Intrinsic Uranium Concentration of Crystalline Rocks in Parts of Central Tamil Nadu, India

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Abstract: Intrinsic uranium concentration of Crystalline rocks in parts of Salem and Namakal districts of Tamil Nadu were identified with the aid of handheld gamma ray spectrometer. For the identification of uranium distribution in the hard rocks, grab samples of 29 numbers were collected from different rock types such as hornblende biotite gneiss, calc-granulite gneiss, granite, dunite and pyroxenite from the study area. The collected samples were assayed for U, Th and K content using handheld portable Gamma Ray Spectrometer model RS-125 in the laboratory. This instruments wereeffectively utilized to identify the presence of radioactive elements in the rock samples where uranium and Thorium aremeasured in the unit of PPM and potassium is represented in percentage. Total Count readout at a 1x / sec rate in the Survey Mode or variable (1 - 20 sec.) in the Scan Mode of the spectrometer. Among the 29 rock samples, 23 samples wereassayed uranium values between 0.2 ppm to4.9ppm and thorium was assayed very higher concentration which ranges from 8.2 to 51.5 ppm. Potassium was measured in percentage which ranges from 1.2 to 3.4 %. In addition to this, ratio maps of U/K and U/Thwere generated totracethe localization of uranium ore. Distribution of uranium, thorium, potassium, U/K and U/Th ratiovalues were contoured and classified into three classes under GIS environment. In these classification higher concentration of uranium was noticed near Nangavalli, Mecheri and Pakkanadu region which falls along the Koratti shear zone and parallel to the carbonatite trend.

Keywords: Intrinsic Uranium, Handheld Gamma ray Spectrometer, U/Th and U/K ratio, Salem and Namakkal District, Tamil Nadu

INTRODUCTION

Uranium is a naturally occurring radioactive element, which is present throughout the mother earth. It is found in low concentration within all rock, soil, and water. This is the heaviest element to be found naturally in significant quantities on earth. According to the United Nations Scientific Committee on the Effects of Atomic Radiation the normal concentration of uranium in soil is 300 µg/kg (micro gram per kg) to 11.7 mg/kg (milli gram per kg). Higher concentrations of uranium are present in certain types of soils and rocks, especially granite, and the ocean. Some important uranium ores found include Pitchblende, Uraninite, Brannerite, Carnotite, Autunite, and Torbenite. In high temperature process the uranium may directly crystallise from silicate magma as uraninite. Other accessary minerals such as allanite, monazite, apatite, sphene, zircon, xenitime, thorite, thorianite, euxenite, pyroclore and brannerite. Granitic rocks rich in uranium are sometime called hot granite where the uranium concentration normally exceeds 15ppm and it may as great as 120ppm sometimes. In general, uranium in water that controls our daily exposure to this radioactive element which is particularly where the drinking water obtained directly from ground water. In view of health impacts it is directly associated with exposure to elevated level of naturally occurring uranium in drinking water. The uranium concentration in ground water various with respect to the source rock and its intrinsic uranium content. Uranium most commonly occurred as oxides, hydroxides, phosphates, etc. and tends to have affinities with hydrocarbon complexes. It exist 4 valence U3+, U4+, U5+ and U6+, in natural material, it is generally present in as either U4+ (Uranus form) or U6+(uranyl form). The U6+ form is a stable form where the strongly oxidizing condition. Natural uranium is a mixture of three isotopes: U-234, U-235 and U-238. The most common is U-238, constituting over 99 percent of natural uranium (U-234 abundance = 0.0055 %, U-235 abundance = 0.72 % and U-238 abundance = 99.27 %). All three isotopes behave the same chemically, but they have different radioactive properties.

