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Preliminary Geophysical Surveys for Hematite Ore near Veldurthi, Kurnool District, A.P. India.

KEYWORDS: hematite, karnool basin, magnetic method, electrical method

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ABSTRACT *The ENE trending Ramallakota- Kalva-Gani fault alignment in the Kumool Basin, extending intoarchaens in the west is a well-known geological feature with occurrence of important minerals. Abutting to this towards south a panoramic structure of a semi-circular basin is positioned about 30kms east of Veldurthi. Geological reports (SatyanarayanaRao.P .1972) reveal occurrences of diamonds in this basin. Recently traces of occurrences of hematite ore isnoticed by villagers in bore holes and stream cuttings. In view of this theauthors have conducted test geophysical surveys employing magnetic andelectrical resistivity methods. Supporting physical property measurements werealso made on samples collected from field. The magnetic field data weremeasured along three traverses, two nearly E- Wand one near N-S.*

Along traverse three, which is about 320 m long, electrical resistivityprofiling for the entire length and schlumberger soundings at five locationsalong this traverse were conducted. Spectral depths from the analysis ofmagnetic data and the resistivity sounding information helped identifying, thesubsurface layering of the geological successions starting from about twometers depth and up to 20 m depth. Magnetic and electrical resistivity profileshave corroborated well in showing the lateral variations in the lithology underthe soil cover and also possible structural features like faults. The lithological units occurring in the area are red soil on the top, Banganapalle sand stone, conglomerate and hematite ore, below which the local basement could be limestone or quartzites of Cuddapah sequence. The present test geophysical survey has clearly brought out the varying responses of different lithological units in the area and therefore further geophysical surveys in detail can be planned.

Introduction:
Iron is the most indispensable metal to man. In present times, country's economic development depends on the mineral exploration oriented industry, and also considered as an index of a national prosperity. The two important ore minerals of iron are magnetite and hematite. The iron content in these two minerals ores varies from 70% to 72% with different grade rating. Massive hematite exposure rich in quality (~ 65% Fe) at shallow depths of 0.5 to 2meters in a few pits in the area near Veldurthi is promising,. This shows characteristic steel gray luster and comparable with the B.I.F. of Donamalai and other regions. Exploration for iron ore with different methods were reported by Gross &Strangway (1966), Krishan&Balasundaram (1944) and Murthy et al (1983). Preliminary strategy of geophysical exploration of hematite ore near Veldurthiis discussed here.

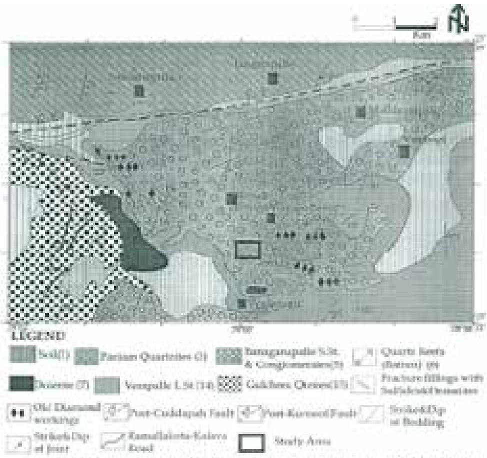
Geology of the Area: Geologically the area of study is located in the part of Kurnoolbasin,spread around 15° 32′ N and 78° 05′ E location in a rectangular shape. It forms a part of Virayapalli village near Veldurthi, Kurnool district, A.P.

