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Geological and Geochemical Characteristics of Gold-bearing quartz veins in the Libiri Prospect, Liptako NW Niger

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Abstract

The main objective of this research is to determine the geological characteristics and areas of gold economic potential in Libiri prospect. The methodology used in this research consists of field work and laboratory. The study area is characterized by metavolcanis and metadolerites. The metavolcanis are petrographically formed clinopyroxenes associated with plagioclases. However, metadolerites are found with massive texture and granular to microporphyritic structure. The petrographic observation of this dolerites revealed an abundance of plagioclase sometimes speckled with sericite, associated with clinopyroxenes. The geological mapping revealed the presence of the hydrothermal signatures (silica, oxides, etc.) testifies to the strong hydrothermal activity that prevailed in the study area. These hydrothermal fluids are worthy of interest because they are associated by concentrations of gold. The gold occurrences associated with quartz veins were detected from field geological mapping and conform to the general trend direction of N-S.The geochemical results outlined threes areas such as area high gold concentration with Au contents more than 100g/t, area of medium concentration of Au content les than 50g/t and area of low concentration of Au.

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Keywords

Artisanally, industrially, Gold mining, granitoids and greenstone belts.

Introduction

Gold mining is one of the oldest industries of humanity. It has been a source of wealth in many regions. Niger is a country with economic gold potential resources that are exploited artisanally or industrially. In Niger gold occurs, in the form of primary deposits (quartz veins) and also secondary form (eluvial or alluvial). This is how the appreciable gold potential of Niger has attracted the attention of investors since the organization of the International Round Table for Gold Prospecting of Liptako (TRIPAL' 93-NIGER) in 1994. Since then, the Niger Liptako has been divided into gold exploration and mining permits.

The geology of the Niger Liptako shows an alternation of granitoids and greenstone belts including those of Gorouol, Diagorou-Darbani and Sirba. The Diagorou-Darbani belt has only experienced artisanal gold mining activities. This is due to the fact that this gold is found in its native state in quartz veins of variable dimensions. On the other hand, the Sirba belt has experienced industrial mining, notably by the Liptako Mines Company (SML) since 2004. Within the SML perimeter, gold is found either in its native state in quartz veins or in disseminated form in graphitic schists.

Recent activities of SML mining have revealed a mineralized zone in a volcanic host rock that was previously considered unexploitable due to its low gold content. It therefore appears important to look at the methods of establishing this gold occurrence. Geophysical maps generally show that mineralized zones are located in lineaments corresponding to deformation corridors that affected the geological formations of Liptako (Milési *et al.,* 1989; Soumaila and Konaté, 2005), and the West African craton in general (Milési *et al.,* 1989; Vidal, 2009). The main objective of this research is to determine the geological characteristics and economic potential of Libiri SE Prospect.

Geological setting

The geology of Niger Liptako corresponds to the northeastern border of the Baoulé-Mossi domain belonging to the Léo-Man Dorsal (Béziat *et al.,* 2000). The basement formations of this Birimian et domain were granitized, metamorphosed and stabilized between 1.8 Ga and 1.6 Ga (Ennih and Liégeois, 2008; Vidal *et al.,* 2009). The Niger Liptako basement is composed of two geological parts, such as greenstone belts of Gorouol, Diagorou-Darbani and Sirba, intersected by the granitoid plutons of Téra-Ayorou, Dargol-Gothèye and Torodi (Dupuis and Pons, 1991).

The Liptako greenstone belts is formed of meta-volcano sediments, metasediments, metabasites and meta ultrabasites (Machens, 1973; Ama *et al.,* 1996; Hamidou *et al.,* 2021 and Ahmed *et al.,* 2023). While the granitoid plutons is composed of calc-alkaline rocks including a series of Tonalites, Trondhjemites, Granodiorites (TTG) and acidic to intermediate rocks of various nature including diorites, syenites, granites and dacites (Lama, 1993; Pons *et al.,* 1995; Abdou *et al.,*1998). According to several authors (Soumaila and Konaté, 2005; Ahmed *et al.,* 2023; Konaté *et al.,* 2018; Ibrahim, 2020; Alzouma, 2020; Ousmane, 2020), the Birimian rocks are cross cutted by dykes of pegmatites, quartzo-feldspars-rich veins and dolerite dykes; and covered by sedimentary formations of various ages (Figure 1).

