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Comprehensive Geochemical And Geospatial Study Of Yellow Ochre In Parts Of Ysr District, Andhra Pradesh, India

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Abstract

Yellow Ochre is naturally occurring Fe rich mineralwith major constituent of hydrated iron oxide. It is seen in several locations especially in villages of Muddanur, Vemula and Obulavaripalli mandals of YSRdistrict. The area of study falls within Cuddapah basin composed of Cuddapah supergroup rocks. The presentinvestigation deals with source identification, geochemistryusing ICP-MS and spatial analysis of Yellow Ochre through Landsat 8LlIsupported with field observations and by preparing data sets such as geology, geomorphology maps. The study revealed that the Yellow Ochre deposits in the study area are confined to structural hills which are comprising of shales of Tadipatriformation and Cumbum formationand quarztitesGandikota formation of Cuddapah Supergroup and falls withinthe Vemula mandal followed by Obulavaripalle and Muddanurmandals of YSR District. The yellow ochre is observed to have enriched Fe_2O_3percentages than the other rocks in the succession.

Keywords: *Yellow Ochre, Geochemistry, Geology, Geomorphology, ICP-MS, Landsat8LlI and YSR District.*

INTRODUCTION

Ochre is a natural earth pigment of hydrated iron oxide (Cornell *et al.,* 1996, Stephen et al., 1995, Hradil *et al,* 2003). The Indian history reveals the use of ochres and clay pigments in the art works dates back to ancient periods (Bhattacharya, 1976; Seth, 2006; Siddall, 2018). It ranges in colour from yellow to deep orange, red and brown (Smith, et al., 1998: Velliky *et al,* 2018). The colour of the ochre depends on the content of hematite or hydrated iron oxides called limonite. Ochre is a family of earth pigments that include 1) Yellow ochre (FeO (OH).nH_2O) composed of hydrated iron hydroxide known as limonite, 2) Red ochre, (Fe_2O_3) composed of anhydrous iron oxide called hematite, 3) Brown ochre (FeO (OH), a partly hydrated iron oxide and 4) Sienna ochre, composed of both limonite and manganese oxide, due to which it show dark colour than yellow ochre (IBM Year Book, Ochre, 2013). It is an inorganic colour pigment (Industrial Mineral and Their uses, hand book 1996). As clays used to make the earthcoloursin pigment terminology, the word ochreis predominantly used as a synonym for yellow ochre. Hydrated iron oxide gives yellow colour, anhydrous iron oxide gives red colour and a mixture of ferrous and ferric oxide gives brown colour to the

mineral. These deposits are widely distributed in India, chiefly in Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan. In Andhra Pradesh clay deposits found to occur in West Godavari, Visakhapatnam, Guntur, Kurnool and YSR Districts.

The Ochre mineral deposits are seen in several parts of YSR Districtthat are related to the ferruginous shale intercalations of the Vempalle formation, Papaghni group, Tadipatri shale formation of Chitravati group and Cumbum shale formation of Nallamalai group of Cuddapah Supergroup which has been using as pigment agent since ancient times. Earlier there were very limited literature regarding Yellow Ochre deposits in YSR District (GSI Report 2015; Reddy et al, 2015).. Hence, the present investigation focused on geochemistry, source identification and spatial analysis of Yellow Ochre using various techniques.

STUDY AREA

The potential Yellow Ochre deposits occur in three different mandalsviz.,Muddanur(77^{0}56′54.374″E, 14^{0}34′3.089″N to 78^{0}23’44.218”E, 14^{0}30’44.129”N, Vemula (78^{0}8`34.448``E, 14$^0$22`916``N to 78^{0}31`46.258``E, 14$^0$20`14.937``N and Obulavaripalle (78^{0}8`34.448``E, 14$^0$22`19.916``N to 79^{0}14`57.654``E, 14^{0}6` 28.22 " N) (Figure 1). The village-wise coordinates of the study area are given in Table 1.

