

Spatial Confirmation of Major Lineament and Groundwater Exploration using Ground Magnetic Method near Mecheri Village, Salem District of Tamil Nadu, India

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Abstract

Geophysical methods are widely used in various applications, especially to know about the subsurface features of the Earth. In the present study, the ground magnetic method has been done to map the NE-SW trending major fault traversing Mecheri block, Salem district for the spatial correlation study and also to locate possible groundwater potential zones within the study area. The instrument used is Proton Precession Magnetometer-600 which produces a weak magnetic field that is picked up by an inductor, amplified electronically, and fed to a digital frequency counter whose output is typically scaled and displayed directly as field strength. The survey is done across the major fault marked by the GSI geologist with 100 m spacing in profile direction and 30 m sample spacing along the profile and for each profile line, 14 to 15 samples have been collected along with coordinates, time and magnetic value with all the necessary precautions. Then the data is processed and diurnal corrections were made for the interpretation using geophysical software. After the necessary corrections, profiles, contours and maps were generated for quantitative and qualitative analysis which includes magnetic contour map, total magnetic intensity, reduction to pole, analytical signal, upward and downward continuation, horizontal and vertical derivative, and radially average power spectrum. Based on the visual interpretation and interpreter's knowledge, it was identified that the major NE-SW trending magnetic break is present at the southeastern corner of the map which is spatially correlated with the major fault marked by the GSI geologist. Apart from that there are two magnetic highs were noticed in the southwestern part of the map which is mainly due to presence of isolated granite and syenite bodies. A small another magnetic break in the E-W direction has also been noticed. Intersection point of the NE-SW and NW-SE fault zones are favorable zone for groundwater potential zone. Other than this, the magnetic anomaly depth has been inferred from the radially average spectrum method shows the anomaly at 11 m, 21 m and 51 m depth.

Keywords: Exploration geophysics; Lithology; Subsurface geology; Geomorphology

Introduction

Geophysics is the branch of Earth science that uses physical measurement and mathematical models to develop and understanding of Earth interior. Exploration geophysics can be used to directly to detect the target style of mineralization via measuring its physical properties directly. The exploration geophysics use physical method at the surface of the Earth to measure physical properties of the subsurface along with the anomalies in those properties.

A magnetic survey is a powerful tool for delineating the lithology and subsurface structure of buried basement terrain. Such a survey maps the variation of the geomagnetic field, which occurs due to changes in the percentage of magnetite in the rock. It reflects the variations in the distribution and type of magnetic minerals below the Earth's surface [1]. Magnetic minerals can be mapped from the surface to greater depths in the rock property, of the rock. Sedimentary formations are usually nonmagnetic and, consequently, have little effect, whereas mafic and ultramafic igneous rocks exhibit a greater variation and are useful in exploring the bedrock geology concealed below cover formations [1].

Magnetic survey used to investigate subsurface geology on the basis of magnetic anomalies resulted from magnetic properties of the underlying rocks [2]. It is also used to map lithological boundaries between magnetically contrasting litho units including faults [3]. A magnetic anomaly originates as a result of magnetization contrast between rocks which shows different magnetic properties. Most rocks contain some magnetite, hematite or other magnetic material which

will produce disturbances in the local magnetic field. Because of this, most soils and man-made objects that contain nickel or iron have magnetic properties detectable by a sensitive magnetometer, because they create local or regional magnetic anomalies in the earth's main field. Anomalies are revealed by systematic measurement of the variation in magnetic field strength with position. Folami and Ojo [4] expressed their opinion about magnetic methods which are sensitive to susceptibility within the subsurface geology and so ideal for exploring in the basement complex regions which make this method suitable for this research work. Total magnetic intensity which traverses over an area can aid understanding geological information and, in the case of iron ore deposits, can indicate very clearly their locations. The main objective of this study is to delineate the trend of major fault marked by the geologist from GSI for spatial confirmation, to delineate subsurface structures and to study about the groundwater potentialities of the study area. To attain these goals, a ground

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magnetic survey area was conducted Mecheri village with the help of PPM-600 magnetometer. The magnetic survey data were subjected to a quantitative interpretation that involved some geophysical processing and interpretational techniques, which include (1) reducing the total intensity magnetic data to the north magnetic pole; (2) isolating the magnetic data into their residual, and regional, components, using Fast Fourier Transformation (FFT) techniques; and (3) power spectrum.

The magnetic method involves the study of lateral changes in magnetic field caused by variations in magnetization due to differing magnetic properties of rocks. This method is relevant to groundwater exploration in hard rock terrains, faults and basic dyke intrusive associated with prominent magnetic signatures [5-8].

Geologically the study area comprises the various geological formations from Archean to early paleozoic period. The most of the study area is covered by hornblende biotite gneiss followed by syenite and granite. Small amount of area is covered by dunite, pyroxene, calc. granulite, meta-limestone, fuchsite quartzite and amphibolites [9]. The amphibolite is found in the areas near Doramangalam, Avadathur and Jalakandapuram. The Fuchsite quartzite is found near Ramaswamymalai. Kumaramangalam area shows the occurrence of Calc granulite and Limestone. The Pakkanadu area shows occurrence of Dunite, Peridotite and Pyroxene [10]. The Granite is formed between the period of late Proterozoic and early Palaeozoic as intrusive which is noticed near Kumarapalayam, Kaveripatti, Thevur, Mothaiyanoor and Devanagoundanur. The Syenite occurs along koratti shear zone (Pakkanadu, Pulampatti, Vanavasi and Koonandiyur) as a dyke [11]. However, the Mecheri area comprises mainly Hornblende biotite gneiss and at places Calc granulite with lot of Pyrite specks and Malachite staining were noticed.

