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Research Article

PETROGRAPHY OF IGNEOUS AND METAMORPHIC ROCKS FROM THE TOUMODI-FÈTÊKRO GREENSTONE BELT (CÔTE D'IVOIRE)

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ABSTRACT
The Toumodi-Fètêkro Birimian belt lies at the heart of the Ivorian Birimian, in south-central Côte d'Ivoire. This belt hosts gold deposits as well as numerous promising prospects. This article addresses some aspects of Birimian volcanism, namely the characterization of the Birimian formations and their lithostratigraphy. The methodology combined field observations with laboratory analyses. The rocks of the Toumodi-Fètêkro belt consist of lavas (basalts, andesites, trachytes, dacites, rhyodacites, and rhyolites) often showing pillow structures, and basic to acidic volcaniclastic rocks (tuffs, breccias, cinerites, and ignimbrites). Hypabyssal and dyke rocks are represented by microgabbros, dolerites, microdiorites/quartz microdiorites, microgranodiorites, microtonalites, microgranites, aplites, and pegmatites. The plutonic suite is made up of rocks ranging from mafic to felsic (gabbros, diorites/quartz diorites, tonalites, granodiorites, and granites). Metamorphic rocks are represented by ortho-schists and amphibolites.

Keywords: *Birimian, Volcanism, Côte d'Ivoire, Toumodi-Fètêkro belt, Petrography*

1. INTRODUCTION
Gold production in West Africa comes mainly from Birimian formations (Milési *et al*., 1989). These formations have therefore become prime targets for mineral exploration. Côte d'Ivoire, which hosts the largest share (35%) of these formations, has a moderate gold output compared with other countries such as Ghana, Burkina Faso, and Mali, where gold plays a major role in the economy. The Toumodi-Fètêkro belt is one of the longest Birimian greenstone belts in Côte d'Ivoire. It hosts several gold deposits (Bonikro, Agbaou, and Dougbafla), as well as many promising prospects (Houssou, 2013; Ouattara, 2015; Ouattara, 2018). Understanding the geology of this greenstone belt is therefore important for characterizing the Birimian formations of Côte d'Ivoire, as well as for understanding the associated mineralization. In this context, the present study of the Toumodi-Fètêkro belt aims, on the one hand, to improve petrographic knowledge of the belt and, on the other hand, to contribute to the revival of the Ivorian mining sector.

2. Geological context
Côte d'Ivoire belongs to the West African craton, more specifically to the Man Rise, the southern part of the craton (Bessoles, 1977) **(figure 1).** Two geological domains cover the entire territory of Côte d'Ivoire: the Precambrian basement, which accounts for 97.5% of the area, and the crescent-shaped coastal sedimentary basin in the south, which extends from Fresco to Axim (Ghana) and covers 2.5% of the territory **(figure 2).** The Precambrian basement comprises two domains of different ages, separated by the Sassandra Fault. These two domains result from the juxtaposition of a western panel (Archean to Neoarchean) with the rest of the basement, which is Paleoproterozoic (Birimian formations). The

Paleoproterozoic domain is characterized by the presence of greenstone belts, generally trending NNE to NE and alternating with granite-gneiss complexes containing granitoid batholiths. Kouamelan (1996) identified a transition zone within the Paleoproterozoic domain between the Sassandra Fault and longitude 6°W. This zone is thought to be characterized by contamination of juvenile Birimian formations by Archean crust (intermediate Nd model ages and inherited zircons). It is particularly marked by the presence of Archean relics within the Paleoproterozoic domain (Kouamelan *et al*., 1997). The Toumodi-Fètêkro Birimian belt is one of the longest in Côte d'Ivoire, extending for nearly 300 km with a width of 5 to 40 km **(figure 3)**. It is divided at the seventh parallel into a northern part (Fètêkro) and a southern part (Toumodi). The geology of the belt is known from the work of Yacé (1976, 1982), Lemoine (1988), Mortimer (1990), Leake (1992) and Daouda (1998). As in all Birimian belts, it comprises volcano-plutonic rocks (gabbros, basalts, andesites and rhyodacites), volcano-sedimentary rocks (basaltic to rhyodacitic pyroclastites and epiclastites) and sandstone-pelitic detrital sediments **(figure 3).** The Toumodi-Fètêkro belt is bordered and intruded by granitoids. According to Yacé (1982), the Birimian formations consist of schists and quartzites containing large lenses of volcano-sedimentary rocks, some of which occupy synclinal or anticlinal positions.

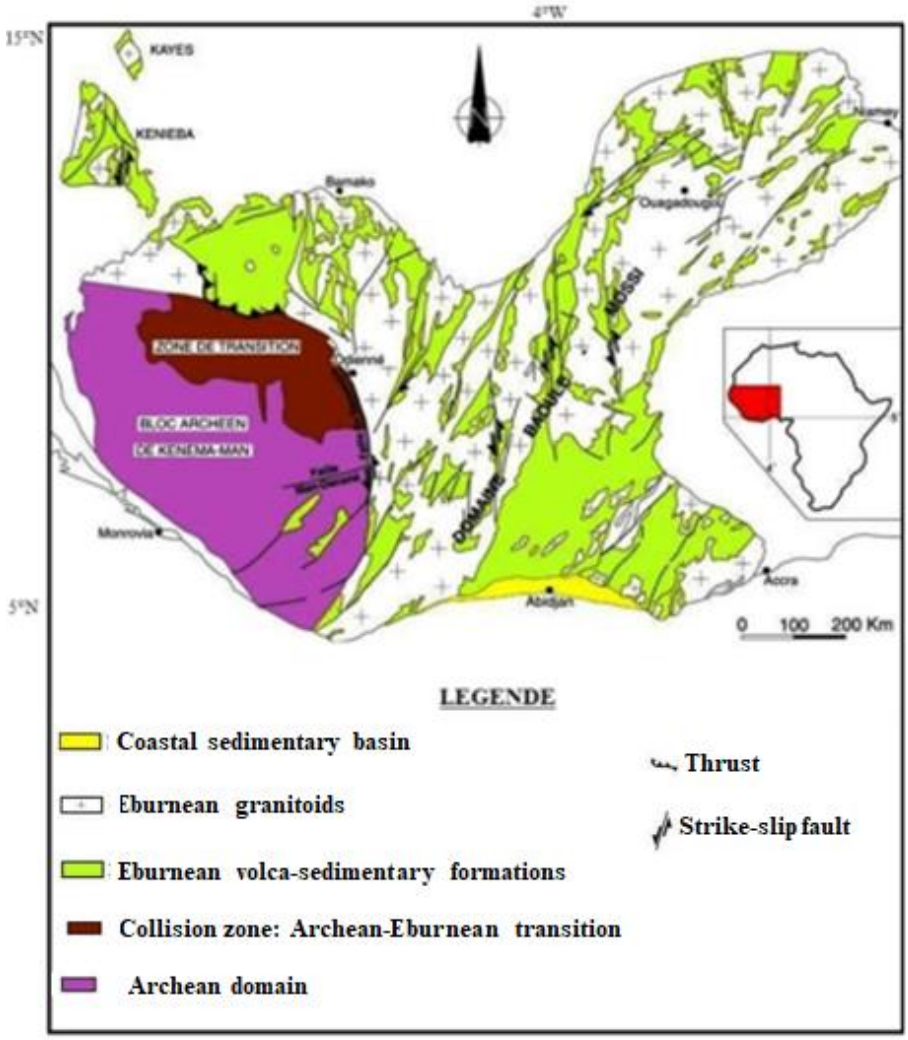


Figure 1: Structural organization of the Man Rise (Milési *et al*., 1989).

3. MATERIALS AND METHODS

The methodology combined field observations with laboratory analyses. It began with macroscopic observations in the field, followed by careful sampling for laboratory analysis. Thin sections were prepared to refine and complement the macroscopic petrography. The microscopic observations were carried out at the Geology, Mineral Resources, and Energy Laboratory of the UFR STRM at Félix HOUPHOUËT-BOIGNY University in Abidjan.

4. RESULTS

4.1. Igneous rocks

4.1.1. Metavolcanic rocks

4.1.1.1. Volcanic lavas

- **Basalts**

These rocks are massive, dark-colored, often deformed, crosscut by quartz-feldspar veins, and crop out throughout the study area **(figure 4A).** In outcrop, pyroxene and/or amphibole crystals, feldspars, and occasionally sulfides can sometimes be observed, especially in drill-core samples. These rocks often show pillow structures **(figure 4C).** Under the microscope, the basalts show a microlitic to microlitic-porphyritic texture, with pyroxene phenocrysts (Cpx and Opx), most often altered to amphibole, as well as carbonates **(figure 4B and D).** The mesostasis generally consists of sericite, epidote, carbonates, chlorite, and plagioclase microlites. Some sections also show biotite, rare quartz aggregates, and carbonate veins most often associated with epidote, chlorite, oxides (magnetite, hematite), and sulfides (pyrite, chalcopyrite, etc.).

