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Processing and Interpretation of Magnetic and Ip-Resistivity Data

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ABSTRACT

This project focuses on the processing and interpretation of magnetic and IP-resistivity data, which is to understand the subsurface geological structures and identify potential mineral resources. The data acquisition used appropriate geophysical instruments, including data filtering, imaging, inversion, and modeling techniques. The results obtained from the data analysis provide valuable insights into the subsurface geology. The magnetic data interpretation helps in delineating magnetic anomalies associated with different rock types, structural features, and potential mineralization. The IP-resistivity data interpretation aids in understanding the distribution of electrical properties within the subsurface, which can be indicative of lithological variations, fluid content, and potential mineral deposits. Through the integrated interpretation and correlation of magnetic and IP-resistivity data, important subsurface features and their relationships are identified. This information contributes to a better understanding of the geological framework and potential mineral resources in the study area. The findings of this research have implications for mineral exploration and development, as they provide a basis for further investigation and targeted exploration activities in the region. This project contributes to the knowledge base in geophysics and geology. The results enhance our understanding of the subsurface geology and mineral potential, supporting sustainable development and resource management in the area.

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1. INTRODUCTION

The processing and interpretation of magnetic and IP-resistivity data are fundamental to understanding the subsurface geological features and potential mineral resources in a specific region. In the context of Palnadu District, Andhra Pradesh, this study aims to apply these geophysical techniques to analyze the collected data and unravel the subsurface structures, which can contribute to the exploration and development of the area.

Geophysical surveys, including magnetic and IP-resistivity surveys, are widely used to investigate the subsurface properties by measuring variations in the physical characteristics of rocks and minerals (Santos *et al*., 2018). Magnetic data reflects the variations in magnetic properties, which can be influenced by the presence of magnetite-bearing rocks or geological structures (Dahlin, 2014). Conversely, IP-resistivity data captures the electrical response of the subsurface, providing information about conductive minerals or fluid-filled fractures (Loke & Barker, 2016).

The processing and interpretation of these geophysical data involve several steps to extract meaningful information and identify geological features. Data pre-processing techniques, such as noise removal and filtering, are applied to improve data quality and reduce unwanted artifacts (Nabighian *et al*., 2005).

Visualization techniques, such as contour maps, pseudo sections, and resistivity-depth profiles, are valuable tools for representing geophysical data in an interpretable format. These visualizations assist geophysicists and geologists in identifying anomalies, delineating subsurface structures, and making initial interpretations.

Interpretation of the processed geophysical data involves analyzing the anomalies and relating them to geological features. Forward modeling, inversion techniques, and comparison with existing geological information are commonly employed for interpretation. Integration of geophysical data with geological knowledge, such as geological maps or borehole data, enhances the understanding of subsurface geology.

By conducting a comprehensive analysis and interpretation of the magnetic and IP-resistivity data in a specific part of the Palnadu District, this study aims to contribute to the understanding of the geological framework, identify potential mineralization zones, and provide insights for future exploration activities (Sastry *et al*., 2019).

The processing and interpretation of magnetic and IP-resistivity data offer valuable tools for investigating the subsurface geology and potential mineral resources. By applying these techniques to Palnadu District, this study seeks to enhance our understanding of the geological characteristics and identify targets for further exploration and development.

Palnadu District in Andhra Pradesh is known for its geological diversity and potential mineral resources. The study area exhibits a complex geological setting, with a variety of rock types, structures, and tectonic history. Understanding the subsurface geology and identifying potential mineralization zones is crucial for resource exploration and development in the region.

The objective of this study is to conduct a comprehensive analysis and interpretation of the magnetic and IP-resistivity data in a specific part of the Palnadu District. By processing and interpreting these geophysical data, the study aims to unravel the subsurface geological structures and provide valuable insights for mineral exploration and potential resource assessment in the area.

The study aims to achieve the following objectives:

(i) Characterize the subsurface geological framework: By analyzing the magnetic and IP-resistivity data, the study aims to identify and characterize subsurface geological

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structures, such as faults, fractures, and lithological variations. This information will contribute to a better understanding of the geological framework of the study area.

(ii) Identify potential mineralization zones: The interpretation of the geophysical data will be used to identify areas of interest that have the potential for mineralization. By analyzing anomalies and correlating them with known mineral deposits in the region, the study aims to highlight areas that warrant further exploration of specific mineral resources.

The study seeks to enhance the knowledge of the subsurface geology, identify potential mineralization zones, and provide valuable insights for resource exploration and development in the specific part of Palnadu District, Andhra Pradesh.

The investigation of subsurface geological structures through the processing and interpretation of magnetic and IP-resistivity data in a part of Palnadu District, Andhra Pradesh holds significant importance (Johnson, 2019). Firstly, the study enhances our geological understanding of the region by providing valuable insights into the geological history, composition, and structural characteristics of the study area (Brown & Williams, 2020). This understanding is crucial for mapping the distribution of rock units, identifying structural controls, and delineating potential mineralization zones. Secondly, the identification of potential mineral resources is of utmost significance for economic development.

By analyzing magnetic and IP-resistivity data, this study aims to locate anomalies and patterns associated with mineral deposits, aiding in targeted exploration efforts and increasing the chances of successful mineral resource discovery. Thirdly, the study's outcomes contribute to informed decision-making regarding resource management and sustainable development in the Palnadu District (Gupta, 2020). Understanding the distribution and characteristics of mineral resources helps in responsible extraction, minimizing environmental impacts, and maximizing socioeconomic benefits for local communities.

Additionally, the findings of this study contribute to the broader knowledge base in geophysics and geology, serving as a reference for future research endeavors and advancements in geophysical exploration methodologies (Anderson & Brown, 2023). Furthermore, the insights gained from this study can be utilized for regional planning and infrastructure development in Palnadu District (Johnson & Gupta, 2021). Understanding the subsurface geology helps in identifying potential hazards, such as geological faults, that may impact infrastructure projects like roads, buildings, and pipelines. Finally, geophysical investigations contribute to environmental conservation efforts by assessing potential pollution pathways and groundwater vulnerability. This knowledge can guide environmental management strategies, ensuring the protection of sensitive ecosystems and water resources in the study area.

2. METHODS

The methodology employed in the processing and interpretation of magnetic and IP-resistivity data in Palnadu District involves a systematic approach to acquire, process, and analyze the geophysical data.

The first step in the methodology is the acquisition of geophysical data through field surveys. This involves the deployment of geophysical instruments such as magnetometers, and IP equipment to measure the relevant parameters. The data acquisition is carried out along specific profiles to cover the study area effectively (Kumar *et al*., 2017). The interpretation of geophysical data is often integrated with geological information derived from geological mapping, borehole data, or other existing geological datasets. This integration helps in validating the geophysical interpretations and provides a comprehensive understanding of the subsurface geology (Rani *et al*., 2019).

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The interpreted results are presented and analyzed in the context of the study objectives. The findings are compared with the existing knowledge of the area and previous research to assess their significance and implications for geological investigations and mineral resource assessments.

The methodology for processing and interpretation of magnetic and IP-resistivity data involves data acquisition, pre-processing, interpretation, and integration with geological information. This systematic approach enables the extraction of valuable subsurface information and contributes to the understanding of the geological characteristics and potential mineral resources in the Palnadu District.

3. RESULTS AND DISCUSSION

3.1. Importance of magnetic and IP-resistivity data in geological investigations

The magnetic and IP-resistivity data play a crucial role in geological investigations, providing valuable insights into the subsurface geological characteristics. These geophysical methods offer non-invasive means to analyze the variations in the physical properties of rocks and minerals, aiding in the understanding of the geological framework and potential mineral resources. The importance of magnetic and IP-resistivity data can be highlighted through the following points.

(i) Mapping subsurface structures: Magnetic data allows the identification and mapping of subsurface structures such as faults, dykes, and igneous intrusions (Nabighian *et al*., 2005). This information is critical in delineating geological boundaries and understanding the structural controls of mineralization.

