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Structural delination using Satellite data for Lead and Zinc mineral Exploration in South Central part of Cuddapah basin

Ramachandra.M[1], Dr.Raghu Babu.K[2]*, Rajasekhar.M[1], Pradeep Kumar.B[1]

[1]Research Schalor, Dept. of Geology, Yogi Vemana University, Kadapa, Andhra Pradesh, India.
[2]Asst. Professor, Dept. of Geology, Yogi Vemana University, Kadapa, Andhra Pradesh, India.

Abstract

The Cuddapah basin is an assemblage Cuddapah Supergroup of rocks consisting of alternate beds of arenaceous, carbonaceous, and argillaceous rocks with multiple basaltic intrusions occurring as sills parallel to bedding planes of lower successions. The Cuddapah basin is formed over the Archaean Peninsular Gneissic Complex (PGC) in three sub-basins viz., Papaghni, Chitravati, and Nallamalai. The present study is focused on the mineral exploration by structural mapping using satellite image for lead and zinc mineralization around Zangamraju palli and Varikunta through Gollapalli villages, known as z-v belt in Badvel and Proddutur talukas respectively of YSR district. The z-v belt occurs in the south central part of the Cuddapah basin and belongs to highly folded and highly disturbed Nallamalai group of Cumbum formation of the Cuddapah Supergroup. The general strike of the belt is N-S. Zangamrajupalli block lies in the western limb of a major anticline and Gollapalle block on the eastern limb of the basin. Mineral Exploration aided by the satellite data is essentially includes the regional survey for some of the guides of mineralization especially geological, geomorphological, and structural guides. Satellite data form an important source for mapping and detail exploration studies. The detailed exploration study includes mapping of structural controls and delineation of lithounits associated with mineralization. Lead and zinc, which have been categorised under base metals, identified by a succession of lithology, faults, dykes, and alteration data layers. Lead and zinc occur together with other metals like silver and cadmium. Zinc is a silvery blue-grey metal with a comparably low melting and boiling point. Potential areas for base-metal resources were identified ground exploration was carried out. Satellite imagery data plays a crucial role in the identification of structures for minerals exploration. The relatively low and high utility of satellite imagery makes it a technology for explorers.

***Key words:** Nallamalai sub basin, Lead Zink mineral Exploration, Lineament, SOI Topo sheet, Remote Sensing and GIS.*

1. Introduction

The Cuddapah Basin is considering a universal sedimentary basin that developed through divide of the continent (Wang et al., 2014; Wang and Li, 2003). It is recognized by disconnected hydrothermal exhalative events (Huang et al., 2011; Wen et al., 2011; Fan et al., 2013; Lott et al., 1999; Fang et al., 2002; Jiang et al., 2006; Chen et al., 2009) and long-term stratiform Cuddapah Supergroup rocks during the Proterozoic period (Li et al., 2010, 2015). Along the boundary of the basin, the Proterozoic and the basal succession host large barite, yellow ocher, more metallic sulphide-rich units, and lead-zinc deposits. The Zangamrajupalle Pb-Zn deposit is situated in the North-South Cuddapah Basin there are generally lead-zinc deposits of this locate along the eastern part of the Cuddapah Basin. The zangamrajupalli-varikunta belt of Pb-Zn deposits is located under the stratiform barite ore deposit, which is investigated to have created through hydrothermal sedimentary exhalative (SEDEX) processes throughout the recent Cambrian. The investigation of drill cores from this region reveal that the lead-zinc mineralization is principally discordant but strata bound and are intruded in the Cumbum Formation (Showing Fig-3). These sulphide mineralization sites have a close structural relationship with the stratiform barite ore. However, the origin of this variety of lead-zinc mineralization is not fine strained, particularly the relationship between stratiform barite mineralization and lead-zinc mineralization. In this study, we report data that refer to the geology, geomorphology, and limneament of the zangamrajupalli-varikunta Pb-Zn deposit.

2. Study Area

The study region belongs to the YSR district, Andhra Pradesh India, located between 14°53'80.00"N-14°53'53.90"N latitudes and 79°79'421.30"E-79°05'58.00"E longitudes. The total area is 90.71 sq.km The Zangamrajupalle Varikunta (z-v) belt is situated in Badvel and Proddatur Talukas of YSR district, AP, covering parts of SOI toposheets Nos. 57 I/16, 57 J/13 and 57 J/14 and bounded by Protorozoic quartzite silica rich shale rocks (The Cumbum formation).