The regional geological setting shows that the present geological picture is evolved with erosion, sedimentation, folding, faulting and other tectonic movements and basic and acidic intrusions in different periods after the eparchean interval (Figure.1). These faults and folds are not only defining the topography and drainage, but some of them might get associated with basic and acidic igneous intrusions, a few of which are the primary sources of useful minerals like specularite hematite with quartz (Jasper and chert) near Veldurthi, Steatite (soap stone) through dolerite/amphibolite's dykes in the Vemalle limestone, copper mineralization along Gani-Kalva fault (SatyanarayanaRao, 1972). Diamonds (which are of secondary origin and occurring in Banaganapalle conglomerates) are known (Krishanaswamy, 1979) to be present in this area as near Balapuram, Virayapalle and other places Ramallakota, Timmapuram, Kalva, Boyanapalle, Yambai, Komarolu, Gattimanikonda, Madavapuram, Pendekallu, Panim, Polur, Uravakallu etc.Hematite, the iron ore of present interest is noticed in a few test pits near Virayapalle village, is of mineral value.

The lithological succession around the area is as follows.

Soil, Panim quartzites, Banganapalle standstones and conglomerates	Kumools (Upper Proterozoic)
Quartz reefs (Barren). Basic Igneous Rocks (Dolerites).	Intrusives of different ages
Vempalle limestones Gulcheru Quartzites	Cuddapahs (Meso-Proterozic

Fig 1



Geology of Virayapalle Area & surrounding areas, near Veldurthi, Kurnool Dist., A.P (Modified after P.Satyanarayana Rao, 1972)

The study area is partly covered by sandstone boulders, quartz, jasper, red sandstone pebbles and partly red loamy soil, probably derived from red sandstone and iron (hematite) (Ramam& Murthy 1997). The area extends to the NE of the SOI 504 hillock and is gently and slopping down by about 20m 1/4 km distance towards NE. Brecciated (jasper) quartz conglomerate boulders and pebbles are seen strewn at places on the slopes. Except for the hematite ore, reached in a few shallow pits (1-2 m depth) located on the NW and western peripheral zone of the area, the surface area is marked by the Banganapallesandstones and conglomerates in certain places. The positioning of the hillocks and the nalas suggest folded anticlinal structures aligned in specific directions and limited by faults on their flanks. Dips as per geological report (Satyanarayana Rao, 1972) are usually gentle up to 10° and occasionally higher (up to 25°) and are towards east in the present area.

Present Geophysical Surveys:

Selection of methods and methodology: The present investigation is to test efficacy use of geophysical methods in the geological environment prevailing in the area. The criteria to select the geophysical methods were simplicity in field operations and effective recording of signal from the anomalous sources of interest. Towards this goal surface magnetic and electrical resistivity methods apart from basic physical property measurements were chosen. As stated earlier, the surface geological picture reveals three types of lithology. Red soil-covered pockets, Banaganapalle Sandstones and conglomerate region and the hematite ore noticed in selective pits at shallow depth. Initially, using the basic portable Kappa meter, response was measured in situ for magnetic susceptibility variation. Values of the order of 50-150* 10^{-6}cgs due to the hematite were recorded compared to the relatively flat response over the surroundings. Besides hematite, ferruginous shales present in the area, together with the structural deformations like faulting can also give rise to sharp magnetic anomalies.

The resistivity information from Table-I suggests that there could be significant variation in the resistivity picture due to changes in the surface and sub-surface lithology. It should however be noted that moisture content shall also effectively influence the resistivity response. In view of the above a Sintrex vertical component flux gate Magnetometer and IGIS DDR -1 electrical resistivity meter were used in the field along with an EDA portable magneticsusceptibility meter. Three traverses were marked on the basis of field conditions.

Traverse - 1 is in the northern end of the area and is connecting the two pits P-1 and P-2 located on its western half. It is a line in near E- W direction (N 73° E) and extents for 170 m. Traverse- II is perpendicular to and passing through station 24 of Traverse-I. The length of traverse-II is also 170 m. Traverse - III is laid parallel to Traverse-I. Station 8 of Traverse-II is the same as station No. 24 of Traverse-III. The length of Traverse-III is 310 m. Station interval on these traverses is 5 m. Layout of these traverses is shown in Figure 2. All these traverses were covered by magnetic observations. Along Traverse-III, 5 electrical resistivity soundings (Schlumbelrger VES) were conducted at stations 14, 19, 24,29 and 34 with a maximum AB/2 upto 100 m. along the same traverse electrical profiling was also conducted from station 10 to 46 at 5 m interval. The accuracy of the magnetic data is estimated as± 3nT. Magnetic observations were referred to a local reference base selected away from the field of interest and also appropriate correction for the diurnal magnetic field was made. Above 20% of magnetic observations were repeated on different dates and also one resistivity sounding repeated. The magnetic anomalies thus obtained were plotted along the respective traverses.

