A Geochemical soil sampling and multi-method geophysical procedure for base metal exploration as applied in sand covered desert of Rajasthan, India

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Summary :
A geochemical soil sampling and multi method geophysical procedure for base metal exploration were applied for identifying the concealed ore bodies in a semiarid terrain in western part of India. The integration of geochemical and geophysical methods was helpful in deciphering the anomalous zone of lead and Zinc mineralization for future exploration work.

Introduction and Geology of the area

The Proterozoic Aravalli-Delhi orogenic belt spans the Aravalli mountain ranges from Palanpur in the northern Gujarat to Delhi and the adjoining parts of Mewar region and parts of western and eastern plains in the Marwar region of Rajasthan . Heron (1953) suggested a four fold classification of these Precambrian rocks of Rajasthan now represented by the Banded Gneissic Complex, the Aravalli Super Group and the Delhi Super Group . The Aravalli supergroup and Delhi supergroup constitute the Aravalli fold belt . The supracrustal rocks are known to unconfrombly overlie the gneissic basement .The contact between the gneisses and supracrustal sequence is for a major part tectonised. The Delhi fold belt lies to the west of the Aravalli fold belt . It bounded by Kaliguman dislocation zone in the Eat and Phulad dislocation zone in the west (Sinha Roy et al 1998) . In the northern part, the rocks of the Delhi supergroup come into contact with the basement gneiss-granulite complex (Sandmata-Mangalwar Complex) and in the south juxtaposed against the rocks of Aravalli supergroup. The study area is a part of the Aravalli ranges and the rocks belong to the Ajmer formation (Ajabgarh group) of Delhi Supergroup (Preterozoic) . The main lithounits are quartzite, Calcsilicate bands, Calcgneissed and quartz mica schist . The area trend NNW –SSW. The Ajmer lead-zinc form a part of Ajmer

belt(Raghunanadan **1981**) . It extend over a strike length of 60 km from Kharwa and 37 km South West of Ajmer) in the South west to Hoshiyara in the north east (13 km Kishangarh) .

II **Methodology**

The thick soil cover and sand dunes of Ajmer district are underlain by Ajabagrh series (Heron 1953). Airborne geophysical (EM & Magnetic) surveys are carried out during 1987& 1988 on a regional scale over entire Ajmer district and parts of Naguar districts for base metals mineralization. Promising areas of mineralisation are demarcated by aeromagnetic anomaly maps. On these anomalous areas ground geophysical surveys (EM, Magnetic and SP) are carried out along the fixed flight path of 310° and at traverse intervals of 400 and 200 meters.

A) **Geochemical methods:**

i) **Soil sampling methodology**

In the Ajmer district old workings (Pits and trenches) for Zinc and lead mineralization are not observed. Detailed geological studies are impossible as the area is covered by sand dunes with scanty rock out crops. The geology of the areas where geochemical sampling is carried out has only to be inferred from the subsurface data of the samples from either boreholes or open dug wells. The strike of the formation is NNE-SSW with steep dips as observed near Hosiyara, Kalyanpura and Roopangarh. An area of ~ 2500 km^2 has been taken up covering 30 areas. A total of 86 traverses were laid and ~ 3000 soil samples are collected. Initially regional geochemical sampling is carried out at random where the airborne geophysical anomalies are high. Pits are dug to ~ 2.5 m depth and collected >10 kg soil samples, coned, quartered, sieved to 80 mesh .

The second stage of geochemical soil sampling is carried out over a specified length demarcated by ground geophysical anomalies. Here the traverse/ profile interval is 400m and the sampling interval is 20m which gives ratio of 20:1, whereas a ratio of 4:1 is ideal for targeting the blind mineralized zones. The residual soil samples are collected by hand augers

from a depth of 4 to 6 feet discarding the 'A' horizon with organic matter etc.., Background soil and soil samples are collected far away from the mineralised areas. Since the traverses are spaced at 400m interval with sample interval of 20m, a reasonable interpretation is difficult to arrive. Sampling at traverse interval of 20m and sample interval of 5m at the geochemical anomalous areas will be useful for contour maps and drill hole planning. An area of ~ 2500 km^2 has been taken up covering 30 areas. A total of ~ 3000 soil samples are collected. A total of 86 traverses were laid for this investigation studies.

