77	28.67	0.36	0.58	0.1	0.76	0.07	0.23	0.25	20.05	292	59	149	37	8	9	29	227	20	29	10	6	154	9	206	36	-
64	UPSBB-2/3	131.00	132.00	1.00	Banded Hematite Chert	62.1	2.74	33.32	0.11	0.11	0.11	0.14	0.02	0.43	0.36	23.30	454	61	36	98	7	10	33	68	8	27	30	8	197	24	101	74	-
65	UPSBB-2/4	132.00	133.00	1.00	Banded Hematite Chert	60.5	1.75	36.88	0.12	0.3	0.1	0.1	0.01	0.32	0.32	25.79	454	44	34	21	5	7	7	9	5	34	14	5	66	8	54	39	-
66	UPSBB-2/5	133.00	134.00	1.00	Banded Hematite Chert	59.3	0.34	39.22	0.11	0.25	<0.1	0.18	0.04	0.07	0.17	27.43	342	52	42	16	6	7	5	8	5	26	6	6	21	7	15	19	-
67	UPSBB-2/6	134.00	135.10	1.10	Banded Hematite Chert	54.1	0.29	42.74	0.13	0.22	0.11	0.17	0.06	0.01	0.2	29.89	334	53	29	20	9	7	8	6	6	21	9	7	20	10	21	17	-
68	UPSBB-2/7	135.10	136.10	1.00	Banded Hematite Chert (few tuff layer)	53.5	0.36	44.48	0.1	0.15	<0.1	0.12	0.01	0.09	0.17	31.11	513	59	44	18	5	7	26	8	11	28	59	9	24	30	27	19	-
69	UPSBB-2/8	136.10	137.15	1.05	Banded Hematite Chert	59.4	0.58	35.9	0.14	0.19	0.1	0.11	0.05	0.01	0.15	25.11	274	31	43	19	6	7	7	9	7	18	13	5	21	12	10	18	-
70	UPSBB-2/9	137.15	138.05	0.90	Banded Hematite Chert/Jasper	51.1	0.37	46.77	0.13	0.24	<0.1	0.14	0.01	0.05	0.08	32.71	435	55	38	24	7	8	22	8	15	26	14	9	41	12	22	21	-
71	UPSBB-2/10	138.05	139.10	1.05	Banded Hematite Chert/Jasper	56.8	0.33	39.93	0.11	0.28	0.11	0.16	0.01	0.07	0.08	27.93	349	55	41	18	5	8	16	5	12	23	11	6	32	14	17	20	-
72	UPSBB-2/11	139.10	140.00	0.90	Banded Hematite Chert/Jasper	55.7	0.26	43.25	0.14	0.24	0.1	0.12	0.01	0.06	0.09	30.25	388	52	37	19	8	7	22	6	11	22	20	8	41	26	24	18	-
73	UPSBB-2/12	140.00	140.70	0.70	Banded Hematite Jasper/Chert	43.4	0.3	56.14	0.11	0.15	0.12	0.17	0.01	0.08	0.09	39.26	491	62	55	13	5	8	29	12	20	34	18	7	39	21	24	19	-
74	UPSBB-2/13	140.70	141.60	0.90	Banded Hematite Chert	54	0.64	45.45	0.13	0.16	<0.1	0.19	0.01	0.01	0.12	31.79	383	53	45	22	6	8	13	23	10	23	12	5	60	15	24	21	-
75	UPSBB-2/14	141.60	142.20	0.60	Banded Hematite Chert/Jasper	50.3	0.35	47.67	0.11	0.21	<0.1	0.13	0.01	0.01	0.08	33.34	415	62	47	23	9	8	13	7	14	27	13	8	33	25	23	21	-
76	UPSBB-2/15	142.20	143.00	0.80	Banded Hematite Chert	49	0.41	50.57	0.1	0.19	0.1	0.14	0.01	0.08	0.07	35.37	455	63	41	19	6	7	19	8	12	28	11	9	42	30	17	20	-
77	UPSBB-2/16	143.00	144.00	1.00	Massive Banded Hematite Jasper/Chert	45.2	0.33	54.74	0.13	0.16	0.12	0.18	0.01	0.01	0.05	38.29	500	71	45	18	7	7	21	5	16	30	13	5	47	21	19	18	-
78	UPSBB-2/17	144.00	145.10	1.10	Limonitized Banded Hematite Chert	68.6	0.79	29.6	0.15	0.14	<0.1	0.15	0.01	0.02	0.09	20.70	239	43	35	41	8	7	10	8	6	18	10	5	28	14	22	21	-
79	UPSBB-2/18	145.10	145.80	0.70	Limonitized Banded Hematite Chert	68.5	1.15	30.14	0.11	0.26	0.1	0.17	0.01	0.04	0.3	21.08	435	41	43	54	6	9	17	13	9	19	29	8	39	31	36	30	-
80	UPSBB-2/19	145.80	146.50	0.70	Limonitized Banded Hematite Chert	82.3	0.86	13.65	0.1	0.24	0.11	0.14	0.03	0.01	0.21	9.55	204	29	25	37	8	7	8	16	7	8	24	6	42	11	26	21	-
81	UPSBB-2/20	146.50	147.50	1.00	Massive Banded Hematite Chert	71.1	0.45	27.25	0.14	0.14	<0.1	0.11	0.02	0.01	0.09	19.06	201	63	29	13	5	7	12	9	9	19	8	7	70	12	15	22	-
82	UPSBB-2/21	147.50	148.50	1.00	Banded Hematite Jasper	61.9	0.56	38.12	0.13	0.2	0.1	0.1	0.04	0.01	0.1	26.66	292	47	37	17	5	8	14	5	11	17	12	5	29	14	22	22	-
83	UPSBB-2/22	148.50	149.60	1.10	Banded Hematite Jasper	53.9	0.3	46.01	0.11	0.15	0.12	0.18	0.01	0.06	0.09	32.18	368	53	46	17	7	7	20	7	17	24	19	10	41	20	26	18	-
84	UPSBB-2/23	149.60	150.60	1.00	Banded Hematite Jasper/Chert	68.1	0.44	28.51	0.13	0.19	0.1	0.14	0.01	0.05	0.1	19.94	204	41	33	23	6	7	13	8	10	17	10	6					

103	UPSBB-2/42	52.60	53.50	0.90	Ferruginous phyllite with tuff	57.07	16.67	18.83	0.16	0.29	0.14	0.54	0.01	0.94	0.07	13.17	363	-	-	-	25	-	-	18	66	21	59	7	236	47	-	158	-
104	UPSBB-2/43	53.50	54.50	1.00	Ferruginous phyllite with tuff	54.99	15.52	22.87	0.10	0.26	0.13	0.41	0.01	0.59	0.07	16.00	429	-	-	-	16	-	-	14	63	24	59	6	221	50	-	139	-
105	UPSBB-2/44	54.50	56.00	1.50	Ferruginous phyllite with tuff	54.25	15.04	25.13	0.11	0.23	0.12	0.32	0.03	0.68	0.07	17.58	428	-	-	-	13	-	-	15	60	28	58	<5	203	53	-	132	-
106	UPSBB-2/45	56.00	57.50	1.50	Ferruginous phyllite with tuff	71.94	12.42	9.87	<0.1	0.20	0.13	0.39	<0.003	0.53	0.07	6.90	229	-	-	-	16	-	-	13	53	13	56	<5	145	36	-	109	-
107	UPSBB-2/46	62.00	63.00	1.00	Ferruginous phyllite with tuff	59.60	20.62	10.13	0.10	0.69	0.14	1.78	<0.003	1.35	0.07	7.08	292	-	-	-	25	-	-	30	113	22	61	5	270	61	-	216	-
108	UPSBB-2/47	63.00	65.00	2.00	Ferruginous phyllite with tuff	53.00	24.02	12.14	0.10	1.26	0.14	3.19	0.01	1.13	0.07	8.49	367	-	-	-	28	-	-	26	181	20	52	5	265	46	-	288	-
109	UPSBB-2/48	65.00	66.25	1.25	Reddish tuff	52.36	21.17	17.30	0.13	0.57	0.13	1.12	0.01	1.99	0.09	12.10	483	-	-	-	22	-	-	23	90	29	69	<5	415	58	-	206	-
110	UPSBB-2/49	66.25	67.80	1.55	Reddish tuff with phyllite	59.66	21.35	7.29	0.10	1.06	0.15	3.26	0.01	0.84	0.06	5.10	240	-	-	-	22	-	-	12	137	12	48	8	118	42	-	216	-
111	UPSBB-2/50	67.80	69.35	1.55	Reddish tuff with phyllite	48.59	22.05	19.78	0.16	0.66	0.12	0.38	0.10	2.93	0.09	13.83	572	-	-	-	23	-	-	27	60	43	84	<5	721	61	-	220	-
112	UPSBB-2/51	69.35	70.35	1.00	Tuff	47.93	26.31	15.43	0.19	0.53	0.13	0.18	0.05	4.01	0.20	10.79	724	-	-	-	25	-	-	30	45	51	123	<5	754	73	-	248	-
113	UPSBB-2/52	70.35	71.35	1.00	Tuff	40.54	28.60	22.98	0.18	0.20	0.13	0.11	0.10	4.05	0.19	16.07	809	-	-	-	26	-	-	33	45	57	108	5	1040	80	-	256	-
114	UPSBB-2/53	71.35	72.00	0.65	Tuff	39.41	24.28	26.46	0.19	0.32	0.14	<0.1	0.24	3.74	0.17	18.51	906	-	-	-	29	-	-	31	51	54	119	7	1137	93	-	256	-
115	UPSBB-2/54	72.00	73.75	1.75	Tuff	45.36	27.24	16.61	0.21	0.37	0.13	0.13	0.08	4.89	0.17	11.62	636	-	-	-	30	-	-	36	49	50	126	5	959	81	-	286	-
116	UPSBB-2/55	73.75	75.50	1.75	Tuff	42.94	21.84	24.11	0.31	1.19	<0.1	<0.1	0.09	3.02	0.08	16.86	560	-	-	-	28	-	-	27	56	48	85	6	815	77	-	229	-
117	UPSBB-2/56	78.10	79.10	1.00	Tuff	46.45	20.28	24.09	0.28	0.76	<0.1	<0.1	0.10	3.11	0.16	16.85	660	-	-	-	29	-	-	28	49	47	124	5	819	80	-	225	-
118	UPSBB-2/57	79.10	80.10	1.00	Tuff	41.82	20.04	29.81	0.32	0.57	0.10	<0.1	0.25	2.64	0.12	20.85	724	-	-	-	26	-	-	25	51	49	106	7	953	87	-	229	-
119	UPSBB-2/58	80.10	81.10	1.00	Tuff	40.64	18.77	29.56	0.36	0.90	0.15	0.16	0.18	2.45	0.11	20.67	681	-	-	-	20	-	-	24	52	52	102	8	734	83	-	216	-
120	UPSBB-2/59	81.10	82.10	1.00	Tuff	60.79	16.01	15.88	0.11	0.70	0.10	<0.1	0.03	1.35	0.07	11.11	310	-	-	-	18	-	-	15	39	25	65	<5	276	46	-	156	-
121	UPSBB-2/60	82.10	83.10	1.00	Reddish phyllite with tuff	55.33	17.25	19.83	0.13	0.81	0.13	1.11	0.03	0.81	0.08	13.87	405	-	-	-	19	-	-	15	80	34	54	6	276	48	-	145	-
122	UPSBB-2/61	83.10	84.60	1.50	Ferruginous phyllite with tuff	57.48	18.71	18.32	0.13	0.40	0.13	0.68	0.02	0.94	0.04	12.81	360	-	-	-	21	-	-	16	72	29	59	<5	338	49	-	165	-
123	UPSBB-2/62	86.15	88.15	2.00	Ferruginous phyllite with tuff	53.62	15.52	24.60	0.12	0.55	0.14	1.07	0.01	0.81	0.06	17.21	533	-	-	-	23	-	-	15	95	36	67	6	379	48	-	153	-
124	UPSBB-2/63	88.15	90.00	1.85	Tuff with Ferruginous phyllite	62.82	15.84	14.20	0.10	0.91	0.15	2.38	0.01	0.69	0.04	9.93	338	-	-	-	22	-	-	15	148	23	56	7	268	42	-	174	-
125	UPSBB-2/64	90.00	91.25	1.25	Tuff	55.18	17.24	17.75	0.38	3.11	0.14	0.41	0.03	0.64	0.05	12.41	364	-	-	-	19	-	-	13	52	29	66	8	235	54	-	158	-
126	UPSBB-2/65	91.25	92.50	1.25	Tuff	46.77	24.70	18.64	0.45	1.88	0.14	0.54	0.06	2.62	0.11	13.04	522	-	-	-	27	-	-	24	58	44	94	5	634	61	-	203	-
127	UPSBB-2/66	92.50	93.50	1.00	Reddish tuff	44.19	21.12	22.70	0.69	3.59	0.15	0.10	0.06	2.18	0.05	15.88	446	-	-	-	26	-	-	23	52	47	86	5	688	61	-	188	-
128	UPSBB-2/67	93.50	94.50	1.00	Reddish tuff	47.95	21.80	19.03	0.56	2.14	0.14	0.11	0.13	2.65	0.07	13.31	422	-	-	-	25	-	-	25	49	49	100	<5	617	66	-	193	-
129	UPSBB-2/68	94.50	96.00	1.50	Reddish tuff	45.42	21.63	22.31	0.76	2.56	0.14	0.15	0.08	2.24	0.07	15.60	468	-	-	-	25	-	-	20	44	50	95	6	568	59	-	166	-
130	UPSBB-2/69	96.00	97.00	1.00	Reddish tuff	47.28	24.50	19.63	0.62	1.90	0.14	0.11	0.14	3.15	0.11	13.73	546	-	-	-	26	-	-	27	48	52	129	5	775	72	-	211	-
131	UPSBB-2/70	97.00	98.00	1.00	Reddish tuff	44.87	27.26	18.77	0.55	1.55	0.14	0.18	0.09	3.37	0.11	13.13	499	-	-	-	29	-	-	29	51	51	117	<5	828	69	-	219	-
132	UPSBB-2/71	98.00	99.00	1.00	Reddish tuff	32.77	28.04	27.35	0.62	1.62	0.17	0.38	0.45	3.78	0.11	19.13	811	-	-	-	32	-	-	34	61	63	121	<5	1413	80	-	242	-
133	UPSBB-2/72	99.00	100.00	1.00	Reddish tuff	31.04	26.73	30.98	0.66	2.32	0.15	0.58	0.23	3.47	0.09	21.67	787	-	-	-	31	-	-	31	64	71	97	10	1530	79	-	220	-
134	UPSBB-2/73	100.00	101.00	1.00	Reddish tuff	33.12	23.04	29.28	0.64	3.24	0.15	0.85	0.63	3.31	0.10	20.48	947	-	-	-	26	-	-	27	68	64	112	<5	1219	70	-	205	-
135	UPSBB-2/74	115.10	116.50	1.40	Reddish tuff/Dolerite	35.21	25.44	28.79	0.62	3.02	0.15	0.90	0.33	2.74	0.10	20.14	868	-	-	-	27	-	-	24	72	57	131	6	935	62	-	198	-
136	UPSBB-2/75	116.50	117.50	1.00	Reddish tuff	38.68	24.73	27.58	0.49	1.87	0.15	0.27	0.16	3.18	0.13	19.29	724	-	-	-	24	-	-	24	55	63	119	5	1062	64	-	186	-
137	UPSBB-2/76	117.50	118.50	1.00	Reddish tuff	49.08	21.90	21.11	0.53	1.48	0.14	0.15	0.25	3.09	0.11	14.76	429	-	-	-	24	-	-	25	48	48	109	5	722	67	-	200	-
138	UPSBB-2/77	118.50	119.50	1.00	Reddish tuff	52.57	14.91	27.03	0.33	1.07	0.13	0.39	0.04	0.59	0.07	18.90	454	-	-	-	21	-	-	11	63	34	76	6	367	70	-	160	-
139	UPSBB-2/78	119.50	120.00	0.50	Ferruginous phyllite with tuff	61.44	10.27	24.14	0.16	0.46	0.12	0.10	0.03	0.31	0.04	16.88	321	-	-	-	18	-	-	10	51	26	57	8	152	45	-	110	-

Borehole No. UPSBB-3 24° 33' 58.0" 82° 53' 51.5" ☒

140	UPSBB-3/1	63.00	64.00	1.00	Ferruginous phyllite with chert nodules interbanded with tuff	45.4	9.52	34.56	0.12	0.1	0.1	0.1	0.01	0.34	0.01	24.17	52	-	-	-	14	13	-	-	-	21	29	-	40	19	-	77	-
141	UPSBB-3/2	64.00	65.00	1.00	Ferruginous phyllite with chert nodules interbanded with tuff	60.3	11.93	20.34	0.1	0.1	0.1	0.11	0.01	0.53	0.02	14.23	153	-	-	-	16	15	-	-	-	36	32	-	114	33	-	101	-
142	UPSBB-3/3	65.00	66.00	1.00	Ferruginous phyllite with chert nodules	58	20.35	9.43	0.15	0.69	0.25	3.12	0.02	1.17	0.01	6.60	122	-	-	-	19	22	-	-	-	29	63	-	93	19	-	157	-
143	UPSBB-3/4	66.00	67.00	1.00	Ferruginous phyllite having chert nodules with few tuff band	68.9	10.25	11.46	0.11	0.11	0.14	0.16	0.01	0.49	0.09	8.02	105	-	-	-	15	12	-	-	-	15	48	-	71	37	-	106	-
144	UPSBB-3/5	67.00	68.00	1.00	Ferruginous phyllite having chert nodules with few tuff band	36.6	15.23	35.61	0.1	0.57	<0.1	1.49	0.01	0.69	0.01	24.91	203	-	-	-	22	18	-	-	-	41	40	-	109	29	-	126	-
145	UPSBB-3/6	68.00	69.00	1.00	Ferruginous phyllite having chert nodules with few tuff	57	16.16	15.22	0.12	0.77	0.15	2.13	0.01	0.95	0.1	10.64	299	-	-	-	16	15	-	-	-	21	41	-	105	31	-	122	-
146	UPSBB-3/7	69.00	70.00	1.00	Ferruginous phyllite with chert nodules interbanded with tuff	61.1	12.92	19.05	0.12	0.44	0.17	1.05	0.01	0.68	0.1	13.32	266	-	-	-	13	14	-	-	-	20	39	-	101	32	-	111	-
147	UPSBB-3/8	70.00	71.00	1.00	Ferruginous phyllite with chert nodules & malachite dissemination	65.2	12.98	14.16	0.13	0.62	0.1	1.1	0.01	1.09	0.09	9.90	297	-	-	-	13	17	-	-	-	21	55	-	92	32	-	127	-
148	UPSBB-3/9	71.00	72.00	1.00	Ferruginous phyllite with chert nodules & malachite dissemination	53.8	13.86	23.82	0.15	0.3	0.1	0.1	0.01	0.67	0.1	16.66	330	-	-	-	15	13	-	-	-	28	47	-	101	41	-	93	-
149	UPSBB-3/10	72.00	73.00	1.00	Ferruginous phyllite with chert nodules & malachite dissemination	50.4	8.3	33.54	0.14	2.19	0.1	0.11	0.03	0.49	0.11	23.46	433	-	-	-	14	11	-	-	-	34	53	-	121	57	-	107	-
150	UPSBB-3/11	73.00	75.00	2.00	Tuff dominant phyllite with malachite	66	16.59	7.9	0.12	0.77	0.11	1.46	0.02	1.01	0.08	5.53	244	-	-	-	23	19	-	-	-	19	71	-	131	41	-	173	-

151	UPSBB-3/12	75.00	76.00	1.00	Weathered oxidized Banded Hematite Chert	62.1	10.92	20.34	0.1	0.3	0.11	0.31	0.01	0.24	0.1	14.23	287	-	-	-	9	8	-	-	-	30	72	-	86	37	-	65	-
152	UPSBB-3/13	76.00	77.00	1.00	Weathered oxidized Banded Hematite Chert	78.4	4.81	10.99	0.1	0.13	0.1	0.1	0.01	0.23	0.09	7.69	114	-	-	-	11	10	-	-	-	17	59	-	50	32	-	72	-
153	UPSBB-3/14	94.00	95.15	1.15	Limonitized, oxidized, brecciated Banded Hematite Chert	42.7	4.52	44.92	0.13	0.12	0.16	0.1	0.08	0.13	0.11	31.42	477	-	-	-	16	9	-	-	-	40	51	-	139	69	-	72	-
154	UPSBB-3/15	95.15	96.00	0.85	Chert dominant Banded Hematite Chert	76.9	1.73	14.77	0.12	0.1	<0.1	0.1	0.02	0.03	0.09	10.33	85	-	-	-	10	7	-	-	-	15	48	-	21	37	-	48	-
155	UPSBB-3/16	96.00	96.95	0.95	Massive Banded Hematite Jasper/Chert	67.9	1.95	24.26	0.1	0.12	0.1	<0.1	0.02	0.02	0.09	16.97	182	-	-	-	9	6	-	-	-	15	43	-	20	47	-	44	-
156	UPSBB-3/17	96.95	97.60	0.65	Massive Banded Hematite Jasper/Chert	67.1	0.52	28.77	0.14	0.11	<0.1	0.1	0.03	0.04	0.09	20.12	269	-	-	-	9	7	-	-	-	21	39	-	25	47	-	49	-
157	UPSBB-3/18	97.60	98.30	0.70	Massive Banded Hematite Jasper/Chert	67.7	1.25	26.38	0.1	0.1	<0.1	0.1	0.02	0.02	0.09	18.45	206	-	-	-	6	7	-	-	-	17	43	-	22	41	-	45	-
158	UPSBB-3/19	98.30	99.50	1.20	Banded Hematite Chert/Jasper	62.1	1.9	31.95	0.09	0.07	0.11	0.1	0.04	0.09	0.1	22.35	363	-	-	-	7	8	-	-	47	30	46	<5	29	62	-	66	-
159	UPSBB-3/20	99.50	100.70	1.20	Limonitized Banded Hematite Chert	42.4	1.11	50.13	0.12	0.07	0.12	0.1	0.04	0.05	0.1	35.06	476	-	-	-	13	7	-	-	48	34	53	<5	43	74	-	54	-
160	UPSBB-3/21	100.70	101.70	1.00	Limonitized Banded Hematite Chert	40.2	0.76	54.77	0.12	0.07	0.16	<0.1	0.04	0.03	0.09	38.31	642	-	-	-	8	6	-	-	59	41	47	5	52	63	-	54	-
161	UPSBB-3/22	101.70	102.70	1.00	Banded Hematite Chert	40.8	0.52	55.56	0.12	0.07	0.15	0.1	0.05	0.01	0.09	38.86	590	-	-	-	6	6	-	-	56	38	45	9	30	63	-	45	-
162	UPSBB-3/23	102.70	103.70	1.00	Brecciated Banded Hematite Jasper	56.7	0.27	38.45	0.12	0.61	0.13	<0.1	0.05	0.01	0.09	26.89	340	-	-	-	12	7	-	-	46	22	39	6	23	49	-	44	-
163	UPSBB-3/24	103.70	104.60	0.90	Chert dominant Banded Hematite Chert	50.5	0.65	45.88	0.11	0.07	0.14	<0.1	0.07	0.01	0.09	32.09	541	-	-	-	5	8	-	-	55	42	45	9	40	71	-	47	-
164	UPSBB-3/25	104.60	105.40	0.80	Brecciated Banded Hematite Jasper	48.1	0.55	44.98	0.11	0.06	0.15	0.1	0.05	0.01	0.1	31.46	583	-	-	-	10	7	-	-	53	41	46	<5	34	71	-	47	-
165	UPSBB-3/26	105.40	106.20	0.80	Brecciated Banded Hematite Jasper	53.3	0.97	41.06	0.11	0.06	0.16	0.15	0.04	0.03	0.09	28.72	523	-	-	-	6	7	-	-	39	38	40	9	21	52	-	44	-
166	UPSBB-3/27	106.20	107.05	0.85	Brecciated Banded Hematite Jasper	55	0.64	39.34	0.1	0.05	0.18	0.12	0.03	0.02	0.09	27.51	483	-	-	-	9	6	-	-	50	34	55	7	26	70	-	50	-
167	UPSBB-3/28	107.05	108.10	1.05	Banded Hematite Chert/Jasper with limonite and reddish phyllite	50.6	2.3	40.97	0.13	0.07	0.16	<0.1	0.03	0.07	0.1	28.65	562	-	-	-	10	7	-	-	50	41	47	11	44	62	-	61	-
168	UPSBB-3/29	108.10	109.15	1.05	Banded Hematite Chert/Jasper with limonite and reddish phyllite	48.5	3.59	44.17	0.17	0.12	0.16	0.1	0.04	0.07	0.09	30.89	537	-	-	-	11	7	-	-	54	40	46	13	49	60	-	70	-
169	UPSBB-3/30	109.15	110.15	1.00	Brecciated Banded Hematite Chert/Jasper with reddish phyllite	54.5	1.83	40.78	0.14	0.09	0.15	<0.1	0.02	0.04	0.09	28.52	505	-	-	-	10	8	-	-	50	38	46	11	38	53	-	61	-
170	UPSBB-3/31	110.15	110.90	0.75	Brecciated Banded Hematite Chert/Jasper with reddish phyllite	56.1	3.09	37.56	0.12	0.09	0.14	0.1	0.03	0.08	0.09	26.27	522	-	-	-	6	8	-	-	47	37	39	7	50	50	-	62	-
171	UPSBB-3/32	110.90	111.90	1.00	Brecciated Banded Hematite Chert/Jasper with reddish phyllite	56.3	4.11	34.89	0.13	0.1	0.12	0.12	0.03	0.11	0.09	24.40	469	-	-	-	10	8	-	-	47	36	49	11	57	58	-	72	-
172	UPSBB-3/33	111.90	112.90	1.00	Brecciated Banded Hematite Chert/Jasper with reddish phyllite	61.5	4.39	30.42	0.11	0.09	0.15	0.1	0.03	0.12	0.09	21.28	398	-	-	-	9	9	-	-	48	26	47	9	50	51	-	69	-
173	UPSBB-3/34	112.90	114.00	1.10	Brecciated Banded Hematite Chert/Jasper with reddish phyllite	56.4	3.38	36.12	0.11	0.08	0.11	<0.1	0.03	0.09	0.09	25.26	504	-	-	-	9	7	-	-	47	37	39	11	49	56	-	68	-
174	UPSBB-3/35	114.00	115.30	1.30	Limonitic chert dominant Banded Hematite Chert	69.1	2.78	24.6	0.12	0.1	0.14	0.1	0.02	0.11	0.09	17.21	267	-	-	-	11	8	-	-	39	18	41	5	32	38	-	67	-
175	UPSBB-3/36	115.30	116.80	1.50	Limonitic Banded Hematite Chert	73	2.69	18.25	0.1	0.12	0.1	0.15	0.02	0.09	0.08	12.76	197	-	-	-	7	9	-	-	34	14	37	6	28	34	-	56	-
176	UPSBB-3/37	116.80	119.40	2.60	Chert dominant Banded Hematite Chert	84.5	2.02	11.4	0.1	0.1	0.12	0.18	0.01	0.07	0.08	7.97	90	-	-	-	7	7	-	-	25	9	32	5	22	21	-	44	-
177	UPSBB-3/38	119.40	120.00	0.60	Banded Hematite Chert	38	1.28	53.44	0.13	0.15	0.11	0.17	0.03	0.04	0.09	37.38	540	-	-	-	6	6	-	-	51	39	44	<5	52	54	-	54	-
178	UPSBB-3/39	120.00	120.60	0.60	Banded Hematite Chert/Jasper	30.8	0.69	63.37	0.13	0.1	0.13	0.12	0.04	0.01	0.09	44.32	661	-	-	-	12	7	-	-	54	42	48	12	50	57	-	49	-
179	UPSBB-3/40	120.60	121.20	0.60	Limonitized, brecciated Banded Hematite Chert/Jasper	44.7	1.45	48.82	0.13	0.11	0.1	0.1	0.03	0.04	0.09	34.14	490	-	-	-	12	8	-	-	49	30	49	15	63	55	-	64	-
180	UPSBB-3/41	121.20	122.00	0.80	Banded Hematite Jasper	42.4	1.45	50.93	0.12	0.22	0.15	0.1	0.02	0.05	0.09	35.62	534	-	-	-	9	8	-	-	52	35	50	14	56	54	-	55	-
181	UPSBB-3/42	122.00	123.00	1.00	Jasper dominant Banded Hematite Jasper	44.7	0.69	50.45	0.1	0.11	0.16	0.12	0.02	0.03	0.09	35.28	521	-	-	-	5	8	-	-	51	35	44	9	46	49	-	46	-
182	UPSBB-3/43	123.00	124.00	1.00	Limonitic Banded Hematite Jasper	24.3	13.88	50.98	0.18	0.17	0.18	0.16	0.03	1.53	0.1	35.66	599	-	-	-	15	18	-	-	46	46	40	10	339	68	-	159	-
183	UPSBB-3/44	124.00	124.70	0.70	Banded Hematite Jasper	38.1	0.58	59.69	0.1	0.11	0.1	0.1	0.03	0.01	0.09	41.75	633	-	-	-	7	6	-	-	56	38	49	14	43	51	-	45	-
184	UPSBB-3/45	124.70	125.35	0.65	Banded Hematite Jasper	38.2	0.65	59.34	0.12	0.12	0.17	0.16	0.03	0.01	0.09	41.50	607	-	-	-	8	8	-	-	50	36	48	17	58	52	-	44	-
185	UPSBB-3/46	125.35	126.00	0.65	Banded Hematite Jasper	41.6	0.88	55.32	0.1	0.14	0.19	0.1	0.02	0.02	0.09	38.69	562	-	-	-	12	6	-	-	52	42	56	12	39	52	-	48	-
186	UPSBB-3/47	126.00	127.00	1.00	Banded Hematite Jasper	40.2	0.98	57.5	0.12	0.1	0.15	0.15	0.02	0.02	0.08	40.22	636	-	-	-	8	7	-	-	56	32	60	12	27	55	-	49	-
187	UPSBB-3/48	127.00	127.45	0.45	Banded Hematite Jasper	14.2	1.2	83.56	0.17	0.13	0.1	0.1	0.02	0.01	0.05	58.44	606	-	-	-	6	6	-	-	49	45	49	10	40	60	-	49	-
Borehole No. UPSBB-4 24° 34' 01.8" 82° 54' 03.7" 西																																	
188	UPSBB-4/1	30.00	31.00	1.00	Reddish tuff with chert	63.9	9.66	22.61	0.1	0.12	0.12	0.15	0.01	0.19	0.08	15.81	210	-	-	-	14	11	-	-	24	18	31	12	140	41	-	128	-
189	UPSBB-4/2	37.50	38.50	1.00	Reddish tuff	38.9	25.79	20.96	0.3	0.44	<0.1	0.19	0.08	1.62	0.08	14.66	382	-	-	-	16	19	-	-	31	62	43	<5	598	35	-	154	-

