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Geotectonic Study of Gold Concentrations in Neoproterozoic Formations of Pala, Mayo-Kebbi Region in South-West of Chad

[1]Doumnang Mbaigane J-C., [2]Kagou A., [2]Boka M., [1]Guideal R.

[1]Laboratory of Geology, Geomorphology and Remote Sensing Faculty of Fundamental and Applied Sciences Po. Box 1027 N'Djaména Chad
[2]University of Dschang, Faculty of Sciences, Department of Sciences of Earth Po. Box 67 Dschang Cameroon

ABSTRACT

Neoproterozoic formations of Pala region are made up of volcanoclastic and plutonic rocks. They were affected by a NE-SW deformation, marked by lineaments extracted from satellite image. Tectonic structure of those formations was probably related to the closure of Gouyegoundoum Basin. This structure would be the extension of tectonic structures of Tcholliré region in Cameroun. Metavolcanic sediments and veins have a high concentration in gold and in other metals. These concentrations were exploited in an artisanal ways in Gamboké, Massonébaré and Gouyegoudou region. The exploitation being made without a good knowledge of the terrain, this study has therefore enhanced various efforts made in exploration and exploitation of gold in the area.
KEYWORDS: Gold, Mayo-Kebbi, Neoproterozoic formation, Satellite images, Chad.

1. INTRODUCTION

Geological formations of Pala region, in Mayo-kebbi (Fig.2), South Western part of Chad form a part of Pan-African chain of central Africa, mostly known as «mobile zone»[1,2]. This chain is defined as a large foliated domain resulting from the collision between Congo craton, West African croton and Nilotic blocks in the Eastern part of Sahara between 900 and 550 Ma (Fig.1)[3,4,5,6,7]. This Pan-African convergence is followed by intense tectonic movements, syntectonic and late tectonic granitisation and of ductile shear zones oriented NE-SN. Nevertheless the remaining formations of paleoproterozoic age (About 2100 Ma) are conserved in various places and constitute volcanoclastic or sedimentary formations represented by gneiss with biotite and hornblende, gneiss with biotite, garnet and amphibole more or less rich in garnet observed in Mayo-Kebbi [2,8]. The formation of great Basins was done later in Jurassic, lower and middle cretaceous by the opening of Atlantic Ocean (Babouri-Figuil, Mayo Oulo-Léré, Benue, Mayo Rey, amakoussou, Koum,…[7,9]) producing a new passive volcanic line. Various phenomena of intense tectonomagmatic geneses were overlapped. These processes are globally very suitable in the production of metallic concentrations as well as in the remobilization, dissemination, differentiation and concentration.

Geological zones of Pala (Fig.3) making part of Pan-Africa chain is an excellent metallogenic province but less studied. Mineralizations are less abundant, multiple and concern particularly metals (Gold, Platinum, Nickel, Chrome, Cobalt, Copper, for basic and ultra- basic rocks in one hand on the second hand, sapphire, Niobium, tantalum, lithium, rubidium, tin and wolframite for granitoid acid)[10,11,12,13]. In addition to the supposed richness in natural resources, the exploration and exploitation of these minerals is blocked by the complexity of deposits resulting from the process of concentration and dissemination. Many concentrations can be found in sub-surface without living any litho-structural indices[12,13,14]. It is difficult to know or search at great depth indices observed on the surface, it is what causes environmental degradations by the uncontrolled artisanal exploitations. It is important therefore to develop geological knowledge, the only mean to guide mining researches and to protect the environment.

1. Geographical and Geological map

The studied area is located in Mayo-Kebbi region, in the South-West of Chad between latitude $9^0$15' and 9^0 55' North and longitude $14^0$15' $14^0$45' East (Fig. 1).

