Geochemistry and landsat satellite data processing of barites (BASO₄) mineral deposits in semi arid region Cuddapah, Southern India

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Abstract
The fundamental intention of research is to investigate the barite(BaSO₄) mineral deposits in semi arid region in Cuddapah basin(Andhra Pradesh). The barites minerals were examined by adopting geochemical analysis and spatial modeling technique. From LANDSAT satellite data, the image was processed and geology and geomorphology and lineament map were prepared of the present research area.

The coordinate points of mineralized zones in the study area were collected during the field work by using Global Positioning System (GPS). The geochemical analysis of barites percentage and areas were represented as false color composite in the grade wise map. Golden yellow color represents 90.71% of barites, reddish violet colour represents 93.75% of barites, light yellow colour represents 95.23% of barites, red colour represents 95.35% of barites, thick brown colour represents 95.64% of barites, blue colour represents 95.71% of barites, green colour represents 95.78% of barites, olive green colour represents 96.74% of barites, cream colour represents 97.08% of barites and pink colour represents 97.36% of barites content in the study area. Lineament density, which is of high value, indicates the high mineralization in the focused area.

Keywords: Barites village wise mapping, Satellite image, Geology, Geomorphology, Lineament map, Lineament density map, Geochemical analysis.

Introduction
Spatial modeling is a competent tool for supervise the mine activities.¹ Mineral modeling is the chief and advanced technique for mine recognition and analysis,²,³,10,19,20 Cripple Creek, Colorado¹,¹³ and South Africa. Fieldwork is commonly a mandatory component. But ground-truthing is time consuming and costly process.¹⁰,¹⁵,¹⁶,¹⁸

The present study intended to combine the geospatial modeling techniques for exploration of white barites and was integrated with geochemical analysis of mineral samples to prepare village wise grade map for white barites. The coordinates of white barite mineral locations were taken by using GPS. These coordinates were transferred into Geocoded satellite image using Geographical Information System software (GIS).

Study Area
The research area lies within 14°24′38″N to 14°20′7.73″N latitudes and 77°57′11.6″E to 78°32′15.9″E longitudes (Fig. 1). The study areas included in Survey of India (SOI) Toposheet nos. are 57 J/2, 57 J/3, 57 J/6 and 57 J/7. Major geological formations were Gulcheru Quartzite's, Pulivendla Quartzite's, Tadipatri Shale's, Vempalle Dolomites, Quartzite's and Volcanic flows.

The origin of the white barites was found in study area due to invasion of volcanic sill intrusions into the Vempalli limestone formation of Papagni of Cuddapah super group of rocks. The research area contains semi arid climatic condition and less rainfall.

Methodology
Modeling of barites mineral deposits in semi arid regions of Cuddapah basin was performed in two phases: The first phase LANDSAT ETM+ 2004,2006,2009 data were prepared from Image Processing Laboratory working with ERDAS Imagine software(http://glcfapp.glcf.umd.edu/). From that satellite, data have been prepared for geology, geomorphology, lineaments, lineament density map of the study area.²⁴ The coordinates were collected from the global position system at the time of collection of the mineral samples.

The samples were analyzed with X-ray fluorescence spectrometry (XRF) and the geochemical analysis data of the study area was obtained. This geochemical analysis data is integrated with the village wise barites mineralogical percentage map of the Cuddapah area. The methodology is explained by flowchart (Fig. 2).

Results and Discussion
Geomorphology: Geomorphological features at Vemula, Vempalle, Pulivendla and Lingala mandals were classified as flood plains, pediments, pediplains, residual hills, structural hill and structural valleys (Fig. 3).

Flood plains covered an area of 8.42 sq.km, pediments extended an area of 94.89 sq.km, pedipalins occupied an area of 538.54 sq.km, residual hills in 11.63 sq.km, structural
hills 202.94 sq.km and Structural valley 119.72 sq.km.\textsuperscript{22,23} The larger part of the study area was mainly covered with pediplains.

**Geology:** The stratigraphic sequence of rocks situated as Papaghni and Chitravati groups was at lower Cuddapah Super group (Fig.4). The study area lithologically was occupied with alternate bands of argillaceous and arenaceous rocks. Igneous activity was seen between Vempalli and Pulivendla formations and below the Tadipatri shale formation.\textsuperscript{11,14,25,26}

**Lineament density map:** It is one of the pre-requisite thematic maps which are remarkable for adopting in natural resources potentiality investigations and extended in East-west direction (Fig. 5 and 6). The linear density (\(L_L\)) was calculated as their total length per unit of area.

\[
\sum_{i=1}^n L_i \\
L_L = \frac{\sum_{i=1}^n L_i}{S_{k6}}
\]

where \(L_i\) is the length of individual lineament in the calculated unit area and \(S_{k6}\) is calculated area.

