

# Petrographic Characterization of the Semi-industrial Mine of the Sav'or-ci Company (Groudji, Djekanou Department, Center of Côte D'Ivoire)

Ouattara Bakary<sup>1,\*</sup>, Coulibaly Inza<sup>2</sup>, Yao Kouakou Alphonse<sup>3</sup>, Ouattara Gbele<sup>3</sup>

<sup>1</sup>Polytechnic Doctoral Scholl, Polytechnic Institute Félix Houphouët-Boigny (INP-HB), Yamoussoukro, Côte d'Ivoire

<sup>2</sup>UFR of Environmental Sciences and Management, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

<sup>3</sup>Department of Earth Sciences and Mineral Resources (STeRMi), National Polytechnic Institute Félix Houphouët-Boigny (INP-HB), Yamoussoukro, Côte d'Ivoire

## Email address:

[danvobekah@gmail.com](mailto:danvobekah@gmail.com) (O. Bakary)

\*Corresponding author

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**Abstract:** SAV'OR-CI's semi-industrial mine is located in Groudji, (Djékanou department), in the central-eastern part of Côte d'Ivoire, in the southern part of the Oumé-Fétékro birimian greenstone belt (West African craton). The Birimian terrains was affected by multiple deformation and mineralization events. This study is a contribution to resolve some issues in the Birimian such as the improvement of petrography and knowledge. The methodology is on macroscopic to microscopic observations. The lithology of SAVO'R gold mine consists of four major units. The first unit, volcanic, made of volcanic lavas (metabasalt and rhyodacite) and volcanoclastics (mafic tuffs and felsic volcanoclastics). The second unit is a plutonic rocks which is summarized by metagranodiorites and granodiorites. The third unit which outcrops in the form of vein is represented by aplites and microgranites. The last unit is composed of metamorphic rock, precisely gneisses. The presence of lavas, and volcanoclastics reveal respectively that the effusive volcanism and the explosive volcanism have occurred during the setting of area rocks. All lithologies have been affected by hydrothermal alteration marked by quartz veins and veinlets, feldspars, carbonates, often associated with sericite, chlorite and sulphides. Gold is not visible to the eye in the observed lithologies. These rocks are affected by a metamorphism of greenschist facies marked by the presence of chlorite, sericite and epidote minerals.

**Keywords:** Ivory Coast, Petrography, Groudji, Birimien, Gold

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## 1. Introduction

The Paleoproterozoic terrains (2.2-2.0 Ga on average) of West Africa (Birimian) are known to dominate the entire West African Craton [1, 2, 6, 24, 25, 28] (Figure 1). The Birimian terrains consist of greenstone belts and intracratonic basins more or less stretched in the NE-SW direction. These terrains contain plutono-volcanic, volcanoclastic and sedimentary rocks, globally metamorphosed under the conditions of greenschist facies to locally amphibolitic and intruded by granitoid massifs. These birimian formations are favourable for gold mineralization. In fact, in West Africa,

gold was mainly localized within the Paleoproterozoic terrains [19, 20], i.e., in the Birimian and Tarkwaian formations. These Birimian terrains therefore constitute a particular target for mining and academic research. The mining research carried out over the last few decades has brought to light numerous deposits including the Angovia, Tongon, Bonikro, Ity, Agbaou, Dougbafla, Afema, Sissingué [3, 9, 16, 17, 18, 19, 22, 23], as well as promising prospects and semi-industrial mines such as SAV'OR-CI SARLU (Figure 2), Ciel Vincent, Ivoire Mining Ressource SARL, Nassa Gold SARL and Gold Koss Scoop. The understanding of the context in which these gold mineralizations are being

developed in these Birimian terrains is therefore necessary. It is in this context that this study was initiated in order to: (i) characterize the different lithologies of the semi-industrial SAVOR mine of Groudji and; (ii) to better understand the

Eburnean orogenic event. All these to understand the setting up of these formations in order to contribute to the revival of the Ivorian mining sector.