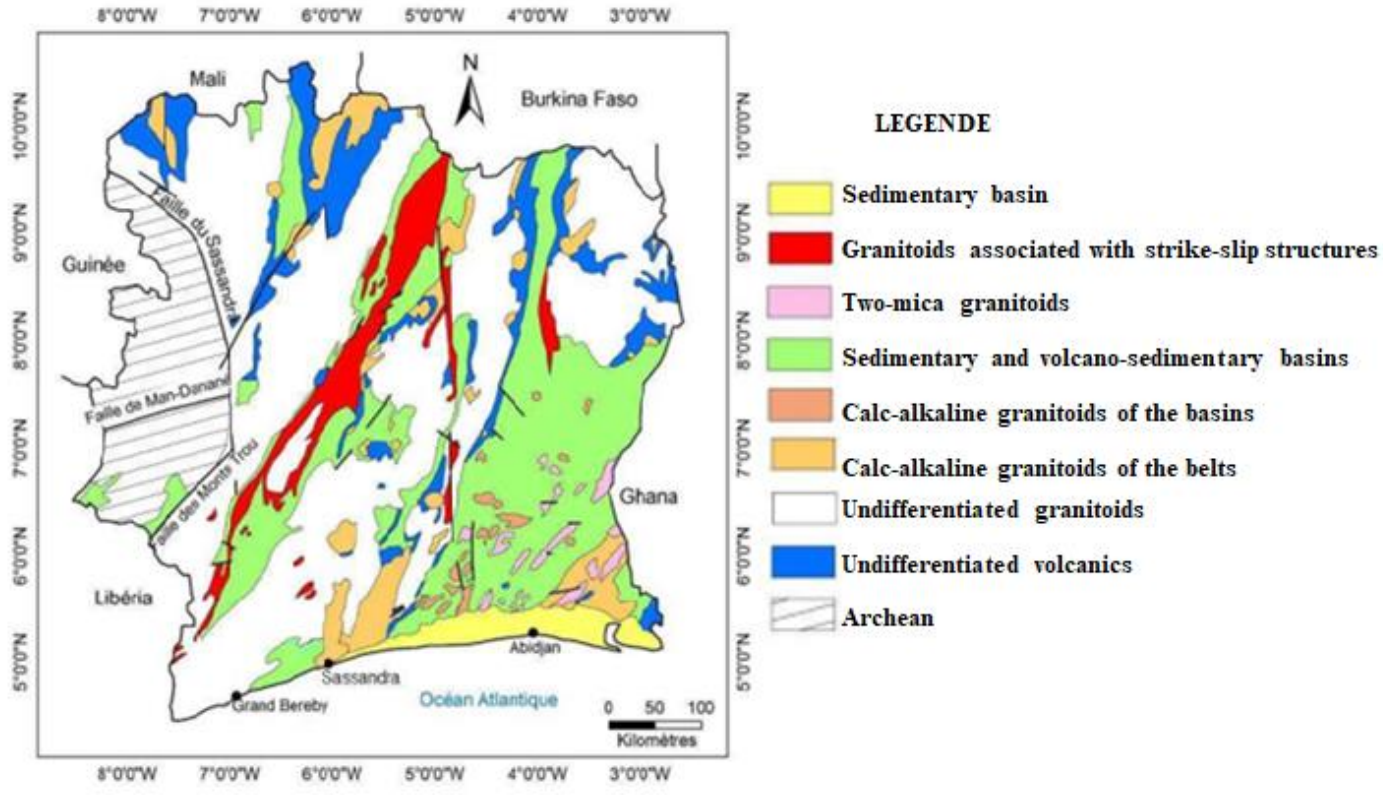


Figure 2: Simplified geological map of Ivory Coast (modified from Tagini, 1971).

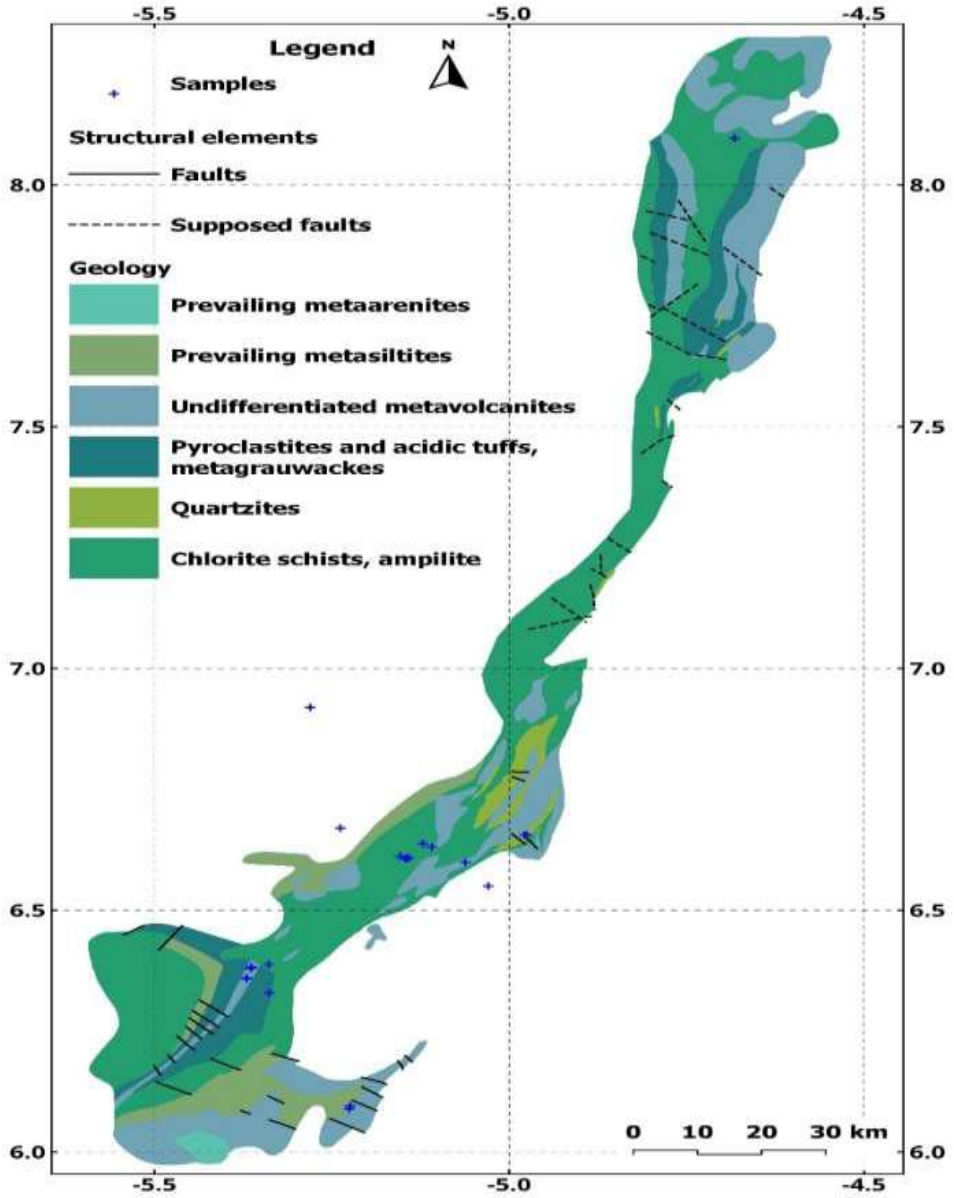


Figure 3: Geological map of the Toumodi-Fètêkro belt (modified from Tagini, 1971 and Daouda, 1998).

- **Andesites**

Andesites are massive, often deformed, gray to gray-green, and widespread in the belt **(figure 4E).** They are often confused with basalts and are difficult to identify because of mineralogical changes caused by alteration and/or metamorphism. Locally, these rocks also show pillow structures with cavities filled with quartz or calcite **(figure 4G).** Clear, transparent quartz phenocrysts with rounded, cushion-like shapes are also visible. Under the microscope, these rocks show a microlitic to microlitic-porphyritic texture with phenocrysts of quartz and heavily chloritized biotite **(figure 4F and H).** Amphibole crystals and plagioclase laths are also set in a dark, aphanitic groundmass. The mesostasis is made up of amphibole minerals, carbonates, chlorite, and epidote. The matrix also contains carbonates, sericite, epidote, chlorite, biotite, secondary quartz amygdules, oxides, and sulfides (pyrite, pyrrhotite, etc.). Veinlets made up of chlorite, carbonates, epidote, and quartz are also observed.