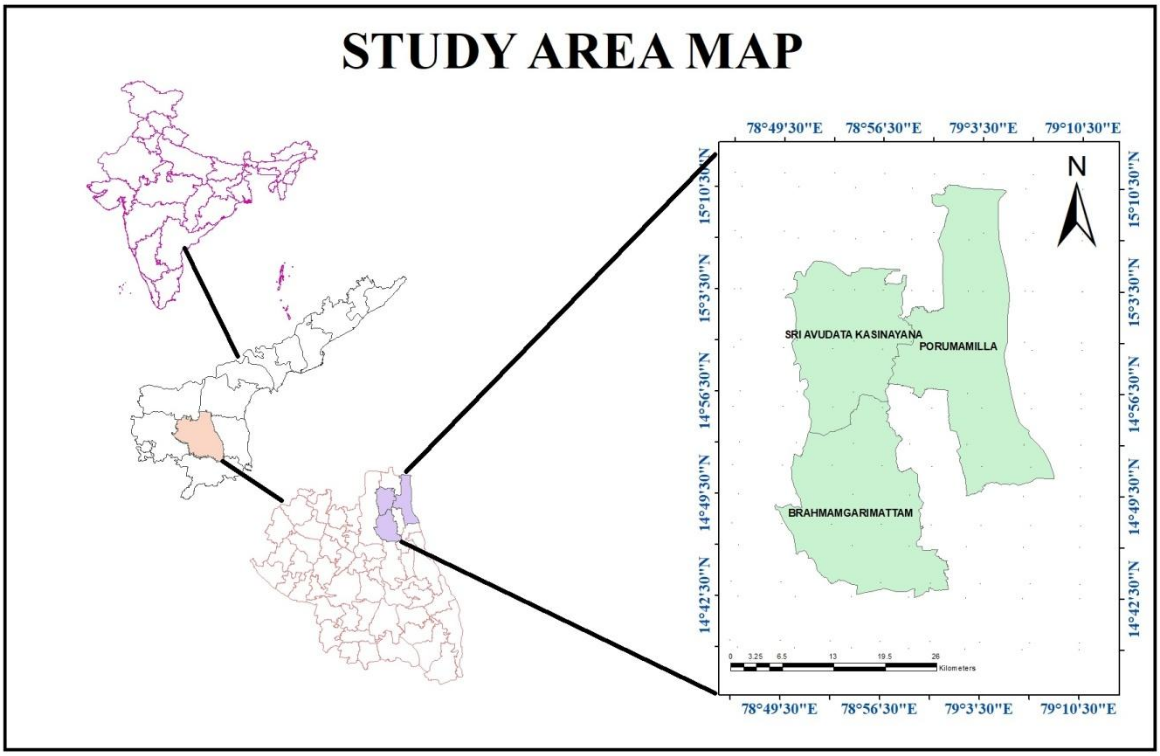

Fig. 1 Location Map of Study area

2.1 Materials used

Remote Sensing Satellite data gives an informative view of the surface of the Earth. Different features return and their compositional energy in various bands of the electromagnetic spectrum, confrontation upon it. This unique substance depends on the property of material (structural, physical and chemical), surface coarseness, angle of prevalence, emphasis and wavelength of radiant energy (Elachi, 1987).

The Geographic Information System (GIS) offers spatial data organization and investigation equipment that can assist users in organizing, control, analyzing storing, and displaying positional and quality information about geographical data (Burrough,1986). Hence, GIS is an sunshade term for the technology which has been successfully used to create, control and analyse structural data in these rapidly-altering times (Longley,2000). In addition, GIS provide a means of delineating the real world through integrated layers of essential structural information (Corwin, 1996).

2.2 Pre-processing

The methodology used in this study is shown in the flowchart (Showing Fig.2) below, which provides a step-by-step break down of the stages taken to arrive at the required result: Landsat 8 containing 12 bands acquired on 2017-02-17 and digital elevation model (30m DEM) was obtained from U.S. Geological Survey. The image was geometrically projected to UTM Zone 32 N and WGS-1984 in order to avoid distortion, and then converted to radiance from digital value (DN). Shape files of the study area were obtained from addition; existing mineral deposit locations were obtained from geological survey of India.

