

Principles of *Mise-a-la-Masse* Method and its Application to Polymetallic Sulphide Deposits of Rajasthan

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Abstract: In surface geophysical surveys, resistivity contrast between the ore and host rock plays a vital role in the success ratio of the surveys. To overcome the problem of insufficient resistivity contrast, a modified method, *Mise-a-la-masse*, was tried and found to be very effective in tracing the extensions of polymetallic sulphides intersected in a borehole. The method was applied to Pb-Zn and sulphide hosted gold prospects in Rajasthan and the results obtained indicate that *Mise-a-la-masse* method can be successfully employed for delineating subsurface extension of polymetallic sulphide deposits.

Keywords: Exploration geophysics, Electrical resistivity contrast, Polymetallic sulphides, Rajasthan.

INTRODUCTION

In a conventional surface resistivity survey for sulphide deposits, only a small fraction of the current injected into the ground from surface electrodes actually intersects any buried mineralised zone of interest. As a consequence, surface indications of subsurface extension of a sulphide deposit are generally weak. The success of surface geophysical methods also depends upon sufficient resistivity contrast between the host rock and the ore.

To overcome limitations of the conventional resistivity surveys it is necessary to place a current electrode directly into the ore body with the second electrode placed on the surface at a large distance away from the source. This is a post-discovery method since the prior knowledge of existence of mineralised zone is necessary. This method has been named *Mise-a-la-Masse*, a French phrase, meaning "excitation of mass".

PRINCIPLES

The principle of this method of mineral exploration is to plant one current electrode in

a borehole passing through a sulphide deposit. The other current electrode is kept at infinity and the resulting potential distribution is measured for constant or normalized current by keeping one of the potential electrodes also at infinity. The equipotential maps in such cases are good indicators of strike length, dip, pitch, shape etc. of the ore body.

Mise-a-la-masse method was first used by Schlumberger in 1920 (Parasnis, 1966). Very limited information is available in literature on this method (McMurray and Hoagland 1956; Garner 1963; Parasnis 1967; Ketola 1972; Pelton and Hallof 1972; Cowan et al. 1975; Mansinha and Mwenifumbo 1983; Elloranta 1985).

Mise-a-la-masse surveys were carried out by IP (Time Domain), Scintrex unit TSQ-3(3KW). One of the current electrodes say C_1 (the positive electrode) is planted in the mineralised part of a borehole. The other current electrode C_2 (negative electrode) is located more than 1 km away from the borehole in the updip side (Fig.1). One of the potential electrodes P_2 should also be kept at a great distance from the chosen borehole on the

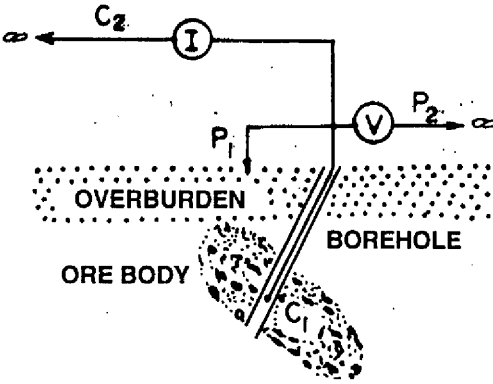


Fig.1. Electrode configuration used in *Mise-a-la-masse* method.

opposite side of C_2 . Surface potentials are measured with respect to the infinity electrode preferably over a grid around the borehole. The current electrode in the borehole consists of a metal rod (lead is preferred) attached to an insulated flexible copper wire. The observed potentials on the ground are normalized for 1A current and equipotential maps then prepared. The method can be used when the conducting ore body is exposed (Fig.2) or intersected in a borehole (Fig.3).

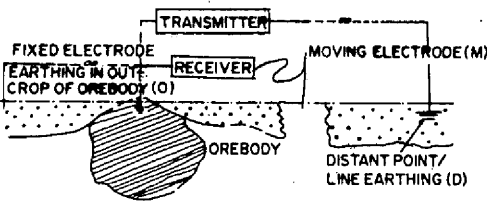


Fig.2. Electrode configuration in *Mise-a-la-masse* measurements when one current electrode is in an outcrop of orebody.

