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Geological Mapping of Basement Rocks in Federal University Gusau And Its Environs, Zamfara State, Northwestern Nigeria

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Abstract: *Field approach and Outcrop descriptions were used in the geological mapping of basement rocks in Federal University Gusau, Zamfara State, Nigeria. The study aims at describing the geological attributes and features of the basement rocks with particular emphasis on structural features in the study area. The geological mapping enhances the visibility and clarity of the existing geologic units in order to produce the geologic map of the study area. The outcrop descriptions were examined at in-situ throughout the geological mapping period. The result of the outcrop descriptions shows three (3) types of exposure: low-lying ridge, river channel, and whale-back exposures. The outcrops descriptions also reveal some features such as fault breccias, scattered boulders, fault and foliation with intrusion of quartz-grain, present of weathering which causes disintegration of granitic rocks, very coarse-grained and fine-grained granitic rocks prevalent. The geological mapping reveals that the study area is associated with high level intrusions of granitic origin with an average depth of 4 meters across the area. The results of the structural features measured at in-situ on the outcrop reveals an average dip amount value of 19.2^o with strike and dip directions ranging from 26^o–182^o and 24^o–191^o respectively. The Rose diagram reveals that the structural trend within the study area is predominantly in the eastern direction precisely at the northeastern (NE) and southeastern (SE) directions. This signifies that the line of mineralization will be in northeastern (NE) and southeastern (SE) directions. Based on the geological mapping results, the study area is predominantly underlain by Older Granites of Northwestern, Nigeria.*

Keywords: *Outcrop, Rose Diagram, Fault, Older Granites, and igneous intrusions*

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I. Introduction

Geological mapping is the process of gathering geological data in the field and adding that to a topographic map in order to create a geological map of that particular region. According to Njue (2010), a geological map will depict the various rock types of the region, the structures, geological formations, geothermal manifestations, age relationships, distribution of mineral ore deposits and fossils etc. and all these features may be super imposed over a topographic map or a base map. In general, it involves the careful observation of exposures, searching for other clues about the hidden geology, interpretation of these data in order to create the map and often, then writing a report to accompany the map.Actually, many authors (Nwajide, (2000); Obaje, (2004); Danbatta and Garba (2007); Olayinka (2009); Njue, 2010; Folorunso *et al.* (2013); Saleh and Maunde (2017). etc.) have written immensely on geological field mapping but none has focussed on this part of the state. Thus, a geological map is a map displaying the distribution of geological (rock) units and structures across a region, usually on a plane surface. Nevertheless, a geological map is a fundamental tool, and because of its importance, various Governments across the world have keyed into establishment of a special geological survey agency within their respective country and Nigeria is not exemption. Geological survey-type mapping involves a geologist in the field examining rocks in their natural location, plotting data onto a field map and recording details in a field notebook, collecting relevant samples, fossils etc., from the outcrop, and transferring the data onto a base map at the of each day's work. Gradually, the database builds up and a map is developed in which the distribution of rocks and the superficial deposits are shown.Finally, it is a known fact that the geological map of the Campus has not been produced. As a result, there is need to carry out detailed geological field mapping of the Main Campus of Federal University Gusau, Zamfara State. This study will for the first time document the geological mapping of the study which include outcrop description at in-situ, identification and measurement of geologic structures, and identification of various rock units encountered during the study.

