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FINAL TECHNICAL REPORT ON THE EXPLORATION WORK CARRIED OUT IN THE DUNGARPUR RP BLOCK, UDAIPUR AND DUNGARPUR DISTRICTS, RAJASTHAN

I. INTRODUCTION:

Premier Nickel Mines Pvt. Ltd. (PNMPL) is involved in exploration and development of Ni-Cu-PGE projects in India. Based on significant "in house" research efforts, the company has identified several potential areas for Ni-Cu-PGE mineralization in India. As a part of that the area within the Rikhabdev Ultramafic Complex has been targeted for detailed exploration and has been applied for Reconnaissance Permit (RP). Government of Rajasthan granted a Reconnaissance Permit to M/S Premier Nickel Mines Pvt. Ltd. (PNMPL), over an area of 1577 sq km in the Udaipur and Dungarpur Districts of Rajasthan vide grant letter No.F18 (10) Mines/Gr.2/2005 dated 16.7.2008. The R.P. Block granted is shown in **Fig.1**.

II. LOCATION :

The R.P. Block is located 50 km south of Udaipur City. The area can easily be accessed by NH 8. Dungarpur town, the district headquarter of the Dungarpur District is located on the western part of the R.P. Block and is the nearest major rail head. The area has a good net work of motorable roads. The road and rail map of the area prepared from the Survey of India Topo sheet Nos. 45H and 46E updated from Google imagery is given **Fig.2**. Inset in the map, shows the location of the R.P. keyed to the India Grid. During the RP period the company has carried out detailed exploration. Details of the work carried out during the RP period are presented in this Final Technical Report.

III. REGIONAL GEOLOGY :

Regional geological map of the R.P. Block modified after the publication by the Geological Survey of India is given in **Fig.3**. Within the R.P. Block, the Archaean basement gneisses and the rock formations of the Proterozoic Aravalli Supergroup are exposed.

The Archaean basement gneiss is represented by migmatitic gneiss with enclaves of quartzites and marbles which are exposed east of Parsnad, close to the northeastern corner of the R.P. Block. The gneissic complex is referred to as Mangalwar Complex by the Geological Survey of India. The Mangalwar Complex is unconformably overlain by the metasedimentary rocks of Debari Group. Among the rock formations of the Debari Group, arkosic conglomerates and arkoses are found at the base, followed by quartzites and phyllites. The ridges in the NEn corner of the area are constituted by these quartzites. South of Dhankawa, along the eastern border of the R.P.block, the gneisses are overlain by rocks of the Delwara Group represented by conglomerates and volcani-clastic rocks. Rocks of Udaipur Group overlie the Debari and Delwara Groups. Three principal rock types of Udaipur Group are observed in the R.P. Block. Most dominant is the phyllite - a meta-argillite/greywacke, which occupies a large part of the R.P. Block. Inter bedded with these phyllites are quartzites and dolomites, mainly seen in the NEn part of the area, east of Kharear and Sonrai. Succeeding the rocks of the Udaipur Group are the rock formations of the Jharol Group, which are exposed in the northwestern part of the R.P. Block. The principal rock formation of the Jharol Group, is the metagreywacke or sub-greywacke. The Jharol greywackes are considered to of deep water facies, while those of Udaipur are considered to be shelf facies. In the R.P. block, there are several beds of quartzites which are interbedded with the metagreywackes of Jharol Group. Unlike the detrital quartzites of the Debari or Udaipur Groups, these are cherty quartzites. In the southeastern part of the R.P. Block, east of Sonwadi, there is a suite of metagreywackes /subgreywackes interbanded with quartzites, which has been assigned a separate and younger stratigraphic status than the Udaipur Group. These rock formations belonging to the Lunawada Group are considered to be younger than Jharol Group as well as the magmatic emplacements that occurred within the Udaipur Group to the west.

The Udaipur Group is invaded by ultramafic suite of rocks principally represented by serpentinites and talc, actinolite/tremolite schists. They are well known as Rakhabdev Ultramafic suite. The ultramafic rocks occur as a linear belt in the central part of the R.P. Block over its entire length from near Sonal in the North to Ghantigola in the south. Their disposition as linear outcrop has come to be well known in Rajasthan regional geology as Rakhabdev lineament.

The rock formations of the Aravalli Supergroup have been affected by superposed folding. The sequence of deformation consists of early isoclinal folding, coaxial refolding and non-coaxial upright folding. The map patterns resulting from the style and sequence of folding are manifest as hook and dome-basin interference patterns. Regional structural features can be inferred on the basis of interpretation of LANDSAT imagery.

The NNW-SSW to N-S trending linear chain of ultramafic rocks of Dungarpur area are well known as "Rikhabdev Ultramafic Complex". Geological Survey of India has carried out detailed geological mapping of the complex, which has revealed the presence of dunite, peroditite and pyroxenite as major litho - components of the complex. During the geological mapping, old workings for base metals were identified around Sakran and Methali. GSI has also initiated preliminary work to identify the potential of the Rikhabdev ultramafic complex to host Ni-Cu-PGE mineralization. However, those efforts were not very successful.