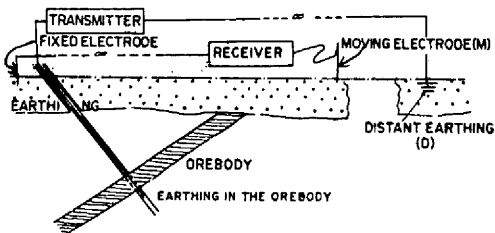


Fig.3. Electrode configuration in *Mise-a-la-masse* measurement when one current electrode is in a borehole in the ore body.

In case 4-5 boreholes are available, then inter borehole *Mise-a-la-masse* would enable us to obtain a vertical section of the ore body. In this case, ore body is energised by inserting one current electrode in a borehole and the other at the infinity. One of the potential electrodes is also kept at infinity while the second potential electrode is moved in the borehole and potentials are measured at different depths. These data are plotted along borehole and contoured (Fig.4). It gives a vertical section of the ore body.

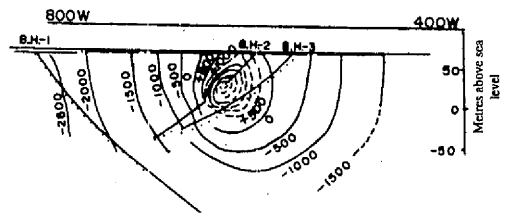


Fig.4. Equipotential contours from inter borehole *Mise-a-la-masse* measurements (Parasnis, 1966).

Equipotential curves at different levels

Potentials measured at different levels in boreholes can be effective in indicating depth continuity of an ore deposit. Potentials measured in various adjoining boreholes at the same level have been contoured and presented in Figs. 5a, b, c, d, and e (Parasnis, 1967). These figures clearly show that the shape of contours varies significantly from level to level. The area enclosed by +2000 mV contour has decreased considerably from -20 m a.s.l. (Fig.5c) to -50 m a.s.l. (Fig.5d), which could be attributed to petering out of the body around 50 m a.s.l.

***Mise-a-la-masse* response for two isolated lenses in the same mineralised block**

In case a small sulphide deposit is located adjacent to a main body, but is not in electrical continuity with the main body, *Mise-a-la-masse* survey of the main body may not pickup the second body. In such a case the response from the second body will be more pronounced if the two bodies are electrically connected.

