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TIME-DOMAIN INDUCED POLARIZATION DIPOLE-DIPOLE METHOD FOR THE INVESTIGATION OF SULPHIDE ORE — EXAMPLE OF SOME COPPER PROSPECTS OF NEPAL

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सारांश

कुरूले, वाप्सा र कालिटार खनिज स्थलहरू (तामा) का गन्धक जन्य धाउ पिण्ड (Sulphide ore bodies) हरूमा प्रलोभित अभिस्पन्दन (Induced polarization) सर्वेक्षण गर्दा तिन वटै खनिज स्थलहरूमा असँगति (Anomalies) हरू पहिचान भए। यी असंगतिहरूमा खोदन (Drilling) गर्दा छिट पुट रूपमा धाउ भएको पाईयो। यस प्रकार छिट पुट रूपमा खनिज विद्यमान भएका पिण्डहरूमा पनि उक्त भू–भौतिक सर्भेक्षण उपयोगी सिद्ध भएको छ।

ABSTRACT

The paper presents the results of geophysical surveys carried out using induced polarization (IP) time-domain method with dipole-dipole configuration for the investigation of sulphide ore bodies in Kurule, Wapsa and Kalitar copper prospects of Nepal.

IP anomalies were observed in all the prospects which were subsequently checked by drilling. Sulphide mineralization in disseminated forms and in lenses were found.

The IP time-domain dipole-dipole method was found successful in the detection of disseminated sulphide mineralization even if its grade was very low.

INTRODUCTION

Geophysical method of investigation for the exploration of mineral deposits started in Nepal in 1967. Magnetic, IP (with gradient, two electrode configuration), Resistivity and Self Potential (SP) methods were used.

Presently, investigations of sulphide mineralization are carried out using magnetic, gravity, IP, SP, resistivity and electromagnetic methods in different prospects worked by the Mineral Exploration Project. Of the different electrode arrays used with the IP method, the dipole-dipole configuration was widely applied.

The purpose of an IP investigation using any electrode configuration is to locate polarized bodies usually sulphides and to obtain information on their shape, size and depth.

ELECTRICAL INDUCED POLARIZATION METHOD

In the dipole-dipole configuration, current I is introduced into the ground through two electrodes distance x apart, forming the transmitting dipoles. The polarization voltage is measured between two electrodes, distance again x apart forming the receiving dipoles. The transmitting and receiving dipoles lie on a straight line and the distance between the nearest transmitting and receiving electrodes is nx where factor *n* is the function of depth penetration and x is the dipole length. The dipole length and factor *n* used for dipole-dipole IP measurement depend on the nature of the body to be investigated and the depth to be probed.

Resistivity and polarization (chargeability) values measured along a profile are normally presented in the form of pseudosections where the plotting points of measured values are represented by the intersection of the lines drawn from the centre of both dipoles at 45° angle.

EXAMPLES OF INDUCED POLARIZATION SURVEYS IN NEPAL

Kurule, Wapsa and Kalitar are three of numerous copper prospects investigated by the Mineral Exploration Project using an integrated geological, geochemical and geophysical methods of exploration. The results of IP time-domain dipole-dipole measurements in these prospects will be presented and compared with drilling results.

The time-domain instruments, transmitters, used for IP surveys in the prospects transmit square waves with equal 'on' and 'off' times and the pulse time used is 2 secs.

Kurule Copper Prospect

The area is situated in the right bank of Sun Kosi river, close to the confluence of Dudh Kosi in eastern Nepal.

The area consists of dark biotite skarned rocks, quartzite and granitic gneiss.

The ore minerals are chalcopyrite, pyrite and magnetite. General strike of the bed is 300°–320° and dip from 30° toawards SW to almost vertical. Geochemical survey in the area showed a strong linear soil copper anomaly zone on the marble skarn paralleling its strike. Trenching revealed the mineralization to be associated with light brown marble, silicified garnet skarn and calcite magnetite skarn.

IP dipole-dipole survey was conducted in many profiles crossing and covering the whole zone of geochemical anomaly using 40 m dipole length. The result in one profile where drilling has also been done is illustrated in fig. 1, in the form of apparent chargeability and apparent resistivity pseudosections.

