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INTERPRETATION OF MAGNETIC DATA CUDDAPAH BASIN, INDIA

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ABSTRACT
In Andhra Pradesh, India in 2007 a sudden gas leakage was observed from the irrigation borewells. To investigate the subsurface structural features which leads to leakage of methane gas Magnetic studies, were carried out in this study area. Few analytical techniques like Horizontal, Vertical and Analytical gradients were applied to the data for delineation of structural features like faults/ fractures. Horizontal Derivative map shows that lateral extent of geological contacts/faults more accurately. From the Vertical Derivative map it is noticed that high anomaly represent sill body and a low indicates the presence of shales which is prevailing in this area. Analytical Signal contour map shows the closures "A, B & C" interpreted as highly magnetic bodies, sills. From all the analysis it is noticed that maximum borewells are located on the edge of the high and low anomalies.

KEYWORDS: ***Irrigation Borewells, Tadipatri shales, Sills, gas emanations and faults.***

1. INTRODUCTION

In the study area few villages of Ananthapur District of Andhra Pradesh, India, the gas emanations were observed along two North-South trending lines, most likely along two faults or fractures. It is likely that the existing deeper fractures extended up to the surface near the gas gushing irrigation borewells. These "gas shows" were first noticed in 2007. It is therefore important to know the locations of these fractures so as to predict the source regions of the gas. Secondly, it is quite likely that these fractures are shallow and geophysical tools such as magnetic methods can bring out important information that might help detect and delineation of these fractures.

2. GEOLOGY

The present study area is located in the western part of the Cuddapah Basin. (Vijayam,1968; Leelanandam,1980). The Cuddapah basin consists of a very thick sedimentary column with minor volcanic intrusions and is formed by the deposition of several discrete sub-basins with two litho-stratigraphic groups, each with distinctive rock assemblages and ages constituting the basin. The lower and older Cuddapah Super group occupying the entire basin is overlain by the younger Kurnool group in the western part (King, 1872, Nagaraja Rao et al., 1987). The study area consist of Tadipatri shales of Chitravati group with a few dyke and sill intrusions.

3. MAGNETIC DATA AND INTERPRETATION

Magnetic surveys were conducted along all available roads with a station interval of 200 m to obtain variation of the observed fields in the study area on a relatively broader scale. Since the station interval is relatively larger this is termed as semi-detailed survey. Figure 1 shows the layout map of magnetic observations along the traverses R1-R10 and T1-T4 covered about 64sqkm. A total of 280 measurements were taken for each method.

Keeping in view of the diverse geology and structure of the study area different computational methods - Horizontal, Vertical and Analytical gradients for delineation of faults, fractures, lineaments and edge detections of the geological formations have been deployed.

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i) Total Magnetic Intensity (TMI) Contour Map

Figure 1 shows the Total magnetic intensity contour map of the study area with 20 nT contour interval. The magnetic anomalies ranges from 40727 nT in the east and middle part of the study area to 42520 nT in the West, North and the middle.