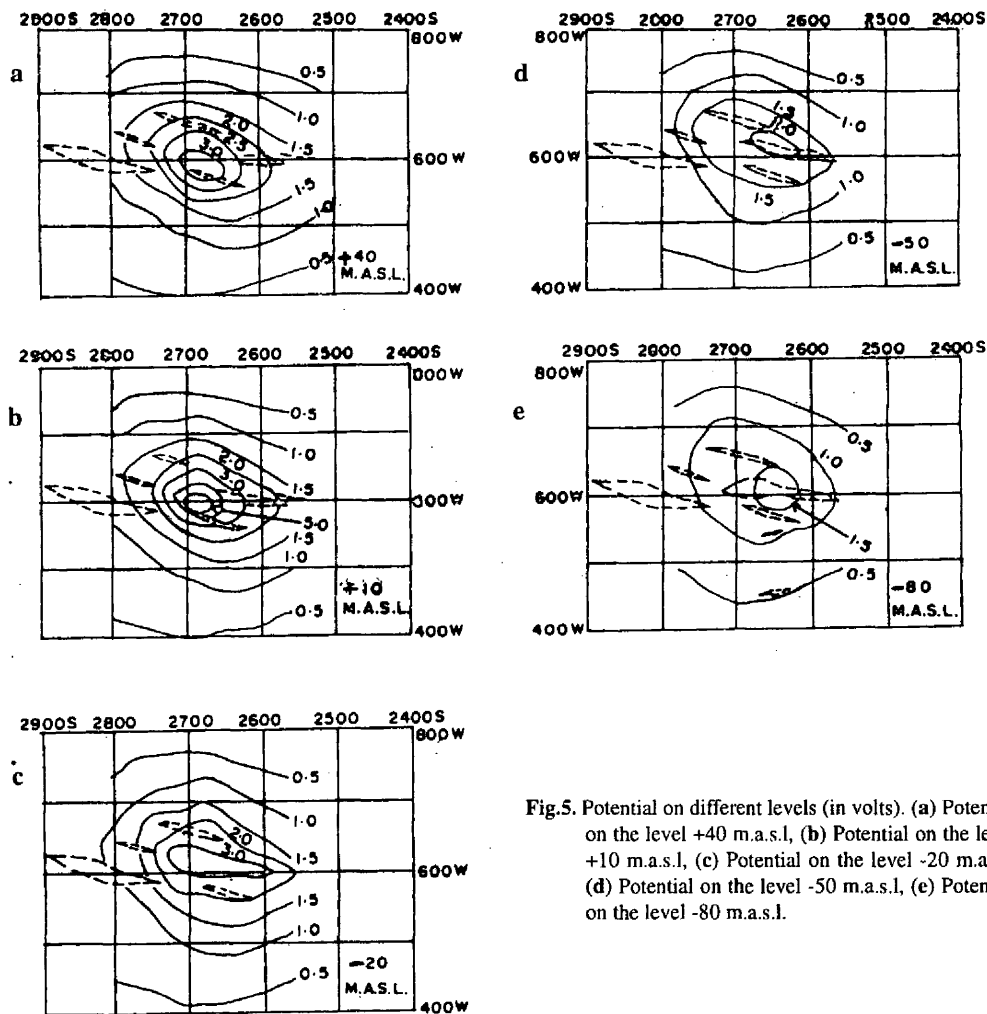


Fig.5. Potential on different levels (in volts). (a) Potential on the level +40 m.a.s.l, (b) Potential on the level +10 m.a.s.l, (c) Potential on the level -20 m.a.s.l, (d) Potential on the level -50 m.a.s.l, (e) Potential on the level -80 m.a.s.l.

EXPLORATION BY MISE-A-LA-MASSÉ IN RAJASTHAN

Mise-a-la-masse surveys have been very successfully employed in exploration for basemetals and gold in Rajasthan. Surveys were carried out in Sawar and Kayar in Ajmer district and Bhukia in Banswara district of Rajasthan (Fig.6).

Sawar belt, Ajmer district

Geology

The Proterozoic Sawar metasedimentary belt in the eastern part of Ajmer district of

Rajasthan contains several small lead-zinc deposits of medium grade. Several isolated linear zones of metasediments, mainly represented by calcareous and calc-silicate rocks, pelitic schists, quartzite and iron formations occur as enclaves within the basement gneisses (Ray,1988). One such enclave of a metamorphosed sedimentary sequence is exposed in the study area. In Sawar area copper mineralisation with varying amounts of lead and zinc is hosted in shear related silicified zones, whereas a stratigraphically controlled low grade lead-zinc

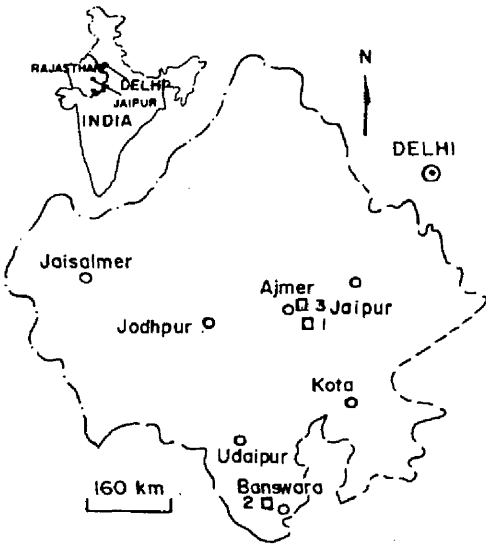


Fig.6. Location of areas studied in Rajasthan (1-Sawar, 2-Bhukia, 3-Kayar).

mineralisation occurs in marble close to the contact with stratigraphically younger schist.

