International Journal of Basic Science and Technology
March, Volume 7, Number 1, Pages 53 - 60
ISSN 2488-8648
http://www.ijbst.fuotuoke.edu.ng/ 53

1 **Megascopic Description of Rock Mineralogical and Textural Characteristics at Kabba Basement Complex of Kogi State, Nigeria.**

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Article Information

Article # 02007
Received: 18th Jan. 2021
Revision: 16th April 2021
Acceptance:2nd May 2021
Published: 5th June 2021

Key Words
Kabba, Basement complex, Structures, Map, Pan-African.

Abstract

This study was carried out at the Kabba axis, northern part of Kogi State, Nigeria, with a view to presenting a preliminary petrogenetic and geotectonic history of the study area so as to determine the field lithologic occurrence and relations, structural features and trends in the rocks exposed in the area. The area was duly mapped and understudied, and a regional map was developed. Field relations of the rock units within the area were determined and field structural measurements taken using Bruton compass clinometer. The main rocks present in the basement complex include migmatite, gneiss, metaconglomerates, banded gneiss, quartzites and quartz-mica schist. In the field, joints, fractures and faults, lineations and foliations were the main structural elements measured, and which revealed the geologic history of the area. It is a basement terrain consisting of different basement rocks. There are four major lithologic units in the study areas. These are: Migmatites, Granite-gneiss, Porphyritic Granite and Garnetiferous Schists. Minor rocks type encountered include: pure quartzite, pegmatite, aplite and quartz veins. The terrain was duly mapped and the main rock types megascopically identified based on field study and relevant literature review.

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Introduction

The Nigerian basement complex is one of the three major litho-petrological components that make up the geology of Nigeria. It forms a part of the Pan-African mobile belt and lies between the West African and Congo Cratons and south of the Tuareg Shield (Reyment, 1965). It is intruded by the Mesozoic calc-alkaline ring complexes of the Jos Plateau and is unconformably overlain by cretaceous and younger sediments. The Igarra-Kabba-Lokoja schist belt is part of the precambrian basement complex of southern Nigeria. It has undergone several episodes of deformation resulting from the tectonism and magmatism. According to Kogbe (1976), the main structure of the Igarra schist belt is an open synform that refolds earlier east-west trending folds.

A barrovian type of metamorphism is believed to have affected the area and metamorphic grade is from green schist to amphobolite facies. The Igarra-kabba-lokoja belt is composed of upper green schist facies metrapellites with interlayered quartzites, marbles and metaconglomerates containing clast derived from the adjacent migmatite gnesis complex (Odeyemi, 1977).

There are various episodes of faulting in the Igarra-kabba-lokoja belt, but notable among them is that which occurred in the shear zone in the Igarra schist belt, giving rise to brecciated rocks of differing sizes and dimensions and led to the development of a host of structural features such as jonts, faults, folds, cleavages, foliations etc.

Although Kabba and other adjoining belts like Igarra, Egbe-Isanlu and Lokoja-Jakura have received considerable study from mineral prospectors, geochemists and economic geologists, such as Kolawole and Olobaniyi (2014), Ekwueme and Ephraim (2005), Elueze and Okunlola (2003), Rahaman (1988) amongst others, due to the unweathered and well exposed outcrops in the terrain, however, only a little has been revealed as regards its structure, lithology, field relations and geochemical controls of mineralization in the area.

In this study, data obtained from geologic field mapping was used to determine the field lithologic occurrence and relations, structural features and trends in the rocks exposed in the area with a view to presenting a preliminary petrogenetic and geotectonic history of the study area so as to provide a tentative discription of rock types found in the study.

