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Reporting of Rare Earth Element and Heavy Metals through Geochemical Mapping in Quaternary Deposit of Costal Andhra Pradesh

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ABSTRACT :

The Geochemical mapping in parts of Quaternary deposit of Prakasam district, Andhra Pradesh The higher values of LREE are recorded due to presence of monazite in the beach sand. It varies from 83.94 ppm to 992.64 ppm with median values of 226.41 The threshold values for LREE is 598.53, whereas HREE is varies from 7.57 ppm to 101.48 ppm with median values of 20.58 The threshold values for HREEs is 50.03 The elevated values obtained might be due to presence of monazite and garnet respectively. It is observed that LREE content is comparatively more than the HREE. Au and Ag (max value = 0.7 ppm) anomalous zone were observed over granitic gneiss with profuse intrusion and epidotization

Key words: Quaternary Alluvium, REE’s, Uranium, Thorium, Silver, Niobium, Hafnium.

Introduction

The Rare Earth Elements (REE’s) and the other associated Heavy minerals i.e. Niobium (Nb), Tantalum (Ta), Thorium (Th), Uranium (U), Hafnium (Hf) & Zirconium (Zr) are categorized as critical and strategic minerals in the concurrent global economic scenario (Binnemans et al., 2018). In the present state of knowledge, nearly 250 REE’s bearing mineral phases ranging from Carbonate, Halide, Silicate, Oxide to Phosphate have been identified. The common REE bearing minerals are Bastnasite (Ce/La/Y)(CO3)F, Fluocerite (Ce,La)F3, Uraninite (U,Th,Ce)O2, Euxenite (Y,Ca,Ce,U,Th)(Nb,Ta,Ti)2O6, Monazite (Ce,La,Nd,Th)PO4, Xenotime (Y) YPO4, Zircon ZrSiO4, Allanite (Ce/Y)(Ce,Ca,Y)2(Al,Fe2+,Fe3+) 3(SiO4)3(OH) (Bradley et al., 2014; Jordens et al., 2013). And Zircon is the most abundant Hf bearing mineral. But the Bastnäsite, Monazite and Xenotime are the only mineral phases utilized for commercial extraction for REE’s, (Jordens et al., 2013) and Zircon is for Hf & Zr (Hedrick, 2002; Pirkle and Podmeyer, 1993). The diversified use of REE’s in high technology applications such as high-strength permanent magnets, catalysts for petroleum refining, metal & glass additives and phosphors used in electronic displays etc. has increased their demand exponentially in last few decades. Placer type deposits for the REE’s and associated heavy minerals are reported from different parts of the globe (Bradley et al., 2014). Nowadays, the placer deposits of Rare Earth Elements (REE’s) and the other associated Heavy minerals play a vital and deterministic role in defining the position of any nation in the global economy. The countries like India, West Australia, South Africa, and Madagascar own the commercially viable economic concentrations of REE’s

within the beach sand placers (Castor and Hedrick, 2006). Ali et al., 2001 has reported 21 Million tonnes (Mt) of Zircon, 8 Mt of Monazite, 348 Mt of Ilmenite, 107 Mt of garnet, 18 Mt of Rutile and 130 Mt of Sillimanite as Indian resources within placer minerals from the 6000 km long Indian shoreline. The total Monazite resources in the beach and inland placer deposits of India had been estimated as 11.935 million tonnes (IBM, 2017 Year Book).

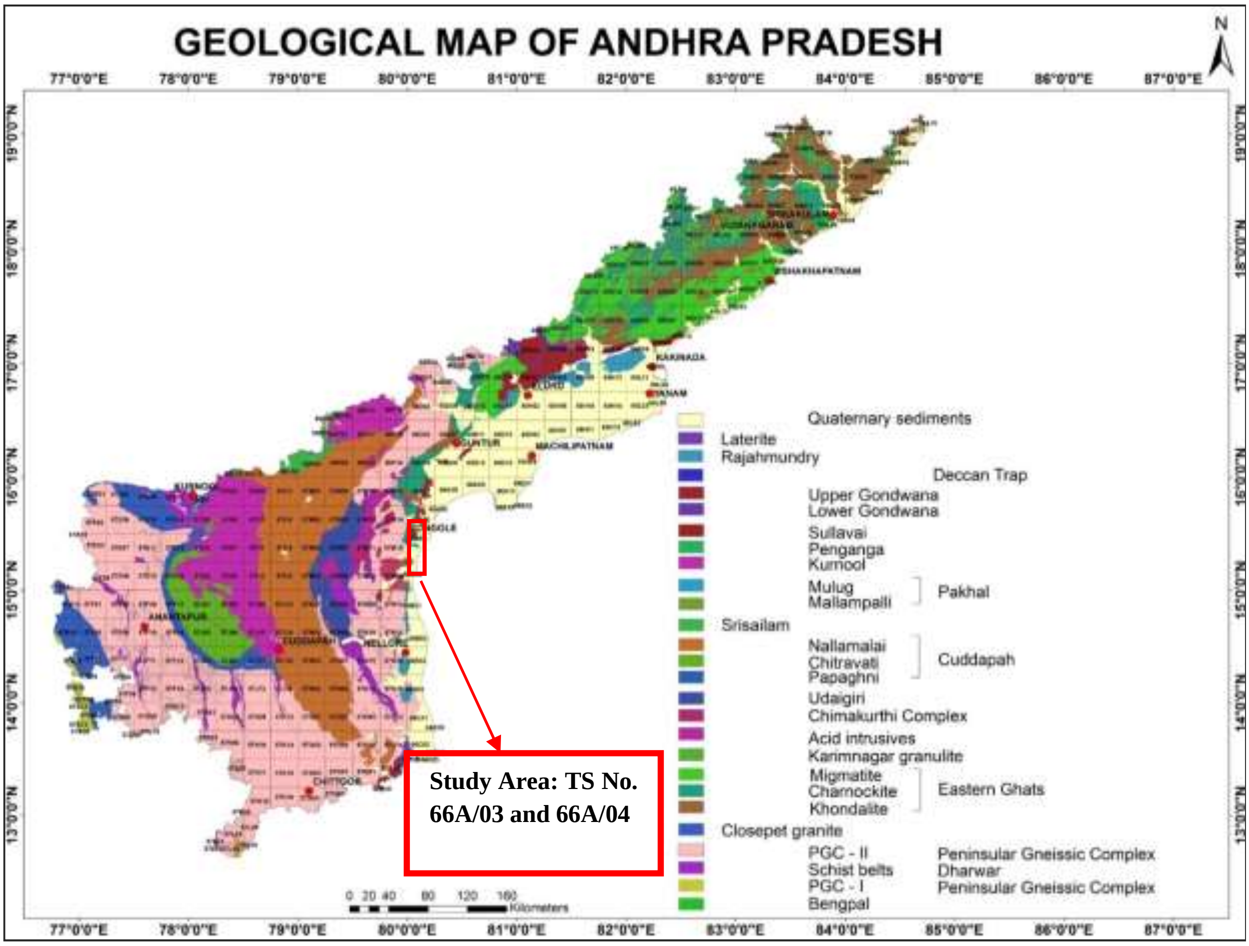

Fig 1: Geological map of Andhra Pradesh showing location the study area.

