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Petrological and geochemical studies on the Yadagirigutta Granites, Yadadri-Bhuvanagiri District, Telangana, Southern India

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Abstract: The granitic rocks of the Dharwar craton, spread in Yadagirigutta, Yadadri- Bhuvanagiri Districts of Telangana have attracted inadequate attention of the researchers made up of a variety of granitic rocks remains unclassified and a meaningful geochemical and petrogenetic study is yet to be taken up even after more than a hundred years of geological investigations.

The study area is covering the toposheet no. of 56 K/14 part of the Yadagirigutta (17°53'55"N-78°10'22"E), area of the Yadadri Bhuvanagiri District, wherein the lithological variants range from granodiorite through granite, syenogranite, alkali feldspar granite-quartz syenites. This paper attempts at highlighting the geochemistry and petrogenesis of around Yadagirigutta, N of Yadadri.

The granites are medium to coarse grained, inequigranular and porphyritic in texture. They are composed of K-feldspar (44-58% by Vol %) represented by orthoclase and microcline perthite, plagioclase (9-20%) and quartz (21- 30%). Mafic minerals include amphibole (1-5%) and biotite (1-8 %) and accessories are magnetite, sphene, and apatite. Presence of discrete plagioclase grains in substantial proportions indicates subsolvus conditions of crystallisation of parental magma. The rocks have high SiO_2 (68.02 – 70.00% by wt.), high K_2O (4.55-5.72%) and low Na_2O (3.50- 4.22%), with a calc-alkaline signature and low iron enrichment trend attesting to a typical of granites.

The chondrite normalised REE ratios of the syenogranites display LREE-enriched and HREE-depleted patterns and have a high LREE/HREE ratio that hints at the fractional crystallisation process as a major process. Further, the negative Eu anomaly indicates fractionation of feldspar. The rocks are originated from a LILE-enriched lithospheric mantle.

Key words: Petrology, Granite, K-feldspar, Geochemistry, REE, Yadagirigutta, Yadadri District, Telangana.

Introduction

The granitic rocks of the Dharwar craton, spread in Medak, Karimnagar, Nizamabad, , Ranga Reddy and Nalgonda Districts of Andhra Pradesh. have attracted inadequate attention of the researchers, that is disproportionate to their predominance as the Precambrian crustal rocks that is evident/ reflected in the fact that much of the terrain in the craton though made up of a variety of granitic rocks remains unclassified and a meaningful geochemical and petrogenetic study is yet to be taken up even after more than a hundred years of geological investigations.

The association of granites and syenites across the Dharwar craton is not unusual and well entrenched in the literature and their coexistence in the field, An important process in the formation of granitic crust was the partial melting of basaltic lower crust/ subducting

slab, which led to the formation of tonalite- trondhjemite- granodiorite (TTG) series of rocks in the late Archean period. Partial melting process of a variety of source regions that include subduction slab, mantle wedge and crust leading to the emplacement of a variety of granitoids in southern India since the Archaean cratons are dominantly constituted by TTG gneisses, greenstone belts, granulites and subordinate calc-alkaline granitoids, a study on these rocks would therefore portray geochemical evolution of magmatic rocks. Magmatic rocks in the late Archaean is of particular importance because during this period when crustal reworking processes assumed increasingly dominant role leading to the generation of calc-alkaline granitoids, Extensive research has been undertaken to last four to five decades during understand the origin and evolution of early formed continental crust and the calc alkaline granitoids, that bear distinctive geochemical characteristic.

The genesis of granitoids took place through interaction of diverse sources including upper mantle, lower and upper crust, and subsequently derived melts (Condie et al., 1985; Allen et al, 1986; Newton, 1990; Stern and Hanson, 1991; Evans and Hanson, 1992). Since the granites mark the stabilization of the craton, and a comprehensive study of these rocks provides an insight in understanding the continental growth through the geological past.

