Granitization of the Gneissic Rocks in the Rani - Pamohi Area, Kamrup Metro, Assam, India.

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ABSTRACT: *The study area is situated to the south of Guwahati, in Kamrup district of Assam, India, which is a part of the northerly extension of the Shillong Plateau.The granite gneiss is the most dominant rock type in the area. Gradation of granite gneiss to migmatitic variety is commonly observed. The origin of granites and migmatites in deep-seated parts of orogenic belts must be considered as directly connected with high-grade metamorphism.The parallelism of the foliation of the granite gneiss with that of biotite schist and amphibolite, lack of cross-cut relationship and the occurrence of feldspathic zones are evidences in support of a palingenetic-anatectic origin. An attempt has been made to elucidate the origin of the granitic rocks of the area and to show that the process of anatexis is of major petrological importance.*

Key Words: *Granite gneiss, mafic, anatexis, palingenetic.*

1.Introduction:The rock types in the area include the most abundant foliated quartzo-feldspathic gneiss (granite gneiss) with other foliated rocks such as biotite schist and amphibolite. Calc-silicate rocks occur as discontinuous lenses along the foliation of the quartzo-feldspathic gneiss. Besides these a pluton of porphyritic granite occur to the north of the area . Nonporphyritic granite is also observed in the area. Pegmatitic and quartzo-feldspathic veins are seen intruding into all the other rock types of the area. A good number of migmatitic outcrops are also present. Amphibolites occur as patches, lenses, sills, etc in quartzo-feldspathic gneiss and porphyritic granite.The rock units can largely be grouped into the metmorphites and the intrusive.

The granite gneiss is the most abundant metamorphic rock in the area. The amphibolite, biotite schist and the calc silicate rock units are the other metamorphites. Gradation of granite gneiss to migmatitic variety are common.The present area has undergone high grade metamorphism, deformation, granitisation and migmatization. Here, an attempt is made to throw some light on the above aspects, based on field observations, petrographical and petrochemical study of the granite gneiss.

2.Location of the study area: The area of study is situated to the south of Guwahati in the district of Kamrup metro, Assam and is confined between latitude 26^{0}1′-26^{0}10′ and longitude 91^{0}35′-91^{0}48′ and is covered by topographic maps, no. 78 N/12 and 78 N/16.of the Geological Survey if India. The area is a part of the northern extension of the “Shillong Plateau” that covers parts of the states of Assam and Meghalaya (Fg:1A and 1B)

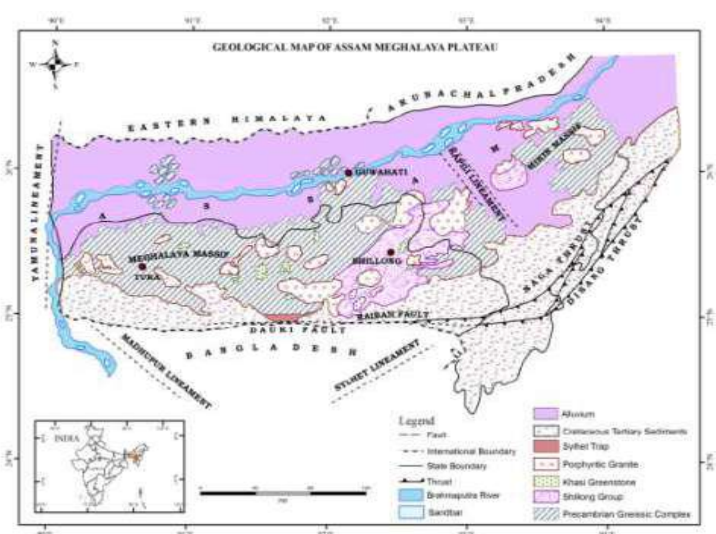

Figure 1A: A generalised geological map of the Shillong plateau

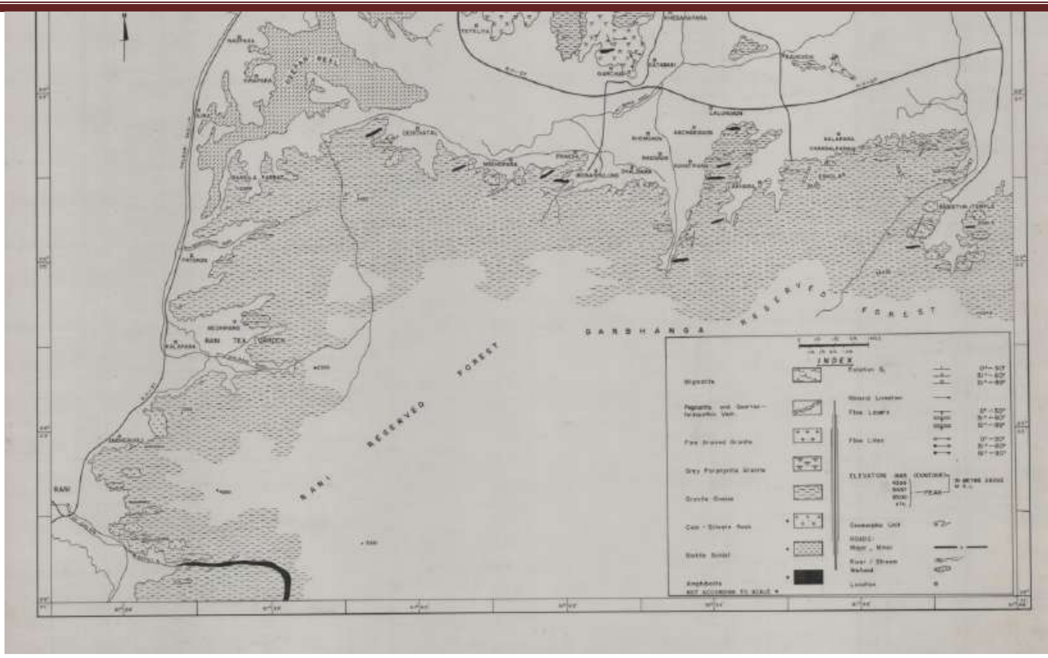

Fig 1B: Geological map of the study area.

