Geology and Radiometric Survey of Tagima area, Northern Part of Adamawa Massif, Northeastern Nigeria

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Abstract

Field mapping and radiometric reconnaissance survey of Tagima and environs was carried out with the aim of producing geologic and isorad maps of the area and identifying possible extension of uranium mineralization southwards from the popular Mika deposit. Geologic study shows that the area is underlain by porphyritic granite, equigranular granite, migmatite and pegmatite. These rocks are characterized by joint and fault structures. Petrographic analysis of the porphyritic granite, equigranular granite, migmatite and pegmatite showed that the plagioclase, k-feldspars, biotite and quartz are the dominant minerals that constitute the rock units. Radiometric survey shows high radiometric values in the northwestern, northeastern and some of the southeastern parts of the area, while lower values are seen in the southern and southwestern parts. Analyses of the results shows high potentials for radioactive minerals in Mika and Jasori areas, while low potential for radioactive minerals in southern part of Tagima area. While Mika area has already been established to have uranium deposits, possible extension of radioactive minerals can be traced around Jasori and Tagima with decreasing potentials towards southern parts of the study area.

Keywords: Radiometric Survey, Field Mapping, Uranium deposits, Tagima, Adamawa Massif

1. Introduction

The study area Tagima, lies in the western part of Zing, which is part of the Adamawa Massif, N.E Nigeria that forms part of the Nigerian basement complex. The study area forms part of sheet 216, Monkin N.W (Fig. 1) and lies on geographical coordinates of longitude 11°37'E-11°41'E and latitude 8°56'N-8°59'N. Research work shows that the regional lithology of the rocks composed mainly of porphyritic granite, equigranular granite, migmatites, and pegmatite. Adamawa Massif is located between the Cameroon highlands in the Benue Trough and consists of deeply dissected and rugged hills, which in some places stand over 2500m above the sea level and it is the major basement complex block in the Northeastern Nigeria.

Weathering and metamorphism are important in modifying and redistribution of radioactive elements. The use of radioactivity in geology and mineral exploration is based on several properties of gamma radiation. The penetrating power of gamma rays, the characteristics energy level of the individual elements and the energy peak used for detection of the energy of the individual elements (Akinlolu and Musa, 2010).

Most of the various rock types constituting the Precambrian rocks (granite-gneiss, porphyritic granites) are characterized by different uranium and thorium contents and the granite-gneiss and coarse porphyritic granites corresponds to the older granite series that are characterized by high thorium and uranium contents (Oshin and Rahaman, 1985). Most of the uranium and thorium in igneous rocks is contained in the accessory minerals Zircon, apatite and sphene. Pyrochlore, allanite, xenotime, uraninite and thorite are highly radioactive and are accessories but generally, they are not evenly distributed (Akerblom and Lindgren, 1997).

Previous works in and around the Adamawa Basement mostly have been on a regional basis, but since the discovery of uranium mineralization by Nigeria uranium mining company (NUMCO) at Guburende, Kanawa, Zona, Dali, Mika, and Monkin-Manza, the area has been highly prospected by many workers (e.g. Funtua, 1988, Funtua et al, 1999, Funtua and Okujeni 1992, Funtua and Okujeni 1996, Suh and Dada, 1998; Dada and Suh, 2006, Haruna 2014, Haruna et al, 2010). (However, geology and radiometric mapping of Tagima area, in Monkin, Northeastern Nigeria was not done and documented before to the best of our knowledge. This contribution therefore, aims at finding information on possible extension of uranium mineralization from the neighboring Mika deposit by studying the geology and radiometric mapping (surveying) in the study area.

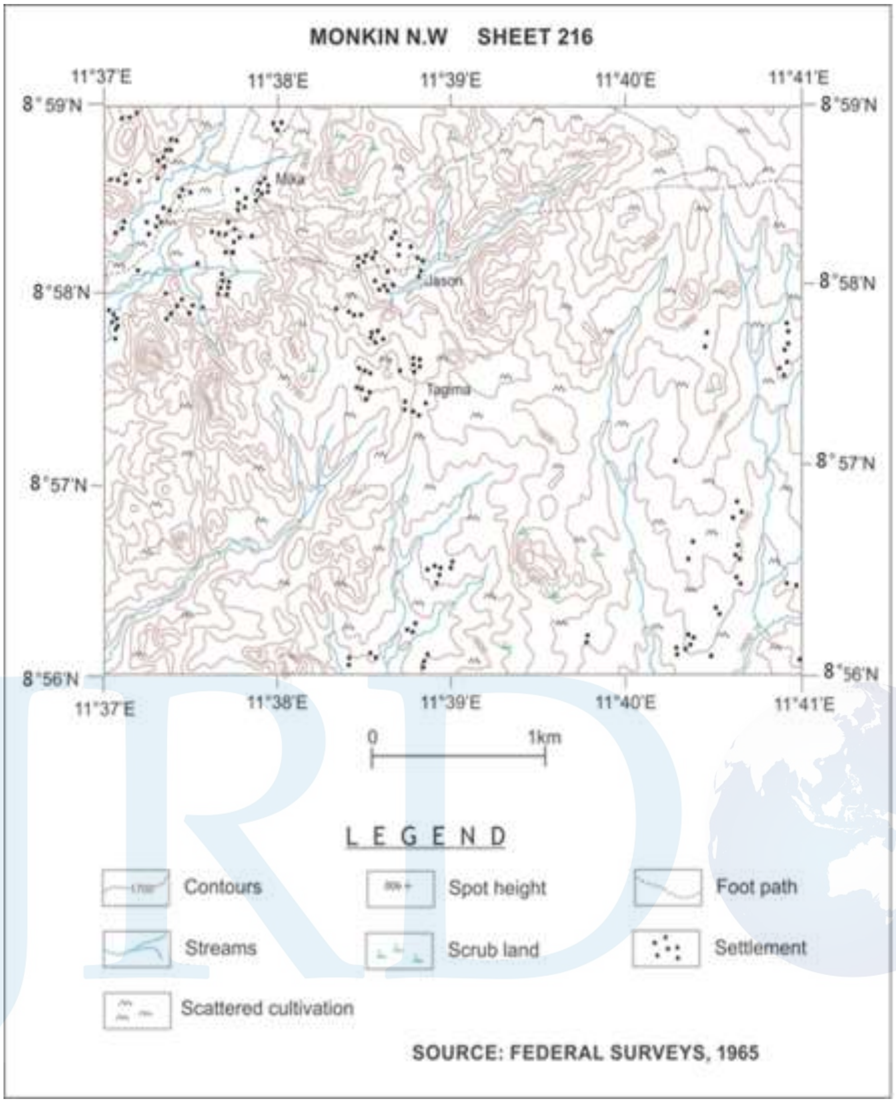

Fig. 1 Topographic Map of the study area (Federal Surveys, 1965)

