GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G-4) FOR NICKEL, COPPER AND ASSOCIATED MINERALS IN SALEWARA-KUMARWARA-MURUM BLOCK

DISTRICT: KHAIRAGARH-CHHUIKHADAN-GANDAI,

STATE: CHHATTISGARH

Under the Minerals (Evidence of Mineral Contents) Rules, 2015
(Amended upto 2021)

MINERAL EXPLORATION AND CONSULTANCY LIMITED
(Formerly Mineral Exploration Corporation Limited)
Ministry of Mines, Government of India Enterprise
An ISO 9001:2015, 14001:2015 & 45001:2018 Certified Company
CORPORATE OFFICE, NAGPUR

OCTOBER- 2023

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CONTENTS

LIST OF ANNEXURES

LIST OF TABLES

LIST OF TEXT FIGURES

LIST OF PLATES

1. EXECUTIVE SUMMARY

Nickel is a lustrous, silvery-white metal. It is the fifth most common element of earth's crust. It has a melting point of 1453ºC, relatively low thermal and electrical conductivities, high resistance to corrosion and oxidation, excellent strength and toughness at high temperatures and capable of getting magnetised. It is attractive and very durable as a pure metal and alloys readily with other metals. Nickel is not produced from primary sources in the country and the entire demand is met through imports. However, it is being recovered as nickel sulphate crystals, a by-product obtained during copper production.

Nickel occurs principally as oxides, sulphides and silicates in India. Important occurrence is nickeliferous limonite in the overburden of chromite in Sukinda Valley, Jajpur district, Odisha, where it occurs as oxide. A suitable process is being developed for its utilisation. Nickel also occurs in sulphide form along with copper mineralisation in East Singhbhum district, Jharkhand. In addition, it is found associated with uranium deposits at Jaduguda, Jharkhand. Other reported occurrences of nickel are from Karnataka, Kerala and Rajasthan. Polymetallic sea nodules are another source of nickel.

Nickel occurs principally as oxides, sulphides and silicates in India. Important occurrence is nickeliferous limonite in the overburden of chromite in Sukinda Valley, Jajpur district, Odisha. In addition, nickel is found associated with uranium deposits at Jaduguda, Jharkhand and a process is being developed for its recovery. Resources are spread over in Singhbhum East district of Jharkhand and Jajpur, Keonjhar & Mayurbhanj districts of Odisha. As per NMI database as on 1.4.2015, based on UNFC, Resources of nickel are estimated at 189 million tonnes. The entire resources fall under Remaining Resources category. The State of Odisha is endowed with the largest share of resources of nickel ore in the country at 175 million tonnes (93%) followed by Jharkhand & Nagaland. These resources are mainly found to occur in three districts, namely, Jajpur (140 million tonnes), Mayurbhanj (27 million tonnes) and Keonjhar (8 million tonnes). Jharkhand has 9 million tonnes (5%) resources most of which are in Singhbhum (East) district. Nagaland has 5 million tonnes (3%) resources which predominantly are in Kiphire district.

Critical minerals are those minerals that are essential for economic development and national security. The lack of availability of these minerals or concentration of extraction or processing in a few geographical locations may lead to supply chain vulnerabilities

and even disruption of supplies. The Ministry of Mines accordingly constituted a seven-member Committee under the chairmanship of Joint Secretary (Policy), Ministry of Mines vide order No. 11/1/2022-IC dated 01.11.2022 to identify the list of minerals critical to our country. The Committee had a series of deliberations amongst the members and decided to have a three-stage assessment to arrive at a list of critical minerals. Based on the three-stage assessments process mentioned above, a total of 30 minerals are found to be most critical for India out of which two minerals are critical as fertilizer minerals. Depending upon the three-stage assessment, the net import reliance and the resource / reserve position of the country, the final set of 30 minerals recommended as critical to India. The Ministry of Mines on 14.06.2023 published a report on critical minerals of India. Nickel is identified as critical mineral amongst the list of 30 critical minerals.

The Reconnaissance Survey in Salewara-Kumarwara-Murum block, Khairagarh-Gandai district, Chhattisgarh, was approved by the 24thExecutive Committee of NMET with 09 months duration. Field work commenced on August07, 2022, and completed the exploration work on January 31, 2023.

Quantum of work achieved against approved NQT

Sl. No.	Item of Work	Unit	Target	Achievement
1	**Geological Mapping**			
	on 1:12,500 Scale	Sq Km	52	52
2	**Geochemical Sampling**	Nos.		
	Bed rock / Soil samples		340	340
3	**Laboratory Studies**			
	i) Surface Sampling (Bed Rock) (Primary samples)	Nos		
	Bed Rock/Soil			
	For Ni, Co, Cu, Pb & Zn		340	340
	ii) Check Samples (5% Internal + 10% External)	Nos		
	For Ni, Co, Cu, Pb & Zn		51	51
4	**Petrological Samples (Surface Samples)**			
	a) Preparation of Thin Section	Nos	10	10
	b) Study of Thin Section	Nos	10	10
9	**Geological Report Preparation**	Nos.	1	

The purpose of the Ni, Co and Cu investigation in Salewara-Kumarwara-Murum block, Khairagarh-Chhuikhadan-Gandai district, Chhattisgarh, involves the following objectives:

- To carry out Geological & structural mapping on 1: 12,500 scale for demarcation of copper, nickel and associated mineral bearing formations with the structural features to identify the surface manifestations and lateral disposition of the mineralized zones.
- To collect grid wise surface (Bedrock/soil) samples in identified anomalous zones of copper near Murum and nickel zones near Kumarwara. The samples will be analysed for Cu, Ni and associated minerals and decide further course of Exploration program.

- Collecting surface samples (bedrock/ soil) for comprehensive elemental analysis of 5 elements viz. Ni, Co and Cu to determine further exploration strategies.

The Salewara-Kumarwara-Murum Block area falls in Survey of India Toposheet No. 64C/14, and covers an area of 52.00 sq.km in and around villages Salewara, Kumarwara, Dhotha, Gatapar and Murum of Chhuikhadan Tehsil, Khairagarh-Chhuikhadan-Gandai District, Chhattisgarh. The block could be approached from Rajnandgaon city by metal road of about 55 km and Khairagarh by metal road of about 30 km. The nearest airport is Raipur, Chhattisgarh is about 90km.

The area is a hilly terrain with a broad valley in the eastern part flanked by steeply rising N-S trending ridges on either side. The general ground level in the valley area is around 620m above msl, whereas the maximum elevation in the northern part is about 710m above msl and 717m in the southern parts. The general slope of the area to the north is indicated by general northerly flowing drainage. The drainage of the area is mainly formed by the Magurdah, and its tributaries. Numerous small streams and stream-lets drain the area.

The area is characterized by meta-volcanics of Nandgaon Group, meta-sediments of Chilpi Group and gently dipping sedimentary rocks of Chhattisgarh Supergroup. Sandstone of Bartalao Fromation, Rhyolite of Bijli Formation and basalt/andesite of Pitepani Formation belonging to Nandgaon Group of Palaeo-Proterozoic age is the oldest rock. These three formations come under Dongargarh Supergroup. Nandgaon volacanics are followed up by rocks of Chilpi Group represented by slaty shale with

lenses of conglomerate, quartzite and gritty quartzite of varying thickness. They are followed up by Conglomerate, ferruginous sandstone and pebbly sandstone of Lohardih Formation. The whole sequence is overlain by basalt of Linga Formation of Amarkantak Group belonging to Deccan Trap of Upper Cretaceous to Palaeocene age.

The lithounits of Nandgaon and Chilpi Groups have been subjected to very low-grade regional metamorphism. Studies of thin sections of meta-volcanics rocks within the study area also indicate metamorphic grade of lower part of green schist facies with chlorite and epidote as index minerals.

Nickel-cobalt (Ni-Co) laterite deposits are supergene enrichments of Ni±Co that form intense chemical and mechanical weathering of ultramafic parent rocks. These regolith deposits typically form within 26 degrees of the equator, although there are a few exceptions. They form in active continental margins and stable cratonic settings. It takes as little as one million years for a laterite profile to develop. The amount of rainfall and the proficiency of drainage help determine the extent of the development of the weathered profile. The Salwara-Kumarwara-Murum area laterite deposits are supergene enrichments of Ni±Co that form from intense chemical and mechanical weathering of basalt rocks.

The area was prospected by geochemical soil and bed rock sampling for nickel, Cobal and Copper. Out of these two anomaly zones of around 16.25 sq. km near Salewara-Murum area and around 9.49 sq. km near Kumarwara area prospected by geochemical soil and bed rock sampling for nickel and copper on a grid pattern. For this purpose, a 400mx400m grid has been drawn to collect the samples. 11 traverse lines near Salewara-Murum area and 8 traverse lines near Kumarwara area were laid in E – W direction at an interval of 400m. Rest of the area was covered by larger spacing of samples. During the course of work 340 geochemical samples were collected, which include 38 bed rock samples, 302 soil samples.

A total of 302 nos. soil samples are analysed for Ni, Co & Cu. One sample showing maximum value of 1413.0 ppm of Ni was recorded near western part of Kumarwara. The isograde contours are drawn on 1:12,500 scale, for easy computation and drawing purpose. The threshold value of Ni is 226.63 ppm. Five samples are showing more than 500ppm and showing in the south western part of the study area. Except few spot values, the whole block is showing meagre values of Ni. The highest value of Co is

827.00 ppm showing north of Dhotha. Overall, the whole block shows meagre values of Co. The anomaly map of copper shows meagre value throughout the block and maximum upto 412 ppm.

The geochemical surveys carried out in Salewara kumarwara-Murum Block, employing bed rock and soil sampling have, in general brought out a rather flat geochemical landscape. The statistical treatment of the chemical data denotes single population log normally distributed. The statistical analyses of the chemical data for the soil samples shows only few samples having more than threshold and anomalous values. The geochemical contour maps for Ni, Co and Cu prepared based on the analytical results of the soil samples, indicate almost uniform distribution of values, though the contour maps for Ni and Co show some concentration of values towards central and south western side. The detailed follow up of the area is probably not worthwhile as it gives flat geochemical landscape.

The extent of sulphide mineralization could not be established due to very poor concentration of Cu associated with laterite and metabasics. The geochemical survey revealed the secondary dispersion of copper from the silicified vein into the metabasic rocks.

The geochemical anomaly picked up by stream sediment surveys during the previous work does not reflect anomalous localization of nickel in the area and might be due to concentration of nickel in limonite developed on weathered surfaces of basic rocks, which was responsible for high nickel accumulation in stream sediment samples.

The geochemical survey indicated soil cover of colluvial nature, separates the weathered bedrock and the upper soil horizons. The geochemical survey revealed the secondary dispersion of copper from the silicified vein into the metabasic rocks.

Overall, the geochemical survey of the area doesn't reveal any encouraging values of Nickel and Copper.

2. DETAILS OF QUALIFIED PERSON/EXPLORATION AGENCY

2.1 MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly Mineral Exploration Corporation Limited)

(A Govt. of India Enterprise-A Miniratna PSE)

Dr. Babasaheb Ambedkar Bhavan, High Land Drive Road,

Seminary Hills, Nagpur-440006

2.2 DETAILS OF PERSONS ASSOCIATED WITH VARIOUS ASPECTS OF EXPLORATION ASSESSMENT OF RESOURCES AND RESERVES

Different Aspects of Work	Name & Designation
General Supervision and Guidance	Shri P. Ravindran, GM (Exploration) Non-Energy Minerals
Overall planning, co-ordination and Supervision	Shri P. Ravindran, GM (Exploration) Non-Energy Minerals Shri P. P. Kulkarni, DGM (Exploration) Non-Energy Minerals
Technical Assistance	Shri Swarup Dhara, Manager (Geology)
Field Operation	Shri Arjun Deshpande, Sr. Geologist
Data processing, Interpretation and Report Writing	Shri Swarup Dhara, Manager (Geology) Shri Arjun Deshpande, Sr. Geologist
Survey and Drawing	Shri Jagadish Thakral, Survey & Map Officer
Chemical Division	Shri Rohit Sharma, Manager (Chemical) Dr. Deepti R. Rahangdale, Manager (Chemical)
Non-Coal Geological Report Cell	Shri Uday Ashok Patil, Sr. Computer Operator

3. TITLE AND OWNERSHIP

3.1 TITLE OF THE REPORT

GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G4) FOR NICKEL, COPPER AND ASSOCIATED MINERALS IN SALEWARA-KUMARWARA-MURUM BLOCK, KHAIRAGARH-CHHUIKHADAN-GANDAI DISTRICT, CHHATTISGARH

Ownership: Government of Chhattisgarh

Name of Prospector: MINERAL EXPLORATION AND CONSULTANCY LIMITED (Formerly Mineral Exploration Corporation Limited)

Address of Prospector: Dr. Babasaheb Ambedkar Bhavan, High Land Drive Road, Seminary Hills, Nagpur, Pin- 440006

E-mail of Prospector: cmd@mecl.gov.in; gm-exploration@mecl.gov.in

Telephone numbers of Prospector: 0712-2510289; 0712-2511829

3.2 DETAILS OF PERIOD OF PROSPECTING

The Reconnaissance Survey for nickel, copper and associated minerals in Salewara-Kumarwara-Murum block, Khairagarh-Chhuikhadan-Gandai district, Chhattisgarh was approved by 24thExecutive Committee of NMET vide Office Memorandum F. No. 23/263/2022 NMET/59 dated 02nd June, 2022, with a time duration of 9 months (Annexure-I). Field work commenced on August7, 2022, and the field components was completed with Geological mapping, and collection of soil samples in 400x400m grid pattern on 31stJanuary, 2023. The allied field-works including sampling were completed simultaneously. The analytical/laboratory studies were carried out in laboratories of MECL and other Government /NABL accredited laboratories.