Mise-a-la-masse survey was carried out in a borehole TEH 27. The mineralised body was energised at 278m depth along the borehole for carrying out *Mise-a-la-masse* survey. The equipotential contour (Fig.7) indicates the strike extension of the mineralised body upto 350m towards NE and 225m towards west (Gupta and Radhe Shyam, 1993a). The contours indicate a definite change in strike. There are two closures 'A' and 'B', NE and west of the mineral intersection in borehole TEH 27 respectively (Fig.7). Closure 'A' has a strike length of about 350m with the peak potential value of 177mV at station W 17 of traverse N 10. The mineralisation intersected in borehole TEH 27 falls between contours 100 and 110 mV, whereas in the NE, the response increases to 177 mV i.e. at station W 17 of traverse N 10 closure 'A' (Fig.7). This rise in potential towards NE may be due to shallow depth as well as increase in sulphide content of the mineralised zone. It is confirmed by intersection of richer mineralisation at shallower depth in borehole TEH 12, 14 and 18. The outline of the mineralised body is more or less defined by

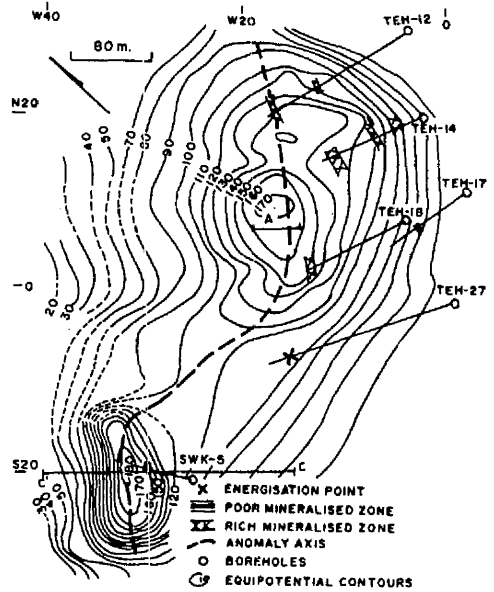


Fig.7. *Mise-a-la-masse* equipotential contour map for borehole TEH-27, Sawar area (ore body charged at 278 m) C'-C' traverse for surface S.P., pa and μ surveys.

90mV contour. TEH 17 has possibly intersected the fringes of mineralisation and sulphide content is not rich. The closure 'B' has its peak value of the order of 183 mV at station W 33 of traverse S 20 (Gupta and Radhe Shyam, 1993a). The closure is about 150 m long. The steep contour gradient indicates that the body is shallower than that at closure 'A'.

The anomaly axis from closure 'A' takes westerly turn from traverse O to S15 after which it takes a southwesterly turn. The closure 'A' and 'B' appear to indicate richer mineralisation at shallower depth than that intersected in TEH 27.

Surface IP cum resistivity and SP profile over closure 'B'

A test traverse C-C' cutting across the closure 'B' was subsequently laid (Fig. 8). SP, IP and resistivity surveys were carried out to ascertain the causative source and its depth parameters. SP survey showed a gradational fall in values from -50 mV to -200 mV from east to west. High chargeability of 40 mS and fall of

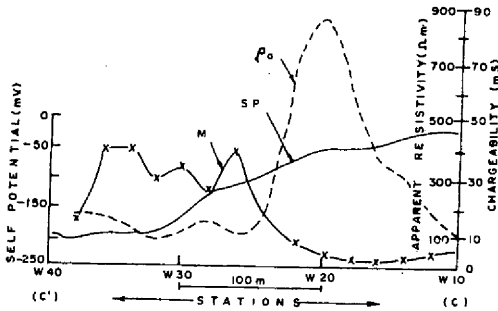


Fig.8. SP, IP and resistivity profile along CC' cutting across Misc-a-la-masse anomaly zone B (borehole TEH 27), Sawar area.

resistivity from 900 ohm m to 100 ohm m is also observed over the same zone. The width of the broad IP and resistivity anomalous zone is approximately from traverse W 25 to W 38, which compares with the width of closure 'B' on the ground. The depth to the top of the body is about 50 m as estimated from SP and IP anomalies employing the method of Apparao (1982), Bhattacharya and Ray (1981) and Shalivahan et al. (in press). A borehole, SWK-5 drilled to test the closure 'B' of *Mise-a-la-masse* survey (Fig.7) intersected a zone of sulphide mineralisation 20 m wide with values of Zn and Pb going upto 14.5% and 2.8% respectively. The intersection of mineralisation in the borehole was nearly at the estimated depths.

