ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

GEOCHEMICAL AND PETROGRAPHICAL STUDIES OF PRECAMBRIAN GRANITOIDS FROM HYDERABAD BATHOLITH, TELANGANA, INDIA

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DOI: 10.5281/zenodo.1173590

ABSTRACT

The granitoids from the Hyderabad area of the Telangana State are confined to Precambrian gneissic complex of the northern-eastern part of Eastern Dharwar Craton. They cover 7760Sq.km of the study area and fall between latitudes 16° 52'- 17°42'N and between East longitudes 77° 21'- 77°51'E. The granitoids are mainly classified into grey and pink granites, granodiorites and aplites. They occasionally contain older mafic enclaves in the form of lensoid bodies and thin bands and cut by younger dolerite dykes, pegmatite and quartz veins. Granitoids form batholitic domes, pointed hillocks, small mounds and sheeted outcrops in the study area. Under the microscope they show varied textural features such as intergrowth perthitic texture between alkali feldspar and plagioclase feldspar and symplectic myrmekitic texture between plagioclase, quartz at the margin of K- feldspar. Norm data sets when plotted in QAP diagram, the samples restricted to the field of syeno granite to monzo-granite to granodiorite. They are mainly composed of feldspar (microcline and plagioclase) and quartz as essential minerals. Biotite, hornblende,epidote, chlorite, apatite and iron oxide occur as accessory minerals. The negative correlation between SiO_2 vs CaO, TiO_2 and MgO indicate plagioclase fractionation.These granitoids lie in the fields of granite and granodiorite on the SiO_2 vs Na_2O+K_2O diagram. Majority of granitoid samples fall in granite, few in quartz monzonite and granitic field of Na_2O+K_2O vs SiO_2binary diagram. The granitoid samples are classified into granites and trondhjemite and at the margins of granodiorite (GGT) in the normative An-Ab-Or ternary diagram.The granitic rocks of the study area are plotted within cal-alkaline field and show typical calc alkaline trend on the AFM diagram.The granitoids are described as both metaluminous and peraluminous types further the granitoids of Hyderabad area in MALI digram, spread over calcic to alkali fields. This shows that the studied suites are not derived from the differentiation of a single parental magma. These granitoids are described as subsolvus in character that are formed at below solvus temperature (<400^0C)under wet conditions. Based on the field, petrography and major element analyse of the granitoids of the Hyderabad area reveal that they are formed from the melts that are generated by partial melting of lower crust due to magma-upwelling.

KEYWORDS: Precambrian gneisses, granitoids, partial melting, lower crust and magma-upwelling, Partial melting.

I. INTRODUCTION

Granitoids are the predominant components of the Archaean cratons, constituting of 70 – 80% volume (Windley, 1995). They have been formed episodically from ~4.0-2.5 Ga (Martin and Moyen, 2002) producing compositionally varied suites with many overlapping characteristics. Their compositions suggest that they are produced by different petrogenetic processes in different geodynamic settings and are key to address numerous questions related to Archaean tectonics and crustal evolution processes. Sederholm (1926) utilized such relations to decipher phases of metamorphism and to distinguish different stages of migmatization and also used basic dykes to distinguish between younger and older granites. Precambrian gneisses often contain mafic bodies whose initial shapes have been greatly modified by deformation, migmatization and related phenomena. Basic bodies were one of the most important indicators of the kinematic history of a gneissic terrane (Sengupta,1993).

II. GEOLOGICAL SETUP OF THE STUDY

The study area occupies the Northern part of Eastern DharwarCraton (EDC) around Hyderabad area of Telangana State. The area is bounded by betweenlatitudes N16° 52'- 17°42'and between longitudes E77ngitudesn et. The area mainly comprises of granitoids of Precambrian age which forms a part of the unclassified crystalline topography of Peninsular Gneissic Complex (PGC). The outcrops include a variety of

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pink granites, gneissic grey granites and aplite rocks, coarse-grained pegmatite veins, quartz veins and epidote veins are observed as cross-cutting or parallel to the foliation in the granitoids and are sometimes folded and deformed. Dolerite dykes are cross-cutting the granitoids. The dikes strike in different directions and are seen as persistent linear ridges extending for several kilometers with varying width.