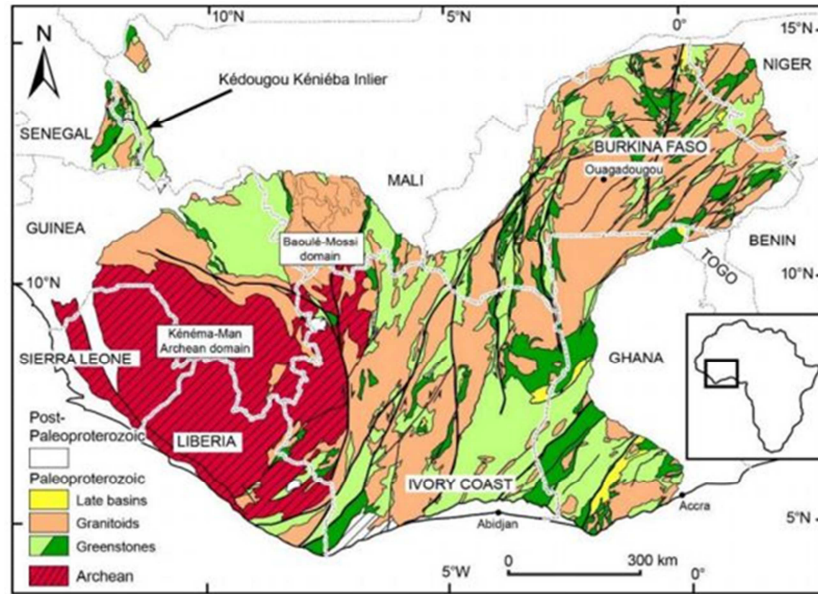


Figure 1. Simplified geological map of the West African craton (modified from [21]).

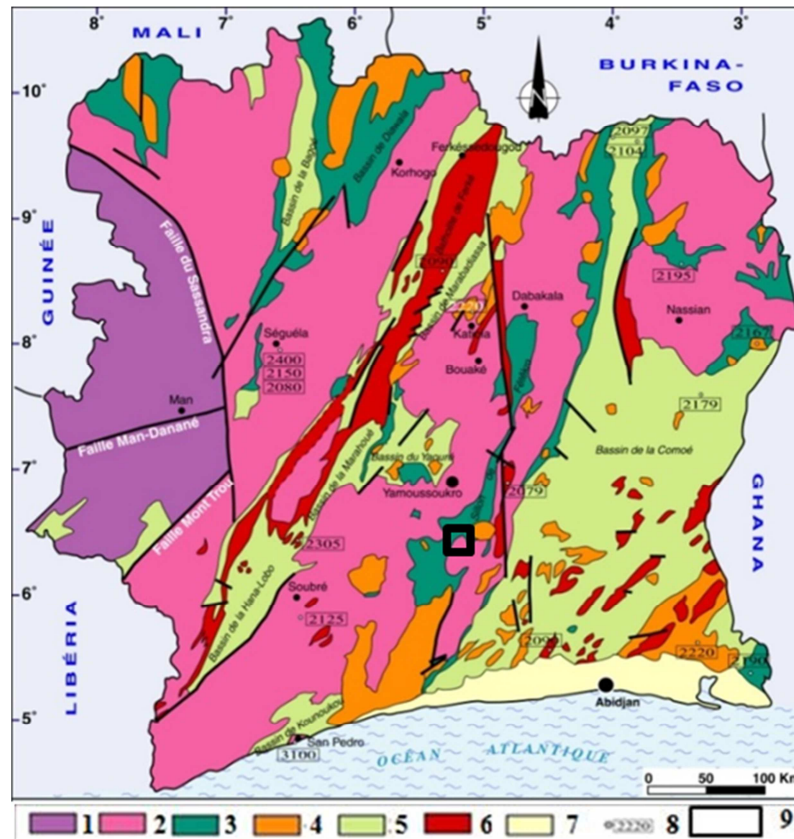


Figure 2. Simplified geological map of Ivory Map at 1/1 000 000 [26].

1- Archean domain. 2- Granitoids, banded granites, gneiss and undifferentiated migmatites (ages greater than 2.4 Ma). 3- Volcanism and volcano-sedimentary rocks undifferentiated. 4- calc-alkaline granitoids located in sedimentary basins. 5- sedimentary and volcano-sedimentary basins. 6- Ferké batholite: two-mica granitoids associated or not with meridian strike-slip structures 7- post-birimian formations; coastal sedimentary basins. 8- ages. 9- study area.