II. Regional Geologic Setting

Federal University Gusau, Zamfara State Main Campus Is Located Along Zaria-Sokoto Road Of Gusau Precisely At Kotokoroshi Community, Zamfara State, Nigeria (Fig. 1). The Study Area Falls Within Basement Complex Of Northwestern Nigeria (Obaje, 2004). The Nigerian Basement Complex Is A Part Of The Pan-African Mobile Belt Which Lies Among The West African And Congo Cratons As Well As South Of The Tuareg Shield (Black, 1980). According To Burke And Dewey (1972) With Dada (2006), The Nigerian Basement Occupies The Reactivated Region As A Result Of The Plate Collision Between The Passive Continental Margin Of The West African Craton And The Active Pharusian Continental Margins Which Was Affected By Pan-African Orogeny. Also, Condie (1989) Revealed That The Kibaran And Pan African Events Affected Mostly The Godwana Continent And Did Not Seem To Have Strong Counterparts In Other Continents. Thus, The Tectonic Activities Between The Tectono-Thermal Events Were Limited Mostly To Anorogenic Magmatism And Rifting.However, The Basement Is Characterised By Synclinorial Belts Of Low Grade Metasediments Down-Folded Into High Grade Gneisses And Migmatites, The Whole Intruded By Batholitic Granites. It Is Characterised By Process Of Several Phases Of Deformation, Recrystallization And Intrusion, The Last Of Which Is The Pan African Orogeny (Mccurry And Wright, 1977). Ajibade And Fitches (1988) Reported That The Basement Comprises Three Major Lithological Groups: (I) The Migmatite Gneiss Complex Which Is Widespread Throughout The Country; (Ii) Metasedimentary And Metavolcanic Rocks Which Form Schist Belts And Appear To Be Dominantly Restricted To The Western Half Of The Country; (Iii) The Older Granites Which Intrude Both The Migmatite Gneiss Complex And The Schist Belts And Have Consistently Yielded Pan-African Ages. Thus, The Study Area Is

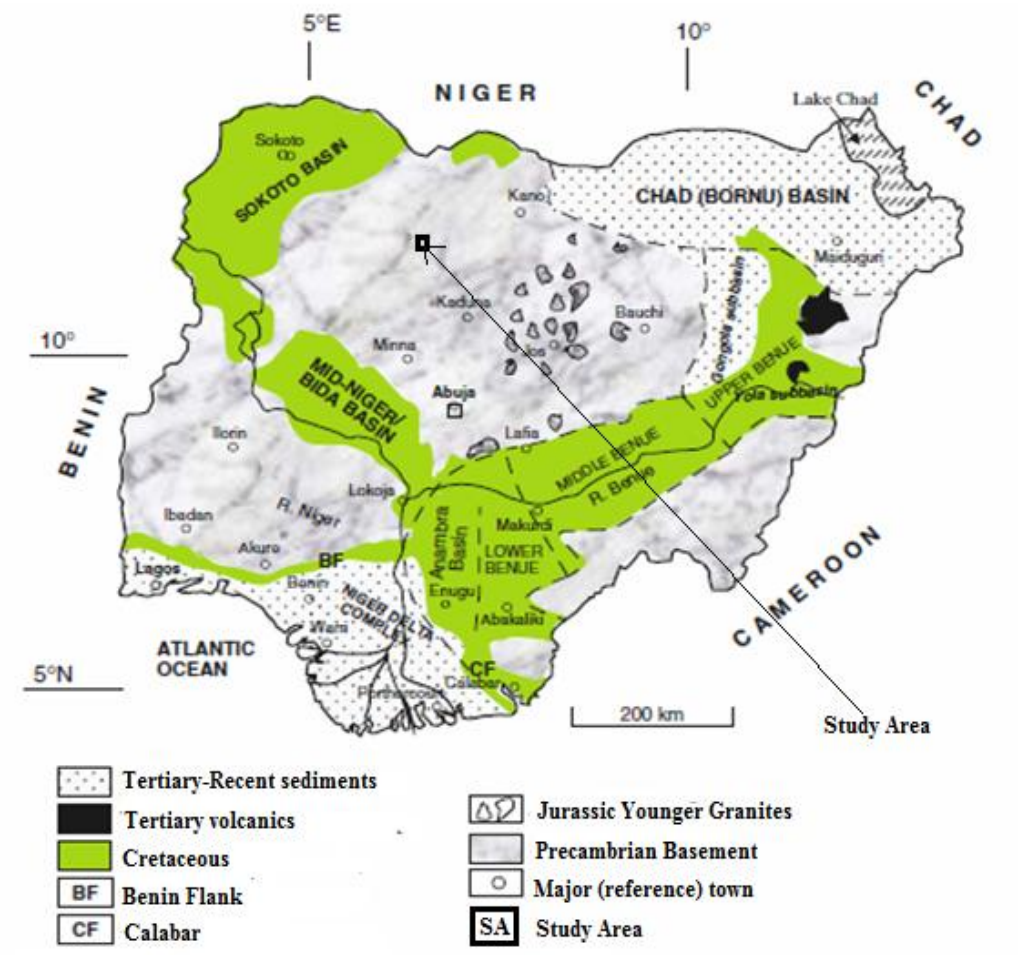

Fig. 1: Geological map of Nigeria showing the study area (After Obaje, 2009)