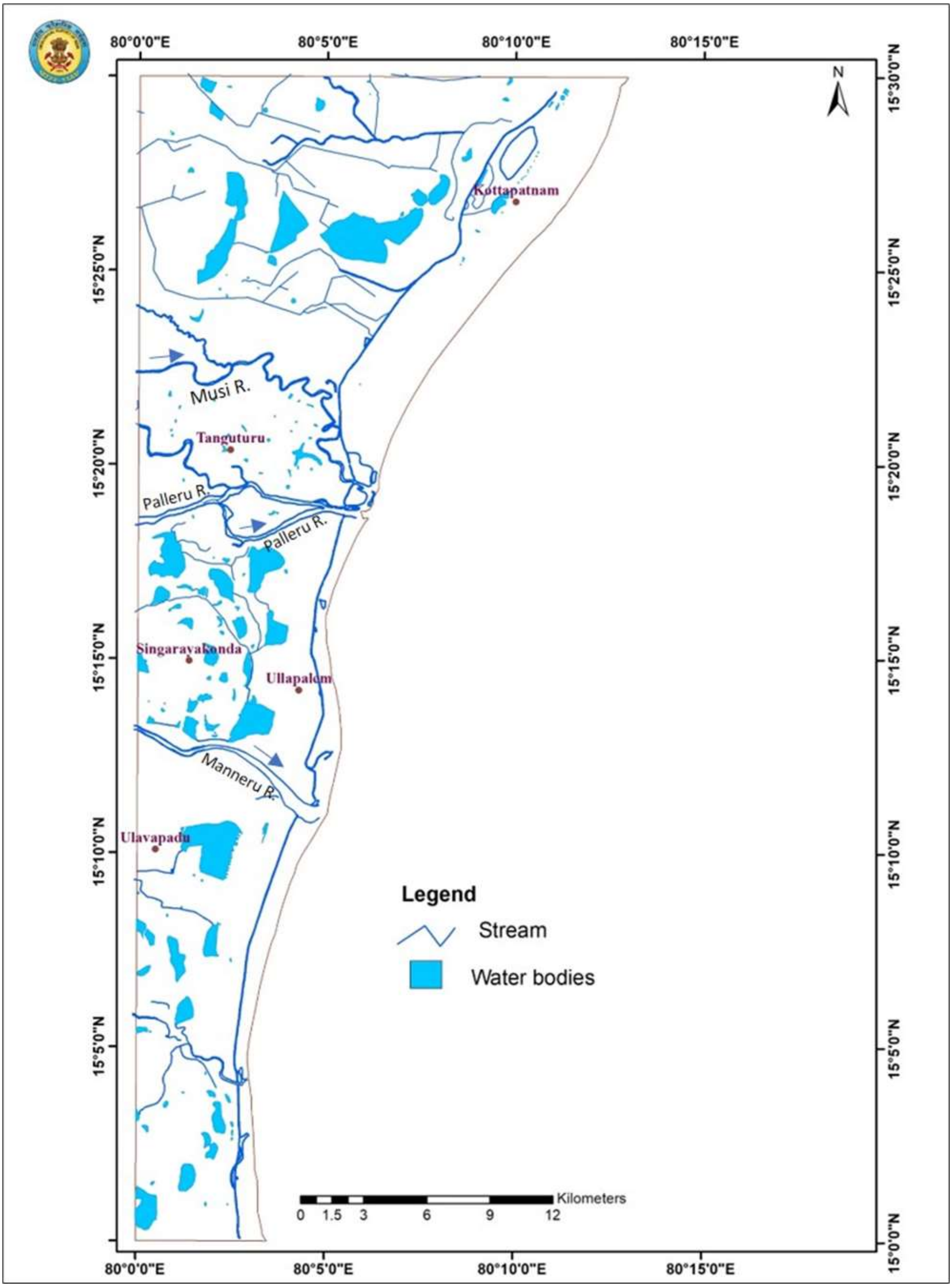

Fig. 2: Drainage map of study area, Toposheet Nos. 66A/3 and 66A/4.

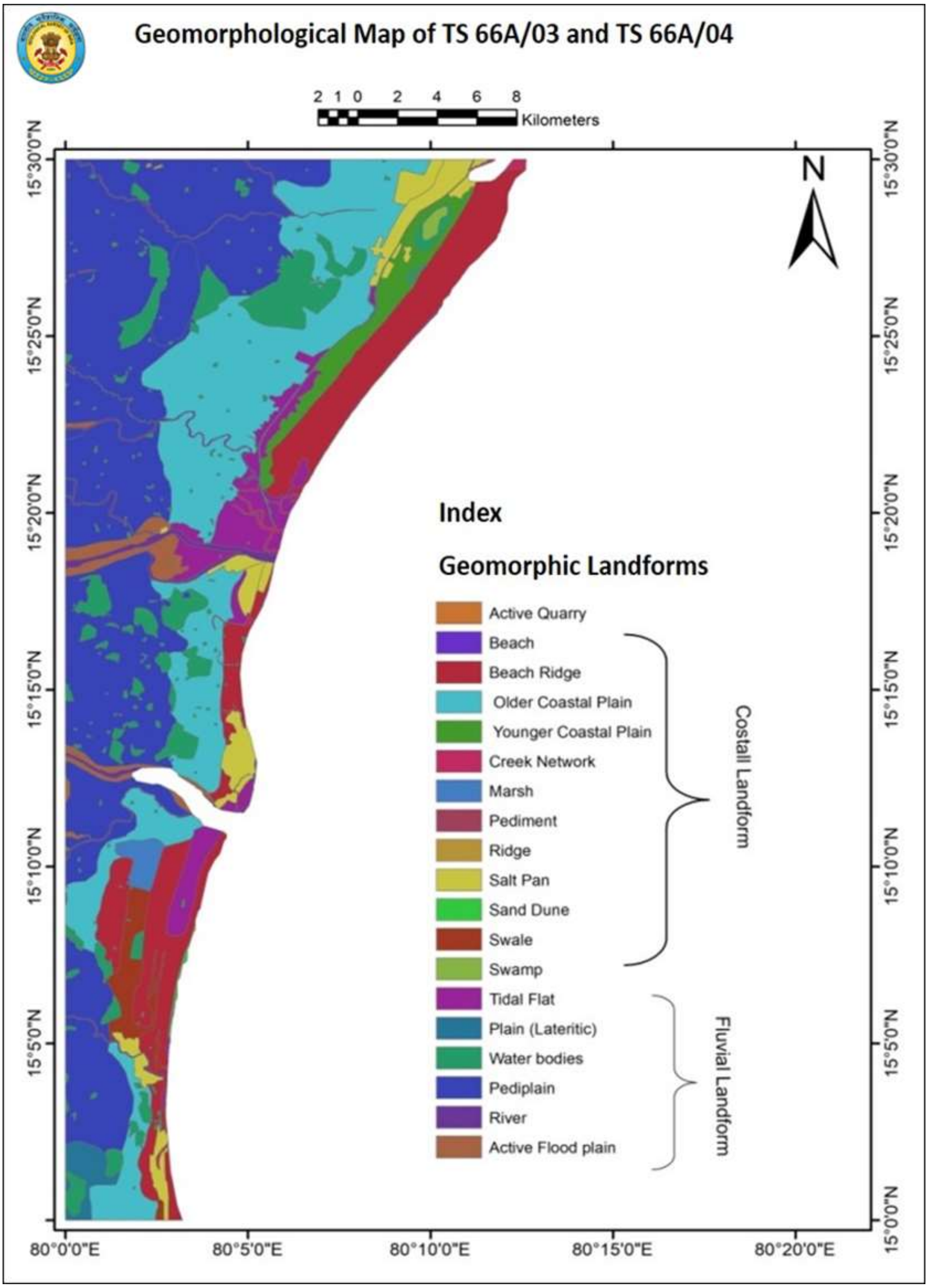

Fig. 3: Geomorphological map of study area, Toposheet Nos. 66A/3 and 66A/4.

Regional Geology

Regionally, the area marks the western part of the south-western tapering end of the Eastern Ghats Mobile Belt (EGMB) in juxtaposition with Gondwana Supergroup of rocks at the eastern side. Traversing eastward, after the Gondwana Supergroup of rocks, Krishna Godavari Group of rocks with Quaternary sediments are found near to the coastal tract of Bay of Bengal (nearest popular beach is at Kothapatnam near to Ongole). To the west of EGMB lies the contact with Peninsular Gneissic Complex (PGC)-II Group of rocks. At the south-western side Chimakurthy Complex of Mesoproterozoic age, an important geological domain in the Eastern Dharwar Craton is found at the junction zone between the Eastern Dharwar Craton and EGMB. Further south, northern part of Nellore Schist Belt hosts a number of younger felsic to alkaline-mafic intrusives constitute Prakasam Alkaline Province.

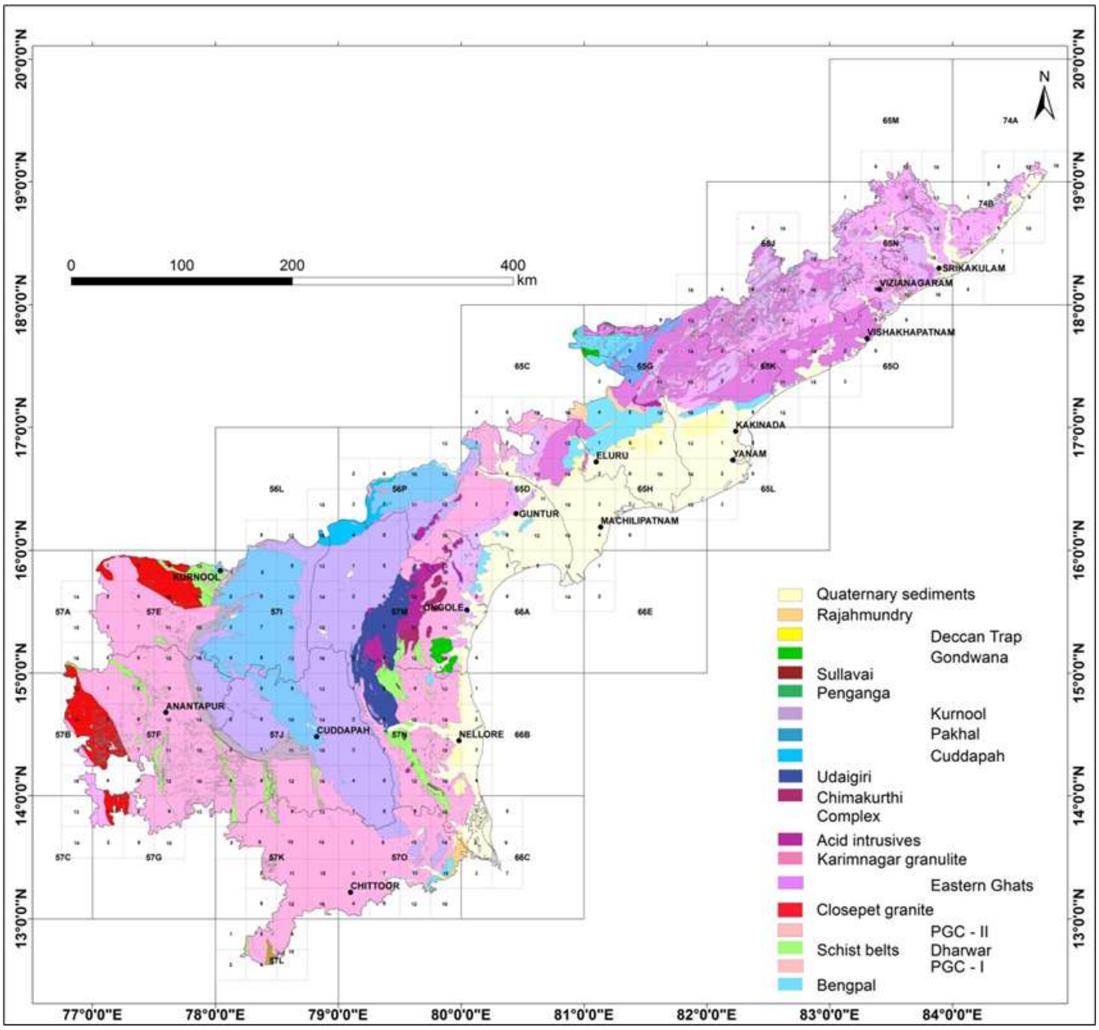

Fig. 4: Geological map of Andhra Pradesh

Geology of study Area

The area forms the south-eastern coastal plain of Andhra Pradesh with extensive Quaternary sediments overlying Charnockite and Migmatite Suites of the Eastern Ghats Granulite Belt in the north. Nearly half of the exposed area is made up of fluvial and marine sediments, and the remaining half by charnockite and other associated rocks of the EGGB with minor laterite in the north-western part. The fluvial sediments are represented by floodplain deposit and active channel deposit of Musi Formation/ Gundlakamma Formation. The marine sediments are paleo-tidal flat deposit, paleo-beach ridge deposit of Kaikalur Formation and active beach ridge deposit, active tidal flat deposit, tidal channel deposit of Polatitippa Formation and coastal dune deposit of Pedana Formation.

