Exploration of Alteration Minerals by application of IDW method to identify Spectral Signature Halos in the processing of a Satellite Image

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Abstact

Alteration minerals are path finder minerals for base metals like lead, zinc and copper etc. Numerous old workings of lead, zinc and copper in the form of ventilation shafts, crosscuts, open quarries tc dating back to the Moghul period, exists in a linear belt stretching 45 km in Varikunta village of Kalasapadu mandal and Zangamrajupalli village of Brahmamgarimatam mandal of north eastern part of YSR District. The mineral assemblages within the rocks that have undergone hydrothermal fluid alteration will be identified by their specific reflectance. The disseminated nature of alteration minerals forms alteration halos. These alteration minerals exhibit spectral signatures unique from the surrounding region which were caught by the satellite sensors. They were measured at the place of mine and using these measurements supervised classification of the entire subset image is made.

The Inverse Distance Weighting is a method for spatial prediction to estimate the values at unsampled point location which could be the area of interest, based on a sample at known location. In the present study spectral reflectance of alteration minerals at a known area in the subset image is measured then spectral signature halos were identified in the image by using IDW method.

Key Words: Inverse Distance Weighting, Spectral Signature, Subset Image, Alteration minerals

Introduction

The estimated reserves of basemetals in this district is 1,41,000 tonnes (V.Raghu et.al., 2013). Many workers like K.Raghubabu et.al., (2012) etc., have worked in many ways to delineate and estimate the alteration zones in the study area. The impressions of the alteration minerals in the form of spectral signatures is generally occur within the spectral ranges 0.4µm to 1.1µm and 1.0µm to 2.5µm are used to identify hydrous minerals. These bands have been successfully used in arid environments to map altered rocks (Abrams et al., 1984; Goerz, 1989; Rowan and Lathram, 1980; Abrams et al., 1977; Hunt and Ashley, 1979; Marsh and Mckeon, 1983; Elvidge and Lyon, 1984; Miller and Elvidge, 1985; Krohn, 1986).

In the present study Inverse Distance Weighting (IDW) method is used for the exploration of alteration minerals in the study area based on a single known value for mapping the spectral signature halos. An area of about 10 Sq.km is considered for the mapping. A known spectral emission is taken from the existing mine (old working) as sample for performing the IDW mapping. The known value being 0.5 µm near Jangamraju palli village of Brahmamgarimattam mandal. The halos thus obtained are accurate and during the ground truth survey mineralization is observed in the mapped area. Spectral emission values of 0.51µm with a spectral dispersion halo of very near values is obtained at about approximately 1.6 km away from the known value of spectral emission of 0.5 µm. The map shows around 3 Sq. km area as highly concentrate with 0.51 µm spectral values and 1-3 Sq.km area as moderately concentrated with 0.51 µm to 0.37 µm and remaining 3 Sq.km

area as low concentrated zone with the spectral emission of 0.25 µm to 0.34 µm. However the entire mapped area is showing alteration mineralization zones with high to low concentrations.

Study area

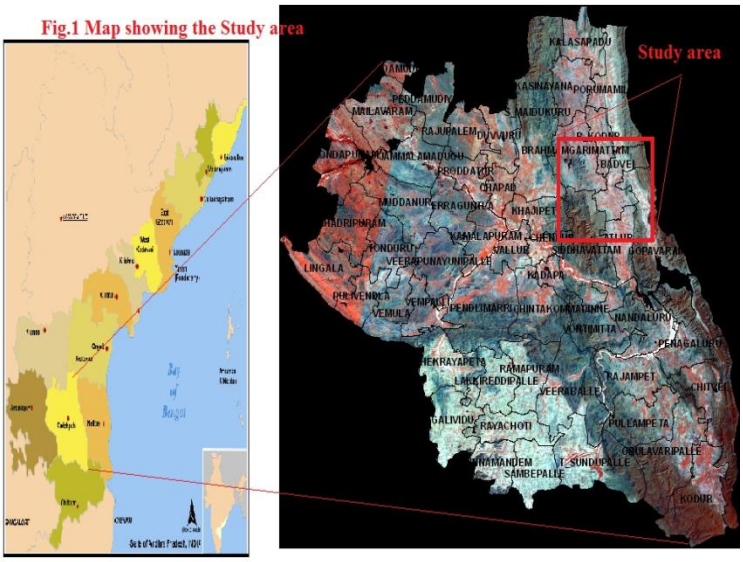
Zangamrajupalli is located in the western margin of the Nallamalai fold belt within the cumbum shales (Table-1) which fall in the Survey of India toposheet No. 57 J/13 between longitudes of 78⁰50`00``,78⁰55`00`` and latitudes of 14⁰45`00``,14⁰50`00`` covering an area of about 10 Sq.km (Fig.1).

