The Petrography and Major Element Geochemistry of the Granite Gneiss of Arigidi area, S/W, Nigeria.

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Abstract: The granite gneiss of Arigidi area, falls within the migmatite-gneiss-quartzite complex of the Nigerian basement and occurs in association with grey gneiss, granite, charnockitic rocks and pelitic gneiss lithologies. The outcrops of the rock were studied in the field, eight samples were analysed for petrographic and geochemical characteristics. In thin section, quartz, plagioclase, biotite and opaque minerals which are ubiquitous ranged from 16.3-42.2, 18.4-42.4, 11.3-28.6 and 6-10.7vol%, respectively while orthoclase, microcline, pyroxene and hornblende ranged from 0-11.1, 0-19.3, 0-12.4 and 0-16.3vol%, respectively showing that most of the samples are tonalitic in composition. Geochemically, the SiO_2 content of the granite gneiss ranged from 63.42-74.30, Al_2O_3 ranged from 11.83-15.46 while Fe_2O_3 ranged from 1.33-3.22wt%. FeO ranged from 2.13-5.83, Na_2O from 0.40-3.91, K_2O from 0.05-3.42, CaO from 0.82-5.78 and MgO from 0.42-5.47wt%. MnO ranged from 0.03-2.11 while TiO_2 ranged from 0.01-1.46wt%. Discrimination diagrams revealed a preference for igneous fields by the granite gneiss. It is therefore deduced that this tonalitic granite gneiss has an igneous origin.

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Key words: Arigidi, granite gneiss, discrimination, tonalite, igneous origin

1. Introduction

Arigidi area, falls within the migmatite-gneiss-quartzite complex of the Precambrian Basement complex of Nigeria as classified by Adekoya *et al.* (2003) and used severally (Rahaman, 2006; Dada 2006). It lies between $5^o45^'$E to $5^o49^'$E and 7^o33'N to $7^o37^'$N of Ikole NE sheet. Major lithologies in the area include granite gneiss, grey gneiss, biotite granite, charnockitic rocks and pelitic gneiss (Fig. 1). Metamorphism in the area is believed to have attained granulite facies grade (Rahaman and Ocan, 1988). Structurally, the occurrence of sigmoidal strike-slip shear zones (Fig 2) and centimetric strike-slip faults make the occurrence of at least three phases of deformation (D3) probable in the area (Ferre *et al*., 1996). Ejimofor *et al*., (1996) worked on the petrography and major element geochemistry of the basement rocks of northern Obudu area, eastern Nigeria. It was shown mineralogically that, the preference of igneous fields by the granite gneisses suggest their affinity for igneous progenitors. Elueze *et al*., (2004) determined the petrochemistry and petrogenesis of granite gneiss from Abeokuta area, southwestern Nigeria and concluded that the abundance and variation of major and minor trace elements suggest that the protoliths of the gneisses are mainly of igneous affinity, though with probable crustal contamination.

2. Materials and methods

The area was mapped on a scale of 1:30,000. The nature of outcrop, geographical location, colour, texture, mineralogy and structures were noted on the field. Fresh samples were collected and subjected to petrographical studies using petrological microscope. Photomicrographs were captured with digital camera. AAS was used to determine Si, Al, Fe, Ca, Mg, Mn and Ti while AES was used to determine Na and K. The content of minerals was plotted on the QAP diagram for the purpose of classification while the geochemical results were plotted on the discriminatory diagrams of Middleton (1960) and Tarney (1977) to infer the petrogenesis.

3. Results

3.1 Field description

The rock occurs as low-lying outcrops, small hills and inselbergs. It is associated with augen gneiss, quartzo-feldsparthic gneiss and granite. It is fine to medium grained, weakly to strongly foliated rock and strikes predominantly in a NNW-SSE direction with a steep dip (averagely 58^o) in both directions. The foliation is defined by biotite streaks which have narrow thicknesses that range between 1 and 2mm. The leucocratic quartz and K-feldspar – rich streaks have a wider thickness that range between 0.2 and 2.5cm.