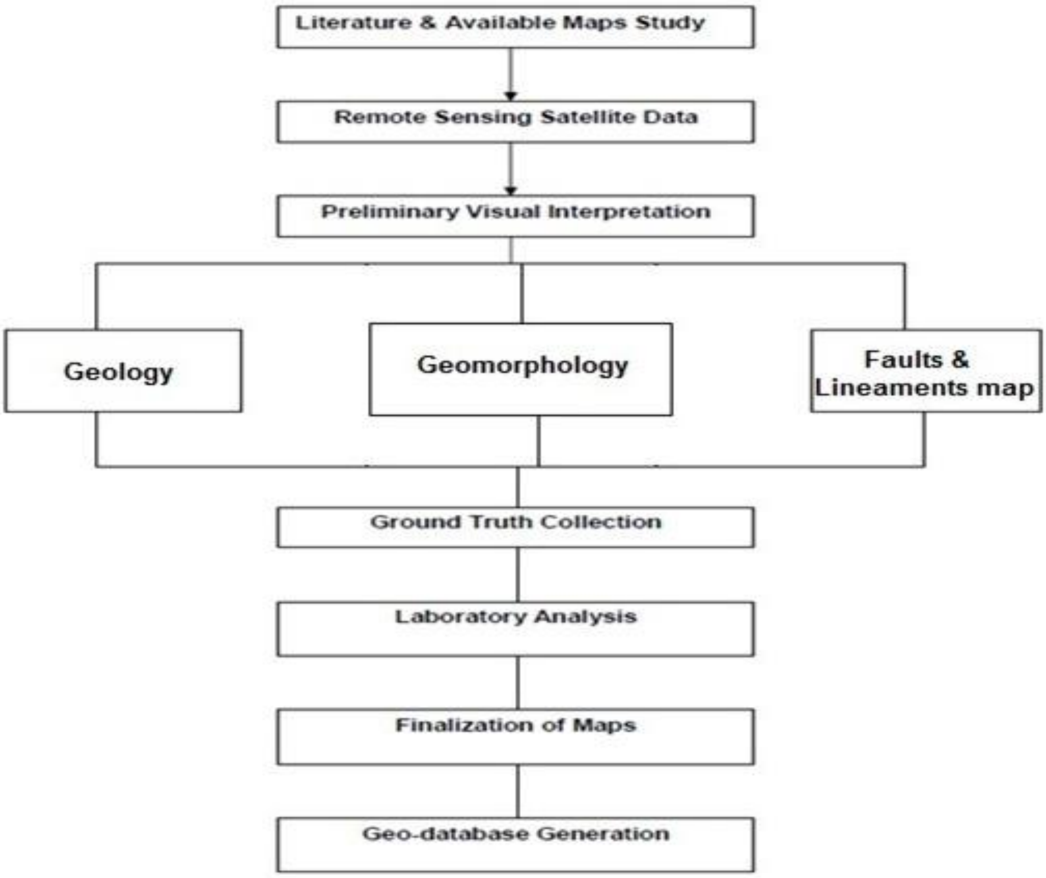

Fig.2 Flow Chart

3. Methodology

The present study includes data collection, sampling, data analysis, report generation etc. The data collection comprises of locating the mineralizing zones in the field of the study area and collecting the GPS point of location of old workings for Pb-Zn minerals. During the data analysis, LANDSAT 8 ETM+ image was processed by the toposheets of the study area are georeferenced with the LANDSAT 8 ETM+ using ERDAS imagine 2014. The GPS point collected during the field work were analyzed and located in LANDSAT 8 ETM+ image. Mandal mineralized location map, geology and geomorphology maps prepared. Structural lineaments were extracted from the image by subjecting the extracted structural lineaments to Arc GIS 10.4 and corrected by removing and filtering irrelevant structures using the knowledge of the ground truth of the study area. The resultant structural lineaments map shows lineament trend or direction. The final process is done by combining bands 4:7:3 to corroborate the result found in the lineament extraction by delineating possible hydrothermal alteration zones. The methodology presented in this paper for the identification of lineaments with possible mineralization of structural origin (S.O.Hermi et al. 2017) using Arc GIS 10.4 (Fig 2). Lineament map has been prepared by observing lineaments from satellite imageries on the basis of visual interpretation aided digitization (Lillesand 1989; Drury 1990) and compared to geological maps of the study area.