Materials and Methods

Spatial confirmation and depth extension survey against the major fault marked by the GSI scientist has been carried with the help of

Magnetometer near Mecheri (Figure 1). Magnetic survey in Mecheri block has been carried out in the NW-SE profile direction with 100 m spacing and 30 m sample spacing along the profile approximately [12]. Traverse was planned perpendicular direction to the major fault which is orienting in the NE-SW direction. There are five profiles covered over an area of 0.21 sq km has been taken up for the present study. For each profile line, 14 to 15 samples have been collected along with co-ordinates, time and magnetic value with all necessary precautions. Then, necessary corrections were made and prepared various images and contours for qualitative and quantitative study. Further, these images visually interpreted and digitized available magnetic breaks. Intersection of magnetic breaks and faults are marked for groundwater potential zones [13]. The magnetic breaks further spatially correlated with the existing lineament (major fault) for validation and confirmation. Power spectrum is also generated to know the depth of the magnetic anomalies noticed in this study area.

Instrument used

The instrument used in this study is Proton Precession Magnetometer-600. The proton magnetometer, also known as the proton precession magnetometer (PPM), uses the principle of Earth's field nuclear magnetic resonance (EFNMR) to measure very small variations in the Earth's magnetic field, allowing ferrous objects on land and at sea to be detected [14]. The principle of the instrument is that, a direct current flowing in a solenoid creates a strong magnetic field around a hydrogen-rich fluid (kerosene and water are popular, and even water can be used), causing some of the protons to align themselves with that field. The current is then interrupted, and as protons realign themselves with the ambient magnetic field, they process at a frequency that is directly proportional to the magnetic field [15]. This produces a weak rotating magnetic field that is picked up by a (sometimes separate) inductor, amplified electronically, and fed to a digital frequency counter whose output is typically scaled and displayed directly as field strength or output as digital data.

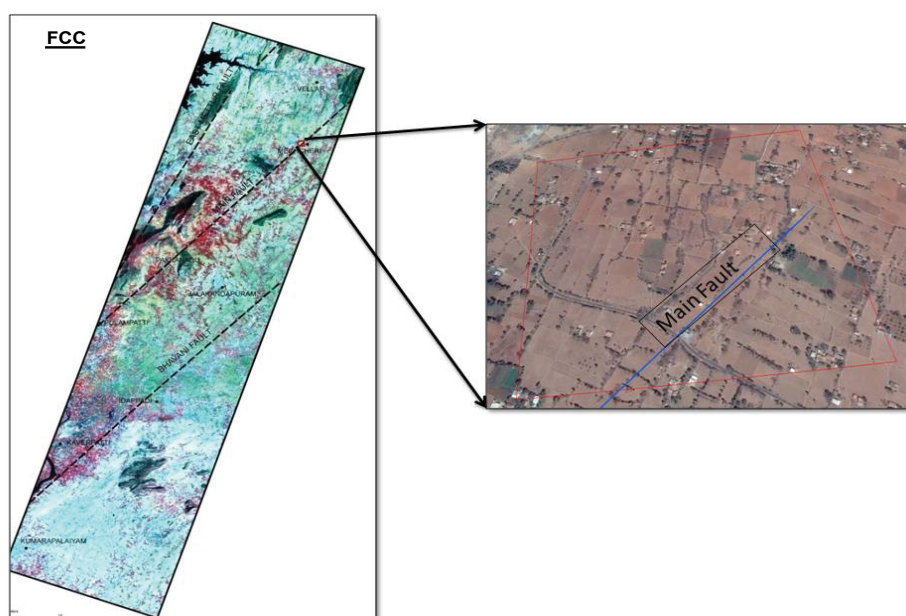


Figure 1: Spatial confirmation and depth extension survey with the help of Magnetometer near Mecheri.

Data preprocessing and analysis

The magnetic data collected in the field is raw data which needs to be corrected to simplify the interpretation. The following corrections are done to the collected data using Oasis Motanj software.

Diurnal correction

Diurnal changes are the daily changes in the magnetic field are related to the rotation of the earth; the changes may range from few Gammas to 100 Gammas or more. A continuous record of the changes in diurnal variations may be obtained using magnetic recording instrument [16]. If that is not available, the field magnetometer may be used to read the variations by repeating the observations over a base station several time during the course of day's survey.

The diurnal changes have been done by taking the readings one hour once at the base station and correcting the field magnetic values by subtracting the base station magnetic value [17]. After the corrections, magnetic profiles were generated (Figure 2).

Total magnetic intensity

Total intensity is the measurement from the magnetometer after a model of earth's normal magnetic field is removed. It is generally a reflection of the average magnetic susceptibility of broad, large-scale geologic features.