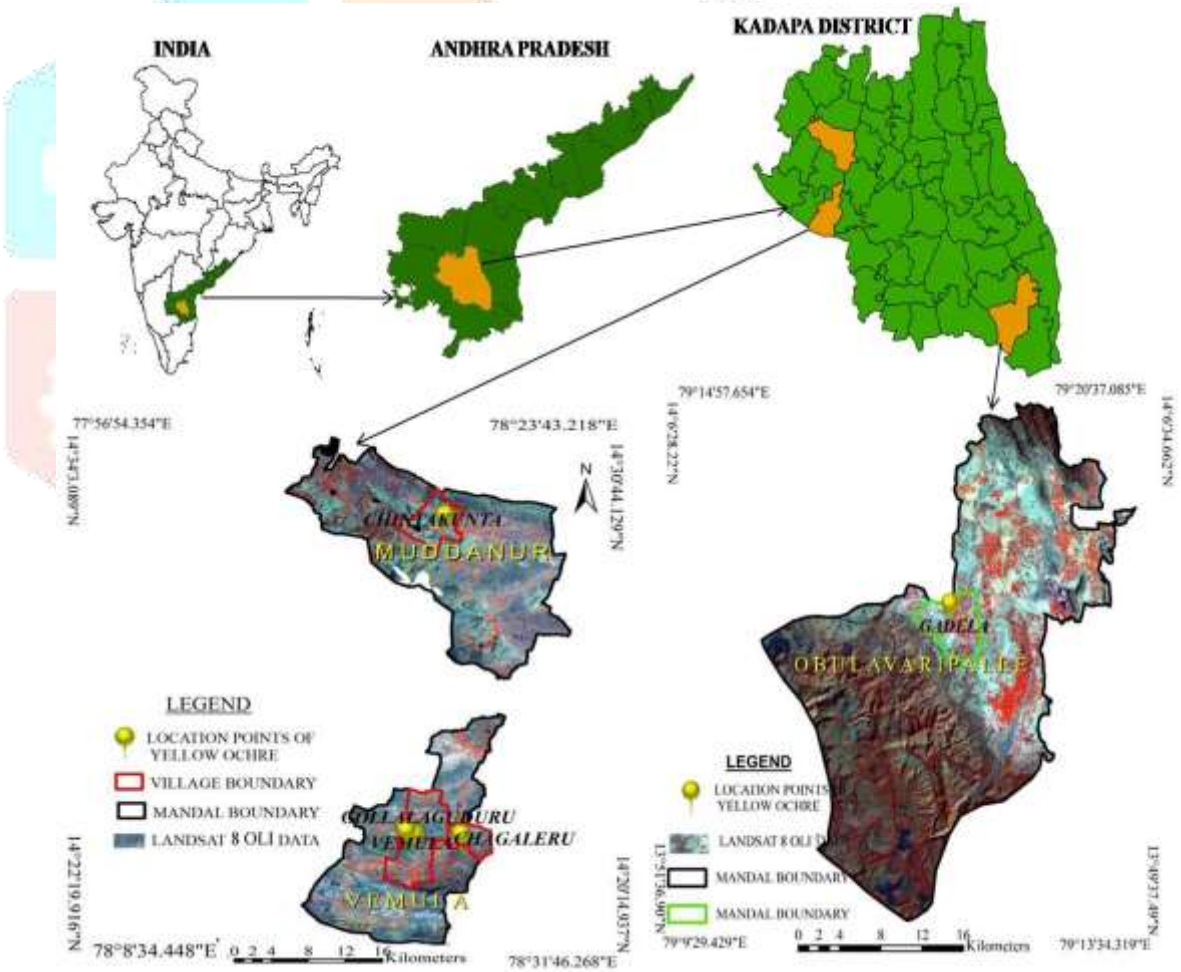

Figure 1: Location Map of Yellow Ochre in the study area

Table 1 VillagewiseCoordinates of Yellow ochre

Sl.No	Village name	Mandal Name	Coordinates
1	Vemula	Vemula	$78^0$19'4"E, $14^0$23'55"N
2	Gollalaguduru	Vemula	$78^0$18'40.18"E, $14^0$23'36.5"N
3	Chintakunta	Muddanur	$78^0$20'33"E, $14^0$42'20"N
4	Chagaleru	Vemula	$78^0$21'40.27.5"E, $14^0$23'35"N
5	Gadela	Obulavaripalle	$75^0$14'15"E, $14^0$0'10"N

Geology of the Study area

The ochre mineralization occurs in two different divisions in the YSR District, one is at the western margin of the district and the other is in the southern margin. However the parent rock in both the divisions is shale of different age. The other rock formations in the western division are quartzites, dolomites and basic intrusive. The rocks belong to the stratigraphic succession of Gandikota quartzite of Gandikota quartzite formation, shale, dolomite, quartzite of Tadipatri formation, quartzites of Vempalle formation, quartzites of Gulcheru formation and basic flows in the form of sills above the Vempalle formation of lower and middle Cuddapah Supergroup (Figure 3). The mineralization in the entire southern division is confined to shale and phyllites belonging to the Cumbum formation of Nallamalai group of Upper Cuddapah Supergroup (Figure 3a). The image characteristics of the rock formations of the study area are given in Table 2 (B.K.Nagarajarao et al., 1987).

Geomorphology of the Study Area

The geomorphology of the mineralized area can be studied in two distinct divisions with reference to the district. First division occurs in the western side of the district consisting of Muddanur and Vemula mandals and the second division is at the southern margin of the district consisting of Obulavaripalle mandal of YSR District. Villages in the western division are Chintakunta, Gollalaguduru,Chagaleru and Vemula. The Chintakunta village of Muddanur mandal shows geomorphological features like Residual hills, Structural hill, Pediment and Pediplain, but the Muddanur mandal is dominated by the Pediplain. Gollalaguduru, Chagaleru and Vemula villages of Vemula mandal is dominated by Pediplain along with Residual hills, Structural hills, Pediment, structural valley (Figure 2). In the southern part of study area Structural hills, Pediplains were dominated (Figure 2a).