The orientations of lineament networks graphically represented in figure 5.\textsuperscript{7,28,29} The high values of lineament density in the map indicate the high barytes mineralization zones.

**Geochemical analysis:** The study area Barytes mineral map has shown village wise distribution and thematic map is integrated with the geochemical grade analysis of barytes by assigning the colour codes to the villages (fig. 7). There are 10 villages belonging to 4 mandals in the study area. The villages are Vempalli, T.Velamavaripalli of Vempalli mandal, Kothapalli, Vemula, Velpula, Meedipentla of Vemulamandal, K.Velamavaripalli of Pulivendulamandal, Velidendla and Ippatla, Lopatnutala of Lingalamandal. The geochemical analysis of the study area has been represented in table 1 and filed photos are presented fig. 8 and 9.\textsuperscript{6}

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![Location map of the research area](image)
Fig. 2: Flowchart diagram

Fig. 3: Geomorphology map of research area
Fig. 4: Geology of the study area

Fig. 5: Lineament map
Fig. 6: Lineament density map

Fig. 7: Grade map of Barites in the study area
Vempalli: Vempalli village belongs to Vempalli mandal within latitude of 14°22’38”N and 78°27’28”E latitudes. Thin veins of White Barytes are occurring along fracture zones in Vempalli Dolomites. The barytes are oriented E-W strike direction and dipping vertically. Shally dolomite is the country rock in this area. This country rock is thin bedded and consisting of shally dolomite. It shows the strike direction of E-W and dipping towards 25° towards north. Ten barytes sample have been collected from Vempalli village. The average percentage of chemical analysis of barytes is 95.78%, with a chemical composition of CaO-0.28%, Fe₂O₃-0.48% and specific gravity of 4.00.

T. Velamavaripalli: Tallapalli Velamavaripalli village is located in Vempalli mandal within the latitude of 14°20’11”N and longitude of 78°22’40”E. T. Velamavaripalli village has a thin vein of white barytes along fracture zone in dolomitic limestone. Barytes vein shows NW – SE strike direction and dipping vertically whereas the country rock of dolomitic limestone shows east-west direction and dipping towards north with 25° to 32° angle. A massive bedded fine grained, soft to medium hard, grey dolomitic limestone is exposed to surface in the entire area as country rock on either sides of the barytes vein to a depth of more than 6m. The dolomitic limestone does not have any economic value. 10 Barytes sample were collected and analyzed in the laboratory. These samples show on an average chemical composition BaSO₄ 95.35%, Fe₂O₃ 0.45 and SiO₂ 1.68 and specific gravity is 4.30.

V. Kothapalli: The village is situated between latitude of 14°20’46”N and longitude of 78°21’07”E. Veins of the barytes in this area are confined to the fractures with steep dips of 70° to 75° towards South. In this villages barytes belt extended for 15km length, trending almost E-W up to an adjacent velpuala village. Barytes vein is exposed at 5m depth onwards as vein type with width ranging from 1m to 1.5m. The trend of the barytes vein is almost E-W and dip is 75° towards south. The colour of barytes is white and buff and the purity seems to be increasing with depth. The strike of barytes vein is E-W and dipping towards south ranging between 70° to 75°. 12 Barytes samples were collected in the study area showing an average percentage of BaSO₄ of 97.36% along with different composition SiO₂ 1.86%, CaO 0.02%, Fe₂O₃ 0.04%, Al₂O₃ 0.12%, and specific gravity of 4.3.