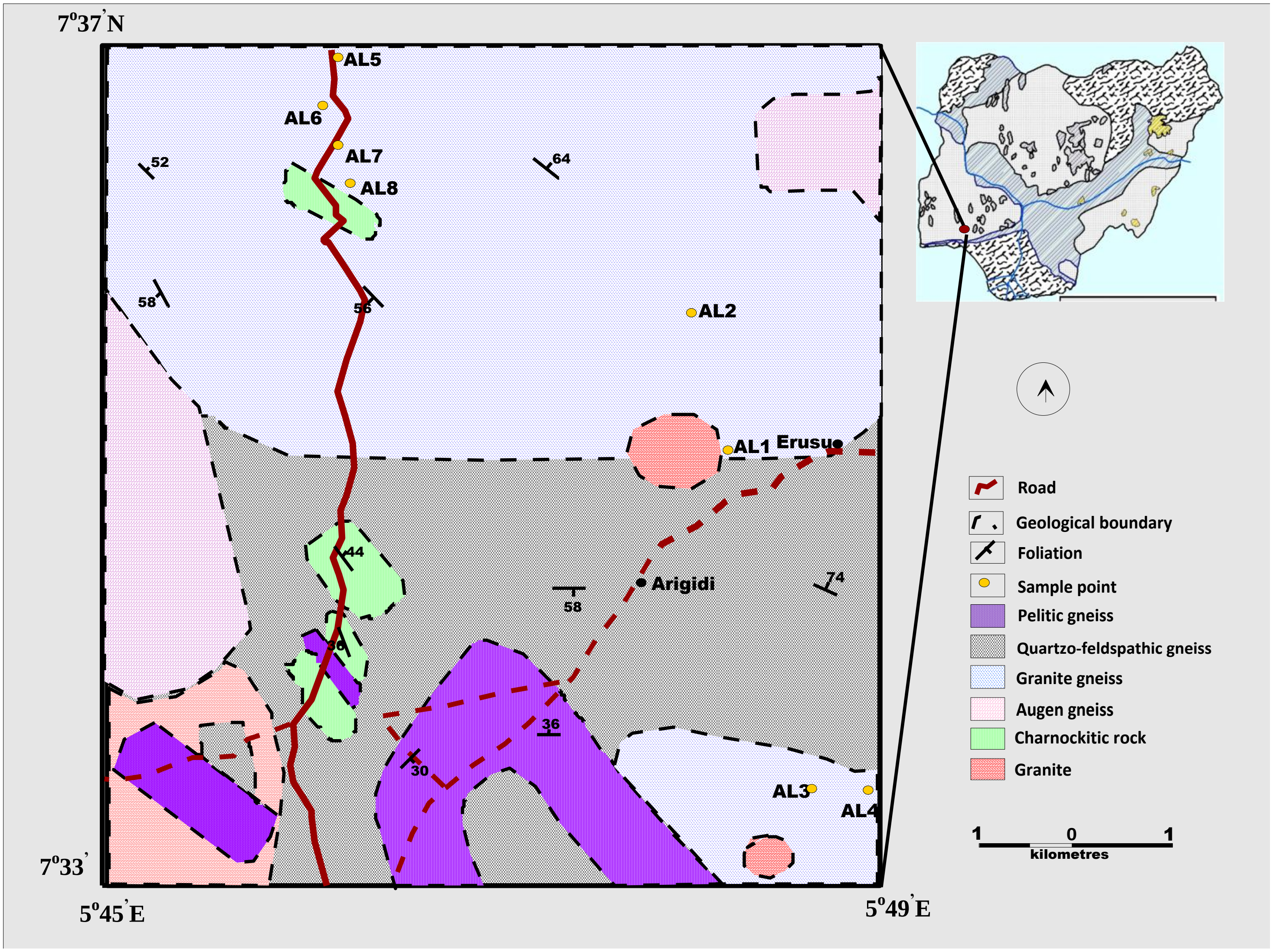

Figure 1. The Geological Map of Arigidi Area (Modified after Arigidi Independent Mapping Group, 2009)

Figure 2. Strike-Slip Sigmoidal Fault

3.2 Petrography

In thin section, the rock contains quartz which is colourless under plane polarized light and occurs as euhedral prisimatic crystals, and plagioclase with its distinguishing polysynthethic twinning according to albite law. Others minerals in the thin section are microcline typified by cross-hatched twinnings; biotite which is brownish in thin section, exhibits pleochroism and occurs as plates and laths which show preferential allignment with the foliation plane; orthoclase is colourless though it may be cloudy in contrast to quartz with twinning according to Carlsbad law as its distinguishing characteristic; pyroxene; and hornblende (Fig. 3) (Table 1). On the QAP diagram, five of the eight samples analyzed plotted as tonalites representing over 60% of the granite gneiss of Arigidi while the remaining plotted as granodiorite and granite (Fig. 4).