Granitic rocks are widely spread in the Telangana that is a part of the western side of the intracratonic Mesoproterozoic Cuddapah basin. On the contrary, granites corresponding to the acidic magmatism together with the syenites of different levels of silica saturation (representing alkaline magmatism) and gabbros (representing the basic magmatism) have been studied in a satisfactory manner. The entire south eastern margin of India is believed to have experienced extensive rift-related magmatism around 1.9 Ga (French et al. 2008) and an important granite forming event occurred in Middle-Proterozoic (~1000-1400 Ma) in the Indian shield (Divakara Rao et.al. 1999). Preceding the Paleo-Mesoproterozoic granite magmatism, a major crustal accretion event, possibly related to mantle plume activity resulted in intrusion of composite magmas into mid-crustal levels, initiating anatexis of the surrounding crust in Dharwar craton (Jayananda, 1995, 2000).

In this paper, we present the petrographic and geochemical data of the granites of the Yadagirigutta (17°53’55”N-78°10’22”E), in the *Yadadri bhuvanagiri* district, that is crucial in throwing light on the genesis of these rocks of the granitic suite of the rocks of the Yadadri in general.

Field Setup

The present study area at Yadagirigutta (Fig.1), Yadadri bhuvanagiri district of Telangana state being reported in detail for the first time is a part of the granitic complex of Precambrian age. The granitic terrain of the Yadagirigutta area is composed of granodiorite, granite, syenogranite quartz alkali feldspar syenites and syenites.

The granites of Yadagirigutta are massive and outcrops assume the shape of tors, knolls, inselbergs and conical mounds (Fig. 2 a – b); they are large bodies that extend for a few kilometers and frequently exhibit sharp contacts with granodiorite (Fig 2.c).

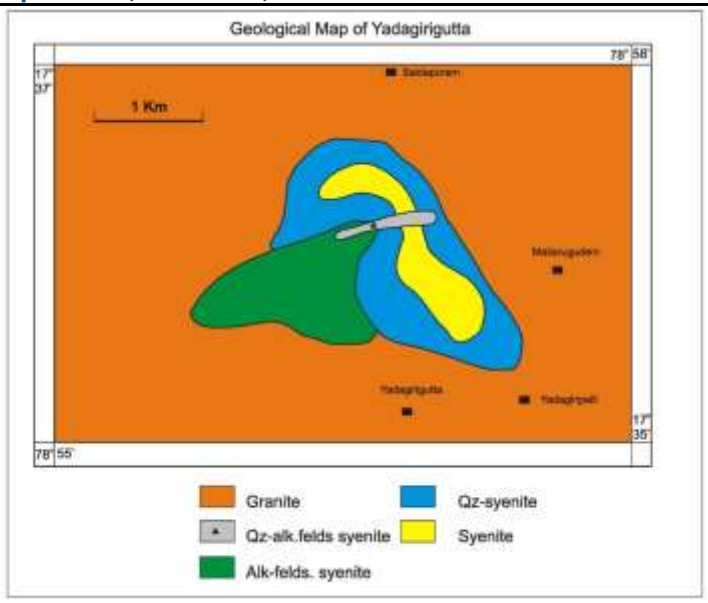

Figure 1. Geological map of Yadagirigutta area showing distribution of different rock types.

They are often seen juxtaposed to sheets of granodiorites. Though the granites do not carry any evidence of deformation, at few places the amphibolites enclaves has been deformed to ptygmatic folding (Fig.2d). The other prominent exposures of granites are noticed in the nearby areas Raigir, Yadagiripally, Mailargudem, Saidapuram, Masaipet, Mallapuram, Datharapally, and Ongaplly. The granites are intruded by pegmatites that belong to two or three generations that run in different directions assuming different shape indicating nature of fluids.

Figure 2. Field photographs depicting the nature and characteristic features of granites of Yadagirigutta area,

Petrography

The Yadagirigutta granite is a leucocratic, with CI <30 and exhibits holocrystalline texture and is devoid of any gneissic fabric. The rock is medium to coarse grained and with equigranular and hypidiomorphic textures, dominated by K- feldspar (microcline perthite) and quartz followed by mafic minerals like amphibole and Biotite (Table 1). Microcline perthite (Fig. 3a) constitutes bulk proportion of the rock. Orthoclase perthite is found displaying vein and string perthitic patterns. (Fig.3.b) Plagioclase is present in substantial proportions and the discrete plagioclase is indicative of subsolvus crystallization of the rock.