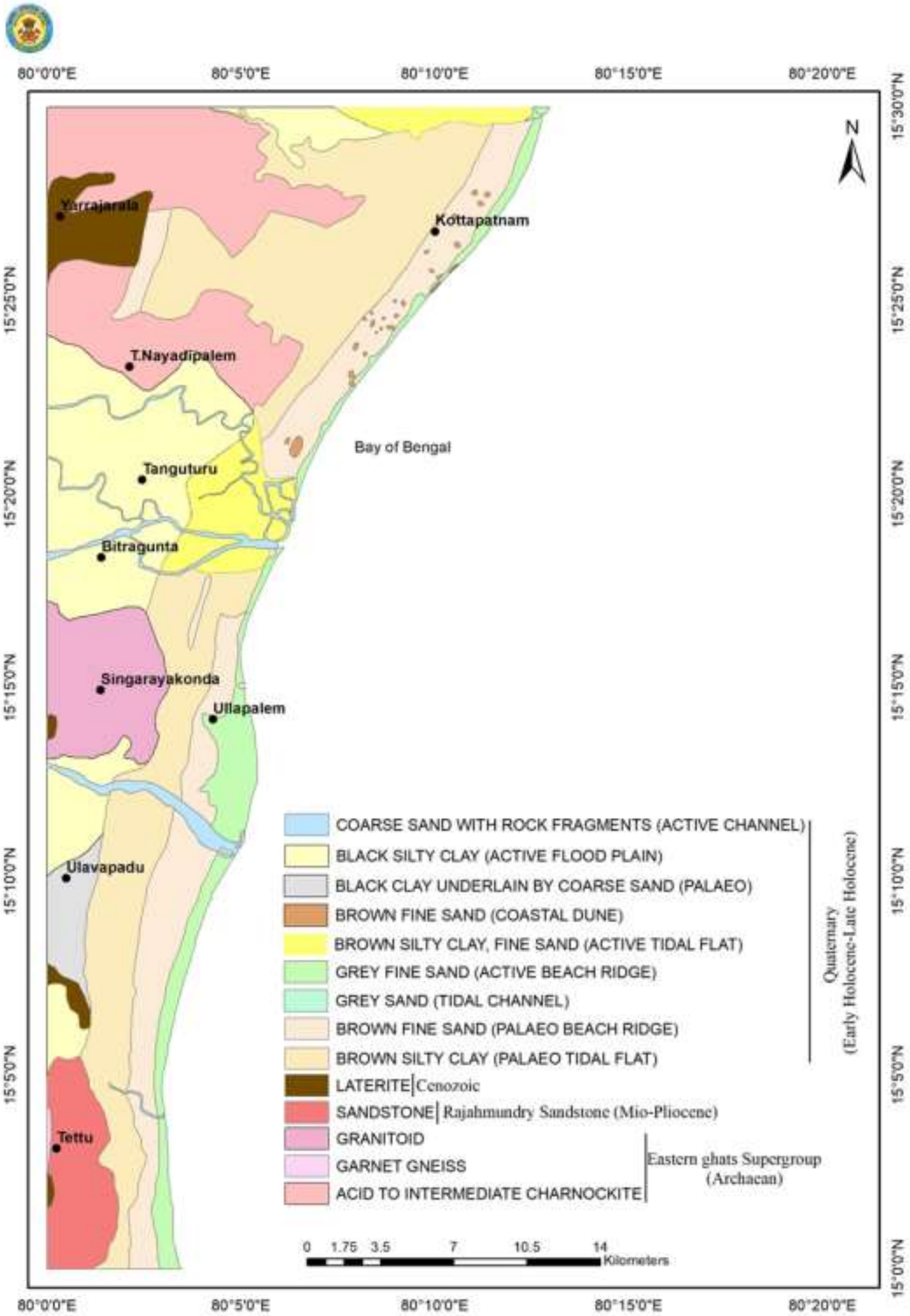

Fig. 5: Geological map of T.S. Nos. 66A/3 and 66A/4 (Source: BHUKOSH)

The area forms the extreme eastern margin of the coastal landmass with extensive Quaternary sediments partly exposing laterite in the NW and SW. The laterite is developed from Rajahmundry sandstones of Mio Pliocene age. The Quaternary sediments of the area are grouped under four Formations.

The fluvial sediments are represented by Tenali-Ramachandrapuram and Palleru formation. The marine sediments are grouped under Kaikalur and Polatitippa Formations. The paleo-channel deposit is mostly buried under floodplain clay. The fluvial sediments are comprised of red, medium to coarse sand, silt and minor clay as seen in the south-western part of Ulavapadu (15°10'00"; 80°00'30") over a length of 2 km. In the area to the north of Goutuguttapalem, the paleo-channel is filled by quartz/chert pebbles, gravels and laterite. These paleo-channel deposits are bordered by black clay of flood plain deposit.

The marine sediments are paleo-tidal flat deposit, paleo-beach ridge deposits of Kaikalur Formation and active beach ridge deposit of Polatitippa Formation. They are disposed in a linear fashion parallel to the coast

Table 1: Stratigraphy of the Study Area in T.S. Nos. 66A/3 & 66A/4. (after Kareemuddin, 1982, Rangamannar,1984 and Kameshwara Rao, 1985)

Quaternary Deposits		Pedana Formation	Holocene
		Palleru Formation/pollatitippa Formation/Musi-Gundlakamma Formation	
		Tenaliramachandrapuram Formation/Kaikalur Formation	
	Rajahmundry Sandstone	Sandstone	Miocene
Eastern Ghat Supergroup	Migmatite Group	Porphyroblastic Granitoid gneiss	Pre Cambrian
	Charnockite Group	Intermediate Charnockite (Charnoenderbite)	

Geomorphology

The study area, in general, exhibits a rolling topography with isolated hills. The northern part of the area is covered by strike ridges and denudational ridges. The area forms a coastal plain having gentle slope towards the Bay of Bengal. It has fluvial and marine landforms. The coastal land forms include active beach ridge, paleo beach ridge and paleo-tidal flat. The southern part of the area is drained by the Palleru and the Musi Rivers and their tributaries. The fluvial landforms are represented by flood plain and paleo-channel and are seen in the central part of the area. The fluvio-marine landform is represented by tidal delta lying at the mouth of Palleru and Musi Rivers.

The area can be divided into physiographic units namely, i) undulating upland of cuesta ridges of laterite, and ii) flat coastal plain of about 6 km width, in the east attaining a height of 8 m. The major drainage in the area is provided by Manneru and Elikeru Rivers flowing in SE direction. It has landforms of fluvial and marine environments.

Geomorphological units of the study area can be broadly discussed as follows.

1. Fluvial Regime

Flood basin deposit: Flood basin deposit comprising black clay is underlain by silty clay and fine to medium sand. The thickness of the black clay varies from 1m to 10 m.

Levee deposit: The levee is mostly composed of brown silt of about 1 m thick. The brown silt grades into fine white sand towards east of Kothapatanam. The zone is highly fertile. The silt is used for manufacturing bricks.

Channel fill deposit: The channel fill deposit mostly comprises coarse to medium white sand with quartz and opaque's. Some channel bars are above the normal flood level, of brown silt and fine white sand and are covered with grass.

2. Marine Regime: The different Morpho-stratigraphic units of the marine environment are barrier beach ridge deposit, tidal flat deposit, mudflat deposit and beach deposit. The lithological characters of the landforms are described below.

Barrier beach ridge deposit: Linear landforms of limited width and length are seen as isolated sand bars within the flood basin. The original dunes are completely altered by human interference. The deposit is composed of medium to fine sands with little clay in the low-lying areas adjacent to the flood plain, derived from the back swamp. The brown colour of the sand is attributed to oxidation. The elevated portions of the ridge where dunes are present contain fine to medium sand, which has undergone relatively little oxidation. The sand is composed of quartz and opaque minerals. Shrubs and palm grow over the dunes. The beach ridge deposits present within the tidal flat zone are encroached by the aquafarmers. They occur as narrow strips of limited strike extent. They are almost reduced to the level of the tidal flat by human interference and fluvial processes. The beach ridge deposit here is composed of fine to medium sand, light brown in colour, and less oxidised. They are almost barren except some Cactus plants at places. They are used for sheep grazing.