***Corresponding Author:** Doumnang Mbaigane J-C., Laboratory of Geology, Geomorphology and Remote Sensing Faculty of Fundamental and Applied Sciences Po. Box 1027 N'Djaména Chad. Email : jdoumnang2002@yahoo.fr

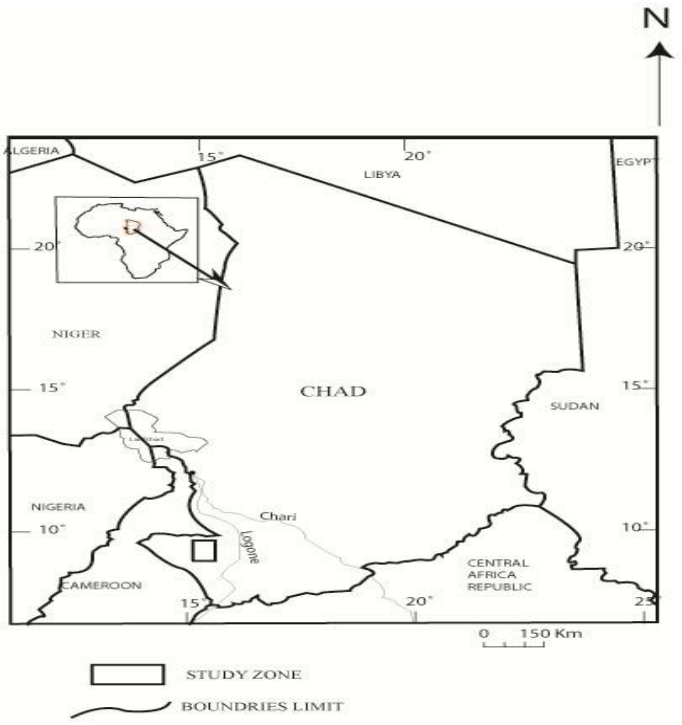


Fig. 1. Location map of the study area

Geological works were summarized into some observations[15, 16] and geological map on scale 1/500,000 [11, 17].

Geological formations of Mayo-Kebbi are the extension of Chadian central massive toward South-West of Chad [6, 8, 18].

Mayo- Kebbi region is made up of neoproterozoic formations (Zalbi series, Gouyegoudoum series, Gony Djalingo series and Amphibole gneiss series), intrusive rocks and the surface formations[6, 8, 18, 19] (Fig.2).

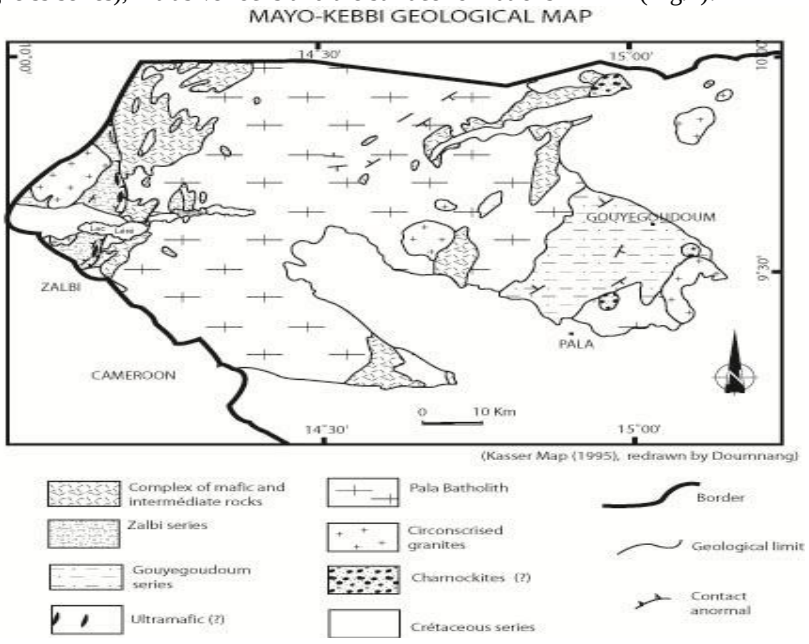


Fig. 2. Mayo Kebbi geological map

Pala region is made up of essentially a huge granitic batholiths (batholiths of Mayo-Kebbi) (Fig. 2) containing metamorphic rocks, a band of volcano-sedimentary and metamorphic formations similar to the green belt rocks (Chlorite schist, Talc schist, metapyroxenites) which form the majority of outcrop. Volcanoclastic and