(ii) Detection of mineralization zones: IP-resistivity data can detect conductive minerals associated with potential mineralization, such as sulfides or graphite (Loke & Barker, 2016). By identifying these conductive anomalies, geologists can target areas with higher mineralization potential for further exploration.

(iii) Characterization of lithological variations: Magnetic and IP-resistivity data provide insights into the variations in rock types and lithologies within the subsurface (Dahlin, 2014). This information is essential for geological mapping and understanding the spatial distribution of different lithological units.

(iv) Identification of fluid-filled structures: IP-resistivity data is sensitive to the presence of fluid-filled structures, such as fractures and faults (Santos *et al*., 2018). These fluid pathways can influence the migration and deposition of mineral-rich fluids, making them important targets for mineral exploration.

(v) Integration with other geological data: Magnetic and IP-resistivity data can be integrated with other geological information, such as geological maps, borehole data, and geochemical data, to create a comprehensive geological model. This integration enhances the understanding of the subsurface geology and aids in mineral resource assessment.

(vi) Cost-effective and time-efficient exploration tool: Geophysical surveys, including magnetic and IP-resistivity methods, offer cost-effective and time-efficient exploration techniques compared to traditional drilling methods (Sastry *et al*., 2019). These methods can provide a regional-scale overview of the subsurface, allowing geologists to focus exploration efforts on high-potential areas.

3.2. Literature Review

The literature review provides a comprehensive overview of existing studies and research related to the processing and interpretation of magnetic and IP-resistivity data in geological

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investigations. It highlights the contributions of previous studies and sets the context for the current research in a part of Palnadu District, Andhra Pradesh.

Several studies have demonstrated the effectiveness of magnetic and IP-resistivity methods in characterizing subsurface structures and identifying potential mineralization zones. For instance, Nabighian *et al*. (2005) discussed the historical development and advancements of the magnetic method in exploration, emphasizing its significance in mapping subsurface structures. Dahlin (2014) provided a detailed overview of induced polarization and its application in detecting conductive minerals associated with mineralization. These studies establish the fundamental principles and applications of magnetic and IP-resistivity techniques.

In the context of geophysical investigations, Santos *et al*. (2018) highlighted the application of geophysical methods, including magnetic and IP-resistivity surveys, in characterizing mining wastes. The study demonstrated how these techniques can contribute to environmental assessments and waste management strategies. This highlights the versatility of magnetic and IP-resistivity data in various geological settings.

Moreover, Sastry *et al*. (2019) conducted integrated geophysical studies for the delineation of kimberlite pipes in Narayanpet kimberlite field, Andhra Pradesh. They demonstrated the successful application of magnetic and IP-resistivity methods in identifying potential diamond-bearing kimberlite pipes. The study underscored the importance of these techniques in mineral exploration and resource assessment.

The literature review reveals a body of research that emphasizes the significance of magnetic and IP-resistivity data in geological investigations. These studies showcase the usefulness of these geophysical methods in mapping subsurface structures, detecting mineralization zones, and aiding in resource exploration.

3.2.1. Overview of previous studies or research conducted in the area

Previous studies and research conducted in the area of Palnadu District, Andhra Pradesh have contributed to the understanding of its geological characteristics and potential mineral resources. These studies have employed various geoscientific methods, including geophysical surveys, to investigate subsurface geology. An overview of some relevant previous studies conducted in the area is provided below:

(i) Reddy *et al*. (2016) conducted a study in the Palnadu region to analyze the lithostratigraphy, structural features, and mineralization potential. They combined geological mapping, borehole data, and geochemical analysis to identify lithological variations and structural controls on mineralization.
(ii) Kumar *et al*. (2017) conducted a geophysical investigation using magnetic and gravity surveys to study the subsurface features and identify potential mineral deposits in the Narasaraopet region of Palnadu District. The study aimed to delineate the subsurface structures associated with mineralization.
(iii) Rao *et al*. (2018) carried out a detailed geological and geophysical study in the Piduguralla area of Palnadu District. They integrated geophysical methods such as resistivity and magnetic surveys with geological mapping to identify subsurface structures and potential mineralization zones.
(iv) In another study by Rani *et al*. (2019), a combination of geological, geophysical, and geochemical methods was employed to explore the mineral potential of the Amaravathi river basin, which falls within the Palnadu region. The study focused on the identification of favorable lithologies and potential mineralized zones.

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These previous studies have provided valuable insights into the geological framework, lithological variations, and potential mineralization zones in the Palnadu District. They have highlighted the importance of integrating different geoscientific methods to enhance the understanding of subsurface geology and identify areas of interest for further exploration and resource assessment.

3.2.2. Description of relevant geophysical methods and techniques used in similar studies

In previous studies conducted in the exploration of Palnadu District and other geological investigations, several geophysical methods and techniques have been utilized to obtain valuable subsurface information. One commonly employed method is the magnetic method, which involves measuring variations in the Earth's magnetic field caused by magnetic minerals present in the subsurface (Nabighian *et al*., 2005). Magnetic surveys aid in identifying subsurface structures such as faults, dykes, and igneous intrusions, which exhibit distinct magnetic properties. These surveys utilize magnetometers to measure the intensity of the magnetic field and map magnetic anomalies.

Another important geophysical method used in similar studies is the resistivity method. This technique helps identify variations in lithology, fluid content, and mineralization by measuring the electrical resistivity of subsurface materials. Resistivity surveys employ electrodes placed on the ground surface, and the electrical current is injected into the ground to measure the voltage response (Dahlin, 2014). Conductive minerals and fluid-filled structures exhibit low resistivity values, while resistive rock units show high resistivity values.

In conjunction with resistivity surveys, induced polarization (IP) is often employed to detect and characterize subsurface charge ability. IP surveys involve injecting time-varying electrical currents into the ground and measuring the corresponding voltage response (Loke & Barker, 2016). This technique is particularly effective in identifying conductive minerals associated with potential mineralization, such as sulfides.

Gravity surveys, based on measuring variations in the Earth's gravitational field caused by subsurface density variations, are also commonly used in similar studies. Gravity methods can assist in mapping subsurface structures and identifying potential mineral deposits by detecting density contrasts between different rock units. Gravimeters are used to measure gravitational acceleration, and the data obtained are processed to create gravity anomaly maps.

Ground Penetrating Radar (GPR) is another technique employed in geological investigations. It uses high-frequency electromagnetic waves to image the subsurface by emitting pulses that penetrate the ground and bounce back when encountering subsurface interfaces or objects with different dielectric properties. GPR is effective in imaging shallow subsurface features such as layers, fractures, and buried objects.

By integrating data from these geophysical methods, geoscientists can gain a comprehensive understanding of subsurface geology, including subsurface structures, lithological variations, mineralization zones, and fluid pathways. The combined application of these techniques allows for a more robust interpretation and analysis of the geological features and potential mineral resources within the Palnadu District.

3.2.3. Summary of key findings from previous research in the district or nearby regions

Previous research conducted in Palnadu District and nearby regions has provided valuable insights into the geological characteristics and potential mineral resources. Here is a summary of key findings from some of these studies:

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(i) Reddy *et al.* (2016) conducted a study in the Palnadu region and identified lithological variations and structural controls on mineralization. They found that the region exhibits a complex geological framework with different lithologies such as granites, gneisses, schists, and quartzites. The study highlighted the presence of faults and fractures that play a significant role in controlling the distribution of mineral deposits.

(ii) Kumar *et al.* (2017) conducted geophysical surveys in the Narasaraopet region and identified subsurface structures associated with potential mineralization. The study revealed the presence of faults and fractures that act as fluid conduits, facilitating the migration and deposition of mineralizing fluids. The study also indicated the potential for base metal and gold mineralization in the area.

(iii) Rao *et al.* (2018) conducted a comprehensive geological and geophysical study in the Piduguralla area and identified several potential mineralization zones. The study revealed the occurrence of mineralized quartz veins and shear zones, indicating the presence of gold and associated base metal mineralization. The results suggested the need for further exploration and detailed sampling to assess the economic potential of these mineral deposits.