IV. CONCEPT BEHIND EXPLORATION :

Ultramafic magma, with its high Ni and PGE contents, can be ideal targets for Ni and PGE exploration, provided these elements are properly segregated into sulphide phase during magmatic evolution. Usually, sulfur required for such segregation is provided by the sulphide-rich sedimentary rocks, which are assimilated into the magma. Thus, contact zones of ultramafic-mafic rocks with the sedimentary rocks become important targets in the search of Ni-PGE deposits. Further, ultramafic rocks of Rikabdev finds similarities with Jinchuan intrusion in China, which hosts one of the biggest Ni-Cu deposit in the world. During the present course of exploration lithocontact between ultramafic suite and the Aravalli Supergroup of rocks were scanned for the possible Ni-Cu-PGE sulphide mineralization.

V. Work Carried out by PNMPL :

PNMPL has carried out the following work during the RP stage of exploration :

1) Compilation of existing geological maps and literature
2) Interpretation of DEM, Landsat and other remote sensing data to identify lithounits and major lineaments
3) Geological mapping on 1:50,000
4) Stream and lithogeochemical rock chip sampling **(Annexures-2 & 3)**
5) Interpretation of the data

SAMPLES STATISTICS						
Sl. No.	Type of sample					Total No. of Samples
	Rock chip	Stream	Soil (Pit)	Trench/ Channel	RC Drillhole	
1		10				10
2	71					71
TOTAL	71	10				81

VII. LANDSAT IMAGE ANALYSIS :

Visual interpretation of False Colour Composite LANDSAT imagery of the R.P. Block has been carried out. Contacts, trend lines and faults have been inferred and drawn on the imagery and presented in **Fig.6.** Comparison of interpreted imagery with the geological map shows the following interesting features:

i. Close to the northeastern corner of the R.P. Block, there is a rugged gneissic country which is bordered by ridges that are apparently constituted of quartzites of the Debari Group.

ii. The Ramgarh fold which lies to the east of the area represents a hook shaped interference pattern while the fold east of Sonwadi exemplifies the dome basin pattern. Western parts of these folds are seen along the eastern boundary of the R.P. Block.

iii. The ultramafic rocks of the Rakhabdev ultramafic suite, have also been affected by folding along with rest of the rock formations of the Aravalli Supergroup. The large Z shaped folding of the ultramafic belt near Rakhabdev apparently conceals coaxially refolded early isoclinal fold. There are a number of outcrops of ultramafic rocks to the west of the main linear belt of ultramafic rocks exposed to the east of Sundra. These appear to be torn limbs of folds with NW-SE axial trace.

iv. The folded ultramafic rocks are invaded by granite near Sundra. This granite has been considered by the Geological Survey of India to be a syntectonic granite that was emplaced around 2275Ma when the rocks of Aravalli Supergroup were being folded. The granite is exposed as NE-SW linear body and appears to be fault bound along its eastern and western margins.

v. All the rock formations of the area are affected by a system WNW-ESE to NW-SE system of faults.

VIII. GEOLOGICAL MAPPING :

Field traverses taken by PNM Geologists indicate that Rikhabdev Ultramafic Complex is made up mainly of dunite, peridotite and their altered equivalents. They occur as N-S trending, intrusions with in the metasediments of Aravalli Group. Both coarse- grained and fine-grained variants are found **(Fig.7).**

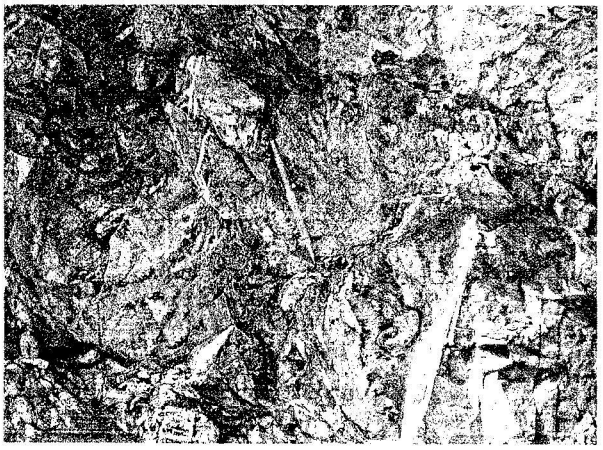

Fig. 7. Sepentinized dunite from Rikhabdev complex

Due to intense serpentinization and associated volume expansion, the ultramafic rocks are brecciated **(Figs.8 & 11).** Brecciation is further enhanced by the shearing that took place subsequent to the emplacement of the ultramafic complex. Though different layers of dunite and peridotite are noticed in the area, systematic magmatic layering, which can be mapped to bring out magmatic stratigraphy, is not identified in the area.