Some authors (Milési *et al.,*1989; Ouattara *et al.,* 2022) mentioned that in the Léo-Man ridge, most of the gold showings discovered are located in the greenstone belts of the Baoulé-Mossi domain part of the Niger Liptako, while the archaean domain of Kenema-Man which presents few clues. The Libiri Prospect is located in the Sirba greenstone belt, the geological formations which is geologically formed with metabasites (basalts, dolerites and gabbros), metasediments (schists, siltstones, pelites, quartzites, greywackes, conglomerates) and plutonic magmatic rocks (granites, granodiorites, diorites, rhyodacites, rhyolites and granophyres) (Machens, 1973; Ama *et al.,* 1996; Ama, 1991) (Figure1).

Geology of the study area

Locally, the Samira-Libiri and Boulon Djounga gold deposits are located at directional change points along a distinct horizon of volcanic sediments over a distance of 25 km (Samira Horizon) that contains almost all the significant gold deposits known in this part of the Sirba belt (SML Study Report). The depth of the horizon varies and its geochemical (As and Sb anomalies, presence of graphite) and geophysical (very low resistivity and high chargeability) characteristics were recognized at the beginning of exploration work in this area. The Samira horizon is bordered on each side by turbidic sediments and massive magic volcanic rocks (SML Study Report). This horizon consists of a succession of sedimentary rocks metamorphosed in the greenschist facies. In the Samira-Libiri sector, in order to delineate the mineralization and geometry of the deposits, the horizon was subdivided into 4 units (Figure 2) which are represented as follows:

- Low-metamorphosed interstratified sandstones and graywackes (SLAG) The base (SLAG) of the Samira sedimentary sequence constitutes a discontinuous succession, composed of laminated sandstones with intercalations of graywackes. When present, this member is variably mineralized; generally it is a weak mineralization, but high-grade zones occur in association with silicification (SML study report).

- Metasediments (SFRG) These are polymictic rocks due to the presence of numerous lithic clasts, tillite of variable origin, coated with a schistose matrix to graphitic sandstones and graywackes. The clasts are generally stretched, sometimes boudined and locally folded (SML study report).

- An intercalation of metavolcanics (SIFV) This rock is a massive to schistose metavolcanic rock, with some sedimentary intercalations of sandstone schists (SML study report).

- Laminated and graded, intersratified metasediments (SLAM)

Materials and Methods

As part of this study, field and laboratory data were collected. The field work consists of geological mapping of the Libiri prospect with a view to carrying out a geochemical investigation. A total of 50 were analyzed by spectrometric technique to measure gold content.

After physical treatment of the samples, spectrometric analysis (Figure 3) is carried out, which consists of atomic bombardment using a gold film lamp that removes the gold contained in the sample. Thus, the dissolved sample is sucked into an acetylene flame through which a light beam with wavelengths corresponding to that of gold passes. The gold sample absorbs light proportionally to the concentration of gold contained in the solution and the absorption is compared to standard solutions (calibration curve) and makes it possible to determine the concentration of gold in the sample.

Results and Discussion

Petrography

Metavolcanics

The basic metavolcanics are represented in the NW Libderado trough by a mesocratic gabroic (microgabro) procession of doleritic appearance generally characteristic of basic plutonism.

These rocks have a light appearance (Figure 4a) on the surface due to alteration and a dark intrinsic appearance (Figure 4b). The rocks are fine to medium-grained, the coloration observed on the facings varies from light green to brown.

The study of thin section of microgabbro sample under microscope reveals that they are mainly formed of clinopyroxenes associated with plagioclases and relatively abundant opaque minerals (Figure 5).

Metadolerites

The dykes associated with basic volcanism are represented by mesocratic metadolerites that are organized into intrusive bodies. These dark green rocks (Figure 6C) occur in veins of metric to plurimetric thickness. This facies, of massive texture, granular to microporphyritic structure and blackish green color, typically forms outcrops in rounded blocks (Figure 6A and B), whose surfaces show an alteration by exfoliation of brownish colors. The structure of the dolerite dykes is massive and no schistosity is visible. These post-Birimian volcanic occurrences are linked to the brittle tectonics that affected the study area. Thin-section study of dolerite samples reveals an abundance of plagioclase sometimes speckled with sericite (result of alteration), associated with clinopyroxenes and relatively abundant opaque minerals (Figure 7). These minerals do not show any apparent structure and are relatively well preserved.

Hydrothermal signatures

Cataclastic zones are observed on the pit faces with crushed rocks in small debris of variable grain size. These crushed zones are found to be affected by a strong circulation of hydrothermal fluids (Figure 8A). Thus, crushed or even milonitized zones are noted corresponding to shear corridors (Figure 8B), these zones would be related to the shear corridors crossing the Samira/Libiri zone. This last tectonic manifestation has an important metallogenic implication. A geophysical study based on the chargeability and resistivity results revealed two major shear zone directions in the Samira horizon (SML Document). These are:

- the NW-SE trending Shear zone observed on the eastern and western part of the Samira horizon;
- the NNE-SSW direction Shear zone observed practically at the center of the Samira horizon.