The values that are corrected are plotted as contour lines with an interval of 10 m. The values vary from -38 to 140 gammas [18]. Magnetic gradient has been noticed in the SW part of the Mecheri block where the main fault traversed in the NE-SW direction. The magnetic gradient trend has spatial correlation with the main fault is confirmed. Apart from this, another magnetic break has been recorded in the NW-SE direction (Figure 3). The magnetic high noticed in the SW corner of the images is due to the intrusion of syenite body which is confirmed during the field work.

Reduction to pole

Reduction to pole uses mathematical filtering methodology to calculate the magnetic anomaly that would be observed at pole $i = \pm 90^\circ$. It is Process by which effects of inclination (9.1) and declination (-1.5) are removed from the data [19]. The data are mathematically

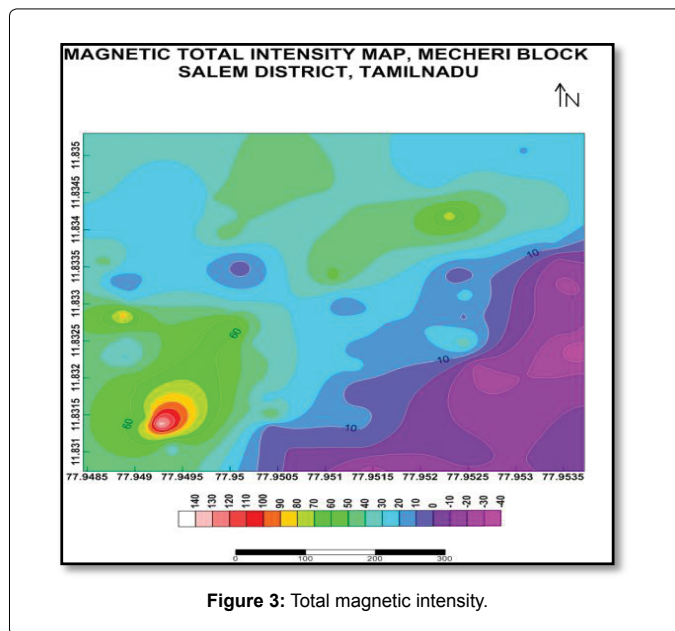


Figure 3: Total magnetic intensity.

transformed to measurements over the same geologic structure, but at the magnetic pole where the inducing field is vertical. So, reduction to pole has been done which shows the exact position of magnetic anomalies in the survey area. The RTP data for our study area shows subsurface occurrence of dykes that is exposed in the surface in E-W direction (Figure 4).

Analytical signal

The analytic signal or total gradient is formed through the combination of the horizontal and vertical gradients of the magnetic anomaly. The analytic signal has a form over causative body that depends on the locations of the body (horizontal coordinate and depth) but not on its magnetization direction Figure 5. The analytical signal image shows magnetic high in S-W part and low in eastern parts of the block.

Upward and downward continuation

Upward continuation predicts the magnetic field at a higher elevation and emphasizes the longer spatial wavelengths. The upward continuation has been done for 100 m (Figure 6) and 200 m (Figure 7) in both the continuation the anomaly is seen prominent i.e. it is not diluted. The upward continuation output shows magnetic anomaly in south and north sides with a break in between [20]. Downward continuation is a mathematical procedure that computes magnetic field at a lower level. This process will emphasize shorter wavelengths, but can be unstable and produce artifacts. The downward continuation has been done for 25 m (Figure 8). The downward continuation output shows magnetic anomaly in parts of south-west and north-east with breaks in W-E and NE-SW.

Horizontal and vertical derivative

Second order vertical derivative is nothing but the change in magnetic intensity in vertical direction. Vertical derivative magnetic map (Figure 9) shows low value in south and east parts and at the center in W-E direction and high values in south-west and north parts of block. Horizontal derivative magnetic map (Figure 10) indicates magnetic anomaly in south and in center part along the break.

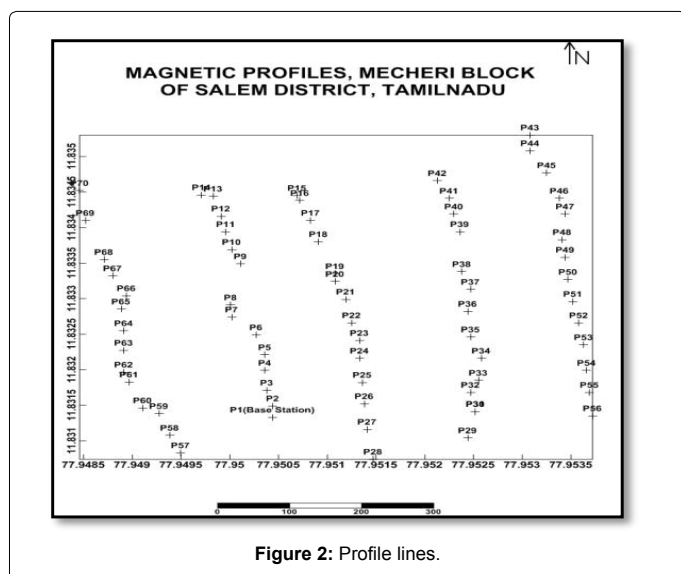


Figure 2: Profile lines.

