International Journal of Advanced Scientific Research | IJASR
International Journal of Scientific Research in Technology, Applied Sciences & Health Studies | IJSRTASHS
ISSN Print: 2579-1036 | ISSN Online: 2579-1044 | Volume 2, Number 2 December, 2017

Geochemical Characterization of Older Granites in Funtua Sheet 78 North-East, Scale 1:50,000 North Western Nigeria

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Abstract

The study of Geology and geochemical characterization of Funtua sheet 78 NE on a scale of 1:50,000 northwestern Nigeria at longitudes 7° 15' E and 7° 30'E and latitudes 11° 45'N and 12° 00'N has been carried out. Detailed chemical analyses for major and trace elements were done on a total of 20 samples of the rocks investigated using the AAS, XRF and FP (Flame Photometry) The harmonized Analytical results showed that the rocks are saturated with respect to silica, and contain moderate to elevated concentrations of Al_2O_3, comparable to most pelitic rocks. There appears to be no consistency in the relative concentration of Alkalis in the rocks, and this possibly indicates a mixed nature of the source materials. The granites contain an average each 72.83% SiO_2, 14.18% Al_2O_3, 1.65% Fe_2O_3, 2.60% Na_2O, 3.54% K_2O, 0.47% MgO, and 1.46% for CaO respectively. In the trace elements have 1,057.80ppm Ba, 273.04ppm Sr, 102.84ppm Rb, and 13.90ppm Cu. The granitic rocks in the area have limited range in Silica (71.1-78.2%), have high Alkali contents, low to moderate CaO and low MgO values and a Shand index of < 2. Results of the chemical analyses which is akin to geochemical characterization based on the major and trace elements indicates the FTNE granitoids to be I-type. The area, as a whole, is characterized by Basement Complex. The granites are considered to be intrusive into the met sediments (schist and quartzite) which originated from post-Achaean greywacke type sediments in a domain of active sedimentations. These have led to the interpretation of geochemical evolution and the production of a geologic map on a scale of 1:50,000.

Keywords: *Geochemistry, Granites, Major oxides, Trace elements, Funtua NE*

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Background to the Study

Tuttle and Bowen (1958) described the granites as they are related to other subordinates. This name Older granites was introduced by Falconer (1911) to differentiate those deep-seated, semi-concordant granitic rocks of the Basement from the high-level and younger granites which are also tin-bearing rocks in northern Nigeria. The older granites were originated as pre-tectonic and post-tectonic rocks which appear both in the migmatite and subordinates metasediments especially in the schist belts (Wilson, 1989). Granites are believed to be a truereflection or manifestation of the Pan-African orogeic event, and constitute about 40-50% of the basement complex outcrop, and occupy important places in the crust (Bowden et al., 1984; Rahaman, 1988b; Souza et al., 2007). They vary in composition from tonalite through granodiorites to granite and syenite. Granodioritic composition is the most common. Texturally they vary from strongly foliated gneiss varieties to undeformed rocks. Rahaman (1988a) described the following petrographic types: migmatite and gneissic granites, primary pegmatites, quartz veinand aplites, undeformed pegmatite to mica granites and quartz vein. For a very long period (750-450Ma) granites represent long-lasting magmatic cycle which was accompanied by the Pan-African Oregeny. In this suite, the rocks range in composition and quartz percentages from tonalities and diorites, to granodiorites and then to syenites. Some volcanic rocks such as the Charnokites form a veryideal group of rocks that were said to have evolved during this period. They are generally high level intrusions and anatexis has played an important role (Rahaman, 1981) There is no or less mineralization in this group of rocks, even though thermal or heat effect play a vital function in the remobilization of mineralizing fluids. Because of the short distance, there could not be a classification, based on geochronology, of granites with during an orogenic cycle. There were many co-existences of magmas as evidently shown on contact features between members of the older granite.

Geochemically, they (older granites) can be fixed into the fields of arc and collision granites on discrimination diagrams. Compositionally, they contain significant amount of alkalis, they are therefore moderately corundum normative. Older granites also fix into calc-alkaline rocks field in the usual AFM diagram. The term Pan-African granitoids may be used for the older granites for two (2) reasons: merit of geochronology or dating which was not even available at the time the name was gien to them, and, secondly, older granites cover so many important petrologic groups formed at the same time. The older granites occur with schist most particularly along schist belts in northwestern and southwestern parts of Nigeria. They include the following: biotite-rich granite, granites, with biotite-muscovite minerals, the syenites, chanockites, serpentinites and anorthosites. Rahaman (1988a) was not satisfied with the intended classification of those members on the basis of their texture, mineralogy and the timing of their evolution, and so disagree with the workers. According to textures this group of rocks can be grouped into the following: Meta-igneous; granite gneisses; early pegmatites and medium-grained granites; coarse-grained porphyritic granites; moderately moifeid and deformed pegmatite aplites and vein-quartz, and pegmatites that were not affected by deformation, andgranites that are rich in mica minerals.