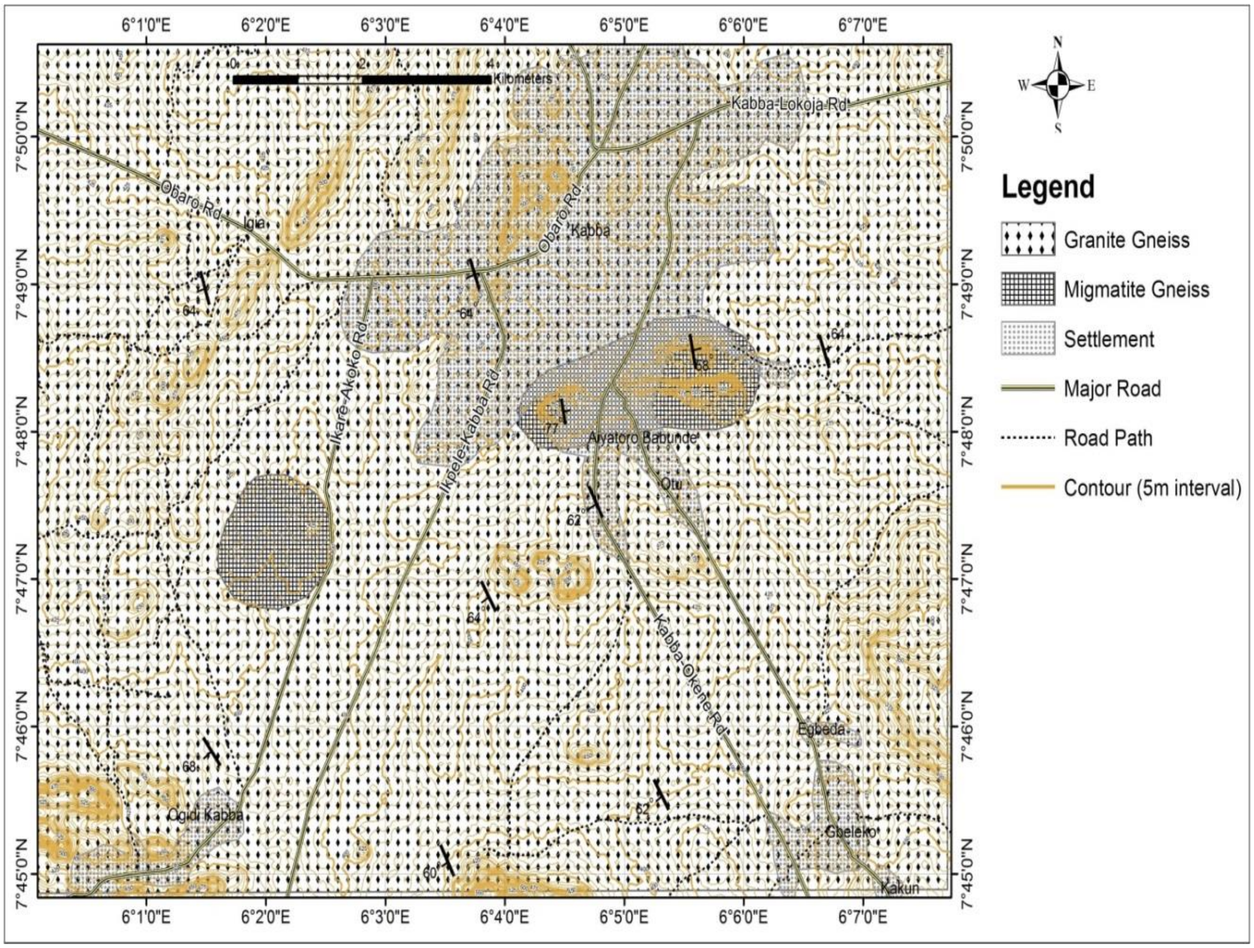
Materials and Methods

Geology of Study Area: The study is located within Longitudes E 006^0 7^1 to E 006^0 75^1 and within Latitudes N 7^0 45^1 to N 7^0 54^1. It is located within the Kabba-Bunu Local Government Area of Kogi State and covers an area of approximately 152.5 km square. It is a basement terrain consisting of different basement rocks. It is located in the northern fringe of Kogi State. It is underlain by Precambrian basement complex rocks, and which extends into Ondo state boundary.

Geomorphology: The plot area is basically characterized by relatively flat terrain with ridges that are gently sloping. The drainage of the area is geomorphically controlled

Vegetation and Accessibility: The study area is principally covered by medium to tall trees characteristic of the Guinea Savannah. However, tall trees locally occur within the banks of rivers. Accessibility was relatively poor considering the lack of major roads within the area.