Analytical results of Major Oxides and Trace Elements of Trench samples from Block - 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	From (m)	To (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)	
TRB-1 (24° 33' 57.7"; 82° 53' 25.8")																																
1	TRB-1/1	0	1	Banded Hematite Chert/Jasper	55.36	0.45	42.97	0.10	0.24	0.10	0.16	0.01	0.01	0.35	30.05	308	44	38	15	8	7	16	7	7	22	11	6	32	14	40	19	
2	TRB-1/2	1	2	Banded Hematite Chert/Jasper	46.36	0.37	53.13	0.10	0.15	0.10	0.12	0.01	0.08	0.30	37.16	424	54	51	14	5	6	29	6	15	29	60	8	49	45	29	19	
3	TRB-1/3	2	3	Banded Hematite Chert/Jasper	57.60	0.29	42.41	0.12	0.22	<0.1	0.19	0.01	0.05	0.34	29.66	336	49	42	7	7	6	14	6	7	21	8	5	35	10	28	17	
4	TRB-1/4	3	4	Banded Hematite Chert/Jasper+Limonitized	54.16	0.38	45.63	0.10	0.15	0.12	0.12	0.01	0.04	0.33	31.91	330	43	47	27	6	6	21	6	9	22	14	5	41	17	39	19	
5	TRB-1/5	4	5	Banded Hematite Chert/Jasper+Limonitized	56.60	0.43	41.54	0.11	0.16	0.10	0.13	0.01	0.01	0.45	29.05	276	45	48	31	8	7	44	13	11	23	12	7	49	15	48	20	
6	TRB-1/6	5	6	Banded Hematite Chert/Jasper+Limonitized	40.11	1.04	55.77	0.13	0.18	<0.1	0.17	0.02	0.01	0.59	39.01	467	52	99	34	6	7	21	11	6	29	12	6	54	16	46	19	
7	TRB-1/7	6	7	Limonitized+Banded Hematite Chert/Jasper	52.36	0.36	45.14	0.10	0.17	0.11	0.18	0.01	0.06	0.25	31.57	328	45	44	26	5	7	25	16	12	22	20	8	34	27	42	21	
8	TRB-1/8	7	8	Limonitized+Banded Hematite Chert/Jasper	53.69	0.35	46.24	0.13	0.16	<0.1	0.10	0.02	0.01	0.27	32.34	358	51	50	14	6	7	18	8	6	24	13	9	29	12	36	18	
9	TRB-1/9	8	9	Limonitized goethite+Banded Hematite Chert/Jasper	24.91	5.01	64.52	0.13	0.12	<0.1	0.19	0.04	0.54	0.67	45.13	528	62	450	60	7	11	227	16	10	64	12	7	414	30	107	53	
10	TRB-1/10	9	10	Limonitized goethite+Banded Hematite Chert/Jasper	54.33	1.80	43.32	0.12	0.23	0.10	0.21	0.03	0.28	0.42	30.30	318	51	196	40	9	9	106	17	9	35	10	<5	135	12	82	36	
11	TRB-1/11	10	11	Banded Hematite Jasper+Limonitized	36.65	0.37	60.68	0.13	0.28	0.11	0.20	0.04	0.01	0.33	42.44	888	86	81	59	5	6	84	17	25	82	11	7	102	20	96	25	
12	TRB-1/12	11	12	Banded Hematite Jasper+Limonitized	43.84	0.47	52.05	0.12	0.26	0.10	0.15	0.03	0.02	0.40	36.40	782	79	66	51	7	6	46	13	11	89	10	6	67	15	60	22	
13	TRB-1/13	12	13	Banded Hematite Jasper+Limonitized	65.05	0.66	34.05	0.11	0.19	0.11	0.25	0.02	0.02	0.36	23.81	604	65	62	60	5	7	81	17	14	69	12	8	40	15	83	22	
14	TRB-1/14	13	14	Whitish Tuff+guage material	80.45	0.37	18.07	0.10	0.20	0.10	0.22	0.01	0.01	0.24	12.64	169	47	32	37	6	7	68	7	8	16	6	7	28	7	56	20	
15	TRB-1/15	14	15	Whitish Tuff+guage material	35.88	1.60	60.85	0.12	0.15	0.12	0.20	0.04	0.02	0.45	42.56	688	93	88	101	8	7	82	14	17	54	11	6	135	24	136	29	
16	TRB-1/16	15	16	Banded Hematite Chert/Jasper	12.97	1.86	80.29	0.12	0.24	<0.1	0.15	0.03	0.02	0.74	56.15	881	104	97	44	7	8	49	14	18	71	10	8	121	27	95	25	
TRB-2 (24° 34' 3.9"; 82° 53' 58.7")																																
17	TRB-2/1	0	1	Silicified Banded Hematite Chert	51.06	1.19	41.71	0.12	0.38	0.13	0.13	0.03	0.02	0.22	29.17	605	-	-	-	11	-	-	6	71	48	63	<5	71	68	-	65	
18	TRB-2/2	1	2	Silicified Banded Hematite Chert	43.16	1.80	50.82	0.13	0.47	0.13	0.16	0.03	0.07	0.27	35.54	790	-	-	-	9	-	-	7	81	66	68	<5	137	76	-	69	
19	TRB-2/3	2	3	Red soil+BIF boulder	53.94	1.01	42.04	0.13	0.34	0.12	0.15	0.04	0.03	0.25	29.40	616	-	-	-	10	-	-	8	72	52	65	5	53	73	-	65	
20	TRB-2/4	3	4	Red soil+BIF boulder	40.05	8.02	47.09	0.19	0.70	0.14	0.78	0.04	0.45	0.19	32.93	851	-	-	-	19	-	-	10	103	86	80	<5	654	86	-	124	
21	TRB-2/5	4	5	Red soil+BIF boulder+limonite	50.58	7.13	38.14	0.15	0.37	0.14	0.28	0.02	0.71	0.27	26.68	710	-	-	-	17	-	-	11	77	66	79	<5	543	78	-	120	
22	TRB-2/6	5	6	Red soil+BIF boulder+limonite	48.31	7.70	38.56	0.16	0.39	0.13	0.25	0.02	0.60	0.25	26.97	694	-	-	-	14	-	-	10	73	68	80	<5	435	69	-	120	
23	TRB-2/7	6	7	Red soil+BIF boulder+limonite	48.24	4.80	40.01	0.13	0.35	0.10	0.21	0.04	0.30	0.14	27.98	386	-	-	-	9	-	-	10	37	35	95	6	379	43	-	62	
24	TRB-2/8	7	8	Red soil+BIF boulder+limonite	32.21	11.47	50.90	0.18	0.48	0.14	0.90	0.28	0.99	0.21	35.60	1042	-	-	-	20	-	-	13	111	86	84	<5	869	88	-	153	
25	TRB-2/9	8	9	Red soil+BIF boulder+limonite	32.15	6.30	56.19	0.16	0.34	0.13	0.19	0.12	0.38	0.18	39.30	949	-	-	-	13	-	-	10	85	85	79	<5	483	87	-	104	
26	TRB-2/10	9	10	Red soil+BIF boulder+limonite	31.36	6.50	58.70	0.15	0.30	0.13	0.14	0.03	0.18	0.26	41.05	891	-	-	-	18	-	-	8	84	73	68	<5	680	75	-	85	
27	TRB-2/11	10	11	Red soil+BIF boulder+limonite	55.27	0.70	43.26	0.14	0.22	0.12	0.11	0.02	0.02	0.10	30.26	680	-	-	-	7	-	-	8	74	53	74	12	39	70	-	62	
28	TRB-2/12	11	12	Red soil+BIF boulder+limonite	30.11	0.51	65.58	0.30	0.19	0.13	0.11	0.03	0.01	0.17	45.87	909	-	-	-	8	-	-	6	89	70	82	15	33	83	-	61	
29	TRB-2/13	12	13	Red soil+BIF boulder+limonite	43.56	3.34	48.27	0.12	0.24	0.13	0.31	0.07	0.21	0.20	33.76	771	-	-	-	14	-	-	7	85	66	76	<5	289	67	-	85	
30	TRB-2/14	13	14	Red soil+BIF boulder+limonite	50.55	0.69	45.25	<0.1	0.20	0.12	0.11	0.03	0.02	0.09	31.65	671	-	-	-	8	-	-	7	76	51	68	6	44	60	-	65	

Annexure - III

Sr. No.	Sample No	From (m)	To (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)	
31	TRB-2/15	14	15	Banded Hematite Jasper	35.79	0.50	60.21	0.32	0.20	0.12	0.11	0.02	0.01	0.20	42.11	903	-	-	-	7	-	-	6	87	72	85	6	37	79	-	64	
32	TRB-2/16	15	16	Banded Hematite Jasper	52.05	0.54	46.05	0.12	0.18	0.12	0.10	0.02	0.01	0.16	32.21	756	-	-	-	8	-	-	6	75	59	78	5	30	72	-	65	
33	TRB-2/17	16	17	Banded Hematite Jasper	35.10	0.50	60.81	0.20	0.21	0.15	0.11	0.03	0.01	0.17	42.53	894	-	-	-	8	-	-	6	87	67	72	15	38	85	-	67	
34	TRB-2/18	17	18	Banded Hematite Jasper	40.92	0.66	52.01	0.13	0.19	0.14	0.11	0.03	0.01	0.18	36.38	847	-	-	-	8	-	-	8	81	62	102	11	55	77	-	63	
35	TRB-2/19	18	19	Banded Hematite Jasper	37.95	0.37	57.95	0.17	<0.1	0.11	0.10	0.02	0.01	0.17	40.53	605	-	-	-	6	-	-	8	75	45	84	6	45	69	-	62	
36	TRB-2/20	19	20	Banded Hematite Jasper	35.88	0.59	60.31	0.14	0.22	0.13	0.10	0.02	0.01	0.13	42.18	971	-	-	-	10	-	-	6	89	67	90	10	66	81	-	63	
37	TRB-2/21	20	21	Banded Hematite Jasper	34.97	0.47	64.85	0.10	0.18	0.13	<0.1	0.02	0.01	0.11	45.36	780	-	-	-	16	-	-	6	75	61	63	6	50	69	-	53	
38	TRB-2/22	21	22	Banded Hematite Jasper	45.22	0.55	48.99	0.12	0.14	0.12	<0.1	0.02	0.01	0.19	34.26	552	-	-	-	13	-	-	7	56	40	53	<5	50	55	-	50	
TRB-3 (24° 34' 8.9"; 82° 54' 28.1")																																
39	TRB-3/1	0	1	Brown soil+BIF	38.92	3.74	45.06	0.17	0.7	<0.1	0.1	0.05	0.11	0.02	31.51	317	-	-	-	11	9	-	-	-	40	29	-	74	35	-	56	
40	TRB-3/2	1	2	Brown soil+BIF	59.54	3.12	28.9	0.14	0.12	0.14	0.07	0.06	0.12	0.1	20.21	404	10	-	-	10	8	-	-	-	30	45	-	60	42	-	57	
41	TRB-3/3	2	3	Brown soil+BIF	4.72	2.59	81.37	<0.1	<0.1	<0.1	0.1	0.04	0.11	0.03	56.91	856	-	-	-	6	7	-	-	-	53	49	-	81	94	-	61	
42	TRB-3/4	3	4	Brown soil+BIF	4.47	0.22	84.6	<0.1	<0.1	<0.1	<0.1	0.01	0.05	0.04	59.17	878	-	-	-	9	6	-	-	-	65	51	-	97	92	-	56	
43	TRB-3/5	4	5	Brown soil+BIF	4.75	2.15	82	0.17	0.15	0.12	0.1	0.1	0.01	0.02	57.35	792	-	-	-	9	7	-	-	-	89	23	-	104	77	-	39	
44	TRB-3/6	5	6	Brown soil+BIF	5.94	1.94	78.4	0.13	0.1	0.1	0.1	0.07	0.01	0.02	54.83	821	-	-	-	5	8	-	-	-	89	26	-	75	69	-	41	
45	TRB-3/7	6	7	Banded Hematite Chert/Jasper	6.95	1.92	79.58	0.23	0.12	0.12	0.05	0.06	0.01	0.08	55.66	1051	-	-	-	8	6	-	-	-	65	55	-	120	99	-	55	
46	TRB-3/8	7	8	Banded Hematite Chert/Jasper	12.64	1.26	76.09	0.2	0.11	0.12	0.05	0.03	0.01	0.08	53.22	960	-	-	-	6	6	-	-	-	63	46	-	66	80	-	51	
47	TRB-3/9	8	9	Banded Hematite Chert/Jasper	30.97	0.9	60.09	0.17	0.25	0.1	0.05	0.05	0.01	0.09	42.03	737	-	-	-	7	7	-	-	-	47	46	-	81	70	-	49	
48	TRB-3/10	9	10	Banded Hematite Chert/Jasper+Limonitized	32.88	1.22	56.65	0.17	0.2	0.1	0.06	0.04	0.03	0.09	39.62	734	-	-	-	10	8	-	-	-	46	45	-	87	65	-	53	
49	TRB-3/11	10	11	Banded Hematite Chert/Jasper+Limonitized	28.98	1.87	58.98	0.15	<0.1	0.1	0.1	0.02	0.01	0.02	41.25	424	-	-	-	8	7	-	-	-	51	24	-	44	36	-	36	
50	TRB-3/12	11	12	Banded Hematite Chert/Jasper	26.99	0.69	62.99	0.1	0.12	0.1	0.1	0.03	0.02	0.02	44.06	516	-	-	-	11	7	-	-	-	55	21	-	46	44	-	36	
51	TRB-3/13	12	13	Banded Hematite Chert/Jasper+Limonitized	32.78	1.38	54.97	0.23	0.22	0.12	0.07	0.05	0.01	0.09	38.45	780	-	-	-	7	6	-	-	-	50	44	-	77	89	-	47	
52	TRB-3/14	13	14	Banded Hematite Chert/Jasper	43.73	3.86	42.42	0.15	0.35	0.12	0.63	0.03	0.07	0.09	29.67	599	-	-	-	12	8	-	-	-	38	43	-	32	61	-	89	
53	TRB-3/15	14	15	Banded Hematite Chert/Jasper	18.11	1.17	70.8	0.11	0.17	<0.1	<0.1	0.06	0.01	0.02	49.52	645	-	-	-	10	8	-	-	-	67	30	-	71	57	-	38	
54	TRB-3/16	15	16	Silicified Banded Hematite Chert	22.88	1.4	66.45	0.11	0.13	0.1	0.12	0.05	0.02	0.02	46.48	545	-	-	-	8	7	-	-	-	63	23	-	111	51	-	40	
55	TRB-3/17	16	17	Silicified Banded Hematite Chert	35.58	1.35	54.52	0.18	0.12	0.1	0.07	0.16	0.02	0.09	38.13	782	-	-	-	10	7	-	-	-	42	45	-	141	71	-	48	
56	TRB-3/18	17	18	Silicified Banded Hematite Chert	45.52	1.95	44.71	0.17	0.17	0.1	0.1	0.04	0.03	0.09	31.27	635	-	-	-	7	7	-	-	-	41	54	-	140	66	-	51	
57	TRB-3/19	18	19	Silicified Banded Hematite Chert	9.65	1.55	79.44	0.27	0.18	0.12	0.08	0.06	0.01	0.08	55.56	1053	-	-	-	9	6	-	-	-	65	54	-	262	93	-	50	
58	TRB-3/20	19	20	Silicified Banded Hematite Chert	30.17	0.68	59.64	0.22	0.15	0.1	0.04	0.03	0.01	0.09	41.71	784	-	-	-	13	6	-	-	-	47	47	-	80	67	-	49	

Annexure - III

Sr. No.	Sample No	From (m)	To (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe %	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)	
TRB-4 (24° 34' 4.7"; 82° 54' 13.2")																																
59	TRB-4/1	0	1	Red soil+Banded Hematite Jasper boulder	34.01	1.35	60.77	0.15	0.12	<0.1	0.1	0.07	0.06	0.03	42.50	698	-	-	-	11	8	-	-	61	47	58	10	113	68	-	64	
60	TRB-4/2	1	2	Red soil+Banded Hematite Jasper boulder	27.78	2.29	64.86	0.15	0.12	0.12	0.13	0.06	0.1	0.01	45.36	711	-	-	-	11	8	-	-	68	50	58	<5	157	77	-	84	
61	TRB-4/3	2	3	Red soil+Banded Hematite Jasper boulder	30.08	1.85	64.38	0.13	0.08	<0.1	<0.1	0.04	0.08	0.01	45.03	695	-	-	-	10	8	-	-	63	47	49	8	76	63	-	64	
62	TRB-4/4	3	4	Red soil+Banded Hematite Jasper boulder	28.71	2.77	60.59	0.19	0.46	0.12	0.2	0.08	0.1	0.01	42.38	668	-	-	-	19	9	-	-	77	46	56	<5	153	78	-	91	
63	TRB-4/5	4	5	Red soil+Banded Hematite Jasper boulder	23.82	1.36	69.95	0.15	0.15	0.14	0.1	0.07	0.06	0.02	48.92	771	-	-	-	10	6	-	-	68	54	51	<5	164	74	-	60	
64	TRB-4/6	5	6	Red soil+Banded Hematite Jasper boulder	19.27	2.99	72.93	0.18	0.17	0.11	0.22	0.06	0.04	0.08	51.01	762	-	-	-	6	6	-	-	71	50	44	8	165	65	-	68	
TRB-5 (24° 34' 14.2"; 82° 54' 52.6")																																
65	TRB-5/1	0	1	Red soil+Banded Hematite Jasper	5.07	0.88	89.42	0.17	0.1	0.11	<0.1	0.08	0.05	0.07	62.54	1024	-	-	-	6	6	-	-	61	68	47	15	130	84	-	50	
66	TRB-5/2	1	2	Red soil+Banded Hematite Jasper	50.07	1.13	47.01	0.13	0.12	0.14	0.1	0.04	0.01	0.1	32.88	557	-	-	-	6	7	-	-	54	38	54	6	38	49	-	48	
67	TRB-5/3	2	3	Red soil+Banded Hematite Jasper	52.31	1.51	43.6	0.12	0.11	0.16	<0.1	0.03	0.03	0.1	30.49	501	-	-	-	9	8	-	-	51	32	43	8	63	54	-	50	
68	TRB-5/4	3	4	Red soil+Banded Hematite Jasper	55.74	1.12	38.73	0.1	0.11	0.15	0.11	0.03	0.02	0.1	27.09	430	-	-	-	10	7	-	-	51	32	46	10	36	44	-	51	
69	TRB-5/5	4	5	Banded Hematite Chert/Jasper+Limonitized	32.19	1.22	63.93	0.17	0.13	0.1	0.1	0.05	0.01	0.09	44.71	753	-	-	-	8	6	-	-	57	48	52	9	70	64	-	51	
70	TRB-5/6	5	6	Banded Hematite Chert/Jasper+Limonitized	55.45	1.55	40.07	0.14	0.14	0.14	0.07	0.04	0.02	0.09	28.02	536	-	-	-	7	7	-	-	52	38	46	11	35	49	-	49	
71	TRB-5/7	6	7	Banded Hematite Chert/Jasper+Limonitized	12.03	1.28	84.41	0.17	0.12	0.11	<0.1	0.06	0.02	0.08	59.04	942	-	-	-	9	6	-	-	72	57	52	8	98	75	-	48	
72	TRB-5/8	7	8	Red soil+Banded Hematite Jasper	10.8	2.46	80.85	0.2	0.13	0.11	0.1	0.06	0.02	0.08	56.55	1007	-	-	-	8	6	-	-	67	66	50	12	114	81	-	53	
73	TRB-5/9	8	9	Red soil+Banded Hematite Jasper	9.78	6.68	76.96	0.25	0.18	0.12	0.12	0.44	0.01	0.08	53.83	1500	-	-	-	6	6	-	-	66	81	52	7	169	91	-	52	
74	TRB-5/10	9	10	Red soil+Banded Hematite Jasper	10.51	1.52	85.85	0.18	0.13	0.11	<0.1	0.06	0.04	0.09	60.04	1002	-	-	-	9	5	-	-	69	65	50	9	107	79	-	52	
75	TRB-5/11	10	11	Red soil+Banded Hematite Jasper	20.14	1.41	73.15	0.16	0.16	0.1	0.1	0.07	0.03	0.1	51.16	813	-	-	-	10	7	-	-	67	56	43	8	73	71	-	45	
76	TRB-5/12	11	12	Red soil+Banded Hematite Jasper	30.62	0.9	65.07	0.13	0.11	0.1	<0.1	0.04	0.01	0.1	45.51	745	-	-	-	8	5	-	-	65	51	54	12	64	57	-	50	
77	TRB-5/13	12	13	Red soil+Banded Hematite Jasper	36.41	1.35	59.64	0.13	0.12	0.1	<0.1	0.07	0.01	0.1	41.71	703	-	-	-	6	6	-	-	61	45	50	6	93	72	-	51	
78	TRB-5/14	13	14	Red soil+Banded Hematite Jasper	55.13	1.11	38.54	0.09	0.09	0.12	0.1	0.03	0.01	0.1	26.95	434	-	-	-	6	7	-	-	54	28	52	6	42	58	-	48	
79	TRB-5/15	14	15	Red soil+Banded Hematite Jasper	52.66	1.03	44.67	0.11	0.1	0.1	0.1	0.06	0.01	0.1	31.24	536	-	-	-	9	7	-	-	50	35	47	11	67	62	-	45	

Annexure IV

Analytical results of Base Metal samples from Block - 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	Lithology	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	Mn (ppm)	Ag (ppm)	Cd (ppm)	Li (ppm)	Cs (ppm)
1	SBB/BRS-16	Quartz vein in banded hematite chert	29	13	49	32	13	10	108	<5	11	20	14.1
2	SBB/BRS-18	Ferruginous phyllite with tuff	23	30	37	36	17	39	130	<5	13	<5	<10
3	SBB/BRS-19	Buff phyllite	54	<20	88	51	12	63	282	<5	<5		
4	SBB/BRS-20	White tuff with ferruginous phyllite	41	<20	12	10	<10	55	8	<5	<5		
5	SBB/BRS-21	Banded Hematite Jasper/Chert	36	<20	68	<10	<10	<10	136	<5	<5		
6	SBB/BRS-22	Ferruginous phyllite with chert nodules and tuff	69	33	127	34	<10	61	84	<5	<5		
7	SBB/BRS-23	Grey phyllite	35	<20	64	26	14	55	1292	<5	<5		
8	SBB/BRS-24	Banded Hematite Chert/Jasper	26	<20	81	<10	<10	<10	177	<5	<5		
9	SBB/BRS-25	Ferruginous phyllite with tuff	110	39	147	41	<10	58	175	<5	<5		
10	SBB/BRS-27	Ferruginous phyllite with tuff	82	<20	83	57	12	32	515	<5	<5		
11	SBB/BRS-28	Ferruginous phyllite ± iron oxide	60	<20	53	68	<10	115	169	<5	<5		
12	SBB/BRS-29	Ferruginous phyllite ± iron oxide, tuff banding	67	<20	10	19	<10	53	19	<5	<5		
13	SBB/CH-3/1	Banded Hematite Chert/Jasper	139	42	125	57	12	<10	399	<5	<5		
14	SBB/CH-3/2	Banded Hematite Chert/Jasper	193	36	155	99	12	27	371	<5	<5		
15	SBB/CH-3/3	Banded Hematite Chert/Jasper	193	39	101	40	<10	<10	358	<5	<5		
16	SBB/CH-3/4	Banded Hematite Chert/Jasper	96	<20	48	33	<10	56	307	<5	<5		
17	SBB/CH-3/5	Banded Hematite Chert/Jasper	186	<20	117	32	<10	16	260	<5	<5		
18	SBB/CH-3/6	Banded Hematite Chert/Jasper	145	26	148	<10	<10	23	271	<5	<5		
19	SBB/CH-3/7	Banded Hematite Chert/Jasper	126	46	226	46	<10	26	225	<5	<5		
20	SBB/CH-3/8	Banded Hematite Chert/Jasper	49	<20	88	<10	<10	<10	158	<5	<5		
21	SBB/CH-3/9	Banded Hematite Chert/Jasper	178	31	207	35	<10	34	252	<5	<5		
22	SBB/CH-3/10	Banded Hematite Chert/Jasper	105	21	122	24	<10	30	227	<5	<5		
23	SBB/CH-3/11	Banded Hematite Chert/Jasper	114	30	235	32	<10	19	247	<5	<5		
24	SBB/CH-3/12	Banded Hematite Chert/Jasper	69	47	120	26	<10	<10	242	<5	<5		
25	UPSBB-1/58	Dolerite	97	<20	490	246	18	410	1226	<5	<5		
26	UPSBB-1/59	Dolerite	83	27	664	375	22	431	1261	<5	<5		
27	UPSBB-1/60	Dolerite	42	<20	115	385	<10	374	791	<5	<5		
28	UPSBB-1/61	Dolerite	153	<20	340	456	38	831	791	<5	8		
29	UPSBB-2/31	Weathered tuff	39	40	45	43	10	29	11	<5	11	<5	<10
30	UPSBB-2/32	Weathered tuff	26	32	35	47	10	30	20	<5	13	<5	<10
31	UPSBB-2/33	Weathered tuff	13	48	35	51	8	30	7	<5	12	<5	<10
32	UPSBB-2/34	Weathered tuff	26	44	54	49	9	46	10	<5	12	<5	<10
33	UPSBB-2/35	Weathered tuff	26	40	107	42	11	54	8	<5	12	<5	<10
34	UPSBB-2/36	Weathered tuff	48	34	36	43	9	79	9	5	11	<5	11.4
35	UPSBB-2/37	Reddish tuff	56	45	48	43	19	99	26	<5	15	<5	<10
36	UPSBB-2/38	Reddish tuff	40	72	37	24	5	38	9	<5	8	<5	12.9
37	UPSBB-2/39	Ferruginous phyllite with tuff	43	47	33	20	8	53	18	<5	10	8	<10
38	UPSBB-2/40	Reddish tuff	119	52	49	26	10	105	25	<5	11	10	<10
39	UPSBB-2/41	Reddish tuff	160	52	94	61	24	67	225	<5	13	17	<10
40	UPSBB-2/42	Ferruginous phyllite with tuff	146	29	35	31	10	65	8	<5	8	5	<10
41	UPSBB-2/43	Ferruginous phyllite with tuff	183	40	35	24	11	42	16	<5	8	11	<10
42	UPSBB-2/44	Ferruginous phyllite with tuff	131	120	27	30	12	59	10	<5	10	5	10
43	UPSBB-2/45	Ferruginous phyllite with tuff	156	161	74	31	11	58	44	<5	11	7	<10
44	UPSBB-2/46	Ferruginous phyllite with tuff	213	62	44	25	9	61	11	<5	11	9	<10
45	UPSBB-2/47	Ferruginous phyllite with tuff	367	47	30	26	10	86	10	<5	9	8	<10
46	UPSBB-2/48	Reddish tuff	691	148	108	42	15	172	20	<5	14	10	17.4
47	UPSBB-2/49	Reddish tuff with phyllite	449	63	50	32	12	30	35	<5	9	10	10
48	UPSBB-2/50	Reddish tuff with phyllite	1562	109	139	109	45	64	675	<5	14	26	<10
49	UPSBB-2/51	Tuff	1346	42	254	126	40	62	288	<5	8	30	<10
50	UPSBB-2/52	Tuff	918	22	339	74	46	50	550	<5	12	25	<10
51	UPSBB-2/53	Tuff	869	27	442	95	53	56	563	<5	12	26	<10
52	UPSBB-2/54	Tuff	656	27	200	76	39	50	497	<5	9	26	10
53	UPSBB-2/55	Tuff	1370	21	452	194	44	47	421	<5	7	26	<10
54	UPSBB-2/56	Tuff	372	21	385	117	43	54	18	<5	14	26	<10
55	UPSBB-2/57	Tuff	364	46	489	114	52	63	1168	<5	20	22	14.1
56	UPSBB-2/58	Tuff	690	39	548	154	59	70	282	<5	16	30	10
57	UPSBB-2/59	Tuff	518	83	124	53	11	38	145	<5	7	12	10.2
58	UPSBB-2/60	Reddish phyllite with tuff	864	119	172	92	19	57	174	<5	13	14	<10
59	UPSBB-2/61	Ferruginous phyllite with tuff	272	77	71	44	19	97	102	<5	8	11	<10
60	UPSBB-2/62	Ferruginous phyllite with tuff	235	46	49	53	15	135	27	<5	11	10	<10
61	UPSBB-2/63	Ferruginous phyllite with tuff	210	39	51	46	11	88	26	<5	8	6	<10
62	UPSBB-2/64	Tuff	653	25	341	262	26	125	190	<5	8	24	10
63	UPSBB-2/65	Tuff	236	37	223	116	34	70	356	<5	14	40	<10
64	UPSBB-2/66	Reddish tuff	245	29	441	192	35	74	434	<5	15	32	<10
65	UPSBB-2/67	Reddish tuff	191	29	318	132	32	61	908	<5	13	34	<10
66	UPSBB-2/68	Reddish tuff	120	32	246	99	43	56	568	<5	11	29	<10
67	UPSBB-2/69	Reddish tuff	211	28	262	115	54	56	744	<5	13	15	<10
68	UPSBB-2/70	Reddish tuff	101	27	119	48	22	33	310	<5	8	5	<10
69	UPSBB-2/71	Reddish tuff	245	311	422	100	53	67	2436	<5	15	22	13.5
70	UPSBB-2/72	Reddish tuff	250	24	392	119	61	83	1113	<5	16	13	29.4
71	UPSBB-2/73	Reddish tuff	164	100	356	125	60	77	2700	<5	16	18	15.3
72	UPSBB-2/74	Reddish tuff/Dolerite	188	38	462	126	59	92	1446	<5	17	17	<10
73	UPSBB-2/75	Reddish tuff	221	27	578	121	59	84	885	<5	18	11	<10
74	UPSBB-2/76	Reddish tuff	211	29	338	99	39	66	1193	<5	19	13	<10
75	UPSBB-2/77	Reddish tuff	313	65	277	198	30	97	224	<5	14	9	11.7
76	UPSBB-2/78	Ferruginous phyllite with tuff	147	43	202	80	20	45	23	<5	11	<5	15

Annexure IV

77	UPSBB-3/8	Ferruginous phyllite with chert nodules & malachite dissemination	1518	50	50	50	36	45	<5	<5	<5		
78	UPSBB-3/9	Ferruginous phyllite with chert nodules & malachite dissemination	2478	<20	64	72	23	37	<5	<5	<5		
79	UPSBB-3/10	Ferruginous phyllite with chert nodules & malachite dissemination	3176	40	280	207	159	36	142	<5	<5		
80	UPSBB-3/11	Tuff dominant phyllite with malachite	951	99	42	57	39	55	112	<5	<5		
81	TRB-3/2	Brown soil+BIF	59	<20	125	22	<10	16	370	<5	<5		
82	TRB-3/7	Banded Hematite Chert/Jasper	143	<20	192	42	<10	12	335	<5	<5		
83	TRB-3/8	Banded Hematite Chert/Jasper	68	30	125	<10	<10	11	113	<5	<5		
84	TRB-3/9	Banded Hematite Chert/Jasper	64	<20	96	18	<10	<10	200	<5	<5		
85	TRB-3/10	Banded Hematite Chert/Jasper+Limonitized	77	46	134	26	<10	10	214	<5	<5		
86	TRB-3/13	Banded Hematite Chert/Jasper+Limonitized	104	478	510	30	<10	14	196	<5	<5		
87	TRB-3/14	Banded Hematite Chert/Jasper	42	74	114	<10	<10	<10	96	<5	<5		
88	TRB-3/17	Silicified Banded Hematite Chert	83	68	150	22	<10	10	794	<5	<5		
89	TRB-3/18	Silicified Banded Hematite Chert	100	479	373	13	<10	18	176	<5	<5		
90	TRB-3/19	Silicified Banded Hematite Chert	89	313	157	18	<10	31	209	<5	<5		
91	TRB-3/20	Silicified Banded Hematite Chert	127	155	144	16	<10	<10	156	<5	<5		