The outcropping of residual granites in Nigeria decreases fron east to north, appearing as isolated intrusions in the area around Danmahawayi, SW of Zaria (McCurry, 1973), and, in the region between the intrusive granites and associated rocks host the remaining of Migmatites-gniess (Mc Curry, 1973) According to their field relationships, Mc Curry grouped the granites in the Zaria area into two categories: the syn-tectonic, which comprises an elongate batholith sheets partly concordant and were foliated, and the late-tectonic rocks, which are made up of highly degraded foliated discordant structures that are also rich in mafic Xenoliths and having a lower percentage of alkali feldspar. The late granites were considered to be the products of re-activation and an intensive and widespread re-mobilization of former basement complex rocks during the Pan-African. Granites are in association with the Migmatite-gneiss complex and the Schist belts into which they cut across. Older granite rocks therefore outcrops along with Migmatite and surbodinate gneiss and Schist belt. They ae noteably prominent in and around Zaria, Wusasa, central Nigeria, north eastern and some parts of south western Nigeria.

Available geochronological data show that most bodies range widely in age or were emplaced between 700-450Ma. Pegmatite associated with the Older Granites show an appreciable degree of mineralization. Jacobson *et al.* (1963) discussed the occurrence and distribution of mineralized pegmatites in Central Nigeria, but these rocks are now found in all parts of the country, intruding the basement complex. Recent work (Garba, 2003; Dada, 2006) indicates that pegmatite emplaced parallel to the basement trend may be important as loci of gold, tantalite, gemstone mineralization.
Some of the Older granites appear as greenish or dark-grey granites with high amount of olivine and pyroxene, occurring with quartz, feldspar and micas. According to Cox *etal* (1979), in Bauchi areathis unusual composition of mineral assemblages makes the rocks to sometimes be called Bauchite.

Study Area
The Funtua NE is part of Lower palaeozoic terrain of NW Nigeria. Geographically, the area cut across Kankara, Bakori, Malumfashi and Faskari Local Government areas in Katsina State and covers a total land area of approximately 745.29km$^{2.}$ The study area of Funtua north east (FTNE) falls within longitudes and latitudes 7° 15',7°, and 11° 45', 12° 00' (Figure 1) The area is characterized by series of discontinuous ridge of inselbergs (gneiss and granite) in the western side which made it a slightly rugged landscape. Some areas around far western and eastern parts are inaccessible due to intense flooding especially in the rainy seasons.

Climate, Relief and Drainage
The natural vegetation of the mapped area is largely Sudan savanna type, that is tropical climate zone of Nigeria and is characterized by two main seasons; rainy season which is from April to October and dry seasons (or Hamattan) for the remaining periods which is typical of northern Nigeria, and which is characterized by sharp regional variances depending on rainfall (Babsal and Co.,1998).Generally, the seasons are moved by the movement of the Inter Tropical Air Mass or Inter Tropical Convergence zone (ITCZ) a zone where dry and often dust-carrying air from the northern Hemisphere, known locally as hammattan collide with moist air from the southern Hemisphere or Atlantic. The study area receives an average precipitation of 1,200 mm in the south per year to 650 mm down in northern Nigeria (Kankara, 2002) Dry season is marked by low humidity and has Harmattan wind that blows from Sahara. \

The area is a gently undulating peneplained surface, consisting of an extensive superficial cover which rises to an altitude of between 570m and 600 m above mean sea level. This prevailing low relief is attributed to the predominance of metasediments and to the absence of intrusives. It also consists of a series of residues of ridges (of metasediments) and prominent inselbergs (of gneisses and granites) which makes the terrain to appear rugged. The highest points are Dutsen Wawa, Dutse Mai Zuma, Dutse Mai Amarya, Baka-Zari, Dutsen Mashi, Dutsen Mununu, Duwatsun Zango, Yan Ajera and Mai Dorayi inserlbergs form the Bakkai complexes (see Table 1) Na-Doshe inserlberg is located at the western border of the area. The lowest points in the project area are found at the areas close to Kwakwaren-Nabadau, around river valleys, with a gradual decrease in slope towards southeast.