The highest concentration of uranium normally occurs with youngest most potassic and silicic rock. The high uranium level are also of an accompanied by alkali rocks high alkali content, alkali syenite and carbonatites. Granitic rocks observed in the study area exhibits late Proterozoic to early Paleozoic. The proposed area hosted most of the above said rock types. The study area exhibits Proterozoic Hornblende biotite gneiss intruded by carbonatite, pegmatite, syenite and granite. In which, the study area covers about of 970sq. km from Mettur and Pakkanadu of north to Suryamalai in the south. Carbonatites of Pakkanadu and Mulakkadu was reported as southern extension of the carbonatites found in Samalpatti and Sevattur region. The Carbonatite found in these areas contain radioactive minerals like U-rich pyrochlore, monazite and REE

Radioactivity due to thorium was reported in general with few uraniferous anomalies in the study area which is associated with granite and pegmatite in western margins of Suryamalai batholiths at the contact of hornblende biotite gneiss in Kullampatti (1955-56), Kodamedu and Serandampalayam (1981-82) areas in Salem districts of Tamil Nadu. Besides, several U-Th-REE-Nb-Ta anomalies were reported in the carbonatites and quartz-barite vein associated with the alkaline complex of Sevattur, Pakkanadu and Mulakkadu (1972-73) (internet: AMD website). Uranium has also been reported in the Sevattur carbonatite resulted 0.202% – 0.240% (n=4 Nos) (Shrinivas.G 2014) and in the U-rich pyrochlore mineral it was recorded between 11.31 wt% and 18.32wt% of UO2. Therefore similar type of uranium mineralisation can also be delineated from Mulakkadu to Pakkanadu tract in the north to Suriyamalai granite and pegmatites in the south.

Carbonatite of Tamil Nadu tectonically emplaced along the Neo-Proterozoic Koratti fault zone is predominantly calci-carbonatite to ferro–carbonatite (M.K.Pandit, 1998). There are roughly 8 carbonatite occurrences related to the major NE-SW fault zone in Tamil Nadu, and together form the largest carbonatite-alkalic sub-province in South India (Subramanian, 1983, Subramanian, ViladkarUpendran, 1978, Borodin et al, 1971, Krishnamurthy, 1977, Viladkarand Subramanian, 1995, Schleicher et al. 1997). The carbonatite from south India have been associated with the Nilgiri rift and it is suggested that the block faulting occurred in several stages which resulted in NE-SW trending fault systems. Grady (1971) has shown six major faults trending between N30°E and N40°E, and carbonatite complexes of Sevathur, Samalpatti, Jogipati, Reddipatti, Karapattu, Pallasurakkarai, and Pakkanadu are located along these fault zones. The cabonatites of Pakkanadu-Mulakkadu region occurs as small dimension, concordant, fracture fills and dykelets within pyroxenite body and as discordant bodies within syenite, emplaced along the NE-SW fault which is parallel to Attur fault (M.K. Pandit et al 1998).

Geologically, high grade gneisses and granulite are observed in the study area with the younger intrusive (800-500 Ma) of gabbroic anorthosite, dunite-pyroxenite, carbonatite alkali granite and syenite (Figure2). The ultramafic suite hosting the Magnesite deposits between Salem and the SW foothills of Shevaroy is another characteristic intrusion in this region. Fissile biotite gneiss christened as Bhavani gneiss of pan African age with few meta sedimentary Lithologies are predominant rock type in the Palaghat gap region. Though the protolith ages of the southern granulite terrain range between 2400 and 2100 Ma, these Pan African age gneisses represent the sheared and retrograde equivalents of the Biligirirangam and Shevaroy granulite (Baskar Rao et al. 1996, Barlett et al. 1998). Another major evidence for the Pan African activity is a series of small plutons of 750 – 550 Ma alkaline granites, including the Sankaridurg granite, that occurs all along the Moyar-Bhavani shear zone.

Scanning of previous works pertaining to Uranium and Rare Earth Elements (REE) around Pakkanadu and Suriyamalai shows the significance of the area pertaining to uranium point of view (Figure 1). Therefore, before startup of any new uranium exploration programme, it is essential to assess the intrinsic uranium concentration of the rock types in the study area. Thus, the present study is aimed to assess the intrinsic uranium concentration in the various rock types of the study area using Gamma Ray Spectrometer.

