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Petrographic and Structural Study Contribution in the Comprehension of the of Gold Mineralisation in the Biboko Area (betare-oya Gold District), East-Cameroon

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Abstract The Biboko locality is located eastward in the central domain of the Pan-African Fold Belt of Central Africa. The task consisted in the cartography of the various types of rocks, to do their petrographic and structural studies with the aim of understanding the geological context of gold which is be exploited in the locality. Weal so brought out the study of environmental impact generated by this exploitation. The main types of rock identified in the locality could be grouped in to two: the metamorphic and plutonic rocks and their associate intrusion. The metamorphic rocks are represented by amphibole-biotite orthogneisses and amphibolites. Their main blade texture is granonematoblastic. The primary assemblage is made up of amphibole, biotite, plagioclase, quartz, zircon and apatite which are in equilibrium in the amphibolite facies. The secondary assemblage is made up of quartz, biotite, chlorite, pyrite, sericites derived from either the alteration or the recristallization of the primary assemblage. The plutonic rocks are slightly deformed and are represented by biotite bearing tonalite, microcline bearing granite, biotite bearing granite, biotite-epidote granite. These rocks have grained-oriented texture made up of quartz + microcline + orthose + plagioclase +/- biotite + accessory minerals. Concerning the structural study of the area, we have four deformationals phases. The first phase D1 is caracterized by subhorizontal shistosity/ foliation. The second phase D2, caracterised by open folds P2, shistosity S2, subvertical to vertical and slightly plonge lineation L2. It is a transpressive deformation with senestral sheared plans. The migmatisation which is the origin of certain plutonic rocks is syn-D1 to syn-D2. The third phase which is not penetrative, is made of folds P3 with straight axes and crenulation S3. The fourth phase is brittle-like and characterized by fractures. The abondances in secondary minerals (microcline, pyrite, chlorite, sericite) in certain facies (microcline bearing granite) is a proof for hydrothermalism. Part of gold found at Biboko could have been derive from altered rocks in the region. This is proved by the presence quartz in intrusion slightly mineralised in pyrite which is associate mineral of gold.

Keywords: *Pétrographie, structural, Biboko, Amphibolites facies, hydrothermalism*

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1. Introduction

The Central African Folt Belt (CAFB) in Cameroon is divided into three domains [1]: the Southern domain which border the Congo Craton, the Central (Adamawa-Yadé) domain characterized by the presence of many faults corridors (Sanage Fault, Adamawa Fault, Tchollairé Fault), and the Northern domain which crop out in the north-west of the Tcholliré fault. In the easthern part of the Central domain, we have the neoproterozoic Lom Serie [2]. Regional geologic works on the Lom Serie permetted to: (1) realize a geological map [2]; (2) to do a structural study of the serie [3,4]; (3) to do geochronologic and isotopic geochemistry studies [3,4]. The Lom Serie abounds in metals and precious stones; notably gold which is subject of artisanal and semi-artisanal exploitation in many localities of the Lom basin [5]. The anarchic characteres of mining activities in the region generates negatives consequences on environment and mining workers health [6]. A petrographic and structural study in view to realize geologic map at large scales may contribute to the reduction of environment destruction by mining workers without a structural guide of mineralization.

The Biboko area which is subject to this study is situated in the North-West of the Bétaré-Oya town, Lom Serie. It is characterized by a gold exploitation activity which do not respect the environment. The aim of this study is to study the geological context of gold mineralization of the Biboko area.

