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Research Article

PETRO-STRUCTURAL AND METALLOGENIC STUDY OF THE GEOLOGICAL FORMATIONS OF THE PR 861 PERMIT, BOUAFLÉ AREA, CENTRAL-WESTERN CÔTE D'IVOIRE

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ABSTRACT
The PR 861 permit is located in the Bouaflé area, central-western Côte d'Ivoire, within the Paleoproterozoic domain of the West African Craton. This work aims to characterize the petrographic, structural, and metallogenic features of the geological formations of the permit and to discuss their implication for hydrothermal sulfide mineralization. The study is based on remote sensing and lineament analysis, field petro-structural observations, petrographic study of thin sections, and metallographic analysis of polished sections. The lithological assemblage consists of granodiorite, microdiorite, andesite, volcaniclastic rocks, sericite schist, chlorite-sericite schist, chlorite schist, mica schist, phyllite, and pegmatite veins. These formations are affected by low-grade greenschist-facies metamorphism, characterized mainly by chlorite, epidote, sericite, calcite, and quartz. Hydrothermal alteration is expressed by epidotization, silicification, chloritization, sericitization, carbonatization, and sulfidation, occurring in both pervasive and vein-controlled styles. Structurally, the study area is affected by brittle and ductile-brittle deformation. The main structures are quartz veins, fractures, schistosities, pegmatite veins, mineral stretching lineations, boudinage, asymmetric folds, strike-slip faults, and C/S fabrics. Lineament analysis highlights a dominant NNE-SSW to NE-SW structural trend, with secondary ENE-WSW to E-W and NW-SE directions. These data suggest the presence of a probable NE-SW shear corridor that may have controlled hydrothermal fluid circulation. Metallographic observations reveal a sulfide-oxide assemblage composed mainly of pyrite, chalcopyrite, and magnetite. Mineralization is therefore interpreted as structurally and lithologically controlled hydrothermal sulfide mineralization, preferentially associated with schistose metasedimentary rocks, quartz-carbonate veining, and shear-related deformation. Further geochemical and micro-analytical work is required to confirm the gold potential of the system.

Keywords: *Birimian; Bouaflé; Côte d'Ivoire; shear zone; hydrothermal alteration; sulfide mineralization*

INTRODUCTION
The West African Craton is one of the major Precambrian domains of West Africa and contains several Paleoproterozoic Birimian greenstone belts (Milési *et al.,* 1989). These belts are well known for their metallogenic fertility, especially for gold mineralization hosted by volcanic, volcano-sedimentary, sedimentary, and granitoid formations (Leube *et al.,* 1990; Markwitz *et al.,* 2016; Milési *et al.,* 1992). In the southern part of the craton, the Man Shield comprises an Archean domain to the west and a Paleoproterozoic domain to the east (Figure 1). The latter corresponds mainly to the Baoulé-Mossi domain, where Birimian belts and associated basins were affected by Eburnean deformation, metamorphism, and granitoid magmatism (Abouchami *et al.,* 1990; Boher *et al.,* 1992; Grenholm *et al.,* 2019; Tagini, 1971).
In Côte d'Ivoire, Birimian formations occupy a large part of the Precambrian basement and constitute important targets for geological and mining research (Gnanzou, 2014; Kone *et al.,* 2025; Pouclet *et al.,* 2006). Several gold deposits and prospects, including Ity, Tongon, Bonikro, Agbahou, Aféma, Angovia, Yaouré, and Lafigué, show that the Ivorian Birimian domain has significant metallogenic potential (Assié,

2008; Coulibaly *et al.,* 2008; Houssou, 2013; Houssou *et al.,* 2017; Tabaud *et al.,* 2015). However, many sectors remain insufficiently studied at a detailed scale. In several exploration permits, the relationships between lithology, deformation, hydrothermal alteration, and mineralization are still poorly constrained. This lack of detailed petro-structural and metallogenic information limits the understanding of mineralizing processes and reduces the efficiency of exploration targeting.

Most Birimian gold systems in West Africa are controlled by structural and hydrothermal processes. Gold mineralization is commonly associated with shear zones, lithological contacts, quartz or quartz-carbonate veins, schistose host rocks, and sulfide-bearing alteration zones (Béziat *et al.,* 2008; Groves *et al.,* 2005; Hodgson, 1989; McCuaig and Hronsky, 2014; Milési *et al.,* 1989; Milési *et al.,* 1992). In Côte d'Ivoire, similar controls have been described in several deposits and prospects. At Agbahou and Bonikro, gold mineralization is mainly related to shear zones, quartz veins, hydrothermal alteration, and sulfide assemblages developed in volcano-sedimentary and intrusive rocks (Houssou, 2013; Houssou *et al.,* 2017; Ouattara, 2015a). At Aféma, Angovia, and other Birimian prospects, mineralization is also associated with quartz veins, sulfides, carbonatization, sericitization, chloritization, and structurally prepared corridors (Assié, 2008; Coulibaly *et al.,* 2008).