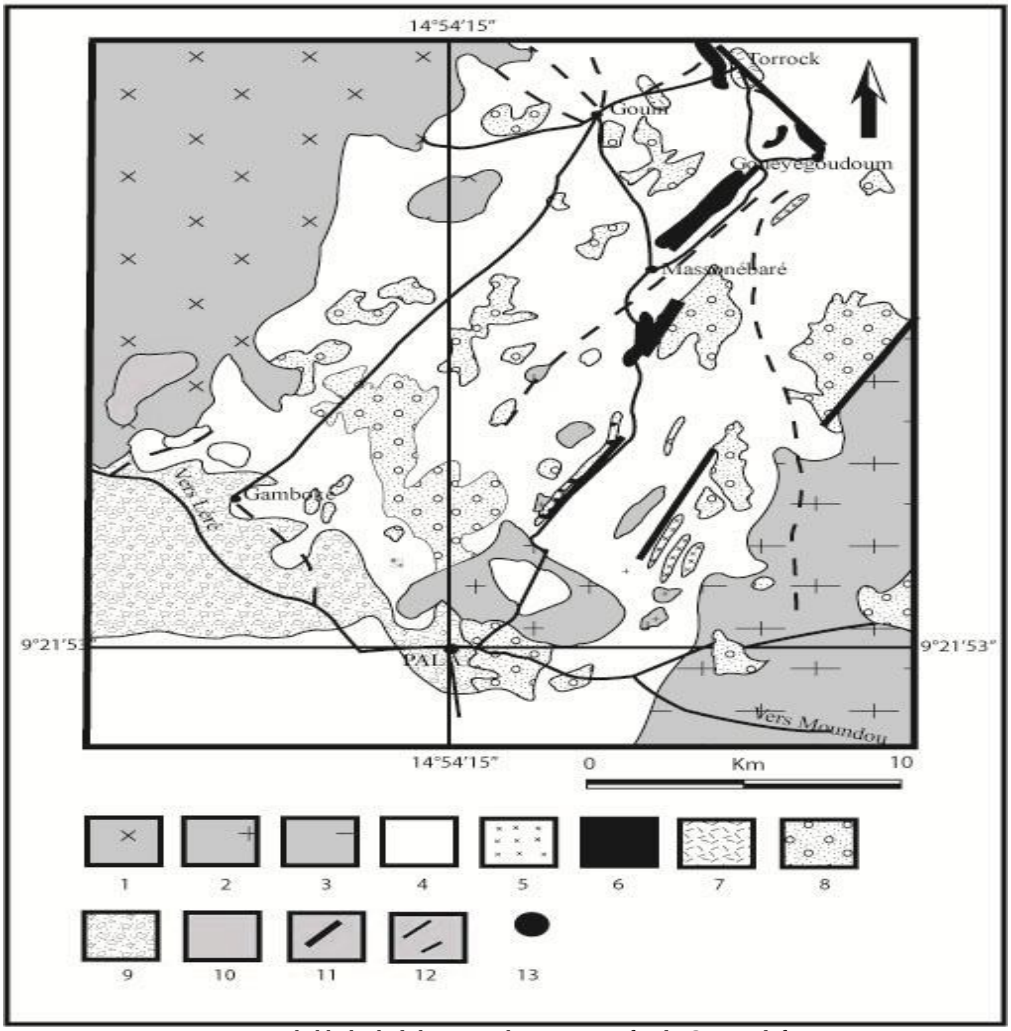
metamorphic outcrop in form of belt called Pala Belt. It is oriented SSW-NNE. This band disappears towards the South in cretaceous basin of Lamé (Fig. 2). Intrusive rocks and veins from alkaline granite to ultra basic rocks pass through the entire formation.

Intrusive rocks especially granitic formations broadly cover a great surface compare to those occupied by metamorphic series. Mayo-Kebbi granitoid batholiths ("Concordant granite" or syntectonic described by ancient authors)[11,19], granitic massive younger and a third group made up of various rocks, starting from fin granites, porphyry granite, of diorites and of two pyroxenes age about 565 Ma [6, 20], syeniteon the second hand to ultra basics [6,8,18]can be observed.

Dykes and veins of rocks outcrop in metamorphic rocks and in granitoid. They are microdiorites, microgranites, dolerites, pegmatite and veins of quartz.

Metamorphic formations are strongly folded and the general directions are NE-SW with high slope. But horizontal movement leads to litho-structural changes. (Fig.3).The tectonic manifests by fractures which limit Precambrian against cretaceous sediments of Pala Basin. Falls are therefore of Jurassic and Cretaceous age.

PALA GEOLOGICAL MAP



1. Mayo kebbi batholith, 2. Porphyric granit of Pala, 3. Non deform granit,
4. Charnokite, 5. Metadiorite, 6. Metabetabasite, 7. Hypersilicified breccia,
8. Metavolcanic, 9. Laterite, 10. Basic enclave, 11. Veins quartz, 12. Road

Fig. 3. Palageological map

2. Analyses sensing

2.1 Methodology and Materials

For analyses sensing study in Pala region, ENVI 3.1 software image treatment, satellite images, existing map and field data were used.

