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ORE PETROGRAPHY AND STRUCTURAL LINEAMENT OF THE MIGMATITE-GNEISS AT TSAUNI AREA, NORTH CENTRAL NIGERIA

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Abstract

The studied area covers about 50^2km and lies between Longitude 06°55'45" to 06°59'15"E and Latitude 09°7'05" to 09°11'10"N of Paiko Sheet 185 (SW). Tsauni is part of the Basement Complex of Nigeria situated within Gwagwalada in Abuja FCT. Structural trends on the rocks suggest control from some deep – seated basement structures. Mineral suite identified include quartz, feldspar, biotite, minor amphibole, pyroxene, calcite and muscovite with accessory epidote, allanite, zircon, titanite, monazite and apatite for the metagranitoids while clinopyroxene, biotite, magnesiohornblende, actinolite, calcite, chlorite, epidote and wollastonite with accessory REE bearing monazite, allanite, apatite and titanite which selectively occur in the skarn. Ore petrography of twenty (20) samples, microprobe and XRD analyses of barren and mineralized samples reveal mineralization to include Pb –Zn, Fe and associated magnetite, Au, Ag, ±Ba and Cu within the skarn while magnetite-ilmenite with minor sulphides, Au, Ag and Ba occur within the metagranitoids. Skarn and vein mineralization in both the skarn and metagranitoids show evidence of open space fillings, replacement and deformation textures. Structural trends of the rocks occur in the NE-SW and NW-SE directions.

Keywords: Basement complex, Ore, Petrography,Sulphides, Mineralization, Tsauni.

Introduction

The study and record of occurrence of lead-zinc and associated mineralization in Nigeria was restricted to the Cretaceous sedimentary rocks until a renewed exploration work for mineral deposits spear headed by the Nigerian Geological Survey Agency (NGSA) triggered a new interest and search within the Basement Complex beginning from the millennium (MMSD, 2000; Dada et al, 2015). Most interesting is the fact that these host

Basement Complex include rocks that are cross cut by pegmatite and granitic intrusions which have resulted to the development of calc-silicate rocks/skarns and skarn deposits (Chiarenzelli, 2019; Hammarstrom et. al., 2003).

Several studies on base metal sulphide and related mineralization within the Basement Complex and associated skarn and skarn deposits have been ongoing across the globe from the past and in recent times. Such studies have proved successful in understanding the relationship between vein-dyke and skarn mineralization in places like New York, Turkey, Czech Republic, Iran, Iraq, China and Norway among other places (Yücel-Oztürk et al., 2005., Drahota et al., 2005., Al Jaboury et al., 2018). Babban Tsauni ores stand out as a classical example for poly metallic, lead-zinc and related mineralization within the Basement Complex because of the significant occurrence of the primary ores in structurally controlled vein-dykes and fractured/sheared calc-silicate rocks around shear zones that favour the formation of skarns. Skarn deposit include major Pb-Fe, and minor Zn, Cu, Ba, Au and Ag. The Babban Tsauni area and environs have two major lead-zinc and alluvial gold and other associated mineral mines located to the north east and south west of Tsauni town. Iron ore (magnetite is significant in both areas).Major and minor pegmatite intrusions, hydrothermal quartz and mineralized veins aligned in a NE-SW, NNW-SSE, N-S and NW-SE directions host the vein-dyke mineralization. Disseminated ore minerals are also important. Skarn Pb-Zn-Fe and associated deposits occur within the mineralized calc-silicate gneisses and minor carbonate rich rock intercalations towards the north eastern part. The south western mineralization is hosted within the augen (porphyroblastic) gneiss and migmatite and include ore minerals such as lead-zinc, gold, magnetite and minor copper (Fig. 1). This research paper deals with ore petrographic descriptions and structural lineament of the minerals in the granitic rocks of the studied area.

Geologic Setting

The rocks of the area consist of gneisses, schist, quartzite, marble, migmatites and granites (Fig. 1). The mapping of Babban Tsauni area shows the existence of two types of gneiss (biotite gneiss and banded gneiss). Field relation shows that granites postdates the schist (Plates 1 and 2). The presence of schist Xenolith is an excellent signature on the age difference between the schist and granites. The proportion of the rocks at the study area varies.

