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Geological features of quartz veins in the southeastern part of the Comoé Birimian basin (Southeast Cote d'Ivoire, North Alépé)

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ABSTRACT: The study area is located in the southeastern part of the Comoé basin (southeast of Côte d'Ivoire, north of the town of Alépé). The geology of this study area is marked by granitoids (two-mica bearing granites, granodiorites, microgranites and pegmatites) and metamorphic rocks (gneiss, micaschists, metawackes and schists) which are crossed by several quartz veins. The aim of this study is to identify the petro-structural and metallogenic features of the quartz veins in this part of the Ivorian birimian. The methodology used focused on geological surveys, petrographic descriptions (macroscopic and microscopic), structural analysis and metallogenic analyzed. The petro-structural study revealed the presence of saccharoid quartz veins, tourmaline bearing quartz veins, banded tourmaline quartz veins, biotite bearing quartz vein, translucent quartz veins, smoky quartz veins, white to milky white quartz vein. The morphology of the veins is variable: rectilinear or fusiform with a main NE-SW orientation and secondary orientations NNW-SSE and E-W. In addition, these veins are generally deformed in the form of folds, tension slots, sigmoidal figures. These structures demonstrate the existence of shear corridors. The presence of rolling extinction and quartz subgrains were highlighted by microscopic observations, confirming the dislocation creep mechanism. This mechanism indicates high temperature and differential stress conditions. Observations with metallographic microscopes coupled with geochemical analysis data show that sulphides and gold are present in the fracture planes and quartz subgrains and generally associated with the quartz-tourmaline veins. Hence, the interest in taking into account the quartz-tourmaline association in gold prospecting in the Birimian rocks.

KEYWORDS: Gold, Tourmaline, Quartz veins, Subgrains, Côte d'Ivoire.

1 INTRODUCTION

The Birimian formations known to carry abundant mineralization [1], are unevenly distributed in the West African craton with a proportion of 35% for Côte d'Ivoire. The Ivorian territory is covered by two thirds of Birimian formations rich in gold sometimes associated with quartz veins. Therefore, quartz veins become an important structure for mineral exploration. Indeed, several gold deposits associated with quartz veins have been identified in Côte d'Ivoire: Tongon [2], Afema [3], Yaouré [4] and Agbaou [5]. The discovery of these resources generated numerous profits for the country. Also, the rise of new information and communication technologies and the increased need for high-tech equipment have led to growing interest in the exploration of these mineral resources. The geological rocks of the south-eastern part of the Comoé basin (north of the town of Alépé) contain numerous quartz veins. Indeed, apart from the studies by Delor et al. (1992) [6] on the presence of indices of alluvial diamond, lode gold, alluvial and rutile in this area and those of Adingra (2020) [7] on the Birimian geological formations of this region, very few geological studies exist on this area of Côte d'Ivoire. The quartz veins in this part of Côte d'Ivoire are diverse and hosted in tholeitic and calc-alkaline volcanics, granitoids, volcano-sediments and metasediments. The main objective of this article is to contribute to the improvement of geological knowledge of quartz veins in this part of Côte d'Ivoire. The specific objectives are as follows: (i) determine the nature of the quartz veins in the study area; (ii) identify the different structures associated with the quartz veins studied; (iii) highlight the different metalliferous paragenesis present within the quartz veins of this part of Côte d'Ivoire.

2 GEOGRAPHICAL AND GEOLOGICAL SETTINGS

The study area is located in the southeast of Côte d'Ivoire in the Mé region, north of the town of Alépé, approximately 45 km from Abidjan (economic capital). It is located between the latitudes 6°00'49'' N and 5°29'36'' N and the longitudes 3°47' 31'' W and 3° 23' 13'' W. It straddles two regions (the region of Mé and the South-Comoé region).

Geologically, Côte d'Ivoire is located at the south of West African craton, more precisely in the southern part of the Man Ridge. It is covered by 2 geological groups: the coastal sedimentary basin (2.5% of the territory) and the Precambrian basement (97.5%). The Precambrian basement is divided into 2 large domains separated by the Sassandra fault [8]: the Archean domain (3600-2500 Ma) to the west of the fault and the Paleoproterozoic domain (2500 -1800 Ma), to the East where most of the gold mineralization is located and also our study area (Fig.1).

The Paleoproterozoic domain covers two thirds of the Ivorian territory and is characterized by Birimian rocks structured during the Eburnean orogeny (2500 to 1600 Ma). These rocks are represented by an alternation of greenstone belts and Birimian sedimentary basins-oriented NNE-SSW, all intruded by several generations of granitoids. These rocks are affected by epi to mesozonal metamorphism [9], [10], [11]. In total, seventeen Birimian volcano-sedimentary furrows have been identified in Côte d'Ivoire [9], [12]. Most of the known gold mineralization in Côte d'Ivoire is located in these volcano-sedimentary furrows [7].

According to Leube et al. (1990) [13], Milési et al. (1992) [14] and Klemb et al. (2002) [15]), the Birimian greenstone belts formed by progressive amalgamation of juvenile island arcs and oceanic plateaus, subsequently thickened by intrusion of late-kinematic, basin-type granitoids and compressional deformation, during which structurally controlled, meso- thermal lode-gold deposits formed. Quartz veins related to gold deposit have been identified by several authors in Birimian rocks [13], [14], [15], [4], [16], [17].

The study area is made up of Birimian rocks which are tholeitic and calc-alkaline volcanics, granitoids, volcano-sediments and metasediments [6]. This area is consisting of two micas bearing granites, granodiorites, gneisses, amphibolites, mylonites, metasediments and several generations of pegmatite and quartz veins [7]. At the structural level, it is crossed by a major structure which is a dextral shear corridor-oriented NE-SW called SSC (Sunyani-Sefwi-Comoé) [18]. This corridor extends into Ghana (Fig.2).