2. Geological Background

The area lies within the Adamawa Massif of Northeastern Nigeria, which is an extension of the Bamenda Massif that forms part of the Cameroun volcanic (Fig. 2) (Ekwueme, 1993). The Adamawa Massif is bounded to the North by the upper Benue Trough. The basement rocks are of Precambrian ages, which are further divided into four (4) major groups, including the

Mandara Mountain, Alantika Mountain, Shebshi Mountain and Adamawa Massif Islam et al (1989). Adamawa Massif has undergone both Pre- Pan African and Pan African Orogeny.

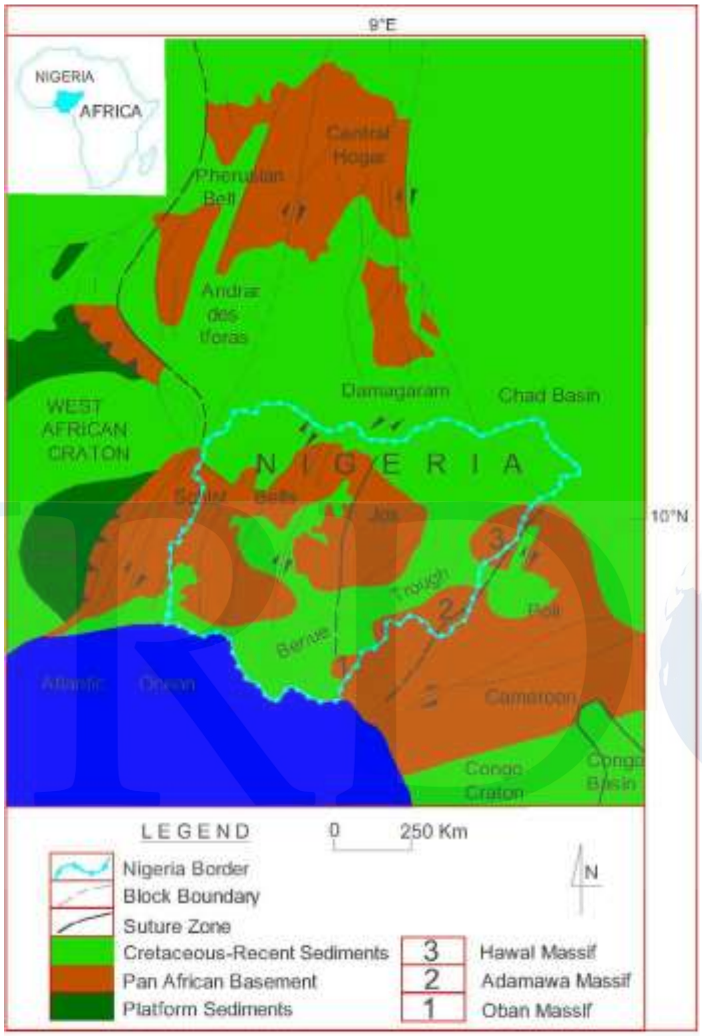

Fig. 2 Regional Geological Setting of Nigeria (From Haruna, 2014)

This has resulted into the consequent metamorphism, migmatisation and granitization of the pre-existing rocks (Rahaman et al, 1988).

Radioactive minerals occurrences, particularly uranium in Nigeria have been recorded from rocks ranging in age from Precambrian to Tertiary. Several organisations and individuals have carried out studies on uranium mineralization in the country. Nigerian uranium ores are found in sedimentary sequences, Younger Granite Complexes and deformed basement rocks of granitoid composition, with most of them small and scattered (Fumilayo and Saleh, 2009, Saleh 2013).

Ojo (1980) and Oshin and Rahaman (1985) have reviewed the Nigerian geologic environments for favorable uranium targets and concluded that there is considerable potentials. The Nigerian Mining Corporation (NMC) independently carried out detailed Uranium exploration in some areas of Kogi State and later worked in collaboration with the defunct Nigerian Uranium Mining Comapany (NUMCO) in the North Eastern part of the country. Exploration work by the NUMCO in this region has revealed numerous uranium occurrences in three basement zones around Gubrunde, Ghumchi and Mika (Funtua et al, 1999). They further concluded that the uranium mineralizations in N.E Nigeria show several characteristics that indicating similar origin and that the Mika deposit can be classified as vein type formed in reactivated fault structures. The uranium deposit at Mika is of the central Massif vein-type in France, and the deposit comprises a series of parallel veins, quite similar to the Lilljuthatten deposit in Sweden, with variable ore grade (Suh and Dada, 1998). The uranium potential in the northeastern part of Nigeria is the major deposits so far prospected (Saleh, 2013). The areas of uranium mineralization are associated with distinct hydrothermal alteration, which include hematization, sericitization and argillization(Funtua et al, 1999). Geochemical data by Funtua and Okujeni, (1996) suggest the rhyolite at Mika to be source rock for the uranium mineralization.