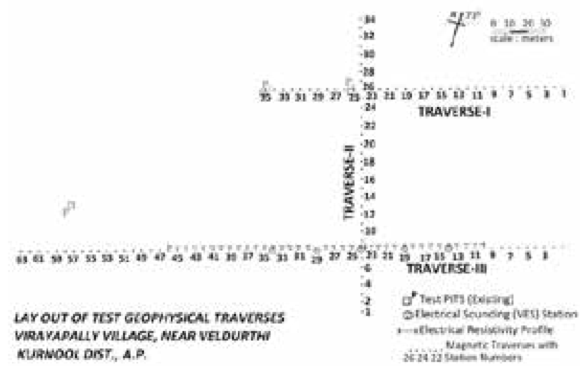


Fig.2

B. Discussion of Geophysical Traverses:

Traverse-I: Magnetic field being a vector quantity can be understood to represent the geometrical position of anomalous sources together with size of the object as well as its magnetic quality. The anomaly variations along this traverse are clearly suggesting the changes in the magnetic character (distribution of Ferro magnetic content) in the lateral as well as depth directions as may be seen in Fig. 3. The nature and magnitude of the variations along the traverse suggests that there are possible lithoboundaries at about station 34, 35, 23, 14/15 and 7/6. These positions may be indicative of transition boundaries from one litho group to another or faults / joints in the strata or difference in Ferro magnetic mineral content locally in the same strata. In all possibility it appears that at stations 33, 34, 23 and at 7 the litho composition of subsurface has taken achange.

Spectral analysis of the anomaly under assumption of lateral homogeneity revealed two interfaces suggesting a three layer sub surface. The top layer is of 1 to 2.5 m thicknesses as marked between stations 13 and 28. Presence of second layer could be felt only between stations 8 & 13 at depths 4 to 6 m. It is possible that the top layer is corresponding to the overburden composed of soil & pebbles of the country rock. The second layer may be revealing the weathered zone of local geological unit, possibly the Banaganapalle sandstones.

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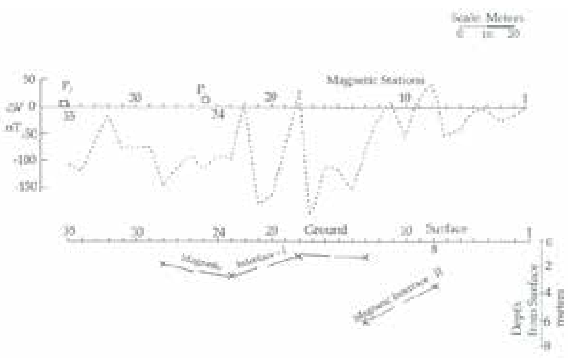
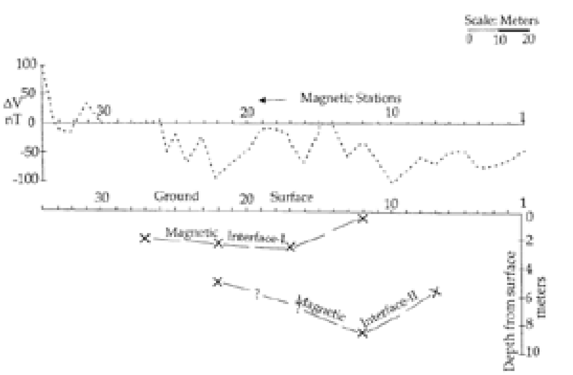
Fig. 3



