International Journal of Basic and Applied Chemical Sciences ISSN: 2277-2073 (Online)
An Online International Journal Available at http://www.cibtech.org/jcs.htm
2013 Vol. 3 (3) July-September, pp.1-10/Raju et al.

Research Article

GEOCHEMISTRY OF GRANITE GNEISSES IN PARTS OF NORTH ARCOT DISTRICT, TAMIL NADU, INDIA

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ABSTRACT
Granites gneisses are the dominant rock types in the study area, Kavuthimalai-Vediyappanmalai of North Arcot district, Tamil Nadu. The granite gneisses can be classified on the basis of modes of quartz, potash feldspar and plagioclase. The modes of quartz, potash feldspar and plagioclase are reduced to 100 and the values fall in the granodiorite and tonalite fields when plotted in the Streckenson (1978) triangular diagram. The values of Na_2O-K_2O and CaO-Na_2O-K_2O have been plotted in the respective diagrams which show the granite gneisses of the study area as granodiorites and tonalites. The plots of FeO/MgO Vs SiO_2 diagram, normative Q_Z-AB-Or diagram and Plagioclase Vs Al_2O_3 diagram indicate that these granite gneisses are calc-alkaline in nature.

Key Words: *Granite Gneisses, Tonalites, Granodiorites, Kavuthmalai, Vadiyapppanmalai*

INTRODUCTION
Granite gneisses of the study area (Figure 1) are massive and exhibit gneissic texture which is due to alternate arrangement of felsic and mafic minerals. Johansen (1938), Chayes (1952, 1957), Bateman (1961) and Streckeinsen (1976) have classified granite gneisses of the study area on the basis of modes. The modes of quartz, potash feldspar and plagioclase of these rocks are reduced to 100 and plotted in Streckenson (1978) triangular diagram (Figure 2), they fall in granodioritic and tonalitic fields. As per the mineralogical and chemical properties the Granodiorites are coarse grained, hard and compact with gneissic texture. They show hypidiomorphic-granular texture. Quatz, plagioclase, potash feldspar and biotite are the major and hornblende, apatite, iron and zircon are minor constituents. Gneissic texture can also be seen under microscope with alternate arrangement of light and dark coloured minerals. Quartz shows undulose extinction, potash feldspar shows perthitic texture with quartz inclusions. Plagioclase is of An_{31-35}. Biotite is the dominant mafic constituent with yellow to brown pleochroism. Hornblend is present with yellow to green pleochroism with 2V=(-) 73^0 and Z^C=18^0. Iron ore surrounded by other mafic minerals is observed. Inclusions of euhedral apatite and zircon are noticed. Modes are given in Table 1. Whereas the Tonalites consists of quartz, plagioclase, potash feldspar and biotite as primary while the iron ore and apatite is found as secondary constituents. Quartz occurs as discrete grains. Potash feldspar is represented by microcline with 2V=(-)83^0. Biotite occurs as laths while the iron and apatite occur as inclusions the modes of the composition of tonalites are given in Table 2.

MATERIALS AND METHODS
Method of Study
The area under study with an aerial extent of110 sqkm. has been mapped geologically on a 1.5 cm to 1 km. Scale. One hundred and forty samples representing various lithologic units have been collected and equal number of thin sections has been prepared with the purpose of conducting a detailed mineralogical and petrographic studies.
The major elements and trace elements were determined by X-ray fluorescence method in the laboratory of the Atomic Mineral Division, Hyderabad. Ferromagnetic concentrates from magnetite-quartzite for the geochemical and X-Ray analyses were separated by a hand –magnet,and silicateswere separated by

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employing heavy liquids like bromoform and cleric solutions.This procedure was repeated several times and the heavy part thus obtained wasdried at 80^0 C and then used for analysis.