3.Regional Geology: Shillong plateau (covering approx. 47614 sq. km.) is the singular representative of Precambrian cratonic block of northeast India tectonically detached from the mainland of Indian Peninsula. This cratonic block is girdled by dextrally moving Dauki fault to the south, Brahmaputra lineament to the north, Garo-Rajmahal graben, Dhubri/Madhupur lineament to the west and belt of schuppen to the east. It consists of high to medium grade Paleoproterozoic basement gneisses and schist designated as Basement Gneissic Group (BGG) overlain by Mesoproterozoic metasediments and metavolcanics of the Shillong Group, both being intruded by Neoproterozoic acidic intrusives such as Mylliem pluton, South Khasi pluton, Umroi granite, Nongpoh pluton and a few others enlisted by Mazumdar (1976); Ghosh *et al.* (2005); Devi and Sarma (2006, 2010).

The gneissic groups of rocks are well exposed in the western, northern and northeastern part of the Shillong plateau. Towards the southern boundary it is covered by Cretaceous-Tertiary sedimentary sequences and within the plateau about 2500 sq. km. (approx.) area is occupied by intracratonic basin sediments. Orthogneiss and paragneiss are the two major components of basement gneissic complex. The main characteristic features of the banded gneiss are of bimodal character. Other constituents are migmatite, augen gneiss, BIF, amphibolites, pyroxene granulite, calc granulite, high grade sillimanite bearing metapelite with characteristic cordierite, corundum, spinal and sappherine, lamprophyre, diorite, granodiorite, mafic intrusion, pegmatite and other vein rocks.

The area south of the River Brahmaputra around Guwahati, was mapped by Maswood (1982), Sarma and his group of researchers who established the regional lithosequences and large scale fold structures around Guwahati.

4.Method of study: Field work was carried out in the successive field seasons for a couple of years. A good number of representative rock specimens were collected systematically. Thin-sections of the collected rock specimens were prepared and studied under the microscope. Their megascopic characters were also studied in handspecimen. Based on the systematic collection of rock specimens and detailed petrological study (thin-section), some representative samples were chosen for petrochemical study. The chemical analyses are expressed as weight percentage of the oxides.

5.Result:

5.1.Field Study: Interfoliation of granite gneiss with biotite schist and amphibolites (mafic) is very common (photo1&2).The granite gneiss grade from streaky gneiss (photo 3) through weakly foliated gneiss (photo 4) to strongly foliated gneiss (photo 5).Granite gneiss, biotite schist and amphibolite are all affected by the same structural deformities (photo 6,7 and 8).


Photo1:Open folding exhibited by mafic interfolial bands and strongly foliated granite gneiss.

Photo 2:Interfoliation of granite gneiss and mafic rocks.


Photo3: Streaky gneiss.

Photo 4: Weakly foliated granite gness exhibiting open folding


Photo 5: Strongly foliated gneiss with mafic bands.

Photo 6: Interfolial isoclinal folds exhibited by mafic bands and granite gneiss.


Photo 7:Open folding exhibited by granite gneiss and mafic bands.

Photo 8: Second generation tight folding exhibited by granite gneiss, biotite schist and quartzo-feldspathc material.

5.2.Petrology: From thin section study of the granite gneiss it is observed that microcline is younger than the other constituents of the rock, the plagioclase is of stable composition, biotite is dirty greenish in colour and is strongly pleochroic, the decrease of plagioclase was accompanied by increase of microcline. The crystalloblastic nature of the microcline is indicated by its relation to pre-blastic components (quartz, plagioclase and biotite, (photo 9a) and by its syntectonic reaction with pre-blastic growth. The corrosion (photo 9b) and reaction margin shown by pre-microcline minerals support later microcline crystallisation. The syntectonic reaction of microcline with biotite often results in corrosion and replacement processes of the mica by the microcline. The quartz shows anomalous extinction which supports that a solid phase had been strained. Observations of quartz between plagioclase and microcline, can be interpreted as plastically deformed quartz, squeezed between plagioclase and microcline. The feldspars behave as brittle substances in comparision to the more plastic deformation of quartz. However, observations of undulating extinction shown by twinned plagioclase and bending of plagioclase twin lamellae (photo 9c) are evidences of plastic deformation of the feldspar. Again polysynthetic twinning shows a bending prior to fracturing. These observations are in accordance with the fact that, when the limit of elasticity is surpassed, rupture take place (photo 9d)

Biotite represents an early phase of crystallisation. Biotite laths often represents a pre-blastic phase of crystallisation often corroded, enclosed and assimilated by later blastic feldspar and quartz (photo 9e). Bending of micas can take place due to tectonic deformation. In addition, undulating of the extinction of biotite may result under tectonic influences. Microfolds consisting mainly of quartz and biotite, show that the microfolding has taken place without plastic deformation of the biotite. Observations shows that the biotite laths are re-oriented with deformed quartz. In such cases of microfolding in gneisses, the tectonic deformation of the rock resulted in a re-orientation and rearrangement of the micas.

Zircons in granite gneiss belong to two different generations. Transformists consider the first zircon as representing a sedimentogenic phase, i.e. the zircon is subjected to rounding due to transportation in the erosion cycle and the overgrowths as representing a later generation under the influence and conditions of granitisation. From the observed textural patterns (1) rounded and corroded zircon of sedimentary derivation and (2) a new zircon crystallization as overgrowths are blastogenic within the granitisation processes, it can be concluded that zircons different in age and derivation exist in the same granite, i.e. sedimentogenic zircons and new zircons formed within the transformation and granitisation. The above opinions are supported by Augustithis (1973,p.58,59).

