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Application of Remote Sensing, Magnetic and VLF (EM) Techniques for Discovery of Lamproites near Ramadugu and Vattikod area, NW margin of the Cuddapah Basin, Eastern Dharwar Craton

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ABSTRACT
Semi detailed 2-D and (precision) geophysical surveys were carried out in the Ramadugu study areas of north western part of Cuddapah basin in Telangana State, India. Qualitative analysis of total magnetic components brought out geological contacts, seven faults (F1 to F7) and four tectonically disturbed zones (A, B, C & D), the surface morphology and structural configuration were obtained from Land Sat 8 ETM Satellite image of the Ramadugu study area of Nalgonda District (longitude 79°5′ to 79°25′and Latitudes 16°42′ to 16°58′), From observed surface correlation of reported lamproites occurrences, characterized by contact between dykes and granitic rocks, lineaments/faults peripherals of domal structures, circular to oval shaped structural features, which could have acted as potential sites for lamproites emplacement. After establishing the correlation between structure and lamproite occurrence, ten potential lamproites zones were delineated (2,3,4,5 6, 8,9,10,11 and 13) in the study region with domal features of morphology. Total magnetic, and VLF (EM) precision geophysical investigations (station interval 1m) have been carried out along the known lamproite fields at the Ramadugu (R1 to R5, Y1-Y2) and Vattikod (Gl-1, V1 to V10) lamproite fields, reveals the location of conductive and non conductive bodies, geological boundaries, lamproite dykes, faults/fractures and shear zones are located along contact between dykes and granitic rocks. The Fraser filtered data plots as well as Karous-Hjelt filter 2-D inversion current density pseudo sections for real and imaginary components has aided in refining the location of conductors, nature of conductivity, dip and the depth of these conductors. The VLF (EM) responses along all lamproite bodies along with the magnetic interpretation, are presented here as a case study.

Keywords: Very Low Frequency Electromagnetic Method (VLF-EM), Qualitative Analysis, Total magnetic, Lamproites, Fraser filter

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I. INTRODUCTION

The Geophysical investigations were carried out on the North western part of Cuddapah basin of Eastern Dharwar Craton consisted of both regional and preceision investigations aimed at the broad structural aspects of the study area as well as identification of lamproites zones. Geological and geochemical studies carried out by Geological survey of India in the Musi and Krishna River basin, (Alok Kumar et al 2013, Reddy et al 2003, Sridhar and Rau 2005 , Chalapathi Rao et al 2004 and 2014) provided information on the emplacement of diamond lamproites/Kimberlites in Northwestern margin of the Cuddapah basin, Eastern Dharwar craton (EDC) to identify the new zones of diamondiferous lamproites, which leads to the delineation of a new clusters of lamproites and termed as Vattikod, Ramadugu and Somavarigudem clusters (Sridhar and Rau 2005).

This paper presents application of total magnetic, VLF (EM) and Remote sensing studies for Discovery of Lamproites near Ramadugu and Vattikod area, NW margin of the Cuddapah Basin, Eastern Dharwar Craton in order to delineate regional and detailed structural pattern of the Ramadugu study area with special emphasis on prevailing drainage, tracing of various linear features such as fractures, faults, dykes, and to demarcate the zones of identification of lamproite.

II. DATA BASE

Cuddapah basin is one of the most prominent Proterozoic basins in southern Indian peninsula,. The present study was carried out along the NW margin of the Cuddapah basin bounded by Longitudes 79°5′ to 79°25′and Latitudes 16°42′ to 16°58′ (Fig. 1). Geologically the area forms part of the Eastern Dharwar Craton (EDC) which is recognized for its emplacement of numerous

lamproite bodies. The geological formations in the area (GSI, 1999) include unclassified granites and gneisses of Archaean age, Cumbum Shales, Phyllites, Srisailam quartzites of the upper Kistna series of Cuddapah super group, and Shales of the older Kurnool group of rocks. The hornblende schist and amphibolites (Older Metamorphic) which are oldest rocks occur, as rafts, enclaves, and discontinuous linear bands, within the Peninsular Gneissic Complex. The district comprises of migmatites, granites granodiorite, a tonalitic-trondhjemite suite of rocks and hornblende-biotite schist.

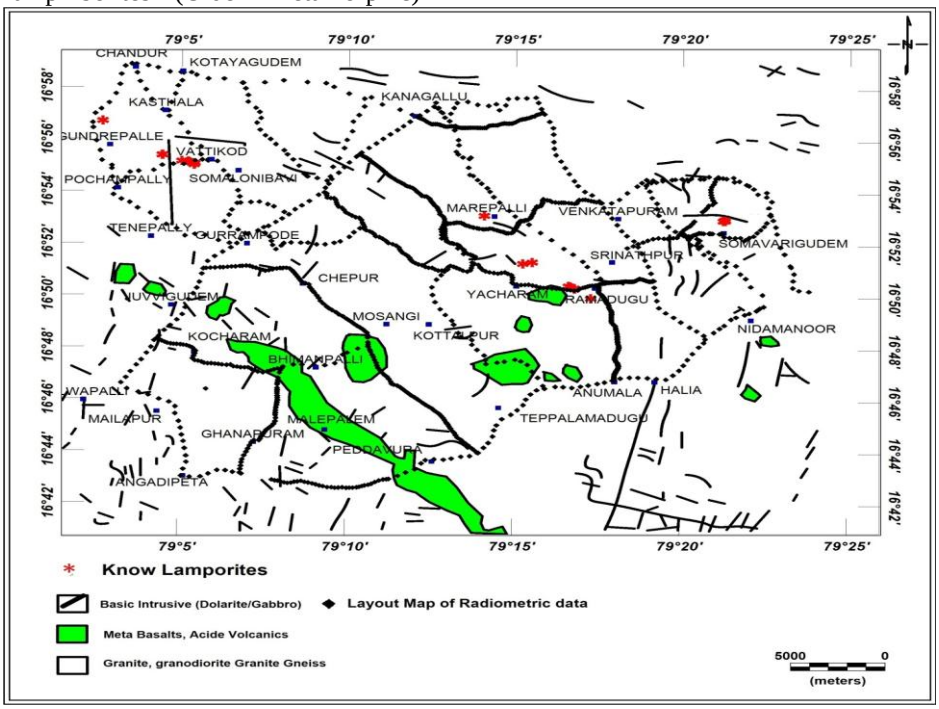

Figure 1: Layout map of Magnetic observations superimposed on the Geological map (GSI 1999) of the study area, Nalgonda District, T.S

The Dharwar super group of rocks is exposed as linear bands near Peddavura on the Hyderabad-Nagarjuna sager road is trending in the NNW-SSE direction runs for about 20 km with a variable with of 500 m to 2 Km which continued beneath the Cuddapah basin. A number of dolerite dykes, reefs of quartz and multiple fracture systems commonly trending

N-S, ENW-WSE and NW-SE, the NW-SE trending dykes followed by N-S and ENE –WSW trending dykes (Sridhar and Raju, 2005). The width of the dykes varies from less than one 1m to 20 m. These dykes are massive and are mostly dolerite in composition, Quartz veins traverse the older rock unit and trend N-S and N 30° E, S 30° W, N 60°E – S 60° W and N 75° W and S 75° E are common in the area.

The geophysical surveys have been selected based on the petrophysical studies and depending on the geological problems envisaged. The surveys were conducted in two stages namely semi detailed 2-D and precision geophysical investigations along the chosen profiles at known lamproites.

Semi detailed investigations in the scale of 1:50,000 were carried out in the Ramadugu (longitude 79°5′ to 79°25′and Latitudes 16°42′ to 16°58′) study area lies in Nalgonda district of State of Telangana, India, along all available approach roads and tracks in the region with a station interval of 200 m. to give a fairly even distribution of magnetic and radiometric values for the entire region covering a total area of 700 sq.km. Fig.1 gives the layout of the Ramadugu study area along with locations of magnetic and radiometric observations. The N-S and E-W extend of this area falls under Survey of India (SOI) (Topo sheet No. E44T1, E44T2, E44T5).

Precision total magnetic and VLF (EM) investigations in the scale of 1:100 were carried out along the chosen profiles at known lamproites in the Ramadugu and Vattikod lamproites fields lies in between(latitude 16^0 42′ to 16^0 57′ N and longitude 79^0 05′ E to $79^0$23′ E) along seven detailed profiles with (one) 1m station to station distance were conducted at the Ramadugu (R1 to R5) and Yacharam (Y1 to Y2) lamproites field (Fig.1). The length of these profiles varied between 20m - 50m were taken perpendicular to the

geological formations. The frequency use in the present investigation is 18 KHz.

Semi detailed 2-D and precision Magnetic and Radiometric observations are taken using the Proton precession Magnetometer Model-600 and ECIL Scintillometer (type SM 141) instrument respectively, The VLF detailed observations were obtained using ABEM WADI instrument The position of the observation points was taken by using Global Position System (GPS) with an accuracy of 1m, to ensure reliability and accuracy of the magnetic and GPS elevation, location of geographic coordinates several (20 %) observations are repeated. The overall effective accuracy obtained for the magnetic data is ± 1nT.

III. REMOTE SENSING STUDIES

The data have been collected from NRSC, Balanagar, Hyderabad and also available on internet source. The primary data collected from Survey of India (SOI) topo sheets at scale of 1:50,000 (No. E44T1, E44T2, E44T5) and 1:250,000 (Toposheet No's 56 K, 56 L,56 O and 56 P) and multi spectral Satellite Imagery of the LANDSAT 8 ETM, 29-10-2011, resolution 28.5 m number of band are 8 and path 144 and row is 48 of Nalgonda district. The ETM acquires the image data in visible (band1: 0.45-0.515µm, band 2: 0.525-0.605µm, band 3: 0.63-0.69µm), near-infrared (band 4: 0.75-0.90µm), mid-infrared (bands 5: 1.55-1.75µm and band 7: 2.09-2.35µm), far-infrared (band6: 10.4-12.5µm) and panchromatic (band 8: 0.52-0.9µm). The spatial resolution is 15m in the panchromatic band, 30m in the visible, near infrared, and mid-infrared bands, 60m in the far-infrared band and each scene represents the Earth in 183 by 170 kilometers. The data of satellite pass-over the area on 29-10- 2011 and the standard data product corresponds to a scene with path/row numbers 144/48. Subsequently the image was geo-referenced and analyzed using appropriate software modules of ERDAS 9.1 and Arc GIS 9.2 software's are used for digital image processing and statistical analysis (Short, 1982, Hammond and McCullough, 1980, Castleman, 1978). Geometrical rectification for satellite data was done using ground control points (GCPs) extracted from the base map.

3.1 Image processing and Structural Analysis

The present study evaluated, the effect on structural studies in and around Ramadugu study area in Nalgonda district, the area is well known for the recent discovery lamproites clusters (Sridhar et al, 2005) are located north western part of Cuddapah basin. Fig.2(a) Land Sat 8 ETM+ image (1:50,000 Scale) covering an area of approximately 1200sq.km (Longitudes 79^0 5′ to 79^0 25′ and Latitudes 16^0 42′ to 16^0 58′) was digitally processed and visually interpreted to elucidate the structural fabric and geomorphology of the region comprising the geology and lineaments shown in Fig.2(d). The geomorphology map of the Ramadugu is falls in partly Topo sheets No. E44T1, E44T2 and E44T5 Nalgonda district of Telangana State is shown in Fig 2(a). The maximum elevation is 242 m south of Ramadugu village and minimum elevation is 150 m at north western side of Halia River. There are number of dykes of dolerite, reefs of quartz and multiple fracture systems commonly trending N-S and ENW-WSE and NW-SE. These dykes run for tens of kilometers intermittently. The width of the dykes varies from less than a meter to 20m.