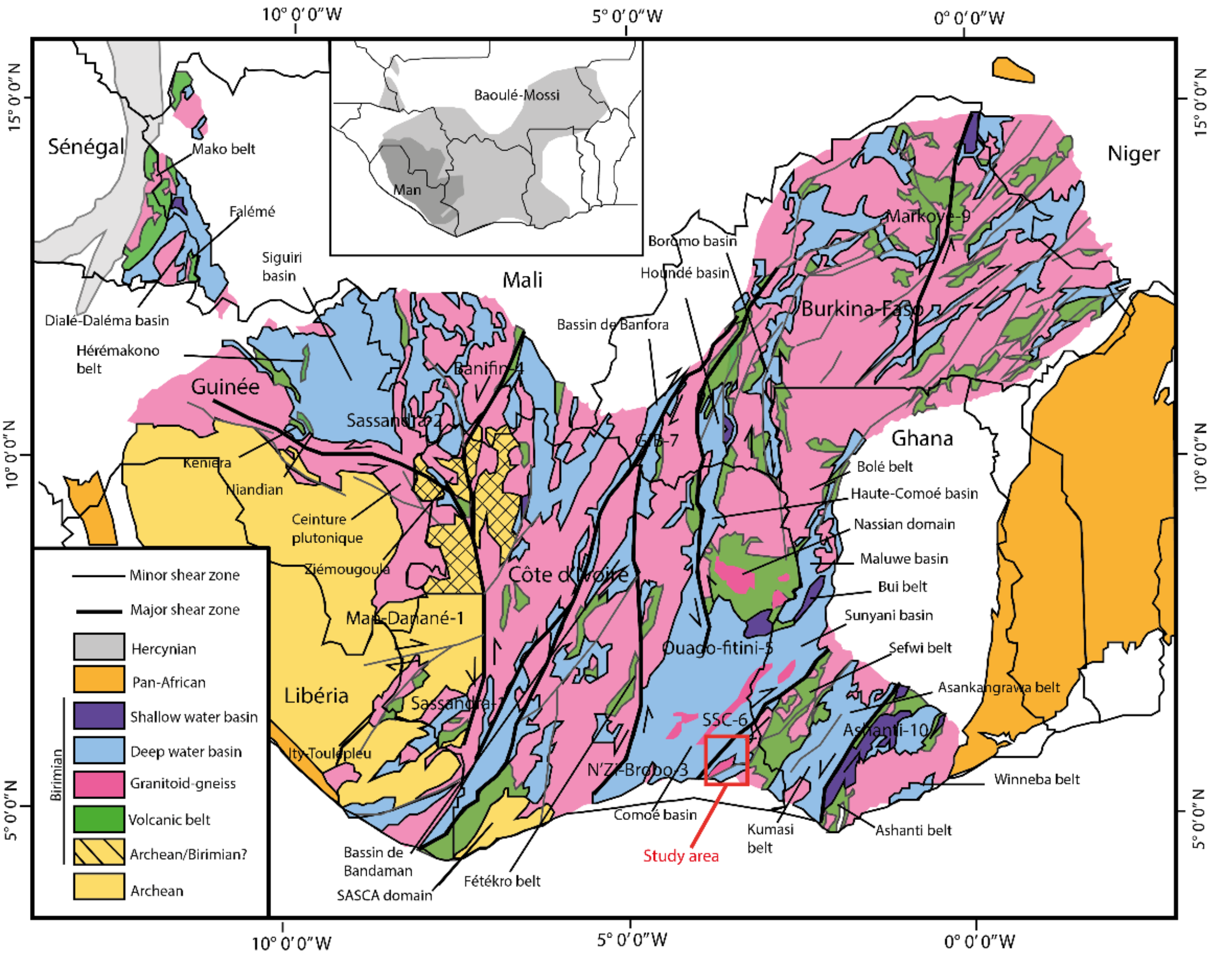

Fig. 1. Simplified tectonic map of the West African Craton showing the location of the study area (Grenholm, 2014 [19] modified)

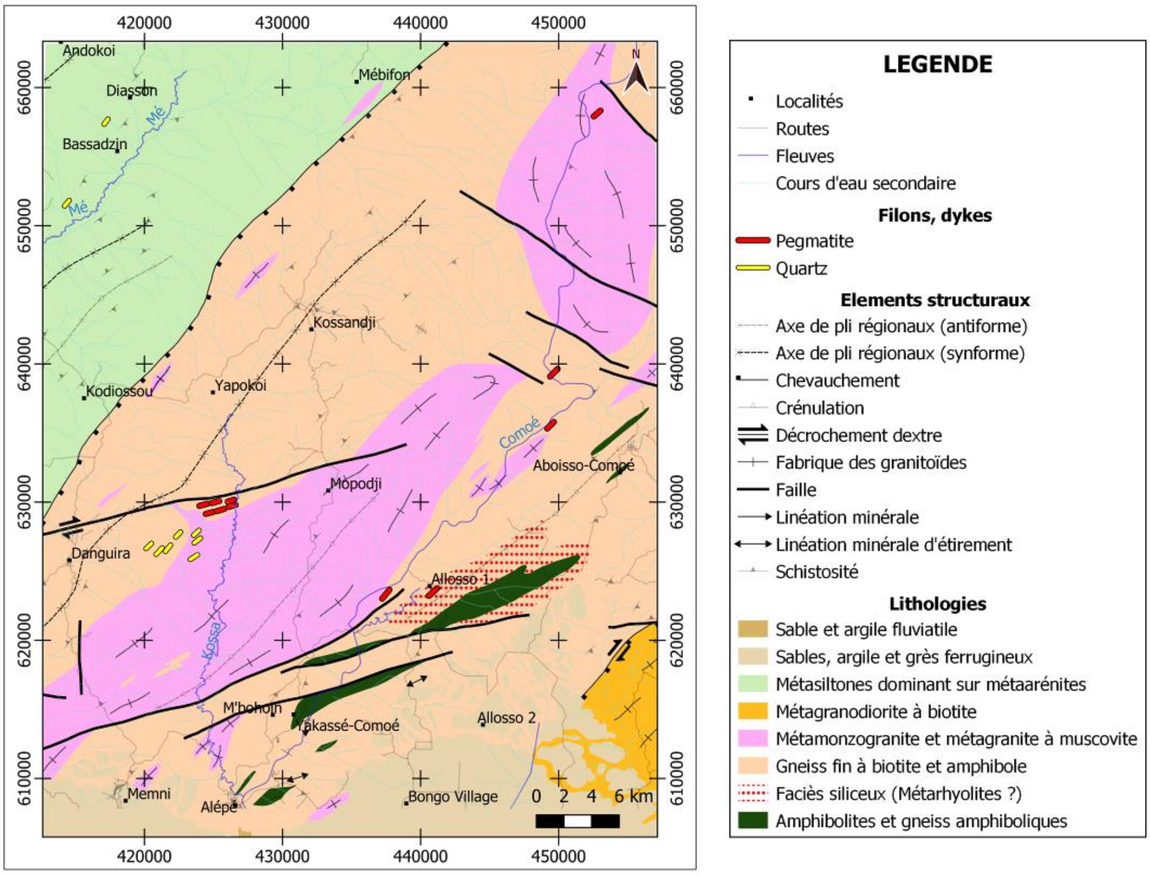

Fig. 2. Geological map of study area (from Delor et al., 1992 [6] modified)

3 METHODOLOGY

The methodology used for this work began with documentation, followed by field work (macroscopic petrography and structural analysis) and ended with laboratory work (microscopic petrography, XRD analysis and geochemical analysis). This involved several disciplines, including petrography, structural analysis and metallogeny.

Several quartz samples were taken during the various field missions for laboratory analysis. Seven polished thin sections were prepared at the Geology, Mineral and Energy Resources laboratory of the Université Félix Houphouët Boigny. Six samples were sent to the "Société pour le développement minier de la Côte d'Ivoire" (SODEMI) for geochemical analysis to determine the gold content in each sample. The method used for gold is fire assay.

X-ray diffractometer (XRD) analysis was carried out at the the scientific pole of Félix Houphouët Boigny University. This analysis helps us to identify the different mineral phases present in the six samples.

4 RESULTS

The results obtained from this study have been structured into three groups: petrographic data, structural data and metallogenic data.

4.1 PETROGRAPHIC DATA

The macroscopic and microscopic petrographic study showed that the study area is crossed by several types of quartz veins hosted in magmatic and metamorphic rocks. The quartz veins observed are smoky quartz veins, banded quartz-tourmaline veins, saccharoid quartz veins, tourmaline bearing quartz veins, translucent quartz veins, biotite bearing quartz veins and milky white quartz veins.

- Smoky quartz veins

Smoky quartz veins have micro-fractures filled with carbonates. This is a grey-coloured quartz in the form of segments that are variously oriented in places, with several micro-fractures full of white minerals that effervesce in the presence of hydrochloric acid (Fig. 3A).

Microscopically, these quartz minerals are anhedral, with low relief, colourless and perfectly clear. These unaltered minerals sometimes show recrystallisation with small quartz grains found around large quartz crystals. These grains are also found in fractures. All those observations indicate that we have two generations of quartz. The second comes from the first in the form of small grains and the first in the form of large quartz crystals (Fig. 3 B&C).