III. PETROGRAPHY

TheHyderabad area granitoids are generally massive, occasionally foliated and rarely gneissic. The rocks are leucocratic showing light grey to grayish pink in color. The petrographic study of these rocks exhibit equigranular and hypidiomorphic granular texture.The rocks are classified as syenogranite, monzo granite and granodiorite based on the modal % of quartz (Q), alkali feldspar (A) and plagioclase (P) by using classification scheme of Streckeisen, 1974. The rocks are plotted in QAP triangular diagram after recalculating into 100%. On the basis of this mineralogical classification scheme of Streckeisen, 1974, 1976, the rocks are plotted in syenogranite, monzogranite and granodiorite fields in the QAP diagram of Le Maitre et al ., 1989 (Figure 1).The primary minerals of granites include quartz, plagioclase, K-feldspars, hornblende and biotite occurring as essential minerals. Apatite, epidote and opaque constitute as minor phases. The secondary alteration products are represented by kaolinisation, sericitisation and chloritisation (Figure2.b), in these rocks by the deuteric alteration of primary K-feldspar, plagioclase feldspar, hornblende and biotite.Microcline is occasionally altered to sericite,road Perthite is developed between plagioclase and K-feldspar by intergrowth phenomenon in grey granite (Figure2.c). Deformed cross-hatched twinning is present in microcline (Figure2.c and d); Carlsbad twinning is prominent in perthite containing opaque inclusions (Figure 2a).Most of the quartz grains exhibit undulate extinction. Altered plagioclase exhibits variable degrees of alteration to sericite, selectively along the cleavage planes. Myrmekitic texture is uncommon in granitoids of study area and it is formed by the intergrowth between quartz and plagioclase at the margins of K-feldspar Figure2.d). Granites of the study area are of subsolvus type because of presence of both feldspars. They show hypidiomorphic and granular texture with perthitic and myrmekitic intergrowths.Recently Anjaneyulu et al. (2017) opinioned on the eastern margin of the EDC part of the Nalgonda area granitoids were generated by partial melting of shallower crust under subsolvus conditions (<400^{0}C).