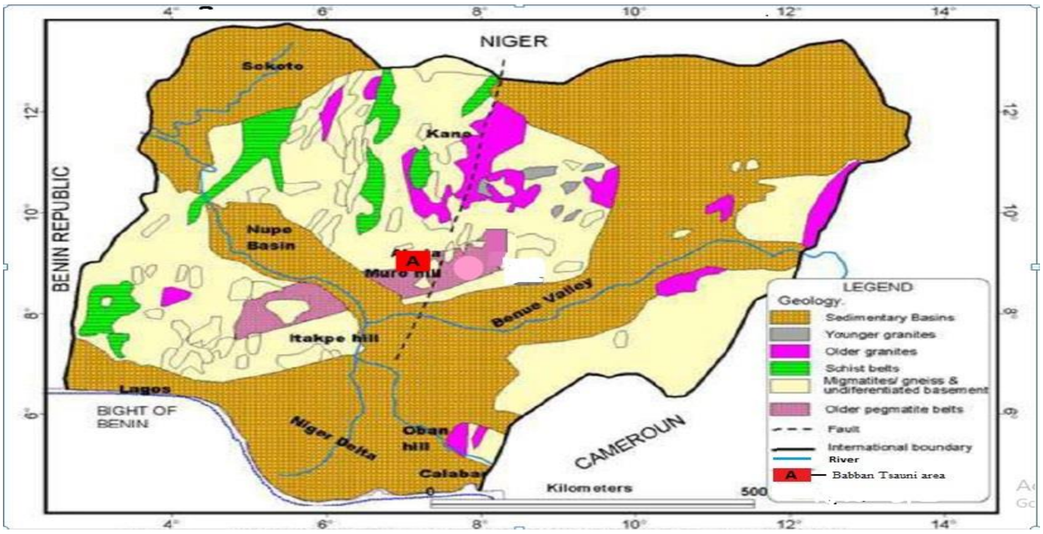
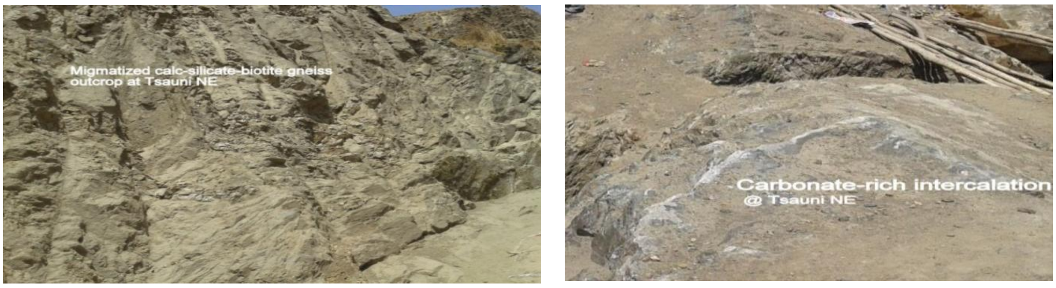


Fig. 1: Outline Geologic map of Nigeria showing the study location.

a. b.

Plates 1 (a - b): Mineralized vein cross cutting a migmatized calc-silicate (skarn) and trending NNE-SSW in the north eastern part of the study area.



a. b.

Plates 2(a - b): out crops of migmitized calc-silicate (amphibolite bearing gneiss) and carbonate - rich intercalation in the study area.

Materials Methods

The area is about 10km south-west of Izom town in Niger State and can be accessed through a minor road linking Gwagwalada- Dobi and Izom towns (Fig. 1). Twenty (20) samples of granitic rocks were randomly collected at the field and examined. The thin section of the rocks was carried out at thin section Lab of Geology and Mining department, University of Jos. The rocks were cut using cutting machine. The cut out rocks sample were polished on a flat surface that contains corbonrandum mixed with water. The rock samples were polished to a thickness of 0.033m so that polarized light can pass through it. The glass slides were slightly polished as well in order to create rough surface on which the rock slide will be glued.

Araldite gum was placed on the glass slide and the rock slice is gummed to it. The slide is placed on a hot plate in order to dehydrate any water or bubble which may have trapped during the slide preparation. The optical properties of the rocks were determined using a petrological microscope.