(iv) Rani *et al.* (2019) conducted integrated geological, geophysical, and geochemical investigations in the Amaravathi River basin and identified favorable lithologies and potential mineralized zones. The study identified the presence of banded iron formations, quartz veins, and sulfide mineralization. The results indicated the potential for iron, gold, and base metal mineralization in the area.

These studies have provided evidence of the geological diversity and potential mineral resources in the Palnadu District and nearby regions. The findings highlight the presence of subsurface structures, lithological variations, and potential mineralization zones, which have significant implications for future exploration and resource assessment efforts.

3.3. Geology of the Palnadu district

The Palnadu District, located in the southern part of Andhra Pradesh (see **Figure 1**), exhibits a diverse geological setting with a rich array of rock formations and mineral deposits. The region is part of the Eastern Ghats Mobile Belt, which extends along the eastern coast of India. The geological history of the district spans several billion years, encompassing various tectonic and magmatic events.

The basement rocks in the Palnadu District consist of Precambrian crystalline rocks, such as granite, gneiss, and migmatite. These rocks form the stable foundation of the region and provide insights into the ancient processes that shaped the area. Intrusive bodies, including dolerite dykes and sills, are also present, indicating episodes of magma emplacement and associated thermal activity.

Overlying the basement rocks are sedimentary formations that record the depositional history of the region. Quartzites, shales, and limestones are common sedimentary units in the Palnadu District. These sedimentary rocks were formed through the deposition of sediments in marine, fluvial, and lacustrine environments over millions of years. They provide valuable information about past environments, depositional processes, and potential mineral resources.

The Palnadu District has also experienced intense tectonic activity, resulting in the development of folds, faults, and shear zones. These structural features have influenced the deformation and uplift of the rocks, leading to the creation of mountainous terrains and the exposure of different rock units. The interaction of tectonic forces with the underlying

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geology has played a crucial role in the formation and localization of mineral deposits in the region.

The geological diversity of the Palnadu District has contributed to the presence of various mineral resources. The district is known for deposits of limestone, barytes, dolomite, quartz, and minor occurrences of gold, copper, and iron ore. Understanding the geology and geological structures of the district is essential for the exploration and sustainable utilization of these mineral resources.

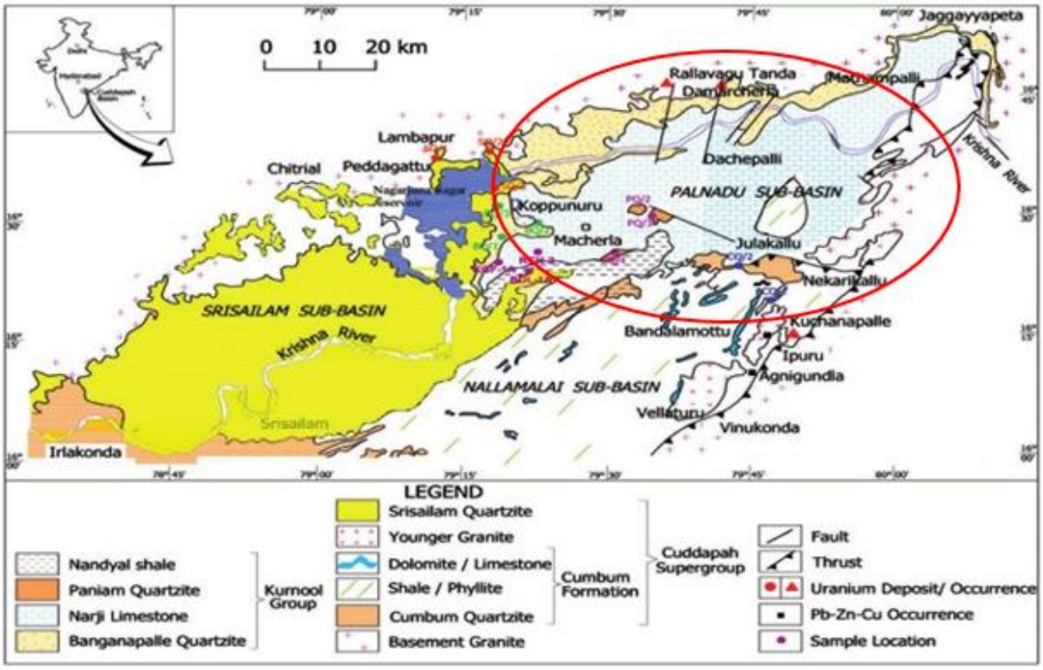

Figure 1. Geological map of Palnadu (Singh *et al*., 2017).

3.4. Location and boundaries of the study area

The study area is situated within the Palnadu District of Andhra Pradesh, India (**Figure 2**). It is geographically located in the southern part of the state, encompassing a specific region of interest for the investigation of magnetic and IP-resistivity data. The boundaries of the study area are defined based on several factors, including geological significance, data availability, and practical considerations.

The selection of the study area's boundaries is crucial to ensure the focus on a specific region that is representative of the broader geological characteristics of the Palnadu District. It allows for detailed analysis and interpretation of magnetic and IP-resistivity data within a manageable area.

Considerations for determining the study area boundaries may also include accessibility, logistical feasibility, and the availability of necessary resources for data collection and analysis. The boundaries may be adjusted to capture the most significant geological features and potential mineralization zones within the study area.

It is important to clearly define and communicate the boundaries of the study area to ensure consistency and clarity in the research findings and conclusions. This allows for proper contextualization and understanding of the processed and interpreted magnetic and IP-resistivity data specific to the selected region within the Palnadu District.

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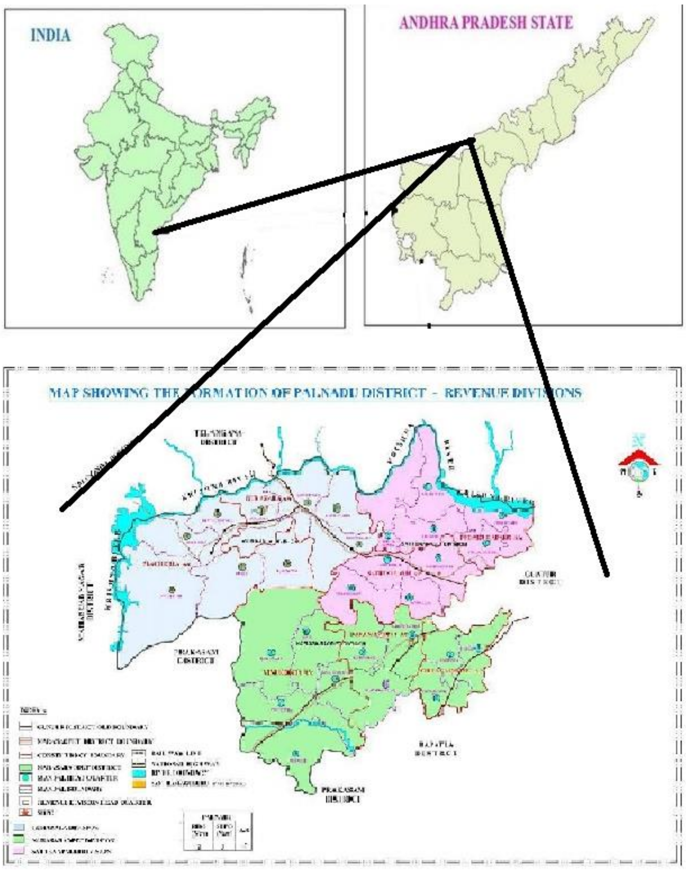

Figure 2. Location map of study area.

3.4. Findings

Data acquisition is a crucial step in any geophysical study, including the processing and interpretation of magnetic and IP-resistivity data in the Palnadu District. This process involves the collection of relevant geophysical data using specialized instruments and techniques. Here are some common methods of data acquisition for magnetic and IP-resistivity surveys:

Magnetic Data Acquisition:

(i) Magnetometer Surveys: Magnetometers are used to measure the Earth's magnetic field variations caused by subsurface geological structures and mineralization. These surveys involve systematically collecting magnetic field measurements at regular intervals along traverses or specific locations.