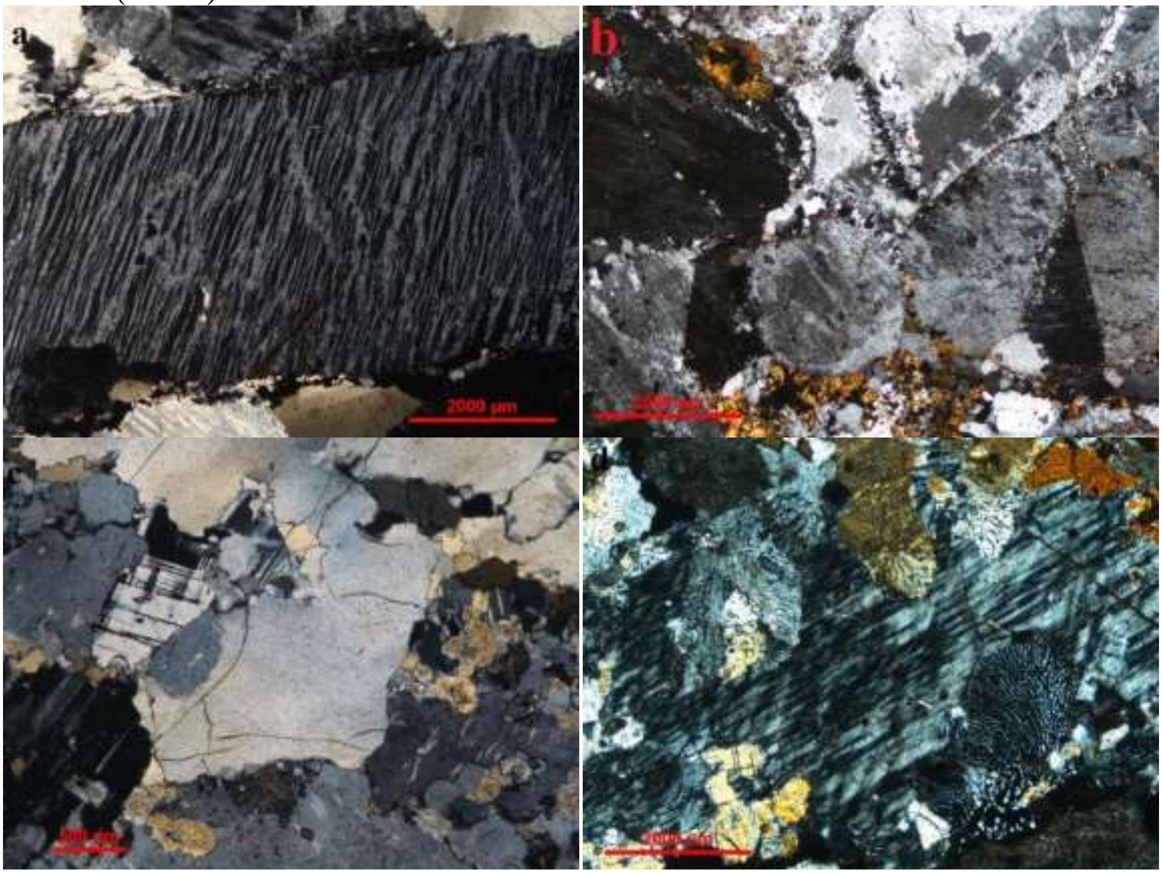

Figure 2. (a) Pertitic texture is shown by pink granite. [scale 1000 µm, XPL] (b) Plagioclase altered to sericite and along the margins re-crystallized quartz accumulated pink granite [scale 1000 µm, XPL (c) Inequigranular texture with big crystals of microcline perthite in grey granite [scale 1000 µm, XPL] and], (d) Myrmekitic texture in pink granite [1000 µm, XPL]

Formation of flame perthite can be explained by replacement reaction mechanism (Na-K exchange) between K-feldspar and plagioclase under low to moderate differential stress condition during rapid cooling (Pandit, 2015). Replacements of plagioclase by K-feldspar are common (Collins,2003). Fractured feldspars are probably a manifestation of submagmatic state as defined by Bouchez et. al.,(1992) who suggested that the pink series have been derived from grey granite by potash metasomatism. In the present study area, granitoids are described as **subsolvus** in character due presence of two feldspars that are formed at below solvus (<400^{0}C) temperature under hydrous conditions.

IV. GEOCHEMISTRY OF THE GRANITOIDS

IV.1 SAMPLING AND ANALYSIS METHODS

A total of 150 samples of granitoids from Hyderabad area were collected. Around 50 thin sections were prepared and studied. 24 samples were analysed for major and minor oxide(SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, K_2O, Na_2O, TiO_2 and P_2O_5)compositions using X-ray fluorescence spectrometry (XRF) at the CSIR-National Geophysical Research Institute (CSIR-NGRI), Hyderabad. .

The geochemistry of granitoids is controlled by their mineralogy including major, minor and accessories. The high proportions of felsic minerals (quartz, K-feldspar and plagioclase) of these rocks are responsible for high concentrations of SiO_2 (75.41-64.17 wt%) with an avg.71.8 wt%, Al_2O_3 (12.22-15.17wt %) with an avg.14 wt %, K_2O (3.61-5.01wt %) with an avg. 4.5 wt %and Na_2O (3.47-5.25 wt %)with an avg. 3.9 wt% (Table1). Of the 24 samples, 20 have K_2O/Na_2O>1 and remaining 4 with <1 K_2O/Na_2O ratio. Mafic components (MgO, CaO and TiO_2) decreasing fromgranodiorite to monzo granite to syenogranite.