4. Result and Discussion

The origin and concentration of sedimentary rock-hosted pb-zn deposits in eastern part of the Cuddapah basin along lineaments is assigned to the structural disturbance of the Nallamalai fold belt (NFB). The lineaments in the study area act as tectonic windows that served as accessible “traps” and intersection of tectonic lineaments infiltrate deep-seated ore in these localized areas. NFB in the eastern part has numerous faulted metasedimentary rocks (Chakraborti & Saha 2006; Saha et al. 2010). The Nallamalai Group consists of the lower dominated arenaceous Bairenkonda Quartzite and the upper Cumbum Formation, consisting primarily of argillaceous Shales with quartzite and dolomite intercalations. The east-central part of the NFB consists of phyllite, quartzite, shale (slate), and minor limestone, dolomite, with a cumulative thickness of 1200 m, as approximated from an exposed section of the Velikonda range east of Porumamilla.

The quartzite is the dominant part with minor quartz phyllites (protoliths of micaceous sandstone and shale) in the lower part of the Bairenkonda formation, and the upper shale and phyllitic intercalations are regarded as the Cumbum formation (Meijerink et, al. 1984). In contrast, the Porumamilla area, the essential rock sequence occurs up to the order the Tekurapeta quartz–phyllite member the Porumamilla quartzite member (Dilip Saha et, al. 2017) and the local preservation of sedimentary structures. The lower part of the succession includes thin curved bedded with ripple structures, fine-grained quartzite (glauconitic sandstone) with intercalations of laminated shale (slate). Which passes upwards to a thin bedded massive to graded stratified fine sandstone–siltstone, moderately thick-bedded, well sorted, medium-grained Porumamilla Quartzite. The lithostatigraphic succession of the study area (B.K.Nagaraja Rao et al., 1087) is shown in Table-1.

Table – 1 Lithostratigraphic Succession of Study part

Group	Formation	Thickness (m)	Lithology
Nallamalai Group	Cumbum (pullampet) Formation	2000	Quartzite, Phyllite, Slate, Dolomite, Pullampet shale,
	---------Unconformity --------		
	Bairenkonda (Nagari) Quartzite	1500 4000	Quartzite Shale

4.1 Geology

The rock strata in the present study are mainly sedimentary, low grade metamorphic rocks, belonging to Cuddaph Supergroup succession. Cumbum shale formation occupies in the form of synclinorium as structure along the river basin within Bairenkonda quartzites. The shales have been subjected to low grade metamorphism and converted into phyllites along the eastern margin of the area (Fig 2). The consolidated rocks show different types of formations in the study area and the types of contacts between them. This map also shows various features like rock formations and their stratigraphical position and contact margins between dolomite, lime stone, quartzite, and shale with phyllite. This map is prepared based on Geology and Mineral map of Andhra Pradesh in 1:50,000 scales made by the Geological Survey of India.