Tidal flat deposit: The old tidal flat deposits in the north are composed of a thin layer of black clay, 50 cm thick underlain by brown silty clay and fine to medium sand as seen in the excavations made for aqua-ponds. The sand is mostly made up of quartz. The younger tidal flat deposits south of Kothapatnam are composed of a thick layer of soft mud underlain by brown fine to medium sand. At places where the thickness of soft clay is more, it gives rise to swampy conditions. However, the original landforms exhibiting their lithology are hardly present due to large-scale aqua-cultural practices in the younger mudflats.

Mud flat deposit: The mud flat deposits are mainly confined to selected places within the younger tidal flat zone. The deposit is composed of brown mud with shells of gastropods and lamellibranches.

Active beach deposit: The zone between the high-water line and the beach dunes consists of material that is still under the process of accumulation. The deposit is composed of fine to medium grained, white sand with some black mineral concentration, in selected patches. The sand is mainly composed of quartz and ilmenite with occasional micaceous minerals.

Methodology

The systematic stream sediment sampling from the 1st or 2nd order streams in grid pattern (1 km x 1 km) was carried out in the Survey of India, Topographic sheet No. 66A/3 and 66A/4, Prakasm District, Andhra Pradesh, in pursuance of National Geochemical Mapping Programme (NGCM). The representative geogenic stream sediment samples were collected as per the Standard Operating Procedure for NGCM of Geological Survey of India and due care was taken for true representation of the underling geology and to avoid anthropogenic contamination. The sampling points were

marked in such a way that each sample represented maximum catchment area in that particular unit cell. In absence of 1st or 2^{nd} order streams in any unit cell, the sediments from other smaller channel(s), here referred as '0' order or slope wash etc. were collected. The processed 120 mesh size unit cell samples of four adjoining grids were thoroughly homogenized by coning and quartering and the composite samples representing 2 Km x 2 Km grid were. All the composite samples were analyzed for the Major Oxide, trace and REE's at Chemical Lab, Geological Survey of India, Southern Region, Hyderabad as per the standard procedure for chemical analysis of GSI. The major oxides and trace elements were analyzed using the M/S Panalytical, X-Ray Fluorescence Spectrometer, using the standards GSD-1 to GSD-9 for calibration. The REE's and RM were analyzed through ICP-MS, Perkin Elmer Sciex, model no. ELAN -6100 and the instrument was calibrated using the standards GSD-2, GSD-9, GSD-10, GSD-12. The 5% of the analyzed samples were re-analyzed as repeat samples to check the precision of the instrument. The precision is better than ±5% for major oxides and ±10% for trace elements including REEs. The Chondrite normalized REE plot of the original & duplicate stream sediment samples shows the similar pattern and confirms the analytical precision

Results

Major Oxides

The Silica (SiO2) abundance within the analyzed samples ranges between 37.69 % and 79.94 % and that of Titanium (TiO2) varies from 0.64 % to 5.11 % (Table 3). The overall abundance of Phosphate (P2O5) ranges from 0.04 % to 0.24 % with outlier having concentration upto 0.39%. The abundance range of other major oxides varies from 1.73% to 19.80% Fe2O3, 4.99% to 19.25 % Al2O3, 0.04% to 0.33% MnO, 0.28% to 2.25% MgO, 0.31% to 7.25% CaO, 0.11 to 5.47% Na2O and 0.69% to 3.46% K2O. Uni-variate statistical evaluation of the major oxide data set suggests that population has normal bell shape i.e. Gaussian distribution and the frequency curve is symmetric being very slightly positive skewed and having slight positive kurtosis. The overall abundances of SiO2, Al2O3 , Fe2O3, P2O5 in the present study area indicate the platykurtic nature of population. The bivariate statistical plots i.e., XY plots of Major Oxides indicate a strong negative correlation of SiO with MgO, MnO, Fe2O3, Al2O3 and CaO whereas scattered slight positive correlation with Fe2O3, Al2O3 and P2O5 (table 3).

Table 3: Correlation Matrix of Major Oxides

	SiO_2	Al_2O_3	Total Fe as Fe2O3	Total Mn as MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5
SiO_2	1.00									
Al_2O_3	-0.95	1.00								
Total Fe as Fe_2O_3	-0.96	0.91	1.00							
Total Mn as MnO	0.26	-0.22	-0.29	1.00						
MgO	0.28	-0.31	-0.42	0.46	1.00					
CaO	-0.70	0.53	0.62	-0.38	-0.02	1.00				
Na_2O	0.23	-0.33	-0.33	0.16	0.32	-0.03	1.00			
K_2O	0.50	-0.45	-0.60	0.30	0.35	-0.38	0.22	1.00		
TiO_2	0.05	-0.09	-0.01	0.60	-0.14	-0.06	-0.04	0.02	1.00	
P_2O_5	-0.62	0.47	0.61	-0.19	-0.13	0.68	-0.08	-0.39	0.19	1.00
Mean	**61.34**	**11.53**	**8.67**	**0.09**	**0.85**	**2.19**	**0.49**	**1.36**	**1.04**	**0.12**
Median	**63.90**	**10.92**	**7.09**	**0.07**	**0.67**	**1.81**	**0.32**	**1.27**	**0.94**	**0.12**
Mode	**58.98**	**12.98**	**2.34**	**0.05**	**0.45**	**1.60**	**0.20**	**0.81**	**0.96**	**0.16**

(red)	**Very Strong correlation**
(blue)	**Strong correlation**
(green)	**Good correlation**
(yellow)	**Weak correlation**

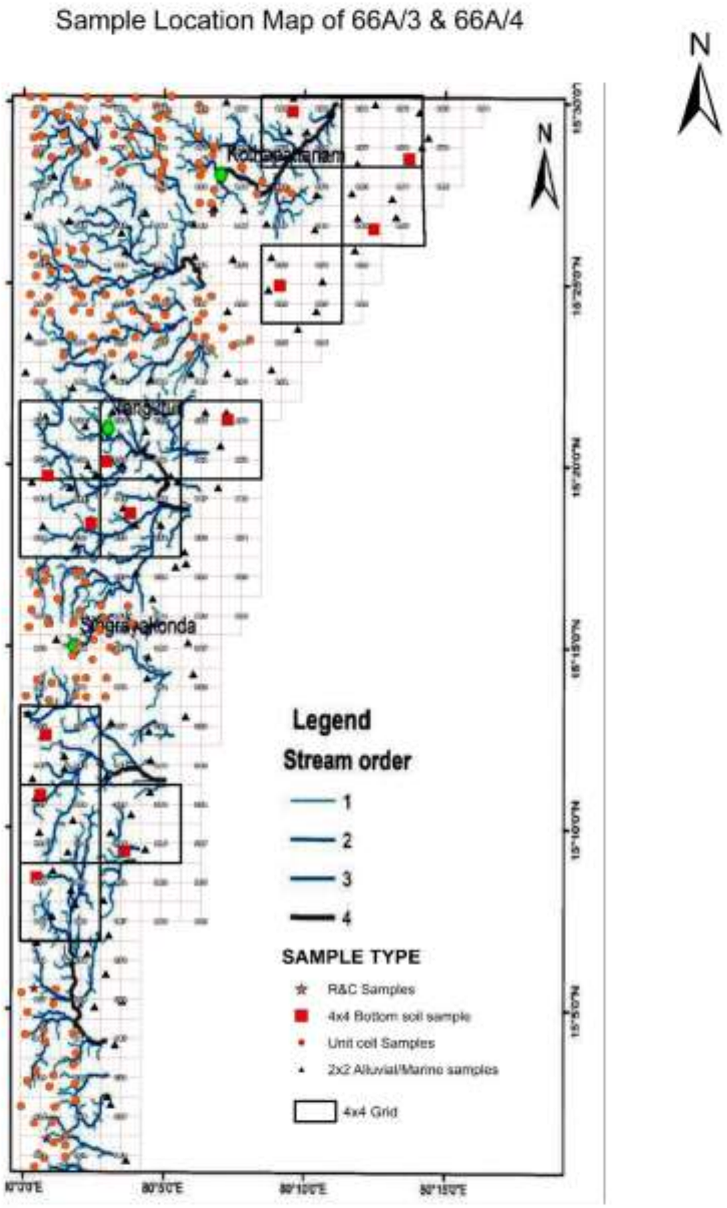

Figure 5A: Sample location map of toposheet 66A/3 and 66A/4

Trace Elements & REE's

The trace elements have a wide range of variations. The concentration ranges are 197 ppm to 623 ppm for Barium (Ba); 11 ppm to 32 ppm for Niobium (Nb); 41 ppm to 151 ppm for Strontium (Sr); 9 ppm to 39 ppm for Thorium (Th); 2.027 ppm to 7.77 ppm for Uranium (U); 23 ppm to 50 ppm for Yttrium (Y); 160 ppm to 1265 ppm for Zirconium (Zr) and 3.85 ppm to 40.74 ppm for Hafnium (Hf). The overall abundance of total REE's in the stream sediments vary between 134.51 ppm and 754.38 ppm; with the ΣLREE ranging from 116.18 ppm to 705.65 ppm and ΣHREE ranging from 17.75 ppm to 52.46 ppm. The chondrite normalized REE plot of all the stream sediment samples shows the enriched LREE and flat HREE with negative Eu anomaly (Fig. 4). LREE enrichment varies from 113 to 721 times of chondrite with the average of 209 times and the HREE enrichment ranging from 14 to 40 times of chondrite with the average of 23. The Bivariate XY plots of Zr vs. Ba, Nb, Th, Y, Hf, Ta, U & Σ REE had shown strong positive correlation except scattered positive correlation with Sr and the univariate statistics implies towards the platykurtic nature of curve for Sr, Nb, Ba, Y & REE's and that of leptokurtic nature of curve for the Hf, Th, U, Zr (Fig. 8). The Multivariate statistical analysis of the data shows that all the Rare Earth Elements have strong to moderate correlation and some of the other Heavy minerals i.e. Th, U, Hf, Ta, Nb, Zr, Y, Ba also shows strong to moderate correlation with each other (Table 4).