2. Geological Setting

The Biboko area is situated in the East region of Cameroon, in the Bétaré-Oya gold district, whiting coordinate system 5°38’-5°42’ latitude north and 13°46’-13°21’ longitude east, and belong to the Adamawa-Yadé domain. In Cameroon, the CAFB is divided into three domains: (1) the Southern domain which extends from the Congo craton to the Adamaoua-Yadé domain; (2) The Central or Adamaoua-Yadé domain is located between the Sanaga fault in the south and the Tchollriré-Banyo shear in the north; (3) the Northern domain located west of the Tcholiré-Banyo Fault (Figure 1) [1,7]. The Adamawa-Yadé domain is made up of palaeoproterozoic and neoproterozoic formations. palaeoproterozoic formations include: metasedimentary and volcanosedimentary rocks (amphibole-biotite gneiss, garnet-biotite gneiss, meta-arkoses, metaquartzites, garnett-pyroxene amphibolites iron formations.) [1,8]; plutonik rocks which are migmatized and completly reworked during the Panafrican orogeny, they are motly composed of diorite and granodiorite [9,10,11]. The neoproterozoic formations are made up of schists which form narrow furrows called Lom Serie. The Lom Serie have been subject to a regional epi to mesozonal metamorphism in green schist facies to amphibolite facies [2,12] suggested that the Lom Serie is a syn-to post collusional basin.

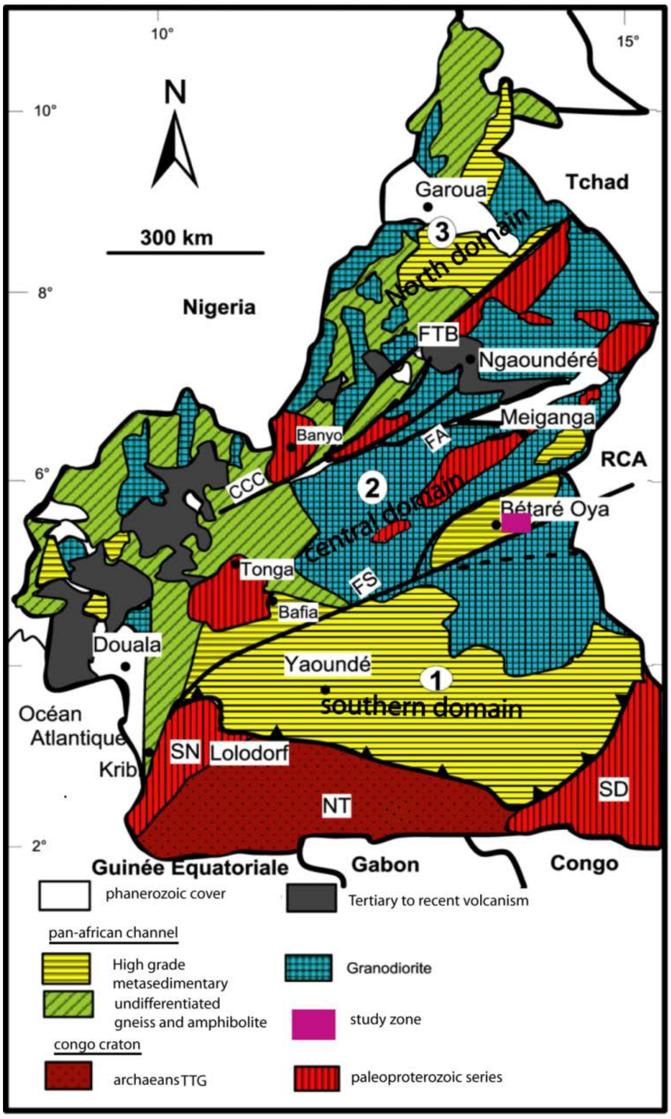

Figure 1. Geological map of Cameroon edit from [15] showing the main lithological domains: (1) South domain; (2) central domain; (3) North domain; CCC: Central Cameroonian Shear; FS: Sanaga Fault; FTB: Tchollriré-Banyo Fault; NT: Ntem complex; SD: dja series; SN: Nyong series; FA: Adamaoua Fault

The Adamawa-Yadé present three deformations phases (D_1, D_2, D_3): D1 is characterized by a flat foliation [1,10,13,14]); the D_2 deformational phase is characterized by the development of tights faults [1]; the D_3 deformational phase is essentially brittle, and characterized by C_3 shear planes.

