Rare Earth Element (REE) Mineralisation in Podile Granite, Prakasam district, Andhra Pradesh.

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***Abstract*—Rare earth elements (La to Lu, Y and Sc) importance increased with the advent of domestic and industrial uses. Rare Earth Elements (REE) finds way in petroleum fluid cracking, electric cars, phosphors, X-ray, high metal alloys, semi-conductors, fluorescent and incandescent lighting. The REEs occur in rock forming minerals, younger granites, pegmatites, and in riverine and beach placers. A series of granite plutons are sandwiched between the eastern margin of Cuddapah Basin and Eastern Ghat Belt (EGB) and traced from Vinukonda in the north to Pamuru in the south. These granites are intrusive into the Nellore Schist Belt (NSB). The granite of Podile is one such pluton and occur 5 km north east of rare metal and rare earth bearing Kanigiri granite. The granite samples (n=11) were analysed for minor elements, trace elements and REE. The analysis indicates very high values of Rb (159-326 ppm), Zr (121-695 ppm), Y (63-245 ppm), Nb (85-334 ppm), Ce (115-398 ppm), LREE (270 -873 ppm), and HREE (20 - 54 ppm). The samples show enrichment of LREE over HREE.**

***Index Terms*—REE, Podile, Kanigiri, Nellore Schist Belt, granite.**

I. INTRODUCTION

The rare earth elements are group of 17 elements composed of 15 lanthanides (with atomic numbers 57 through 71), scandium and yttrium. Rare metals and rare earth elements occur as carbonates, oxides, phosphates, silicates, arsenates, molybdates and niobates. These elements occur in rock forming minerals like micas, apatite, allanite, garnet, monazite, xenotime, sphene, rutile and in carbonatites, syenites, nepheline-syenites, phosphorites, granites (especially in anorogenic granites- A Type), pegmatites, lithium brines, residual clays, laterite/ bauxite, and placers (beach and riverine).

The study area granite occurs around Podile, Marripadu, Erukulasangam, Nishan Konda and Andhra Konda villages as mounds, hills and linear ridges covering an area of 30 Sq. Km and is located 5 km north east of established rare metal and rare earth bearing Kanigiri granite (Fig-1). The granite outcrops are located in parts of toposheet number/s 57 M/10 and 57 M/11.

II. GEOLOGY OF THE AREA

Numerous granite plutons are located to the east of Cuddapah Basin from Vinukonda (Guntur district) in the north to Anumalakonda in the south (Prakasam district). These granites are sandwiched between Eastern margin of Cuddapah Basin and Eastern Ghat Belt (EGB) and are emplaced into the Nellore schistose rocks. The area around Podile is mostly biotite granite, associated with syenites, dolerites, gabbro's and are traversed by quartz veins, quartz-tourmaline veins, and quartzo-feldspathic veins. Megascopically, the granites are pale grey in color, medium to coarse grained, non-foliated with visible minerals of quartz, pink feldspar, biotite, plagioclase felspar, pyrite and purple fluorite. Common alterations noticed are silicification and ferrugination. Biotite mineral (1-2 cm) lineation is observed. The granites are dissected by three sets of fractures viz., N-S, $N25^0E$-$S25^0W$, and $N60^0W$-$S60^0E$.