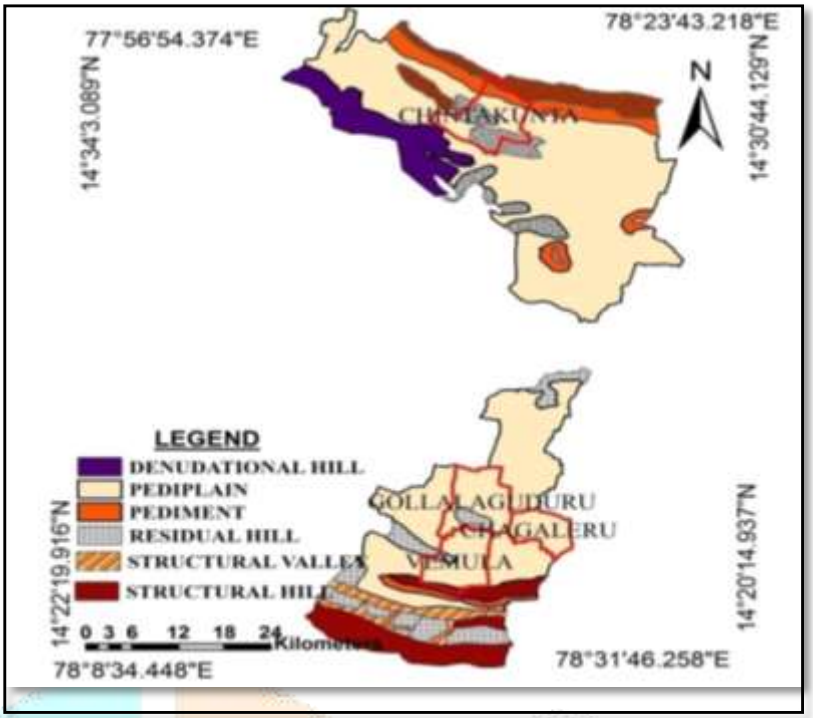

Figure 2: Geomorphology Map of study area in Western part

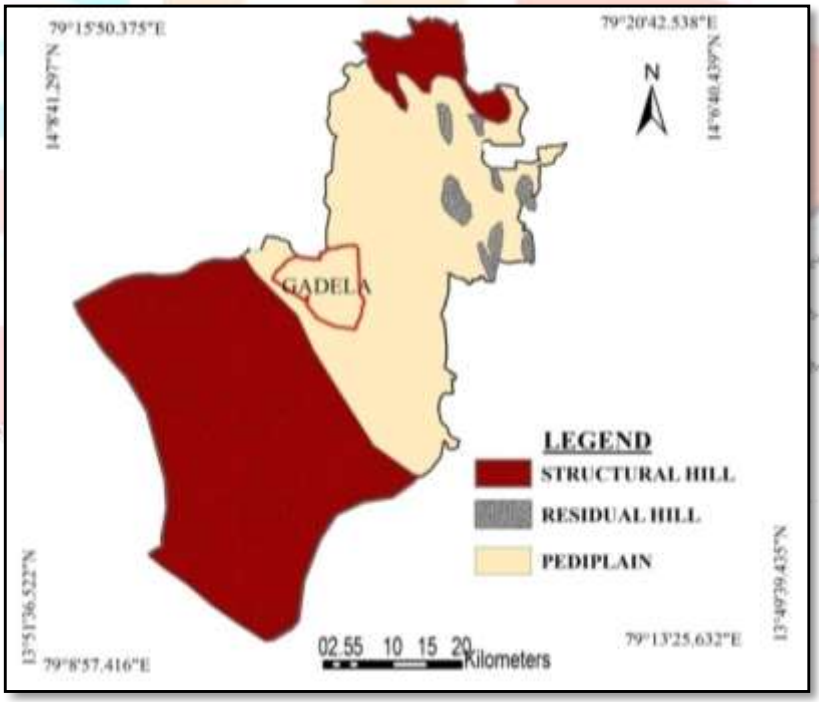

Figure 2a Geomorphology Map of study area in Southern part

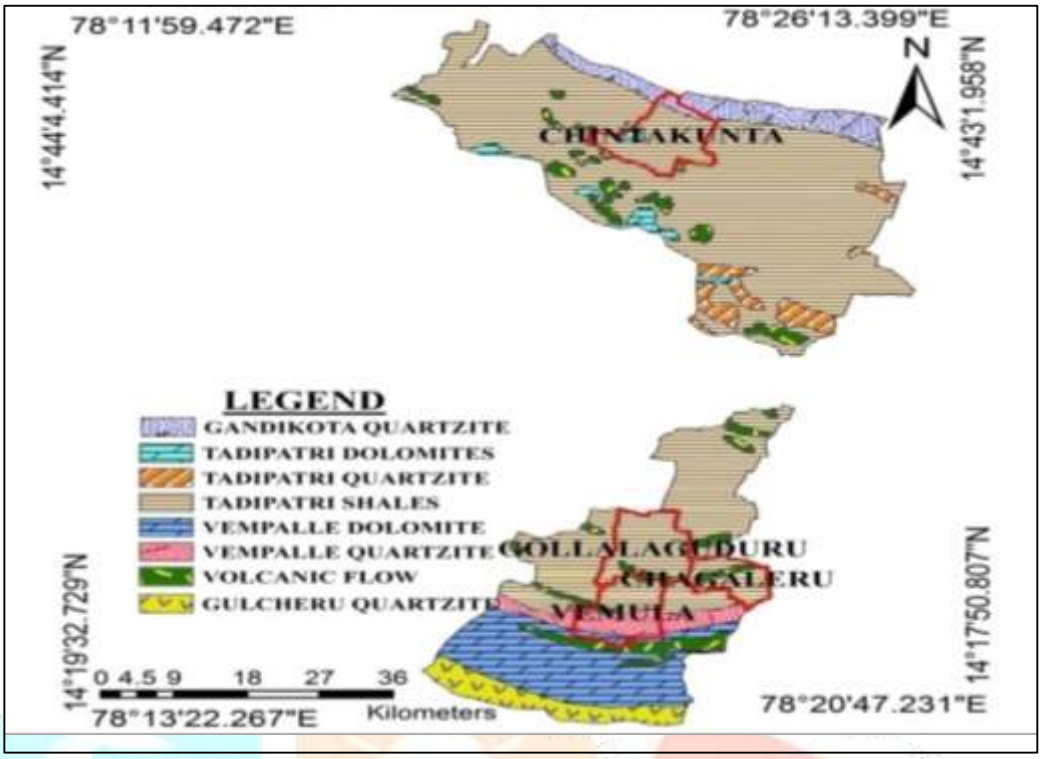

Figure – 3 Geology map of study area in Western part

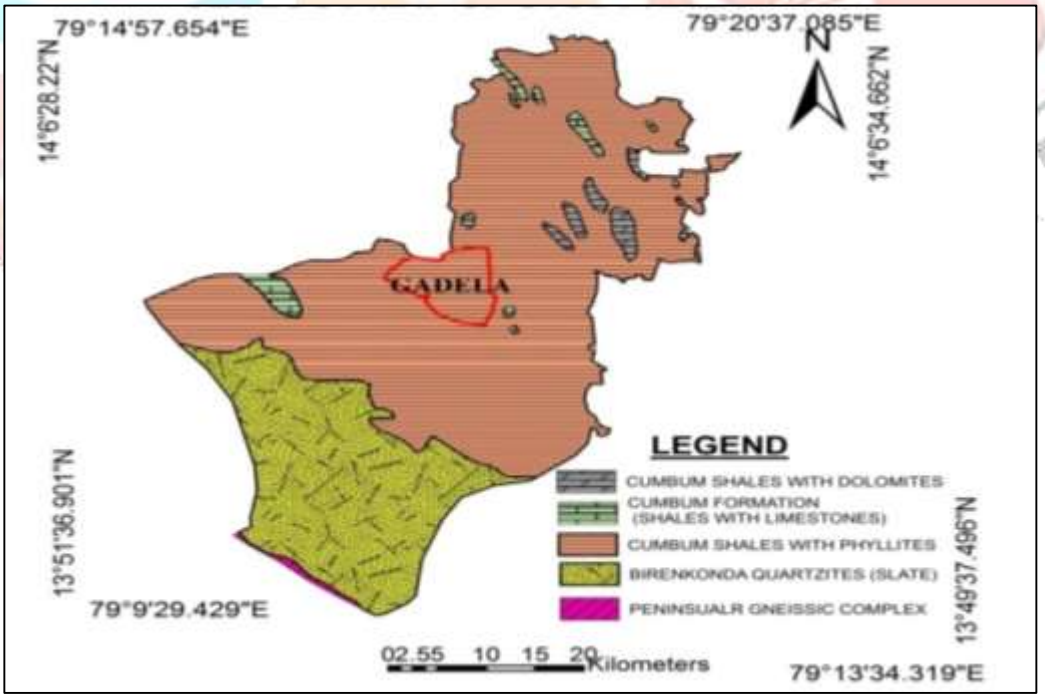

Figure - 3a Geology map of study area in Southern part

Table2: Image Characteristics of various geological units

Sl.No	Village name	Rock Type/Lithounits	Image Characteristics		
			Tone	Texture	Drainage pattern
1	Chintakunta	Tadipatri Dolomites	Lighter	Smooth	Dendritic
		Tadipatri shales	Darker	Smooth	Dendritic
		Gandikota Quartzite	Lighter	Smooth	Parallel
2	Gollalaguduru	Tadipatri Shales	Darker	Smooth	Dendritic
		Volcanic flows	Darker	Coarse	Parallel
3	Chagaleru	Volcanic flows	Darker	Coarse	Parallel
		Tadipatri Shales	Darker	Smooth	Dendritic
4	Vemula	Vempalle Dolomites	Lighter	Smooth	Dendritic
		Vempalle Quartzites	Lighter	Coarse	Rectangular
		Volcanic flows	Darker	Coarse	Parallel
		Tadipatri Shales	Darker	Smooth	Dendritic
5	Gadela	Cumbum Shales with Phyllites	Lighter	Smooth	Dendritic