## 2. Geological Context

Côte d'Ivoire belongs to the southern part of the West African Craton and more precisely to the Man or Leo Ridge (Figure 1). It consists of a Precambrian basement which represents 97.5% of its surface area and a secondary-tertiary coastal sedimentary basin covering 2.5% of the territory. This Precambrian basement comprises an Archean domain (Kenema-Man) to the west (3600-2500 Ma) and a Paleoproterozoic domain (Birimian) also called the Baoulé-Mossi domain to the east (2500-1800 Ma), separated by the Sassandra fault ([5]; Figure 2). The semi-industrial mine SAV'OR, located in the department of Djékanou, belongs to the Baoulé-Mossi domain (Figure 2). The Birimian consisting of juvenile formations generated during a major crustal-episode between 2.2 and 2.1 Ga ([2, 4, 6, 24, 27, 28]). Birimian rocks cover two thirds of Côte d'Ivoire and are materialized by alternating furrows and volcano-sedimentary basins generally oriented NS to NE and encased by areas of granito-gneiss. These different lithological units are intruded by granitoids of various nature, shape and size ([7, 12, 15, 30]).

The geology of the Djékanou Department is composed of chlorite-schists, ampelites, metavolcanic rocks with brecciated facies, biotite granitic orthogneiss, biotite and/or hornblende granodiorite, and biotite and/or hornblende metagranodiorites ([11]; Figure 3).

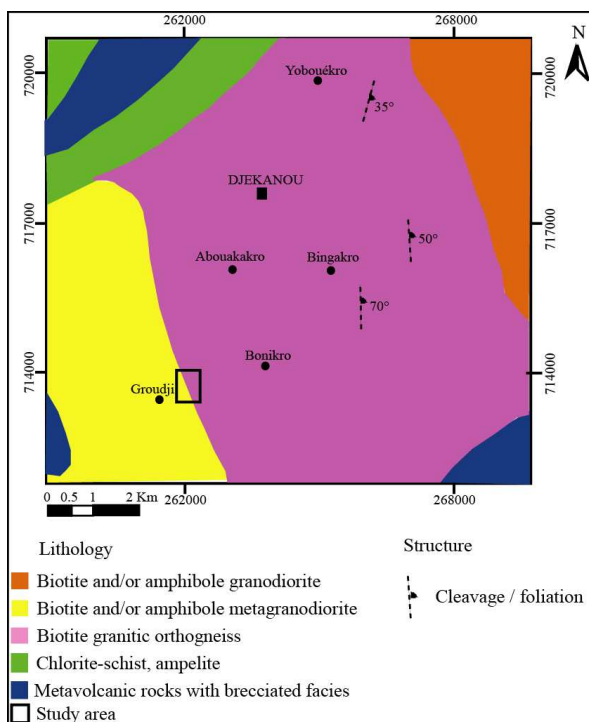


Figure 3. Geological map of the Djékanou Department ([11]).

## 3. Methodology

This stage will focus on petrographic description (macroscopic and microscopic). Representative samples of

the different facies were selected for the laboratory phase in order to bring more precision to the macroscopic petrography. The preparation and the study of thin sections took place at the Ressources Minérales et Energétiques.

Geology, Mineral and Energy Resources Laboratory of the UFR of Earth Sciences and Mining Resources (UFR STRM) of the Félix Houphouët-Boigny University of Abidjan-Cocody.

## 4. Results

The lithologies of the study area consist of volcanic rocks (volcanic lava and volcanoclastics), semideep rocks (aprites and microgranites), granitoids (métagranodiorites and granodiorites, metasediments (chlorite-sericite-schists) and metamorphic rocks (gneiss). All of these lithologies are affected by a mineralized quartz vein oriented N20°, sheared in its western part causing a dextral strike.

### 4.1. Volcanic Rocks

Volcanic rocks are represented by volcanic lavas (metabasalts, rhyodacites) and volcanoclastics (felsic and mafic volcanoclastics).

#### 4.1.1. Metabasalts

The metabasalts are melanocratic and crossed cut by carbonate veins (Figure 4 A). With the naked eye, chloritization of the ferromagnesian minerals can be observed. Under the microscope, these rocks show a porphyritic microlitic texture with pyroxene phenocrysts (Figure 4 B). The latter are most often altered and transformed into amphiboles, chlorite and epidote. Mesostasis consists of carbonates, chlorite and epidote minerals. To this we must add quartz-carbonates veinlets. Sulphides and oxides are also observed.

