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PETROGRAPHIC CHARACTERISTICS OF THE BIRIMIAN FORMATIONS OF THE DOUGBAFLA-BANDANA GOLD ZONE (SOUTHERN PART OF THE FÈTÊKRO BIRIMIAN BELT, CENTRAL-WESTERN CÔTE D'IVOIRE)

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ABSTRACT

This study was carried out in order to contribute to the characterization of the lithologies of the Dougbafla-Bandama gold zone, located in central-western Côte d'Ivoire in the southern part of the Fètêkro Birimian belt. The methodological approach used in this study first involved macroscopic observations with the naked eye and/or hand lens of outcrops and rocks obtained from drilling (RC and DD) in the field. Then, thin sections of the different lithologies were prepared in the laboratory for study under the polarizing microscope, in order to provide greater precision to the macroscopic observations. The work carried out made it possible to identify mafic to acidic volcanic rocks (basalts, andesites and rhyodacites). These volcanic rocks are intimately associated with mafic volcaniclastic rocks (autobreccias, polybreccias and hyaloclastites) and with metasediments (quartzites, black shales, sericite schists and chlorite schists). This complex is intruded by various plutonic (epidiorites, lamprophyres, granites, granodiorites, tonalites) and hypovolcanic (granophyres, microgranodiorites and microdiorites) formations. The volcano-sedimentary complex described in the Dougbafla-Bandama zone fits within the framework of most of the Birimian formations described in Côte d'Ivoire.

Keywords: Birimian; Gold zone; Dougbafla-Bandama; Lithology; Côte d'Ivoire

1 INTRODUCTION

The Oumé region is located in central-western Côte d'Ivoire, about 250 km from Abidjan, the economic capital. The geological history of this region, which lies in the southern part of the Fètêkro belt [1], belongs to that of the Baoulé-Mossi domain [2-4], structured during the Eburnean orogeny (Figure 1). The various geological units encountered can be subdivided into two major groups as described by [5-7]. The group of volcano-sedimentary rocks crops out in the south of the region. It is composed, on the one hand, of metasediments (flysch, shales, spilites, conglomerates, and grauwackes) and undifferentiated rocks; and, on the other hand, of metavolcanic rocks consisting of amphibolites,

andesites and basalts. The predominant formations in this assemblage are the shales. Their greenish hue long maintained the designation of greywackes, but the work carried out by [8] showed a predominance of shales (meta-arenites) over greywackes. The volcano-sedimentary rocks are affected by structures generally trending NE-SW. The granitoid group, for its part, has no particular orientation. This assemblage consists largely of homogeneous and heterogeneous biotite granites, intrusive granites and granodiorites. The Oumé region is made up of 70% heterogeneous biotite granites. The granodiorites occur in the extreme SE and NE **(figure 1).** The intrusion of granitic massifs is noted in the centre and east of the region.

Since ancient times, this region has been the site of intense mining activity and continues to be so today, as shown by the work of [9-10]. The PR105 mining research permit located in this region hosts the current Bonikro gold mine, commissioned in 2007 as described by [11], as well as the modest Dougbafla gold deposit and about ten potential targets. Given the gold potential offered by this permit, the mining company Newcrest Mining Limited, holder of the permit, decided from the 2010s onward to increase its gold reserves in order to extend the lifespan of the Bonikro processing unit. To this end, it launched an extensive hammer-prospecting campaign supported by a drilling programme in order to better understand the geology of the permit. This work was justified by the insufficiency of deep investigations in the region, which until then had not allowed a very detailed geological study to be carried out. The geological contours shown on old cartographic documents are based on geomorphological observations or on photo-interpretation work. The lithostratigraphy remains rudimentary and poorly detailed. It is in this context that the present study, intended as a contribution to the knowledge of the petrographic characteristics of the Birimian, was specifically conducted with the aim of clarifying the petrography of the formations of the Dougbafla-Bandama zone. This zone, located in the northern part of the PR105 permit of Oumé, is composed of the Bandama, Dougbafla Centre, Dougbafla North, Dougbafla West, Dougbafla South and Dougbafla East prospects; the latter hosts the modest Dougbafla deposit of about 14 tons of gold, whose oxidized portion was partially mined and processed at the Bonikro mine in 2014.