3. Methodology

The methodology consist of field works, and laboratory works.

3.1. Field Works

Standard field equipement was used to carry out field study. Various rocks types were identified by using hammer prospection. Rocks were systematically described using observable field parameters (color, mineralogy and structure) and sampled. Structural elements were also identified and measured. The relative chronology of tectono-metamorphic and magmatic events was also established.

3.2. Laboratory Study

After collecting samples in the field, we cut the eleven (11) sugars from the rocks at the litholamelage laboratory of the Center for Geological and Mining Research (CRGM) in Garoua. From its sugars we had made the thin sections at the litholamelage laboratory Georessources of the University of Lorraine in France. Petrographic observations were performed using an ordinary microscope and a refexive light microscope at the Laboratory of Georessources of the University of Lorraine in France; and by a monocular microscope at the “laboratory of Cartography, Petrography, geochemistry and Metallogeny of the University of Ngaoundéré”.

The structural data allowed the realization of the stereograms. To do this we used the "Stereo 32" software to materialize the linear and stereo net elements and COREL DRAW to materialize the plans. Its different processing of structural measurements allowed us to classify and interpret the different phases of deformation that affected the area.

4. Results

4.1. Petrography

The Biboko area is made up of metamorphic and plutonic rocks.

4.1.1. Metamorphic Rocks

Metamorphic rocks consist of amphibole-biotite orthogneiss and amphibolites.

Amphibole-biotite orthogneiss is the most aboundant rock type of the region. It appear as plusi-decametrics subhorizontals flagstones (Figure 2 a and Figure 2b). It present a foliated or striped structure (Figure 2 a). It diplay discontinous alternating quatzo-feldpathic and ferromagnesian rich layers. At microscopic scale, the orthogneiss present a granolepido or a granonematoblastic texture (Figure 2c and Figure 2d). The paragenesis is made up of biotie+amphibole+quartz+orthose+plagioclase (Figure 2c and Figure 2d), accessory minerals as apitite, opaques minerals zircon and sphene. secondary minerals are chlorite and epidote.

