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Structural Inferences from Radiometric Surveys in and around Ramadugu Lamproite Field, NW margin of the Cuddapah basin, Eastern Dharwar craton

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ABSTRACT

An attempt has made to map radiometric intensity over a part of the Ramadugu, Vattikod, and Somvarigudem lamproite fields of Nalgonda District, Telangana State, North Western margin of the Cuddapah basin and their relationship with geological structures and tectonics.

Interpretation of radiometric data brought out the structural features, trends, faults and contacts corresponding to the lithological formations observed in the area. The formations are amphibolites, schists, biotite gneisses, granites, granodiorites and dolerites. They are qualitatively inferred from the radiometric map, which may enable more precise geological mapping of these formations. A geological map of the study area with observed radioactivity of each formation is presented. The corresponding radioactivity for amphibolites, schist, biotite gneiss, granites, granodiorite, quartz vein and dolerites are 23.15 μR/hr (22.87 μR/hr to 23.4 μR/hr), 22.77 μR/hr (20.94 μR/hr to 24.8 μR/hr), 27.69 μR/hr (20 μR/hr to 37.05 μR/hr), 25.62 μR/hr (24.77 μR/hr to 27.7 μR/hr), 20.85 μR/hr (15.69 μR/hr to 23 μR/hr) and 26.5 μR/hr (12.38 μR/hr to 40.71 μR/hr), respectively. A low radioactivity has been registered over Ramadugu lamproite field (18.25 μR/hr to 21.58 μR/hr) and Yacharam lamproites field (19.91 μR/hr to 20.41 μR/hr), Vattikod lamproites field 25.56 μR/hr to 27.82 μR/hr) and Somavarigudem lamproites field (17.38 μR/hr to 18.13 μR/hr) .

Coefficient of variation values calculated for the radiometric data revealed seven deep-seated faults (F1 to F7), two running NW-SE, three NE-SW, one N-S and one another NNW-SSE. In addition, radiometric data revealed in the region disposition of schist belts, various faults and other lineaments /dykes and contact between granite gneiss and dolerite dykes.

Key words: Radiometric surveys, Lamproite field, clusters, enclaves and Geological structures.

INTRODUCTION

Radiometric methods employed are mainly in the exploration of Uranium and Thorium mineral deposits. In recent times, the application of radiometric methods of exploration is more diversified (Nsikak E Bassey et al., 2013 and Labani Ray et al., 2015) , and are used for the indirect location of deposits of certain rare elements and of certain rare earth metals occurring in genetic or paragenetic association with radioactive minerals. As different rocks contain varying amounts of radioactive minerals, the radiometric methods find application also in geological mapping (Amadi, 2012 and Aswathanarayana, 1971), like delineation of contact between different rock types (Himabindu and Ramadass, 2003), location of faults, shear zones etc, overlain by a thin soil cover.

Recent geological and geochemical studies carried out by Geological survey of India (Alok Kumar et al., 2013, Reddy et al., 2003, Sridhar and Rau, 2005, Chalapathi Rao et al., 2004 and 2014), under systematic diamond exploration program at the Northwestern margin of the Cuddapah basin, Eastern Dharwar craton (EDC) to identify the new zones of diamondiferous lamproites, helped in the delineation of new clusters of lamproites named as Vattikod, Ramadugu and Somavarigudem clusters (Sridhar and Rau, 2005).These lamproites are emplaced within the granitic rocks of Peninsular Gneissic Complex, Eastern Dharwar Craton, Southern India.

The present paper details the result of radiometric surveys carried out over a part of the Ramadugu, Vattikod, and Somvarigudem lamproite fields in the Nalgonda District, Telangana State, along the North Western margin of the Cuddapah Basin, Eastern Dharwar Craton, to understand the radioactive nature of the litho- structural entity of the study area.