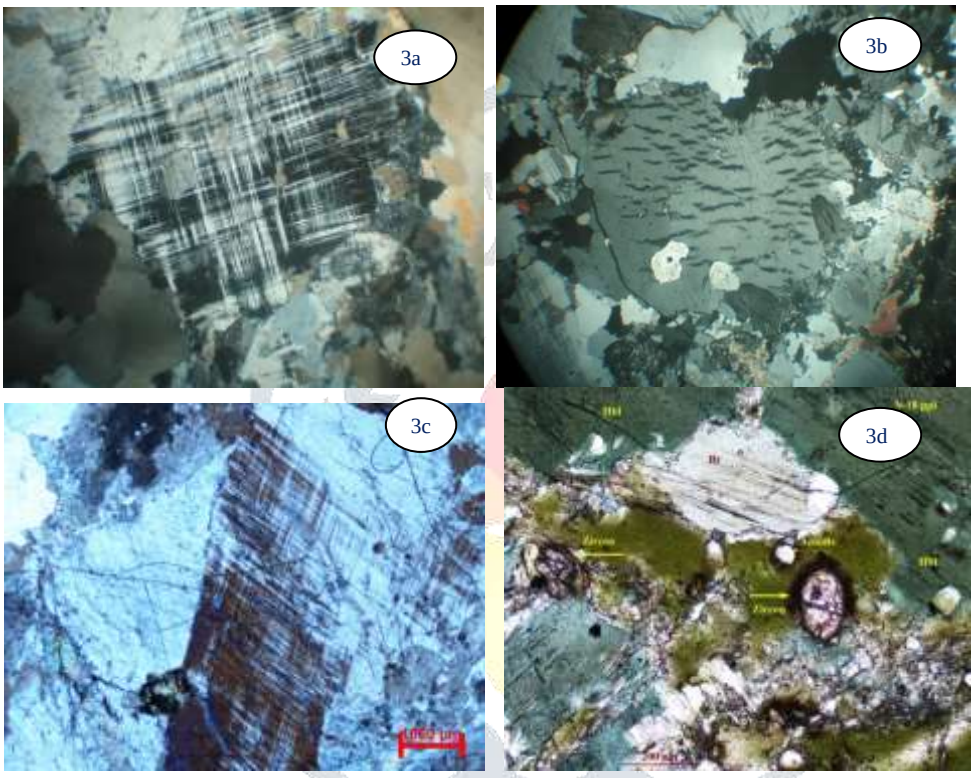

Fig.3. Photomicrographs of granites of Yadagirigutta showing (a) cross hatched twinning microcline perthite, (b) orthoclase perthite with string pattern, (c) hornblende in association with biotite and (d) amphibole having rounded to sub rounded inclusions and zircons.

Anhedral quartz is seen as an independent phase in association with plagioclase and microcline and occasionally exhibits interstitial habit. Myrmekites and anti-perthites are noted at plagioclase-quartz/K-feldspar contact. The amphibole is noticed as large subhedral grains with two prominent sets of cleavages and occasionally alters to biotite. Primary biotite is seen as a discrete phase (Fig.3c) in the form of as flakes within the matrix and also as fine aggregates within the interstices.Thus the presence of both amphibole and biotite demonstrates the role of volatiles in the evolution of the granites of Yadagirigutta. Apatite, zircon (Fig.3d), fluorite, calcite, magnetite constitute the accessory minerals. In the QAP diagram (Streckeisen, 1967) the rocks fall in the fields of alkalifeldspar granite, syenogranite and quarz syenites feldspar (fig. 4a)