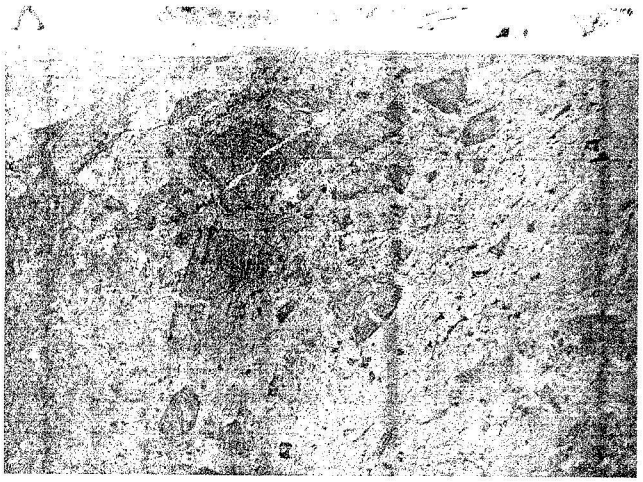

Fig. 8. Serpentinized and brecciated dunite from Rikhabdev ultramafic complex

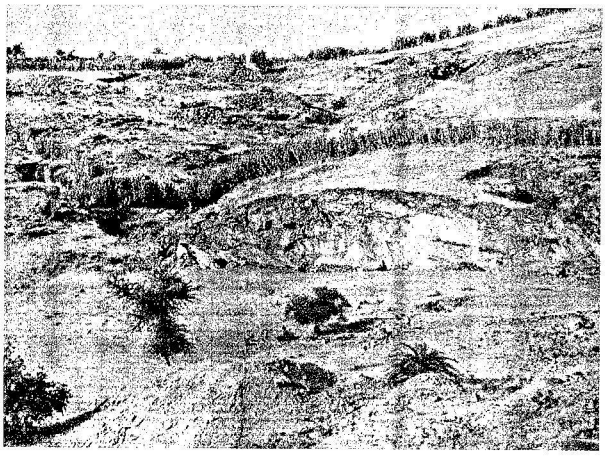

Fig. 9 Contact of the ultramafic rocks with the metasediments

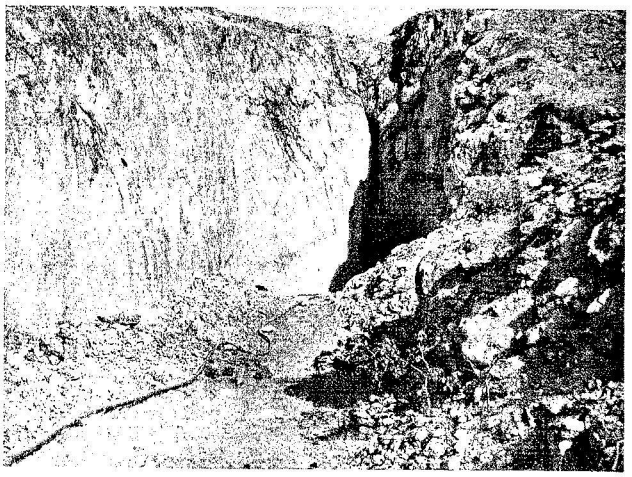

Fig. 10 Contact of the ultramafic rocks with the metasediments

At many places intrusive contacts between ultramafic rocks and the host metasedimentary rocks of Aravalli Group are found **(Figs. 9 & 10).** The contact is very sharp and no obvious evidences suggesting magma-host rock interaction were found. Absence of any country rock xenoliths in the ultramafic rocks led the earlier workers to interpret the Rikhabdev complex as an "Alpine-type" cold intrusion. However, it is pertinent to note that at many places along the contacts sulphide mineralization is identified with elevated Cu and rarely Ni. Presence of sulphides may be related to magma-wall rock interaction. Similar feature is noted around Jobat Complex, which contains highly anomalous Ni-Cu-PGE association. Since, Rikhabdev Complex forms the northern extension of Jobat complex, a similar tectonic setting as well as Ni-Cu-PGE mineralization can be expected.

Fig.11 Sheared ultramafic rocks

IX. WHOLE ROCK GEOCHEMISTRY – MAGMA CHARACTERIZATION :

Representative rock samples from various lithounits were collected and analysed for major, trace and precious elements **(Annexures.4, 5 & 6)**. This study is done with an aim to understand the magma evolution and its potential to hold Ni-Cu-PGE mineralization. On AFM diagram all the samples plot along Mg-Fe tie line and also near to Mg corner **(Fig.12)**. This clearly shows high-Mg nature of the magma, and its evolution along tholeiitic trend. On Jensen plot all the samples plot in komatiite field, except for one sample which falls in high-Fe tholeiitic basalt **(Fig.13).** Both these diagrams clearly show iron enrichment trend during the magmatic evolution. On MgO-Ni binary plot **(Fig.15)** all the samples plot along the silicate – controlled fractionation curve. This feature, coupled with the above observations clearly indicate that all the samples of the present study belong to the same magmatic suite and possibly related by silicate-controlled fractionation. On the spidergram, negative peaks are seen at K, P and Ti **(Fig.14)**. However, no significant –ve peaks are seen at Nb, which suggest that crustal contamination in the Rikhabdev Complex is very minimal or absent.