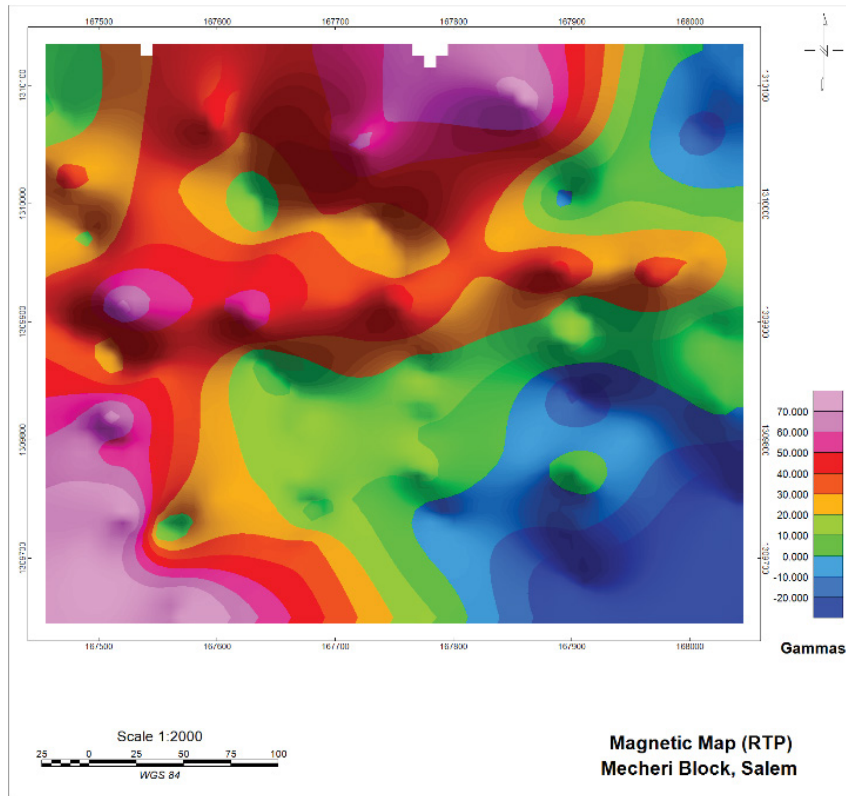


Figure 4: Reduction to pole image.

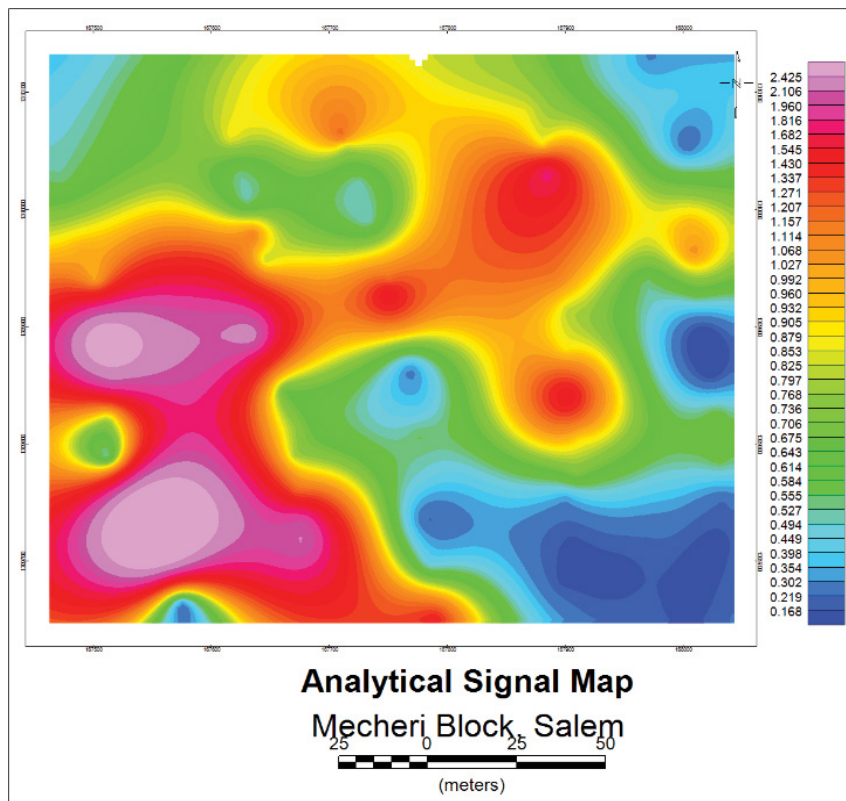


Figure 5: Analytical signal map.