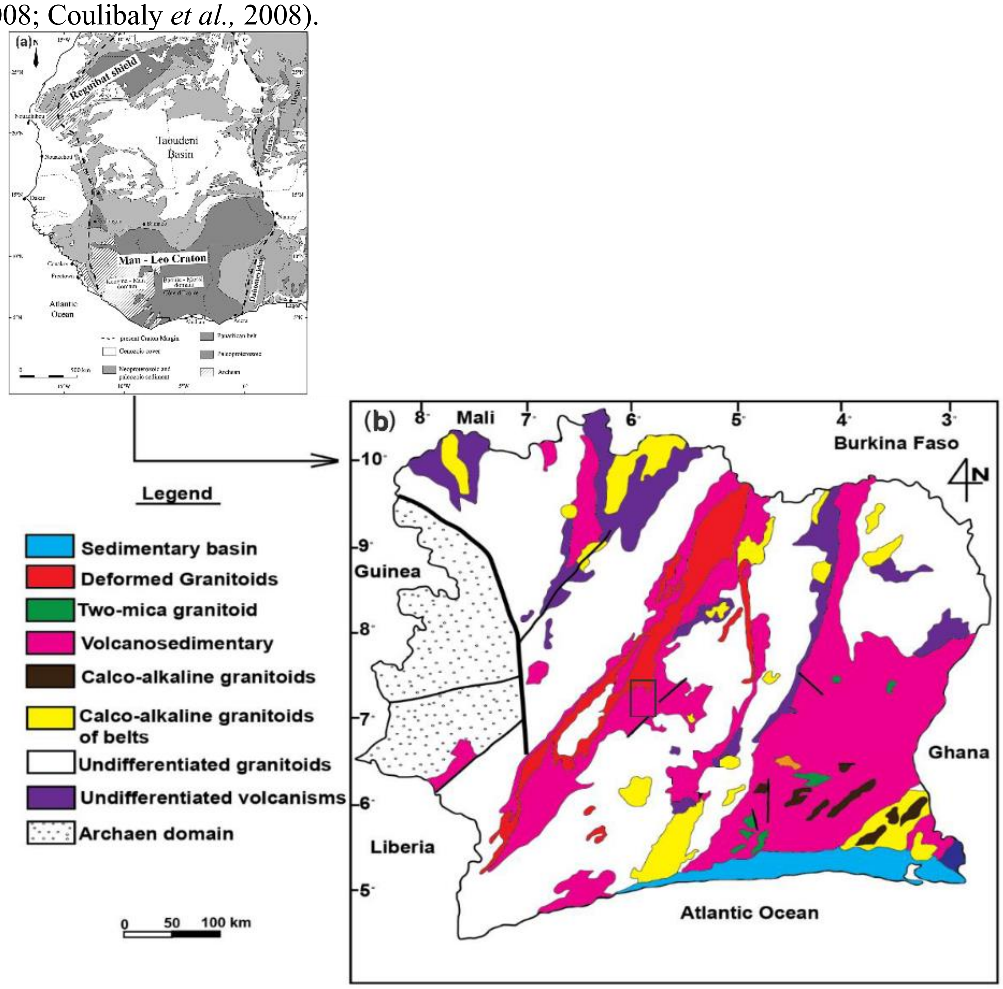

Figure 1: Geological context maps of the study: A) map showing the West African Craton and geological map of Côte d'Ivoire; the black square denotes the study region.

The Bouaflé area, located in central-western Côte d'Ivoire, belongs to the Paleoproterozoic domain of the Man Shield. Previous works in central-western Côte d'Ivoire indicate that the region is marked by Birimian

volcano-sedimentary and plutonic formations, greenschist-facies metamorphism, hydrothermal alteration, and several Eburnean structural directions (Dago, 2020; Gnanzou, 2014; Kone *et al.,* 2025; Pouclet *et al.,* 2006). The area is also located near the southern part of the Ferkessédougou batholith system, where granitoids and pegmatitic bodies are locally associated with metalliferous concentrations such as columbo-tantalite, gold, beryl, lithium, and rare earth elements (Adam, 1969; Allou, 2005; Boffouo, 2021). This geological position makes the Bouaflé area favorable for petro-structural and metallogenic investigations.
The PR 861 permit is located in this geological context (Figure 1). Previous observations on the permit indicate the presence of magmatic rocks, volcaniclastic rocks, sericite schist, chlorite-sericite schist, chlorite schist, mica schist, phyllite, and pegmatite veins. These rocks are affected by greenschist-facies metamorphism and hydrothermal alteration. These features suggest that the permit may contain a structurally controlled hydrothermal sulfide system, but its geological framework remains insufficiently constrained. The main problem addressed in this paper is therefore to determine how lithology, alteration, and deformation are related to the sulfide-oxide mineralization in the study area.
The objective of this study is to characterize the petrographic, structural, and metallogenic features of the geological formations of the PR 861 permit. More specifically, the work aims to: 1) identify the main lithological units; 2) describe the metamorphic and hydrothermal alteration assemblages; 3) determine the main structural features and deformation trends; and 4) propose a preliminary interpretation of the structural and lithological controls on hydrothermal sulfide mineralization in the Bouaflé area.

Geological setting

Regional geological framework

Côte d'Ivoire belongs to the southern part of the West African Craton, commonly referred to as the Man Shield (Bessoles, 1977; Caby *et al.,* 2000; Tagini, 1971). The Ivorian basement is mainly composed of Precambrian rocks, while a narrow sedimentary basin occurs along the southern coastal margin (Bessoles, 1977; Caby *et al.,* 2000; Tagini, 1971). The Precambrian basement is classically divided into two major domains separated by the Sassandra transcurrent fault: an Archean domain to the west and a Paleoproterozoic domain to the east (Caby *et al.,* 2000; Pouclet *et al.,* 2006).
The Paleoproterozoic domain corresponds mainly to the Birimian formations of the Baoulé-Mossi domain. In West Africa, these formations are represented by volcanic belts, volcano-sedimentary basins and granitoid intrusions (Abouchami *et al.,* 1990; Boher *et al.,* 1992; Grenholm *et al.,* 2019; Milési *et al.,* 1989; Vidal and Alric, 1994). The Birimian volcanic belts are commonly composed of basaltic to andesitic rocks, pyroclastic rocks, and volcaniclastic units, whereas the sedimentary basins are dominated by schists, greywackes, shales, sandstones, and carbonate-bearing rocks (Kone *et al.,* 2025; Leube *et al.,* 1990; Taylor *et al.,* 1992). These formations are generally affected by Eburnean deformation and low- to medium-grade metamorphism, commonly of greenschist facies (Houssou, 2013; Leube *et al.,* 1990).
From a metallogenic point of view, the Birimian formations of the West African Craton constitute one of the most important gold-bearing geological provinces in Africa (Markwitz *et al.,* 2016; Milési *et al.,* 1989; Milési *et al.,* 1992). Several gold deposits and prospects in Côte d'Ivoire are hosted by Birimian volcano-sedimentary and intrusive formations. Examples include Ity, Tongon, Bonikro, Agbahou, Aféma, Angovia, Yaouré, Lafigué, and several smaller prospects (Assié, 2008; Coulibaly *et al.,* 2008; Houssou *et al.,* 2017; Ouattara, 2015a). In most of these deposits, mineralization is spatially associated with shear zones, lithological contacts, quartz or quartz-carbonate veins, sulfide-bearing alteration zones, and greenschist-facies metamorphic assemblages (Assié *et al.,* 2024; Koffi *et al.,* 2025; Nestor *et al.,* 2022).

Geological framework of the Bouaflé area

The PR 861 permit belongs to the Paleoproterozoic domain of central-western Côte d'Ivoire. In the Bouaflé region, the geological formations are broadly oriented according to Eburnean structural directions and have been interpreted as a structural continuation of the large syn-kinematic two-mica granite massif of Ferkessédougou (Tagini, 1962). The main granite outcrops of the region are generally oriented N110°-150°E, N60°-90°E and N0°-30°E. The metamorphic formations commonly show steep to subvertical dips, with main directions of N30°-60°E in most of the region and N10°-25°E toward the Daloa sector (Adam, 1969; Boffouo, 2021).

The southern part of the Ferkessédougou batholith is also known for metalliferous concentrations of variable importance, including columbo-tantalite, gold, beryl, lithium, and some rare earth elements (Allou, 2005; Boffouo, 2021). This regional metallogenic background gives the Bouaflé area a favorable geological position, especially where granitoids, pegmatitic bodies, schistose formations, hydrothermal alteration, and deformation structures occur together.

MATERIALS AND METHODS

The methodology used in this study combines remote sensing, petro-structural analysis, and metallographic observations. This approach is commonly used in Birimian terrains to characterize lithological units, structural organization, hydrothermal alteration, and sulfide mineralization (Koffi *et al.,* 2025; Kone *et al.,* 2025; Nestor *et al.,* 2022). The work was organized into four main steps: lineament analysis, field mapping and structural measurements, petrographic study, and metallographic observation.