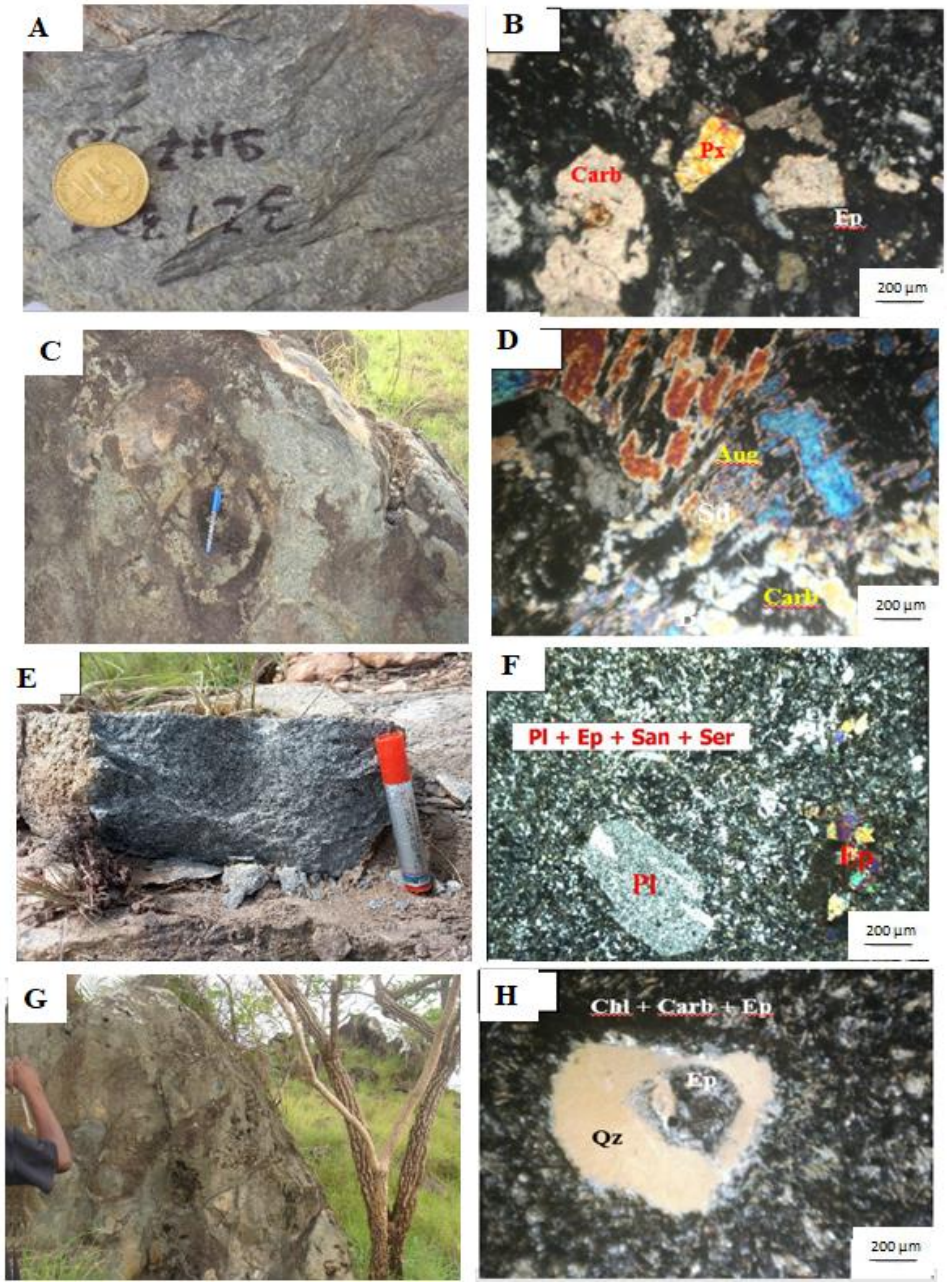


Figure 4: Macroscopic and microscopic aspects of basalts and andesites.
A-B: Basalt; C-D: Pillow basalt; E-F: Andesite; G-H: Pillow andesite. Px: Pyroxene; Carb: Carbonates; Ep: Epidote; Pl: Plagioclase; San: Sanidine; Ser: Sericite; Chl: Chlorite; Qz: Quartz.

- **Dacites**

These rocks are gray or greenish, often deformed, and appear in massive outcrops near the volcaniclastic deposits **(figure 5A).** Under the microscope, they show microlitic to microlitic-porphyritic textures with plagioclase, quartz, and albite phenocrysts **(figure 5B).** The mesostasis mainly consists of carbonate minerals, quartz, sericite, epidote, albite, biotite, and thin plagioclase laths. Carbonate-chlorite-epidote veins and sulfides (pyrite, pyrrhotite, etc.) are also present.

- **Trachytes**

Trachytes are granular in appearance, consist mainly of feldspars, and usually occur as domes or blocks, which are sometimes deformed **(figure 5C).** Microscopic observation shows a porphyritic microlitic texture with phenocrysts of plagioclase, quartz, and sanidine **(figure 5D).** These feldspars are often altered to carbonates and sericite. The mesostasis is fine and made up of carbonates, sericite, quartz, sanidine, and thin plagioclase laths. The opaque minerals are small and subhedral.

- **Rhyodacites**

Rhyodacites are gray, very slightly greenish, and occur either as massive bodies or as veins. These rocks are generally in contact with metasediments and mafic metavolcanics, and are most often affected by fracture cleavage **(figure 5E).** Under the microscope, they show a microlitic, often porphyritic, texture with phenocrysts of quartz, biotite, and feldspars that are often altered to carbonates **(figure 5F).** The groundmass is made up of crystals of quartz, carbonates, chlorite, sericite, and albite. These rhyodacites are cut by quartz-feldspar veinlets associated with sericite, iron-titanium oxides, and sulfides, mainly pyrite.

- **Rhyolites**

In outcrop, these rocks are generally deformed, beige or gray, and occur as roughly circular intrusions within the greenstones, as narrow bands along the margins of the greenstones, as scattered blocks within the schists, or as veins **(figure 5G).** They contain quartz phenocrysts scattered in the matrix as well as feldspar crystals and sometimes pyrite. Under the microscope, rhyolites are made up of phenocrysts of quartz and orthoclase **(figure 5H).** Quartz is often corroded and contains amphibole inclusions. The groundmass consists of quartz, carbonates, epidote, and sericite. These rocks also have amygdules filled with carbonates, quartz, and feldspars, often associated with sericite and biotite that is frequently chloritized. The sulfides and oxides present are mostly associated with quartz-feldspar veinlets.

4.1.1.2. Volcaniclastic rocks

4.1.1.2.1. Mafic and intermediate volcaniclastic rocks

These volcaniclastic rocks occur either as massive beds or as finely layered units and usually contain millimeter- to centimeter-sized pyroxene and amphibole crystals. In some areas, they appear as breccias, lapilli tuffs, and ash tuffs.

- **Lapilli tuffs**

Tuffs make up more than 60% of the lithologies encountered. These rocks outcrop throughout the study area and are made up of pyroxene and amphibole phenocrysts set in a very fine matrix **(figure 6A).** Under the microscope, these tuffs show a porphyritic microlitic texture **(figure 6B).** The pyroxene (Opx and Cpx) and amphibole appear as subhedral to euhedral phenocrysts, generally altered to amphibole, chlorite, and epidote. These ferromagnesian minerals are set in a fine mesostasis made up of chlorite, carbonates (calcite ± dolomite), epidote, and sericite, along with fine plagioclase laths. Veins of calcite-quartz-sericite, as well as iron oxides and hydroxides, are also observed. The sulfides are small but abundant, anhedral to euhedral, and often located within the amphibole crystals.

- **Breccias**

These rocks are massive, grayish-green, and usually appear as hills or blocks, often deformed, near tuffs and ash layers **(figure 6C).** This type generally contains fragments of basaltic composition, ranging from very small, millimeter-sized pieces that look like phenocrysts to larger, centimeter-sized sub-rounded lapilli. Under the microscope, these rocks show a porphyritic microlitic texture with pyroxene and amphibole phenocrysts, often associated with ghost clasts of basalt (figure 6D). The groundmass is fine and consists of thin flakes of sericite, chlorite, epidote, carbonates (calcite ± dolomite), and fine plagioclase laths. There are also inclusions of opaque minerals.