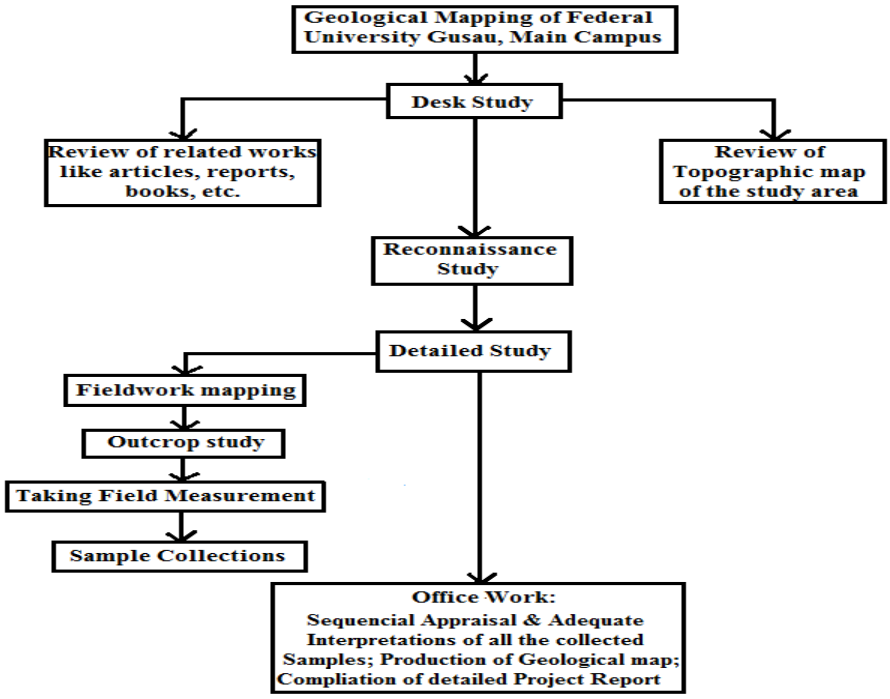

Fig. 2: Research Workflow

III. Methodology

The data set available for this research work includes regional topographic and geologic maps. Thus, the necessary instruments used during the mapping period are clinometers-compass, geological hammer, global positioning system (G.P.S.), fieldwork note, base map and sample bag(s).he workflow approach used in this present study is illustrated in Fig. 2. The study involved four main stages namely desk study, preliminary (reconnaissance) survey, geological fieldwork, and office work. The execution of these steps was done in accordance with the geological principles. The target of the workflow diagram (Fig. 1) is to generate all necessary interpretation and input for production of a geological map for Federal University Gusau and its Environs, Zamfara State, Nigeria. The descriptions of methods are given below:The desk study involved extensive and careful literature reviews of relevant reports, review of existing geological materials or works and topographic maps covering Federal University Gusau, Main Campus, Zamfara State were carried out. This study helped in identifying potential area for detailed investigations. Meanwhile, the reconnaissance study or preliminary survey was carried out with a mission to obtain, by visual observation or method, some necessary information about the human activities and mineral resources data concerning Federal University Gusau, Main Campus, Zamfara State. However, the activities carried out under detailed study include proper **g**eological mapping using compass-traverse method of mapping, outcrop logging, taking field measurement, pre-mining studies and collection of samples for petrographic analysis. Seventeen (17) outcrops were studied altogether within the study area. Next to this is the office work which include compilation and processing of accumulated field data and samples; interpretation and analysis of data; systematic appraisal and evaluation of processed field data; reserves estimation, digitization/production of maps and compilation of Detailed Project Report (DPR).

IV. Result And Discussion

Topographic Mapping:

The result of revalidation of topographic map of the study area reveals presence of different kind of features such as access roads, streams (Fig. 3), heights, human activities and valleys. Actually, the acquired data (Table 1) were integrated with the existing data in order to produce a localized topographic map of Federal University Gusau and its evirons, Zamfara State at scale 1:50,000 (See Fig. 3).