Remote sensing and lineament analysis

Remote sensing was used to establish the lineament map of the PR 861 permit. Landsat 8 satellite imagery was processed to enhance linear structures that may correspond to fractures, faults, veins, schistosities or lithological contacts. The use of satellite imagery for lineament extraction is particularly useful in tropical areas, where lateritic cover, vegetation, and poor outcrop exposure can limit direct field observation (Masoud and Koike, 2011; Youan Ta, 2002). The lineaments were extracted from the processed images using ENVI software and then transferred to QGIS for map production and spatial analysis. Their orientations were analyzed using a directional rose diagram in order to determine the main structural trends of the study area. Similar approaches have been used in several Ivorian Birimian studies to define fracture networks, shear directions, and possible structural corridors related to mineralization (Assié *et al.,* 2024; Pour *et al.,* 2021; Saley, 2003).

Field mapping and structural measurements

Fieldwork consisted of locating and describing representative outcrops across the study area. Each outcrop was positioned using a GPS and described according to its mode of occurrence, weathering state, color, structure, texture, mineralogical composition, alteration, and lithological family. Particular attention was given to the relationships between lithologies, alteration zones, quartz veins, fractures, schistosities, and pegmatite veins.

The structural study consisted of identifying, describing, and measuring the main deformation markers observed in the field. These include schistosities, fractures, faults, quartz veins, pegmatite veins, mineral stretching lineations, boudinage, and folds. The collected structural data were plotted on Wulff stereographic projections using GeOrient software. These data were then compared with the lineament map in order to better constrain the structural architecture of the permit and the possible deformation phases.

Petrographic study

Representative rock samples were collected from the main lithological units within the permit area. Thin sections were prepared and observed under a polarizing microscope at the Laboratory of Geology, Mineral Resources and Energy. The petrographic study focused on mineralogical composition, textures, metamorphic minerals, alteration assemblages, and microstructural features. This analysis enabled the identification of magmatic and metasedimentary rocks, as well as secondary minerals associated with hydrothermal alteration.

Metallographic study

Polished sections were prepared from selected samples showing sulfide or oxide minerals. These sections were studied using reflected-light microscopy in order to identify the ore minerals and define the metalliferous paragenesis. The metallographic study focused mainly on the recognition of pyrite, chalcopyrite, and magnetite, their textural relationships, and their association with hydrothermal alteration and deformation structures.

Sample set

The petrographic and metallographic study was carried out on representative samples collected from the main lithological units of the PR 861 permit. Eleven rock samples were collected. These samples provide the basis for the petrographic, structural, and metallogenic interpretation presented in this work.

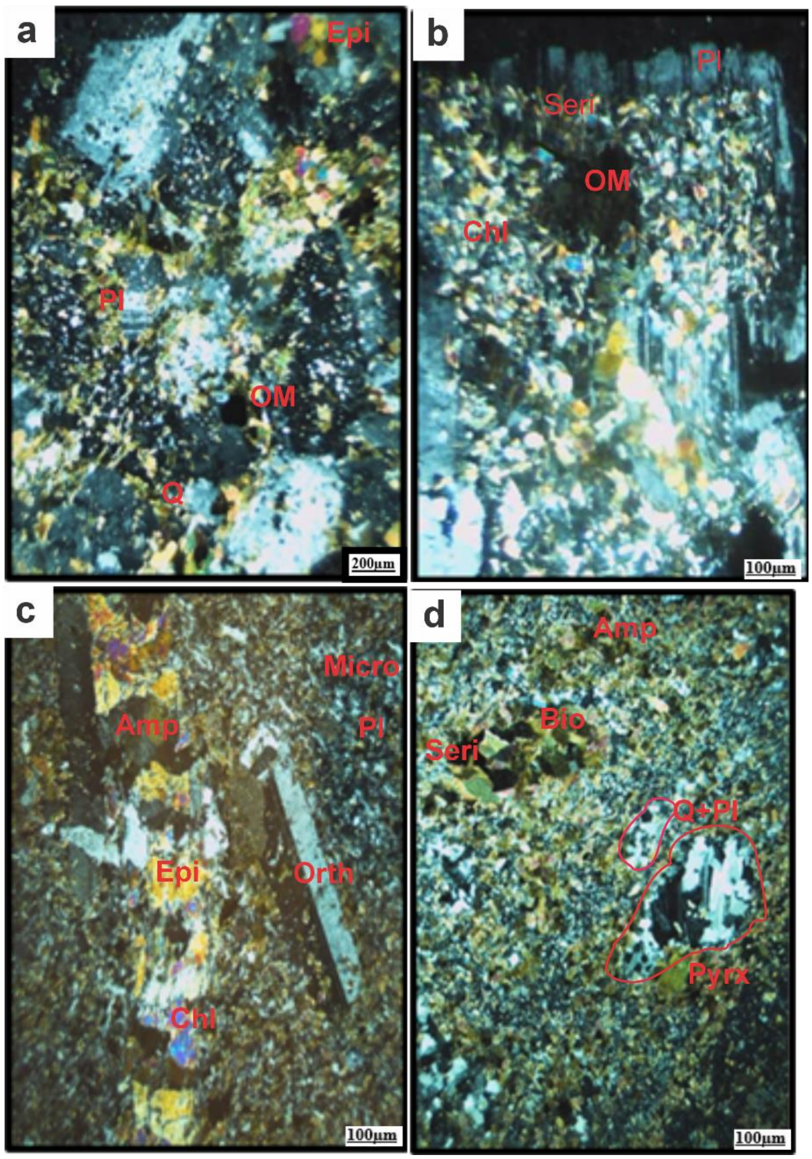

Figure 2: Microscopic aspects of magmatic rocks: **a) granodiorite; b) microdiorite; c) andesite; d) volcaniclastic rock.** *Epi: epidote; Pl: plagioclase; Q: quartz; OM: opaque mineral; Seri: sericite; Chl: chlorite; Amp: amphibole; Micro: microcline; Orth: orthoclase; Bio: biotite; Pyrx: pyroxene*.

RESULTS AND DISCUSSION

Petrographic characteristics

The geological formations of the PR 861 permit can be grouped into two main lithological families: magmatic rocks and metamorphic rocks. The magmatic rocks are represented by granodiorite, microdiorite, andesite, and volcaniclastic rocks. The metamorphic rocks are mainly composed of sericite schist, chlorite-sericite schist, chlorite schist, mica schist, and phyllite. Pegmatite veins are also observed locally.

Magmatic rocks

The granodiorite generally occurs as slabs and blocks. It is weakly altered, mesocratic, and massive, with a medium-grained texture. Microscopic observation reveals a mineral assemblage dominated by plagioclase and quartz, accompanied by epidote and opaque minerals (Figure 2a).

The microdiorite is massive and weakly altered. It is dark green to melanocratic and displays a microgranular texture. Under the microscope, the rock shows a porphyritic microgranular texture with phenocrysts of amphibole and plagioclase. The mineral assemblage also includes biotite and quartz (Figure 2b).

The andesite occurs as melanocratic blocks and is locally deformed. It is affected by hydrothermal alteration, which has partly transformed the primary minerals into secondary chlorite, epidote, and sericite. Quartz and epidote veins and veinlets commonly crosscut the rock. Microscopically, the andesite shows a porphyritic microlithic texture dominated by plagioclase (Figure 2c).