The hydrothermal activity that has prevailed in the Libderado NW pit takes various forms and is characterized in several ways:

- Areas affected by several quartz veins and veinlets with several directions are observed, some of which occur in parallel series (Figure 9A). Some of these veins are found to be affected by N160 subvertical strikes (Figure 9E).
- On other surfaces, we observe a diffuse massive silicification impregnating certain parts of rocks which are found to be covered by fine deposits of quartz silica (Figure 10). In places, these deposits form automorphs.
- We also note in places rocks affected by small quartz veinlets (Figure 11A) and others affected by the circulation of iron oxides (Figure 11B) through microfractures present in the rock.

Table.1 Results of geochemical analysis

Prospect	HoleID	Au contents
Libiri SE	BDP01	1.52
Libiri SE	BDP02	2.4
Libiri SE	BDP03	0.5
Libiri SE	BDP04	10
Libiri SE	BDP05	2.58
Libiri SE	BDP06	3.84
Libiri SE	BDP07	5.1
Libiri SE	BDP08	122
Libiri SE	BDP09	15
Libiri SE	BDP10	25
Libiri SE	BDP11	14
Libiri SE	BDP12	36
Libiri SE	BDP13	14
Libiri SE	BDP14	12
Libiri SE	BDP15	0
Libiri SE	BDP16	2
Libiri SE	BDP17	14
Libiri SE	BDP18	58
Libiri SE	BDP19	75
Libiri SE	BDP20	80
Libiri SE	BDP21	14
Libiri SE	BDP22	58
Libiri SE	BDP23	12
Libiri SE	BDP24	2.58
Libiri SE	BDP25	5.69
Libiri SE	BDP26	124
Libiri SE	BDP27	47
Libiri SE	BDP28	18
Libiri SE	BDP29	25
Libiri SE	BDP30	1.52
Libiri SE	BDP31	2.4
Libiri SE	BDP32	0.5
Libiri SE	BDP33	10
Libiri SE	BDP34	2.58
Libiri SE	BDP35	3.84
Libiri SE	BDP36	5.1
Libiri SE	BDP37	122
Libiri SE	BDP38	15
Libiri SE	BDP39	25
Libiri SE	BDP40	14
Libiri SE	BDP41	36
Libiri SE	BDP42	14
Libiri SE	BDP43	12
Libiri SE	BDP44	0
Libiri SE	BDP45	2
Libiri SE	BDP46	14
Libiri SE	BDP47	58
Libiri SE	BDP48	75
Libiri SE	BDP49	80
Libiri SE	BDP50	14

Figure.1 General geological map showing the main gold showings of West Africa and the study area: Samira (modified from Milési *et al.,* 1989).

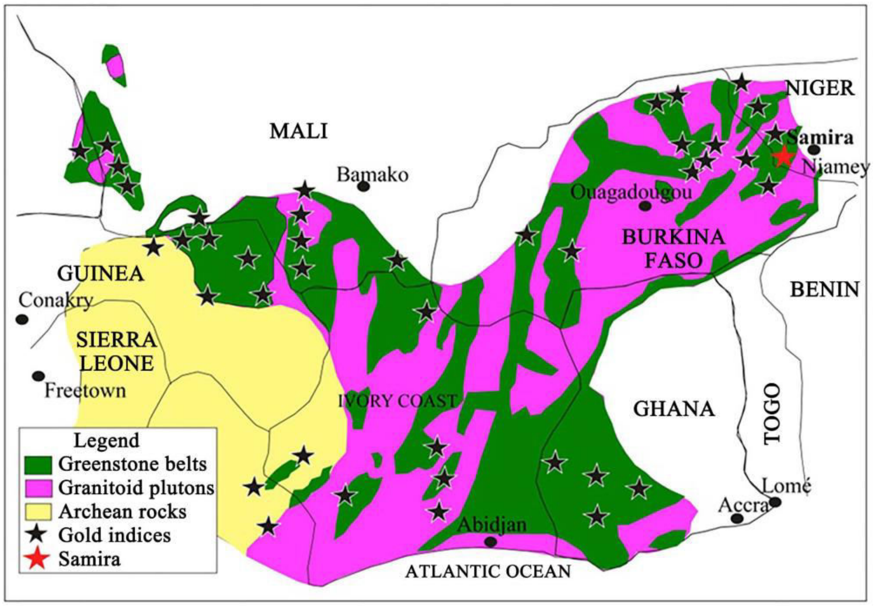


Figure.2 Simplified geological map of the study area (SML, 2008; modified).