	Ba	***Ga***	***Sc***	***V***	***Sr***	***Y***	***Zr***	***Nb***	***Cr***	***Be***	***Rb***	***Lu***	***Hf***	***Ta***	***Th***	***U***
Ba	1.00															
Ga	-0.20	1.00														
Sc	-0.54	0.77	1.00													
V	-0.50	0.66	0.75	1.00												
Sr	0.22	0.09	0.06	0.05	1.00											
Y	-0.35	0.25	0.24	0.59	0.26	1.00										
Zr	-0.06	-0.09	-0.14	0.38	0.41	0.77	1.00									
Nb	-0.03	0.11	0.05	0.47	0.61	0.73	0.89	1.00								
Cr	-0.50	0.25	0.48	0.36	0.08	0.13	-0.03	0.05	1.00							
Be	-0.14	0.71	0.69	0.45	0.17	0.02	-0.31	-0.05	0.34	1.00						
Rb	0.76	-0.10	-0.45	-0.34	-0.02	-0.15	0.02	-0.01	-0.45	0.01	1.00					
Lu	-0.30	0.13	0.14	0.54	0.32	0.91	0.87	0.81	0.10	-0.06	-0.10	1.00				
Hf	-0.08	-0.09	-0.15	0.34	0.34	0.70	0.93	0.79	-0.08	-0.35	-0.02	0.84	1.00			
Ta	0.00	0.02	-0.03	0.36	0.51	0.68	0.84	0.92	0.03	-0.14	0.05	0.77	0.77	1.00		
Th	-0.11	0.10	-0.01	0.42	0.23	0.82	0.84	0.73	-0.01	-0.22	-0.01	0.84	0.79	0.70	1.00	
U	-0.18	0.15	0.05	0.47	0.20	0.87	0.82	0.71	0.02	-0.12	0.04	0.89	0.77	0.68	0.93	1.00
Mean	**311.82**	**16.33**	**17.72**	**116.44**	**117.25**	**30.22**	**584.19**	**18.70**	**161.71**	**1.44**	**53.17**	**0.59**	**19.46**	**1.60**	**31.40**	**3.62**
Median	**301.00**	**16.00**	**17.00**	**114.00**	**121.00**	**27.00**	**431.00**	**17.00**	**167.00**	**1.42**	**47.53**	**0.50**	**13.83**	**1.33**	**19.59**	**2.98**
Mode	**217.00**	**14.00**	**13.00**	**146.00**	**121.00**	**25.00**	**312.00**	**17.00**	**167.00**	**0.86**	**Multi modal**	**0.55**	**Multi modal**	**1.37**	**Multi modal**	**2.74**

Table 4: correlation matrix of trace element data (Toposheet no 66A/3 and 66A/4)

Silver anomalous zone in Granulite rocks of peninsular gneissic rocks and BIF bands of Ongole group . the source of anomalous zone of Silver might be resulted from interaction of hydro-thermal fluid with the granitic -gneissic host . profused epidotization and stains of malachite all over the granitic -gneissic terrain is itself a proof of hydrothermal fluid -rock interaction . sericitzation and epidotization two important observable alteration pattern present in the host lithology . malachite stains are secondary in nature /origin they might resulted from carbonic fluid interaction

Figure : 6 A. Epidotization and malachite stain over the gneissic rock B. BMQ band outcrop in the study Area

Heavy Mineral Analysis

Heavy Minerals (HM) represent detrital occurrences of rock-forming or accessory minerals that have specific gravities >2.8 g/cm3. These grains typically form less than 1 % of siliciclastic rocks. After a standard, rigorous procedure to concentrate HM, The HM composition can be related to specific source Lithologies, and thus to specific provenance areas. For instance, occurrence of Sillimanite and Kyanite indicate high-grade metamorphic rocks are in the sediment source area, while presence of Cr spinel indicates contribution from ultra-mafic rocks

Correlation and provenance of sediments/sedimentary rocks can be achieved by several techniques; a common approach is through the identification and quantification of heavy minerals using a petrological microscope

The results are compared with those derived from traditional optical microscopy. These show good agreement for minerals with specific geochemical signatures, whilst the overall geochemistry of the heavy mineral concentrate was diagnostic of potential sediment sources. This geochemical approach is capable of processing large numbers of samples rapidly and is advocated as a screening technique. A combination of geochemical and mineralogical data produced by these techniques provides a powerful diagnostic tool for studies of heavy mineral signatures in sediments frequently used in mineral reconnaissance.

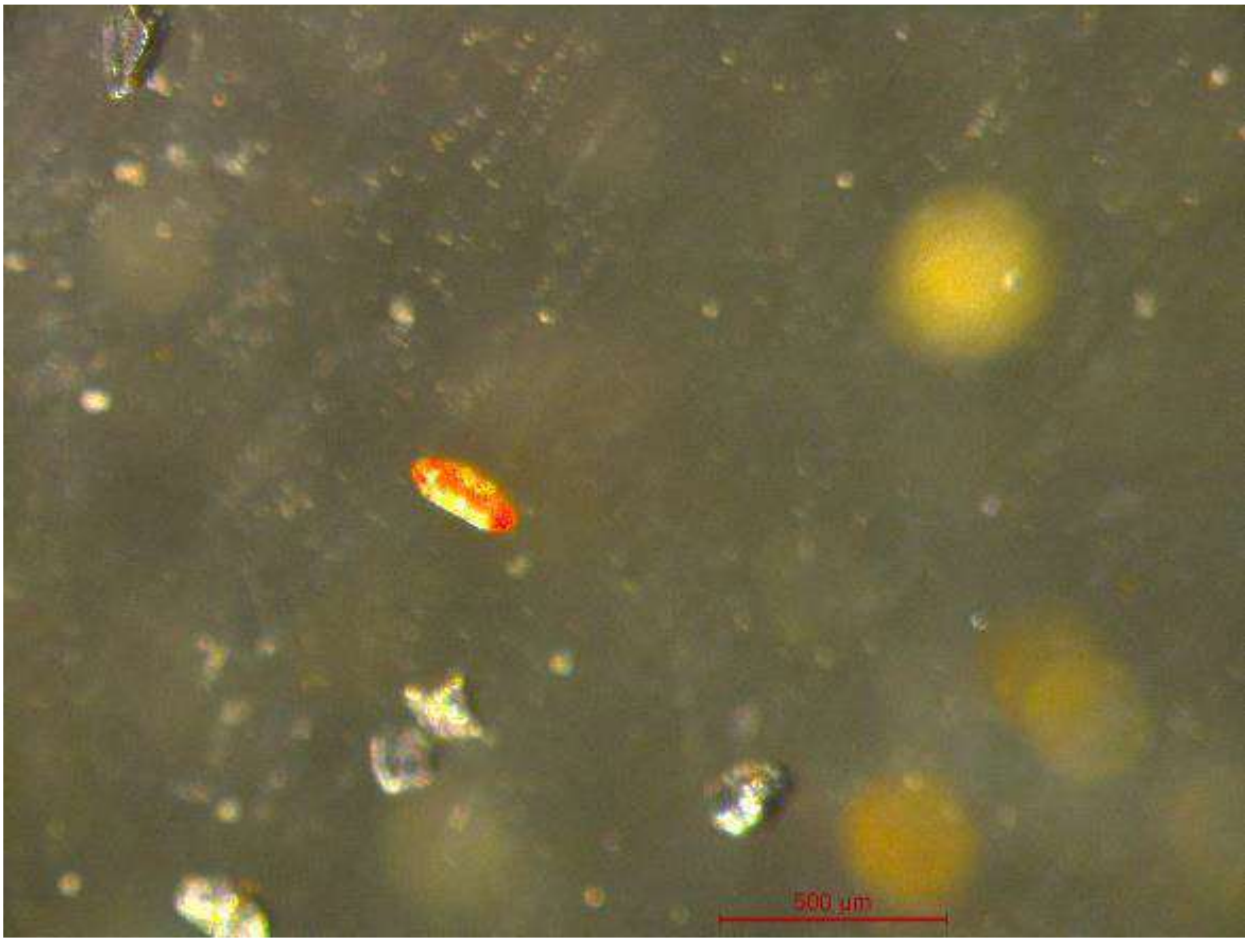

Figure 7: spinel ,rutile and grains of magnetite observed in the samples collected from kothapatnam beach