Geophysical methods

The application of Self potential geophysical method in search of sulphide minerals is a well know methodology in exploration, across the globe (Nayak, P.N.(1981) . Ore bodies frequently differ in physical properties (magnetics, susceptibility, electrical conductivity, density etc) from the rocks with which they are associated. By choosing a suitable geophysical method, ore bodies can be reasonably delinated from the subsurface masses differing in relevant physical properties (T.S. Ramakrishna (2006). Two phases of surveys were carried in this semi arid terrane 1) survey over the known deposit employing integrated surveys (orientation surveys to prove the efficacy of various methods 2) carry out the methods in anaomalous areas identified by airborne surveys etc.., . Kayar , a village , about 5km northeast of Ajmer with proven mineralised zone was chosen for the orientation survey (GSI report 1994) . Gravity, Magnetic, Self-potential , Electromagnetic (time and frequency domains) surveys were carried out in the area. Although Induced polarization and resisitivity may be useful, but due to lack of infrastructural facilities this could be taken up. Five traverses wer laid (T1, T2, T3, T4 and T5) with 400m separation and with 20m station interval on each traverse.

iii) Data collection

At Kayar, five parallel profiles are selected across the strike (T1, T2, T3, T4 and T5) with an interval of 400m in N115°E direction .The point of intersection of the profile with the strike of the

airborne anomaly is designated as '0' point on all profiles. These points are identified on the ground check using global positioning system (GPS) . The profiles are extended on either side of the center point .The station number are incremented by 1 for every 10m increment on the profile. For example a station at 20m west of the center point will be '-2'(W2) and station 300m east of the centre will be station '30' (E30).

Results

Area	Pb (ppm)	Zn(ppm)
Kayar	20	1200
Dhani Rathod	200	300
Hoshiyara	80	200
Meron Kas Basada	20	70
Salaimabad	--	200
Muhamai	--	200
Untra	---	120
Nituti	300	300
Jalya Ki Dhani	15	150
Marda		

Geophysical results

On the T-1 profile (Fig) a sharp anomaly in gravity between W30-W14 may be due to contact of different rock formations. The gentle increase in gravity between W14-E70 is due to the variation in bedrock topography. Magnetic profile, on western side (W16) shows an anomaly of 175nT.This anomaly when interpreted, assuming as a thin sheet yields a depth of 37 m to the top of the body and a dip of 65°E.This could be due to the contact between geological formations .The rest of the profile is more or less flat. SP between W8 –W2 shows a nagaive anomaly about 200 milli volts with a background level of -40 milli volts , which may be indicative of conductive zone .The EM survey shows the presence of a conductor at station W4. The

interpretation gives a depth (h0 to the body as 50m and dip (α) as 80° E. The second profile show a broad low between W22-E 48 and a sharp anomaly at W22, may be due to some geological contact. magnetic survey doesnot indicate any anomaly. SP shows two negatives lows at W8 and E32 with -20 mV and -30 mV respectively. These zones may be due to the presence of conductors .EM with 150m separation also shows 2 conductors at the same stations W8 and E 33 with a depth to the top of the body 72m and 14m and their dips are 78° E and 62° W respectively. Gravity profile shows a gradual increase towards east and a sharp anomaly at W20.This may be due to geological contact .Magnetic profile is more or less flat with a sharp low at W4 which may be due to increased noise levels and discontinuity in the rock formations The response from SP did not contribute any appreciable anomaly anomaly over this profile EM with 150 m separation shows a conductor at W 12 with 70° E dipping, at 78 m depth. A broad gravity low between W10-E4 shows a low-density material , whereas in magnetic a high with 600 n T is seen and interpreted as a shear zone associated with magnetic material . SP has not responded any feature. On the fourth profile time domain EM also show a conductive zone between W20-E2.As the conductors were identified from time domain airborne surveys , it was considered that TEM methods is ideal for correlation. However, due to several hindrances , such as harvest of crops , presence of human habitation , laying of transmitter loop and high ambient noise levels in the area, it is felt that further surveys using this method is not advisable and time consuming. The fifth profile are indicative of bedrock topography, Magnetic profile shows a broad anomaly between W 50-W6, Interpretation of this anomaly also reflect a broad anomaly with some magnetic responsive source from a depth of ~ 20 m.SP profile along reflect a sharp anomaly at 48W due to high Pb variation in lithounits. EM survey along this profile show conductors at 50W, 42W and 30W depth and dipping 50° W, 45° and 65°W respectively .The FEM was carried out with separations 50m, 100, 150m for T-1 ; 100m, 150m for T2, T3 andT5 and TEM survey at T4 (Fig 1-10) .

Discussion

Among the geophysical methods adopted the horizontal loop EM method using Maxm in instrument responded well to the conductor zones up to a depth of ~ 75 m.SP shows negative anomalies over the conductors under favourable conditions. The gravity anomalies showing the contact at T1 to T4 .The magnetic method also show significant anomaly zones. These anomalies may also be due rocks containing remnant magnetization .TDEM survey along the profile also resulted in picking anomalies, but due

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