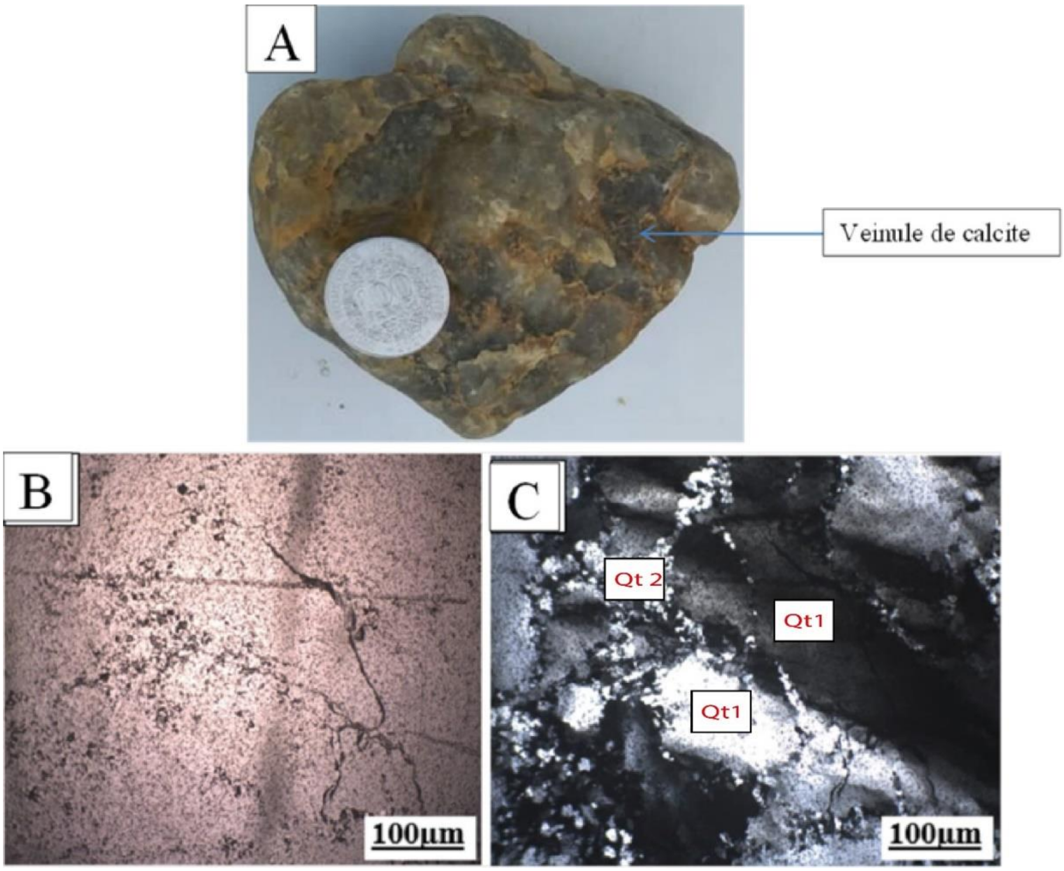

Fig. 3. ***Macroscopic and microscopic aspects of smoky quartz***

(A): smoky quartz sample; (B): microscopic observation in LPNA of smoky quartz; (C): microscopic observation in LPA of smoky quartz. (Qt 1): 1st generation of quartz; (Qt 2): 2nd generation of quartz.

- Saccharoid quartz veins

They outcrop in the form of a quartz block with white and milky white sugar crystals. The white crystals are intersected by the milky white crystals. This block of saccharoid quartz has several differently oriented fractures. This sample has brown to orange spots due to weathering. It contains veinlets of carbonate minerals because of effervescence reaction in the presence of hydrochloric acid (Fig. 4A&B).

Microscopically, the veins appear as large crystals and small crystals with the presence of opaque minerals. This sample shows two generations of quartz. The primary generation is large crystals and the secondary generation is the sub-grains crystals. Inside the fractures are a few small, opaque and euhedral minerals (Fig. 4 C&D).

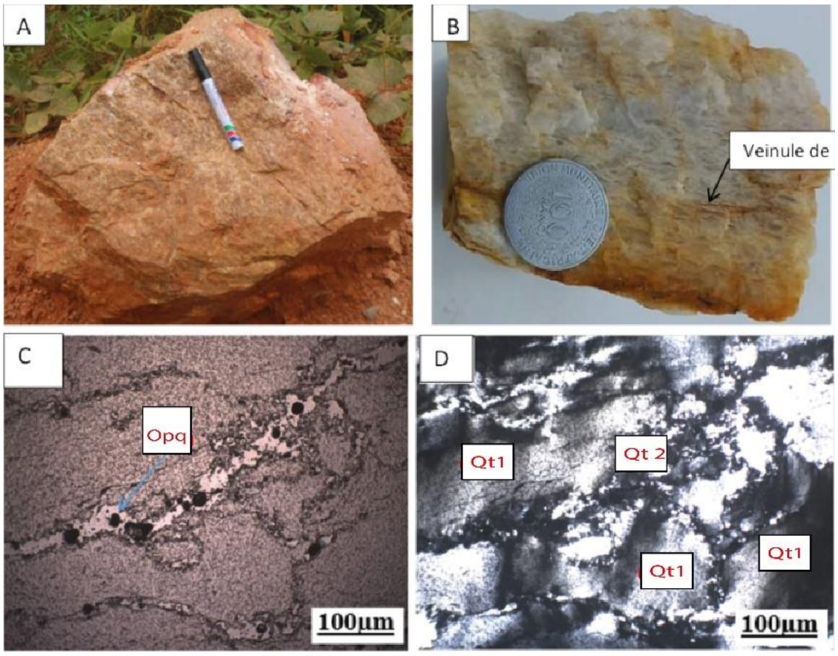

Fig. 4. Macroscopic and microscopic aspects of saccharoid quartz

(A): Outcrop of saccharoid quartz; (B): saccharoid quartz sample showing a calcite veinlet; (C): saccharoid quartz in LPNA; (D): saccharoid quartz showing the quartz subgrains in LPA. Qt 1: First generation of quartz; Qt 2: second generation of quartz; Opq: opaque minerals.

- Milky quartz veins

These are rectilinear, decimetre-thick quartz veins, mottled brown to orange in colour due to weathering, with several fractures of varying orientation set in laterites. These fractures are empty or sometimes filled with carbonates (Fig. 5A).

Microscopic observation revealed the presence of quartz only. It shows the beginnings of crystal recrystallisation through the presence of sub-grains. These sub-grains are in small quantities and are found around the large quartz crystals (Fig. 5B&C).

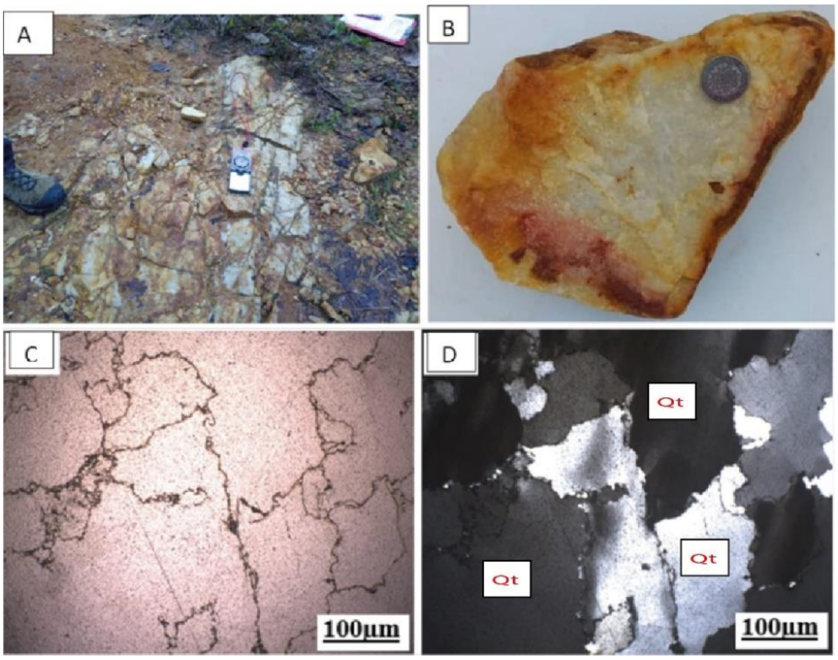

Fig. 5. Macroscopic and microscopic aspects of milky quartz

(A): Outcrop of saccharoid quartz; (B): saccharoid quartz sample; (C): saccharoid quartz in LPNA; (D): saccharoid quartz showing the quartz subgrains in LPNA. Qt 1: First generation of quartz; Qt 2: second generation of quartz; Opq: opaque minerals.

- Biotite bearing quartz veins

These are white quartz veins, centimetric to decimetric in thickness, and non-rectilinear. The sample has several milky-white cracks. The hydrochloric acid test on these cracks produced an effervescence that indicated the presence of carbonates (Fig. 6A&B).

At the microscopic level, 3 minerals have been identified in order of abundance: quartz, biotite and opaque minerals. In natural light (LPNA), biotite is brown, euhedral with a medium relief and perfect cleavage in longitudinal section. It is found in micro-fractures. Opaque minerals are very small, few in number and euhedral (Fig. 6C&D).