Methodology

Twenty (20) major lithological units were identified and sampled during the mapping (reconnaissance survey and actual field investigation), using a 1:50,000 scale and this covered a total land area of approximately 153km^2. The Funtua NE is part of Nigerian Basement. Each lithological unit have been described in accordance with reference to their locations in the map provided. For the geological mapping, granitic lithological units were identified and as well, their structures, field and contact relationships. Laboratory analysis was carried out to ascertain the various percentages of minerals, by the use of AAS, XRF and FP.

Results and Interpretations

Geology of the Study Area

Lithology, distribution and field relationship have shown that part of the Funtua north east is underlain by grey to pink colored granitoids, which occur as inselbergs and low lying whale-backs. The granitoids occur as massive fractured plutons irregular shapes, roughly occupying two belts in the NW-SW parts of the map area. The granites sharply intrude the metasediments and migmatite-gneiss unit, with the sharp contacts suggesting their younger age. There is a close contact between the granites and the gneiss.

Physical relations (example, sharp contacts) show clearly that porphyritic biotite granites in the study area were emplaced as liquid melts, and that the fine-medium grained varieties are older than the porphyritic varieties. In addition to that, structural grain that dips in north-southdirection in the eastern neighbouring sheets has influenced the surfacing of phorphiritic granites.

Medium grained granites and coarse granites are found to occur, but due to their limited exposure they do not constitute mappable units (mostly in a locality west of Dunfui inselberg). Biotite granites outcrop the SW parts of Funtua NE, bounded by migmatite-gniesses (FTNE 107, 137, 128, 141, 111, 125, 2, 109, 136, 149) They extend to the upper northern end, at the northern part of Kankara town. They occupy about 25% of the total area. The outcrops form low ridges in some places, and are aligned in NE-SW and probably have gradational boundaries with the strongly lineated, pink-grey rocks with an even-grained texture coarser than in the other gneisses. It consists principally of quartz, biotite and feldspar minerals with minor accessories.

Pegmatitic veins occur in the outcrops, varying in width from 5-30cm and stretching throughout the length of most outcrops for over 50m. The veins are oriented at $205^{O}/25^{O}$ NE-SW. These structural features explain the intensity of metamorphism resulting in secondary deformation by the gradational transition into the granites as they become more porphyroblastic with the increase in microcline content. The ideal composition of granite (from hand specimen) is quartz+alkali feldspar+plagioclase feldspar. The syn-tectonic features such as folds, foliation, banding and lineation explain the intensity of metamorphism resulting in secondary deformation by the gradational transition into the granites as they become more porphyroblastic. The Porphyritic Biotite granite outcrops frequently in the SW of Funtua NE, and are devoid in the south-eastern part around Unguwan Danbaushe. At the areas around Bakkai, Zango and Shemen-Makarya, the granitoids experience marginal contact with a lot of pegmatite pods, and that is where they are bounded by migmatites-gniess. Granitoids extend to the upper northern end, at the northern part of Kankara town. They occupy about 20% of the total area. The outcrops form low ridges aligned in NE-SW and probably have gradational boundaries with the strongly lineated, pink-grey migmatites with an even-grained texture coarser than in the other gneisses.

The rocks vary in dimensions from great elongate batholiths, tens of kilometers long and several kilometres across, aligned more or less parallel to the structural grain to small sub circular stocks only a kilometer or two across. The larger bodies tend to be foliated and many of them are porphyritic, with feldspars reaching several centimeters in size, whereas the smaller intrusions are unfoliated and generally fine-grained. They mostly exist in the extreme NW corner, especially at Kaurawa-Pauwa road and at *Ungwan* Alhaji Yuguda. Most of the inselbergs that characterize many of the land forms in the Funtua north east are formed by erosion of these granitic masses, with their characteristic exfoliation weathering patterns. Where they are emplaced in the basement, the batholithic granites are commonly elongate and concordant and have gradational boundaries with surrounding gneisses and migmatites. The basement rocks become progressively more granitic in appearance as the intrusions are approached. For example, pegmatitic and aplitic veining becomes more common, there is metasomatic growth of feldspar crystals and banding becomes more diffuse. The smaller granite bodies generally have sharp boundaries that cut across the basement structures. Where they are emplaced into the supracrustal belts, however, even the larger granites generally have sharp cross-cutting boundaries. Intrusions of whatever size within the supracrustals may affect contact metamorphism of the schists and phyllites, leading to the development of 'spotted' rocks, due to the growth of minerals such as cordierite and andalusite.