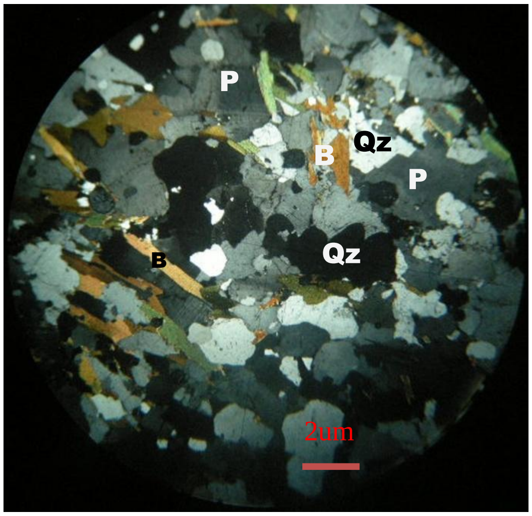

Figure 3. Photomocrograph of granite gneiss under cross nicols showing guartz (Qz), plagioclase (P), and biotite (B).

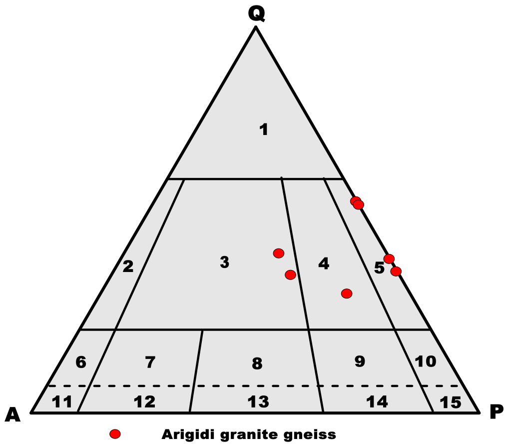

Figure 4. QAP Diagram for Arigidi Granite Gneiss (after Streckeisen, 1976).
1=Not Igneous; 2=Alkali Granite; 3=Granite; 4=Granodiorite; 5=Tonalite; 6=Alkali Quartz Syenite; 7=Quartz Syenite; 8=Quartz Monzonite; 9=Quartz Monzodiorite; 10=Quartz diorite; 11=Alkali Syenite; 12=Syenite; 13=Monzonite; 14=Monzodiorite; 15=Diorite.

3.3 Geochemistry

3.3.1 Major element data

The SiO_2 content of the granite gneiss ranges from 63.42-74.30% which corresponds to an intermediate to acid composition. Al_2O_3 ranges from 11.83-15.46% while Fe_2O_3 ranges from 1.33-3.22% and FeO varies from 2.13-5.83%. The Na_2O content ranges from 0.40-3.91%, K_2O from 0.05-3.42%, CaO from 0.82-5.78% and MgO from 0.42-5.47%. MnO ranges from 0.03-2.11% while TiO_2 ranges from 0.01-1.46% (Table 2). Geochemically, the Arigidi granite gneiss is similar to that of Southern India except for its higher FeO, Na_2O and K_2O contents and lower MnO and TiO_2 (Table 3). All other species are about the same.

4. Discussion

4.1 Petrogenesis

The geochemical data are plotted on discriminatory diagrams to establish the geochemical evolution of the rock. On the plot of K_2O versus Na_2O (after Middleton, 1960), six of the eight samples plotted outside the field of eugeosynclinal sandstones (Fig. 5) while on the TiO_2 versus SiO_2 discrimination diagram (Tarney, 1977), two of the eight samples plotted outside, one on the boundary line and the remaining five plotted in the igneous field (Fig. 6). A consensus is yet to be reached on the evolution of the Nigerian granite gneisses. Grant (1970), used $^{87}Sr/^{86}Sr$ studies to arrive at an igneous origin for the Ibadan granite gneiss. Burke *et al.* (1972), on the other hand, argued that the parent banded gneiss from which the granite gneiss was derived could have evolved by isochemical metamorphism of a shale-greywacke sequence. Rahaman and Ocan (1978), believed that the most of the granite gneisses in the Nigerian basement complex are intrusive. In the case of Onyeogocha (1984), partial melting of crustal rocks was used to explain the granite gneisses of north-central Nigeria. Rahaman (1988) stated that geochemical data available were insufficient to unequivocally distinguish between sedimentary and igneous origin for the granite gneisses.