Methodology

The Ochre samples were collected and analysed using standard procedures in the Department of Mines of Geology lab, Kurnool and Bhagavathi Anna lab (Pvt.), Hyderabad for chemical obtaining chemical data. It includes data collection, sampling, data analysis, report generation etc. The samples were collected in the mineralizing zones and the GPS point of each location for mineral was noted. Then the source identification was performed by geology and geomorphology maps which were generated using existing literature andLandsat8LlIwhich was Georeferenced by using ArcGIS 10.1 Software. Field checks also performed in order to avoid spatial discrepancies. Finally, village wise mineral percentage map was prepared by using ArcGIS 10.1 software. The detailed methodology is given in Figure 4.

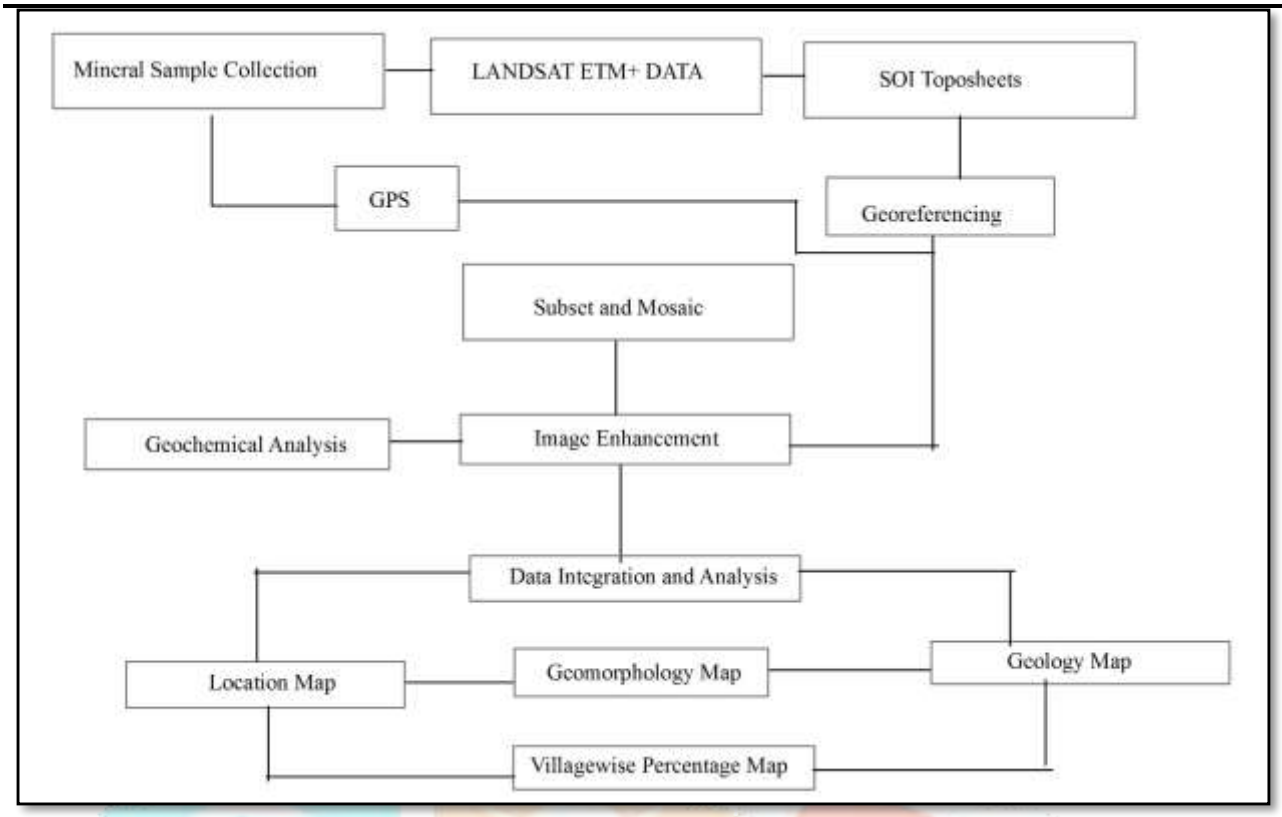

Figure 4 Flow chart showing the methodology of the present study

Results and Discussion

The study area consisting Ochre deposits are formed in to two divisions, the western part consisting of four villages namely, Chintakunta, Chagaleru, Gollalaguduru, Vemula, and the southern part consisting of Gadela village. The file samples from each village were collected and analysed in the laboratory for percentage of mineral.