Under petrological microprobe and XRD analyses of barren and mineralized samples reveal mineralization to include Pb –Zn, Fe and associated magnetite, Au, Ag, ±Ba and Cu within the skarn while magnetite-ilmenite with minor sulphides, Au, Ag and Ba occur within the metagranitoids.

Results and Discussion

Under the microscope, the gneisses, migmatite, pegmatite, granite and skarn of the study area displayed consistent mineralogy and near similar texture across individual or separate rock units.

Ore Petrography

The Olympus Ortholox (polarizing) reflected light microscope was used to study the optical properties of the ore minerals using their physical properties. The optical properties studied under PPL (without analyzer) include colour, reflectivity, bireflectance or reflection pleochroism.

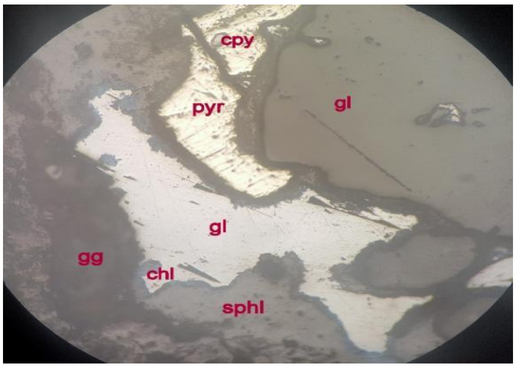


Plate 3: Photomicrograph showing the primary ore minerals in the area. Pyr = pyrite, gl = galena, sphl = sphalerite, gg = gangue, chl = chalcocite. Note replacement of galena by chalcocite at the edges of galena (ppl x400µm).

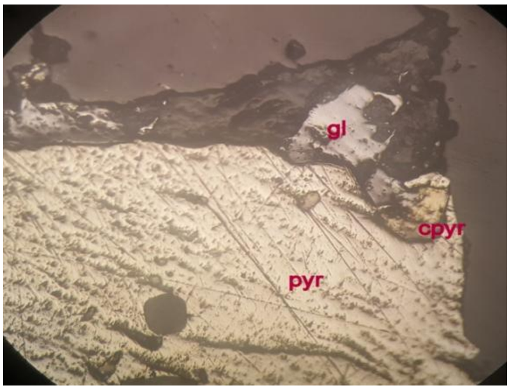


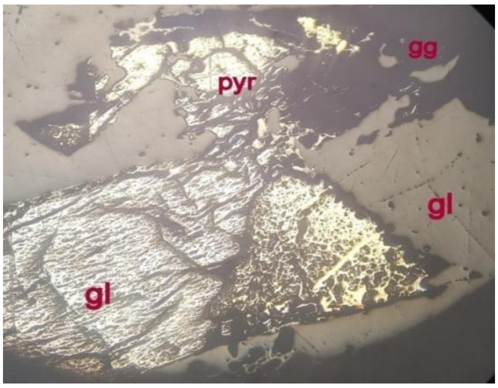
Plate 4: Photomicrograph of galena, pyrite and chalcopyrite in the area.pyr = pyrite, gl = galena, cpyr = chalcopyrite (ppl x400µm).

Plate 5: Photomicrograph showing galena at the area.gl = galena, gg = gangue. Note the replacement at the edges of galena by secondary minerals which include cerussite, anglesite, chalcocite and malachite (ppl x1.25µm).

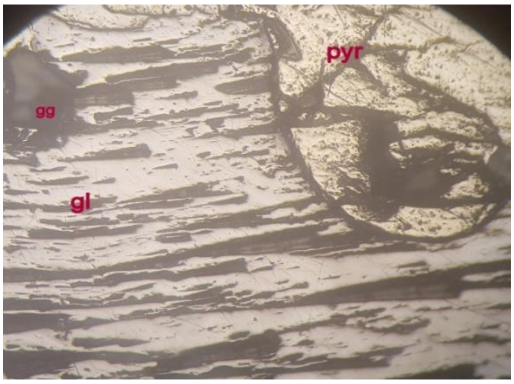
Under xpl (crossed nicols), internal reflections, phase differences, isotropism/ anisotropism etc are studied. The physical properties studied include cleavage, zoning, crystal form/ shape and boundary relationships (Craig, and Vaughan, 1994). Major/ primary ore minerals identified include sulphides such as galena, pyrite, sphalerite and chalcopyrite. The accessory oxide is primarily magnetite and accessory gold. Secondary minerals include cerrusite, barite, anglesite, chalcocite, malachite and goethite. Gangue minerals are mostly calcite and quartz. (Plates 3-5).