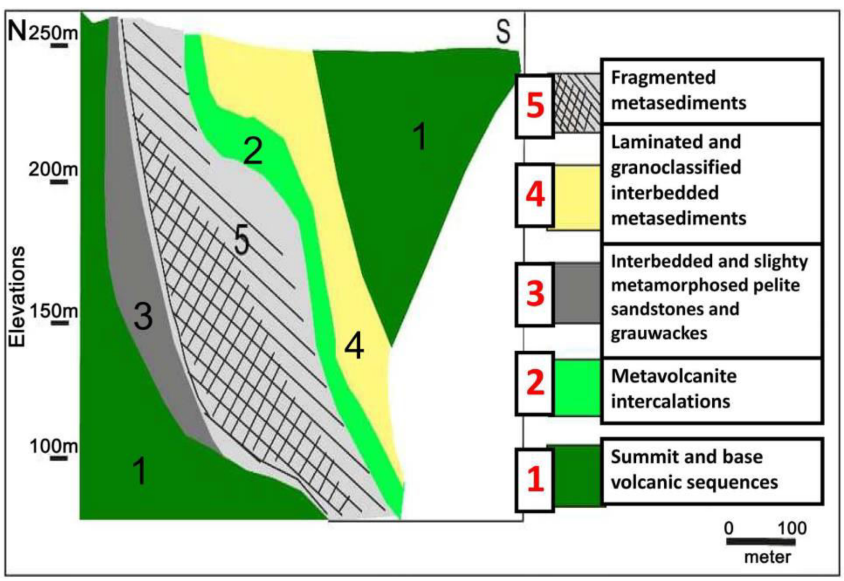


Figure.3 Analyse au spectromètre**.**

Figure.4 Microgabbro sample.a: dark face.b: light face.

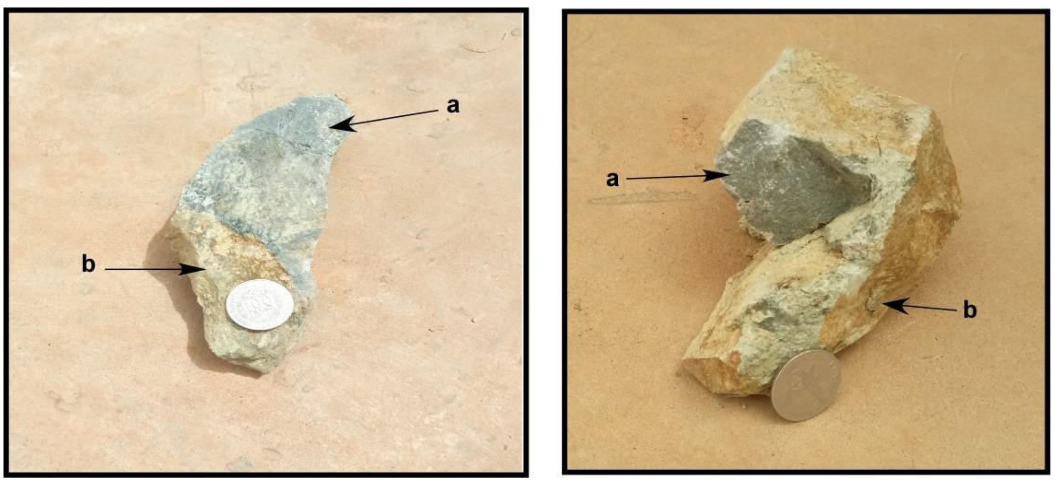


Figure.5 Thin section of microgabro. Ser: Sericite. Cpx: Clinopyroxene. Pl: plagioclase.

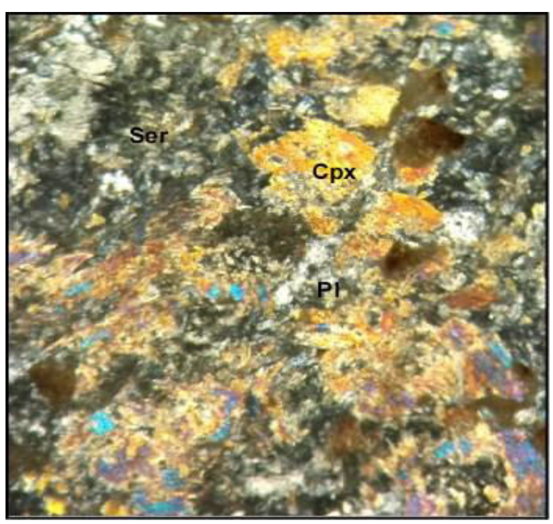


Figure.6 A: Dolerite dyke at the eastern face.B: Dolerite ball in place.C: Dolerite sample.