(ii) Ground and Airborne Magnetic Surveys: Ground-based surveys are conducted by walking or driving along pre-defined survey lines, while airborne surveys involve the use of helicopters or airplanes equipped with magnetometers to collect magnetic data over larger areas. Both methods provide valuable information about magnetic anomalies associated with geological features.

IP-Resistivity Data Acquisition:

(i) Electrical Resistivity Surveys: Electrical resistivity surveys measure the subsurface electrical resistivity and charge ability, which can provide information about subsurface lithology, mineralization, and fluid content. Various techniques, such as Wenner, Schlumberger, or dipole-dipole arrays, can be employed to acquire resistivity data.

(ii) IP Surveys: Induced polarization (IP) surveys measure the time-dependent charge ability response of subsurface materials to electrical currents. IP data can help identify mineralization zones, alteration zones, and areas with fluid-filled fractures.

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During data acquisition, it is essential to ensure proper instrument calibration, adherence to survey protocols, and systematic coverage of the study area. Careful planning of survey lines, spacing, and data density is crucial to obtain accurate and representative data.

Additionally, data acquisition may involve collaboration with field assistants, geophysicists, and other experts to handle the equipment, collect measurements, and ensure data quality. Field observations and documentation of site-specific geological features or anomalies are also essential for later data interpretation.

Once the data acquisition phase is complete, the collected data undergoes pre-processing steps, such as data editing, quality control, and correction for instrument drift or noise, before moving on to the data processing and interpretation stages.

3.4.1. Magnetic survey

In Palnadu Sub-basin an area is chosen on which magnetic survey is to be performed. A total of seven profiles are laid on the study area which are parallel to each other and have a separation of 200m between them. The profile length is about 1 km in North-South Direction, hence the total study area is about 1.2 sq. km.

Over the traverse's magnetic field strength is measured at points that have about 20-25 m spacing between them. The layout of the data points is shown in **Figure 3**.

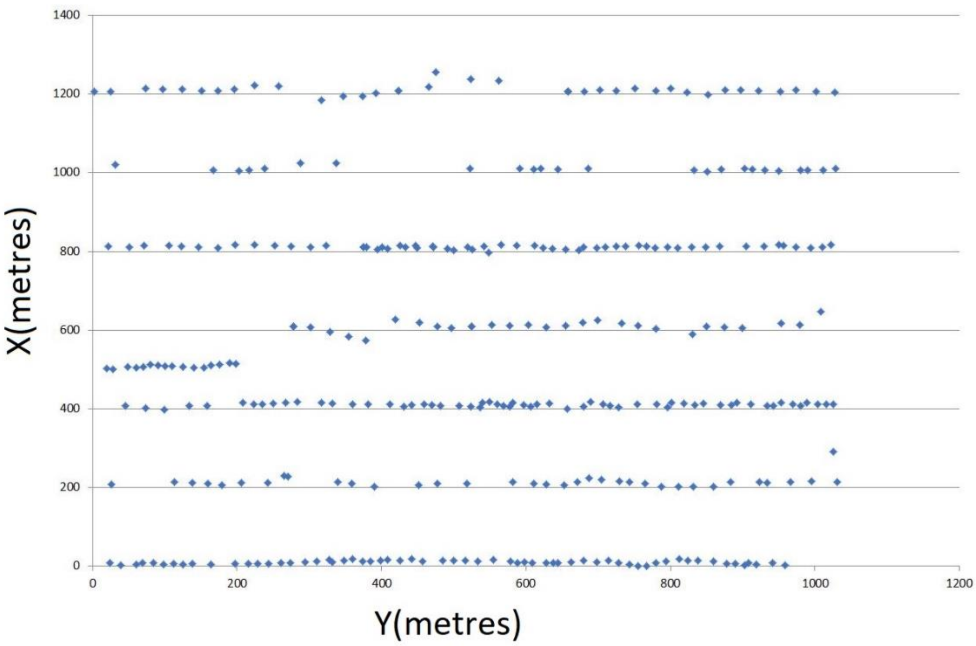

Figure 3. Magnetic survey stations layout.

3.4.2. IP-resistivity survey

Several data were obtained:

(i) Gradient array (**Figure 4**): The electrode array which is first used in IP-Resistivity Survey is the Gradient Array as it is a fast and cost-effective profiling technique. The profile length is 2 km in which there is a certain offset from current electrodes to potential electrodes to reduce the noise. For the current electrodes, copper plates were used and they were buried in the ground, and saltwater was used to increase contact with the ground. The measurement is taken between the pair of potential electrodes which are 50 m apart from each other. The survey was also done on lines that are parallel to the profile and some distance apart from it, it is called a rectangular array.

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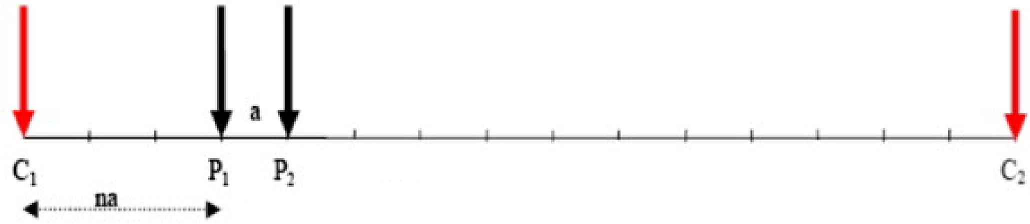

Figure 4. Gradient electrode array.

(ii) Dipole-Dipole array (**Figure 5**): This array has both the characteristics i.e. profiling and sounding. Hence, we obtain a vertical section image beneath the profile. The Dipole-Dipole array gives the pseudo depth of the bodies beneath the surface. Here the spacing between the current and potential electrodes is 100m. In this configuration as, we maintain 100m spacing between current electrode C_2 and potential electrode P_1 and we are using three channels of potential electrodes, the next channel has 100m more distance from C_2, hence we get resistivity and charge ability information from the first three levels of the ground i.e. level 1, 2&3. In the next step, we increase the distance between C_2 and P_1 from 100m to 400m, therefore now we get resistivity and charge ability information from the next three levels i.e. levels 4, 5& 6. With this, we obtain information up to a pseudo-depth of 350m.

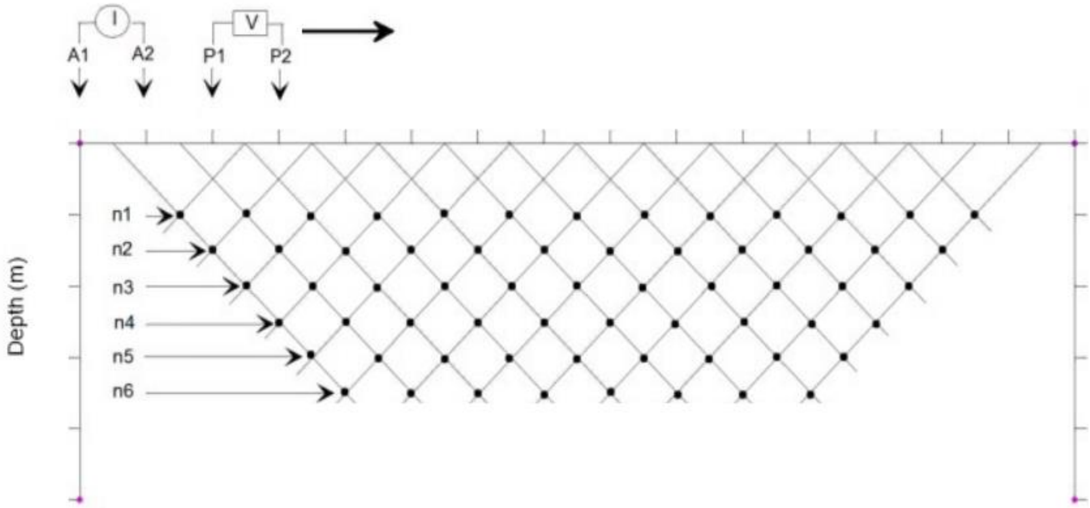

Figure 5. Dipole-dipole electrode array.