Geology of the Area

The study area is located along the NW margin of the Cuddapah basin bounded by Longitudes 79° 5' to 79° 25' and Latitudes 16° 42' to 16° 58' Figure 1. Geologically the area forms a 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 Cuddapah super group, and Shales of the younger Kurnool group. The hornblende schist and

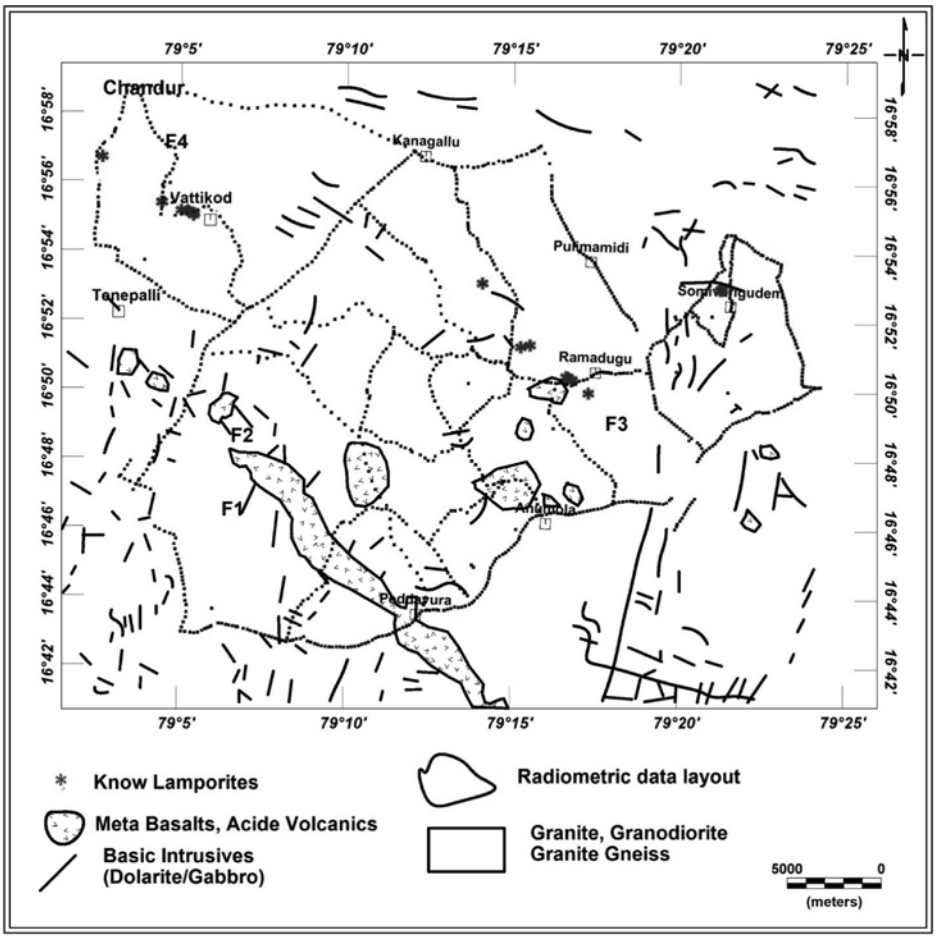

Figure 1. Layout map of radiometric data superimposed on Geological map of the study area

amphibolites (Older Metamorphic), which are the oldest rocks, occur as rafts, enclaves and discontinuous linear bands, within the Peninsular Gneissic Complex. West and Southwest of the study area comprises migmatities, granites granodiorite, tonalitic-trondhjemite suite of rocks and hornblende-biotite schist, meta-basalts, meta-rhyolite and banded hematite quartzite. Dharwar super group rocks are exposed as linear belts near Peddavura on the Hyderabad-Nagarjuna sagar road. They are trending in the NNW-SSE direction and run for about 20 Km with a variable width of 500 m to 2 Km, flanked on either side by the peninsular gneissic complex. A number of dolerite dykes and quartz reefs traverse these rocks trending N-S, E-W, NE-SW and NW-SE directions. Sridhar and Rau (2005) recorded a total of 10 NW-SE trending lamproite dykes. They are found over an area of 25 Km^2 in three different clusters in the Ramadugu area, namely, first at Ramadugu (R1, R2, R3, R4 and R5), second near Yacharam (Y1 and Y2) and third near Somavarigudem (S1, S2 and S3). These lamproites occur as dykes and trend essentially along NW-SE direction, as discontinuous isolated outcrops associated with intrusive contact with the basement granitoids.