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4. DETAILS OF THE AREA UNDER STUDY

4.1 VILLAGE, DISTRICT & STATE

The Salewara-Kumarwara-Murum Block area falls in Survey of India Toposheet No. 64C/14, and covers an area of 52.00 sq.km in and around villages Salewara, Kumarwara, Dhotha, Gatapar and Murum of Chhuikhadan Tehsil, Khairagarh-Chhuikhadan-Gandai District,Chhattisgarh.

4.2 COORDINATES OF ALL CORNER POINTS OF THE AREA IN LATITUDE AND LONGITUDE (DEGREE MINUTES SECOND) FORMAT WGS-84 DATUM

The statement of cardinal points of block is furnished in Annexure-II. The location map is furnished as Plate-I. The details of cardinal points are mentioned below:

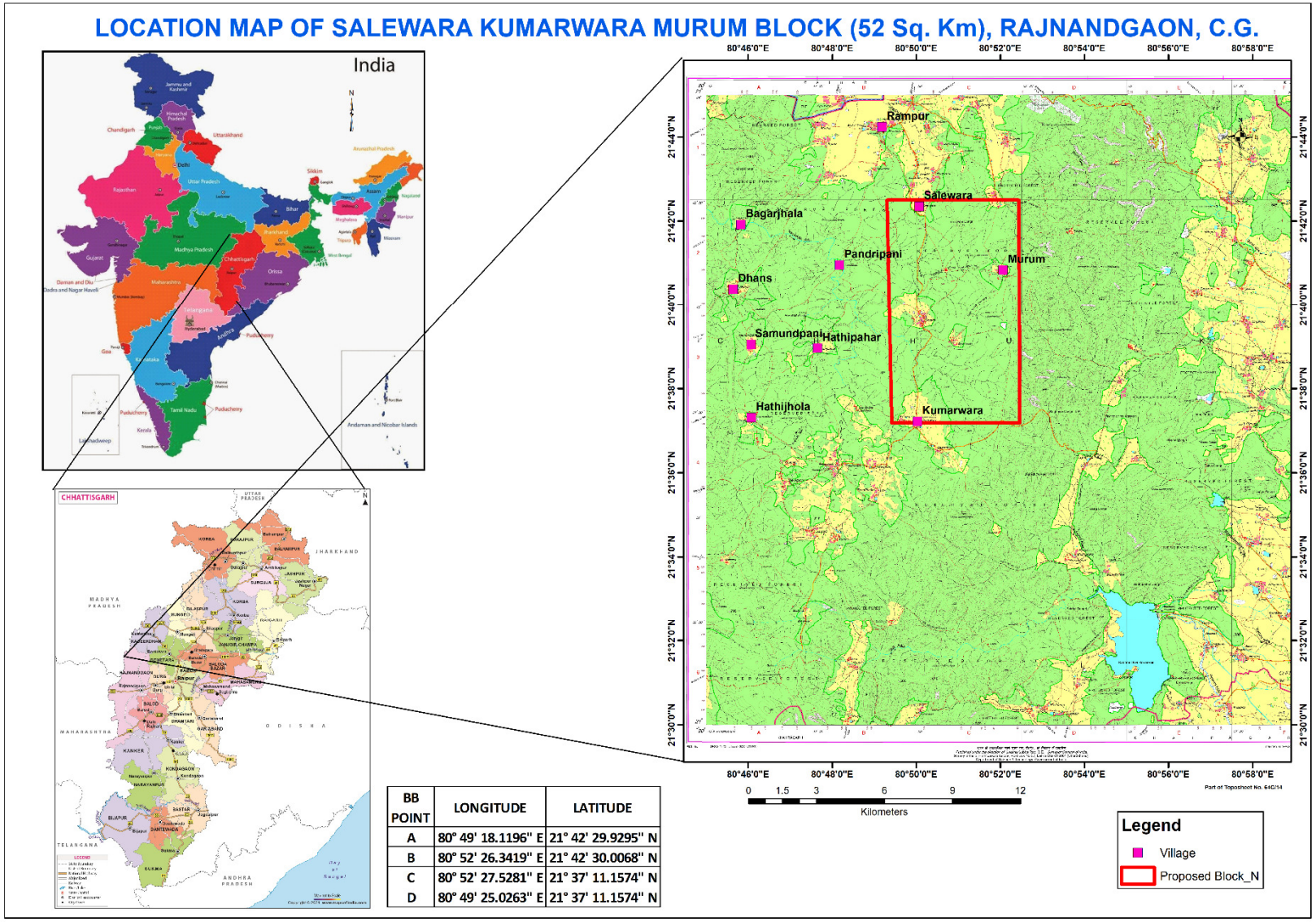
Corner Point	Geographic (DMS)	
	Longitude	Latitude
A	80° 49' 18.1196" E	21° 42' 29.9295" N
B	80° 52' 26.3419" E	21° 42' 30.0068" N
C	80° 52' 27.5281" E	21° 37' 11.1574" N
D	80° 49' 25.0263" E	21° 37' 11.1574" N

4.3 CADASTRAL DETAILS OF THE AREA WITH LAND USE, AREA UNDER FOREST WITH TYPE OF FOREST

The major portion of the block falls under Reserved Forest area. Northern and southern part under private land.

4.4 MINERAL UNDER INVESTIGATION

The block has been explored for **Nickel, Copper and Associated Minerals.**



BB POINT	LONGITUDE	LATITUDE
A	80° 49' 18.1196" E	21° 42' 29.9295" N
B	80° 52' 26.3419" E	21° 42' 30.0068" N
C	80° 52' 27.5281" E	21° 37' 11.1574" N
D	80° 49' 25.0263" E	21° 37' 11.1574" N

Figure 1: Location map of Salewara-Kumarwara-Mururm Block, District- Khairagarh-Chhuikhadan-Gandai, Chhattisgarh

5. PHYSIOGRAPHY AND ENVIRONMENT

5.1 RELIEF OF THE AREA WITH MINIMUM AND MAXIMUM ELEVATION, DRAINAGE PATTERN, NATURAL WATER COURSES, RESERVOIRS, ETC.

The area is a hilly terrain with a broad valley in the eastern part flanked by steeply rising N-S trending ridges on either side. The general ground level in the valley area is around 620m above msl, whereas the maximum elevation in the northern part is about 710m above msl and 717m in the southern parts. The general slope of the area to the north is indicated by general northerly flowing drainage.

The drainage of the area is mainly formed by the Magurdah Nala, and its tributaries. The Magurdah Nala flows towards north, whereas other two are westerly flowing as far as the area is concerned. The drainage pattern formed by them and their tributaries is of dendritic type. Few streams having westerly flow in the extreme western part exhibit sub-parallel pattern. Numerous small streams and stream-lets drain the area.

The area is covered by the deciduous forest with extensive bamboo plantation in parts of the area. Other common plants observed are Bija (Pterocarpus Marsupium) Sal (Shorea robusta) Tendu (Dyospyros tomentosa) and Saja (Terminalia tomentosa).

5.2 ROADS, RAILWAY TRACK, ELECTRIC TRANSMISSION LINE, TELEPHONE LINE, ETC., PASSING THROUGH THE AREA OR NEARBY

The block is 55 km north west of Rajnandgaon and connected by metalled road, which passes through the block. Salewara, Kumarwara, Dhotha, Murum are main villages in Chhuikhadan Tehsil of Rajnandgaon district situated within the block. The block could be approached from Rajnandgaon city by metal road of about 55km and Khairagarh by metal road of about 30 km. Chhuikhadan town is about 20 km south east of the block. The nearest railway station is Rajnandgaon, Chhattisgarh of South East Central Railway zone,which is about 55km. The nearest airport is Raipur, Chhattisgarh is about 90km. A few Fair-weather jeepable tracks provide access to the interior parts of the area.

5.3 HOST POPULATION (LOCAL TRIBES), HUMAN SETTLEMENTS WITHIN AND NEARBY THE AREA

The human settlement found within the block in Salewara, Kumarwara, Murum, Gerukhadan and Dhotha villages. Population of the area is estimated to be 3123 in 2011census. Chhuikhadan Tehsil of Rajnandgaon district has a total population of 176,222 as per the Census 2011. Schedule Caste (SC) constitutes 9.1% while Schedule Tribe (ST) were 19% of total population in Chhuikhadan Tehsil of Chhattisgarh.

As per 2011 census, the adult population density of the villages in and around the study area is given in table below:

Sl. No.	Village	Toposheet No	Male	Female	Literacy
1	Salewara	64C/14	1070	943	69.90%
2	Kumarwara	64C/14	283	244	49.15%
3	Murum	64C/14	64	55	31.93%
4	Dhotha	64C/14	494	510	62.25%
5	Gerukhadan	64C/14	306	299	29.42%
6	Dalli	64C/14	85	69	38.96%

5.4 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

Chhuikhadan Tehsil of Rajnandgaon district has a total population of 176,222 as per the Census 2011. Out of which 87,398 are males while 88,824 are females. In 2011 there were a total 36,726 families residing in Chhuikhadan Tehsil. The Average Sex Ratio of Chhuikhadan Tehsil is 1,016.

As per Census 2011 out of total population, 11.6% people live in Urban areas while 88.4% live in the Rural areas. The average literacy rate in urban areas is 74.6% while that in rural areas is 66.8%. Also, the Sex Ratio of Urban areas in Chhuikhadan Tehsil is 1,014 while that of Rural areas is 1,017.

The population of Children of age 0-6 years in Chhuikhadan Tehsil is 27192 which is 15% of the total population. There are 13656 male children and 13536 female children between the age 0-6 years. Thus, as per the Census 2011 the Child Sex Ratio of Chhuikhadan Tehsil is 991 which is less than Average Sex Ratio (1,016) of Chhuikhadan Tehsil.

The total literacy rate of Chhuikhadan Tehsil is 67.74%. The male literacy rate is 66.69% and the female literacy rate is 48.03% in Chhuikhadan Tehsil.

5.5 HISTORICAL SITES AND ARCHAEOLOGICAL MONUMENTS, PLACES OF WORSHIP, PUBLIC UTILITIES ETC. WITHIN OR NEARBY

Khairagarh is the site of Indira Performing Art and Music University, which holds the dignity of the first university in Asia of its kind. Khairagarh is also well known as a gateway to a popular natural tourist destination Dongargarh-Khaara Reserve Forest.

Gandai-Pandaria is a village town and a nagar panchayat in Chhuikhadan Block In the Khairagarh-Chhuikhadan-Gandai district in the state of Chhattisgarh, India. It is located about 80 kilometers northwest of Raipur, the state capital. Gandai is one of the centers of Gond people in contemporary times, particularly the kandra tribe. Prior to the 15th-century, Gandai-pandaria was a significant center of Buddhism and Shaivism. It is an important archaeological site of historic 9th to 14th-century Shiva and Buddhist temples, most of which were destroyed after the 14th-century. Excavations of mounds after 1965 and the accidental discoveries of ruins by farmers have revealed a number of sites. One major Shiva temple's sanctum and spire in Gandai has survived. It is called the Deour Shiv Mandir, a temple restored and managed by Archaeological Society of India, Raipur circle. Bhoramdeo temple is situated 20 km from the area and holds archaeological importance.It is a Lord Shiva temple built in stone during the reign of Naga Vamsi kings in early 11th Century AD and is known as the Khajuraho of Chhattisgarh.

Sevaral Archaeological sites nearby area of the block are viz. Gandai, Ghatiyari, kritbas, Bhadbhadi, Bagur, Kodka, Katangi, Khudmudi, Katori, Kopebhatha, Thakurtola, Narmada, Mandavabhatha, Salewara etc.

The Bank, School and Hospital facilities available at Khairagarh and Chhuikhadan town.

5.6 FORESTS, SANCTUARIES, NATIONAL PARK AND WILD LIFE SANCTUARIES

The block falls under reserved forest. Other than that, grazing lands are also present within the study area. The nearest national park is Pench and Kanha National Park, situated at a distance of 150 km from the area, whereas Bhoramdeo Sanctuary lies about 45 km northeast from the northern boundary of mapped area

5.7 FLORA AND FAUNA

The area is covered by the deciduous forest with extensive bamboo plantation in parts of the area. The dense forest supports luxuriant growth of sal (*Shorea robusta*), teak (*Taetona grandis*), bija (Pterocarpus marsupium), saj (*Tharminalia tomantosa*), mahua (*Madhuea latifolia*), tendu (*Diospyros malanoxylon*) and bahera (*Tharminalia belerica*). During the monsoon months, the hills and gently undulating valleys are blanketed by a thick undergrowth of creepers and shrubs. The limited plain area is utilized for paddy (*Oriza sativum*) cultivation, where sporadic mango (Mangifera indica) groves are also found. The most abundant fauna in the area are monkeys (*Semipithecus entellus*).

Agriculture is practiced in the area during Kharif and Rabi season every year. During the Kharif, cultivation is done through rainfall while during the Rabi season, it is done through ground water as well as partly through surface water like ponds and other sources. The groundwater abstraction structures are generally Dugwells, Borewells /tubewells. The principal crops in the block are Paddy, Wheat and Gram. In some areas, double cropping is also practiced.

The most abundant fauna in the area are monkeys (*Semipithecus entellus*). Besides, a rich variety of wild life is also present. They are jackal (*Canis aureus*), fox (*Vulpes vulpes*), bear (*Meluvsus Ursinus*), wild boar (*Sus Cristatus*), spotted deer (*Cervus axis*) and rabbit (*Oryctolagus cuniculus*). A variety of insects thrive in the area. Occasionally, snake species like python (Pythonidae), cobra (Ophiophagus Hannah) and krait (Bungarus caeruleus) are also found.

5.8 WATER BODIES SUCH AS RIVER, NALA, STREAM, RESERVOIR

The drainage of the area is mainly formed by the Magurdah, and its tributaries. The Magurdah Nala flows towards north, whereas other two are westerly flowing as far as the area is concerned. The drainage pattern formed by them and their tributaries is of dendritic type.