Widespread and extensive development of porphyritic granite occurs throughout the study area. The porphyritic granites are outcropping in areas like Mika and Jasori. The Western hills of Tagima are formed by equigranular granite, while coarse-grained granite like the migmatite is of subordinate occurrence in the study area, It occurs only in two locations: around Jasori and at N.E of the study area (Fig. 3) found cross cutting the host equigranular granite. Structurally, the area consists of mainly joints and faults trending NW-SE and NE-SW respectively. This is in conformity with the stressed orientation during the tectonic event.

3. Sampling and Analytical Procedure

Fieldwork was embarked to determine the field relations in the study area. Rock types and geological structures were examined and samples collected for petrographic analysis. Thin sections were prepared and studied under a polarizing microscope and the mineral constituents are identified. Observation of the various optical properties was done under both plane polarized light (PPL) and cross-polarized light (XPL). The structural features examined in this study are mainly joints and faults.

A McPherson Scintillometer, an instrument that detects radiation from radioactive minerals beneath the earth's crust was held at about one meter height above the ground, the average background value of the area was deducted from the scintillometer taken from several locations. Readings from scintillometer was taking in counts per seconds (cps) and was recorded in the field book. Each reading taken was noted and GPS coordinates recorded. A total of 85 scintillometer readings were taken during the field work and data were later subjected to software interpretation which was used to produce the Isorad map of the study area both in 2-D and 3-D showing areas of high and low radioactivity.

4. Results

4.1 Geology and Structures

Four main Lithologic units were identified during the geologic field mapping of the area which include the migmatite, porphyritic granite, equigranular granite and pegmatites (Fig. 2). The lithological and structural description of these rock units is briefly described.

The migmatites encountered in the study area are dominantly found around the northern and southeastern part of Tagima (Fig. 3). Most of the mapped migmatite occurs as low-lying outcrop ranging in textural characteristics from medium to coarse-grained with mafic and felsic minerals (Fig 3 and 5). The porphyritic granites outcrop around Mika, and trending north-south of the mapped area. They form about 60% of the entire outcrops in the area, the most striking characteristic of the porphyritic granites is their porphyritic texture having a very large phenocrysts (20 mm×30 mm to 35 mm×40 mm)(Fig. 3). The dominant minerals of the porphyritic granites in both hand specimen and thin section are quartz, feldspar and biotite (Fig. 5).