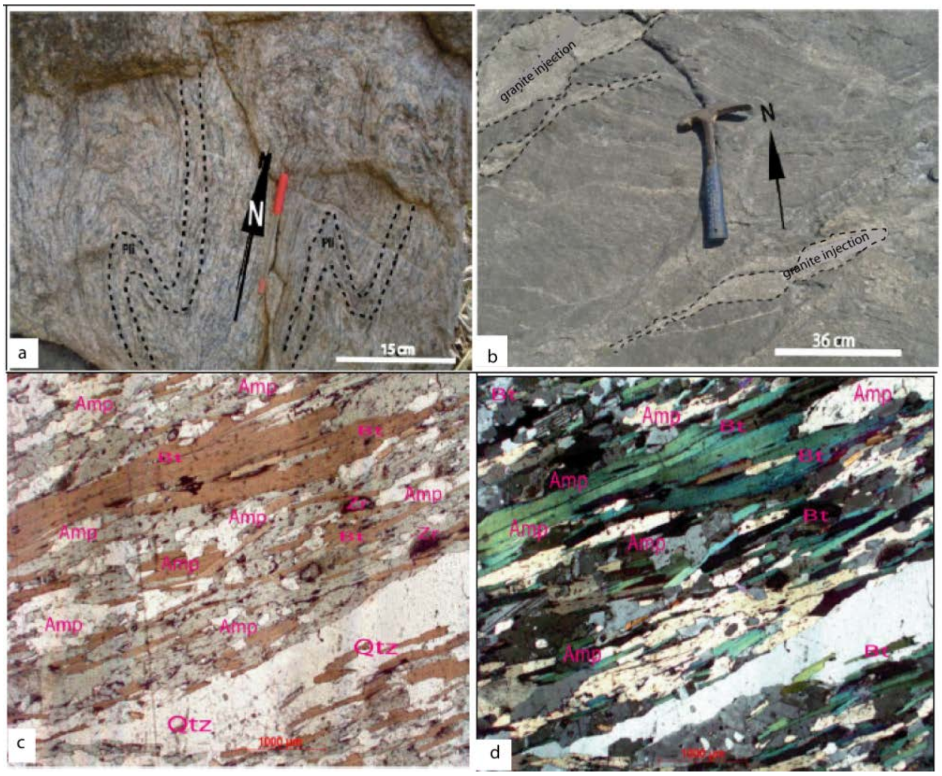

Figure 2. a: Foliated and folded structure of biotite and amphibole orthogneisses; **b-** Orthogneiss containing granite injections in the foliation and shear planes, **c-** Granonemato- to lepidogranoblastic texture of orthogneiss in LPNA, **d-** Granonemato- to lepidogranoblastic texture of orthogneiss in LPNA

Figure 3. a- Amphibolite enclave in an orhogneiss slab; **b-** Amphibolite septa in orthogneiss affected by granite; **c-** Granonematoblastic texture of amphibolites in LPNA, **d-** Granonematoblastic texture of amphibolites in LPA

Amphibolites outcropt a fusiforms enclaves of variable size scales (centimetric to decametric) in orthogneiss and granites (Figure 3a and Figure 3b), or are embededas layers in orthogneiss (Figure 3a). Amphibolites are foliated and present medium to fine grain sizes. At microscopic scale, they present a granonematoblastic texture (Figure 3 c and Figure 3d); they also present a granolepidoblastic texture in level where leucocrates veins are aboundants. The paragenesis is made up of amphibole+plagioclase+quartz and accessory minerals as sphene, opaques minerals, apatite, zircon. Secondary minerals are chlorite, epidote, actinote, pyrite (Figure 3c and Figure 3d).

4.1.2. Plutonick Rocks

Plutonock rocks crop out as bigs massifs locally called “Kaya” or “Ngari”. They are slightly deforms and represented by: biotite tonalite, microlcine granite, biotite granite and biotite-epidote granite.