In the face of the various schools of thought outlined above, the granite gneiss of Arigidi shows a preference for an igneous protolith as shown by the discrimination diagrams. This is further reinforced by the petrographic studies of the samples of the granite gneiss which revealed the absence of minerals, which are typical of paragneisses, like sillamanite, kyanite, staurolite or cordierite. The indication of this is that the rock is not likely to be of sedimentary origin.

In addition, Rahaman and Ocan (1988), also proposed an igneous origin for the gneisses that are associated with the pellitic gneisses of Ikare area, southwestern Nigeria of which the Arigidi granite gneiss is a part.

Finally, the tonalitic composition of the granite gneiss of Arigidi buttresses the Tonalite-Trondhjemite-Granodiorite (TTG) composition reported for the gneisses of western Nigeria (Pidgeon *et al.* 1976; Bruguier *et al.* 1994).

TABLE 1: MODAL COMPOSITION OF GRANITE GNEISSES (Vol %)

	AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	Range
Quartz	33.2	42.2	16.3	18.2	25.2	38.1	37.3	27.2	16.3-42.2
Orthoclase	-	-	11.1	-	-	-	-	-	0-11.1
Microcline	19.3	-	-	8.3	-	-	-	-	0-19.3
Plagioclase	28.2	34.2	18.4	32.3	42.4	32.6	30.4	40.2	18.4-42.4
Biotite	13.2	14.3	28.6	18.4	22.6	21.5	23.3	11.3	11.3-28.6
Opaque Minerals	6.0	9.2	9.3	10.7	9.3	8.2	8.5	6.3	6.0-10.7
Pyroxene	-	-	-	12.4	-	-	-	14.4	0-12.4
Hornblende	-	-	-	16.2	-	-	-	-	0-16.3
Total	99.9	99.9	100.0	100.3	99.5	100.4	99.5	99.4	99.4-100.4

TABLE 2: MAIN ELEMENT GEOCHEMISTRY OF GRANITE GNEISSES (Wt %)

	AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	Range	Mean
SiO_2	74.30	70.94	73.22	63.42	70.36	73.45	73.26	68.37	63.42-74.30	70.92
Al_2O_3	13.03	11.83	12.62	13.35	15.46	12.37	12.70	13.32	11.83-15.46	13.09
Fe_2O_3	1.33	1.42	2.11	2.72	2.29	2.52	3.22	2.74	1.33-3.22	2.32
FeO	2.42	4.14	3.22	4.10	3.20	3.84	3.36	5.83	2.13-5.83	3.76
Na_2O	2.98	3.91	3.43	0.10	1.00	0.84	0.40	0.80	0.40-3.91	1.81
K_2O	2.32	3.42	3.22	1.02	0.05	0.60	0.51	0.42	0.05-3.42	1.45
CaO	1.20	1.42	0.82	4.60	5.82	3.06	2.88	5.78	0.82-5.78	3.20
MgO	0.42	1.21	0.80	5.47	1.40	2.11	1.58	2.21	0.42-5.47	1.11
MnO	0.10	0.04	0.04	2.11	0.04	0.03	0.11	0.08	0.03-2.11	0.32
TiO_2	0.50	0.30	0.40	1.46	0.20	0.40	0.01	0.32	0.01-1.46	0.45
Total	98.62	98.6	99.88	99.26	99.82	99.42	98.03	99.87		

TABLE 3: COMPARISON OF ELEMENT OF GRANITE GNEISSES (Wt %)

	1(8)	**2(3)**	**3(4)**	**4**	**5**
SiO_2	70.92	65.48	63.46	70.36	64.60
Al_2O_3	13.09	17.94	19.87	14.42	17.00
Fe_2O_3		1.97	1.50	0.66	3.60
FeO	6.08	2.93	1.44	1.95	-
Na_2O	1.81	4.07	3.48	3.35	4.17
K_2O	1.45	1.07	5.37	5.38	3.48
CaO	3.20	3.01	5.05	2.03	3.43
MgO	1.11	-	-	0.90	1.58
MnO	0.32	0.03	0.03	-	-
TiO_2	0.45	1.75	0.64	0.32	0.54