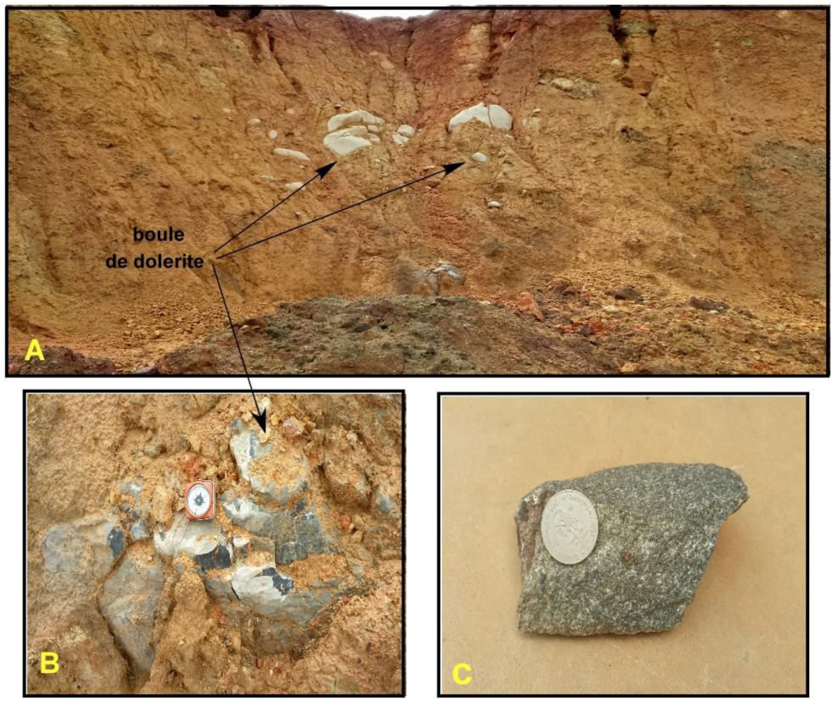


Figure.7 Dolerite mine blade.Cpx: Clinopyroxene.Pl: Plagioclase.Sr: Sericite.

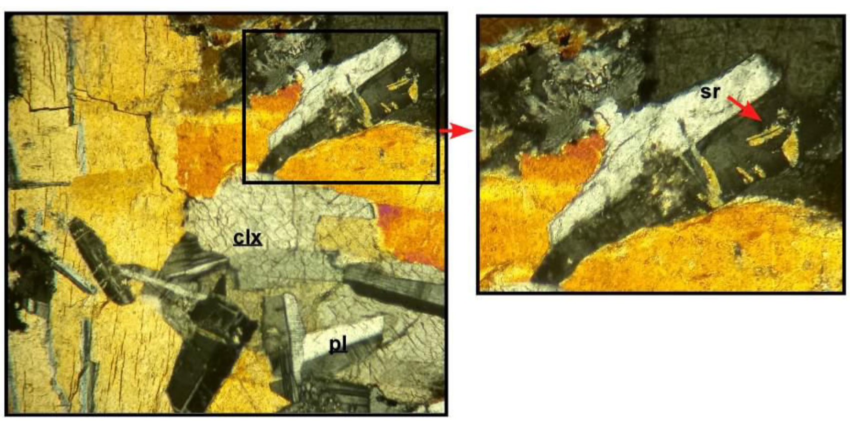


Figure.8 Illustration of a fracture schistosity.