The myrmekitised reaction margin is due to a 'synanatectic' reaction between a pre-existing plagioclase and later k-feldspar. According to V. Mathavan. 1991, the intracrystalline and replacement model of Augustithis (1973) is to a large extent based on the evidence of corroded myrmekite and myrmekitic quarz. The vermicular quartz associated with plagioclase may have formed in the plagioclase by intracrystalline infiltration and replacement of quartz forming solution prior to the crystallisation of microcline. Subsequent corrosion and replacement of plagioclase by microcline, set free the myrmekite quartz from its association with plagioclase. Incorporation of these myrmekitic quartz grains by microcline results in the formation of intragranular myrmekites (photo 9e) many of which show protruding quartz. That the plagioclase twinning of the pre-existing host has exercised a control on the form of the later myrmekite quartz. That in other cases, however myrmekitic quartz bodies have crossed the twin lamellae. That in such cases the twin lamellae has acted as a barrier which prevented the further penetration of quartz. That the inclusion of relics of fine plagioclase twinning in myrmekite quartz bodies are all clear indications of replacement of the pre-existing plagioclase by the quartz-forming solutions as stated by Augustithis, 1973 (p.29-34).

According to Augustithis (1973) the relation of perthite-cleavage (photo 9f) can be seen as a direction of greater penetrability of the k-feldspar host to the perthite infiltrating solutions, however, metasomatic replacement can take place at the side walls as defined by the cleavages. In addition to the penetrability directions provided by cleavage directions, other directions of penetrability may be formed by tectonic fractures, fissures and strained planes within the microcline. The association of perthites along such penetrability directions is caused after the crystallisation of the host rock microcline and supports a later formation of these perthites (post-tectonic). This is in contradistinction to the unmixing hypothesis which would require a simultaneous crystallisation of the host microcline and the perthitic plagioclase. The side walls of the cracks act as 'paths' of greater penetrability within the microcline host along which the perthite forming solutions penetrated as a result of which replacement perthites are formed. In contradistinction to the post-kinematic perthites, it is dubious whether the perthitic bodies following strain planes within the microcline are post or synkinematic. Pronounced undulosity and fracturing in quartz grains, undulose extinction, bent twin lamellae and fracturing in plagioclase, micro-folding in biotite, penetrative form of chlorite suggest the effects of post-tectonic forces. Chloritisation of biotite is a late-phase hydration.

The modal composition of the granite gneiss plotted on QAP diagram (fig 2) shows that the composition of the majority of the gneiss is granitic, with very few exceptions. While plotting in QPM diagram (fig 3), shows that majority falls on the gneiss field.

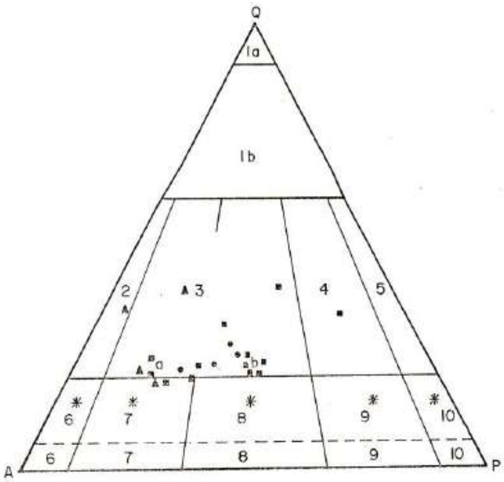

Fig 2.

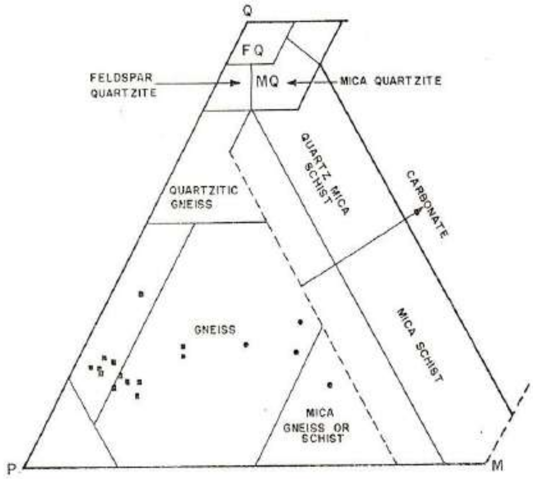

Fig 3.

Fig 2: QAP diagram showing the modal values of quartz, plagioclase and alkali feldspars of granite gneiss (squares), grey porphyritic granite (dots) and fine grained granite (triangles). The fields (after Streckeinsen, 1976) are: 2-Alkali feldspar granite, 3-granite, 4- granodiorite, 7*- quartz-syenite. Fig 3: QPM diagram representing the modal values quartz, total feldspar, and mica in granite gneiss (squares)and botite schist (dots). The fields in the diagram show the compositon of metamorphic rocks (after Winkler, 1976, p. 329).