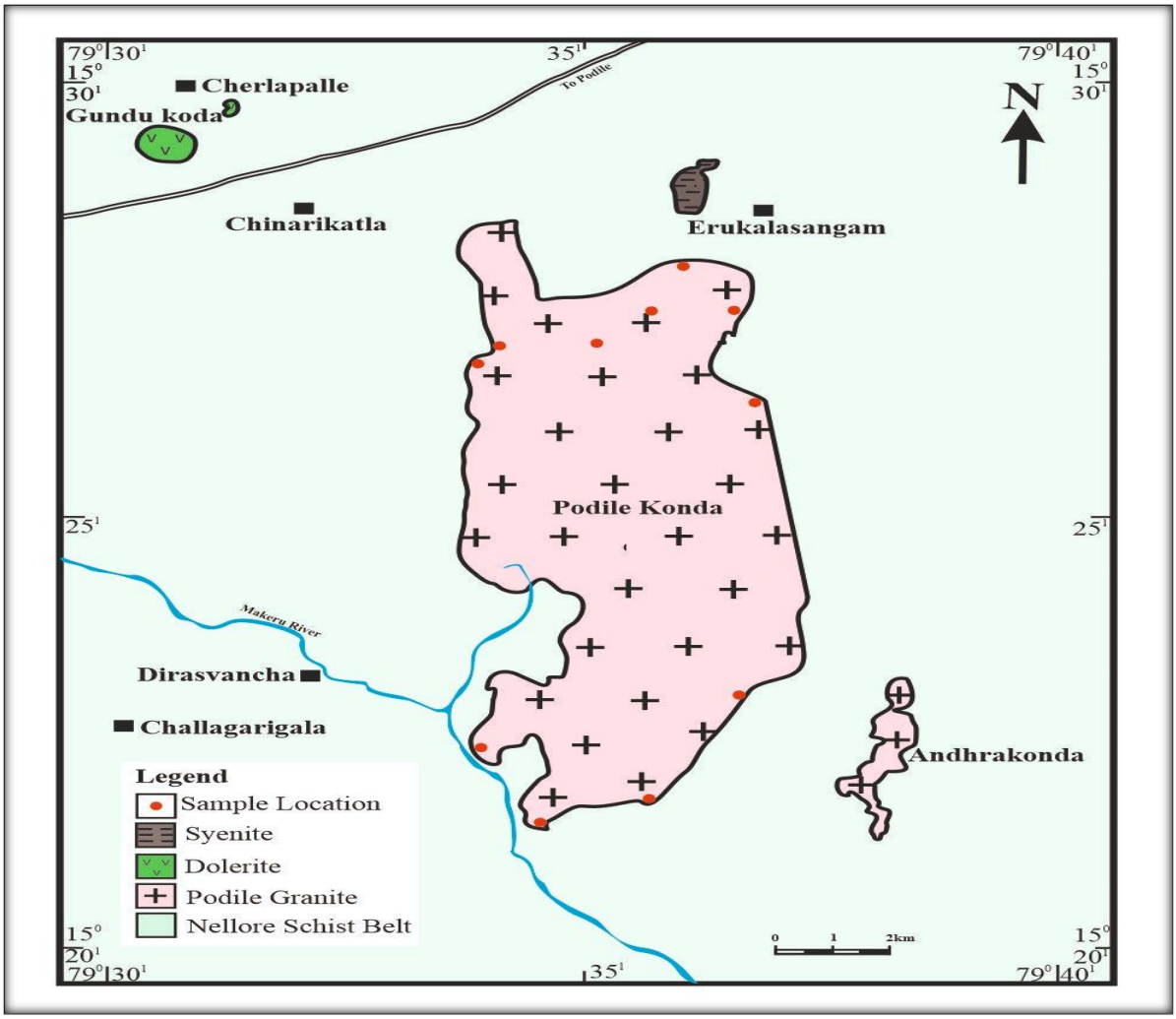

Fig 1. Generalized Geological map of Podile Granite

III. GEOCHEMISTRY

Sampling was carriedout covering all the exposed granite outcrops around Podile. A total of 11 granite samples were analysed for major oxides, minor/ trace elements and REE. The sample results were compared with the already established rare metal and rare earth Kanigiri granite (Thirupathi etal,1996).

A. Minor and Trace Elements

The minor and trace elements of the samples were analysed by Atomic Absorption Spectrophotometry (AAS). The assay results (in ppm) are given in the table-1. The data of granites indicate high values of Rb (159-326 ppm), Zr (121-695 ppm), Y (63-245 ppm), Nb (85-334ppm) and Ce (115-398 ppm). Anomalous values of Cr, Co, Ni and Zn is also noticed. The granite data was plotted in ternary diagram (Rb-Ba-Sr) of EL Bouseily and EL Sokkary (1975), the samples occupy the field of normal granite to strongly differentiated field (Fig-2). In Tectonic discrimination plots of Pearce etal (1984), the samples occupy the field of Within Plate Granites (WPG) in Fig-3 and Fig-3a. The sample data of granites plotted in Binary diagrams of Whalen etal,1987, for distinguish A-Type granites from other types. The data on plotting indicated the granites are of A-Type in character (Fig- 4).