Several ponds and wells are located within the blocks. No major dams/water reservoirs are available within the block.

5.9 CLIMATIC CONDITIONS

The area experience moderate temperature, the lowest being 4°C recorded during the winter and the highest temperature (43° c) being recorded during the summers. Summer season reigns from middle of March to early June. May is the hottest month of the year. The winter months from November to February are moderately cold. December and January are the coldest months. The area receives heavy rainfall through the south-west monsoon, prevailing from early June to September. The months of July and August are the heaviest rainfall months and nearly 95% of the annual rainfall is received during June to September months.Theaverage annual rainfall in the study area is937 mm.

6. INFRASTRUCTURE

Khairagarh-Chhuikhadan-Gandai district is a district of the central Indian state of Chhattisgarh. It was carved out of Rajnandgaon in 2022. Chhukhadan, Khairagarh and Gandai are the townships near the study area with modest population and satisfactory socioeconomic conditions. These towns are connected with all major cities of Central India like Raipur, Jabalpur, Nagpur via metalled state highway. Schools, hospitals, and other basic amenities are available in the area. The villagers grow two crops a year by the help of stores surface run-off during monsoon season and canals. Chhattisgarh State Power Distribution Company Limited (CSPDCL) supplies electric power through Chhuikhadan and Khairagarh sub-stations.

7. GEOLOGY

7.1 BRIEF REGIONAL GEOLOGY OF THE AREA OUTLINING THE BROAD GEOLOGICAL, STRATIGRAPHICAL AND STRUCTURAL FRAME WORK

The area forms a part of toposheet nos. 64C/14 and is characterized by meta-volcanics of Nandgaon Group, meta-sediments of Chilpi Group and gently dipping sedimentary rocks of Chhattisgarh Supergroup. Sandstone of Bartalao Fromation, Rhyolite of Bijli Formation and basalt/andesite of Pitepani Formation belonging to Nandgaon Group of Palaeo-Proterozoic age is the oldest rock. These three formations come under Dongargarh Supergroup. Amgaon gneiss of Archaean age forms the basement for Nandgaon volcanics but the Amgaon Group of rocks are not exposed in these toposheets. Nandgaon volacnics are followed up by rocks of Chilpi Group represented by slaty shale with lenses of conglomerate, quartzite, BHJQ, iron ore, dolomite and gritty quartzite of varying thickness. They are followed up by conglomerate, glauconitic sandstone, ferruginous sandstone and pebbly sandstone of Lohardih Formation, Chandarpur Group of Chhattisgarh Supergroup of Meso to Neo Proterozoic age. They are further followed up by Gunderdehi shale, Chandi stromatolitic dolomitic limestone, Tarenga shale and Hirri dolostone of Raipur Group belonging to Chhattisgarh Supergroup. The whole sequence is overlain by basalt of Linga Formation of Amarkantak Group belonging to Deccan Trap of Upper Cretaceous to Palaeocene age. The regional Geological Map furnished at Plate No. -II.

Table- 1: Regional Stratigraphic Sequence (after GSI)

Age	Supergroup/Group	Formation	Lithology
Cenozoic			Laterite
Upper Cretaceous-Lower Palaeocene	Upper Cretaceous-Lower Palaeocene	Linga Formation	Linga Formation (Basalt)
Meso - Neo Proterozoic	Raipur Group (Chhattisgarh Supergroup)	Maniari Formation	Shale
		Hirri Formation	Dolomite
		Tarenga Formation	Shale
		Chandi Formation	Stromatolitic dolomitic limestone
		Gunderdehi Formation	Shale
	Chandarpur Group (Chhattisgarh Super group)	Lohardih Formation	Sandstone
			Ferruginous sandstone

			Grit / conglomerate
Meso - Proterozoic	Chilpi Group (Dongargarh Supergroup)		Shale
			Slaty shale
			Quartzite
			Conglomerate
Palaeo - Proterozoic	Nandgaon Group (Dongargarh Supergroup)	Pitepani Formation	Basalt/Andesite
		Bijli Formation	Rhyolite

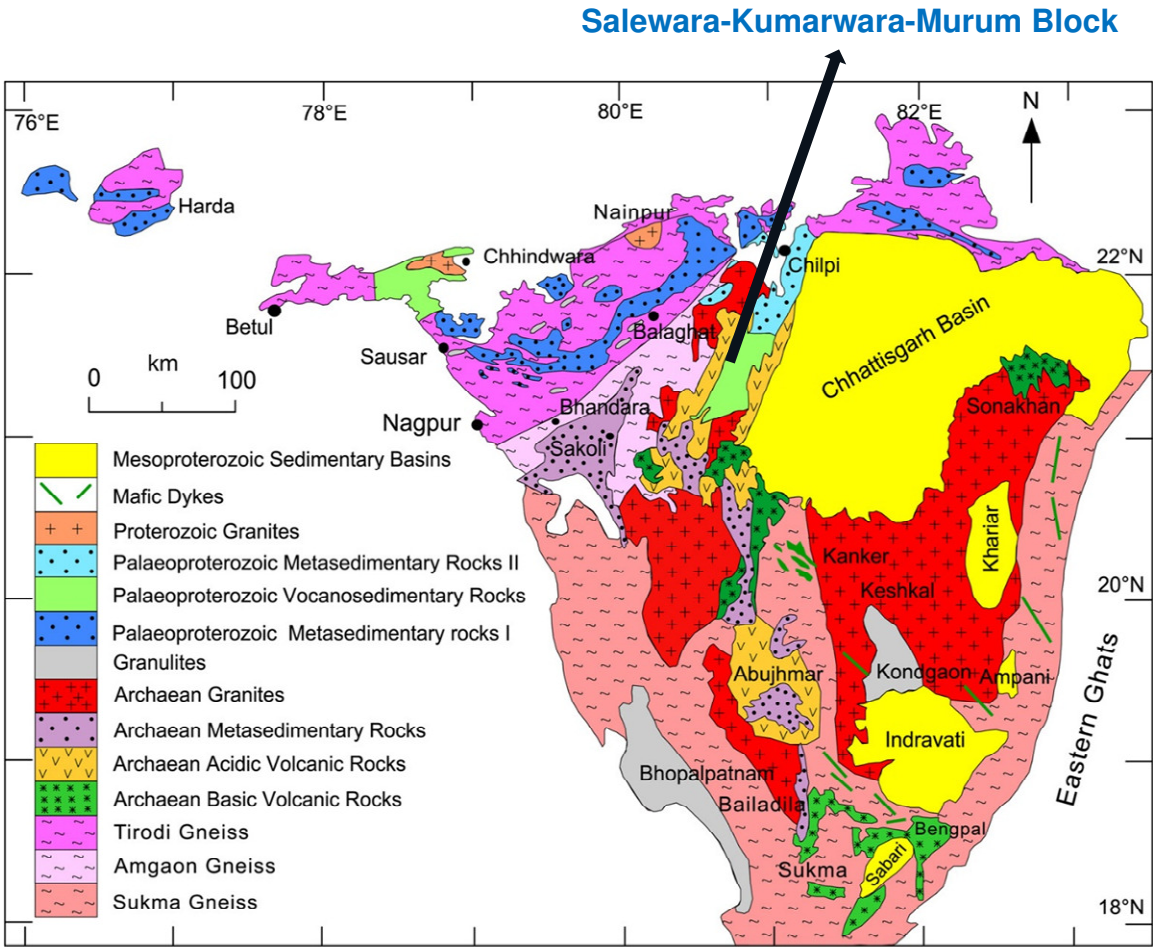


Figure 2: Simplified geological map of Bastar Craton (Source: Memoirs, Volume 43, Pages 151 – 164, Sarada Prasad Mohanty, Geological Society of London).

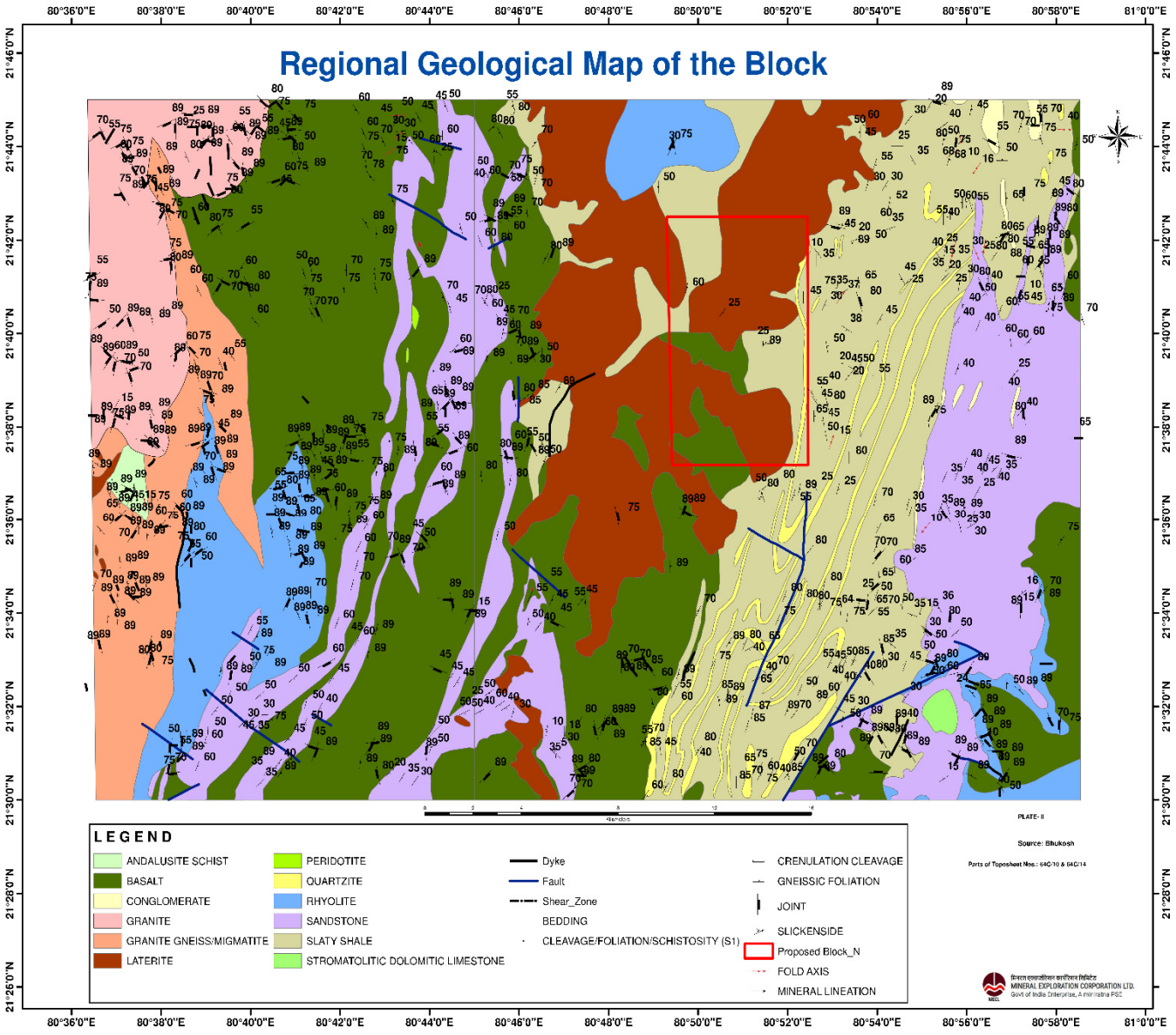


Figure 3: Regional Geological Map, Salewara-Kumarwara-Murum Block, District Khairagarh-Chhuikhadan-Gandai, Chhattisgarh

7.2 LOCAL GEOLOGICAL SETTING DETAILING THE COMMON ROCK TYPES, CONTROLS OF MINERALIZATION, DETAILS OF OLD WORKINGS IF ANY, SURFACE EXPOSURES, ETC., OF THE AREA UNDER STUDY

In the present area, the lithologies mapped are altered volcanics (andesite/basalt) of Nandgaon Group, slaty shale with lenses of quartzites, grey quartzite of Chilpi Group and conglomerate, of Chandarpur Group belonging to Chhattisgarh Supergroup. Quartz vein is intrusive in these rocks. The geological map is furnished as Plate-III.

Table- 2: Stratigraphic succession of the mapped area

Age	Supergroup/Group	Formation	Lithology
Cenozoic			Laterite
Meso - Neo Proterozoic	Chandarpur Group (Chhattisgarh Super group)	Lohardih Formation	Grit / conglomerate
Meso - Proterozoic	Chilpi Group (Dongargarh Supergroup)		Slaty shale
			Quartzite
			Conglomerate
Palaeo - Proterozoic	Nandgaon Group (Dongargarh Supergroup)	Pitepani Formation	Basalt/Andesite

Description of rock types:

Different litho-units found in Salewara-Kumarwara-Murum block are Laterite, Altered volcanics, Quartzite, Conglomerates etc. Detailed description of the different litho-units encountered in study area is furnished in the following paragraphs.

Basalt/Volcanics: Basalt is dark green, hard and consists of amygdules exposed in the nala section, near Gerikhadan and Kumarwara. The amygdules are calcite and glassy material. In the study area, isolated outcrops of basalts are observed in the field area as well as nala section while the major part of the mapped area is covered by dark grey soil and laterite cover. There is no sharp contact of this rock with the adjacent rock. At places

due to weathering fabric developed as weak schistosity and parallel chlorite grains associated with sericite and quartz. The basalt at places altered to metabassalt, where chlorite is dominant constituents with sericite and quartz.