All the dykes in the region are associated with the younger granites and granitoids. The overall drainage is dendritic to sub-dendritic, dendritic homogenous nature of the area controlled by numerous joints and fractures. The general slope of the area is observed toward the south east. The Peddavagu -Halia River is also showing the flood plain features in the study area even though this stream is dry throughout the year except few rain days.

In Ramadugu areas there are seven (F1-F7) faults/lineaments (Fig.2a) have been identified. The fault/lineament F1 is observed is located in south western part of the study area which is a contact zone between the younger granites and granodiorite, granite gneiss. The fault F2 indicating the contact between the western margin of Peddavura schist and granite, granodiorite granite gneiss. F3 is observed near Tenepalli and is abutting the north western part of the schist belt from the biotite gneiss. The faults F4, F5 and F6 are trending in NW-SE are the important tectonic lineaments/fault zones in the study area which are highly disturbed nature. The emplacement of lamproites near Somvarigudem, Marepalli, Yacharam and Ramadugu regions are associated within fault/shear environment of F5 & F6. The F7 is separating the Lamproites of Vattikod and Gundrapally. The reactivation of these major crustal lineaments in this region, probably during upliftment of the Nallamala sub basin, caused mantle up-warping and facilitated the emplacement of mineralization (lamproites) (Alok Kumar et.al 2013) close to the E-W and the NNW-SSE trending faults/fractures.

Domal (Radial) structures are reflected in the geomorphology of the region as elevated circular drainage pattern of the region from which the disposition and various geomorphological units are identified. The major drainage of the region is followed by the river Krishna and its tributaries. A well-developed weathered layer along with main drainage Fig. 2d give rise to numerous ponds in this region. Topographic highs and lows in turn were indicated by regions of circular or radial alignment

of the drainage. Such radial structures taken in conjunction with faulted zones are contact between dolerite dykes, granite and gneisses are potential zones as lamproites indicators Domal / radial structures are reflected in the geomorphology of the study area as elevated circular features.

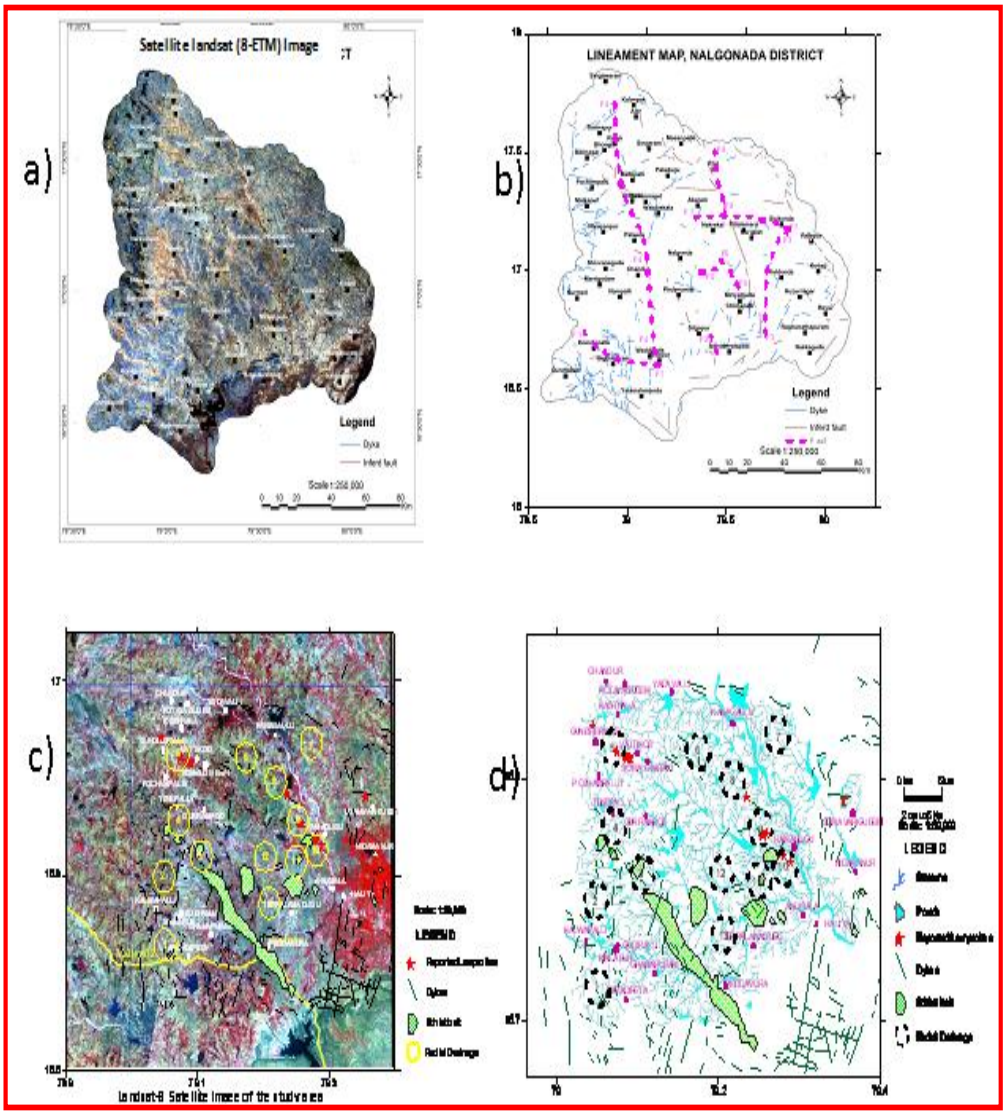

Fig.2. a) Landsat-8 Satellite image of the Nalgonda District. (b) Lineament map derived from satellite image, Nalgonda District. (c) Landsat-8 Satellite image of the Ramadugu study area. (d) Drainage and lineament pattern of the Ramadugu study area.

The Remote sensing data is used to locate potential lamproites/ kimberlites zones is to delineate the region of domal morphology characterize by topography highs. The general slope of the area is observed towards the south eastern side. The lineaments that fall within the migmatites gneisses show a concordant relation with the regional Dharwarian trend, i.e., NW-SE, where as lineaments that fall over the biotite granites show both parallel as well as transverse relation i.e. NW-SE, WNW-ESE, E-W, ENE-WSW and N-S. Circular or radial alignment of the drainage structures taken in conjunction with the contact zone between the dyke environment and granitic gneisses and implying the involvement of distinct deep seated faults/fractures in controlling their lamproite emplacement. Thirteen main circular zones have been identified numbered 1 to 13 are presented in table: I

IV. TOTAL MAGNETIC STUDIES

In the present study ground magnetic data the co-ordinates for the each observation points for IGRF is calculated. The geomagnetic field parameters were calculated for the study areas, using Geosoft software and declination, varies from 1.27° to 3.0°, inclination vary from 21.24° to 21.70° and the magnetic observations were subjected to

diurnal variation and artificial objects were checked and removed Fig.3 (a) shows the color shaded contour map of Total magnetic Intensity map of in and around Ramadugu area and the locations of villages also shown on it. The total magnetic field varies from 40210 to 42310 nT. The magnetic anomalies in the area range from 40676 nT in the northwestern side to about 42810nT in the northeastern side, with the trend of contours being NW-SE. The conspicuous feature in this map is the NW-SE trend that corresponds with Peddavura schist belt and is characterized by steep magnetic gradients. Broadly, while magnetic highs are recorded over basic dolerite dyke and the correlation of lows over fracture zones is noticed. The basic dyke shown with N-S, E-W, NE-SW and NW-SE trends, noticed as the magnetic high/lows closures. The highest magnetic intensity values are observed at the northeast part of the study area might be due to high magnetic susceptibility and the magnetic intensity varies from 40429 to 42810 nT can be attributed to the variation of rock units in zones of fracturing/shearing/faulting or superposition by later metamorphic events. Thus, the flexures of linear second order anomaly trends reflect occurrences of dykes are later tectonic activity and are important in the emplacement of lamproites.

The International Geo-reference magnetic Reference Field (IGRF) of the study area was removed from the reduced to diurnal magnetic data. Fig. 3b shows the IGRF corrected contour map of the total magnetic intensity of the Ramadugu region (contoured interval of 100 nT) along the locations of villages, shows the distinct pattern of highs (positive) and lows (negative) indicate magnetic source are bipolar nature. At some places, steep gradients between them are described as prominent magnetic lineaments, which are attributable to the complex assemblage of features of varied dimensions and directions from different phases of magmatic activity.

The (Fig 3b.) map shows an acute variation in the magnetic intensity indicating variations in the magnetic intensity. These variations are possibly related to the zones of structural variations based on the geological investigations. While the comparison of the magnetic signatures with the geology of the region not shown many inferences because the various forms of granites (migmatites, gneisses, pink/grey granites and/or biotite granites) are magnetically not much responding. The magnetic highs and lows are in conjunction to subsurface faults in the granitic terrain, not with the composition of the granites, the study area covers various forms of granites along with little Peddavura schist. Few basic/ultrabasic dykes are farmed as intrusive rocks as the NW-SE to NE-SW trend is shown with highs and lows. Two other trends of magnetic high responses are also traversing in the same direction. There are eleven magnetic high are noticed with distinctive trends and characters H1(running in between Ghanpuram to Mailapura), H2 (South of Teppalamadugu trending in the NW-SE direction and abrupt changes its direction to East - West), H3 (situated in between Anumala – Halia striking NE-SW direction) H4 also trending NW - SE direction at east of Nidamanur which is indicating a broad high in the region. H5, H6 trending showing isolated pockets of high, H7 is situated at the west of Vattikod, H8 moves in a zigzag manner at the west of Yacharam. All the isolated highs closures are observed over the banded iron- formation, and also highs are observed over dykes in the eastern side of the study region. The highs may be due to the upwards in the upper crustal layer and consequent thinning of the peninsular gneissic layer. The isolated magnetic highs (H7, H8 to H11) closures probably represent relict schistose associated banded iron formation or older metamorphic rocks within the granitic rocks. H9 is situated at east of Kanagallu, H10 is on the west of Kotayagudem in the N-S direction and H11 is trending in the NE-SW direction.

Seven magnetic lows are found appeared and marked in Fig (3c) L1 (trending NW-SE direction lies in between Ghanapuram to Kacharam), L2 (East of Peddavura), L3 (NE-SW in between Malepalem to Kottlapur), L4 (in the eastern part of the study region traversing in the direction of NW-SE and continued up to Marepally east. Then the direction changes abruptly to North – South. L5 is a small negative closure in the east - west direction, located west of Marepally. L6 is passing from Chepur to Gurrampod in the direction of NW-SE, L7 falls northern part of the study region and east of the Kottayagudem with NS trend. These prominent magnetic lows are indicating relatively deep and or/non - magnetic source/or basement with a slope directed towards west. The alignment of closures from Ramadugu, magnetic lows are significant for lamproites exploration smaller off-shoot of larger intrusions migrates up through fault in the form of pipes and deposits lamproites. It is very difficult to arrive to draw a pattern to the occurrence of Kimberlite/Lamproites deposits. However, in general, the intersection of linear trends, bulging of contours, low second order magnetic anomalies, contact between dykes and gneisses (shear zones) are the favorable indicators (Ramachandran et al., 1999) in the search for Kimberlite/Lamproites.

The magnetic lows in the study area appear to be associated with lamproites pipes at Ramadugu and occur in the form of small pockets in the central and northeastern part of the region at the intersection of various contour trends and have

zigzag and accurate shapes. The existence of the inferred faults associated with these trend pattern in the radiant Peddavura-Ramadugu region are also likely to be associated with lamproites, may be confined to Archaean and Proterozoic cratons are linked to upwelling mantle due to drifting or a mantle plume (Kullerud et al 2011). However, the geochemistry and petrogenetic modeling of RLF samples (Chalapathi Rao et al 2014) suggest a predominant contribution of sub-continental lithosphere mantle to their magmas, with a limited contribution from connecting (asthenospheric) components.