Ten lamproite bodies near west of Vattikod (VL-1 to VL-10) village, one lamproite dyke located 1.5 km west of Marepalli (Ml-1) village and one located in the close vicinity of Gundrapalli (Gl-1) village, have been discovered (Alok Kumar et al., 2013). These lamproites are emplaced along the WNE-ESE to NW-SE trending fractures in the granite-gneiss basement. Apart from these, indications for the presence of more lamproites are noticed in the form of stray boulders at two other locations at Kastala and Samulonobavi in the Paluvayi block.

Data Acquisition

Semi-detailed radiometric observations have been taken along the available roads, accessible paths and tracks with a station interval of 200 m, to give a fairly even distribution of radioactive values for the entire study region covering the total area of ~700 Sq. km, using the ECIL Scintillometer type SM141 instrument. The Scintillometer is a light weight portable radiation measuring instrument powered by a D-size dry cells featuring solid state design and is ideally suited for radiometric investigations. It has time constant of

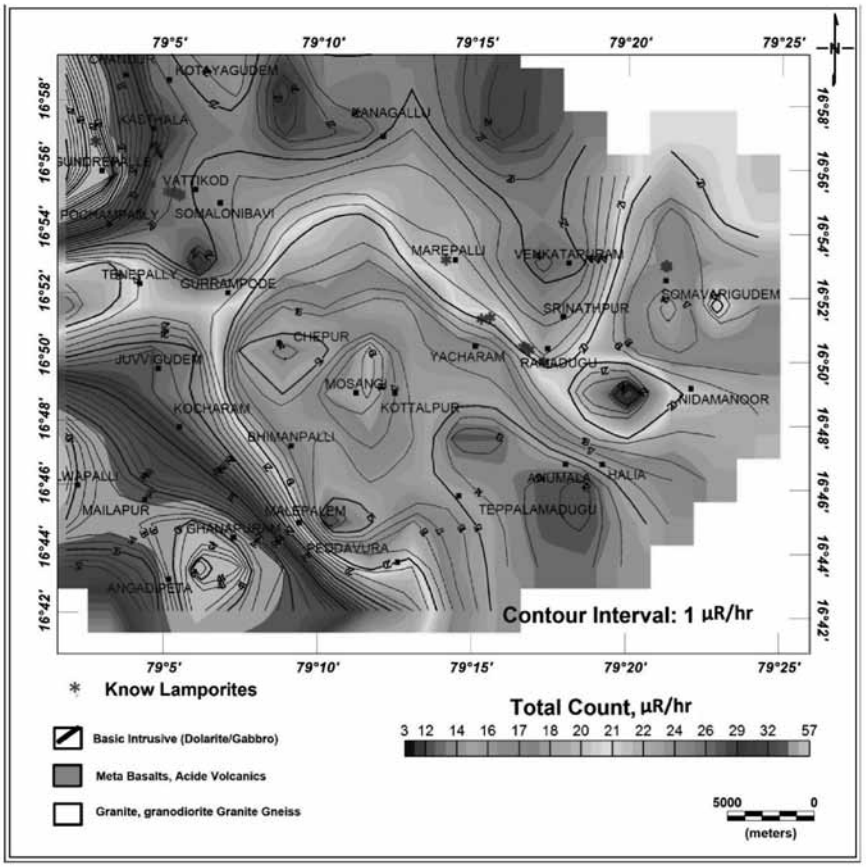

Figure 2. Total Radiometric Intensity Map of Study Area

5.5 sec. It is directly calibrated in μR/hr (micro roentgens per hour). The sensitivity of the measurement varies from 0.1 to 1 μR/hr. The layout map of radiometric observation is shown in Figure 1. A total of 1200 stations are occupied along Nalgonda- Nagarjuna sagar road, south of Chandur to Kanagallu, Ramadugu in the Anumala mandal, Nalgonda district (Corresponding to scale of 1:50,000). The N-S and E-W extends of this area fall under Survey of India (SOI) Topo sheet No. E44T1, E44T2 and E44T5. 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 radiometric and GPS elevation, location of geographic coordinates. Twenty (20%) percent of observations were repeated. The overall effective accuracy obtained for the radiometric data is +/- 2 μR/hr.