Kayar area, Ajmer district

Geology

Kayar area forms part of the Delhi Supergroup. The lithostratigraphic units exposed in the area comprise quartzite, phyllites and calc-silicates. The mineralisation occurs in quartz mica schist and calc silicates and is possibly controlled by fault zones.

Mise-a-la-masse survey

Mise-a-la-masse survey was carried out in two boreholes (KYR 19 and KYR 20) by charging the richest mineralised zone. Surface potentials were observed in a grid with traverses spaced 50 metres apart and stations at 10 metres interval. Traverses were laid

orthogonal to the regional strike of the formations i.e. S 70° E - N 70° W. Measured potentials were normalized for one ampere current. Observations were taken to determine the extent of the body in northern side since its southern extension was already known.

Borehole KYR 19

Mise-a-la-masse equipotential contour map (Fig.9) has brought out an elongated contour pattern with an open end towards southwest and closing in northeast (between traverse N 20 and N 25). This elongated pattern has one

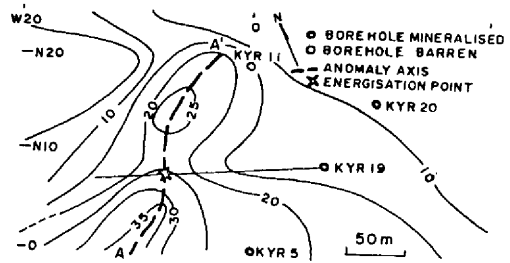


Fig.9. *Mise-a-la-masse* equipotential contour map for borehole KYR 19, (ore body charged at 151 m).

closure with the peak value of 27 mV located at station no. W 6 of traverse N 15 (Ramgopal and Gupta, 1992). The open closure towards southwest indicates a peak value of 38 mV on traverse 'O', signifying a shallower depth to the top of the body in southwest. It was confirmed by borehole KYR 5 on traverse 'O', which has intersected the mineralisation at a shallower depth. *Mise-a-la-masse* equipotential contours show that the mineralised body has a pitch towards NNE and dipping SE. The dip of the body agrees with the available geological information. It may be mentioned here that the earlier borehole KYR 11 missed the mineralisation as it was planned for intersecting the ore body at a shallower depth. However, borehole KYR 5 intersected the body at a shallower depth as expected. Based on the results of *Mise-a-la-masse* survey, a borehole KYR 20 was proposed to intersect the ore body at a relatively deeper level. This borehole intersected three mineralised zones:

top (133-139m), intermediate (164-167m) and bottom (251-267m).

The most conductive part of each mineralised zone was deciphered from logging borehole for effectively energising the mineralised zone (Gupta et al. 1998). Figs.10a, b and c show equipotential contours where the locations of energisation points are in the top,

intermediate and bottom mineralised zones respectively. The top zone indicates anomaly axis A-A' and the closure of 90 mV at station E 7 of traverse N 25 (Fig.10a). The trend of the contours show that the body is of limited strike length. It is also confirmed by the earlier borehole as mineralisation is not encountered at shallower depth in borehole KYR 19. Fig.10b presents the equipotential contour map based on charging the zone at 164 metres depth. The anomaly axis is B-B' and the peak potential value is 39 mV at station W 9 of traverse N 5. In NE side, the contours are closed between traverse N 25 and N 30, indicating that the strike of mineralised zone is limited in NE side. This zone was intersected in borehole KYR 19 also. The equipotential contour map based on charging of the bottom zone at 255 metres (Fig.10c), indicates a body limited in NE direction, dipping NW, unlike the top and intermediate zones. The peak potential value is 60 mV at station W13 of traverse N 10. The anomaly axis C-C' represents the general strike of the body. The open contours suggest probable extension of the body in SW direction. In the absence of any deeper borehole, so far, in SW side, the exact extension of the mineralisation in SW direction is yet to be verified.