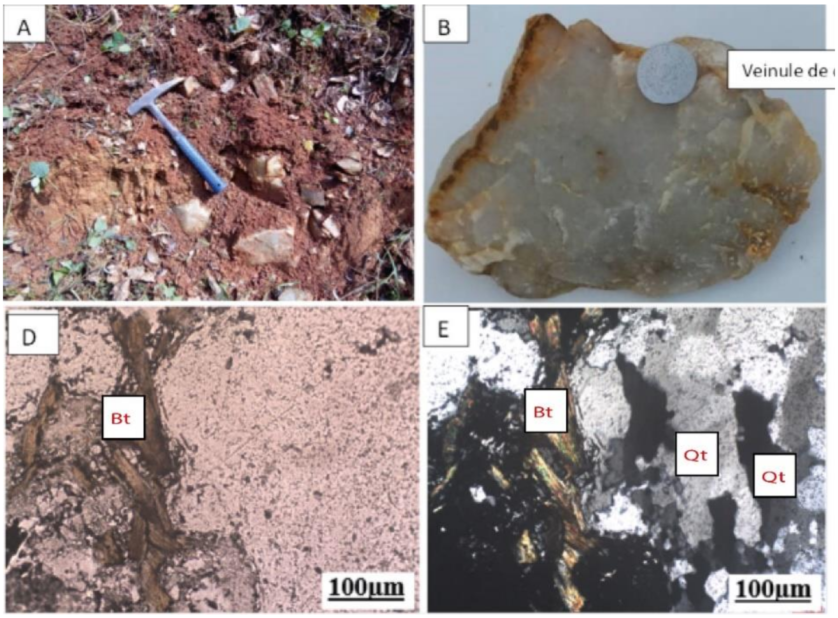

Fig. 6. Macroscopic and microscopic aspects of biotite bearing quartz veins

(A): Biotite bearing quartz outcrop; (B): biotite bearing quartz sample; (C): biotite bearing quartz in LPNA; (D): biotite bearing quartz in LPA; (Qt): quartz; (Bt): biotite

- Banded tourmaline quartz veins

These veins are composed of alternating dark bands of tourmaline and light bands of quartz. They are centimetre-thick and segmented (Fig. 7A&B).

Under the microscope, tourmaline appears as a subeuhedral to euhedral mineral with strong relief, colour, fractures and a bright hue. It is later than quartz minerals because it is found superimposed on quartz or in the vicinity of quartz (Fig. 7C&D).

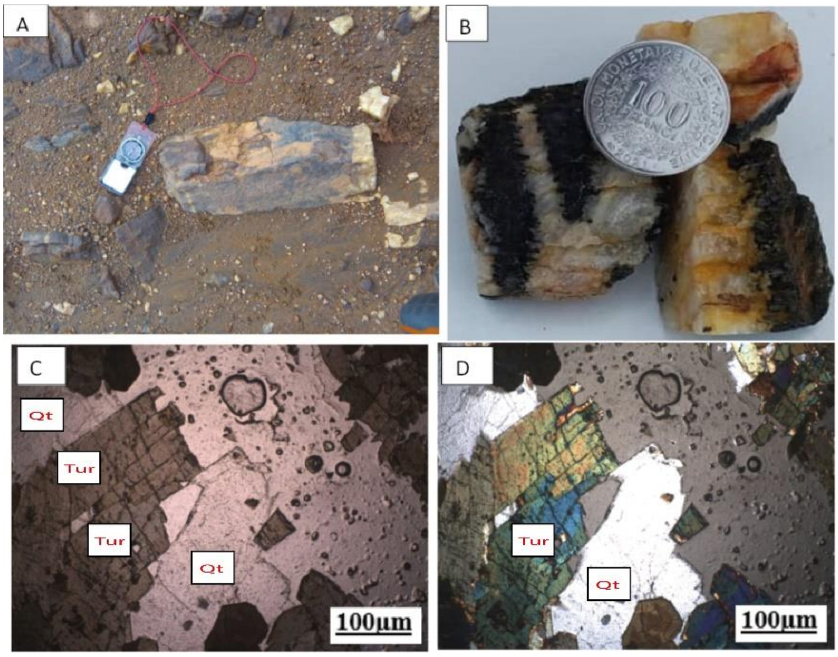

Fig. 7. Macroscopic and microscopic aspects of banded tourmaline quartz veins

(A): Banded tourmaline quartz outcrop; (B): banded tourmaline quartz sample; (C): banded tourmaline quartz in LPNA; (D): banded tourmaline quartz in LPA; Qt: quartz; Tur: tourmaline.

- Tourmaline bearing quartz veins

These are veins of white quartz with the presence of tourmaline minerals. The sample shows several full or empty fractures intersecting each other. The veinlets observed are milky white in colour and have an effervescent reaction to acid. This sample therefore contains calcite veins and veinlets (Fig. 8A&B). Quartz, tourmaline and opaque minerals were observed under the microscope. Quartz is present in large quantities and in anhedral form, while tourmaline is present in very small quantities and in clusters in one part of the vein. The opaque minerals are very small in size and scattered in the fractures intersecting the veins (Fig. 8C&D).

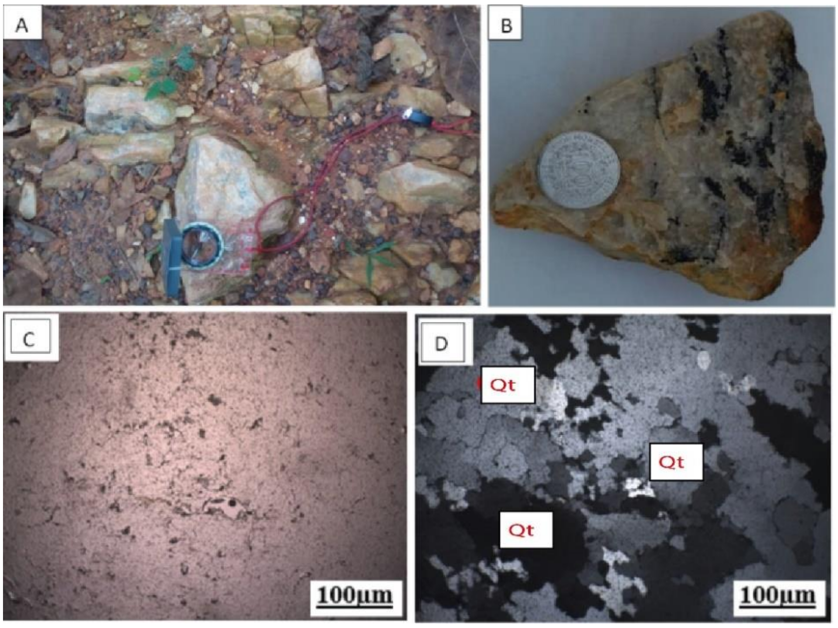

Fig. 8. Macroscopic and microscopic aspects of the tourmaline bearing quartz vein

(A): Tourmaline quartz outcrop; (B): tourmaline quartz sample; (C): tourmaline quartz in LPNA; (D): tourmaline quartz in LPA; Qt: quartz.

- Translucent quartz veins

These are boudin veins, sheared into echelons in the laterites, and contain two types of quartz: a colourless quartz which intersects a white to milky-white quartz. These two different veins are intersected by calcite veinlets. The colourless crystals predominate over the white crystals in this vein (Fig. 9). The only mineral observed under the microscope is quartz. This mineral appears in a stretched form with rolling extinction.