The volcaniclastic rocks are melanocratic and massive. They show a porphyritic microlithic texture, with plagioclase microlites, sericite, orthoclase, altered plagioclase phenocrysts, quartz grains, and amphibole. Lithic fragments are also present, indicating the volcaniclastic origin of the rock (Figure 2d).

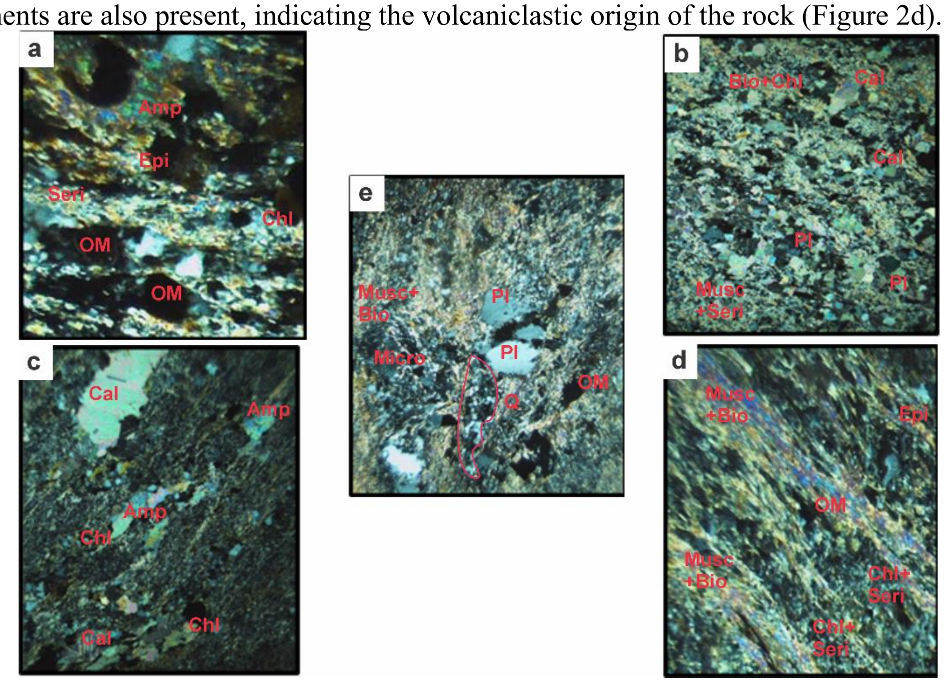

Figure 3: Microscopic aspects of metamorphic rocks: a) sericite schist; b) chlorite-sericite schist; c) chlorite schist; d) mica schist; e) phyllite. *Epi: epidote; Amp: amphibole ; Seri: sericite ; Chl: chlorite; OM: opaque mineral ; Bio: biotite; Pl: plagioclase ; Cal: calcite; Musc: muscovite; Q: quartz; Micro: microcline.*

Metamorphic rocks

The sericite schist is brown, deformed, and moderately altered. It has a schistose structure and a lepidoblastic texture under the microscope. It is mainly composed of sericite, chlorite, opaque minerals, amphibole, and epidote (Figure 3a).

The chlorite-sericite schist is brown to greenish-brown, deformed, and moderately altered. It shows a well-marked schistose structure, locally expressed by tight layering. Microscopically, the rock has a lepidogranoblastic texture and contains muscovite, sericite, biotite, chlorite, calcite, and plagioclase (Figure 3b).

The chlorite schist is soft and friable, with a marked schistosity but without clear compositional layering. Its grey-green color is related to strong chloritization. The mineral assemblage includes chlorite, sericite, amphibole, epidote, and opaque minerals (Figure 3c).

The mica schist is grey and shiny, with a schistose structure. It is strongly deformed and altered, with minerals oriented parallel to the schistosity plane. The main minerals are muscovite, biotite, chlorite, sericite, epidote, and opaque minerals (Figure 3d).

The phyllite crops out as a slab and ranges in color from grey-black to brown. It shows a lepidoblastic texture and contains more than 50% mica minerals, partly altered to sericite and chlorite. The rock is cut by fractures filled with quartz and tourmaline-bearing material (Figure 3e).

Metamorphism and hydrothermal alteration

The mineral assemblages observed in the studied rocks indicate low-grade greenschist-facies metamorphism. This metamorphism is marked mainly by chlorite, epidote, sericite, calcite, and quartz. These minerals result from the transformation of primary minerals such as feldspar, biotite, amphibole, and pyroxene (Figure 4).

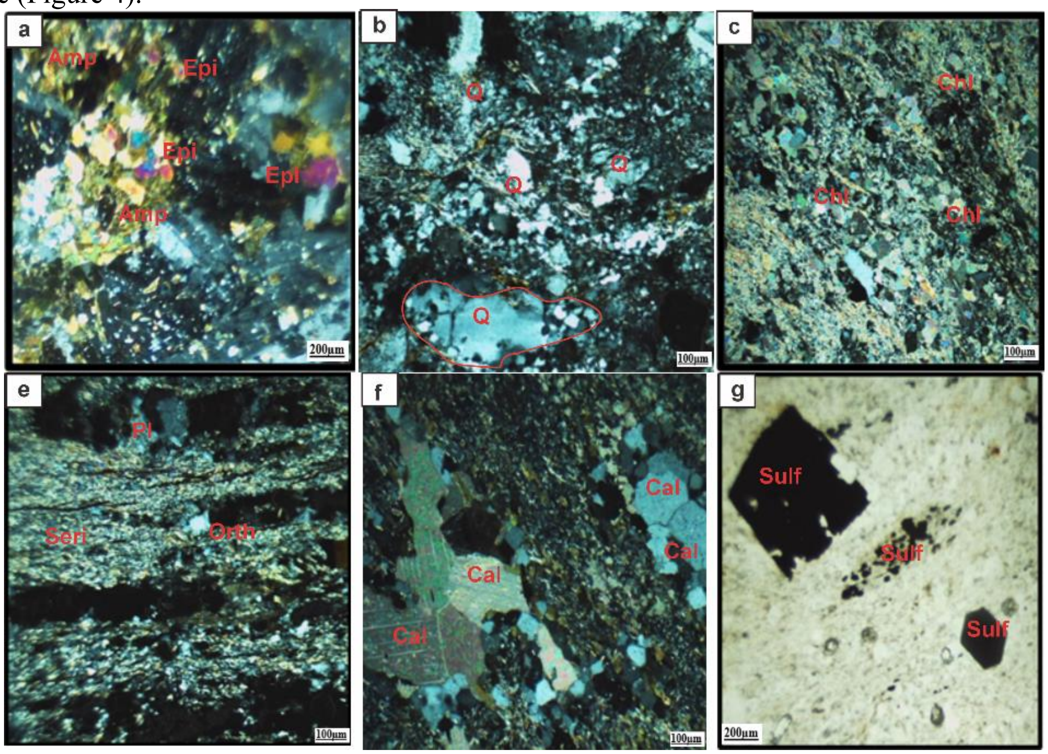

Figure 4: Hydrothermal alteration: a) epidotization; b) silicification; c) chloritization; d) sericitization; e) carbonatization; f) sulfidation. *Epi: epidote; Amp: amphibole; Seri: sericite; Chl: chlorite; Bio: biotite; Pl: plagioclase; Cal: calcite; Q: quartz.*

Hydrothermal alteration is widespread in the study area and affects almost all lithologies. Two alteration styles are recognized: pervasive alteration and vein-controlled alteration. Pervasive alteration is expressed by epidotization, silicification, chloritization, sericitization, carbonatization, and sulfidation (Figure 4). Vein-controlled alteration is represented by epidote veinlets, quartz-carbonate veinlets, and quartz veinlets. These alteration features indicate fluid circulation through both the rock matrix and fracture networks (Figure 5).