Annexure-V

Analytical results of Gold samples from Block - 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	Lithology	Au (ppb)
1	SBB/BRS-05	Bedded Tuff	<50
2	SBB/BRS-08	Reddish white altered tuff	<50
3	SBB/BRS-18	Ferruginous phyllite with tuff	<50
4	SBB/BRS-19	Buff phyllite	<50
5	SBB/BRS-20	White tuff with ferruginous phyllite	<50
6	SBB/BRS-21	Banded Hematite Jasper/Chert	<50
7	SBB/BRS-22	Ferruginous phyllite with chert nodules and tuff	<50
8	SBB/BRS-23	Grey phyllite	<50
9	SBB/BRS-24	Banded Hematite Chert/Jasper	<50
10	SBB/BRS-25	Ferruginous phyllite with tuff	<50
11	SBB/BRS-27	Ferruginous phyllite with tuff	<50
12	SBB/BRS-28	Ferruginous phyllite ± iron oxide	<50
13	SBB/BRS-29	Ferruginous phyllite ± iron oxide, tuff banding	<50
14	SBB/CH-3/1	Banded Hematite Chert/Jasper	<50
15	SBB/CH-3/2	Banded Hematite Chert/Jasper	<50
16	SBB/CH-3/3	Banded Hematite Chert/Jasper	<50
17	SBB/CH-3/4	Banded Hematite Chert/Jasper	<50
18	SBB/CH-3/5	Banded Hematite Chert/Jasper	<50
19	SBB/CH-3/6	Banded Hematite Chert/Jasper	<50
20	SBB/CH-3/7	Banded Hematite Chert/Jasper	<50
21	SBB/CH-3/8	Banded Hematite Chert/Jasper	<50
22	SBB/CH-3/9	Banded Hematite Chert/Jasper	<50
23	SBB/CH-3/10	Banded Hematite Chert/Jasper	<50
24	SBB/CH-3/11	Banded Hematite Chert/Jasper	<50
25	SBB/CH-3/12	Banded Hematite Chert/Jasper	<50
26	TRB-3/2	Brown soil+BIF	<50
27	TRB-3/7	Banded Hematite Chert/Jasper	<50
28	TRB-3/8	Banded Hematite Chert/Jasper	<50
29	TRB-3/9	Banded Hematite Chert/Jasper	<50
30	TRB-3/10	Banded Hematite Chert/Jasper+Limonitized	<50
31	TRB-3/13	Banded Hematite Chert/Jasper+Limonitized	<50
32	TRB-3/14	Banded Hematite Chert/Jasper	<50
33	TRB-3/17	Silicified Banded Hematite Chert	<50
34	TRB-3/18	Silicified Banded Hematite Chert	<50
35	TRB-3/19	Silicified Banded Hematite Chert	<50
36	TRB-3/20	Silicified Banded Hematite Chert	<50
37	UPSBB-1/58	Dolerite	<50
38	UPSBB-1/59	Dolerite	<50
39	UPSBB-1/60	Dolerite	<50
40	UPSBB-1/61	Dolerite	<50
41	UPSBB-2/31	Weathered tuff	<50
42	UPSBB-2/32	Weathered tuff	<50
43	UPSBB-2/33	Weathered tuff	<50
44	UPSBB-2/34	Weathered tuff	<50
45	UPSBB-2/35	Weathered tuff	<50
46	UPSBB-2/36	Weathered tuff	<50

Annexure-V

47	UPSBB-2/37	Reddish tuff	<50
48	UPSBB-2/38	Reddish tuff	<50
49	UPSBB-2/39	Ferruginous phyllite with tuff	<50
50	UPSBB-2/40	Reddish tuff	<50
51	UPSBB-2/41	Reddish tuff	<50
52	UPSBB-2/42	Ferruginous phyllite with tuff	<50
53	UPSBB-2/43	Ferruginous phyllite with tuff	<50
54	UPSBB-2/44	Ferruginous phyllite with tuff	<50
55	UPSBB-2/45	Ferruginous phyllite with tuff	<50
56	UPSBB-2/46	Ferruginous phyllite with tuff	<50
57	UPSBB-2/47	Ferruginous phyllite with tuff	<50
58	UPSBB-2/48	Reddish tuff	<50
59	UPSBB-2/49	Reddish tuff with phyllite	<50
60	UPSBB-2/50	Reddish tuff with phyllite	<50
61	UPSBB-2/51	Tuff	<50
62	UPSBB-2/52	Tuff	<50
63	UPSBB-2/53	Tuff	<50
64	UPSBB-2/54	Tuff	<50
65	UPSBB-2/55	Tuff	<50
66	UPSBB-2/56	Tuff	<50
67	UPSBB-2/57	Tuff	<50
68	UPSBB-2/58	Tuff	<50
69	UPSBB-2/59	Tuff	<50
70	UPSBB-2/60	Reddish phyllite with tuff	<50
71	UPSBB-2/61	Ferruginous phyllite with tuff	<50
72	UPSBB-2/62	Ferruginous phyllite with tuff	<50
73	UPSBB-2/63	Ferruginous phyllite with tuff	<50
74	UPSBB-2/64	Tuff	<50
75	UPSBB-2/65	Tuff	<50
76	UPSBB-2/66	Reddish tuff	<50
77	UPSBB-2/67	Reddish tuff	<50
78	UPSBB-2/68	Reddish tuff	<50
79	UPSBB-2/69	Reddish tuff	<50
80	UPSBB-2/70	Reddish tuff	<50
81	UPSBB-2/71	Reddish tuff	<50
82	UPSBB-2/72	Reddish tuff	<50
83	UPSBB-2/73	Reddish tuff	<50
84	UPSBB-2/74	Reddish tuff/Dolerite	<50
85	UPSBB-2/75	Reddish tuff	<50
86	UPSBB-2/76	Reddish tuff	<50
87	UPSBB-2/77	Reddish tuff	<50
88	UPSBB-2/78	Ferruginous phyllite with tuff	<50
89	UPSBB-3/8	Ferruginous phyllite with chert nodules & malachite dissemination	<50
90	UPSBB-3/9	Ferruginous phyllite with chert nodules & malachite dissemination	<50
91	UPSBB-3/10	Ferruginous phyllite with chert nodules & malachite dissemination	<50
92	UPSBB-3/11	Tuff dominant phyllite with malachite	<50

Annexure - VI

Litholog of borehole UPSBB-1, Block –‘B’, Bharhari area, Sonbhadra district, Uttar Pradesh

R.L. - 399 m
 Bearing - 350°
 Inclination - 45°
 Depth drilled - 127.10 m

Latitude - 24°33'55.2" N
 Longitude - 82°53'25.2" E
 Commenced on - 24/05/19
 Closed on -24/08/19

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	7.60	7.60	Buff colored fine grained soil
2	7.60	12.80	5.20	Light grey to reddish colored medium grain sandy tuffaceous sludge and fragments of tuff mixed with fragments of banded hematite chert
3	12.80	16.60	3.80	Reddish phyllite interbanded with tuff mixed with core fragments of BHC (overburden type)
4	16.60	22.50	5.90	Reddish to light grey colored medium to coarse grained sandy sludge with core/core fragments/loose fragments of BHC (crushed & leached)
5	22.50	61.50	39.00	Banded hematite chert/jasper with thin (1mm-8mm) ash color tuff and limonitized parting at places. Hematite band thickness varies from 1mm to 8 cm whereas chert bands thickness varies from 1mm to 7cm. Chert is also present in boudinage form
6	61.50	63.30	1.80	Reddish colored fine grained sludge
7	63.30	67.50	4.20	Banded hematite chert with reddish to muddy color phyllite banding in between at places.
8	67.50	72.50	5.00	Light greenish grey to dark grey, also buff color dolerite
9	72.50	72.90	0.40	Off-white tuffs
10	72.90	96.10	23.20	Banded hematite chert/jasper. At places interbanded with thin tuff parting. In hematite band at 73.0 m depth 2 mm thick recrystallized needle shaped fibrous olive green quartz grain vein is present along fracture plane.
11	96.10	100.20	4.10	Reddish sludge with few grey tuff and chert fragments at places
12	100.20	106.10	5.90	Banded hematite chert with limonitic bands (2mm) at places.
13	106.10	113.00	6.90	Reddish sludge with chert core fragments having occasionally hematite bands of 1-2mm thickness.
14	113.00	127.10	14.10	Buff to greenish grey, weathered to massive dolerite.

Annexure - VII

Litholog of borehole UPSBB-2, Block –‘B’, Bharhari area, Sonbhadra district, Uttar Pradesh

R.L. - 450 m
 Bearing - 343°
 Inclination - 47°
 Depth drilled - 160.45 m

Latitude - 24°33'55" N
 Longitude - 82°53'37.8" E
 Commenced on - 02/09/19
 Closed on -10/12/19

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	13.50	13.50	Reddish white sludge with few fragments of reddish white tuff
2	13.50	26.50	13.00	Reddish white tuff having color banding of reddish/mehrun color with few broken rock fragments of chert
3	26.50	33.70	7.20	Sandy yellowish sludge with few rock fragments of reddish white tuff
4	33.70	41.40	7.70	White also reddish soft tuff
5	41.40	60.50	19.10	Reddish ferruginous phyllite having 1mm to cm thick white tuff banding with chert nodules. At 60m, 7cm chert and 3cm thick iron oxide (hematite) is present.
6	60.50	72.00	11.50	Reddish mehrun phyllite with 2mm-7cm thick off white tuff banding in between
7	72.00	75.60	3.60	Off-white to reddish color tuff
8	75.6	76.5	0.90	Greenish buff dolerite
9	76.5	81.2	4.70	Reddish white tuff, comparatively hard
10	81.2	90	8.80	Reddish ferruginous phyllite having 1mm-2cm thick off-white tuff banding
11	90	101.4	11.40	Reddish tuff
12	101.4	117.5	16.10	Greenish dolerite, at the end off-white to reddish tuff is present
13	117.5	120	2.50	Banded ferruginous phyllite mixed with tuff banding, also chert nodules/banding is present
14	120	123.5	3.50	Weathered, leached silica dominant banded hematite chert mixed with reddish phyllite
15	123.5	131	7.50	Greenish massive dolerite with few sulphide specks
16	131	156.25	25.25	Banded hematite chert/jasper. Hematite bands thickness varies from 1mm-3cm while jasper/chert bands are 1mm-2cm.
17	156.25	157.65	1.40	Yellowish to reddish, phyllite with few chert bands
18	157.65	160.45	2.80	No core, borehole was abandoned due to jamming of drilling rod at 160.45m

Annexure - VIII

Litholog of borehole UPSBB-3, Block –‘B’, Bharhari area, Sonbhadra district, Uttar Pradesh

R.L. - 407.5 m
 Bearing - 355°
 Inclination - 45°
 Depth drilled - 130.25 m

Latitude - 24°33'58" N
 Longitude - 82°53'51.5" E
 Commenced on - 25/12/19
 Closed on -04/03/20

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	6.00	6.00	Reddish sludge of tuff
2	6.00	20.50	14.50	Reddish white banded tuff showing bands of red and white tuff. Also showing reddish ferruginous phyllite banding in between
6	20.50	29.30	8.80	Off-white tuff
7	29.30	39.00	9.70	Reddish ferruginous phyllite interbanded with off-white tuff
8	39.00	58.85	19.85	Reddish white sludge of tuff
9	58.85	73.55	14.70	Ferruginous phyllite having chert nodules interbanded with off-white tuff
10	73.55	76.30	2.75	Weathered, limonitized, oxidized BHC
11	76.30	78.55	2.25	Weathered dolerite often reddish on surface
12	78.55	87.20	8.65	Reddish tuff
13	87.20	94.00	6.80	Reddish to greenish dolerite
14	94.00	127.45	33.45	BHC/BHJ, at few places core is highly oxidized and limonitized, also showing brecciation at few places after 102.30m depth. Hematite bands are upto 5.5cm thick whereas jasper bands are 1mm to 2.5 cm thick. At 126.50 m showing micro faulting with 1 cm displacement in bands.
15	127.45	130.25	2.80	Highly fractured, brecciated, altered, weathered reddish/greenish dolerite having tuff content trapped in intertriangular spaces, ± intrusion of thin quartz vein.

Annexure - IX

Litholog of borehole UPSBB-4, Block –‘B’, Bharhari area, Sonbhadra district, Uttar Pradesh

R.L. - 429.5 m
 Bearing - 340°
 Inclination - 45°
 Depth drilled - 43.50 m

Latitude - 24°34'01.8" N
 Longitude - 82°54'03.7" E
 Commenced on - 15/03/20
 Closed on -24/03/20

Sr. No.	From (m)	To (m)	Run Length (m)	Lithology
1	0.00	35.00	35.00	Reddish sandy sludge (also some broken pieces) of phyllite interbanded with tuff. Also at 30m depth few chert fragment upto 5cm is also present.
2	35.00	38.50	3.50	Reddish tuff
3	38.50	43.50	5.00	Weathered, earthy dolertie

Annexure X

Analytical results of Major Oxides and Trace Elements of check samples from Block - 'B', Bharhari area, Sonbhadra district, Uttar Pradesh

Sr. No.	Sample No	From (m)	To (m)	Sample Length (m)	Lithology	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	CaO %	MgO %	Na ₂ O %	K ₂ O %	MnO %	TiO ₂ %	P ₂ O ₅ %	Total Fe%	Ba (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Ga (mg/kg)	Nb (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Rb (mg/kg)	Sc (mg/kg)	Sr (mg/kg)	Th (mg/kg)	V (mg/kg)	Y (mg/kg)	Zn (mg/kg)	Zr (mg/kg)
1	SBB/DP-1/1	45	45.9	0.9	Banded Hematite Chert/Jasper with Tuff	44.7	2.49	50.33	0.1	0.15	<0.1	0.01	0.01	0.03	0.08	35.20	390	-	-	-	7	8	-	-	28	23	37	6	76	37	-	43
2	SBB/DP-1/2	46.7	47.45	0.75	Banded Hematite Chert/Jasper+iron hydroxide (limonite/goethite)	46.72	1.79	49.14	0.13	0.13	<0.1	0.1	0.01	0.02	0.08	34.37	346	-	-	-	9	7	-	-	26	18	29	12	38	28	-	39
3	SBB/DP-2/1	35.5	36.4	0.9	Weathered tuff	86.49	8.61	2.44	0.16	0.11	0.1	0.08	0.01	0.7	0.09	1.71	59	-	-	-	11	14	-	-	11	19	53	8	60	27	-	106
4	SBB/DP-2/2	62	63	1	Reddish ferruginous phyllite with tuff	61.93	17.56	10.81	0.1	0.72	0.1	1.82	0.02	1.31	0.07	7.56	287	-	-	-	24	37	-	-	100	32	37	10	301	51	-	214
5	SBB/DP-3/1	120	120.6	0.6	Banded Hematite Chert/Jasper	31.83	1.66	59.7	0.1	0.12	0.1	<0.1	0.03	0.02	0.19	41.75	467	-	-	-	5	7	-	-	28	35	27	14	79	39	-	39
6	SBB/DP-3/2	125.4	126	0.65	Banded Hematite Jasper	41.38	1.62	51.38	0.12	0.1	<0.1	0.1	0.02	0.03	0.12	35.94	387	-	-	-	6	8	-	-	27	25	39	9	53	40	-	38

		Zone -IV		Fe content $\geq 30\%$			
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-1/33	80.80	82.50	1.70	61.39	42.94	72.991
Total length $\Sigma L =$				1.70	Total L x G =		72.991
Zone -IV Avg. grade i.e. $\Sigma L \times G / \Sigma L =$						42.94%	

Zone -V				Fe content $\geq 30\%$			
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-1/39	90.10	91.10	1.00	48.63	34.01	34.012
2	UPSBB-1/40	91.10	92.10	1.00	47.85	33.47	33.466
3	UPSBB-1/41	92.10	92.80	0.70	46.58	32.58	22.805
Total length $\sum L =$				2.70	Total L x G =		90.283
Zone -V Avg. grade i.e. $\sum L \times G / \sum L =$						33.44%	

Zone -VI				Fe content $\geq 30\%$			
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-1/51	102.10	103.40	1.30	52.79	36.92	47.998
2	UPSBB-1/52	103.40	104.75	1.35	65.43	45.76	61.778
3	UPSBB-1/53	104.75	106.10	1.35	63.73	44.57	60.173
Total length $\sum L =$				4.00	Total L x G =		169.949
Zone -VI Avg. grade i.e. $\sum L \times G / \sum L =$						42.49%	

BH NO : UPSBB-2

Zone -I				Fe content $\geq 30\%$			
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-2/5	133.00	134.00	1.00	39.22	27.43	27.43
2	UPSBB-2/6	134.00	135.10	1.10	42.74	29.89	32.88
3	UPSBB-2/7	135.10	136.10	1.00	44.48	31.11	31.11
4	UPSBB-2/8	136.10	137.15	1.05	35.90	25.11	26.36
5	UPSBB-2/9	137.15	138.05	0.90	46.77	32.71	29.44
6	UPSBB-2/10	138.05	139.10	1.05	39.93	27.93	29.32
7	UPSBB-2/11	139.10	140.00	0.90	43.25	30.25	27.22
8	UPSBB-2/12	140.00	140.70	0.70	56.14	39.26	27.49
9	UPSBB-2/13	140.70	141.60	0.90	45.45	31.79	28.61
10	UPSBB-2/14	141.60	142.20	0.60	47.67	33.34	20.00
11	UPSBB-2/15	142.20	143.00	0.80	50.57	35.37	28.29
12	UPSBB-2/16	143.00	144.00	1.00	54.74	38.29	38.29
Total length $\sum L =$				11.00	Total L x G =		346.45
Zone -I Avg. grade i.e. $\sum L \times G / \sum L = 31.50\%$							

Zone -II				Fe content $\geq 30\%$			
Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-2/21	147.50	148.50	1.00	38.12	26.66	26.66
2	UPSBB-2/22	148.50	149.60	1.10	46.01	32.18	35.40
3	UPSBB-2/24	150.60	151.75	1.15	42.2	29.51	33.94
4	UPSBB-2/25	151.75	152.70	0.95	42.80	29.93	28.44
5	UPSBB-2/26	152.70	153.30	0.60	62.19	43.50	26.10
6	UPSBB-2/27	153.30	154.05	0.75	49.55	34.66	25.99
7	UPSBB-2/28	154.05	154.70	0.65	54.93	38.42	24.97
8	UPSBB-2/29	154.70	155.60	0.90	56.98	39.85	35.87
9	UPSBB-2/30	155.60	156.25	0.65	55.27	38.66	25.13
Total length $\sum L =$				7.75	Total L x G =		262.49
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$						33.87%	

Zone -VII Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-1/51	102.10	103.40	1.30	52.79	36.92	48.00
2	UPSBB-1/52	103.40	104.75	1.35	65.43	45.76	61.78
3	UPSBB-1/53	104.75	106.10	1.35	63.73	44.57	60.17
Total length $\sum L =$				4.00	Total L x G =		169.95
Zone -VII Avg. grade i.e. $\sum L \times G / \sum L =$					42.49%		

BH NO : UPSBB-2

Zone -I Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-2/15	142.2	143	0.8	50.57	35.37	28.29
2	UPSBB-2/16	143	144	1	54.74	38.29	38.29
Total length $\sum L =$				1.80	Total L x G =		66.58
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$					36.99%		

Zone -II Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-2/26	152.7	153.3	0.6	62.19	43.50	26.10
2	UPSBB-2/27	153.3	154.05	0.75	49.55	34.66	25.99
3	UPSBB-2/28	154.05	154.7	0.65	54.93	38.42	24.97
4	UPSBB-2/29	154.7	155.6	0.9	56.98	39.85	35.87
5	UPSBB-2/30	155.6	156.25	0.65	55.27	38.66	25.13
Total length $\sum L =$				3.55	Total L x G =		138.05
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$					38.89%		

BH NO : UPSBB-3

Zone -I Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-3/20	99.50	100.70	1.20	50.13	35.06	42.07
2	UPSBB-3/21	100.70	101.70	1.00	54.77	38.31	38.31
3	UPSBB-3/22	101.70	102.70	1.00	55.56	38.86	38.86
Total length $\sum L =$				3.20	Total L x G =		119.24
Zone -I Avg. grade i.e. $\sum L \times G / \sum L =$					37.26%		

Zone -II Fe content $\geq 35\%$

Sl. No.	Sample No.	From (m)	To (m)	Length (m)	Fe ₂ O ₃ %	Fe % (G)	Length x grade (Fe%)
1	UPSBB-3/38	119.40	120.00	0.60	53.44	37.38	22.43
2	UPSBB-3/39	120.00	120.60	0.60	63.37	44.32	26.59
3	UPSBB-3/40	120.60	121.20	0.60	48.82	34.14	20.49
4	UPSBB-3/41	121.20	122.00	0.80	50.93	35.62	28.50
5	UPSBB-3/42	122.00	123.00	1.00	50.45	35.28	35.28
6	UPSBB-3/43	123.00	124.00	1.00	50.98	35.66	35.66
7	UPSBB-3/44	124.00	124.70	0.70	59.69	41.75	29.22
8	UPSBB-3/45	124.70	125.35	0.65	59.34	41.50	26.98
9	UPSBB-3/46	125.35	126.00	0.65	55.32	38.69	25.15
10	UPSBB-3/47	126.00	127.00	1.00	57.5	40.22	40.22
11	UPSBB-3/48	127.00	127.45	0.45	83.56	58.44	26.30
Total length $\sum L =$				8.05	Total L x G =		316.80
Zone -II Avg. grade i.e. $\sum L \times G / \sum L =$					39.35%		

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**GEOPHYSICS DIVISION
GEOLOGICAL SURVEY OF INDIA
NORTHERN REGION**



**A REPORT ON GEOPHYSICAL BOREHOLESLOGGING IN BLOCK 'B'
BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH**

ITEM CODE: STSSSI/NR/2019/25593

FIELD SEASON 2019-2020

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June, 2020

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INTRODUCTION

Geophysical borehole logging has been carried out in Block 'B' Bharhari area, Sonbhadra district, Uttar Pradesh. This geophysical borehole logging method is used to identify location of fracture, conductive zones, information of subsurface lithology and detail record the physical parameters like Short normal (SHN), Long normal (LONG) resistivities, Single point resistance (SPR), Self-potential (SP), Temperature, induce polarization (IP), Density-Density along with Caliper, Neutron count etc. in detail.

Resistivity Logs

Resistance is impedance to flow of current and is a function of geometry and intrinsic resistivity of the material. Resistivity is the inverse of conductivity. Current flow in the porous medium is mainly through the fluid filling the pore space and is affected by pore volume, pore connectivity and pore fluid compositing, degree of alteration and mineralogy & temperature. Pore space character varies from formation to formation and for this reason, resistivity logs are often useful for exploring lithological units.

Self-Potential (SP) Logs

SP log is a measurement of the natural potential differences or self-potentials between a movable electrode in the borehole and a reference electrode at the surface. The potentials arise from electrochemical and electro kinetic processes and are typically in the range of a few mV to a few tens of mV.

Induce Polarization (IP)Logs

IP uses a transmitter loop to charge the ground with high current. The Transmitter loop is then turned off and the change in voltage with time is monitored using a secondary loop. In a well, the primary loop induces current flow in the rock beyond the bore wall and the current leads to a charge build-up on conductive particles. The time dependent dissipation of this charge is then reflected as a decaying voltage. The IP can be used in detection of alteration.

Natural Gamma logs

This is the simplest Geophysical well logging method. The logging tool record the level of naturally occurring Gamma ray emission from the rocks around the borehole. The signal comprises Gamma ray emission at different energy levels from the radioactive isotopes of Potassium (^{40}K), Thorium (^{232}Th) and Uranium (^{238}U) and their daughter produce of the decay series. Distribution of K, Th and U varies widely in the crust and as a result, logging of the Gamma ray signals emanating from the rocks around the borehole can provide considerable information about Geology along the borehole.

GEOLOGY OF THE STUDY AREA

The study area consists of brecciated chert-jasper-quartzite, banded siliceous haematite-magnetite quartzite, banded siliceous haematite jasper-chert, banded haematite-magnetite chert, ferruginous quartzite-jasper-chert, phyllite and carbonaceous phyllite of Agori Formation of Mahakoshal Group. The rocks of Mahakoshal Group are disposed along ENE-WSW trending shear zone.

DISCUSSION AND INTERPRETATION

Geophysical logging was carried out in borehole Nos. SBB-01 and SBB-02 in Block 'B' Bharhari area, Sonbhadra district, Uttar Pradesh at the instance of Director, Project: Mineral Investigation, GSI, NR, Lucknow. The details of boreholes are given below.

Sl.no.	Borehole nos.	Drilled depth (m)	Logged depth (m)	Casing (m)	Angle
1.	SBB-01	114	113	18.5	45°
2.	SBB-02	156	151.2	6	45°

Borehole SBB-01: The borehole was drilled up to 114m depth at an angle of 45° and it was cased up to 18.5m depth. The borehole was logged up to 113m depth by using RG Portable Micrologger. Resistivities (SHN& LONG) Single point resistance (SPR), Temperature and Chargeability parameters

were recorded by using ELTG, Magnetic Susceptibility & INPS probes.

Based on Geophysical logs(Fig.1), the four conductive zones (I to IV)have been recorded. Conductive zones are characterized by low values of SPR, Short normal & Long normal resistivity.

Moderate to high Chargeability responsezones (I to III) have been recorded which indicate the presence of sulfide mineralization/clay in the borehole at different depths. Conductive zones associated with low values of Single point resistance,Short normal resistivity, Long normal resistivity high Chargeability and high natural gamma count, indicate the presence of sulphide mineralization/ may be due to clay mineralization within the formation from 67.3-70.0m depth. Moderate to High Magnetic susceptibility response zones (I to IV) have been recorded at the depth range from 28.4-28.8m, 46.4-46.6m, 48.2-48.4m and 52.1-52.5m, it indicates the presence of magnetic minerals in the formation. Natural gamma log reflects lithological changes depending upon the variation of sand and shale content in the rock units. Low gamma count indicates the presence of sand content whereas high gamma represents the presence of clay/radioactive mineral in the formation. Low SP response from 18.9-19.3m & 89.5-89.7m depths and low Natural gamma counts indicate the presence of Sulphide mineralization. The Temperature log showing the normal gradient along the borehole (Figure-1). The inferred conductive,moderate to high chargeability and moderate to high magnetic susceptibility zones are shown in the table 1(a), 1(b) and 1(c) respectively.

Table 1(a):Conductive Zones

Conductive Zone	Depth Range(m)	Thickness (m)
I	67.3-69.6	2.3
II	88.7-89.4	0.7
III	97.5-100.5	3.0
IV	103.9-111	7.2

Table 1(b):Chargeability Zones

Moderateto high chargeability Zone	Depth Range(m)	Thickness (m)
I	56.3 - 56.6	0.3
II	65.6 - 65.8	0.2
III	67.3 - 70.0	2.7

IV	72.8 – 73.1	0.3

Table 1(c):Magnetic Zones

Moderate to high magnetic Zone	Depth Range(m)	Thickness (m)
I	28.4- 28.8	0.4
II	46.4 - 46.6	0.2
III	48.2 - 48.4	0.2
IV	52.1 – 52.5	0.4

Borehole SBB-02: The borehole was drilled up to 156m depth at an angle of 45° and it was cased up to 6m depth. The borehole was logged up to 151.2m depth by using RG Portable Micrologger. The ELTG probe and Magnetic susceptibility probe could not be lowered beyond 122.6m & 123.89m depths respectively due to obstruction in the borehole. Natural Gamma, Self-potential (SP), Short normal (SHN) resistivity, Long normal (LONG) resistivity, Single point resistance (SPR), Temperature, Magnetic susceptibility and Chargeability parameters were recorded by using ELTG, BMSG& INPS probes.

Based on Geophysical logs(Fig.2), the following conductive zones (I to II) are inferred. The conductive zones are recorded by analyzing low values of SPR, Short normal resistivity & Long normal resistivity.

From IP, Magnetic susceptibility and SP logs, no any anomalous zones have been recovered. Which indicates the absence of ferruginous magnetic material and sulphide. Natural gamma log reflects lithological changes depending upon the variation of sand and shale content in the rock units. The Temperature log showing the normal gradient along the borehole (Figure-2). The inferred conductive zones are shown in the table 2(a).

Table 2(a):Conductive Zones

Conductive Zone	Depth Range(m)	Thickness (m)
I	113.0 – 118.3	5.3
II	120.2 – 121.4	1.2

Figure: - 1

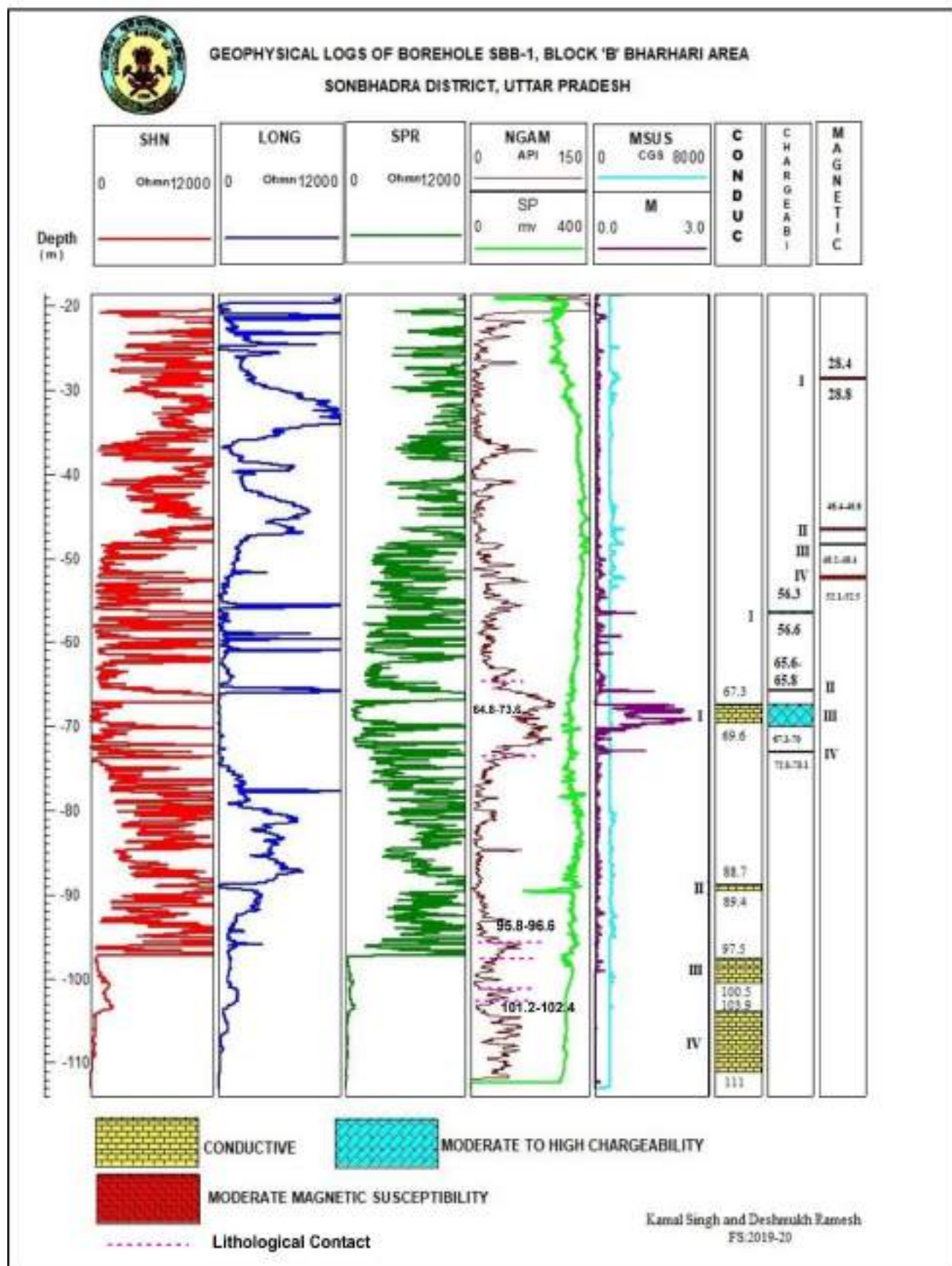
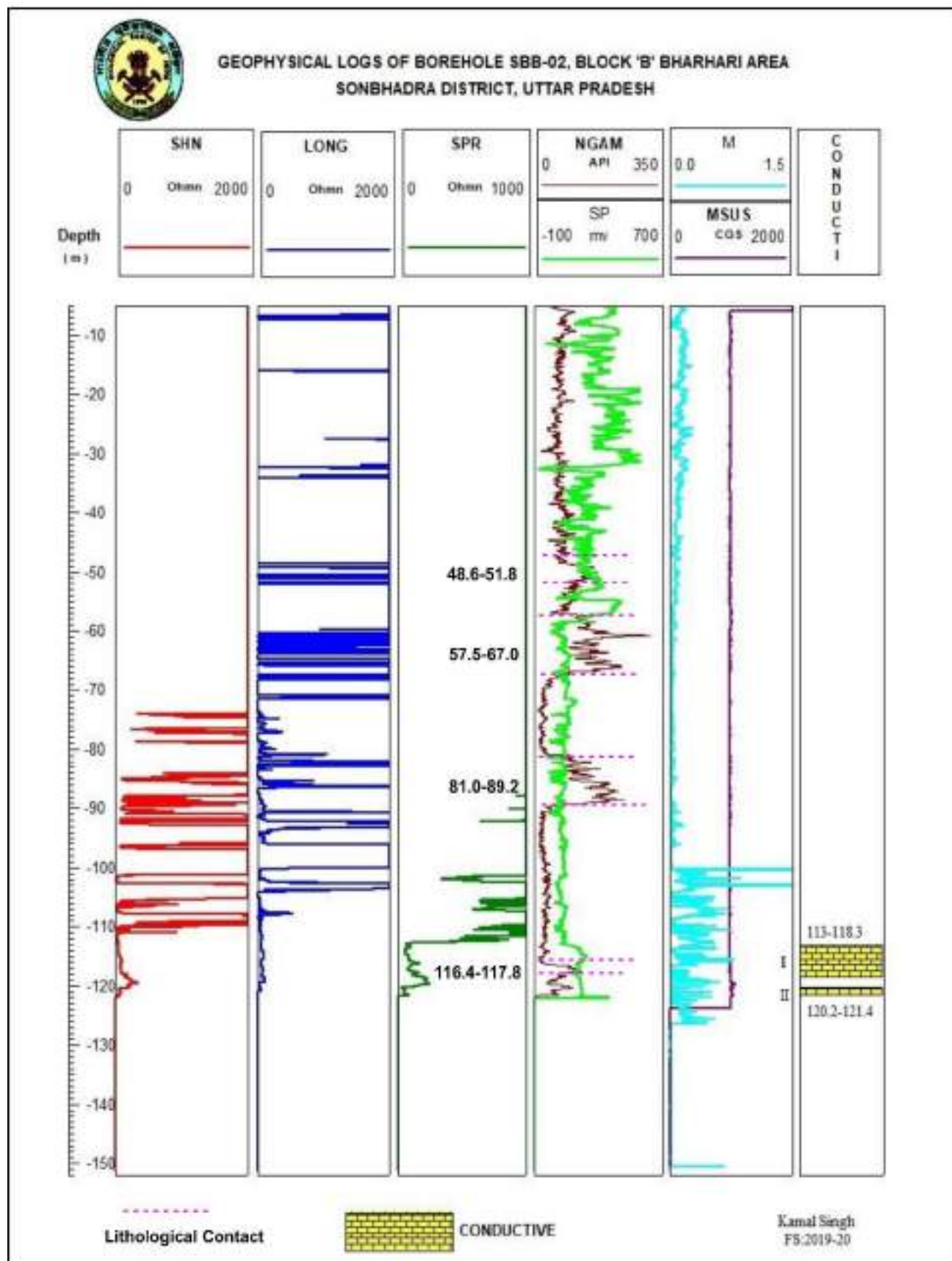