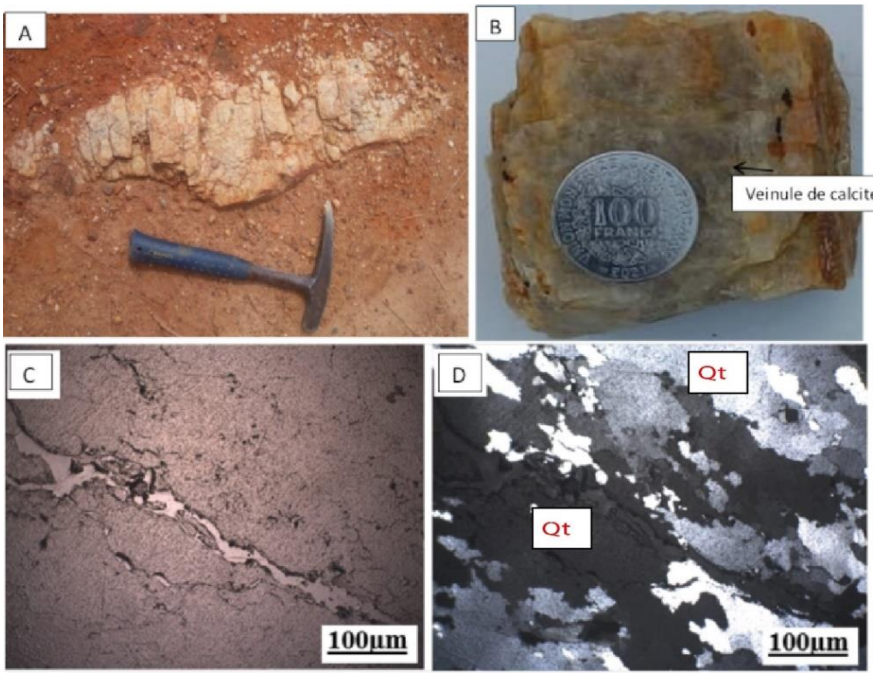

Fig. 9. Macroscopic and microscopic aspects of the translucent quartz vein

(A): outcrop of translucent quartz vein; (B): sample of translucent quartz vein; (C): quartz vein translucent in LPNA; (D): stretched quartz mineral in LPA; Qt: quartz.

4.2 Structural Data

These data consist of ductile and brittle structures.

4.2.1 Ductile Structures

They are made up of folded veins (macroscopy) and dislocation creep (microscopy).

- Folded veins

The folded quartz veins are found in the laterite and micaschists. The folded vein hosted in the laterite shows a W-shaped entrainment fold with an axial plane oriented N40° (Fig. 10A). This type of fold is typical of hinge zones. The quartz vein hosted in the micaschist has a S-shaped fold, observed in the Songan classified forest. The axial plan of the fold is oriented N58° and is oblique to the NNW-SSE oriented shear plane (Fig. 10B). These structures show that the veins underwent in ductile deformation.

- Dislocation creep

A dislocation in the crystalline system is a deformation of the crystals under the effect of stress and slippage along defects in the crystal lattice. This type of creep forms a particular texture under the microscope. This is the mosaic texture with rolling extinction. This textural characteristic results from the dislocation of large quartz crystals edges into small grains that crystallise under the new temperature and pressure conditions. These sub-grains constitute a second generation of quartz, which in our case is associated with opaque minerals. This is a dynamic recrystallisation that follows the fracture planes linked to the quartz veins (Fig. 10 C&D).

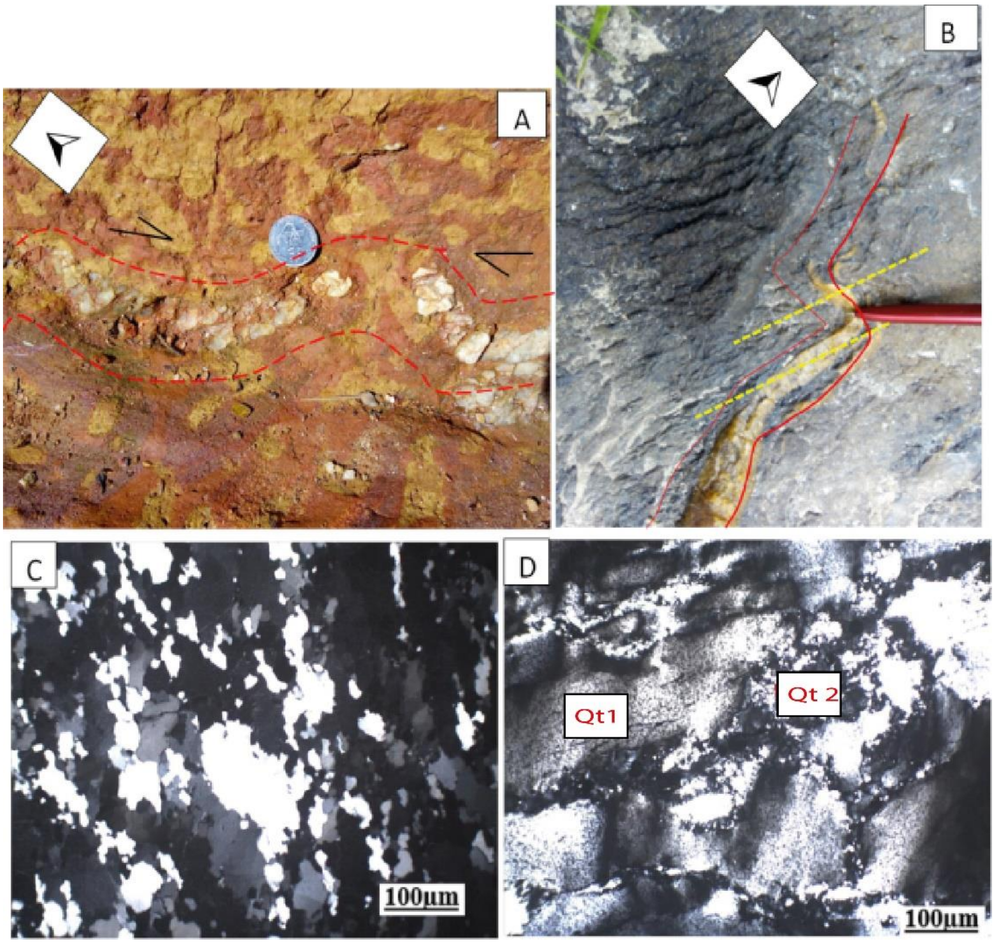

Fig. 10. Macroscopic and microscopic aspects of the different ductile deformations

(A): W-shaped fold in the laterite with an axial plane oriented N40°; (B): S-fold in micaschist with axial plan oriented N58°; (C&D): characteristics of dislocation creep; (C): rolling extinction of quartz and quartz crystals following one direction; (D): recrystallization of quartz crystals in the fracture planes. Qt1: first generation of quartz; Qt2: second generation of quartz.

4.2.2 BRITTLE STRUCTURES

They consist of fractures and fracture schistosity.

- Fractures

They are observed in all lithologies of the study area. Networks of conjugated fractures can be observed in quartz veins but also in other lithologies (Fig. 11A&B). The fractures are generally oriented NE-SW, E-W and NW-SE. The fractures oriented N45° and N86° are conjugated and intersected with each other and intersect fractures N172° (Fig. 11 B).

- Fracture schistosity

A fracture schistosity was identified in a quartz vein sheared in dextral movement oriented N75° (ENE-WSW). The fracture schistosity observed is oriented N30° (NE-SW). This NE-SW schistosity is associated with dextral ENE-WSW shearing in a shear corridor (Figure 12C).