Under the microscope, a greenish grey colored fine to very fine-grained rock showing granular texture. It is a greenish grey coloured fine to very fine grained rock showing granular texture and amygdaloidal structures. The rock composed of Augite, Plagioclase, Zeolite, Epidote, Chlorite, Quartz, Calcite and tremolite. Augite occurs as fine to very subhedral prismatic grains. Plagioclase occurs as turbid patches, subhedral prismatic laths and as very fine aggregates. Quartz occurs as medium subrounded clustered. Pockets, filled along as pores, cavities and vesicles and accompanying fine calcite filings with it. Zeolite is present as fine fibrous aggregates, occurring as amygdaloidal fillings. Epidote occurs as fine subhedral aggregates mostly along the core of zeolite amygdaloidal structures (Pmg-1). Chlorite is present as flaky aggregates and patches along pores and cavities. Quartz and calcite are also seen present as cavity fillings in areas. Opaques are noted as very fine specks in accessories.

Under microscope altered meta basalt is seen as very fine grained massive rock. Chlorite occurs as very fine flaky aggregates showing crude alignment and as very fine cryptocrystalline aggregates, segregating into patches and showing probable relicts of fine and altered pyroxenes. Quartz occurs as fine and very fine micro-crystalline aggregates and pore & cavity fillings. Sericite is noted as very fine disseminated flakes. Opaques are present as very fine specks in accessories.

Volcanics of Nandgaon Group is exposed as patches in the study area, north of Kumarwara west of Dhotha. Most of the exposures on the plains are weathered and altered. Volcanics range in composition from Basalt to Andesite (Field Photograph1 & 2). Sometime the volcanics altered to clay stone as exposed near Gerukhadan and south of Murum. This rock is totally made up of very fine aggregate of clay minerals (Pmg-2).

Megascopically, rock with basaltic composition forms the most dominant volcanic rock, followed by andesite. Generally, it is pale green to green rock and is fine grained. When weathered, the rock appears reddish brown. Andesite is dark green to pale green, mostly aphanitic, occasionally porphyritic with phenocrysts of plagioclase but devoid of quartz. It is vesicular at places and the vesicles are filled by milky white quartz amygdules. All variants show granular or amygdaloidal texture defined by rounded

subhedral plagioclase or minor quartz phenocrysts. They record a number of joint planes. The volcanics are unconformably overlain by slaty shale/quartzite of Chilpi Group. However, their contact is concealed in the mapped area.

Under the microscope, the rock is greenish grey colored fine to very fine-grained rock showing granular texture. The major minerals area Augite, Plagioclase and Chlorite. Augite and plagioclase are the primary constituent minerals, occurring as very fine crypto-crystalline aggregates, very fine to fine subhedral prismatic grains and as turbid patches. Chlorite occurs as very fine crypto-crystalline aggregates and as patches replacing all primary constituent minerals. Chlorite occurs as very fine to fine flaky aggregates showing crude alignment and as very fine cryptocrystalline aggregates, segregating into patches and showing probable relicts of fine and altered pyroxenes at some places. Epidote is present as fine to medium subhedral prismatic grains and its aggregates in pockets. Opaques are noted as very fine specks in accessories.

Conglomerate: Conglomerate of Chhattisgarh Supergroup is exposed northwest of Dhotha in an outcrop of small surface area. It belongs to Lohardih Formation belonging to Chandarpur Group. It is off-white to pinkish grey, gritty to pebbly, with sporadic angular clasts of andesite of Nandgaon Group, and jasper and chert of Chilpi Group. The matrix is siliceous to ferruginous and composed of quartz with few iron concretions developed along joint planes. Bedding is defined by alternate gritty and coarse grain bands.

Quartz-Arenite (Quartzite) inter-banded with slaty shale: Chilpi Group rests unconformably on the rocks of Nandgaon Group. Rocks of this Group form N-S trending hill range. The Chilpi Group consists of slaty shale, quartzite and sub greywacke. Variegated, fine grained quartzite interbanded with slaty shale occurs as a considerably thick.Upright folding of both quartz-arenite and shale are also observed. Quartz-arenite with argillaceous cement is exposed around Makhurahi and Murum. Slaty shale shows wide variation in shades of dark reddish pink, dark purplish red, reddish yellow and buff. They exhibit excellent colour and compositional banding defining bedding plane. Thin laminations are noticed. Lenses of white, grey to pink massive quartzite forming high and steep hills in the eastern part of the block. It is mostly medium to coarse grained, massive and rarely display laminations. It dominantly strikes along NNE-SSW with

moderate to moderately high dips towards ESE and WNW. Locally N-S strikes are measured with easterly or westerly dips. Composition is mostly argillaceous to siliceous.

Under the microscope, it is a fine to medium grained rock showing granular texture. The rock composed of quartz, lithic fragment, Feldspar, Clay minerals, Ferruginous matter, Sericite and opaques. Quartz occurs as fine to coarse sand sized and even fine gravel sized sub-angular to subrounded clasts floating over clayey matrix (Pmg-3). Coarser grains are showing better roundness. Reddish ferruginous matter mixed with dirty clay patches are seen present and showing fine to very fine feldspar relicts. Ferruginous matter is present as reddish fillings and patches, working as cementing agent. Fine subrounded lithic fragments are noted, comprising very fine quarzitic aggregates. Opaques are seen present as fine to very fine relicts within ferruginous patches. Grains are poorly sorted and loosely packed. Field photographs of Shale and Quartzite in Field Photograph:3 and 4.

Quartz vein: Milky white, medium grained quartz vein is intrusive in to Nandgaon Group and Chilpi Group in the area and occurs in thickness varying from 2 mm to 20 cm.

Laterite: Fairly large areas of the study area are covered by laterite, capping, and different rock types. It varies in thickness from two meters to a maximum of 20m. It is well exposed in the area between Kumarwara, Murum, Dhotha and Salewara. Bauxitic laterite also noticed near Bhulwahi Dongri. Locally it has developed pisolitic structure, where lateritic thickness of over 4m. The Field photograph 5 and 6 showing exposures of laterite near Murum and Kumarwara.

Under microscope, the specimen of bauxitic laterite is mostly made up of reddish ferruginous matter, occurring as amorphous aggregate and as patches showing colloform texture. Gibbsite occurs as patches and fillings comprising fine to medium prismatic and very fine granular aggregates. Cliachite is present as fine to medium patches and pisolites, often being replaced by gibbsite (Pmg-4). Opaques are seen present as fine to medium anhedral patchy relicts with ferruginous patches. Clayey patches are noted in areas and often seen being intermixed with cliachite patches.

Field Photograph 1: Metabasalts showing fine grained texture.

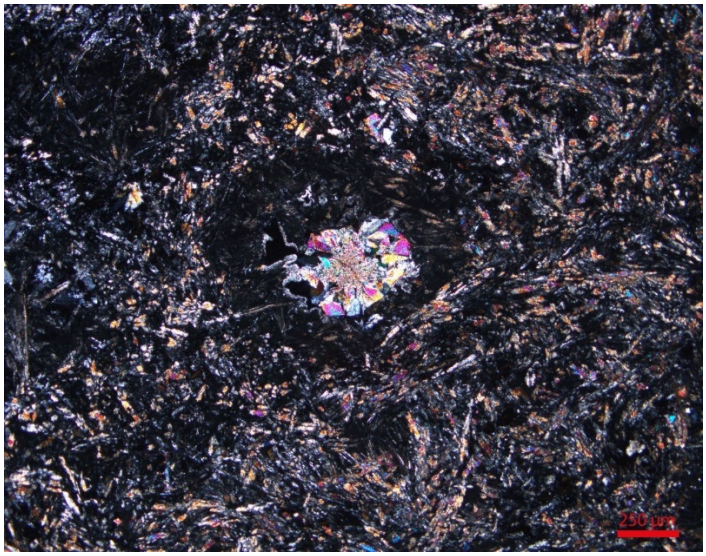
FieldPhotograph 2: Exposure of Volcanic rock in composition of Basalt to Andesite.

Field Photograph 3: Exposure showing slaty shale.

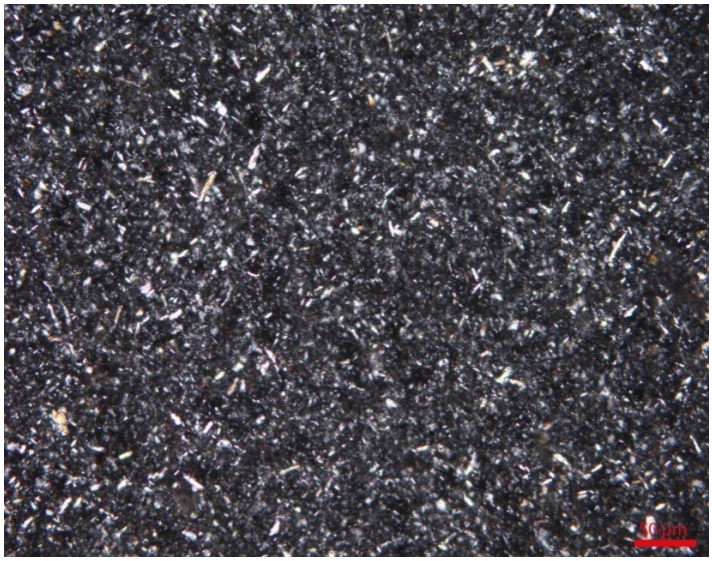
Field Photograph 4: Exposure showing quartz arenite with quartz veins.

Field Photograph 5: Photograph showing exposure of laterite.

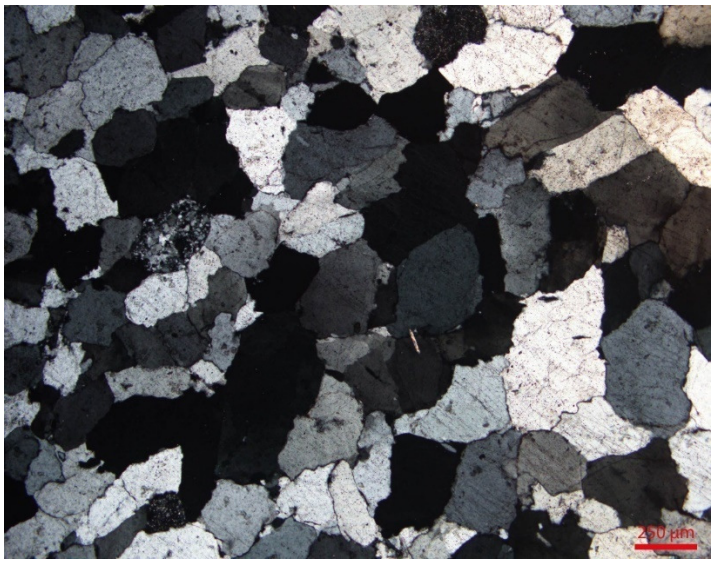
Field Photograph 6 Photograph showing exposure of laterite.



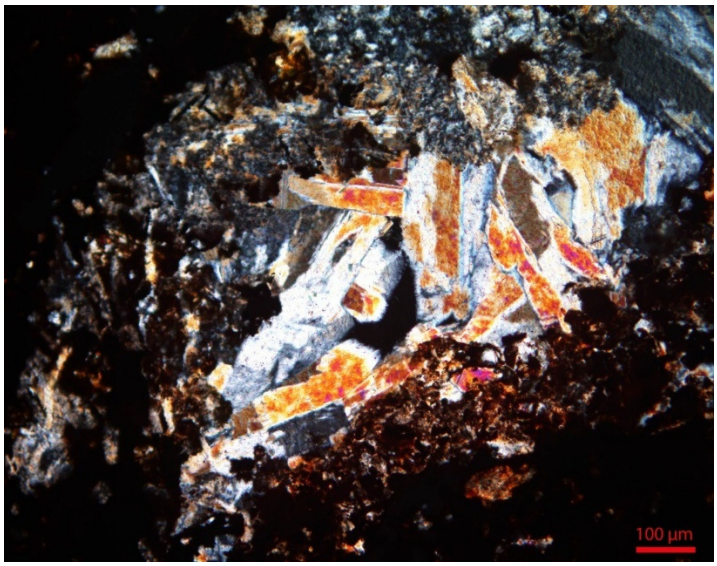
Pmg – 1: Photomicrograph showing fibrous zeolite and subhedral aggregates of epidote at the core of amygdaloidal filling within basaltic rock as seen under crossed nicols.
Specimen No.: SKP04 Magnification: 40X



Pmg – 2: Photomicrograph showing very fine flaky aggregates of clay minerals as seen under crossed nicols.
Specimen No.: SKP02 Magnification: 200X



Pmg – 3: Photomicrograph showing well sorted and tightly packed subrounded clasts of quartz and lithic fragments as seen under crossed nicols.
Specimen No.: SKP11 Magnification : 40X



Pmg – 4: Photomicrograph showing fine to medium subhedral prismatic aggregates of gibbsite replacing clichitic patches as seen under crossed nicols.
Specimen No.: SKP13 Magnification: 100X

7.3 STRUCTURAL DETAILS OF THE AREA

Both primary & secondary structures are observed and discussed below:-

a) **Primary structures:** Primary structures comprise primary depositional surface in the form of bedding, laminations,. Primary depositional bedding plane i.e., S_0 is the most conspicuous planar fabric in the meta-sedimentary sequence exposed in the area. Bedding and laminations in inter-banded quartzite and slaty shale of Chilpi Group are distinctly defined by compositional and colour banding between alternate grey, yellow and pinkish red bands. The general attitude of meta-sedimentary litho units is N-S with predominant low to moderate dips towards E. The strike direction locally varies from N-S to NNE-SSW due to regional scale open folds.

b) Secondary structures: Secondary structures observed in the area consist of foliations. Attitude of S_0 is sub-parallel to S_1. The general attitude of S_1 is N-S/60° dip towards east.

c) Joints: Three prominent joints are noticed in the area. Their general attitude is N40°W/70°SW and N30°E/50°SE.