Table – 1 The Stratigraphic succession of the study areas is as follows.

CUDDAPAH SUPER GROUP	KURNOOL GROUP	Nandyal shale Koilakuntla limestone
	---------- Unconformity ----------	
	NALLAMALAI GROUP	Cumbum formation Bairenkonda quartzite
	---------- Unconformity----------	
	CHITRAVATHI GROUP	Gandikota quartzite Tadipatri shale Pulivendla quartzite
	---------- Disconformity ----------	
	PAPAGNI GROUP	Vempalli formation Gulcheru quartzite

(After Nagaraja Rao et al 1981)

Fig. 1 Map showing the Study area in N-E Part of Kadapa district



Geology of the study area

In the Study area the Cumbum formation is the basic unit with intercalations of quartzite and dolomite at various levels. The argillaceous unit is identified as shale, slaty shale, slate and phyllite. The stratigraphic sequence of Cumbum formation in zangamrajupalle is as follows

Siliceous dolomite
Brown siliceous slate with intercalated siliceous dolomite bands
Browinish grey carbonaceous slate/phyllite
Upper cherty dolomite with interbedded chert
Greenish grey cherty slate
Middle dolomite
Greenish grey slate
Lower dolomite
Greenish grey slate

Carbonate rocks occur at different levels and are the host rocks for basemetal mineralization (Plate 1 and 2).

Dolomite

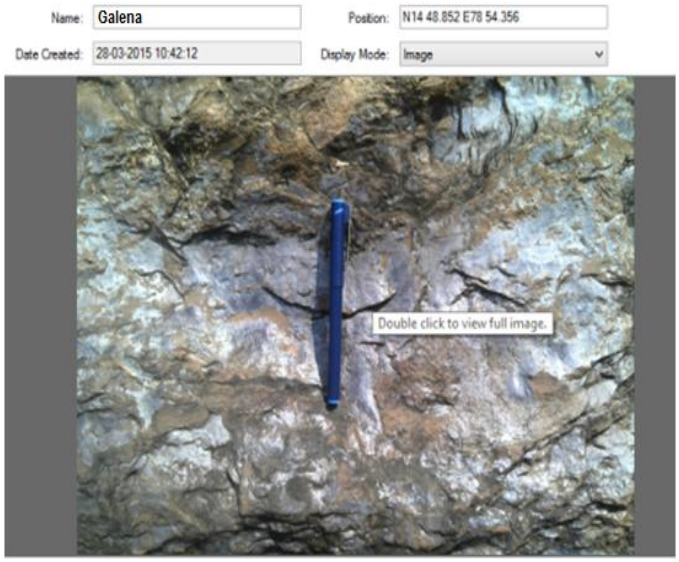
The siliceous dolomite in the digital imagery of the study area is showing low drainage density due to poor availability of water. Bedding is weekly shown owing to the chemical origin of the carbonate rocks. The dolomites showing light coloured calcareous soil. The study area shows dense vegetation. The spectral characteristics in the VIS-NIR-SWIR images images bare slopes of lime stones appear light toned.

Slate/phyllite

Slate/phyllite in the study area shows characteristic darker tone in visible region. Vegetation is sparse. The slate in the study area is well jointed and fractured with thick soil cover. The drainage pattern is well developed.

Plate 1 Showing the slates & Phyllites in the study area

Plate 2 Showing Galena mineralization in the study area



Mineralization

There are two well defined dolomite horizons in the Zangamrajupalle block namely the upper cherty and the lower main dolomites, to which the lead-zinc mineralization is confined, in the form of conformable veins (Plate – 3) (Exploration report, Feb. 1986). Lithologically the galena mineralization is confined to the slates and phyllites