Figure: - 2



भारत सरकार
GOVERNMENT OF INDIA
भारतीय भूवैज्ञानिक सर्वेक्षण
GEOLOGICAL SURVEY OF INDIA
उत्तरी क्षेत्र
NORTHERN REGION



मिशन -II
MISSION -II
परियोजना: लौह खनिज
PROJECT: Ferrous Minerals

उत्तर प्रदेश के सोनभद्र जनपद के भरहरी ब्लॉक 'बी' के महाकोशल समूह में
लौह अयस्क के अन्वेषण पर प्रतिवेदन
(टोपोशीट सं 63L/14)

(मद सं: एम 2 ऐ एफ जी बी एम – एम ई पी/ एन सी/ एन आर/ एस यू- यू पी/2019/26399, कार्यसत्र : 2019-2020)

REPORT ON GEOPHYSICAL SURVEY FOR PRELIMINARY EXPLORATION FOR
IRON ORE IN MAHAKOSHAL GROUP, BLOCK 'B', BHARHARI AREA,
SONBHADRA DISTRICT, UTTAR PRADESH
(TOPOSHEET NO. 63L/14)
(FSPID M2AFGBM-MEP/NC/NR/SU-UP/2019/26399, F.S.: 2019-20)

द्वारा

सौदामिनी साहू, भूभौतिकीविद्

एवं

चंद्रबदन तिवारी, भूभौतिकीविद्

By

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and

Chandrabadan Tiwari, Geophysicist

लखनऊ / LUCKNOW

जून/June -2020

प्रतिवेदन की सॉफ्ट प्रति एवं आंकिक आंकड़ें महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण, कोलकाता-700016 की अनुमति से प्राप्त किये जा सकते हैं।

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**REPORT ON GEOPHYSICAL SURVEY FOR PRELIMINARY
EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP, BLOCK 'B',
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ABSTRACT

Geophysical surveys employing Magnetic (TF) has been conducted in block 'B', Bharhari area, Sonbhadra district, Uttar Pradesh, vide FSP ID M2AFGBM-MEP/NC/NR/SU-UP/2019/26399. The objective of the survey was to assess the economic potentiality of iron ore occurrence in the area. A total of 10.8 L. Km. was covered by magnetic (TF) survey. The magnetic (TF) contour map shows a wide range of magnetic variation from -5391.8nT (observed in the southern portion over traverses 'W400' to 'E800 (western portion)') to +6369nT (observed in the southern portion over traverses 'E800 (eastern portion)' to 'E1800') in the study area. High magnetic gradients running in NE-SW and E-W direction in the Block indicate the lithological contacts/fault. Residual map of Magnetic (TF) anomaly shows various high magnetic anomaly zones (RH1 to RH7) with values ranging from 150 to 350 nT indicating bipolar nature of the bodies lying at shallower level in subsurface. The causative sources delineated over northern part over traverses E200, E400, 'E800' and 'E1000' in Magnetic (TF) anomaly contour map may be due to the presence of BIF bands/ferruginous rocks in the study block. The two prominent residual magnetic anomalies (RH8, RH9) with values more than 350nT in southeastern part of the block may indicate the dominance of ferromagnetic material (magnetite) in the subsurface rock. Horizontal Derivative map of Magnetic (TF) anomaly has brought out a number of elongated gradient zones. These gradient zones attribute the linear features dominated in the study area. The magnetic anomaly values vary from 100-900 nT along the strike direction over BIF band and other lithological units while the values are lying more than 900 nT in northern part between stations N100 to N300 at all traverses and southeastern part between station N50 to S300 from traverses E800 to E1400 of the block. The veriegated phyllites/phyllites shows magnetic anomaly values in the range of 300 to

600 nT. The low magnetic anomaly values (<100 nT) is recorded mostly in southern part (from traverses W800 to E800) over weathered dolerite/phyllites with tuffs and soil covered area. The large variation in magnetic (TF) anomalies indicates the presence of different lithological units in subsurface. The shape of magnetic anomalies is elliptical with NE-SW strike and lies over the BIF/ferruginous body.

The analysis of magnetic data has shown that the average depth to the top of most of the causative bodies lying along BIF marker band in strike direction and other shallow bodies as estimated from Euler 3D deconvolution, radially averaged power spectrum, P- depth sections, Peter's half slope method and 2D magnetic models, ranges from 20 to 80m with minimum 10% variation. The maximum depth extension of shallow causative bodies may be upto 150m as evident from 2D magnetic model. However, the depth is extended to about 400m in case of few deeper bodies lying in northern and southeastern parts of the block.

1. INTRODUCTION

1.1. General

Most geophysical applications related to iron and its oxides are based on the magnetic properties of iron-containing rocks and minerals. Ferrous iron oxide is paramagnetic and ferric iron oxide is antiferromagnetic, but only ferric oxide can be part of ferri- and ferromagnetic minerals, excluding magnetite. This means that Iron Oxide (IO) transformations can give origin to a magnetic anomaly, which could be measured by geophysical prospecting methods. The stability of ferric iron decreases with depth within the crust and upper mantle. Depending on the geothermal regime and oxidation conditions, there is a depth at which IO changes will take place. Below that depth, ferric-iron containing minerals will no longer have strong magnetic properties. On the other hand, every ferromagnetic mineral has a Curie point (TC), above which it is no longer ferromagnetic. Thus, there are two possibilities for losing magnetic properties by rocks and minerals: reaching the Curie point, and IO changes. Magnetic properties of rocks and stability of their NRM are strongly dependent on the composition, grain-size and amount of magnetic minerals. The fact that most sedimentary rocks and surface-cover formations (including water) are effectively nonmagnetic means that the anomalies are attributable to the underlying igneous and metamorphic rocks (the so-called “magnetic basement”), even where they are not accessible to observation at the surface. The amplitude, shape, and internal configuration of magnetic anomalies may be used to indicate the chance of finding certain ore types (Luis M. Alva-Valdivia et al, 2011). In view of this, the geophysical surveys employing Magnetic (TF) method has been carried out in Bharhari area, Block ‘B’ with an objective to assess the economic potentiality of iron ore occurrence in the area. The block area under investigation forms part of Toposheet No. 63L/14.

The area for geophysical investigation has been identified based on the field evidences of mineralization and analytical results established in the past. The magnetic (VF) survey carried out in Bharhari area, Block ‘A’ in FS: 2017-18 indicates that the causative sources delineated over traverses E400, E600, E800, E1000 & W200 may be due to the presence of BIF bands in the formation in the study block and the magnetic anomaly is extending towards eastern direction (Kumari K., Nekkanti P. and Tiwari C.B., FS: 2017-18). In view of the conclusion drawn in the report of FS 2017-18, the present item has been taken vide FSP ID M2AFGBM-MEP/NC/NR/SU-UP/2019/26399 of FS: 2019-20 of Geological Survey of India, Northern Region, Lucknow (Mission – II). The work component includes Magnetic (TF) method. The geophysical survey was carried out between 1st November 2019 to 21st January 2020. The assigned target of 10 L.km. employing Magnetic (TF) method has been completed.

1.2. Geology:

The block area of investigation lies between NE 24° 34' 29.68" 82° 54' 49.66"; NW 24° 34' 04.39" 82° 53' 09.93"; SW 24° 33' 44.04" 82° 53' 12.07" and SE 24° 33' 59.71" 82° 55' 09.83" and falls under SOI toposheet no. 63L/14. It is situated in the east of the Bharhari village. The litho-units exposed in the block are variegated phyllite, phyllite with interbanded tuff, felsic tuff, banded hematite chert / jasper, ferruginous phyllite and dolerite dyke. The banded hematite chert / jasper band forms a continuous band at the hill top with a strike length of 3.12 km. The general trend of the rock types in the study area is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with dip amount of 41° to 80° towards south.

1.3 Location and Accessibility:

Bharhari is around 22 km west of Chopan town falling in Sonbhadra district, Uttar Pradesh. The district Headquarter of Chopan is Robertsganj. Chopan is situated on National Highway (NH-) which connects Allahabad and Varanasi via Mirzapur cities. Chopan is also well connected by rail situated on Allahabad-Mirzapur-Shaktinagar rail section. The nearest railway station to the working area is Chopan.

2. GEOPHYSICAL SURVEYS

2.1. Methodology and Instruments used:

Magnetic (TF) survey was carried out to assess the iron ore potential in Bharhari area, block 'B', Sonbhadra district, U.P. The layout of the geophysical survey is presented in (Plate 1). The reference point 0/0 was fixed in consultation with concerned Geologist. The reference point 0/0 (24°34'01.8"N, 82°53'51.7"E) was fixed near "0/0" established by Geologists. The base line was laid in E-W direction and the traverses were laid perpendicular to the baseline i.e. N-S direction. The traverses were laid at regular interval of 200m and station spacing was kept 20m. Total length of base line laid was 2.8 km and the magnetic (TF) survey was carried out at 10.8 L. Km. as per assigned target. A total fourteen traverses of length varying from 700m to 1km. was laid to cover 10.8 L. Km. by magnetic survey. The magnetic data was reduced to the magnetic base established outside of the area of working block (**in front of Prathmik Vidyalaya, Chhilahwa, Lat 24°33'28.4"N, Long 82°5209.4"E, Height 255.29m, Magnetic value 44945.23 nT**). After diurnal correction, The International Geomagnetic Reference Field (IGRF) model 2000-2015 of Geosoft Oasis Montaj software product was applied to remove geomagnetic field, also called regional magnetic field to obtain magnetic field anomaly due to local source. The corrected Magnetic data were gridded by using minimum curvature of grid cell 20m. The data processing and preparation of total intensity

magnetic map and other derivative maps was done using Microsoft office (excel) and Geosoft Oasis Montaj software.

The magnetic survey was conducted in the area using following instrument:

Sl. No.	Name of instruments	Make	GSI Reference No.	Resolution
1.	Proton precession magnetometer (TF) (GSM 19T)	M/s GEM System -19 T Canada	TM-16	0.01nT

3. DISCUSSION OF GEOPHYSICAL RESULTS

3.1 Qualitative Interpretation:

3.1.1 Magnetic (TF) profiles

The magnetic (TF) anomaly profiles are plotted and shown in Plates 2a, 2b and 2c. From the profiles, it is evident that magnetic response slowly increases towards north from station S140 over traverses W800 to E600, where the value of magnetic (TF) anomaly ranges between 0 to 800nT. There is also rise in magnetic values with gentle gradient from station 0 on traverse E600 to S 160 on traverse W600. This gentle gradient may be interpreted as lithological contact/shear running ENE-WSW. Over traverses from E1200 to E1800, the magnetic (TF) response is almost flat in the range of 1400 nT from station S400 to N600. It indicates the presence of subsurface material with uniform composition. There is a sharp rise in magnetic value (upto 5000 nT) with steep gradient south of station S160 to S240 over these traverses indicating lithological contact.

The profiles plotted from Magnetic data shows a variation of magnetic (TF) anomaly from 0 to 800nT in the northern portion of all traverses. The amplitude of magnetic (TF) anomaly is decreasing towards south in all traverses except traverses W600, E400 and E800. The amplitude of magnetic (TF) anomaly in northern portion is comparatively low from southern portion in traverses W600, E800, E100, E1200, E1400, E1600 and E1800.

3.1.2 Magnetic (TF) anomaly map

The magnetic (TF) anomaly Contour map is shown in Plate 3. A wide range of magnetic variation from -5391.8nT (observed in the southern portion over traverses 'W400' to 'E800 (western portion)') to +6369nT (observed in the southern portion over traverses 'E800 (eastern portion)' to 'E1800') has been observed in the study area. Based on the magnetic signatures, values and shape of contours, the area is broadly divided into following zones:

a) Magnetic high zones (Magnetic highs)

The magnetic high 'H1' near stations S300 to S500 between traverse E800 and E1000, 'H2'

near stations S200 to S400 between traverses E1600 to E1800 and stations S200 to S300 between traverses E1400 to E1600 indicates that the subsurface rocks are composed of material of high susceptibility/ferruginous in nature. Two more prominent magnetic highs namely 'H3' near stations N100 to N300 in between traverses E200 to E400 and 'H4' near stations N200 to N300 between traverses E800 to E1200 with anomaly values more than 1500 nT may due to the ferruginous rocks (magnetite bearing) present in the area.

b) Magnetic moderate zones

The feeble uneven magnetic anomalies 'M1' along the traverse 'W600' (between stations '0' to 'N100') and 'M2' along the traverse 'W200' (between stations '0' to 'N100') may be due to the presence of Banded-Hematite-Jasper/Chert (BHJ/BHC).

c) Magnetic Low zones

The magnetic low 'L1' near stations S300 to S500 over traverses W400 to E200 and 'L2' near stations S200 to S500 over traverses E400 to E800 indicate the presence of nonmagnetic material (phyllite, tuffs) in subsurface.

d) Gradient zone

Based on the steep gradient of contours, the lithological contacts/fault are marked with blue dashed line in the map. The major contact running NE-SW in the central part of the block between traverses W400 to E1200 separates the low magnetic zone from the high and moderate magnetic zones. Another contact may be seen in northern part of the block E-W between stations N100 to N300 from traverses W400 and E800 and in Southeastern part running NE-SW between stations S100 to S300 from traverses E1000 to E1800. Two minor contact/fault may be noticed in southwestern part between traverse W800 and W400 running NW-SE and NE-SW respectively.

3.1.3 Residual map of Magnetic (TF) data

Residual maps show local magnetic variations, which may have exploration significance. Most magnetic anomalies are caused by lithological changes and the corresponding changes in susceptibility. Several high and low magnetic patches present in Magnetic (TF) Residual map (Plate 4) represent that the magnetic materials (BIF/BHJ) are in discontinuous form at variable depth in the study area. The residual magnetic highs are shown as RH1, RH2 etc. and residual magnetic lows are shown as RL1, RL2 etc. in the map. There is a noticeable N-S trending feature present in the area from station S100 to S500 between traverses W400 to W800. The moderate magnetic values between stations 0 to N200 over traverses E1400 to E1800 observed in Magnetic (TF) anomaly contour map (Plate 3) disappears in Magnetic (TF) Residual map. It implies that the feature is of regional nature and deep seated. A NE-SW trending magnetic high features is observed in the central part within stations 'S50' to 'S200' along traverse 'W200'; between stations '0' to

‘S150’ over traverse ‘0’; between stations ‘0’ to ‘S100’ over traverse ‘E200’; between stations ‘N100’ to ‘S50’ over traverse ‘E400’; between stations ‘N100’ to ‘0’ on traverse ‘E600’; between stations ‘N20’ to ‘N200’ over traverse ‘E800’ and between stations ‘N200’ to ‘N300’ along traverse ‘E1000’, between stations ‘S250’ to ‘S300’ along traverse ‘W200’, between stations ‘0’; ‘S200’ to ‘S300’ over traverse ‘E200’ and ‘E400’; between stations ‘S100’ to ‘S300’ along traverse ‘E600’. The causative source for residual anomaly zones (values more than 150-300nT) marked as RH3, RH7 in northern part and RH8 and RH9 (values more than 350nT) in south-eastern part of the block appears to be deep-seated and the magnitude of these anomalies indicate presence of magnetite bearing rocks and dolerite dykes. The other residual magnetic anomaly (RH1, RH2, RH4, RH5, RH6) zones follow the strike direction. These moderate to high magnetic anomalies are bipolar in nature characterized by a low/high sequence and are indicative of presence of ferruginous material at shallow depth.

3.1.4 Horizontal derivative map of Magnetic (TF) data

Magnitude of Horizontal gradient of magnetic data was computed by using Geosoft software. The result of this horizontal gradient data is presented in Plate 5. This map has brought out a number of elongated gradient zones. These gradient zones attribute the linear features dominated in the study area. In the Horizontal derivative map of Magnetic (TF) anomaly map, few N-S trending features (lithological contacts) may be noticed in the area between station S100 to S500 from traverses W800 to W600; between stations N300 to S500 from traverses E600 to E800 and between stations N300 to S400 from traverses E800 to E1000. A NW-SE trending feature is also seen between stations N200 to S400 from traverses E1000 to E1400.

3.1.5 1st Order Vertical derivative map of Magnetic (TF) data

The first vertical derivative of the magnetic field is the rate of change of the magnetic field in the vertical direction. Computation of the first vertical derivative removes long-wavelength features of the magnetic field and significantly improves the resolution of closely spaced and superposed anomalies.

From the First Order Vertical derivative map of Magnetic (TF) anomaly (Plate 6), A NE-SW trending magnetic high feature is observed in the central part within stations ‘S50’ to ‘S200’ for traverse ‘W200’; ‘0’ to ‘S150’ for traverse ‘0’; ‘0’ to ‘S100’ for traverse ‘E200’; ‘N100’ to ‘S50’ for traverse ‘E400’; ‘N100’ to ‘0’ for traverse ‘E600’; ‘N20’ to ‘N200’ for traverse ‘E800’ and ‘N200’ to ‘N300’ for traverse ‘E1000’ may be due to the presence of ferruginous material at shallow depth. Another NE-SW trending magnetic high feature is observed within stations ‘S250’ to ‘S300’ for traverse ‘W200’ and ‘0’; ‘S200’ to ‘S300’ for traverse ‘E200’ and ‘E400’; ‘S100’ to ‘S300’ for traverse ‘E600’ may be due to the presence of ferruginous material at shallow depth. The magnetic high is observed near stations N100 to N300 in between traverses ‘0’ to ‘E400’ is due to the thin BIF band present in the area which is also reported geologically.

A noticeable N-S trending feature is present in the area from station N200 to S500 between traverses W800 to W400. The magnetic high near stations S120 to S400 between traverses E1600 and E1800; S200 to S300 between traverses E1400 to E1600; S300 to S420 between traverses E1000 to E1200 and S300 to S500 between traverses E800 to E1000 indicate the presence of highly susceptible/ ferruginous materials in the area.

3.1.6 Magnetic (TF) Contours overlaid on Geology Map:

Magnetic (TF) contour overlaid on geology map of the study area is shown in Plate 9. On the basis of magnetic intensity, the study area can be divided into three magnetic domains i.e. low, moderate and high. The trends of Magnetic (TF) contours are in conformity with the general geological strike of the area i.e. NE-SW. Different Magnetic highs (H1, H2, H3...) having varying magnitudes are well corroborating with the exposed rocks. The nosing of magnetic (TF) contours and their abrupt discontinuities near stations N100 and 0 of traverse E 1200 and E 1400 represent different rock types which are well corroborated with the geology map of the area. The magnetic anomaly values vary from 100-900 nT along the strike direction of BIF band and other rock units while the values are lying more than 900 nT in northern part between stations N100 to N300 at all traverses and southeastern parts between station N50 to S300 from traverses E800 to E1400 of the block. These high magnetic (TF) anomalies may be the results of rocks containing magnetite and dolerite dykes. The low magnetic anomaly values (<100 nT) is recorded mostly in southern part (from traverses W800 to E800) over weathered dolerite/phyllite with tuffs and soil covered area. The large variation in magnetic (TF) anomalies indicates the presence of different lithological units in subsurface in surveyed block.

3.2 Quantitative Interpretation of Magnetic (TF) Data

3.2.1 3D-Euler depth solutions of Magnetic (TF) data

With an aim to locate and estimate the depth of the geological bodies/structures, Euler 3D Deconvolution mathematical operation is performed on magnetic in frequency domain. This method generates many solutions from a huge data bank and creates clustering providing a three dimensional visualization of the source depths (Fitzgerald et al., 2003). Several attempts have been made for Euler solutions by using Euler 3D module of Geosoft Oasis Montaj Software with different window size and different Structural Index (SI). Finally, a window length of 10 Km and structural index of 1 for Magnetic (TF) data (Plate 7) has been selected which have produced the better solutions and superimposed over the Magnetic (TF) anomaly contour map of the study area. It is clear that for Euler-3D solution of magnetic data, most of the depth solutions for the causative sources lie in the range of 25-75m depth, however some reflection from deep causative sources greater than 75m depth

is also obtained. These bodies are lying near borehole SBB2, between station N100 to S100 over traverse E400 and between stations S300 to S500 from traverses E400 to E600. These zones have produced low magnetic (TF) anomaly. The depth solutions are falling over the magnetic gradient at different locations, representing contacts/fault and other linear patterns. The maximum depth to the top of the causative body calculated from Euler 3D solution is between 25-75 in central, northern, south-eastern parts of the block.

3.2.2 Radially Averaged Power Spectrum

Power spectrum analysis is a frequency domain approach which is capable of extracting the information from sources at different depths. The radially averaged power spectra of Magnetic anomaly is used to identify subsurface interfaces of magnetic susceptibility variation. Therefore, this technique is useful in identifying depth to the contact interfaces of major subsurface lithological changes. The average radial power spectra of magnetic anomaly (Fig. 7a) have been obtained by plotting average logarithmic energy of magnetic against angular radial frequency using Geosoft MAGMAP module.

The radially averaged power spectrum from magnetic data of the study area has indicated two susceptibility interfaces at ~70 m (for shallow bodies) and ~160 m depth (for deeper bodies).

3.2.3 P-depth section of Magnetic (TF) data

P depth section is used to find out the Depth to Basement extension to determine the position (distance along the profile and depth), dip (orientation) and intensity (susceptibility) of magnetic source bodies for a magnetic profile. This extension includes three different Profile Depth to Basement (P depth) techniques; Werner Deconvolution, Analytic Signal and Extended Euler Deconvolution. Each Depth to Basement function uses a different accepted technique for determining the depth to the source. Each method has advantages in particular geologic situations. Applying multiple methods to the same anomaly profile greatly improves the reliability of results. Depth to Basement methods are designed primarily for use with total-field magnetic data. All of the methods assume that the anomaly profile is perpendicular to the geologic structure generating the field. The methods use horizontal and vertical derivatives in the calculations.

Representative P-depth section (using Analytic signal) of Magnetic data along traverses is presented in Plate 8(a) to 8(b).

For traverse W800, the contacts/causative bodies are found in between stations S400 to S340; S180 to station S60; N20 to N40; N60 to N80 and N140 to N160 having average depth 0 to 70m.

For traverse W600, most of the solutions for the contacts/causative bodies are found in between stations S240 to S120. The average depth of these contacts are lying between 0 to 80m and the corresponding Magnetic (TF) anomaly plot shows high value represents magnetic rich material

here. Some dykes are extended below this.

For traverse W400, most of the solutions for the contacts/causative bodies are found in between stations S400 to S300 and S120 to N40. The average depth of these contacts falls between 0 to 70m, which are extended to 80 m or beyond this for causative bodies lying between stations S300 to S80.

For traverse W200, most of the solutions for the contacts/causative bodies are found in between stations S460 to S400; S300 to S240 and S60 to N100. The average depth of these contacts is between 0 to 75m. The depth of causative source lying between stations S200 to N200 is upto 300m.

For traverse 0, most of the solutions for the contacts/causative bodies are found in between stations S440 to S300 and S40 to N120, for which the average depth is from 0 to 150m and for causative source lying between stations S280 to S240, the average depth is between 0 to 75m.

For traverse E200, most of the solutions for the contacts/causative bodies are found in between stations S440 to S320; S200 to S100 and N40 to N100. The average depth of these contacts is in between 0 to 100m. Magnetic (TF) anomaly plot shows high peak represents magnetic rich material here. Some sources are extended in between stations S100 to S0 whose average depth is 150m.

For traverse E400, most of the solutions for the contacts/causative bodies are found in between S180 to S100 and N20 to N220. The average depth of these bodies lies between 0 to 150m and for body lying between stations S400 to S320, the average depth is in between 0 to 80m. The depth is extended to 250 m in case of magnetic body lying between stations S40 to N20.

For traverse E600, most of the solutions for the contacts/causative bodies are found in between stations S360 to S280; S240 to S200 and N100 to N180 showing average depth in between 0 to 200m. The solutions for the contacts/causative bodies between stations S120 to S60, indicates average depth 70m. The depth to the top of the causative body lying between stations S40 to N80 is extended to 400m.

For traverse E800, most of the solutions for the contacts/causative bodies are found in between stations S420 to S340; S60 to 0 and N200 to N280. The average depth of these bodies ranges between 0 to 75m. Some sources are extended in between stations S20 to S40 whose average depth is 150m.

For traverse E1000, most of the solutions for the contacts are found in between stations S440 to S320 having average depth in between 0 to 50m and another contact is found in between S100 to N80 whose average depth varies from 0 to 150m.

Over the traverse E1200, the average depth of contact/causative body between S300 to S240, is 34m. Most of the solutions for contact/causative body are found in between stations S20 to N80

and N220 to N300 having average depth ranging from 0 to 100m.

For traverse E1400, most of the solutions for the contact/causative body are found in between stations S240 to S200 having average depth ranging between 0 to 30m. Few small contact/causative body are found in between S80 to 0; N100 to N140 and N200 to N380 having average depth lies in between 0 to 150m.

For traverse E1600, most of the solutions for the contact/causative body are found in between stations S180 to S140 having average depth varying from 0 to 34m. Small contacts/causative bodies are found in between stations S40 to N20; N80 to N100 and N160 to N200. The average depth of these is in the range of 0 to 100m.

Over traverse E1800, the average depth of the contact/causative bodies lying between stations S260 to S200, is 50m. Most of the solutions for the contact/causative body found between stations S380 to S340 show average depth between 0 to 150m.

3.2.4 Peter's half Slope Method:

Peter's rule is based on the mathematical expression for magnetic anomalies over vertical dykes with vertical polarization (Akintayo O. Ojo, Toyin O. Omotoso, and Olorunyomi J. Adekanle,, 2014). For bodies having very small width-to-depth ratios (i.e., thin sheets),

$$d = 1.2h$$

and for bodies having very large width-to-depth ratios,

$$d = 2.0h.$$

Therefore, for a 2D body with vertical sides, uniform and nearly vertical;

For very thin body,

$$d = 1.2h$$

For intermediate thickness,

$$d = 1.6h$$

and for very thick body,

$$d = 2.0h$$

Where d is the horizontal distance corresponding to half the maximum slope, that is tangent to the curve, and 'h' is depth to the basement of the body.

Table 1: Summary of depth estimates from the ground magnetic data

Profiles	Depth for Very thin body (m) $h=d/1.2$	Depth for Intermediate thickness (m) $h= d/1.6$	Depth for Very thick body (m) $h=d/2.0$	Average Depth (m)

W 800	100/1.2=83.33	100/1.6=62.5	100/2.0=50	65.27
W 600	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
W 400	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
W 200	60/1.2=50.0	60/1.6=37.5	60/2.0=30.0	39.17
0	60/1.2=50.0	60/1.6=37.5	60/2.0=30.0	39.17
E 200	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
E 400	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
E 600	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
E 800	65/1.2=54.17	65/1.6=40.63	65/2.0=32.5	42.43
E 1000	50/1.2=41.67	50/1.6=31.25	50/2.0=25.0	32.64
E 1200	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
E 1400	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
E 1600	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
E 1800	20/1.2=16.67	20/1.6=12.5	20/2.0=10.0	13.06
Mean	30.66	22.99	18.39	24.01

From Table 1, mineral rocks with very thin, intermediate, and very thick bodies have their depths ranges as 30.66m, 22.99m and 18.39m, respectively.

For traverse W800, the peak near station S160, the average depth calculated by Peter's half-slope method is 65.27m and N180 the average depth calculated by Peter's half-slope method is 13.06m; for traverse W600, the peak near station S480, the average depth calculated by Peter's half-slope method is 17.63m and for peak near S180, the average depth calculated by Peter's half-slope method is 13.06m; for traverse W400, the peak near station S380, the average depth calculated by Peter's half-slope method is 13.06m and the peak near station N20, the average depth calculated by Peter's half-slope method is 13.06m ; for traverse W200, the peak near station S380, the average depth calculated by Peter's half-slope method is 39.17m; for traverse 0, the peak near station S280, the average depth calculated by Peter's half-slope method is 39.17m; for traverse E200, the peak near station S480, the average depth calculated by Peter's half-slope method is 13.06m; for traverse E400, the peak near station S260, the average depth calculated by Peter's half-slope method is 42.43m and for peak S380, the average depth calculated by Peter's half-slope method is 13.06m; for traverse E600, the peak near station N120, the average depth calculated by Peter's half-slope method is 13.06m and peak near S100, the average depth is 13.06m; for traverse E800, the peak near station S380, the average depth calculated by Peter's half-slope method is 42.43m; for traverse E1000, the peak near station S340, the average depth calculated by Peter's half-slope method is 32.64m; for traverse E1200, the peak near station S280, the average depth calculated by Peter's half-slope

method is 13.06m; for traverse E1400, the peak near station S220, the average depth calculated by Peter's half-slope method is 13.06m; for traverse E1600, the peak near station S160, the average depth calculated by Peter's half-slope method is 13.06m; for traverse E1800, the peak near station S240, the average depth calculated by Peter's half-slope method is 13.06m. Based on this method, The shallower the depth, the thicker the body of the mineral rocks and the anomaly will be more pronounced. Also, the deeper the depth, the thinner the body of the mineral rocks and the anomaly will be less pronounced.