Fig. 3: River Channel in the study area [Lat: $12^{o}07^{l}06.8^{ll}$N & Long: $006^{o}46^{l}45.2^{ll}$E]

Table 1: Summary of Field Geological Mapping within F.U.G. and its Environs

Location	Coordinates	Measurement	Outcrop Description	Economic activity	Geology
1	Lat: $12^{o}07^{l}21.5^{ll}$N Long: $006^{o}47^{l}09.5^{ll}$E Elev: 481m	Strike: 86^{o} Dip dir: 182^{o} Dip amou:24^{o} Length: 32m Width: 18m Height: 0.6-1.2m	Low lying ridge of mainly granitic rock. Instrusives are prevalent around the outcrop. Fractures are present.	Quarrying is on-going.	Older Granite
2	Lat: $12^{o}07^{l}19.5^{ll}$N Long: $006^{o}47^{l}11.2^{ll}$E Elev: 471m	Strike: 83^{o} Dip dir: 191^{o} Dip amou:19^{o}	Low lying ridge of mainly fault breccia.	Quarrying is on-going.	Older Granite
3	Lat: $12^{o}07^{l}18.0^{ll}$N Long: $006^{o}47^{l}13.8^{ll}$E Elev: 473m	Strike: 180^{o} Dip dir: 88^{o} Dip amou:16^{o} Length: 29m Width: 20m Height: 0.7-1.5m	Low lying ridge of mainly granitic rock. Boulders are prevalent. Fault and foliation with intrusion of quartz-grain. Weathering is present.	None	Older Granite
4	Lat: $12^{o}07^{l}18.0^{ll}$N Long: $006^{o}47^{l}15.9^{ll}$E Elev: 475m	Strike: 86^{o} Dip dir: 182^{o} Dip amou:24^{o} Length: 320m Width: 282m Height: 1.3-2.2m	Low lying ridge of mainly granitic rock. Boulders are prevalent.	None	Older Granite
5	Lat: $12^{o}06^{l}42.5^{ll}$N Long: $006^{o}47^{l}17.3^{ll}$E Elev: 484m	Strike: 162^{o} Dip dir: 68^{o} Dip amou:16^{o} Length: 289m Width: 217m Height: 4.3-10.7m	Whale back exposure of mainly granitic rock. Highly fractured with traces of fault breccias. Scattered boulders all over the area.	None	Older Granite
6	Lat: $12^{o}07^{l}17.7^{ll}$N Long: $006^{o}47^{l}01.5^{ll}$E Elev: 466m	Strike: 116^{o} Dip dir: 41^{o} NE Dip amou:24^{o} Length: 42.5m Width: 2.9m Height: 1.5-1.5m	River channel exposure of granitic rock. Highly weathered granite. Presence of fractures.	None	Older Granite
7	Lat: $12^{o}07^{l}31.1^{ll}$N Long: $006^{o}46^{l}49.3^{ll}$E Elev: 464m	Strike: 88^{o} Dip dir: 24^{o} NE Dip amou:22^{o} Length: 250m Width: 100m Height: 0.8-3.5m	Low lying boulders of granitic rocks scattered across the area.	None	Older Granite
8	Lat: $12^{o}07^{l}31.1^{ll}$N Long: $006^{o}46^{l}49.9^{ll}$E Elev: 462m	Strike: 148^{o} Dip dir: 46^{o} NE Dip amou:14^{o}	River channel exposure of granitic rock. Highly weathered granite	None	Older Granite