In order to qualitative interpretation of magnetic data such as estimation of the depth to the magnetic sources, analytical techniques like, horizontal, vertical derivative, analytical signal

(Nabhigaian, 1972) and tilt derivatives (Miller and Singh 1994, Veroduzcoet al., 2004, Orcue and keskinsezer, 2008) techniques were used in the present analysis.

Figures (Fig.4a) shows the horizontal gradient along the X direction, Vertical derivatives (Fig.4b), analytical signal (Fig.4d) and tilt derivative (Fig.4c) maps delineated NW-SE and NE-SW striking anomaly trends. It can be inferred that Peddavura schist belt trending in the NW-SE direction and occurs as discontinuous body. However, in the study region Peddavura schist belt shows varying trends of NW-SE, NE-SW and E-W.

The vertical gradient (Fig.4b) and tilt derivative (Fig. 4c) maps are similar with closures at the same locations and the BIF exhibits irregular trends with small closures, occurs as discontinues body. The correlation between magnetic trends, horizontal and vertical gradients, analytical signal, tilt derivative and structure of the Ramadugu region are brought out both on the general trends as well as geomorphology.

The coefficient of variation (CV) is calculated using (Himabindu and Ramadass 2001) equation (1), five point segment of the magnetic observations for calculating the CV. This technique immensely helps for picking up the geological contacts, tectonically disturbed zones, faults, structurally disturbed zone. Fig. 4e shows the profile and contour image map of the coefficient of variation of the magnetic anomalies in the study area indicating four broad zones A, B, C & D. These are tectonically disturbed zones might be identified potential lamproite zones consisted of examining the association of reported lamproites at Vattikodu (D) & Ramadugu (C), whereas A and B zones required for further detailed investigations for possible mineralization.

For comparative analysis, structural features inferred from the Total magnetic anomaly (TMI) analytical techniques (horizontal, vertical, analytical and tilt gradient) shown in Fig10. Some of these lineaments correlate or coincident with the mapped structures such as faults shear zones and dykes and a total ten (F1-F10) fault are mapped and shown in Fig10.

The fault / lineament F1 observed is located in the south western part of the study area which is the contact zone between the younger/homophorous granites. The fault F2 indicate the contact between the western and eastern margin of Peddavura schist and granite, F3 observed near Teppalamadugu is trending in the N-S direction. The fault F4 is trending in E-W direction from North of Teppalamadugu to Anumala. The fault F5 (NW-SE) passing from Anumala to Ramadugu, Marepalle beyond extending from Haliya to Ramadugu East and F6 (NE-SW) are the important tectonic lineaments / fault zones in the study area which are highly disturbed. The emplacement of lamproites near Somvarigudem, Marepalli, Yacharam and Ramadugu regions is associated within fault/shear environment F5 & F6. The F7 fault trending in the NE-SW direction from east of Kanagallu, F8 separate the Lamproites of Vattikod from Gundrapalli Lamproites running in the NW-SW direction. The observed total magnetic intensity over the Gundrapalli, Vattikod Lamproites and Somavarigudem lamproites recorded with high magnetic intensity might be due the association with the homophorous granite. F9 fault is situated at extreme west of Gurrampod to further north and F10 fault falls western part of the study region near east of Kalwapalli.

Sridhar and Rau (2005) recorded a total of 10 NW-SE trending lamproite dykes found over an area of $25Km^2$ in three different clusters in the Ramadugu area, five near Ramadugu, two near Yacharam and three near Somavarigudem Village. These lamproites occur as dykes and trend essentially NW-SE as discontinuous isolated outcrops associated with intrusive contact with the basement granitoids (Chalapathi Rao et al 2014). Lamproites in the study area are emplaced along NE-SW directions parallel to oblique to the foliation, joint, dyke and regional fault / fracture trends. Ramadugu and Yacharam lamproites are emplaced along the contact zone between the dyke environment and granite gneisses and imply the involvement of distinct deep-seated faults/fractures in controlling their emplacement. Likewise, the Ramadugu lamproites occur as dykes. Lamproites at Somavarigudem occur in close association with dolerite dykes and fault contact is observed in lamproite emplacement in the study area. At Vattikod, most of the lamproites are emplaced at the contact zone between the Alkali Feldspar granite and biotite gneiss granitic gneiss basement and in dolerite dykes.

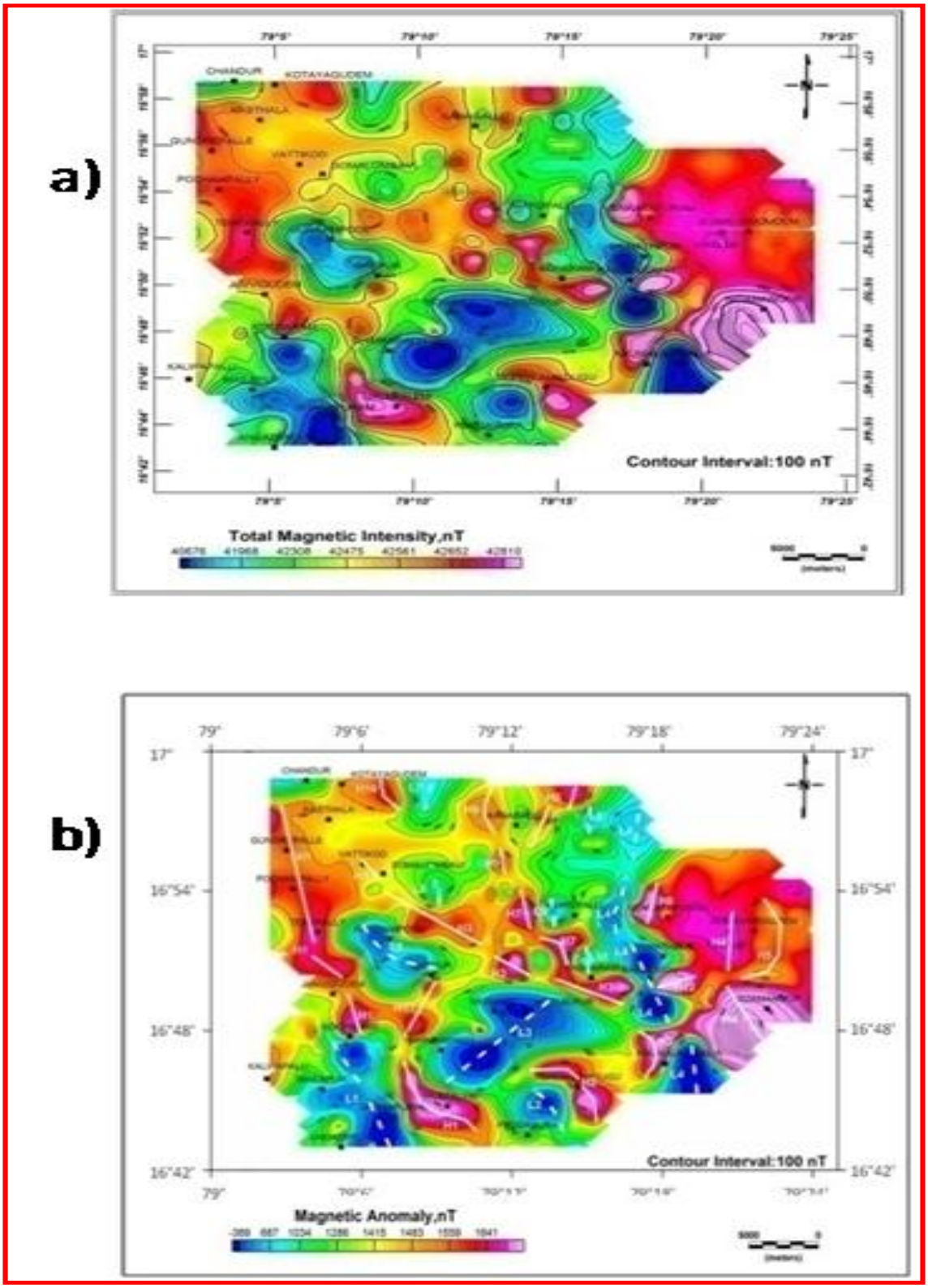

Figure 3:- (a) Total magnetic Intensity of the study area, (b) IGRF of corrected magnetic anomaly of the study area.

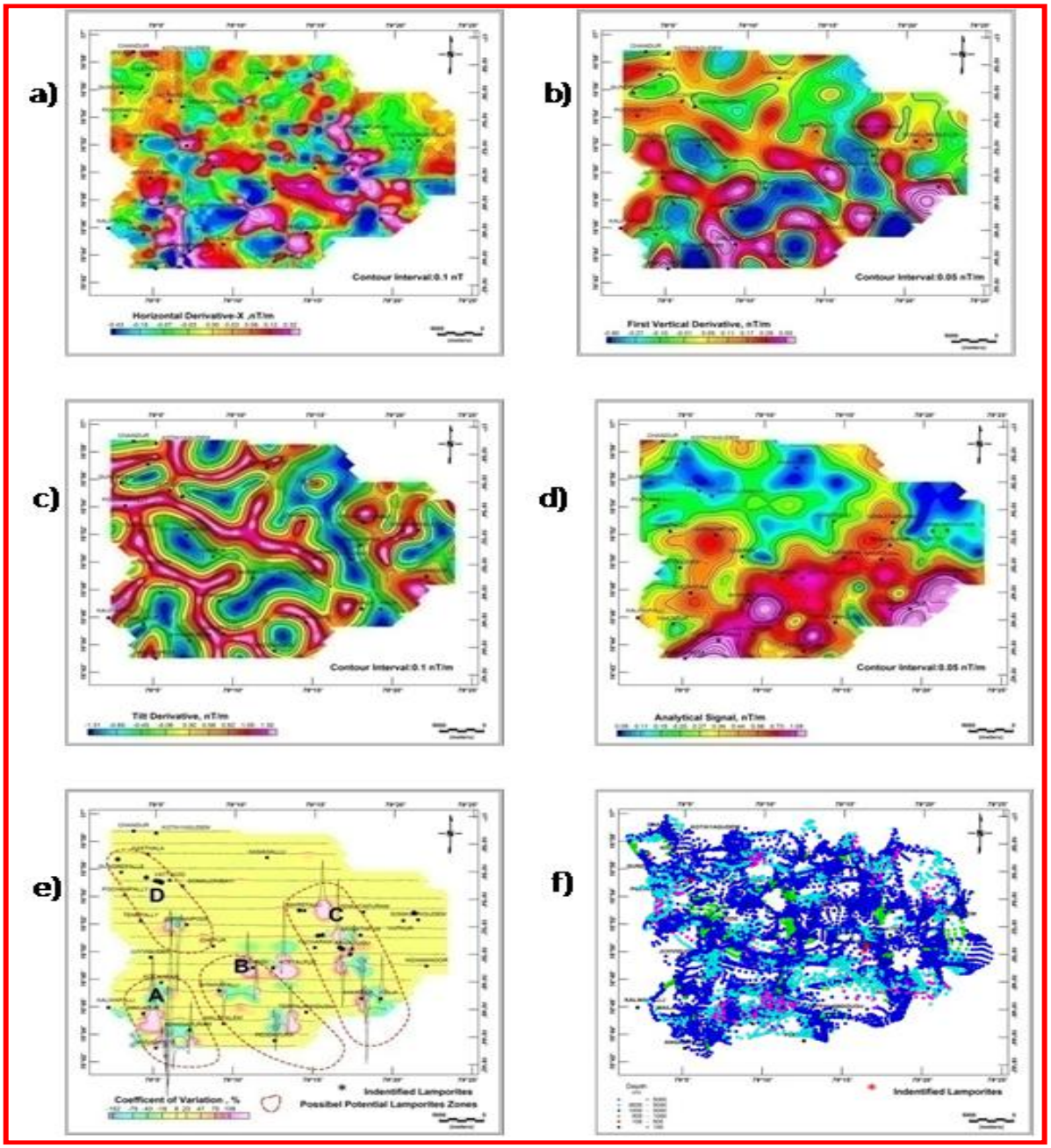

Figure 4:- (a) Horizontal derivative of the magnetic anomaly in X direction, (b) Horizontal derivative of the magnetic anomaly in Y direction, (c) Vertical derivative of the magnetic anomaly with identified Lamproites, (d) Analytical Signal of the magnetic anomaly with identified Lamproites, (e) Tilt derivative of the magnetic anomaly, (f) Coefficient of Variation profiles magnetic anomaly and image of the study area with probable mineralized zones (A, B, C & D), (f) Euler Deconvolution depths.