Galena (PbS)

This is the principal ore mineral in the area. Crystals of galena are generally white to light grey in colour showing the characteristic angular pit cleavage in poorly polished sections. Galena in the study area is anisotropic to weakly isotropic and generally anhedral to subhedral in shape. Grain boundary and textural relationships reveal that it postdates the pyrite and chalcopyrite (Plates 3 and 6). Curved texture of some cleavage planes in galena as seen in Plate 6b is considered a result of deformation and/or as result of the presence of silver in galena thereby, distorting the galena structure (Craig and Vaughan, 1994; Hobart, 2005). At least two generations of galena deposition occur in the area, 'an early anhedral to subhedral galena intergrown with sphalerite in most cases and a late galena vein lets that cut across early formed galena pyrite and sphalerite (Plate 6).



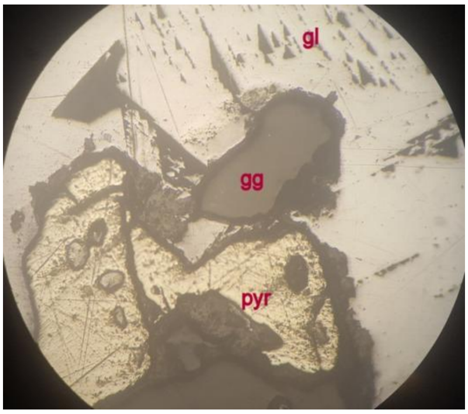
a



b

Plates 6 (a-b): Photomicrograph showing late galena vein lets cross cutting early galena and pyrite gl = galena, pyr = pyrite, gg = gangue Note the early galena replacing pyrite at centre top. b: Photomicrograph showing Pyrite within galena gl = galena, pyr = pyrite, gg = gangue. Note the slight curving of the galena cleavage planes indicating deformation or the presence of silver which distorts galena structure, a characteristic of "argentiferous galena" (ppl x400µm).

The early forms are mostly anisotropic. Alteration of galena into cerussite is seen in one section but not common in the area. Skeletal and blebs of galena seen in pyrite is probably indicative of early sub- euhedral forms trapped within the earlier pyrite during the deformational events that produced the late formed galena vein lets or may be exsolution features (Plates 7a and b). The early formed galena are probably pre kinematic galena indicating its formation before the deformational events that introduced the minerals. Pseudomorph galena that has totally replaced pyrite thereby taking the shape of the original cubic pyrite porphyroblast also occur in the area (Plate 8) indicating deformation during metamorphism activities related to the ore minerals (Craig & Vaughan, 1994).



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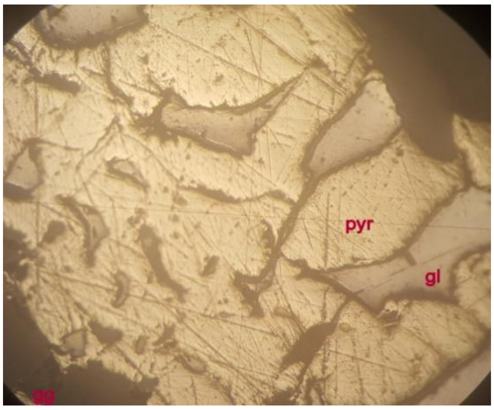


b

Plate 7 (a-b): Photomicrograph showing galena and pyrite gl = galena, pyr = pyrite, gg = gangue. Note blebs of galena within pyrite. Plate 44: Photomicrograph of skeletal (thick lamellae) galena in pyrite gl = galena, pyr = pyrite, gg = gangue (ppl x400µm).