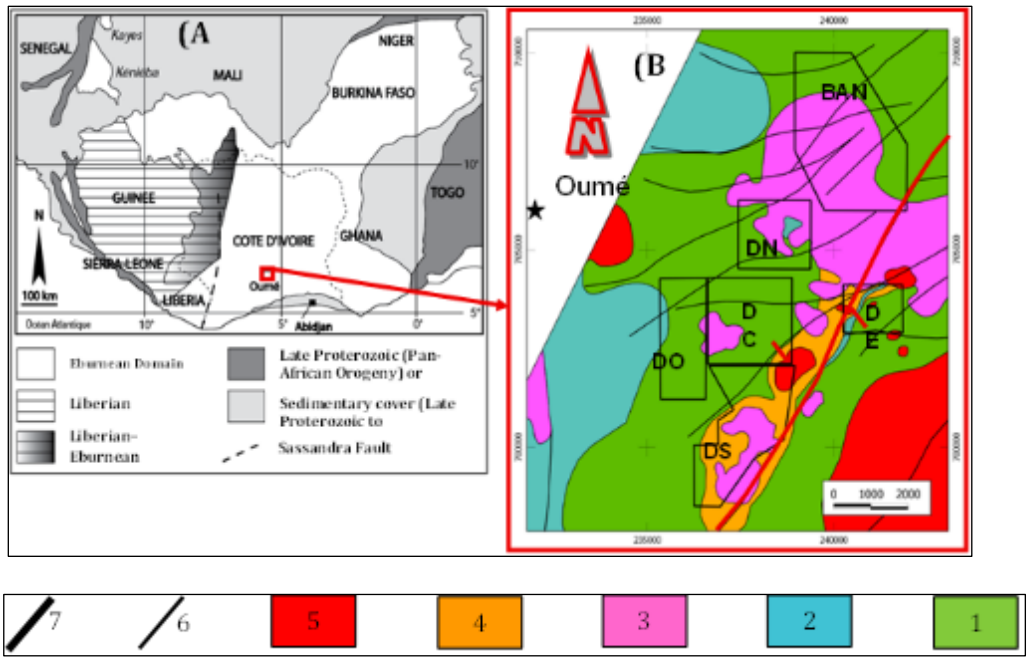


Figure 1: (a) Map of the Man Shield [2]; (b) Map of the southern part of the Oumé-Fètêkro greenstone belt [1] (modified).

1) Mafic volcanics; 2) sediments; 3) Granitoids; 4) Microdiorites ; 5) Granophyres ; 6) Fault ; 7) Major Fault. 1) Lower Birimian: neutral to ultrabasic greenstones; 2) Lower sedimentary Birimian: schist, tuff, quartzite and sandstone; 3) Upper flyschoid Birimian; 4) Acidic metavolcanic rocks; 5) Discordant mesocratic granitoids; 6) Concordant undifferentiated two-mica granites; 7) Undifferentiated granites.

2 METHODOLOGY

The Oumé region is marked by the scarcity of outcrops because of the thick layer of supergene alteration, which can sometimes reach 120 m. Owing to the thick lateritic alteration layer (40 to 120 m thick), which makes any observation of outcrops almost impossible, this study focused essentially on the description of about one hundred samples obtained from mining drilling. During this study, we used samples from percussion drilling (a so-called destructive device) with reverse circulation of compressed air (Air Reverse Circulation) of the Explorer 1000 type, and from diamond core drilling of the KL900 type. Nevertheless, a few rare, very slightly altered outcrop samples collected with a hammer also contributed to this study. The methodological approach used in this study first consisted of macroscopic petrography.

It involved describing the outcrops and the rocks obtained from drilling according to several naked-eye identification criteria. Then, the laboratory phase, based on the microscopic identification of minerals through thin sections, served to provide greater precision to the macroscopic observations. Thus, sixty thin sections were prepared at the University of Paris XI, in France, and at the Analysis and Research Centre (CAR) of the Petroleum Operations Company of Côte d'Ivoire (PETROCI). The petrographic study of the thin sections was carried out at the Basement Geology and Metallogeny Laboratory (LGSM) of the Félix HOUPHOUËT-BOIGNY University of Cocody using an OPTIKA microscope.

3 RESULTS

The petrographic study carried out in the Dougbafla-Bandama zone made it possible to distinguish five main distinct units: the volcanic rocks, the plutonic rocks, the vein (dyke) formations, the volcaniclastic rocks and the sediments.

3.1 Volcanic unit

The volcanic unit is essentially made up of basalts, andesites and rhyodacites.

3.1.1 Basalts

Basalts constitute the majority of the mafic extrusive rocks of the study area. Most of the basalts are massive and fine-grained in appearance, with a melanocratic color for the fresh facies (figure 2A). Metamorphism can give them a dark green color. Although cogenetic, depending on the size of the minerals they contain, two other varieties of basalt can be distinguished: porphyritic basalts (figures 2C and 2E) with medium phenocrysts ($1 < Ø < 2$ mm) or coarse phenocrysts ($Ø > 2$ mm); and, more discreetly, spotted basalts dotted with millimetric phenocrysts of whitish leucoxene defining a porphyritic structure giving a pseudo-tuffaceous appearance (figure 2G). Under the microscope, the basalts display an intersertal microlitic texture, generally poorly preserved because of the effects of metamorphism and hydrothermalism. Nevertheless, the following mineralogical composition can be distinguished: pyroxene uralitized into hornblende (10%), plagioclase (5%), biotite (20%), quartz (2%), chlorite (10%), calcite (15%) and sericite (30%). The accessory minerals are apatite, epidote, magnetite and zircon (figures 2B, 2D, 2F and 2H).

3.1.2 Andesites

Andesites are less widespread than basalts and display petrographic features very close to those of basalts; this is why, in the field, the term "andesitic basalts" is readily used to designate these formations (figure 2I). Their identification is difficult given the mineralogical transformations due to metamorphism and/or hydrothermal alteration. They are generally aphanitic, frequently dotted with millimetric chlorite phenocrysts, defining a porphyritic texture and giving a pseudo-tuffaceous appearance. Under the microscope, the andesites generally display a poorly preserved fluidal microlitic texture highlighted by strongly chloritized biotite phenocrysts (40%) and amphiboles (5%), sometimes chloritized or pseudomorphosed into fine epidote rods arranged in clusters. All these phenocrysts are set in a dark, aphanitic groundmass composed of plagioclase microlites (Figure 2J). Accessorily, the matrix contains calcite, sericite, epidote, chlorite, biotite, quartz amygdules (1%) and sulphides (pyrite and pyrrhotite).

3.1.3 Rhyodacites

These felsic volcanic rocks, very poorly represented in the Dougbafla zone, are hololeucocratic (figure 2K). Rhyodacites generally crop out in the form of domes. However, some boreholes show rhyodacitic dykes in sharp contact with the metasediments (black shale and sericite schist) and the basalts. These rocks are essentially composed of alkali feldspars (35%), plagioclase (35%), quartz (25%) and, accessorily, chloritized biotite and pyrite (figure 2L).