Field Technique: Reconnaissance survey which is a preliminary field investigation was first carried out followed by a more detailed systematic geological mapping on scale of 1:50,000. This was made possible by employing the use of topographic map (divided into grids to aid mapping and accessibility to different locations) as a guide to the various locations of rock exposures in the study area. Other instruments employed include compass clinometer, cutlass, field note book, ruler, protector, pencils (including colored pencils and markers), hand lens, digital camera, geologic hammer, chisel, sample bags, measurement tape. Observations made on each outcrop include megascopic identification of minerals present in the rock outcrops, mineral composition, texture, degree and pattern of weathering, color of fresh rock surface, and measurement of strike and dip values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Kilometers
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Igia
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Kabba-Lokoja Rd
Ikare-Akoko Rd
Ikpele-Kabba Rd
Aiyatoro Babunde
Otu
Kabba-Okene Rd
Egbeda
Gbeleko
Kakun
Ogidi Kabba
64
64
64
68
62
64
68
62
60
N
W
E
S
Legend
Granite Gneiss
Migmatite Gneiss
Settlement
Major Road
Road Path
Contour (5m interval)

Results and Discussion

Field geologic data obtained from ground geologic mapping was used to produce a geologic map of the study area on a scale of 1:50,000 (Fig 2a). A geologic cross section along the profile AB in the study area is shown in Fig. 2b. The rocks mapped from the area can be classified into two main suites, namely: the gneiss-schist suites and the Intrusive
suites. The gneiss-schist suite refers to the metamorphic tectonites includes migmatite gneiss, migmatized schist, quartz mica schist, quartzites and metaigneous bodies which form the host rocks into which undeformed to partially deformed granitoids intrude. This suite accounts for about 65% of the study area and is believed to be the northward continuation of the Igarra schist belt (fig 1). The intrusive suites form prominent topographic features at the western and south-eastern corner of the map area. These granite plutons are mainly composed of fine to medium grained granite granodiorite, porphyritic granites, garnetiferous granite and foliated granite. They are associated with dolerite, pegmatite and aplite veins.

Description of the Major Rock of the Study Area

Migmatite: This rock types have a wide occurence in the plot area. It is the major basement rocks in the plot occupying about seventy percent of the plot. The migmatite dips in both SW directions and NE directions, suggesting a regional folded structure. The rock is a mixed rock of both igneous and metamorphic rock. The igneous material is of granite composition and the metamorphic is characterized by a banded appearance, often accompanied by evidence of plastic deforemation. The theories for the origin of migmatite include the idea that their igneous material is as a result magma intrusion. In most cases, migmatite appear to represent the most extreme case of metamorphism in which the component of gneiss starts to melt. Best (2003), summarized the origin of migmatite as follows: (1) through local partial melting and segregation of minimum temperature-composition melt that solidify in place within the morerefractory host rocks, (2) injection of small volumes of felsic magma from external soure, or (3) subsolidus metamorphic differentiation.
The older part of the rock is known as the paleosome, which in most cases is made up of gneiss material. The younger/later component is called neosome which are normally granitic in composition. Migmatite consists of mafic metamorphic rock mingled with felsic rock in the form of planar to folded and contorted layers, crisscrossing veins and irregular pods, best (2003). Typical migmatite structures such as folded structures, prygmatic structures, also occur. Joints are also a common feature within the migmatite.

Banded Gneiss

This is a coarse-grained irregularly banded crystalline rock with poorly defined schistosity and having grain size of about 2-3mm. According to Bafor (1981), banded gneiss often contains alternating bands of light quartzo-feldspathic minerals and dark ferromagnesian minerals (mica, amphibole and pyroxene). The thickness of the bands is variable. Gneiss displays compositional banding where the minerals are arranged into bands of more mafic minerals and more felsic minerals. This is developed under high temperature and pressure conditions.

Granite Gneiss

This rock constitutes about 15% of the lithologic unit in the plot area. They are gneisses that are granitic in composition. They are part of the migmatite gneiss complex except that have not been as severely deformed as the migmatite. It consists of alternate bands of light and dark colored minerals. It is highly foliated with texture ranging from medium to coarse grained. From megascopic studies, the leucocratic band is made up of a white or clean mineral with a vitreous lustre and conchoidal fracture suggestive of quartz and a mineral with pinkish coloration and distinct cleavage planes suggestive of k-feldspar. The dark band is dominated by dark colored minerals with a characteristic's basal cleavage flaky and shiny appearance suggestive of biotite. From field studies, tentatively named as a granite gneiss.