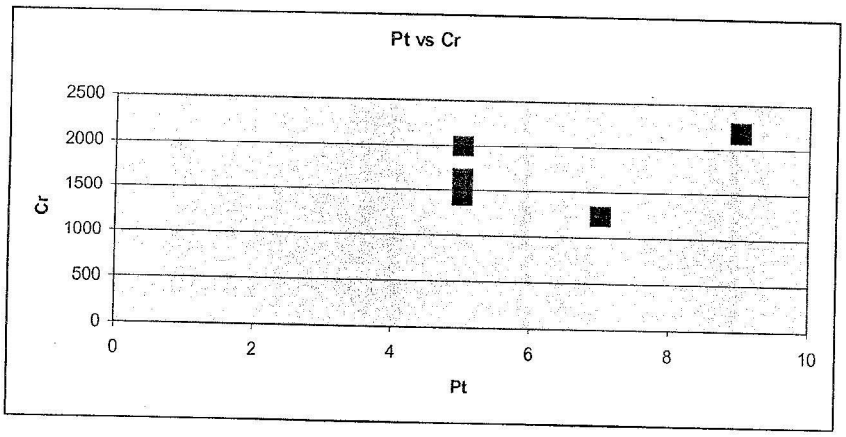

Fig. 19. Cr Vs Pt binary plot

On Ni-Cu binary plot no positive correlation is noted, which indicates absence of sulphide-participation in the magmatic evolution **(Fig.17).** On MgO–Cr plot a positive correlation is noted, which could be due to either silicate – or oxide- controlled fractionation **(Fig.18).** As will be show later that the heavy mineral concentrates collected around the area show significant amounts of chromite, which indicates the presence of chromite as one of the fractionating phase during magma evolution. Further, on Cr-Pt diagram, through not very significant, but distinct positive correlation is noted **(Fig.19).** Thus, it can be conjectured that PGE from the magma fractionated with chromite, which is the case with many only PGE-type deposits, where oxide-controlled fractionation leads to the accumulation of PGE minerals.

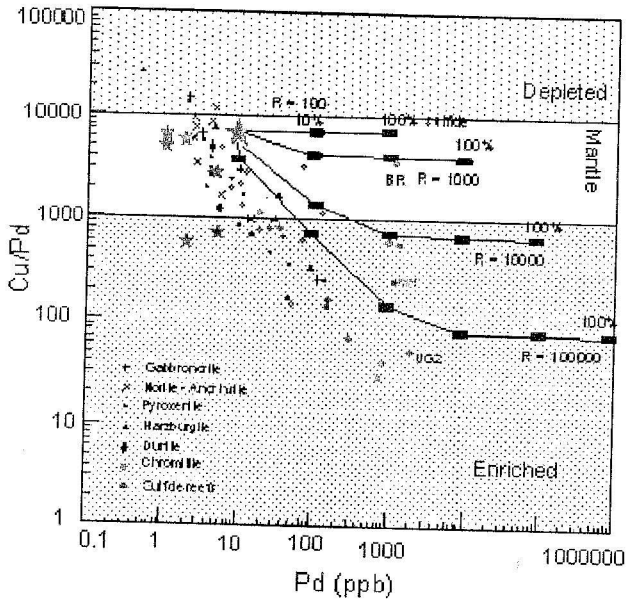

Fig. 20. Cu/Pd vs Pd diagram

On Cu/Pd vs Pd diagram samples from the study area fall in mantle as well as in enriched field **(Fig.20).** Further, they indicate a trend where in R>100,000, which suggests lack of any sulphide control over PGE fractionation. On the other hand, the observed trend follows close to the chromite-reefs, which host UG-2 type PGE reefs (eg. Bushveld Complex). Thus, a similar only-PGE type mineralization can be expected in the complex.

Based on the geological and geochemical observations, it can be concluded that :

1) Sulfide-controlled fractionation is absent, that the complex may not hold promise for Ni-Cu-PGE type massive sulphide deposits.

2) Chromite seems to have fractionated PGE, which indicates the potential for finding a "only-PGE" type deposit, similar to UG-2 of Bushveld Complex, SA or Nizhny Tagil deposit of Russia.

X. MINERALIZATION :

It is well known that Ni-Cu-PGE type mineralization is associated with dessiminated to massive sulphides, where as only-PGE style mineralization can occur with dessiminated sulphides as well as with chromite reefs. During the present study efforts have been made to identify both the kinds of mineralization in the study area. Presence of sulphides is identified in the Sakran and Methali area. However, chromite reef with elevated PGE values is not identified during the present study. The sulphide occurrences in Methali and Sakran areas were further pursued to identify Ni-Cu-PGE type mineralization. Detailed work carried out in these areas is provided below.

Methali area :

Methali is about 11.5km north of Dongarpur town. The Methali village falls in survey of India toposheet 46 E/9.