NOTE: (n) Refers to average number of samples

1) Arigidi granite gneiss
2) Orthogneiss Vandeikya (Ejimofor *et al.*, 1996)
3) Orthogneiss Ushongo (Ejimofor *et al.*, 1996)
4) Granite gneiss, Jos Plateau, Nigeria (Wright, 1971)
5) Granite gneiss, S. India (Condie *et al.*, 1982)

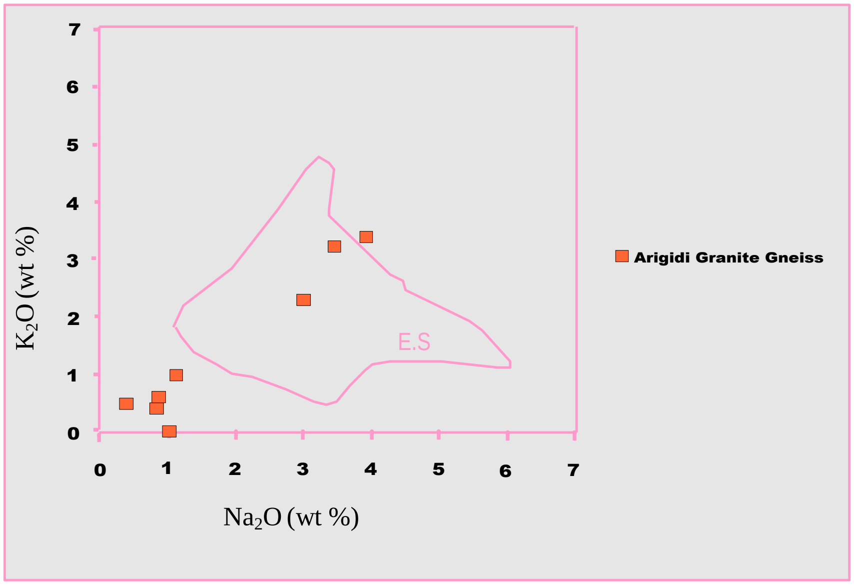

Fig. 5: K_2O versus Na_2O Discrimination Diagram (after Middleton, 1960)

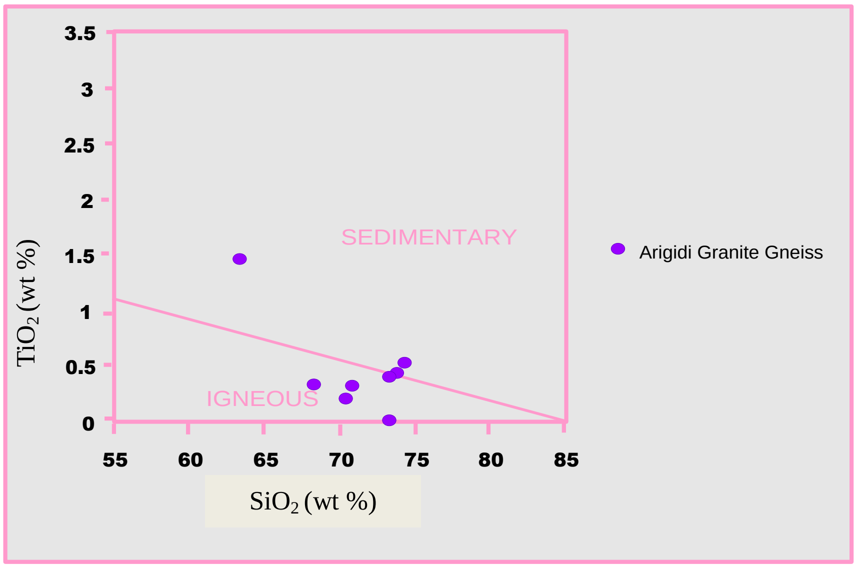

Fig. 6: TiO_2 versus SiO_2 Discrimination Diagram (after Tarney, 1977)

5. Conclusions

From the forgoing, it is therefore thought that the granite gneiss of Arigidi is an orthogneiss of tonalite composition.

6. Recommendations/Suggestion

However, it is candidly recommended that Isotope and rare earth element (REE) studies be carried out on the study area to conclusively determine the petrogenesis of the granite gneiss seeing that major element geochemistry alone cannot be used to decipher conclusively, the petrogenesis of a metamorphosed rock.

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