Table -1: Minor and trace elements (ppm) of Podile Granites, Prakasam district, Andhra Pradesh.

Minor/ Trace element	Average Kanigiri Granite @	PD/7	PD/8	PD/9	PD/10	PD/11	PD/12	PD/13	PD/14	PD/15	PD/16	PD/17
Cr	15	29	45	21	42	23	37	40	22	33	42	28
Co	NA	31	30	17	89	19	34	78	18	31	69	83
Ni	NA	<10	16	<10	12	10	13	18	<10	14	<10	17
Cu	NA	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Zn	NA	176	124	82	57	86	69	72	52	128	79	273
Ga	31	33	30	22	20	37	32	28	12	31	13	45
Rb	433	229	213	262	236	391	253	230	159	208	224	326
Sr	15	10	11	11	23	16	14	14	13	26	13	16
Y	94	116	104	68	63	190	120	114	81	109	95	245
Zr	316	695	457	381	201	272	144	182	121	162	250	268
Nb	210	180	122	98	85	334	171	101	112	132	185	334
Ba	82	389	232	461	143	24	20	36	30	70	21	18
Ce	NA	312	187	395	153	132	198	115	270	261	320	398
Pb	43	19	12	40	24	13	21	11	18	22	21	19
Th	63	35	34	49	37	52	48	39	43	51	50	46
U	15	15	13	15	15	12	5	11	13	12	16	12

@ Thirupathi etal, 1996

Table -2: Rare Earth Elemental analysis of Podile granites, Prakasam district, Andhra Pradesh.

REE (ppm)	PD/7	PD/8	PD/9	PD/10	PD/11	PD/12	PD/13	PD/14	PD/15	PD/16	PD/17
La	148	80	180	86	73	100	57	154	150	184	239
Ce	288	160	350	164	137	201	115	274	265	327	401
Pr	<10	<10	28	<10	14	25	14	23	27	27	42
Nd	80	38	108	35	48	93	57	84	96	93	159.
Sm	16	<5	18	<5	11	23	14	20	19	20	37
Eu	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Gd	14	10	16	10	10	18	12	17	14	3	3
Tb	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dy	12	14	14	14	20	13	19	16	17	17	39
Ho	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Er	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Tm	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Yb	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Lu	1	1	1	1	2	2	2	1	2	2	4
Y	68	116	68	104	190	120	114	81	109	95	245
Sc	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
∑LREE	551.50	296.00	700.50	303.00	293.50	460.50	269.50	572.50	571.50	651.53	878.00
∑HREE	20.00	22.00	21.00	22.00	29.50	22.50	26.50	24.50	26.50	26.50	54.00
LREE/ HREE	27.35	13.45	33.36	13.77	9.95	20.47	10.17	23.37	21.57	24.59	16.26