Results of Magnetic (ΔV) Data Inversion along Traverse - I
(Under assumption of Laterally homogeneous Layering)
P1, P2 — Existing Test Pits

Traverse-II: In figure 4 are shown the magnetic anomaly variation along this traverse and also the depths inferred from spectral analysis. Station 24 of Traverse -I corresponds to the midpoint between Stations 25 & 26 of Traverse II. Besides the characteristic fluctuations in the anomaly pattern which may be attributed to changes in the subsurface litho composition, the anomaly gradually decreases from N to S by about 100 nT in 170m. As the topography gently rises from N to S roughly by 10m, one may see the cause of this decreasing gradient at least partly to be the effect of topographic raise. On this traverse there are possible subsurface lithoboundaries at about station 32, between stations 25 & 26 at about station 20, station 14 and between stations 14 & 15.Spectral depths along with traverse also show a 3-layer configuration of the shallow subsurface. The top layer, probably the over burden/soil cover, has the thickness 2.5m, second layer suggesting a small sync1inal fold with the axis positioned beneath station 12. Depth to this interface as mapped between station 7 & 22, appear to vary from 5.5 m to 8.5m and to 4.5m.

Fig. 4



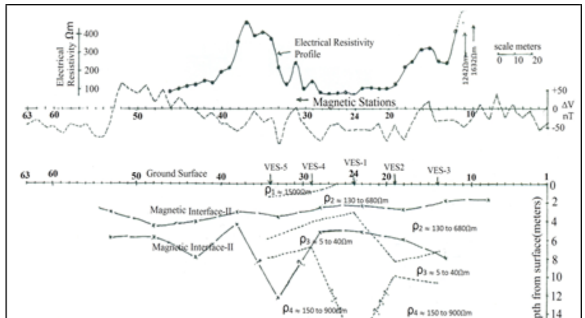
Results of Magnetic (ΔV) Data Inversion along Traverse - II
(Under assumption of Laterally homogeneous Layering)

Traverse-III:Along this traverse magnetic and electrical resistivity profiles are shown III Figure.5. Depth from magnetic spectral analysis and electrical VES interpretation are also shown in this figure. The anomaly variations both in magnetic & electrical profiles are more significant and characteristic suggesting lateral change in lithology, variations and depth to interfaces has also sharp faulted boundaries especially in magnetics as at station 53. In the magnetic anomaly profile the variation positioned at about station 53, stations 37 to 38, stations 28, 18 & 10 are significant and might be suggesting litho-contacts or lateral change in the composition of formations.

The electrical resistivity profile data clearly lends support to magnetic profile through suggesting two high resistivity zones between stations 30 and 40 and between 10 and 18. It is possible that these two positions are marked by the presence of quarzites. In the zone from stations 20 to 30 the relatively low resistivity could be due to the tilled wet soil covering a litho unit different from that of the two adjacent zones. The availability of the massive hematite ore in a pit about 25m north of station 53, the magnetic anomaly trend in this zone, the decreasing trend of the resistivity profile towards west of station 40 may be viewed together and the probable presence of hematite ore in this zone imagined.

The magnetic depth section inferred between stations 8 and 53 reveals a three-layer shallow subsurface. The magnetic interfaces are gently rising from W-E by 3m in 200m corresponding with the subsurface topography.