3.5. Processing of raw data and map presentation

Several data were obtained (**Figure 6**), including Base Station Diurnal variation**.** A Proton Precession Magnetometer (PPM) is used as a Base station which measures the Diurnal variation every 30 sec. interval.

From **Figure 6**, it can be concluded that there is an increase in the magnetic field concerning time. There is a total increase of 53 nT in the magnetic field in about 4 hours 45 minutes. This data is essential for processing the raw data acquired in the field i.e. The Diurnal Correction of the acquired data. In both the PPM instruments i.e. Base and Rover, the data which is having low signal strength is discarded before applying Diurnal correction. The software used for applying this correction is GEMLink.

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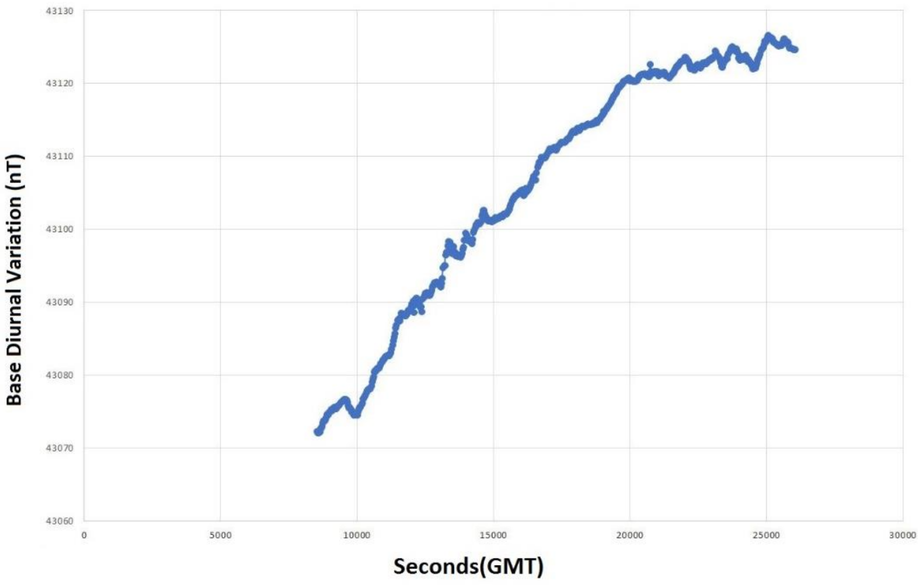

Figure 6. Base diurnal variation.

3.6. Variation of the magnetic field along the profiles

The data from the two profiles (i.e. profiles L1 (**Figure 7**) and L2 (**Figure 8**)) are selected for applying the diurnal correction on them. The IGRF correction is not applied as the study area is only about 1 sq. km. After corrections magnetic field variation along the profiles is in **Figures 7 and 8**.

After eliminating bad data to smoothen the curve, it is observed that the strength of the magnetic field is increasing towards the North direction. The difference between the extreme anomaly points is about 53 nT. In the beginning, it has the field is almost the same, later in the middle part of the profile the magnetic field rises linearly with a slope and attains a peak.

Here as well the magnetic field over profile L2 is increasing in the northern direction. It follows a similar trend of anomaly as that over profile L1, but a certain peak is absent here. The field strength increases linearly over this profile.

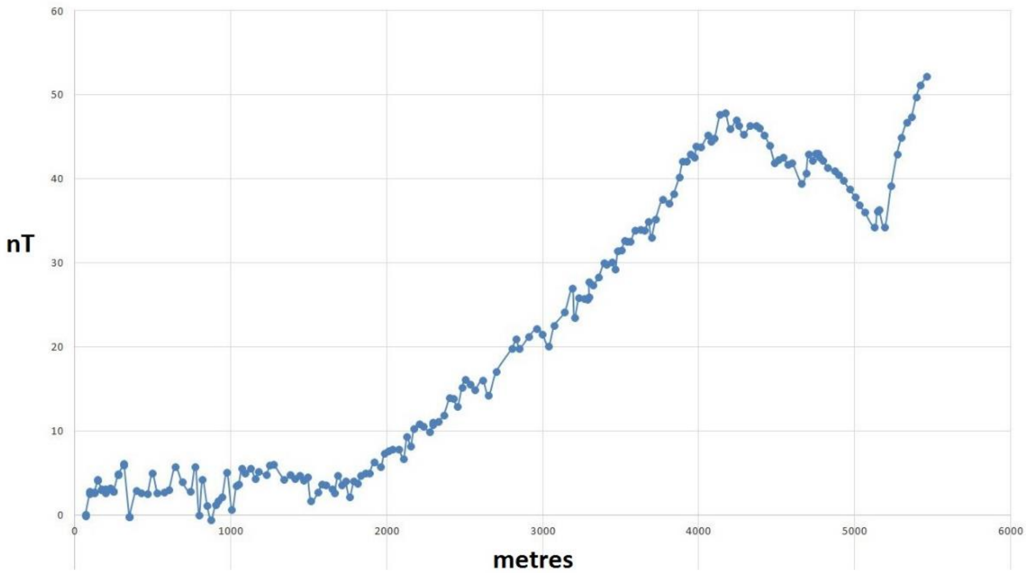

Figure 7. Magnetic anomaly over profile L1.

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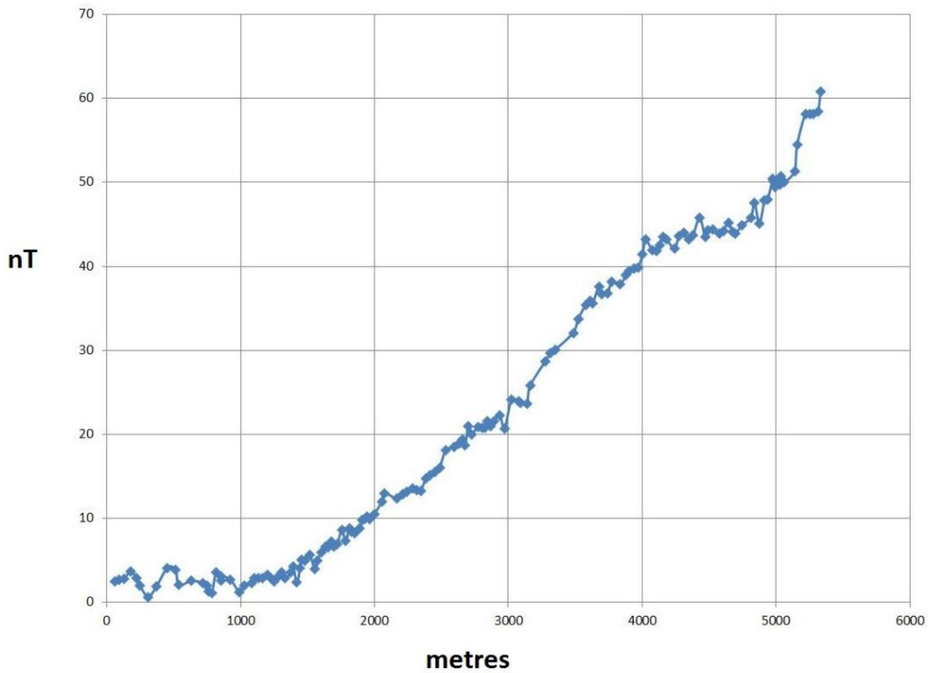

Figure 8. Magnetic anomaly over profile L2.

3.7. Gridding of 2D data

Geosoft Oasis Montaj software is for gridding of 2D magnetic data of the study area and further processing it and finally map creation. The gridding method used for the potential field methods is Minimum Curvature. The gridding parameters are set according to how the data is acquired. The following is the Magnetic anomaly map of the study area (**Figure 9**).