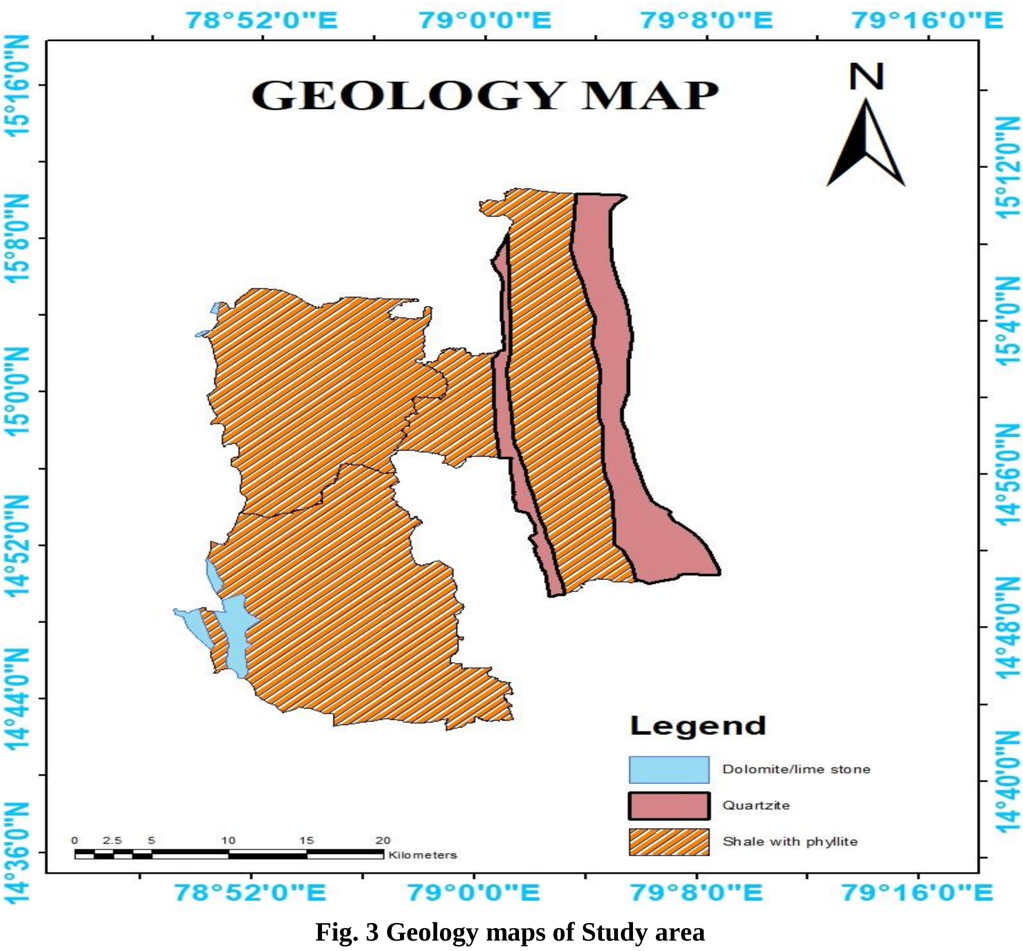

Fig. 3 Geology maps of Study area

4.2 Geomorphology

Morphological features were observed in LANDSAT 8 imagery and different features like Denudational hills, Denudational valley, Structural hills, Structural valleys, Pediment, Padiplain, Anthropogenic terrains, and Water bodies were delineated. Geomorphology maps were useful for analyzing the morphological features of the study area. Corresponding geomorphology schematic diagram is shown in Fig 4.