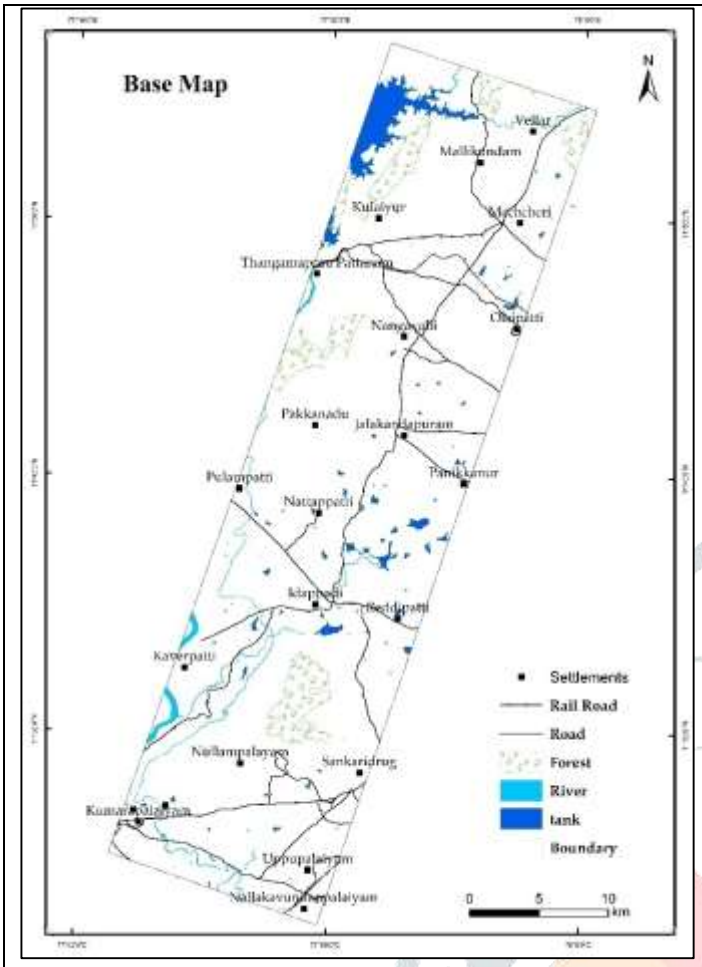


Figure 1: Base Map