The pseudosection shows the presence of a strong chargeability anomaly zone from points 120S to 230S. The chargeability values decrease on either side of it. Within the strong anomaly zone, the magnitude of the apparent chargeability attains values up to 50 msec. at a certain depth. A closed contour is thus formed indicating that the lower depth of the polarizable body is predictable.

The resistivity values in the chargeability anomalous zone are low and vary from 50 to 150 ohm metre. The low resistivity and high chargeability thus indicate the presence of a fairly good conducting and strongly polarizable body. From geological evidences, the polarizable body might be represented by skarned rocks containing chalcopyrite, and magnetite. The presence of magnetite in abundance was indicated by magnetic observations, not presented here.

The upper depth of the polarizable body is interpreted to be about 20 m where as the lower depth is 90 m or more. It represents, thus, a wide polarizable body with limited depth extent.

Drilling intersected chalcopyrite and pyrite mineralizations in disseminated forms and magnetite from 8 metres depth. The highest percentage of chalcopyrite was found to occur from 92.65 m to 95.20 m inclined depth with 0.86% as the average Cu value (Fig. 1).

Discussion : The high chargeability and low resistivity values are the combined effect of the total sulphide and the oxide mineralization. Pyrite and magnetite play a major role and this is the reason why the IP response is reasonably high despite of low copper content. The mineralizations, though start from a depth of 8 m and continue to the bottom of the hole, are weak above 20 m depth and below 95 m or more depth.

Wapsa copper Prospect

Wapsa is situated in eastern Nepal on the east bank of the middle course of

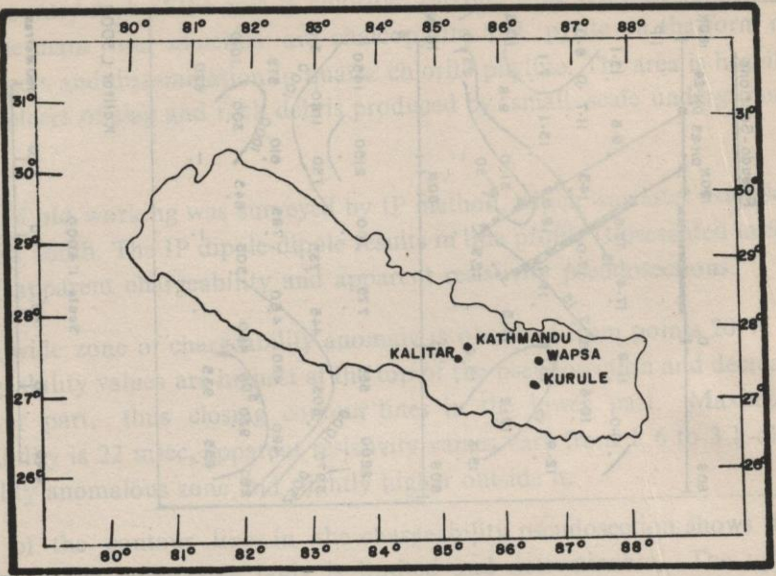

Fig. 1 Location map

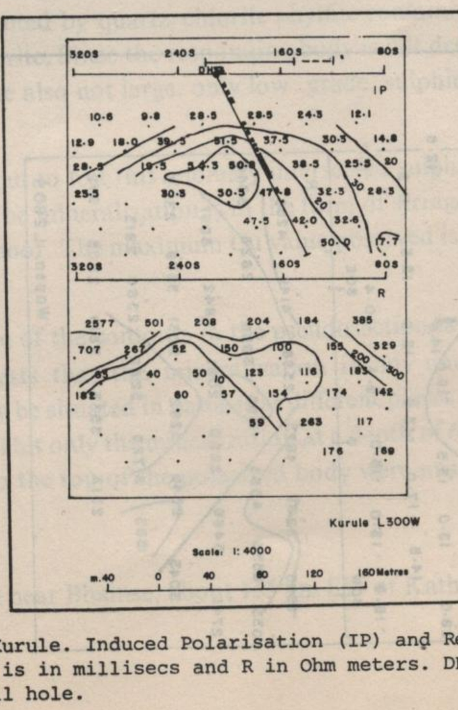

Fig. 2 Kurule. Induced Polarisation (IP) and Resistivity (R). IP is in millisecs and R in Ohm meters. DH 33 is the drill hole.