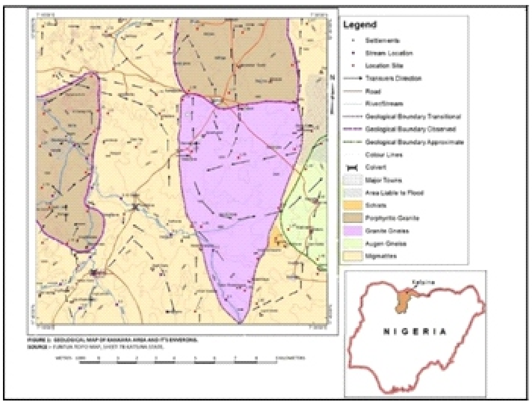

Fig. 1: Geological map of the study area showing the Older granites; Plate i: Multiple Pegmatites at the extreme western portion, near Bakarya village

Table1: Geochronometric Samples Description, Locality and Co-Ordinates of Granites

Sample No.	Description/ Lithological Name	Nature of Outcrop	Locality	Co-ordinates	
				Elvtn.	Long/Lat.
FTNE 56	Porphyritic Granite	Bouldery Inserlberg	Zari Tudu, 1km SW of Kakumi	1885ft	°48.547'N 7° 16.929'E
FTNE 81	Porphyritic Granite	Bouldery Inserlberg	Dutse mai Zuma	1930ft	11°49.467'N 7° 16.818'E
FTNE 82	Porphyritic Granite	Bouldery Inserlberg	Near River Fetsa, at Mununu Site	1860ft	11°50.230'N 7° 16.580'E
FTNE 108	Porphyritic Granite	Bouldery Outerop	Dutse Mai Amarya Site	1826ft	11°50.474'N 7° 16.200'E
FTNE 137	Porphyritic Granite	Bouldery Outcrop	Near Na-Kadaddaba River	1812ft	11°50.664'N 7°15.965'E
FTNE 128	Porphyritic Granite	Whaleback (occasional)	Baka-Zari Inselberg	1819ft	11° 50.587'N 7° 15.894'E
FTNE 111	Porphyritic Granite	Whaleback	1.5 km West of Dunfui Village	1849ft	11°50.646'N 7° 17.189'E
FTNE 141	Porphyritic Granite	Bouldery Outcrop	Granite close to Mabai	1897ft	11° 50/290'N 7° 17.680'E
FTNE 120	Porphyritic Granite	Bouldry Outcrop	Sheme Road, close to Kakumi	1886ft	11° 50/313'N 7° 18.357'E
FTNE 125	Porphyritic Granite	Bouldery Inserlberg	Along Kankara -Zango Road	1993ft	11° 57.049'N 7° 16.018'E
FTNE 2	Porphyritic Granite	Whaleback	1km after Zango Town	1889 ft	11°54.92'N 7° 16.34'E
FTNE 109	Porphyritic Granites		NW of Kankara Town	1831ft	11°56.19'N7°24. 50
FTNE 136	Porphyritic Granites		At Malali Village	1828ft	11°56.50'N 7°19.00'E
FTNE 149	Porphyritic Granites		500m NE of Malali	1836ft	11°58.01'N 7°20.00'E
FTNE 47	Porphyritic Granites		Gidan Kare, 15k from Sheme	1889ft	11°46.72'N 7°16.92'E
FTNE 35	Porphyritic Granites		At Gambo Karfi Village	1818ft	11°47.50'N 7°29.52'E
FTNE 134	Porphyritic Granites		1km West of Unguwan-Nagunda	1830ft	11°51.28'N 7°20.45'E
FTNE 65	Porphyritic Granites		Pauwa outcrop	1939ft	11°58.20'N 7°18.10'E
FTNE 3	Porphyritic Granites		An Outcrop at Marake	1822ft	11°59.10'N 7°23.50'E
FTNE 1	Porphyritic Granites		At Danmarabu	1821ft	11°57.82'N 7°25.00'E

 

Plates ii: Typical Porphyritic granite, Kankara-Zango road, western part of Funtua North-East, and iii: A 30cm wide Pegmatite in a granite at Zango, western part of Funtua north east.