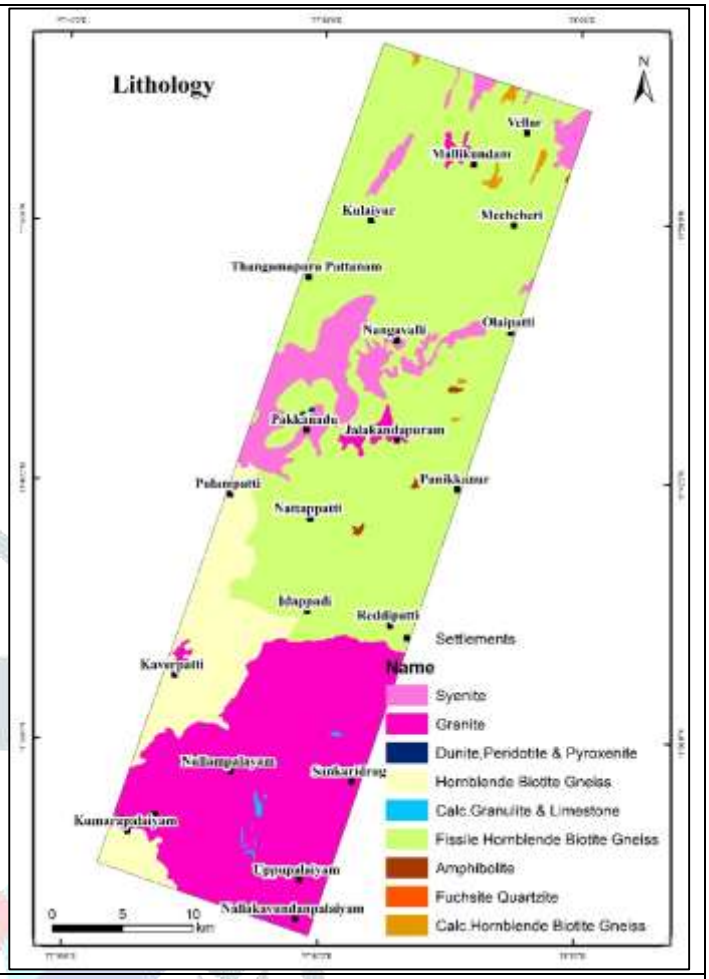
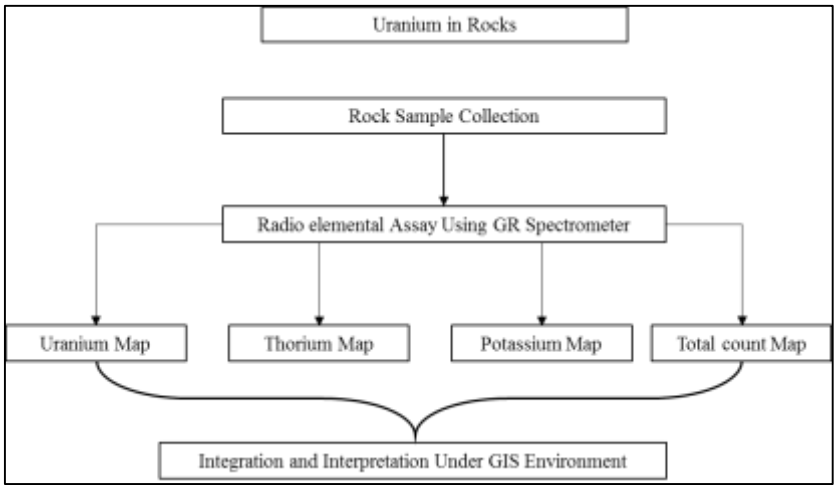