Major Elements

In granite gneisses of the study area SiO_2 varies from 69.13% to 73.75%. The other major elements are Al_2O_3, Fe_2O_3, FeO, MgO, TiO_2, MnO, CaO, Na_2O, K_2O and P_2O_5, indicating that the granite gneisses of the study area are more siliceous with greater variation of SiO_2 (Saini *et al.*, (1998). The values of Na_2O-K_2O and CaO-Na_2O-K_2O of granite gneisses of the present area when plotted in corresponding diagrams fall in the fields of granodiorites and tonalites (Figure 3a & 3b). The plots on the FeO/MgO Vs SiO_2 diagram (Figure 4a) (Miyashiro, 1974), Normative Q_Z-AB-Or diagram (Figure 4b) and plagioclase Vs Al_2O_3 diagram (Figure 4c) (Barker and Arth, 1976) indicate the granite gneisses are calc-alkaline in nature. The alumina saturation index of Shand, agphatic index and A/CNK values (Table 2 & Figure 5 & 6) indicates the paraluminous nature of the granite gneisses of the study area (Faruque Hussain *et al.*, 2004). The mineralogical composition, Shand index and the A/CNK of Piparan granites suggest its sedimentary parentage and the anatectic origin (Jamual *et al.*, 1996). The granite gneisses of the study area showing the atomic ratio of Al/Na+K+2Ca is 0.769, that similar to the value shown by igneous rocks which is upto 1 (Chappel and White, 1974; Faruque Hussain *et al.*, 2004) indicating the igneous nature of granite gneisses. Larsen index and acidic index were indicative of diffraction (Figure 7a, b).

Trace Elements

Trace elements observed in the granite gneisses of the present study, compared with the other Indian granite gneisses is given as follows.

Cobalt

Cobalt in the granite gneisses of the study area ranges from 3 to 14 ppm, where as in general the granite gneisses contain 1 to 52 ppm (Sandell and Goldich, 1943; Vinogradov, 1962; Glickson, 1976) and in Indian granites gneisses it ranges from 1 to 30 ppm (Howie, 1955; Condie *et al.*, 1986). The range of Cio in Shimoga granites is 1 to 7 ppm (Ali and Divakar Rao, 1980), and in gray granite gneisses of Channarayapatnam is 2 to 9 ppm (Bhaskar Rao *et al.*, 1983).

Nickel

The study area granite gneisses contain nickel values range from 40 to 72 ppm. The reported range of nickel in Shimoga granites is from 6 to 78 ppm (Ali and Divakar Rao, 1980). For Channarayapatnam gray gneisses it is from 12 to 19 ppm (Bhaskar Rao *et al.*, 1983). In Southern India Archaean high grade granite gneisses nickel ranges from 1 to 35 ppm (Condie *et al.*, 1986).

Barium

Barium concentrations in granite gneisses of the study area have a range of 750 to 1156 ppm, when compared with the concentration of barium in granite gneisses ranges form 300 to 1800 ppm (Sahama, 1945; Turekin and Wedepohl, 1961; Arth and Hanson, 1975; Jenner *et al.*, 1981; Condie and Timorthy, 1982). The gray granite gneisses of Channarayapatna have 70 to 1036 ppm (Bhaskar Rao *et al.*, 1983). Whereas the Archaean high grade granites have 900 to 1750 ppm (Condie *et al.*, 1985).

Strontium

In present study granite gneisses, strontium ranges from 380 to 576 ppm. The reported value for granitic rocks is 100 to 1020 ppm. Range in Southern India granites of Archaean high grade terrain is from 181 to 705 ppm (Condie *et al.*, 1986).

Rubidium

The rubidium in the granite gneisses of the present study ranges from 69 to 103 ppm and the estimated range of rubidium in granites gneisses of Southern Indian Archaean high grade terrain is from 68 to 120 ppm (Condie *et al.*, 1986).

Chromium

It ranges from 24 to 85 in the study area, in Channarayapatna granite gneisses it ranges from 11 to 18 (Bhaskar Rao *et al.*, 1983), whereas in acidic rocks of Shimoga it is from 10 to 102 ppm (Ali and Divakar Rao, 1986) and in Archaean granites of Southern India it is from 1 to 105 ppm.

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Zirconium

The zirconium of the present granite gneisses ranges from 143 to 210 ppm. The reported values of zirconium in granitic rocks range from 50 to 500 ppm. (Turekin and Wedepohl, 1961; Vinogradov, 1962; Kolbe and Toylor, 1966; Glikson, 1976; Condie and Timothy, 1982) where as the Channarayapatna gneiss, shows 59 to 180 ppm (Bhaskar Rao *et al.*, 1983). In the granites of Archaean terrain it is from 24 to 280 ppm (Condie *et al.*, 1986), and in peninsular gneisses it is from 110 to 245 ppm.