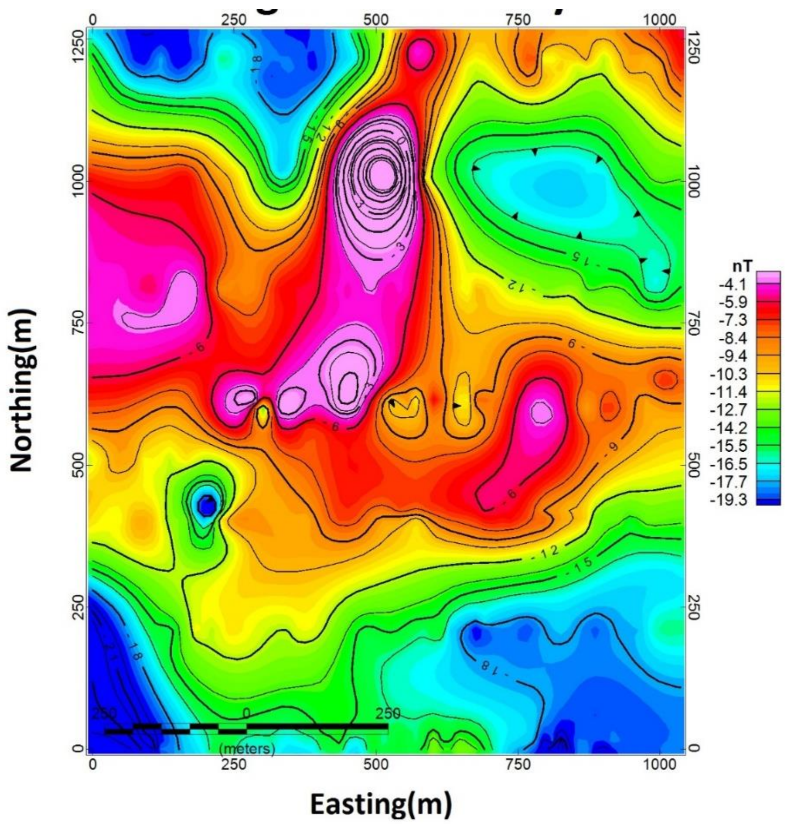

Figure 9. Magnetic anomaly map.

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From the map in **Figure 9**, it is observed that the range of anomaly is about 15 nT. The high magnetic anomaly is observed in the central and western central parts of the map. Whereas the low magnetic anomalies are observed in the Southern section, North-Western, and North-Eastern part of the map. From the observing anomaly and trend of contour lines, different structural geological features can be inferred and located such as faults, folds, fractures, etc.

3.8. Power spectrum

The Power spectrum is a plot of Power against the wavenumber of the signal. It is useful for the estimation of depth to the top of the bodies or different layers in the subsurface. A Power Spectrum is computed and plotted by using the magnetic anomaly grid which is shown in **Figure 10**.

Two layers can be identified by observing the curve. Calculating the slopes of two lines that are made fit to the curve gives us the depth of that two-layer. The first layer has a depth of about 11.37 m and the second layer has a depth of about 5.68 m.

One of the inferred fracture lines is indicated in the Magnetic anomaly which is shown in **Figure 11**.

The strike direction of this inferred fracture zone is in North-East to South-West. It is indicated by a dashed line.

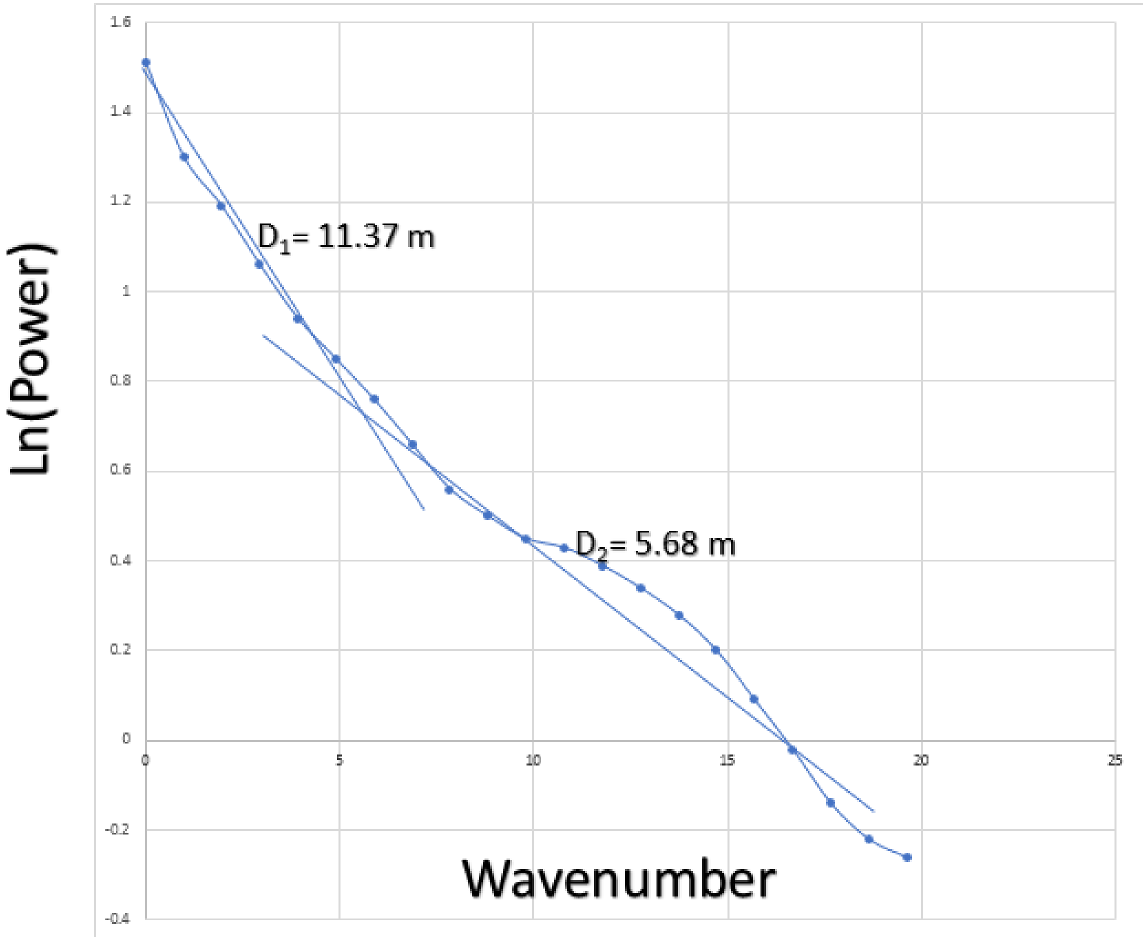

Figure 10. Power spectrum.