The rocks vary in dimensions from great elongate batholiths, tens of kilometers long and several kilometres across (see plate ii), and aligned more or less parallel to the structural grain, to small sub circular stocks only a kilometer or two across. The larger bodies tend to be foliated and many of them are porphyritic, with feldspars reaching several centimeters in size, whereas the smaller intrusions are unfoliated and generally fine-grained. They mostly exist in the extreme NW corner, especially at Kaurawa-Pauwa road and at Ungwan Alhaji Yuguda. Most of the inselbergs that characterize many of the landforms in the Funtua north east are formed by erosion of these granitic masses, with their characteristic exfoliation weathering patterns. Where they are emplaced in the basement, the batholithic granites are commonly elongate and concordant and have gradational boundaries with surrounding gneisses and migmatites. The basement rocks become progressively more granitic in appearance as the intrusions are approached. For example, pegmatitic and aplitic veining becomes more common, there is metasomatic growth of feldspar crystals and banding becomes more diffuse. The smaller granite bodies generally have sharp boundaries that cut across the basement structures. Where they are emplaced into the supracrustal belts, however, even the larger granites generally have sharp cross-cutting boundaries. Intrusions of whatever size within the supracrustals may affect contact metamorphism of the schists and phyllites, leading to the development of 'spotted' rocks, due to the growth of minerals such as cordierite and andalusite.

Features of the larger concordant batholithic-granites indicate that they are syntectonic; that is to say, they were emplaced during the climax of deformation and metamorphism, when temperatures and pressures were at a maximum, and there was extensive incomplete metamorphism and metasomatism. Pegmatites are extensively developed in them (see plates i and iii). The unfoliated nature of the smaller cross-cutting (discordant) granites indicates that they evolved later, following the first climax of metamorphism. There are, of course, all gradations between these two extremes, and in some areas it has been possible to identify a number of stages of granite emplacement, according to initial relationships, textures and composition. Porphyritic granites contain variable amounts of inclusions of country rocks, particularly around their margins. In the larger batholithic granites, with their more pervasive and gradational boundaries, these inclusions have been largely 'digested', obscuring their original nature, and modifying the granite, generally making it more basic. In the smaller crosscutting bodies, however, original textures and lithologies can often be identified example biotite-rich gneisses, amphibolites and folded metasediments because the inclusions are rarely altered to any extent. The intrusions are not all of granitic composition. The larger batholiths range from adamellite to granodiorite, but the smaller bodies are more variable, with compositions between true granite and diorite and syenite being represented; and gabbros are also sometimes seen. These other intrusive rock types almost certainly represent new additions to the crust, that is to say they are probably derived from beneath the crust, in the upper mantle. This may apply to some of the granitic intrusions also, but many of the large syntectonic batholithic masses are probably products of deep-seated metasomatism and partial melting of older rocks that is they represent crustal remobilization and recycling, rather than new additions to the continental crust.In the southwest there are deformation which was poly-phasal, with primary deformed and ductile structures which were in contact with expansion and contraction of rocks affected by orogenic circlewere followed by secondary brittle structures. Also, there has been primary ductile deformation produced the regional tectonic folds and faults, and tight to isoclinal unpronounced folds.

Table 2: Chemical (Weight Percent) Composition of Porphyritic Biotite Granites

Sample No.	**F1**	**F3**	**F2**	**F65**	**F134**	**F126**	**F125**	**F35**	**F109**	**F136**
Sio_2	71.45	71.86	71.62	72.8	72.8	71.6	73.4	70.3	71.8	73.0
Al_2o_3	14.66	14.77	14.40	13.6	12.2	14.8	13.4	15.3	14.2	13.0
Cao	1.82	1.55	1.33	1.45	1.78	1.61	0.92	2.3	1.8	1.9
K_2o	3.55	3.96	3.90	3.24	4.08	2.61	3.4	3.82	4.08	3.61
Na_2o	2.41	2.94	3.07	3.42	2.81	3.61	2.0	2.38	2.71	2.92
Mgo	0.37	0.42	0.34	0.6	0.6	0.8	0.21	0.75	0.76	0.22
P_2o_5	0.08	0.15	0.12	0.02	0.09	0.21	0.32	0.16	0.19	0.06
Fe_2o_3	1.06	1.86	1.69	1.08	2.03	1.97	2.55	1.65	1.46	1.42
Tio_2	0.25	0.22	0.20	0.51	0.28	0.31	0.24	0.20	0.32	0.29
Mno	0.052	0.028	0.031	0.61	0.79	0.72	0.011	0.086	0.016	0.081
LOI	1.58	1.52	1.20	1.88	1.44	0.48	1.33	0.98	1.23	1.9
Total	**97.28**	**99.28**	**97.90**	**99.21**	**98.90**	**98.72**	**97.79**	**97.93**	**98.57**	**98.40**

Table 2: Chemical (Weight Percent) Composition of Porphyritic Biotite Granites (Cont.)