Figure 2: Lithology Map

METHODOLOGY AND DATA PRODUCT USED:

The rock samples were collected in the field were brought into the laboratory and the samples were assay in the assay mode in the handheld gamma ray spectrometer to identify the Total counts, U, Th and K concentration. Initially the background values were identified and threshold were fixed to the instrument. The scanning time for the each samples were fixed as 90 seconds. The spatial value of the each samples were gridded and contour map, images were prepared for all the radioactive elements. It was further superimposed over the lithology map to know the intrinsic uranium level in the various rock types of the study area.

Flowchart



S.No	Longitute	Latitude	Location	U in PPM	Th in PPM	K in %
1	77.97	11.88	Thethigiripatti	0.3	13.4	1.8
2	77.94	11.90	Solaiyanallur	3.5	10.2	1.2
3	77.94	11.90	Solaiyanallur	3.7	11.3	2.5
4	77.95	11.90	Thopaiyar	0	13.6	2.7
5	77.93	11.90	Mallikundam	0	14.5	2.1
6	77.93	11.90	Mallikundham	4.3	10.2	2.2
7	77.78	11.69	Vachampalli	4.9	8.2	1.6
8	77.79	11.68	North of kovilpalayam	1.9	13.4	2.3
9	77.85	11.70	Savuriyur	1.4	8.5	2.6
10	77.85	11.70	Savuriyur	1.7	11.4	1.8
11	77.86	11.76	Semmannankattuvalavu	4.8	11.2	2.5
12	77.75	11.50	Katheri	1.1	13.4	1.8
13	77.73	11.47	Samadhuvapuram	2.9	16.2	1.3
14	77.74	11.44	Kumarapalayam	0	16.5	2.1
15	77.80	11.40	Paatharai	1.4	12.4	2.2
16	77.82	11.43	Padaivedu	0.3	17.3	1.5
17	77.86	11.57	Mosakumarapalayam	0.2	19.4	2.1
18	77.86	11.56	Verayappanpalayam	0	20.4	1.7
19	77.83	11.47	Kuppankadu	1.5	13.4	2.5
20	77.79	11.49	Kongumothaiyanur	3.9	14.2	1.9
21	77.79	11.51	Kallampallam	1.3	11.4	1.9
22	77.79	11.53	Pachapuliyur	3.4	13.2	2
23	77.79	11.53	North of kurukupalayam	0	51.5	3.4
24	77.79	11.54	Kurukupalayam	4.2	17.1	1.7
25	77.87	11.83	Koolaiyur	0.3	13.4	1.9
26	77.97	11.81	Ponmalai	4	11.2	1.6
27	77.97	11.80	Selangalthittu	1.9	17.2	1.7
28	77.95	11.80	Paanapuram	0	14.5	1.8
29	77.90	11.77	Palakaranoor	3.6	14.2	2.1
		Avg		2.46	14.92	2.02