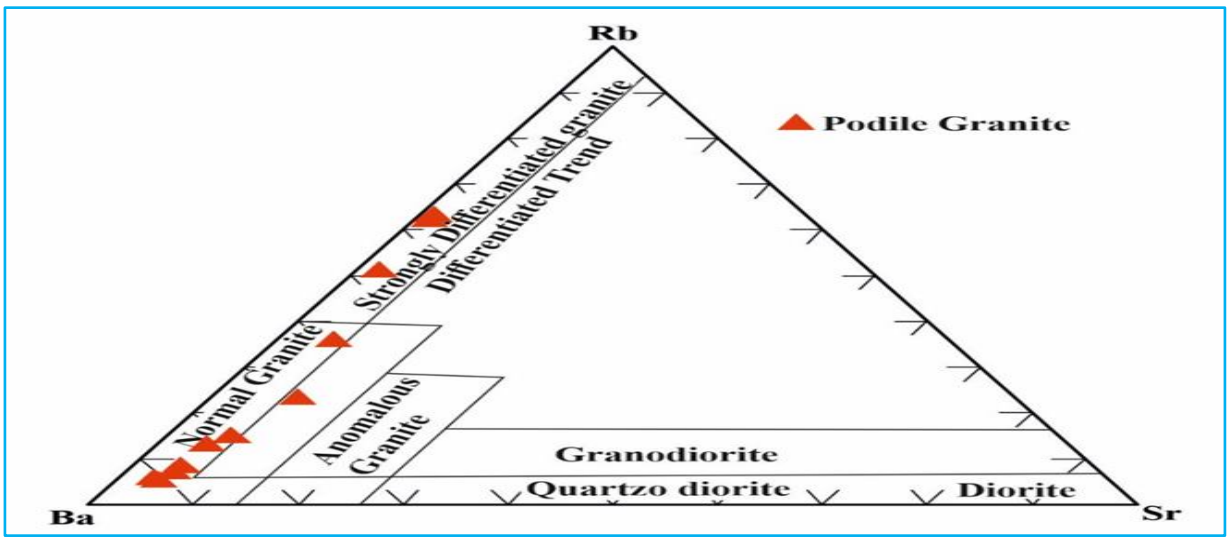

Fig-2: Rb-Ba-Sr ternary diagram (EL Bouseily and EL Sokkary, 1975)

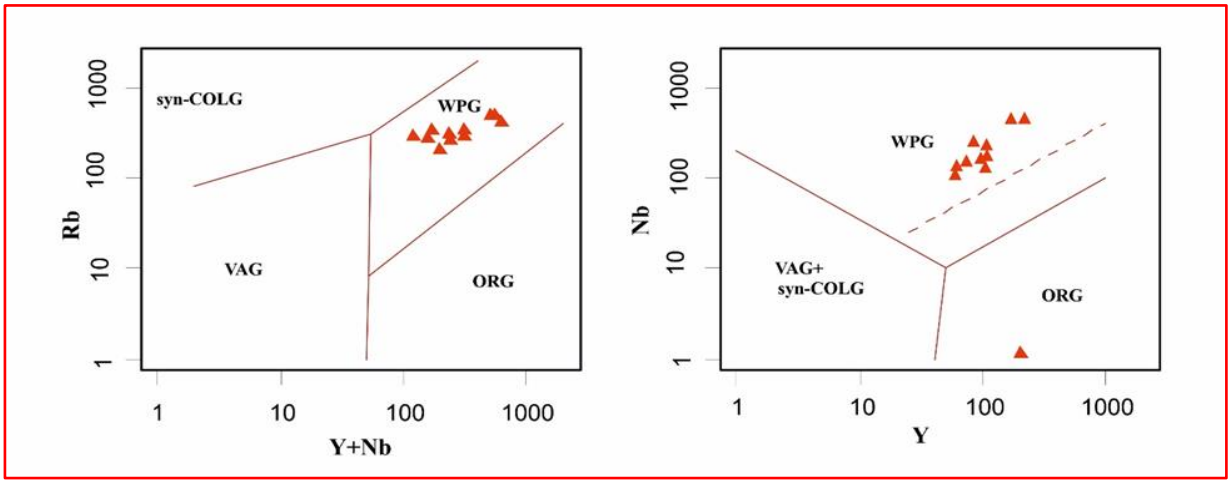

Fig-3 and 3a: Tectonic Discrimination plots (Y+Nb vs Rb) and (Y+Nb) of Pearce etal,1984.