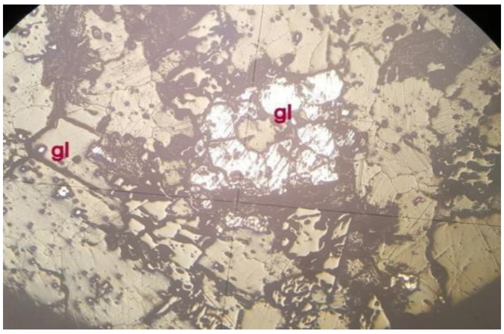
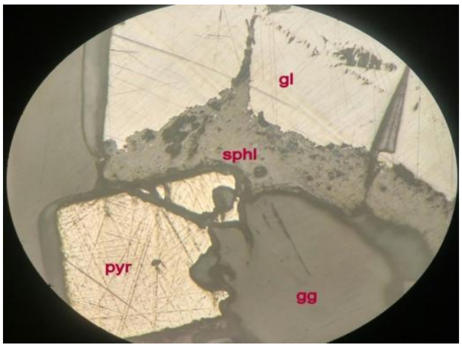


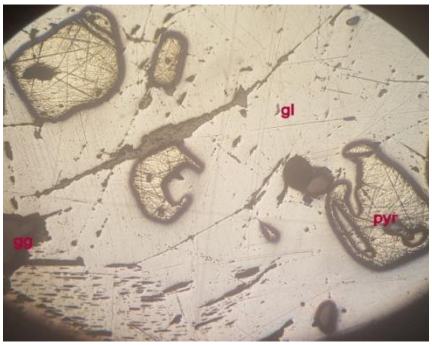
Plate 8: Photomicrograph showing deformed galena and pyrite. gl = galena, py = pyrite. Note the pseudomorph (cubic) galena crystal (whitish) that has totally replaced the original cubic pyrite (yellowish) leaving an atoll feature of the latter at the centre (ppl x400µm)

Pyrite (FeS)

This appears to be the oldest formed ore which continued into the late stage mineralization. Characteristic cubic shape is preserved. In some samples pyrite occur as early framboidal –anhedral to late subhedral- euhedral crystals which are mostly cubic and concave in shape (Plates 6b and 9a). Skeletal pyrite crystals that represent the earlier formed generation within the associated ore minerals also occur (Plate 9b). Colour is light yellow and rare white. In the skarn, pyrite is commonly replaced by magnetite in some samples indicating that the oxide is a later growth.



a.

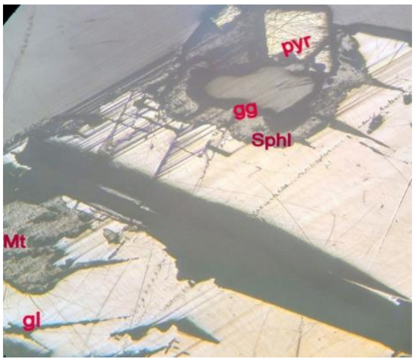


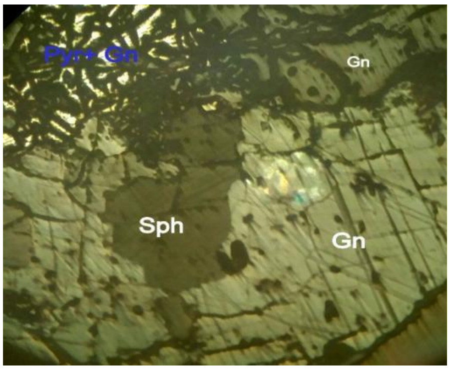
b.

Plates 9 (a-b): Photomicrograph showing pyrite-galena-sphalerite gl = galena, pyr = pyrite, sphl= sphalerite, gg = gangue. Note the well-formed euh.edral pyrite cube as an indication of early formation with respect to the associating galena-sphalerite intergrowth. 9b: Photomicrograph showing early pyrite within galena gl = galena, pyr = pyrite, gg =gangue. Note the concave, pentagonal and rectangular shapes of pyrite within galena which are indicative of pre kinematism in which the pyrite probably formed before the later event that introduced the galena. The kettle shape at center right hosts a galena lamella probably suggestive of the flow of the latter into the pyrite before the "kettle tear" was sealed (ppl x 400µm)

Sphalerite (ZnS)

Sphalerite in the study area is not very common compared to galena and pyrite. It's usually occurs in association with galena and generally appear as dark grey coloured mineral in the photomicrographs of the studied ore minerals with moderate to strong internal reflection (Plates 10a - b). Sphalerite-galena association in the study area indicate that the former is younger. Some samples show galena – sphalerite intergrowths being cut across by later veinlets of galena (Plates7a and b). Alteration of sphalerite in the area into smithsonite ($ZnCO_3$) is uncommon.



