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Full Length Research Article

Identification of Mineral Prospecting Zone Using Structural Feature in South-Western Part of the Cuddapah Basin, Andhra Pradesh, India

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Abstract

Geospatial tools have mostly helped geologists to identify the Natural Resources viz., minerals prospective zones for sustainable growth. The origin, existence, movement of minerals depend on numerous factors such as slope, geology, geomorphology lineament and lineament density. Created on these, the mapping and identification of mineral and mine areas were passed out in a south-western part of Cuddapah basin, Andhra Pradesh, India. Relevant thematic layers were prepared and assigned to identify minerals and mine areas in the study area. Even though the western part of the Cuddapah basin is categorized by moderate to high lineament density, the above area is originating to be poor to moderate mineral movement zone because of high density and structural features. The zone of intersection of structural trends resulting in linear to circular shaped features, faults, dykes are mapped which could have accepted as prospect areas of minerals resources in the study region. Results expose that the showing assessment method future in this study is an operative tool for interpreting the mineralized zones for their proper development over various geological topography. In order to identify the majority of sites for minerals prospecting zones in the Cuddapah basin, geospatial techniques like satellite remote sensing (RS) and Geographic Information System (GIS) tools were utilized to prepare and evaluate thematic layers of geological structure, lithology, and topography. The most prospective locations for mineral exploitation were then identified using various GIS intersection and spatial analysis tools to create the final map. By employing a Landsat ETM + image, it was also possible to identify the most prospective locations for mineral development using digital classification of remote sensing information. The findings demonstrate that lithology, topography, and geologic structures were linked elements that influenced the most attractive areas for mineral exploration.

***Key words*:** Lineament, Geology, Structural features, Mineral prospecting zones, Cuddapah basin

Geological mapping including lithology and structural deformations consequent of fracture systems are important geological studies made for mineral deposits exploration studies. Lineaments are favorable structural features in line with exploration, result of deformations caused by internal activities in the Earth's crust. The importance of the best remote sensing technology in geological mapping has been highlighted in numerous publications [1-4]. Many authors throughout the world have used the idea of lineament extraction from digital satellite pictures for a variety of purposes, such as structural and tectonic study [5-7]. Mineral and groundwater exploration are also important [8-10]. According to Veraverbeke *et al*. [11], remote sensing is the simultaneous capture of pictures in numerous narrow, contiguous spectral bands. Remotely sensed information has end up extensively applied in a variety of natural resource management disciplines in current years. With the accessibility of remotely sensed records from modified gadgets of various platforms with an extensive variety of spatiotemporal, radiometric and spectral resolutions has made far remote sensing as, possibly, the best source of records for huge scale programs and take a look at. Several environmental process modelling tools presently use the enormous facts generated by means of remote sensing as an input [12]. The development of management plans for a range of mineral resource management applications will be made possible by the integrated use of remotely sensed data, GPS, and GIS by

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consultants, mineral resource managers, and researchers in government agencies, conservation groups, and industry [13]. The prospectors, exploration geologists, mining engineers, attorneys, and economists involved in finding, exploring, and valuing mineral deposits face several difficulties. The material restrictions' that enclose and conceal the deposits, which lie subterranean, obfuscate their presence (Weszkalnys, 2015). As recent resources must be exploited to find untapped resources, overcoming these obstacles is essential. After all, mineral reserves are intrinsically non-renewable. The majority of exploration efforts fail, making it difficult to find and develop new resources. This is a slow-moving and uncertain process [14]. Both resource management and resource exploration can benefit from the use of geospatial technology as a planning and decision-making tool [15]. For the assessment and management of mineral resources, where integrating data from many sources is a crucial necessity, remote sensing and GIS technologies are extremely important [16-17]. In a GIS, remote sensing data can easily be combined with information from other sources that has been geocoded [18-19]. This makes it possible to combine different levels of information from applications and remotely sensed data and application of practically unrestricted forms of data analysis [20]. The provisions of the lineament map and delineate different mineral deposits in the study area. It also reviews the pains of the mine deposit at innovative the structure of Remote sensing capabilities to utilize mineral resources.

