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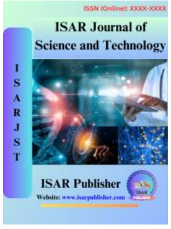

ISAR Journal of Science and Technology
Abbriviate Title- ISAR J Sci Tech
ISSN *(Online)*- 2584-2056
https://isarpublisher.com/journal/isarjst
Vol-2, Iss-8 (Aug- 2024)
OPEN ACCESS

Quartz veins, evidence of hydrothermalism and postmagmatic process for mineral deposit gold and sphalerite ore in KAAKA area (ADAMAWA- CAMEROON)

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Article History

Received: 06.05.2024
Accepted: 06.07.2024
Published: 01.08.2024

Abstract: The locality of M **KAAKA** is just part the rearrest zones of rich mineral deposits in Cameroon from its high demonstration of geological evolution. The geology of the mineral deposits of KAKAA show the heterogeneous of the rocks types and variable mineralization with the highest concentration in the sector. Quartz veins, and gold deposit that are sufficiently accessible to be studied in detail and seemed deserving of intensive study for the following reasons: It was well exposed; its mineralogy and paragenesis were sufficiently varied yet regular; and its environment was readily susceptible to interpretation. The application of multispectral imagery in mineral exploration and field work reveals the favor zone of mineralization. The distribution of the quartz veins shows a predominant NNE-SSW and NW-SE orientation, similar of the multispectral images orientation, which correlates with the presence of gold mineralization associated with the sphalerite, suggesting strong control by structural elements. The mineralized quartz veins in KAKAA range between 2 to 10 centimeters, fractured, and characterized by mineral assemblage: quartz ± gold ± sulphide ± pyrite ± chalcopyrite ± hematite ± limonite. They commonly display a simple mineralogy of pink feldspar, quartz and mica are also associated with vein quartz. Numerous quartz veins present the high hydrothermal process which affected the host rocks type characterized by a fine grain quartz- muscovite - biotite and sericite ± chlorite. The ideal target of this work was to identify potential zones associated to gold mineralization and also to evaluate if the mineralogical composition of rock indicates the potential mineralization of the study zone. Detailed relations observed along the quartz veins and sphalerite veins zone suggest that mineralization took place toward the end of the late period of faulting during the post-tectonic event in Adamawa domain through post-magmatic emplacement combined with hydrothermalism.

Keywords: Quartz veins, Hydrothermal, post-magmatic, Mineral deposit, multispectral image, Adamawa-Cameroon.

Cite this article:

Mama, N., Adama, A., Ntieche, B., Nsang, F. S., Anchimbom, N., (2024). Quartz veins, evidence of hydrothermalism and postmagmatic process for mineral deposit gold and sphalerite ore in KAAKA area (ADAMAWA- CAMEROON). *ISAR Journal of Science and Technology*, *2*(8), 5-14.

I. Introduction

The study zone is located in Mbere-Adamawa Region, Dir sub-division and is about 70 km from Meiganga town with geographical coordinates as N 06^{0}09′54.33″ E014^0 02′ 59.9″ and N06^0 09′ 17.0″ E014^0 02′ 31.7″. This zone (Kaaka) is situated at the boundary between Meigana and Dir covering a surface area of about 120 km^2. Villages found along this trajectory are Kpaamaa, Yelle and Baina and limited by the south part by Betaré-Oya district. The exploitation of native mineral like gold is considered as one of the most demanded minerals in industries due to its rareness, malleability and its high resistant to corrosion. Native gold is mostly found along hydrothermal veins, pyrites as primary deposits and along river, stream as secondary deposits. Gold can be found as inclusion in minerals such as pyrites and in association with other minerals such as silver (Boyle., 1979). The mineralogy of the auriferous veins and the host rock remain varied et depend of the genesis and evolution of the mineralizing fluid are still enigmatic (Ngatcha et al., 2021). Sphalerite is also a common ore mineral of polymetallic epithermal quartz veins in this research area for first time. Most deposits derived from hydrothermal fluids are rich in sulfur presenting temperatures greater than 200^{0}C (Philipps et and Evans., 2004). Remote sensing is the science of acquiring, processing, and interpreting images and related data, acquired from aircraft and satellites that record the interaction between matter and electromagnetic energy (Sabin.1999). Remote

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sensing enhances the cartography of regional maps, structural interpretation by their spectral signatures in mineral exploration. In the last decades, geological remote sensing has proved to be a great tool in mineral exploration. Many ore deposits have been recognized using satellite imagery (Sabins, 1999; Van der Meer. 2012). The aim of this work is, to determine the regional distribution of primary gold mineralization and quartz veins relationships of the host rocks type, and rocks minerals as well as indicator to identify the gold deposit and other mineralization KAAKA locality and surroundings. In this geological context of the tectonic zone (central Cameroon shear zone) stands out as a dominant region for mineralization, the mineral occurrences along the quartz vein stay predominant in south-eastern part of Meiganga.