9	Lat: 12°07'45.0"N Long: 006°47'20.5"E Elev: 473m	Strike: 182° Dip dir: 160° Dip amou:18° Length: 189m Width: 125m Height: 1.5-4.4m	Low lying ridge of boulders of granitic origin. Intrusives are prevalent in the area. Presence of foliation and fracture i.e. jointing	None	Older Granite
10	Lat: 12°07'42.7"N Long: 006°47'27.3"E Elev: 473m	Strike: 170° Dip dir: 64° Dip amou:12° Length: 300m Width: 249m Height: 0.5-1.4m	Low lying ridge of boulders mainly granite. Intrusives and fault breccias are prevalent in the area.	Quarrying is on-going	Older Granite
11	Lat: 12°07'33.5"N Long: 006°47'30.5"E Elev: 476m	Strike: 58° Dip dir: 144° Dip amou:18° Length: 66m Width: 4.2m Height: 0.7-1.2m	A whale-back of mainly granitic rock. Highly fractured and foliated. Kris-cutting of faults and joints is present.	None	Older Granite
12	Lat: 12°07'46.2"N Long: 006°47'15.5"E Elev: 474m	Strike: 136° Dip dir: 44° Dip amou:18° Length: 27m Width: 12m Height: 0.5-1.3m	Low lying ridge of granitic rock.	None	Older Granite
13	Lat: 12°07'48.0"N Long: 006°47'14.9"E Elev: 467m	Strike: 86° Dip dir: 178° Dip amou:20° Length: 19m Width: 8m Height: 0.4-0.8m	Low lying ridge of granitic rock. Highly fractured with traces of fault breccias.	None	Older Granite
14	Lat: 12°08'34.7"N Long: 006°45'36.6"E Elev: 455m	Strike: 118° Dip dir: 157° Dip amou:19° Length: 69m Width: 32m Height: 3-12m	River channel exposure of granitic rock. Highly weathered, faulted and jointed. Brownish-yellow top soil overlying the granitic rock. Very coarse-grained granitic rock.	None	Older Granite
15	Lat: 12°08'03.1"N Long: 006°45'54.9"E Elev: 456m	Strike: 26° Dip dir: 110° Dip amou:18° Length: 14m Width: 11m Height: 0.7-1.2m	Low lying ridge of granitic rock. Highly faulted. Very coarse-grained granitic rock. Presence of Faults which result to formation of boulders. Intrusives are prevalent	None	Older Granite
16	Lat: 12°08'06.8"N Long: 006°46'45.2"E Elev: 452m	Strike: 70° Dip dir: 158° Dip amou:30° Length: 11.3m Width: 4.8m Height: 0.9-2.2m	River channel exposure of granitic rock which has been weathered to kaolin. Highly weathered and faulted. Parent material is granitic rock.	None	Older Granite
17	Lat: 12°07'45.0"N Long: 006°46'50.6"E Elev: 464m	Strike: 182° Dip dir: 94° Dip amou:14° Length: 49m Width: 19m Height: 0.7-1.3m	Low lying-whale back of granitic rock. Highly fractured with traces of fault breccias. Fine grained granitic rock.	None	Older Granite