Structural characteristics

The structural organization of the PR 861 permit was defined from remote sensing, field observations, and microstructural study. Landsat 8 lineament analysis identified 79 lineaments of variable lengths, ranging from several hundred meters to several kilometers. The dominant lineament family trends NNE-SSW to NE-SW. Secondary directions are ENE-WSW to E-W and NW-SE (Figure 6).

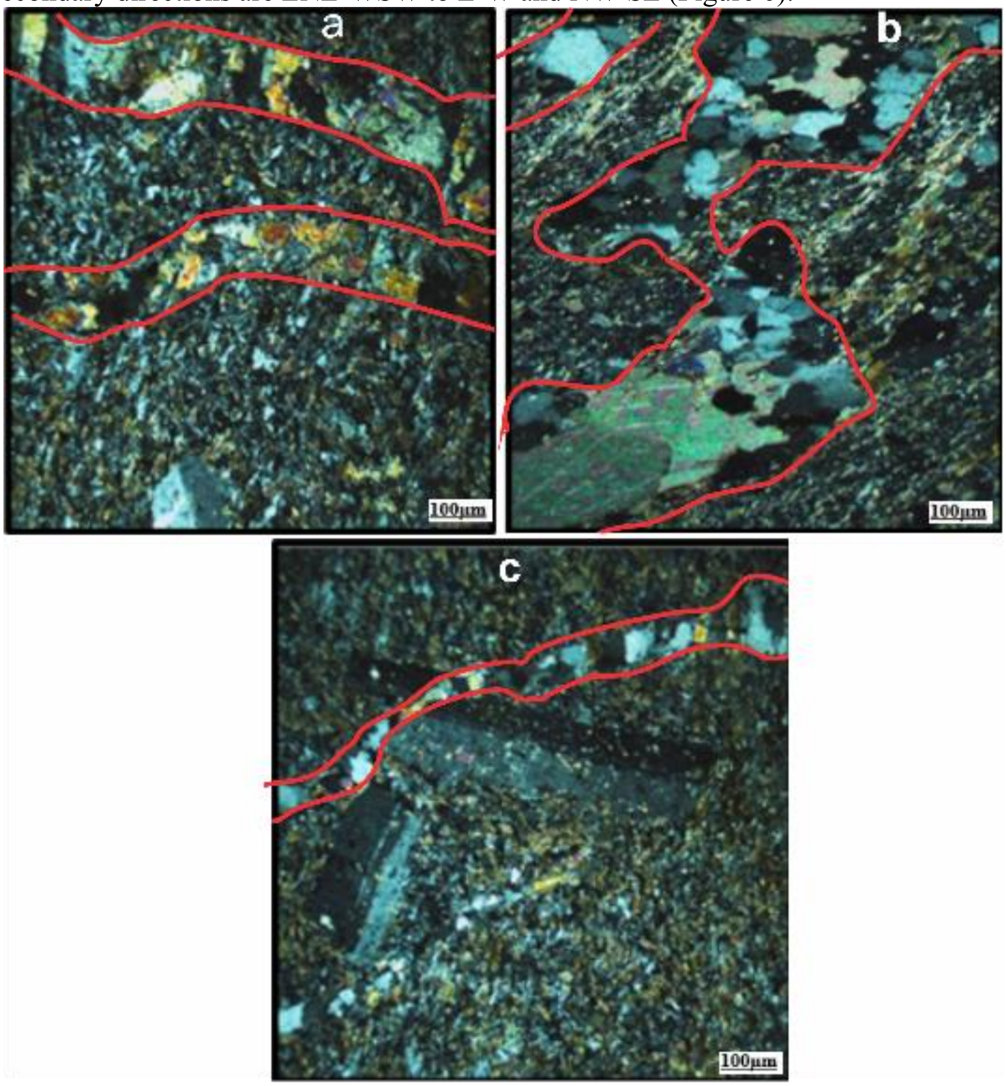

Figure 5: Vein-type hydrothermal alteration: a) epidote veinlets; b) quartz-carbonate veinlet; c) quartz veinlet.

Field observations show that the study area contains both brittle and ductile-brittle structures. Brittle structures include fractures, quartz veins, pegmatite veins, strike-slip faults, and fracture schistosities. Ductile to ductile-brittle structures include foliations, mineral stretching lineations, boudins, asymmetric folds, foliation deflections, and C/S fabrics (Figure 7).

The deformation history can be divided into two main phases. The first phase, D1, corresponds to a synmagmatic compressional event. In the Pakouabo area, it is expressed by mineral lineations trending N10 to N40 and plunging steeply to the NE, at about 70°. The second phase, D2, corresponds to a transpressional event and can be subdivided into a compressional component, D2a, and a shear component, D2b. The main deformation mechanisms are flattening and simple shear.

The presence of asymmetric folds, boudinage, mineral stretching lineations, C/S fabrics, winding structures, and strike-slip faults suggests the existence of a NE-SW shear corridor in the study area. This corridor probably controlled the circulation of hydrothermal fluids and the development of quartz-carbonate veinlets and sulfide-bearing zones.