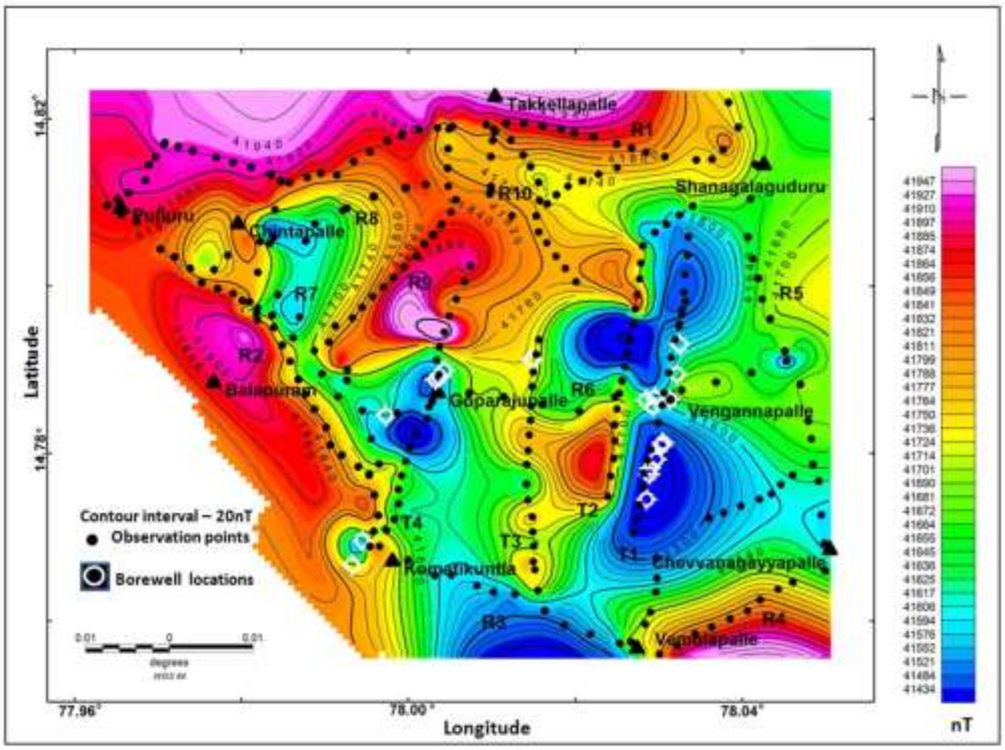

Figure 1. Total Magnetic Intensity contour map of the study area.

ii) Horizontal Derivative Contour Map

The total horizontal derivative is given by (Cordell and Grauch,1985)

$$THDR = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2}$$

Where T is the total intensity magnetic field, $\partial T/\partial x$ and $\partial T/\partial y$ are the two orthogonal horizontal derivatives of the magnetic field in the x and y directions respectively. Horizontal derivative represents the rate of change of magnetic field in the x and y directions.

Horizontal derivative is very useful to detect the outline of the target bodies. The horizontal gradient peaks over the edges and is minimum over the body (Telford ,1990). contacts, fractures, faults and other lineaments and these features can be delineated or identified from magnetic intensity derivative maps (Dobrin and Savit 1988) - both vertical and horizontal. In view of this both horizontal and vertical derivative maps have been prepared for the study area.

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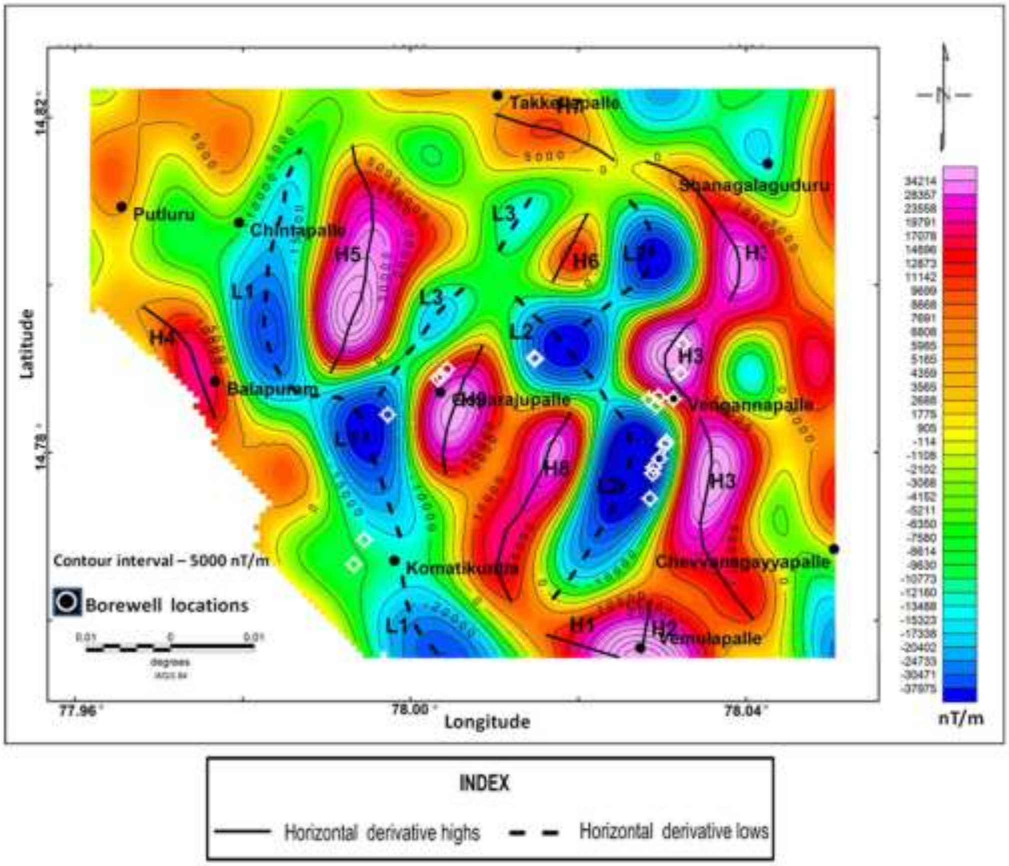

Figure 2. Horizontal Derivative contour map of the study area.