RESULTS AND DISCUSSION

The maximum trace elements except zirconium and the average values of the constituents of the study area are conformable to the average crustal type, (Park, 1989). Low to moderate Al_2O_3 and low K/Rb ratio of granite gneisses of the present study area are comparable with gneissic suits of Channarayapatna (Bhaskar Rao *et al.*, 1983) and suggest that the crustal anatexis of basic rocks with low Rb/Sr values are the source in generation of parental melts. High values of Ba, K and Rb contents in granite gneisses of the study area indicates the partial melting of the tonalitic crust which is the source for the granites of Archaean high grade terrains of South India (Condie *et al.*, 1986).

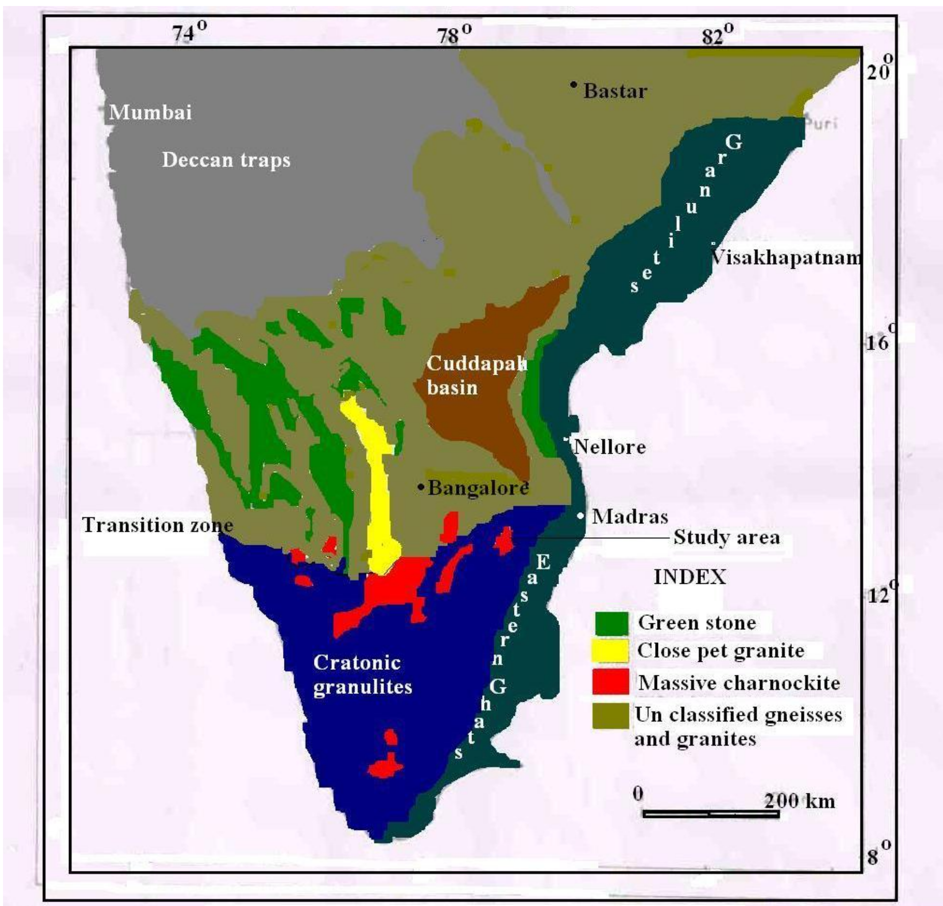

Figure 1: Location map of the study area

High Ni, Cr, Mg, Al_2O_3, Ni/Mg ratio and on the basis of Ni/Co, Ni/Cr ratios, the granite gneisses of the present area may be formed due to the partial melting of basic crust (Syed Ali and Divakar Rao, 1980). The An-Ab-Or and Or-Ab-Qz (Yoder *et al.*, 1967), Figure 7, for temperature show 625^o – 685^oC for the

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granite gneisses of the present study. A plot of Qz-Ab-Or (Tuttle and Bowen, 1958; Arth *et al.*, 1987) for pressure gives 4-6.5 Kb (Figure 8 & Figure 9) for the granite gneisses of the present study.