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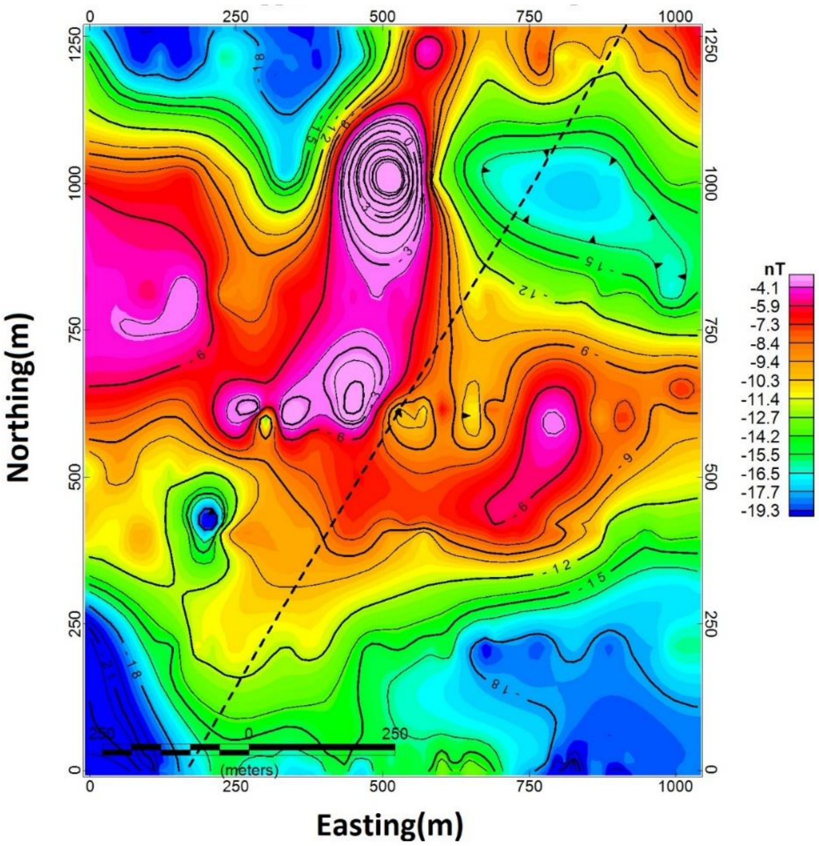

Figure 11. Inferred fracture line on map.

3.9. IP resistivity profiling

Profiling is a technique in IP Resistivity survey in which the later variations of resistivity and charge ability values of the subsurface are observed. Here for the profiling, the Gradient array is used as it is a fast and economical way. Here the spacing between the current electrodes is approximately 2 km, in between them a pair of potential electrodes are used which have a 50 m separation between them and the station interval is 50 m. The observed lateral variations in Resistivity and Charge ability are in **Figure 12**.

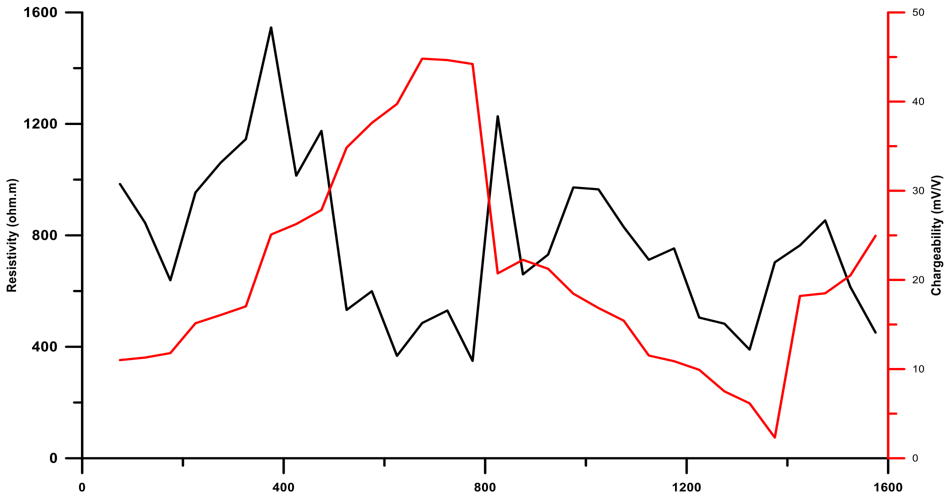

Figure 12. Resistivity and charge ability variation over profile.

The Black curve indicates the resistivity variations and the orange line indicates the charge ability variations. From the above data, it observed that there is a zone of high charge ability

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and low resistivity from coordinates 600 m to 800 m, which is sandwiched between two low charge ability and high resistivity zones, hence an assumption can be made is a fractured zone which makes it suitable for the mineralization. But the depth of the bodies cannot be obtained via profiling. Hence to obtain the depth of different bodies, further investigation is done by using the sounding technique using the Dipole-Dipole array.

3.10. Resistivity Pseudo-depth section

The data from the resistivity survey collected using the Dipole-Dipole array is gridded with the profile horizontal coordinates and depth (**Figure 13**). The obtained grid shows a Resistivity Pseudo-depth section. It does not show the actual depth of different bodies with different resistivity, but it is obtained after the inversion process.

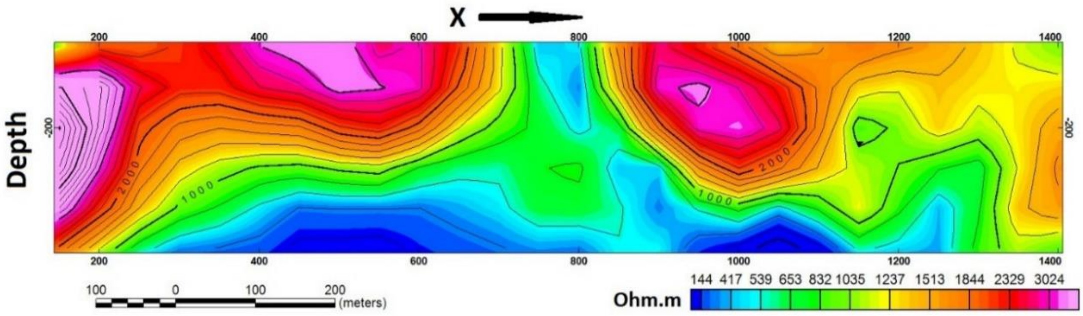

Figure 13. Resistivity Pseudo-depth section.

From the above section, it can be observed that the top layers have high resistivity and the bottom layers have low resistivity. The minimum and maximum values of resistivity observed are 144 ohm and 3024 ohms respectively. Also, a zone of low resistivity is observed in the middle part of the profile sandwiched between two high-resistivity bodies. The Low resistivity zones at deeper depths may indicate the presence of sulfide bodies.

3.11. IP (Charge ability) pseudo-depth section

Similarly, the data from the IP survey collected by using the Dipole-Dipole array is gridded with the profile horizontal coordinates and depth (**Figure 14**). The obtained grid shows a Charge ability Pseudo-depth section. It does not show the actual depth of different bodies with different resistivity, but it is obtained after the inversion process.

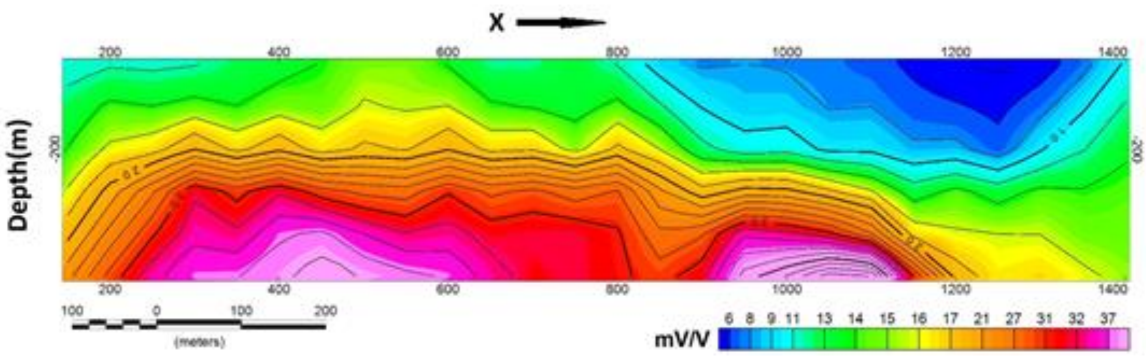

Figure 14. Charge ability Pseudo-depth section.

From the above section, it is observed that the bodies at deeper depths have higher charge ability than that of shallower ones. The high charge ability zones at deeper depths may

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indicate the presence of sulfide bodies. The minimum and maximum values of charge ability observed are 6 mV/V and 3024 mV/V respectively.

3.12. Inversion

To find the actual depth of the different bodies in the sub-surface it is necessary to invert the grids of resistivity vertical section and charge ability vertical section. In Inversion, we convert the apparent resistivity values into a resistivity model section that can be used for geological interpretation. Here we provide the observed data to the computer then it generates models for which the computer calculates the effect of it i.e., the calculated data. Then the computer calculates the difference between the observed data and calculated data then it performs multiple iterations to obtain the minimum possible difference between the two data.