#### 4.1.2. Rhyodacites

The rhyodacites are leucocratic and Crossed cut by quartz-feldspars veins (Figure 4 C). At the naked eye we can observe an intense sericitization of these rocks. In thin sections, these rocks show a porphyritic microlithic texture (Figure 4 D). The phenocrysts observed are quartz and plagioclase. These plagioclase crystals are generally altered and transformed into sericite and epidote. Mesostasis consist of quartz-feldspars minerals associated with sericite, epidote and chlorite crystals. Quartz veinlets are often associated with plagioclase, chlorite and epidote crystals.

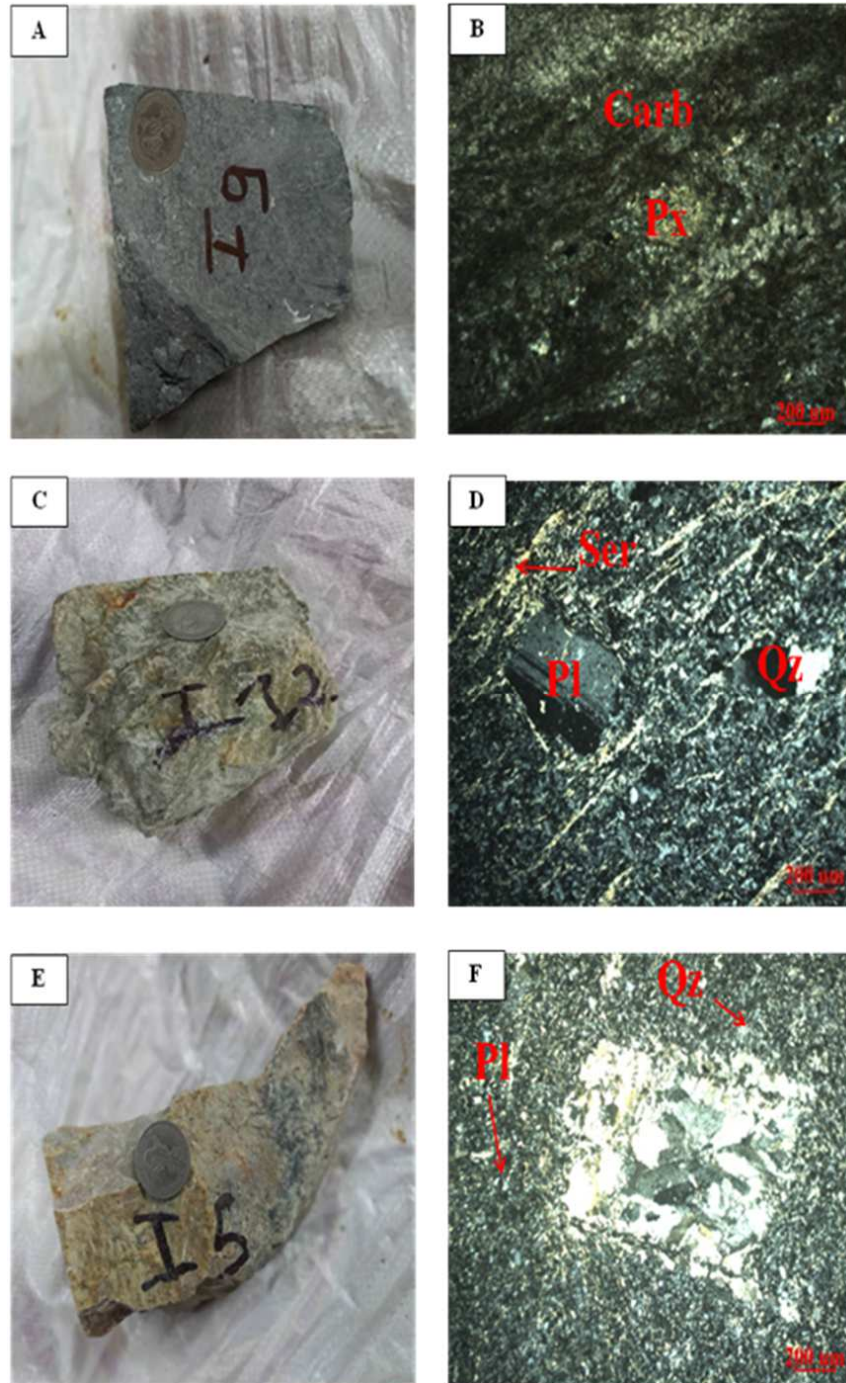
#### 4.1.3. Felsic Volcanoclastics

These rocks are massive and consist of a quartz-feldspar matrix and felsic clasts (Figure 4 E). In thin sections, these rocks show a porphyritic microlitic texture (Figure 4 F). Plagioclase occurs in phenocrysts generally altered and transformed into sericite and carbonates. Quartz also occurs as phenocrysts with remarkable rolling extinction. Mesostasis consists of quartz, carbonates and sericite. Clasts are felsic and generally consist of quartz and feldspars. There



are also carbonates-quartz-sericite veinlets and some opaque

minerals.