Geological maps of Wucrenier and Kasser were scanned and redrawn using Adobe Illustrator version 9.0 and comparisons were made by those previews authors. Based on topographical map, hills, roads, villages, rivers were noticed for analytical sensing treatment.

2.2 Satellite Data

The access to the area being difficult and the area less mapped, satellite images Landsat TM of 05 February 2002 (Path 184 row 53) were used. This image obtained is the result of Landsat 7 which is the last satellite generation. Landsat 7 lunched in April 1999.

2.3 Analytical sensing treatments

Analytical sensing treatment was done for image Landsat TM of 05 February 2002 part 184 Row 53. To produce visual interpretation a colored composition TM5, TM4, TM3, with a complete restriction of the image on the paper was done. A Gaussien Filter applied to the image made lineaments, cycle lineament and faults appear (Fig.4).

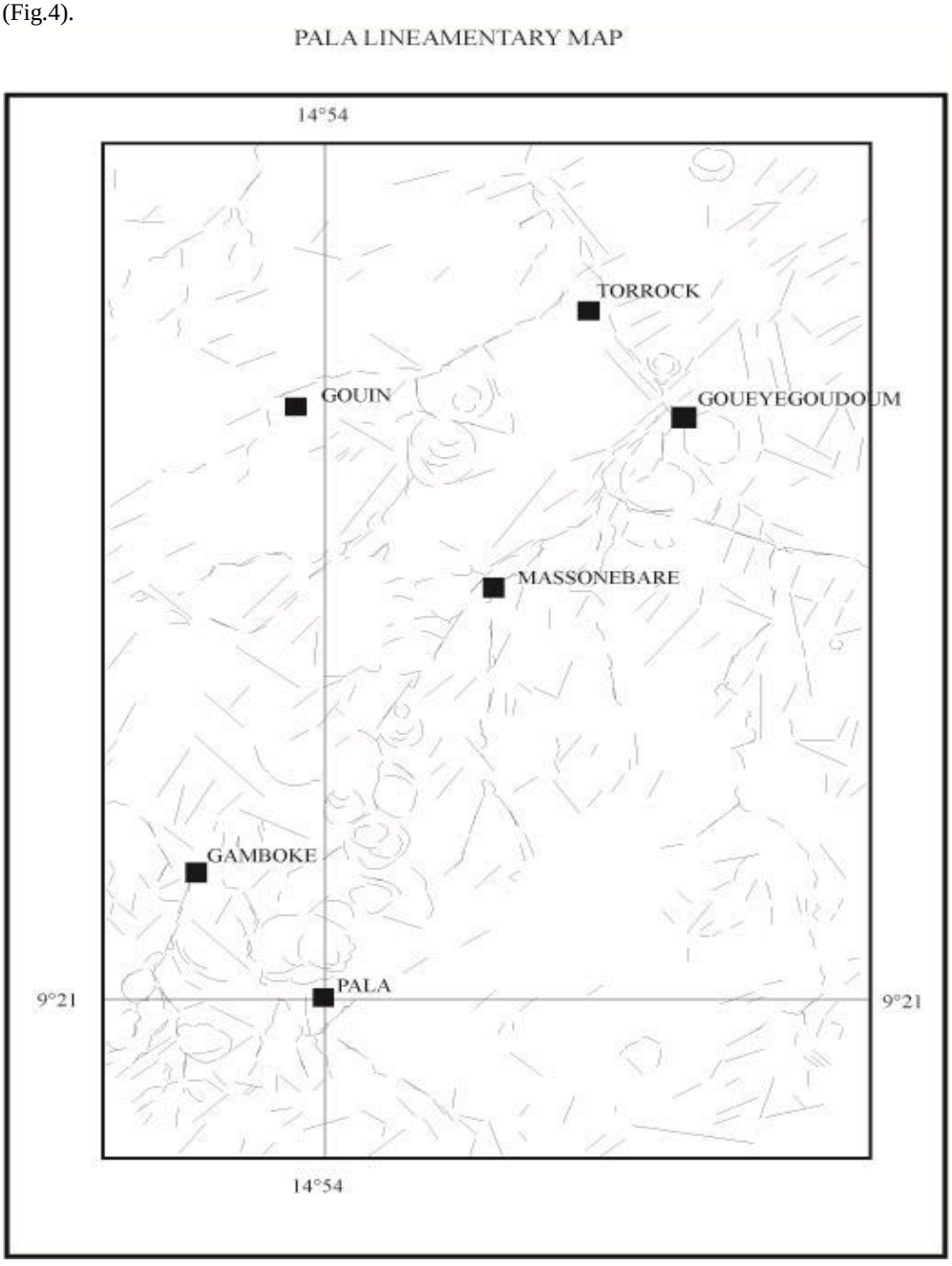


Fig. 4. Pala lineamentary map

Satellite images analyses show that lineaments and faults were broadly oriented NE-SW. Nevertheless some few lineaments were oriented NW-SE. Cycle lineaments characterize granitoids domes of the region. (Fig. 4)

2.4 Tectonic

Field measurement of schistosities plans gave stereogram (Fig. 5). Analyses done in geological formations of Pala show advanced distributions oriented NE-SW characterizing schistosity fractures and veins of quartz. Schistozity plans, fractures veins of quartz oriented $N20^0$ to $N40^0$.