Figure 2 shows the contour map of the horizontal gradient along the X- direction, with a contour interval of 5000 nT/m. The contour map gives the approximate location of the source body. The high and low gradient trends (eight high trends - H1 to H8 and three low trends - L1 to L3) are delineated from this map. Figure 2 shows the contour map of the horizontal gradient along the X- direction, with a contour interval of 5000 nT/m. The contour map gives the approximate location of the source body. The high and low gradient trends (eight high trends - H1 to H8 and three low trends - L1 to L3) are delineated from this map.

iii) Vertical Derivative Contour Map

Vertical derivative ($\partial T/\partial Z$), is the rate of change of magnetic response with depth (Oruc, 2010). First vertical derivative data have become almost a basic necessity in magnetic interpretation. It is a zero phase filter, hence it will not affect the location of anomaly peaks, but it will sharpen the potential anomalies. Since Vertical derivatives generally exhibit a narrow width and these features are found to be locating the source bodies more accurately. In general, it is positive over the source, zero over the edge and negative outside of a vertical sided source. Units are Eotvos Unit (EU) (Telford,1990).

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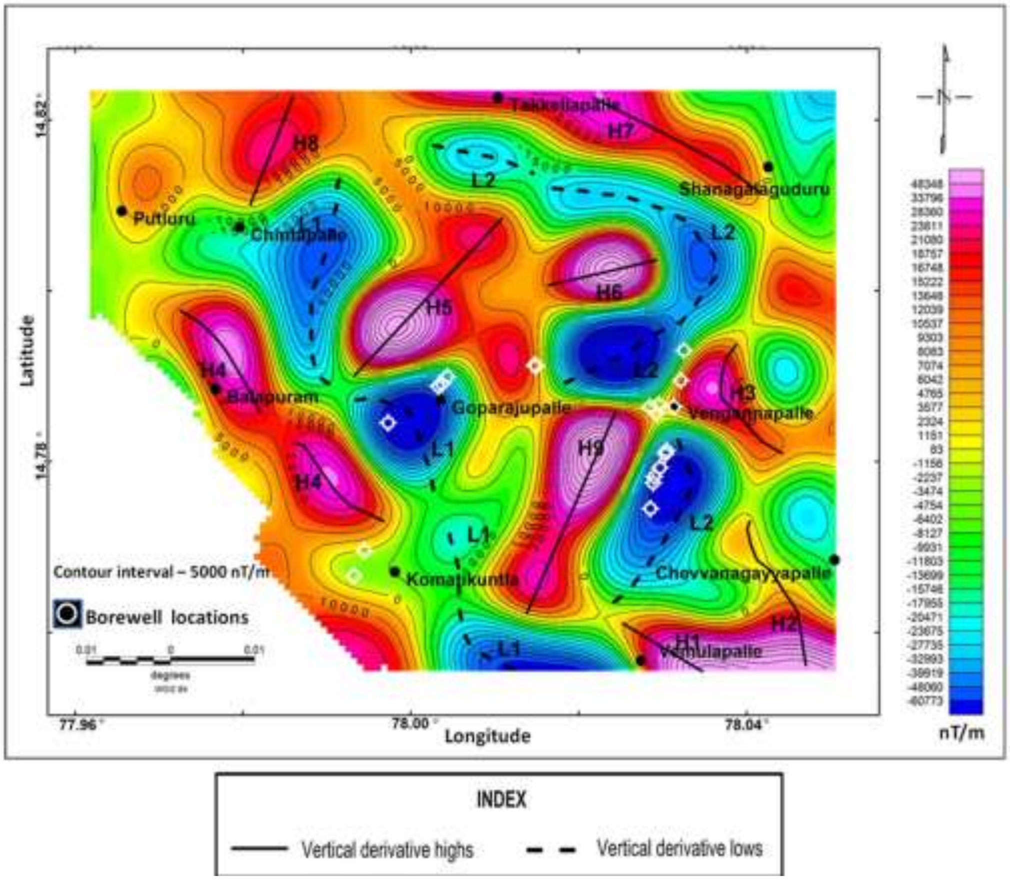

Figure 3. Vertical Derivative contour map of the study area.

The vertical derivative of the total magnetic intensity contour map is shown in Figure 3 with a contour interval of 5000 nT/m. The Magnetic highs H1 to H9 and lows (L1 to L2) trending in NE and NW directions are delineated in this map.

iv) Analytical Signal Contour Map

The analytic signal (Roest et al., 1992) an important function that shows the relation of the magnetic fields to its derivatives, i.e.

Analytic signal:
$$AS = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2}$$

Where T = total magnetic field intensity, $(\partial T/\partial x)$, $(\partial T/\partial y)$ and $(\partial T/\partial z)$ are orthogonal components of the gradient vector of the total magnetic field.

While this function is not a measurable parameter, but it is extremely useful in the interpretation, as it is independent of the direction of magnetization and the direction of the Earth's field. This means that all bodies with the same geometry have the same analytic signal. Further more, as the peaks of analytical signal functions are symmetrical and occur directly over the edges of wide bodies and directly over the centers of narrow bodies.