Lamproite occurrences with intersecting lineaments/faults within the region of domal peripheries, nine potential lamproites zone were delineated at 4, 5, 8, 9, 10, 11 and 13 domal peripheries. However, the prospects are not bounded to these three areas and the occurrences of lamproites in the surrounding in the areas can also be considered. Ramadugu lamproite clusters occur as isolated dykes and NW-SE trending dykes. These are covered by top soil, lamproites near Yacharam and Somivarigudem showing intrusive contact with granitoid (Chalapathi Rao et al 2014). The available EDC Lamproite.

Euler Deconvolution (Thompson, 1982, Reid et al 1990) computed for gridded semi detailed magnetic data. It is based don Euler equation which related the magnetic field and its gradients to the location of source and provides automatic estimate of depth, it used a structural index (SI) to characterize different source types are sphere,

cylinders, faults, contacts etc (Fitz Gerald et al, 2004). On assuming the source as a narrow dyke based on the structural index of SI=1, Euler Deconvolution delineates the plausible spatial locations of sources of depth varying from100m to 500m (Fig.4f).

V. STRUCTURAL IMPLICATIONS FOR LAMPROITE EMPLACEMENT:

There are no characteristic structural patterns for Kimberlite/lamproites occurrences. However, total magnetic Intensity surveys bring out complex patterns of highs and lows suggestive for close association with structural features such as shear zones, faults, fractures and contact between dykes and granites etc. They also aid in determination of the disposition of ultrabasic intrusions and doleritic dyke clusters. These inferences, intern may have a bearing on Lamproite emplacement. Furthermore, smaller off-shoots of larger intrusions migrate up through fault system in the form of pipes and deposit diamonds. Thus, intersection of linear trends, bulging of contours, low magnetic anomalies is favorable indicators in the search of diamonds (Ramachandran et al 1999). Interestingly, the magnetic anomalies in the Ramadugu region (Fig.5) occur at the intersection of various contour trends as bipolar features having zigzag and accurate shapes any may have some bearing on lamproite emplacement. Reported lamproites occur at west of Vattikod about 22 km from the Known Ramadugu and Somavarigudem Lamproite Field, (Joy et al. 2012; Kumar et al. 2013; Reddy et al. 2003; Sridhar and Raju, 2005) revealed that they are associated with an E-W trending strike-slip faults and associated NE-SW resultant fracture domain in Ramadugu and Somavarigudem and Vattikod regions are predominantly NNW-SSE trending fractures. From similarity of characteristic magnetic anomaly patterns (lows) associated with these lamproites with those in the rest of the study area.

Morph - structural features have a strong affinity to Kimberlite /lamproites emplacement at various locations in the cratonic shields of the world. Ramadugu region also constitutes such favorable morphostructural features which are favorable for lamproites emplacements. Integrated studies magnetic (analytical techniques) lineament patterns over lamproites occurrences may reveal further investigations in the vicinity of defined morph structural features (1 to 13) at intersections of lineaments and in surroundings of the domal peripheries (2, 3, 4, 5, 6, 8, 9, 10, 11and 13) and in conjunction with faulted zones, will probably favorable zones for lamproites locations are showing in Fig.5 details are given in Table-I. Among these three zones (1, 7 and 12) in Fig.5 no Lamproites basics were reported. However a fair possibility for lamproites in these zones, in view of its structural significance in these zones required further detailed study.

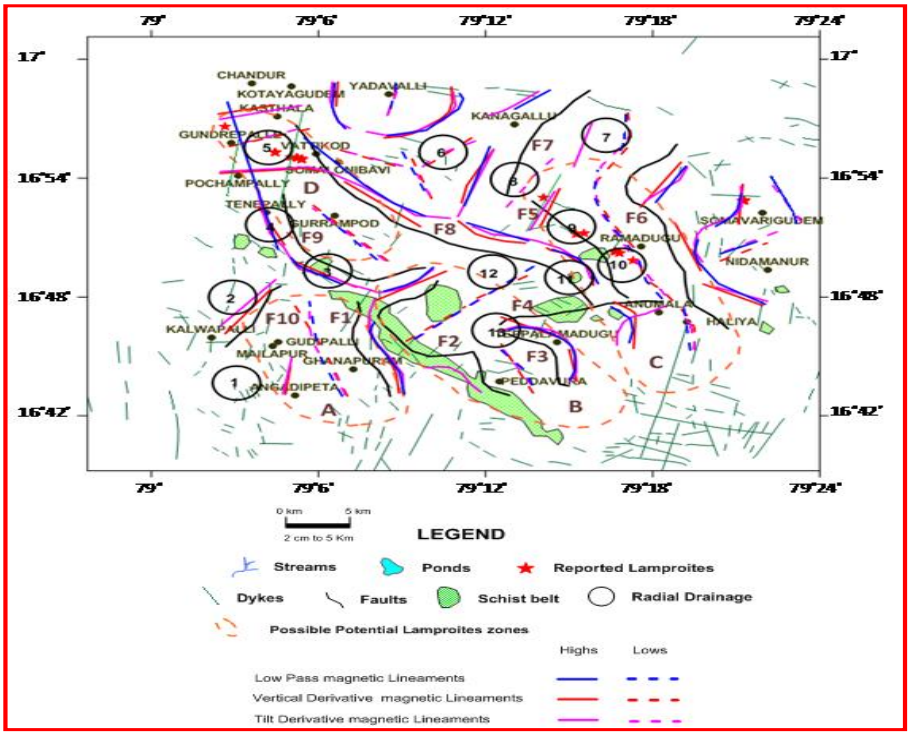

Figure: 5 Structural map of the study region in and around Ramadugu, T.S., India, as inferred from Total magnetic Intensity data analysis

Zone five (5) is located at west of Vattikod region has already reported ten clusters of lamproites (Alok kumar et al 2014) which are passing through the fault F6 and F7 trending in the NW-SE direction, most of these lamproites are emplaced at the contact zone between the Alkali Feldspar granite and biotite gneiss, granitic gneiss basement and in dolerite dykes.

Zone 6 is situated in between Samulonibavi and Kanagallu in Pulavay block reported few lamproites, similarly zone 8 represented with one lamproite near west of Marepally village, Zone 9 occurring east of Yacharam and is the smallest zone reported two lamproites (Sridhar

Table-I: Morphostructural details of Ramadugu study area derived from Integrated Geophysical studies

Circle No.	Location	Latitude in degrees	Longitude in degrees	Remarks
1.	Angadipet	16.72775724	79.05033432	---
2.	Kalwapalle (North)	16.79823752	79.04795858	F1 fault(NW-SE)
3.	Gurrampode (South)	16.82041109	79.10576824	F2 fault(NW-SE)
4.	Between Tenepalle and Gurrampode	16.85842293	79.07171598	F2 fault (NW-SE) & F3 (NE-SW)
5.	Vattikodu	16.92510555	79.06955147	Reported 9 Lamproite bodies (Alok Kumar etal.,2013) f7(NE-SW to N-S) fault
6.	Between Samulonibavi and Kanagallu	16.92098407	79.17387278	Reported Intrusive Lamproite bodies (Alok Kumar etal.,2013),fault F4 (NE-SW)
7.	East of Kanagallu	16.93365468	79.27286193	---
8.	Marepalle	16.89671022	79.21720719	Reported one lamproite , fault F5 (NW-SE)
9.	Yacharam	16.85763101	79.25227219	Reported two Lamproite bodies (Chalapathi Rao etal.,2014) fault-F5(NW-SE)
10.	Ramadugu (South west)	16.82667477	79.27968791	Reported 10 Lamproite bodies (Sridhar et. al., 2005) Fault F 5 (NE-SE)
11.	Between Ramadugu-Anumala	16.81436376	79.24844205	---
12.	Mosangi (near)	16.81933294	79.20229964	---
13.	Teppalamadugu	16.76972864	79.20713314	----

et al 2005) and Zone 10 and 11 are located around Ramadugu passing through the NW-SE trending fault F5 has reported occurrence of Lamproites (Sridhar et al 2005 and Chalapathi Rao 2013) ,while eight lamproites occur as dykes. Lamproites at Somavarigudem occur in close association with dolerite dykes and fault contact is observed in the study area.

VI. PRECISION GEOPHYSICAL SURVEYS

6.1 Very Low Frequency Electromagnetic survey

The very low frequency electromagnetic (VLF-EM) method is well established for quick identification of buried conductive targets. The method makes use of signal radiation from military navigation radio transmitters. There are about 42 global ground military communication transmitters operating in VLF frequency range of 15.0 to 29.0 kHz with a band width of 150 Hz (ABEM, 2007). These stations located around the world, generate signals which are effectively used for variety of applications including navigation, communication, mineral exploration, mapping of fault zones etc. (Wright, 1988, Philips and Richards, 1975, Sundararajan et al., 2008, Ramesh Babu et al., 2009).

The present investigations in the Ramadugu study area are performed using the signal from the transmitters are utilized in the survey to ensure strong signal response VLF transmitters, at USSR (UMS), UK and USSR (ROR) are operated with a frequency of 17.1kHz, 19.8kHz and 17kHz respectively was used as the source of VLF measurements employing ABEM Wadi equipment, global Position system (GPS) was used for exact special position of collected data in the study area.

The VLF data (real and imaginary components) of the EM fields measured was subjected to Fraser (1969) filtering to increase the

signal to noise ratio of the data set and enhance the anomaly signatures. For quantitative interpretation, it is more useful to plot the real and imaginary data. This procedure was developed by Karous and Hjelt (K&H, 1983) made use of linear filtering filter proposed by Karous and Hjelt (1977&1983) allows geophysicists to filter the in phase (Real) and out phase (Imaginary) data and generate an apparent current density pseudo section and therefore image the geological underground structure (Coney, 1977; Fisher et al., 1983; Sundararajan et al., 2006; Fraser, 1969) in analyzing VLF real and imaginary data, which an extension of the Fraser filter. According to Ogilvy and Lee (1991), the current density pseudo section provides good visualization of targets such as mineralized veins, fractures (Parker, 1980), and sub vertical conductors.

6.2 Analysis of precision Ramadugu VLF data

The area of investigation is situated to the south of Nalgonda town and includes the Halia river basin is a part of the Indian Peninsular Shield Rocks of the Archaean, Late- Proterozoic Kurnool group of sedimentary rocks overlying the gneiss-granite Archaean basement with the enclaves and rafts of Dharwar rocks. The geology of Ramadugu area shown in Fig.6 (GSI, 1999) the area forms a part of peninsular gneissic complex comprising of migmatites and intrusive granitoids with enclave patches of older metamorphic rocks. Multiple sets of fractures trending N-S., E-W NW-SE and NE-SW trending dykes (Chalapathi Rao, et al., 2014), are common. A total of 14 (0.5-3 m thick), NW-SE trending dykes were discovered (Sridhar and Rau, 2005) eleven dykes, spread over an area of 26 sq.km on the right bank of Halia river in close vicinity of Ramadugu village and three of them in about three dykes, spread over an area of 3 sq.km occur near Somavarigudem village. The lamproites of Ramadugu (RLF) are very fine grained, yellowish green to greenish grey, dense, hard and compact. They show faint NW-SE trending foliation, which is parallel to the trends of these dykes. However we cloud locate only seven of these bodies-five near Ramadugu (R-1 to R-5) and two near Yacharam (Y1to Y2), these lamproites occurs as dykes and trend essentially NW-SE discontinuous isolated out crops. The Yacharam lamproites are occurrences showing intrusive contacts with the basement granitoids.