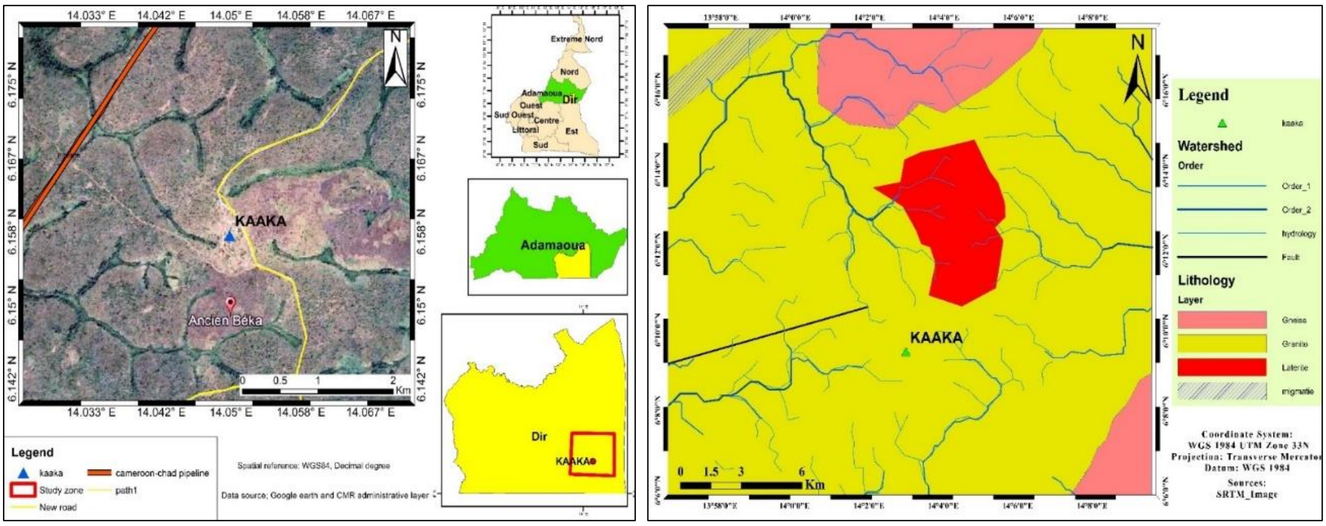

Figure 1 : location map of the study area a) Cameroon b) Adamawa c) study area

I-1. Geological back ground

Adamawa region has undergone an intense volcanic activity during the tertiary and quaternary period. These activities were favored by fractures orientated in NW-SW secondary accidents observed in E-W affecting basement rocks around Ngaoundere and played several times is responsible for its structure in horst and graben (Ngounouno et al., 1998; Toteu et al., 2008). It is generally believed that the present structure of the Pan-African belt in Cameroon is characterized by continent- continent collision and post collision of the Congo Craton and the north Cameroon active margins with Archaean-Paleoproterozoic inheritance (Toteu et al., 2004). It also belongs to the Adamaoua basement consisting of metamorphic and granitoid rocks related to the Pan-African orogeny (615 ± 27 to 652 ± 10 Ma) or earlier (880 ± 55 to 1008 ± 65 Ma) (Tchameni et al., 2006). Granitoids plutonism dated at about 635 Ma (early Pan-African) to south of KAAKA (Bétaré Oya) gold district is inferred to be related to gold mineralization (Ateh et al., 2017). The Adamawa-Yade batholith consists of a great variety of more or less deformed rock-types of different ages (Tchameni et al., 2006). Meiganga is part of the Adamawa-Yadé domain (AYD) is situated between the Congo Craton and the Sahara Metacratron (Ganwa, et al., 2016). The southern part of Meiganga composed of mainly undated graphite schists, amphibolites, mica-rich quartzites, amphibole-biotite gneisses, orthogenesis, migmatites, calc-alkaline granitic rocks, biotite amphibole, and biotite-chlorite granites whose formation periods are assumed to be Precambrian as they also belong to the central part of the Cameroon mobile belt (Kylander-Clarke et al., 2013**).** Basement rocks in Meiganga are composed of paragneisse, orthogneisses, amphibolite, mylonite, granulite, migmatites, quartzites, metadiorite, schists, and granites which derived from the dissymmetrical structure and the deformations affect the granitoids to the Adamawa (Lassere, 1961; Dumont, 1987). Some gneisses and amphibolites underwent retrograde metamorphism that led to the formation of greenschist facies overprints (Kepnamou et al., 2017). Assembly mineral of Meiganga area constitute: amphibole-orthogneiss, amphibole gneiss, biotite gneiss, amphibole-biotite gneiss, calc-alkaline and two mica-granites. Pyroxene-amphibole orthogneiss locally enclose mafic xenoliths (Ganwa et al., 2005). The study zone (Kaaka) is highly influences by igneous, sedimentary and metamorphic activities. Basement rock in this area compose of biotite, orthogneiss, amphibole, biotite gneiss, quartz, feldspars, chlorite, and mica-rich quartzites. The most pronounced rock types observed in this locality where granite (with a color variation from dark, pink to white). Migmatite gneiss which presented a parallel alignment of bark and light band and Sediments from alluvium, sand, clay, gravel was equally observed along meanders and swamps. This high concentration of lateritic soils, lateritic outcrops and cuirass constitute a lithologic formation. Gold mineralization and granite are the most exploitable materials in KAAKA area despite the gold concentration is highly focalized on riverbed and placer deposit.

I-2. Methodology

The methods used in the realization of this work are: field method, satellite imagery field work. The difference in rock types sampling was based on the hand specimen’s variation in mineral composition and variation in grain size and orientation. Some representative samples were polished for visual illustration as shown in (Figure. 3). For identifying the rock-forming minerals, grain texture, and alteration or deformation indices using a polarized light microscope (petrographic analysis), thin sections of the rock types were prepared by cutting into slabs of few millimeters thick using rock cutting machine at the Department of Mining Geology, School of Geology and Mining Geology of the University of Ngaoundere (Cameroon). The field planning of work included pretreatment of satellite images (Remote sensing) gotten from earth explorer to identify potential zones of mineralization.