MATERIALS AND METHODS

Study area

The present study area is located in southwestern part of Cuddapah basin falling within the YSR district, Andhra Pradesh, India covering by Survey of India toposheet numbers 57J/3, and it is situated between latitudes 14° 23' 21" to 14° 24' 19" N and Longitudes 78° 18' 4" to 78° 24' 21" E. The study area covered by an about 408.68 sq. km (Fig 1). These areas are evidently host minerals like baryte, limestone, yellow ochre, pyrophyllite, uranium, quartzite, dolerite dolomite etc. Geologically the area contains Gulcheru quartzite, dolomites, shales quartzites and basic flows from Vempalli formation, Tadpatri shales, dolomite, and quartzite from Chitravati group. In which, most of the area is covered with Tadpatri shales.

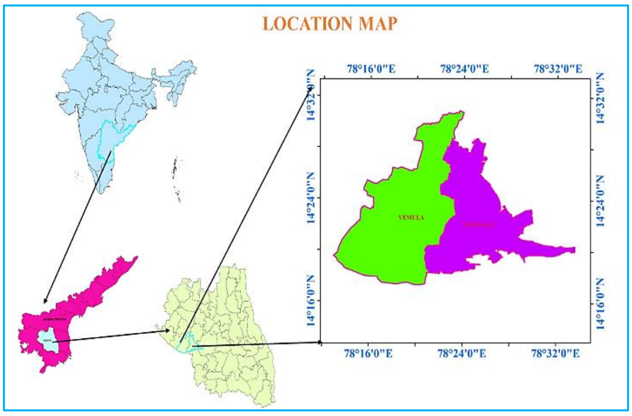

Fig 1 Location map of the study area

The present study includes data collection, data analysis, map preparation, report generation etc. The data collection includes locating the mineralizing zones in the field of the study and collecting the GPS point of each location for different minerals. The data analysis was processed by histogram equalization and the toposheets of the georeferenced area study with the IRS P6 LISS III using ERDAS imagine 2014. The GPS data collected during the fieldwork were analyzed and located in satellite image and mineralized locations, geology, and geomorphology were delineated using ArcGIS 10.4 software (Fig 2).

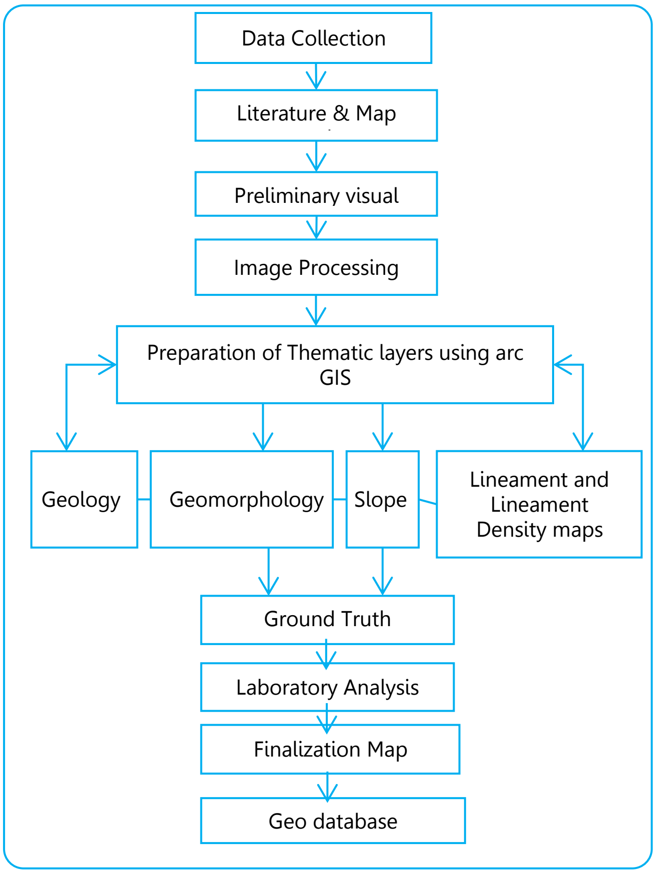

Fig 2 Flowchart showing the step followed in study

RESULTS AND DISCUSSION

Mineral resources are being increasingly implemented in the recent years because of increased valuable for mineral. The indicators of mineral occurrence are related to structural features, land use, geology, topographic elevation, slope and density features of the area. Satellite data have come out to be very useful for surface study, especially in detecting surface features and characteristics such as lineaments and geology. In order to predict the mineral prospecting zones, different thematic maps were prepared. These include geology, geomorphology, slope and lineament density. Integrated assessment of thematic maps using weighted index overlay method, developed based on GIS techniques has been found to be suitable for delineating mineral prospect zones.