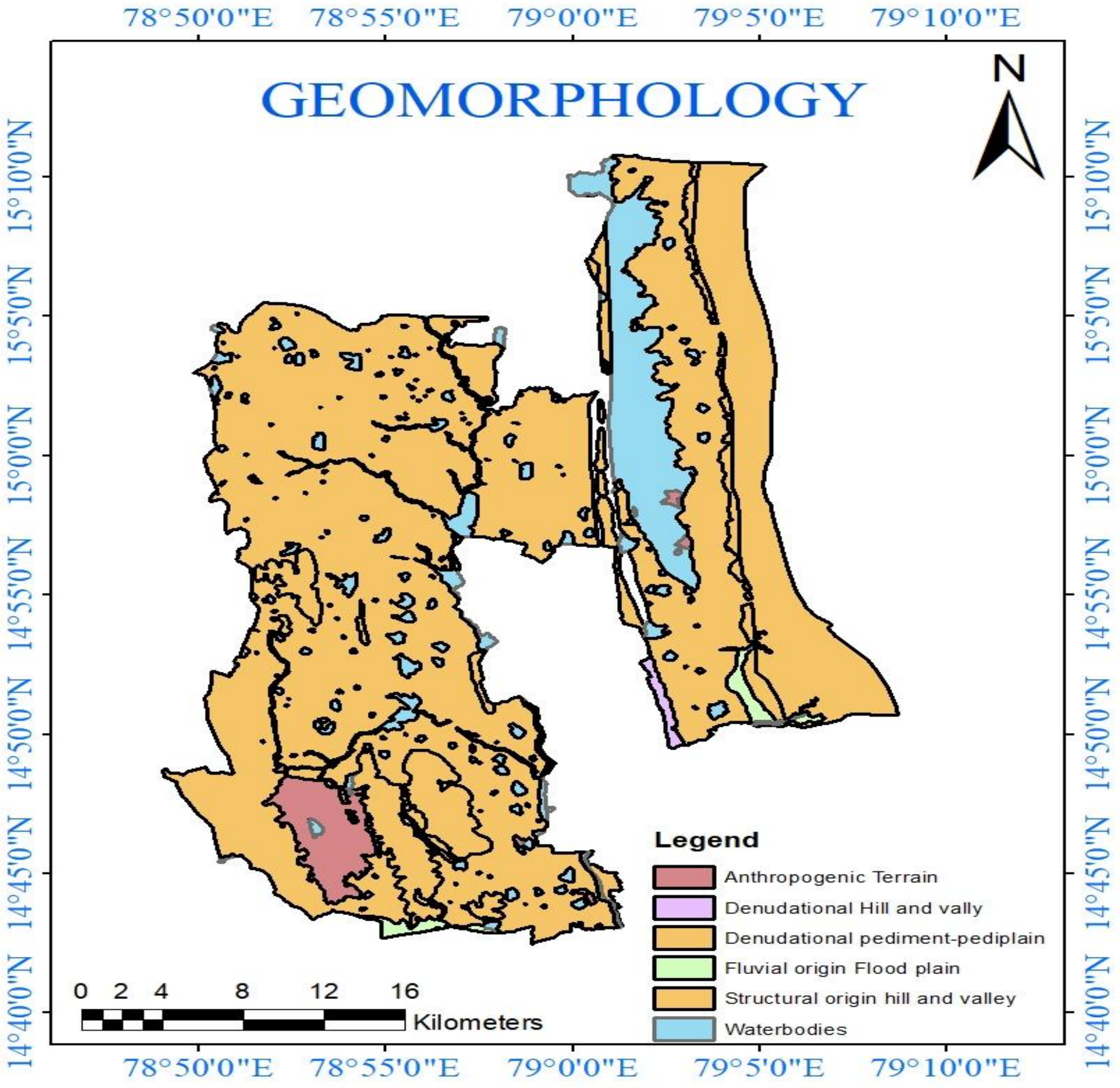

Fig. 4 Geomprohology maps of Study area

4.3 Lineament analysis

Presence of lineaments may act as sites for mineral movement which made an increased importance of lineament study; therefore, it can serve as mineral prospective area (Obi Reddy et al., 2000). The lineament map of the present study area is prepared through ArcGIS 10.4 software. Mandal wise lineament variables were extracted by analysing the map and assessment of all the lineaments is noted. The study indicates that the length of the lineaments in the study area is same. Lineaments like joints, fractures, and faults are geologically very important and may provide the way for mineral movement (Sankar, 2002). Lineaments can guide the movement of mineral bearing solutions (Subba et al., 2001) and therefore are important guides for mineral exploration. Recently, many mineral exploration projects made in many different countries have obtained higher success rates when sites for drilling were guided by lineament mapping (Teeuw, 1995). Lineaments are large scale linear features which expresses itself in terms of topography which is in itself an expression of the underlying structural features. From the mineralization point of view such features includes valleys controlled by folding, faulting and jointing, hill ranges and ridge lines, un expected transition of rocks, straight segments of streams and right angled off setting of stream courses (Ravindran et al., 1995) as these linear features are commonly associated with dislocation and deformation they provide the ways for mineral solution movements (Small, 1970).

Lineaments are important in rocks where the fracture zones forms an alternate network of high transmissivity and acts as mineral conduits in massive rocks in inter fractured areas. The lineament intersection areas are considered to be good mineral zones. The areas with higher lineament density and topographically low elevated grounds are considered to be the best mineral zones. All the linear features in the study area are marked on the lineament map. These lineaments range between a few kilometres to several kilometres in length (Fig.5). The Remote Sensing techniques have given further expansion to lineament studies through a satellite image. Identification of lineaments becomes quite easy because of the synoptic view, availability of data in different spectral bands and receptivity. Even lineaments of inaccessible terrains can be mapped and analyzed using remotely sensed data. Dykes and ridges also appear as linear features on image but can be segregated from other linear features because of the positive relief (Ganesh Raj, 1994). On a satellite image, the lineaments of the study area have been traced from the satellite data of Landsat 8 ETM+.

Cluster of mega and micro lineaments delineated and mapped at 1:50,000 map scale from the satellite imagery are further checked by ground truth (Fig.5). Varikunta-Zangamrajupalli belt is a fracture zone running NE-SW direction clearly indicates the presence of NE-SW lineaments. The river course is also an evidence of these fractures.