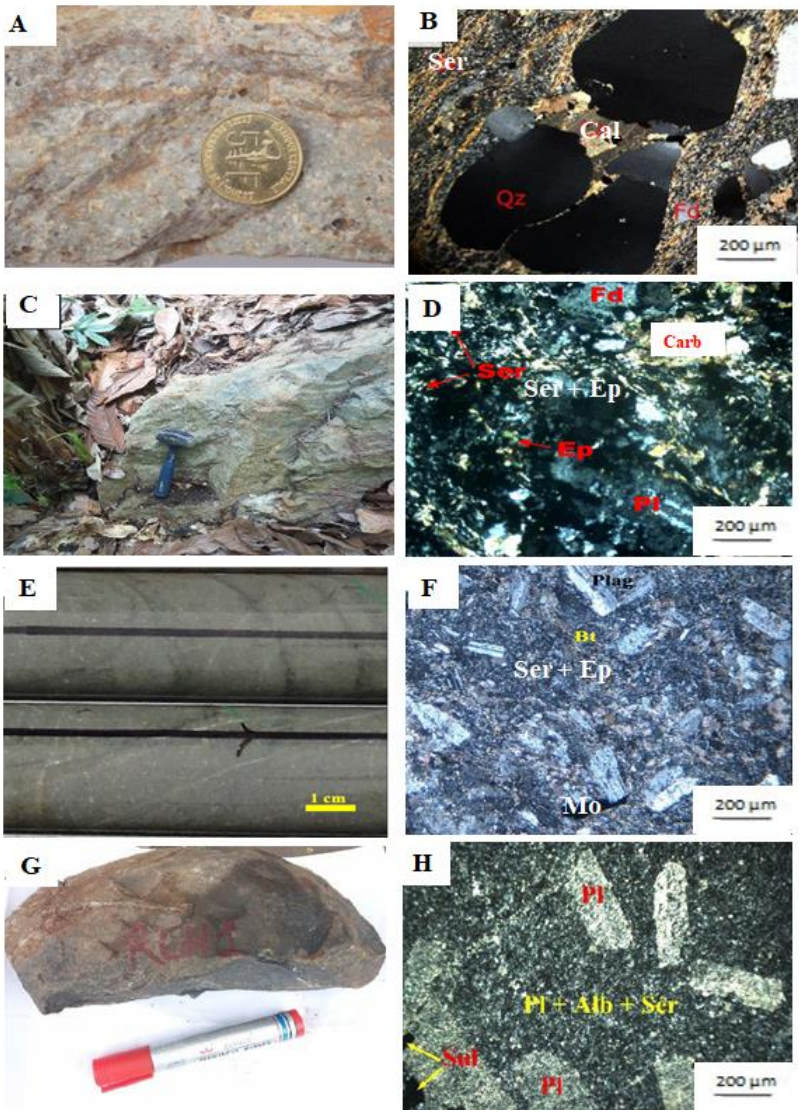


Figure 5: Macroscopic and microscopic aspects of dacites (A-B), trachytes (C-D), rhyodacites (E-F), and rhyolites (G-H).
Cal: Calcite; Fd: Feldspars; Mo: Opaque minerals; Sul: Sulfide.

- **Cinerite**

The cinerites are massive and often show cross-bedding and graded bedding **(figure 6E)**. Under the microscope, these rocks display a microlitic to microlitic-porphyritic texture, with a mineral composition generally made up of pyroxene phenocrysts (clinopyroxene and orthopyroxene) and plagioclase **(figure 6F).** Amphibole is also present in large amounts. These ferromagnesian minerals are often altered to epidote and chlorite. In some sections, plagioclase is altered to carbonates and sericite.

4.1.1.2.2. Felsic volcaniclastic rocks

These felsic rocks are mainly represented by ignimbrites. They are massive, pale green to light gray, crop out as blocks, and contain glass and rock fragments (granites, rhyolites, and rhyodacites) **(figure 6G).**

Under the microscope, they show a porphyritic microlitic texture with phenocrysts of plagioclase, which are usually altered to carbonates, as well as sanidine and quartz **(figure 6H).** The mesostasis contains glass and minerals such as carbonates, sericite, often corroded quartz, and chlorite. There are also quartz-feldspar veins that are often deformed, along with opaque minerals and iron-titanium oxides (magnetite and/or hematite).

4.1.2. Hypabyssal and dyke rocks

- **Microgabbros**

The microgabbros are melanocratic, slightly deformed, especially in contact zones, fine-grained, and generally associated with gabbros **(figure 7A).** Under the microscope, they show a fine-grained, often porphyritic texture, and are made up of pyroxene minerals (clinopyroxenes and orthopyroxenes) and plagioclase, partially altered to amphibole, chlorite, epidote, sericite, and carbonate minerals **(figure 7B).**

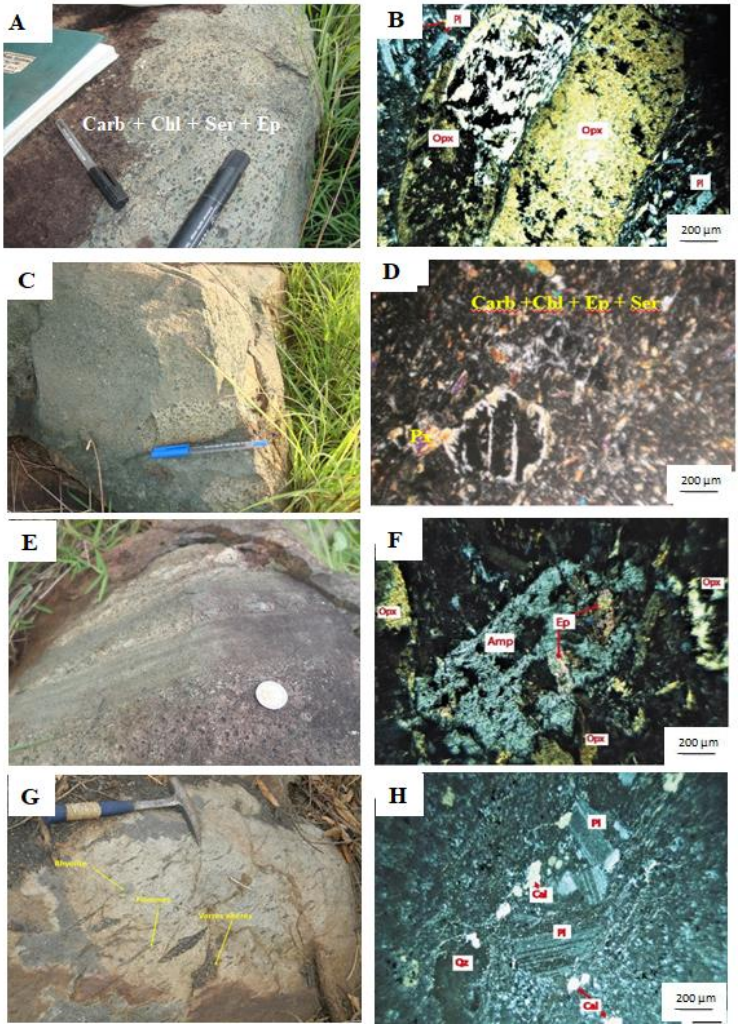


Figure 6: Macroscopic and microscopic aspects of tuffs (A-B), breccias (C-D); cinerites (E-F) and ignimbrites (G-H). *Opx: Orthopyroxene; Cpx: Clinopyroxene.*

- **Dolerites**

These rocks are melanocratic and in direct contact with the mafic metavolcanics **(figure 7C).** Under the microscope, they are identified by their interlocking plagioclase laths and are rich in partially altered

pyroxene phenocrysts **(figure 7D).** Carbonatization is weak, whereas chloritization is more pronounced. A few rare actinolite crystals are observed. In some sections, the sulfides are fractured, suggesting destabilization. Oxides are also noted.

- **Microdiorites/Quartz Microdiorites**

These rocks are melanocratic, gray-green, and generally crop out on hilltops and at the base of hills (figure 7E-G). Microscopic observation reveals a fine-grained to porphyritic fine-grained texture (figure 7F-H). Phenocrysts of amphibole and plagioclase are observed, along with biotite and microcline. Additionally, chlorite, sericite, epidote, carbonates, oxides, and sulfides, mainly represented by pyrite, are present. In quartz microdiorites, the quartz is scarce and microcrystalline.