Comparison of Depths Calculated for a particular anomaly of the profiles in PDEPTH and Peter's half slope method

Profiles	Depth calculated using PDEPTH (m)	Avg. Depth calculated using Peter's half slope method (m)
W 800	70 (S180 to S100)	65.27 (S180 to S100)
W 600	80 (S240 to S220)	13.06 (S240 to S220)
W 400	70 (S400 to S360)	13.06 (S400 to S360)
W 200	75 (S460 to S400)	39.17 (S460 to S400)
0	75 (S280 to S240)	39.17 (S280 to S240)
E 200	100 (S440 to S320)	13.06 (S440 to S320)
E 400	80 (S400 to S320)	13.06 (S400 to S300)
E 600	70 (S120 to S60)	13.06 (S120 to S60)
E 800	75 (S420 to S340)	42.43 (S420 to S340)
E 1000	50 (S380 to S300)	32.64 (S380 to S300)
E 1200	34 (S300 to S240)	13.06 (S300 to S240)
E 1400	30 (S240 to S200)	13.06 (S160 to S200)
E 1600	34 (S180 to S140)	13.06 (S220 to S140)
E 1800	50 (S260 to S200)	13.06 (S260 to S200)
Mean	62.36	24.02

The average depth to the causative body (shallow) calculated for the area by Euler 3D solution is 70m; for radially averaged power spectra is 70 m, by PDEPTH analysis is 62.36m and by Peter's half slope method the depth is 24.02m. Thus, the average depth to the causative body (contacts/BIF/dykes) lies in the range of 20-80m in the surveyed area. However, in some cases, the depth to the top of body extends to 400m.

3.2.5 2D Geological Model from Magnetic (TF) Data:

a) Profile A-A'

An attempt has been made to prepare simple 2D geological model along the magnetic (TF) profile A-A' near to traverse 0 (Plate 6) using GM-SYS module of Oasis Montaj Software. The rock samples were collected from the study area during the magnetic survey and the susceptibility value was measured in MS2 magnetic susceptibility meter present in Geophysical lab, GSI, NR, Lucknow for preparation of magnetic model. The average measured susceptibility values for BHJ is 0.007 CGS unit and for Phyllite is 0.000012 CGS unit which was used for preparation of model. The susceptibility value for BIF has been taken as the standard value as 0.079 CGS unit. The depth estimated from Euler 3D deconvolution, P-Depth sections and Peter's half slope method have been utilized to generate 2D Geological model from magnetic data for this profile and is shown in Plate 10 (a).

The profile A-A' of about 225m length in NE-SW direction approximately orthogonal to the trends of contour from stations S150 to N50 of traverse 0 and passing through borehole SBB03, which cut across maximum features is selected for the modelling. The model profile shows the litho-units in the area are Ferruginous Phyllite, BIF and Phyllite. The average depth of the BIF/BHJ over magnetic high between stations N150 to N210 ranges between 40-60m and extended upto 150m.

a) Profile B-B'

Another 2D geological model along the magnetic (TF) profile B-B' near traverse E400 (Plate 6) has been prepared and shown in Plate 10 (b).

The profile B-B' of about 200m length in NE-SW direction approximately orthogonal to the trends of contour from stations S80 to N100 of traverse E400 and passing through proposed borehole SBB04, which cut across maximum features is selected for the modelling. The model profile mainly shows two litho-units in the high and low values named BHJ and Phyllite respectively. The variation of average depth of causative body over magnetic high between stations S80 to N270 is about 40m and extends up to 150m.

4. CONCLUSIONS AND RECOMMENDATIONS

Processing of the magnetic data helped to infer the shape, geometry and position of the bodies that produce the magnetic anomaly. The magnetic (TF) anomaly, magnetic Residual and Vertical derivative maps of magnetic data have revealed that the causative bodies are bipolar having NE-SW strike and elliptical in nature. The magnetic bodies are extending towards east and southeast. The magnetic (TF) anomaly map has brought out few contacts/fault in the surveyed block. These are NE-SW trending contact zone from traverses W600 to E1000 between stations N100 to S200 in central part, from traverse W400 to E800 between stations N40 to N260 in northern part, from traverse E800

to E1800 between stations 0 to S300 in southeastern part and between traverse W800 and W600 in southwestern part of the block. Residual high magnetic zones denoted as RH1 to RH7 (values ranges from 100-350nT) observed between stations ‘S50’ to ‘S200’ for traverse ‘W200’; ‘0’ to ‘S150’ for traverse ‘0’; ‘0’ to ‘S100’ for traverse ‘E200’; ‘N100’ to ‘S50’ for traverse ‘E400’; ‘N100’ to ‘0’ for traverse ‘E600’; ‘N20’ to ‘N200’ for traverse ‘E800’ and ‘N200’ to ‘N300’ for traverse ‘E1000’ and from stations ‘S250’ to ‘S300’ for traverse ‘W200’ and ‘0’; ‘S200’ to ‘S300’ for traverse ‘E200’ and ‘E400’; ‘S100’ to ‘S300’ for traverse ‘E600’ may be due to the presence of ferruginous material (BIF) at shallow depth. The two significant residual magnetic high anomalies (RH8, RH9) observed between stations 0 to S400 over traverses E1000 to E1800 showing values more than 350nT may be due to combined effect of magnetite bearing rocks and dolerite dykes in subsurface. These magnetic high anomalies are directly over the magnetic body in surface.

The Euler 3D deconvolution map, radially averaged power spectra, P-depth solution of Magnetic anomalies at each profile, Peter’s half slope methods and representative 2D geological models along two sections suggest that the average vertical depth to the top of causative body varies from 20-80m with minimum variation of 10%. The depth of the causative source increases towards south between traverses W800 to E1000 where it is greater than 75m. However, the depth of the source at some places reaches to 400m also. The maximum depth extension of the shallow causative bodies as estimated from 2D magnetic model is about 150m. The depth estimates obtained from magnetic data is in fair agreements with the drilling results.

Based on the results of magnetic (TF) survey, it is recommended to conduct detail magnetic survey in southeastern and eastern portion as the magnetic (TF) and residual magnetic anomaly values are increasing. Further, two test borehole points along BIF marker band and two deep boreholes, one in northern and other in southeastern parts are recommended. The details are:

Traverse/station	Lat./Long.	Estimated depth to the top of body
1. E800/N60	24 ⁰ 34’03.51”/82 ⁰ 54’20.18”	60-70m (with min. 10% variation)
2. E1200/N80	24 ⁰ 34’03.98”/82 ⁰ 54’34.40”	60-70m (with min. 10% variation)
3. E1000/N160	24 ⁰ 34’06.67”/82 ⁰ 54’27.33”	40-50m (with min. 10% variation) (upto max. 400m)
4. E800/S460	24 ⁰ 33’46.61”/82 ⁰ 54’19.92”	20-30m (with min.10% variation) (upto max.400m)

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6. PARTY PERSONNEL

Smt. Saudamini Sahoo,	Geophysicist
Sri C.B. Tiwari,	Geophysicist
Sri R. K. Saxena,	Senior Surveyor
Sri R.K. Verma,	Driver

DAYS SPENT IN FIELD BY PARTY MEMBERS

Saudamini Sahoo	Geophysicist	61 days
C.B Tiwari	Geophysicist	34 days

7. REFERENCES

1. Aaron K. Waswa1, Christopher M. Nyamai, Eliud Mathu, Daniel W. Ichang'i 'Application of Magnetic Survey in the Investigation of Iron Ore Deposits and Shear Zone Delineation: Case Study of Mutomo-Ikutha Area, SE Kenya'. International Journal of Geosciences, 2015, 6, 729-740.
2. Akintayo O. Ojo, Toyin O. Omotoso, Olorunyomi J. Adekanle, 'Determination of Location and Depth of Mineral Rocks at Olode Village in Ibadan, Oyo State, Nigeria, Using Geophysical Methods', Hindawi Publishing Corporation International Journal of Geophysics Volume 2014, Article ID 306862, 13 pages.
3. Cooper G.R.J., Manzi M.D., 'Determining the depth of magnetic sources'. School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa.
4. Fitzgerald, D., Reid, A. and McNerney, P., 'New discrimination techniques for Euler deconvolution: 8th SAGA Biennial Technical Meeting and Exhibition', 7-10, October 2003.

5. Ismail S., Saada A., Youssef M.Y. Ali and Youssef M.Y. Ibrahim: 'An Integrated Study of Gravity and Magnetic Data to Determine Subsurface Structure and Depth to Basement in Alamein Area, Western Desert, Egypt'. IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) e-ISSN: 2321-0990, p-ISSN: 2321-0982. Volume 3, Issue 6 Ver. II (Nov. - Dec. 2015), PP 11-29.

6. Kumari K., Nekkanti P.K., Tiwari C.B.: 'Report on geophysical survey for preliminary exploration for iron ore in Mahakoshal group, block 'A', Bharhari area', Sonbhadra district, Uttar Pradesh (toposheet no. 63I/14). Field season: 2017-18.

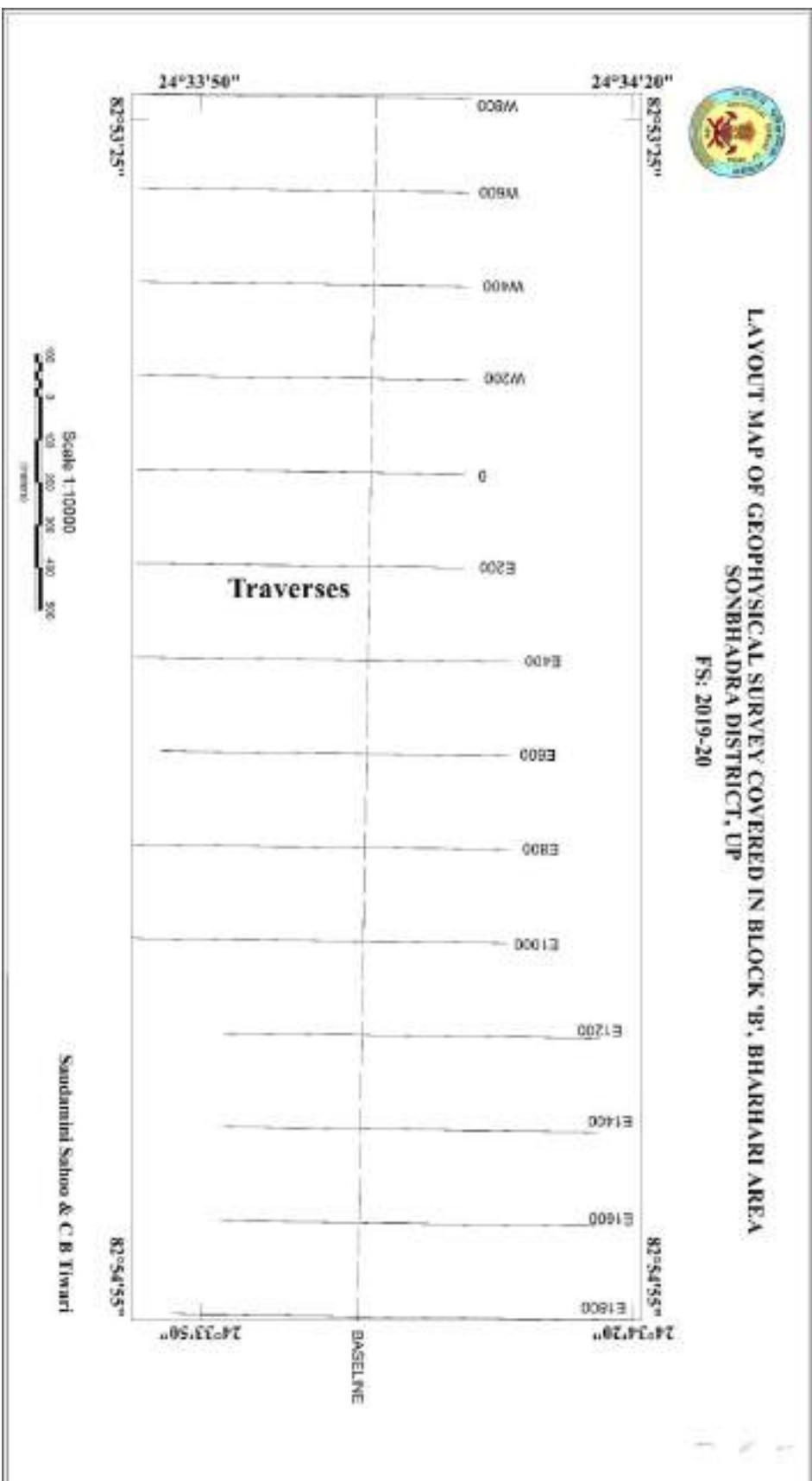
7. Luis M. Alva-Valdivia and Hector López-Loera: A review of iron oxide transformations, rock magnetism and interpretation of magnetic anomalies: El Morro Mine (Brazil), a case study-Geofísica Internacional (2011) 50-3: 341-362

**APPENDIX-I: COORDINATES OF MAGNETIC TRAVERSES OF BHARHARI BLOCK 'B',
FS: 2019-20**

SI.	TRAVERSE ID	ST.NO.	LONG			LAT			REMARK
			DD	MM	SS	DD	MM	SS	
1.	W 800	N 200	82	53	23.39	24	34	08.78	TRAVERSE DIRECTION NORTH-SOUTH.
2.		0	82	53	23.29	24	34	02.28	
3.		S 500	82	53	23.05	24	33	46.03	
4.	W 600	N 200	82	53	30.50	24	34	08.69	
5.		0	82	53	30.40	24	34	02.19	
6.		S 500	82	53	30.16	24	33	45.94	
7.	W 400	N 200	82	53	37.60	24	34	08.06	
8.		0	82	53	37.51	24	34	02.10	
9.		S 500	82	53	37.26	24	33	45.85	
10.	W 200	N 200	82	53	44.71	24	34	08.51	
11.		0	82	53	44.61	24	34	02.01	
12.		S 500	82	53	44.37	24	33	45.76	
13.	0	N 200	82	53	51.82	24	34	08.42	
14.		0	82	53	51.72	24	34	01.92	
15.		S 500	82	53	51.48	24	33	45.67	
16.	E 200	N 200	82	53	58.92	24	34	08.33	
17.		0	82	53	58.83	24	34	01.83	
18.		S 500	82	53	58.58	24	33	45.58	
19.	E 400	N 300	82	54	06.08	24	34	11.49	
20.		0	82	54	05.93	24	34	01.74	
21.		S 500	82	54	05.69	24	33	45.49	
22.	E 600	N 300	82	54	13.19	24	34	11.40	
23.		0	82	54	13.04	24	34	01.65	
24.		S 440	82	54	12.82	24	33	47.35	
25.	E 800	N 300	82	54	20.29	24	34	11.31	
26.		0	82	54	20.15	24	34	01.56	
27.		S 500	82	54	19.90	24	33	45.31	
28.	E 1000	N 300	82	54	27.40	24	34	11.22	
29.		0	82	54	27.25	24	34	01.47	
30.		S 500	82	54	27.01	24	33	45.22	

31.	E 1200	N 500	82	54	34.60	24	34	17.63	
32.		0	82	54	34.36	24	34	01.38	
33.		S 300	82	54	34.21	24	33	51.63	
34.	E 1400	N 500	82	54	41.71	24	34	17.54	
35.		0	82	54	41.47	24	34	01.29	
36.		S 300	82	54	41.32	24	33	51.54	
37.	E 1600	N 500	82	54	48.82	24	34	17.45	
38.		0	82	54	48.57	24	34	01.20	
39.		S 300	82	54	48.42	24	33	51.45	
40.	E 1800	N 600	82	54	55.97	24	34	20.61	
41.		0	82	54	55.68	24	34	01.11	
42.		S 400	82	54	55.48	24	33	48.11	

Plate 1

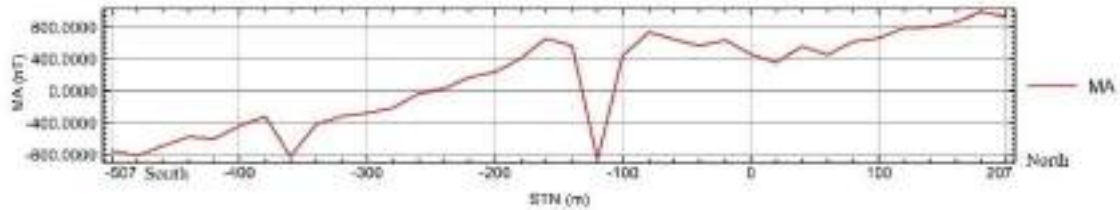




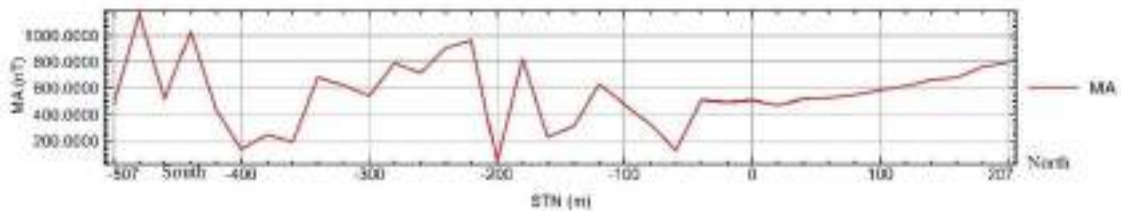
MAGNETIC (TF) PROFILES ALONG TRAVERSES W800, W600, W400, W200 AND 0, BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT, U.P.,

FS: 2019-20

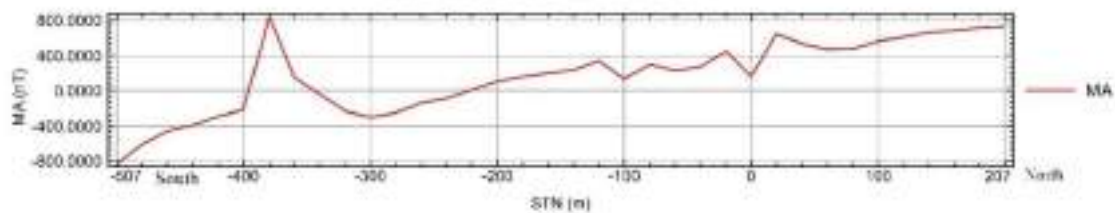
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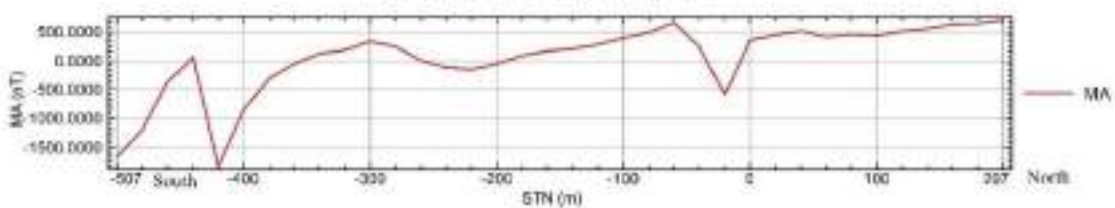
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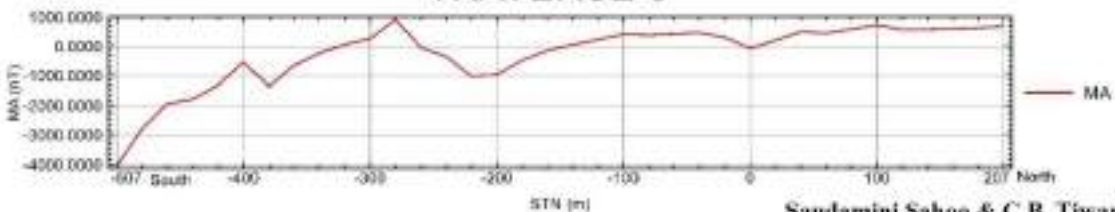
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TRAVERSE W200



TRAVERSE 0



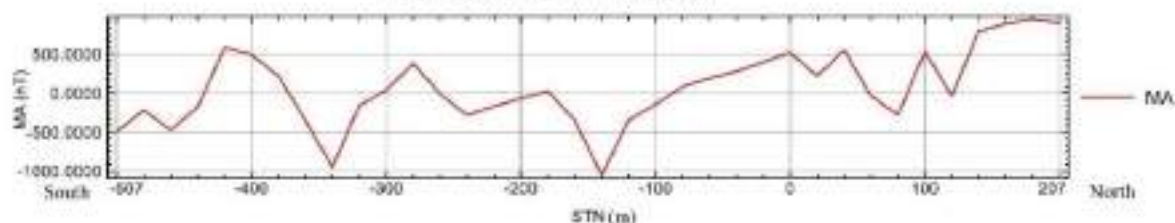
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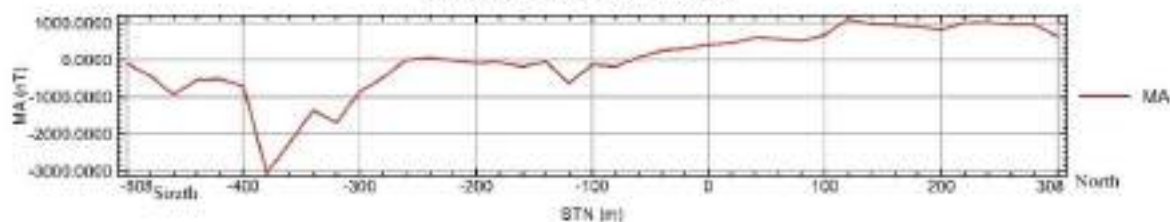
MAGNETIC (TF) PROFILES ALONG TRAVERSE E200, E400, E600, E800 AND E1000, BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT, U.P.,

FS: 2019-20

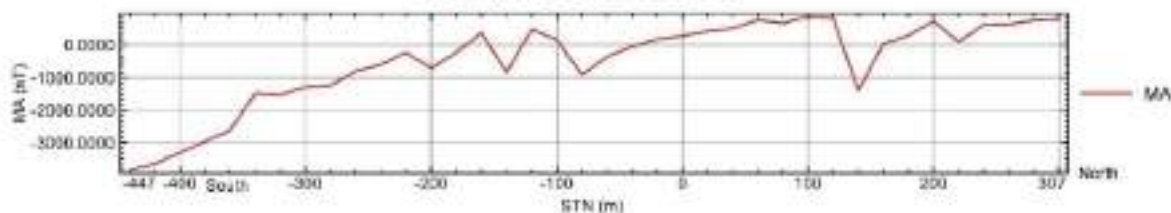
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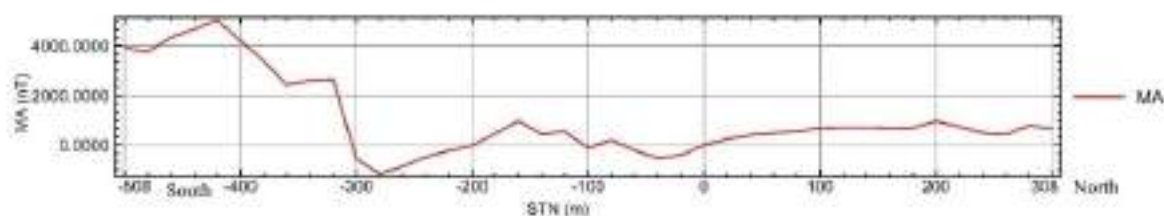
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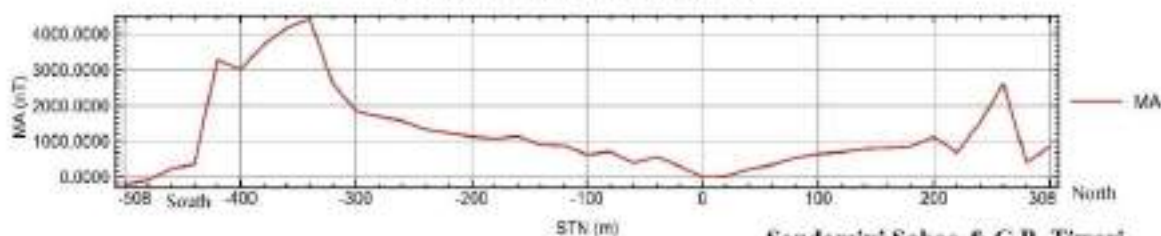
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TRAVERSE E800



TRAVERSE E1000

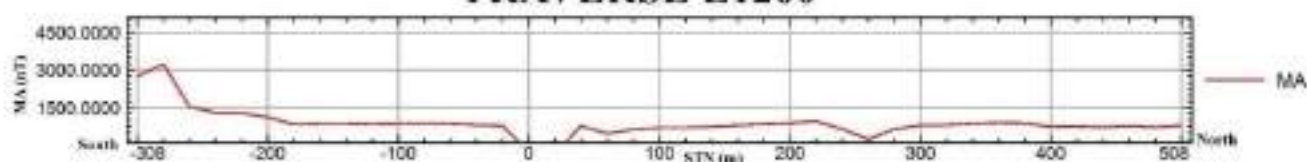


Saudamini Sahoo & C.B. Tiwari

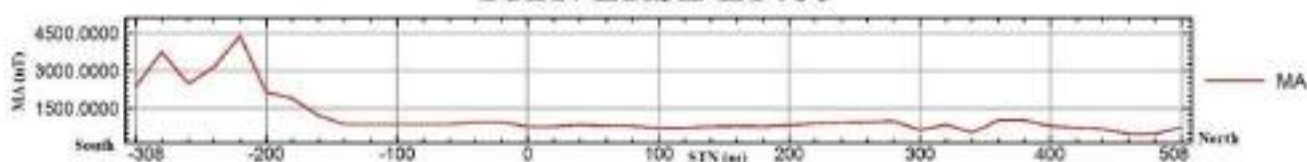


**MAGNETIC (TF) PROFILES ALONG TRAVERSES E1200,
E1400, E1600 AND E1800, BLOCK 'B', BHARHARI AREA,
SONBHADRA DISTRICT, U.P.,
FS: 2019-20**

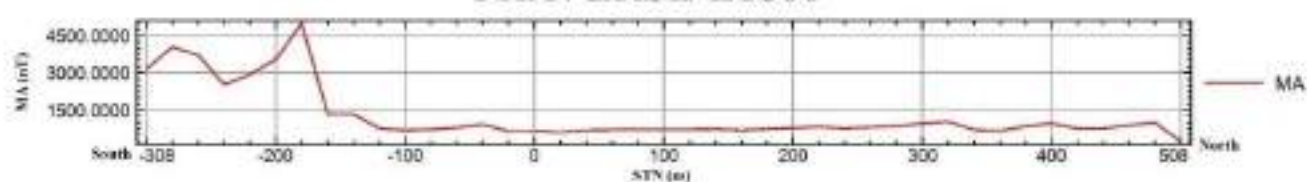
TRAVERSE E1200



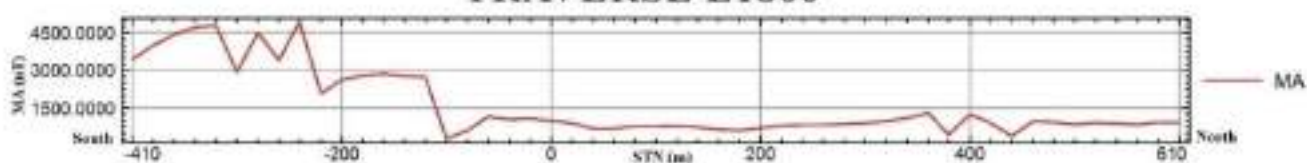
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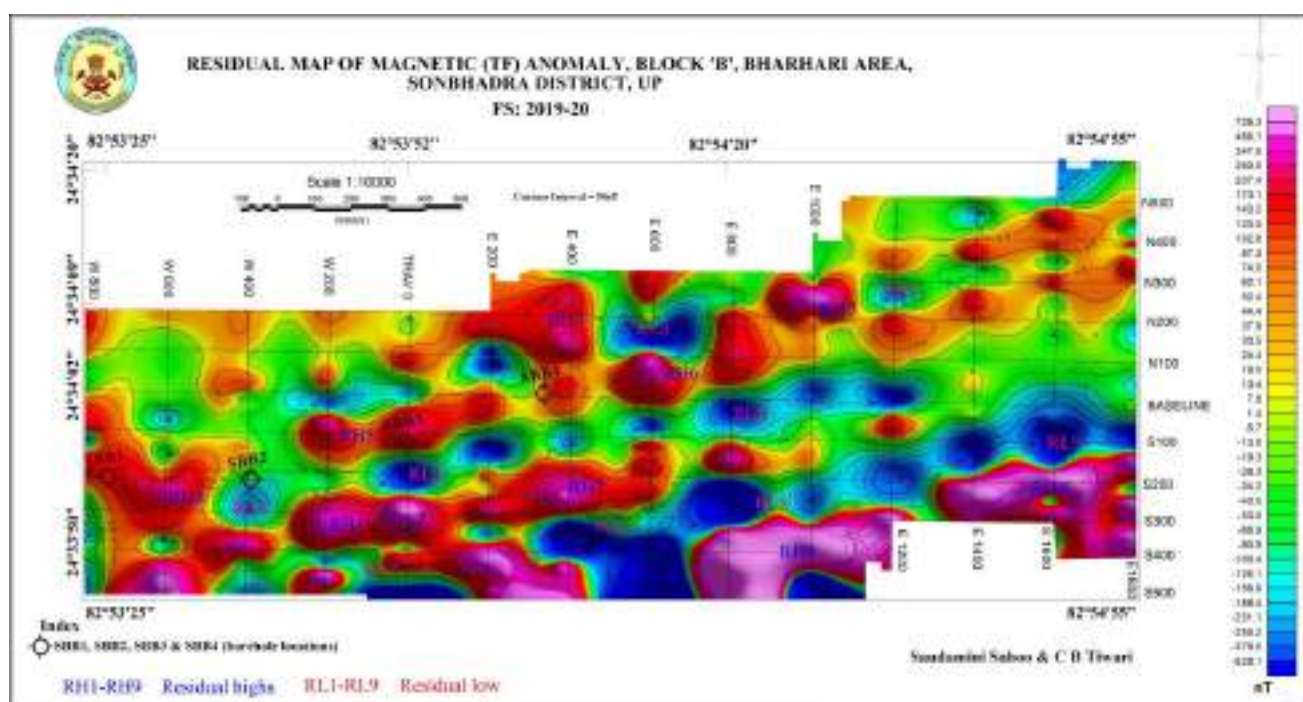
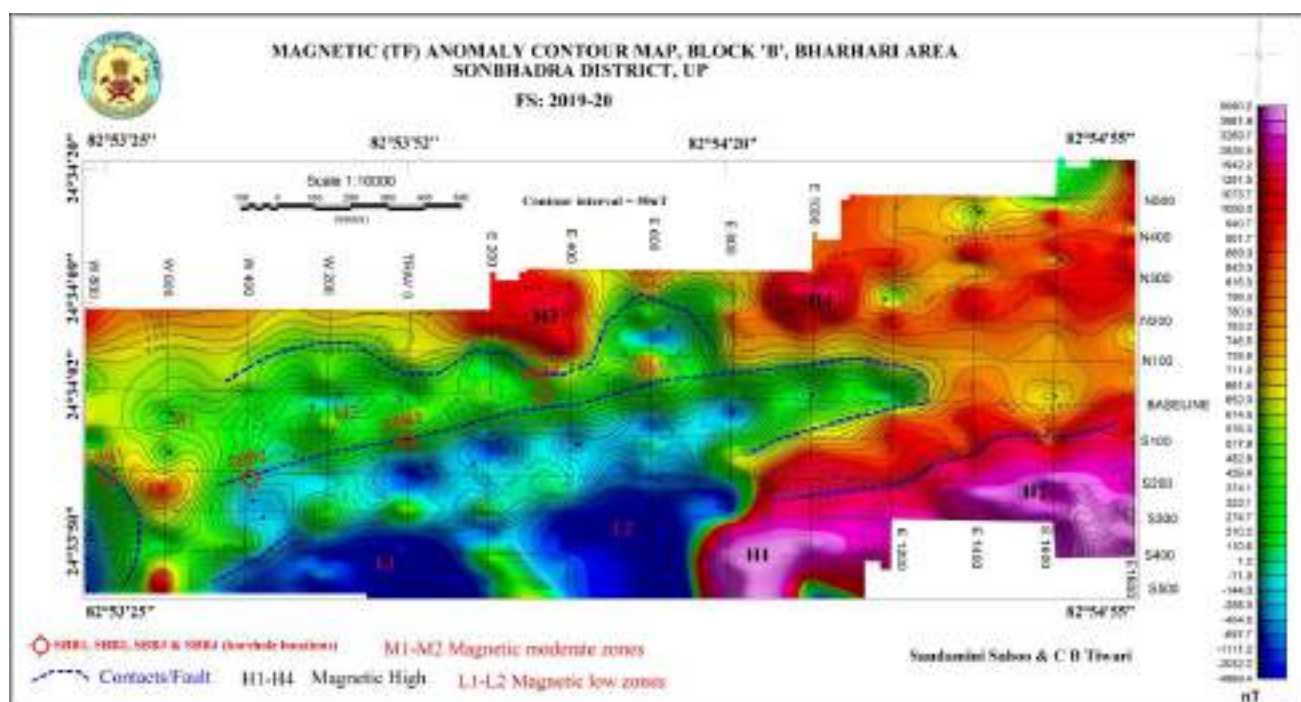
TRAVERSE E1600