Granitiferous Schist (Granite-Schist)

This rock type occurs locally within the plot constituting only about 5% of the major lithologic unit. The rock is megascopically a crystalline foliated metamorphic rock characterized by a typical schistose structure. The rock is made up of alternation of dark and light-colored band with the band having some general thickness of some mm-cm. From megascopic studies, the light-colored band is basically made up of white or clear minerals with vitreous lustre and conchodial fracture suggestive of quartz while the dark band is dominated by dark minerals with a characteristic's basal cleavage, flaky and shiny appearance, suggestive of biotite. But in addition to these minerals, there is also a preponderance of a distinct kind of mineral within the rock. This mineral is reddish brown in color, has no cleavage, and tends to occur in perfect equidimensional crystal usually 12-sided. The rock is then tentatively named as granitiferous schist.

Porphyritic Granite
These rock type occur within the western border of the plot area constituting only about 10% of the major lithologic unit. It intruded the migmatite-gneiss complex and occur as hills with low lying exposure as well. The rock is thought to be of pan-African age believed to have intruded the migmatite-gneiss complex during the pan-African orogeny (600±150Ma). The rock is set to have a porphyritic texture because relatively large crystals (phenocrysts) are embedded in a finer-grained groundmass. The phenocrysts are made up of pinkish minerals with distinct cleavage planes suggestive k-feldspar and white or clear minerals with vitreous lustre and conchoidal fracture suggestive of quartz. The feldspar crystals are larger than the quartz. The feldspar crystals are larger than the quartz crystals with dimensions of about 1 cm by 2 cm. The groundmass is essentially made up of dark minerals with a characteristic basal cleavage, fleaky and shiny appearance suggestive of biotite and dark minerals which tend to occur as needle-like or elongate crystals with vitreous to dull lustre suggestive of hornblende. Because the rock is granitic in composition and porphyritic in texture, the rock was tentatively named porphyritic granite.

Quartzites
Quartzites were seen to be randomly distributed within the mapped area and they overlie the migmatite-gneiss, and the varieties of quartzite encountered are massive, milky, smoky, sugary, ferrugineous and schistose quartzites. They are monominerallic, and composed mainly of quartz. They are formed from metamorphism of sandstone with the individual quartz grain recrystallizing along with the former recrystallize material to form an interlocking mosaic of quartz crystals when subjected to intense increase in temperature and pressure usually related to tectonic compression associated with tectonic belt (Odeyemi, 1976). Minor amount of former cementing materials; iron oxide, silica, carbonate, often migrate during recrystallization. The rock was mainly red to grey with varying amount of iron oxide (Fe_2O_3). The quartzites have varying textures from equigranular, medium grained to coarse-grained. The varieties of quartzites are closely related that, often, it is impossible to indicate them as separate units on the map. The quartzites consist of mainly quartz which is usually more than 70% with minor amounts of interlocking grains of biotite and orthoclase.
The massive quartzites are not foliated but hard and are compact, the schistose quartzites are foliated and exhibit alternations of felsic mineral such as quartz and mafic mineral such as biotite with planar fabric. The milky ones have milky appearance by inspection and developed slickenside surfaces with specks of muscovite. The smoky ones are formed by different oxidation states of iron in the crystal lattices of the rock or due to impregnations of some transition elements during the rock formation. The sugary ones have granular textures and are friable when struck with hammer. The ferruginous types are rich in iron. Structurally, some of the quartzites are jointed, while others are foliated.

Description of the Minor Rock Types.

Pegmatites
Pegmatites which compose of k-feldspar and quartz occur as dykes and are widespread throughout the study area. They occur alongside the migmatites as part of the migmatites-gneiss complex. They have pinkish colouration. It is very coarse grained due to its quartzo-feldspathic composition. The well-formed crystals of feldspars are elongated in some outcrops. The mineralogy is mainly quartz and k-feldspar, with little biotite and muscovite. Its thickness varies from 0.8 to 12cm and it developed a chilled margin along the contact with the country rock. It is granitic in compositionThe pegmatites associated with the migmatite basement are conformable but they are commonly cross-cutting and they also occur as pockets. Some orthoclase crystals within the pegmatites have dimensions as high as 10 cm by 5 cm.