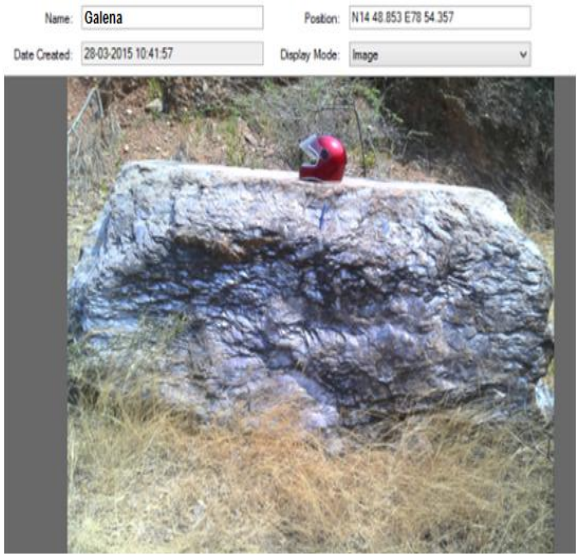
Plate – 3 Galena in the form of conformable veins

Lead-zinc mineralization is mostly confined to the top horizons of the non-clastics represented by chert or cherty dolomite. Copper mineralization also occurs within the lower units of the dolomite member. Sulphide minerals include sphalerite, galena, pyrite and chalcopyrite. Exploration has led to the delineation of two medium sized deposits with a marginal or slightly better grade.

From the analysis carried out in the study area concluded that the mineralization is mostly syngenetic and stratiform. These studies also indicated that, though the general environment for formation of basemetals was favourable in the entire belt, occurrences of basemetal sulphides are

very few and far apart. This aspect perhaps is indicative of a biogenic and/or hotspot control of a highly localized nature. Large blocks of Galena mineral is found around the study area (Plate 4).

Plate 4 Galena Mineral block



Inputs Used

LANDSAT (ETM+) images are of 8 band satellite data with 15 m resolution belonging to Kadapa district is procured from US website http://eros.usgs.gov/satellite-imagery. Georectification of these images is done with the corresponding Survey of India Toposheet No. 57J/13 at a scale of 1:50,000 scale with the aid of ERDAS software (K.Raghu Babu et al., 2012; G.Sudarsana Raju et al., 2013). Landsat Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7. The resolution for Band 8 (panchromatic) is 15 meters.

	Landsat 7	Wavelength (µm)	Resolution (m)
Enhanced Thematic Mapper Plus (ETM+)	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.77-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	60 (30)
	Band 7	2.09-2.35	30
	Band 8	0.52-0.90	15

Methodology

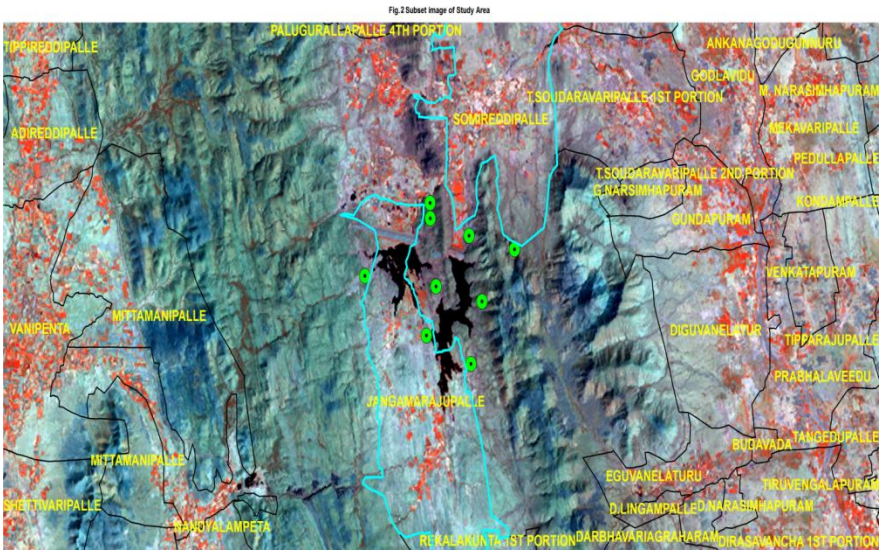
The IDW method involves the process of assigning the values of known point to the unknown points. The points at the unknown point are a weighted sum of the values of N known points. In the present study the spectral signature of alteration zones at a known point were measured and the same kinds of pixel values were identified in the entire image by supervised classification. The spectral signature hallows have been identified in the study area by adopting

various digital image processing techniques like subset the study area, histogram equalization of the subset image, supervised classification and application of IDW method.