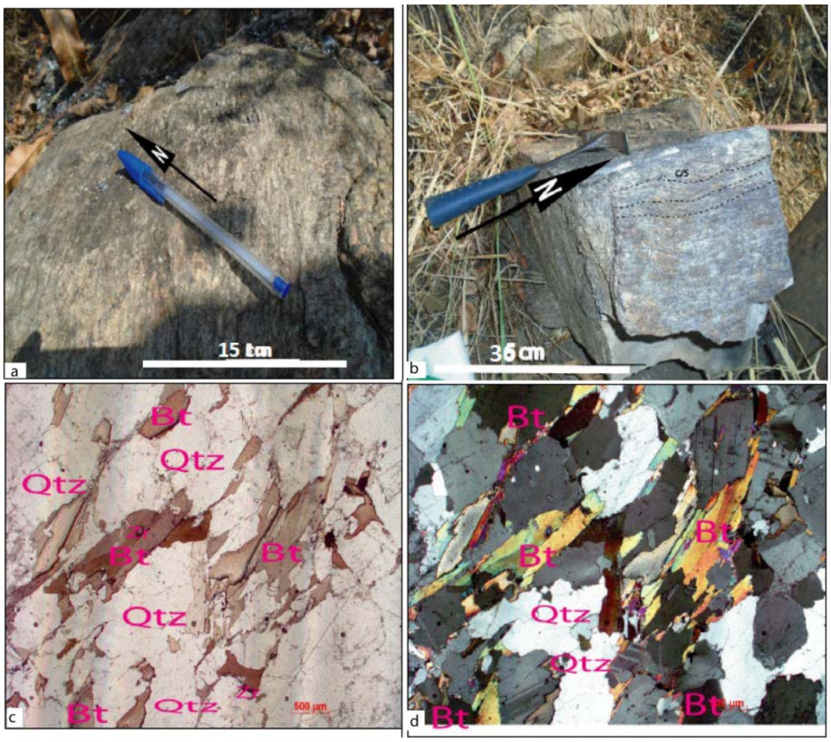

Figure 4. a- Biotite tonalite block outcrop; **b-** Biotite tonalite blocks showing the C and S sub-horizontal planes; **c-**oriented grainy texture of biotite tonalite in LPNA; **d-**Oriented grainy texture of biotite tonalite in LPA

Biotite tonalite crop out as centimetrics to decametrics flagstones (Figure 4 a and Figure 4b); it present an oriented grainy strucutre, but also a mylonitic structure at some places. At microscopic scale, it present an oriented grainy texture (Figure 4b). The paragenesis is made up of plagioclase+quatz+biotite with accessory minerals as sphene, apatite, zircon and opaques minerals (Figure 4 c and Figure 4d); secondary minerals are present as recristallization products (quartz, plagioclase, k-feldspar, biotite), and by epidote and sericite.

The microcline granite present an oreinted grainy structure, and is characterized by a pink color due to the orthose aboundance. It is cross-cut by many quartz veins. Microscopically, it present an oreinted porphyroïd grainy texture (Figure 5a), inclined to a granoblastic texture in high recristallized facies (Figure 5 b). The paragenesis is made up of quartz+K-felspar+biotite+pyrite and accessory minerals as sphene, apatite, opaques minerals, zircon.

Biotite granite crop out as decametrics (Figure 6 a) as smalls massifs formed by metrics to hectometrics blocks. It present a medium to coarse grain size. At the microscope scale, it present a grainy texture (Figure 6 b). The paragenesis is made up of biotite + orthose + plagiocle + quartz, accessory minerals are sphene and apatite.

Epidote-biotite granite crops out as decametrics blocks (Figure 7 a). Microscopic observation show that rock present a grainy texture and is composed of orthose + plagioclase +quatz+biotite+epidote (Figure 7 b); accessory minerals are apatite, zircon and opaques minerals (Figure 7 b). All these rocks are cross-cut by quartz, quartzo-feldspatic and granitic veins.

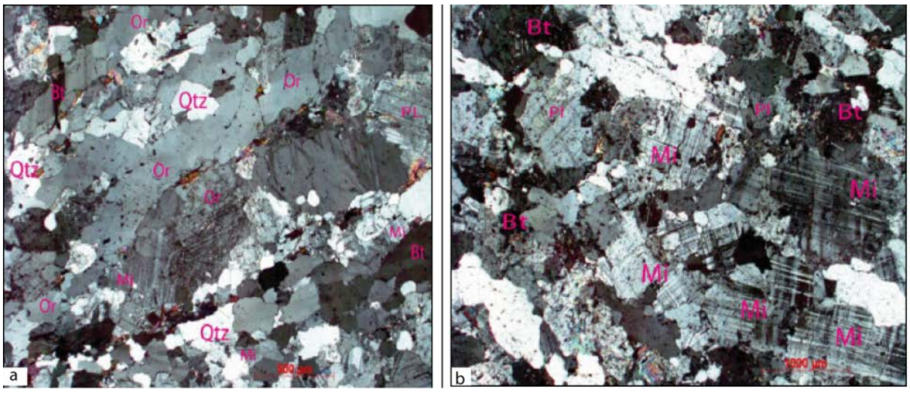

Figure 5. a- Oriented grainy texture seen in LPA in a microcline granite; **b-** LPA grainy texture showing recrystallized microcline crystals