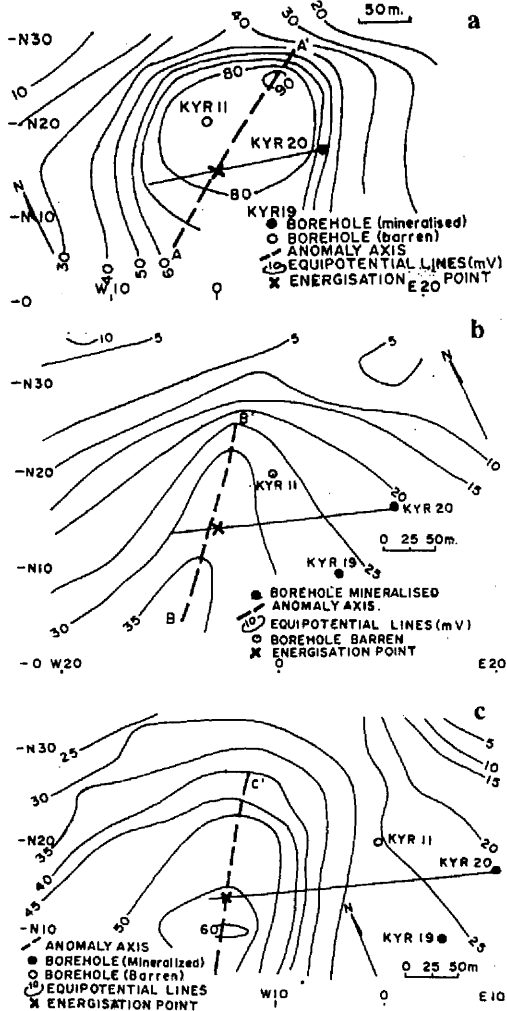


Fig.10. (a) *Mise-a-la-masse* equipotential map using borehole KYR 20 (Top zone) (ore body charged at 138 m), (b) *Mise-a-la-masse* equipotential map using borehole KYR 20 (Intermediate zone) (ore body charged at 164 m), (c) *Mise-a-la-masse* equipotential map using borehole KYR 20 (Bottom zone) (ore body charged at 255 m).

Fig.11 is a superimposed map of Figs.9 and 10b. The solid lines are equipotential contours for the intermediate zone of borehole KYR 20

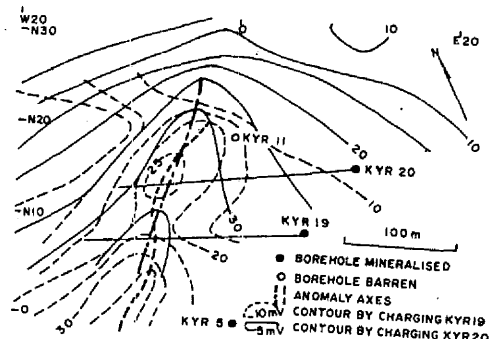


Fig.11. Superimposed *mise-a-la-masse* equipotential contour map for borehole KYR 19 (Fig.9) and KYR 20 (Fig.10b).

whereas broken lines are for KYR 19. The general trend of contours are broadly the same and the axis of the two anomalies are almost overlapping. This clearly indicates that both boreholes KYR 19 and KYR 20 (intermediate zone) intersected one and the same lode.

Bhukia area, Banswara district

Geology

The rocks occurring in the area belong to Debari Group of Aravalli Supergroup. Major lithounits present in the area are Banded Gneissic Complex (BGC), Kuri conglomerate, Ghatol-Khamera Formation (quartzite, dolomitic marble, impure/amphibole marble), Dagal Formation (calc-gneiss, amphibolite, garnetiferous amphibole schist and mica schist) and Ganora Conglomerate with overlying Deccan Trap (Grover and Verma, 1993). Gold bearing sulphides are hosted by dolomite and dolomite marble with appreciable amount of amphiboles. Massive sulphide with dominance of pyrrhotite followed by chalcopyrite and arsenopyrite are present in the area. These occur as veins, fracture fillings and disseminations.