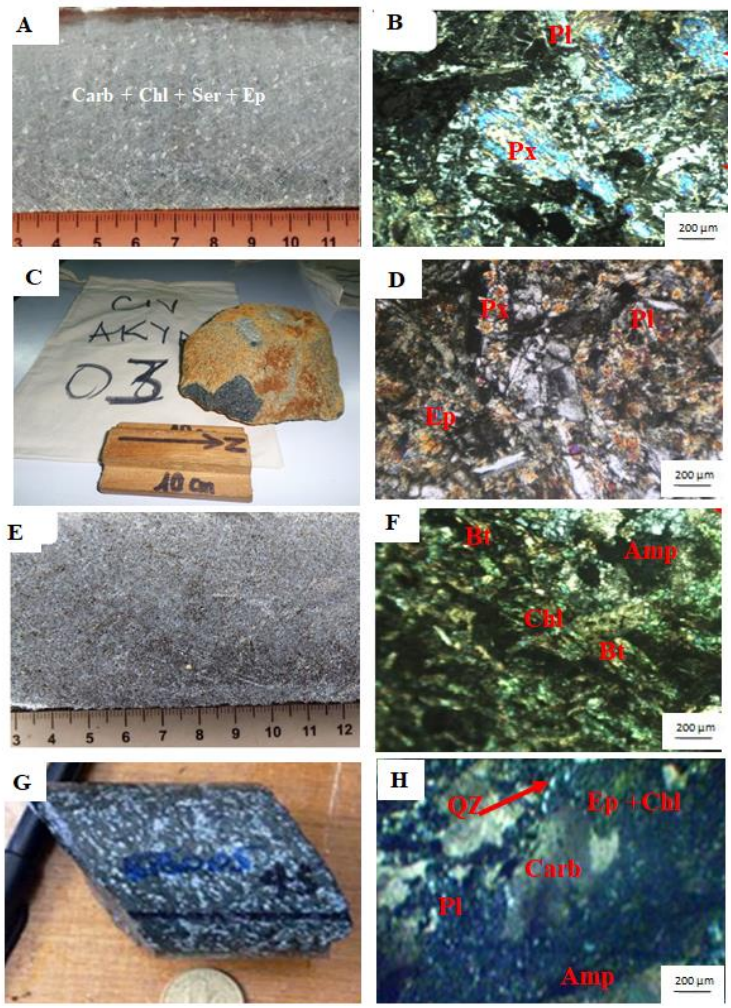


Figure 7: Macroscopic and microscopic aspects of microgabbros (A-B), dolerites (C-D); microdiorites (E-F) and quartz microdiorites (G-H).
Bt: Biotite

- **Microgranodiorites**

These rocks are massive, generally medium-grained, with a homogeneous fine-grained texture **(figure 8A).** Microscopic observation reveals quartz phenocrysts and large subhedral feldspar crystals (orthoclase and plagioclase), as well as biotite. The accessory minerals include chlorite, epidote, carbonates, titanite, and pyrite **(figure 8B).**

- **Microtonalites**

They are light-colored, occur as small hills, and are made up of feldspars, quartz, and amphiboles **(figure 8C).** The amphiboles are euhedral and occur as scattered phenocrysts. Under the polarizing microscope, numerous medium-sized plagioclase laths, partially altered to sericite, are visible, along with large crystals of calcite and amphibole associated with chlorite **(figure 8D).** A significant amount of interstitial quartz, as well as fine crystals of epidote and sericite, is also present in the matrix.

- **Pegmatites/Aplites**

The pegmatites in the study area are generally associated with aplites **(figure 8E).** In outcrop, they are leucocratic and consist of mica flakes, large feldspar crystals (plagioclase and alkali feldspar), quartz, and, to a lesser extent, tourmaline. They are cut by quartz-feldspar veins that also contain tourmaline. Aplitic veins most often cut across the granitoids of the belt **(figure 8F).** These rocks are light-colored and fine-grained, consisting of feldspars, quartz, and micas.

- **Microgranites**

Microgranites generally crop out along the margins of granite massifs or as elliptical masses within metavolcanic rocks **(figure 8G).** These rocks are light-colored, fine-grained, and often cut by quartz veins. In thin section, they show a fine-grained to porphyritic texture with phenocrysts of feldspars (K-feldspar and plagioclase), muscovite, biotite, and quartz **(figure 8H).** There are also occasional occurrences of orthoclase, epidote, oxides, and sulfides.

4.1.3. Plutonic rocks

- **Gabbros**

They are melanocratic, generally form hills, and consist of pyroxene and feldspars **(figure 9A).** The gabbros are in direct contact with mafic metavolcanics, and locally in discordant contact with mostly pelitic metasediments. Under the microscope, gabbros show a granular to porphyroblastic texture with phenocrysts of pyroxene (most often augite) and plagioclase **(figure 9B).** Pyroxene crystals are usually altered to amphibole, epidote and chlorite, accompanied by carbonates, sulfides, and oxides.

- **Diorites/Quartz Diorites**

These rocks are mesocratic to melanocratic, coarse-grained, and light gray to gray-green (figure 9C-E). Locally, some diorites are quartz-rich, especially in deformed and/or mineralized areas. Under the microscope, these rocks show a granular to porphyritic-granular texture, rich in feldspar (K-feldspar and plagioclase), amphibole, and biotite phenocrysts (figure 9D-F). The phenocrysts are pseudomorphosed by chlorite, epidote, sericite, and carbonates. The plagioclase is often zoned and, in some sections, shows the beginning of albitization. In quartz diorites, the quartz is interstitial and occurs as small crystals and subgrains embedded in a microcrystalline matrix. These rocks are cut by carbonate veins associated with chlorite, epidote, sulfides, and oxides.

- **Tonalites**

The tonalites are massive, medium-grained, granular, and crop out locally in the study area **(figure 9G).** They are rich in feldspar, biotite, and quartz. Under the microscope, these rocks show a granular to porphyritic granular texture and are made up of plagioclase, quartz, and green hornblende **(figure 9H).** These rocks also contain apatite, chlorite, epidote, carbonates, and opaque minerals.

- **Granodiorites**

The granodiorites are massive, medium-grained, often porphyritic, with feldspars, quartz, and biotite **(figure 10A).** Under the microscope, they generally contain feldspars (K-feldspar and plagioclase), many of which are altered to carbonates, sericite, and epidote **(figure 10B).** Quartz, green hornblende, biotite (partly altered to chlorite in some sections), sphene, albite, iron-titanium oxides (magnetite and/or hematite), and sulfides (pyrite) are also present.