3.2 Plutonic unit

The plutonic rocks consist of deep-seated formations represented, on the one hand, by the felsic domes of granite, granodiorite and tonalite and, on the other hand, by the mafic dykes of epidiorites.

3.2.1 Granites

Granites are leucocratic and display a granular texture (Figure 3A). Microscopic study shows a mineralogy composed of quartz (35%), plagioclase (27%), microcline (20%) somewhat altered into sericite, and biotite (15%) often chloritized. Accessorily, apatite and a few generally subhedral opaque minerals are noted (figure 3B).

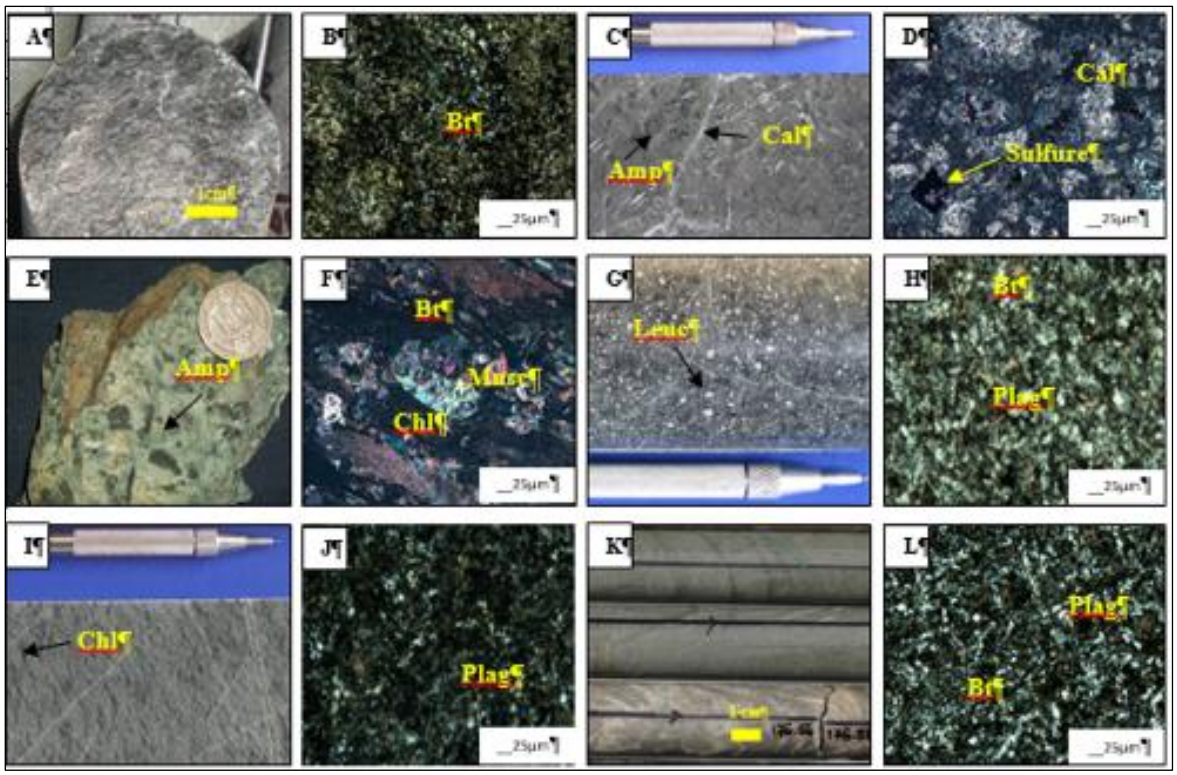


Figure 2: Macroscopic and microscopic aspects of the volcanic rocks of Dougbafla-Bandama.

A: Aphanitic basalt; B: Photomicrograph of the aphanitic basalt; C: Core of porphyritic basalt with medium amphibole phenocrysts; D: Photomicrograph of the porphyritic basalt with medium phenocrysts; E: Porphyritic basalt with amygdaloidal amphibole phenocrysts; F: Photomicrograph of the basalt with amygdaloidal phenocrysts; G: Core of spotted basalt with leucoxene phenocrysts; H: Photomicrograph of the spotted basalt; I: Andesite core; J: Photomicrograph of the andesite; K: Rhyodacite core; L: Photomicrograph of the rhyodacite. Amp = Amphibole; Bt = Biotite; Cal = Calcite; Chl = Chlorite; Plag = Plagioclase; Fk = Alkali feldspars.

3.2.2 Granodiorites

Granodiorites (figure 3C) are the most widely represented intrusive felsic magmatic formations in the Oumé-Hiré district. From a macroscopic point of view, the granodioritic pluton is massive in appearance and mesocratic to melanocratic. Under the microscope, an abundance of alkali feldspars and large plagioclase crystals is observed, a large proportion of which is altered and transformed into carbonates. Quartz is present in microcrystalline form. The observed chlorite results from the destabilization of amphibole and biotite. Accessorily, apatite, sericite and pyrite are noted (figure 3D).

3.2.3 Tonalites

These plutonic rocks with a phaneritic texture are massive in appearance, slightly deformed and are often confused with granodiorites in the field (figure 3E). However, tonalites display an abundance of biotite phenocrysts (Ø > 2 mm), giving them a darker color than the granodiorites. These rocks also contain feldspar phenocrysts (Ø > 2 mm), biotite and quartz. Under the microscope, these tonalites are composed in particular of plagioclase (60%) partially sericitized and transformed into carbonates (calcite) and epidotes, and of biotites (25%) arranged in clusters. They also contain about 10% quartz of variable size, ranging from micrograin to coarse grain, as well as generally euhedral amphibole phenocrysts. Amphibole and biotite alter and are transformed in some sections into chlorite and epidote. The accessory phase consists of apatite and opaque minerals (figure 3F).