Image subset of the study area

Area of interest for the present study in the geo-referenced LANDSAT ETM+ satellite image belonging to SOI Toposheet No. 57J/13 is taken. The area of interest has been subset to perform intense and exclusive studies on alteration minerals in the study area. The subset image covers villages like Zangamrajupalli, Somireddipalli, Narsimhapuram, Eguvanelaturu etc., which bear probable zones that host alteration minerals

Fig.3 Subset image of the Study area



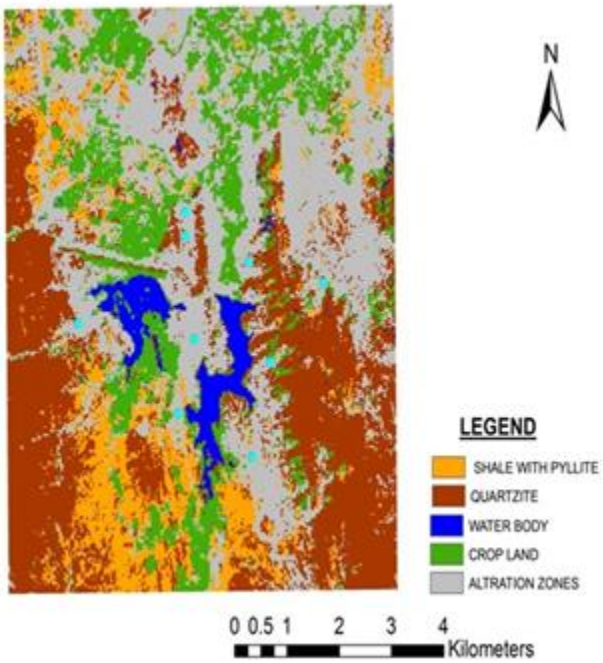
Histogram Equalization

Histogram equalization of a satellite image allows equal spreading of frequent intensity pixel values so that the spectral properties of every object caught in the satellite image can be effectively studied. Histogram equalization implies the uniform distribution of brightness values in the image. Before equalization show all the pixel values concentrated at its centre, but after the equalization the histogram show the distribution of the piexls in entire image. Hence the image subset of the study area is made histogram equalization to study the alteration features effectively.

Supervised Classification

Supervised classification is performed on the subset image by making used of one known area of alteration mineral zone to identify the other places with the same kind pixel values of reflection, so as to cross check the values after the delineation of spectral dispersion halos by using IDW method. Five classes have been taken in the present study namely Shale with phyllite, Quartzite, Water body, Crop land and finally the Alteration zones (Fig.2). However the supervised classification map show gray colour assigned to the alteration mineralized zone in entire subset image. To eliminate the weakly mineralized zones in the study area IDW method is applied to accurately mark the alternate mineralization zones

Fig. 2 Supervised classification of AOI



Inverse Distance Weighting

The Inverse Distance Weighting (IDW) assumes that things that are close to one another are more alike than those that are farther apart. To predict a value for any unmeasured location, IDW used the measured values surrounding the prediction location. The measured values closest to the prediction location have more influence on the predicted value that those farther away. IDW infers that each measured point has a local influence and diminishes with distance. It give greater weights to oints closest to the prediction location and the weights diminish as a function of distance (M.Arif et al., 2014).

Spectral Dispersion Halos

The surface geochemical signature of each mineral deposit is always unique in some respects due to differences in geological, geomorphological and environmental settings. Towards the electromagnetic emissions these signatures possess same kind of pixel values which could be named as Spectral Dispersion Halos and they are intended to illustrate the nature and origin of the surface expression of mineralization. In the present study these values are predicted by making use of one known value mineralized zone and applying same to the entire subset image through a method called Inverse Distance Weighting. The high concentration values of unknown location were examined by ground truth and found to be accurate Plate 3 & 4

Results and Discussion

The study area is present in north eastern part of the Kadapa (YSR) District. The area form the N-E part of the Cuddapah Basin. It is composed of Bairenkonda Quartzites and Cumbum shale formations of Nallamalai group of rocks belonging to the lower Cuddapah Supegroup of rocks. The rocks are partially metamorphosed and contain Quartzites, shales and phyllites.