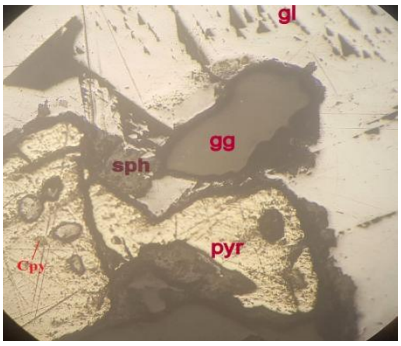


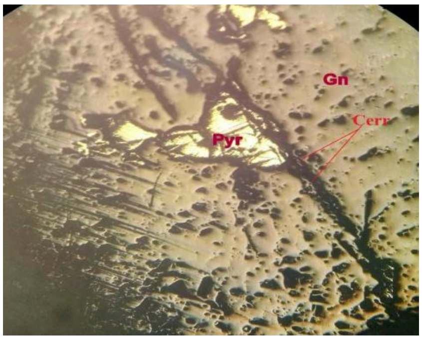
a b

Plate 10a-b): Photomicrograph showing sphalerite- galena- sphalerite – pyrite association. gl=galena, sphl=sphalerite, pyr = pyrite, mt = magnetite, gg= gangue. Note sphalerite (dark grey) at the boundary of pyrite (light yellow) and gangue all within galena (ppl x400µm). 10b: Photomicrograph showing sphalerite- galena association. Note sphalerite (dark grey) "injected" into the galena (whitish) indicating that it is younger. Equant pyrite and galena grains occur at the upper left side of field of view indicating brecciation (xpl x 400µm).

Chalcopyrite ($CuFeS_2$)

Chalcopyrite is the least common primary ore mineral in the study area and occurs at the boundary of pyrite. It also occurs as inclusions within pyrite and/or galena which are probably exsolution textures from the host mineral(s). Chalcopyrite occurs as yellow coloured mineral and generally anhedral in shape. Small blebs and lamellae are common (Plates 11a and b).





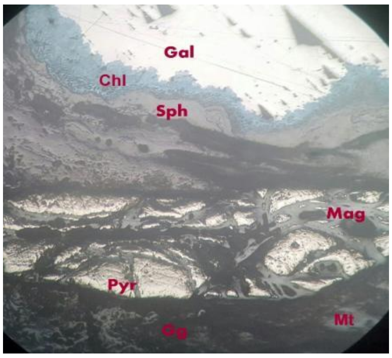
a b

Plate 11a-b: Photomicrograph showing chalcopyrite-galena inclusions in pyrite gg = galena, pyr = pyrite, cerr = cerrusite, cpy = chalcopyrite, gg= gangue. 11b:

Photomicrograph showing exsolution texture of chalcopyrite in fractured pyrite – galena. pyr = pyrite, cerr = cerrusite, cpy = chalcopyrite, gn= galena (ppl x 400µm)

Magnetite (Fe_3O_4)

This is an important ore of iron. It is ferromagnetic and occurs commonly as a major accessory oxide mineral in skarns. It is also an important accessory component in some gneisses of the study area. It is generally grey in colour with a bluish tint. Magnetite in most samples collected appear to be replacing pyrites in an anastomosing/dendritic pattern (Plate 12a). The magnetite crystals generally show colloform texture and zoning which may represent a change in the composition of the mineralizing fluid. (Plate 12b).Magnetite in the study area occur in association with Ilmenite and less commonly with rutile. Other secondary ore minerals of importance in the area include anglesite, barite and cerrusite. Bornite seems to be a very minor secondary mineral that occur among the secondary mineral varieties probably because of the accessory nature of chalcopyrite or that the latter may be generally in its pure state and almost unaltered. Cerussite, malachite and goethite (Plates) represent the supergene enrichment products in the area.