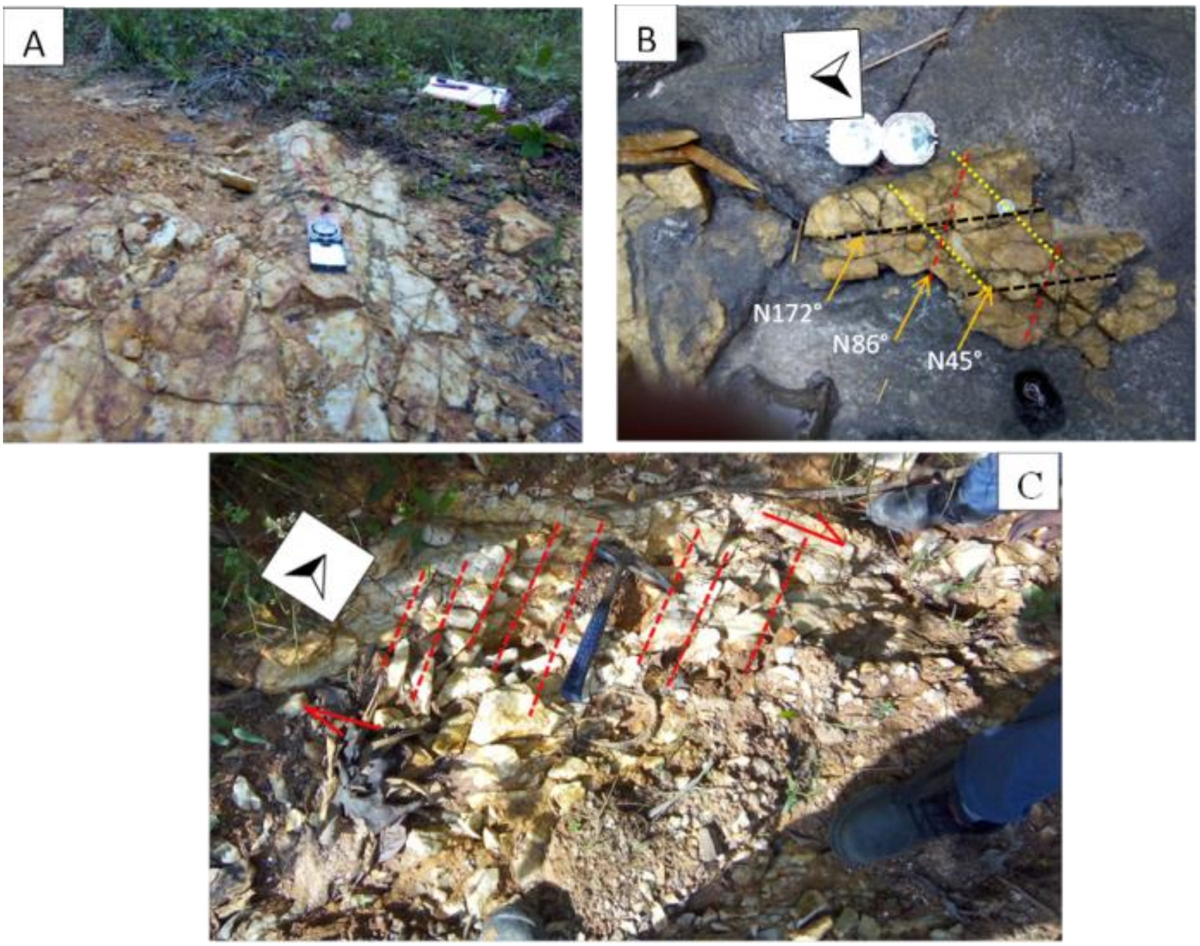

Fig. 11. Macroscopic aspects of the brittle deformations

(A): fractures in a straight vein; (B): multiple fractures in quartz vein; (C): fracture schistosity oriented N30° in a quartz vein sheared in dextral movement;

4.3 Metallogenic Data

The metallogenic study consisted of determining the metalliferous nature of the veins. It began with a study using a reflected-light optical microscope, followed by analysis on gold and finally by XRD.

4.3.1 Metallographic Features

Samples observed under a reflected-light optical microscope revealed the presence of opaque minerals. These minerals have been observed under a transmitted-light optical microscope. The minerals are generally very small, disseminated in fractures, with a metallic brightness, various shapes (elongated, rounded), yellow to golden yellow in colour. They have similar characteristics to sulphides such as chalcopyrite and pyrite. Sulphides are often found disseminated in the veins or following the fracture planes. Sulphides are also mobilised around and/or in quartz veins (Fig. 12).

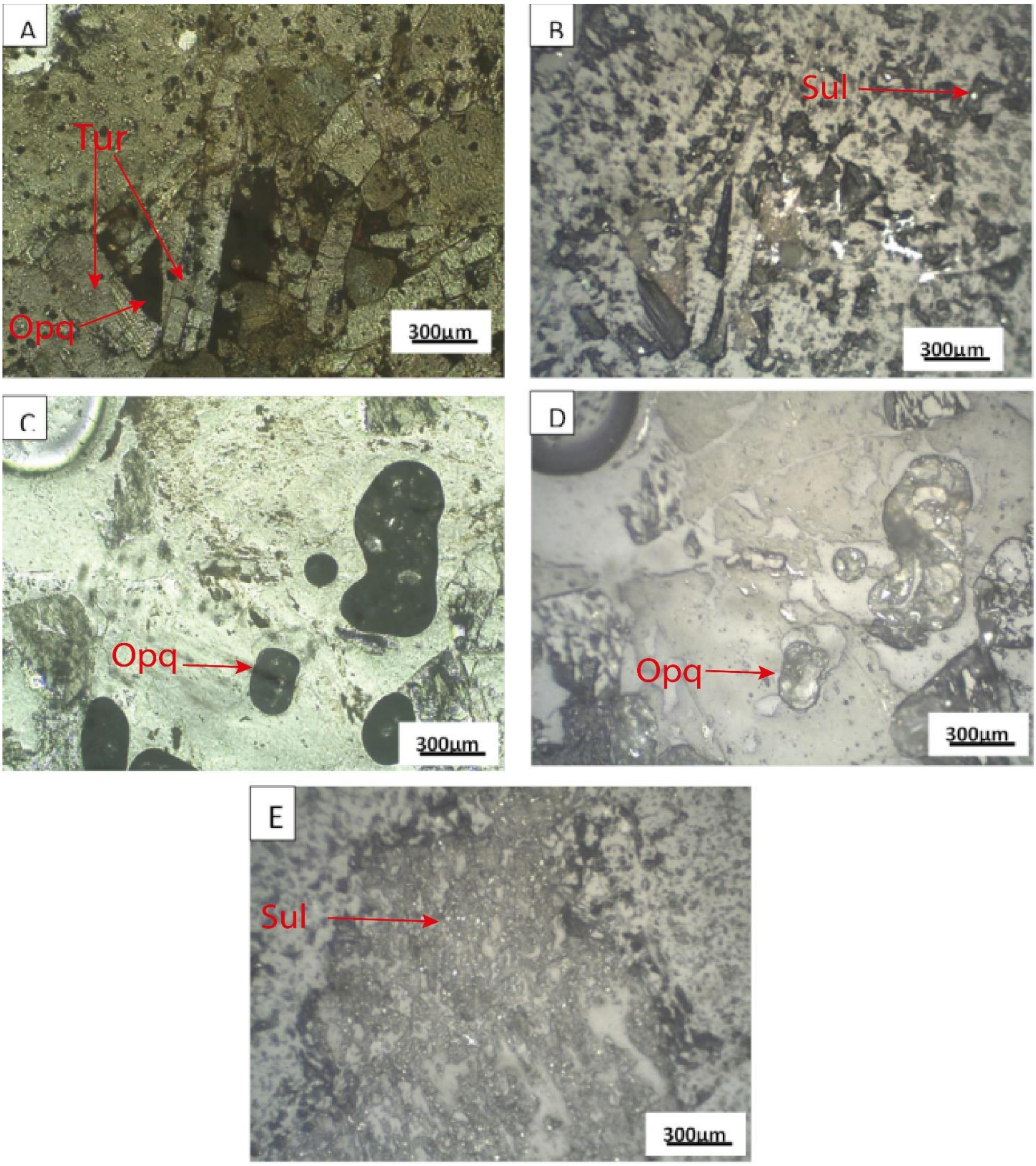

Fig. 12. Microscopic aspects of sulphides in quartz veins in the study area

(A): opaque minerals in banded tourmaline quartz in LPA; (B): sulfides in banded tourmaline quartz in reflected light; (C): tourmaline quartz vein in LPA showing opaque minerals; (D): tourmaline quartz in reflected light showing sulfides; (E): sulphides hugging a fracture plane in biotite quartz in reflected light. Tur: Tourmaline; Opq: opaque minerals; Sul: sulphides

4.3.2 GOLD CONTENT

Table I presents the results obtained for gold analyzed in the quartz vein samples. The results indicate the presence of gold in the saccharoid quartz, biotite quartz, banded tourmaline quartz and tourmaline quartz samples. The banded tourmaline quartz sample taken from a shear corridor and the tourmaline quartz are the samples with the highest gold content (Fig. 13). Consequently, the presence of tourmaline associated with quartz could be an excellent indicator of gold mineralisation in the study area.