RESULTS AND DISCUSSIONS

Figure 2 shows the shaded contour map of radiometric data in and around Ramadugu region. The locations of towns/villages are shown on it to get a representative picture of radiometric variation of the region, to understand the lithological and structural fabric of the area. This map has been contoured with an interval of 1μR/hr. It is evident that the region has radioactivity range from 5 μR/hr to 47 μR/hr. High responses are observed at central western part to southern part and these highs are reflected by bulging in essentially linear contours, with distinct individual closures at places within the linear system. Low radioactivity of about 10 μR/hr anomalies is observed near Anumala, Peddavura and towards Vattikod, trending in NW-SE direction. The area is occupied by metabasalt and Biotite gneiss, exhibiting elliptical contours. Other low radioactivity has been recorded over Banded Iron formation (Gundrapalle, and in between Vattikod to Yacharam) ranging from 12.55 to 22.65 μR/hr. Intermediate anomalies in the range of 20 to 30 μR/hr are observed over the metamorphic basement, partly occupied by a migmatite gneiss, homophorous granite, alkali Feldspar granite, hornblende granite and granodiorite near Kanagallu and Ramadugu regions.

From a close examination of Figure 3, the distinct features along the entire traverse representing geological contact, faults, and shear zones can be observed. The broad low of 10 to 20μR/hr corresponds to the quartz & pegmatite veins and within quartz & pegmatite veins a NW –SE trending schist belt (5-23 μR/hr). The western and eastern margins of this belt are sheared and faulted and

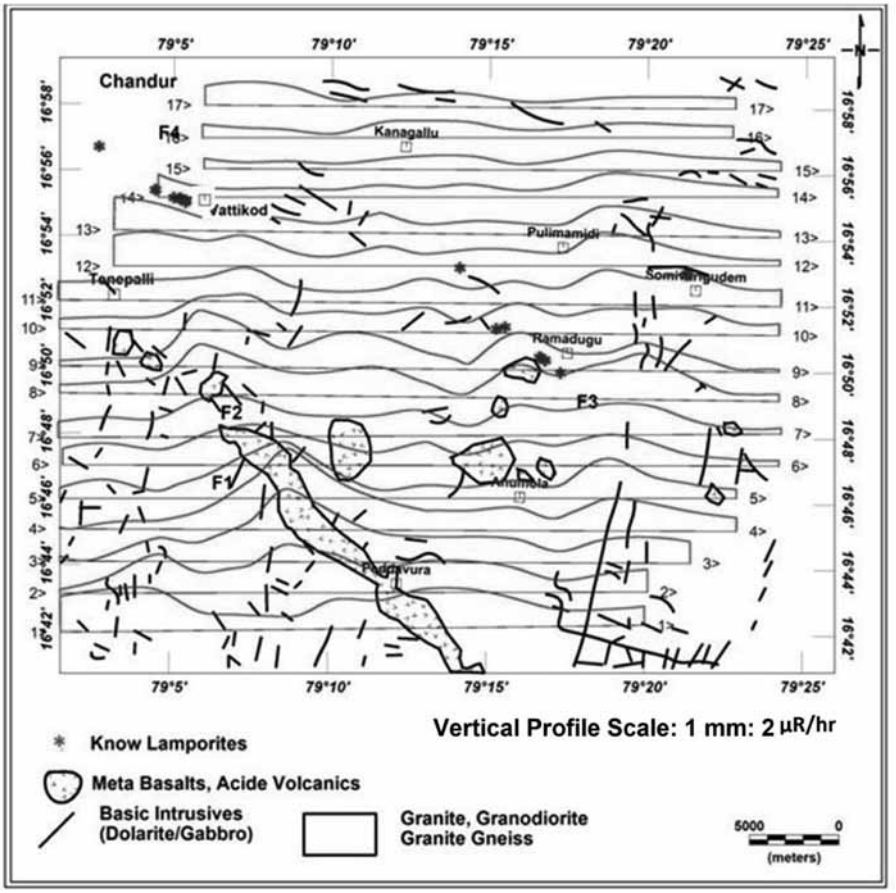

Figure 3. Stacked profile map the radiometric data superimposed on geology

are reflected by sharp peaks. The highs flanking the low over the schist belt can be attributed to younger granites and peninsular gneisses, with the former registering higher radio activity (20.73 - 36.67 μR/hr) as compared to the later (11.32 - 27.08 μR/hr). Pegmatites found in the region are also reflected by relatively high radioactivity.