Lithology and mineralization :

Main rock types encountered in this area are carbonate, phyllite, BMC, talc-chlorite-carbonate schist and metapyroxenite. Large mine dumps are observed with extensive malachite stains. BMC, talc-carbonate schist and metapyroxenite rocks are observed in the old working dump. The talc schist and metapyroxenite show extensive reddish, yellowish oxidations with or without malachite **(Fig.21).** In this area maximum old workings are located in the BMC, which is exposed along contact between ultramafic and metasediments. On the top of the ridge, one of the old workings is situated along the contact between carbonate and metapyroxenite. Eastern wall of the old working exposed metapyroxenite with extensive malachite, disseminations of oxidized sulphides and traversed by discordant gossanous veins.

East of Methali a linear ultramafic body exposed. The western contact of the ultramafic body with the sediments is sharp and in ultramafic rocks extensive carbonate oxidations are observed. White color fractured quartz vein are also observed at the contact. Carbonate and rare phyllite boulders are observed as enclaves with in the ultramafic rocks (Fig. 21). Pale green color serpentine with spotty reddish and yellowish oxidations, rare malachite stains and disseminations of sulphides, is exposed to the east of the above said outcrop. Sulphides are mostly chalcopyrite and suspected pyrrhotite **(Fig.22).**

Structure :

In this area old workings are in the form of linear pits and trenches parallel to strike of the rocks and they extend over 750m. Width of the old workings varies from 6m to 15m. The rock units trend NNW-SSE steeply dips to NE.

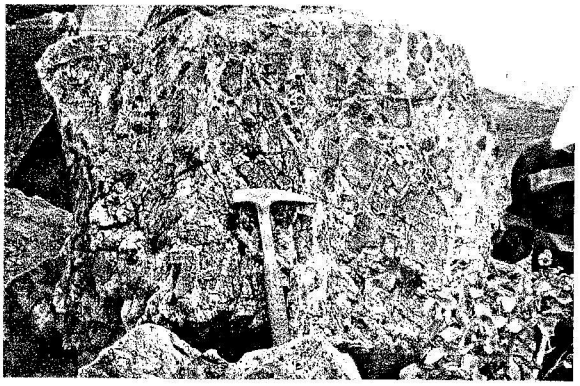

Fig. 21 *Ultramafic rock with enclaves of metasedimentary rocks in Methali area*

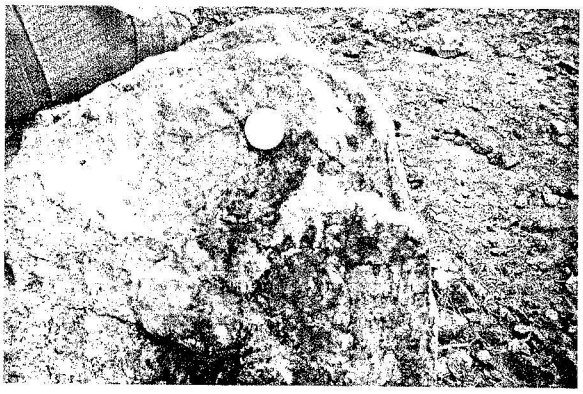

Fig. 22 *Sulphide and malachite bearing serpentinite from Methali area*

Sarkan area :

Sarkan is about 5km east of Dongarpur town. The Sarkan village falls in survey of India toposheet 46 E/13. GSI carried out the exploration in this area for copper.

Lithology and mineralization :

Main rock types encountered in the area are carbonate, phyllite, BMC, serpentine, talc-chlorite-carbonate schist and meta pyroxenite. In general, the old workings are found along the contact between ultramafic rocks and meta sediments. Old workings are located mainly in BMC and a few old workings are located within ultramafic rocks, particularly in the northern part of the area . On top of the ridge 2 types of old workings are observed, a) cave type vertical shafts and b) linear pits. Cave type of old workings are open along the down the dip.

Shafts are observed in the hanging and foot wall. Shafts are refilled and thus the exposed diameter is about 1m to 2m. Linear, trench-like old workings extend for few tens of meters with the exposed width of about 2m.

In the Sakran area mineralization is observed in BMC and ultramafic rocks. In the northern part of the prospect, ultramafic rocks contain box works with malachite. Box works are located across the foliation. Also the malachite occurs along the irregular fractures along the foliations in serpentine **(Figs.23 and 24).** The malachite bearing zone is about 100m x 20m and is exposed along the western contact of the ultramafic rock with the carbonate.