The localization of structures, mapping of lineament in a well-defined and precise manner (Toutin., 1996) satellite imagery presents the earth in various spatial, temporal, radiometric and increasingly spatial resolution. These interpretations allowed them to delineate representative sites of the various physiographic regions within the park and thus identify the locations where fieldwork should occur.

II. Fields work

This study zone is dominated by structures like intrusions faults, fractures and veins. The rock is completely crushed and separated from the gangue to obtain the desired component in the quartz veins. Although the mineralized rock is clearly localized in highly fractured ground along the vein zone, all the highly fractured ground is by no means well mineralized, and some thoroughly shattered segments are virtually barren (Figure 2). Structural measurement of the dip and trike of these veins, faults and intrusions were made hence realizing a rose diagram which presents the orientation. A lineament map determines of geological contacts and structures elements also the discontinuities like faults geologic contacts to provides detail information of the surface and subsurface of the earth. The fractures identified were simply cracks, and veins. The contact between pegmatite and gneiss (foliated) is in nearly all areas very sharp, whether the pegmatite lies parallel to or cuts across the folia and whether its mass is large or small (Figure 2). Large crystals of pegmatite in intrusions are characterized by crystal sizes which ranges from 3 – 4 mm. Though showing minor irregularities of form, most of the pegmatite masses in the foliated rocks are of sheet like character and lie parallel or nearly parallel to the schist or gneiss foliate. Numerous instructive exposures of a foliate of this type occurs on the east sector, where porphyroid granite of normal composition, with feldspar phenocrysts from one-half to three-fourths of an inch in length. Migmatite are a medium-coarse grain metamorphic rock formed as a result of pronounced foliation and intense shearing during large-scale movements along faults and thrusts (Figure 3c). The migmatitic rocks displays a tectonite texture shown by the presence of foliation and lineation (Figure 3). Mineral present rocks show the presence of orthoclase, biotite and quartz with often a large variation in biotite abundance over a short distance. The paragenesis of mineral consisted of the chalcopyrite, pyrite with an assemblage of quartz-chlorite and fine-grained pyrite porphyroblasts. Pyrite and quartz minerals show their euhedral crystal form. Quartz veins occur as narrow concordant lenses, pods and veins in high-grade metamorphic rocks in selected particular locations. Macroscopically, this outcrop occurs as a phaneritic foliated rocks containing ferromagnesian minerals like amphibole and biotite which dominate the mineral assembly. The grain size of all of the crystals is significantly larger in this amphibole biotite granite than in other the other quartz veins. The rock massif presents massive texture with the quartz veins approximately 4 mm thick and the grain sizes of the quartz crystals ranges from 1mm-1.5 mm, orthoclase and muscovite (Figure 3). Massive texture is frequently characterized by euhedral or anhedral grain of variable size throughout the vein due to uniform growth rates. The presence of micro-faulting with a slight displacement of the laminations/quartz veinlets are observed in the field work (Figure 2).

Figure 2. Intrusive structures observed in the field: pegmatitic intrusion

Quartz veins are small accumulation of quartz crystals with a thickness of 1cm to 2 cm with the NNE-SSW and NW-SE (Figure 3). The quartz veins of the latter type are particularly likely to contain scattered crystals of orthoclase-microcline and some muscovite. These cracks on rocks are formed by shattering during tectonic events or by a decrease in pressure during the uplift of a rock. There is a high degree of mineral accumulation in veins since they are derived from external activities that are not highly related to their parent rock.