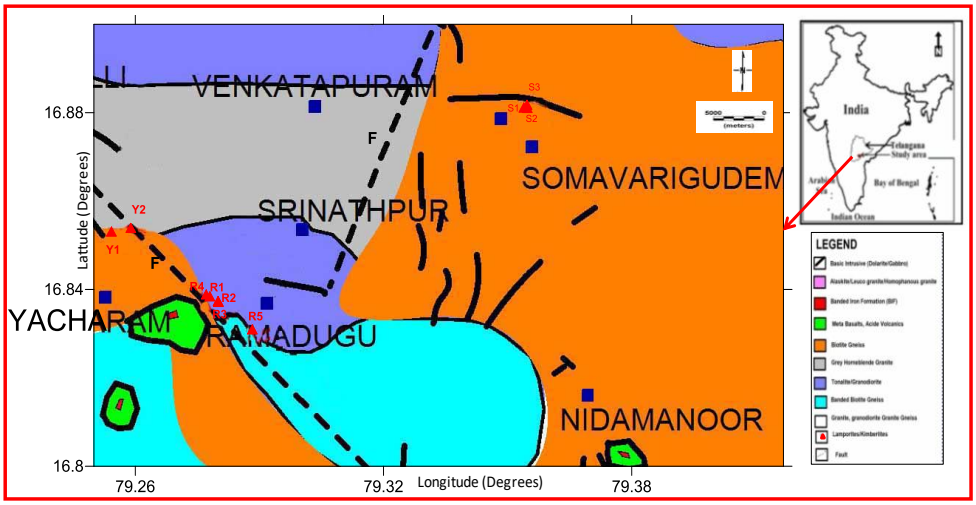

Figure: 6 Geological (after Chalapathi Rao et al 2014) and VLF location map of the Ramadugu study area.

The VLF data obtained were presented as profiles (Fig. 7 to 11) by plotting of the filtered real and imaginary components against distance using Microsoft Excel package, while corresponding Karous-Hjelt filters processed using Ramag (VLF-2010) software the corresponding pseudo sections of the profiles are shown in Fig.7c to and these sections for real and imaginary components are presented red color indicates the high current density and black color indicates low current density reflects the non-conductors or and resistive formations respectively.

i) Profile R1 (Ramadugu R1)

Profile R1 shown in Fig.7 start from west of the R1 Lamproite body (16º50′17.1″ latitude, 79º16′40.1″ longitude), the total length of the profile is 28m. Fig.7b the filtered real and imaginary response ranged from -150% to 150 %. From these components cross over points indicate the (Fr) contact boundaries between rock units at and maximum amplitude of real component indicates the three conductive bodies at 4m, 19m and 23m. The cross over points of real and imaginary at 19.3m is identified as fault at the same location R1 lamproite body inferred.

Fig. 7c is the apparent current density distribution of the pseudo- section along this traverse indicates presence of conductive (Red color) and resistive formations (black color) as three lamproite dyke at three locations 10-12m and 18-21m and 23-24m are marked, these are dipping towards left side of the traverse. There is a sequence of alternating low and his response on magnetic profile Fig.7a, suggest the presence of fracture contact or contact between two geological formations.

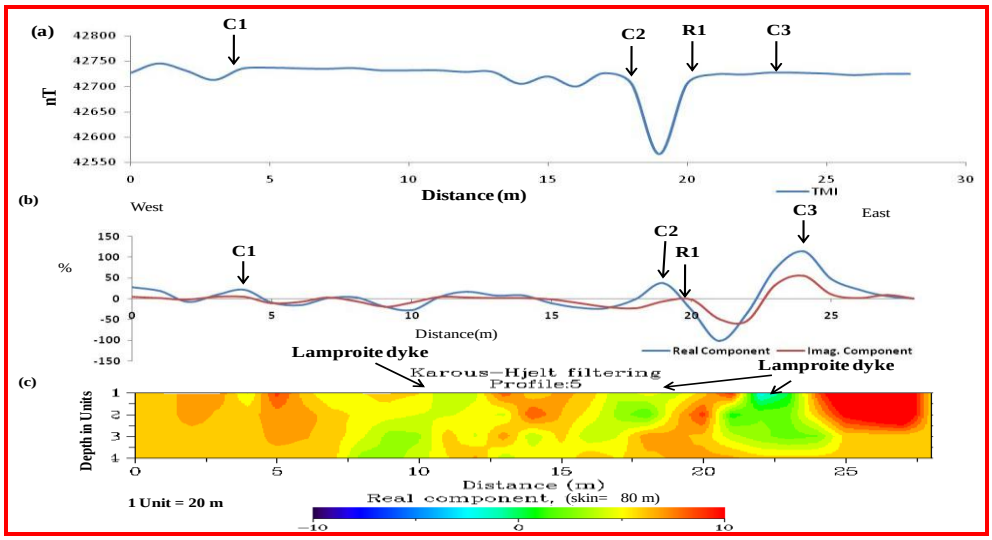

Figure: 7(a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Ramadugu **(R1 - 16^{0}50′17.1″, 79^{0}16′40.9″)**

ii) Profile-R2 (Ramadugu R2)

Profile–R2 is run across the R_2 Lamproite body (16º50′13.3″latitude, 79º16′48″ longitude) the Total profile length of 21meters the observations were made at every one meter Interval.

Figure.8 (b) shows the values ranged from -300 to 300 % are real and imaginary components response of Fraser filtered data. The positive amplitude of Real Imaginary components figure (8 b) four conductors C_1, C2, C3 and C4 identified at 9m 13.17 and 26m respectively. The apparent current density pseudo section shown in Fig 8c three thin dykes (lamproite) and two shear zones at 2-7m and 21-24m extended vertically up to 60m are seen, bed rock topography is varying 30 to 7om along this traverse. The total magnetic (Fig 8a) exhibit similar variations observed on R1 lamproite body.

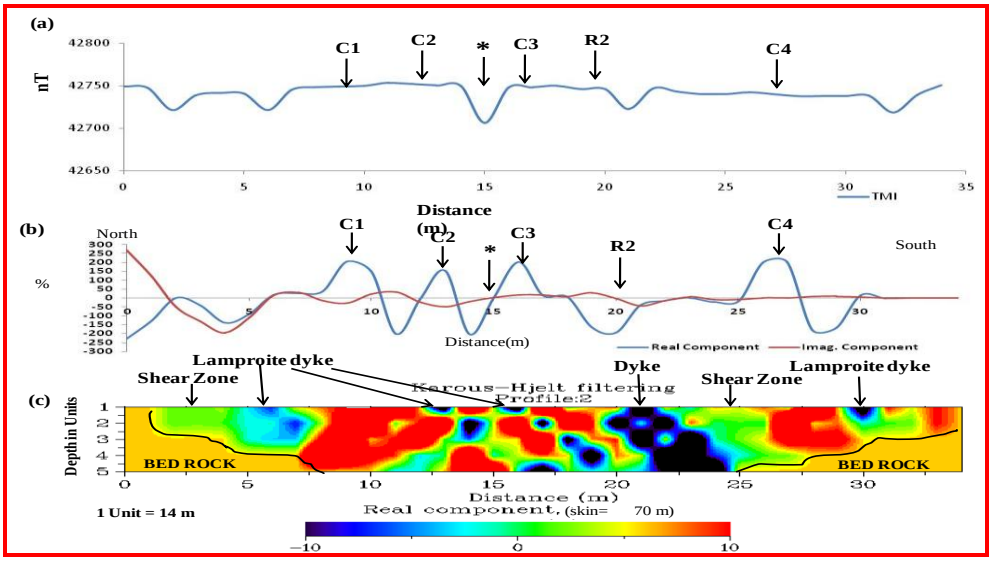

Figure: 8 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Ramadugu **(R2 - 16^{0}50′13.3″, 79^{0}16′38.0″, * Probable Lamproites)**

iii) Profile-R3 (Ramadugu R3)

Profile–R3, Fig9 (16º50′12.6″ latitude, 79º16′48.3″ longitude) is further East of profile 2,

Fig 9b shows the values ranged from -150% to 150 % is real and imaginary components response of Fraser filtered data. The real and imaginary data Indicate on and cross over points positive real imaginary components Indicates presence of conductive bodies along the profile (Fig.9c) at 6 and 11m designated as Fr1 and C1 respectively Apparent Current density Pseudo Cross Section Show.

Fig. 9(c) indicates two lamproite a dykes in between 4-6m and 5-14m) with a low response on real and imaginary values, the R_3 Lamproite bodies laying the 15 Station and also expected and the Lamproite body at Station 5th.and reflected the total magnetic intensity (Fig. 9a).

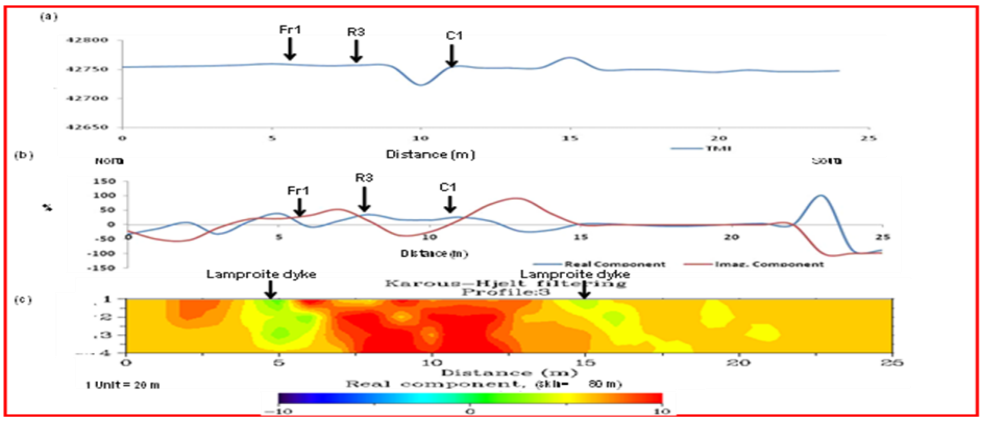

Figure: 9 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Ramadugu **(R3 - 16^{0}50′12.6″, 79^{0}16′48.3″)**

iv) Profile-R4 (Ramadugu R4)

This Profile- R-4 (16º50′18.7″ latitude, 79º16′37.7″ longitude), likes western part of the point study is a 51meter length Fig 10. Fig10 b shows the values ranged from -200% to 250 % is real and imaginary components response of Fraser filtered data.

Fig.10b real anomaly curves suggest present of two conductors (C1 and C2) and one fracture (Fr1) at 10m, 26m, and 18m respectively along the profile. Lamproites is located at 16th station lies at crossover of real and imaginary components. The contact between conductive non conductive bodies located at R4 Lamproite dyke with a 4m width, dipping towards right west of the profile Fig10c with a varying 32m to 70 bed rock thickness on apparent current density pseudo section. The magnetic behavior Fig 10a over this traverse at 2m, 15-20m and 50m were observed with fluctuations indicating a fracture zone corroborating with the VLF results.