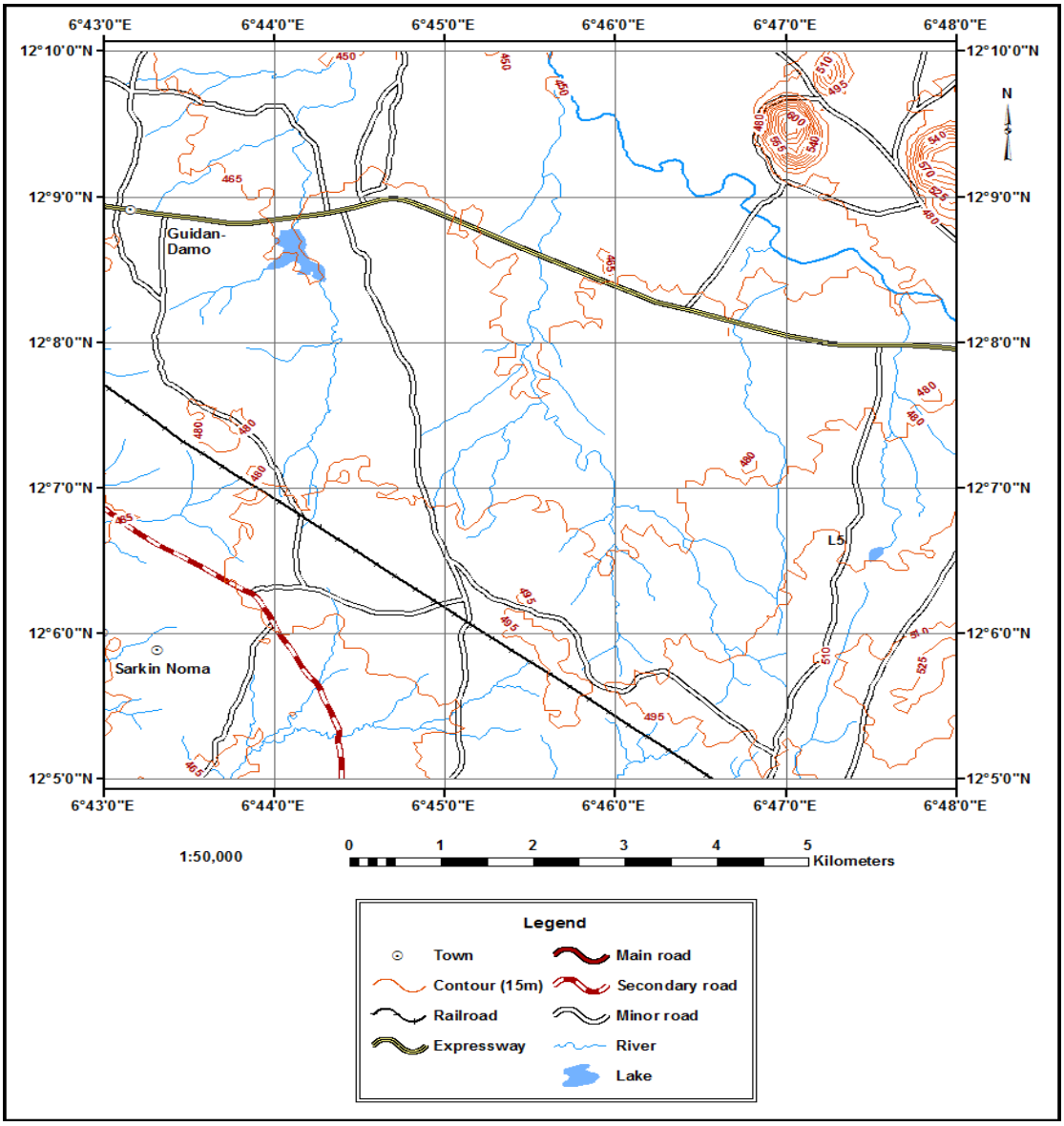

Fig. 4: Topographic Map of Federal University Gusau and its environs, Zamfara State

V. Geologic Mapping

The result of the detailed geological field mapping of seventeen outcrops (Table 1) strongly revealed that the Federal University Gusau and its environs is underlain by Old-Granite associated with the Basement Complex rocks of Nigeria. Three (3) types of exposure were encountered namely; low lying ridge, river channel and whale back exposures (Table 1 and Fig. 5). These outcrops are mainly granitic rock with prevalent instrusives which are scattered across the area. The outcrops descriptions reveal some features such as fault breccias, scattered boulders, fault and foliation with intrusion of quartz-grain, present of weathering which causes disintegration of granitic rocks, very coarse-grained and fine-grained granitic rocks prevalent (Fig. 6).

Fig. 5: Exposure types: a) Low lying- ridge [Lat: $12^{o}07^{l}48.0^{ll}$N & Long: $006^{o}47^{l}14.9^{ll}$E]

b) A whale-back exposure [Lat: 12o07l45.0llN &Long: 006o46l50.6llE]

c) A river Channel exposure Lat: $12^{o}08^{l}06.8^{ll}$N & Long: $006^{o}46^{l}45.2^{ll}$E

d) Describing a low lying whale back [Lat: $12^{o}07^{l}45.0^{ll}$N &Long: $006^{o}46^{l}50.6^{ll}$E]

Fig. 6a: Deposits of fault breccias
[Lat: $12^{o}06^{l}42.5^{ll}$N & Long: $006^{o}47^{l}17.3^{ll}$E]

Fig. 6b: Intrusion of quartz-grain
[Lat: $12^{o}07^{l}33.5^{ll}$N & Long: $006^{o}47^{l}30.5^{ll}$E]

Fig. 6c: Effect of weathering on granite
[Lat: $12^{o}08^{l}34.7^{ll}$N Long: $006^{o}45^{l}36.6^{ll}$E]

Fig. 6d: Bioturbation as a result of weathering
[Lat: $12^{o}08^{l}34.7^{ll}$N Long: $006^{o}45^{l}36.6^{ll}$E]

Fig. 6e: Extensive outcrop of boulders
12°07'18.0"N & Long: 006°47'13.8"E]

Fig. 6f: Presence Fault on a low lying ridge Lat:
[Lat: 12°08'03.1"N & Long: 006°45'54.9"E]

Nevertheless, along the river channel exposure at location 14, the exposed granitic rock is highly weathered, faulted and jointed (Fig. 6c). There are brownish-yellow top soils overlying the highly weathered and fractured granitic rock. The texture is delineated as very coarse-grained granitic rock (Figs. 7 & 8).