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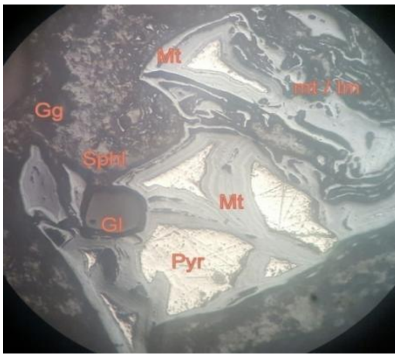
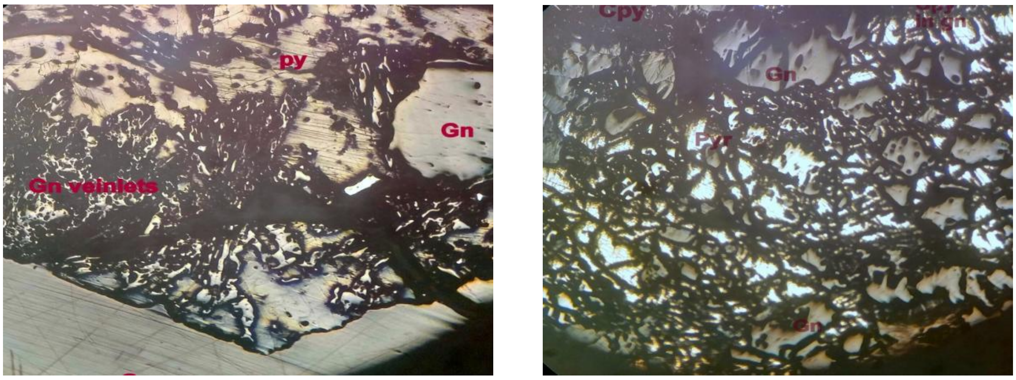


b

Plates (12a-b): Photomicrograph showing magnetite occurrence in the study area.gn = galena, sph = sphalerite, pyr = pyrite, chl = chalcocite, mt = magnetite, gg = gangue. Note: Magnetite (dark grey) replacing pyrite (light yellow) in a dendritic pattern. Sphalerite (lighter grey) occurs at the boundary of the "enclosed magnetite-pyrite" system". Chalcocite (blue) is replacing galena (white) at the rim. 12b: Photomicrograph showing magnetite-pyrite association in the study area. mt = magnetite, py = pyrite, gg = gangue, im = ilmenite. Note magnetite (grey with bluish tint) showing colloform banding indicative of changing fluid composition. Magnetite is also replacing pyrite. Subhedral pyrite in both photos appear to have formed in an open vein system (xpl x400µm).

Deformed Ore Textures

In addition to the replacement and/or deformational textures discussed above, other deformational and/or replacement textures observed in the study area includes intense fracturing and brecciation textures associated with metamorphism of ore deposits. These types of features are considered common in shear zones and fault planes mostly found in skarn and metamorphic/hydrothermal environments (Craig and Vaughan, 1994). Metamorphosed ore textures as observed in the area have been illustrated in (Plates 63 and 64).



a b

Plates (13a-b): Photomicrograph showing fractured/brecciated pyrite intruded by galena vein lets. A secondary fracture also cut across the older or earlier galena vein lets and pyrite. Note the "youngest anhedral galena over the earlier formed minerals and fractures to the centre right. The entire system appears to be enclosed within a larger galena. gn = galena, py = pyrite. 13b: Photomicrograph showing equant pyrite crystals overgrown by anhedral galena grains that appear to be brecciated also. This is an indication of metamorphosed and deformed ore textures in the study area. gn = galena, pyr = pyrite (ppl x 400µm).