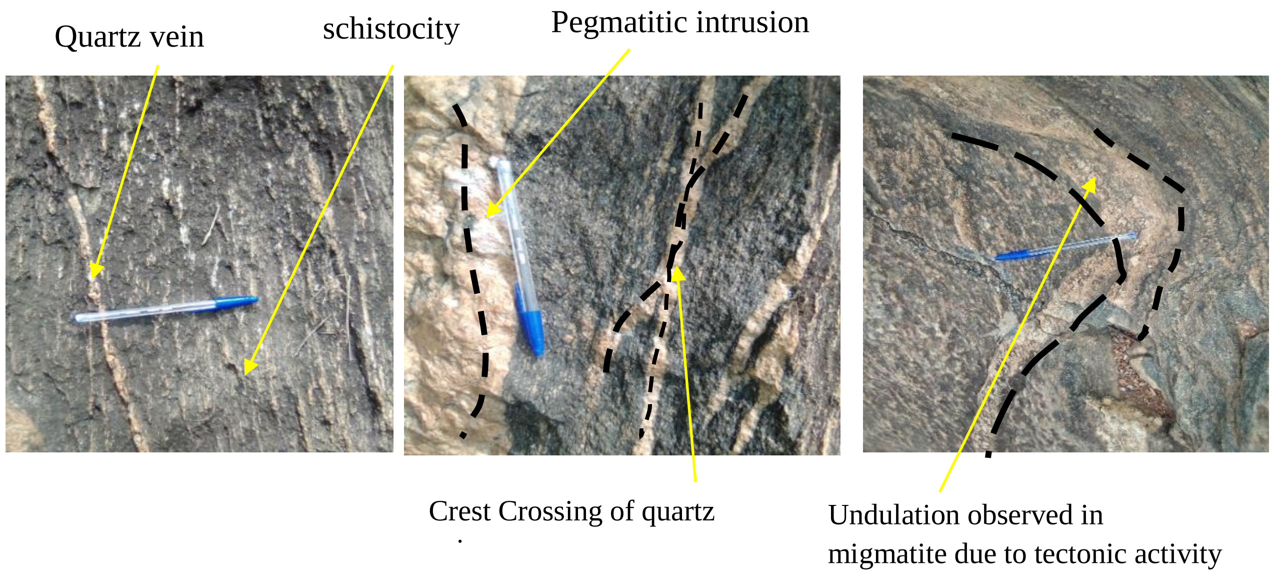

Figure 3. Quartz veins undulation observed in migmatite due to tectonic activity

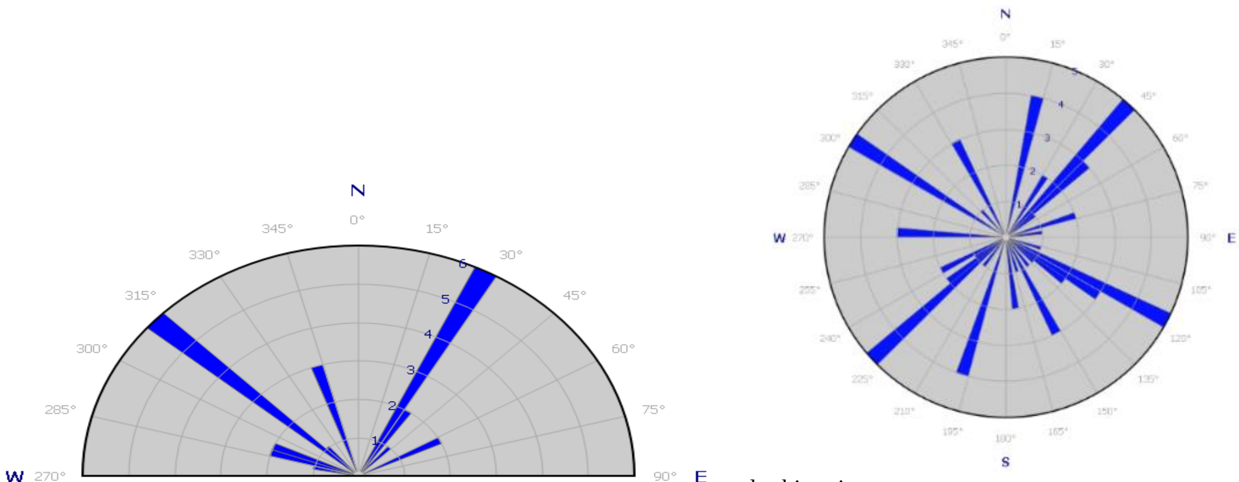

Figure 4. Rose diagram of the quartz vein and schistosity

III. Results and discussion

III-1. PETROGRAPHY

The description of the analytical methods used in this study concerned four polished thin sections were prepared for mineralogical and petrographic studies using optical polarizing microscope. The rock's zone consists of 3 rock types which are classified under magmatic, and metamorphic: Amphibole biotite granite**,** Migmatite, gneiss, and Biotite muscovite granite. The petrography of this rock highlights the presence of quartz, biotite, feldspars, plagioclase, microcline and opaque minerals. The tin section presents a helicitic texture (figure 5c) demonstrating light bands in inclusions which corresponds to the original bedding of parent rock. The prophyroidic texture varies from coarse to fine grain. Essentially, they are coarse granites, their principal light-colored constituents being potash feldspars, quartz, and muscovite, and their principal dark-colored constituents black mica (biotite), and oxide. The rock also consists of microcline, minor quartz, and varying amounts of ragged biotite, ranging from approximately 5 to 25%. Euhedral Biotite phenocryst constitutes 30 % of the rock mass and mostly occur in inclusions. Gneiss presents the lepidoblastic and pyroclastic texture with two distinctive properties which are microlithic and granular (Fig 4). The microlitic properties of the thin section best describe migmatite gneiss while the granular properties describe. Accessory minerals include zircon, chlorite and magnetite. The plagioclase shows a dusty appearance while quartz is clear. Hornblende and biotite are the main dark colored minerals in the rocks with the particularity that the biotite crystals are partially altered to chlorite. Myrmekite dispose orthomorphic crystals in the form of quartz vermicules that are developed on plagioclase. The opaque minerals occupy approximately 1% of the total volume of the rock mass. The paragenesis of minerals present as well as: Bt+ Qtz+ Pl+ Op+ Fs. Large euhedral crystal of plagioclase occupies about 17 % of the rock mass and presents medium relief between its minerals. Crystal of plagioclase, approximately 1-2 mm size, are highly alliterated but not destroyed and presence of polysynthetic marks. Tabular crystals of plagioclase are partially to completely altered saussurite. Biotite occurs as fine-grained faky crystals that mostly present as cluster minerals. It is altered to chlorite and stained by iron oxides certainly along its peripheries (figure 5 e). Other minerals include green apatite, grey quartz and an unidentified light brown, possible phosphate mineral. Quartz crystals are disposed in variable forms and ranges from 1-2 mm enclosing small crystals of amphibole and opaque minerals in inclusion. Amphiboles crystals are mostly found in association with biotite inclusions occupying 30% of the rock. The rocks presented a high degree of foliation due to the presence of leaf-like structures observed on thin section. it can be clear that sphalerite replaces the margins of galena.