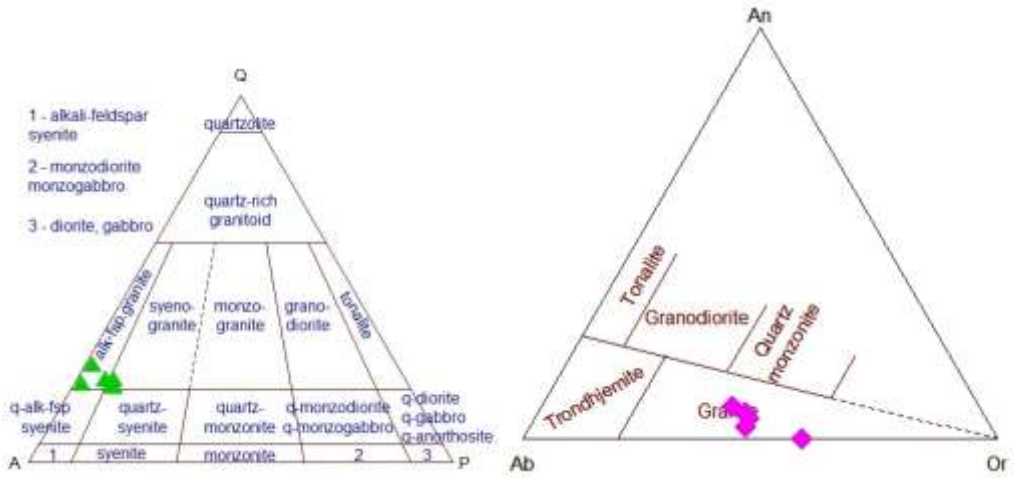

Fig. 4. (a) Plots of granites of the Yadagirigutta area in the QAP 'modal' diagram (Streckeisen, 1967) and (b) 'normative' feldspar triangle (O'Connor, 1965)

Table.1. Modal compositions (Vol %) of granites and of Yadagirigutta, Telangana.

S. No.	Y/2	Y/17	Y/18	Y/20	Y/23
Quartz	23	22	25	22	30
K-Feldspar	58	48	44	46	52
Plagioclase	9	18	20	14	11
Hornblende	5	_	_	6	2
Biotite	1	8	7.5	4	2.5
Sphene	2.6	_	3	4	0.5
Magnetite	0.5	2.2	_	4	1.5
Apatite	0.4	0.8	0.5	_	0.5

Geochemistry

The whole rock composition of the Yadagirigutta granites was determined at the National Geophysical Research Institute, Hyderabad with the X-ray fluorescence spectrometer (XRF) (Philips Magi PRO model PW 2440 wavelength dispersive X-ray fluorescence spectrometer coupled with automatic sample changer PW 2540) and ICP-MS (Model: Perkin Elmer Scitex ELAN DRC II). The trace and RE elements were determined using 0.1% solution prepared by HF-HCl-HNO_3 acid decomposing procedures. The major

element data of granites of Yadagirigutta is provided in Table 2, and the trace and REE compositions are in Table 4. In the CIPW normative Ab-An- Or triangle diagram (fig 4b) and in TAS (fig 5a) the rocks of Yadagirigutta fall in granite field.

In general, the granites of Yadagirigutta have SiO_2 exceeding 60% with narrow range of variation from 68.02 to 70 wt%. The Al_2O_3 also depicts a limited variation that ranges from 11.48 to 13.87% .and are metaluminous (Fig. 5b.) The granites exhibit $K_2O < Na_2O$ and the high contents of Al_2O_3 and K_2O is attributed to K feldspar. The FeO_t and MgO contents are low. The CaO content ranges from 0.87- to 2.80% is attributed to amphibole and plagioclase feldspar. The low abundances of compatible elements like Ni (6-30 ppm), Cr (197-267 ppm) and Co (2-7 ppm) suggest that Yadagirigutta the rocks represent evolved compositions. In the AFM diagram (Fig.6.a) form a smooth and distinct trend that is characteristic of any subalkaline series, where in the magma does not show preferential enrichment in either MgO or FeO and with increasing differentiation, there is a drop in the concentration of MgO and FeO and the trend line moves towards alkali rich corner.The Differentiation index (DI) normative Or+Ab+Qtz+Lc+Ne) (Thornton and Tuttle, 1960) ranges from 98.04 to 99.67, supports limited differentiation by fractional crystallization. The granites has a rather high Ba and Sr and low Cr, Co, Ni, (6b) similar to granites differentiated from a mafic rich magma originating from a mantle source.