3.2.4 Epidiorites

These mafic rocks, massive in appearance, derived from late basic magmatism, are melanocratic and display a noritic gabbro facies (figure 3G). Epidiorites are generally magnetized, very slightly deformed and display amphibole phenocrysts clearly visible to the naked eye. In thin section, the epidiorites display a poorly preserved doleritic ophitic texture and are composed of acicular pyroxene phenocrysts uralitized into amphibole (50%), plagioclase (15%) and clusters of rutile (figure 3H). A few rare primary green hornblendes that destabilize into biotite are also observed. The observed accessory minerals comprise chlorite, epidote, sericite, carbonates (calcite), very rare quartz crystals and pyrite.

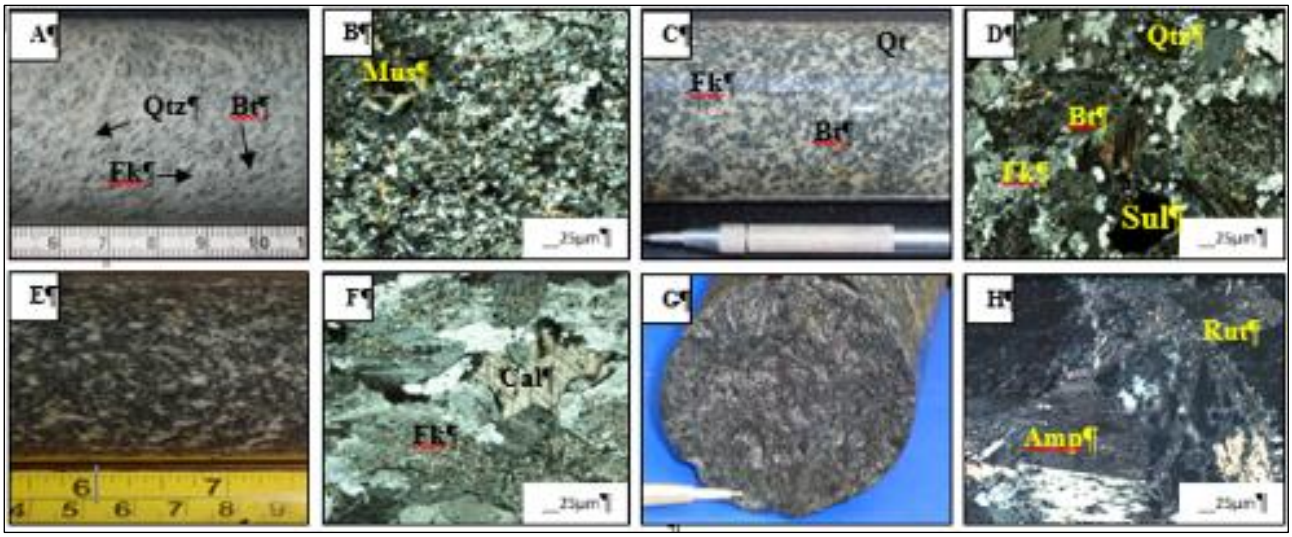


Figure 3: Macroscopic and microscopic aspects of the plutonic rocks.

A: Granite core; B: Photomicrograph of the granite; C: Granodiorite core; D: Photomicrograph of the granodiorite; E: Tonalite core; F: Photomicrograph of the tonalite; G: Epidiorite core; H: Photomicrograph of the epidiorite. Bt = Biotite; Fk = Alkali feldspar; Musc = Muscovite; Sulf = Sulphide; Qtz = Quartz.

3.3 Hypovolcanic formations

These formations are represented by granophyres, microgranodiorites, microdiorites and lamprophyres.

3.3.1 Granophyres

Granophyres, a kind of microgranite, are massive, leucocratic rocks with a very remarkable isogranular microgranular texture (figure 4A). These rocks crop out mainly in the form of plurimetric elliptical massifs within the metavolcanic rocks. In the mineralized intercepts they are strongly altered into sericite and silica induced by hydrothermalism. Under the microscope, a mineralogy is observed consisting essentially of euhedral to subhedral plagioclase phenocrysts, albite, muscovite, biotite and quartz (figure 4B). These plagioclases are most often altered and transformed into sericite and epidote. Accessorily, orthoclase, magnetite/hematite and sulphides (pyrrhotite, arsenopyrite and pyrite) are noted.

3.3.2 Microgranodiorites

Microgranodiorites, observed at Dougbafla Centre, are massive in appearance, mesocratic, with a homogeneous microgranular texture (figure 4C). In thin section, these rocks show a mineralogical composition characterized by an abundance of quartz phenocrysts (30%) in aggregates, orthoclase (15%) and plagioclase (15%). The ferromagnesian minerals (amphibole and biotite) are abundant (30%) and sometimes ragged or arranged as fine flakes partially altered into chlorite. Accessorily, sphene, calcite and pyrite are observed (figure 4D).

3.3.3 Microdiorites

Microdiorites form the set of intermediate dykes of the Oumé-Hiré gold district. They are massive, mesocratic, microgranular (1 mm ≤ Ø ≤ 2 mm) to porphyritic microgranular with feldspar phenocrysts (Ø < 2 mm) (figure 4E). Under the microscope, an abundance of plagioclase, amphibole and biotite is observed (Figure 4F). To this are added chlorite, calcite, epidote, rare quartz minerals and pyrite.