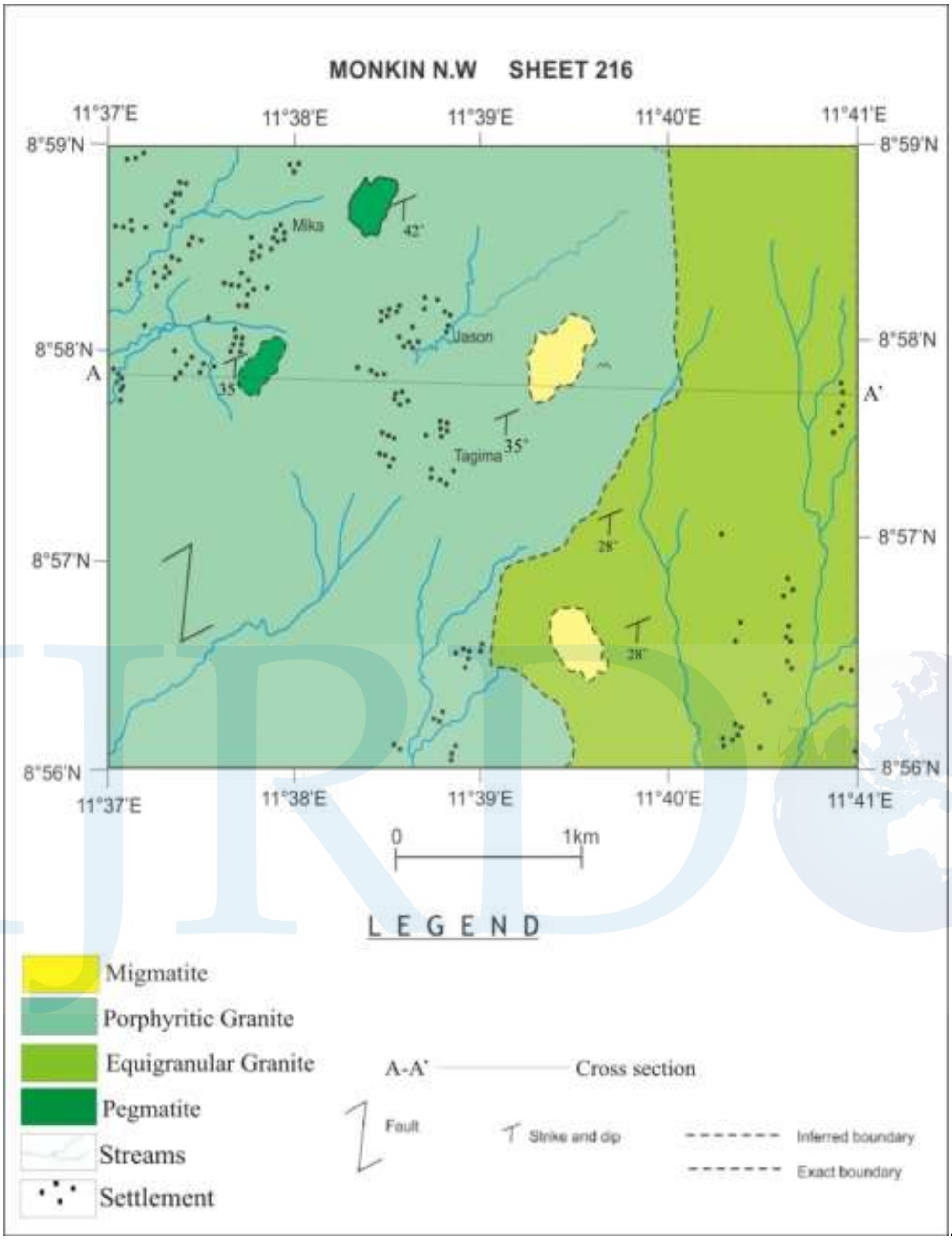

Fig. 3 Geologic Map of the Study area

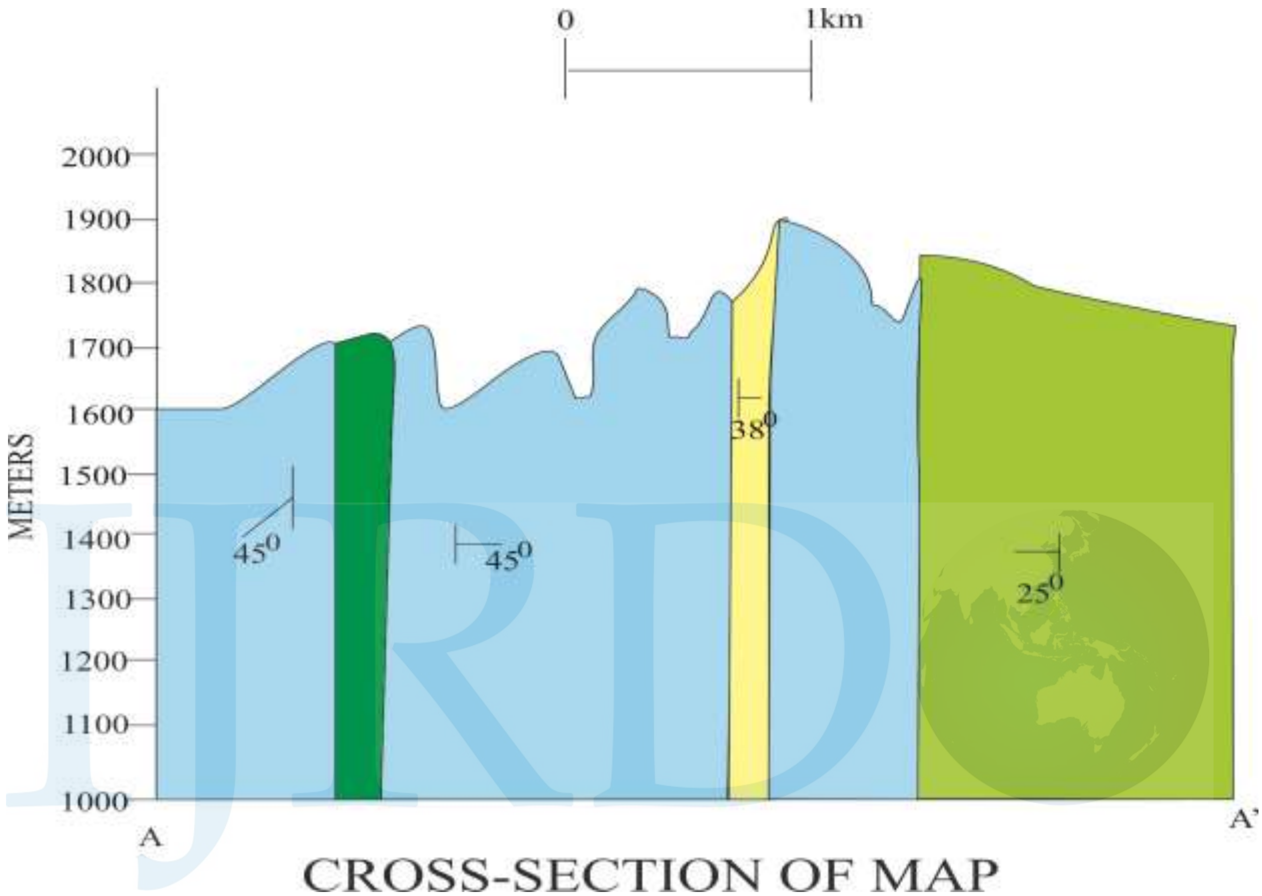

Fig. 4 Crossection of Geological Map of the area

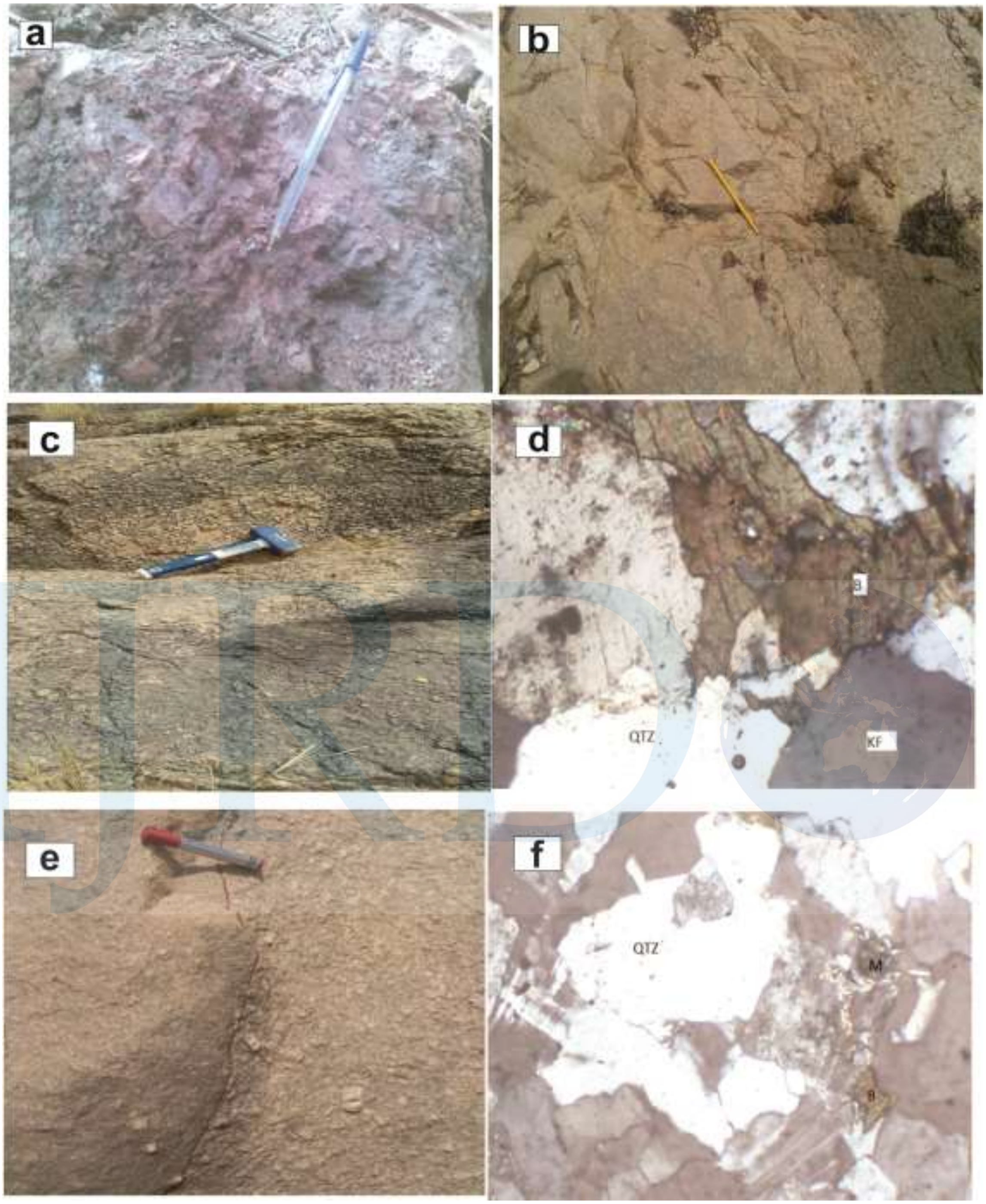

Fig. 5 Photographs of some rock outcrops and photomicrographs (a) exposure of Migmatite at Jasori, (b) Pegmatite at Northern part of Mika, (c) Porphyritic Granite at Mika, (d) Photomicrograph of Porphyritic Granite, (e) Boundary between Porphyritic and equigranular granites and (f) Photomicrograph of equigranular granite.

The equigranular granites are next in abundance to porphyritic granites, which constitute about 20% of the total area, dominantly around eastern part of the study area (Fig. 3). Around Tagima locality, the porphyritic granites and the equigranular granites lie side by side and are separated by a sharp contact (Fig. 5). Patch of migmatites occurrences are found within the equigranular granite, suggesting that the equigranular granites were emplaced after the formation of the migmatites. They are generally medium-grained in texture; minerals identified in hand specimen are biotite, quartz, and feldspar that characterized the outcrops.

The pegmatites in this study area occur as an intrusion into the porphyritic granite, they are extremely coarse grained and show great variation in size (Fig. 5).The mineralogy of the outcrop is characterized by feldspar, quartz and biotite. They are in association with the porphyritic granite in Mika locality. In this location they are in variable sizes crosscutting each other and are regularly tabular bodies, with a constant strike and dip and are complex types ranging between 3-5 m wide and several kilometers long.