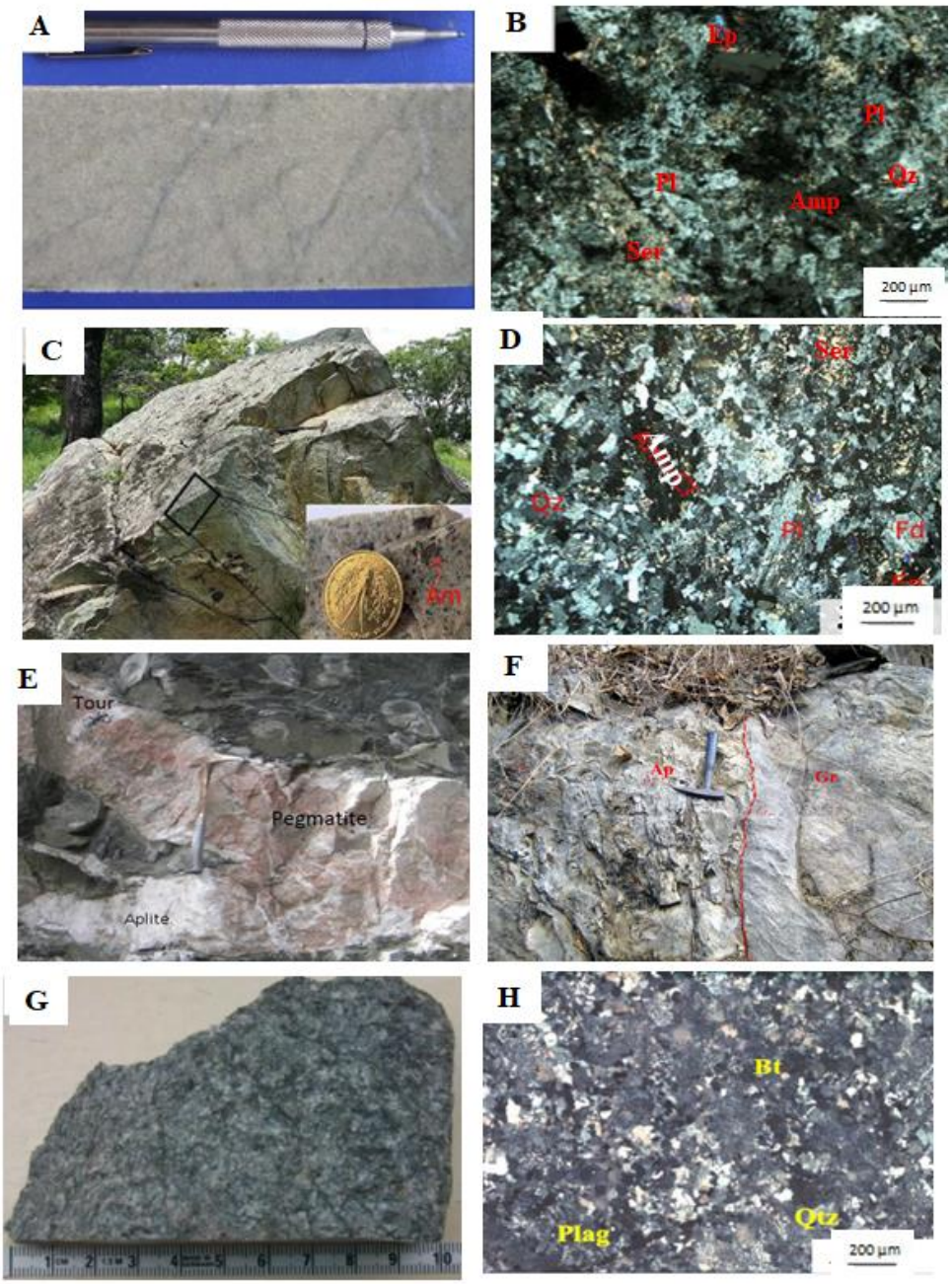


Figure 8: Macroscopic and microscopic aspects of microgranodiorites (A-B), microtonalites (C-D); pegmatites and aplites (E-F), and microgranites (G-H). *Ap: Aplite; Gr: Granite.*

- **Granites**

The observed granites are leucocratic, with a coarse-grained texture and often large crystals of quartz, feldspars, and biotite **(figure 10C).** Under the microscope, these rocks are rich in phenocrysts of quartz, plagioclase, and microcline, associated with elongated biotite and muscovite flakes **(figure 10D).** Chlorite, carbonates, epidote, and sericite are occasionally observed. Oxides, often located along the edges of or within biotite, and rare sulfides are also present.

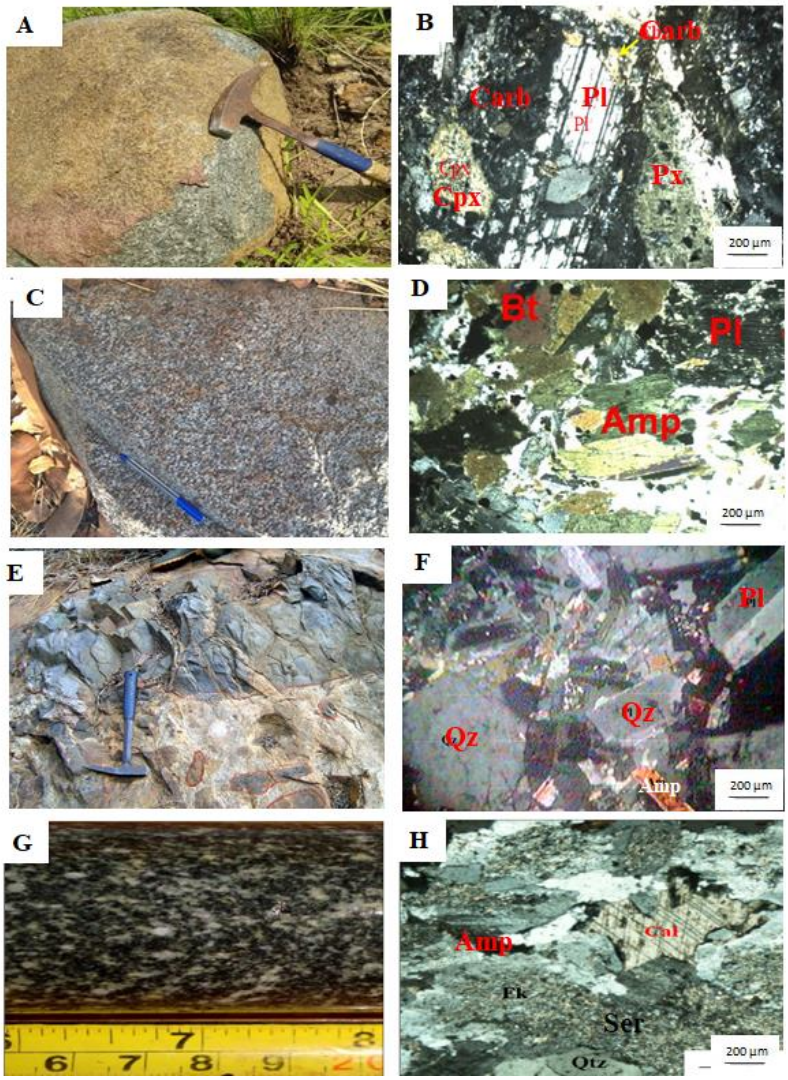


Figure 9: Macroscopic and microscopic aspects of gabbros (A-B), diorites (C-D); quartz diorites (E-F), and tonalites (G-H).
Cal: Calcite

4.2. Metamorphic rocks

- **Amphibolites**

Amphibolites are massive, greenish, and deformed, with a preferred orientation of amphibole crystals **(figure 10E).** Under the microscope, amphibolites are generally made up of amphiboles arranged in a matrix of epidote and chlorite crystals **(figure 10F).** The most common amphiboles are actinolite, tremolite, and green hornblende, along with plagioclase, sericite, carbonates, and opaque minerals. Opaque minerals are usually associated with the amphibole layers.

- **Ortho-schists**

These schistose rocks are variably weathered, deformed, and affected by fracture cleavage **(figure 10G).** Under the microscope, the ortho-schists show a granolepidoblastic texture with large carbonate crystals

(calcite ± dolomite) **(figure 10H).** They contain plagioclase, quartz, garnet, as well as secondary minerals made up of chlorite, sericite, and epidote.

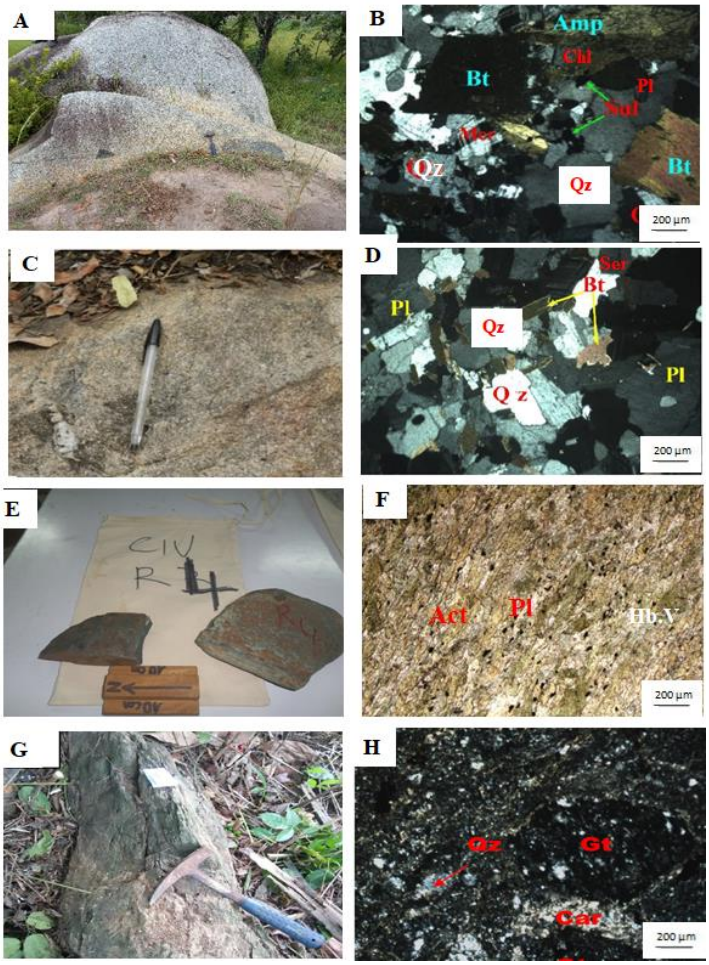


Figure 10: Macroscopic and microscopic aspects of amphibolite (A-B) and granites (C-D); amphibolites (E-F), and ortho-schists (G-H).
Gt: Garnet