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Interpretation of analytic signal maps and images should, in principle, provide simple, easily understood indications of magnetic source geometry (Milligan and Gunn, 1997). This function and its derivatives are therefore independent of strike, dip, magnetic declination, inclination and remanent magnetism (Debeglia and Corpel, 1997).

Figure 4 shows the contour map of the analytical signal (Nabighian 1972, 1974). From this map there are three prominent clusters marked A, B and C. "A" in the Goparajupalle, "B" in Vengannapalle and "C" in Vemulapalle villages. There are six highs (H1 to H6) and eight lows (L1 to L8), individual features delineated in the map and these features trend in NE and SW directions similar to the same as in the vertical and Horizontal derivative maps.

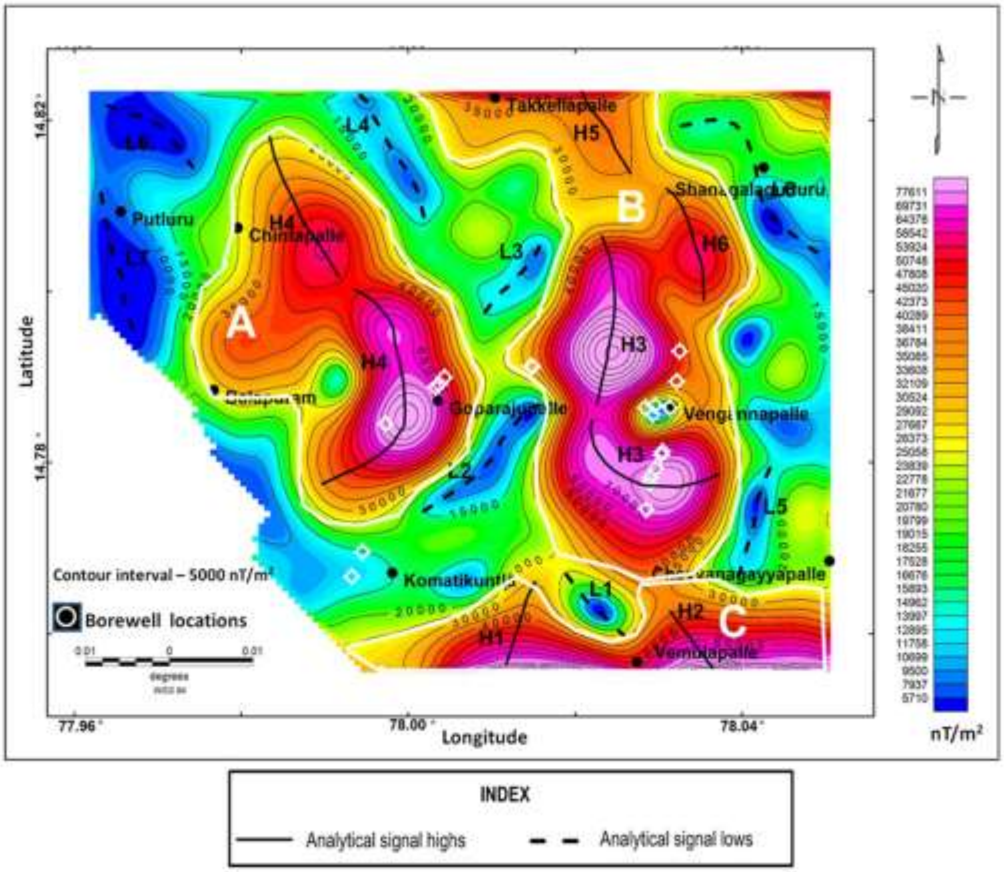

Figure 4. Analytical Signal contour map of the study area.

4. CONCLUSIONS

From the Horizontal Derivative map (Figure 2), the anomalous features on this maps are often useful in defining the lateral extent of geological contacts/faults more accurately. The 'highs' and 'lows' obtained in the present study area show two prominent trends, viz., NE-SW and NW-SE. It may be noticed, maximum number of borewells yielding gas are located on the edges of the bodies.

Considering the geology of the study area, in this Vertical Derivative map (Figure 3), for example a magnetic highs (red) represent a sill body at depth while a low (blue), can be attributed to shales and sedimentary rocks. Thus These are inferred to represent such as sill bodies the geological contacts/faults and fractures etc. The borewell locations may be seen to be either falling on the cross over of the high and low magnetic field or in the low values.

In the Analytical Signal contour map (Figure 4), geologically the closures "A, B & C" may be interpreted to correspond to highly magnetic exposed/ hidden sills. It is clearly seen in the figure that maximum borewells are located on the high anomaly zones "A and B".

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