Table-1: Concentration of Radioactive Elements

RESULT AND DISCUSSIONS

Uranium in Rocks

29 rocks samples collected from the study area were assayed for intrinsic uranium concentration in granite, syenite, hornblende biotite gneissand calc-granulite rocks (Table:1). Distribution of uranium values ranges from 0.2 ppm to 4.9 ppm were contoured and manually classified into three classes under GIS environment. In these classification higher concentration of uranium was noticed nearNangavalli, South of Idappadi, north of Pulampatti, south east of Mecheriand Pakkanadu region (Figure 3).

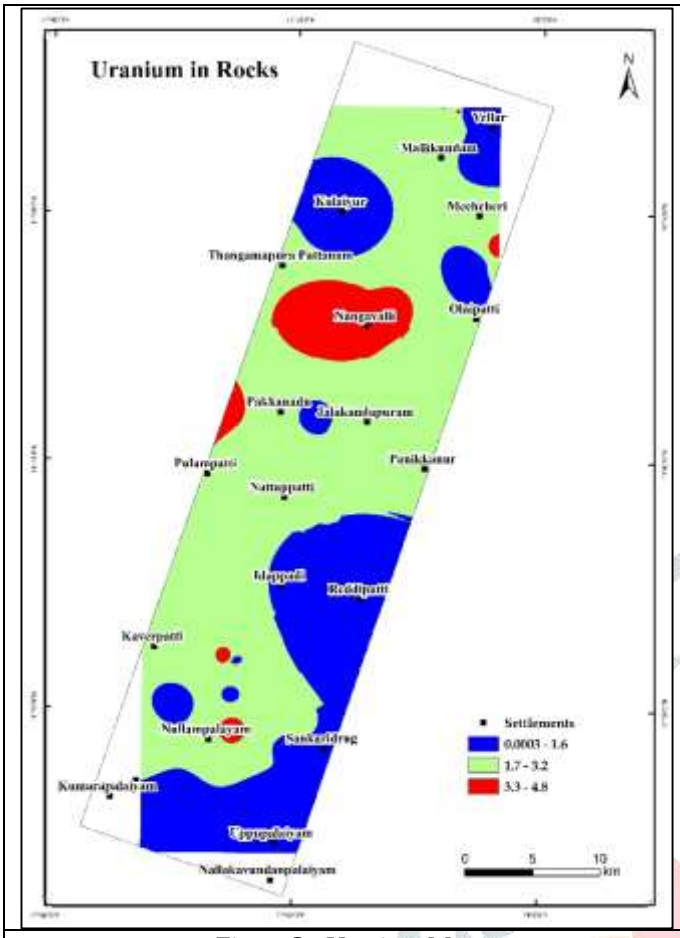


Figure 3: Uranium Map

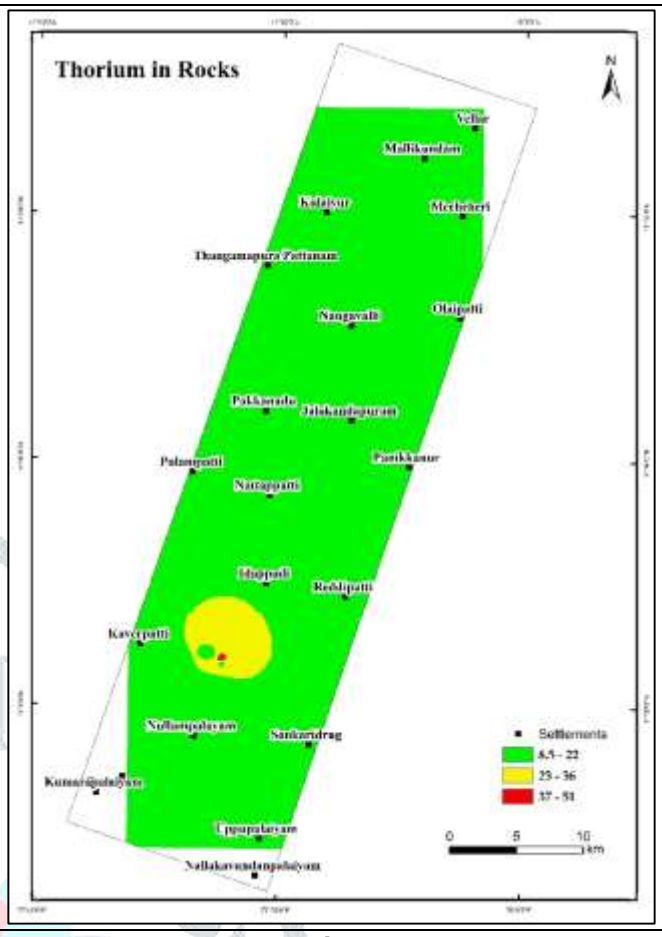


Figure 4: Thorium Map

Thorium in Rocks

Thorium has been recorded in this area are higher than the uranium concentration. This may be due to the high leachability nature of the U elements. Thorium does not move easily with water however uranium can move very easily with water in the form of uranyl.All the 29 samples were assayed for Thorium which ranges from 8.2 to 51.5 ppm from which the thorium map was generated. Maximum value of Th was recorded in the south west of Idappadi. Further, Thorium values also classified in to three category like uranium which shows that the moderate and high values around Kaverippati and Idappadi area only (Figure 4).

Potassium in Rocks

All the samples are assayed for potassium concentration in percentage unlike uranium and Thorium which recorded in ppm. The values are ranging from 1.2 to 3.4%. Though the study area mostly covered by the younger intrusive such as granite, syenite and granite pegmatite, the potassium concentration is very low (Figure 5).