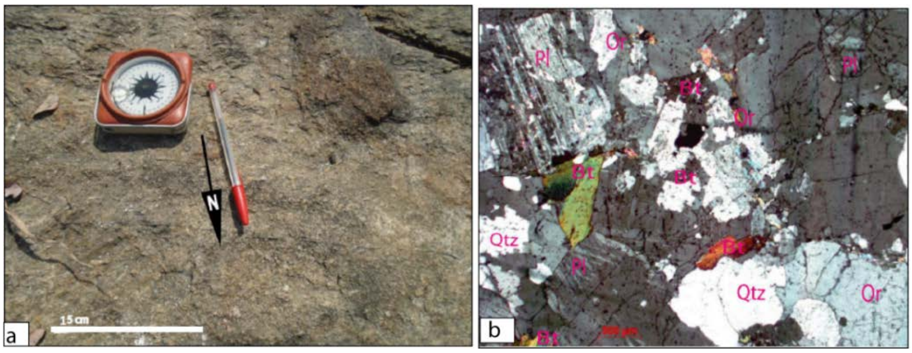

Figure 6. a-Biboko biotite granite outcrop; **b-**Grainy texture of LPA biotite granite

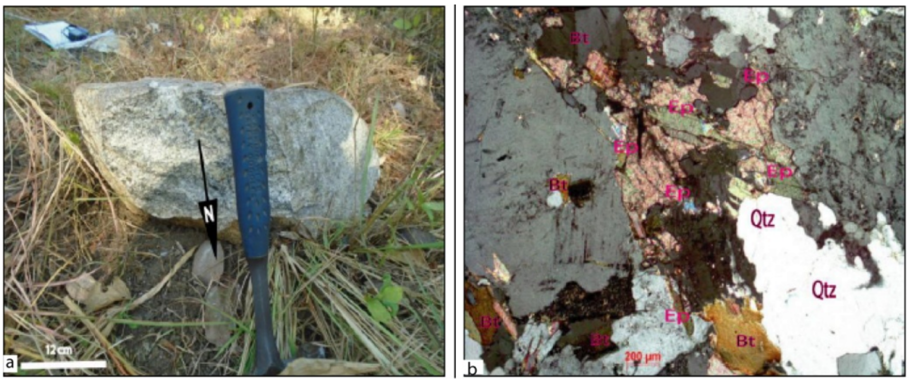

Figure 7. a- block of biotite and epidote granite; **b-** Granite biotite and epidote in LPA