Quartz Veins: Quartz veins and lenses occur in all the major rock types of the basement complex encountered in the study area. They are small, varying in thickness from a few millimeters to about a meter. They show great irregularities in their form and are seen in places to thin out or widen. Some veins are conformable within their host and many have been involved in the tectonism affecting the host, while most are discordant with respect to the host.

Pure Quartzite: This rock type occurs locally in the study within the migmatites. They tend to occur mostly at the top of the migmatite ridges from where they are rolled down the slope. They essentially occurred as pockets of quartzite and are thought of as thermally metamorphosed rocks.

Aplite: Aplite is widely spread within the study area. They are igneous rocks of granitic affinities. They are light colored, fine-grained rocks having the same mineralogy as granites, although biotite is rarely, if ever, present. Aplite has a relationship with the pegmatites as they commonly found in association in the field, occuring as dykes or veins. Whereas a pegmatite forms from a residual magma rich in volatiles, an aplite forms from a residual magma low in volatiles, thus promoting fineness of grains. Aplites have a characteristic sugar texture or appearance. According to Richard and Frank (1963), aplites and pegmatites have long been recognized as texturally contrasting rocks whose composition and features of occurrence bespeak close genetic affiliations. They also pointed out that at thousands of localities throughout the world, aplites and pegmatites are so intimately associated in both space and time that derivation from a common stem seems plainly indicated.

Geologic History: Based on the field relationship observed, the major lithologies in the study area can be represented in the following geochronological order from the oldest to the youngest: Migmatite >> Granite Gneiss >> Porphyritic Granite

The migmatite-gneiss complex is thought to have resulted from a complex association of deformative shearing and folding, and granitization and migmatization processes with a final episode of acute erosional activities. After series of metamorphic events, there was a period of magmatism which ultimately led to the intrusion of the granites into the metamorphic rocks about 600 ± 150 million years ago (Pan African Orogeny). This makes Granite the youngest rock in the area. Rahaman (1988) stated that two phases of folding believed to be related to the older granite orogeny (Pan African) have been described as affecting the migmatite-gneiss complex.

Structural Geology

Faults: Faults are planes showing relative displacement. There are little direct evidence of faults found in the study, due to weathering. Variety of marker-bands occur indicating displacement. According to Wikipaedia, a fault in other words is a planar fracture or discontinuity in a volume of rock, across which there has been significant displacement along the features as a result of earth movement. Girty (2009) described faults as surfaces across which Earth material has lost cohesion and across which there is perceptible displacement Large faults within the Earth's crust result from the action of tectonic forces. Energy release associated with rapid movement on active faults is the cause of most earthquakes. Also, there is probability of intense faulting associated with the main period of tectonic activity prior to metasomatism that produced the granite-gnesis and even the migmatite. Fault trends on the western side trend mainly west of north. The amount of displacement ranged from about 8cm to 52cm and the orientation of the fault planes within the study are as follows 82^0, 358^0, 68^0, 188^0, 170^0 and 188^0.

Folds: This is formed when a rock responds to stress in a ductile way.i.e. formed by ductiledeformation. Micro fold was seen in the quartz mica schist and the migmatite. This term 'fold' is used in geology when a stack of originally flat and planar surfaces, such as sedimentary strata, are bent or curved as a result of permanent deformation. Rocks found in study displayed various types of minor folds, with varying shapes, fold tightness, fold symmentary etc. A total of 27 axial plane directions of the folds were taken in the field, and the geostatistical analysis of the fold axis obtained is ;Fold axis orientations: 2^0, 2^0, 4^0, 4^0, 4^0, 6^0, 6^0, 10^0, 12^0, 15^0, 16^0, 19^0, 24^0, 26^0, 28^0, 36^0, 43^0, 58^0, 90^0, 120^0, 154^0, 157^0, 158^0, 160^0, 164^0, 178^0, 179^0. Thus; Range = 179 – 2 = 177^0 ; Interval width = 177/9 = 19.88 i.e 20

Class limit	Frequency	Fractional frequency	% r frequency
2-22	11	0.41	41
23-43	5	0.24	24
44-64	1	0.048	4.8
65-85	0	0	0
86-106	0	0	0
107-127	1	0.048	4.8
128-148	0	0	0
149-169	7	0.33	33
170-190	2	0.095	9.5
Total	27	1	100

Table 1: Showing Distribution of Fold Axis Direction within the Study

The table above shows that the major trend of the fold axis lies between the range of 2^0 – 22^0, 23^0 – 43^0 ... and 170^0 – 190^0 direction; and which is indicative that the direction of maximum principal stress which is perpendicular to the fold axis lies in the Northwest to Southeast direction.