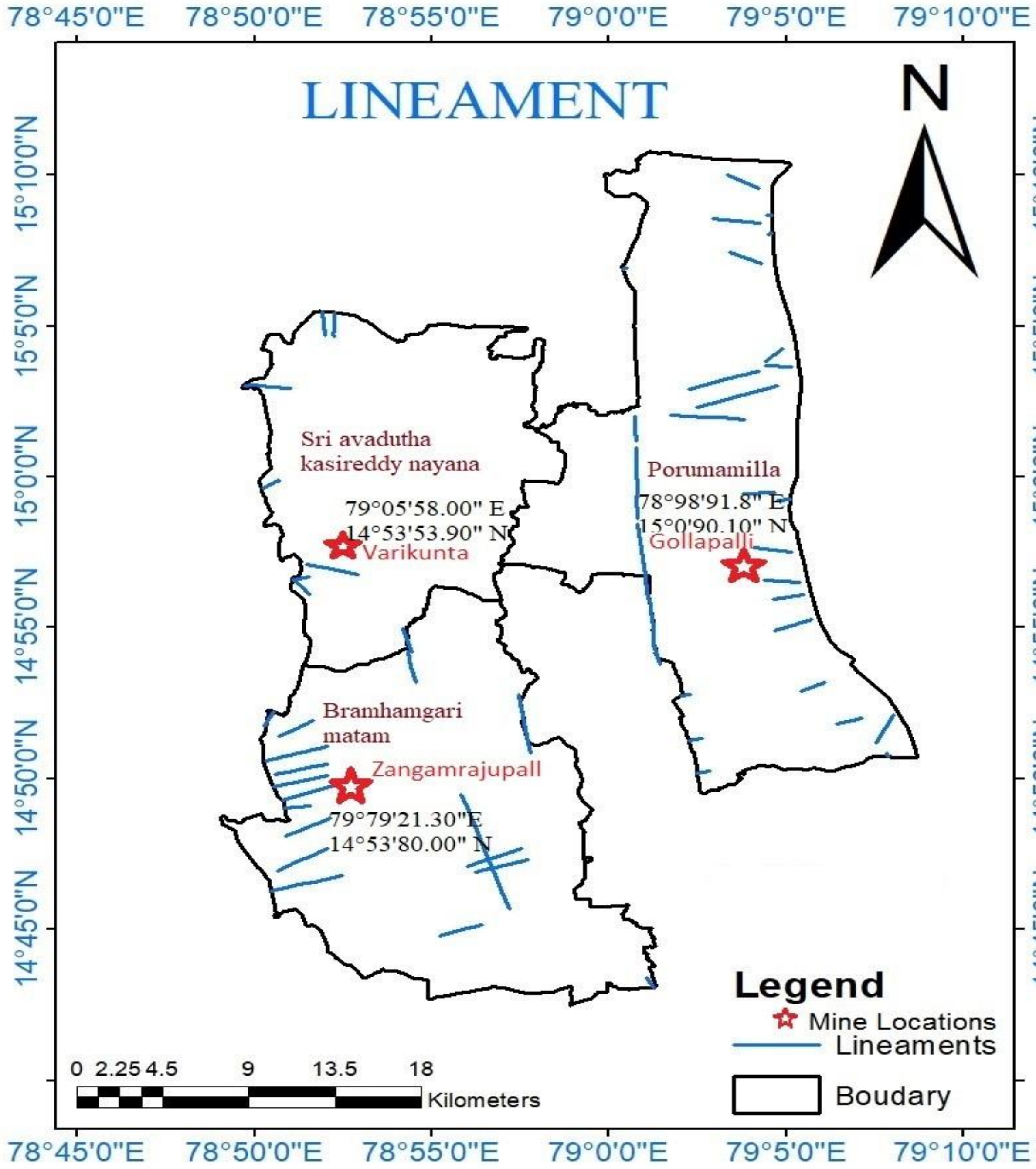

Fig.5 Lineament maps of Study area

4.5 Mineralization in Cuddapah Basin

Cuddapah Basin comprises a succession of four overlapping integrated sub-basins, developed on the high grade Archaean crust of the Eastern Dharwar Craton. The development of the sub-basins was controlled by north-south (M.Deb&T.Pal et al. 2015) trending associated faults overlapped with large dolerite dykes. The presence of sufficient alkali rocks, such as lamproites, kimberlites and ultra-potassic volcanic rocks (Reddy,1999), as well as deep crustal structures visible on satellite image, show the direction of rifting on the development of the Cuddapah Basin with the lower strata constituted by arenaceous, argillaceous, carbonaceous sediments with minor igneous intrusions in the form of sills between the strata. The Cuddapah basin is known for its resources of non-metallic industrial minerals and rocks such as, asbestos, barite, high-grade limestone, phosphorites, diamond, as well as significant concentration of base metal deposits like lead and zinc. In the study area, mineralization occurs in the structurally fault zones between the basement and the overlying quartzite with shale at shallow depths of about 60 m (Verma et al. 2008, 2011). Exploration in the present study area is along the eastern margin of the Cuddapah basin. Base metal sulphide mineralization in Cuddapah Basin occurs mainly in Cumbum Formation Varikunta–Zangamrajupalle belt of Kadapa district. There is Pb, Zn sulphide occurrences known within calcareous shales, quartzites, and dolostones inter bedded with phyllites and argillites of the Cumbum Formation of the Nallamalai Group of Cuddapah Supergroup. Pb–Zn mine of Vikunta-Zangamrajupalle belt (Raghu Nandan et al. 1981) are shown in Fig.5. The host rocks comprise dolostone and brecciated dolostone, calcareous and cherty quartzite, and shale/slate of Cumbum Formation. The lead-zinc mineralization in the study area is confined to about 1200 m in the upper dolomitic horizon, trending ENE–WSW and dipping 20^0–30^0 towards NNW. The dolostone bed is thick in the middle and thins down in the east and west. Localization of the Pb-Zn mineralization has been brought about by NE–SW trending major folds which cut across by a set of N-S folds accompanying shears, where the thickness of the bed is up to 10 m. The mineralization is found mostly in zones of brecciation in dolostones (Raghu Nandan et al. 1981). The Varikunta-Zangamrajupalle belt extends for about 50 km with a width of around 15 km along the eastern flank of the south-central part of the Nallamalai hill range. The major prospects are at Zangamrajupalle and Gollapalle. Other occurrences are at Varikunta, Zangamrajupalle area forms the western limb of a major anticline in the folded sequence of Nallamalai Group of rocks with north–south axial trend and is represented by quartzites, grey slates and phyllites with three dolostone intercalations (the upper, middle and lower dolostone), separated by carbonaceous slate bands. Some clasts in the brecciated dolostone have been found as kimberlitic and lamprophyre. The Pb–Zn mineralization is localized in the upper part of the non clastic sequence of chert, dolostone. Copper mineralization occurs in the lower