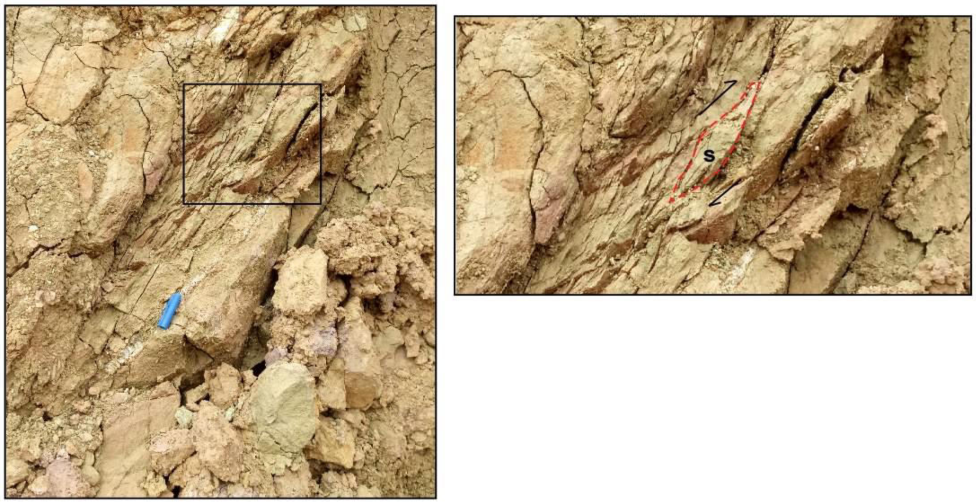


Figure.9 A: Parallel quartz veins of N50 strike. B: Quartz vein of N170 strike. C: Quartz veinlet of N165 strike; D: Quartz veinlet of N170 strike. E: Quartz vein of N40 strike showing fractures.

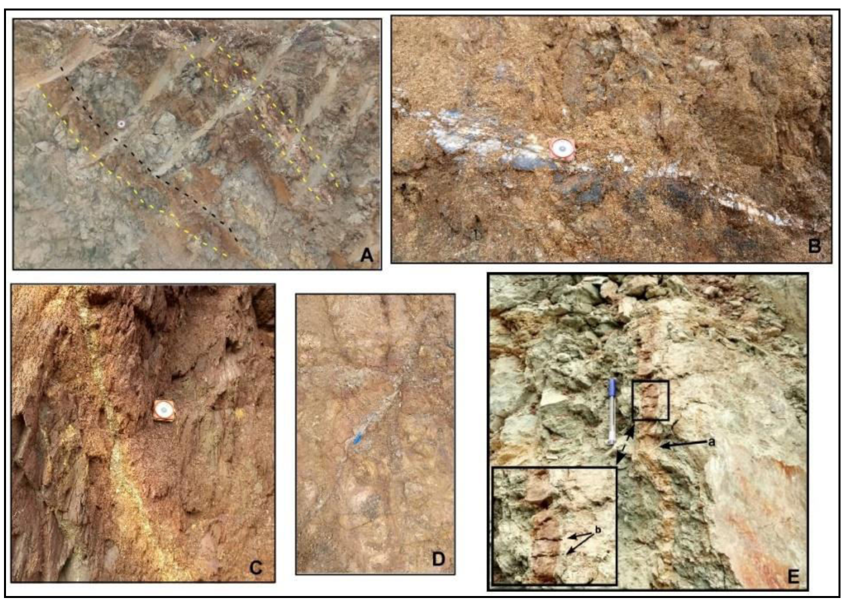


Figure.10 Illustration of areas covered by silica.

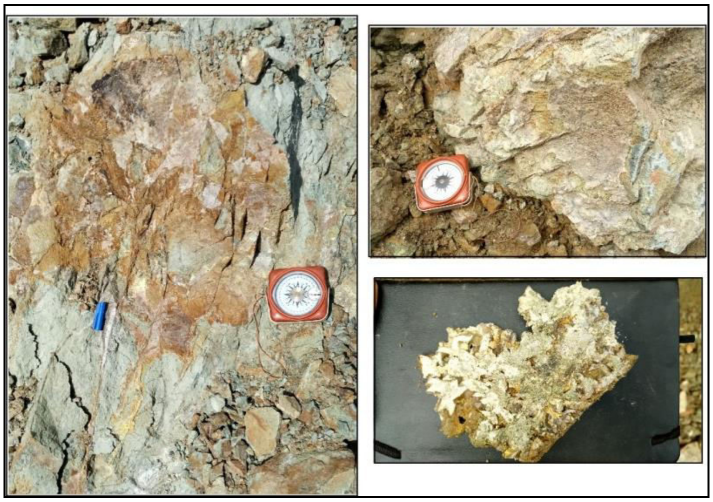


Figure.11 A: quartz veinlet in a rock; B, micro-facture filled by the circulation of iron oxides.