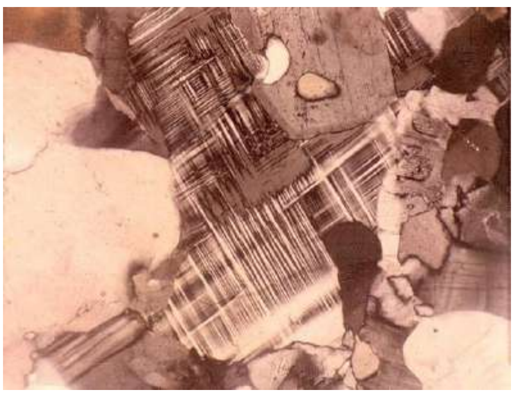

Photo: 9a

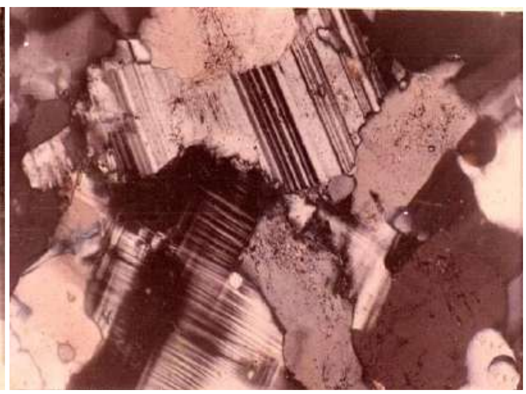

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Photo: 9c

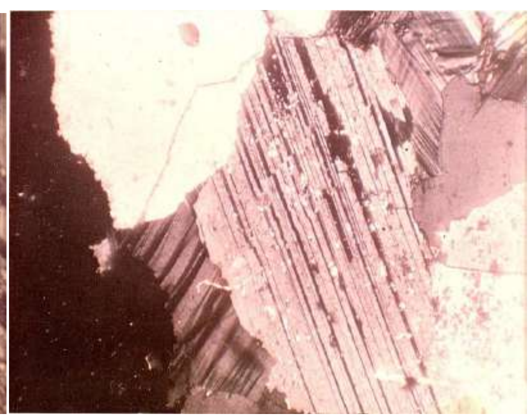


Photo: 9d

Photo: 9e

Photo: 9f

Photo 9: Photomicrographs of granite gneiss of maginification X10. **Photo 9a:** Microcline with characteristic cross- hatch twinning occupying the interstitial spaces between quartz and plagioclase grains in granite gneiss. **Photo 9b:** A strained plagioclase grain with serrated margin in granite gneiss. The twin lamellae are at right angles to the elongation direction. Note the replacement relationship of microcline with plagioclase. **Photo 9c:** Bending twin lamellae of plagioclase in granite gneiss. **Photo 9d:** Distortion in twin lamellae of plagioclase in granite gneiss.**Photo 9e:** Intergranular myrmekitic growth in granite gneiss. Note that a biotite flake occurs as inclusion. **Photo 9f :** String perthite along one set of cleavage of a microcline grain in granite gneiss. Note that flakes of biotite occur at the contact of microcline and perthite.

5.3.Petrochemistry: The chemical composition, the normative values, the niggli values, and cation percentage of five represented samples of granite gneiss are given in tables 1, 2, 3 and 4.The average composition of the granite gneiss can very well be compared to the average composition of quartzo-feldspathic gneisses given by Poldervaart (1955,p.135).

Table 1: Chemical composition of the granite gneiss (weight percentage)

Chemical composition	Sample numbers				
	Sau_{1-4}	K_{2-5}	R_{1-5}	$Kuka_{1-5}$	MP_{20}
SiO_2	71.3	72.21	74.01	72.38	72.18
Al_2O_3	15.10	13.83	12.73	15.39	15.70
Fe_2O_3	0.71	0.79	0.96	0.59	0.79
FeO	2.43	1.60	1.61	1.34	2.25
MgO	1.64	0.43	0.73	0.97	1.02
CaO	0.75	0.90	0.97	1.84	1.04
Na_2O	3.33	4.62	4.04	2.98	3.42
K_2O	4.32	4.66	4.41	3.92	3.09
TiO_2	0.05	0.2	0.36	0.20	0.25
P_2O_5	.04	0.28	0.09	0.04	0.03
MnO	Tr	0.04	Tr	0.04	Tr
H_2O	.32	0.43	0.04	0.30	.23

Table 2: Normative values of the granite gneiss

Normatives	SAMPLE NUMBERS				
	Sau_{1-4}	K_{2-5}	R_{1-5}	$Kuka_{1-5}$	MP_{20}
Q	29.34	24.48	30.18	33.84	35.28
Or	25.58	27.80	26.13	23.35	18.35
Ab	28.30	39.30	34.06	25.15	28.82
An	3.61	2.78	3.61	9.17	5.28
C	3.57	0.10	-	2.86	4.79
Hy	8.0	3.08	3.25	3.98	5.64
Mt	.93	1.16	1.39	.93	1.16
Il	-	.30	.76	.46	.46
Ap	-	.67	.34	-	-

Table 3: Niggli values of the granite gneiss

Niggli	SAMPLES NUMBERS				
	Sau_{1-4}	K_{2-5}	R_{1-5}	$Kuka_{1-5}$	MP_{20}
Si	344.76	376.25	403	369.9	367
ti	.29	.625	1.63	.92	.91
Al	43.02	43	41	46	47
fm	24.12	13	17	16	20
c	3.77	5	6	10	6
alk	29.23	39	36	28	27
k	.46	.04	.419	.04	.37
mg	.49	.26	.346	.46	.39
P	.09	.6	.33	.46	.06
qz	+128.52	+120.25	+159	+158	+159

Table 4: Cation percentage of the granite gneiss

Cation	SAMPLE NUMBERS				
	Sau_{1-4}	K_{2-5}	R_{1-5}	$Kuka_{1-5}$	MP_{20}
Si	66.63	67.28	69.18	67.98	67.75
Ti	.04	.14	.25	.14	.17
Al	16.63	15.16	13.99	17.01	17.33
Fe^{+++}	.50	.55	.67	.42	.55
Fe^{++}	1.89	1.24	1.25	1.04	1.75
Mn	Tr	.03	-	.03	Tr
K	5.17	5-54	5.26	4.70	3.70
Na	6.03	8.32	7.30	5.41	6.21
Ca	.75	.90	.97	1.85	1.04
Mg	2.30	.60	1.02	1.37	1.43
P	.03	.22	.07	.03	.02

The Niggli c Vs al-alk diagram (after Evans and Leake,1960) clearly delineates the fields of igneous and sedimentary origin. The plotting of the data in the variation diagram (Fig.4) shows that the majority of the granite gneiss falls in the field designed by Leake (1964) for sedimentary material, while two samples fall in the demarcating line between the sedimentary and igneous field. This may be due to the presence of some neosomatic material in the granite gneiss (migmatization).Plotting in Fig.5 (after Leake, 1964) where the fields of shales and greywackes are shown shows that the majority of the granite gneiss falls in the greywacke field. Plotting in the 100 mg-c-(al-alk) diagram, Fig.6 (after Leake 1964) of the granite gneiss shows that while two samples fall in the greywacke field, two others are seen to fall between the igneous trend and greywacke field and another between the fields of greywackes and shales. Thus all the analysed samples are distributed away from the igneous trend line supporting the sedimentary parentage.