Table 1. I: Gold content of some samples

Vein types	Au (ppb)
Smoky quartz	<2
Saccharoid quartz	2
Milky white quartz	<2
Biotite quartz	2
Banded quartz-tourmaline	9
Tourmaline bearing quartz	17

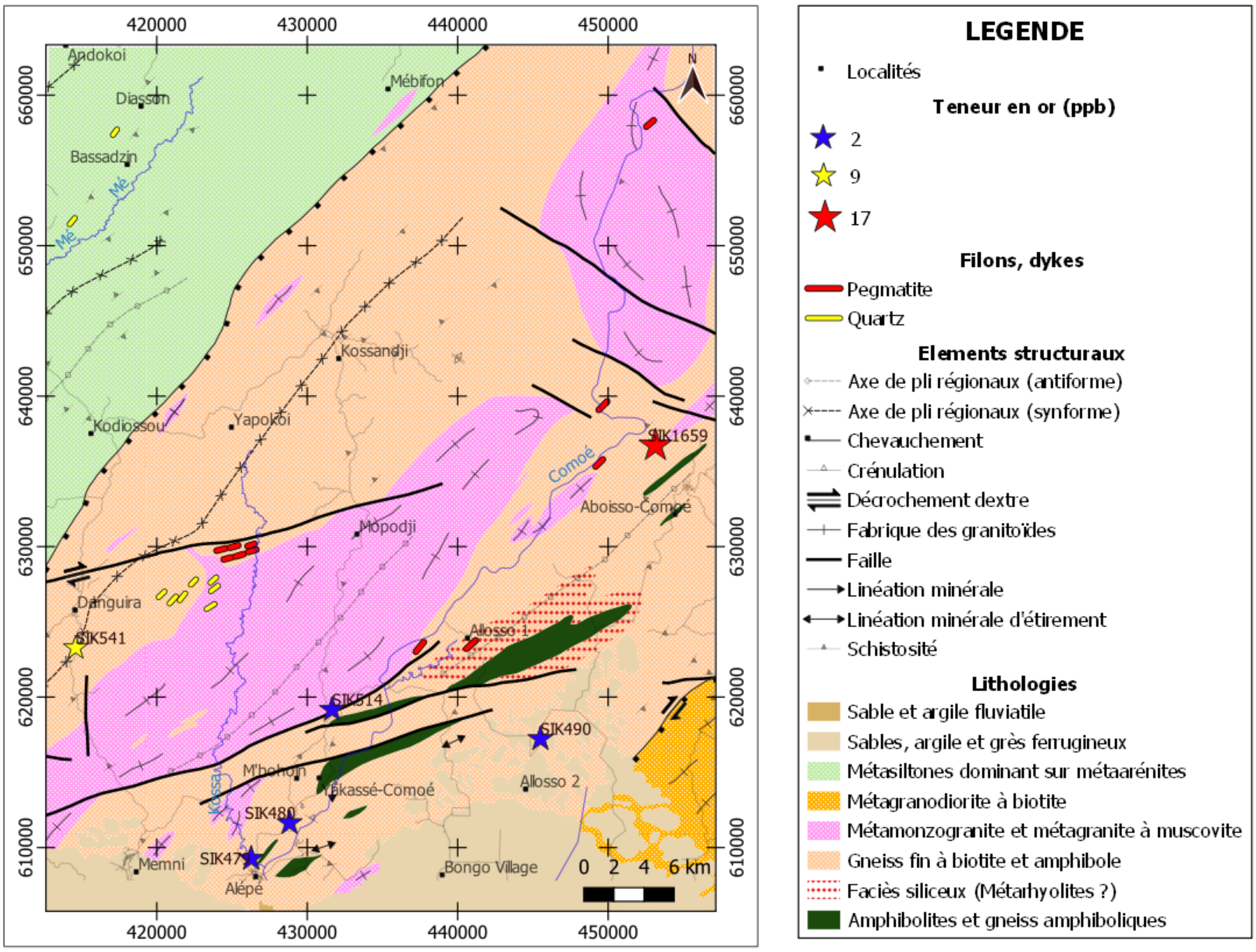

Fig. 13. Location map of samples analyzed on geological background (Delor et al., 1992 [6] modified)

5 X-RAY DIFFRACTOMETER ANALYSIS

This analysis revealed more than 2 mineral phases in the samples SIK541 (banded tourmaline quartz sample) and SIK1659 (tourmaline quartz sample). For samples SIK479 (smoky quartz), SIK480 (saccharoid quartz), SIK 490 (milky white quartz), the diffractogram graphs obtained by qualx software showed a single phase identified as quartz crystals. For samples SIK 541 and SIK1659, the diffractograms show three crystalline phases. These phases were identified in order of decreasing abundance. They are quartz, tourmaline and gold crystalline phases (Figure 14A&B). This analysis confirms that the presence of tourmaline associated with quartz is indicative of gold mineralization in the study area.

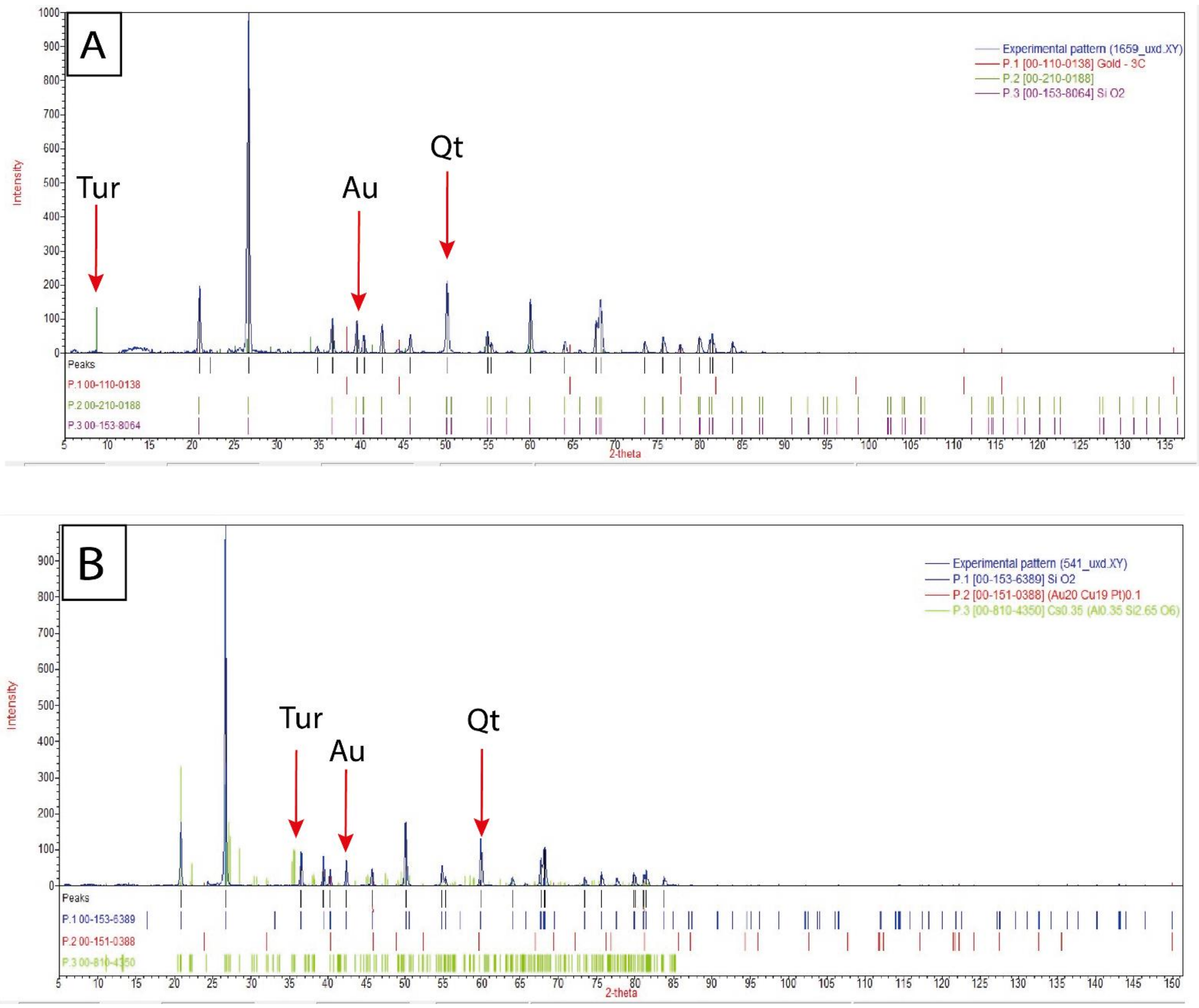

Fig. 14. Diffractrograms of quartz veins in the study area

(A): Diffractogram of Tourmaline bearing quartz vein (SIK 1659); (B): Diffractogram of banded tourmaline quartz vein (SIK 541)
Qt: quartz; Tur: tourmaline; Au: Gold

6 DISCUSSION

This section will summarise the results obtained and compare them with those of other authors. The discussion will cover petrographic, structural and metallogenic aspects.