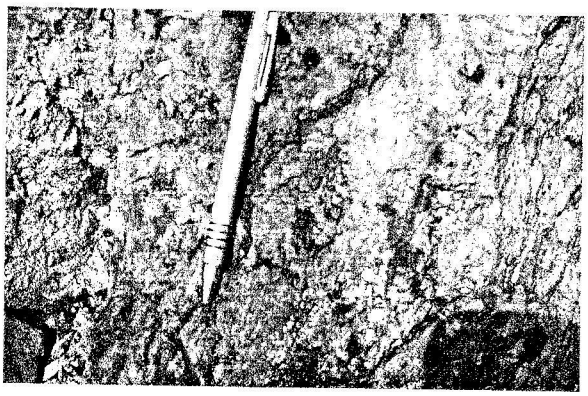

Fig. 23 *Box-works in the serpentine*

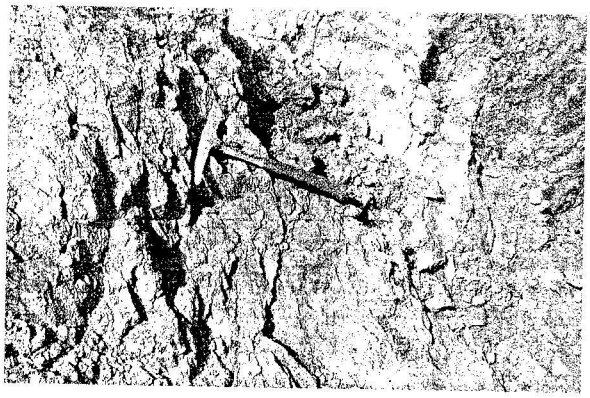

Fig. 24 *Malachite in the irregular fractures along the foliation of serpentine*

Structure :

In general the trend of the lithounits in the area is NNW – SSE to ENE – SWS and dip 36^0 to 84^0 towards SW to NW. The old workings in the area extend for about 350 m in NNE – SSW direction. Thus, they are at high angle to the regional trend. The BMC exposed in the area exhibit broad hook shape fold pattern.

Based on the field observation it is concluded that

1. The contact between the ultramafic rocks and the metasedimentary units is the potential site for the base metal mineralization in the area
2. Based on the morphology of the old workings it is estimated that the mineralization may be in the form of steeply plunging lenses
3. Morphology of the sulphides, viz., box works overprinting schistosity etc., indicates that the mineralization may be related a post deformational event
4. The lithocontact of the ultramafic rocks and the sedimentary units might have provided avenue for the mineralizing fluids

Geochemical Surveys :

Stream Sediment Sampling : One of the major aims of the reconnaissance exploration in the granted R.P. Block has been to examine, whether the Rakhabdev ultramafic suite holds potential for mineralization of nickel and PGE group elements. Towards accomplishing this goal, a detailed geochemical sampling programme has been planned. As a first step, preliminary stream sediment sampling has been carried in the northern part of the ultramafic belt close to Rakhabdev. 10 samples have been collected at the sites shown in **Annexure-3** and analyzed for copper, nickel, chromium, platinum and palladium. Nine out of ten samples have shown more than 1000 ppm of nickel, the highest nickel content noted is 8378 ppm. Cr content in the stream concentrates vary from 1124 ppm to 13,844 ppm. Cu content in these samples range from 13 ppm to 344 ppm. Most samples have platinum and palladium less than 5ppb which is

the lower detection limit. Two out of ten samples have Pt+Pd of 13 to 19ppb. No significant correlation is noted between Cr, Ni, Cu, Pt and Pd.

Sample No.	GPS No.	Easting	Northing	Location	Description	Cu (ppm)	Ni (ppm)	Cr (ppm)	Pt (ppb)	Pd (ppb)	Mg (ppm)	S (%)
69101	645	372643	2643746	Rakhabdev	2nd order stream, active width 3 m, gravels of serpentinite	18	1645	3715	<5	<5	44946	<10
69102	646	372737	2643545	Rakhabdev	2nd order stream, active width 1mt, gravels of serpentinite	14	3180	13383	<5	<5	67715	<10
69103	647	372324	2643599	Rakhabdev	1st order stream, active width 50 cm, clay and silt	42	1188	6245	<5	5	31331	<10
69104	649	372683	2643168	Rakhabdev	1st order stream, active width 50 cm, gravels of serpentinite	21	8375	3734	<5	<5	30544	<10
69105	650	372796	2642895	Rakhabdev	2nd order stream, active width 3m, scree of serpentinite.	13	3778	3088	<5	<5	31145	<10
69106	651	365963	2666676	Rakhabdev	1st order stream, active width 3 m, gravels of serpentinite	17	3380	9311	<5	<5	28454	<10
69107	653	365425	2667271	Rakhabdev	2nd order stream, gravels of mica schist and serpentinite, active width 2.5m	31	1304	3654	12	7	28028	<10
69108	654	368150	2664043	Rakhabdev	1st order stream, active width 0.75 cm, gravels of ultramafic	344	282	1124	6	7	17415	<10
69109	655	368367	2663121	Rakhabdev	1st order stream,active width 1.5 cm, gravels of ultramafic and calc silicate rock	29	3813	13844	<5	<5	42135	<10
69110	656	369949	2652311	Rakhabdev	1st order stream, active width 0.75 cm, gravels of ultramafic	73	1106	2387	<5	<5	37241	<10

Annexure 3 : chemical analysis data of Stream sediment concentrates

Lithogeochemical Sampling :

About 7 samples of the ultramafic and other relevant rocks were collected during the field work and same samples with visible sulphides and malachite encrustations were analyzed for Ni, Cu, MgO, Pt and Pd **(Annexure-4)**. The MgO in these samples vary from 15 to 34%. The Ni values vary from 1124 to 2004 ppm. Many of the samples exhibit very high Cu values. The Cu values, in general, vary from 8 to 17,854 ppm. However, many of the samples have anomalous Cu, which is in the range of 2000 to 7000 ppm.