Vemula

The rock formation in Vemula area belongs to the Vempalle formation of Papaghni group of lower Cuddapah system constituting mainly shales and traps. The source rocks in Vemula village of Vemula mandal are ferruginous shales of Vempalle formation. Yellow Ochre deposits in this area occur within latitudes of $14^0$23'55"N, longitude of $78^0$19'4"E and falls in SOI toposheet No. 57J/7. The strike of the ore body is N75^0W S75^0 and dipping at 11^0 towards north east. The process of weathering and alteration of ferruginous shales result in the formation of yellow Ochre occurring 0.5m below the trap boulders. The yellow ochre is a typical alteration mineral in which Iron Oxide is highly diffused. They have prominent colour and are used as pigment in paints and also used in ceramic industry. A total of five samples of yellow ochre have been collected from Vemula village. The Fe_2O_3 content of yellow ochre deposits of Vemula village is of 8.49%. The detailed geochemical analysis of Yellow ochre of Vemula is shown in Table 3.

Table 3 Geochemistry of Yellow Ochre of Vemula village

Sl.No.	Test parameters (% by mass)	Results obtained
1.	Silica as SiO_2	61.72
2.	Iron as Fe_2O_3	8.49
3.	Alumina as Al_2O_3	14.30
4.	MgO	2.20
5.	CaO	2.80
6.	Na_2O	2.20
7.	K_2O	1.80
8.	TiO_2	0.52
9.	Loss on ignition LOI	7.16

Gollalaguduru

The source rock formations of Yellow Ochre, outcropping in the Gollalaguduru village of Vemula mandal are ferruginous shales belonging to Tadipatri shales of Chitravati group of Cuddapah Supergroup of rocks. The village is situated within the latitude $14^0$23'36.5"N, longitude of $78^0$18'40.18"E and falls in the SOI Toposheet No. 57J/7. The entire area is covered with top soil having 0.5 to 1 m thickness and followed by Yellow Ochre. Old workings in this area indicate that Yellow Ochre occurring in the entire study area up to 30mts thick general surface and followed by dolerite trap rocks. The general trend of formations is N-W-S-E and dipping towards NE with dip ranging from 8^0 to 10^0. Samples of yellow ochre are collected from Gollalaguduru and the chemical analysis of the samples show an average Iron Fe_2O_3 content 7.44%. The detailed geochemical analysis of Yellow Ochre of Gollalaguduru is shown in Table 4.

Table 4 Geochemistry of Yellow Ochre of Gollalaguduru village

Sl.No.	Test parameters (% by mass)	Results obtained
1.	Silica as SiO_2	53.64
2.	Iron as Fe_2O_3	7.44
3.	Alumina as Al_2O_3	16.62
4.	MgO	2.80
5.	CaO	2.80
6.	Na_2O	1.40
7.	K_2O	3.11
8.	TiO_2	0.96
9.	Loss on ignition LOI	10.26

Chintakunta

Chintakunta village is present in South of Muddanur mandal, between latitude of $14^0$42'20"N, longitude of $78^0$20'33"E, falls in SOI toposheet No. 57J/6 and is constituted by the Shale unit of Tadipatri formation of Chitravati group of Cuddapah Supergroup. In this area basic sills are very conspicuous intruding into the shale. The Tadipatriformation is capped by Paniam Quartzite in the area under discussion. The trend of formation is WNW-ESE with northerly dips. This has the shale in the lower stratigarphical level unconformably followed by the white sachrodial quartzite belonging to the Paniam Quartzite of the Kurnool Group. The quartzite represents 'Mesa' type of landform. In addition there are loose boulders rolled down from the top, which have a pinnacle nature. These pinnacles rolled down the slope and are stabilized. The pinnacle nature is the characteristic of the Paniam Quartzite. Yellow Ochre is a weathered product of basic rocks, shale and ferruginous quartzite. In the Chintakunta area Ochre might have formed from the shale and ferruginous quartzite. The percentage of Fe_2O_3 in Yellow Ochre is 4.01%. The detailed geochemical analysis was shown in Table 5.

Table 5 Geochemistry of Yellow Ochre of Chintakunta village

Sl.No.	Test parameters (% by mass)	Results obtained
1.	Silica as SiO_2	70.04
2.	Iron as Fe_2O_3	4.01
3.	Alumina as Al_2O_3	16.52
4.	MgO	0.5
5.	CaO	0.98
6.	Na_2O	1.1
7.	K_2O	1.35
8.	TiO_2	0.20
9.	Loss on ignition LOI	10.26

Chagaleru

The rock formation outcropping in Chagaleru village of Vemula mandal are Tadipatri shale formation of Chitravati group of Cuddapah Supergroup. The entire area is covered with top soil with 0.5 to 1mt thickness and followed by Yellow Ochre. The general trend of the formations is northwest-southeast and dipping towards north-east with dip ranging from 8^0 to 10^0. The area occurs within $14^0$23'35"N latitudes, $78^0$21'40.27.5"E longitudes and falls under SOI toposheet No. 57J/7. The mineral Yellow Ochre having over 11.80% Iron Oxide (Table-6) is useful only in Ceramic Industry (Table 6).