3.3.4 Lamprophyres

These poorly widespread intrusive rocks were described in the Dougbafla Centre and Bandama prospects. They appear in the form of late dykes of low thickness (25 cm to 1 m). To the naked eye, they are melanocratic, with a microgranular texture and characterized by the presence of innumerable sparkling biotite flakes (figure 4G). Microscopic observation reveals a banding formed by the interweaving of innumerable biotite minerals, clinopyroxenes uralitized into amphibole, feldspar phenocrysts (plagioclase and alkali) and sulphide inclusions (figure 4H).

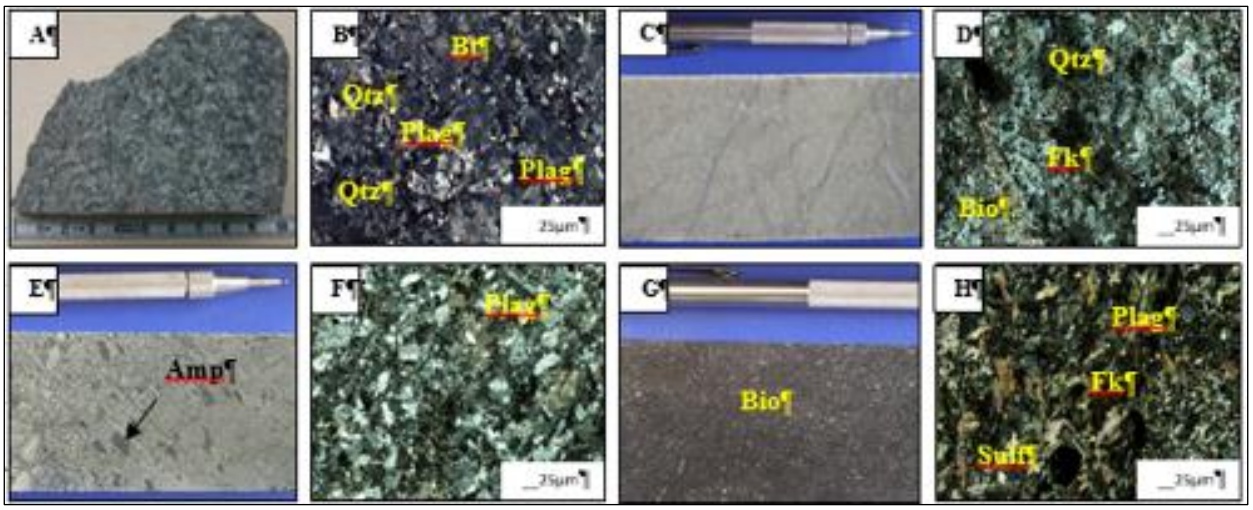


Figure 4: Macroscopic and microscopic aspects of the vein (dyke) rocks

A: Microgranite core; B: Photomicrograph of the granite; C: Microgranodiorite core; D: Photomicrograph of the granodiorite; E: Microdiorite core; F: Photomicrograph of the microdiorite; G: Lamprophyre core; H: Photomicrograph of the lamprophyre. Bt = Biotite; Fk = Alkali feldspar; Musc = Muscovite; Sulf = Sulphide; Qtz = Quartz.

3.4 Volcaniclastic rocks

This facies includes three variants: autobreccias, polybreccias and hyaloclastites, which attest to explosive volcanism in a subaqueous environment.

3.4.1 Autobreccias

Autobreccias are dark green in colour and generally correspond to plurimillimetric debris of elements of basaltic composition (i.e. 40 to 50% of the total volume of the rock) bound together by a basic cement (figure 5A). Under the polarizing microscope, a matrix dominated by fine sericite flakes is observed, within which amphibole (10%), biotite (10%) and plagioclase (1%) phenocrysts are set. These phenocrysts are completely replaced by secondary minerals of chlorite, epidote, calcite, actinolite and sericite. They also display numerous inclusions of pyrite and quartz (figure 5B).

3.4.2 Polybreccias

The heterobrecciated type has a mineralogical composition similar at first sight to that of the autobreccias but differs from them by clasts that are generally felsic and of a different nature from the basic cement (figure 5C). Under the microscope, a matrix dominated by sericite is observed, within which amphibole (10%), biotite (10%) and plagioclase (1%) phenocrysts are set. The clasts are completely replaced by secondary minerals of chlorite, epidote, calcite and actinolite. The presence of numerous pyrite inclusions is also noted (figure 5D).

3.4.3 Hyaloclastites

Hyaloclastites occur in the form of autoclastic volcanic breccias, dark green in colour with a lustrous appearance, containing 30 to 40% of millimetric to plurimillimetric angular elements, probably basalt fragments (figure 5E). This facies, described at Dougbafla Centre, is weakly represented compared with the autobreccias. Under the polarizing microscope, the hyaloclastites appear rich in plagioclase (30%), in pyroxene altered into amphibole (10%) and in biotite (10%), set in a matrix that is chloritized, epidotized, sericitized and weakly carbonated (calcite) (figure 5F). Inclusions of pyrite and secondary quartz are noted.