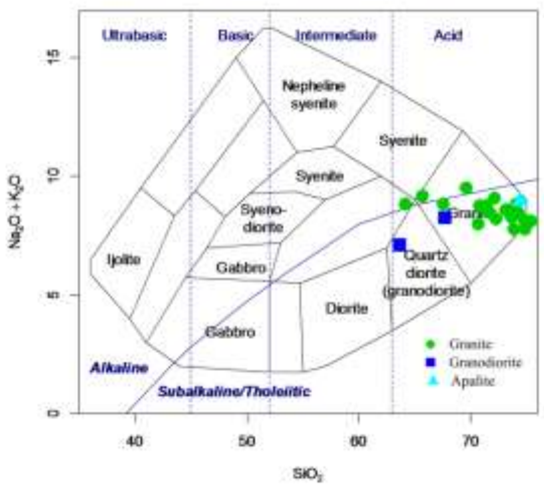

Figure 5. SiO_2vs. Na_2O+K_2Owt%, binary diagram for the granitoid rocks from the Hyderabad area (after Cox et al., 1979)

Table 1. Major element analysis (wt %) of granitoids of the Hyderabad area

Seq	sample	SiO2	Al2O3	Fe2O3	MnO	MgO	CaO	NA2O	K2O	TIO2	P2O5
	HG2	67.55	15.87	2.83	0.04	1.22	1.93	4.87	3.96	0.45	0.21
	HG6	73.88	13.35	1.28	0.01	0.44	1.09	3.46	4.31	0.12	0.06
	HG15	74.82	12.52	1.5	0.01	0.25	0.94	3.43	4.71	0.19	0.06
	HG16	74.25	13.54	1.04	0.01	0.18	0.94	4.13	4.32	0.07	0.01
Granites	HG12	75.41	12.22	1.62	0.01	0.28	0.97	3.33	4.77	0.21	0.02

	HG27	72.26	14.59	2.2	0.02	0.5	1.44	3.62	4.57	0.28	0.09
	HG33	64.17	15.45	4.5	0.05	1.88	2.46	5.23	3.61	0.58	0.21
	HG64	74.05	13.3	1.08	0.02	0.16	0.75	4.29	4.55	0.1	0.02
	HG69	74.85	13.22	1.54	0.01	0.34	0.94	3.17	4.98	0.21	0.06
	HG72	71.4	14.23	2.32	0.02	0.58	1.33	4.07	4.69	0.36	0.08
	HG74	74.88	14.15	0.44	0.02	0.1	1.03	3.72	4.04	0.01	0.02
	HG80	71.43	14.19	2.05	0.02	0.71	1.08	3.58	5.01	0.32	0.12
	HG93	71.71	13.77	2.06	0.02	0.7	1.04	3.49	4.96	0.3	0.11
	HG94	69.61	15.7	1.3	0.02	0.78	0.98	4.83	4.67	0.19	0.17
	HG98	65.67	15.4	4.27	0.04	1.35	1.88	4.53	4.63	0.68	0.34
	HG116	70.78	14.86	1.67	0.02	0.47	1.34	4.66	4.1	0.18	0.06
	HG123	73.67	13.47	1.84	0.01	0.49	1.03	3.32	4.96	0.27	0.08
	HG125	73.14	13.19	2.23	0.02	0.47	1.03	3.49	5.09	0.33	0.12
	HG146	73.24	14.02	1.82	0.01	0.56	0.94	3.47	5.1	0.26	0.06
	HG160	72.16	13.99	2.29	0.03	0.52	0.85	4.13	4.95	0.24	0.07
	HG174	70.66	14.67	2.35	0.01	0.73	1.57	3.9	4.09	0.22	0.08
granodiorites	HG106	63.63	15.04	5.69	0.07	3.52	2.26	4	3.11	0.64	0.25
	HG119	67.69	13.73	3.95	0.04	1.64	1.63	4.06	4.21	0.43	0.26
Aplite	HG154	74.38	13.72	1.67	0.01	0.24	0.76	4	4.94	0.17	0.03

IV.2 Geochemical diagrams for granitoid

Harker diagram (Figure 3) exhibits decrease in the amount of MgO, TiO_2, CaO, P_2O_5 and total Fe with increase in SiO_2.The negative correlation between SiO_2 vs CaO, SiO_2 vs TiO_2 and SiO_2 vs MgO indicating plagioclase fractionation as well as differentiation or fractional crystalisation and hence granodiorite is observed. The granitic rocks of the study area are plotted within cal-alkaline field and show typical calc alkaline trend in the AFM diagram of Irvine and Baragar 1971 (Figure 7). Granites including aplite are in general toward alkaline (A) corner and granodiorites are in the interior of the calc-alkaline field.