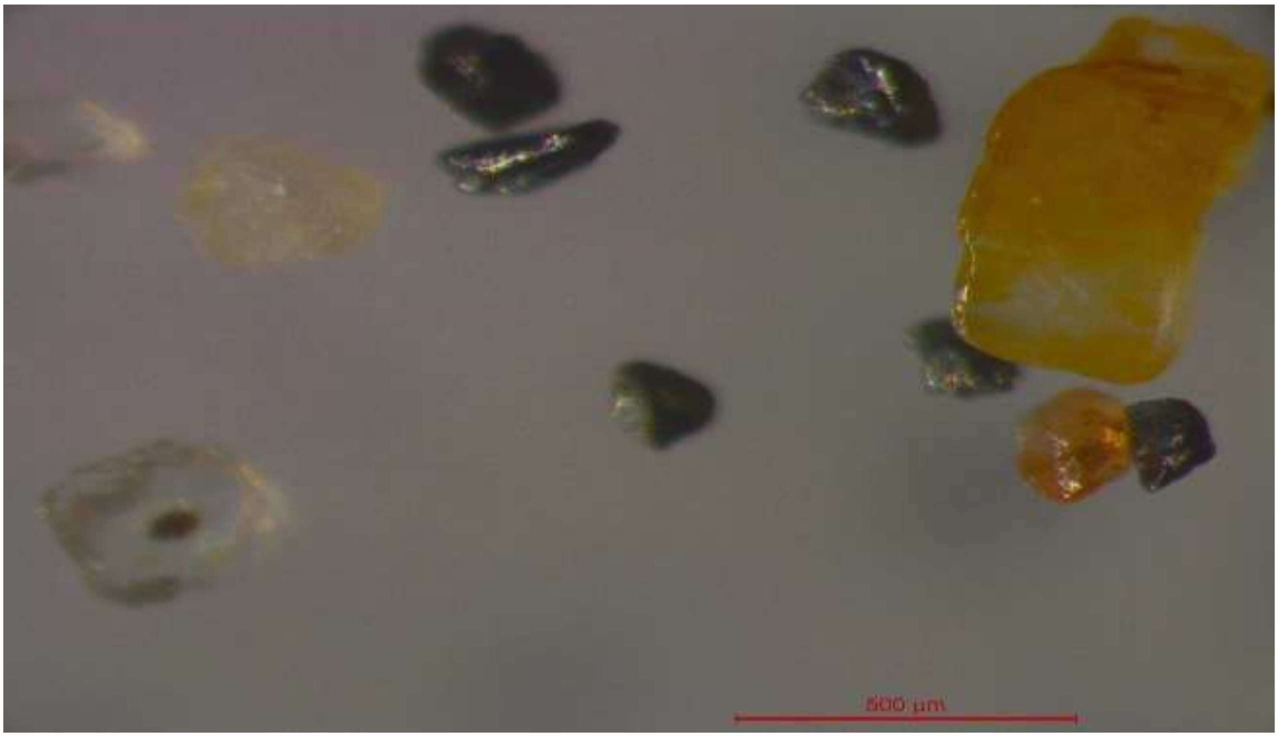

Figure 8: garnet ,monazite, topaz and zircon were identified in the samples collected from uljapatnam and ramnathpatanam

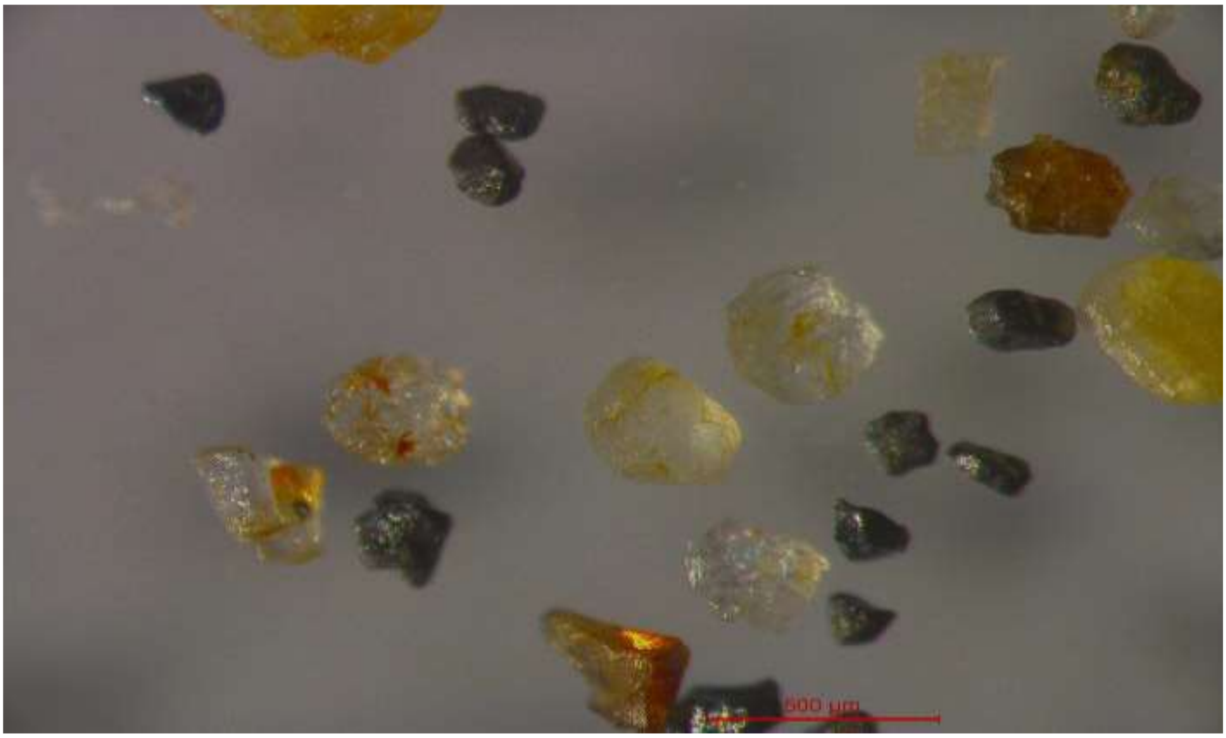

Figure 9: garnet ,zircon and magnetite identified in samples collected from chakicherla beach

Figure 10 : garnet and rutile grains were identified from kotapatnam beach

Cluster Analysis for Geochemical data in toposheet 66A/3 and 66A/4

Agglomerative Hierarchical Clustering (AHC) is a clustering (or classification) method, works by grouping the objects based on the dissimilarities between them. The AHC once applied on the present data set with the five clusters of populations belonging to Eastern Ghat Group, Alluvium, PGC, laterite and marine sediments had reclassified them in to three classes.Eastern ghat lithounits have similar geochemical signatures and they are grouped in Class number 1 whereas those collected from the Alluvium of river were grouped in Class number 2. Besides, the class number 3 has only one sample that may be chemically distinct due to anthropogenic contamination . These are well represented by means of profile plot (Fig. 12) and dendrogram (Fig. 13) of all the classes defined by Agglomerative hierarchical clustering based on dissimilarity or proximity

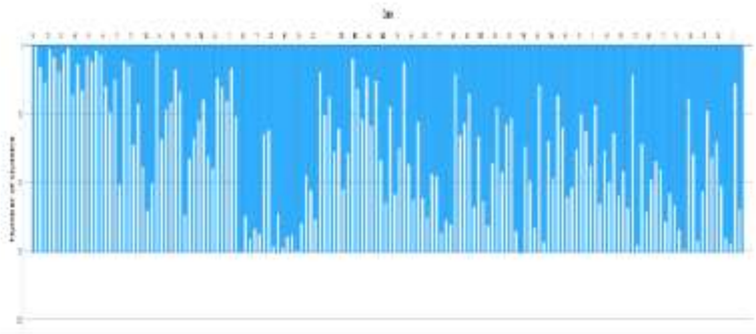

Fig 11 :Scatter diagram of various elements showing average group linkage

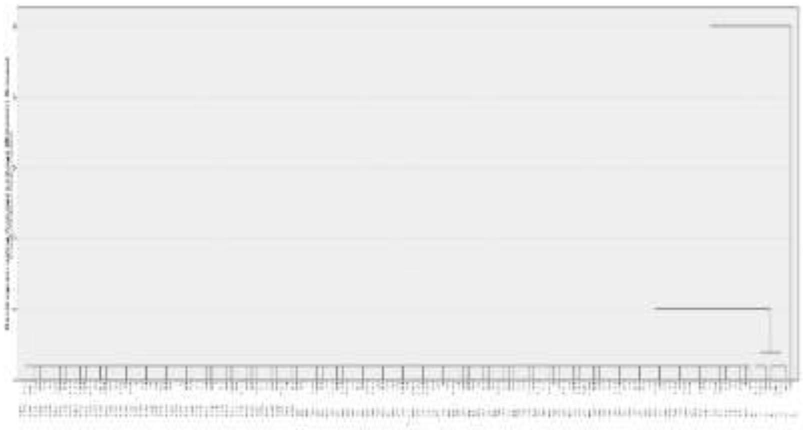

Figure 12 : Dendrogram showing group linkage (average- centroid clustering method) between stream sediments collected from toposheet 66A/3 and 66A/4