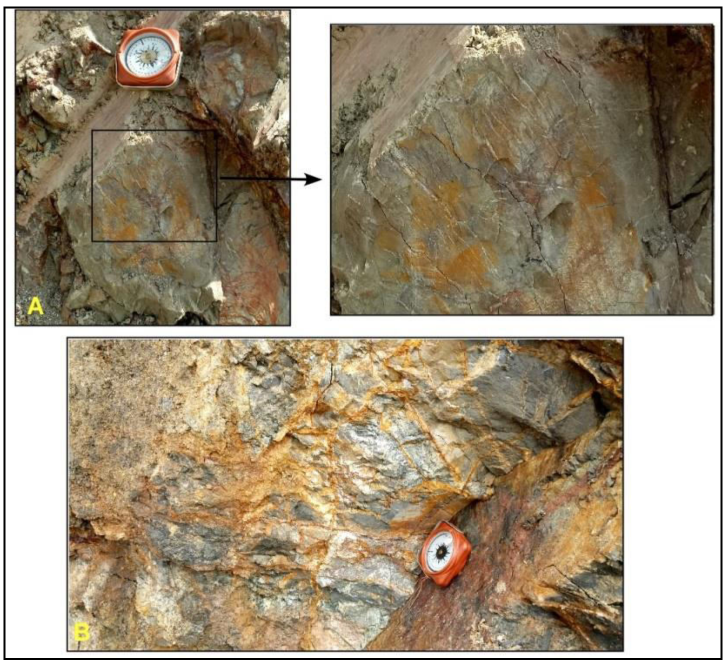


Figure.12 Plot of geochemical analysis results of Au

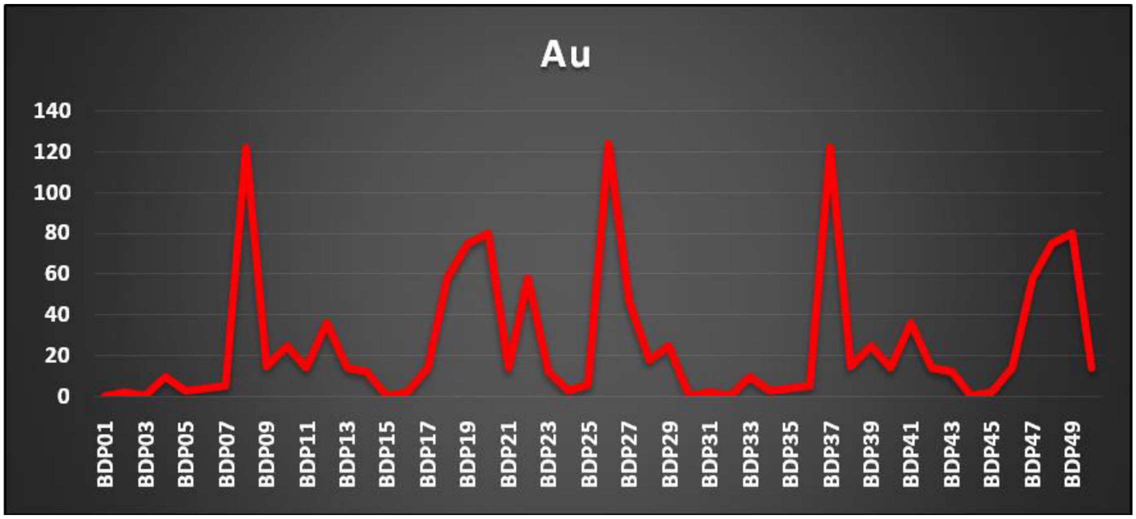


Figure.13 Distribution of Au content in Libiri prospect

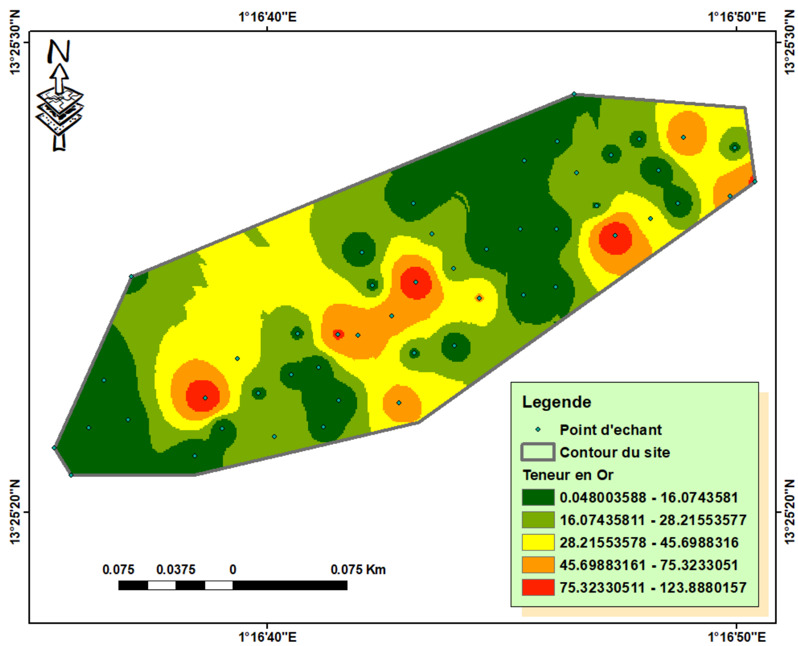
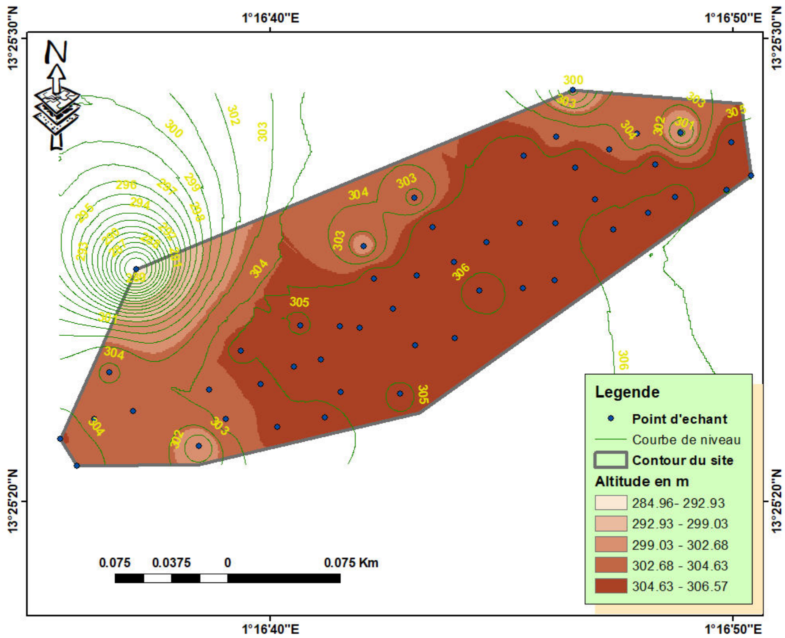


Figure.14 Level curve in Libiri prospect



The presence of all this hydrothermal procession (silica, oxides, etc.) testifies to the strong hydrothermal activity that prevailed in the study area. These hydrothermal fluids are worthy of interest because they are accompanied by concentrations of metallic substances in this case, Gold. Several locations of gold mineralization were detected the study area. The gold occurrences associated with quartz veins were detected from field geological mapping and conform to the general trend direction of N-S.

This gold mineralization occurs along shear zones and parallel to the shear zones. The N-S trending quartz veins (N170°, N175°) are the most representative of the area and have a steep dip compared to those described by Ouattara *et al.,* 2024 and Valea *et al.,* 2024, in the Kalama deposit (Northern Mali) which have slight dips. The intense deformation observed made these volcanics permeable to the infiltration of hydrothermal fluids and meteoritic waters, thus making possible the formation of mineralized deposits at the study area. This silicification is accompanied by gold concentration deposits, in fact the transport of gold to the concentration sites is ensured by hydrothermal fluids (Ouattara *et al.,* 2024; Valea *et al.,* 2024; Noura *et al.,* 2024).