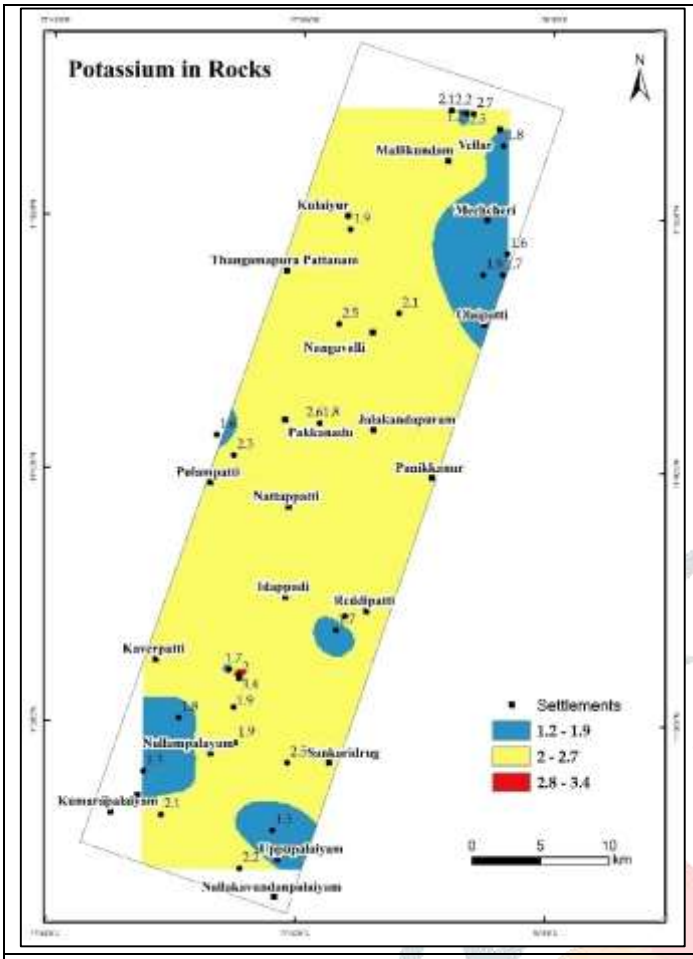


Figure 5: Potassium Map

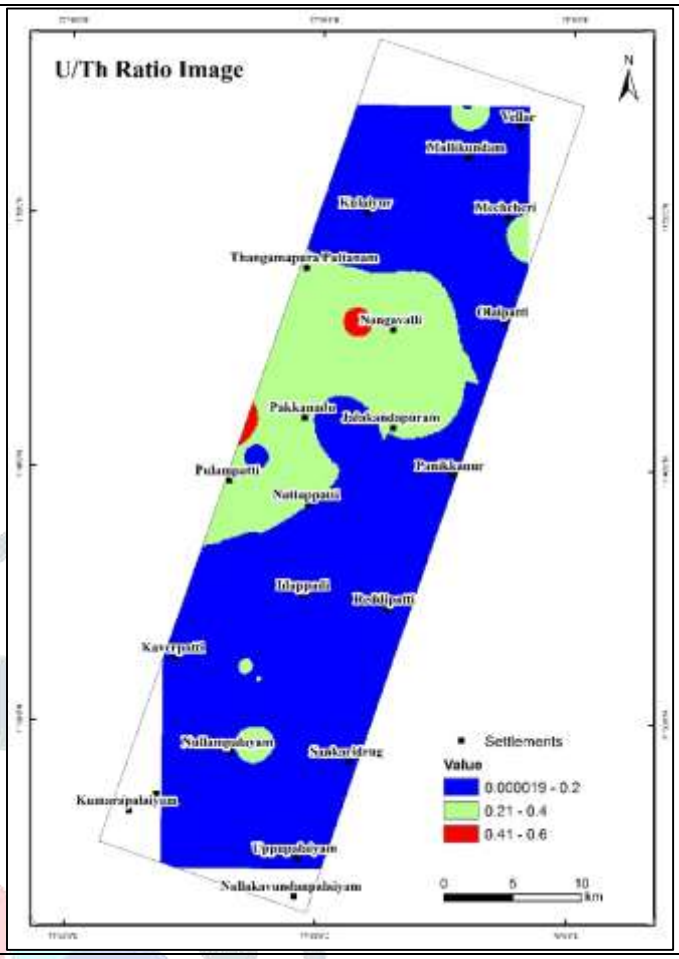


Figure 6: U/Th Ratio Map

U/Thand U/K Ratio Maps

U/Th ratio images have particular significance in uranium exploration because these ratio increases locally where the regions containing uranium ore (Figure 6). High U/Th ratio was noticed around Nangavalli and north of Pulampatti area indicate the possibility of uranium ore occurrence in this area. Similarly, U/K ratio maps prepared for the study area to find out the locaisation of uranium ore (Figure 7). The result shows that the area south east of Mecheri, north of Pulampatti, north and north east of Kumarapalayam shows the possible occurrences of uranium ore.

Visual Interpretation

Based on the interpreter knowledge and the radioactive elemental values noticed in the study area indicates that uranium concentration was uniformly distributed in the younger intrusive rocks. Higher concentration of uranium values were recorded at the contacts of igneous and metamorphic rocks. Sample assayed around Nangavalli area are associated with syenitewhich is younger intrusive rock. The contacts of calc-granulite and granite region also shows higher concentration of uranium. Carbonatite samples were not assayed in this area however the samples of syenite and granites were collected from Pakkanadu and Mulakkadu region (carbonatite cropped out) which is also assayed higher concentration of radioactive elements. Intrinsic uranium concentration is high in granite and syenite when comparted to the calc-granulite and hornblende biotite gneiss(Figure 8).