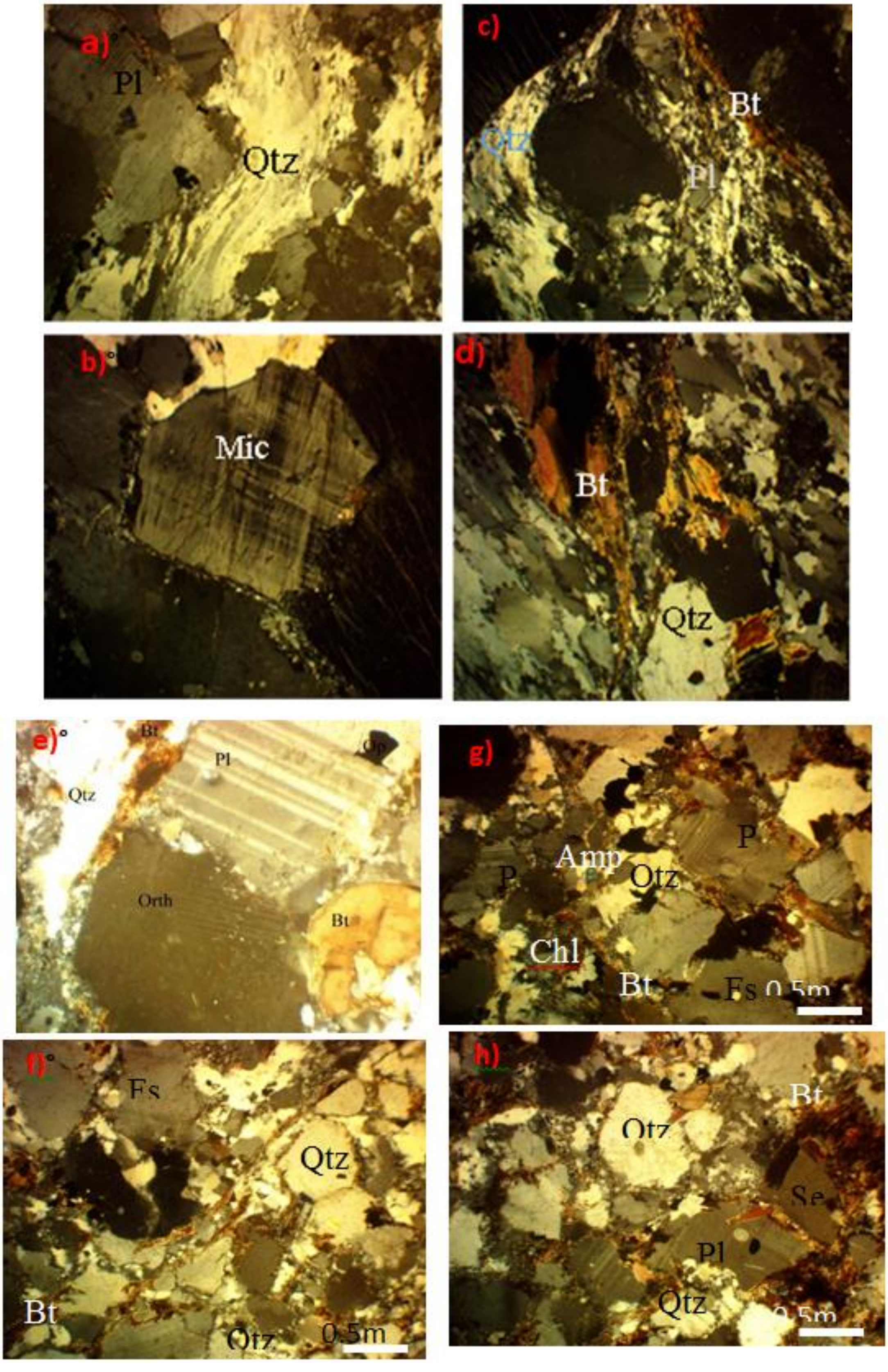

Figure 5: Photomicrographs showing mineral assemblages of quartz vein and rocks type around the study area

The sphalerite occurred in association with quartz vein in the zone of study and the morphology of ore characterize by epigenetic process. The location of sites where sphalerite was collected (Figure 6) with numerous ore veins are mainly composed of gold, pyrite, oxide, magnetite, and quartz, with lesser amounts of chalcopyrite. Most of sphalerite show intergrowth texture with oriented an unoriented inclusions of chalcopyrite, biotite and quartz. The quartz vein exists in association with sphalerite indication a clear existence of post magmatic fluids also determines the morphology of ore. Sphalerite shows a lot of cracks which are replaced by chalcocite and pyrite. The outlines of sphalerite minerals are in general concave toward quartz minerals (Figure 6). It means that sphalerite is younger than quartz in order of deposition.

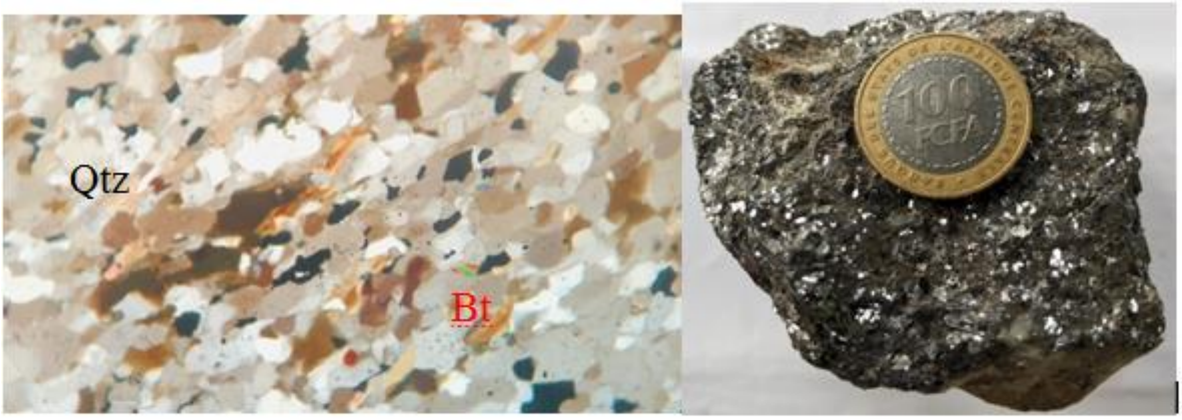

Figure 6. Thin section of sphalerite and the sample of rock with megacrystal of quartz