Few of the granites are fall within the plate granite field (WPG). The tectonic discrimination diagrams exhibiting that these granites are intruded into the craton. Most of samples fall in the field of VAG and the reason may be attributed to the values of Y, Nb and Rb which are diluted by gathering of plagioclase feldspar (Pearce et al., 1984) (Fig. 7.4)

The granites of Yadagirigutta have high LILE and HFSE and display a LREE enriched and HREE depleted patterns in the chondrite normalized plots (fig.7a) with Eu anomalies and thereby hinting at the role of plagioclase fractionation in the genesis of granites. In the spidergram (fig.7b), the spikes for Nd and Gd and troughs for Nb, Ta, Sr and Ti suggest “arc setting” for the Yadagirigutta area, the conspicuous Gd anomly is apparently due to pursue of ‘monazite’ in these rocks.

Table 2. Major element composition, ratios and CIPW norms of the granites of the Yadagirigutta, Yadadri district, Telangana.

S. No.	Y/2	Y/17	Y/18	Y/20	Y/23
SiO2	70	69.91	69.07	68.29	69.33
TiO2	0.09	0.12	0.62	0.25	0.2
Al2O3	12.64	12.93	11.48	12.97	12.59
FeO	4.3	4.48	5.26	4.66	4.73
Fe2O3	0.48	0.5	0.59	0.52	0.53
MnO	0.01	0.03	0.05	0.02	0.03
MgO	0.11	0.18	0.55	0.28	0.2
CaO	0.87	1.06	2.8	1.55	1.39
Na2O	3.87	4.22	3.5	3.75	3.95

K2O	5.66	4.55	5.28	5.72	5
P2O5	0.03	0.05	0.47	0.08	0.06
Total	98.06	98.03	99.67	98.09	98.01
Na_2O+K_2O	9.52	8.77	8.78	9.46	8.95
K_2O/ Na_2O	1.46	1.08	1.51	1.53	1.21
Fe_2O_3+FeO	4.78	4.98	5.85	5.18	5.26
FeO/Fe_2O_3	8.96	8.96	8.92	8.96	8.92

Table 3. CIPW Norm calculation for granites of Yadagirigutta, Yadadri Area, Telangana.

S. No.	Y/2	Y/17	Y/18	Y/20	Y/23
Q	24.72	26.08	25.34	22.28	25.12
C	0.00	0.00	0.00	0.00	0.00
Or	33.42	26.86	31.18	33.79	29.54
Ab	32.71	35.70	29.62	39.68	33.39
An	0.422	2.92	0.03	1.68	1.85
Ac	0.00	0.00	0.00	0.00	0.00
Di	0.59	0.98	2.95	1.51	1.07
Wo	1.11	0.16	2.12	1.52	1.12
Hy	0.00	0.00	0.00	0.00	0.00
Il	0.03	0.06	0.11	0.47	0.05
Hm	4.77	4.98	5.85	5.17	5.26
Ap	0.07	0.12	1.10	0.18	0.13
Total	98.05	98.04	99.69	98.08	97.99

Table 4. Trace and REE chemistry of the granites of Yadagirigutta, Yadadri Area, Telangana.

S. No.	Y/2	Y/17	Y/18	Y/20	Y/23
Li	11.83	27.61	23.23	16.03	15.62
Be	2.239	5.212	3.45	1.444	2.332
Sc	1.341	3.906	12.82	1.973	2.9
V	7.116	12.05	36.66	22.06	17.17
Cr	197	252	226.8	223.8	267.8
Co	1.996	2.158	6.784	3.753	3.312
Ni	30.71	8.319	5.909	8.343	14.4
Cu	4.245	5.534	11.16	11.47	7.979
Zn	13.09	19.02	58.38	26.51	16.88
Ga	14.83	11.82	79.59	24.11	17.79
Rb	223.5	221.2	124.7	128.4	210.5
Sr	61.94	64.45	422.3	139.2	95.54
Y	5.165	17.78	79.16	21.99	18.27
Zr	105.3	114	502.7	345.3	224.5

Nb	6.603	29.53	56.33	11.56	15.24
Cs	0.802	2.055	0.952	0.573	0.837
Ba	351.7	189.8	4362	745.4	477.3
Hf	3.409	4.1	12.15	8.588	6.169
Ta	0.703	5.066	2.728	0.894	1.136
Pb	80.46	85.22	73.44	64.07	61.9
Th	51.09	34.56	49.02	102.5	90.76
U	8.275	34.14	2.721	6.976	13.11

Table 5. REE concentrations (ppm) of the granites of Yadagirigutta, Telangana.