7.4 METAMORPHISM OF THE AREA

The varied lithounits observed in the area have the following mineral assemblages: -
a. Meta andesite: plagioclase+augite+chorite+epidote+uralite+saussurite+calcite

b. Meta basalt: Chlorite K-feldspar + quartz

c. Meta-arenite: recrystallised quartz

d. Slaty shale: chlorite+ +epidote

The lithounits of Nandgaon and Chilpi Groups have been subjected to very low grade regional metamorphism. This is clearly evident from the abundant occurrence of shales in the area representing gradational variation in metamorphism from lower amphibolite facies to lower green schist facies. Studies of thin sections of meta-volcanics rocks within the study area also indicate metamorphic grade of lower part of green schist facies with chlorite and epidote as index minerals. Arrival at such a conclusion was facilitated on finding signatures of decalcification of plagioclase and development of chlorite-epidote-carbonate assemblage in the meta-volcanics. Meta-volcanic rocks have mineralogical composition similar to calc-alkaline rocks altered by low grade metamorphism. Recrystallisation effects due to low grade of metamoprhism are observed in massive quartzite.

7.5 A DISCUSSION ON THE TYPE OF THE DEPOSIT BASED ON THE STYLE OF MINERALISATION

Nickel-cobalt (Ni-Co) laterite deposits are supergene enrichments of Ni±Co that form from intense chemical and mechanical weathering of ultramafic parent rocks. These regolith deposits typically form within 26 degrees of the equator, although there are a few exceptions. They form in active continental margins and stable cratonic settings. It takes as little as one million years for a laterite profileto develop. The time required for the formation of a Ni-Co laterite deposit depends on the rate of weathering, the tectonic stability, and the rates of mechanical erosion. The rate of weathering depends on the amount of rainfall and evaporation in a region, which determines the amount of water infiltrating the laterite profile each year (Nahon and Tardy, 1992). The amount of rainfall and the proficiency of drainage help determine the extent of the development of the weathered profile. The thickness of the profile depends on how the weathering front and rate of erosion progress and the time in which these processes are allowed to develop (Elias, 2002).

Three subtypes of Ni-Co laterite deposits are classified according to the dominant Ni-bearing mineralogy, which include hydrous magnesium (Mg)-silicate, smectite, and oxide. These minerals form in weathering horizons that begin with the unweathered protolith at the base. Although these subtypes of deposits are the more widely used terms for classification of Ni-Co laterite deposits, most deposits have economic concentrations of Ni in more than one horizon. Because of their complex mineralogy and heterogeneous concentrations, mining of these metallurgically complex deposits can be challenging. Modern techniques of ore delineation and mineralogical identification are being developed to aid in streamlining the Ni-Co laterite mining process, and low-temperature and low-pressure ore processing techniques are being tested that will treat the entire weathered profile. There is evidence that the production of Ni and Co from laterites is more energy intensive than that of sulfide ores, reflecting the environmental impact of producing a Ni-Colaterite deposit. Tailings may include high levels of magnesium, sulfate, and manganese and have the potential to be physically unstable.

The Salwara-Kumarwara-Murum area laterite deposits and are supergene enrichments of Basalt rocks and Ni±Co that form intense chemical and mechanical weathering of basalt rocks.

The orientation survey indicated soil cover of colluvial nature, separating the weathered bedrock and the upper soil horizons. The geochemical survey revealed the secondary dispersion of copper from the silicified vein into the basic rocks.

The silicified vein traversing the andesites about 500m east of Kumarwara contains disseminated specks of pyrite and chalcopyrite mineralization and malachite stains.

Field Photograph 8: **Occurrences of Laterite in the block**

Field Photograph 9:**Occurrences of Laterite in the block**

Field Photograph 10: **Occurrences of Laterite in the block**

8. PREVIOUS EXPLORATION

William King (1885) who mapped the area fringing the Chattisgarh basin refers to the Saletekri hills situated to the northwest of the area under report, as an extension of the type Chilpis southwards (Pascoe, 1965, p.164). During the period from 1933 to 1937 D.S. Bhattacharya carried out geological mapping in Toposheet Nos. 64C/03, 64C/07, 64C/08, 64C/11, 64C/12, 64C/14, 64C/15, 64C/16 and 64G/02 (Fermor, 1934, 1935, Heron, 1936, 1937, 1938). According to Bhattacharya the sedimentary formations of the area which include shale, phyllite, ferruginous sandstone, grits and sandstone, conglomerate and greenstone which lie at the base form the Sakoli Series. Subsequently Sarkar (1957, 1958) carried out mapping intermittently between 1949 to 1957, in the Toposheet Nos. 64C/07, 64C/08, 64C/12 and the adjoining parts of Toposheet Nos. 64C/15 and 64C/16 which cover the area to the southwest of the present area. The 'mylonites, conglomerate and recrushed mylonite' of Bhattacharya (1937) have been identified by Sarkar (1957) rhyolites with flow layers and rhyolitic conglomerates of sedimentary origin respectively. Sarkar (1957) has found that most of these rocks which Bhattacharya had considered of Sakoli age are Post-Sakoli and Pre-Cuddapah in age designated as the Dongargarh System.

In the Field Season 1974-1975, S.G. Udhoji carried out regional stream sediment survey in the parts of toposheet No. 64C/13, which is immediately to the north of the area under report. Dr. T.K. Charlu carried out regional stream sediment surveys in the SE parts of the toposheet 64C/14 during 1974-1975 field season. That area is to ESE of the area under report. G.V. Rao (1976) carried out reconnaissance mapping with the help of Photogeological maps and proposed that as the Bortalao sandstone formation of Sarkar was found to grade along strike into Chilpighat shales and continues westward forming the Mansar formation of Sausar, the Dongargarah and Chilpighat formations are one and the same.

S.G. Udhoji carried regional stream sediment sampling during Field Season 1975-1977, along with the geological mapping over an area of 260 sq. km in parts of toposheet No. 64C/14. In the course of work, 521 stream sediment samples and 64 bed rock samples were collected. On the basis of regional stream sediment survey in the malajkhand extension area, central block, Rajnandgaon district, he recommended that the anomaly zones near Dhans and Kamarwara may be further investigated in detail for nickel mineralization and near Murum for copper mineralization.

S.G. Udhoji recommended that the anomaly zones near Dhans and Kumarwara may be further investigated in detail for nickel mineralization and near Murum for copper mineralization. It was mentioned in the report that copper, lead, zinc, cobalt and nickel content of the stream sediment samples vary from 10 to 240, <10-60, 30-120, <10-190 and 150-260 ppm respectively. This area is underlain by folded metavolcanics (andesites and minor rhyolites) and metasediments (grits, sandstones, shales?) of the Dongargarh Super Group. On the basis of statistical processing of the analytical data of 521 samples, brought out an anomaly zone for copper to the West of Murum and two zones for nickel near Dhans and Kamarwara. The anamolorus nature of the values is also supported by the coefficient of correlation between Cu, Co and Ni. The copper anomaly zone is about a kilometre long, whereas the nickel anomaly zones are 2.5 and one sq km respectively. The anomaly zone for copper traced in the area near Murum is restricted to a tributary stream and its source is not known. Further works is required condition and establish the extent of the anomaly. The two anomaly zones of nickel, the one near Kumarwara is associated with the NNW-SSE trending shear zone. This suggests that there may be a high concentration in such a zone leading a low grade deposit. He also recommended that the anomaly zones near Dhans and Kumarwara may be further investigated in detail for nickel mineralization.

9. EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

9.1 SCHEME OF EXPLORATION

An area of 52.00 sq.km. was prospected by geochemical soil and bed rock sampling for nickel. Out of these two anomaly zones of around 16.25 sq. km near Salewara-Murum area and around 9.49 sq. km near Kumarwara area prospected by geochemical soil and bed rock sampling for nickel and copper on a grid pattern. For this purpose, a 400mx400m grid has been drawn to collect the samples. 11 traverse lines near Salewara-Murum area and 8 traverse lines near Kumarwara area were laid in E – W direction at an interval of 400m.The sample points were located along the traverse line at 400 m. apart. Rest of the area cover by larger spacing of samples. During the course of work 340 geochemical samples were collected, which include 38 bed rock samples, 302 pit/ soil samples.

The primary objective of the exploration was to assess potentiality of identified anomalous zones and their characteristics. The exploration involved large scale geological mapping, geochemical sampling in the area that falls in part of Survey of India Toposheet No. 64C/14.

9.2 LARGE SCALE GEOLOGICAL MAPPING

The work involved large-scale geological mapping at a scale of 1:12,500 in an area of 52.0 square kilometers in and around Salewara-Murum-Kumarwara area. The mapping aimed to determine the lithological contact and stratigraphic arrangement of various litho units and to identify potential mineralized zones and their characteristics. Geological traverses were conducted within and around the study area to decipher the lithological associations, structural features, and traces of potential mineralization. Hand-held GPS devices were used to identify and mark the lithological contacts between larger litho-units.

The lithologies exposed in the area are altered volcanics (andesite/basalt) of Nandgaon Group, slaty shale with lenses of quartzites, grey quartzite of Chilpi Group and conglomerate, of Chandrapur Group belonging to Chhattisgarh Supergroup. Quartz vein is intrusive in these rocks.

The Basalt is dark green, hard and consists of amygdules exposed in the nala section, near Gerikhadan and Kumarwara. The amygdules are calcite and glassy material. Isolated outcrops of basalts are observed in the field area as well as nala section while the major part of the mapped area is covered by dark grey soil and laterite cover. There is no sharp contact of this rock with the adjacent rock. In some places basalt altered to meta basalt.

Volcanics of Nandgaon Group is exposed as patches in study area. They are exposed north of Kumarwara west of Dhotha. Most of the exposures on the plains are weathered and altered. Volcanics range in composition from Basalt to Andesite. Sometime the volcanics altered to clay stone as exposed near Gerukhadan and south of Murum. This rock totally made up of very fine aggregate of clay minerals. Megascopically, rock with basaltic composition forms the most dominant volcanic rock, followed by andesite. Pale green to green rock, fine grained, with minor quartz. When weathered, the rock appears reddish brown. Andesite is dark green to pale green, mostly aphanitic, occasionally porphyritic with phenocrysts of plagioclase but devoid of quartz. It is vesicular at places and the vesicles are filled by milky white quartz amygdules. All variants show granular or amygdaloidal texture and record a number of joint planes. The volcanics are unconformably overlain by slaty shale/quartzite of Chilpi Group. However, their contact is concealed in the mapped area.

Conglomerate of Chhattisgarh Supergroup is exposed northwest of Dhotha in an outcrop of small surface area. It belongs to Lohardih Formation belonging to Chandarpur Group.

Chilpi Group rests unconformably on the rocks of Nandgaon Group. Rocks of this Group form N-S trending hill range. The Chilpi Group consists of slaty shale, quartzite and sub greywacke. Variegated, fine grained quartzite interbanded with slaty shale occurs as a considerably thick. Upright folding of both quartz-arenite and shale are also observed. Quartz-arenite with argillaceous cement is exposed around Makhurahi and Murum. It dominantly strikes along NNE-SSW with moderate to moderately high dips towards SE and NW. Locally N-S strikes are measured with easterly or westerly dips. Composition is mostly argillaceous to siliceous. Milky white, medium grained quartz vein is intrusive in to Nandgaon Group and Chilpi Group in the area.

Fairly large part of the study area are covered by laterite capping, with scanty exposures of basalt, quartzite etc. It is well exposed in the area between Kumarwara, Murum,

Dhotha and Salewara. The best exposures of laterite appearance to the typical laterite. Bauxitic laterite also noticed near Bhulwahi Dongri. Locally it has developed pisolitic structure.

The general attitude of meta-sedimentary litho units is N-S with predominant low to moderate dips towards E. The strike direction locally varies from N-S to NNE-SSW due to regional scale open folds.

The lithounits of Nandgaon and Chilpi Groups have been subjected to very low grade regional metamorphism. This is clearly evident from the occurrence of shales in the area representing gradational variation in metamorphism from lower amphibolite facies to lower green schist facies.

9.3 GEOCHEMICAL SAMPLING

During the first phase of the reconnaissance survey, bedrock samples and soil samples were collected to assess the elemental values of Ni, Co and Cu allied with ultramafics and laterite. The samples were primarily collected in a grid pattern of 400mx400m grid from the earlier identified anomaly zones by GSI (1975-77). Rest of the area of the block was covered by bedrock and soil samples with uniform distribution manner as the majority of the area is covered by laterite with patchy occurrences of basalt and its varieties.

A total of 302 soil samples and 38 bedrock samples totaling to 340 samples were collected following the Standard Operating Procedure. Total 340 nos. of bedrock and soil samples were analysed for Ni, Co, Cu, Pb and Zn, by XRF method.

Before collection of in-situ sample of rock from outcrop, the surface is thoroughly cleaned with wire brush and chisel-hammers and then a sample was taken out. Coordinates of the sample location were recorded with help of hand-held GPS devise and Megascopic characters of the sample were noted. The collected samples were sent to MECL laboratory for sample preparation. The samples were crushed and powdered to -200 mesh fractions and powdered samples were then subjected to coning and quartering. A representative sample of 150g was drawn, the same was sent to MECL Chemical laboratory for analysis and remaining samples were preserved as duplicate samples for further studies, if required. The samples were carefully packed with appropriate label. Powdered samples (38 nos.) were analysed and details of analytical

results of bed rock and soil samples for Ni, Co, Cu, Pb and Zn, by XRF method is given in Annexure-IVA & IVB and location of the Bedrock and soil samples are enclosed in Annexure-IIIand Plate –III.