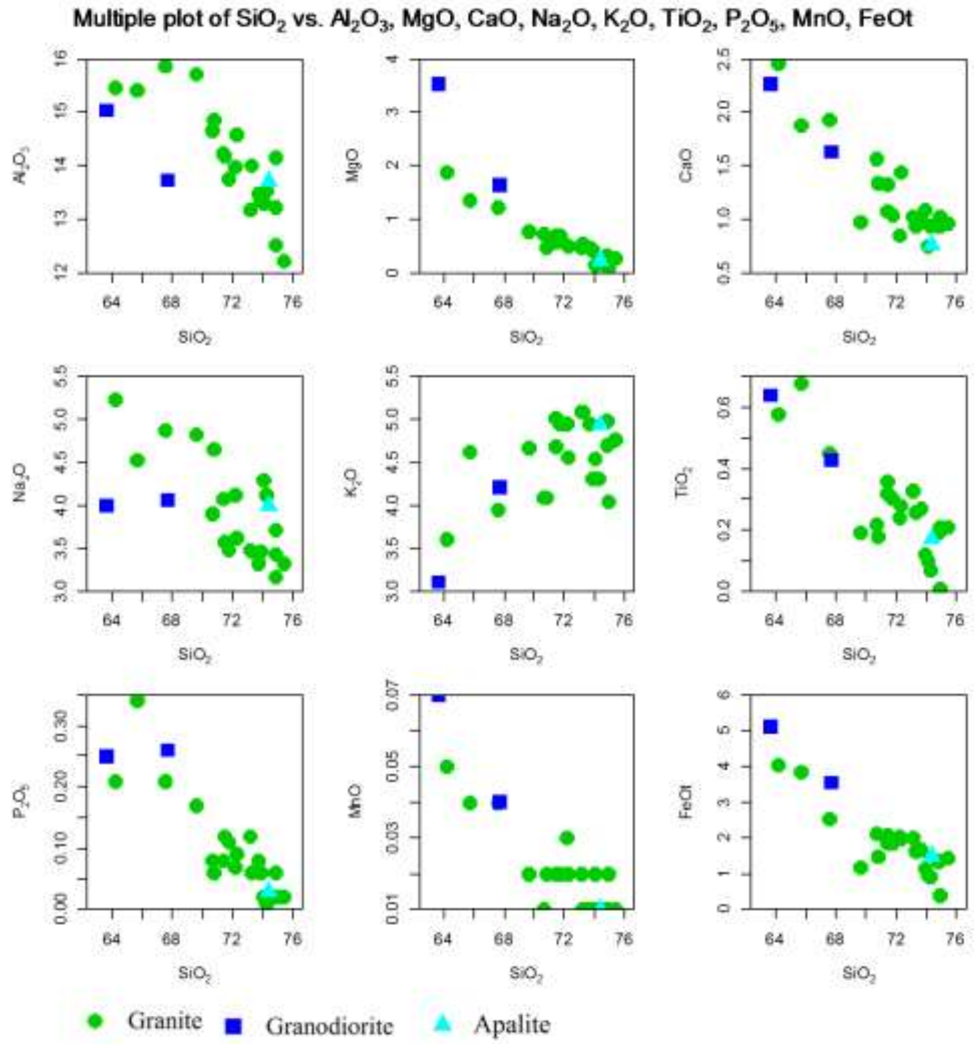

Figure 3.Harker variation diagram for the granitoids from Hyderabad

Various geochemical discrimination diagrams are being used to classify the granitoids of the Hyderabad area and to understand their tectonic setting. The granitoids of the Hyderabad area lie in the fields of granite and granodiorite of the SiO_2 vs Na_2O+K_2O diagram after Cox et al., (1979;Figure5). The major and minor oxide geochemistry of granitoids indicates that they are of sub-alkaline in nature. Majority of granitoid samples fall in granite, few in quartz monzonite and granodiorite fields of Na_2O+K_2O vs SiO_2binary diagram of Middlemost, (1994;Figure 6).The granitoid samples are classified into granites,trondhjemitesand lie at the boundary of the granodiorites (GGT) in the normative An-Ab-Or ternary diagram of Barker and O'Connor (1965;Figure 4).