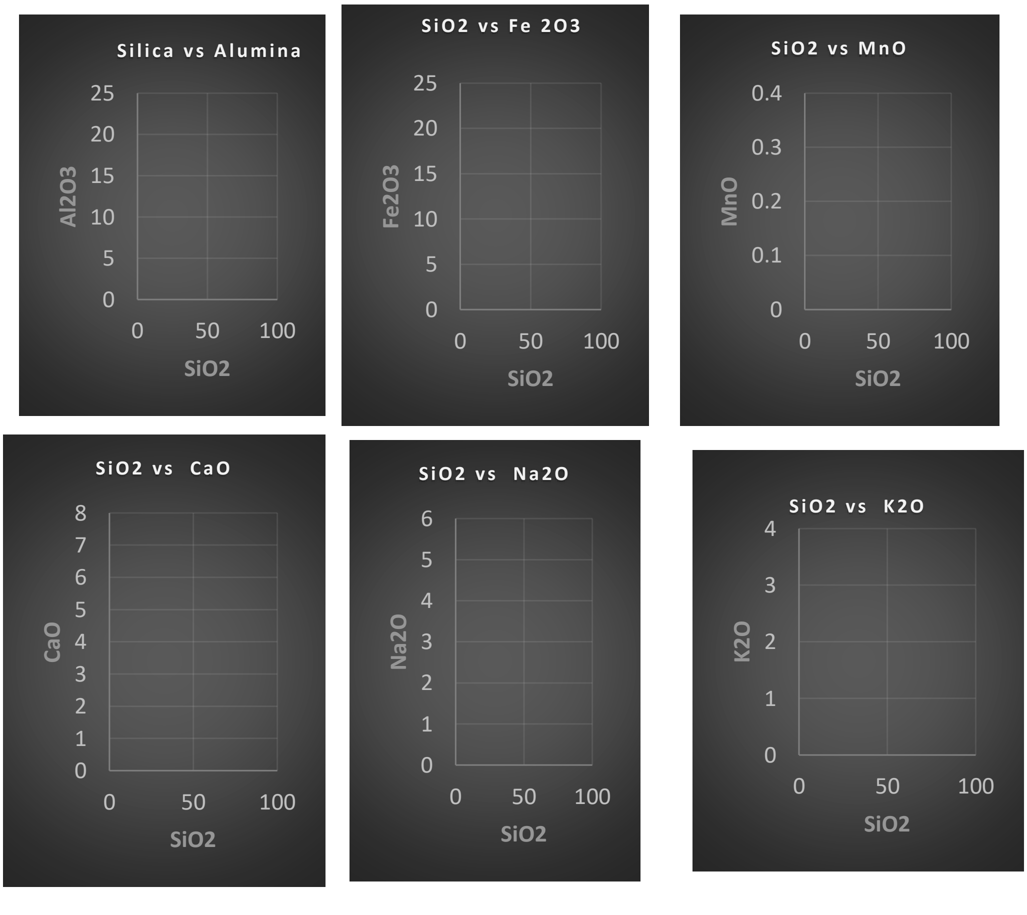

Figure 13 : Bivariate diagram of Major oxides showing unique geochemical signature

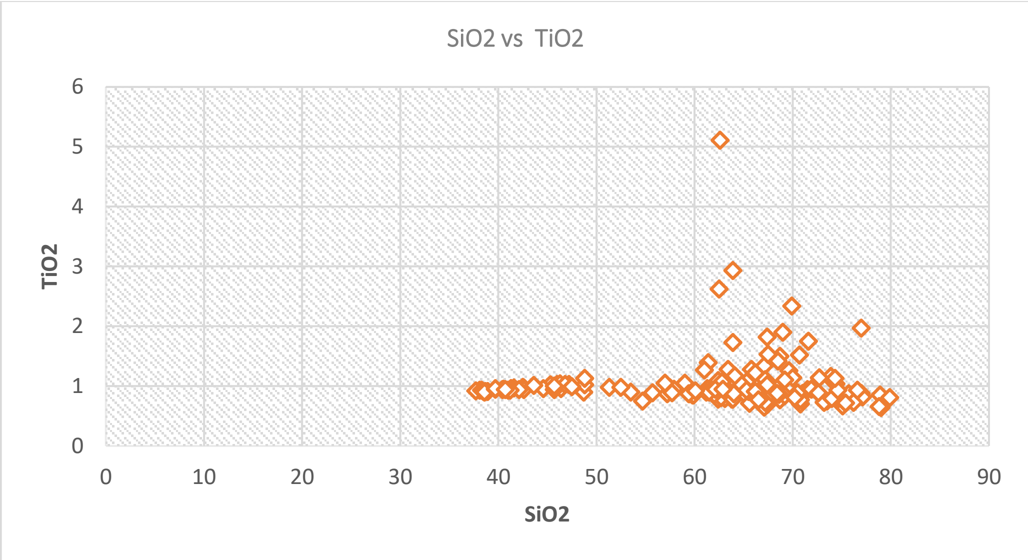

Figure 14: Titanium oxide vs silica plot

From bivariate diagram showing Fe enrichment observed due to presence of magnetite band and laterite outcrops in the study area , In figure 15 enrichment of titanium dioxide can be observed with increase of Silica .this is due to presence of rutile grains in the beach sand high peak of Ti observed

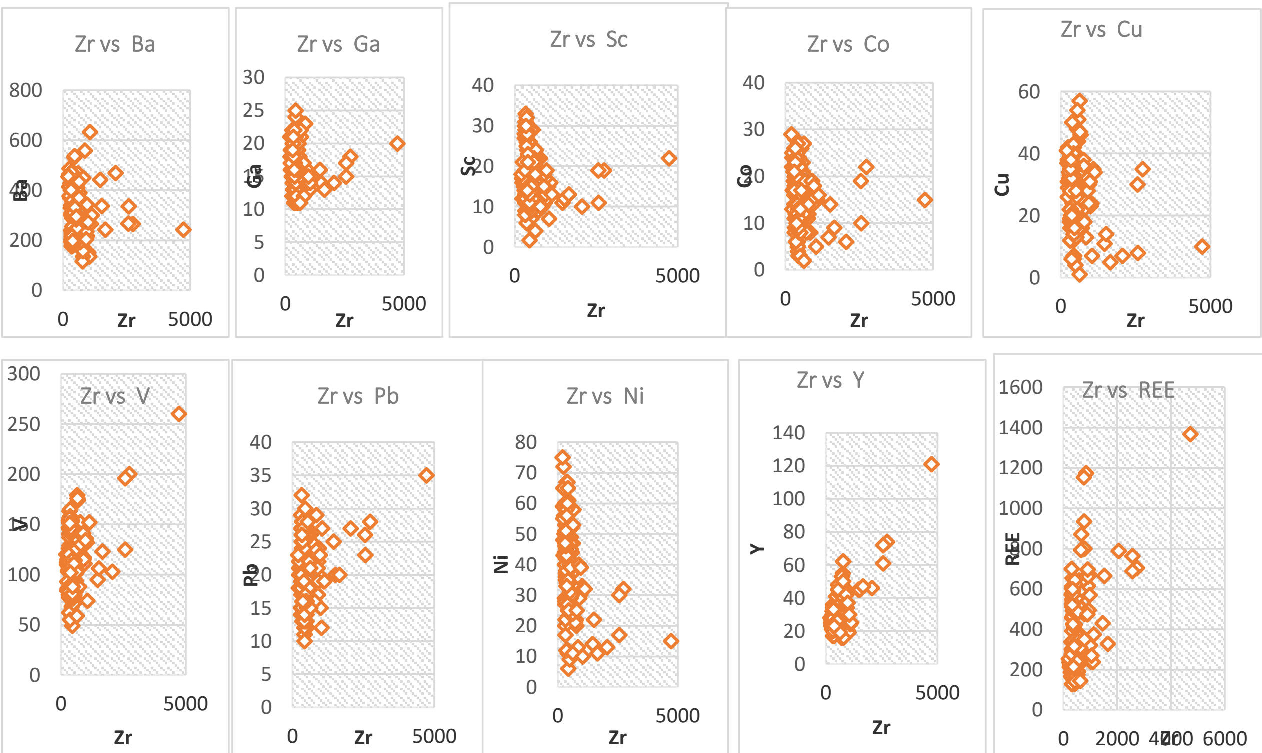

Figure 15: Bivariate plot of trace metals showing enrichment of REE

To ascertain the influence of underneath geology on surface geochemistry the uni-variate, bi-variate and multi-variate statistical analysis was performed. The Coefficient of Variation (CV) which is an indicator for determination of the geogenic, mixed or anthropogenic source of any particular element, is also calculated with the available data set. The equation for calculation of CV is {CV=(Standard deviation/Mean)*100}. The value of CV > 85 represents the 'Anthropogenic source' whereas the CV < 50 represents the 'Geogenic source'. The values in between 50 to 85 indicate the 'Mixed sources' (Reimanna and Caritat, 2005). Thus greater the relative variance expressed by an element, the greater is the apparent influence of anthropogenic process on that particular element (Khan and Bhaumik, 2019