Geology

The research region is made up of a stratigraphic succession of rocks from the lower Cuddapah Supergroup's Papaghni Group and Chitravati Group (Fig 4). The research region is Lithologically composed of alternating bands of argillaceous and arenaceous rocks. Under the Tadipatri shale formation and between the Vempalli and Pulivendla formations, igneous activity has been observed [21]. Using ArcGIS 10.4 Software, geology maps were prepared using the mineral and ground water resources map (GSI) using Landsat8 imageries. Depending on tone, texture, and drainage patterns, different kinds of rock formations, and geographical imagery. The position of rock formations in relation to one another is shown on this map along with other elements. This map was created using a 1: 50,000 scale geology and mineral map of Andhra Pradesh (Fig 3).

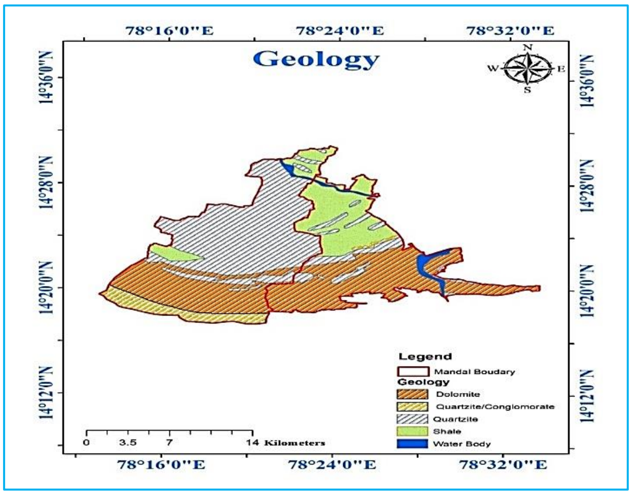

Fig 3 Geological map of the study area

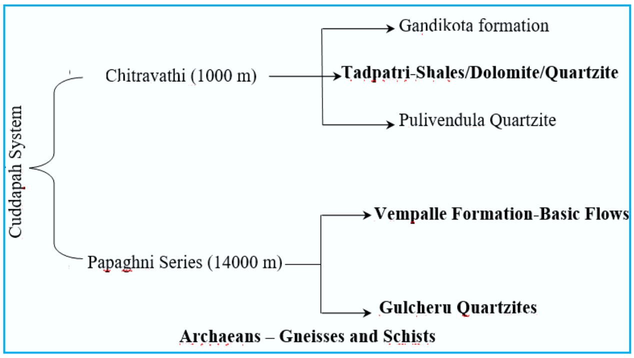

Fig 4 Vemula and Vempalli formation

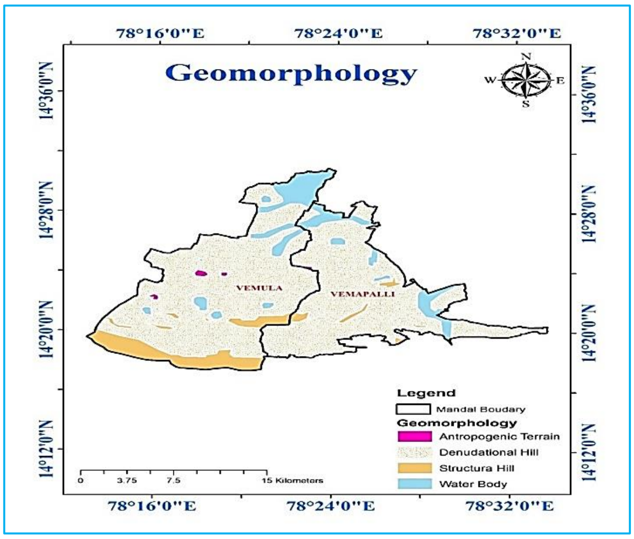

Fig 5 Geomorphological map of the study area

Geomorphology

Geomorphology of an area is a valuable factor in assessing the groundwater potential and mineral prospects because it is control of the subsurface change of natural resources. The research area's nature is predominately characterized by some degree of hydrological features. The size and structure of the underlying formations are reliant on the geomorphology of the area, which is a key factor in determining the potential for ground water [22]. The Vempalli formation-related materials. The research area's geomorphological features can be divided into various types, including rivers and other bodies of water, floodplains, pediment pediplains, structural valleys, structural hills, and ridges (Fig 5). The study area's geomorphology is dominated by porous sedimentary rock. the size of the surface. waterbodies such as river was covering 1.85% of the study area which act as recharge zone.