In terms of the structures, several joints and faults were observed in the area and their strike and dip were examined and recorded (Table 1). The data is used to plot rose diagram in other to determine the structural trends of the outcrop of the study area (Fig.6). Most of the faults in the area are dextral faults in which the displacement occurred. The fault was observed at the western part of the study area on the porphyritic granite. The joints are dominantly trending in the NE-SW directions, while the faults are dominantly trending in the NW–SE directions, indicating the direction of stress that caused the deformation.

Table 1 Showing Field measurements of joints and faults

Joint Data		Fault Data	
Strike	**Dip**	**Strike**	**Dip**
011	11°NE	045	28°NE
090	85°SW	149	19°NE
005	15°NW	110	30°NE
010	20°NE	160	30°NW
070	27°SE	080	35°NE
070	35°NE	165	40°NW
162	05°SW	115	31°SE
140	15°SW	120	29°NW
091	29°NE	125	19°SE
060	17°SE	072	26°NE
010	90°NE	121	10°SW
011	13°NE	130	45°SE
030	70°NE	140	21°SE
020	80°SE	146	17°SW
070	30°SW	175	35°NE
125	19°SE	100	38°SE
100	90°SE	125	25°NE
130	60°NE	130	10°SW
100	25°NE	115	19°NW
149	50°SW	091	29°NE
080	20°NE	124	40°NW
065	15°SW	090	13°SW
055	25°SE	150	29°NE
025	15°NW	162	20°SE
009	22°NW	105	12°NW
016	25°SW	-	-
018	15°SW	-	-
020	40°NW	-	-