Geochemical soil surveys are carried out to identify areas characterized by high concentrations of Ni, Co, Cu, Pb and Zn, which may indicate a mineral deposit at depth. The concentration of an element in soils is a function of the primary dispersion of that element within the underlying rock, together with the effects of the secondary dispersion factors that were operative during soil formation. So, soil samples are taken from the location where no outcrop are found. A total of 302 samples were collected to know presence of Ni, Co, Cu, Pb and Zn in the soil. Soil sample collected from undisturbed horizon by digging pit from B horizons of soil discarding top regolith and plant humus. The soil would give information about elemental behavior in weathering process and environmental changes affecting the layers. The subsoil sample ('B') was taken up at a depth range upto 1m (the 'B' soil horizon). After drying, soils were subjected to sieving using (-)2mm mesh size initially at field. The whole sieved sample was mixed thoroughly to homogenize and representative sample was collected weighing 5 Kg by progressive conning & quartering. This whole sieved samples were further sieved to (-) 80 mesh size. Afterwards this sieved sample was further grounded and sieved to (-) 200 mesh size powder. Reduction in sample quantity was done through progressive coning and quartering. Therefore, a representative sample of 150g was drawn, the same were sent to MECL Chemical Laboratory for analysis and remaining samples were preserved as duplicate samples for further studies, if required. The details of soil samples with analysis for Ni, Co, Cu, Pb and Zn is given in Annexure-IVB.

The orientation survey for soil geochemical sampling not carried out as time of exploration as the time field execution is very short and major part of the blocks falls under reserve forest. Hence making deep pit is not possible. Though grid wise samples was collected as per approved quantum. The nala cutting section was observed, where the top soil layer as the humus layer. This layer consists of both organic matter and other decomposed materials. The topsoil is soft and porous to hold enough air and water. Thickness of the layer is varying from 25cm to 40cm. It is the subsurface horizon, present just below the topsoil and above the bedrock. The B horizon is comparatively harder and more compact than topsoil. It contains less humus, soluble minerals, and organic matter. It is a site of deposition of iron oxide and mostly lateritised. This layer is much thicker throughout the block. The thickness varies from 1.5m to >3m. The layer

above the metabasalt rock and just below the above layer is devoid of any organic matter and is made up of broken leteritized or limonitised bedrock and cementing clay material. Thickness of the layer is about 1m.

Field Photograph11:**Pit being excavated to collect soil samples**

Field Photograph12:**Pit being excavated to collect soil samples**

9.4 CHEMICAL ANALYSIS

All the bed rock and soil samples were analyzed for 5 radicals of Ni, Co, Cu, Pb and Zn.

Nickel-Ni: In the study area, a total of 38 nos. of bed rock and 302 nos. of soil samples have been analyzed, in which Ni concentration ranges from minimum 50.00 ppm to maximum 600.00 ppm in bed rock and from minimum 50.00 ppm to 1413.00ppm in soil samples. The concentrations of Ni are showing more than 500 ppm in the 2 nos. of bed rock samples collected from the Laterite and rest of the five samples are soil samples. The maximum value of Ni is 1413.00 ppm showing in soil samples number NS03.

Cobalt-Co: In the study area, a total of 38 nos. of bed rock and 302 nos. of soil samples have been analyzed, in which Co concentration ranges from minimum 52.00 ppm to maximum 144.00 ppm in bed rock and from minimum 50.00 ppm to 827.00ppm in soil samples. The concentrations of Co are showing more than 500 ppm in the 1 no of soil in sample number NS125.

Copper –Cu: In the study area, a total of 38 nos. of bed rock and 302 nos. of soil samples have been analyzed, in which Cu concentration ranges from minimum 58.00 ppm to maximum 697.00 ppm in bed rock and from minimum 52.00 ppm to 412.00ppm in soil samples. The concentrations of Cu are showing more than 500 ppm in the 2 nos. of bed rock samples collected from the Laterite. The maximum value of Cu is 697.00 ppm showing in bed rock sample number NS23. In general, the study area doesn't reveal any signature of primary copper occurrences.

Lead-Pb: In the study area, a total of 38 nos. of bed rock and 302 nos. of soil samples have been analyzed and the majority of samples doesn't show any signature of Pb value except eight soil samples. The eight samples showing ranges from 50.00 ppm to 100.00 ppm. Rest of the samples showing value of below detection limit.

Zinc-Zn: In the study area, a total of 38 nos. of bed rock and 302 nos. of soil samples have been analyzed, in which Zn concentration ranges from minimum 52.00 ppm to maximum 424.00 ppm in bed rock and from minimum 50.00 ppm to 225.00ppm in soil samples. No samples showing value of more than 500.00 ppm. The maximum value of Zn is 424.00 ppm showing in bed rock sample number C107A.

Geochemical anomaly map has been prepared on 1: 12,500 scale for soil samples for Ni, Co and Cu. Among the 302 nos. of soil samples. The methods of approach to derive threshold values is Mean + 2x Standard Deviations (SD) (Hawkes and Webb, 1962; Matschullat et al., 2000; Reimann and Garrett, 2005) of geochemical dataset obtained from the present study.

A total of 302 nos. soil samples are analysed for Ni. One sample showing maximum value of 1413.0 ppm of Ni was recorded at about western part of Kumarwara. The isograde contours are drawn on 1:12,500 scale, for easy computation and drawing purpose. The threshold value of Ni is226.63 ppm. Five samples are showing more than 500ppm and showing in the south western part of the study area. Except few spot values, the whole block showing meagre values of Ni. The highest value of Co is 827.00 ppm showing north of Dhotha. Overall, the whole block showing meagre values of Co. The anomaly map of copper showing meagre value throughout the block. The anomaly maps are furnished as Plate- IV-A, IV-B & IV-C.

The Stream Sediment Surveys carried out by GSI (1975-77) over an area of 260 sq km in the Rampur-Kamarwara part of toposheet No. 64C/l4, suggested that copper, lead, zinc, cobalt and nickel content of the stream sediment samples vary from 10 to 240, <10-60, 30-120, <10-190 and 150-260 ppm respectively. This area is underlain by folded metavolcanics and metasediments of the Dongargarh Super Group. The anomaly zone for copper traced in the area is restricted to a tributary stream and its spring.

The geochemical anomaly picked up by stream sediment surveys by GSI does not reflect anomalous localization of copper & nickel in the area and might be due to concentration of nickel in limonite developed on weathered surfaces of basic rocks, which was responsible for high nickel content in stream sediment samples.

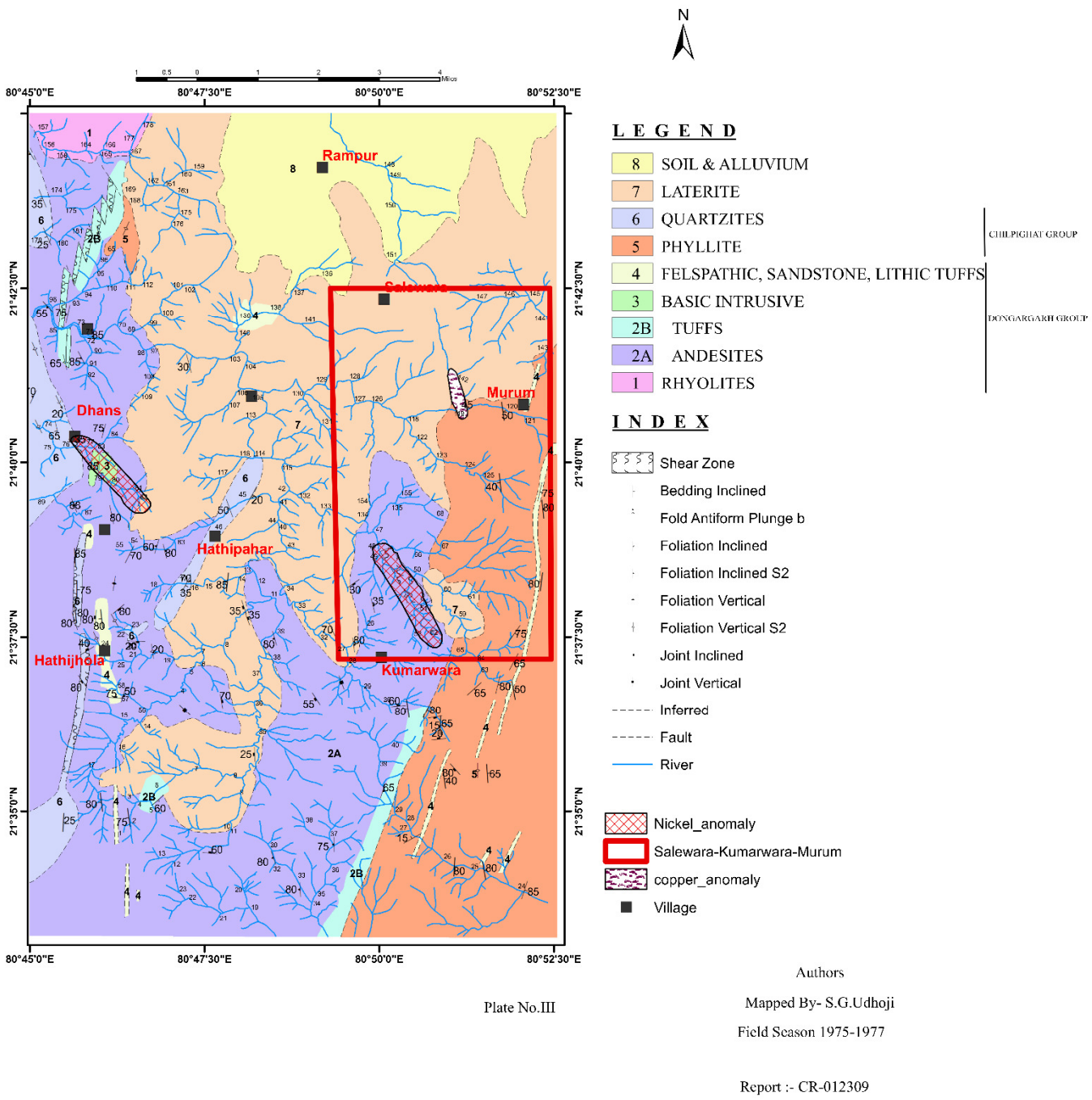
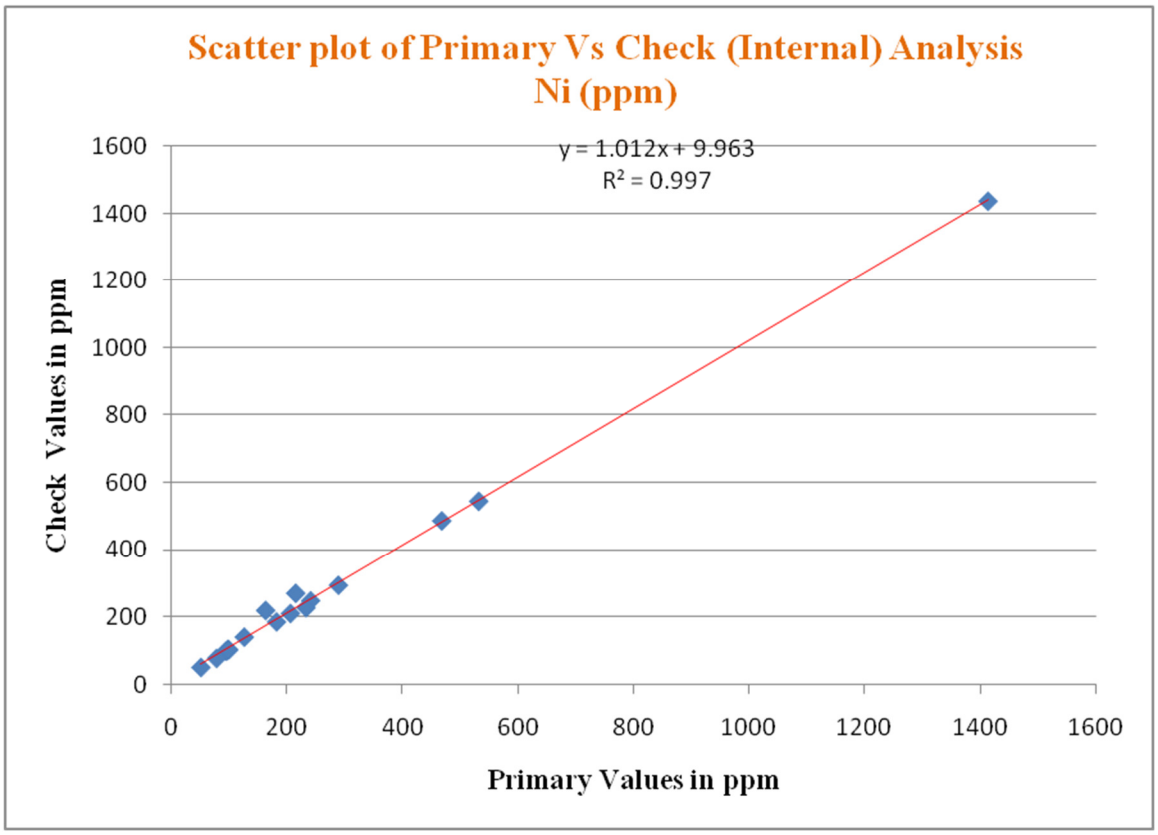


Figure 4: Geological Map with analytical value of stream sediment samples collected by GSI showing Salewara-Kumarwara-Murum Block, District Khairagarh-Chhuikhadan-Gandai, Chhattisgarh (S.G. Udhoji, 1975-77)