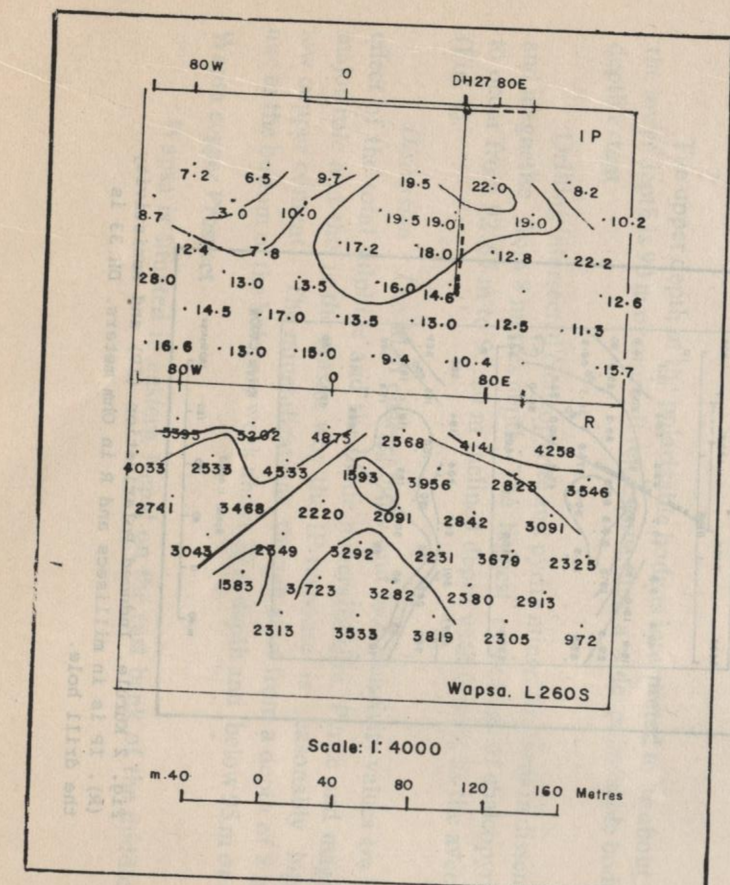

Fig. 3 Wapsa. Induced Polarisation (IP) and Resistivity (R) pseudosections. IP is in millisecs and R in Ohm meters. DH27 is drill hole.

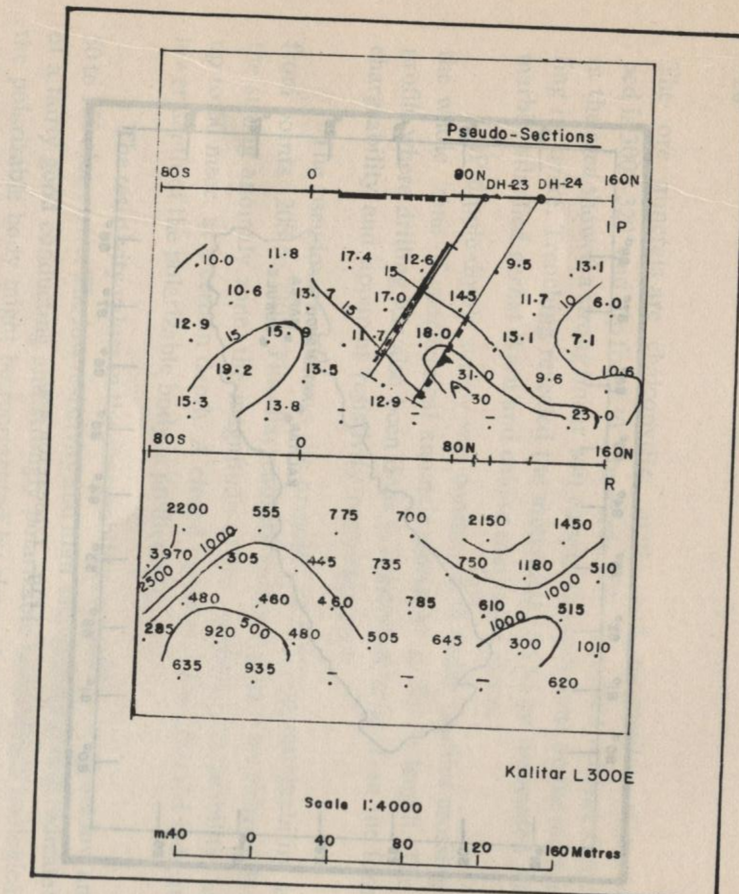

Fig. 4 Kalitar. Induced Polarization (IP) and Resistivity (R) pseudosections. IP is in millisecs and R in Ohm meter. DH-23 and DH-24 are the drill holes.