Vemula: Vemula village of Vemula mandal is situated between latitude of 14°20’59”N and longitude of 78°19’59”E”. Thin veins of white Barytes are occurring along

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Village Name</th>
<th>Silica as SiO₂ %</th>
<th>Iron as Fe₂O₃ %</th>
<th>Alumina as Al₂O₃ %</th>
<th>Barium sulphate as BaSO₄ %</th>
<th>Calcium as CaO% by mass</th>
<th>Loss on ignition %</th>
<th>Specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vempalli</td>
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<td>0.48</td>
<td>0.58</td>
<td>95.78</td>
<td>0.28</td>
<td>1.4</td>
<td>4.00</td>
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<td>2.</td>
<td>T.Velamavaripalli</td>
<td>1.68</td>
<td>0.45</td>
<td>0.65</td>
<td>95.35</td>
<td>0.02</td>
<td>1.85</td>
<td>4.3</td>
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<tr>
<td>3.</td>
<td>V. Kottapalli</td>
<td>1.86</td>
<td>0.04</td>
<td>0.12</td>
<td>97.36</td>
<td>0.02</td>
<td>0.6</td>
<td>4.3</td>
</tr>
<tr>
<td>4.</td>
<td>Vemula</td>
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<td>0.07</td>
<td>0.76</td>
<td>97.08</td>
<td>0.88</td>
<td>0.09</td>
<td>4.39</td>
</tr>
<tr>
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<td>Velpula</td>
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<td>0.62</td>
<td>0.75</td>
<td>95.23</td>
<td>0.08</td>
<td>1.82</td>
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<td>6.</td>
<td>Meedipentla</td>
<td>1.32</td>
<td>0.92</td>
<td>0.65</td>
<td>95.71</td>
<td>0.2</td>
<td>1.2</td>
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<td>7.</td>
<td>K. Velamavari palli</td>
<td>7.24</td>
<td>0.13</td>
<td>1.50</td>
<td>90.78</td>
<td>0.28</td>
<td>0.07</td>
<td>4.58</td>
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<td>8.</td>
<td>Velidandla</td>
<td>2.80</td>
<td>0.08</td>
<td>0.05</td>
<td>96.74</td>
<td>0.30</td>
<td>0.03</td>
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<td>9.</td>
<td>Ippatla</td>
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<td>0.44</td>
<td>0.10</td>
<td>95.64</td>
<td>0.28</td>
<td>0.4</td>
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<td>10.</td>
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<td>1.54</td>
<td>1.02</td>
<td>93.75</td>
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<td>0.96</td>
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fracture zones in dolomites in Vemula village. The barytes veins shows E-W strike direction and dipping almost in vertical. The country rock in this village is dolomite intercalated with shale. The dolomites have being showing strike direction of E-W and dipping towards north with 25° dip.

A thin bedded, fine grained, soft to medium hard, grey shaley dolomite is exposed in old outcrops on either sides of the Barytes vein as country rock. This shaley dolomite does not have any economical value because it contains the high SiO₂ and low MgO Content.12 Barytes samples were collected in the study. It is showing an average chemical composition percentage of BaSO₄ of 97.08% and remaining chemical composition was: SiO₂1.12%, Fe₂O₃0.07%, Al₂O₃ 0.76%, CaO 0.88% and specific gravity is 4.39.

**Velpula:** Velpula is situated between the latitude of 14°22’00”N, and longitude of 78°15’45”E. In this area four old working pits appeared with a 3m width. The trend of the barytes vein is almost east west and dipping towards south with an angle of 75° to 80°. The barytes color in this area is white and buff. Barytes samples of 12 numbers were collected in the study area. It is showing an average percentage of BaSO₄ of 95.23% and remaining chemical composition was: SiO₂1.5%, Fe₂O₃ 0.62%, Al₂O₃ 0.75%, CaO 0.08% and specific gravity is 4.3.

**Meedipentla:** The rock formations Meedipentla village of Vemula mandal is related to the Vempalli formation. Geological rocks were occupied with dolomites and traps overlaying the Gulcheru quartzites. The village lies within the latitude of 14°19’59.91”N and longitude of 78°18’24.46”E. The area is occupied by grayish dolomites which are thick bedded, massive, fine grained and compact. It is examined through outcrop and old pits.

They are mostly siliceous and often contain chert bands of varying thickness. The traps are fine grained and compact and highly vesicular. The barytes veins are confined to the fracture zone of dolomite. The strike of the formation as well as barytes vein is N75°W-S75°E to N85°W-S85° with steep dips of 80° towards SW direction.

The typical pinching and swelling characteristics of the vein and inclusion of lenses or slices of dolomitic country rock as ‘horses’ are observed in the old pits. These features are related to shear fractures. Many other features like brecciation, slickensides etc., are obliterate due to heating effects in the dolomites. The contact of barytes vein with wall rocks is sharp without any indication of replacement effects. The ore is generally sorted visually into white and colour commonly referred as buff. The grade by way of higher specific gravity and brightness is better for the white than buff. 10 samples of barytes are collected from the village. The average composition of the analysis report of samples of this area shows the BaSO₄ content of 95.25% and specific gravity 4.5. Thus, the quality of barites is good.