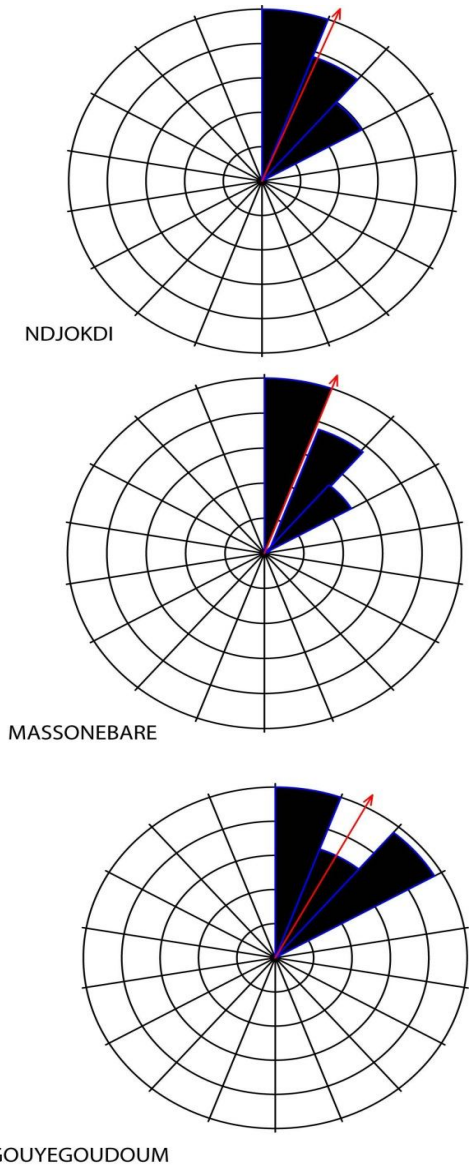


Fig. 5. Compass of direction of foliation

Green rocks underwent ductile deformation characterized by schistozity S1 oriented between $N10^0E$ and $N20^0E$.Schistozity was marked on satellite image by lineaments oriented $N10^0$ E to 20^0E. This schistozity is equally parallel to veins of quartz less importance. Schistozity S1 was resumed by a deformation S2 characterized by great veins of quartz in Gamboke region and which are oriented NW-SE and WNW-ESE.

3. Gold mineralization

Mineralization of Gold is spread in three different sectors.

- Gold-bearing zone of GamboKé
- Gold- bearing zone of Massonebare

- Gold-bearing zone of Goueyegoudoum (Fig. 5)

3.1 Gamboké zone

In Gamboké zone, gold is related to quartz vein, to metadiorite oriented $N10^0E$ with subsurface dip, intercalated by metasediments and of volcanoclastic rocks which the schistosity is oriented globally NE-SW.(Fig. 5). This formation is affected by fractures of direction $N30^0E$-$N60^0E$ with the dip from $N20^0$ to $N40^0$ SW. Mineralized veins are observed in shear zones. Other polymetallic mineralizations are present in transformed rocks. Geochemical analyses carried out by Korea Company KIGAM (Table 1) show that Gamboké zone present a Gold-bearing anomaly of great importance. Analyses done on all the parallel veins of quartz of direction NE-SW show that veins were mineralized into Gold with the content which varies from 90 ppb to 1000 ppb.