Mise-a-la-masse survey was carried out in two boreholes of this prospect where gold mineralisation has been hosted by sulphides.

Borehole BHU 1

The sulphide lode was charged at a depth of 230 m along the hole at a point of maximum conductivity obtained by logging. The equipotential contour map has indicated a broad anomalous zone (Fig. 12). The contours are open towards north as well as south beyond traverse N 20 and S 20 respectively. It is thus indicative of extension of the mineralised lode intersected in borehole BHU 1 by more than 400m. The hatched contour envelope of 55mV, roughly delineates the width of the body. The contours also show westerly dip of the body (Gupta and Radhe Shyam, 1993b).

Gold is associated with the sulphide mineralisation in the area. On the basis of *Mise-a-la-masse* results, boreholes BHU 3, BHU 5 and BHU 8 were recommended to

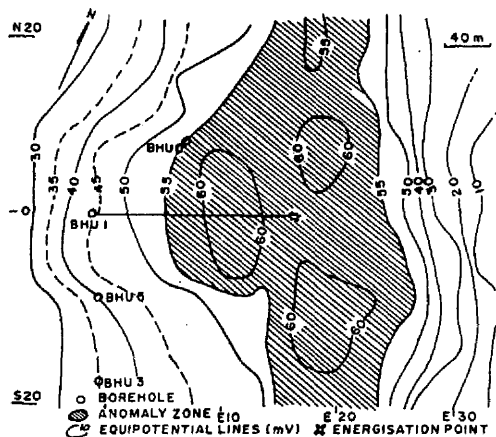


Fig. 12. *Mise-a-la-masse* equipotential contour map for borehole BHU 1, Bhukia area (ore body charged at 230 m).

intersect the ore body (Fig. 12). All the three boreholes did intersect sulphide mineralisation.

Borehole BHU 8

The mineralised body was charged at 162m depth along the hole, again at the point of maximum conductivity identified by logging (Gupta and Singh, 1994). The equipotential contour map has clearly brought out the NNW-SSE trend of the mineralised body (Fig. 13). The contours are closely spaced in the eastern side. The trend of contour in NNW is indicative of termination of the ore in this side. This is corroborated by four subsequent boreholes located 100m apart, along a profile parallel to the strike of the ore body. BHU 9 located on traverse N 10 and BHU 10 located on traverse N 20 intersected rich sulphide mineralisation. Poor sulphide mineralisation, was intersected in BHU 12 located on traverse N 30 and borehole BHU 14 (not shown in map) located on traverse N 40. These results confirm the interpretation made on the basis of *Mise-a-la-masse* surveys.

Since the intersections in boreholes BHU 1 and BHU 8 lie 100 m apart on the same strike profile, an attempt was made to prepare a composite equipotential map (Fig 14) based on the data of *Mise-a-la-masse* surveys in both the

correlation between different parts of an orebody with varying sulphide percentage which are located distantly but are in electrical continuity.

Different ore lenses may be identified by means of *Mise-a-la-masse* measurements.

Dip and structural attitudes of an orebody such as trend, dip and pitch can be estimated with considerable certainty by adopting *Mise-a-la-masse* survey.

If sufficient number of boreholes are available a cross section of an ore lens can be

broadly interpolated from one level to another level and also the variations in the strike of the orebody from one level to another can be outlined. In certain cases it is possible to deduce depth extension of an ore body.

Acknowledgements: The authors are highly thankful to the Deputy Director General, Geological Survey of India, WRO, Jaipur for kind permission to publish this paper. They are grateful to Sh. Ganga Dhar Meena, Draftsman Geological Survey of India, Jaipur for help in drawing figures.

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(Received on 10 December 1997; Revised form accepted: 18 August 1998)