Table 1. Summary of petrographical description of KAAKA granitic rocks, migmatitic rocks and gneiss rocks. Qz Quartz; Pl Plagioclase; Or Orthoclase; Mc Microcline; Bt Biotite; Ms Muscovite; Zr Zircon; Chl Chlorite; Ser Sericite, (+) presence, (−) absence

Petrographic description											
Sample			**Mineral composition**								
			Primary						Accessory		Secondary
	Predominant grain size	**Rock nomenclature**	Qz	Pl	Or	Mc	Bt	Ms	Zr	Ox	Chl
Gneiss rocks	Medium-grained (1–4 mm)	Biotite-gneissose granite	+	-	-	-	+	-	-	+	-
Migmatitic rocks	Fine-grained (< 1 mm	Biotite-gneissose granite	+	+		+	+	+	-	+	+
Granitic rocks	Coarse-grained (>5 mm)	Alkali-feldspar granite	+	+	-	-	+	-	-	+	-
Granitic rocks	Medium-grained (3–5 mm)	Alkali-feldspar granite	+	-	+	-	-	+	+	+	-

III-2. Mineralisation and lineament from satellite imagery

The generation of lineaments from remote sensing data ensures accurate identification of potential primary sources of mineralization which are liked to cross lineaments. The potential of mineralization zones is identified by subsequent crest – crossing of lineaments which are highly concentrated in the NW and SE of the map (Figure 7a). This lineament map is derived from the combination of maximas of horizontal gradient, Euler deconvolution and satellite imagery. It shows zones with high concentration of fractures and lithological contacts. Lineaments from a satellite image maps out surface information and those from gravity give detail information about the subsurface density of geologic formations found in the study area. The lineament from Euler and remote sensing crest-cross each other at specific point with an aspect highly related to mineralization zones. Study area presents a high degree of crossing of lineaments and fracturing density. The presence of gold in kaaka is due to tectonic movement of Adamawa basement where gold can be identified in swamps, rocks and highly fracturated zones. More, the presence of opaque minerals in thin section confirmed the exsistence of gold in rocks and other heavy metals. Meiganga area is located between two important faults: the Adamawa fault and the Betaré-Oya fault (Kepnamou et al., 2011). Pyrite with a little chalcopyrite and the quartz forms 'lode' occur mainly in silicified and non silified mudstone. Buestone is an intimate mixture of argentifious galena and sphalerite with lesser chalcopyrite, purite and quartz. It forms a fine grained, dark bluish, granularlooking ore which occur mainly

This lineament map is derived from the combination of maximas of horizontal gradient, euler deconvolution and satellite imagery (Figure 7a). It shows zones with high concentration of fractures and lithological contacts. Lineaments from a satellite image maps out surface information and those from gravity give detail information about the subsurface density of geologic formations found in the study area vary to S-W and E-W (Figure 7b). From the map it is observed that lineament from euler and remote sensing crest-cross each other at specific point. This aspect is highly related to mineralization zone.

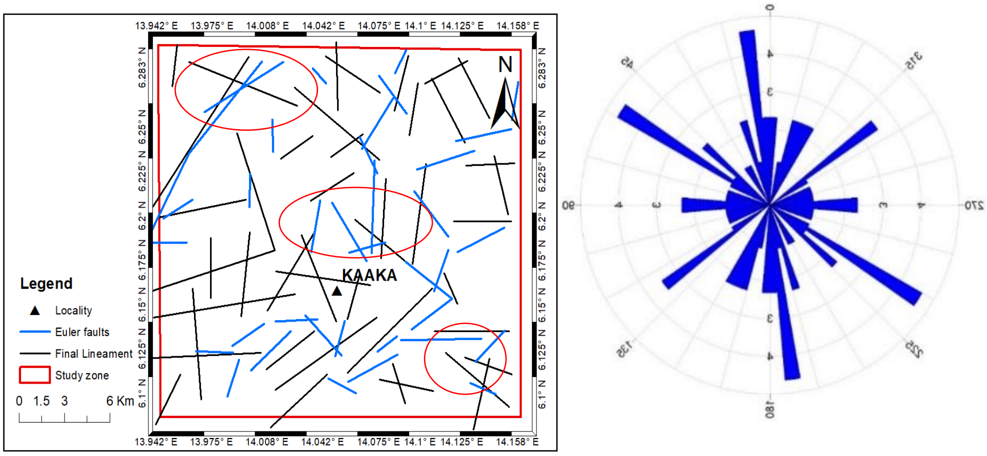

Figure 7. a) Lineament from Euler fault (left) and b) lineament diagram (right)

III-3. Gravity lineament density

The high mineralization zone is obtained by the superposition of horizontal gradient, X, Y and Z derivative and lineament (Figure 8a). Low density zones have a colour variation which ranges from brown to green while average density zones range from blue to purple. Very high-density zones are represented in red. The zones in red are indicated as potential mineralization zone since they present a high degree of crossing of lineaments and fracturing density. Correlating this map with the lineament density map obtained from satellite imagery it is observed that areas where lineaments crest cut each other can be termed as areas of mineral accumulation.