Samples No.	F157	F47	F56	F111	F141	F81	F82	F107	F137	F128	Average of 20 samples	Range of 20 samples
Sio_2	74.8	72.4	78.2	72.3	72.2	73.1	71.8	74.6	71.1	75.4	72.83	
Al_2o_3	14.6	15.6	13.1	12.6	14.8	14.2	15.8	15.7	14.8	12.0	14.18	12.2 – 15.8
Cao	1.67	1.03	0.58	0.75	0.98	1.28	1.4	1.3	2.0	1.9	1.46	0.58 – 2.0
K_2o	3.06	3.10	3.20	4.21	4.28	4.81	2.45	2.61	3.81	3.09	3.54	2.61 – 4.81
Na_2o	1.77	2.21	1.33	1.82	2.61	2.61	3.26	3.07	2.06	2.89	2.60	1.33 – 3.42
Mgo	0.62	0.82	0.11	0.20	0.86	0.68	0.78	0.92	0.29	0.10	0.47	0.10 – 0.92
P_2o_5	0.12	0.12	0.13	0.14	0.23	0.28	0.69	0.31	0.41	0.32	0.84	0.02 – 0.69
Fe_2o_3	1.09	1.08	1.56	1.86	2.34	1.59	2.09	1.22	1.70	1.69	1.65	1.06 – 2.55
Tio_2	0.10	0.33	0.35	0.61	0.25	0.31	0.23	0.22	0.19	0.22	0.28	0.10 – 0.61
Mno	0.055	0.088	0.86	0.033	0.016	0.099	0.023	0.061	0.021	0.081	0.15	0.011 – 0.099
LOI	0.12	1.68	1.06	1.62	0.82	0.82	0.77	0.23	0.99	1.06	1.14	0.12 – 1.9
Total	**98.01**	**98.50**	**99.71**	**99.14**	**99.39**	**99.78**	**99.30**	**100.2**	**97.40**	**98.75**	**98.71**	

Table 3: Trace Elements Composition (ppm) of Porphyritic Biotite Granites

Sample No.	F1	F3	F2	F65	F134	F126	F125	F35	F109	F136
Cu	22.6	7.5	18.5	10.5	11.0	10.0	12.2	13.8	15.7	15.0
Co	58.0	11.7	52.6	48.0	48.6	41.8	42.2	51.7	58.7	52.6
Ni	12.7	7.8	12.4	8.0	8.0	7.5	7.5	12.6	12.7	8.0
Zn	44.7	38.0	40.0	39.5	41.0	41.8	43.6	43.6	44.8	44.7
Rb	105.0	90.0	116.6	98.8	98.3	102.3	102.1	112.2	116.7	100.0
Cr	12.8	15.0	12.2	15.9	13.2	14.7	13.5	14.6	11.0	12.8
Pb	25.0	26.5	29.0	24.0	24.5	26.6	27.8	27.7	29.5	26.0
Sr	217.0	317.0	270.7	318.0	326.0	310.0	211.8	250.5	261.5	296.7
Zr	188.8	178.5	222.0	192.0	196.7	210.0	179.7	182.9	186.8	200.0
Ba	1,177.4	1,321.5	838.2	902.3	960.2	992.6	806.9	1,250.0	1320.5	1,182.5
La	36.8	27.3	27.0	28.9	28.2	28.0	30.6	32.8	31.7	35.6

Table 3: Trace Elements Composition (ppm) of Porphyritic Biotite Granites (Cont.)

Sample No.	F157	F47	F56	F111	F141	F81	F82	F107	F137	F128	Average of 20 samples	Range of 20 samples
Cu	21.0	23.5	8.6	8.0	9.9	10.0	21.8	22.3	7.6	8.5	13.9	7.5 – 22.6
Co	56.6	13.8	51.7	57.7	32.0	31.5	31.4	20.4	22.0	26.5	40.50	11.7 – 58.0
Ni	8.7	8.5	10.0	8.4	10.4	12.3	12.0	7.8	9.5	9.5	9.72	7.8 – 12.7
Zn	38.1	38.0	37.7	45.1	42.9	42.7	44.6	40.2	40.8	39.0	41.54	38.0 – 45.1
Rb	92.5	98.4	98.6	101.2	103.7	105.0	117.8	91.7	90.8	115.0	102.84	90.0 – 117.8
Cr	12.8	14.8	12.5	15.2	13.3	10.9	17.6	17.6	16.7	10.8	13.90	10.8 – 17.6
Pb	24.5	30.0	27.4	28.0	27.4	25.6	25.5	26.8	26.8	29.0	26.88	24.5 – 30.0
Sr	292.2	301.1	280.0	261.5	245.0	245.0	218.7	218.7	308.6	310.0	273.04	217.0–317.8
Zr	228.5	179.0	196.7	196.0	182.6	189.2	188.1	192.3	198.4	220.0	195.41	178.5–228.5
Ba	890.0	896.5	1360.7	1,344.8	1,228.8	1,118.5	861.1	858.1	845.0	1,000.2	1,057.80	838.2-1360.7
La	28.4	35.3	34.1	32.5	30.6	29.6	29.9	31.2	36.0	27.8	30.62	27.0 – 36.8