The orientation and disposition of shear zones can be identified from a contour map from either a change in gradient or truncation of contours along a linear, curvilinear zones and/or dislocation fractures (Ramachandran et al., 1999 and Ramadass et al., 2013). Thus, features inferred from the profile map can more readily be appreciated from the radiometric intensity contour map Figure 2. From this Figure, it is observed that while shear zones appear on both the western and eastern side of schist, the shear on the western margin is more clearly demarcated than its eastern, with attendant leaching of radioactive minerals. Correspondingly, it shows low radioactivity. The decrease in radiation intensities associated with the tectonically disturbed zones delineated strengthens the analysis.

Coefficient of variation is a statistical technique employed for detection of weak radiometric (any geophysical) signals for analysis of concealed litho-logical contacts, faults and structural trend detection. The coefficient of variation Figure 4 of radiometric data was computed along stacked radiometric profiles Figure 3 using a moving 5-point average window (Bhimasankaram, 1980) to improve the signal to noise ratio, using following equation.

$$C.V = \frac{\sigma}{x} \times 100\%$$

Where, σ is the standard deviation and x is average value of window

Based on lithological observation with coefficient map and radioactivity intensity map of the study region a geological map of in around Ramadugu (Chalapathi Rao et al., 2014 and Alok Kumar et al., 2013) region was prepared Figure 5. Each formation details are shown in Table. 1 and Figure 6. The corresponding radioactivity for amphibolite's schist, Biotite Gneiss, granites, granodiorite, quartz vein and dolerites are 23.15 μR/hr (22.87 μR/hr to 23.4 μR/hr), 22.77 μR/hr (20.94 μR/hr to 24.8 μR/hr), 27.69 μR/hr (20 μR/hr to 37.05 μR/hr), 25.62 μR/hr (24.77 μR/hr to 27.7 μR/hr), 20.85μR/hr (15.69 μR/hr to 23 μR/hr) and 26.5 μR/hr (12.38 μR/hr to 40.71 μR/hr), respectively.

In Figure 5 lineaments are mapped following structural closures or nosings of radiometric anomalies. Some of these lineaments correlate/or are coincident with the mapped structures such as faults, shear zones, dykes and