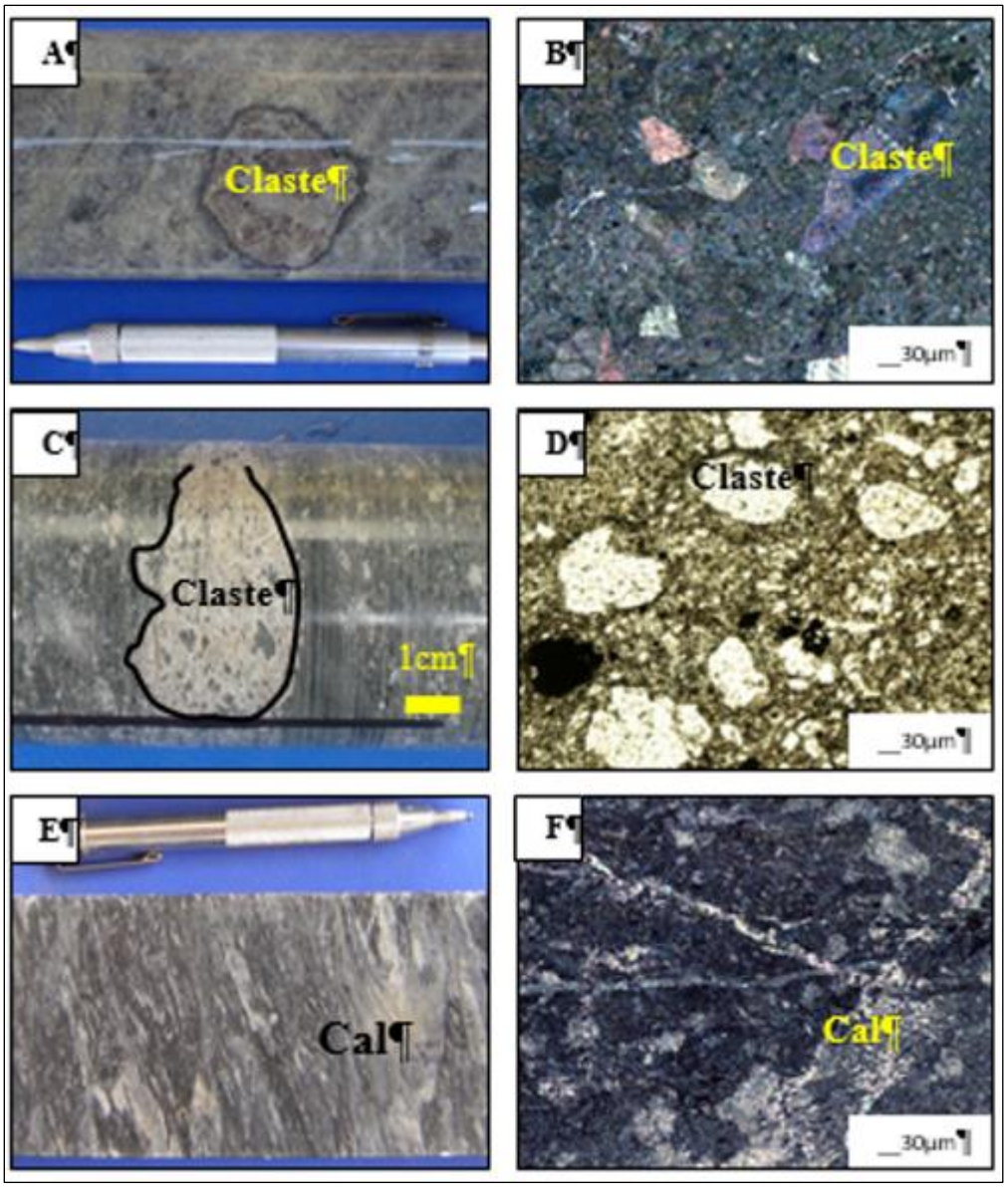


Figure 5: Macroscopic and microscopic aspects of the volcaniclastic rocks.

A: Core of the fine-clast autobrecciated volcaniclastic rock; B: Photomicrograph of the fine-clast autobreccia; C: Heterobreccia core; D: Photomicrograph of the heterobreccia; E: Hyaloclastite core; F: Photomicrograph of the hyaloclastite. Cal = Calcite.

3.5 Metasediments

This assemblage, which occupies a relatively smaller volume than the preceding ones, is represented by black shales, sericite schists, chlorite schists and quartzites.

3.5.1 Black shales

These shales, trending NNE-SSW to NE-SW, occupy a relatively large volume, of almost equal extent to that of the metavolcanic rocks with which they are generally interstratified (figure 6A). They are fine-grained and dark grey to black. These pelites may appear with or without layering. Under the microscope, the dark layers are essentially composed of phyllitic minerals such as biotite (5%) and chlorite (3%), whereas the light levels are essentially composed of very fine-grained, fibrous-looking sericite (30%), small-sized quartz (30%), carbonates (calcite/dolomite) and graphite (figure 6B). Within these light bands are lighter, parallel veinlets composed of quartz (15%), carbonates and feldspars. Accessorily, apatite, rutile and sulphides (arsenopyrite, pyrite and pyrrhotite) are observed.

3.5.2 Sericite schists

Sericite schists are generally satiny yellow to the naked eye with discontinuous intercalations of small muscovites and biotites (figure 6C). Under the polarizing microscope, these rocks display a finely deformed lepidoblastic texture (figure 6D). They are composed mainly of sericite (65%) in kink-bands (crenulated), fine-grained graphite, late, more or less

equant and stretched carbonates, chlorite and quartz. The accessory minerals are represented by pyrite, pyrrhotite and apatite.

3.5.3 Chlorite schists

These rocks display an alternation of greenish colour rich in chlorite and whitish colour (rich in feldspars and carbonates), containing opaque minerals (pyrrhotite and pyrite) (figure 6E). Under the microscope, these rocks reveal a lepidoblastic texture consisting essentially of large chlorite lamellae and a smaller quantity of biotite showing a clear schistosity. These chlorite lamellae are surrounded by phenocrysts of carbonates and quartz with triple points (figure 6F). These rocks also contain plagioclase, orthoclase, green hornblende, epidote, sericite, pyrite and pyrrhotite.