Table 6 Geochemistry of Yellow ochre of Chagaleru village Gadela

Sl.No.	Test parameters (% by mass)	Results obtained
1.	Silica as SiO_2	57.15
2.	Iron as Fe_2O_3	11.80
3.	Alumina as Al_2O_3	18.20
4.	MgO	0.80
5.	CaO	2.24
6.	Na_2O	1.35
7.	K_2O	0.82
8.	TiO_2	0.05
9.	Loss on ignition LOI	7.56

The rock formations in Gadela village of Obulavaripalle mandal are ferruginous Bairenkonda quartzites and Cumbum shale formations of Nallamalai group of Cuddapah Supergroup. The village is situated between $14^0$0'10"N latitudes, $75^0$14'15"E longitudes and falls within the SOI toposheets 57N/4, 57N/8, 57NO/1, and 57O/5. The Cumbum shales are the dominant rock type occurring within the study area and its surroundings. These shales are exposed in nala cuttings and adjacent old mine workings but in most parts, these shales are covered by 1.0m to 2.0 m thick cover of lateritic pebbly soil. It occurs here as alteration product of ferruginous shales. The Cumbum shale is generally purple in colour with bands of yellow and whitish shades. Old workings southern-western limb of the study area have exposed yellow Ochre laying under a 1.2m to 1.5m thick laterite soil overburden. Yellow ochre seems to be confined to a small portion in the south-western part. There is no major fault or fold in and around the study area. The Bedding strike of shale and clays is N15^{0}E-S15^{0}W with south-easterly dips of 20^0 to 30^0.The mineral produces proposed to be sold consumers in Andhra Pradesh. The white clay will be sold to refractory units whereas yellow Ochre to paint industry and traders dealing in colour wash material. The market will depend upon the quality of material produced. It shows 5.92% of $Fe_2O_3$of Yellow Ochre in Gadela village. The other constituents are shown in Table 7.

Table 7 Geochemistry of Yellow ochre of Gadela of village

Sl.No.	Test parameters (% by mass)	Results obtained
1.	Silica as SiO_2	53.64
2.	Iron as Fe_2O_3	5.95
3.	Alumina as Al_2O_3	19.82
4.	MgO	1.68
5.	CaO	1.35
6.	Na_2O	0.32
7.	K_2O	0.82
8.	TiO_2	5.62
9.	Loss on ignition LOI	10.6

Conclusion

The study revealed that the source of Yellow Ochre in the study area is shales and quartzites which further endorsed by geology and geomorphology maps prepared by Landsat 8LlIdata.The geochemical analysis resulted that the Vemula mandal shows the highest Fe_2O_3% of 11.80 followed by Obulavaripalli and Muddanur with Fe_2O_3% are of 5.95% and 4.01%. Then the village wise percentage of yellow Ochre maps

were prepared (Figure 4 and 4a). This helps in choosing mining of Yellow Ochre mineral at a glance for the sustainable development of the study area.