S. No.	**Y/2**	**Y/17**	**Y/18**	**Y/20**	**Y/23**
La	24.89	156.2	96.48	32.5	53.79
Ce	48.35	392.9	170.6	57.29	103.1
Pr	5.375	24.92	16.43	6.047	10.03
Nd	18.07	74.55	50.42	19.49	29.63
Sm	3.892	10.9	7.595	3.121	3.976
Eu	0.482	1.344	0.948	0.756	0.536
Gd	13.29	39.94	27.61	11.03	13.79
Tb	0.51	1.066	0.774	0.331	0.302
Dy	2.974	4.885	3.754	1.656	1.133
Ho	0.605	0.885	0.72	0.327	0.208
Er	1.816	2.375	1.99	0.907	0.602
Tm	0.303	0.312	0.284	0.136	0.082
Yb	1.577	1.515	1.436	0.748	0.484
Lu	0.291	0.228	0.208	0.117	0.085

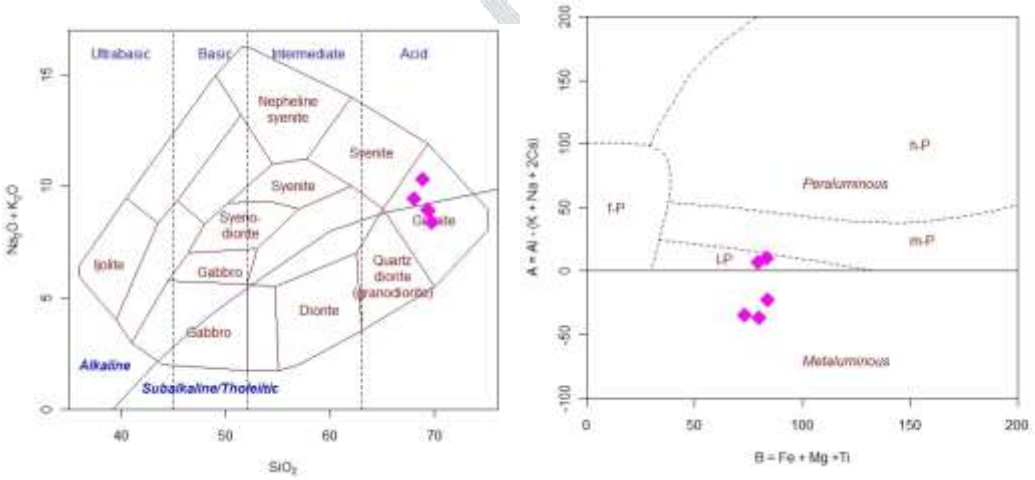

Fig. 5. Plots of granite samples of Yadagiriguttain (a) TAS diagram (Cox et al, 1979); (b) A- B diagram (Villasce et al., (1996)