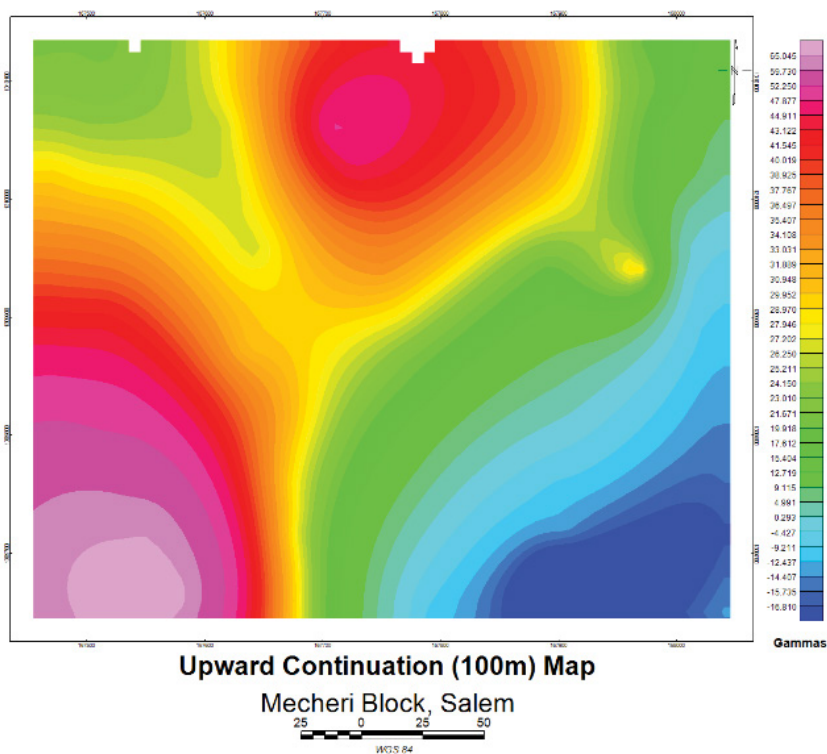


Figure 6: Upward continuation (100 m) map.

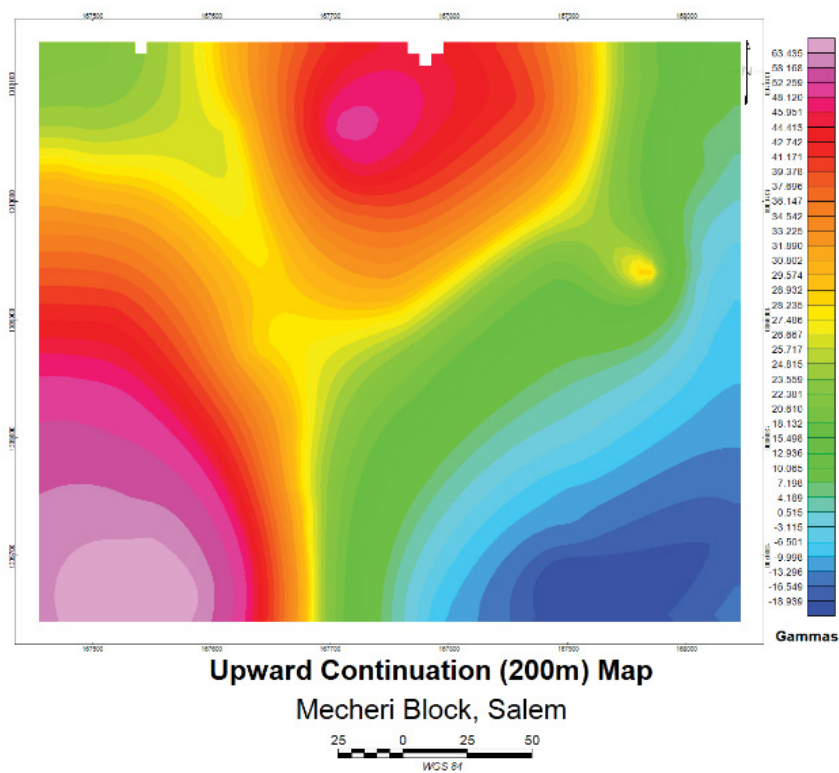


Figure 7: Upward continuation (200 m) map.

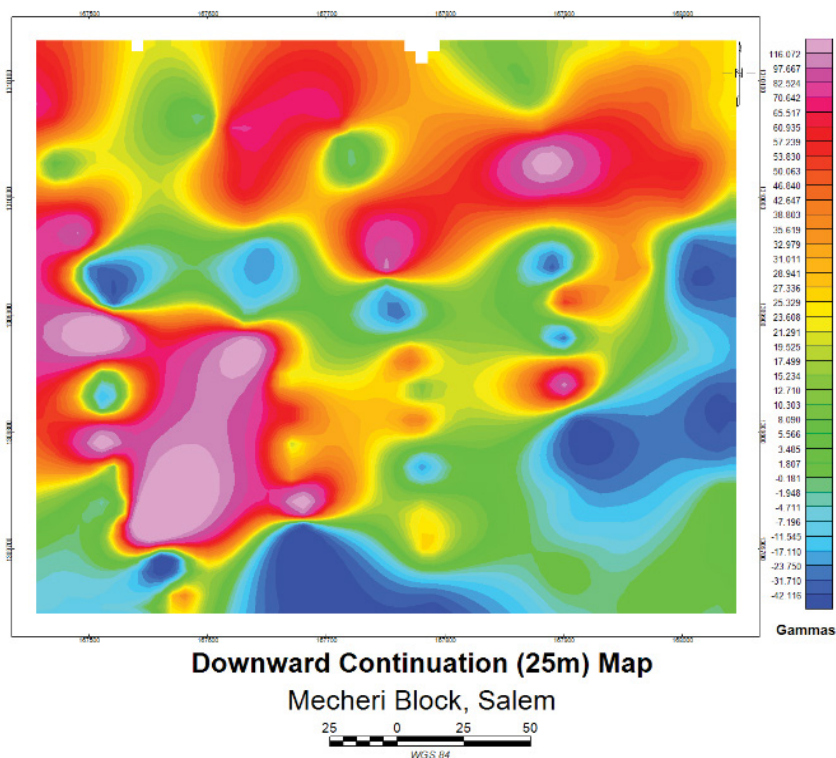


Figure 8: Downward continuation (25 m) map.