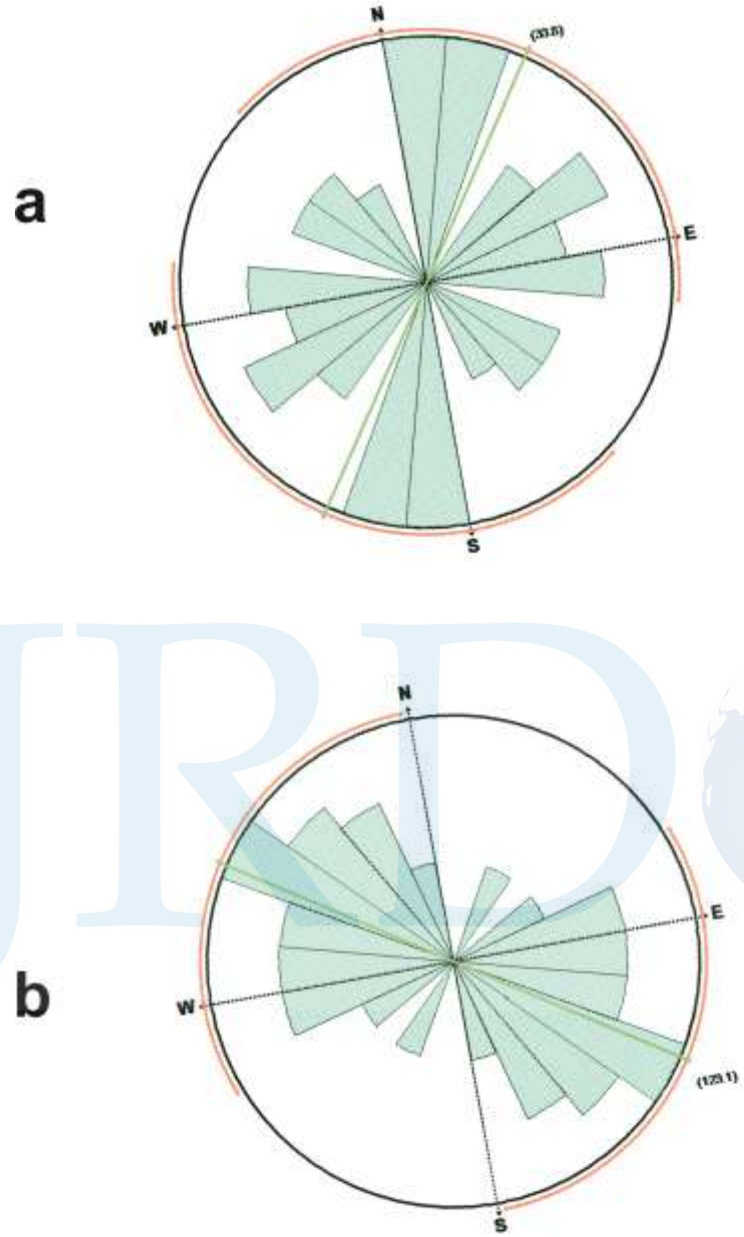

Fig. 6 Rose diagram for (a) Joints (n=28) and (b) Faults (n=25)

4.2 Radiometric Data

The readings obtained from the radiometric survey (Table 2) were used to plot the isoradiometric map of the study area both in 2-D and in 3-D using the software interpretation to know the spatial dispersion of the radioactive minerals in the study area and to relate it with possibility of mineralization.

Table 2 Showing Radiometric data and coordinates of the study area

SN	Longitude	Latitude	Radioactivity (cps)
1	11°37'00"E	08°56'00"N	130
2	11°38'00"E	08°56'00"N	125
3	11°37'07"E	08°57'03"N	125
4	11°37'05"E	08°57'13"N	140
5	11°37'03"E	08°57'34"N	150
6	11°37'04"E	08°58'01"N	135
7	11°37'02"E	08°58'02"N	155
8	11°38'35"E	08°58'03"N	140
9	11°38'45"E	08°57'58"N	150
10	11°39'00"E	08°57'51"N	140
11	11°39'08"E	08°57'52"N	145
12	11°39'30"E	08°56'15"N	140
13	11°39'20"E	08°58'05"N	160
14	11°39'00"E	08°58'13"N	140
15	11°38'57"E	08°58'12"N	150
16	11°38'53"E	08°57'42"N	145
17	11°38'56"E	08°57'44"N	148
18	11°39'31"E	08°58'08"N	142
19	11°40'00"E	08°58'40"N	140
20	11°39'52"E	08°59'00"N	130
21	11°41'00"E	08°56'00"N	137
22	11°40'09"E	08°56'00"N	130
23	11°39'10"E	08°56'06"N	130
24	11°38'15"E	08°56'10"N	120

25	11°37'04"E	08°56'15"N	124
26	11°37'34"E	08°57'22"N	175
27	11°37'12"E	08°57'18"N	120
28	11°38'05"E	08°57'28"N	130
29	11°39'04"E	08°57'19"N	135
30	11°39'34"E	08°57'58"N	140
31	11°40'24"E	08°57'58"N	140
32	11°41'00"E	08°57'00"N	175
33	11°41'00"E	08°58'00"N	165
34	11°40'15"E	08°58'20"N	155
35	11°39'04"E	08°58'00"N	160
36	11°38'04"E	08°58'25"N	160
37	11°37'01"E	08°58'06"N	150
38	11°37'08"E	08°59'00"N	155
39	11°38'14"E	08°59'00"N	150
40	11°38'24"E	08°59'00"N	150
41	11°39'20"E	08°59'00"N	140
42	11°40'34"E	08°59'00"N	150
43	11°41'00"E	08°59'00"N	160
44	11°38'44"E	08°58'28"N	150
45	11°38'14"E	08°58'50"N	182
46	11°39'44"E	08°59'00"N	140
47	11°39'30"E	08°58'18"N	136
48	11°39'34"E	08°56'54"N	130
49	11°38'25"E	08°56'48"N	132
50	11°37'28"E	08°56'28"N	125
51	11°40'01"E	08°58'43"N	120
52	11°39'46"E	08°58'14"N	130
53	11°39'28"E	08°57'49"N	135
54	11°39'24"E	08°57'52"N	145
55	11°39'12"E	08°57'56"N	179
56	11°38'18"E	08°58'09"N	135
57	11°38'28"E	08°57'01"N	138
58	11°39'29"E	08°58'11"N	140
59	11°39'53"E	08°58'43"N	145
60	11°39'35"E	08°59'00"N	149

61	11°38'14"E	08°58'15"N	168
62	11°39'09"E	08°58'16"N	170
63	11°39'16"E	08°58'14"N	169
64	11°39'15"E	08°57'55"N	180
65	11°39'00"E	08°57'45"N	170
66	11°38'45"E	08°57'46"N	130
67	11°40'18"E	08°58'20"N	161
68	11°40'32"E	08°58'22"N	160
69	11°40'42"E	08°58'21"N	155
70	11°40'43"E	08°57'42"N	150
71	11°40'31"E	08°57'43"N	158
72	11°40'20"E	08°57'40"N	159
73	11°39'10"E	08°56'11"N	100
74	11°39'30"E	08°56'12"N	107
75	11°39'96"E	08°56'14"N	115
76	11°39'49"E	08°56'30"N	120
77	11°39'30"E	08°56'33"N	118
78	11°39'13"E	08°56'35"N	122
79	11°39'11"E	08°56'13"N	125
80	11°39'32"E	08°56'49"N	130
81	11°39'53"E	08°56'59"N	128
82	11°37'45"E	08°57'17"N	123
83	11°37'55"E	08°56'05"N	119
84	11°37'15"E	08°58'56"N	147
85	11°38'15"E	08°58'56"N	147

The isorad map shows high radiation in Mika and Jason areas and low radiation in southern part of Tagima area. (Fig.7). Likewise the areas with dark colour shows low radioactivity whereas the areas with white colour shows high radioactivity. (Fig.7).This is clearly delineated from the wireframe or 3-D view of the isorad map of the study area showing that the highland areas depict high radioactivity whereas the low lands represent low radioactivity. (Fig. 8).