**Figure 4.** Macroscopic and microscopic aspects of the SAV'OR mine volcanites. A-B: Metabasalt; C-D: Rhyodacite; E-F: Felsic volcaniclastics. Carb: Carbonates; Px: Pyroxene; Ser: Sericite; Pl: Plagioclase; Qz: Quartz.

#### 4.1.4. Mafic Volcaniclastics

These rocks are mainly represented by the lappilis tuffs. These basic tuffs are made of pyroxene and amphibole phenocrysts. In the vicinity of the study area, these tuffs are in contact with metasediments (Figure 5 A). Microscopically, these rocks show a porphyritic microlitic texture with pyroxene and green hornblende phenocrysts. The majority of the pyroxene crystals have destabilized into amphibole (Figure 5 B). These green hornblende and pyroxene minerals

are often altered and transformed into chlorite and epidote. Mesostasis consists of very fine Euhedral lath-shaped plagioclase crystals more or less destabilized into sericite and epidote associated with chlorite. Ferrotitanium oxides are also visibles.

#### 4.2. Hypovolcanic Rocks

hypovolcanic rocks are represented by microgranites and aplites.

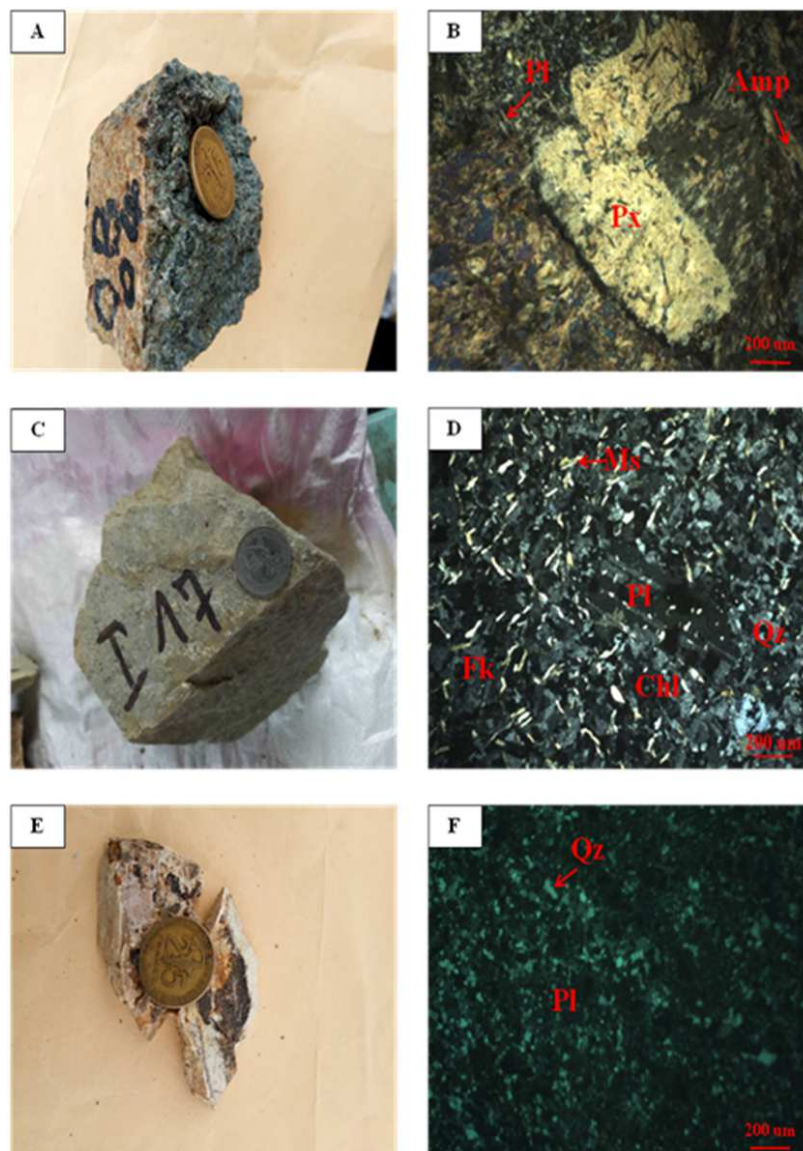
#### 4.2.1. Microgranites

These rocks with leucocratic color consist of quartz, feldspar, muscovite and biotite (Figure 5 C). Quartz-feldspars veinlets can also be observed with the naked eye. Under the microscope, these rocks show a porphyritic microgranular texture (Figure 5 D). Plagioclase occurs in phenocrysts often altered to sericite and epidote. Quartz often occurs in phenocrysts with remarkable rolling extinction. Mesostasis consists of quartz, alkaline feldspar and plagioclase alkaline plagioclase. In addition, some others minerals like biotites which are usually biotite crystals, usually altered and transformed into chlorite and epidote. Feldspars are altered

and often transformed into epidote and sericite. Muscovite is also observed. Deformed quartz veinlets as well as quartz-feldspars veinlets associated with chlorite and sericite are observed. Small amount of oxides and sulphides are present.