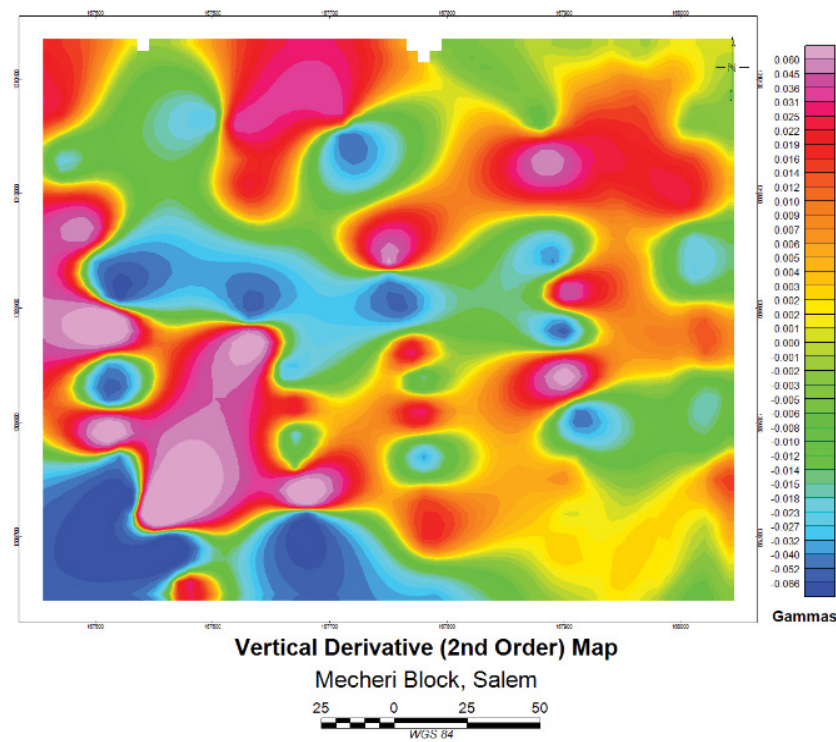


Figure 9: Vertical derivative map.

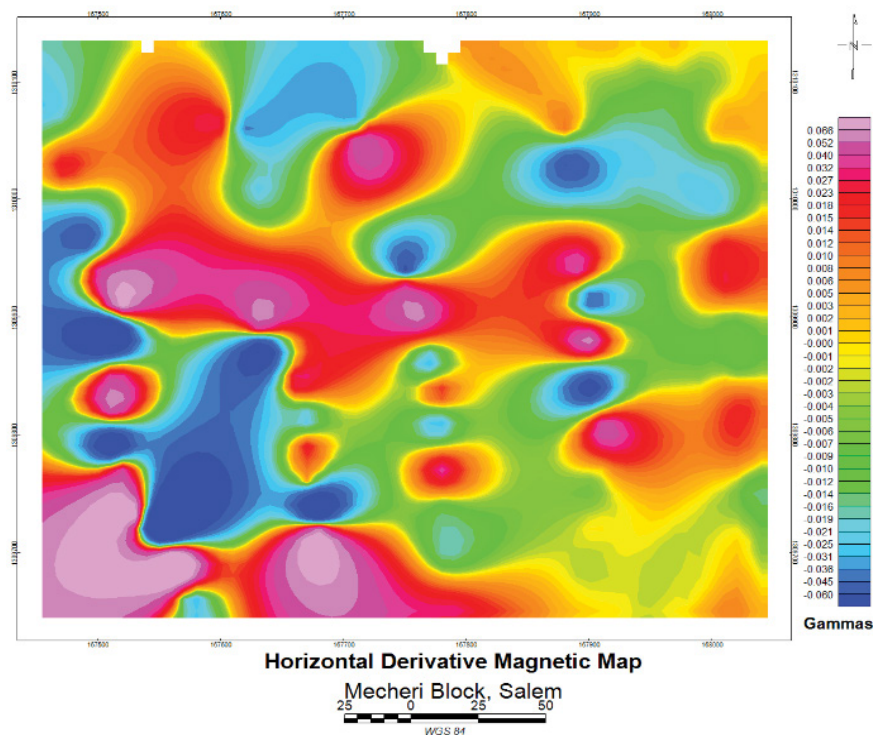


Figure 10: Horizontal derivative map.

Radially average power spectrum

It is a technique done to approximately locate the depth of magnetic anomaly. Based on this, the slope is determined and from the slope the depth is estimated using the formula $\left[h = \frac{s}{4\pi} \right]$. For the study area this spectrum shows anomaly at 11 m, 21 m and 51 m (Figure 11).