Fig.7: Feeling the porphyritic texture
[Lat: 12°08'34.7"N & Long: 006°45'36.6"E]

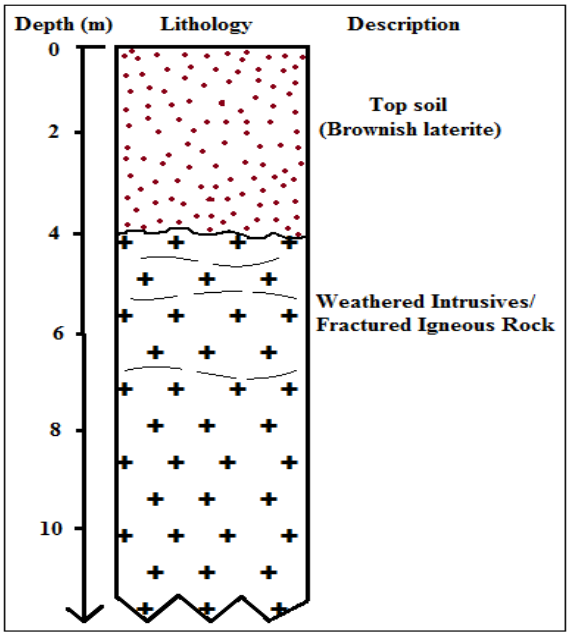

Fig. 8: Model along river channel
[Lat: 12°08'34.7"N and Long: 006°45'36.6"E]

The outcrops field measurement reveal an average dip amount value of 19.2° with strike and dip directions ranging from 26°–182° and 24°–191° respectively (Table 1). The Rose diagram (Fig. 9) reveals that the structural trend within the study area is predominantly in the eastern direction precisely at the northeastern (NE) and southeastern (SE) directions. This signifies that the line of mineralization will be in northeastern and southeastern directions.

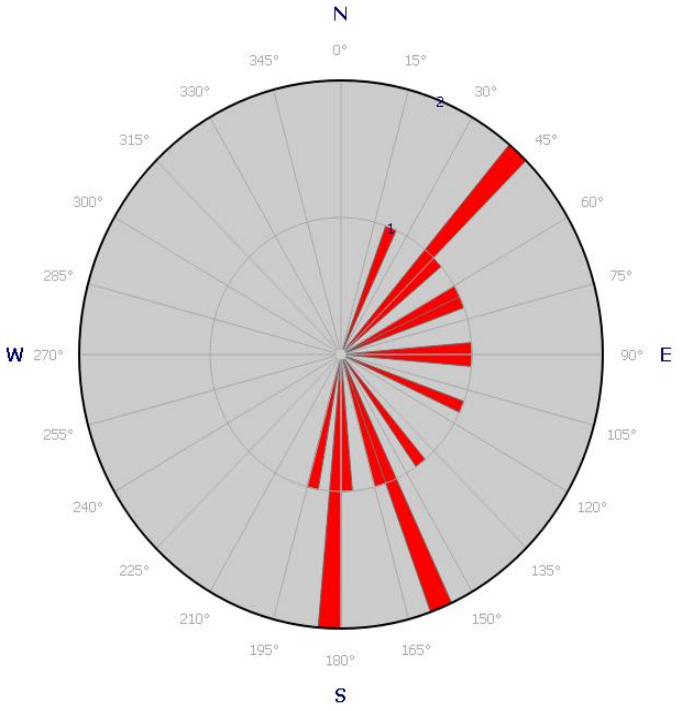

Fig. 9: A Rose Diagram showing dip direction within the study area

Integrating all the results from the outcrop decriptions, taking measurement and Rose diagram, the geologic map of Federal University Gusau and its Environs was produced at scale 1:50,000 (See Fig. 10).