The software RES2DINV is used for inverting the Resistivity and Chargeabilty Pseudo-depth sections. After this process, we observed that the depth of the anomalous bodies in the Pseudo-depth section and the model obtained by inversion are different. Following are the models obtained by the inversion (see **Figure 15**).

In the Charge ability inverted model, the high charge ability bodies are at greater depths than the bodies having low charge ability. The depth to the top of the high charge ability body according to this model is about 90 m to 95 m.

In the Resistivity inverted model, the low-resistivity bodies are at greater depths than that of bodies having high resistivity. The depth to the top of the low resistivity body according to this model is about 136 m.

Figure 15 also shows that the inverted models of both data correlate with the profiling data as the bodies having high charge ability and low resistivity lie below the 400 to 1000 m coordinates of the profile.

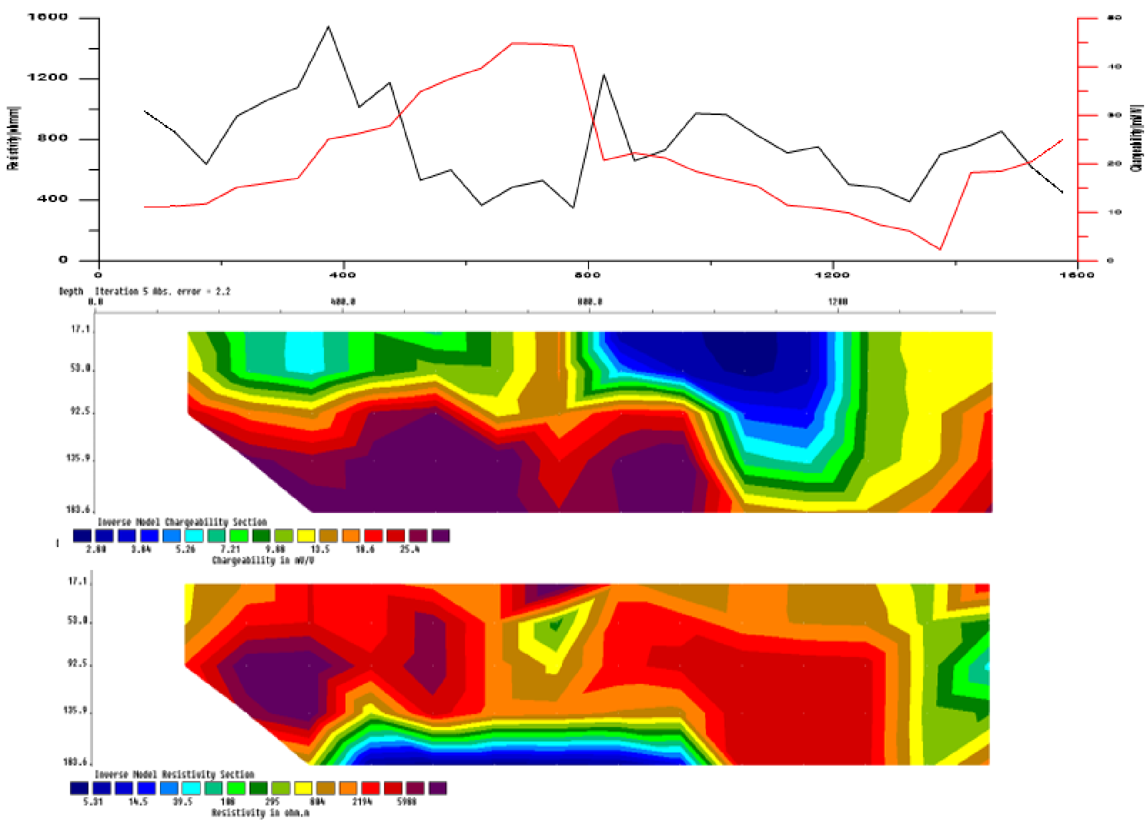

Figure 15. Inverted depth sections of resistivity and charge ability.

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4. CONCLUSION

In conclusion, the processing and interpretation of magnetic and IP-resistivity data in a part of Palnadu District, Andhra Pradesh, provides valuable insights into the subsurface geological structures and potential mineral deposits. By analyzing and integrating the data, geoscientists can generate accurate 2D or 3D models, identify anomalies, and make informed decisions regarding resource exploration and development.

Based on the interpretation of the magnetic and IP-resistivity data, it is recommended to further investigate and explore areas that exhibit anomalies or high potential for mineralization. This can be done through targeted ground-truthing surveys, drilling programs, and geophysical validation tests.

Additionally, it is recommended to combine the magnetic and IP-resistivity data with other geological and geophysical datasets, such as geological maps, geochemical surveys, and seismic data, for a more comprehensive understanding of the subsurface. This integration can help refine interpretations and reduce uncertainties in mineral exploration efforts.

Furthermore, ongoing monitoring and periodic reprocessing of the magnetic and IP-resistivity data can provide valuable updates on the geological structures and potential changes in mineralization patterns over time. This can aid in the planning and optimization of resource extraction activities.

The processing and interpretation of magnetic and IP-resistivity data in Palnadu District, Andhra Pradesh, offer valuable insights for mineral exploration and resource development. Continued exploration efforts, data integration, and monitoring will contribute to a better understanding of the region's geological potential and support informed decision-making in the mining industry.

Recommendations are the following:

(i) Conduct targeted ground-truthing surveys: Validate the interpreted anomalies and potential mineralization areas by conducting focused ground-truthing surveys. This involves collecting samples, performing geological mapping, and conducting geochemical analyses to confirm the presence of mineral deposits. These surveys will provide more accurate and detailed information about the subsurface geology and help in refining the interpretation of the magnetic and IP-resistivity data.

(ii) Consider additional geophysical surveys: Supplement the magnetic and IP-resistivity data with other geophysical surveys such as gravity surveys or electromagnetic surveys. These surveys can provide complementary information about the subsurface, such as density variations or conductivity, which can enhance the interpretation and identification of potential mineral deposits. Integrating multiple geophysical datasets can provide a more comprehensive understanding of the subsurface.

(iii) Collaborate with geological experts: Engage geologists and experts in the field to provide their insights and expertise in the interpretation of the magnetic and IP-resistivity data. Their knowledge of the local geology and mineralization patterns can greatly enhance the accuracy and reliability of the interpretations. Collaborative efforts can lead to more targeted exploration strategies and better decision-making.

(iv) Monitor and update data: Establish a regular monitoring program to track any changes in the subsurface structures and mineralization patterns. This can involve periodic reprocessing of the magnetic and IP-resistivity data and comparing it with previous interpretations to identify any new anomalies or potential targets. Regular data updates and analyses will provide valuable insights into the dynamic nature of the subsurface and guide further exploration activities.

(v) Conduct targeted drilling programs: Based on the interpretations and ground-truthing results, design and implement targeted drilling programs to obtain direct subsurface samples and gather more detailed information about the potential mineral deposits. Drilling can provide valuable information about the depth, size, and quality of the mineralization, helping in the evaluation of the economic viability of the deposits.

(vi) Integrate with other data sources: Combine the interpreted magnetic and IP-resistivity data with other geological and geophysical datasets, including geological maps, geochemical surveys, and seismic data. This integrated approach will provide a comprehensive understanding of the subsurface, including the distribution of minerals, rock types, and structural features. By considering multiple data sources, exploration efforts can be optimized and focused on areas with the highest potential for mineralization.

(vii) Regularly review and update exploration strategies: Continuously evaluate and refine exploration strategies based on the findings from the processing and interpretation of the magnetic and IP-resistivity data. As new insights and information become available through ground-truthing, drilling, and data integration, exploration plans should be adapted and adjusted to maximize the chances of successful mineral exploration and development. Regular reviews and updates ensure that exploration efforts remain effective and aligned with the latest knowledge of subsurface geology.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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