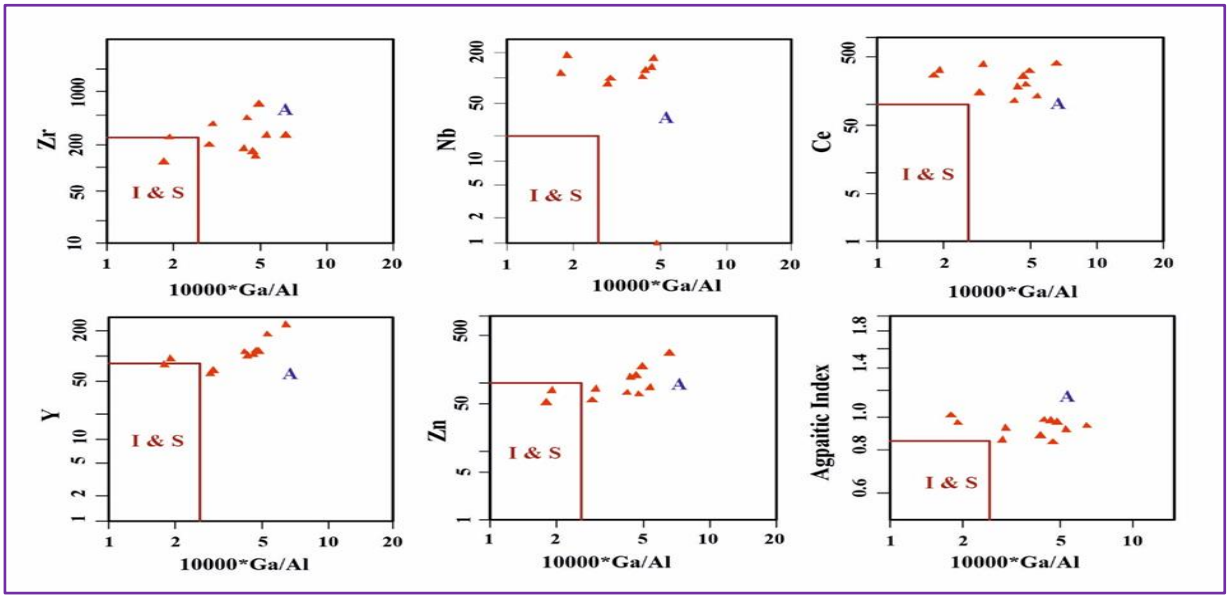

Fig-4: Plots to distinguish A-type granites (Whalen etal, 1987)

B. Rare Earth Elements (REE)

All the samples were analysed by Inductively coupled plasma emission mass spectrometry (ICP-MS) for all the elements from La to Lu, Y and Sc and are given table-2. The REE data is in ppm and normalized by chondrite values of Boynton (1984) for preparing spider diagram. The REE data of granites show strong europium anomaly with minor variation (Fig-5). The Europium anomalies are chiefly controlled by feldspars, particularly in felsic magmas. Thus, the removable of feldspar from magmatic melt by crystal fractionation or by the partial melting of a rock in which feldspar is retained in the magmatic source will lead to a negative Europium anomaly (Rollinson.1993).