Figure 8b below shows a possible mineral prospection pattern, this pattern is classified and plotted with respect to zones of very high, high and medium gold mineralization. Most importantly, the probability to identify gold deposits along this pattern is very high due to the re-classification and the evaluation of the properties geologic formations found along mineralization zones in the map. This means that apart from very high mineralization zones presented in red other zones can equally be identified along the same trace if this prospection tracks are strickly followed.

From the map, high mineralization zones are presented in red and are found at the N - NW, S-SW-SE which corresponds to zones of contact between linearment from remote sensing and euler faults. The N-S lineaments corresponds to foliation reported in granitic rocks south of Meiganga area (Soba, 1989); the E-W trending lineaments are equivalent to the foliation in gneiss and orthogneiss from Meiganga area (Kankeu et al., 2021). These zones are considered as potential mineralisation zones (Figure 8b) possible mineral prospection pattern. This pattern is classified and plotted with respect to zones of very high, high and medium gold mineralization. Quartz veins are indicators of paleo-movement of fluid, it also represented a discontinuity and homogeneous mechanical properties that occurred on a rock. Most importantly, the probability to identify gold deposits eluvial along this pattern is very high due to the re-classification and the evaluation of the properties geologic formations found along mineralization zones in the map. This means that apart from very high mineralization zones presented in red other zones can equally be identified along the same trace if this prospection tracks are strictly followed. Correlating the map with the lineament density map obtained from satellite imagery it is observed that areas where lineaments crest cut each other can be termed as areas of mineral accumulation.

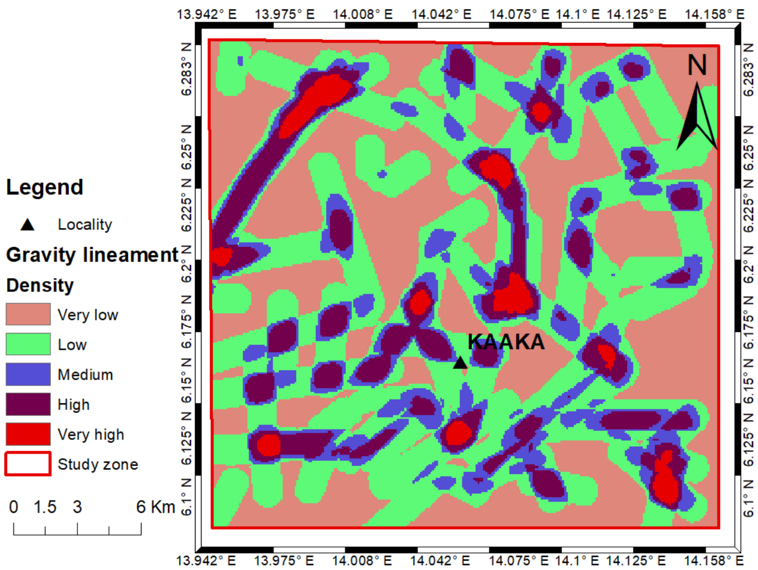

Figure 8a) Lineament density from gravity data

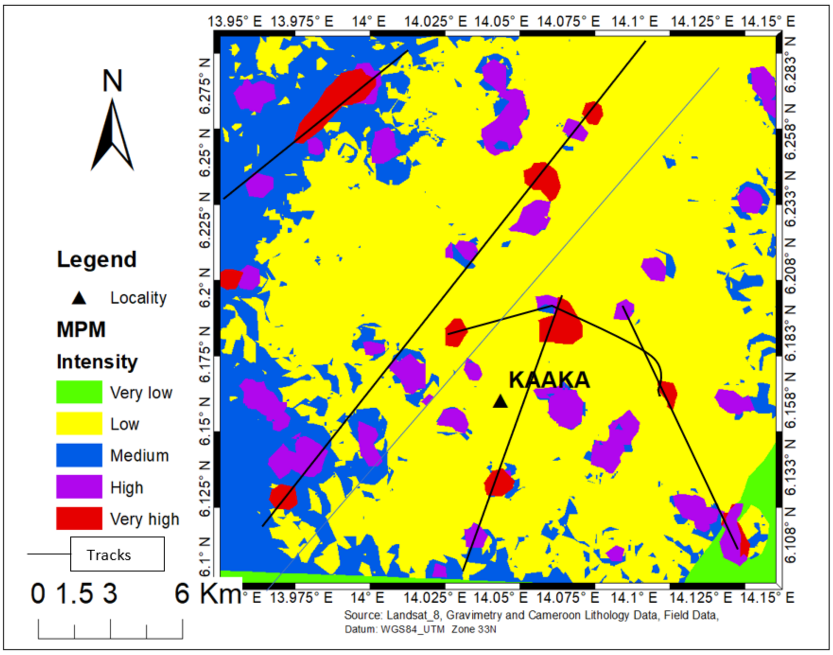

Figure 8b). Lineaments trajectories of mineral exploration gold deposit eluvial and sphalerite in Kaaka area