units of the dolostone member. The common sulphides are sphalerite, chalcopyrite, Pyrite and galena, They are strata bound and it occur as cavity-breccia filling and fine-grained stratiform layers showing evidence of simultaneous folds and faults. Exploration has established two prospects in Zangamrajupalle and Gollapalle blocks of syngenetic, stratiform mineralization (Nagaraja Rao et al. 1987). In the 2 km-long prospect at Zangamrajupalle, there are five lodes rich in lead in the 'main dolostone' and one Zn-rich lode in the cherty dolostone. The central and southern section is 1.34 mt. The ore reserve estimated at the Gollapalle block in the Varikunta- Zangamrajupalle belt is on the northern extension of the eastern border of the Nallamalai hill range. There are extensive old working extend over 1.2 km at Gavulabhavi. Sulphide mineralization occurs as alternating parallel bands in inter bedded sequence of quartzite, limestone, dolostone and chert of the Cumbum Formation in the Rayavaram–Chinnavanipalle belt in the Cuddapah Supergroup. The sulphides are mostly of copper and occur as disseminations, stringers along bedding or foliation of the rocks.

Plate: - Photographs of (a) galena / pyrite in brecciated dolostone and (b) equigranular, coarse, mass of galena.

5. Conclusion

The image processing techniques were utilized to process and extract three data sets representing the distribution of different rocks and physiographic features and lineaments for detecting the potential mineralization zones based on the image spectra of the known lithologies and deposits. The mapping accuracies were upheld by the ground truth. The Satellite data is processed by matched filtering method to identify lineaments with best accuracy in mapping. Furthermore, during the field verification work two Pb–Zn mineralization zones were discovered (14°53'53.90"N 79°79'421.30"E or 14°53'53.90"N 79°05'58.00") in the region. The results of the study show that Landsat 8 ETM+ data accompanied with series of image processing techniques have provided a simple, approach for exploration mineral indicators associated with lead–zinc ore and related host rock. Due to the extensively distributed structures along the Varikunta-Zangamrajupalli belt, the ore prospecting methodology could be applied in other places of similar geological settings. On the basis of the geological, geomorphological, hydrogeological, studies mineral exploration is carried out, the following conclusions have been summarised.

Remote sensing and GIS techniques can be unified to construct an operational system for selection making in a mineral exploration background studies. Results indicate that remote sensing imagery plays an essential role in mineral potential investigation. The great interest, were the results implemented by the GIS technique and digital classification to locate altered zones characterised by minerals of hydrothermal origin like lead-zinc and barites. Based on the Geology, Geomorphology, and Leanimeants maps, intense focus on Lineament map of the three Mandals namely Porumamilla, Sri Avadutha Kasireddynayana, and Bramhamgari mattam we may have to conclude that, in the existing mines much lead-zinc deposit is present.

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