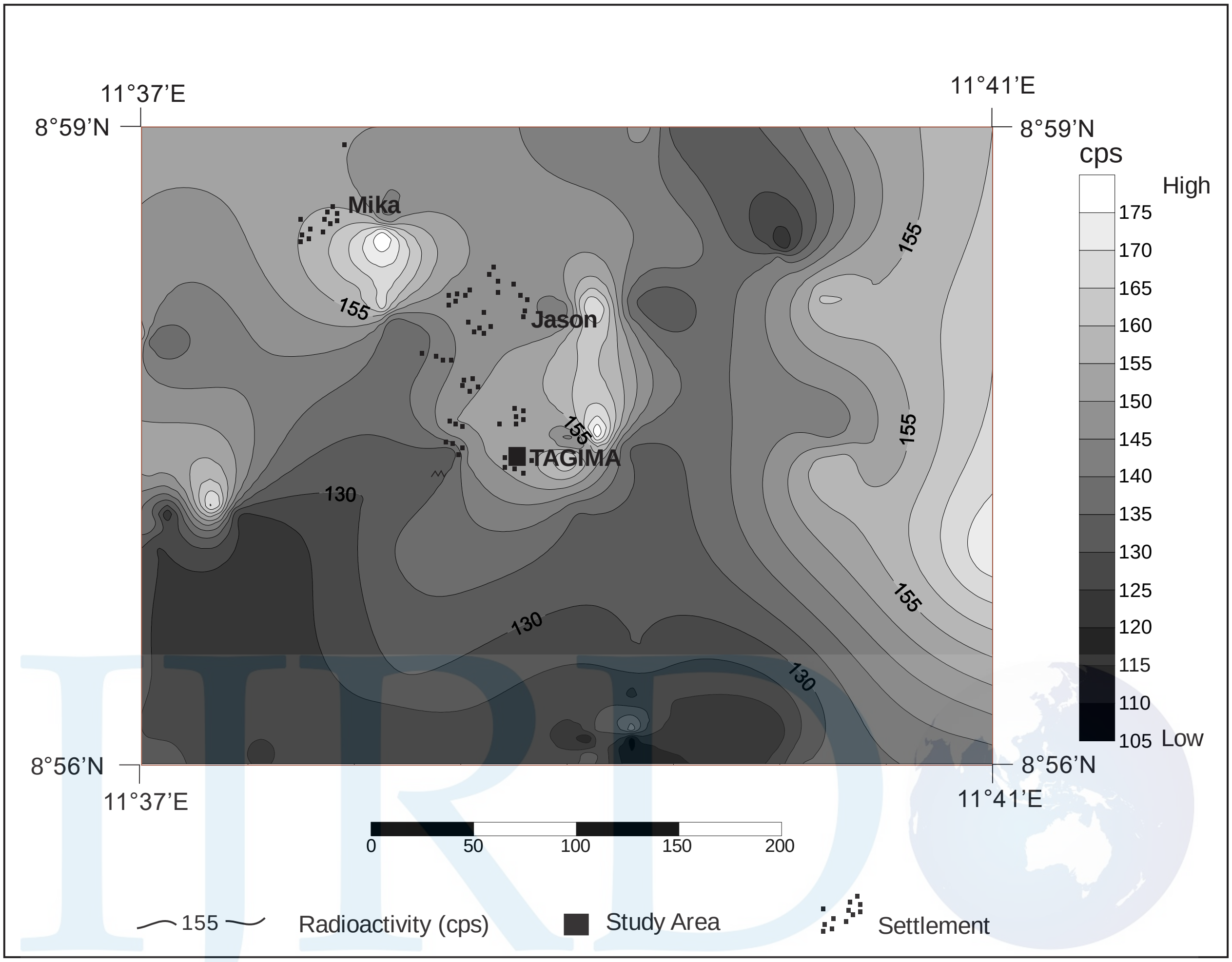

Fig. 7 Isorad map of the Study Area and Environs (Colour fill)