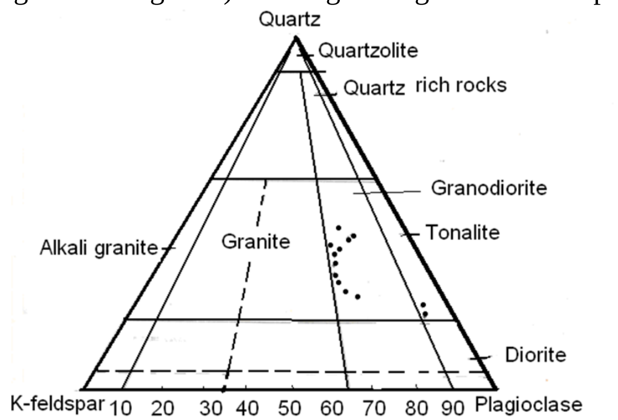


Figure 2: Model Qz- K Feldspar – Plagioclase diagram (after Streckeisen, 1973)

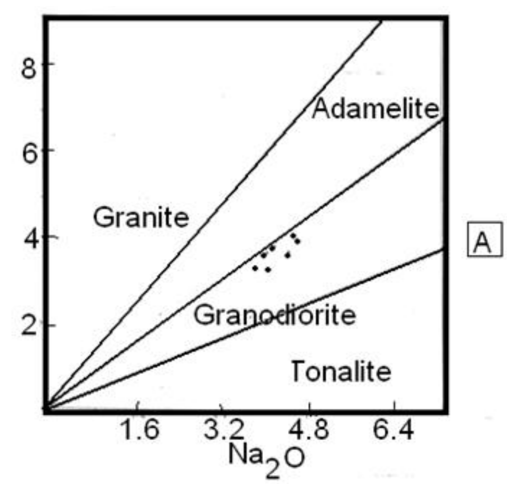
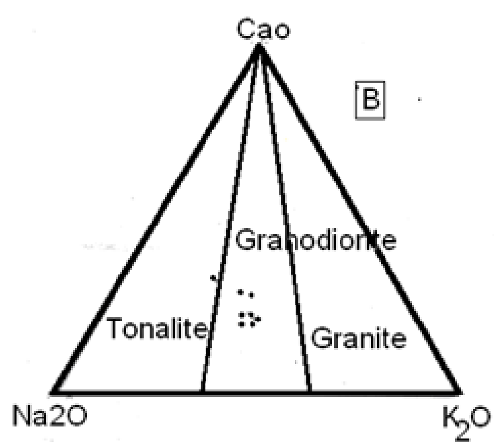


Figure 3 a) K_2O – Na_2O diagram of granite gneisses (after Harpur, 1963)



Fifure 3 b) Frequency distribution diagram of Cao- Na_2O-K_2O

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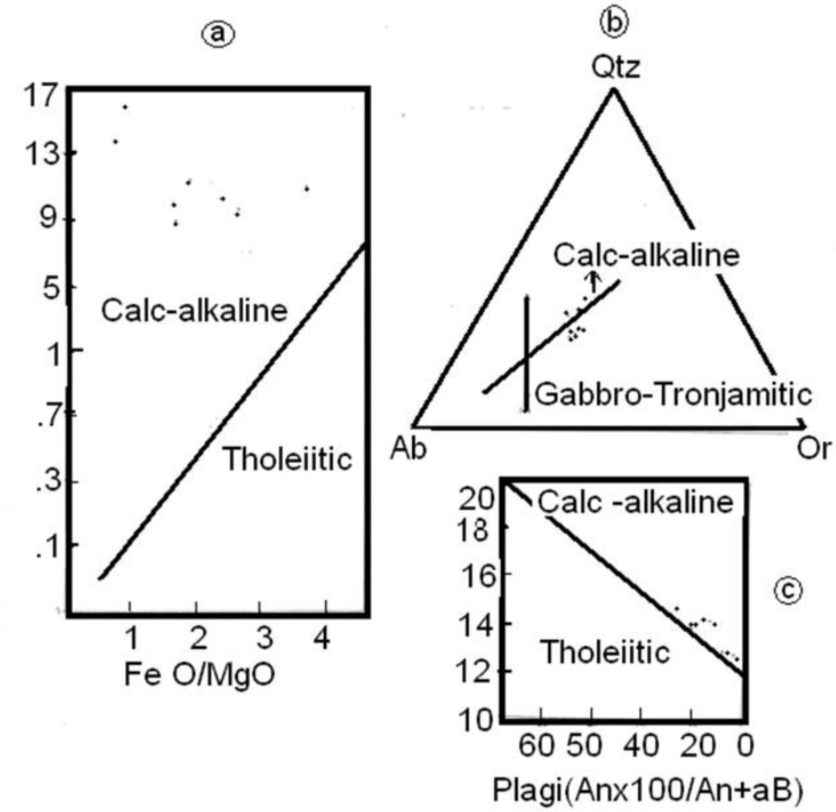