The analysed granite gneiss plot inside or very close to the typical pelite - semi-pelite away from Karoo dolerite trend showing a sedimentary origin in the Niggli c against mg plot (fig.7, after Leake,1964)

The ACF (Fig.8) plots for the granite gneiss fall in the field of andalusite-anorthite-cordierite, and A′KF (fig.8) plots fall in the field of K-feldspar-biotite-muscovite, except one which falls in the cordierite-biotite muscovite field (after Winkler, 1976,p.47 and Harris and Godwin, 1976,p.1204).The ACF values indicate that the granite gneiss is to some extent richer in alumina and deficient in lime.While the A′KF diagram indicates richness in potassium compared to alumina and deficient in iron.

The Ca-Na_2O-K_2O ternary diagram (Fig 9) (after Ali and Rao) shows that granite gneiss is of quartz monzonite and granodiorite in composition.The K_2O Vs Na_2O diagram (fig 10) shows that the granite gneiss falls in the adamellite and granodiorite field.The Na_2O/K_2O ratios of the rocks are less than 1which is a characteristic feature of the microcline bearing granites. It is most likely that the rocks have suffered potassium metasomatism during their evolution. While the K_2O – CaO discrimination diagram (fig 11) shows that granite gneiss plots fall in the granite and adamellite field. The low Na_2O/K_2O ratio is in the favour of anatexis and pelitic rocks (Sinha Roy and Sengupta, 1986). The Na_2O/K_2O ratio decreases drammatically from Archaean to the Proterozoic time (Engel et al., 1974). The S-type granitoids have relatively low Na and high K-contents (Dhana Raju,1982). The low average of Na_2O and higher K_2O concentrations in the analtsed samples show affinity towards sedimentary parentage. The subtle variations in their Na_2O/K_2O ratios indicate uneven distribution of potassium and suggest a late stage enrichment due to anatexis source.

The positive correlation (fig.12) of the K_2O and Al_2O_3 is more characteristic of sediments than of igneous rocks (Naqvi et al., 1980).The Al_2O_3 concentrations of gneisses can be important indicator for assuming the mode of formation. The excess of molecular Al_2O_3 over molecular (CaO + Na_2O + K_2O) indurated by normative corundum, is characteristic of pelitic and different groups of sedimentary rocks (Rogers et.al 1965; lute, 1947). The granite gneiss when plotted in a normative Q-Or-Ab+An diagram (fig 13), wherein the fields are marked after Streckeinsen's (1976) classification based on their modal mineralogy shows granitic composition, and a slight variation towards granodiorite. Again normative orthoclase-albite-anorthite plots (fig 14) of the granite gneiss also shows major concentration in the granite field while one sample falls between granite and quartz monzonite field.

The ternary plots of Al_2O_3-CaO-FeO-MgO (after Rao et al. 1974,p.274; Fig 15) show that the granite gneiss falls in the arkose, siliceous shale (ortho-quartzite) fields and in the transitional zone between the two indicating that the source material was alumina rich. Negative correlation of modal values of microcline and quartz with plagioclase (Figs 16a &16b) in granite gneiss suggests increase of quartz and microcline. In the Al_2O_3-(Na_2O+K_2O+CaO)-(FeO+MgO+MnO) diagram (fig 17) granite gneiss of the area are seen to be plotted between the plots of granitic rocks and pelitic rocks of Masi area of Kumaon, Himalaya.

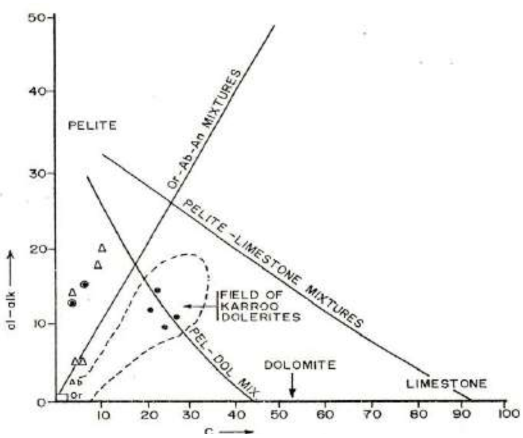


Fig 4.

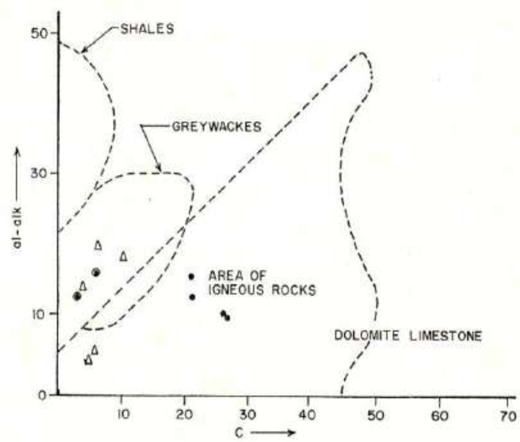


Fig 5

Fig 4: Niggli (al-alk) – c plot of the granite gneiss (triangles), amphibolites (dots) and biotite schist (dotted circles) Fig 5: Plot of Niggli (al-alk) Vs c values of granite gneiss (triangles), biotite schist (dotted circles) and amphibolites (dots) (after Leake,1964)