5. DISCUSSION

Our work in the Toumodi-Fètêkro belt, at the heart of the Ivorian Birimian, reveals metavolcanic rocks consisting of lavas, often with pillow structures, and basic to acidic volcaniclastic rocks. The lavas range in composition from basalt through andesite, trachyte, dacite, and rhyodacite to rhyolite, and the volcaniclastic rocks include tuffs, breccias, ash deposits, and ignimbrites. These lavas usually alternate with the volcaniclastic rocks. Such alternations between volcanic and volcaniclastic rocks, which are common in the Birimian greenstone belts of West Africa, were described by Leube *et al*. (1990), who considered them to be broadly coeval. These lithological facies record effusive, submarine effusive, and explosive episodes of Birimian volcanism in the Toumodi-Fètêkro belt. Similar episodes have been documented in the Korhogo belt (Fofana, 2022) and in the Dabakala region (Gnanzou, 2014). However, unlike those of the Korhogo belt, the metavolcanic rocks of the study area include felsic volcaniclastic rocks. The hypabyssal and dyke rocks are represented by microgabbros, dolerites, microdiorites/quartz microdiorites, microgranodiorites, microgranites, microtonalites, aplites, and pegmatites. Some of these rocks have also been described elsewhere in the Ivorian Birimian (Houssou, 2013; Gnanzou, 2014;

Coulibaly, 2018; Dago, 2020; Fofana, 2022). The plutonic suite consists of gabbros, diorites/quartz diorites, tonalites, granodiorites, and granites. In addition, Ouattara (2018) reported felsic (granophyres), mafic (epidiorites), and ultramafic (lamprophyres) intrusions in the Dougbafla-Bandama deposit. The Comoé Basin also contains, in addition to the granitoids of the belt, granitic orthogneisses and quartz monzonites (Teha, 2019). The lithologies of the Toumodi-Fètêkro belt are similar to those of the southern and central parts of the Mako supergroup (Sabodala-Kerekounda) in Senegal (N'Gom, 1995). Broadly similar lithologies have been described in the late-Eburnean Kalana gold deposit in Mali (Sangaré *et al*., 2014). These authors reported diorites, quartz diorites, andesitic dykes, and tonalitic dykes that chemically correspond to dacites or rhyodacites. Basalts and most volcanic rocks are thought to have formed between 2.2 and 2.15 billion years ago (early Birimian) (Kouamelan, 1996; Hirdes and Davis, 1998; Castaing *et al*., 2003), whereas volcaniclastic rocks and sediments generally formed between 2.15 and 1.9 billion years ago (late Birimian), roughly coeval with the granitoids that intrude them (Hirdes *et al*., 1996; Bossière *et al*., 1996; Doumbia *et al*., 1998; Gasquet *et al*., 2003). The rocks studied indicate that the lithostratigraphy of the Toumodi-Fètêkro belt is similar to that of most West African Birimian belts (Arnould, 1961; Tagini, 1971; Pouclet *et al*., 1996; Vidal *et al*., 1996; Baratoux *et al*., 2011). The metamorphic rocks consist of amphibolites and orthogneisses. Such metamorphic lithologies have been identified in the Korhogo belt (Fofana, 2022). In contrast, studies of the Bonikro deposit (Ouattara, 2015) mainly report hornfelses. The metamorphism observed in the study area is generally low-grade, locally reaching the amphibolite facies, as in other West African Birimian belts (Hirdes *et al*., 1992; *Taylor et al*., 1992; Sylla and Ngom, 1997; Bourges *et al*., 1998; Coulibaly, 2018; Fofana, 2022) and in most West African gold deposits (Feybesse *et al*., 2006; Houssou, 2013; Ouattara, 2015; Block *et al*., 2015).

The rocks of the Toumodi-Fètêkro belt are affected by intense pervasive and vein-controlled alteration, reflecting the intensity of hydrothermal activity in the belt. Most primary minerals are transformed into secondary minerals, generally carbonates, chlorite, sericite, and epidote. Silicification, oxidation, and sulfidation are also observed. Hydrothermal activity is marked by quartz-feldspar veins associated with gold, pyrite, carbonates, and sericite. These alteration types are similar to those described in the Agbahou (Houssou, 2013), Bonikro (Ouattara, 2015; Adingra *et al*., 2024), and Dougbafla (Ouattara, 2018) deposits, and at the Bobosso prospect in the Dabakala region (Gnanzou, 2014).

6. CONCLUSION

The petrographic data show that the Toumodi-Fètêkro Birimian belt contains magmatic, metamorphic, and sedimentary rocks. The metavolcanic rocks consist of lavas (basalts, andesites, trachytes, dacites, rhyodacites, and rhyolites) and basic to acidic volcaniclastic rocks (tuffs, breccias, ash layers, and ignimbrites). The basaltic and andesitic lavas often show pillow structures. Hypabyssal and dyke rocks are represented by microgabbros, dolerites, microdiorites/quartz microdiorites, microtonalites, microgranodiorites, microgranites, aplites, and pegmatites. The plutonic suite consists of gabbros, diorites/quartz diorites, tonalites, granodiorites, and granites. Metamorphic rocks are represented by amphibolites and ortho-schists. The rocks of the Toumodi-Fètêkro belt have generally undergone both vein-controlled and pervasive hydrothermal alteration.

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REFERENCES

Adingra M., Koffi Y., Houssou N., Ouattara Z., Boya T. and Allialy M. (2024) Multi-Scale Approach for Gold Targeting in Côte d'Ivoire Paleoproterozoic Rocks. *Open Journal of Geology*, 14, 155-176. doi: 10.4236/ojg.2024.142010.

Arnould M. (1961). Étude géologique des migmatites et des granites précambriens du Nord-est de la Côte d'Ivoire et de la haute volta méridionale. Bulletin n°1, Direction de la Géologie et de la Prospection Minière, Abidjan, Mém. BRGM, France, 174p.

Baratoux L., Metelka V., Naba S., Jessell M.W., Gregoire M., Ganne J. (2011). Juvenile Paleoproterozoic crust evolution during the Eburnean orogeny (~2.2-2.0 Ga), western Burkina Faso. Precambrian Res. 191: 18-45.

Bessoles B. (1977). Géologie de l'Afrique, Le craton ouest-africain. Paris, Mém. B.R.G.M., France, n°88, 404 p.

Block S., Ganne J., Baratoux L., Zeh L., Parra-Avila A., Jessell M., Aillères L., Siebenaller L. (2015). Petrological and geochronological constraints on lower crust exhumation during Paleoproterozoic (Eburnean) orogeny, NW Ghana, West African Craton. J. Metamorphic Geol., 33, 463–494, http://dx.doi.org/ 10.1111/jmg.12129.

Bossière G., Bonkoungou I., Peucat J.-J., Pupin J-P. (1996). Origin and age of Paleoproterozoic conglomerates and sandstones of the Tarkwaian Group in Burkina Faso, West Africa. Precambrian Research 80:153–172.

Bourges F., Débat P., Tollon F., Munoz M. & Ingles J. (1998). The geology of the Taparko gold deposit, Birimian greenstone belt, Burkina Faso, West Africa. Mineralium Deposita, 33: 591-605.

Castaing C., Billa M., Milési J.P., Thiéblemont D., Le Mentour J., Egal E., Donzeau M., Guerrot C., Cocherie A., Chèvremont P., Tegyey M., Itard Y., Zida B., Ouedraogo I., Kote S., Kabore B.E., Ouedraogo C., Ki J.C., Zunino C. (2003). Notice explicative de la carte géologique et minière du Burkina Faso à 1/1 000 000. BRGM BUMIGEB: 147.

Coulibaly I. (2018). Pétrologie des volcanites et des plutonites du sud du sillon Birimien de Toumodi-Fètêkro (Côte d'Ivoire): Implications pétrogénétique et tectonique. Doctorat, Univ. FELIX HOUPHOUËT -BOIGNY, 218 p.

Dago, A. G. B. (2020). Les granitoïdes birimiens de la région de Daloa (centre-ouest de la Côte d'Ivoire) : genèse et implication dans l'évolution thermique du craton ouest africain. Thèse de Doct. Univ. Félix HOUPHOUET-BOIGNY, 218p.