**K. Velamavariypalli:** K.Velamavariypalli village lies within the coordinates of 14°22’59.97”N latitude and 78°13’86”E longitude. Ten samples of Barytes were collected from village. The samples have shown the following chemical analysis of BaSO₄-90.78%, Fe₂O₃-0.13% and specific gravity of 4.58.

**Velidandla:** Velidandla village lies within the latitude of 14°31’54”N and longitude of 78°02’58”N. The rock formation in mineralized area of these villages belongs to the Papagni group of lower Cuddapah supergroup constituting mainly dolomites and limestone overlying the basement granitic rocks. The barytes vein is occurring in the shears and fractures of the dolomites. The strike of the barytes vein is N80°W – S80°E with steep dips of 80° towards SW direction. The mineralization of barytes is due to the action of hydrothermal solutions. 15 samples of the barytes were collected from this village, analyzed and the average chemical composition of BaSO₄ is 96.74% and remaining Fe₂O₃ being 0.08 and SiO₂ 2.80.

**Ippatla:** The Ippatla village of Lingala mandal is located at latitude of 14°25’18”N and longitude of 78°10’28”E. Thin vein of Barytes is occurring along fracture zones of the Dolomitic limestone or along the contact of intrusive rock and the Dolomitic limestone. These dolomites belong to the Vempalli formation of upper Papaghni group overlying the Gulcheru quartzite formation. There are two old pits located adjacent on northern boundary of the area. The barytes vein is exposed in these old pits and it is showing ESE-WNW strike direction and dipping towards SSW with 60° to 70°. The host rock in this area is intrusive tuff and occurs as a hanging wall and dolomitic limestone is forming at footwall. 12 Numbers of Barytes sample were collected, these sample show the chemical composition of BaSO₄ 95.64%, Fe₂O₃ 0.44 and SiO₂ 3.42 and specific gravity 4.30.

**Lopatnuthala:** The rock formations in Lopatnuthala village of Lingala mandal are dolomitic limestone belonging to Vempalle formation of Papagni group. The entire area is covered by dolomitic limestone. The area is situated in latitude of 14°30’25”N and longitude of 78°04’11”E. Veins of the barytes are confined to the fractures with steep dips of 68° to 70° towards south. The research area is located in the barytes belt, which is trending almost east west roughly from Vempalli Village of Kadapa district up to Muchakota village of Ananatapur district confining to Vempalli stage of kadapa system.

In this area two old pits are existing with 6m in length, with an average width of 3m and depth of 6m. Barytes vein is exposed as vein type with width ranging from 1.5m to 2.5m mixed with the country rock of dolomitic limestone.

The trend of the barytes vein is almost east west and dip is 70° towards south. The colour of the barytes is white and buff and percentage is increasing with depth.10 Barytes sample were collected, these sample show the average
chemical analysis of $\text{BaSO}_4$ 93.75%, $\text{Fe}_2\text{O}_3$ 1.54 and $\text{SiO}_2$ 4.00, and specific gravity 4.30.

**Conclusion**
The study area lies in semi-arid and proterozoic basin of Andhra Pradesh. In this research, LANDSAT -8 satellite data was processed and the geology and geomorphology, lineament, lineament density maps were prepared. The geology of the study area lies in alternative bands of argillaceous, arenaceous and limestone rocks. The geomorphology of the study area were flood plains, pediments, pediplains, residual hills, structural hills and structural valleys. Lineaments are oriented in northwest to southwest. Lineament density high values indicate the high percentage of barities mineralisation zone and geochemical analysis reveals that high grade baryte mineral of an order of 97.36% $\text{BaSO}_4$ occurs in V. Kottapalli village of Vemula mandal and least grade of baryte mineral of 90.78% of $\text{BaSO}_4$ occurs in K. Velamavaripalli village of Pulivendla mandal.

The average content of barytes in all the villages is 95.34%. A grade wise thematic map of barytes mineralized villages has been prepared and false colours are given to the village for each grade. These maps will be helpful to persons or companies who wish to extract barites in this area.

**References**


21. Veeraswamy G., Balaji E., Veeranjaneyulu A., Subbarao M., Surekha A. and Narasimhlu K., Data sets on delineation of


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