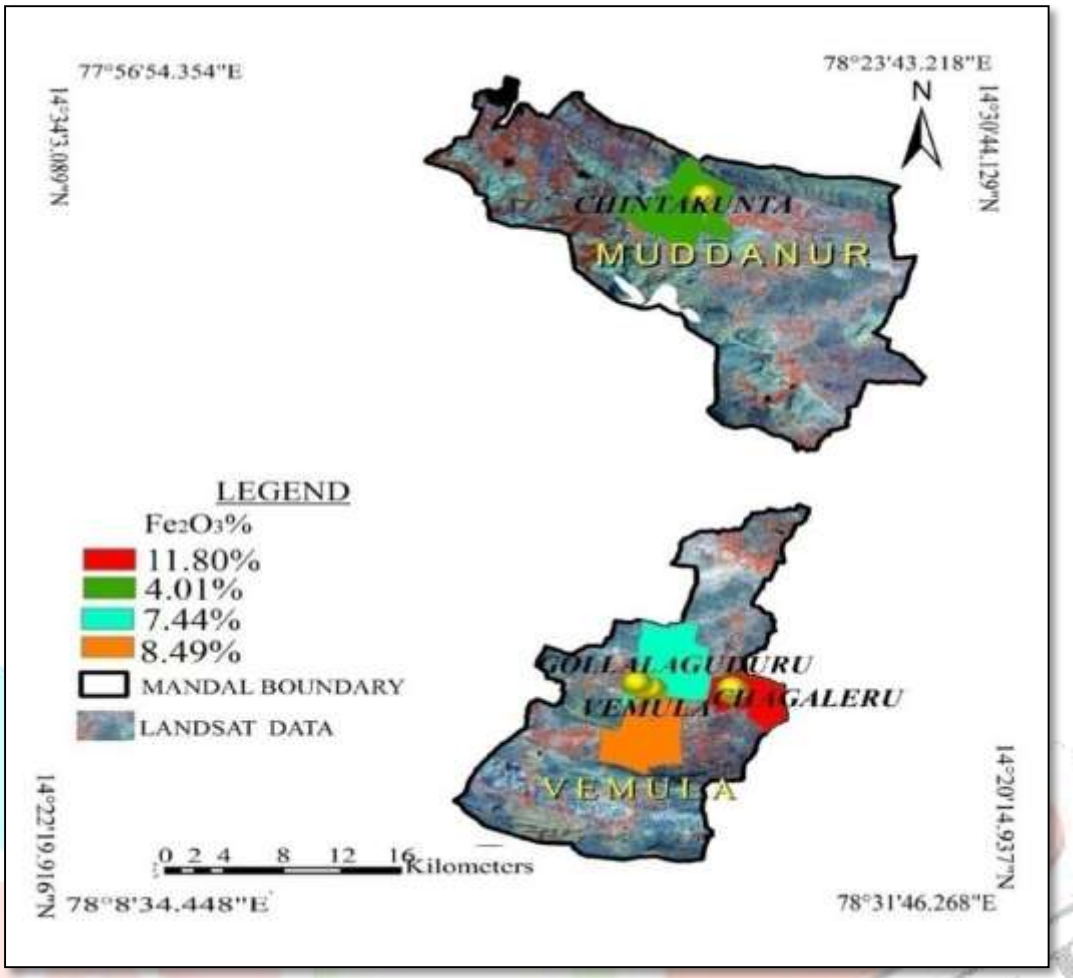

Figure 4:Map showing Villagewise Percentage of Yellow Ochre in Western part of YSR District

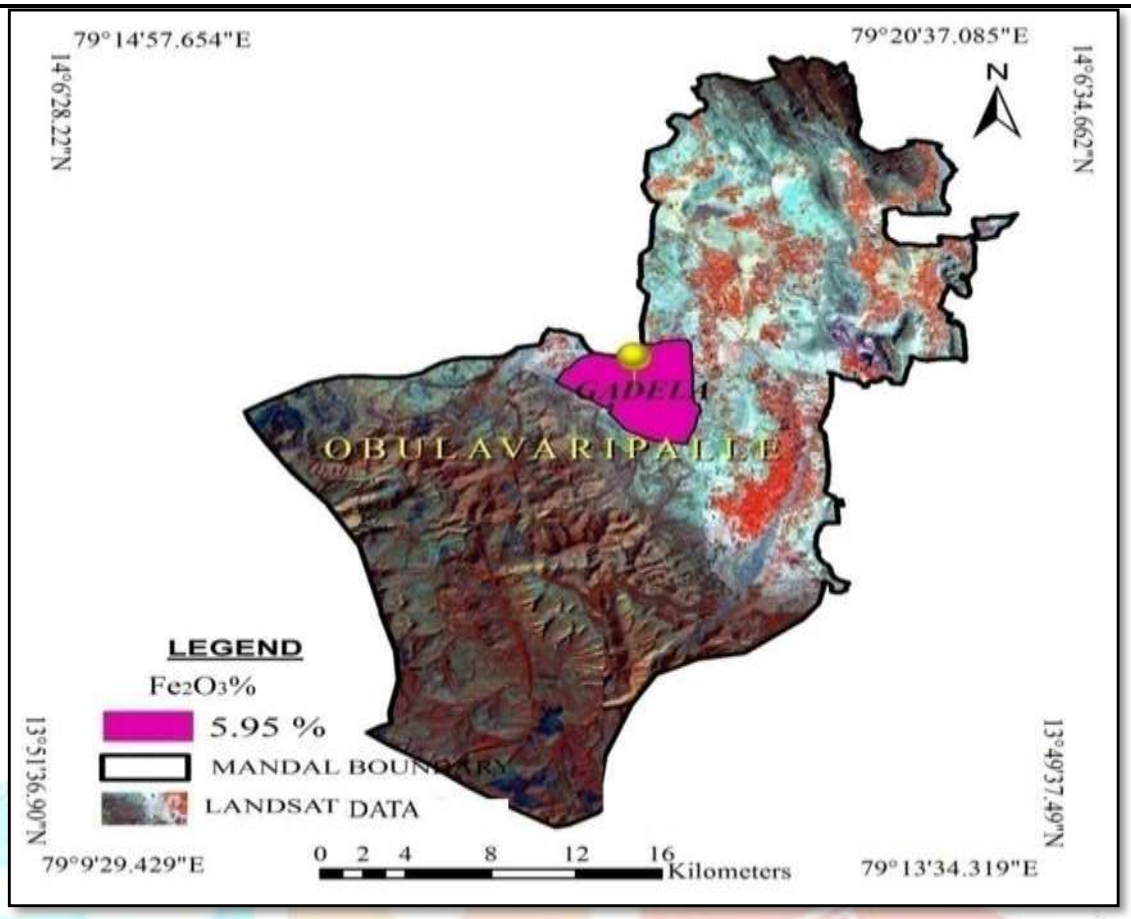

Figure 4a Integrated Map showing Villagewise Percentage of Yellow Ochre in Southern part of YSR District

Plate 1 Field Photo of Yellow Ochre in Gollalaguduru village

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