Pinch and Swell: This structure was also observed on some of the gneiss rock body in the study, and which were formed as a result of the difference in the competence of the psammitic and pellitic bands with the psammitic bands being more competent. They are formed when relatively strong layers of rock are stretched and become elongated during deformation. They may separate into blocks or pillow-shaped structures separated by narrow necks. The process of elongation that produced boudins is called boudinage. Where the separation is incomplete and the layers show a narrowing or "necking", the structures are often termed pinch-and-swell structures.

Boudins are particularly useful as indicators of the directions of extension in very intensively deformed rocks.

They occur if there is a low ductility contrast between the competent and incompetent rocks. This structure is formed as a result of difference in the mechanical strength of rocks it is defined by pegmatite vein that has reacted competently relative to the enclosing rock to form an incompetent boundinage. The vein is necked but not broken through.

Hydrogeology of the Area: Hydrogeology involves the quantitative distribution and quality of surface and groundwater. The surface water present in the area are seen to take off usually from the basement areas and generally increases their volume downstream. Major rivers and streams that occur in the area are structurally controlled by the rocks underlying the terrains, moreover, they tend to flow in the direction of strike.

The basement rocks like migmatites, quartz-biotite-shist, granite-gnesis etc are compacted and crystalline hence they do not possess pores (are not porous), and so cannot be water bearings. They do not have Primary Porosity. However, they can store water when fracture systems occur in them forming Secondary Porosity which house water temporarily. If these fractures system are interconnected, the water from nearby rivers and streams can flow through these fractures and comes out of the rocks to the surface springs. The fractures and joints networks within the rocks encountered are sources of springs. Water can also occur in the basement when hydrous minerals like micas lose their water of crystallization due to increasing temperatures.

Engineering Geology of the Area

This is a branch of geology that is related to engineering. Engineering structures such as roads, buildings, bridges, dams, telecommunication mask, drainage systems, embankments e.t.c are normally erected in the lithosperic part of the part of the earth. To avoid the failure of these structures, geological structures like faults, joints, folds, fault and shear zones, fractures etc must be put into considerations before these are built.

Some engineering structures found in the area are:

Roads and Roads Cuts: These are engineering structures that are built on the top soil. Blasted rocks are usually lain on the soil before coal tar are laid on it. They are built for accessibility between different areas.

Crystalline rocks such as granite-gnesis are used.

Building:Granite-gnesis and Quartzite are employed in building of houses. Foundation depths varies for the stability of the structures being those founded on crystalline basement rocks that are indurated in sequence. They are used as settlements in the area.

Bridges: Concretes made from rocks like granite-geisses and migmatites are used in the construction of bridges which provide access to otherwise non-accessible areas.

Conclusion

The study area embarked on is made up hard rock types and are part of the basement complex, since Nigeria is divided into the basement complex and the sedimentary terrains. The basement is composed of 'hard rocks' while the sedimentary terrains are basins for the formation of 'soft rocks. However, in this report, the rock types observed in the study area have been categorized into major and minor rocks as shown below: The Major Rock Type: these are rocks that are mappable due to their extensive occurence, and they make up to 80% of the plot area, they are granite-gneisses, migmatites and porphyritic granite .The Minor Rock Type: These rocks occured in very small amount. They constitute about 20% of the study area. They include aplites, quartz-veins and pegmatites, and pure quartzite.

The views expressed here are solely based on field observations backed up by literatures. Therefore, only a tentative description of rocks are given as they are based on megascopic field observation without thin section. Also, the age sequence of rocks highlighted here is based on field relationship with the help of relevant literature reviews, and of which the views held are tentative and are subject to further research in the light of new information in our technologically advancing age.