9.8 QUALITY OF ASSAY DATA AND LABORATORY TESTS

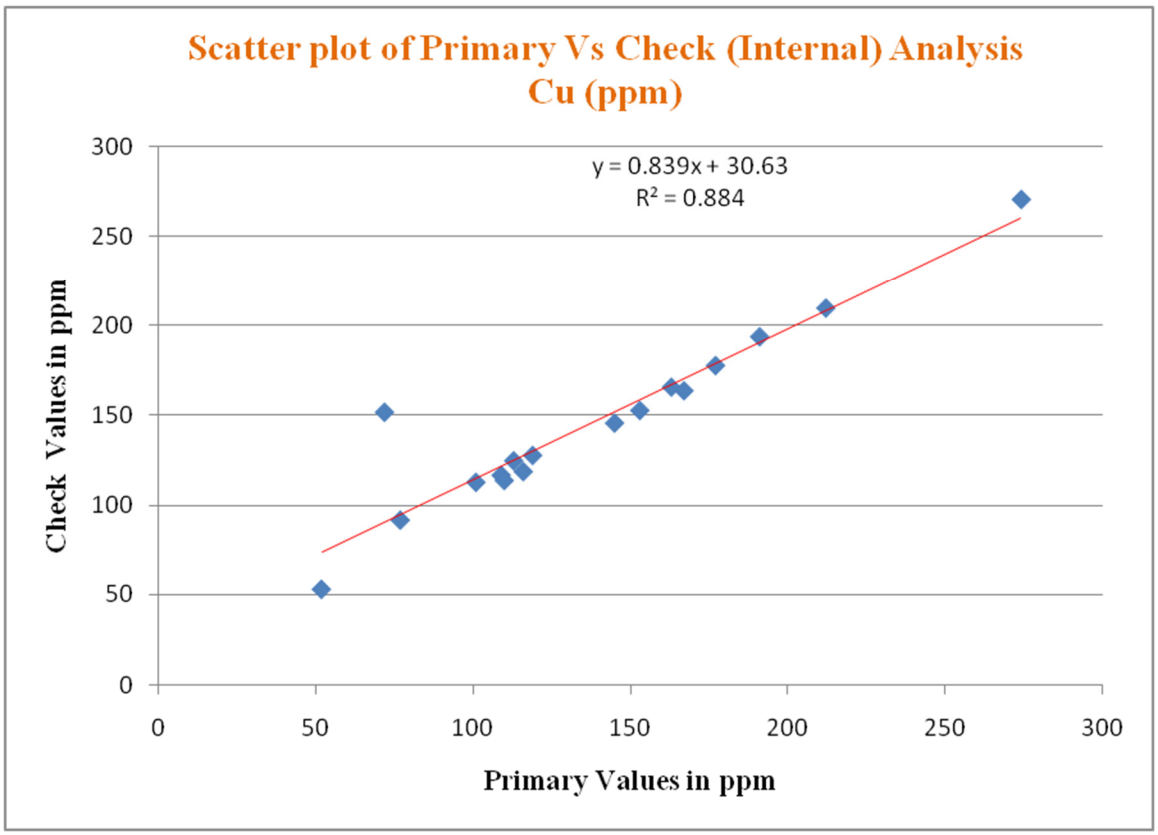
Comparison of Primary Vs Internal Check Assay Value

The comparative study made in respect of total 17 nos. of sample (approx. 5%) for 5 elements subjected to internal checks for establishing the reproducibility of analysis. These internal checks are analyzed at MECL laboratory Nagpur. A summary of comparative statement of primary Vs internal Check Assay (34 elements) Value have been given in Annexure –VA. The statistical analysis of Ni, Co, and Cu has been prepared to check the reliability of assay. The scatter plots of aforesaid radicals show the correlation coefficient more than 0.90, which is very near to 1 showing homogeneity of the sample prepared as well as reliability of chemical analysis.



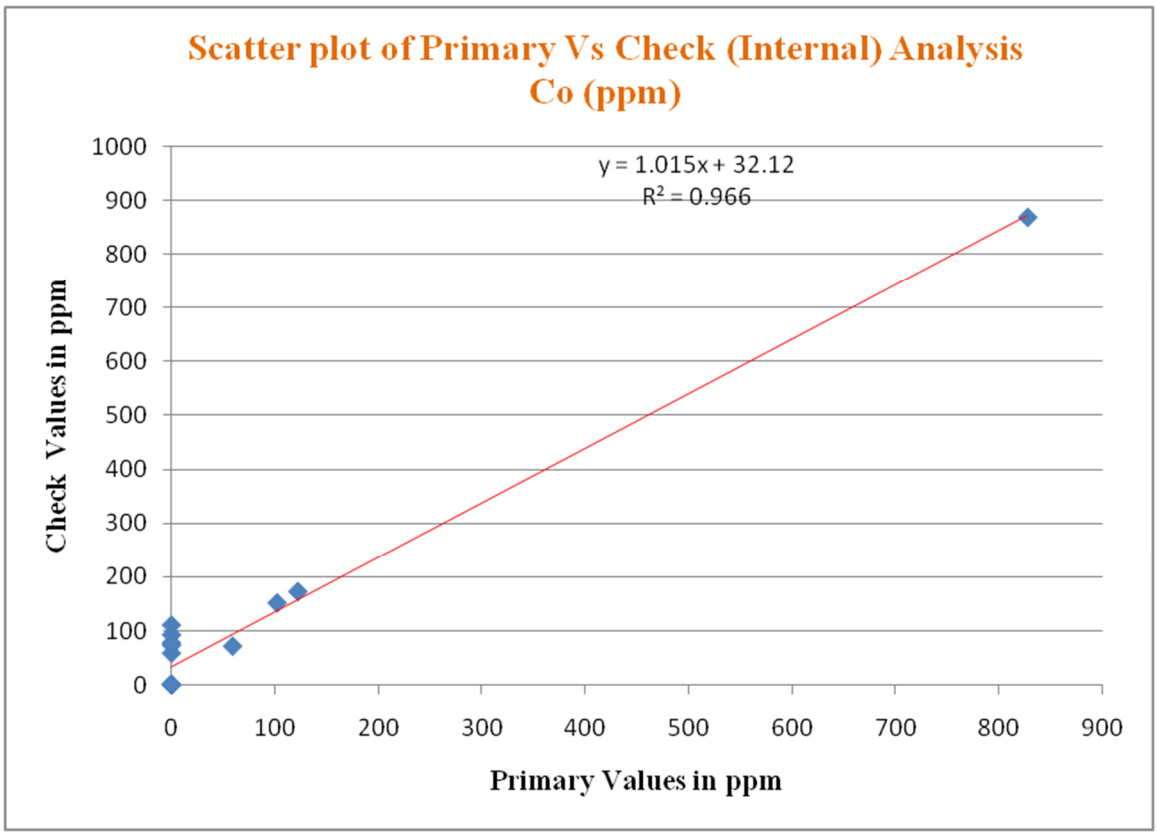
COMPARISON OF PRIMARY Vs.INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Ni (ppm)	
	Primary	Check
No. of Sample Pairs	17	
Arithmetic Mean	268.706	282.0
Standard Deviation	313.529	317.864
Std. Error of Mean	76.042	77.093
Variance	98300.325	101037.529
Mean of Deviation	-13.294	
Standard Deviation (Error)	17.333	
Correlation Coefficient	0.999	
Mean Absolute Error	13.882	
Mean Relative Random Error	5.166%	
Paired T value	-3.162	
F - test value	0.973	



COMPARISON OF PRIMARY Vs.INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Cu (ppm)	
	Primary	Check
No. of Sample Pairs	17	
Arithmetic Mean	138.294	146.765
Standard Deviation	54.22	48.423
Std. Error of Mean	13.15	11.744
Variance	2939.855	2344.768
Mean of Deviation	-8.471	
Standard Deviation (Error)	18.639	
Correlation Coefficient	0.940	
Mean Absolute Error	9.412	
Mean Relative Random Error	6.806%	
Paired T value	-1.874	
F - test value	1.254	

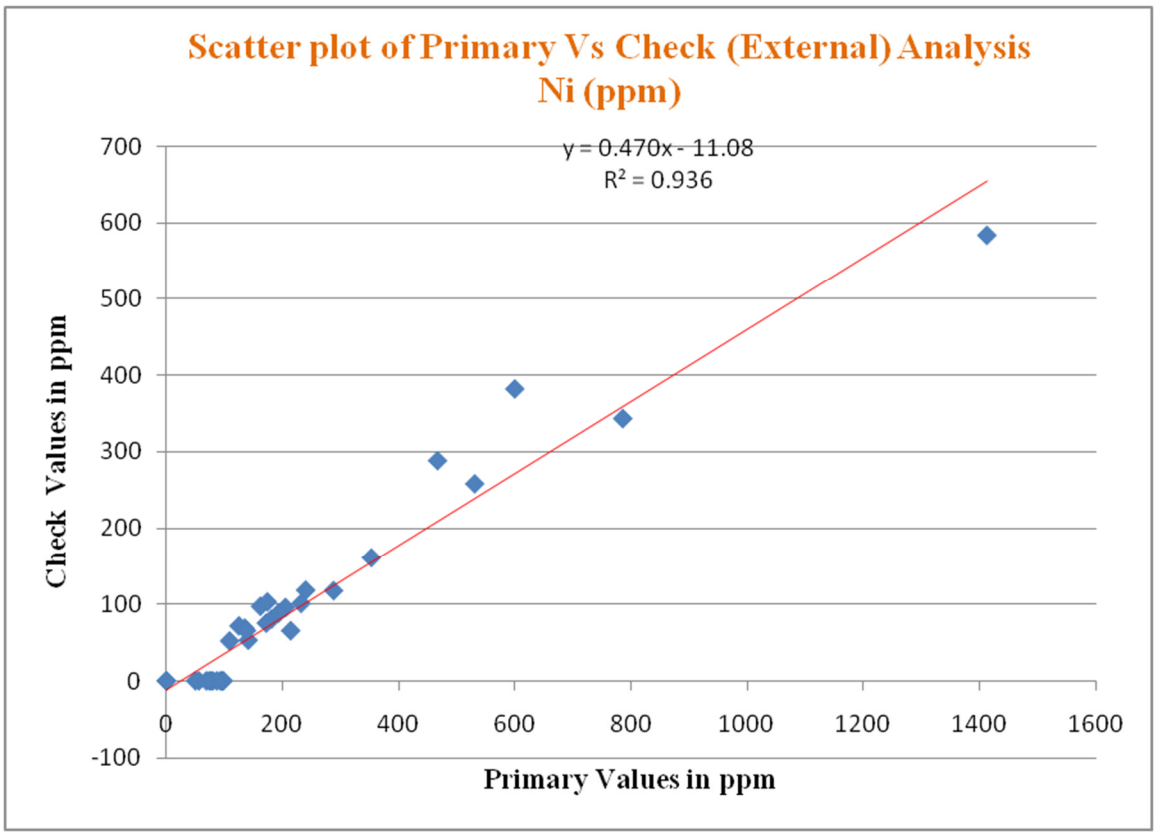


COMPARISON OF PRIMARY Vs.INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Co (ppm)	
	Primary	Check
No. of Sample Pairs	17	
Arithmetic Mean	65.294	98.412
Standard Deviation	194.062	200.46
Std. Error of Mean	47.067	48.619
Variance	37660.09	40184.125
Mean of Deviation	-33.118	
Standard Deviation (Error)	37.061	
Correlation Coefficient	0.983	
Mean Absolute Error	33.118	
Mean Relative Random Error	50.721%	
Paired T value	-3.684	
F - test value	0.937	

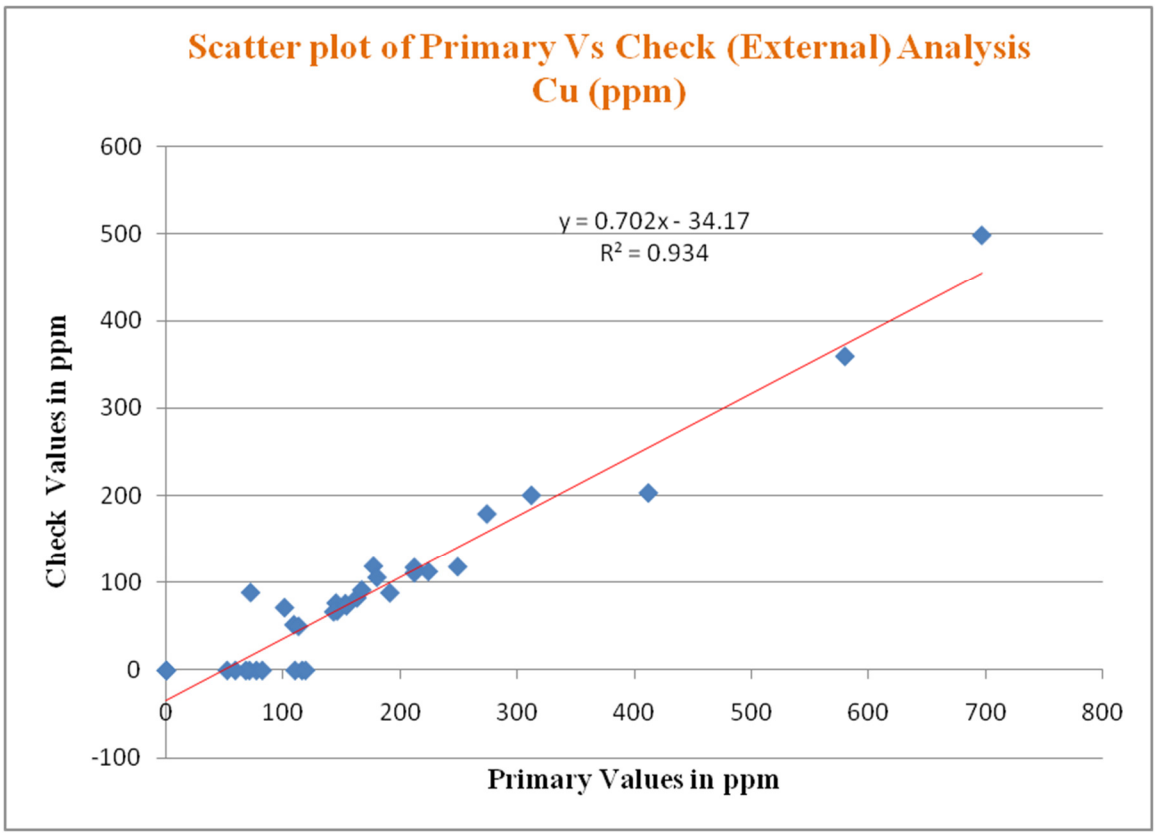
Comparison of Primary Vs Internal Check Assay Value

The comparative study made in respect of total 34 nos. of sample (approx. 10%) for 5 elements subjected to external checks for establishing the reproducibility of analysis. These external checks are analyzed at JNRDDC, Nagpur. A summary of comparative statement of primary Vs external Check Assay (5 elements) Value have been given in Annexure –VB. The statistical analysis of Ni, Co, and Cu has been prepared to check the reliability of assay. The scatter plots of aforesaid radicals show the correlation coefficient more than 0.90, which is very near to 1 showing homogeneity of the sample prepared as well as reliability of chemical analysis.