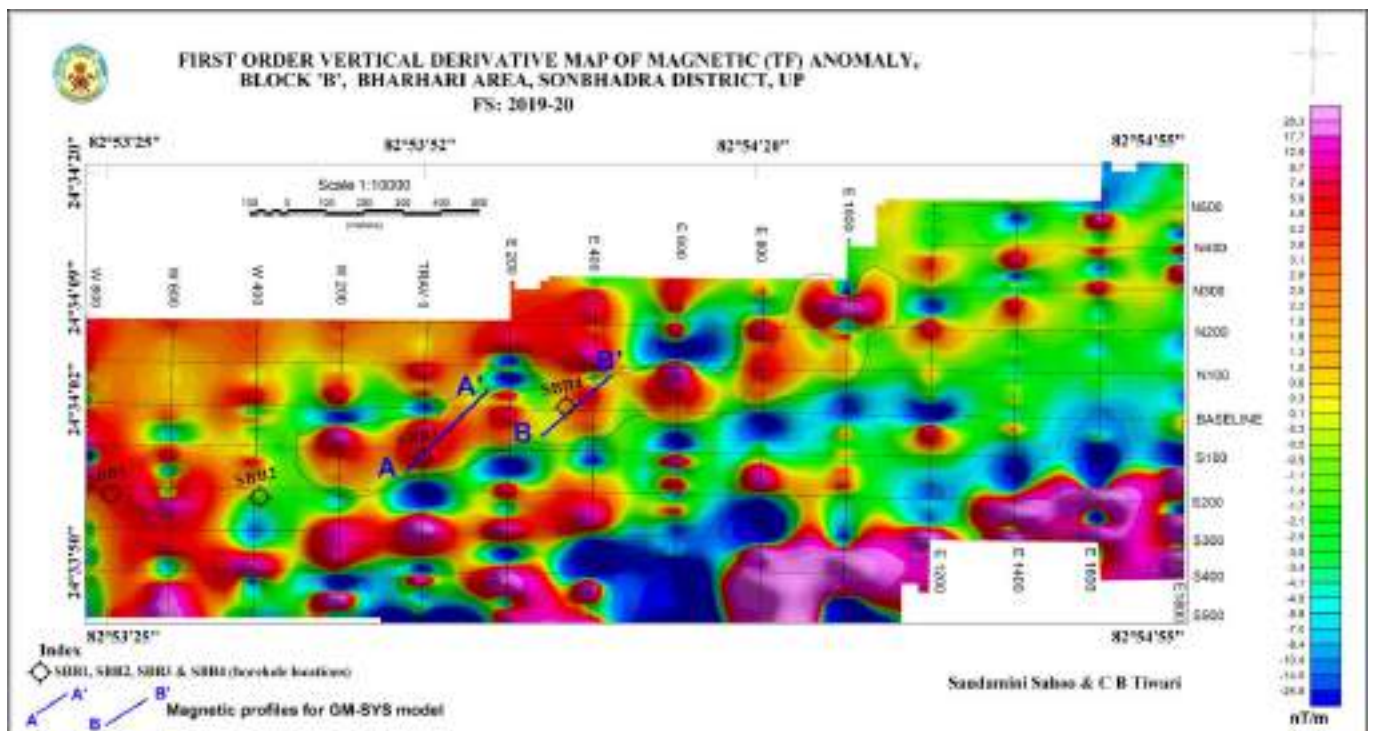
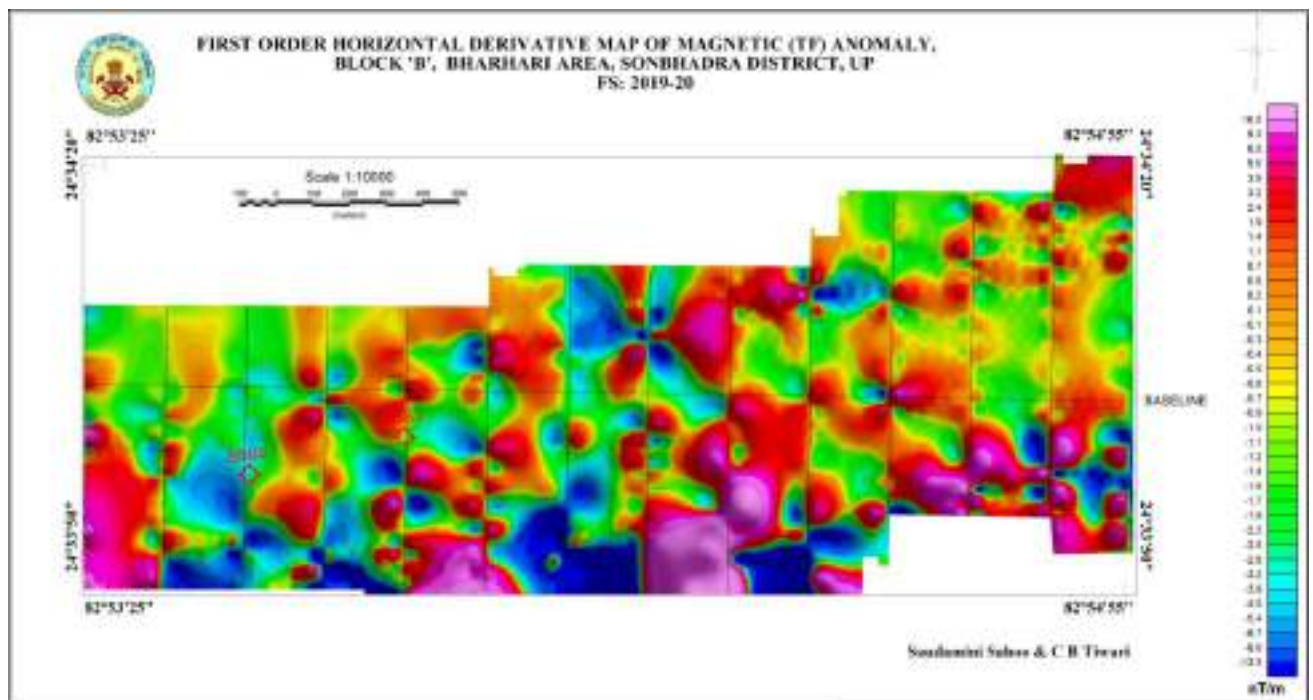


TRAVERSE E1800



Saudamini Sahoo & C.B. Tiwari





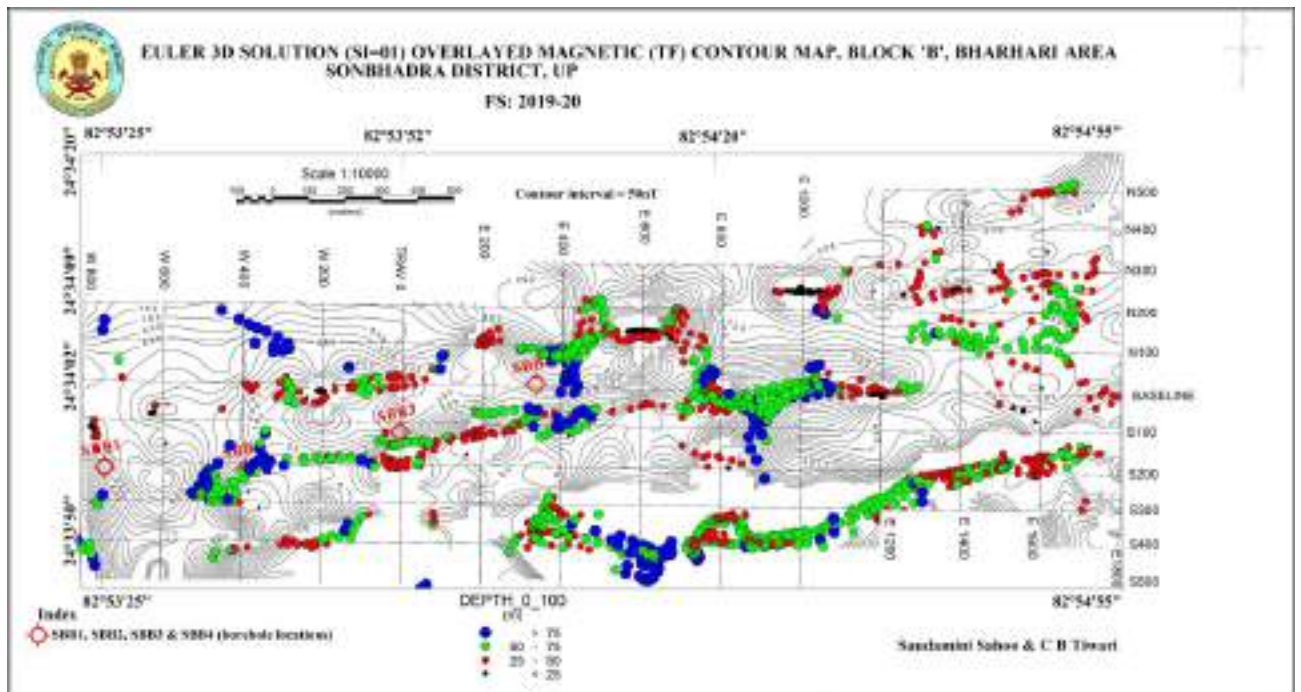
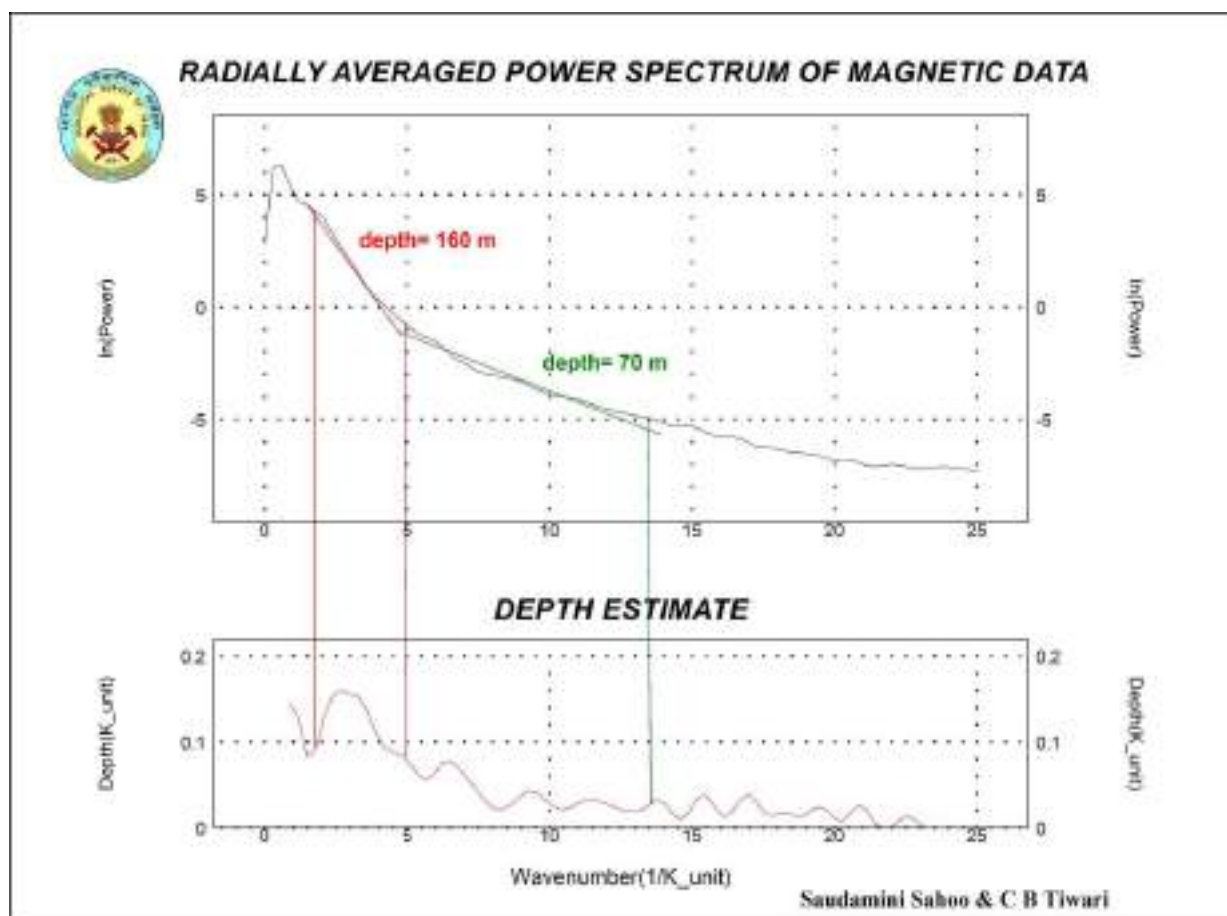


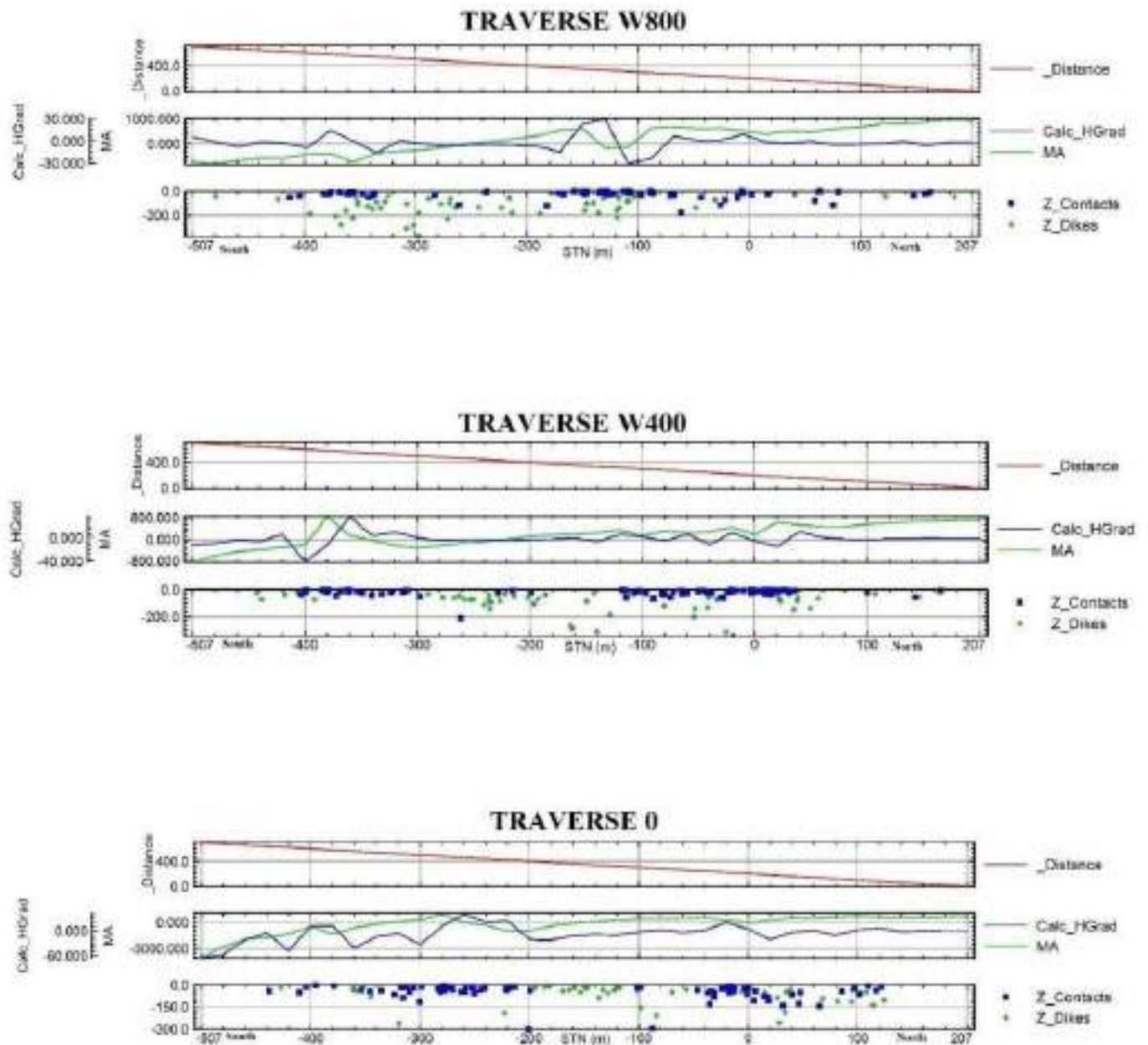
Plate 7 (a)





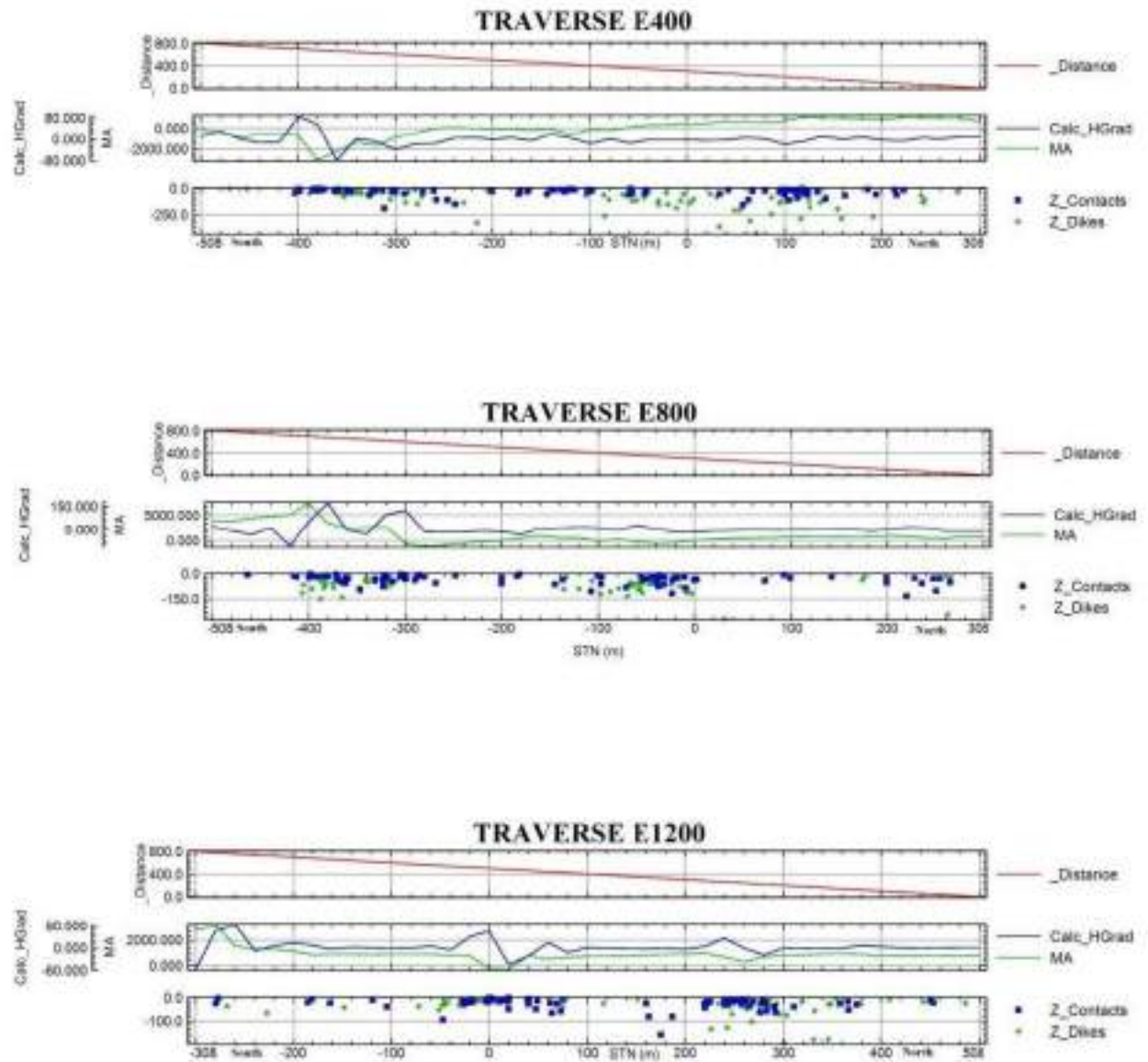
REPRESENTATIVE PDEPTH (USING ANALYTIC SIGNAL)

SECTION OF MAGNETIC (TF) DATA ALONG TRAVERSES W800, W400 & 0, BLOCK 'B', BHARHARI AREA



Saudamini Sahoo & C.B. Tiwari

REPRESENTATIVE PDEPTH (USING ANALYTIC SIGNAL)
SECTION OF MAGNETIC (TF) DATA ALONG TRAVERSES E400,
E800, E1200 & E1600, BLOCK 'B', BHARHARI AREA



Saudamini Sahoo & C.B. Tiwari

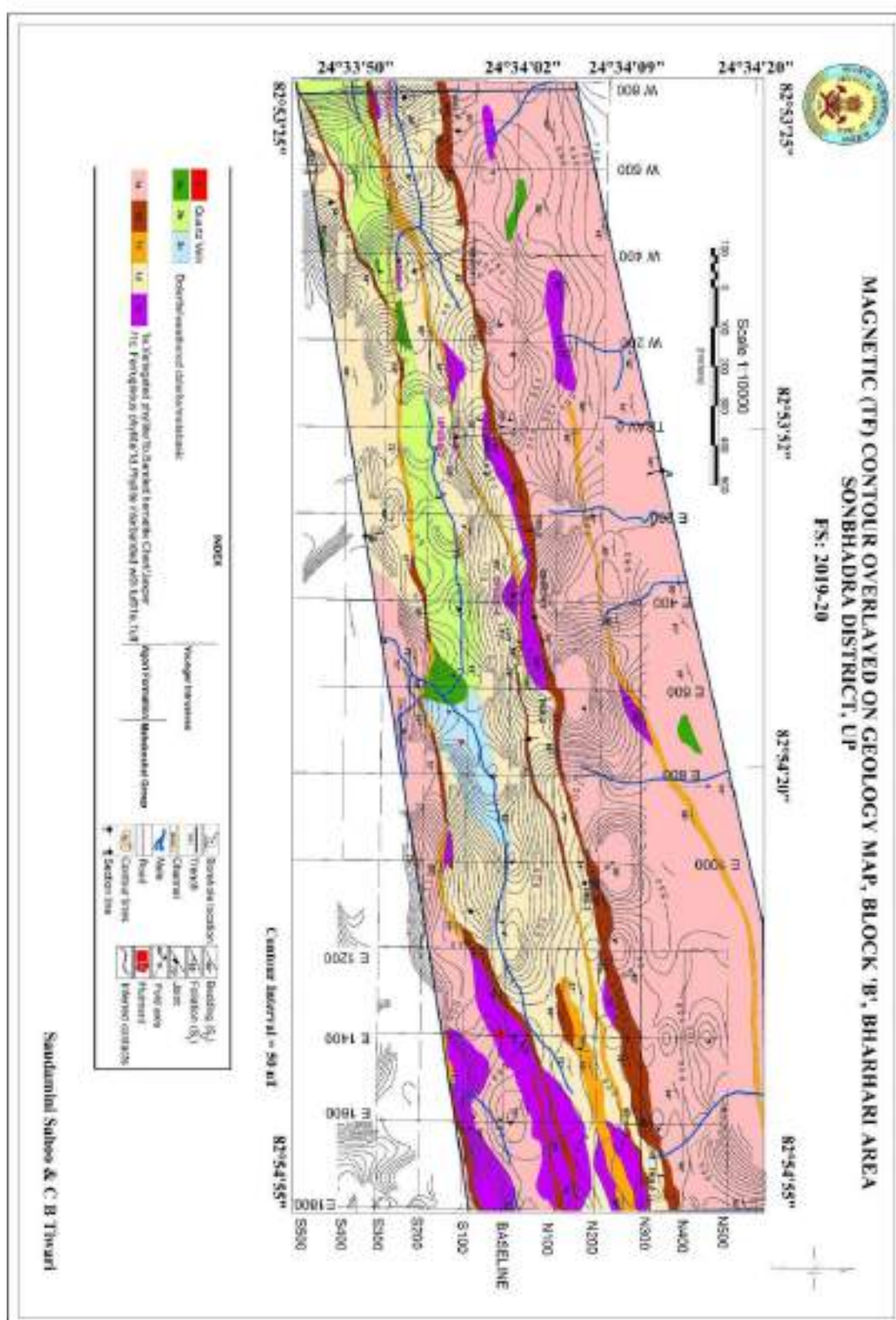
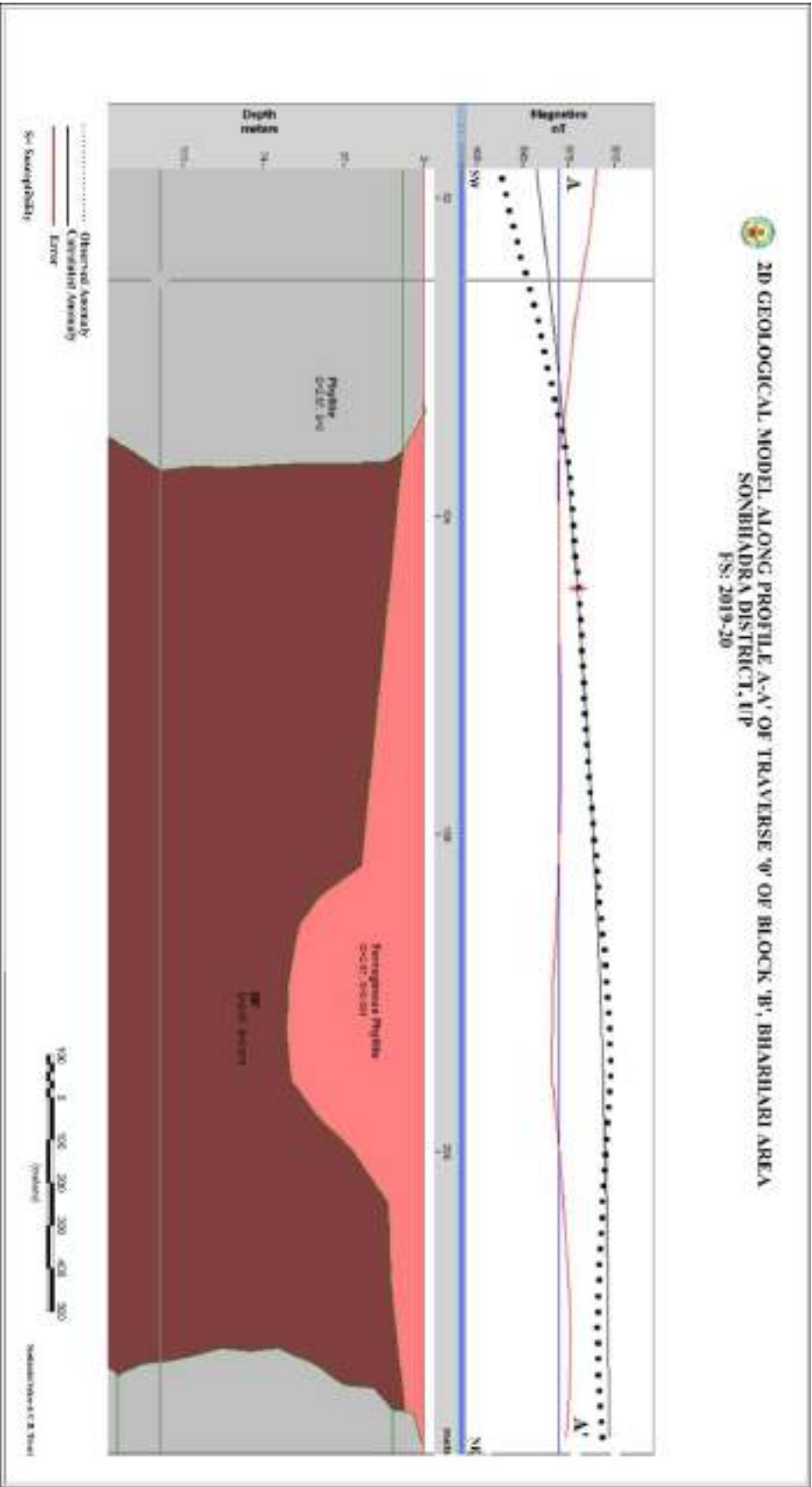
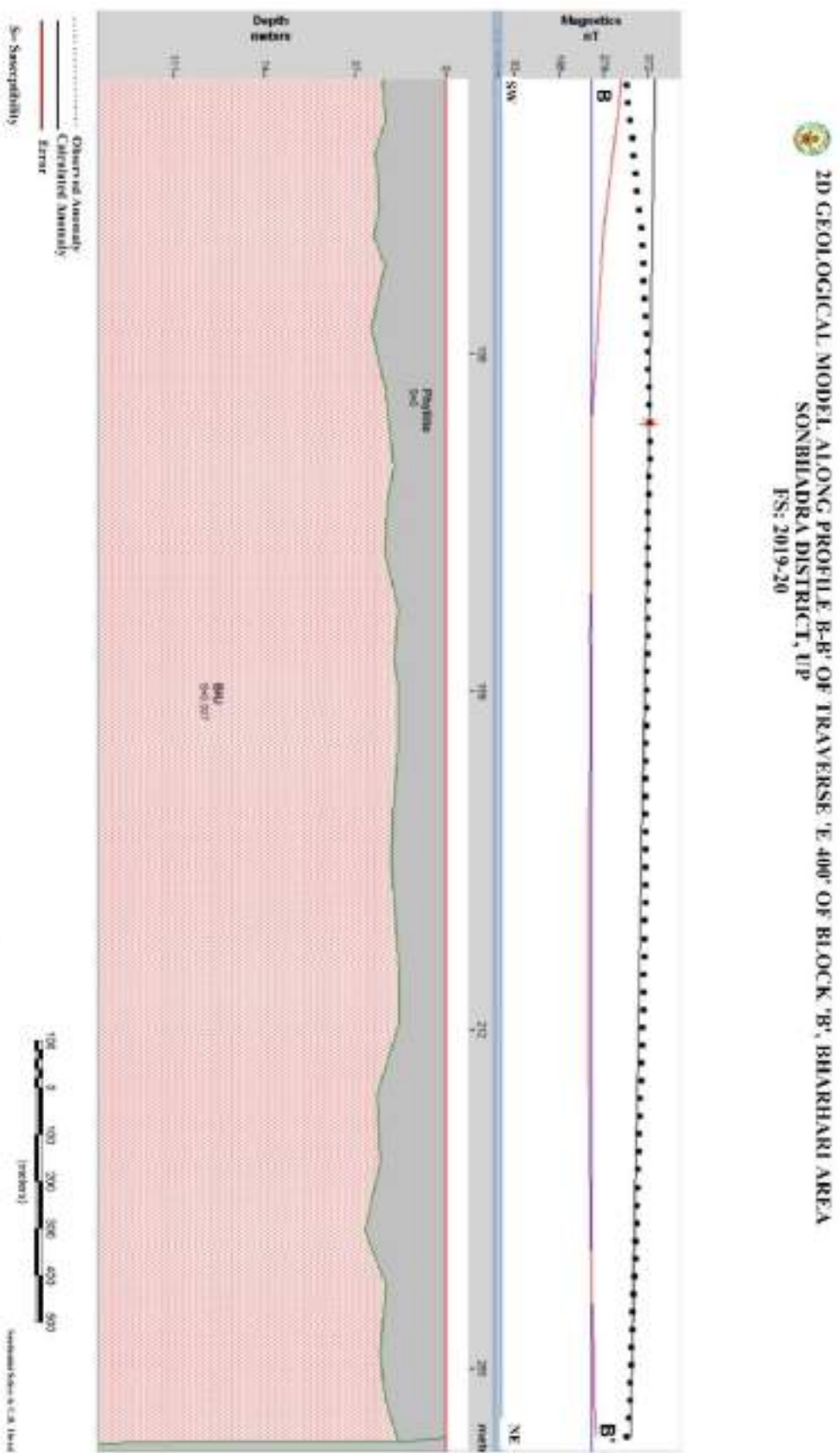


Plate 10a





FIVE POINT PROFORMA

Title of the report:	PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH. (Stage - G3)
Authors:	Mukeshkumar Rajkumar Shrivastav, Senior Geologist Shamiuddin Ahmad, Assistant Geologist Uday Narayan, Senior Geologist (additional charge)
1. Background of information i.e. whose instance or with what particular objective in view the investigation was undertaken	The NGCM was carried out by Sarkar et. al. during F.S. 2013-14 in toposheet no 63L/14 and shows high Fe_2O_3 (>14%) value in the composite samples. Geophysical mapping carried out during F.S. 2009-2012 has also revealed a gravity high supplemented with high magnetic values in the southern part of the Toposheet No. 63 L/14. Shri Modak et. al. carried out large scale mapping on 1:12500 scale covering parts of toposheet 63 L/14 during FS 2014-15. The total strike length of these Banded hematite chert / jasper bands is around 20 kms and width varies from 2m to 10m with cumulative width of 170 m to 450 m. The value of Fe_2O_3 varies from 32.79% to 64.18 %, with 14 samples having more than 60% of Fe_2O_3 in two eastern most blocks. On the basis of the iron ore investigation in western block of the area by Shree Mukesh Kumar Shrivastava and Shamiuddin Ahmad it was observed that the trench samples (18 nos) from trench-1 show Fe_2O_3 values ranging from 44.69% to 67.49% with average value of 54.71%. In TR-2 (13 nos), Fe_2O_3 values varies from 1.46 % to 44.13 % with an average value of 17.63% and in TR-3 (10 nos) Fe_2O_3 ranges from 14.88 % to 49.67 % averaging 30.53 %. In TR-4 (10 samples) Fe_2O_3 values varies from 41.98 % to 61.78 % averaging 50.57 %. In channel samples (10 BIF samples), the Fe_2O_3 values varies 26.92% to 44.22% with an average of 37.5 %. A total of 8 boreholes were planned to achieve the drilling target of 750m. A total of 822.70 m drilling has been achieved by the drilling of eight boreholes namely SBE-1, SBE-2, SBE-3, SBE-4, SBE-5, SBE-6, SBE-7 and SBE-8. The estimated resource of 14.89 million tonnes (MT) with average grade of 34.73% Fe at 30 % cut off and 8.41 million tonnes (MT) with average grade of 38.34% of Fe at 35 % cut off was reported in FS: 2017-18.
2. Whether the item of investigation was included in approved programme for the year concerned, if so particulars such as item No., page etc. may be given.	YES Item no. M2AFGBM-MEP/NC/NR/SU-UP/2019/26399
3. Date of commencement of the investigation with month, year and exact number of days spent in the field in connection with the investigation.	30-04-2019 Number of field days: Mukeshkumar Rajkumar Shrivastav, Senior Geologist – 131 days Shamiuddin Ahmad, Assistant Geologist – 67 days Uday Narayan, Senior Geologist (additional charge)- 56 days
4. Brief account by you on the conclusions and recommendations made by the author with suggestions for implementing the same.	I agree with the conclusion and recommendation made by the authors.
5. Please state specifically how the results of investigation compare with the objective for which it was undertaken.	Results of the investigation fulfill the objective for which the investigation was undertaken.