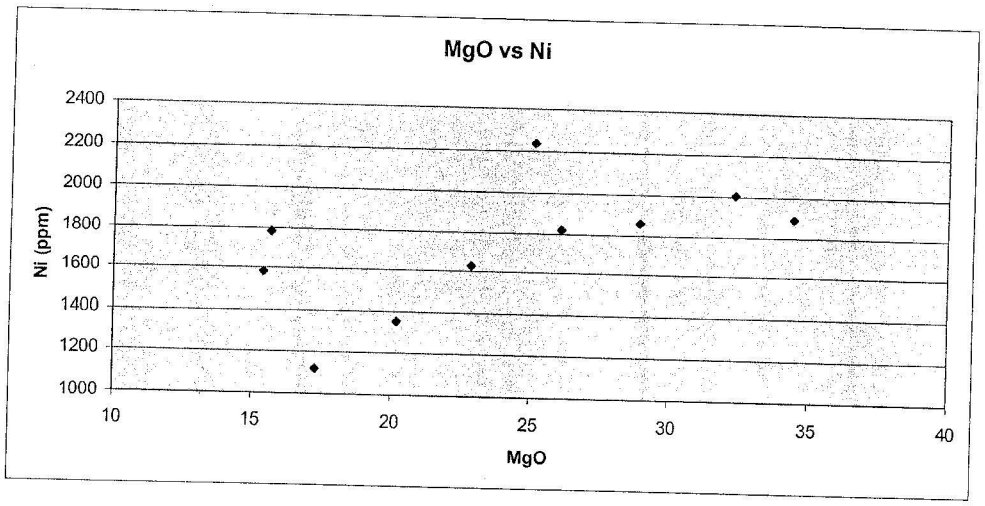

Fig. 25. MgO vs Ni diagram

On MgO vs Ni diagram a positive correlation is noted between the two elements, which clearly indicates silicate controlled fractionation ***(Fig.25).*** On MgO vs Cu diagram a negative correlation is seen between both the elements, which also supports above contention **(Fig. 26).**

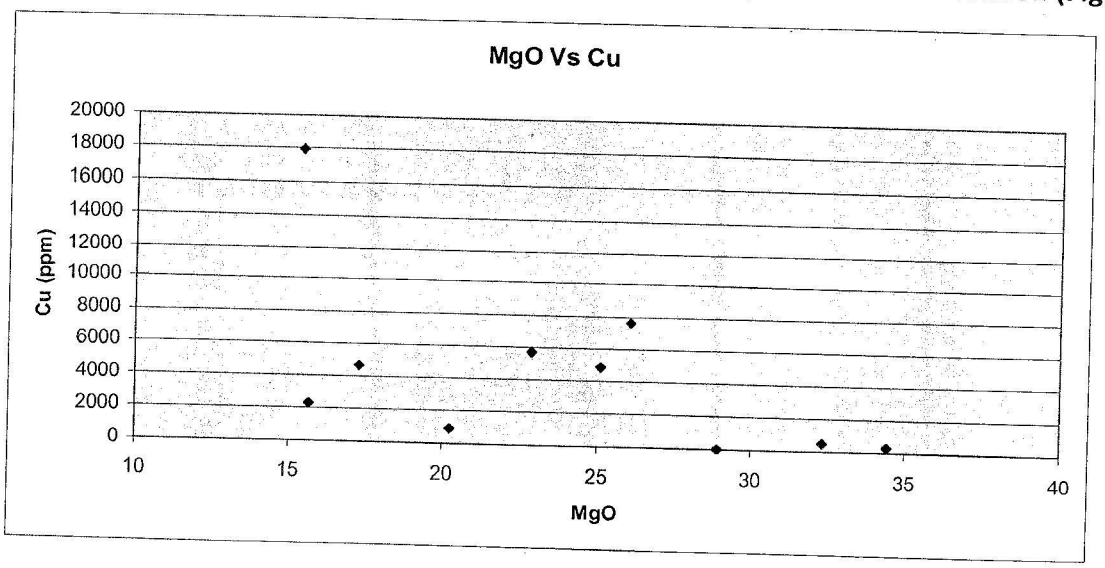

Fig. 26. MgO vs Cu diagram

On Ni vs Cu diagram all the samples are scattered and no correlation is observed between the two elements ***(Fig.27).*** Lack of sympathetic relationship between Ni and Cu indicates absence of sulphide-controlled fractionation in the magma.