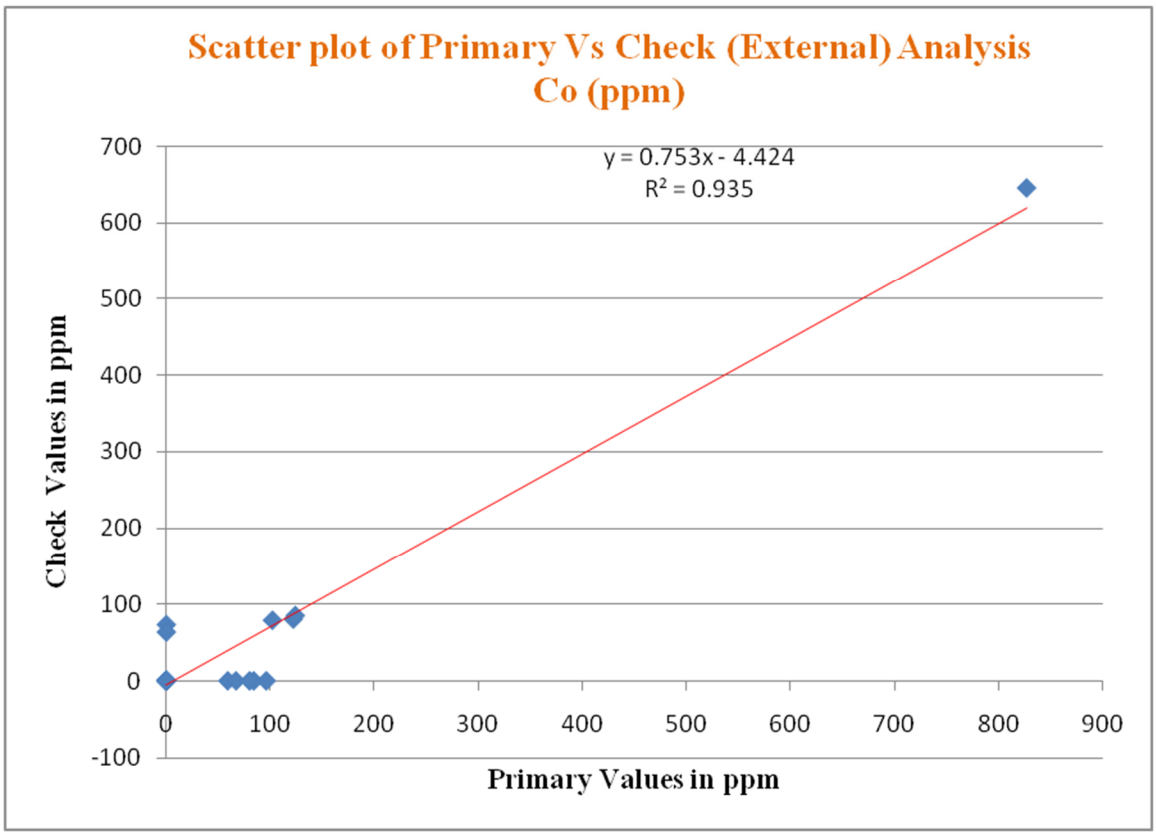
COMPARISON OF PRIMARY Vs.INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Ni (ppm)	
	Primary	Check
No. of Sample Pairs	34	
Arithmetic Mean	227.5	96.0
Standard Deviation	267.6	130.194
Std. Error of Mean	45.893	22.328
Variance	71609.662	16950.513
Mean of Deviation	131.5	
Standard Deviation (Error)	145.412	
Correlation Coefficient	0.968	
Mean Absolute Error	131.5	
Mean Relative Random Error	57.802%	
Paired T value	5.273	
F - test value	4.225	



COMPARISON OF PRIMARY Vs.INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Cu (ppm)	
	Primary	Check
No. of Sample Pairs	34	
Arithmetic Mean	174.706	88.582
Standard Deviation	143.642	104.408
Std. Error of Mean	24.634	17.906
Variance	20633.031	10900.953
Mean of Deviation	86.124	
Standard Deviation (Error)	50.378	
Correlation Coefficient	0.967	
Mean Absolute Error	87.106	
Mean Relative Random Error	49.859%	
Paired T value	9.968	
F - test value	1.893	



COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Co (ppm)	
	Primary	Check
No. of Sample Pairs	34	
Arithmetic Mean	45.912	30.188
Standard Deviation	141.792	110.523
Std. Error of Mean	24.317	18.954
Variance	20104.904	12215.282
Mean of Deviation	15.724	
Standard Deviation (Error)	44.79	
Correlation Coefficient	0.967	
Mean Absolute Error	23.747	
Mean Relative Random Error	51.723%	
Paired T value	2.047	
F – test value	1.646	

9.6 PETROGRAPHIC STUDIES

A total of 10 numbers of surface rock samples were collected from various litho units representing the study area for better understanding of the mineral assemblages, metamorphic reactions and genesis of the rock type. These samples were sent to Petrological Laboratory of MECL for petrographic studies, a detail of which is provided as Annexure- VI.

9.7 QUANTUM OF WORK ACHIEVED

With reference to the objectives of the exploration discussed, following quantum of work has been achieved against approved NQT.

Table- 3: *Quantum of work achieved against approved NQT*

Sl. No.	Item of Work	Unit	Target	Achievement
1	**Geological Mapping**			
	on 1:12,500 Scale	Sq Km	52	52
2	**Geochemical Sampling**	Nos.		
	Bed rock / Soil samples		340	340
3	**Laboratory Studies**			
	i) Surface Sampling (Bed Rock) (Primary samples)	Nos		
	Bed Rock/Soil			
	For Ni, Co, Cu, Pb & Zn		340	340
	ii) Check Samples (5% Internal + 10% External)	Nos		
	For Ni, Co, Cu, Pb & Zn		51	51
4	**Petrological Samples (Surface Samples)**			
	a) Preparation of Thin Section	Nos	10	10
	b) Study of Thin Section	Nos	10	10
9	**Geological Report Preparation**	Nos.	1	

10. SUMMARY AND RECOMMENDATION

10.1 SUMMARY

The Salewara-Kumarwara-Murum Block area falls in Survey of India Toposheet No. 64C/14, and covers an area of 52.00 sq.km in and around villages Salewara, Kumarwara, Dhotha, Gatapar and Murum of Chhuikhadan Tehsil, Khairagarh-Chhuikhadan-Gandai District, Chhattisgarh. The block could be approached from Rajnandgaon city by metal road of about 55km and Khairagarh by metal road of about 30 km. The nearest airport is Raipur, Chhattisgarh is about 90km.

The area is a hilly terrain with a broad valley in the eastern part flanked by steeply rising N-S trending ridges on either side. The general ground level in the valley area is around 620m above msl, whereas the maximum elevation in the northern part is about 710m above msl and 717m in the southern parts. The general slope of the area to the north is indicated by general northerly flowing drainage. The drainage of the area is mainly formed by the Magurdah, and its tributaries. Numerous small streams and stream-lets drain the area.

The area is characterized by meta-volcanics of Nandgaon Group, meta-sediments of Chilpi Group and gently dipping sedimentary rocks of Chhattisgarh Supergroup. Sandstone of Bartalao Fromation, Rhyolite of Bijli Formation and basalt/andesite of Pitepani Formation belonging to Nandgaon Group of Palaeo-Proterozoic age is the oldest rock. These three formations come under Dongargarh Supergroup. Nandgaon volacnics are followed up by rocks of Chilpi Group represented by slaty shale with lenses of conglomerate, quartzite and gritty quartzite of varying thickness. They are followed up by Conglomerate, ferruginous sandstone and pebbly sandstone of Lohardih Formation. The whole sequence is overlain by basalt of Linga Formation of Amarkantak Group belonging to Deccan Trap of Upper Cretaceous to Palaeocene age.

The lithounits of Nandgaon and Chilpi Groups have been subjected to very low-grade regional metamorphism. Studies of thin sections of meta-volcanics rocks within the study area also indicate metamorphic grade of lower part of green schist facies with chlorite and epidote as indicator minerals.

Nickel-cobalt (Ni-Co) laterite occurrences are supergene enrichments of Ni±Co that from intense chemical and mechanical weathering of ultramafic parent rocks. The seregolith deposits typically form within 26 degrees of thee quator, although there are

a few exceptions. They form in active continental margins and stable cratonic settings. It takes as little as one million years for a laterite profile to develop. The amount of rainfall and the proficiency of drainage help determine the extent of the development of the weathered profile. The Salwara-Kumarwara-Murum are alaterite deposits are supergene enrichments of Ni±Co that form from intense chemical and mechanical weathering of basalt rocks.

The area was prospected by geochemical soil and bed rock sampling for nickel, Cobal and Copper. Out of these two anomaly zones of around 16.25 sq. km near Salewara-Murum area and around 9.49 sq. km near Kumarwara area prospected by geochemical soil and bed rock sampling for nickel and copper on a grid pattern. For this purpose, a 400mx400m grid has been drawn to collect the samples. 11 traverse lines near Salewara-Murum area and 8 traverse lines near Kumarwara area were laid in E – W direction at an interval of 400m. Rest of the area is covered by larger spacing of samples. During the course of work 340 nos. geochemical samples were collected, which include 38 bed rock samples, 302 soil samples.

A total of 302 nos. soil samples are analysed for Ni, Co, Cu, Pb & Zn. One sample showing maximum value of 1413.0 ppm of Ni was recorded at about western part of Kumarwara. The isograde contours are drawn on 1:12,500 scale, for easy computation and drawing purpose. The threshold value of Ni is 226.63 ppm. Five samples are showing more than 500ppm and showing in the south western part of the study area. Except few spot values, the whole block showing meagre values of Ni. The highest value of Co is 827.00 ppm showing north of Dhotha. Overall, the whole block showing meagre values of Co. The anomaly map of copper showing meagre value throughout the block.

The geochemical surveys carried out in Salewara kumarwara-Murum Block, employing bed rockand soil sampling have, in general brought out a rather flat geochemical landscape. The statistical treatment of the chemical data denotes single population log normally distributed. The statistical analyses of the chemical data for the soil samples only few samples show more than threshold and anomalous values. The geochemical contour maps for Ni, Co and Cu prepared based on the analytical results of the soil samples, indicate an almost uniform distribution of values, though the contour maps for Ni and Co show some concentration of values towards central and south western side. The detailed follow up of the area is probably not worthwhile as it gives flat geochemical landscape.

The extent of sulphide mineralization could not be established due to traces with very poor concentration of Cu associated with laterite and metabasics.The geochemical survey revealed the secondary dispersion of copper from the silicified vein into the metabasic rocks.

10.2 RECOMMENDATION

On the basic of geochemical prospecting carried out for nickel, copper and associated minerals following conclusions are drawn.

- Analytical results of bed rock and soil samples do not exhibit significant anomaly.
- Average nickel content of the basic rock is of the order of 400 ppm and compares well with the clarke value for any basic rock.
- Due to weathering and limonitisation nickel content is accentuated in the basic rock as is evident from profile section.
- The geochemical anomaly picked up by stream sediment surveys during the previous work does not reflect anomalous localization of nickel in the area and might be due to concentration of nickel in limonite developed on weathered surfaces of basic rocks, which was responsible for high nickel accumulation in stream sediment samples.
- The orientation survey indicated soil cover of colluvial nature, separates the weathered bedrock and the upper soil horizons. The geochemical survey revealed the secondary dispersion of copper from the silicified vein into the metabasic rocks.
- Overall, the geochemical survey doesn't reveal any encouraging values of Ni, Co and Cu.

11. CERTIFICATE FROM THE QUALIFIED PERSON

This is to certify that geological report has been prepared in respect of Salewara-Kumarwara-Murum Block, District- Khairagarh-Chhuikhadan-Gandai, Chhattisgarh at G-4 level for exploration for Ni, Co & Cuby Mineral Exploration and Consultancy Limited (MECL) on behalf of National Mineral Exploration Trust. The report has been prepared in accordance with the Minerals (Evidence of Mineral Contents) Rule 2015 specified under Mineral Auction Rule, 2015 and amended up to 2021.

GENERAL MANAGER (EXPLORATION)

LOCALITY INDEX

Sl. No.	Village Name	Lat.	Long.
1	Dhotha	21° 39' 38.5821" N	80° 50' 10.1637" E
2	Dalli	21° 42' 36.2454" N	80° 51' 52.1002" E
3	Gerukhadan	21° 39' 06.3471" N	80° 50' 55.6508" E
4	Gorrha	21° 40' 50.1109" N	80° 50' 42.6971" E
5	Kumarwara	21° 37' 11.1574" N	80° 49' 59.4319" E
6	Murum	21° 40' 49.7456" N	80° 52' 03.8959" E
7	Salewara	21° 42' 20.6801" N	80° 50' 04.2484" E

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