Figure 4: Variation diagrams for granite gneisses
a) SiO_2 Vs. FeO/MgO (after Miyashiro, 1974)
b) Q-Ab-Or diagram (after Barker and Arth, 1976)
c) Plagioclase Vs. Al_2O_3 (after Baraker and Arth, 1976)

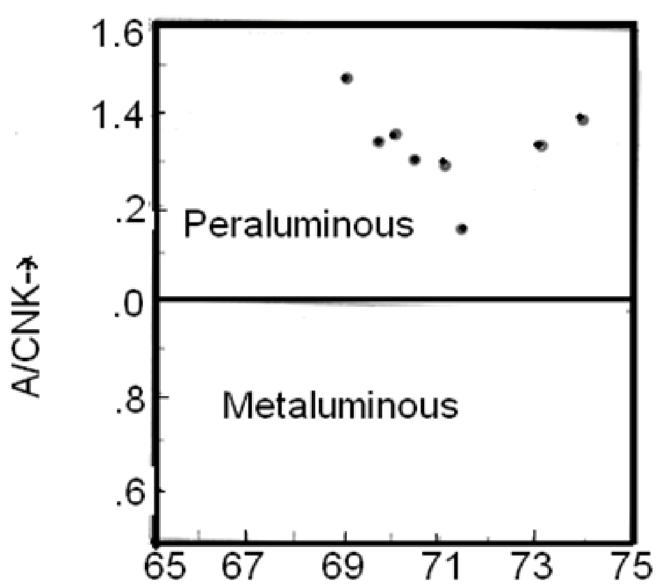

Figure 5: A/CNK Vs. SiO_2 diagram for granites of the study area (after Prakash, 1996)

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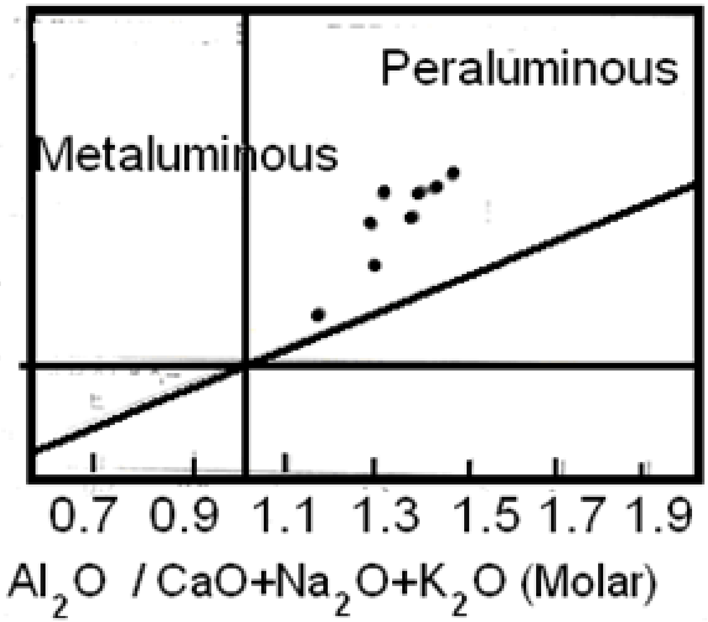

Figure 6: Sands Index diagram for granite gneisses of the study area (after maniar and piccoli, 1989)

Table 1: Modal composition of granite gneisses (Vol%)