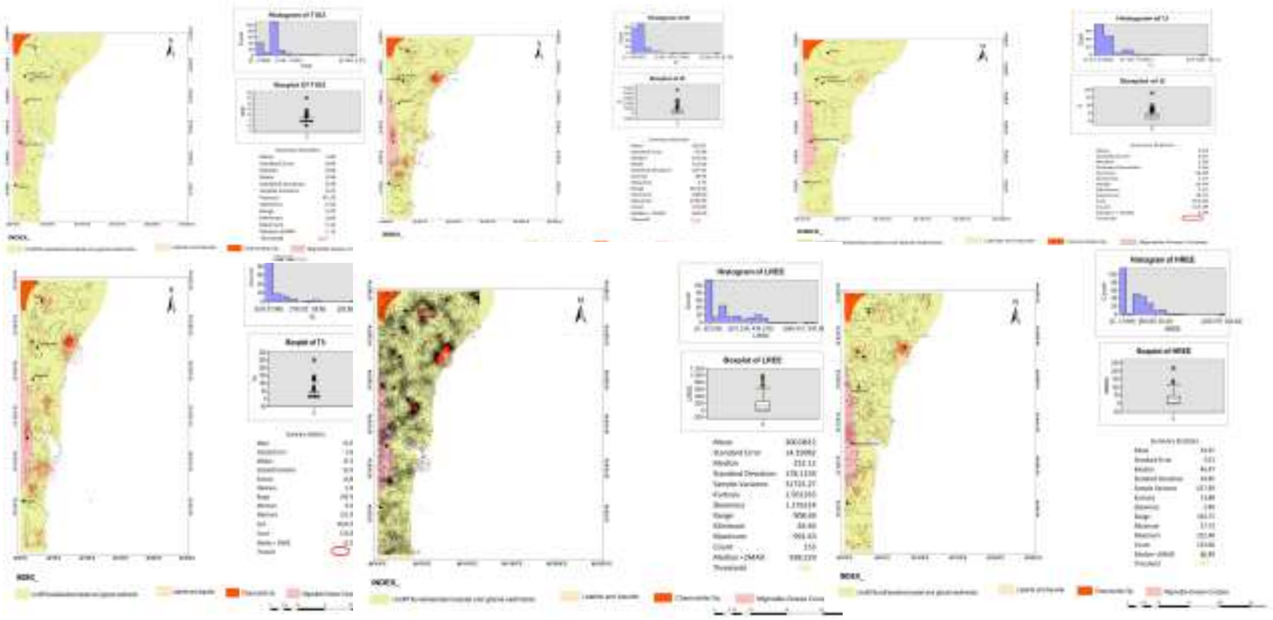

Fig 16: Spatial distribution of trace elements and REE over the Geology

Table5: Table for coefficient of variation

	Ba	***Ga***	***Sc***	***V***	***Sr***	***Y***	***Zr***	***Nb***	***Cr***	***Rb***	***Lu***	***Hf***	***Ta***	***Th***	***U***	***LREE***
Mean	311.82	16.33	17.72	116.44	117.25	30.22	584.19	18.7	161.71	53.17	0.59	19.46	1.6	31.4	3.62	300
Median	301	16	17	114	121	27	431	17	167	47.53	0.5	13.83	1.33	19.59	2.98	178
Minimum	117	10	1.75	49	29	16	280	10	56	12	0.19	4.48	0.35	6.54	1.61	83.94
maximum	633	25	33	260	330	121	4730	112	253	122.78	3.36	139	18.15	263.4	18.1	992.3
thresold	508	22.8	32	183.4	221.66	37	643	19	234.6	76	1.4	22.37	3.89	32.22	4	598.2
CV	31.5	19.8	40.4	28.8	43.87	41.79	90.3	90.6	22.22	43.8	61.6	94.5	97.5	10.58	56.04	59.3

Factor Analysis for geochemical data of toposheet 66A/3 and 66A/4 (stream sediments

Total Variance Explanation

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.200	37.715	37.715	13.200	37.715	37.715
2	6.173	17.636	55.352	6.173	17.636	55.352
3	3.483	9.951	65.303	3.483	9.951	65.303
4	2.435	6.958	72.260	2.435	6.958	72.260
5	2.179	6.225	78.485	2.179	6.225	78.485
6	1.894	5.411	83.896	1.894	5.411	83.896
7	1.170	3.344	87.239	1.170	3.344	87.239
8	1.056	3.018	90.258	1.056	3.018	90.258
9	.729	2.083	92.341			
10	.480	1.373	93.714			
11	.422	1.206	94.919			
12	.375	1.072	95.991			
13	.316	.904	96.895			

14	.213	.610	97.505			
15	.164	.469	97.973			
16	.135	.384	98.358			
17	.120	.343	98.701			
18	.103	.295	98.996			
19	.079	.226	99.221			
20	.062	.178	99.399			
21	.060	.170	99.569			
22	.040	.114	99.683			
23	.036	.104	99.787			
24	.024	.069	99.856			
25	.020	.057	99.914			
26	.014	.039	99.953			
27	.007	.019	99.972			
28	.003	.010	99.982			
29	.002	.006	99.987			
30	.001	.004	99.991			
31	.001	.003	99.994			
32	.001	.002	99.996			
33	.001	.002	99.998			
34	.000	.001	99.999			
35	.000	.001	100.000			

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Table 6 : Total variance table extracted by principal component Analysis (Data from stream sediments)

Component Matrix [a]

	……….……………………………Components………………………………							
	1	2	3	4	5	6	7	8
Ba	-.195	-.376	-.181	.085	.284	-.361	.568	-.220
Ga	.296	.618	.347	.362	.276	-.124	.002	-.216
V	.241	.575	.462	.352	.133	.341	-.239	.037
Pb	.259	.577	.267	.354	.402	.174	.078	-.066
Ni	.140	.527	.269	.458	.006	-.544	-.080	-.113
Co	.233	.656	.382	.426	.014	-.296	-.062	.020
Sr	-.081	-.071	-.087	.453	.174	.488	.548	.000
Zr	-.034	-.151	.139	.193	.300	.799	.048	.073
Nb	-.284	-.455	-.231	.477	.517	.085	-.265	.070
Cr	.315	.558	.191	-.308	-.490	.281	.245	-.011
Cu	.357	.670	.450	-.088	-.280	-.048	.051	-.033
Zn	.358	.663	.375	-.122	-.300	.146	.324	-.018
Be	.112	.546	-.394	.155	.123	-.227	.195	.561
Ge	.369	-.365	.435	-.075	.265	-.178	.080	.404
As	.309	.616	-.435	-.171	.177	-.026	.088	.408
Rb	-.268	-.353	.146	.225	.081	-.363	.327	.080
La	.901	.054	-.104	-.209	.252	-.032	.007	-.185
Ce	.888	.161	-.193	-.211	.250	-.010	-.001	-.135
Pr	.869	.184	-.196	-.270	.285	-.009	.025	-.085
Nd	.860	.207	-.198	-.283	.281	-.003	.027	-.061
Eu	.445	-.258	.580	-.451	.378	-.048	.052	.069
Sm	.583	.424	-.675	.071	-.016	.023	-.019	-.056
Tb	.447	-.337	.629	-.388	.304	-.044	.017	.097
Gd	.634	.341	-.648	.139	-.076	.022	-.042	-.114
Dy	.958	-.108	-.069	.056	-.082	-.003	-.064	.088
Ho	.930	-.201	-.008	.117	-.137	.001	-.062	.127
Yb	.910	-.253	.009	.159	-.185	.013	-.042	.128
Lu	.888	-.297	.068	.178	-.191	.017	-.040	.162
Hf	.881	-.322	.048	.197	-.207	.017	-.032	.138

Ta	.861	-.357	.035	.226	-.225	.016	-.020	.109
Th	.627	-.573	.198	.167	-.192	.035	-.016	-.066
U	.547	-.484	-.051	.278	-.326	.007	.230	-.064
TREE	.833	-.400	.036	.092	.020	-.034	.042	-.237

Extraction Method: Principal Component Analysis.

Table 7: Component matrix as a result of Factor Analysis of geochemical data (Stream sediments)

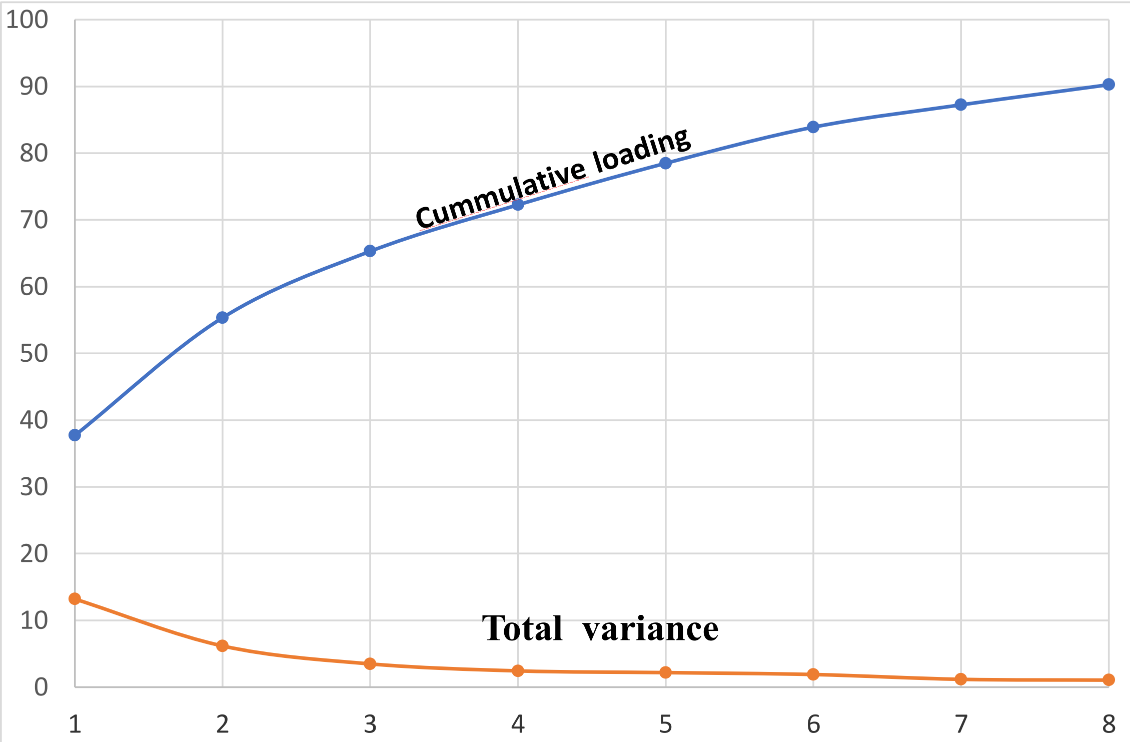

Figure 17; Scree plot showing relationship between Factors and Variance

Conclusion :

The systematic statistical evaluation of the stream sediment data, belonging to different geological units fromPrakasm district, Andhra Pradesh was attempted for the first time for identification of zones of enrichment for REE's and associated heavies . The CV suggests that not all the elemental signatures of the studied population belongto the geogenic sources , some belongs to mixed sources and some from anthropogenic activity .

.from cluster and factor analysis its confirmed that enrichment of LREE and other elements are geogenic and influence of other factor are negligible the source of such enrichment due to late intrusion within the gneissic rocks / migmatites

Presence of monazite within the beach sand is reason behind the anomaly of LREE . iron and titanium oxide anomalous zone were also evident in the study area . the bands of magnetite and laterite bodies present within the study are the major factor for such mentioned anomalies

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