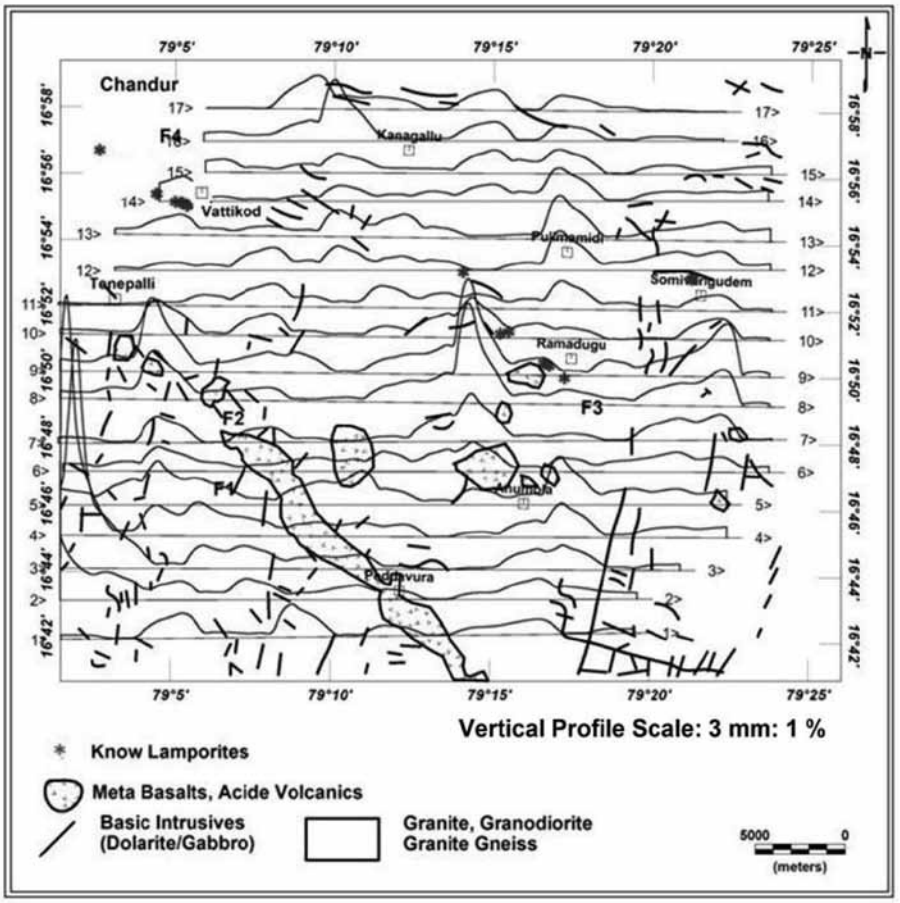

Figure 4. Stacked profile map of coefficient of variation of the radiometric data superimposed on geology.

foliation. They are also parallel or sub-parallel to fluvial channels. Seven (F1-F7) faults/lineaments are mapped, using radiometric data Figure 5. The fault/lineament F1 observed in southwestern part of the study area is the contact zone between the younger/ homophorous granites and granite, granoditorite granite gneiss. The fault F2 indicates the contact between the western margin of Peddavura schist and granite, granoditorite granite gneiss. F3 observed near Tenepalli is abutting to the northwestern part of the schist belt. The fault F4 is trending in NE-SW direction. The western part of this fault is associated with high radioactive nature formations like homophonous granite, alkali Feldspar Granite, whereas the eastern part is occupied by a low radioactive nature of the biotite gneiss and banded biotite gneiss. The fault F5 (NW-SE) and F6 (NE-SW) are the important tectonic lineaments/fault zones in the study area, which are of highly disturbed nature. The emplacement of lamporites near Somvarigudem, Marepalli, Yacharam and Ramadugu regions are associated within fault/shear environment of F5 & F6. The F7 fault separates the Lamporites of Vattikod from Gudrapalli Lamporites. The observed radioactivity over the Gudrapalli lamporites is high compared to the Vattikod Lamporites. The high radioactivity observed over the Gundrpalli is due to the association with the homophonous granite, whereas moderate radioactivity over the Vattikod lamproites is due to the association with the granite, granoditorite granite gneiss.

Lamproites in the study area emplaced along NE-SW directions are parallel to oblique to the foliation, joint, dyke and regional fault/fracture trends. Ramaudgu and Yacharam lamproites are emplaced along the contact zone between the dyke environment and granitie 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. Fault contact environment is observed in lamproite emplacement in the study area.

At Vattikod most of the lamproites are emplaced at the contact zone between the Alkali Feldsapar granite and biotite gneiss granitic – gneiss basement and in dolerite dykes. They are also observed along NE-SW to NW-SE trending fractures.

A fault contact environment (Alok kumar et al., 2013) is observed in lamproite emplacement in the study area. At