 (Pushpesh Narayan)
 Director

REPORT DATA

1. Title: PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH. (Stage: G-3)
2. Author(s): Mukeshkumar Rajkumar Shrivastav, Senior Geologist
Shamiuddin Ahmad, Assistant Geologist
Uday Narayan, Senior Geologist
3. Field season: 2019-20
4. Year (s) (in case item continues from an earlier FSP): 1 year
5. FSP Code No.: M2AFGBM-MEP/NC/NR/SU-UP/2019/26399
6. Theme: Mineral Investigation
7. Subtheme: To assess the economic potentiality of iron ore occurrence in the area.
8. Status: Limited circulation report.
9. State: Uttar Pradesh.
10. District: Sonbhadra
11. Toposheet: 63 L/14
12. Key Locations: Bharhari, Bargawan, Jogail, Chopan
13. **Short Abstract:**

The preliminary exploration for Iron ore in Block 'B', Bharhari area, Sonbhadra, U.P. was carried out in 2.1 sq km by detailed mapping on 1:4000 and G-3 stage drilling. The block area of investigation lies between NE 24° 34' 29.68", 82° 54' 49.66"; NW 24° 34' 04.39", 82° 53' 09.93"; SW 24° 33' 44.04", 82° 53' 12.07" and SE 24° 33' 59.71", 82° 55' 09.83" and falls under SOI toposheet no. 63L/14. It is situated in the east of the Bharhari village. The litho-units exposed in the block are variegated phyllite, phyllite interbanded with tuff, tuff, banded hematite chert / jasper (BIF), ferruginous phyllite of Agori Formation of Mahakoshal Group and dolerite dyke and quartz vein as intrusives. The banded hematite chert / jasper is exposed at the hill top with a strike length of 3.12 km and width ranging from 9m to 54m. The general trend of the rock types in the study area is ENE-WSW (N65°E-S65°W to N85°E-S85°W) with dip amount of 50° to 80° towards south.

The banded hematite chert / jasper is a distinct rock unit with bands of iron oxide, chert and/or jasper. The iron oxide is dark grey to reddish brown and chert bands are light grey while the jasper bands are brilliant vermilion red in colour. The thickness of the individual hematite bands varies from a 1mm to 8cm while chert/jasper bands generally

having thickness of 1mm to 4cm.

A total of 80 nos. bed rock samples (including 26 nos. channel samples), 79 nos. trench samples from five trenches and 195 nos. core samples (including 6 nos. check samples) from four boreholes were collected. The chemical results suggested Fe values of banded hematite chert / jasper in bed rock samples vary from 6.67 % to 46.39 % with an average of 26.51 %. The analytical values of 26 nos. channel samples have revealed the Fe values ranging from 25.20 % to 62.81 % with weighted average of 43.28 % Fe.

Total five trenches were excavated in the area during the course of the present investigation to study the strike / width continuity of banded hematite chert / jasper. The trenches were cut across the trend of the banded hematite chert / jasper wherever it is not exposed and 79 samples were collected. The Fe values in trench samples of TRB-1 varies from 12.64 % to 56.15 % with 34.39% Fe as weighted average, while in TRB-2, Fe values vary from 26.68 % to 45.87 % with weighted average value of 35.53 % and Fe values of TRB-3 samples range from 20.21 % to 59.17 % with weighted average of 44.33 %. The trench TRB-4 suggests Fe ranging from 42.38 % to 51.01 % and weighted average of 45.87 %. In trench TRB-5, Fe values ranges from 26.95 % to 62.54 % with weighted average of 43.45 %.

A total of 461.30m of drilling was carried out through four boreholes. The drilling was planned to intersect the banded hematite chert / jasper to understand the subsurface continuity of exposed bands. At the sub-surface, the exposed BIF were planned to intersect at 30 m vertical depth from 400m datum line. A total of four boreholes viz. UPSBB-1, UPSBB-2, UPSBB-3 and UPSBB-4 were drilled at an interval of 400m each. Due to rugged terrain conditions, the drilling was a challenging task.

In the borehole no. UPSBB-1, a total 72.30 m thick banded hematite chert / jasper band was intersected at the depth interval of 22.50 to 61.50m, 63.30 to 67.50m, 72.90 to 96.10 and 100.20 to 106.10m. In the drilled borehole of UPSBB-2, total BIF thickness is 28.75 m, in which the typical BIF was intersected at the depth interval of 131.0 to 156.25m. In the borehole UPSBB-3, the BIF intersected from 94.00m to 127.45m having total thickness of 33.45 m. The borehole UPSBB-4 was drilled only to the depth of 43.50m, the BIF could not be intersected due to early closing of borehole (at 43.50m depth). The further drilling of borehole was stopped as per order no.____ /45A/FS 2019-20/Mod/PSS:P&M-2/2020 dated 29/05/2020. A total of 195 core samples were submitted for chemical analysis from borehole nos UPSBB-1, UPSBB-2, UPSBB-3 and UPSBB-4. Mineralized zones have been demarcated at 30% and 35% Fe cut off for borehole no. UPSBB-1, UPSBB-2 &

UPSBB-3. At 30 % Fe cut off, the maximum grade of 42.94% Fe has been established for a total thickness of 1.70m in UPSBB-1 while at 35% Fe cut off, the maximum thickness of 8.05m has been brought out with an average grade of 39.35% Fe in borehole UPSBB-3. The highest grade of Fe mineralization is 43.64% with total thickness of 1.20m in the investigated block.

A total resource of 10.77 million tonnes (MT) with average grade of 34.50% Fe at 30% cut off and 5.03 million tonnes (MT) with average grade of 39.51% of Fe at 35 % cut off have been estimated in block-‘B’ of the Bharhari area, Sonbhadra. The investigation fulfils 333 category of UNFC classification.



Geological Survey of India

Data sheet on report movement in connection with its scrutiny

Project/Division

M. 2A FGBM-MEP/NL/NR

FSP No

M 2A FGBM-MEP/NL/NR

SU-UP/2019/26399

Mission - II

Title of the report

Preliminary Exploration for Iron ore in Mahakosal Group Block - B, Bhatkai area Sambalpur district U.P. (Stage - G-3)

Name of author(s) Mukesh Kumar R. Shrivastava Shamimuddin Ahmad, Sr. Geol. Uday Narayan, Sr. Geol.	Date of submission of report to the Supervisory Officer 30-06-2020 Signature of the senior most author [Signature] 30-06-2020
Name of Supervisory Officer Pushpesh Narayan	Date of receipt of report (soft copy) 30/06/2020 Date of completion of scrutiny 12/07/2020 Date of handing over report to the author after scrutiny 13/07/2020 Signature [Signature] 13/07/2020
Name of author(s) To whom the report has been handed over by the Supervisory Officer UDAY NARAYAN	Date of receipt after scrutiny 13-07-2020 Signature Uday Narayan Date of resubmission 21-08-2020 Signature Shamimuddin Ahmad
Supervisory Officer Pushpesh Narayan	Date of receipt after modification 21/08/2020 (soft copy) Date of handing over report to the Regional Mission Head 31/08/2020 (soft copy) Signature [Signature]
Name of Regional Mission Head Shri. S. K. Saha DDG & RMH-II, NR	Date of receipt of report 07-09-2020 Date of handing over the report after peer review to the Project Director 21-09-2020 Signature [Signature]
Name of Supervisory Officer Pushpesh Narayan Director, MEPII, SU-UP	Date of receipt from the Regional Mission Head after peer review 21-09-2020 Date of handing over to author(s) 21-09-2020 Signature [Signature]
Name of author(s) SHAMIMUDDIN AHMAD	Date of receipt of report from Supervisory Officer 21/09/2020 Date of handing over report after modification to Supervisory Officer 17/10/2020 Signature Shamimuddin Ahmad
Name of Supervisory Officer	Date of receipt of report after

<u>Pushpesh</u> <u>Narayan</u>	modification from the author(s) <u>17/11/2020</u> Date of handing over report to Regional Mission Head <u>17/11/2020</u> Signature <u>GO. 12/11/2020</u>
Name of Regional Mission Head <u>Supriya Kr. Sela</u>	Date of receipt after modification from the Project Director. <u>17-11-2020</u> Date of handing over the report to the HoD of the Region for approval <u>23-11-2020</u> Signature <u>GO. 12/11/2020</u>
Name of the HoD of the Region <u>Smt. Vansha Ashok</u> <u>Aglawe</u> <u>DDG & HOD</u>	Date of receipt of report for approval <u>24-11-2020</u> Date of approval <u>24/11/2020</u> Date of sending back report to Project Director. <u>24/11/2020</u> Signature of the HoD <u>GO. 12/11/2020</u>
Name of the Project Director <u>Pushpesh Narayan</u> <u>an</u>	Date of receipt of report after approval of HoD <u>27/11/2020</u> Date of circulation of report Signature <u>GO. 12/11/2020</u>



Geological Survey of India

Certificate of Quality of the report

Project/Division
Title of the report

FSP No

Mission - II

Part-A

This is to certify that the following officer(s) have carried out the above mentioned FSP, and are responsible for collection of field data, carrying out the required laboratory analysis, compilation and synthesis of field data, coalition of the data and writing of the report as per the approved guidelines. The duration of field stay of each officer(s) is as against his/her name.

Name(s)/Designation of the Field Officer	Total field stay during the FSP (no. of days)	Signature with date
1. Mukesh Kumar R. Shivraj	131	[Signature] 20.06.2020
2. Shaminuddin Ahmad, R. Geol.	67	[Signature] 20.06.2020
3. UDAY NARAYAN, Sr. Geologist	56	[Signature] 20.06.2020

Part-B

This is to certify that drilling has been carried out and completed as per the table given below:

Drilling Unit No	Date of commencement of drilling	Date of completion of drilling	Name and Signature of the Director Drilling
1. DU-467	24.05.2019	24.03.2020	[Signature] 20.06.2020
2.			

Part-C

This is to certify that geophysical component of the item has been carried out as per the table given below:

Name(s)/Designation of Geophysist	Date of commencement of work	Date of completion of work	Signature with date of the Geophysist
1. SAUDAMINI SAHOO, Geophysist	01.11.2019	22.01.2020	[Signature] 16.11.2020
2. C.B. Tiwari, Geophysist	" "	" "	[Signature] 13.11.2020
Name and signature with date of the Director (Geophysics)			[Signature] 18.11.2020

Part-D

This is to certify that the chemical analysis of the geological samples has been carried out as per the table given below:

Name of Director in charge of the Chemical Lab	Dates of receipt of samples from the field officer/party	Date of providing complete analytical results to the field officer	Signature with date of the Director Chemistry
U.C. Gauran	22.06.20	15.10.20	[Signature] 18.11.2020

Part-E

This is to certify that the below mentioned Supervisory Officer(s) have supervised the above item and have provided guidance to the Field Officer(s). The number of inspection visits and total duration of field visits is as per the below table. It is also certified that the work carried out

under the project is of high standards, the norms of field work, lab work etc. have been followed. It is also certified that thorough scrutiny of the report for maintaining the scientific contents and its Quality has been overseen.

Name(s)/Designation of the Supervisory Officer	No. of inspection visits made to the field area	Total no. of days spent on inspection visit	Signature with date
<i>Asit Kesh Nandan</i> Director	7	12 days	<i>P. Nandan</i> 17/11/2020

Part-F

This is to certify that the report has been thoroughly scrutinized at the Regional Mission Head level. The scientific contents and the Quality of the report are certified. The report has been peer reviewed and the needful corrections have been attended to.

Name(s)/Designation of the Regional Mission Head	Signature with date
SUPRIYA KR. SAHA	<i>Supriya K. Saha</i> 23/11/2020

Part-G

This is to certify that the above report has been scrutinized at various levels and has also been peer reviewed. On being satisfied regarding the scientific contents and the Quality of the report, the undersigned has accorded approval for its circulation.

Name(s)/Designation of the Regional HoD	Signature with date
<i>Smt. Varda Kshobh Ray</i> DDG & HOD	<i>Varda Kshobh Ray</i> 24/11/2020

FORMAT OF REPORT ON MINERAL EXPLORATION IN TERMS OF UNFC COMPLIANCE

TITLE OF REPORT: PRELIMINARY EXPLORATION FOR IRON ORE IN MAHAKOSHAL GROUP BLOCK 'B', BHARHARI AREA, SONBHADRA DISTRICT, UTTAR PRADESH. (Stage - G3)

STAGE G-3	NATURE OF COMPLIANCE REQUIRED	COMPLIED (PAGE NO) /NOT COMPLIED	REMARKS
I Summary	(1) Factual Data - (2) Recommendations (3) Cost estimation	- 9 - 77 - NA	
II. Introduction	(4) Scope & Purpose (5) Authority (6) Current/Past Property Examination (BGI) (7) Principal Sources of Information (8) Acknowledgement	- 6 - 6 - 9 - 9 - 8	
III. Property Description	(9) Size, Continuity, shape, surface rights (10) Third party issue (11) Claims/rights with dates (12) Land Title Officer (13) Lat/Long/village/town/district/mine site (14) Accessibility/infrastructure (15) Land nature/water/timber/power/gas/ agriculture/ manpower - 9 (16) Environmental issues/plan act/park/preservation - 9-10 (17) Climate/topography (18) Impact on landscape on mining (19) Map of area/ Block with roads/accessibility - Plate - I	- 9-10 - NA - NA - 9 - 9 - 10 - 10 - NA - 10 - NA - Plate - I	
IV. History	(20) Previous work highlights (21) Attachment of previous maps/sections/tables- Plate - II (22) Previous Mining History (23) Reasons for closure (24) Earlier production data (25) Data on nearby Mines	- - Plate - II - NA - NA - NA - NA	
V. Geoscience Investigation			
(i) Geology	(26) Stratigraphy (27) Lithology (28) Structure (with maps/profiles) (29) Alteration Zones (30) Geotechnical (31) Adequacy of data density (32) Reliability (quality & quantity)	- 18-20 - 21-31 - 32 - 54 - NA - Yes - Yes	
(33) Geological Model			
(ii) Investigation Methods	(34) Instrument & Technique (35) Geology (Map with Scale) (36) Geophysical (with Map & Scale) (36) Geochemical (with Map & Scale) (37) data density of above	- 34 - Plate IV - NA - Plate V - Adequate	

	(38) Size & style of Mineralised Zone	- NA
	(39) Diagrams	- NA
	(40) Metallurgical Tests	- NA
	(41) Deleterious/Contamination source	- NA
VI. Mineral Deposits		
(i) Features of deposit	(42) Type of mineralisation	- 53
	(43) Mode of occurrence	- 53
	(44) nature of Mineralisation (gossan/alteration/ structure)-	- 53
	(45) Reflectance of Mineralisation on geology/ gp/gc -	53
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	(48) Reliability on resource estimation	- Adequate (333 category)
	(49) Nature of Sampling Bed rock/grab/channel	- 34
	(50) Sampling Method	- 34
	(51) Introduction of Duplicates in Analysis	- 66-67
(iii) Analysis Details	(52) Laboratory	- 34
	(53) Analytical Methods	- 34
	(54) Precision & Accuracy	- NA
	(55) Cross Check analysis details	- 66-67
(iv) Quality/Grade	(56) Statistical data processing	- 67
	(57) Cut Off grade	- 67
	(58) Assumptions	- 68-69
(v) Resource Estimation	(59) Geological Interpretation	- 75
	(60) Statement of tonnage & grade	- 75
	(61) Geometry of Mineralisation assumed	- 68
	(62) Method adopted to arrive estimation	- 69-74
	(63) Estimation	- 69-74
(vi) Economic viability	(64) Rough estimation of Economic viability	- NA
	(65) Intrinsic economic interest	- NA
	(66) Eventual Economic exploitation.	- NA

CERTIFICATE: Certified that this REPORT is in compliance with UNFC 333 Stage of Mineral Investigation.

PLACE: Lucknow

DATE:

Uday Narayan

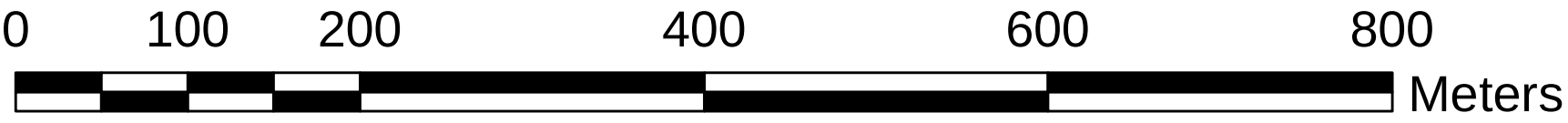
Signature of Author(s):

Dr. Anil Kumar

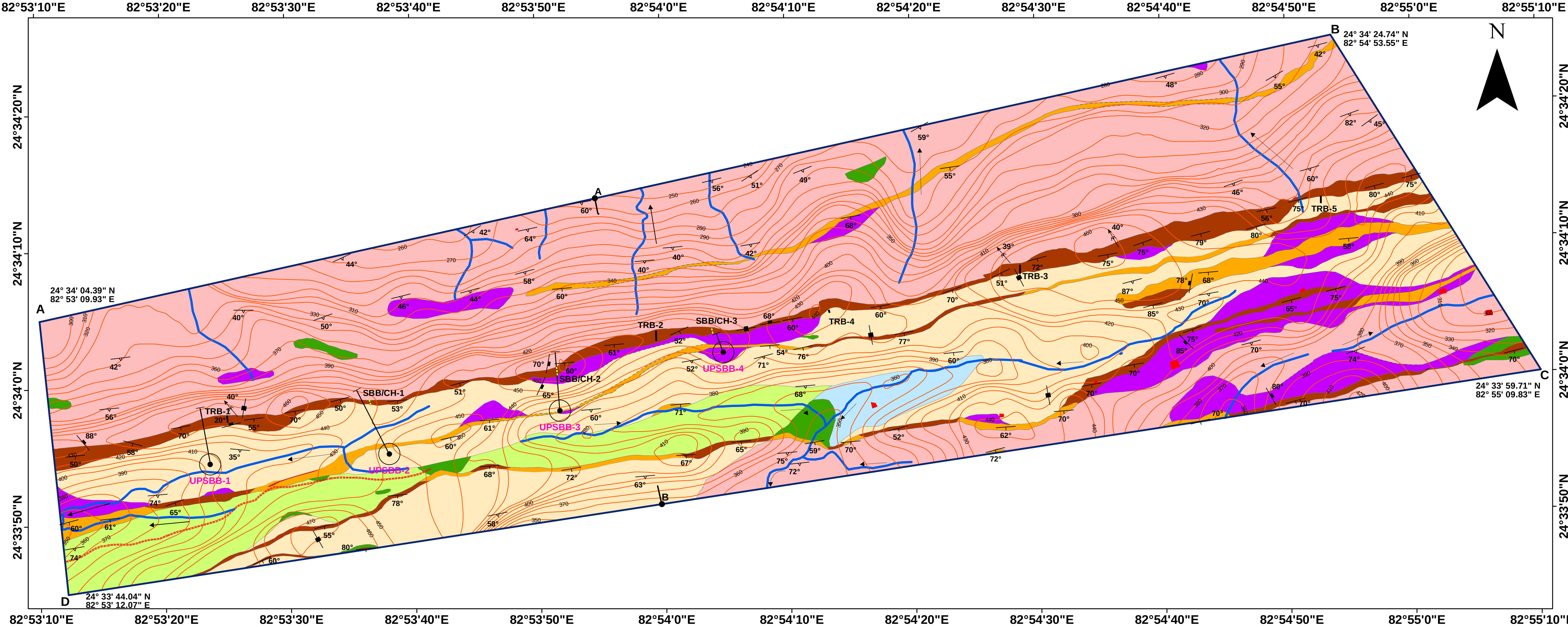
Signature of Project Director:

DETAILED GEOLOGICAL MAP OF BLOCK 'B', BHARHARI AREA
SONBHADRA DISTRICT, UTTAR PRADESH

Scale
(1:4,000)



(Part of Toposheet No. 63L/14)



INDEX

3	Quartz Vein				
2a	2b	2c	Dolerite/weathered dolerite/metabasic		
1a	1b	1c	1d	1e	1a.Variegated phyllite/1b.Banded hematite Chert/Jasper /1c. Ferruginous phyllite/1d.Phyllite interbanded with tuff/1e.Tuff

Younger Intrusives

Agori Formation

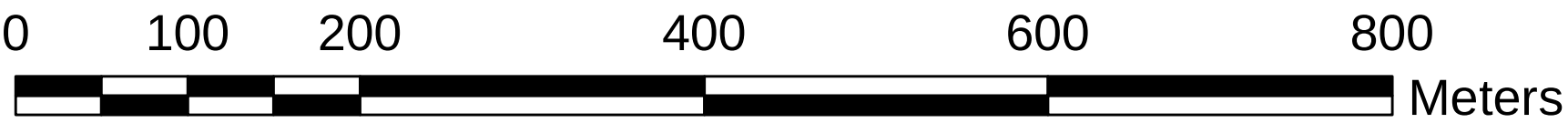
Mahakoshal Group

	Borehole location		Bedding (S_0)
	Trench		Foliation (S_1)
	Channel		Joint
	Nala		Fold axis
	Road		Hutment
	Contour lines		Inferred contacts
	Section line		

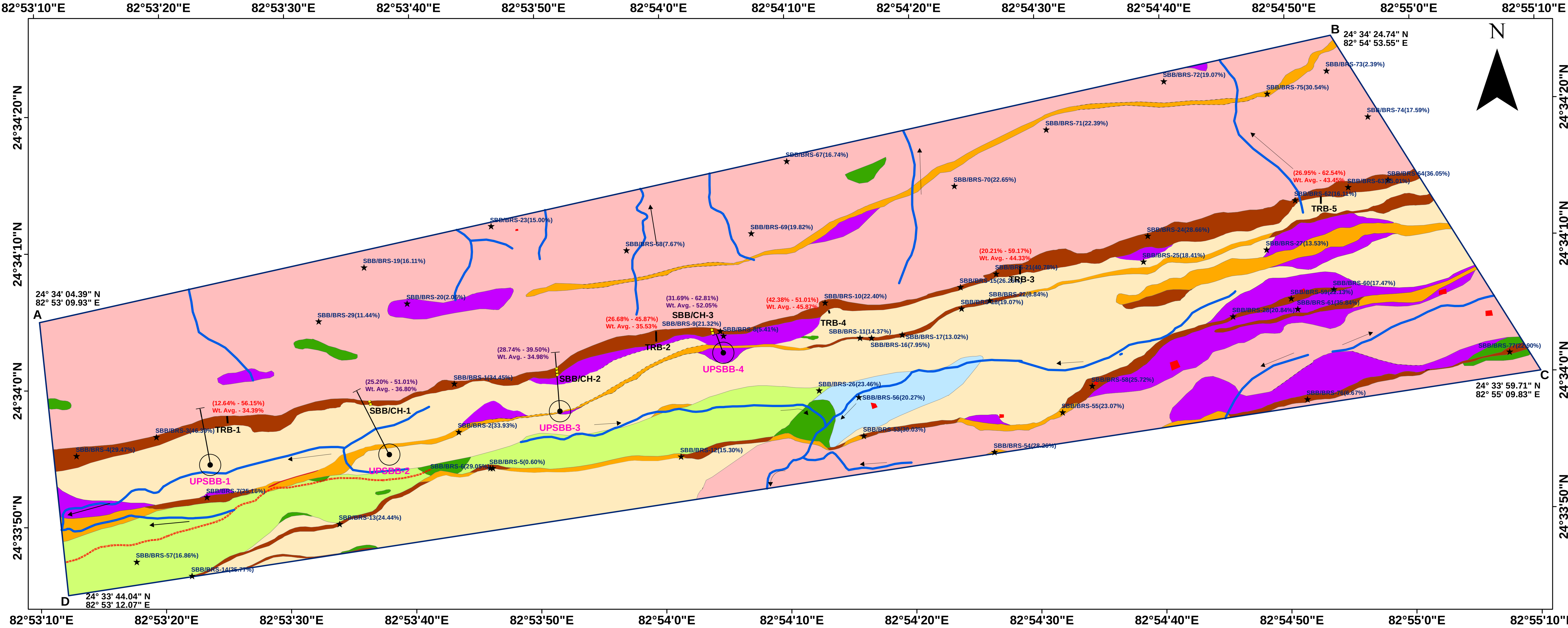
Mapped by
Mukeshkumar R. Shrivastav, Sr. Geologist
Shamiuddin Ahmad, Assistant Geologist
Uday Narayan, Sr. Geologist (addl. charge)
F.S. : 2019-20
Surveyed by
Ramashray Ram, Sr. Surveyor

SAMPLE LOCATIONS MAP WITH Fe% OF BLOCK 'B', BHARHARI AREA
SONBHADRA DISTRICT, UTTAR PRADESH

Scale
(1:4,000)



(Part of Toposheet No. 63L/14)



3

Quartz Vein

2a

2b

2c

Dolerite/weathered dolerite/metabasic

1a

1b

1c

1d

1e

1a.Variegated phyllite/1b.Banded hematite Chert/Jasper
/1c. Ferruginous phyllite/1d.Phyllite interbanded with tuff/1e.Tuff