Fig. 5



RESULTS OF MAGNETIC (ΔV) & ELECTRICAL VES DATA INVERSION ALONG TRAVERSE - III.
(Under Assumption of Laterally Homogeneous Layering)

Table-I (Traverse-III -Results of VES data)

VES No.	St. No	No.of Layers	Layers Resistivity ohm-m				Layer Thickness meters		
			ρ_1	ρ_2	ρ_3	ρ_4	h_1	h_2	h_3
1	24	4	136	59	22.5	850	2.41	5.08	5.75
2	19	4	160	5.3	900	1.1	8.46	1.55	10.5
3	14	4	275	10.6	554	12.7	7.36	3.32	12.5
4	29	4	1460	479	13.7	264	0.84	3.21	2.73
5	34	4	1518	687	9.03	152	1.38	4.53	2.03

In the VES results (Table - I) the subsurface layers with a maximum of fitting up to 9.14% appear to be shallowing from west to east as could be noticed between VES 5 and VES 1. It is possible that the area surveyed is indicating a gentle anticline structure with its axis in the near N-S direction. The magnetic depths revealing sagging in the top layer and sudden thickening of second layer at places and at stations 33 and 43 are interesting. The depression in these interfaces especially at station 33 may be corresponded to the increasing depth of the resistivity interfaces. [Positioned at station 24 of resistivity layer (5-40 ohm-m) and at station 20 of layer with resistivity (130-680 ohm-m) may be viewed as corresponding with the above magnetic feature]. These features together might be suggesting a possible faulting in the sedimentary sequence with the fault plane positioned at about station 27. The resistivity depth section has shown sedimentary layering sequentially with top higher resistivity (1500 Ohm-m) sandstone and quartzite west of station 26, the second layer in the western zone with approximate thickness of 4m and resistivity 130-680 Ohm-m becoming the top layer with thickness about 8m in the eastern zone of the traverse. This layer could be representing the sandstone horizon with moisture content to a limited extent. The third layer with resistivity 5-40 Ohm-m and of thickness about 2m on either side and increased thickness under station 24 may be viewed as conductive shale or phyllite layer. The zone under station-24 may be a faulted horizon with brecciated quartz or conglomerate pocket. The 4th layer is again a moderately high resistivity zone comparable to that of the 2nd layer under VES-3. A bottom layer at a depth of about 22m appears and existing with a low resistivity of 1-12 Ohm-m which may be indicating a shale band.

Correspondence of magnetic features on Traverses-I & III, being parallel to each other, may be attempted. From East to West for the 35 stations, as discussed in the earlier section, the magnetic anomaly features are clearly comparable, but for the effect of tilled soil cover in reducing the magnetic oscillations on Traverse-III. The anomaly pattern on the exposed sandstone zone from stations 5 to 10 on Traverse-III corresponds to that between stations 5&12 on traverse- I. Similarly the magnetic feature between stations 30 - 34 on either of the traverses appear to be comparable.

Thiscorrespondence in magnetic features leads to imagining the continuity of the features between the two traverses (i.e., the strike direction of the subsurface lithology could be N 17° W). Extending this concept of strike alignment for the prominent magnetic feature from stations 43 to 63 of Traverse-III, it may be imagined that on Traverse - I also at these distances the same anomalous feature may be expected. It is of significance that this inference suggests probable occurrence of iron ore at least in the zone 51 to 59 stations, on Traverse-III and also at corresponding positions on Traverse-I.

Conclusions:
The significant magnetic & electrical resistivity variations/ anomalies recorded at different points on the traverses show notable correspondence with hematite ore existing in the test pits in Virayapalle area. The magnetic anomaly located on traverse-III between stations, could be due to faulting with the fault plane located under station 53 to approximately to the west of which possible presence of iron ore at shallow depths may be inferred. Or the anomaly could be due to a thick tabular body positioned between stations 50 to 57 which may be corresponding with the hematite ore. Similarly occurrence of hematite ore may be expected on traverse-I at stations positions 33, 34 & 23 on the West word extension side, where the anomaly is significant.

Magnetic depth interpretations and the geo-electrical section from VES on Traverse - III suggest a fault-like structure located between stations 27& 30 and dipping towards east approximately at 25°. It is possible that along this fault there could be brecciated quartz, which may or may not carry any useful minerals.

On the basis of detailed geophysical survey in the area further inferences like subsurface geology and mineralization including its composition, structure may be studied.

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