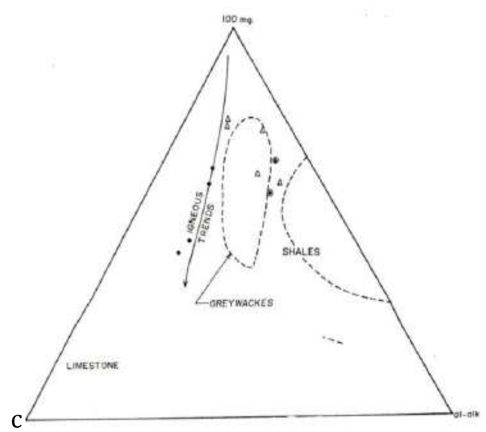


Fig 6

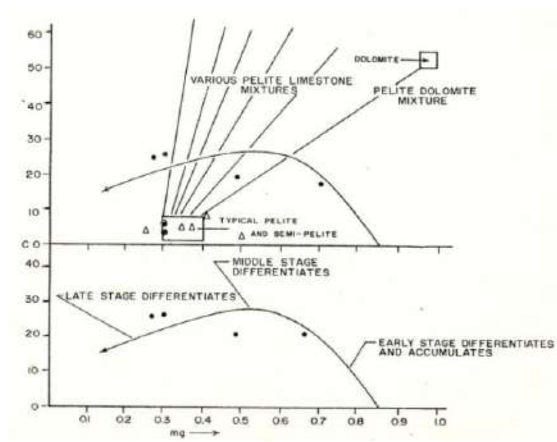
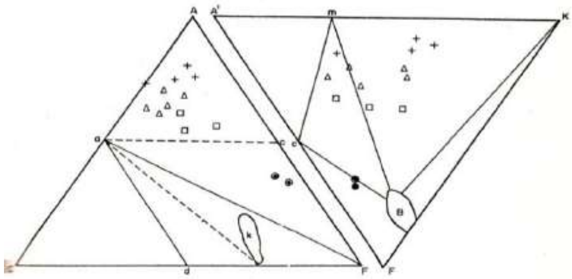


Fig 7

Fig 6: Niggli 100mg-c-(al-alk) plot (after Leake, 1964) of amphibolites (dots) granite gneiss (triangles) and biotite schist (dotted circles). Fig 7: Plots of amphibolites (dots), granite gneiss (triangles) and biotite schist (dotted circle) of the area on Orville's diagram (1969) niggli mg Vs c,) modified from Leake (1964



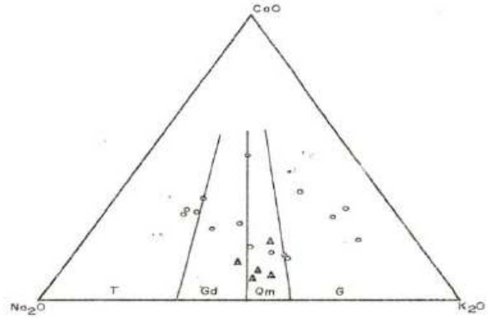
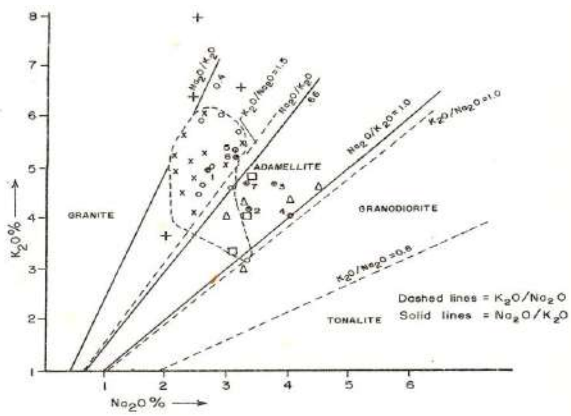


Fig 8 Fig 9

Fig 8: ACF and A′KF plots of granite gneiss (triangles), grey porphyritic granite (squares) fine grained granite(plus) and biotite schist (dotted circles).The triangular diagrams are after Winkler (1976,p.67) and Harris and Goodwin (1976,p.1204). AA′ - andalusite, C- calcite (wollastonite), F- talc, anthphyllite and cummingtonite, K= K-feldspar, m- muscovite, c- cordierite, (triangles).The a- anorthite, d- diopside, k- hornblende, b- biotite. Fig 9: CaO- Na_2O-K_2O diagram of the granite gneiss (triangles) with plotting of gneisses from the Kankapura area Karnataka, South India are given for comparison (open circle).



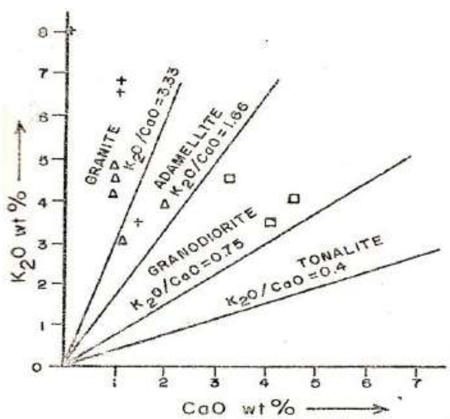
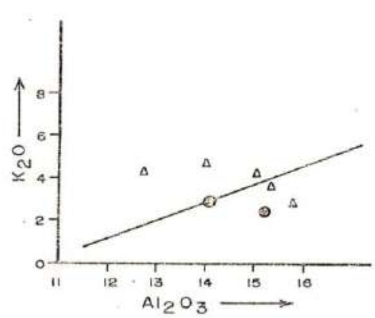


Fig 10. Fig 11.