Younger Intrusives

Agori Formation

Mahakoshal Group

UPSBB-1

Borehole location

TRB-1

Trench

SBB/CH-1

Channel

SBB/BRS-14

BRS sample locations

Nala

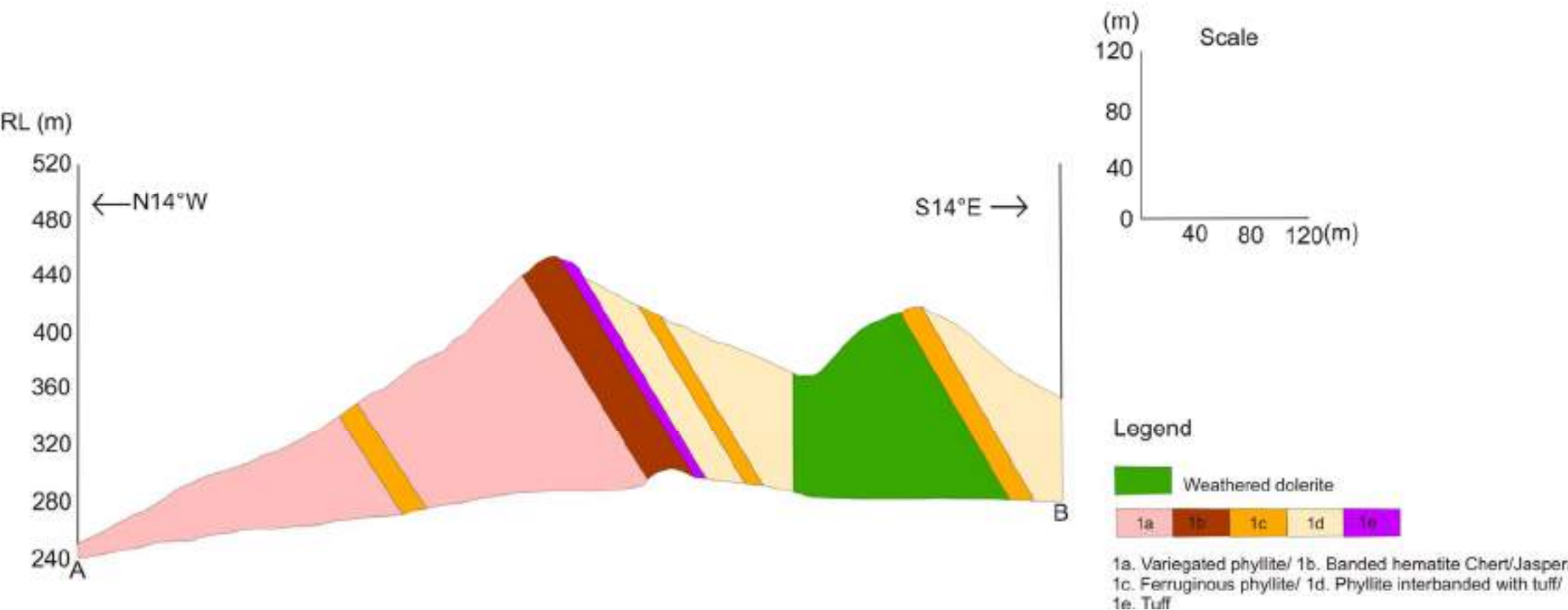
Road

Hutment

Inferred contacts

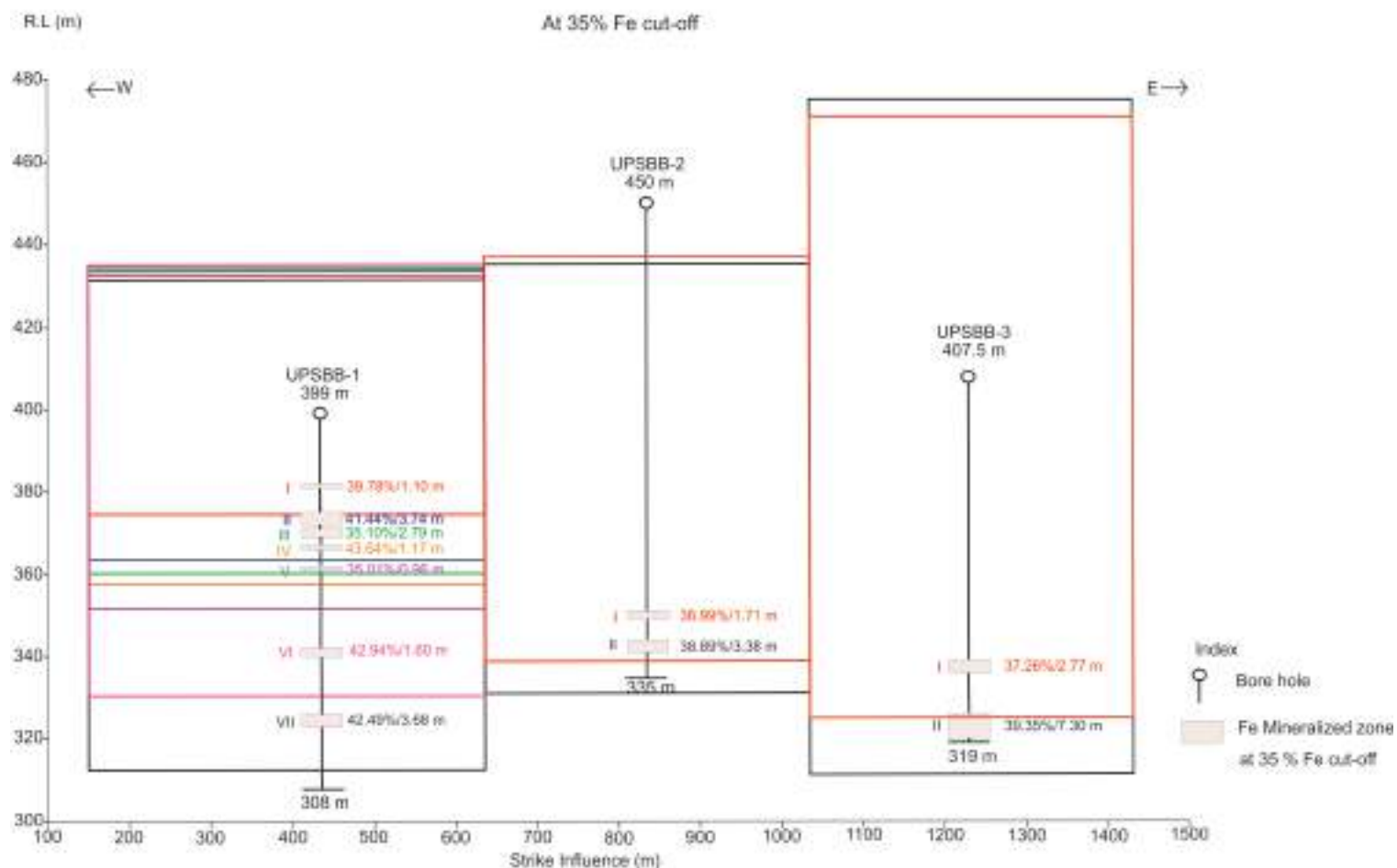
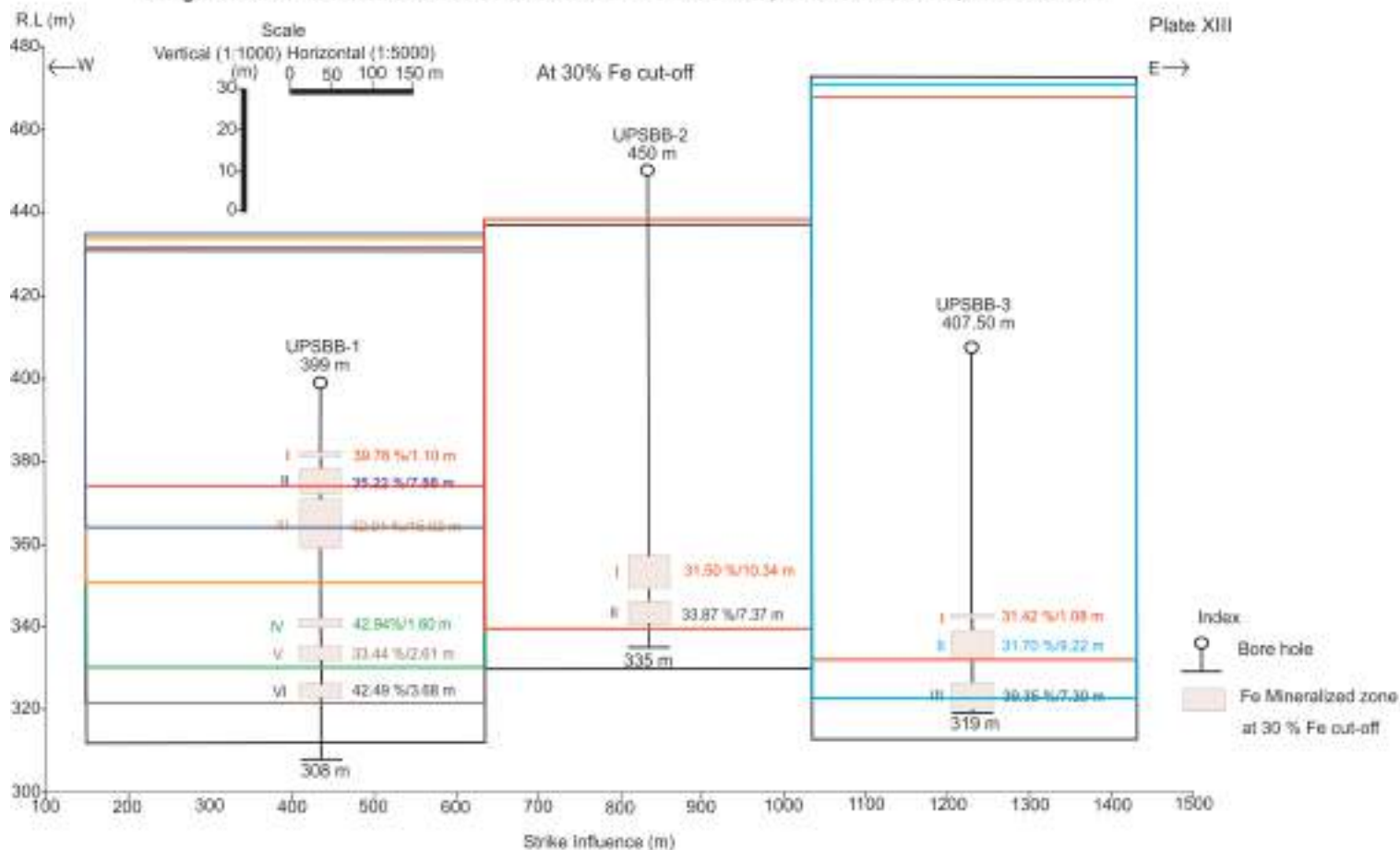
Mapped by
Mukeshkumar R. Shrivastav, Sr. Geologist
Shamiuddin Ahmad, Assistant Geologist
Uday Narayan, Sr. Geologist (addl. charge)
F.S. : 2019-20
Surveyed by
Ramashray Ram, Sr. Surveyor

Geological section along line A-B in block 'B' Bharhari Area, Sonbhadra district, U.P

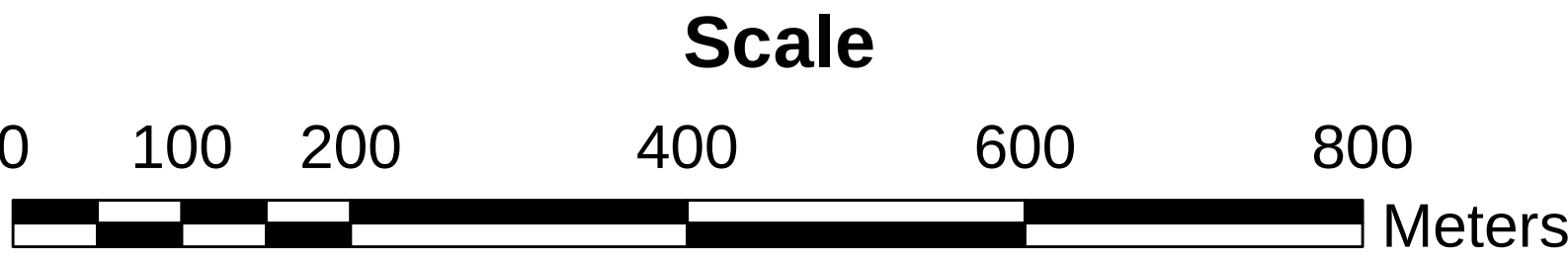


Longitudinal-Vertical section of bore holes block 'B' Bharhari Area, Sonbhadra district, Uttar Pradesh

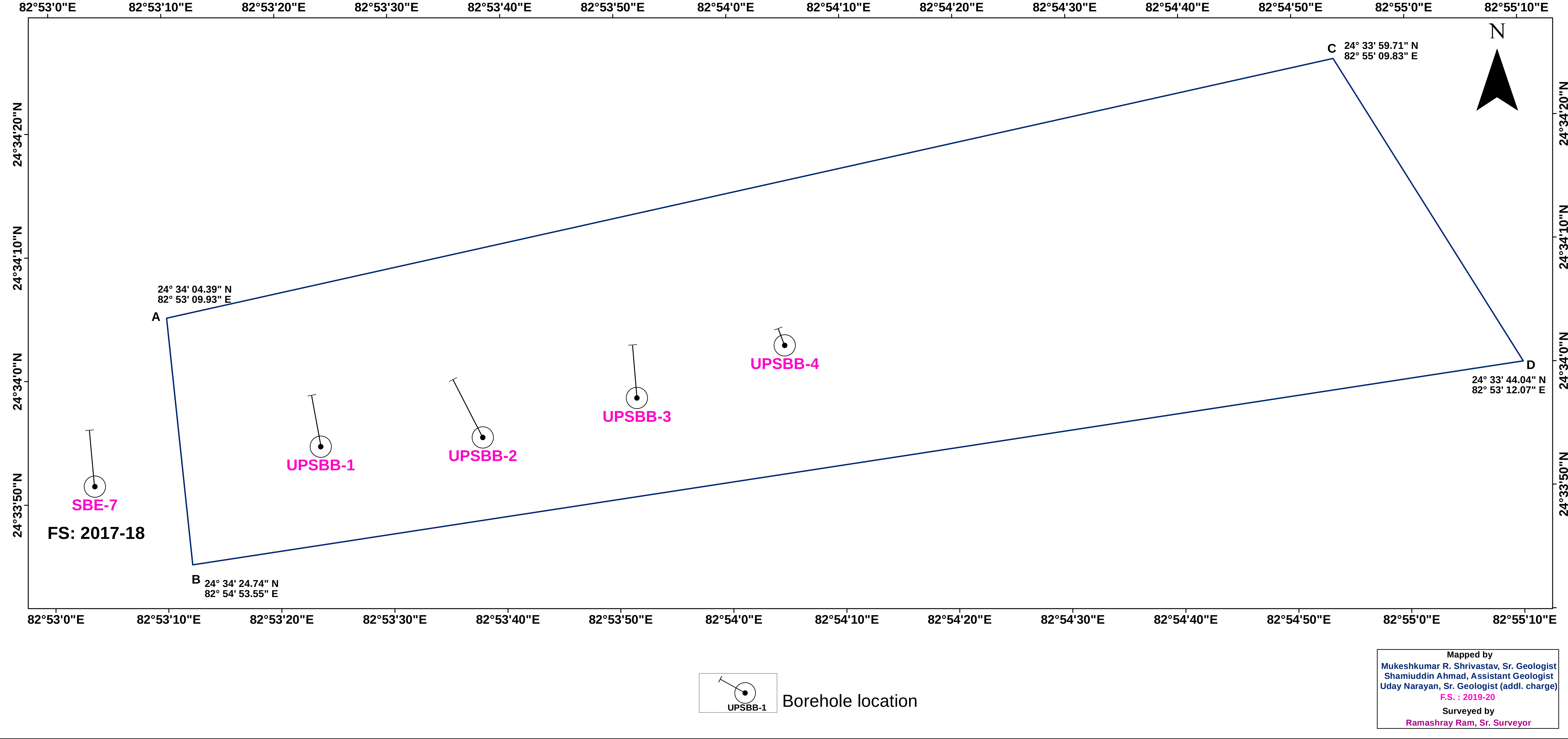
Plate XIII



LOCATIONS OF DRILLED BOREHOLES, BLOCK 'B', BHARHARI AREA WITH BOREHOLE SBE-7 (FS 2017-18)
SONBHADRA DISTRICT, UTTAR PRADESH



(Part of Toposheet No. 63L/14)



Geological section along borehole SBE-7 in extended
Block 'A' Bharhari area, Sonbhadra district, Uttar Pradesh. (at Fe - 35% cut off)

Plate-XIII-B

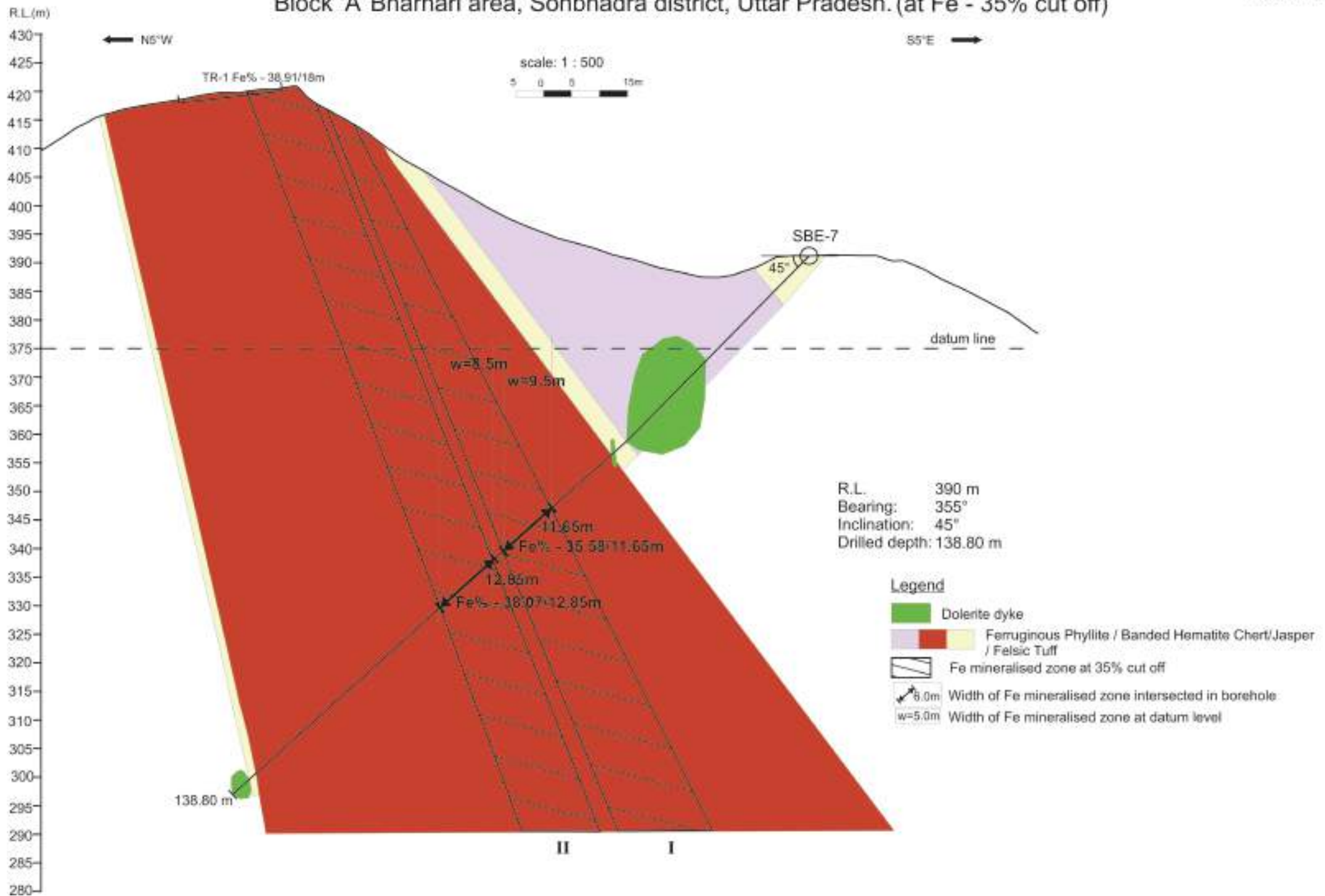
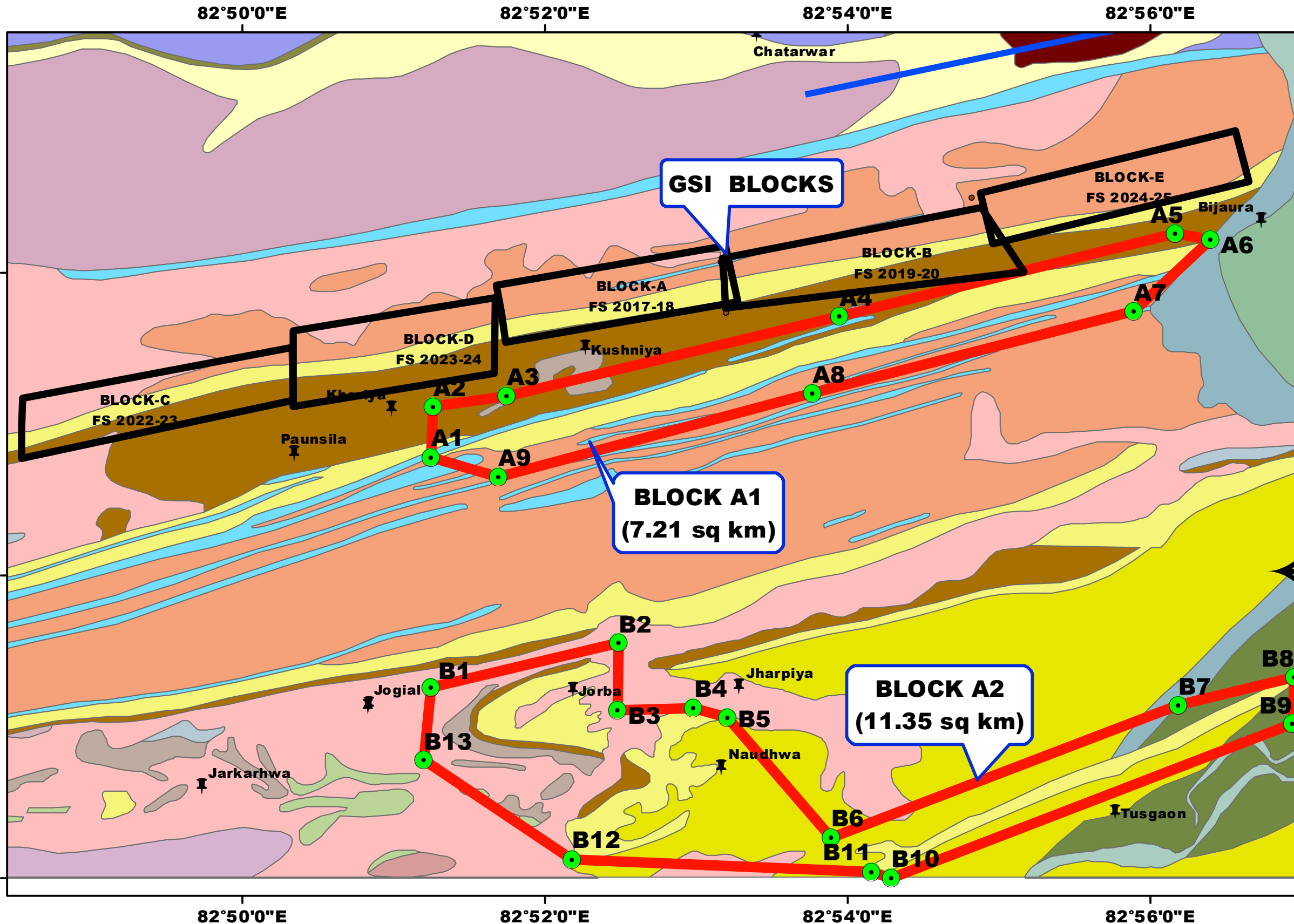
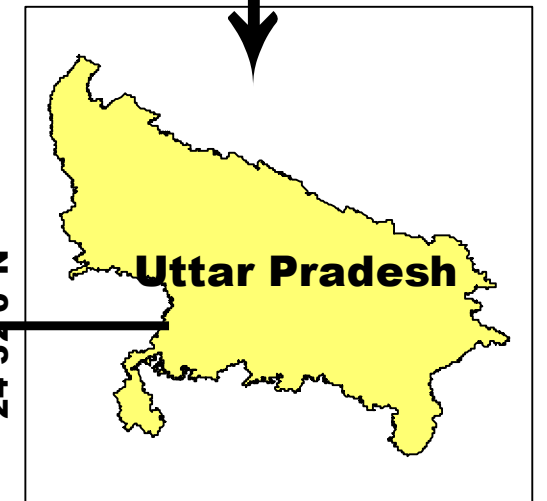
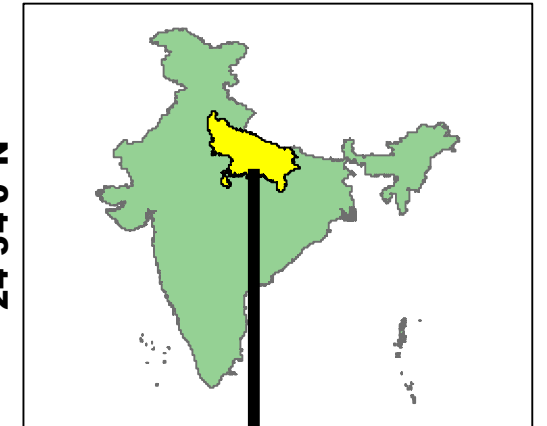
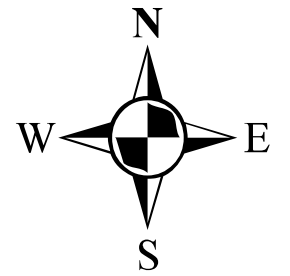


PLATE-1

GEOLOGICAL MAP ON 1:50,000 SCALE WITH LOCATION INDEX PROPOSED (G4) BLOCK (A1 & A2) FOR IRON ORE AROUND CHAKDAIYA, KUSHNIYA, JORBA AND TUSGAON VILLAGES, SONBHADRA DISTRICT, UTTAR PRADESH.



GeoExpOre Pvt. Ltd.		
1:50,000 		
MAP SOURCE: BHUKOSH WEBSITE		
PLATE-1 GEOLOGICAL MAP ON 1:50,000 SCALE WITH LOCATION INDEX PROPOSED (G4) BLOCK (A1 & A2) FOR IRON ORE AROUND CHAKDAIYA, KUSHNIYA, JORBA AND TUSGAON VILLAGES, SONBHADRA DISTRICT, UTTAR PRADESH. DOC NO : NMET/UP/SON/GM-02/R 1/2024-25(31-01-2024)		
PREPARED BY	Mr. SHRINIVAS ASSISTANT GEOLOGIST	
VERIFIED BY	Dr. RADHIKA K.N SENIOR GEOLOGIST	

PLATE-2
 GEOLOGICAL MAP ON 1:50,000 SCALE PROPOSED (G4) BLOCK (A1 & A2) FOR IRON ORE
 AROUND CHAKDAIYA, KUSHNIYA, JORBA AND TUSGAON VILLAGES, SONBHADRA DISTRICT, UTTAR PRADESH

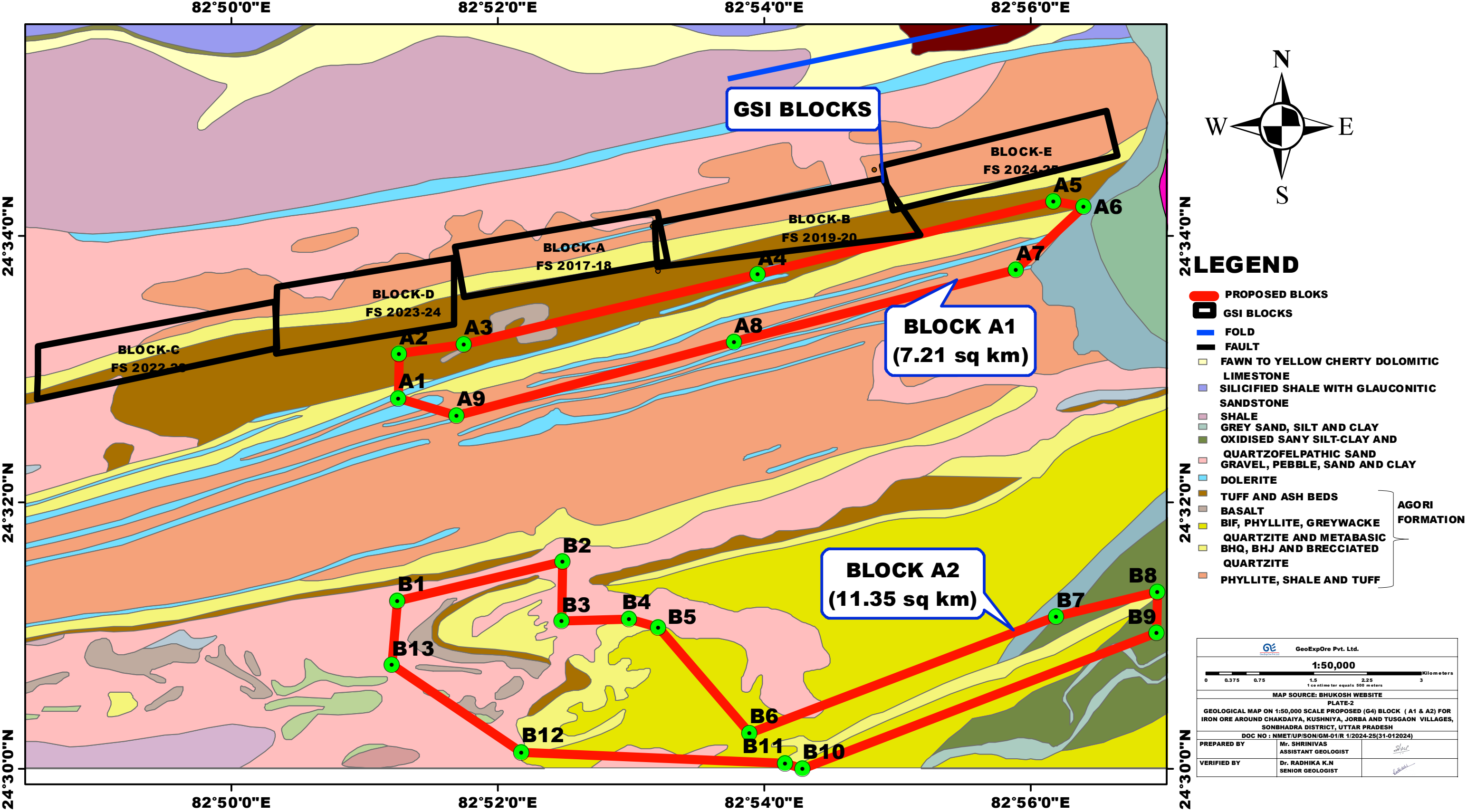
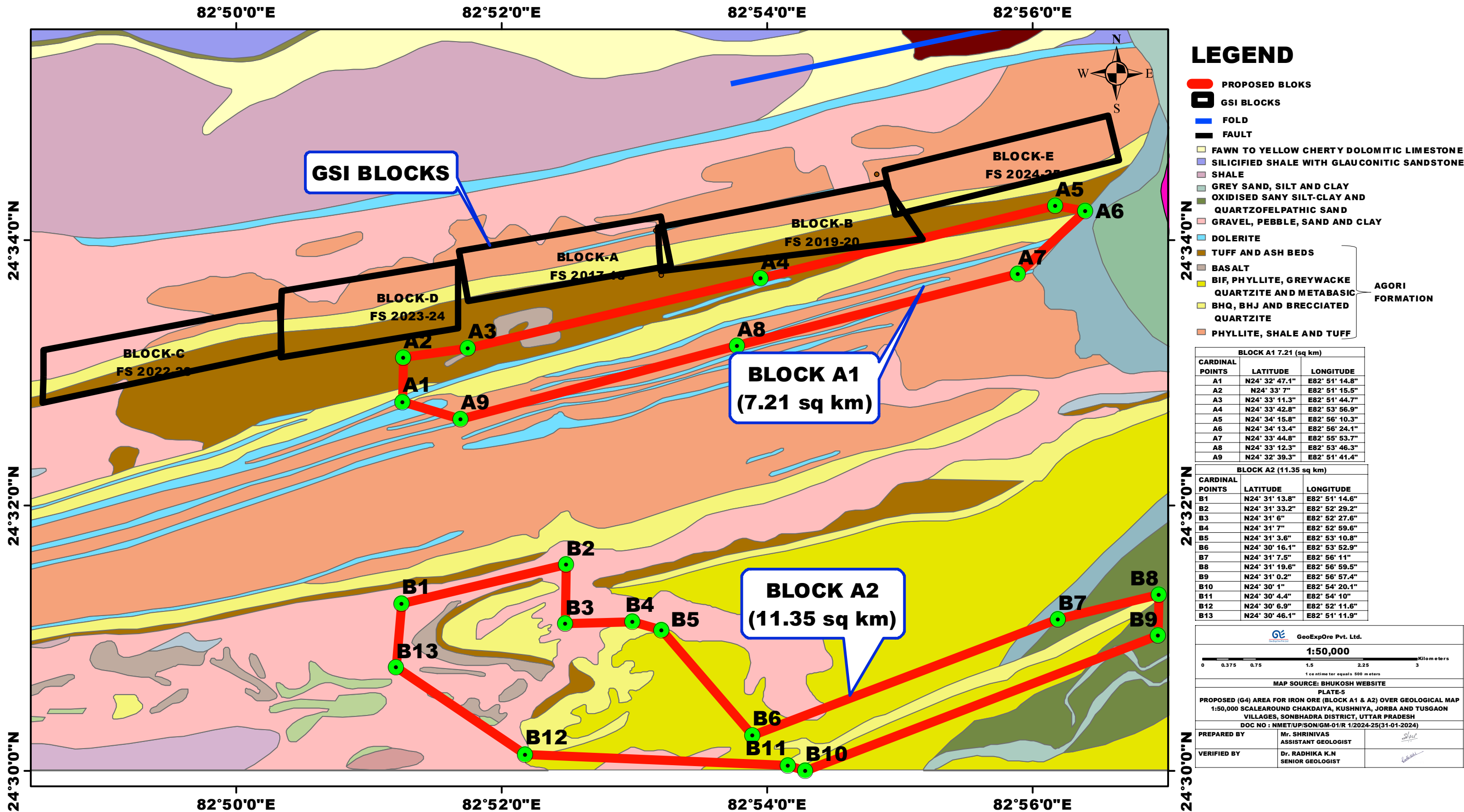


PLATE-5
 PROPOSED (G4) AREA FOR IRON ORE (BLOCK A1 & A2) OVER GEOLOGICAL MAP 1:50,000 SCALE
 AROUND CHAKDAIYA, KUSHNIYA, JORBA AND TUSGAON VILLAGES, SONBHADRA DISTRICT, UTTAR PRADESH



**PROPOSED (G4) AREA FOR IRON ORE (BLOCK A1 & A2) OVER TOPOSHEET NO 63L/14 1:50,000 SCALE
AROUND CHAKDAIYA, KUSHNIYA, JORBA AND TUSGAON VILLAGES, SONBHADRA DISTRICT, UTTAR PRADESH**