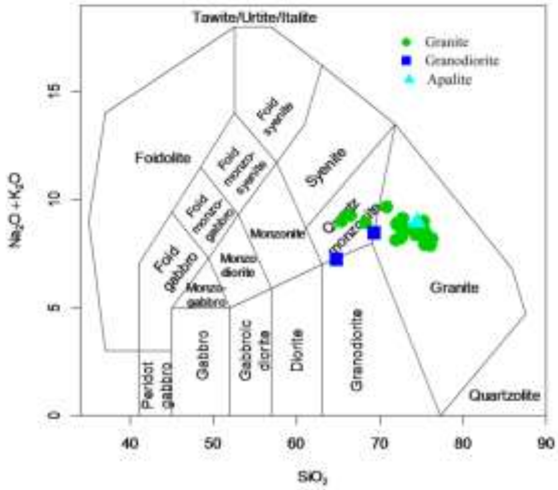

Figure 6. Na_2O+K_2O vs. SiO_2wt%, binary diagram (after Middlemost, 1994) for the granitoid rocks from the Hyderabad

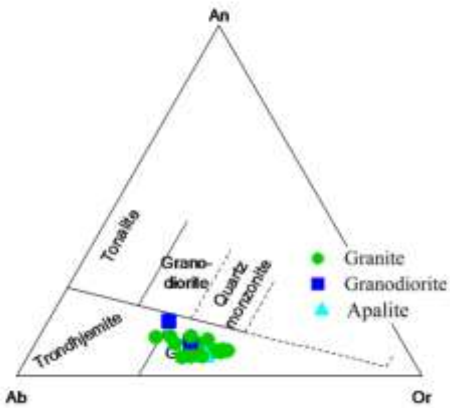

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Figure 4. Hyderabad area granitoids on Ab-An-Or normative diagram (after Barker and O'Connor, 1965).

IV.3 Magma type of the Hyderabad area granitoids

The granitic rocks of the study area are plotted within cal-alkaline field and show typical calc-alkaline trend in the AFM diagram of Irvine and Baragar (1971;Figure 7). Granites and aplite are in general trend toward alkaline (A) corner and granodiorites are in the interior of the calc-alkaline field**.**

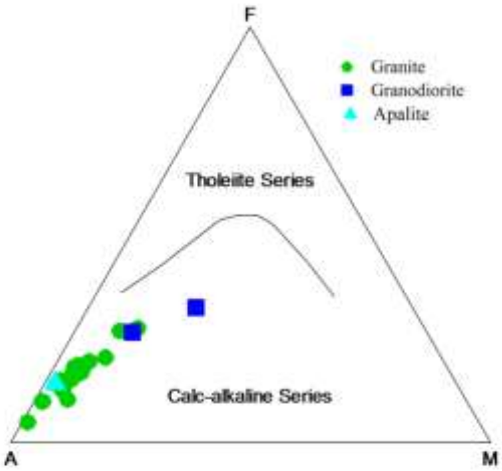

Figure 7. A-F-M plot for the granitoids of the Hyderabad area(after Irvine and Bargar, 1971)

ISSN: 2277-9655
Impact Factor: 5.164
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IV.4 Alumina Saturation Index (A/CNK)

Shand (1947) has suggested a diagram that is based on alumina saturation, calculated by the molar proportion of Al_2O_3/ ($CaO+Na_2O+K_2O$) =A/CNK. Alumina Saturation Index (ASI) is an important parameter in the study of the granitoids. Granitic rocks with A/CNK values >1 are termed as peraluminous and granitic rocks with A/CNK values <1 are termed as metaluminous. The granitoids of present study show both A/CNK values <1 and A/NK values >1 when plotted in the Shand diagram (Figure 8). Based on these criteria, the granitoids of the study area are described to possess both metaluminous and peraluminous characteristics.