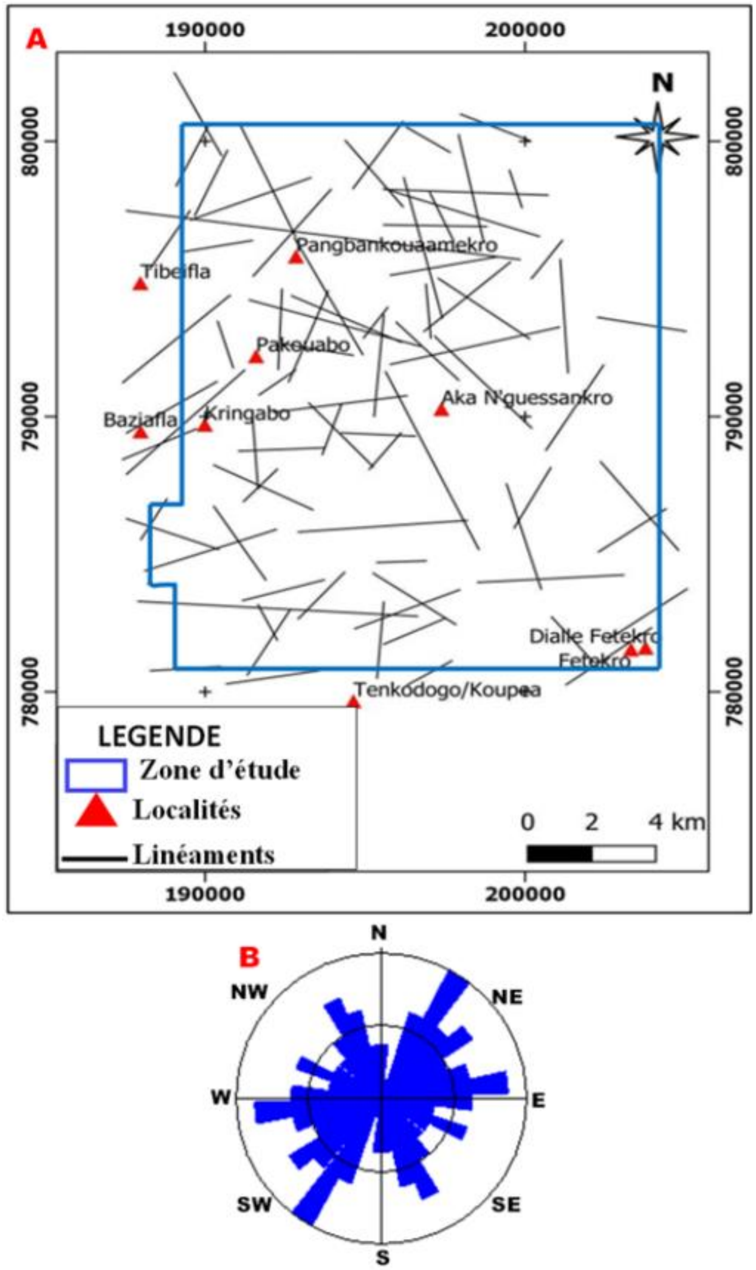

Figure 6: Lineament map and directional rose diagram of the study area: A) lineament map; B) directional rose diagram associated with the lineament map.

Microstructural characteristics

Microscopic deformation is observed in most of the studied rocks. It affects biotite, muscovite, plagioclase, chlorite, sericite, epidote, and quartz. Some chlorite, sericite, and feldspar crystals contain microfractures filled with quartz and/or carbonate. These features indicate that part of the deformation occurred in the presence of fluids. Other microstructures indicate solid-state deformation. They include C/S fabrics in mica-rich domains, mineral stretching lineations, microfaults, and microboudins. These microstructures are consistent with field-scale evidence for ductile-brittle deformation and shear-related fabric development (Figure 8).

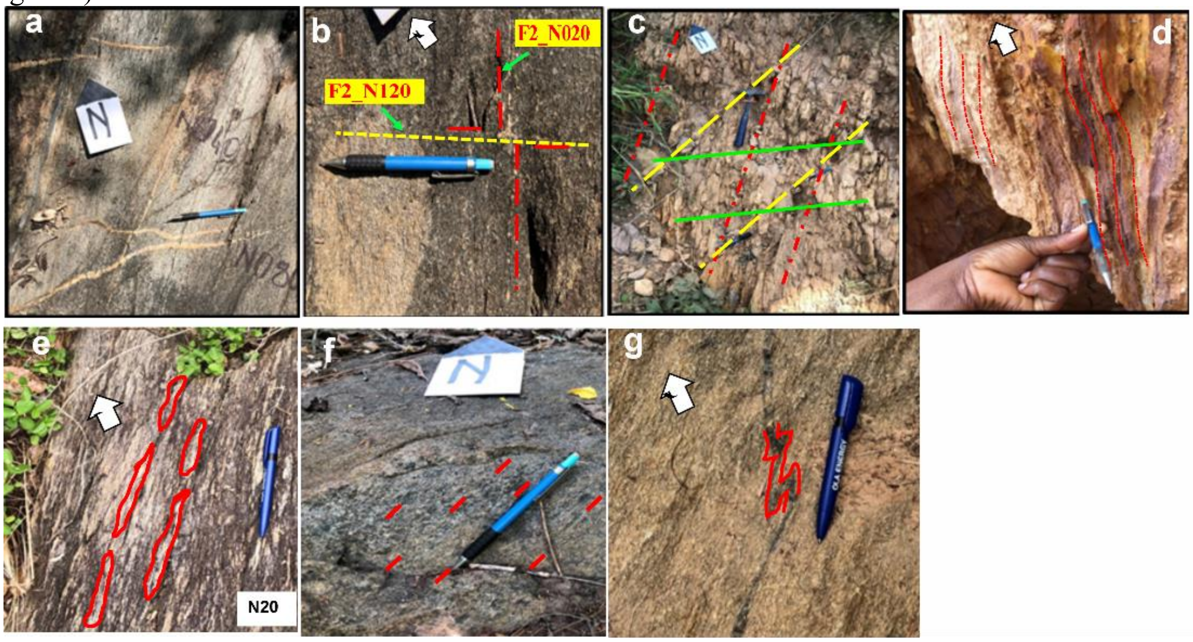

Figure 7: Different structures observed in the field: a) quartz veins; b) strike-slip faults; c) fractures; d) fracture schistosity; e) boudinage; f) mineral stretching lineation; g) Z-type asymmetric fold.

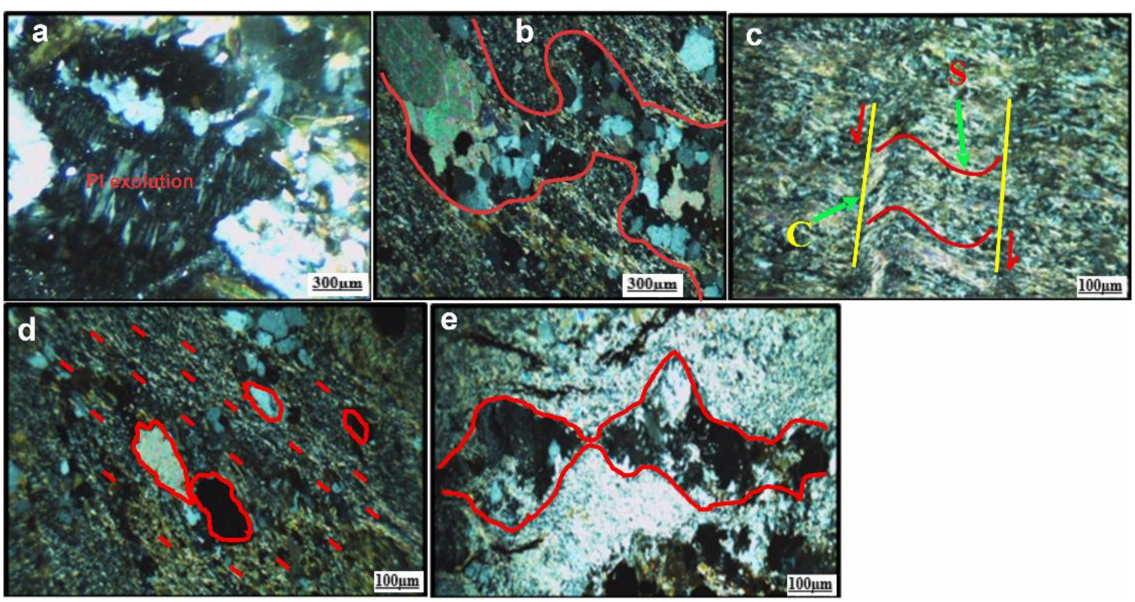

Figure 8: Microstructures: a) perthite formed by exsolution in plagioclase; b) microfracture filled with quartz and calcite; c) C/S fabric; d) mineral stretching lineation; e) boudinaged quartz veinlet.