Slope

Slope, in the context of mineral formation and identification, refers to the gradient or rate of change of a specific property of a mineral as it relates to another factor or property. In the realm of mineralogy, slope can be metaphorically used to describe the reactivity curve of a mineral to specific treatments, such as heat or pressure. For instance, certain minerals might exhibit a steep "slope" of color change in response to increasing temperature, rapidly transitioning from one hue to another. Conversely, a gentle "slope" would imply a gradual change over a broad range of conditions. This gradient or "slope" can be vital for mineral identification, as the manner in which minerals react or transform under various conditions can provide critical insights into their composition, structure, and origin. The nuances captured by examining such slopes in mineralogical contexts help geologists and researchers to distinguish between otherwise similar-looking specimens and to understand the geological processes that gave rise to them (Fig 6). The elevation drops from the northern region to the southern region with a slope of 0° to 10° in level and steep locations, respectively, according to the slope calculated from digitalized contours heights. The ground runoff is slowed at the area around level (gentle area).

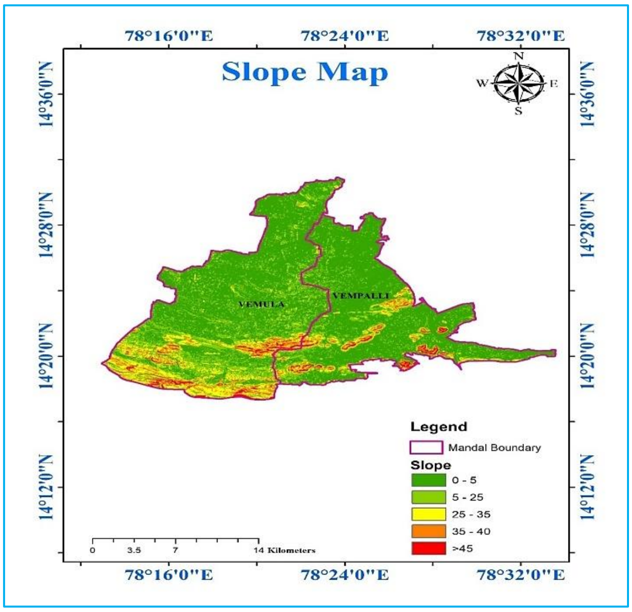

Fig 6 Slope map of the study area

Lineament

Lineaments refer to the distinctive linear features on the Earth's surface, often discernible from aerial or satellite imagery. These features can be a manifestation of underlying geological structures such as faults, fractures, or joints in the Earth's crust. In the context of mineral exploration and identification, lineaments play a crucial role. They often indicate zones of structural weakness where mineral-rich fluids might have migrated and precipitated minerals during various geological epochs. Identifying and analyzing these lineaments can therefore provide valuable clues about the possible locations of mineral deposits. Geologists and mineral exploration professionals utilize the pattern, orientation, and intersection of lineaments to prioritize areas for detailed geological investigations and potential drilling activities. In many mineral-rich regions around the world, major ore deposits are found in proximity to these geological structures, making lineament analysis a fundamental step in mineral exploration (Fig 7).