Groundwater potential zone

Magnetic method is one of the best and simple methods for groundwater exploration related studies in the hard rock terrain. Mecheri area comprises two major magnetic breaks which are trending in NE-SW and NW-SE directions (Figure 12). The NE-SW break spatially well correlated with the major fault (lineament) marked by the GSI scientists. Intersection of these magnetic breaks was noticed about 500 m west of Mecheri village (Figure 13). Intersection of lineaments is good for groundwater exploration, because, in that particular zone structural porosity and permeability will be very high which can act as hard rock aquifer for groundwater.

During the data collection, it was also noticed that the area falls in the northwestern side of the NE-SW magnetic breaks are having good amount of groundwater and lot of agricultural activities going on when compared to the northeastern side of the magnetic breaks [21]. In addition, Stanley reservoir is located about 9 Km along the direction of NW-SE magnetic breaks which is not exposed on the surface. This lineament must be the reason for good groundwater potential in the western part of the major fault.

The area falls on the eastern side of the major fault can be artificially recharged through the direct and indirect methods of artificial recharge. In this regards, further detailed study about lithology, geomorphology,

land use land cover soil type etc. are required to suggest suitable method.

Conclusion

The present study is taken up for the spatial confirmation of lineament and groundwater potential in Mecheri block using ground magnetic survey. Magnetic data has been collected across the main fault near Mecheri block recorded by GSI scientists. Data has been corrected and processed to simplify the interpretation. Total Magnetic Intensity map shows the gradient of magnetic values that leads to identification of two breaks in NE-SW and NW-SE directions. The RTP images shows the magnetic anomaly in NNW-SSE direction of the block which is not exposed in the surface. Analytical signal image for the block shows high magnetic value in southern and western parts and low magnetic values in the east.

The upward continuation has been done at 100 m and 200 m. In both the images the breaks are seen prominent in NW-SE and NE-SW direction indicates its depth persistence. The downward continuation has been done for 25 m. The magnetic high values are observed on SW and NE sides of the magnetic breaks. The second order vertical and horizontal derivative has been done which shows that the magnetic low values in south and east parts and magnetic high values in north and SW parts which may be due to presence of syenite or granite dykes in the subsurface. The radially average power spectrum shows the anomaly may occur at 11 m, 21 m and 51 m depth in Mecheri block.

The study carried out in this area so far suggest that the magnetic methods are best suitable method for locating subsurface fault, fractures and shear. This method is also suitable for spatial confirmation and

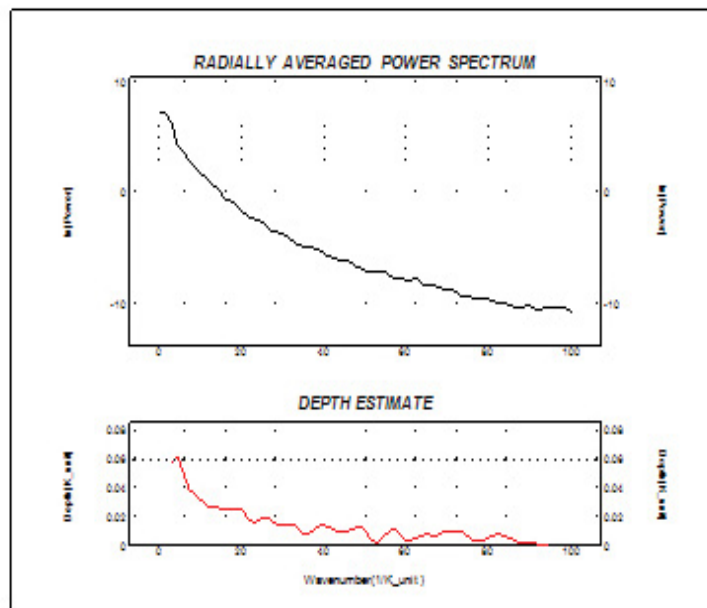


Figure 11: Radially average spectrum.