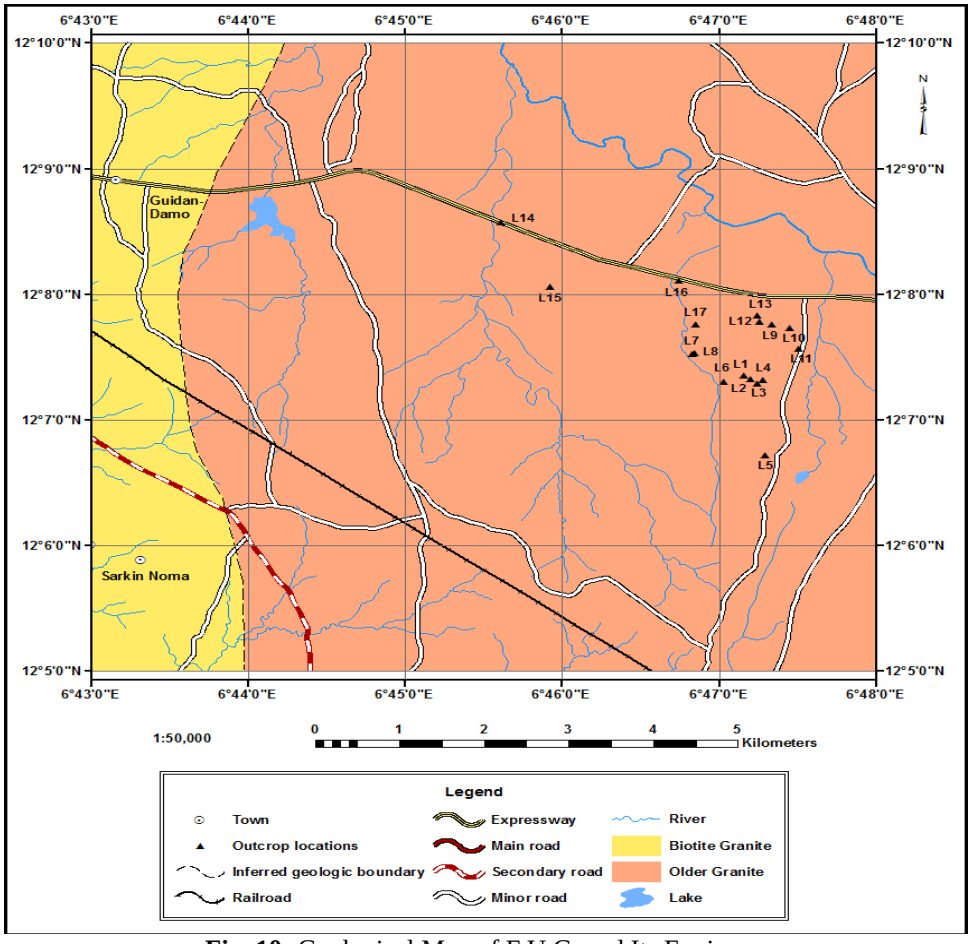

Fig. 10: Geological Map of F.U.G. and Its Environs

VI. Conclusions

A detailed geological mapping has been carried out within Federal University Gusau (F.U.G.) Main Campus and its environs, Zamfara State in order to unveil the various rock units through a field based approach. Thus the following conclusions were deduced.

1. Federal University Gusau (F.U.G.) Main Campus and its environs, Zamfara State is predominantly underlain by Older Granites of Northwestern, Nigeria.
2. The Older granites of the study area are classified as homogeneous to coarse porphyritic granites based on their textural characteristics.
3. Compass-traverse method of mapping was used for effective outcome within the study area.
4. The geological field mapping within the study area reveals three (3) types of exposure which were encountered namely: a low lying ridge; a river channel exposure; and a whale back exposure.
5. Outcrop descriptions were carried out at in-situ during the mapping period. The outcrops description reveal some features such as fault breccias, scattered boulders, fault and foliation with intrusion of quartz-grain, present of weathering which causes disintegration of granitic rocks, very coarse-grained and fine-grained granitic rocks prevalent.
6. The outcrops description and measurement revealed an average dip amount value of 19.2^{o} with strike and dip directions ranging from 26^{o}–182^{o} and 24^{o}–191^{o} respectively.
7. The Rose diagram reveals that the structural trend within the study area is predominantly in the eastern direction precisely at the northeastern (NE) and southeastern (SE) directions. This signifies that the line of mineralization will be in northeastern (NE) and southeastern (SE) directions.

VII. Recommendation

Having completed this study, we hereby recommend further application of geophysical methods such as remote sensing, electrical, gravity and magnetic in order to unveil the various depth to intrusives and possibly minerals within the study area.

Acknowledgements

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