The alteration minerals are hosted by the Carbonate rocks occurring at different levels within the Cumbum formation of Nallamalai group of Cuddapah Supergroup rocks. One known value of alteration minerals near Jangamrajupalli village of north eastern part of the Kadapa district is taken as reference. The pixel value of that point of interest has been used for supervised classification of the LANDSAT ETM + image georeferenced with 57 J/13 (Fig. 2)

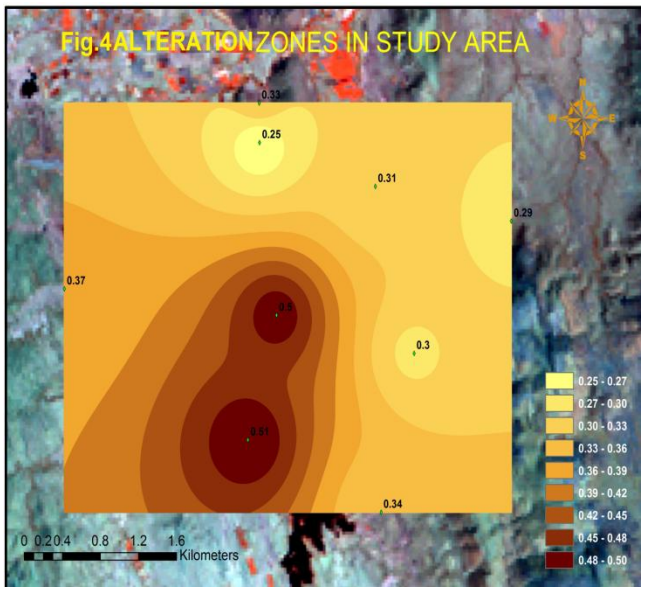
The identical spectral emission values are found to present within the hill tops composed of quartzites, barren land in the valley portions composed of carbonaceous shales. Subsequently when Inverse Distance Weighting method is applied, more concentration of alteration zones are identified within the carbonaceous shales near water bodies, where as the concentration is gradually decreased towards the margin of the subset image (Fig.3). The concentrations spectral dispersion halos are given in the table-2

The known electromagnetic emission value of 0.5 µm is obtained in the study area at longitude of 78º 53' 39.37" and latitude of 14º 47' 44.04". When this value is applied in IDW method the maximum reflection of 0.51 µm in the unknown location is found at longitude of 78º 53' 29.97" and latitude of 14º 47' 08.32" within the valley portion composed of shales near the water bodies. Low concentration value of 0.25 µm is obtained at longitude of 78º 53' 33.59" and latitude of 14º 48' 33.57" with moderate values shown in table-2 and Fig.3.

Table – 2 Spectral Signatures

Sl.No.	LONGITUDE	LATITUDE	SIGNATURE VALUES µm
1	78º 53' 39.37"	14º 47' 44.04"	0.5
2	78º 53' 29.97"	14º 47' 08.32"	0.51
3	78º 54' 14.95"	14º 46' 47.56"	0.34
4	78º 54' 26.19"	14º 47' 33.11"	0.3
5	78º 54' 12.98"	14º 48' 21.01"	0.31
6	78º 52' 27.11"	14º 47' 51.64"	0.37
7	78º 54' 59.26"	14º 48' 11.10"	0.29
8	78º 53' 33.47"	14º 48' 44.92"	0.33
9	78º 53' 33.59"	14º 48' 33.57"	0.25

Fig. 3 Spectral Dispersion Halos in the Study area



Ground Truth

Mineral exploration through a satellite image need to be counter corrected by checking the results in the ground, the process is called ground truth. Thus the results obtained in the above study have been verified going to the field and found to be more accurate and reliable.

Conclusions

Carbonaceous shales present in the study area are found to be host rocks for alteration zones. A series of image processing techniques like histogram equalization, supervised classification were performed in order to improve the quality of the image. Later Inverse Distance Weighting method is adopted for accurate determination of alteration zones. The IDW method is based on the principle of spatial autocorrelation. Nearer location which have more similar spectral reflectance can be more accurately delineated. It is a very flexible method of finding same kind of electromagnetic emission in a satellite image, irrespective of its spectral resolution. This could be counter checked by supervised classification of the area of interest with the known location.

Spectral emission values of 0.51µm with a spectral dispersion halo of very near values is obtained at about approximately 1.6 km away from the known value of spectral emission of 0.5 µm. The map shows around 3 Sq. km area as highly concentrate with 0.51 µm spectral values and 1-3 Sq.km area as moderately concentrated with 0.51 µm to 0.37 µm and remaining 3 Sq.km area as low concentrated zone with the spectral emission of 0.25 µm to 0.34 µm.

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