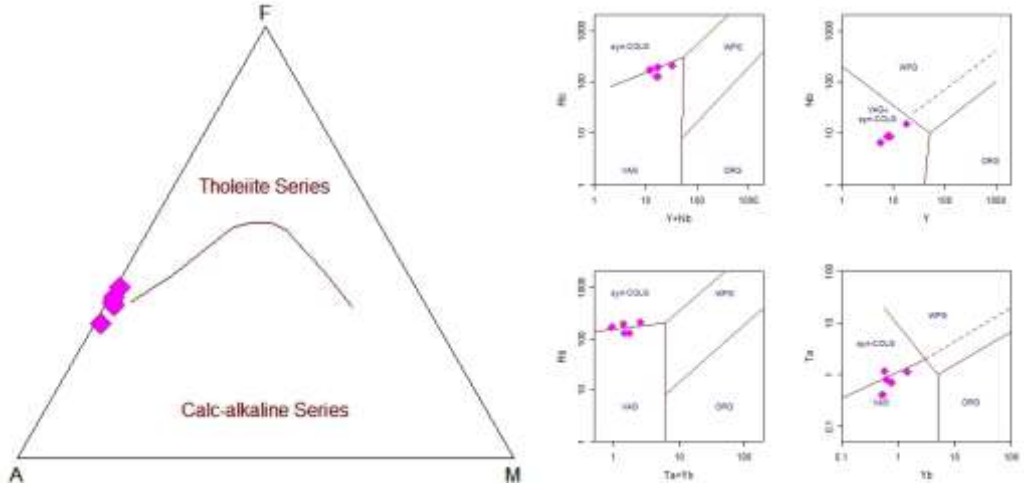

Fig. 6. Plots of granite samples of Yadagiriguttain (a) AFM diagram (Cox et al, 1979); (b) A- B diagram (pearce et al., (1984)

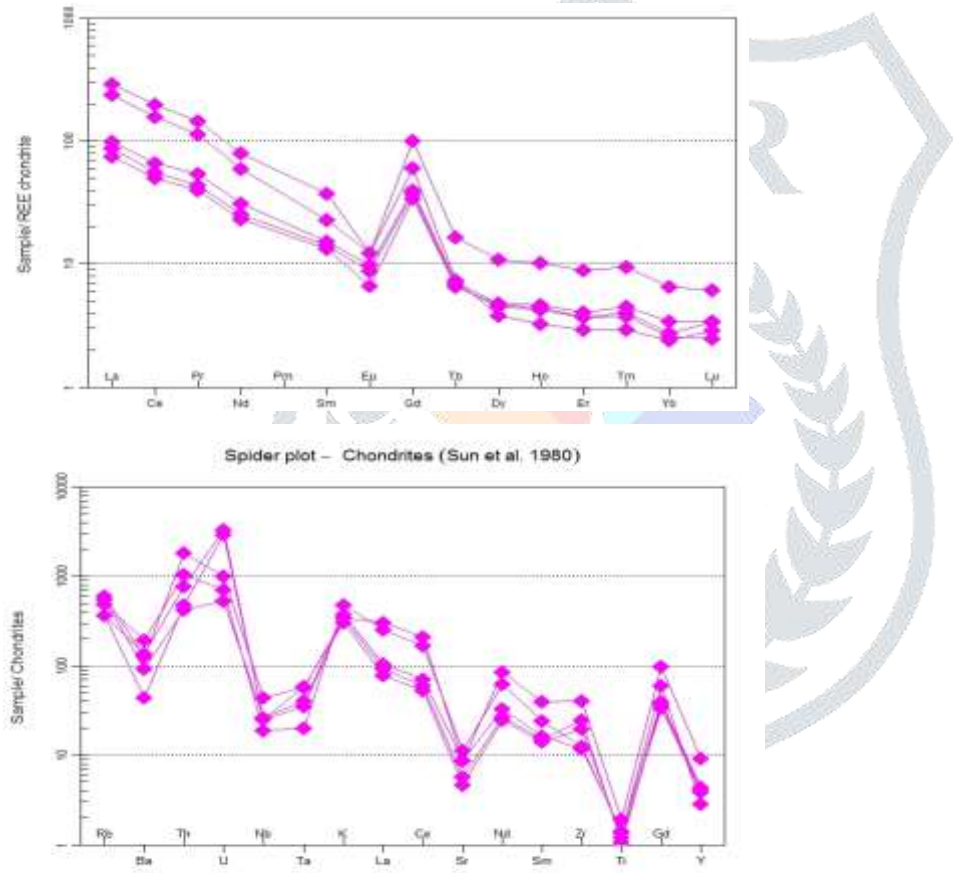

Fig.7. (a) Chondrite normalized REE plots and (b) Multielement spidergram (Mc Donough and Sun, 1985)for the granites of Yadagirigutta, , Telangana.

Conclusions

The Precambrian Yadagirigutta granitic rocks are formed at mesozonal levels in the crust. The parental liquids are of mixed character and represent from “arc granites” through “withinplate granites” and “syn collisional granites” REE 0 X chondrite concentrations in a sample indicates that garnet is removed from the source liquid involving fractionation of feldspars with attend and accumulation of volatiles that lead to subsolus crystallization of feldspar.

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