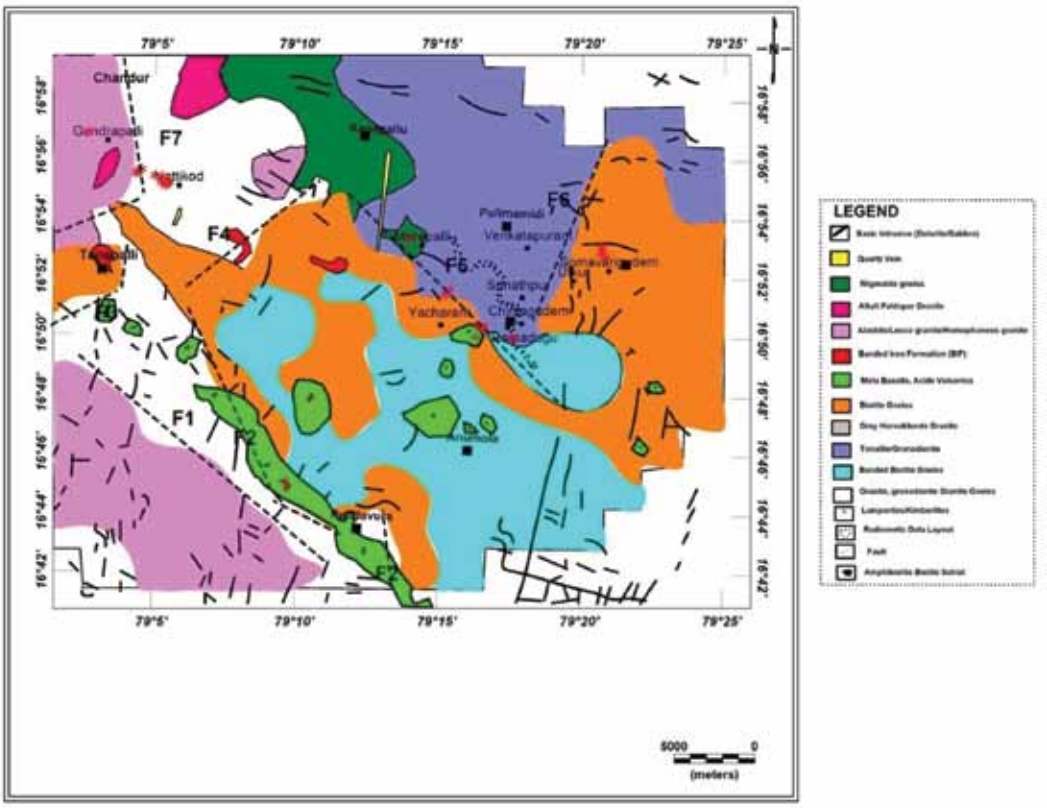

Figure 5. Interpreted geological map of the study area by using radiometric data

Table 1. Radioactivity of geological formations

S.No	Foramtion (New)	Minimum Radioactivity (μR/hr)	Maximum Radioactivity (μR/hr)	Average Radioactivity (μR/hr)
1.	Amphibolite Biotite Schist	22.87	23.44	23.15
2.	Banded Iron Formation	12.55	22.65	-
3.	Biotite Gneiss	20.94	24.89	22.77
4.	Granite, Granodiorite, Granite Gneiss	24.77	27.78	25.62
5.	Alkali Feldspar Granite	20.00	37.05	27.69
6.	Homophorous Granite	19.01	41.31	28.84
7.	Quartz Vein	15.69	23.03	20.85
8.	Basic Intrusive (Gabbro/Dolerite)	12.38	40.71	-
9.	Vattikod Lamporites	25.56	27.82	-
10.	Gundrapalli Lamporites	40.77		
11.	Marepalli Lamporites	21.44		
12.	Yachram Lamporites	19.91	20.41	-
13.	Ramadugu Lamporites	18.25	21.58	-
14.	Somvarigudem Lamporites	17.38	18.13	-
15.	Migmatite Gneiss	21.91	28.25	25.40
16.	Tonalite Granite	16.90	23.08	19.65
17.	Metabasalt, Acid Volcanics	12.43	13.18	12.80