Fig 10: K_2O Vs Na_2O diagram of granite gneiss (triangles) grey porphyritc granite(squares) and fine grained (plus) granite. Plots of Manihari (open circles) and Banresar (cross) granites and 1,2,3,4,5,6 and 7 represent mean composition of Manihari and Banresar, Mayurbhanj granite (MBG), Arkasani granophyre (ARKG), Chakradbarpur pegmatitic granite (CKPG-II), Wolf river granite (WRG), Sicunusa granite (Scun) and Chhotanagpur granite (intrusive variety CNGP) are shown for composition are shown for comparision.

Fig 11: Plots of granite gneiss (triangles) fine-grained granite (plus) and grey porphyritic granite (squares) the K_2O-CaO discrimination diagram for the granite rocks (after Harpum, 1963).



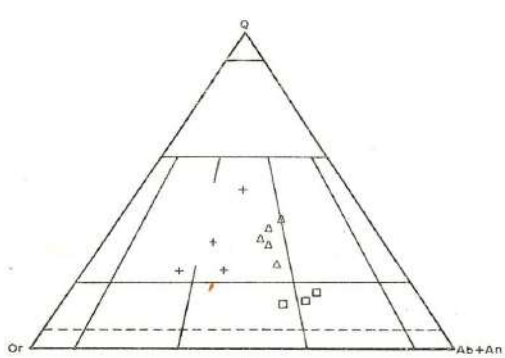


Fig 12 Fig 13.

Fig 12: Plotting of K_2O Vs Al_2O of the granite gneiss (triangles) and biotite schist (dotted circles) of the area.

Fig 13: Q-Or-Ab+An normative triangular diagram (after Streckeinsen,1976) of grante gneiss (triangles) grey porphyritc granite(squares) and fine grained granite (plus).

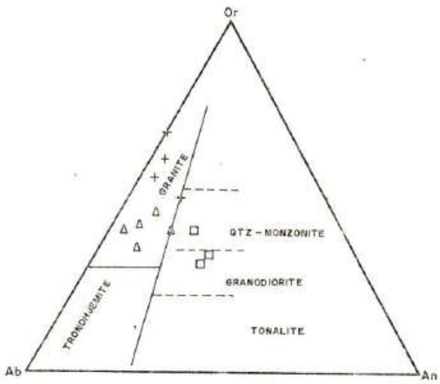


Fig 14

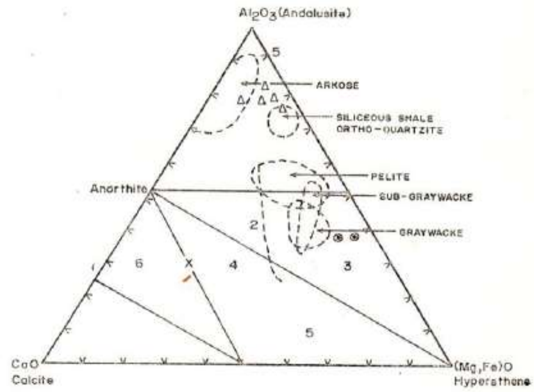


Fig 15

Fig14:The normative orthoclase (Or) – albite (Ab) – anorthite (An) plots of the granite gneiss (triangles) grey porphyritic granite (squares) and fine grained granite(plus). The compositional fields in the Or-Ab-An diagram is after Iden (1981, p.156). Fig 15: Plots of Al_2O_3-CaO-MgO+FeO of the granite gneiss (triangles) and biotite schist (dotted circles) in the triangular (after Rao et.al.,1974, p.274)

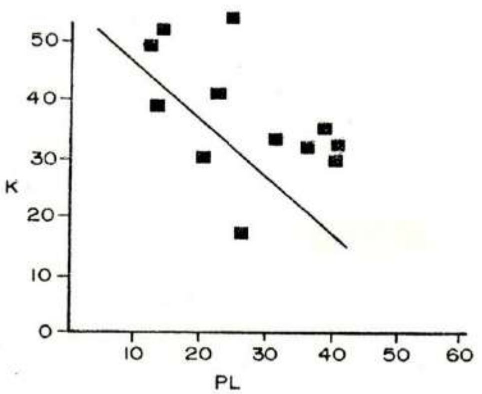


Fig 16a.

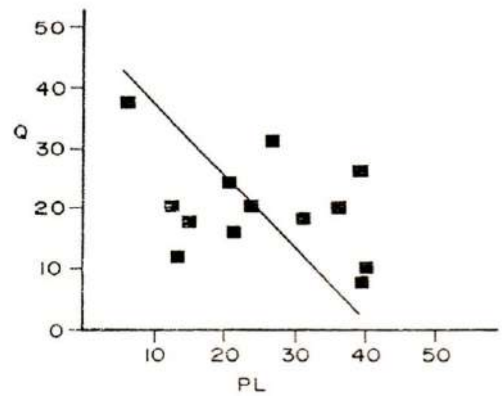


Fig 16b.

Fig 16a: Negative correlation of the modal values of microcline (K) and plagioclase (PL) in granite gneiss.
Fig 16b: Negative correlation of the modal values of quartz (Q) and plagioclase (PL) in granite gneiss.

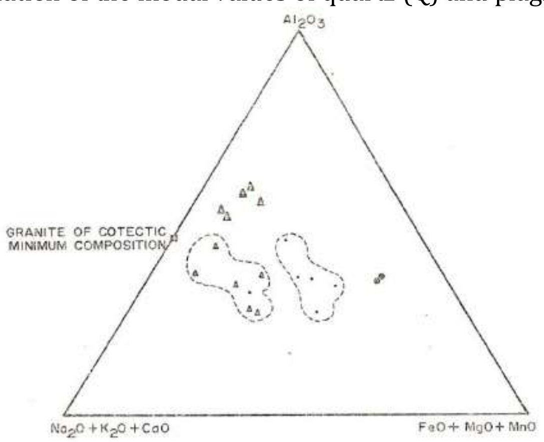


Fig 17: (Al_2O_3) – (Na_2O + K_2O + CaO) – (FeO + MgO + MnO) diagram for the biotite schist (dotted circles) and the grante gneiss (big triangles). The plots of the granitic rocks (small triangles) and the pelitic rocks (dots) of Masi area, Kumaun Himalaya are shown for comparison.