3.5.4 Quartzites

These are strongly silicified rocks, massive in appearance, with very fine grains and of variable colour (brown, grey, yellow, pink or purplish) (figure 6G). Although discreetly banded, they are particularly resistant to hammer blows and their fracture is conchoidal. They have a granoblastic texture. Under the microscope, they show a granoblastic texture and are formed almost exclusively of equigranular quartz (90%) (figure 6H). The accessory minerals comprise sericite, muscovite, biotite, chlorite, epidote, carbonates and ferruginous inclusions.

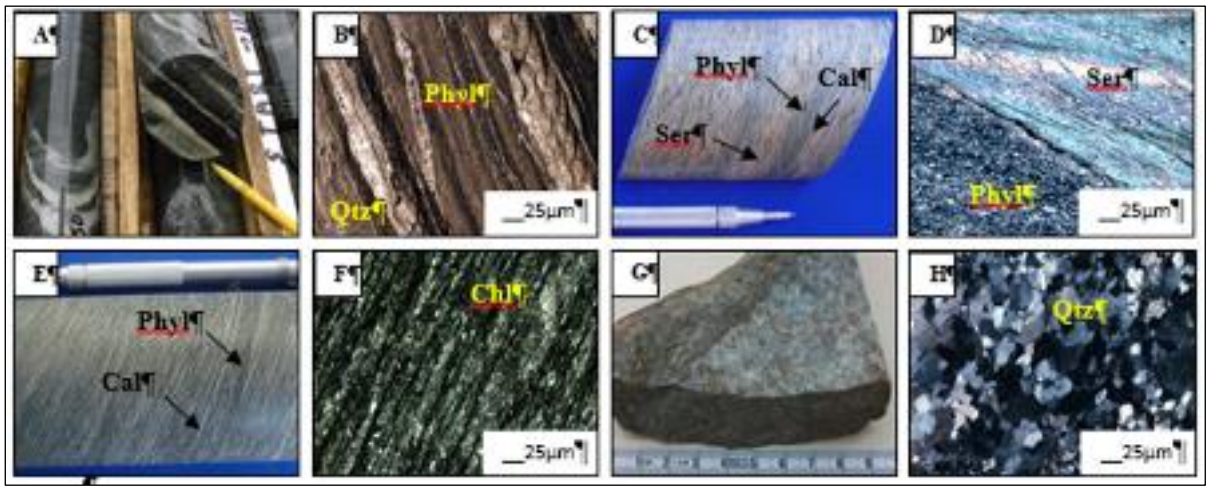


Figure 6: Macroscopic and microscopic aspects of the metasediments.

A: Core of the layered black shale; B: Photomicrograph of the layered shale; C: Sericite schist core; D: Photomicrograph of the sericite schist; E: Chlorite schist core; F: Photomicrograph of the chlorite schist; G: Sample collected from outcrop; H: Photomicrograph of the quartzite. Musc = Muscovite; Phyl = Phyllite; Qtz1 = Deformed primary quartz; Qtz2 = Undeformed secondary quartz; Cal = Calcite; Chl = Chlorite; Qtz = Quartz.

4 DISCUSSION

4.1 Volcano-sedimentary complex

The results show that the study area is dominated by a volcano-sedimentary complex formed of metavolcanic rocks (basalts, andesites and rhyodacites) associated with mafic volcaniclastic rocks (autobreccias, polybreccias and hyaloclastites) and with metasediments (black shales, sericite to chlorite schists and quartzites). Indeed, this volcano-sedimentary complex, which constitutes the essential framework of the geological basement of the study area, is affected by greenschist-facies metamorphism, locally reaching amphibolite facies, characterized by a generally greenish hue due to recrystallized amphiboles, chlorites, sericites and epidotes, as mentioned by [3]. This is corroborated by the observations of [6; 12-13] respectively at Bonikro, Agbahou and in the southern part of the Fètêkro belt, who also reported low-grade metamorphism locally reaching amphibolite facies in the region. These observations are fully in line with the work carried out by [14] in the Korhogo belt. The Birimian formations of the Dougbafla-Bandama zone can be subdivided into three units according to their lithological particularities.

The first, the Dougbafla East and Dougbafla South unit, characterized by mafic to felsic metavolcanic rocks (basalts, andesites and rhyodacites), is remarkably fine-grained and homogeneous, and intimately interlocked with the metasediments. The mafic and intermediate terms, intimately linked and of almost equal extent, are very difficult to distinguish with the naked eye, except that the basalt is slightly darker. The aphanitic andesitic facies are interstratified with the basalt flows. The rhyodacite lavas and the metasediments were observed exclusively at Dougbafla East. These metasediments comprise black shales, sericite and chlorite schists and quartzites of modest extent, also called “jasper”.

Black shales occupy a relatively large volume, of almost equal extent to that of the metavolcanic rocks with which they are interstratified. As for the sericite and chlorite schists, they generally serve as transitions between the various facies. Relics of basalt were observed within these schists, which suggests that the schists were originally metamorphosed and deformed basalts.

The second, the Dougbafla North and Bandama unit, coarser than the previous one, contains basic (porphyritic basalts) to intermediate (porphyritic andesites) porphyritic volcanic formations and mafic volcaniclastic rocks of the autobrecciated type with clasts ranging from (Ø < 1/16 mm) to (1/16 mm < Ø < 2 mm). This type of facies is represented by xenomorphic autoclastic breccias generated by the non-explosive in situ fragmentation of basaltic lava. They are associated with flows of basaltic composition often interbedded with water-saturated sediments, causing the formation of small peperites and thicker hyaloclastites. In the latter, fragmentation occurred through thermal shock during sudden cooling upon contact with water.