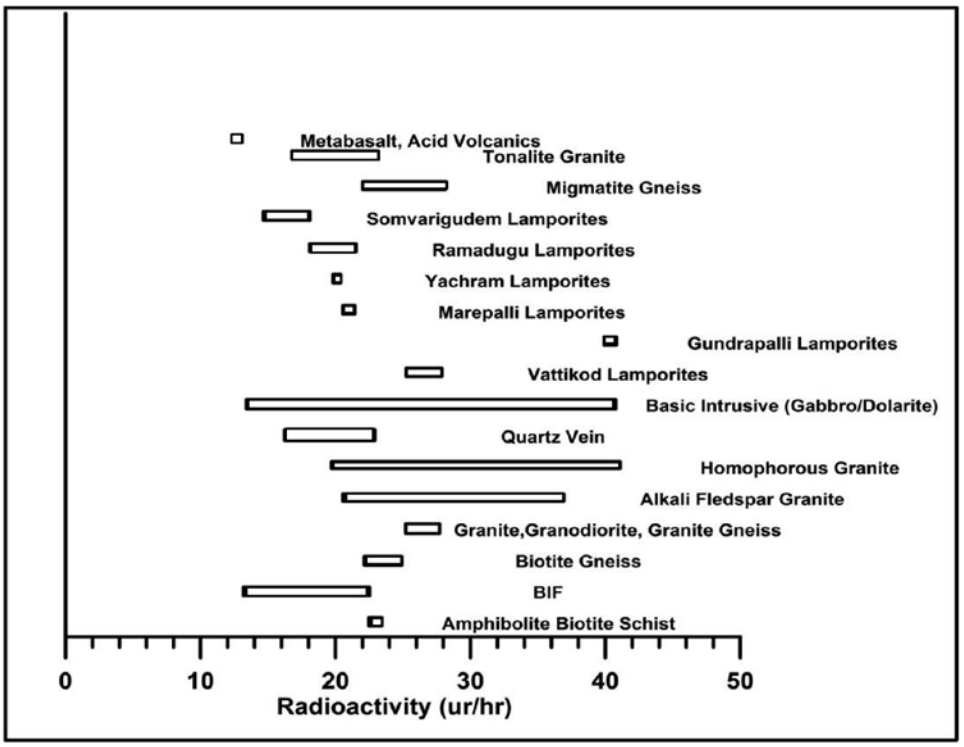

Figure 6. Distribution of radioactivity in different formations in the study area

Vattikod (25.56 μR/hr to 27.82 μR/hr) most of the lamproite zones are emplaced at the contact zone between the alkali feldspar granite and biotite gneiss. They exhibit 27.69 μR/hr and 22.77 μR/hr radioactivity, respectively. Ramadugu and Yacharam lamproites emplaced along the contact zone of schist and granite gneisses exhibit radioactivity in the range of 23.44 μR/hr and 22.78 μR/hr.The Somavarigudem lamproites (17.38 μR/hr to 18.13 μR/hr) lie on the contact of dolorite dyke and granite gneisses (24.77 μR/hr to 27.78 μR/hr).

CONCLUSIONS

Radiometric investigations are successfully employed to map various geological formations and structural elements, orientation and disposition of lineaments, dykes, minor / major shear zones and structural features.

The corresponding radioactivity for amphibolites biotite schist, banded Iron formation, biotitie gneisses, alkali feldspar granite, quartz vein and basic intrusive (gabbro/dolerite), migmatite gneiss, tonalite granite and metabasalt, acid volcanic are 23.15 (22.87-23.44) μR/hr, (12.55-22.65) μR/hr, 22.77 (20.94-24.89) μR/hr, 25.65 (24.77-27.78) μR/hr, 27.69 (20-37.05) μR/hr, 28.84 ((19.01-41.31) μR/hr, 20.85 (15.69-23.03) μR/hr, (12.39-40.71) μR/hr (25.56-27.82) μR/hr, 24.40 (21.91-28.25) μR/hr, 19.65 (16.9-23.08) μR/hr and 12.80(12.43-13.18) μR/hr, respectively. A low radioactivity has been observed over Ramadugu lamproites field (18.25 μR/hr to 21.58 μR/hr) and Yacharam lamproites field (19.91 μR/hr to 20.41 μR/hr), Vattikod lamproites field (25.56 μR/hr to 27.82 μR/hr). Somavarigudem lamproites field (17.38 μR/hr to 18.13 μR/hr) lies on the contact of dolerite and granidiorite granites.

Broadly, younger granites register high radioactivity and the irregular variation is attributed to the exposure of granite at places and due to the variation of radioactive mineral content in the weathered portion of granites. The schist is found to be associated with low to moderate high radioactivity. Coefficient of variation map brought seven deep-seated faults F1 to F7, lineaments, fractures and dykes extending along NW-SE, NE-SW, N-S and E-W trends. They are responsible for the emplacement of the lamproites at contact between granite gneiss and dolerite dykes. Based on lithological observation and radiometric anomalies, a new lithological structural map of the study area has been prepared.

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Compliance with Ethical Standards

The authors declare that they have no conflict of interest and adhere to copyright norms.

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