Daouda B.Y. (1998). Lithostratigraphie et pétrologie des formations birimiennes de Toumodi-Fettèkro (Côte-d'Ivoire) : implication pour l'évolution crustale du Paléoprotérozoïque du craton Ouest-Africain. Thèse de Doctorat, Université d'Orléans, 191 p.

Doumbia S., Pouclet A., Kouamelan A.N., Peucat J. J., Vidal M. (1998). Petrogenesis of juvenile-type Birimian (Paleoproterozoic) granitoïds in Central Côte d'Ivoire, West Africa: geochemistry and geochronology. Precambrian Research 87: 33-63.

Feybesse J.-L., Billa M., Guerrot C., Duguey E., Lescuyer J.-L., Milesi J.-P., and
Bouchot V. (2006). The Paleoproterozoic Ghanaian Province: Geodynamic model and ore controls, including regional stress modeling. Precambrian Research, 149(3): 149–196.

Fofana K. (2022). Pétrologie, Analyse Structurale et Géochimie des formations géologiques du sillon de Korhogo (Nord de la Cote d'Ivoire). : Implication géodynamique et minéralisations aurifères associées. Doctorat, Université Félix HOUPHOUET-BOIGNY d'Abidjan, 225p.

Gnanzou A. (2014). Etude des séries volcano-sédimentaires de la région de Dabakala (Nord-Est de la Côte d'Ivoire) : genèse et évolution magmatique. Contribution à la connaissance de la minéralisation aurifère de Bobosso dans la série de la Haute- Comoé. Thèse de doctorat, Univ. Paris-Sud Orsay, France et Univ. Félix HOUPHOUËT - BOIGNY, 303p.

Gasquet D., Barbey P., Adou M., Paquette J.L. (2003). Structure, Sr-Nd isotope geochemistry and zircon U–Pb geochronology of the granitoids of the Dabakala area (Côte d'Ivoire): evidence for a 2.3 Ga crustal growth event in the Palaeoproterozoic of West Africa? Precambrian Res. 127: 329–354.

Hirdes W. & Davis D.W. (1998). First U-Pb zircon age of extrusive volcanism in the Birimian Supergroup of Ghana/West Africa. Journal of African Earth Sciences, 27: 291-294.

Hirdes W., Davis D.W., Eisenlohr N.N. (1992). Reassessment of Proterozoic granitoid ages in Ghana on the basis of U/Pb zircon and monazite dating. *Precambrian Res*., 56: 89-96.
HIRDES W., DAVIS D.W., LÜDTKE G. and KONAN G., (1996): Two generations of Birimian (Paleoproterozoic) volcanic belts in northeastern Côte d'Ivoire (West Africa): consequences for the 'Birimian contoversy'. *Precambrian Res*., 80: 173-191.
Houssou N. (2013). Etude pétrologique, structurale et métallogénique du gisement aurifère d'Agbahou, Divo, Côte d'Ivoire. Doctorat, Université Félix HOUPOUET-BOIGNY d'Abidjan, *Côte d'Ivoire*, 177p.
Kouamelan A. N. (1996). Géochronologie et Géochimie des formations archéennes et protérozoïques de la dorsale de Man en Côte d'Ivoire: Implication pour la transition Archéen-Protérozoïque. Doctorat Uni. Rennes, Mémoire Géoscience n° 73 Rennes, 293 p.
Kouamelan A. N., Delor C., & Peucat J. J. (1997). Geochronological evidence for reworking of Archean terrains during the early Proterozoic (2.1 Ga) in the western Côte d'Ivoire (Man rise–West African Craton). *Precambrian Research*, 86, pp. 177–199.
Lemoine S. (1988). Evolution géologique de la région de Dabakala (NE de la Côte d'Ivoire) au protérozoïque inférieur. Possibilités d'extension au reste de la Côte d'Ivoire et au Burkina Faso. Thèse ès Sci., Univ. Clermont-Ferrand, 388 p.
Leake M.H. (1992). The petrogenesis and structural evolution of the early proterozoic Fetekro greenstone belt, Dabakala region, NE Côte d'Ivoire. *PhD. thesis*, Univ. Portsmouth, U.K., 315 p.
Leube A., Hirdes W., Mauer R. & Kesse G.O. (1990). The early Proterozoic Birimian Supergroup of Ghana and some aspects of its associated gold mineralisation. *Precambrian Res*., 46:139-165.
Milesi J.P., Feybesse J.L., Ledru P., Dommanget A., Ouedraogo M.F., Marcoux E., Prost A., Vinchon C., Sylvain J.P., Johan V., Tegyey M., Calvez J.Y. et Lagny P. (1989). Les minéralisations aurifères d'Afrique de l'Ouest, leurs relations avec l'évolution du Protérozoïque inférieur. Chon. Rech. Min., Fr. 497, pp1-98.
Mortimer J. (1990). Evolution of early Proterozoic Toumodi volcanic group and associated rocks, Ivory Coast. *Ph.D. Thesis*, Portsmouth Polytechnic, U.K., 244p.
N'Gom P.M. (1995). Caractérisation de la croûte birimienne dans les parties centrale et méridionale du supergroupe de Mako. Implications géochimiques et pétrogénétiques. *Doctorat ès Sciences Naturelles*, Université Cheikh Anta Diop, Dakar, 243 p.
Ouattara A.S. (2018). Le gisement aurifère de Dougbafla-Bandama (Sud du sillon birimien de Fettékro, Oumé, Côte d'Ivoire) : Pétrographie, déformation, géochimie et métallogénie. *Doctorat*, Univ. FELIX HOUPHOUET-BOIGNY, 313 p.
Ouattara Z. (2015). Caractères lithostratigraphique, structural, géochimique et métallogénique du gisement d'or de Bonikro, sillon birimien de Fettekro, centre-sud de la Côte d'Ivoire. *Doctorat*, Univ. FELIX HOUPHOUËT -BOIGNY, 256 p.
Pouclet A., Vidal M., Delor C., Simeon Y. and Alric G. (1996). Le volcanisme birimien du Nord-Est de la Côte-d'Ivoire, mise en évidence de deux phases volcanotectoniques distinctes dans l'évolution géodynamique du Paléoprotérozoïque. *Bull. Soc. Géol. France*, t.167, n°4:529-541.
Sangaré A., Driouch Y., Salvi S., Féménias O., Siebenaller L., Belkasmi M., Béziat D., Dahire M., Ntarmouchant A., Adil S., Debat P. (2014). Géologie des minéralisations aurifères du gisement tardi-éburnéen de Kalana (Birimien, Sud-Ouest du Mali), Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Terre, 2014, n° 36 : 85–108.
Sylla M., Ngom P. M. (1997). Le gisement d'or de Sabodala (Sénégal Oriental): une Minéralisation filonienne d'origine hydrothermale remobilisée par une tectonique cisaillante. *J. of Afr. Earth Sces*, 25, No. 2: 183-192.
Tagini B. (1971). Esquisse structurale de la Côte d'Ivoire. Thèse de l'Université de Lausanne et publication SODEMI, 302 p.

Taylor P.N., Moorbath S., Leube A. & Hirdes W. (1992). Early Proterozoic crustal evolution in the Birimian of Ghana: constraints from geochronology and isotope geochemistry. *Precambrian Res*., 56: 97-111.

Teha K.R. (2019). Les Formations Éburnéennes du Sud-ouest du bassin de la Comoé et du secteur de Singrobo (Sud de la Côte d'Ivoire) : Pétrologie, Analyse structurale et Magmatisme associé. Doctorat, Université FELIX HOUPHOUET -BOIGNY, 247 p.

Vidal M., Delor C., Pouclet A., Simeon Y., Alric G. (1996). Evolution géodynamique de l'Afrique de l'Ouest entre 2.2 et 2 Ga : style « Archéen » des ceintures vertes des ensembles sédimentaires birimiens du nord-est de la Côte d'Ivoire. *Société Géologique de France*, t. 167, n°3: 307-319.

Yacé I. (1976). Le volcanisme éburnéen dans les parties centrale et méridionale de la chaîne précambrienne de Fettekro en Côte d'Ivoire. *Thèse de Doctorat*. Univ. Abidjan. 373 p.

YACE I. (1982). Etude géologique du volcanisme éburnéen dans les parties centrales et méridionales de la chaine précambrienne de Fétèkro. République de Côte d'Ivoire, Ministère des mines, Direction de la Géologie, Abidjan, 156p.