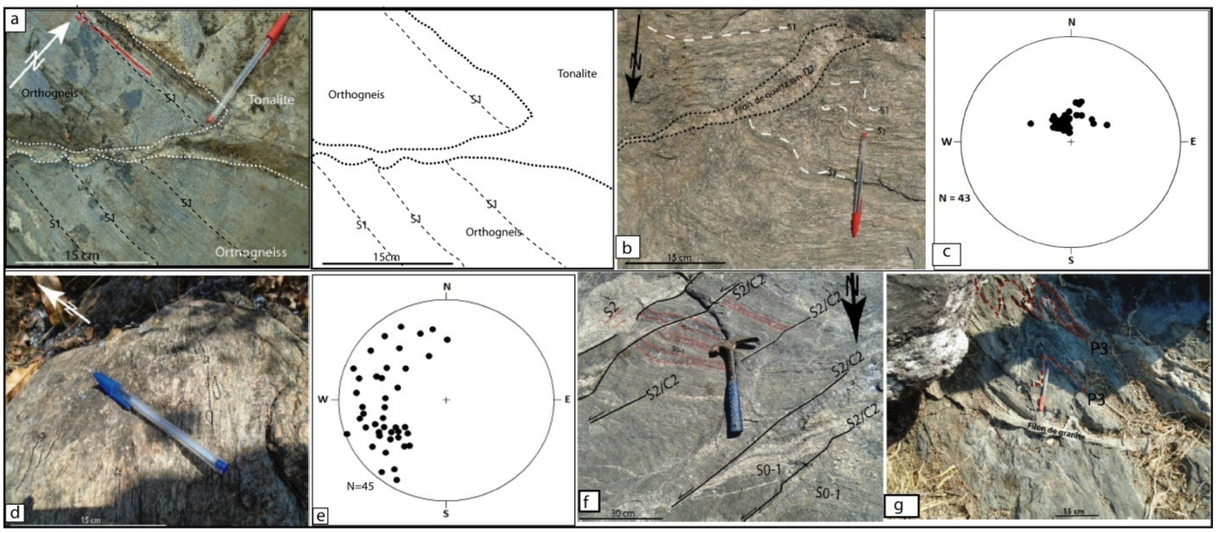

Figure 8. a: S1 foliation in an orthogneiss marked by the alternation of beds of different composition; **b-** Schistosity S1 in the gneiss marked by the debitage in subhorizontal millimetric plates of the rock; **c**-Stereogram of S1 foliation in the Biboko orthogneisses; d-Trace of the S2 schistosity in a deformed tonalite; e- Stereogram of the S2 schistosity in the Biboko orthogneiss; **f**-Planes C2 affecting surfaces S0-1; **g-** Vertical axis P3 fold

4.2. Structural

The Bikoko area was affected by four deformational phases: D_1, D_2, D_3, D_4. The D_1 deformational phase is marqued by a S_1 foliation and schistosity. The schistosity is charasterized by the mineral recristallization the mineral recristallization following a maximal flattening plan (Figure 8 a). S1 foliation is characterized by an alternating quartzo-felspathic and ferromagnesian layers (Figure 8 b). The S1-0 surface is generally reinforced by different type of veins as migmatisation products. The S1 schistosity and foliation are horizontals or subhorizontals with a general orientation ENE-WSW to ESE-WNW. In the stereogram, the poles of the foliation planes align along the great circle along the ENE-WSW to ESE-WNW direction (Figure 8 c). The D_2 deformational phase is materialized by F_2 folds, S2 schistosity (Figure 8 d), C_2 shear planes and B_2 boudins. F2 folds are symetrics and varies with the deformation intensity. S2 schistosity correspond to the axial plan trace of F2 folds (Figure 8 d); S2 orientation varies between N-S and NW-SE. C2 shear planes are present on deforms metamorphics and plutonicks rocks. The stereograms of the S2 schistosity, in the orthogneiss and in the deformed granites show that the poles are concentrated in the NW and SW quadrants and are aligned on the great circle of attitudes N170E18SSE (Figure 8 e) these poles correspond to the axes of the P3 folds. The D3 deformation is characterized by P3 folds which are ondulation of folds sides and hinges (Figure 8 e). S3 schistosity is a crenulation. The D4 is characterized by faults and veins (Figure 8f). Many generations of vein have been identified: F2 which are earlier to synD1, F2cwhich are syn-D2, and F3 faults (Figure 8 g) which are post D2 and cross-cut D2 structures. Pyrite and tourmaline beiring quartz veins are post D3 and oriented N-S. In general veins are oriented N160E.

5. Conclusion

The Biboko area in the Bétaré-Oya gold district have been subject to a petrographic structural and environment study in oder to know the geological context of gold mineralization, and to highlight the impact of the gold exploitation on the environment and mining workers health. The lithology is made up of metamorphic rocks (amphibole-biotite orthogneiss and amphibolites) which present paragenesis linked to amphibolites facies; and plutonicks rocks (biotite tonalite, microcline granite, biotite granite and biotite-epidote granite) which have been classified into syn-tectonic, late-tectonic and post-tectonic granitoids. The Biboko tectonics display four deformational phases D_1, D_2, D_3, D_4. The D1 is characterized by the S1 foliation and schistosity. D_2 is materialized by F_2 folds, S_2 schistosity, C2 shear planes and B2 boudins; D_3 is characterized by F_3 folds which correspond to the regional folding; and D_4 is represent by faults and veins and is due to the NE-SW extension.

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