Metallographic characteristics

The metallographic study reveals a simple sulfide-oxide paragenesis composed mainly of pyrite, chalcopyrite, and magnetite. Pyrite is the most abundant ore mineral observed. Chalcopyrite is locally associated with magnetite, while magnetite occurs as discrete grains and in association with sulfide minerals (Figure 9).

The abundance of sulfides in schistose metasedimentary rocks suggests that these formations may be favorable hosts for hydrothermal sulfide mineralization. Mineralization is associated with quartz-carbonate veining, carbonatization, sericitization, chloritization, and ductile-brittle deformation. At the present stage, the data support the existence of structurally and lithologically controlled hydrothermal sulfide mineralization. Direct gold confirmation still requires geochemical and micro-analytical studies.

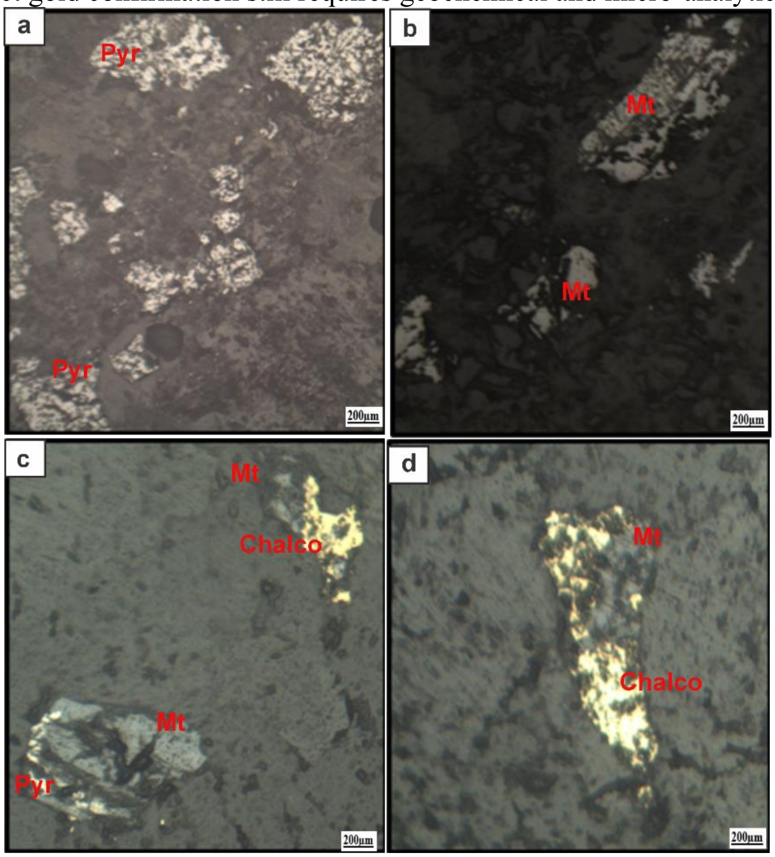

Figure 9: Microscopic aspects of the metalliferous paragenesis: a) pyrite; b) magnetite; c) chalcopyrite-magnetite and pyrite-magnetite associations; d) chalcopyrite-magnetite association. *Pyr: pyrite; Mt: magnetite; Chalco: chalcopyrite.*

Discussion

Petrographic and metamorphic significance

The petrographic study shows that the PR 861 permit is composed of both magmatic and metamorphic rocks. The magmatic rocks include granodiorite, microdiorite, andesite, and volcaniclastic rocks, whereas the metamorphic rocks are represented by sericite schist, chlorite-sericite schist, chlorite schist, mica schist, and phyllite. This lithological association is consistent with a Birimian volcano-sedimentary and plutonic context described in several parts of Côte d'Ivoire and the southern West African Craton (Caby *et al.,* 2000; Gnanzou, 2014; Grenholm *et al.,* 2019; Kone *et al.,* 2025; Pouclet *et al.,* 2006; Tagini, 1971).

The presence of andesite and volcaniclastic rocks indicates a volcanic contribution to the geological evolution of the permit. Similar volcanic and volcaniclastic units have been described in the Fêtêkro, Marabadiassa-Katiola, Kimoukro-Kokumbo, and Koffissiokaha sectors, where they are commonly associated with schistose metasedimentary rocks and granitoid intrusions (Gnanzou, 2014; Koffi *et al.,* 2025; Kone *et al.,* 2025; Nestor *et al.,* 2022). The granodiorite and microdiorite observed in PR 861 may

therefore represent intrusive phases emplaced within, or close to, the Birimian volcano-sedimentary sequence.
The dominance of schistose rocks is an important feature of the permit. Sericite schist, chlorite-sericite schist, chlorite schist, mica schist, and phyllite are strongly affected by deformation and hydrothermal alteration. These rocks may have acted as mechanically weak horizons during deformation, favoring the development of schistosity, quartz-carbonate veinlets, microfractures, and sulfide-bearing alteration zones. Similar relationships between schistose host rocks, deformation, and mineralization have been described in the Koffissiokaha permit, Kimoukro-Kokumbo area, Aféma district, Agbahou deposit, and Bonikro deposit (Assié, 2008; Coulibaly *et al.,* 2008; Gnanzou, 2014; Houssou *et al.,* 2017; Koffi *et al.,* 2025; Nestor *et al.,* 2022; Ouattara *et al.,* 2015b).
The mineral assemblage consisting of chlorite, epidote, sericite, calcite, and quartz indicates low-grade greenschist-facies metamorphism. This metamorphic grade is common in many Birimian greenstone belts and has been reported in several Ivorian gold-bearing areas (Houssou, 2013; Koffi *et al.,* 2025; Kone *et al.,* 2025; Nestor *et al.,* 2022; Ouattara, 2015a). However, metamorphic grade alone does not define mineralization. Its metallogenic importance in PR 861 comes from its association with hydrothermal alteration, sulfide minerals, and ductile-brittle deformation.

Hydrothermal alteration and fluid circulation

Hydrothermal alteration is widespread in the PR 861 permit. It is expressed by epidotization, silicification, chloritization, sericitization, carbonatization, and sulfidation. Two main alteration styles can be distinguished: pervasive alteration, which affects the rock matrix, and vein-controlled alteration, expressed by epidote veinlets, quartz-carbonate veinlets, and quartz veinlets.
This alteration assemblage is significant because it is comparable to alteration halos described in several Birimian gold systems. In West Africa, hydrothermal alteration related to mineralization commonly includes silicification, carbonatization, chloritization, sericitization, and sulfidation (Coulibaly *et al.,* 2008; Houssou, 2013; Houssou *et al.,* 2017; Milési *et al.,* 1989). At Koffissiokaha, mineralization is associated with quartz-carbonate veins, chlorite, sericite, carbonate, and sulfides (Nestor *et al.,* 2022). At Kimoukro-Kokumbo, gold and sulfides are reported in quartz or calcite veins and in the host rocks, particularly greenstones and sericite schist (Koffi *et al.,* 2025). At Agbahou and Bonikro, hydrothermal alteration is also closely associated with shear zones, quartz veins, and sulfide-bearing assemblages (Houssou, 2013; Ouattara, 2015a).
In PR 861, the coexistence of carbonatization, chloritization, sericitization, silicification, and sulfidation suggests that hydrothermal fluids circulated both through the fracture network and schistose host rocks. Carbonatization and silicification may reflect repeated fluid-rock interaction, whereas sulfidation indicates that the hydrothermal system was able to precipitate sulfide minerals. The association of quartz-carbonate veinlets with deformed schists is therefore one of the most important metallogenic features of the permit.