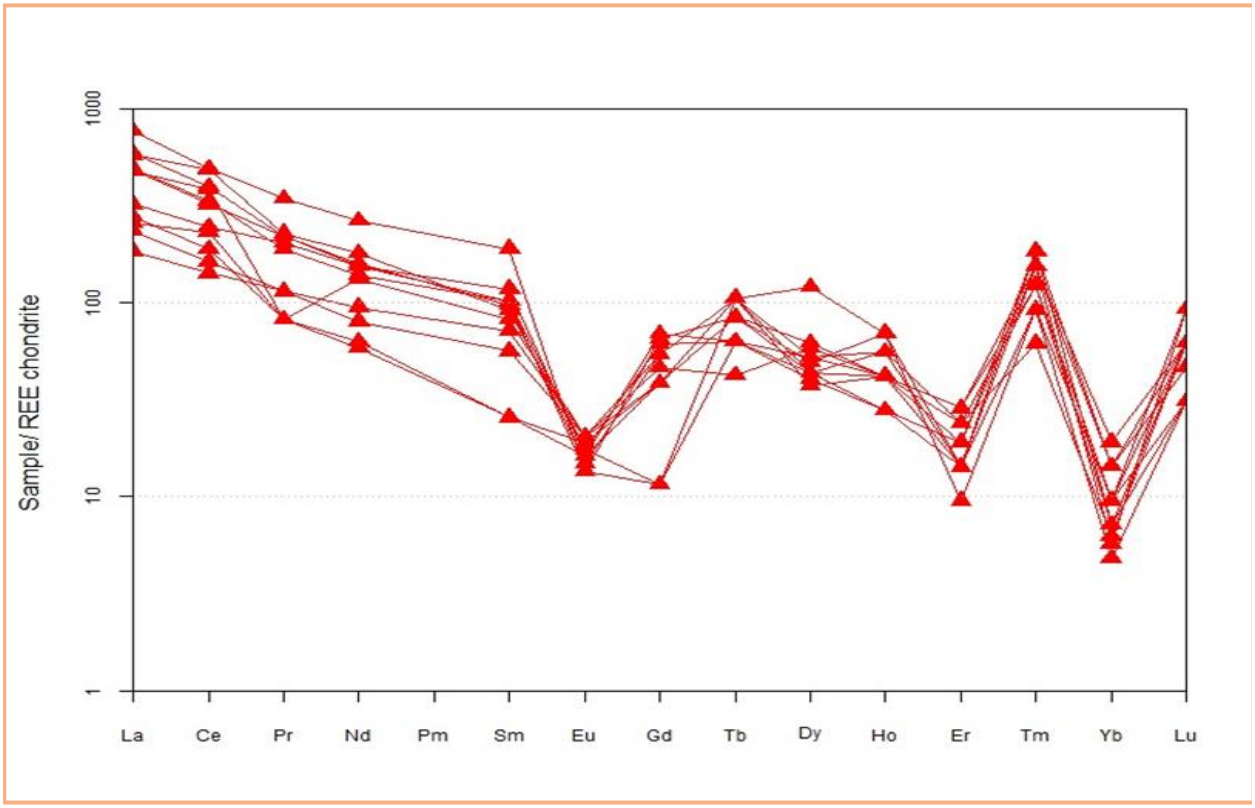

Fig-5: Spider Plot-REE distribution Pattern (Boynton, 1984)

IV. DISCUSSION

Proterozoic granite magmatism was witnessed along the eastern margin of Cuddapah Basin (Seshasai,2013). Numerous granites are located within the NSB as intrusives from Vinukonda (Guntur) in the north to Pamuru in the south over a stretch of 300km. The Kanigiri and Podile granites (Prakasam District) are one among them. The Kanigiri granite was studied in detail by various authors (Banerjee etal,1983; Thirupathi etal,1996; Nagendra Babu etal,2013) and established that the granite hosts rare metals and rare earths (columbite-tantalite, bastnaesite, hydroxyl bastnaesite, fergusonite, monazite, thorite, ilmenite, rutile and zircon) besides molybdenite, pyrite, fluorite and gold (in ppb). The Podile granite is located 5 km north of Kanigiri pluton, and is similar in mineralogy and geological setup. Hence, the Podile granite was considered for study.

Podile granite is coarse, grey crudely foliated, biotite granite associated with dolerite, gabbro, calc-silicates, syenites, quartz-tourmaline veins, fluorite and pyrite veins, and with presence of enclaves of schistose rocks, quartzite, meta-volcanic lithounits belonging to Nellore Schist Belt. A total of eleven (11) granite

samples were collected from the outcrop and were analysed for, minor elements, trace elements and REE.

V. CONCLUSION

- The granite is biotite to two micas (biotite and muscovite) with typical presence of aegirine-augite (alkali pyroxene) and riebeckite (sodic amphibole) along with pyrite and fluorite.
- High content of Rb, Zr, Y, Ce and Nb. Rb (upto 326 ppm), Zr (695 ppm), Y (upto 245 ppm), Nb (upto 334 ppm) and Ce (upto 398 ppm). Besides, anomalous values of gallium, zinc, chromium, cobalt and nickel are also indicated. Based on the concentration of elements, it can be inferred that discrete mineral phase of columbite (Nb), xenotime (Y), monazite (La, Ce, Th) may be present. Astrophyllite – a mineral of titanium was already reported from Podile granite.
- The granites of Podile are biotite to two mica granites: are to normal granite to strongly differentiated; tectonically within plate granites (WPG), spider diagram of REE with strong europium anomaly.
- All the above parameters point towards A-type nature of the granite and appears to be good host for rare metals and rare earths.

VI. ACKNOWLEDGEMENTS

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