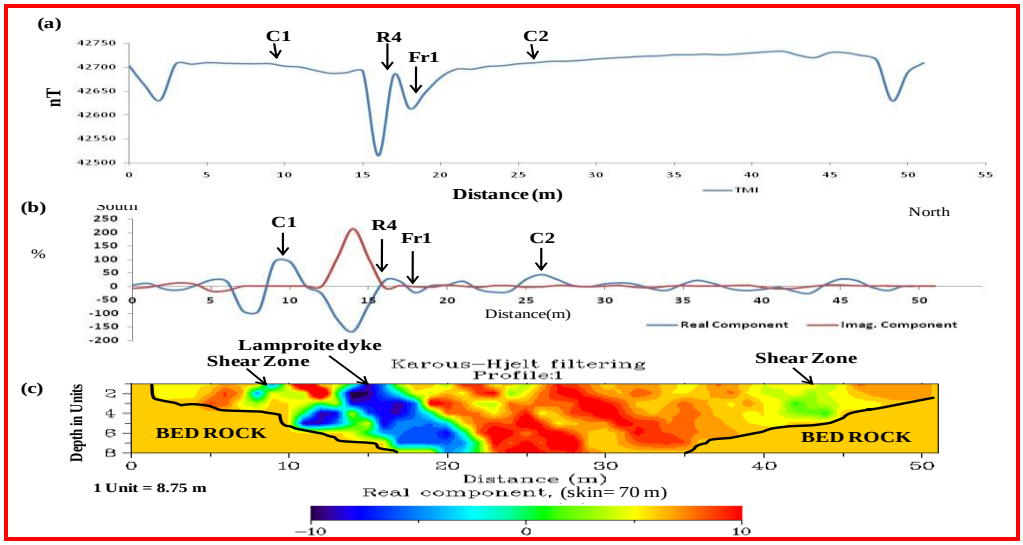

Figure: 10 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Ramadugu **(R4 - 16^{0}50′18.7″, 79^{0}16′37.7″)**

v) Profile-R5 (Ramadugu R5)

This Profile R-5 (16º49′50.2″ latitude, 79º17′17.8″ longitude), R-5 is located near Eastern part of the study area the total length is 30meter. Fig. 11b shows the values ranged from - 300% to 200 % is real and imaginary components response of Fraser filtered data.

Fig11b VLF anomaly curve (Real and Imaginary curves) Indicate the presence three conductive futures C1, C2 and C3 around Station 3m, 8m and 12m at maximum amplitude of real components and cross over indicating a fractures zone's R5 lamproite is located at12m in between dyke and granitic intrusion.

Apparent Current density Pseudo section Fig (11c) is characterized by, in between shear zone and la thin dyke. They are dipping towards right side of the profile.

Magnetic data Fig (11a) suggest cooperative the magnetic negative value along the profile the Station 14 and 15 Lamproite bodies and R5.

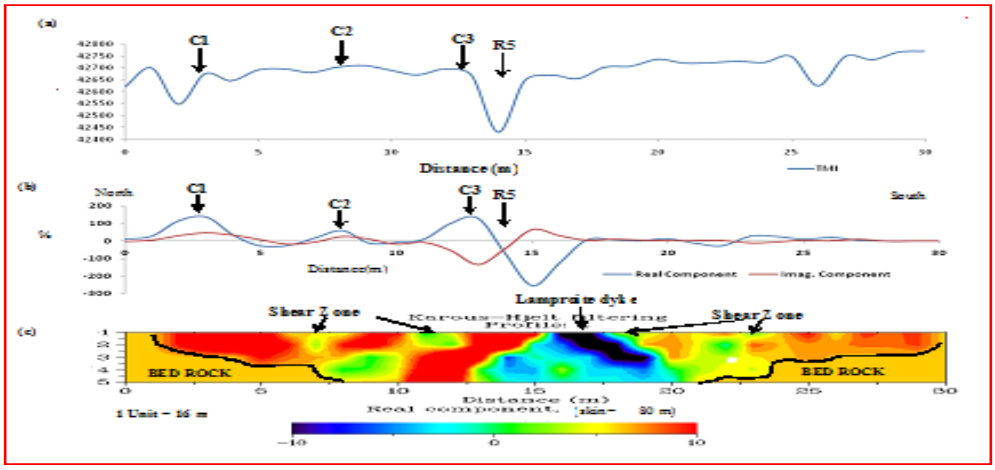

Figure:11 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Ramadugu **(R5 - 16^{0}49′50.2″, 79^{0}17′17.8″)**

vi) Profile -Y1 (Yacharam Y1)

ProfileY1 (16º51'12.9″ latitude, 79º15'32.1″ longitude) runs through the Y1 lamproite at Yacharam village Fig.12. Fig. 12 b shows the values ranged from -30% to 30 % is real and imaginary components response of Fraser filtered data.

Positive amplitude of real and imaginary component clearly brought out three conductive bodies given C1, C2 and C3 at 3m, 8m and 13.5m respectively. Fig 12c is the current density distribution indicates three dykes with a moderate current density distribution and contact between dyke and granitic intuition two probable zones of Lamproite bodies traced at 3.5m and 15m.

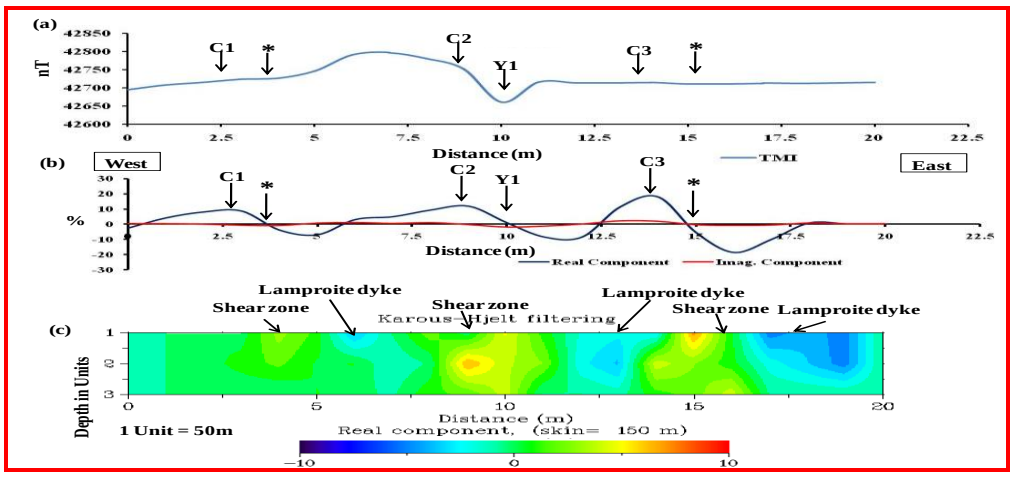

Figure:12(a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Yacharam **(Y1 - 16^{0}51′12.9″, 79^{0}15′32.1″, * Probable Lamproites)**

vii) Profile-Y2 (Yacharam Y2)

This Profile Fig13 Y-2 is a total length of 20 m running from (16º51'09.9″ latitude, 79º15'15.2″ longitude) lies 2km away from the Yacharam village. Fig13b shows the values ranged from -30% to 30 % is real and imaginary components response of Fraser filtered data. Fig13b is the plot of flittered real and imaginary components along the traverse shows three high amplitude of real anomalies indicates location of conductors C1, C2 and C3 at 3m, 9m and 13m respectively. Fig13c shows the corresponding K-H apparent current density pseudo sections of profile Y2 is a measure of conductivity of the subsurface as a function of depth. Total magnetic profile Fig13a show two lows at lamproite body Y2 and (*) new lamproite bodies.

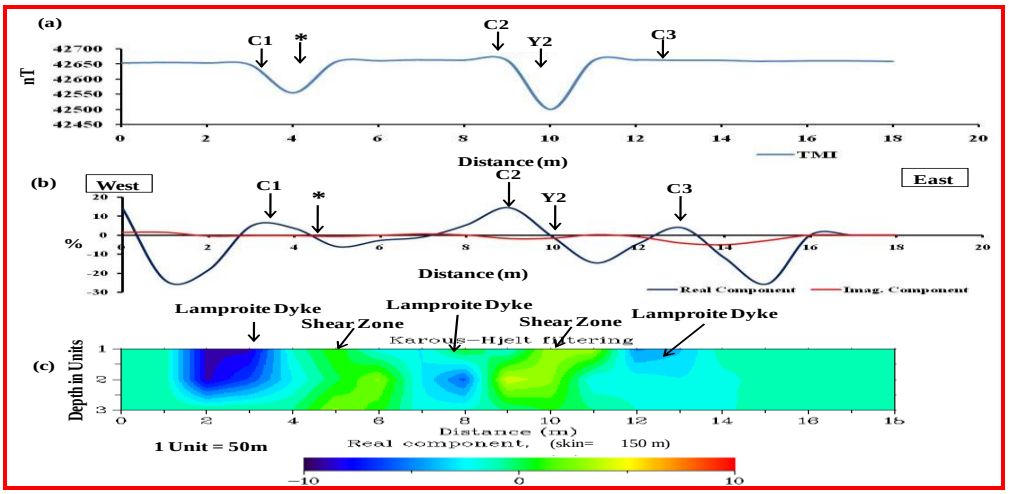

Figure:13 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Yacharam **(Y2 – 16^{0}51′09.9″, 79^{0}15′15.2″, * Probable Lamproites)**

VII. ANALYSIS OF PRECISION VLF DATA (VATTIKOD)

The study area falls in the North western margin of the Cuddapah basin lies in between latitude 16º 52' to 16º 58' N: longitude 79º 00' to 79º 10' E, Dharwar craton, Southern India,.

within the Vattikod and Gundrapalli lamproite field (VLF) and are located about 22km west of the Ramadugu lamproite field (Sridhar and Rau 2005). The area forms apart of Peninsular Gneissic Complex (PGC) comprising migmatites and intrusive granitoids with enclave patches of older metamorphic rocks Fig14. The ten lamproites bodies (Alok kumar et al., 2013) identified at the west of Vattikod village (16º 55' 13.2″& 79º 05' 55″) are VL1 to VL10, one lamproite dyke located in the close vicinity of Gundrapalley village (16º 56' 35.9" N 79º02'38.6") is GL1. These lamproites are emplaced along ENW-ESE to BW-SE trending fractures in the granitic–gneiss basement. Dolerite dykes are also seen emplaced alongside of the lamproites in the WNW-ESE fractures. Apart from these a few more lamproites are noticed (Alok kumar et al., 2013) in the form of stray boulders at two other locations Kastala and Samulonivaribavi in the study region.

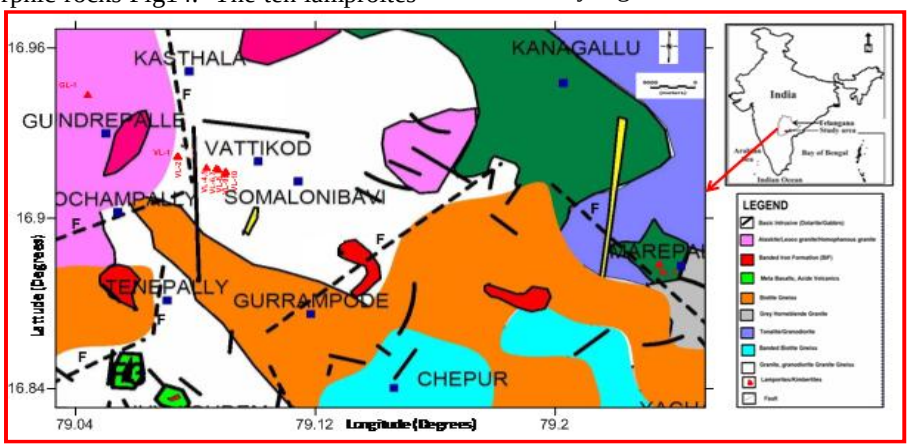

Figure: 14 Geological (Alokkumar et al 20130 and VLF location map of theVattikod study area.