#### 4.2.2. Aplites

Aplites were observed in the study area (Figure 5 E). Near the study area, these veins cross-cutting other rocks in the N100° direction. In thin section, the rock consists of quartz with a remarkable rolling extinction (Figure 5 F). In addition, there are feldspars crystals totally altered and transformed into carbonates (calcite  $\pm$  dolomite) and apatite. It is crossed by quartz veinlets. Opaque minerals are also present.



**Figure 5.** Macroscopic and microscopic aspects of the lappilis tuffs, microgranites, and aplites of the SAV'OR mine. A-B: Lappilis tuffs; C-D: Microgranite; E-F: Aplite. Amp: Amphibole; Ep: Epidote; Ms: Muscovite; Hb: V: Green Hornblende; Fk: Alkaline Feldspars; Chl: Chlorite

#### 4.3. Plutonic Rocks

Plutonic rocks observed in the semi-industrial SAV'OR mine at Groudji are represented by metagranodiorites and granodiorites.

##### 4.3.1. Metagranodiorites

They are mesocratic and deformed (Figure 6 A). At the outcrop level, these rocks are schistose and consist of crystals of amphibole, biotite, feldspars and quartz are well



identifiable. Under the microscope (Figure 6 B), these rocks show a porphyroid grained texture. The phenocrysts observed are green hornblende, plagioclase and quartz. The quartz shows a remarkable rolling extinction, with crystals of variable size. The green hornblende is altered in some chlorite sections. Plagioclase crystals are often altered to sericite and epidote. Muscovite is also observed. Biotite crystals are present, sub-euhedral with zircon inclusions. The latter are altered and often transform into chlorite and muscovite. Sphene crystals are visible. Sulphides, mainly represented by pyrite and ferrotitanium oxides are also present.

#### 4.3.2. Granodiorites

These rocks with mesocratic color consist of and consist of amphibole, biotite, feldspars and quartz are well identifiable. (Figure 6 C). Microscopically, these rocks show a grained porphyroid texture with green hornblende, plagioclase and quartz phenocrysts (Figure 6 D). In addition, biotite crystals of medium grain size, muscovite and microcline are present. Plagioclase crystals show magmatic zonation on some sections and are often altered and transformed into sericite and epidote. Ferromagnesians are destabilized into chlorite and epidote. Sphene crystals are visible. Sulphides represented mainly by pyrite and ferrotitanium oxides are