The last unit, that of Dougbafla Centre and Dougbafla West, is characterized by a basaltic matrix rich in large hornblende phenocrysts (2 mm < Ø < 5 mm) and in plurimillimetric to pluricentimetric polygenic clasts composed mainly of volcanic particles such as crystals and fragments of volcanic rocks representing 30 to 50% of the total volume of the rock, produced by primary autoclastic volcanic processes. This unit, coarser in appearance than the two units described previously, generally displays inverse to normal grading, which indicates a penecontemporaneous interstratification of their emplacement and isoclinal folding.

4.2 Intrusive rocks

The volcano-sedimentary complex is intruded by various felsic (granites, granophyres, granodiorites, microgranodiorites and tonalites), intermediate (microdiorites), and ultramafic to mafic (epidiorites and lamprophyres) formations. These intrusive rocks are generally organized as domes or elongated bodies sub-concordant with the Birimian structures trending NNE-SSW to NE-SW. The felsic intrusive rocks are most often closely linked to the gold mineralization. The most widely represented facies of the acidic domes (granodiorite) borders the volcano-sedimentary host rock observed in all the studied sectors. The granodiorites described at Bonikro and Hiré by [6; 9] are more porphyroid than those of the Dougbafla-Bandama zone. These granodiorites differ from those identified in the south-west of the Comoé basin and in the Singrobo sector, and from the Birimian plutonism of the Réguibat Shield by [15-16]. Indeed, the work of these authors highlights three (3) granodioritic facies: the granular facies, the oriented facies and the migmatitic facies. The work of [15-16] also shows that the granitic intrusive rocks of the south-west of the Comoé basin and of the Singrobo sector comprise biotite granites, amphibole granites, leucocratic granites and two-mica granites. Granophyres crop out mainly in the form of elliptical massifs within the metavolcanic formations of Dougbafla East, in the vicinity of the village of Doka in the north-east of the district. The direction of the dykes conforms to the local Birimian direction, which is NE-SW or NNE-SSW. Granites and microgranodiorites generally appear as pluricentimetric domes in the Dougbafla Centre and North zones. As for the tonalites, they were identified only at Bandama.

The sub-intrusive mafic and ultramafic formations derived from late magmatism are represented respectively by the epidiorites and the lamprophyres. The epidiorites occur in the form of plurimetric domes in the north-west of the Bandama zone. They originate from the alteration by uralitization of the pyroxenes of a gabbro of noritic composition. Their poverty in olivine suggests that the epidiorites of the Oumé-Hiré district are tholeiitic. The lamprophyres, composed of 95% biotite, constitute the most distinctive intrusive periplutonic magmatic facies of the Oumé-Hiré district. They are very rare and were described in the prospects of Dougbafla Centrale and in the north-west of the Bandama prospect. They occur in the form of pluricentimetric dykes. These ultramafic facies differ from the facies (dunite, wehrlite, olivine clinopyroxenite, kimberlite and chromitite) observed in the Katiola-Marabadiassa region [17].

Indeed, the set of lithologies observed falls within the framework of the rocks that characterize the Birimian formations as described by [3]. In the Fettékro belt, the lithologies of the Dougbafla-Bandama zone display many similarities with those of Bonikro resulting from the work of [6], but differ from them by the particular presence of dacites, epidiorites, granophyres, lamprophyres, black shales and tonalites. They are also close to those identified at Agbahou by [12], but differ from them by the absence of orthoamphibolites, pyroclastic rocks and amphibolic schists. It should be noted that granophyres may be akin to rhyolites or rhyodacites, and lamprophyres to the biotite schists of Agbahou. The lithologies of the Dougbafla-Bandama gold zone also display similarities with those of Toumodi described by [18-19], but differ from them by the andesites, diorites, dacites, microdiorites, epidiorites, granodiorites and lamprophyres. They are distinguished from those observed by [20] at Dabakala by the ignimbrites, pegmatites and pyroclastic rocks.

Outside the Fettékro belt, the lithologies of the study area differ from those described by [21-22] at Aféma, in the Aboisso belt, by the absence of arenites, conglomerates, argillites and silts; and from those of the work of [23] at Angovia, in the Bouaflé belt, by the absence of metadolerites and polygenic conglomerates.

Outside Côte d'Ivoire, the lithologies observed in Burkina Faso by [24] are very close to those of the study area but differ from them by the presence of dolerites. In Senegal, apart from the pyroclastic rocks, they are much closer to the Sabodala-Kérékounda sector described by [25].

5 CONCLUSION

This petrographic study carried out in the PR 105 mining permit of Oumé, located in the south of the Oumé-Fettékro Birimian belt, has shown that the geological formations of the Dougbafla-Bandama zone are very varied. They can be subdivided into three major lithological assemblages. The first assemblage (volcano-volcaniclastic) is formed of volcanic lavas (basalts, andesites and rhyodacites) and mafic volcaniclastic rocks (autobreccias, polybreccias and hyaloclastites). The second assemblage comprises the metasediments represented by black shales, sericite schists, chlorite schists and quartzites. The third assemblage, for its part, intrudes the first two, and is composed of ultrabasic to basic formations (epidiorites and lamprophyres), intermediate formations represented by microdiorites, and acidic formations (granites, granophyres, granodiorites, microgranodiorites and tonalites).

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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The authors declare no conflicts of interest regarding this manuscript.

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