Constituents	1	2	3	4	5	6	7	8	9	10	11	12	13
Quartz	40.30	42.99	33.24	39.43	45.95	37.59	43.14	24.96	23.50	34.53	27.90	20.60	30.68
Plagioclase	36.73	42.00	39.54	39.07	35.97	38.96	41.00	48.44	65.12	37.64	47.07	66.20	41.48
K-Feldspar	18.10	13.40	22.18	17.62	15.10	19.50	12.35	19.53	5.85	27.54	21.39	7.50	22.71
Biotite	4.00	0.97	2.79	2.15	1.43	2.09	1.85	4.75	4.94	4.53	3.00	3.45	2.56
Hornblende	0.33	0.00	0.75	0.00	0.64	1.03	0.00	0.00	0.48	0.11	0.19	1.25	0.83
Zircon	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.16
Opaque	0.32	1.64	1.00	1.38	0.34	0.74	1.51	1.98	0.11	1.54	0.20	0.00	1.46
Apatite	0.22	0.00	0.28	0.35	0.57	0.14	0.15	0.45	0.00	0.12	0.25	0.00	0.21

Samples 1 to 11 = Granodiorites; 12 & 13 = Tonalites

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Table 2: Major element content (Wt%), CIPW Norms and Niggli values of Granite gneisses

Constituents	1	2	3	4	5	6	7	8
SiO_2	70.01	69.08	71.35	71.05	70.43	69.13	73.24	73.75
TiO_2	0.32	0.40	0.25	0.29	0.46	0.52	0.36	0.48
Al_2O_3	14.03	14.75	13.00	14.15	13.96	14.35	13.25	13.82
Fe_2O_3	1.71	1.85	1.65	1.15	1.42	1.62	0.84	1.40
FeO	1.53	1.24	1.00	1.65	1.23	1.35	0.64	1.17
MgO	1.57	1.10	1.55	0.75	1.06	1.65	1.74	1.39
MnO	0.06	0.13	1.55	0.75	1.06	1.65	1.74	1.39
CaO	3.40	2.85	2.58	2.25	2.00	2.92	1.97	2.50
Na_2O	4.58	4.00	4.60	4.55	4.49	4.09	3.98	4.27
K_2O	2.25	3.15	4.00	4.06	3.74	3.64	3.55	3.43
P_2O_5	0.12	0.15	0.09	0.14	0.25	0.18	0.10	0.11
Total	99.88	99.42	99.65	99.92	99.21	99.60	99.75	99.71
			Normative	Mineral				
Quartz	25.70	27.00	23.82	s	24.78	24.12	30.24	33.00
Orthoclase	13.30	18.35	23.85	23.82	21.68	21.12	17.79	21.13
Albite	38.80	34.06	38.78	23.91	38.25	34.06	33.01	35.54
Anorthite	10.80	12.79	3.06	37.78	6.59	10.56	9.17	7.51
Corundam	0.00	0.00	0.00	6.12	0.00	0.00	0.00	0.51
Diopside	4.20	0.65	7.18	0.00	1.76	2.40	1.09	0.00
Hypersthene	3.70	2.76	0.83	3.24	2.26	3.50	4.05	4.33
Magnetite	2.60	2.55	2.32	1.26	2.09	2.30	1.16	1.39
Ilmenite	0.60	0.76	0.30	1.86	0.91	0.91	0.16	0.91
Apatite	0.30	0.34	0.34	0.61	0.33	0.33	0.33	0.31
				0.33				
			Niggli					
si	301.50	313.00	336.83	values	346.00	314.00	375.50	379.00
al	35.40	41.04	35.98	348.00	40.41	38.85	39.68	41.031
fm	23.51	16.21	18.13	40.87	15.98	19.24	18.13	18.52
c	15.76	14.82	12.75	13.35	10.68	14.18	10.75	11.11
alk	25.33	27.93	33.14	11.47	32.93	28.02	31.34	29.32
			Rations	34.39				
Al/(Na+N+2C	0.73	0.81	0.66		0.79	0.74	0.80	0.84
a	1.37	1.48	1.16	0.75	1.31	1.35	1.40	1.47
A/CNK	0.49	0.48	0.66	1.30	0.59	0.54	0.57	0.53
Al				0.61				