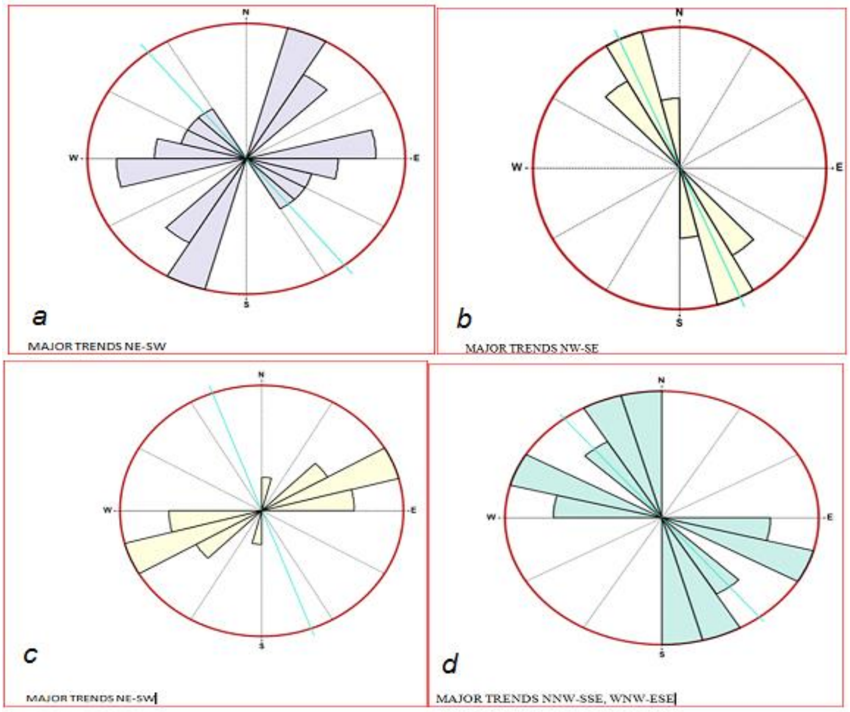
Structural Lineament

Geologic structures reflect the type of stress they have undergone or are undergoing as well as the rate at which the stress has been applied or is being applied. They also tell their properties, therefore some of the properties of these structures are determined by the type and rare of their deformation or stress undergone. (Rhaman, and Ogezi, 1988). The fractures in the area assume a dominant northeast-southwest trend (Fig. 2).

The dominant NW-SE trend of the most structure in Nigeria has been considered as result of later of deformational episode during Pan-African orogeny (Mc Curry 1989). Some of the structures might be tectonic in nature, resulting from deformational stresses and exhibiting diverse trends. These stresses could be probably due to the effect of the Pan-African orogeny, which has affected the entire Nigerian Basement Complex.

The major structural directions in Nigeria are oriented in N-S, NE-SW, NW-SE, NNE-SSW, and ENE-WSW, corresponding to the major structural trend in the Basement complex (Rahaman et al., 1988). The form and general distribution of the ring centres may have been controlled by these pre-existing lines of weakness in the Pan-African Basement into which the Younger Complex intruded. Most structural elements of the project area, Joints, veins, dykes, minor folds and foliations dominantly trend in the N-S, NE-SW, NNE-SSW, NW-SE, E-W and ENE-WSW. Figs. a-d shows rose plots of major structural elements in the studied area. These seem to correspond to the major structural trends in the Nigerian Basement Complex.

Some of the structures might be tectonic in nature resulting from deformational stresses and exhibiting diverse trends in the surrounding basement rocks of the mapped area. This diversity in the structural tend indicates that the stresses could be probably due to the effect of Pan-African Orogeny which has affected the entire Basement Complex. The vein displacement which corresponds to ENE-WSW directions are the oldest and could be imprints of Eburnean Orogeny.



Figs. 2(a-d): Rose plots of structures on the major rock types in the studied area.

They have been displaced by the N-S, NNE-SSW veins which are the Pan-African. Therefore the NNE-SSW and N-S structures are younger than the ENE-WSW structures. Rock structures exert important influence upon the activities and pattern of rivers. This could be related to the courses of river channels in the study area. The dominant N-S trend of most structures in Nigeria as observed in the basement rocks of the study area, have been observed to be the result of a later deformational episode during the Pan-African (Mc Curry, 1989)

Conclusion

Mineralization in the area occur as both vein dyke and skarn deposits. Major ore minerals include galena, pyrite, sphalerite, chalcopyrite and accessory magnetite, ilmenite and rutile. Secondary minerals are barite, anglesite, cerussite, chalcocite, malachite and minor goethite. Native gold is also present and being currently mined as alluvial gold in the studied localities. Structurally, the area is made up of joints, veins, folds, foliations and dykes. The most dominant structural trend is the N-S structures in the basement rocks of the area which may be as a result of a later deformational episode during the Pan-African.

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