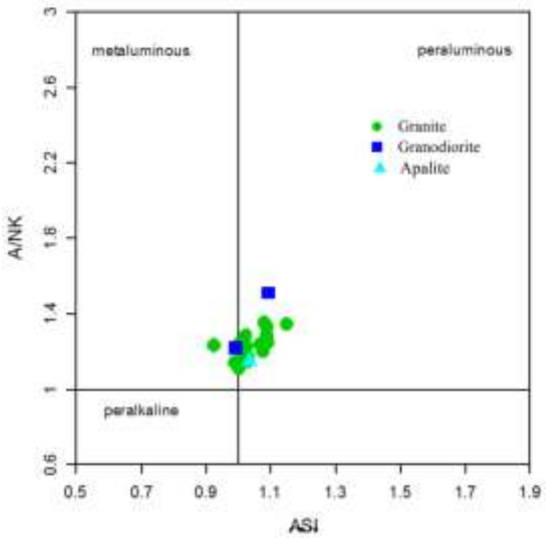

Figure 8. A/CNK – A/NK binary plot for the granitoids of the Hyderabad area (after Shand, 1943)

IV.5 Modified Alkali-Lime Index (MALI)

Peacock (1931) volcanic suites are divided into four classes according to the alkali-lime index of in his alkali-lime index diagram, the alkalies (Na_2O+K_2O) in a suite of lavas equaled to CaO at a given SiO_2 content. If thealkali-lime index is >61% of SiO_2 content, the suite of lavas are described as calcic; and if the alkali lime index (ALI)is between 56-61% SiO_2 are called as alkali-calcic and it is < 51% of SiO_2 are knownto be alkalic in character. The modified alkali –lime index (MALI) after Peacock 1931, was recently applied by Frost et al. (2001) for the granitoids of the world. When we plotted the granitoids of Hyderabad area in MALI diagram, spread over alaklic to calc alkalic fields of (Figure 9) without confined to any single field.

This shows that the studied suites not derived from the differentiation of a single parental magma. Based on the field, petrography and major element analyse of the granitoids of the Hyderabad area reveal that they are formed from the melts that are generated by partial melting of lower crust due to magma-upwelling.

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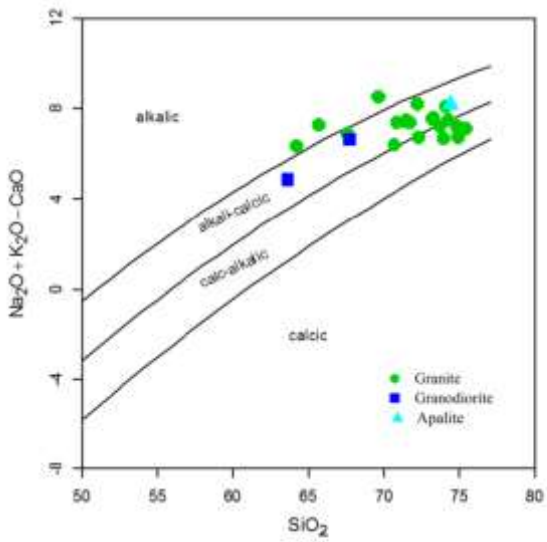

Figure 9. Plot of Na_2O+K_2O-CaO against SiO_2, showing the ranges of alkalic, calc-alkalic, and calcic rock series (after Frost et al., 2001)

V. CONCLUSION

Based on the field evidences, petrography and major analysis of granitoids of Hyderabad area reveals that they were formed from the melts that are generated by partial melting of lower crust due to magma upwelling.

VI. ACKNOWLEDGEMENTS

I would like to thank the head Dept of Applied Geochemistry, Osmania University for lab and field support. I extend my thanks to financial support by UGC-BSR Fellowship. Lastly I express my sincere thanks to reviewers of this manuscript.

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CITE AN ARTICLE

Praveen, K., Anjaneyulu, M., & Reddy, U. (n.d.). GEOCHEMICAL AND PETROGRAPHICAL STUDIES OF PRECAMBRIAN GRANITOIDS FROM HYDERABAD BATHOLITH, TELANGANA, INDIA . *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *7*(2), 468-476.