Table 3: Trace element content(ppm) of Granite gneisses

Constituents	1	2	3	4	5	6	7	8
Co	10.00	3.00	8.00	5.00	6.00	14.00	9.00	12.00
Ni	72.00	51.00	68.00	40.00	55.00	70.00	63.00	59.00
Cr	85.00	73.00	24.00	61.00	38.00	53.00	60.00	83.00
Ba	1045	890	1156	750	920	845	975.00	1109.00
Sr	456.00	380.00	576.00	492.00	503.00	401.00	392.00	435.00
Rb	103.00	85.00	69.00	90.00	74.00	78.00	89.00	92.00
Zr	185.00	210.00	165.00	190.00	165.00	143.00	152.00	164.00
K/Rb	181.00	307.00	481.00	375.00	419.00	388.00	331.00	275.00
Rb/Sr	0.23	0.22	0.12	0.18	0.15	0.19	0.23	0.21
Ba/Rb	10.15	10.47	17.00	8.33	12.40	10.80	11.00	12.00
Ni/Mg	0.64	0.77	0.73	0.91	0.86	0.70	0.60	0.53
Ni/Co	7.20	17.00	8.50	8.00	9.16	5.00	7.00	4.90
Ni/Cr	0.84	0.74	5.68	0.66	1.45	1.32	1.05	0.7

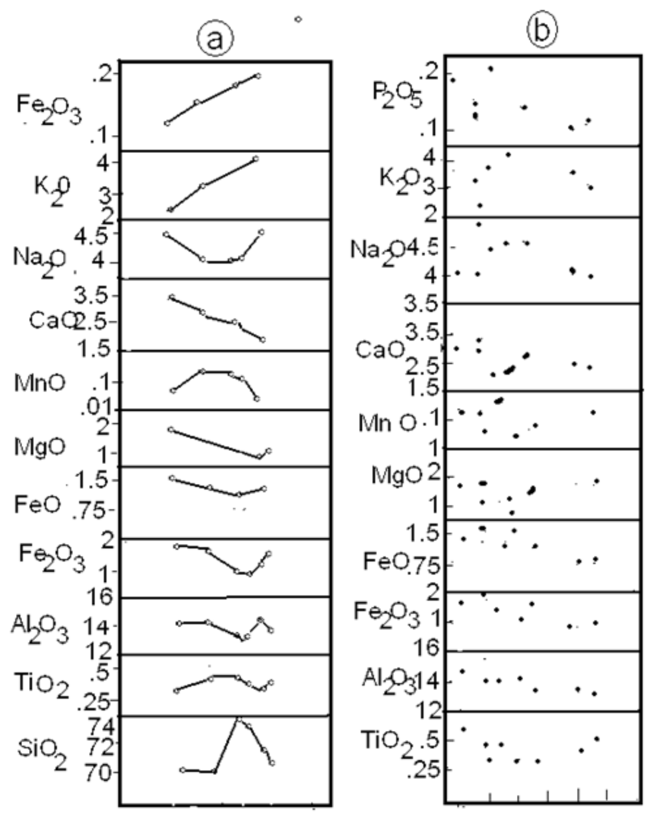

Figure 7 a. Larsen variation diagram for granite gneisses, b. Variation diagram of chemical constituents against SiO_2

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Conclusion

The Alumina saturation index of Shand, Agphatic index and A/CNK values indicate the peraluminous nature of granites gneisses of the study area. The atomic ratios of Al/(Na+K+2Ca) of granites gneisses of the present study is 0.769, which is nearer to 1 of rocks of igneous type (Chappael and White, 1974) indicating that these are igneous in nature.

The low to moderate Al_2O_3 and low K/Rb ratio of granite gneisses of the study area suggest the crustal anatexis of basic rocks. The high Ni, Cr, Mg, Al_2O_3 and Ni/Mg, Ni/Co, Ni/Cr ratios of the granite gneisses of the study area suggest that these rocks are formed due to the partial melting of basic crust. On the basis of the mineralogical composition, the A/CNK values, concentrations of different element ratios and P-T conditions conclude that granite gneisses of the study area are peraluminous, calc-alkaline in nature and have been formed by the crustal anatexis of basic rocks.

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