Structural control and deformation history

The structural data indicate that the PR 861 permit was affected by polyphase deformation. The first deformation phase, D1, is interpreted as a synmagmatic compressional event expressed by mineral lineations trending N10 to N40 in the Pakouabo area. This phase may be related to early deformation during or shortly after magmatic emplacement. The second deformation phase, D2, corresponds to a transpressional event and is expressed by both compressional and shear structures.
The main structural markers observed in the permit are schistosities, fractures, quartz veins, pegmatite veins, strike-slip faults, mineral stretching lineations, boudinage, asymmetric folds, winding structures, and C/S fabrics. These structures indicate brittle to ductile-brittle deformation. C/S fabrics, sigmoidal structures, boudinage, and asymmetric folds are typical shear indicators and are commonly used to interpret deformation in shear zones (Mandal, 1995; Passchier and Trouw, 1998).
The Landsat 8 lineament analysis shows a dominant NNE-SSW to NE-SW structural trend, with secondary ENE-WSW to E-W and NW-SE directions. This pattern is compatible with the regional structural grain described in several Birimian belts of Côte d'Ivoire (Assié *et al.,* 2024; Koffi *et al.,* 2025; Kone *et al.,* 2025;

Nestor *et al.,* 2022). In the southern Fêtêkro belt, lineament studies have shown that high fracture density and shear-zone intersections may coincide with gold geochemical anomalies (Assié *et al.,* 2024). In the Kimoukro-Kokumbo and Koffissiokaha areas, NNE-SSW to NE-SW shear zones are also interpreted as important structures controlling hydrothermal alteration and mineralization (Koffi *et al.,* 2025; Nestor *et al.,* 2022).

The probable NE-SW shear corridor interpreted in PR 861 is therefore a major metallogenic feature. Such a corridor may have increased permeability, channelled hydrothermal fluids, and localized quartz-carbonate veining and sulfide deposition.

Secondary ENE-WSW to E-W and NW-SE structures may have acted as cross-fractures or late reactivation structures, creating favorable sites for fluid focusing and mineral precipitation.

Metallogenic implications

The metallographic study of PR 861 revealed a sulfide-oxide paragenesis composed mainly of pyrite, chalcopyrite, and magnetite. Pyrite is the most abundant ore mineral, whereas chalcopyrite and magnetite occur in smaller proportions. This paragenesis confirms the existence of hydrothermal sulfide-oxide mineralization within the permit.

The association of sulfides with schistose metasedimentary rocks, quartz-carbonate veining, and hydrothermal alteration suggests that mineralization is controlled by both lithology and structure. Similar controls are known in several Birimian gold systems, where mineralization is hosted by sheared metasediments, metavolcanic rocks, or granitoids, and is commonly associated with quartz veins and sulfide-bearing alteration (Béziat *et al.,* 2008; Hodgson, 1989; Houssou *et al.,* 2017; Milési *et al.,* 1989). In the Koffissiokaha permit, the sulfide paragenesis consists mainly of pyrite, pyrrhotite, arsenopyrite, and chalcopyrite, with mineralization controlled by structural and hydrothermal parameters (Nestor *et al.,* 2022). In the Kimoukro-Kokumbo area, pyrite and chalcopyrite are also reported with gold, grey copper, and zinc in veins and host rocks (Koffi *et al.,* 2025).

In PR 861, no systematic gold assay, XRF dataset, or direct micro-analytical evidence of gold has yet been provided. For this reason, mineralization should be described as hydrothermal sulfide mineralization, not as confirmed gold mineralization. Nevertheless, the geological association observed in the permit is favorable for gold exploration because it combines several important metallotects: schistose host rocks, NE-SW shear structures, quartz-carbonate veining, carbonatization, chloritization, sericitization, and sulfidation.

Exploration implications

The most favorable zones in the PR 861 permit are expected where schistose metasedimentary rocks are affected by NE-SW shear structures, quartz-carbonate veining and sulfide-bearing alteration. Particular attention should be given to structural intersections between the dominant NNE-SSW to NE-SW corridors and secondary ENE-WSW to E-W or NW-SE fractures. These intersections may represent higher-permeability zones and possible sites of fluid focusing.

CONCLUSION

The petrographic, structural, and metallogenic study carried out on the PR 861 permit has improved the geological knowledge of the Bouaflé area in central-western Côte d'Ivoire. The geological formations of the permit consist of magmatic and metamorphic rocks, as well as pegmatite veins. The magmatic rocks include granodiorite, microdiorite, andesite, and volcaniclastic rocks. The metamorphic rocks are represented by sericite schist, chlorite-sericite schist, chlorite schist, mica schist, and phyllite.

All these formations are affected by low-grade greenschist-facies metamorphism, marked by chlorite, epidote, sericite, calcite, and quartz. Hydrothermal alteration is also well developed and is expressed by epidotization, silicification, chloritization, sericitization, carbonatization, and sulfidation. Two alteration styles are recognized: pervasive alteration and vein-controlled alteration, the latter being marked by epidote, quartz-carbonate, and quartz veinlets.

The structural study shows that the permit is affected by brittle and ductile-brittle deformation. The main structures are schistosities, fractures, quartz veins, strike-slip faults, mineral stretching lineations, boudinage, asymmetric folds, and C/S fabrics. Lineament analysis and field observations indicate a dominant NNE-SSW to NE-SW structural trend, with secondary ENE-WSW to E-W and NW-SE directions. These structures suggest the presence of a NE-SW shear corridor in the study area.

The metallographic study reveals a sulfide-oxide paragenesis composed mainly of pyrite, chalcopyrite, and magnetite. Pyrite is the most abundant ore mineral observed. The sulfides are preferentially associated with schistose metasedimentary rocks, quartz-carbonate veining, and hydrothermal alteration. These observations suggest that mineralization is controlled by both lithology and structure.

The PR 861 permit can therefore be interpreted as a structurally controlled hydrothermal sulfide system developed within Birimian formations. However, the present dataset does not yet allow a direct confirmation of gold mineralization. Further work is required before any economic interpretation can be made. Future studies should include systematic rock and vein geochemistry, gold and pathfinder-element assays, geochronological dating, SEM-EDS or electron microprobe analysis of sulfides, and fluid-inclusion studies in order to better constrain the nature, timing, and origin of the mineralizing fluids.

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