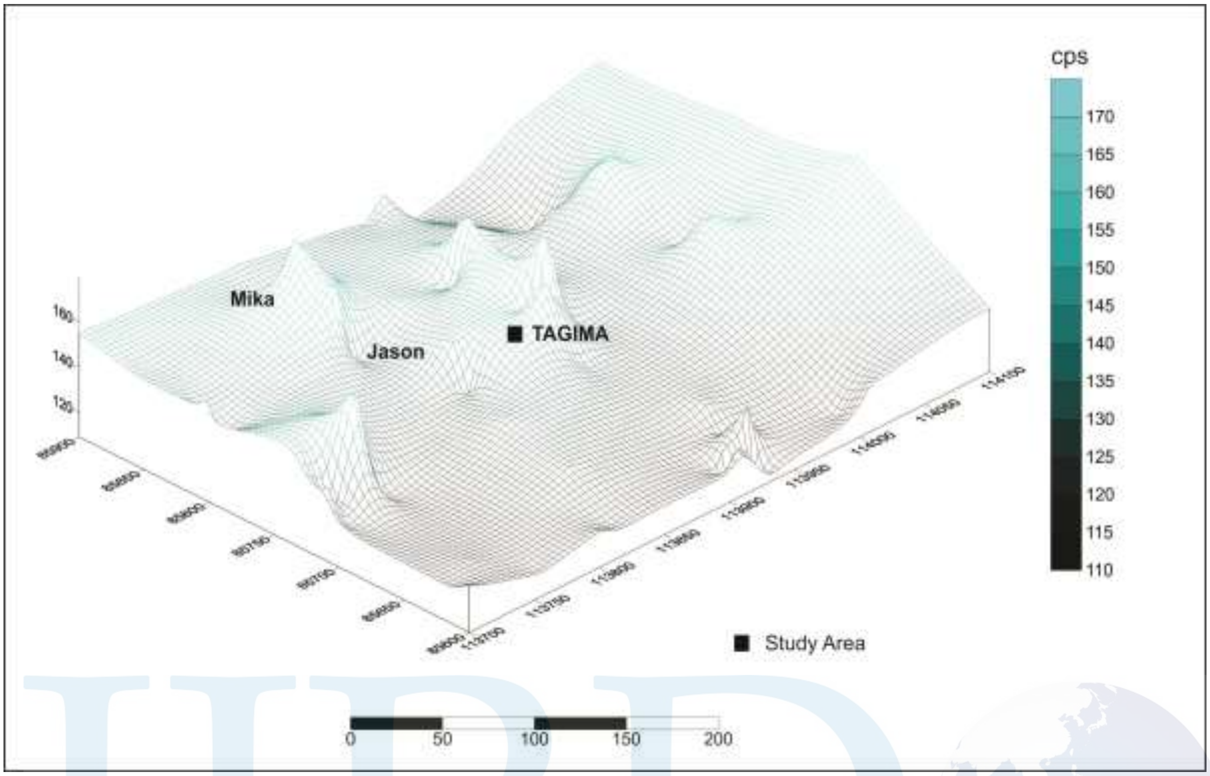

Fig. 8 3-D view of isorad map of the Study Area and Environs

5. Discussion

The research work has shown that the predominant rocks within the study area are granitic rocks namely: the migmatite, porphyritic granite, equigranular granite and pegmatite. They are the major lithological unit in the study area occurring in different textures and in varying proportion of rock forming minerals. High level of magmatic activity perhaps during the Pan-African orogeny have resulted into the granitic intrusions of variable composition and textures, which are evidenced by the different structures found during this research work, such as the joint and faults. The oldest rocks in the area are the porphyritic granites, and this is evidenced by the emplacement or intrusion of granites of coarser textures. The older granite bodies were emplaced during epeirogenic uplift and regional cooling towards the close of the Pan-African Orogeny. McCurry (1976).The chemical and mechanical process of weathering affecting the rocks in the area resulted in the alluvial deposits, which is believed to be the latest events in the area.

The rocks of the area are believed to belong to a suite of Syntectonic and late tectonic granite that marked the intrusive phase of late Precambrian to Early Paleozoic Pan-African Orogeny in Nigeria. The Granitoids of Tagima area probably formed by partial melting of basic rocks (most likely derived from igneous source) in the uppermost mantle and/ or lower crust, as the magma made it way from the zone of generation to the sites of emplacement, it differentiated by progressive fractionation of hornblende, plagioclase, biotite, potassium, feldspar, apatite and zircon minerals leading to compositional and mineralogical variation from granodiorite to the granite. (Haruna et al, 2011, 2014).

Field structural geology investigation of the area reveals the principal structural features as the faults and joints, which are caused by tectonic stresses resulting from fracturing essentially contemporaneously with the tectonic activity, residual stresses due to events that happened long before the fracturing, and surface movements such as downhill movements or rock falls or mountain glaciers (Billings, 1972). The orientations of these structures are mainly NW-SE, and NE-SW directions. These directions show a relation with the regional trend of the Pan-African tectonic activities and indicate impact of the orogenic event.

The mineral composition of the rocks in the study area observed under the petrographic microscope indicates that the mafic mineral such as the biotite and the felsic minerals such as the quartz, k-feldspar and plagioclase as the dominant minerals that constitute the rock units in the area. Haruna, (2014), concluded in his work that the granitoids of the northern Adamawa Massif are I-type, generated in a syn- to within-plate collision-related tectonic setting.

5.1 Radioactive Potentials

The radiometric investigation carried out for the purpose of this research has revealed high radioactive values in northeastern, northwestern and some of the southeastern parts of the study area with about 180-182cps enhanced on the porphyritic granite of Mika locality. Jasori and Tagami areas also show high values of radioactive minerals. The high readings indicate occurrences of radioactive (uranium) mineral deposits in the area. Since previous workers, e.g. Funtua et al, (1999), Suh and Dada (1998), Dada and Suh (2006), reported uranium deposits at Mika, possible extension of this deposit towards Jasori, Tagima and southeastern part of the study area can be inferred. The southern and southwestern parts of the area seem insignificant and indicate low radioactive values with about 100-107cps.

6. Conclusion

Geologic study shows that the area is underlain by porphyritic granite, equigranular granite, migmatite and pegmatite. These rocks are characterized by joint and fault structures. Petrographic analysis of the porphyritic granite, equigranular granite, migmatite and pegmatite showed that the plagioclase, k-feldspars, biotite and quartz are the dominant minerals that constitute the rock units. Hydrothermal alterations of these minerals including hematization, sericitization, silicification and argillization are believed to be associated with the uranium mineralization in the area.

Radiometric survey shows high radiometric values in the northwestern, northeastern and some of the southeastern parts of the area, while lower values are seen in the southern and southwestern parts. Analysis of the results shows high potential for radioactive minerals from Mika deposit towards Jasori and Tagima areas; and to the southeastern part of the study area. While these high anomalous values of radiometric values indicate possible extension of Mika deposits towards Jasori, Tagima and southeast, the south and southwestern areas have very low potentials for radioactive mineralization.

7. Recommendation

Although this work was carried out on a small scale, we recommend that a more detailed petrographic, structural mapping and regional geochemical work to be done in the area. This detailed work when carried out will give more insights on the geochemical distribution of the radioactive elements, and probably locate the radioactive mineral deposits in the area.

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