Dudh Kosi. The country rock of the area is chloritic phyllite with regional dip of 10° to 30° to NW. The main ore minerals are chalcopyrite and pyrite in the form of lenses, pods, stringers and dissemination in quartz chlorite phyllite. The area is heavily contaminated by pieces of slag and rock debris produced by small scale underground mining.

The area of old working was surveyed by IP method, which was later extended towards north and south. The IP dipole-dipole results in one profile is presented in fig. 2 in the form of apparent chargeability and apparent resistivity pseudosections.

A 120 m wide zone of chargeability anomaly is observed from points 20 W to 100 E. The chargeability values are highest at the top of the pseudosection and decrease towards the lower part, thus closing contour lines in the lower part. Maximum value of chargeability is 22 msec, apparent resistivity values vary from 1.6 to 3 k-ohm in the chargeability anomalous zone and slightly higher outside it.

Closing of the contour lines in the chargeability pseudosection shows that the depth extent of the polarizable body is limited and determinable. The upper depth is interpreted to be 20 m and the lower depth 120 m.

The polarizable body may thus be 100m thick and 120 m wide buried at a depth of 20 m. This body is represented by quartz chlorite phyllite containing weak mineralizations of pyrite and chalcopyrite. Since the responding body is not deep and the magnitude of the chargeability value also not large, only low grade sulphide mineralization could be expected.

A vertical drill hole put to test this anomaly intersected sulphide mineralization starting at a depth of 57 m. The mineralization is in the form of stringers and disseminations and the grade of Cu is poor. The maximum Cu value observed is 0.14 % at 67.26–67.79 m.

Discussion: The shape of the contours in the pseudosection is not a regular type but is distorted. This suggests that the mineralization is not uniformly distributed in the polarized body but may be situated in patches at different places and different depths in it. The reason that the drill hit only the minerlization at a depth of 67 m is that probably mineralized patches closer to the top of the polarized body were missed by the hole.

Kalitar Copper Prospect

This area is situated near Bhainse, about 155 km SW of Kathmandu and adjacent to Tribhuvan highway.

In Kalitar the Chisapani white to cream coloured, massive quartzite is overlain by Kulekhani micaceous dark quartzite and schists in which the shear zones are common. Copper mineralization has been observed in pods, veins, veinlets and in crushed and sheared zone in the form of chalcocite, chalcopyrite, malachite, azurite and covellite. The geochemical soil anomaly in the area follows the subparallel and en-echelon mineralized bedrock source.

The area was surveyed by various geophysical methods such as magnetic, electromagenetic (Turam), IP and resistivity. IP dipole-dipole result in one profile is given in the form of chargeability and resistivity pseudosections (Fig. 3).

A strong chargeability anomaly is observed from points 6N to 15N. The contour lines do not close but the values go on increasing on the lower portion of the pseudosection. Thus, only the upper depth of the polarizable body could be determined while the lower depth remains unknown. The IP response is due to a thin polarizable body with unknown depth extent and could be represented by a mineralized body of pyrite, chalcopyrite, chalcocite and magnetite. The presence of magnetite was indicated by magnetic readings. The depth of the polarizable body was interpreted to be 10 m. The dip of the polarizable body was determined from the geological information of the area and what should be the direction and inclination of the drill hole was thus known.

The two drill holes put to test the anomaly intersected mineralizations at an inclined depth of 27 m in one hole and at 77.8 m in another. The maximum grade observed in the first drill hole was 0.5% Cu from 56.2 m to 64.36 m inclined depth, while in the second hole it was 0.8 % Cu from 110.75 m to 111.62 m.

Discussion: The shape of the chargeability anomaly is typical for a thin, close to the surface inclined polarizable sheet. The upper depth of the body was determinable while the dip could not be known. The dip was instead known geologically and drilling confirmed the presence of mineralization.

CONCLUSION

1. IP dipole-dipole method of survey can detect polarizable bodies though they are weakly mineralized.

2. The upper depth of polarizable body was predicted by DP–DP IP survey and was found to be reasonable as observed by drilling.

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