Source: Field, 2008

Results of Geochemical Analysis (*Geochemistry of Porphyritic Granites)*

Summary of Whole-Rock Geochemical Data of Granites (Granitoids)

The result of chemical analysis carried out on the Porphyritic Biotitic Granites revealed an average SiO_2 value of 72.83%. This value is exactly similar to average analyses of Maradun group and Gorrusu granite dyke complex from northwestern Nigeria, (McCurry, 1976). It is also closely similar to, but a little higher than the average SiO_2 contents of Porphyritic Granites in Kazaure Dam Area (71.04, by Danbatta, 1999) and the medium grained granites of Daura SW (Danbatta, 1999). This value is higher than the Gorrusu granites (McCurry, 1976) and Kisemi granitic groups (McCurry, 1976; 65.22%). It is also higher than Quartz Diorites of Inkill Hill, ENE of Bauchi Town Centre (51.97) which is significantly true of Diorites. Diorites are having less amounts of quartz and Alkali feldspar than the porphyritic granites. This silica amount is also higher than those in the Mangas biotite hornblende granite (64.48%). This amount is lesser than SiO_2 content of Albala granitic plutons, Spain (75.51%) and SW Obudu granites, Eastern Nigeria (Ekerere and Barth, 2009; 72.2%) as shown in Tables 2-3.

Average K_2O values of 3.54% and Na_2O values of 2.60% were recorded in the granites. These values differ little and are higher and lower than the granite rocks of Inkill Hill or (K_2O = 1.89) the Gorrusu granites (K_2O = 2.34) the Maradun granitic groups (Na_2O = 3.75) and the Mangas biotite hornblende granites (Na_2O = 3.56). They are similar in composition to Burum-Takalafia Granites (K_2O chemical composition of FTNE 3 of 3.57, and Na_2O composition of 2.67, FTNE 3) The FTNE Porphyritic granites compositions are similar to Biotite granites of Rozvadov type 0.6km SSE from Ostruvek, Bohemia. For the trace elements concentration, average values of 1,057.80ppm and 273.04ppm for Ba and Sr were recorded respectively. These values conform to the proportion or normal granites and comparable also to those of Burum-Takalafia and Obudu of South Eastern Nigeria (Bassey, 2009b) and those of SW Obudu Plateau (Ekerere and Bath, 2009) The Rb and Ni values of 102.84ppm and 9.72ppm are also normal and within the range of granitic rocks and are also comparable to those of Obudu SW Plateaus (Ekerere, 2009) but higher than those of the Burum-Takalafia granitic rocks.

Oxides of Major Elements

Data from FTNE (Funtua north-east) granitoids are discussed or shown in Tables 2-3. Their normative felsic compositions were plotted on the conventional Q-Or-Ab projection (Bassey, 2009 b; Tuttle and Bowen, 1968). This has revealed a geochemical percentage of the granitic rocks and their broad classification. A brief summary of rock types in all the analyzed 160 samples show that porphyritic granites has the highest average value of silica contents (≤78.2).

The granites show a slightly small range of variation in their SiO_2 content (71.10 – 78.20 weight-percent), with high alkali-oxide (Bowden, 1982) content ($Na_2O + K_2O \geq 5$ weight-percent), high Na_2O content (average; 2.60 weight-percent, low Calcium Oxide and Magnesium Oxide, P_2O_5, MnO and $5TiO_2$ and subordinate Fe_2O_3). This low ratio of MgO is 0.47 to FeO (1.65) in the bulk composition of the granites suggests that the rocks are enriched in iron. The P_2O_2 and MnO in all the analyzed granite has proportion of 0.02-0.69 and 0.01-0.099. Furthermore, the granites has similar trend with calc-alkaline AFM diagram. Data for major elements in the twenty (20) porphyritic granite samples fall within the range reported by other workers (McCurry and Wright, 1971).