Geochemical potential

The systematic geochemical survey work,a large structural and geological mapping program was undertaken in the study area. This mapping consisted of taking structural measurements of quartz veins and lithological units at the gold panning holes and on very rare outcrops in almost all the target area. The drilling program was undertaken to outline the economic potential of gold mineralization.

The geochemical results show an economic potential of gold mineralisation ranged in holes BDP26, BDP08, BDP37, BDP20, BDP49, BDP19 and BDP48 with respectivelly. Au contents of 124g/t, 122g/t, 122g/t, 80g/t, 80g/t, 75g/t and 75g/t.

A medium concentration is observed at holes BDP27, BDP18, BDP22 and BDP47 with respectivelly the follwing concentration contents 27g/t, 58g/t, 58g/t and 58g/t. At the others holes, it has been oberved an Au contents varied from 30g/t to 0.5g/t (Table 1, Figures 12 and 13). The highest concentration of Au is generally in the areas of high altitude (Figure 14).

Conclusion

The geological mapping of the gold bearing quartz veins mineralization appears to indicate hydrothermal mineralization in connection with shear zones. The process of structural and lithological study in this work indicates two aspects. Firstly, the interpretation of the work carried out in the area showed that the gold mineralization is in quartz veins. Secondly, not all the quartz vein bearing gold mineralization. The geochemical showed areas of Au concentration, such as zones of high, medium and low Au concentration.

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