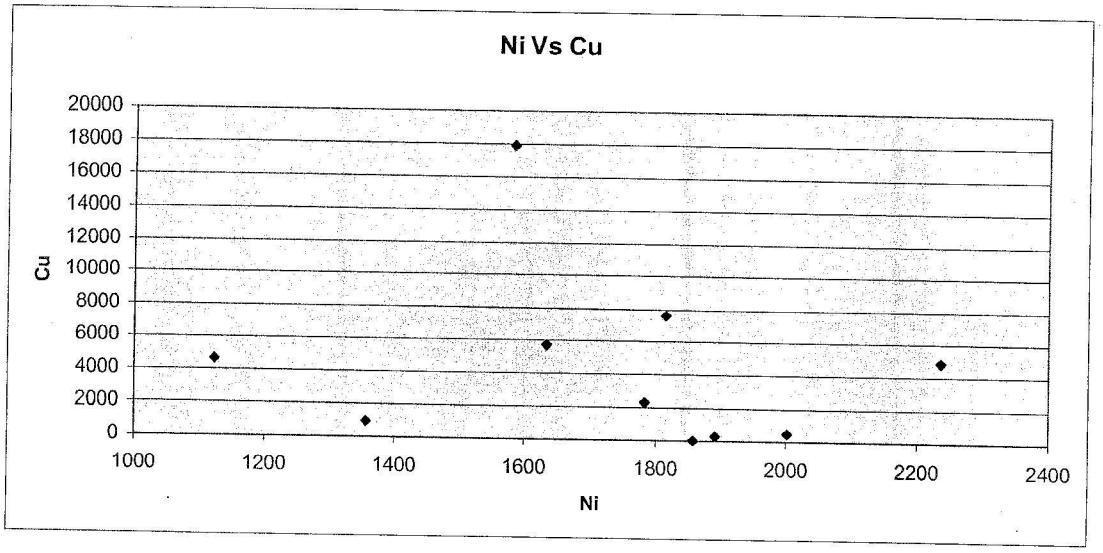

Fig. 27. Ni Vs Cu Binary plot

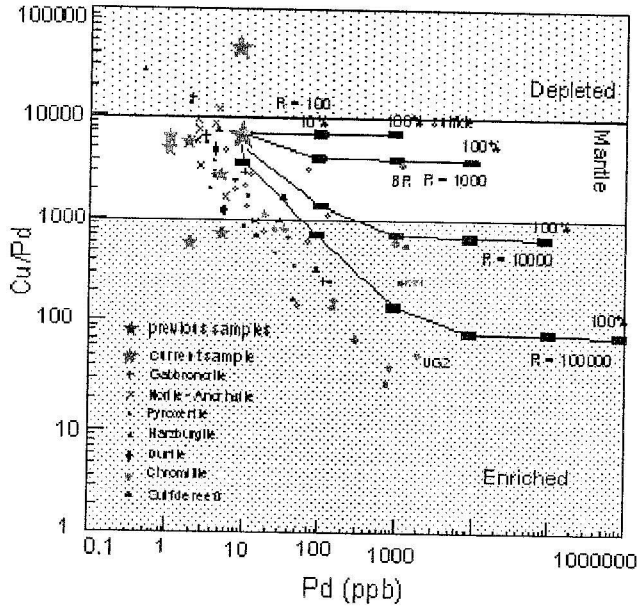

Fig. 28. Cu/Pd vs Pd diagram

In general, the Pt and Pd values in all the samples are very low. The Pt value varies from <3 to 5 ppb and Pd value, from <3 to 8. One of the samples of the group could be plotted on Cu/Pd vs Pd diagram ***(Fig.28)***. This sample is plotted in depleted field, which indicates that the magma was depleted in chalcophile elements before its final emplacement. This implies that there was sulphide-fractionation in the magma at deeper levels, which depleted both PGE and Cu.

In the study area copper mineralization is noticed without the association of Ni or PGE. Further, field studies indicate that the mineralization is part of the post-deformational event and not magmatic. This interpretation is further supported by lack of correlation between Ni and Cu as well as absence of any chemical signatures which are indicative of magmatic sulphide association. Hence, it can be held that copper mineralization in the area is a hydrothermal feature, formed either during or subsequent to the deformation in the area

XI Conclusion :

Based on the geological and geochemical observations, it can be concluded that :

1) Sulfide-controlled fractionation is absent, that the complex may not hold promise for Ni-Cu-PGE type massive sulphide deposits

2) Chromite seems to have fractionated PGE, which indicates the potential for finding a "only-PGE" type deposit, similar to UG-2 of Bushveld Complex, SA or Nizhny Tagil deposit of Russia. However, sizeable chromite layers are not present in the Complex.

3) Cu mineralization post dates the magmatic crystallization, thus may be related a later hydrothermal event in the area.

4) Based on the above, it is concluded that the Rikhabdev Complex may not hold promise for large Ni-Cu-PGE deposits, and thus entire area is surrendered without applying for any PL.