Trace Elements

All the granitic samples show a consistent variation of trace element contents and some of these could be used in tectonic discrimination diagrams (O'Hara, 1980). There is a similarity in the average Zirconium content of 195.4 ppm for all the granitic specimens has similarity with average of 180 ppm in granitic rocks (McLennan, 1985) Lead (Pb) values range from 24.5 ppm-30.0 ppm indicating a distinctive "Arc/or syn-collisional fields" signature (Pearce et al., 1984). The silica saturated granites were therefore probably formed through syn-collisional processes related to subduction related magmatism.

The high content of average Strontium (Sr) of 273.04ppm and Rubidium of 102.84ppm indicates that the magma source must have been rich in Sr and Rb. It also indicate the likely crustal origin of the magma and the less efficient removal of these elements by mafic and salic phenocrysts. The syn-collisional nature of FTNE granitoids was further confirmed on a Rubidium-Silica diagram which gives the tectonic classification of granitic rocks after Pearce et al. (1984).

Discussion

Considering the evidences from the major and trace elements contents, it can be suggested that these rocks are possibly of mixed igneous and sedimentary parentages. From field work to geochemical analyses a research was coming closer to reality about the various rocks surveyed. Geochemical analyses are a junction where major and trace elements were studied. Geochemistry, strictly speaking may be defined as the study of the geochemical character of elements as they are found in the rocks of a given area, and this implies to studying a rock toward the original magma that formed it. It is the description of the percentages of each mineral in a rock. Textural descriptions, visual estimates and mineralogy was done to ascertain the geochemistry of different lithologies, although it was not a major target of the research. The least of the granite rocks to be used for geochemical analyses are coarse grained porphyritic rocks. The research is focused on generation of reliable geochemical data of rocks in the Funtua Sheet 78 NE, northwestern Nigeria.

Geochemical data of the rocks may have become scanty or poor because researches in geology are now mostly focused on mineral Deposits and structural geology or geophysical survey, in the search for hydrocarbons and water. It is because of this level of poor geochemical data that this research intends to unravel. This study is necessary because a relatively large proportion of geochemical investigation is lacking. The use of geochemistry as the major source of portable mineralization and geochemical characterization in NW area of northern Nigeria has assumed a high proportion that attention has turned fully to it Geochemical characterization is a key source in its usefulness, availability of its trace and major elements and their relative abundance and abstraction depends on certain factors. Many researchers have expanded a lot on Geology and geochemistry of the granitic and migmatitic Basement rocks in NW Nigeria.

Conclusion

The aim of geochemical analyses in this research is to find the ratio of certain elements, example K-Rb, Sr-Rb ratios. Going by this believe, thus it could be concluded that the lithologies were once put 1under one block called Pangea, before it disintegrated further. In addition to that, the minor elements with non-mobility character share same nature of protoliths with the sedimentary rocks under pressure or migmatites with those of the gneissic complexes. This also provided clue that they were from the same the sequences of supracrustal.

The proposed geochemical model of evolution of the rocks in FTNE is in agreement with that for some neighboring belts whose geochemistry was ascribed to ensialic processes. As already observed, there are significant similarities between rock-types, structural and metamorphic events in the Funtua north east granitic and migmatite-gniess rocks and thearea at the western part.

Dating of early or ancient Proterozoic era from the research has similarity to other Borborema Province, the African provinces, and Congo craton. Validity of the Eburnean event was highlighted, and it was re-affirmed that these tectonic units may have been part of a larger continental landmass, the Pangea. Likewise, similarities in post-Transamazonian (or post Eburnean) metamorphic and magmatic events in the Borborema and African provinces suggest that they shared a common origin and remained in close proximity until when Atlantic Ocean was opened.

Economically, the rocks meet the standard for use as constructional and building materials. The availability of Ca, Na and K minerals can aid manufacture of Sodium bicarbonate, bicarbonate and hydroxides, in agriculture as acid soil ameliorants and nutrients status enhancer. Because of their economic potential the granites can be put into one or more uses, and abundant evidences show that the granites are being quarried for other domestic and industrial purposes.

Recommendations

A part from the above statements, further recommendations are suggested below:

1. The study recommends a much more detailed analysis of the rocks, taking into considerations their character variation with depth and lateral change.
2. Though the rocks does not meet the standard for use for some other particular purposes more research should be carried out to see if the lithologies can be put into any use.
3. It is required that the Federal Government of Nigeria should encourage small scale miners to invest in the deposits. The result of the analysis provides that more mineral deposits can be sourced from the rock outcrops.
4. Apart from these deposits, others occur in many areas of Nigeria, which have equally high economic value. In view of this, Government should encourage more researches.
5. Geological and topographical maps of the country should be updated and made available and affordable to researchers.

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