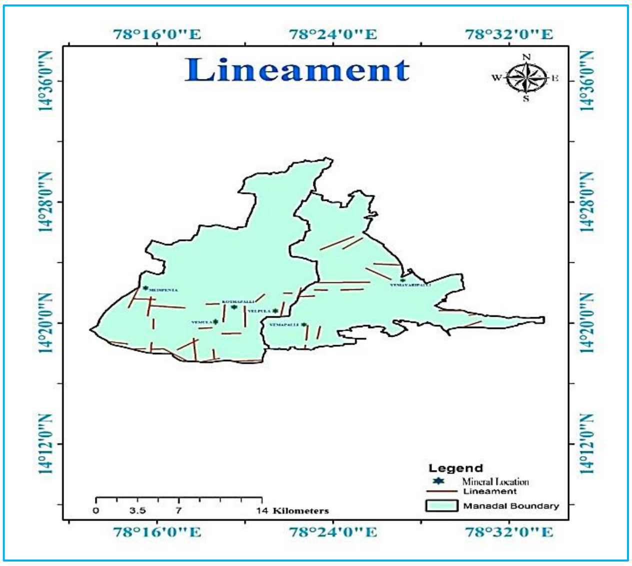

Fig 7 Lineament map of the study area

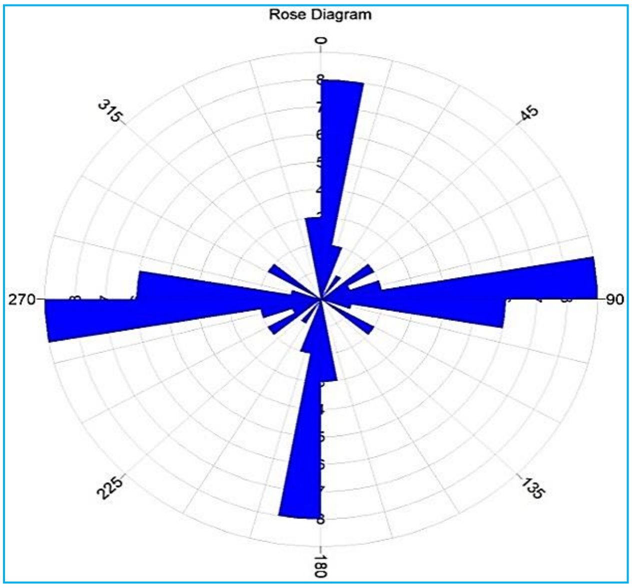

Fig 8 Rose diagram represent direction of lineaments

Lineament – Rose diagram

A Lineaments Rose diagram, commonly referred to as a rose diagram or wind rose, is a graphical tool employed by geologists to display the orientation and, often, the frequency of linear structural features, like fractures or faults, from a specific region. These diagrams are particularly invaluable in the realm of mineral exploration and identification. Minerals often form in specific geological settings, guided by the structural framework of the Earth's crust. By plotting the predominant orientations of these structures, geologists can make informed inferences about the tectonic forces at play and the potential locations of mineral deposits. These diagrams present data in a circular format, with the orientation of lineaments represented as 'spokes' radiating outward from the center. The length or thickness of each spoke is often indicative of the frequency or intensity of that particular orientation. By analyzing patterns in a Lineaments Rose Diagram, geologists can identify dominant structural trends, which can be critical in predicting the locations of mineralized zones. A rose diagram that was created from many datasets for a particular research section shows similar movements in frequency and direction. Most of the study's sections are oriented in the S-W, N-E, and NNE-SSW directions (Fig 8).

Lineament density

The total sum of lineaments per unit extent is what is suggested to as lineament density. It provides much valued geological information on the strength of tectonic distortion, the fracturing and shearing of rocks, and mineral possibilities. As a result, controlling lineament density is a significant and practical method for including a variety of applicable geological characteristics and appropriate information. In the case of lineament absorption of the study area, careful examination offers more precision. The lineament concentration outline inside the research area was related to the lineament density map of all lineaments that was extracted from the entire dataset. Frequency histograms, rose diagrams, and/or lineament density maps are widely used to evaluate lineaments [23-25]. The most typical approach is to perform linear concentration based on the number of lineaments per unit area (number/km²), or the total segment of lineaments per unit area (km / km²) or combination all. However, there are hand evidences. The first index is the number of lineaments per unit area (N-number/km2), and the second index is the total length of lineaments per unit area (= here are two modified indexes, the ratio of the intersections (NI) as against the number of lineaments (N), and the ratio of the intersections (NI) versus the total length of lineaments (L), which are frequently used for studying fracture zones. specific guidance. When the scale of the investigation is small (less than 1 / 100,000), the last changed index, the average length of lineaments (L N), is typically utilized. We can reduce the size of the lineament and its overall length by using this index. For a specific grid cell resolution, the lineament density indices are determined, which can be identified based on the statistical signifiers and can be reclassified into varieties of values and reported as a density map (Fig 9).