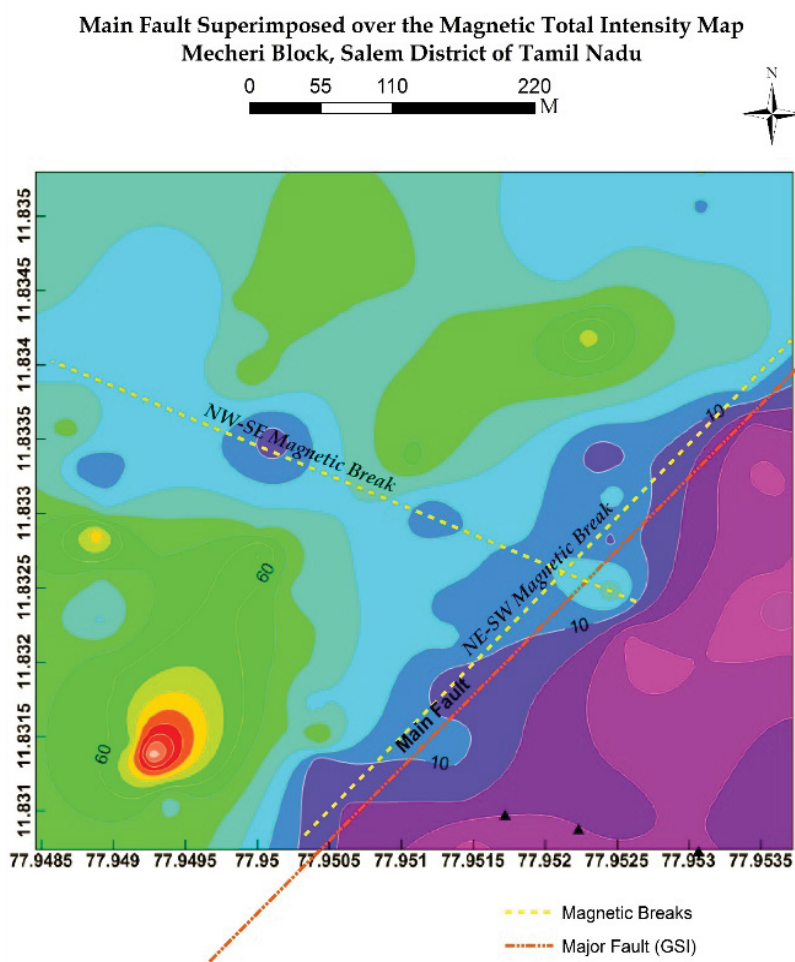
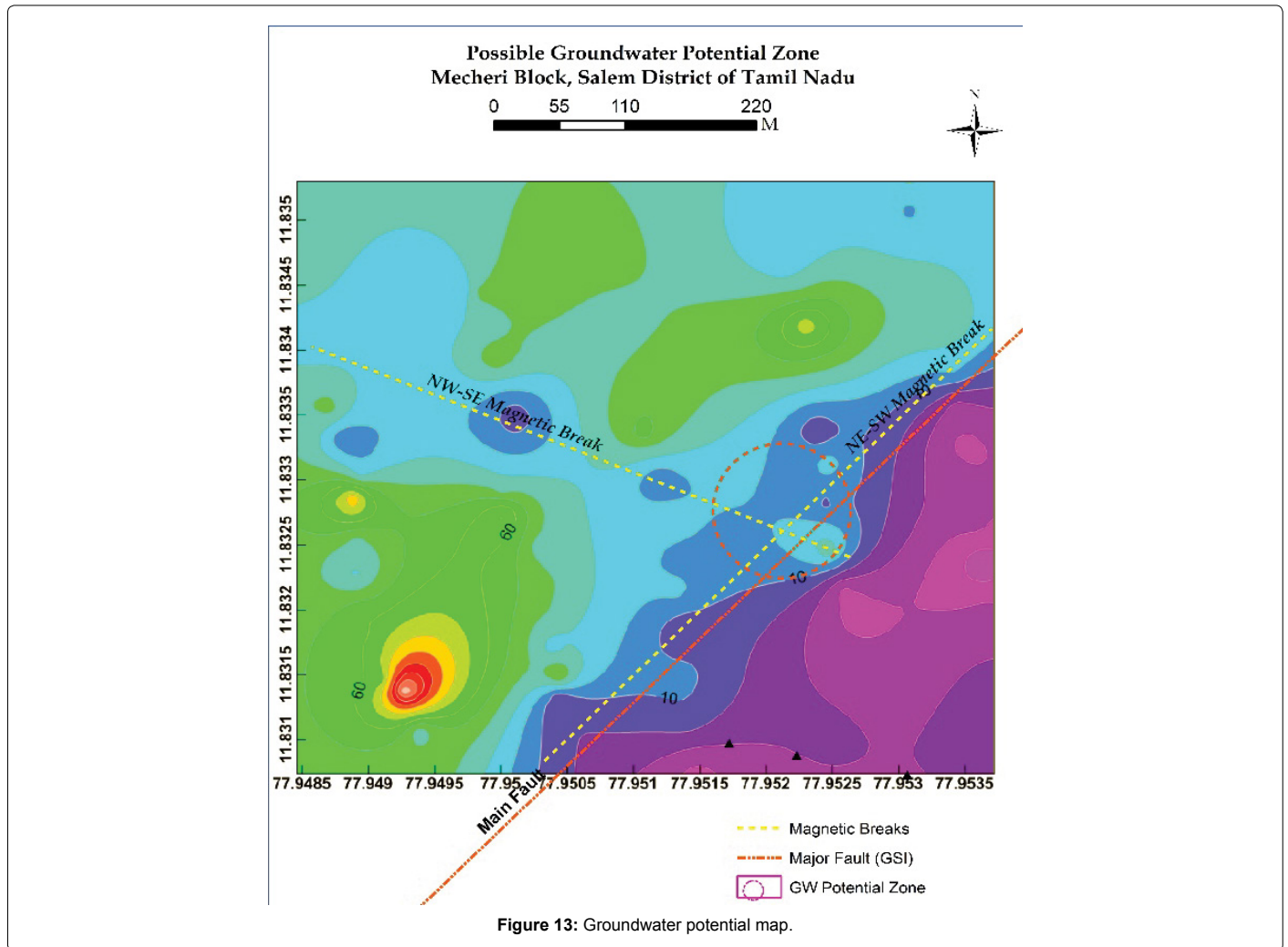


Figure 12: Major Fault (GSI) superimposed over total magnetic map.



ground validation study done by the remote sensing technique. Apart from that the intersection of magnetic breaks and major faults are assumed to be good zone for groundwater exploration.

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