The Karous-Hjelt filters was used data was processed using Ramag (VLF) modeling processing software 1.04 version (2010), modeled nine traverses, using skin depth 150 m. The set of apparent current density pseudo sections for Real and Imaginary components and graph for Real and Imaginary component amplitude generated for each traverse. The corresponding pseudo-sections (plots of station interval vs. depth) are shown in figures (15 to 20). The depth of the section obtained up to 150m. The Red color indicates the high current density (conductive body) and blue color indicate low current density (high resistivity body as dykes) and intermediate green color moderate resistive bodies, as shear zones.

i) Profile-GL1 (Gundrapally GL1)

The profile-(Gundrapally - GL1 latitude 16º56'35.9" N, longitude 79º02'38.6"E) trends approximately N 36^0 E direction across the Gundrapally lamprorite bodies and is 55 m long. Fig15a is the total magnetic intensity are obtained along the traverse is characterized susceptibility less than the back ground levels over the conductive and lamproite bodies.

Figure 15b shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -150 % to 150% along the traverse GL1 Fig15b is the filtered real and imaginary components along the profile, positive amplitude of real and imaginary components and crossovers indicates the presence of one conducive zone between station to 15 to 20m and one fracture zone (Fr1) at 23 m and lamproite body at 30m along the profile GLI are identified. Fig 15c is the apparent current density pseudo section of the real component reveals the subsurface nature of the conductive and resistive bodies. The conductive body is between 15 to 20 m dipping towards west and resistive bodies between 24m to 47m dipping towards east. The data show four parallel small moderate current density distribution on real components, which is possibly indicating a fault related depression zones is recognized as 3m width shear zone in between 29-30m are responsible for location of lamproite dykes (GL1) show irregular to circular surface configuration with occasional protuberances into the sheet/sub-vertical joints in the host granitoids. The basement topography is ranging between 45 m to 150m.

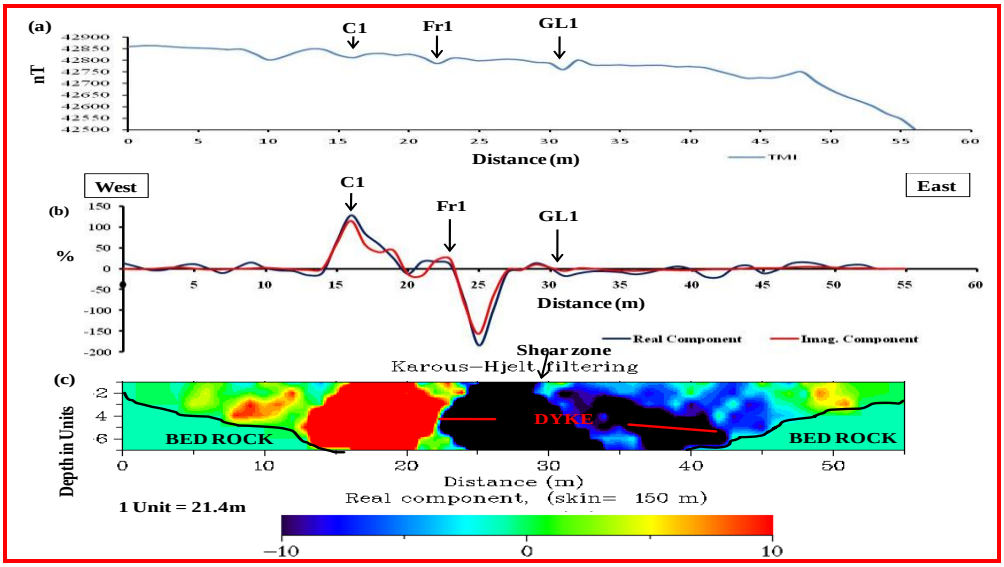

Figure:15 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Gundrapally **(GL1 - $16^0$56′35.9″, $79^0$02′38.6″)**

ii) Profile-VL1 (Vattikod VL1)

Profile VL1 trends approximately N 18^0 E (latitude 16º55'03.5"N, longitude 79^{0}05'01.2" E) and is 32.5m long shown in Fig.16. The double plots of filtered real and imaginary components Fig16b shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -150 % to 250% along the traverse VLI enables qualitative identification of the linear features i.e. Points of coincident of crossovers and positive peaks of the real and imaginary anomaly. From these plots Fig16b one conductive (C1) at 7m and two bodies at 8m and 20m along the profile were delineated. VLF - EM filtered real data have been converted to the pseudo section using the KH filter Fig.16c. The visual examination of these sections allows depth of occurrence, width and dip of the body to be determined. Two lamproite dykes, at 2 to 6m and 28m to31m, one vertical dipping dyke at 14m to 18m, and one shear zone identified, which is associated with a new lamproite associated with a moderate current density distribution.

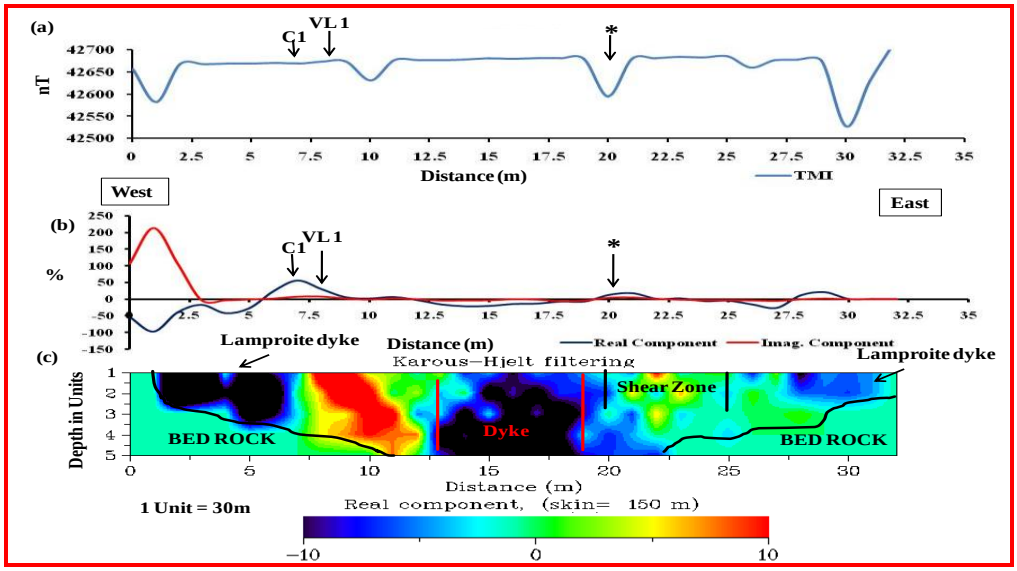

Figure16 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Vattikodu **(VL1- 16^{0}55′03.5″, 79^{0}05′01.2″, * Probable Lamproites)**

iii) Profile-VL2 (Vattikod-VL2)

This profile-VLI (16º54'55.4"-79º05'23.3") is total length of 25 m shown in (Fig.17a) shows total Magnetic. Fig. (17b) and filtered real and imaginary Components of the VLF shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -150 % to 150% along the traverse VL2 Broad variation of radiometric intensity with few lows and three magnetic lows were observed. Figure (17b) shows the filtered real and imaginary components of the VLF data along the profile shows two conductors at distance 7.5 m and 12.5m, designated C1 and C2 respectively and two lamproite bodies at 9m and 21m along this traverse were identified indicated on the real positive amplitude and crossover of the real and imaginary components. Fig.17c represents apparent current density pseudo cross-sections have been constructed for specific and distinctive profile to show the variation of apparent current density, and to derive the change of conductivity with depth. The data analysis revealed the presence of conductive and resistive (western) dipping dyke in between 11 to 12.5m are responding with high resistive body extending beyond 150m vertically and one thin lampoite dyke identified at 17.5m with a 1.5m width extending with 70m vertical direction dipping towards west Fig (17c) is the current density Pseudo section of imaginary components is the inversion of real component.

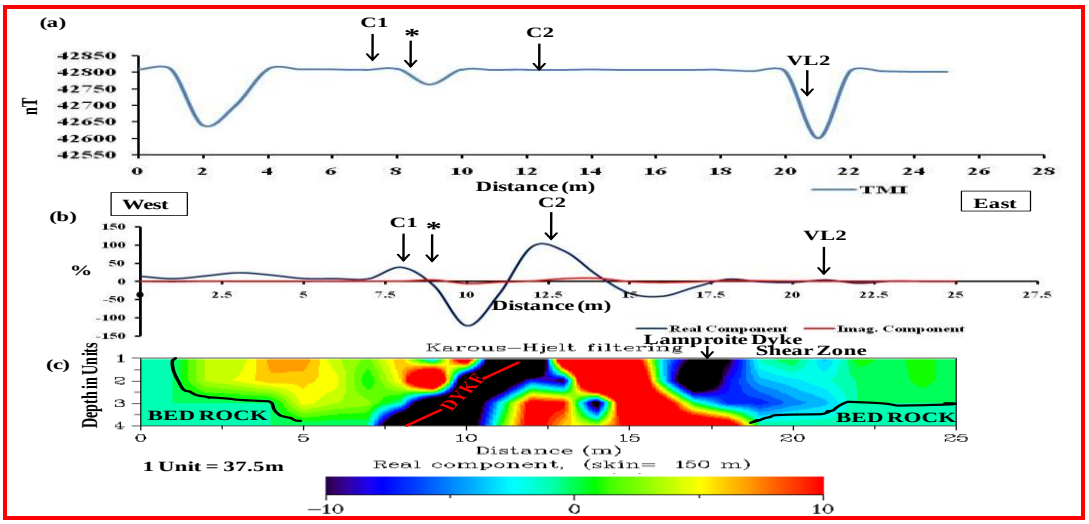

Figure: 17 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Vattikodu **(VL2 - 16^{0}54′55.4″, 79^{0}05′23.3″, * Probable Lamproites)**

iv) Profile-VL4 & 5 (Vattikod VL4 & 5)

This profile Vl4 & 5 extended total length of 55m crossing two lamproite bodies VL4 (16º54' 58.2" -79º05'24.3″) and VL5 (16º54'58.2" - 79º05'24.2") Fig. (18b) shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -60 % to 30% along the traverse VL4 & 5, the real and imaginary plots the indicate presence of the multiple resistive and five conductive bodies along obtained at (C1) 6m, (C2) 24m, (C3) 28m, (C4) 38m and (C5) at 42m along the profile. The apparent current density cross section Fig .18 (c) reveals three lamproites bodies VL4, VL5 and (*) new body situated at 21, 25 and 11.5 m respectively, along the profile a shear zone (40-5m) is characterized by a moderate resistivity contrast with a multiple thin dykes dipping towards west direction were identified. Fig. 18(a) is the magnetic response over the lamproite bodies observed low values compare to background values.