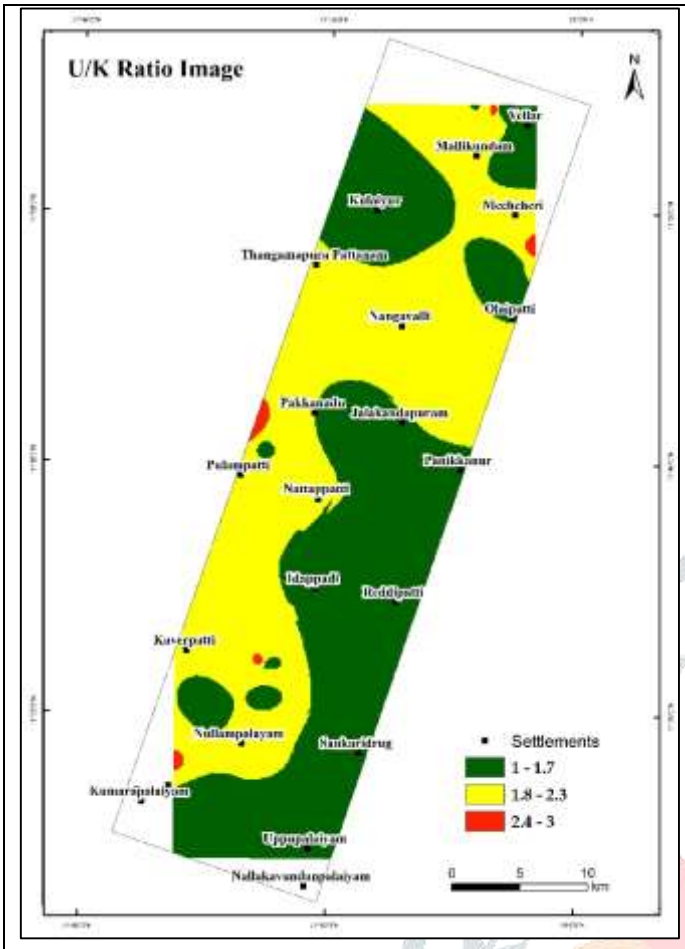


Figure 7: U/K Ratio Map

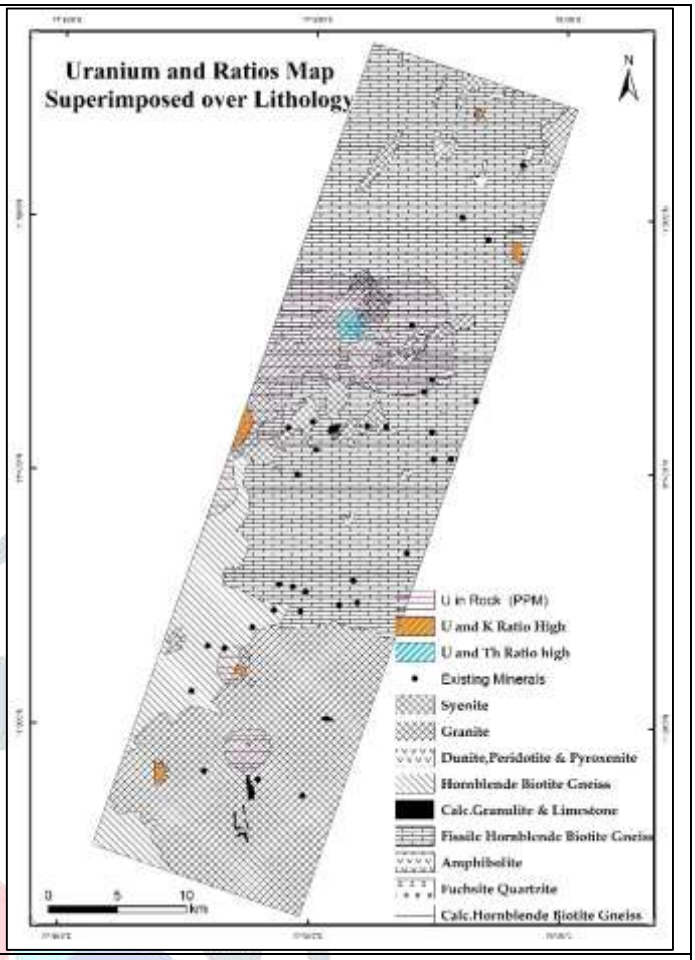


Figure 8: Uranium and Ratio Maps Superimposed on Lithology

CONCLUSION

The present work brought to light very significant distribution of radioactive elements in the different rock types. Intrinsic uranium in the study area are ranged from 0.2 ppm to 4.9 ppm in which the higher side values are recorded in the younger intrusive rocks. Ratio maps generated from the study area indicated the possible ore localization apart from its intrinsic concentration. Nangavalli, Pulampatti, Pakkanadu, Mulakkadu and Kumarapalayam areas are very prominent areas for uranium exploration point of view. Present study shows that GIS is one of the effective tool for integration and analysis of spatial and non-spatial data.

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