6.Discussion and Conclusion: Considering the above mentioned field, petrological and petrochemical evidences it may be assumed that the granite gneiss is para-gneiss and that they are the metamorphic and metasomatic products of some earlier sedimentary rocks (Huang, 1962,p.416-17), petrochemical evidences support the derivation of granite gneiss from argillaceous and arenaceous sediments. It may be mentioned that siliceous shale or impure feldspathic sandstones respond easily to metamorphism and transform easily to gneisses (Mehnert, 1969,p.515).

With the increase of pressure and heat, these massive quartzo-feldspathic rocks gradually graded into patchy and streaky types with the development of gneissosity and foliation, The patches and streaks are mostly biotite which are thought to have been formed from the iron and magnesium contents of the original sediments (Rast,1965 p. 80)

Thus it may be stated that granite gneiss derived from argillaceous and arenaceous sediments as a result of metamorphism under the amphibolite facies condition accompanied by migmatisation and granitisation during the regional metamorphism.

The main metamorphism took place at P-T conditions of amphibolite facies. Metamorphic processes accompanied by tectonic influences were responsible for the development of granite gneiss from the sediments. The granite gneiss in parts show gradation into migmatitic variety (Maswood,1973,p.112). The study of the microtectonic history of the rock is marked by the stressed quartz and feldspar and undulose extinction of quartz. Similarly the distorted cross-hatched and lamellar twinning (photo 9d) is attributable to a phase of deformatiom. The gneiss is regarded as the granitised product of the basic and pelitic rocks (Maswood, 1981). Petrochemical evidences show that granite gneiss of the area falls in the adamellite and granite field.

Towards the end of the twentieth century many geologists have favoured a palingenetic-anatectic origin for the granitoids, and this represents a compromise between the two extreme thoughts considered by the magmatists and the transformists.

In the present area, the occurrence of the parallelism of the foliation of the gneiss with that of the metasediments, lack of cross cut relationship, the occurrence of feldspathic zones in the country rocks are characters which are generally considered to be evidences of a transformed origin. The textural evidences also favours transformation. The extreme sutured relationship exhibited between microcline, plagioclase, quartz and mica indicates replacement. The occurrence of sieved texture with the presence of quartz inclusions in mica and feldspar can be explained by replacement (Powar and Bhale, 1978).

V. Marmo (1971) stated that the factors which all the synkinematic granite have in common, however is"granitization" that is microcline, which infills the interstices was formed after the other constituents. The final stage of granitization is characterized by a notable increase of potash feldspar and by a decrease of plagioclase (fig 16a). The essential feature of granitization is potassium metsomatism, in this sense "granitization" may be equated with "Feldspathisation". The microcline of the synkinematic rocks is usually younger than the other constituents of the rock. It occurs either filling in the interstitices of the other minerals or replacing plagioclase. Specially typical of the synkinematic acid rocks is the replacement of plagioclase. Thus the granite gneiss can be classified as "synkinematic" granite. The fact that the amphibolite facies is the most typical metamorphic facies of old Precambrian synkinematic granites, favours the interpretation that granitization takes place at a temperature not much over and very likely somewhat below 500^0C.

The main event of granitisation was probably syntectonic with the regional metamorphism of the amphibolite facies condition and deformation as evident by the presence of mineral assemblage in the granite gneiss (Maswood and Pathak,1983).

The texture in granite gneiss tend to be complex and have been interpreted as indicating feldspatization approximately simultaneously with deformation. Feldspatization may take place syntectonically and be accompanied by metamorphic differentiation such that the dark minerals viz. biotite tends to be concentrated in folia with elongated quartz and feldspar layers in between. A second possibility is that while the schist is held at high temperatures and pressures, feldspathic or quartzo-feldspathic material is introduced as a granite fluid. Movement of these materials is easiest parallel to the foliation and quartzo-feldspathic material crystallizes so as to give the impression of a "lit-par-lit" injection (Spry, 1969). Again an increase in the amount of microcline and quartz in the gneiss is observed (fig.16a,16b). This may result due to K and Si metasomatism and granitisation of the sediments (Engel and Engel, 1958; Marma.1971;read.1953).

The modal composition of the granite gneiss plotted on the Streckeinsen's diagram (fig.2) shows that the composition of granite gneiss ranges from granite to granodiorite. Increase of microcline with decrease of plagioclase is marked (fig.16a). In the (Al_2O_3) – (Na_2O + K_2O + CaO) –(FeO + MgO + MnO) diagram (fig 17), granite gneiss plots are in midway between the point of the granite of cotectic minimum composition and the field of pelitic rock. This suggests that the granite gneiss was formed as a result of the introduction of granitic melt of cotectic minimum composition in the schists (Powar and Bhale,1978).

Winkler (1967) suggests that by anatexis a rock splits into a melt fraction consisting essentially of quartz and feldspar, a crystalline residue enriched in MgO, FeO, Fe_2O_3, Al_2O_3 and possibly CaO. This suggests the mixing of pelitic rocks and a melt generated by anatexis. The melt must have developed at a fair depth where conditions of granulite facies were attained (Powar and Bhale, 1978). This permeated to higher levels along metamorphic foliation of the metapelites transforming them into granitic rocks by the process of "permissive emplacement" (Badgley, 1965). In the present area, the lit-par-lit injection of the quartzo-feldspathic material occurs which supports the above opinions. The formation of granite gneiss represents metamorphism and granitisation. The metamorphism, the deformation and the granitisation were followed by magmatic emplacement accompanied by migmatisation.

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