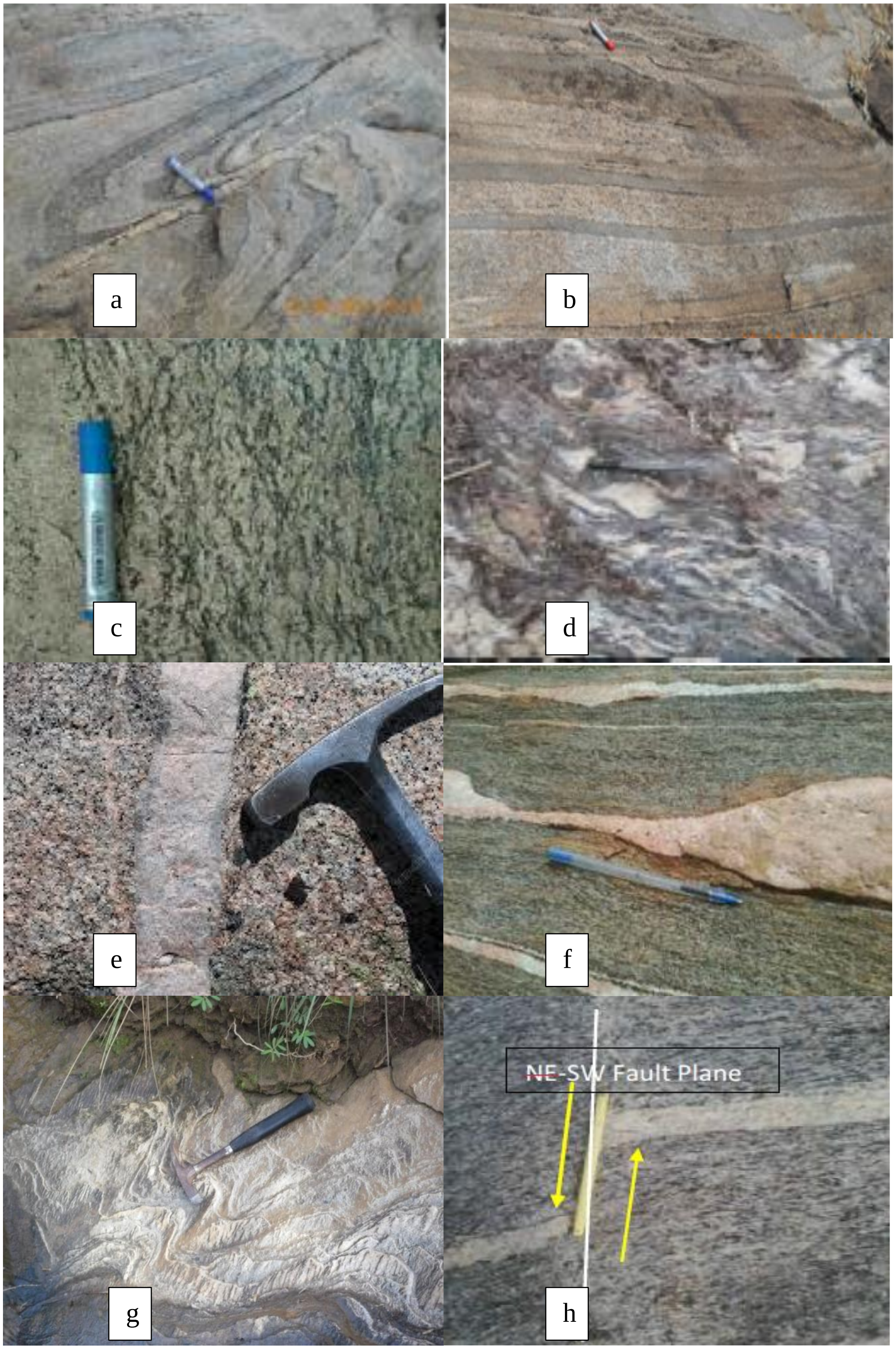

Figure 2: (a) Migmatite (b) Banded gneiss (c) Granite gneiss (d) Granitiferous schist
(e) Aplite dyke on a granite bedrock (f) Pinch and swell (g) Folds in gneissic rock (h) fault

Acknowledgement
Authors wish to acknowledge Professor Emofurieta, W.O. for his immense help of instructions and guidance to ensuring a successful field excessive.

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