Volcanoclastic formations trench realized (Pal TG1 to Pal TG9) gave a Gold content varying between 554 ppb to 610 ppb (Table 1). Gold in Mayo Binder alluviums was also exploited by farmers using traditional means.

3.2 Massonebare zone

In Massonebare zone, mineralization is related to quartz veins, to metavolcanites and to metasediments. Quartz veins are parallel to schistizity plans of direction NE-SW with sub- vertical slope. Green rocks were crossed by small veins of quartz parallel to the mineralized schistosity in Gold. The analysis of some samples shows that the average content in Gold varies from 9 ppb to 90 ppb.

In Massonebare formations a mineralization of sulfur such as Pyrite, galena, chalcopyrite can also be found. They are associated to gold.

3.4 Goueyegoudoum zone

In Goueyegoudoum, Gold mineralization is related to metavolcanic formations gathered in crushing zone and forming breccias of talc. Those formations are crossed by veins of quartz oriented NE-SW, parallel to the schistosity observed. Metamorphic aureole has an iron oxide concentration (magnetite) with a high content. Geochemical analyses of surface samples gave a gold content of about 156 ppb.

In the three gold bearing zone of Pala, mineralization presents a high percentage compare to other metals.

Table 1. Percentage in Gold and silver in drilling zone of Gamboké and Goueyegoudoum

N° of sample	% of gold	% of silver	Ratio Ag/Au
PalGS1	93	6,3	0,12
PalGS2	91,9	6,4	0,13
PalGS3	85,8	14,6	0,31
PalGS4	85,7	15,2	0,32
PalGS5	85,2	15,1	0,33
PalGS6	83,3	14,8	0,32
PalGS7	91,8	7,4	0,15
PalGS8	90,3	7,6	0,15
PalTGG1	77,5	22,8	0,29
PalTGG2	78	22,3	0,28
PalTGG3	78,1	20,7	0,26
PalTGG4	78,5	19,7	0,25
PalTGG5	78,7	19,9	0,25
PalTGG6	81	8,5	0,1
PalTGG7	90,1	8,5	0,09
PalTGG8	92	7,4	0,08
PalTGG9	92,6	7,3	0,07

The Gold-bearing zone mineralization of Pala is generally a type of quartz bearing zone interstratified in neoproterozoic green rock. Therefore there are two types of quartz veins: Big veins of direction NW-SE and small veins of direction parallel to the schistosity of green rocks are very rich in Gold and are observed in shear-zones.

Alluviums gold is exploited in streams (Mayo-Dallah) with a rate varying between 0.01 to 0.58 g/t [10]

Conclusion

Pala region is made in great part by neoprotezoic formation epimetamorphic formation forming a green belt rocks. Those epimetamorphic formations are in general Chlorite schist, metavolcano, meta-volcanoclastic and metabasits.

These formations have undergone a ductile deformation marked by the schistozity oriented $N10^0$ E and $N20^0$ E. Post-tectonic, plutonic intrusions outcrop in the region in form of granitoid dome [6, 8, 14, 18,].

Basic intrusions were observed in granitoids marking a late formation of granitoids. Those granitoids have undergone any deformation. Magmatic formation marked by coarse crystals of feldspar oriented $N90^0$ to $N115^0$ E was observed in the porphyry granite of Pala.

Structural directions observed were generally oriented N 10^0 E. Those directions are generally observed in the South of Pala in Tchollire region in Cameroon [21]. The compass card (Fig. 5) shows a major direction $N10^0E$ which

was a direction of schistosity and veins of less importance. Based on this geotectonic work, it can be noticed that Gold mineralization in Pala region was globally related to the deformation stage S1, marked by veins of quartz of great importance, of direction $N10^0E$ compared to the direction of the schistosity of green rocks.

The second deformation stage was related to big veins of quartz of direction NW-SE which were less mineralized. This mineralization is probably related to hydrothermal.

Alluviums Gold exploited in streams result from the alteration of primary gold of veins of quartz. This work has drawn a relationship between tectonic and mineralization of Gold in Pala region, but it is important to carry out a work on the dating of rocks and an advanced geochemical isotopic analyses to deepen the knowledge on the mineralization of Gold in the region.

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