6.1 PETROGRAPHIC ASPECTS

A study of the quartz veins in the south-eastern part of the Comoé basin has revealed several types of veins. These veins are hosted in two-mica granites, granodiorites, micaschists, gneisses and laterites. These rocks are highly deformed, producing fracture permeability for hydrothermal fluids.

There are banded tourmaline quartz veins, biotite quartz veins, tourmaline quartz veins, saccharoid quartz veins, milky white quartz veins, smoky quartz veins and translucent quartz veins. These veins were highlighted by the work of Adingra (2020) [7], with the exception of the saccharoid veins, tourmaline quartz veins and biotite quartz veins. In his work, he describes tourmaline quartz veins as alternating dark tourmaline minerals and light quartz minerals. In the present study, this type of vein has been identified as the banded tourmaline quartz vein, because another type of quartz vein containing tourmaline minerals has been identified. In addition, the work of Perrouty (2015) [16] in the

WASSA deposit in south-west Ghana, and that of Assié (2008) [3] in the Afema deposit in south-east Côte d'Ivoire, characterise similar veins to which they add quartz-carbonate veins.

It should be noted that the quartz veins in the study area are intersected by non-penetrative calcite veinlets, which would therefore have an exogenous origin. The presence of numerous veins implies that large quantities of hydrothermal fluids have passed through the lithological formations in the south-eastern part of the Comoé basin, and that these have considerable permeability in the form of fissures or interconnected pore spaces. Hydrothermal vein alteration has therefore affected the healthy rocks in the study area, mainly the formations present in the deformed zones. Hydrothermal fluids clog or fill fractures. In the study area, it can be summed up as veins and veinlets generally affecting all the lithologies in the study area, with variable thicknesses ranging from millimetres to centimetres. The main minerals that very often fill the fractures are quartz and calcite. The silica-rich hydrothermal fluids cooled and crystallised in the fractures in the host rock. Patches of carbonate (calcite) can be seen in the shoulders of quartz veins.

6.2 Structural Aspects

Structurally, the main direction of the veins studied is NE-SW, followed by a secondary NNW-SSE direction and an E-W direction. These same directions were highlighted in the work of Adingra (2020) [7]. On the other hand, the work of Diakité (2019) [20] in the Alépé area indicates the NNW-SSE direction as the dominant direction and WNW-SE as the secondary direction. The work by Teha (2019) [21] in the south-western Comoé basin shows NW-SE as the main direction and NNE-SSO, N-S and ENE-ONO as secondary directions.

These veins are deformed both macroscopically and microscopically. They exhibit W and S folds, fracture schistosity, shears, tension cracks, sigmoidal figures and fractures, and dynamic quartz recrystallisation with the formation of secondary minerals. These microstructural features of these veins are similar to those observed by Ouattara (2015) [17] in the Bonikro deposit. In his work on the Bonikro deposit he indicates that two generations of quartz can be observed in the veins; a primary one that has undergone fracturing thus giving secondary quartz made up of fine crystals occupying primarily the spaces between the altered minerals. The structures show a dextral shear-oriented ENE-WSW, unlike the sigmoidal quartz figures identified in the micaschists, which indicate a sinistral shear oriented N170°.

Consequently, all these structures linked to the quartz veins indicate the presence in the study area of a NE-SW trending shear corridor with dextral movement.

According to Passchier and Trouw (1998) [22], evidence for the existence of a shear corridor includes sigmoidal structures, shear joints or veins, boudins, shear-schistosity plane associations (C/S structure) and folds.

This result corroborates those of Jessel et al (2012) [18], who characterised the shear corridor as the major structure that crosses the study area and named it SSC (Sunyani-Sefwi-Comoé) and proposed a dextral movement to this corridor. Work by Adingra (2020) [7] confirms the presence of dextral shearing-oriented NE-SW.

This analysis indicates that the study area is an attractive prospect for mining. According to Sonnendrucker (1969) [23], particular structures such as echelon cracks, schistosity, quartz and pegmatite veins, boudins, mineral stretching lineations, detachments, sigmoid figures, quartz veins, fractures and intra-foliar folds are zones of particular importance for the emplacement of deposits.

6.3 Metallogenic Aspects

The metallogeny of the quartz veins in the study area revealed gold mineralisation and the presence of sulphides specifically in the quartz-tourmaline veins, in the biotite quartz veins and in the deformed veins. These minerals are mostly found in highly deformed zones and also in secondary quartz minerals. Ouattara (2015) [17] in his work on the Bonikro deposit finds that secondary quartz is regularly associated with sulphides and calcite. This is a vein-type mineralisation that is said to have developed under structural control. This vein-type mineralisation has already been reported in most of Côte d'Ivoire's Birimian gold deposits: Tongon (Lawrence et al., 2017) [2], Angovia (Coulibaly et al, 2008) [4], Aféma (Assié, 2008; Kadio [3] et al., 2010 [24]), Agbahou (Houssou, 2013), the Bobosso deposit (Gnanzou, 2014) [25] and Bonikro (Ouattara, 2015) [17] in West Africa (Milési et al., 1989 and 1992 [1], [14]). Elsewhere, the Sigma mine in Canada (Robert et al., 1983) [26] and the Wassa mine (Perrouty, 2015) [16] show the same configuration.

This study highlighted that quartz-tourmaline veins taken in shear and fracture zones are richer in gold than other veins. This result corroborates the work of Perrouty (2015) [16], he classifies quartz veins associated with tourmaline, sericite, sulphides as the quartz generation containing the highest gold content in the WASSA deposit in Ghana east of the study area. They add that the highest grades were obtained in drill hole zones showing the presence of lenses, veins and veins of quartz ± tourmaline caught in fractures, faults or shear zones. He thus characterises the mineralisation associated with the quartz veins as post-dating the formation of the veins but synenetic with the deformation. Furthermore, it can be assumed that the quartz veins in the zone have deformation-synenetic mineralisation, although no drilling has been carried out. This mineralisation is also more significant with the presence of tourmaline or secondary minerals such as biotite and sulphides.

7 CONCLUSION

This work highlighted the petrographic, structural and metallogenic characteristics of the quartz veins in the south-eastern part of the Comoé basin.

Field and laboratory work revealed the presence of smoky quartz veins, saccharoid quartz veins, banded quartz-tourmaline veins, biotite bearing quartz veins, tourmaline bearing quartz veins and translucent and milky white veins. These veins are hosted by two-mica granites, granodiorites, micaschists, gneisses and laterites.

Structural studies of the veins have revealed a dominant NE-SW direction followed by secondary NNW-SSE and E-W directions. These veins are highly deformed, with W and S folded structures, tension cracks, fractures, sigmoidal and shear figures. All these features indicate the presence of a shear corridor, which is a regional corridor-oriented NE-SW. The microstructural analysis showed rolling extinction and two generations of quartz. The first, in the form of large crystals, underwent creep by dislocation, resulting in a second generation in the form of small grains.

The metallogenic nature of the veins was demonstrated by microscopic observation, gold analysis and X-ray diffractometry. The tourmaline quartz veins are rich in sulphides, with the presence of gold. The study area is therefore suitable for mineral exploration.

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