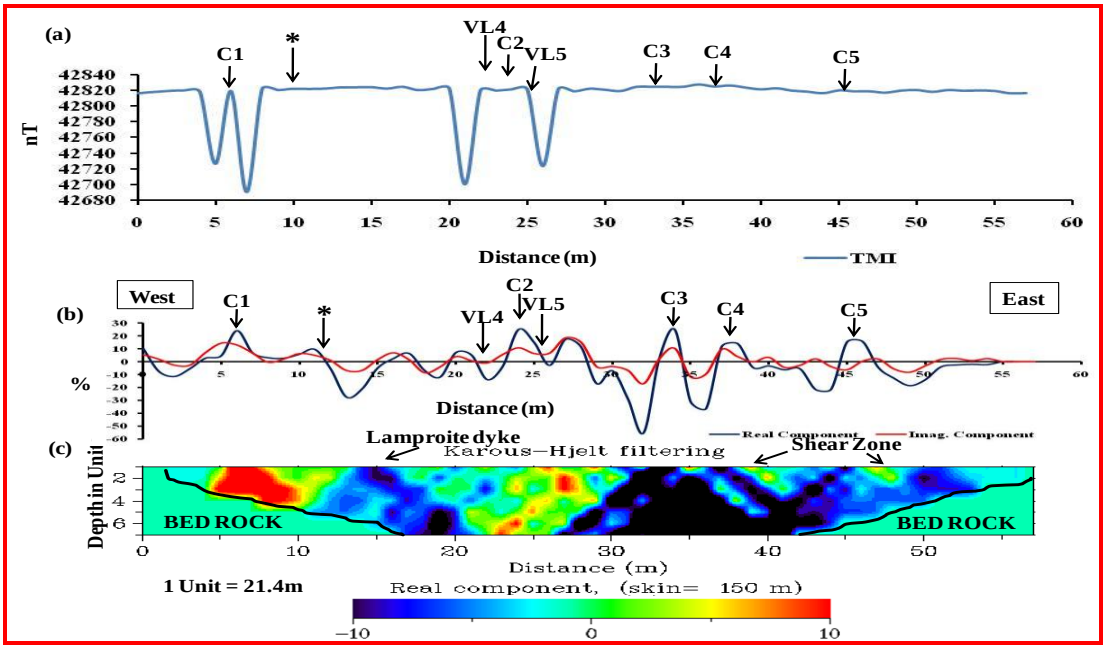

Figure: 18 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Vattikodu **(VL4-16^{0}54′58.2″,79^{0}05′24.2″,VL5 - 16^{0}54′58.2″, 79^{0}05′24.3″ * Probable Lamproites)**

v) Profile-VL6 (Vattikod, VL6,7 & 8)

Profile VL 6, 7 & 8 (16º55'17.6"-76º04'26.1"), Fig.19 shows the across VL6, VL7 and VL8 bodies at Vattikod having a total length of 50m. The VLF, magnetic and radiometric observations obtained at every one meter. Figure (19b) shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -80 % to 80% along the profile.

Profile VL6, Fig. (19b) shows filtered real and imaginary components represent the positive and negative values. Figure (19c) shows current density pseudo section has been constructed distinct to traverse to show the vertical variation of a current density, and consequently to derive the change of conductivity with depth qualitatively. It is possible to differentiate between conductive and resistivity formations using apparent current density pseudo sections multiple nonconductive bodies and conductive bodies. There are six resistivity bodies and three conductive bodies (C1, C2 and C3) at 2 to 4, 8 to 10 and 16 to 20, 30 to 32, 42 to 43, and station 24, station28, station 35 respectively. VL6, Vl7 and VL8 lamproite dykes identified at 28, 29 and 14 m respectively. Two shear zones are associated with Lamproites at western and eastern side of the profile. The bedrock photography is varying traverse 70 m to 150 m at station 25m basement is traced. Figure: 19a is the total magnetic intensity (Fig. 6.23b) exhibiting broad low with fluctuations over the conductive and Lamproites bodies.

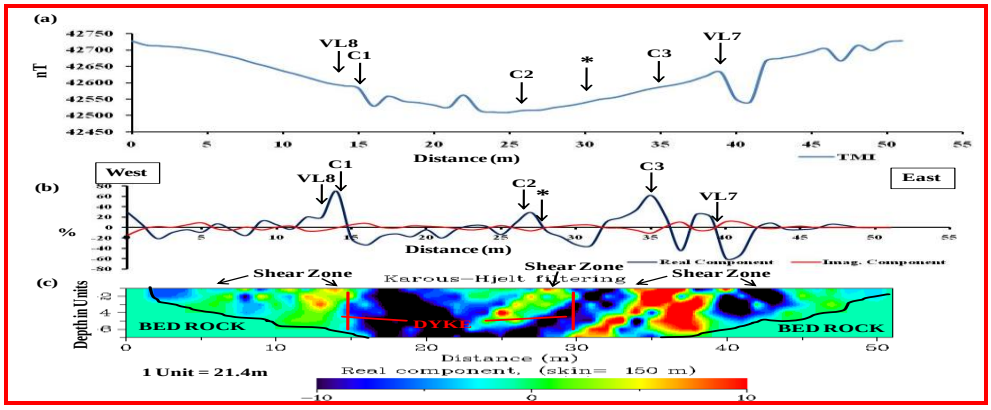

Figure: 19(a) Total Magnetic Intensity, (c) Fraser filter Real and Imaginary Components (VLF) and (d) Karous Hjelt current density pseudo section along the profile Vattikodu **(VL8 -16^{0}54′17.6″, 79^{0}04′25.6″, VL7 - 16^{0}55′17.6″, 79^{0}04′26.21″**
*** Probable Lamproites)**

vi) Profile-VL9 (Vattikode, VL9)

Profile VL9 runs across the lamproite body VL9 (16º55'02.5"-79º5'13.00") trending N-W direction, is about 20 m long. The filtered real and imaginary components show in Fig.20b shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -20 % to 300% along the traverse V-II Fig. (20b) indicate the presence of two resistive and one conductive (C1) bodies in between 2 to 3m, and 17.5 to 21m and C1 conductive body at 15m and two mafic dykes are identified. From figure: 20c is the apparent current density pseudo section reveals the vertical dip of the formations with moderate current density distribution. The lamproite VL9 is located at 13 m along the profiles in the suspected mafic Lamproite dyke in the shear zone. The response of total magnetic (Fig. 20a) also corroborated with VLF (EM) results.

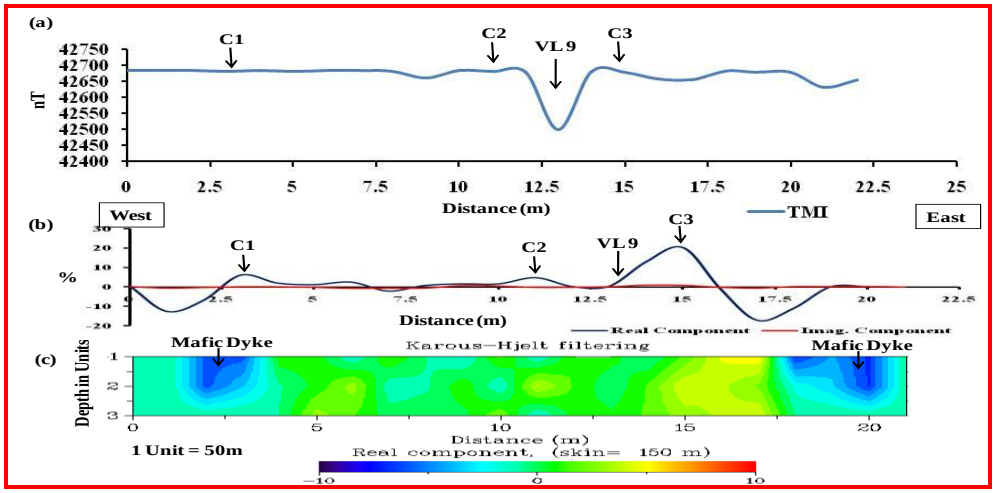

Figure: 20 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Vattikodu **(VL9- 16^{0}55′02.5″, 79^{0}05′13.00″)**

vii) Profile-VL10 (Vattikodu, VL10)

Profile VL-10 (latitude 16º55'0.8" and longitude 79º05'15.5") west of Vattikod village, the total length of 18 m station interval is 1 m a Figure:21b shows the percentage of real and imaginary component of Fraser filtered data with ground distance ranged in values from -30 % to 40% along the traverse.

Figure: 21b represents the filtered real and imaginary components of the VLF-EM data brought out three conductors C_1 at 2m, C_2 at 6m and C_3 at 12m and three resistive formations at 4-6m, 9-11m and 13-15 m were traced along the profile. Figure:21c is the apparent current density pseudo section distribution revived the across the major conductive zones and resistive formation are dipping vertically two lamproite bodies situated at 4m (new) and 12 m are along the contact of resistive and conductive zones. Figure 21a is the total magnetic intensity agrees with the VLF results.

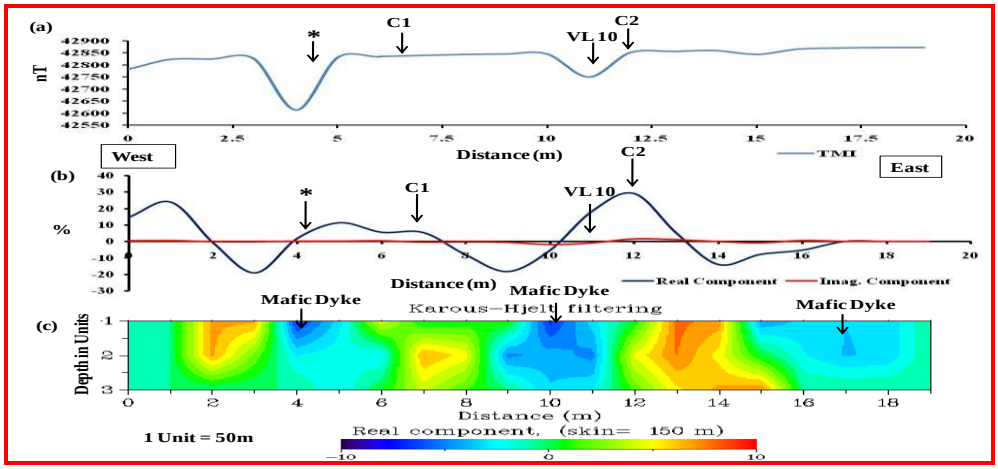

Figure: 21 (a) Total Magnetic Intensity, (b) Fraser filter Real and Imaginary Components (VLF) and (c) Karous Hjelt current density pseudo section along the profile Vattikodu **(VL10 - 16^{0}55′00.8″, 79^{0}05′15.5″, * Probable Lamproites)**

VIII. SUMMARY AND CONCLUSION:

Remote sensing Land Sat 8 satellite image analysis and geophysical investigations (Total magnetic and VLF) carried near Ramadugu and Vattikod lamproites fields with a view to delineate areas with good potential zones for lamproites.

The location of lamproites is governed by geotectonic controls and or Geomorphological indicators such as domal geomphologic structures. From Landsat-8 satellite image and qualitative analysis of total magnetic anomaly maps of Ramadugu study area, the structure fabric of the region elucidated. Seven deep seated faults are F1 to F7 and thirteen (1 to 13) domal structures identified. Morpho - structural features (marked as circles in Fig.1b) are identified the presence of major structural features such as faults (F1 to F7 , F8 to F10 are smaller extent), dykes, fractures / lineaments and in conjunction with the faults have coincided with the known lamproites Several lineaments trending main NW-SE, NE-SW, N-S and E-W trends, and a few dykes and fractures associated with the intrusions (younger granites) are responsible for the emplacement of the lamproites at contact granite gneiss and dolerite dykes.

The precision geophysical investigations in the study areas reveals the location of conductive bodies, geological boundaries, lamproite dykes, faults/fractures and shear zones are located along contact between dykes and granitic rocks. The Fraser filtered data plots as well as Karous-Hjelt filter 2-D inversion current density pseudo sections for real and imaginary components has aided in refining the location of conductors ,nature of conductivity, dip and the depth of these conductors. The VLF (EM) responses along all lamproite bodies along with the magnetic interpretation, are presented here as a case study.

It is infer that the source for observed lamproites shows as a contact between high and low resistive intrusive features which might have created conditions favorable for thermogenic origin of the lamproites through this fracture zone essentially the involvement of distinct deep seated fault fractures in controlling their emplacement. From pseudo sections of real and imaginary components tectonically disturbed zones are identified as faults/fracture zones. RLF lamproites bodies are essentially emplaced as hypabyssal dykes this would imply intrusion closer to the surface and this would additionally indicates that either only minor erosion or more uplift followed by erosion took place in the RLF likewise while the RLF lamproites occur as dykes. The lamproite body at Ramadugu and Yacharam field occurred in close a specifically associate with NW-SE strike, trending dolerite dykes and fracture system and are mostly emplace at the contrast between dolerite (high resistivity) and grandiosities basement [conductive] which is parallel to the trends of the dyke. Lamproite are emplacing along north east south east direction parallel oblique to the pollination joint dyke and regional fault.

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