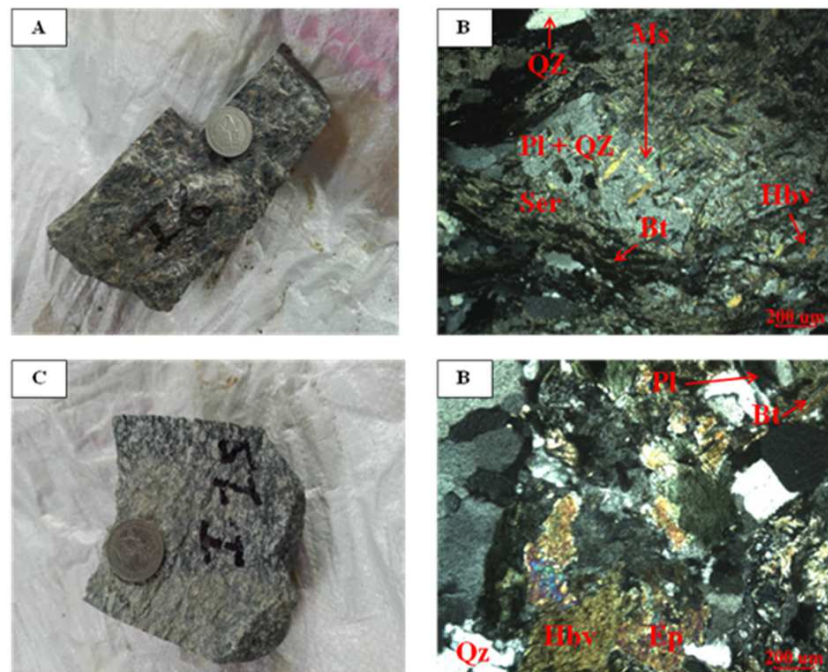
also observed.

#### 4.4. Metamorphic Rocks

The metamorphic rocks observed in the semi-industrial SAV'OR mine at Groudji consist mainly of gneiss. These orthogneiss are medium to coarse-grained and show millimetric to centimetric foliation (Figure 6 C). Microscopically, the rock has a granoblastic texture consisting of quartz, the size of the average grain of the rock (Figure 6 D). Plagioclase often occurs over a wide range, with some sections showing destabilization in carbonates (calcite  $\pm$  dolomite), epidote and sericite. The biotite is sub-euhedral with zircon inclusions and is mostly altered and transformed into chlorite and epidote. In addition, green hornblende is also present. Sphene and rare opaque minerals as well as ferrotitanium oxides are also observed.

#### 4.5. Metasediments

The metasediments generally observed in the study area are chlorite-sericite-schists (Figure 7 C). These rocks contain a significant amount of sericite and chlorite, which gives them a color ranging from yellowish green to greenish grey. They are in fact schists whose protolith is probably a mafic to intermediate volcanic rocks (basalt or andesite).



**Figure 6.** Macroscopic and microscopic aspects of the granitoids of the SAV'OR mine. A-B: Metagranodiorite; C-D: Granodiorite. Hbv: Green Hornblende.