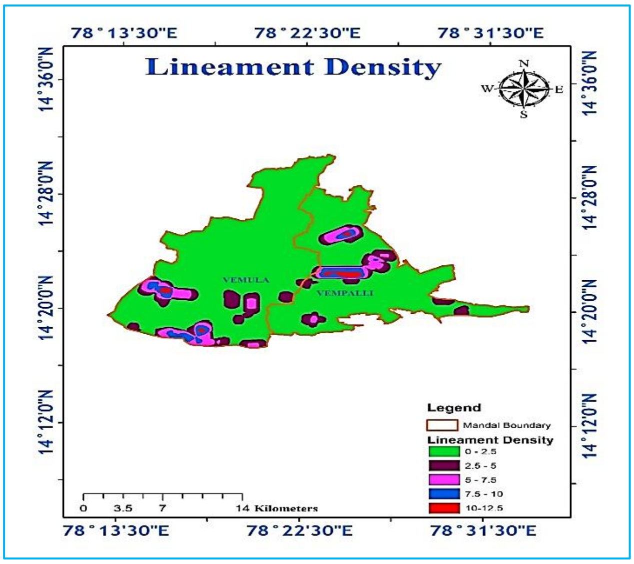

Fig 9 Lineament density map of the study area

Identification of mineral prospecting zones

A lineament map is generated through the integration of various thematic maps using GIS (Geographical Information System). The analysis of lineaments is conducted through field investigations, where the geological features in the study area are systematically examined at all measurement sites. This is done to validate the results obtained from Remote Sensing data regarding lineament analysis. The information acquired from these methods serves to elucidate contentious aspects related to lithology and lineaments in the region, facilitated by innovative remote sensing techniques. Moreover, these findings enable the revaluation of existing predictive and search criteria, pinpointing the most effective ones considering the current economic conditions.

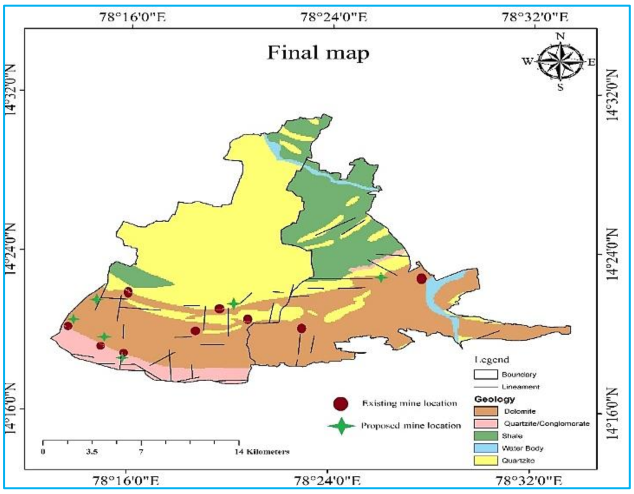

Fig 10 Integrated map showing lineament and geology of the study area

A thematic map illustrating the distribution of vein-type barytes mineralization across different locations has been crafted and merged with a structural density analysis of barytes. This integration involves assigning the current and proposed mining locations. The occurrence of uranium mineralization, controlled by fractures, is observed in both basement granite and sediment-hosted settings (particularly within the Gulcheru Formation, the oldest stratum of the Cuddapah Super Group). Within the study area, nine established barytes mines are situated, and based on a comprehensive investigation into the structural influence on lineament density, six additional barytes mines are proposed for the southwestern segment of the Cuddapah basin.

CONCLUSION

Utilizing remote sensing techniques for mineral exploration has proven advantageous in resolving mineral-related queries. Further enhancement of interpretation was accomplished through scrutiny of a digital elevation model. The evaluation of data pertaining to lineaments and fractures indicates a degradation within the target fracture region. While cross-cutting lineaments exhibit modest presence elsewhere, they display greater prominence in the southwestern quadrant of the study area. Potential for mineral prospecting exists in areas characterized by high-grade joint occurrences within the study zone. Remote sensing imagery proved effective in accurately identifying many key orientation trends in the region. The study's outcomes underscore the viability of extracting lineament trends across expansive territories through remote sensing methodologies. Therefore, it is recommended that the elevated density of linear connections should be complemented by thorough field surveys to enable a comprehensive evaluation of the mineral potential within the study region. The geological, geomorphological, and lineament maps should prominently feature Vemula and Vempalli areas. Identification of lineaments could be associated with specific criteria. Particularly salient are those recognized as straight segments and steep inclines. The presence of uranium mineralization, linked to fractures, manifests in both basement granite and sediment-hosted environments, especially within the Gulcheru Formation, the oldest layer of the Cuddapah Super Group. The study locale accommodates nine established barytes mines, and an exhaustive exploration into the structural impact on lineament density proposes an additional six barytes mines for the southwestern part of the Cuddapah basin. This accessible methodology can serve as an initial phase in research endeavors, facilitating the identification and mapping of features on satellite imagery. Integrating both fieldwork and remote sensing methodologies is crucial for rectifying and updating the geological map's existing information.

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