III.4. Discussions

Microscopic observation show that biotite and muscovite could be observed together in the same rock. Texture relation describing inclusions in biotite similar to inclusions of zircon and apatite suggest that biotite as well as muscovite, feldspars and quartz did coexist during the magmatic stage in the geological context of KAKAA thus suggesting a buffering reaction for the magma using the composition of igneous biotite and muscovite. Massive texture have been interpreted to result where voids are filled after, not during their formation similar process as Chappell, and White, (2001) The minerals assemblage as chalcopyrite, pyrite with an assemblage of quartz-chlorite-pyrite present as veins or as a replacement of the rocks show the petrogenetic relations between the oxide mineral, combined with of these silicate assemblage from the two major phases of Fe-oxide deposition, and suggest that the later mineralizing fluids were at a lower temperature. Many investigators agree that sphalerite from low-temperature deposits to be higher in germanium content than those from mesothermal or high-temperature deposits (Stoiber, 1940; Warren and Thompson, 1945, Fleischer, 1999). The emplacement of gold deposit could have been associated with the circulation of the ore-bearing fluids that produced locally silicified gold-bearing veins along the wall rock host (granitoid, gneiss ant schist units) similar of the investigation to Asaah et al., 2014, Ateh et al., 2017, Ngatcha et al., 2021. Mineral accumulation was identified in thin section by the presence of opaque mineral which mostly consist of heavy metals like gold, chrome, iron. Also, hydrothermal fluid in enhance the circulation of underground mineral component. The paragenesis of minerals =Fs + Pl + Bt+ Qtz + Se. The homogeneous minerals composition and coexistence of plagioclase, biotite, and K-feldspar as well-formed crystals indicate a same magmatic origin which are not affected by crustal. Metasomatic process by late- to post-magmatic fluids is also evidenced by the alteration of a few biotite crystals in chlorite and plagioclase and sericite. The alteration of plagioclase due to the presence of hydrothermal fluids resulted to the formation of anhedral crystals of sericite. The occurrence of inclusion minerals in the samples suggests, the influence of late- to post-magmatic fluids during the evolution of the rocks. Textures of hydrothermal minerals are indicative of relative levels of saturation of the fluids and can be a guide to ore genesis (Barton, 1991). The presence of the same textural and mineralogical characteristics in different veins suggests that a similar formation environment is responsible for gold mineralization throughout the quartz vein. Quartz veins and pegmatite intrusions identified on out crops are strong indicators of mineralization and suggested the importance of the post magmatic fluid. Quartz Vein occur as narrow concordant or discordant lineaments and veins in high-grade metamorphic rocks which predominate the Adamawa region in selected particular locations. Petrographical, textural and mineralogical data suggest that quartz veins most enriched with quartz (SiO_2), which bear evidence of single stage crystallization of hydrothermal solution. This reveals that crystal grains do not have defined regular crystal habits or crystal boundaries due to fast cooling processes of crystallization. Rock in this locality is subjected to crushing and deformation and also suggest the tectonic movement which affected the Adamawa region. It is evident that the rare metal-bearing minerals are primarily associated with fluorite, which is one of the last phases to crystallize. The localization of sphalerite with galena, pyrite and chalcopyrite results from epigenetic filling of voids such as fractures but also of the metamorphic fluid processes. The gold occurrences in KAKAA are typical disseminated type deposit morphology in the host rock, sometime weathered or shale and strongly in quartz veins, suggesting a possesses has been influenced by low temperature and pression fluid, characteristic of hydrothermalism (hypotermal) specially with the formation of sphalerite, known for its emplacement at low temperature (between 180 and 240◦C) compared with quartz (Win et al., 2014). The other hydrothermal mineral assemblage identified in KAAKA is similar to the one accompanying gold mineralization in the river Lom and (Azeuda et al., 2021b).

IV. CONCLUSION

The correlation of this methods confirmed the information derived from data processsing and field observations where natural resources like gold were identified. The presence of migmatite in this zone confirm that is highly affected by tectonic activities. Meiganga-East belongs to the central part of the pan-African chain in Cameroon. The data processing and field work in Kaaka confirm the results where some corresponds to the old mining sites while other a zones where villagers to their small scale artisanal mining. Through gold mineralogy, the potential mineralization around the biotite gneiss and muscovite in the KAAKA area, represent target zones with a high degree of mineral accumulation of the eluvial gold. The presence of opaque minerals and coexist of those minerals is indicator many phases of the magmatic stage during the gold deposits. Numerous microfractures play a significant role to the circulation of mineralizing fluids probably to the origin of Au, As_2 O_3, FeS_2 and Cu FeS deposit. Quartz veins are indicators of paleo-movement of fluid, it also represented a discontinuity and homogeneous mechanical properties that occurred on a rock. The high density and cross lineament which affected the lithologic formation as amphibole granite corresponds to potential zone of the eluvial source and any other heavy metal. The types of a quartz vein observed are a result of the filling of crack that already existed in rocks. Epigenetic process is responsible for the all-structural distribution and certainly the residual magma rich in mineralization. The intrusive rocks studied were classified into three main categories: gneissose granites (Biotite) of medium- to fine-grained size, alkali-feldspar granites of course- to medium-grained size with the mineral assembly as well as pyrite, chalcopyrite and schist. The significant role of the hydrothermal process through the quartz veins is high to contribute of the different type of mineralization where the sphalerite (ZnS) can replace galena (PbS). The quartz and pyrite veining occurred throughout the mineralization phase, locally producing multistage veins showing open-space growth texture. The mineralized rock along the quartz vein consists mainly of pyrite, galena and fine-grained chalcopyrite, demonstrating the hydrothermalism of the mineralized gold quartz veins during emplacement, despite their post-magmatic status.

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