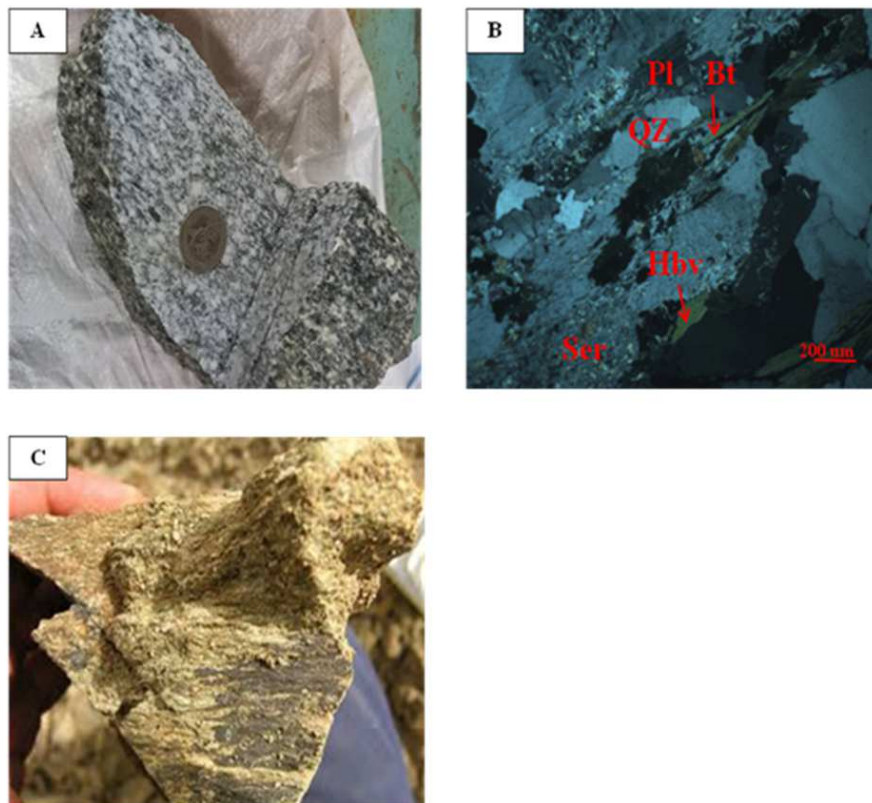
## 5. Discussion

The petrographic study of the semi-industrial SAV'OR mine in Groudji shows a lithological diversity. The lithologies encountered consist of metavolcanic rocks including volcanic lavas (basalts, rhyodacites) and volcanoclastics (mafic tuffs and felsic volcanoclastics). Plutonic rocks are represented by metagranodiorites and

granodiorites. In addition to this, there are rocks veins represented by microgranites and aplites. Metamorphic rocks are mainly represented by orthogneiss. The metasediments correspond to chlorite-sericite-schists. All of these lithologies are generally affected by schistosity. According to [11], the geology of the Djékanou department is composed of chlorite-schists, ampelites, metavolcanic rocks with brecciated facies, biotite granitic orthogneiss, biotite and/or hornblende granodiorite, and biotite and/or hornblende

metagranodiorites. Our work in the Groudji zone corroborates more or less the observations of [11] in the Djékanou department. Indeed, our work has highlighted granodioritic gneisses, microgranites and aplites. The petrographic analysis shows that most of the granitoids are very poor in potassium feldspar, which could indicate that they were put in place during deformation rocks. The presence of volcanic lavas in the study area is related to birimian volcanism. The presence of volcanoclastics indicates an explosive episode. This explosive character has already been demonstrated in the Birimian terrains of Côte d'Ivoire ([8, 14, 16, 23, 31]). These lithologies have generally been affected by phenomena of alteration and/or metamorphism. The primary minerals in these rocks are often altered and transformed into carbonates, sericite, epidote, chlorite, and muscovite. The presence of secondary minerals such as chlorite, epidote, sericite show that these lithologies have been affected by metamorphism of greenschist facies. This corroborates the observations of [23] in the Bonikro deposit.

However, some authors such as [29, 30], [16], and [8] highlight in the Birimian terrains, locally, a metamorphism of amphibolite facies, in addition to greenschist facies. All lithologies were affected by hydrothermal alteration marked by quartz, feldspars, and carbonates veins and veinlets, often associated with sericite, chlorite and sulphides. Gold is not visible to the eye in the observed lithologies. This corroborates the observations of [10] in the Bobosso prospect. In fact, these authors found significant hydrothermal alteration in this prospect marked by veins and veinlets of quartz, calcite,  $\pm$  tourmaline,  $\pm$  sulphides. Gold is not visible to the naked eye even in the highest grade drill sections. However, at Groudji, tourmaline is absent. At Groudji, the mineralized zones are localized zones rich in quartz veins and veinlets; enrichment due mainly to shear zones. This type of mineralization has already been reported in most of the Birimien deposits of Côte d'Ivoire (Afêma: [3, 17]; Angovia: [9]; Bonikro: [13, 23]) and West Africa ([19, 20]).



**Figure 7.** Macroscopic and microscopic aspects of the gneiss and metasediments of the SAV'OR mine. A-B: Gneiss; C: Schist.

## 6. Conclusion

The department of Djékanou is at the heart of the Ivorian Birimian lands in Côte d'Ivoire. Our investigations on the SAV'OR mine highlighted different lithologies. Metavolcanic rocks are composed of volcanic lava (basalt, rhyodacites) and felsic and mafic volcanoclastics. In addition, there are hypovolcanic rocks represented by aplites and microgranites. The plutonic rocks is composed of metagranodiorites and granodiorites. The metasediments are essentially composed

of chlorite-sericite-schists. The metamorphic unit consists of gneisses. All lithologies have been affected by hydrothermal alteration marked by quartz, feldspars and carbonates veins and veinlets, often associated with sericite, chlorite and sulphides. Gold is not visible to the eye in the observed lithologies. Metavolcanic rocks indicate that effusive volcanism as well as explosive volcanism prevailed in the study area. Secondary minerals observed are carbonates, sericite, epidote, chlorite, and muscovite. These lithologies were affected by a metamorphism of greenschist facies.

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