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CHARACTERIZATION OF PAN-AFRICAN MOBILE BELT DEFORMATIONS OF SOUTHERN MARADI (SOUTH NIGER)

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ABSTRACT

This present paper discusses the characterization of Pan African Mobile belt deformation of South Maradi. The methodology adopted was mainly primary data, and in that, in the deformation characterization, a multidisciplinary approach has been implemented, including geophysical correlations, cartographic and petrostructural observations. This approach has made it possible to establish a map of the geological formations of the area. The result shows that during the two episodes/phases, the setting of granitoids was associated with the re-playing of the regional shear-zones. The radiometric dating of the rocks revealed that Pan-African deformation phases affected both paleo-proterozoic and Neo-proterozoic formations. In the findings, the analysis highlighted at least three (3) deformational phases, noted D1, D2 and D3. The D2 Pan-African deformation phase, also ductile, consists of two (2) episodes (D2a and D2b) The more brittle D3 phase was associated with two (2) episodes of strain-slip schistocity; one of orientation N80^0 to N120^0 (S3) followed by a second orientation of N40^0 (S4)

Keywords: Shear zones, Paleo-proterozoic, Pan-African mobile Belt, Southern Maradi.

INTRODUCTION

As the preliminary dating shows, the Southern Maradi Basement Complex corresponds/correlate to the northern edge of Benin-Nigeria shield which is part of Pan African mobile zone on the Eastern side of West African Craton, consisting mainly of gneiss, migmatites, schists and granitoids.
The South Maradi base (or promontory of South Maradi) corresponds to the Northern terminal end of the Benin-Nigerian field which belongs to the Pan-African mobile zone on the eastern side of the West African Craton. (Konate, 1996) It is made up of gathered blocks during the Pan-African thermo-tectonic event (Danbatta, 1999; Daniel et al, 2004; Abdelsalam et al, 2002; Caby, 1987) The documentation of Southern Maradi Basement geology amount to no more than the Mignon's (1970), Burry (2012) and the PRDSM's (2005) works.

It emerges from those different works that the southern Maradi Basement is made up of a set of mica-schists and schist outcropping in strips form in a NE-SW direction intruded by some more or less deformed granitoids. Compared with the Nigerian Pan-African province, proceeding towards the South, only few works related to the structural evolution have been undertaken in the Nigerian side (South of Maradi) The only works available related to that are those of Mignon (1970) and of the PRDSM (2005) Mignon (1970) interpreted the deformations of the southern Maradi base, essentially in the context of brittle tectonism whereas the synthetic maps of the geophysical data was issued by means of air lifted levers realized in the cader of the PRDSM (2005) brought to the fore the existence of structures of ductile and semi-ductile deformations (D1, D2 and D3), affected by an episode of later period, splitting up (D4)

However, this description of the deformation worked out by the PRDSM (2005) and Talaat et al, (2010 does not rely on the data from the field, but rather on the interpretation of air-lifted geophysical maps. Such an approach have not allowed to clearly characterize and specify the chronological succession of tectonic events throughout the time. Thus, in light of what has preceded, it appears that the studies of the structure of the southern Maradi regional geology is yet to be done.

The present study therefore, based on petro-structural and radiometric analysis aim to: Correlate the Basement formations of south Maradi with those of northern Nigeria. The following are the objectives of the study:

1. Determine the main deformation phases and Characterize the structural evolution of the region,
2. Determine the nature of the magnetic structures revealed by the geophysical maps,

3. Correlate the geological formations of south Maradi and the northern Nigerian part, and
4. Characterize the main phases of deformation and classify them according to its relative chronology.

MATERIALS AND METHODS

Geological Context of the study Area

The formations and the geological structures of Southern Maradi (Figure 2) are in correlation with those of northern Nigeria (Ferre et al., 1996; PRDSM, 2005) According to Grant et al (1972) the polycyclic of north-west Nigeria corresponds to an ancient continental crust including some Archean Plates (2,700 Ma) and Paleo-proterozoic (2,000 Ma) Given the fact that there is no Archean plate in the southern Maradi, it can thus reasonably be said that the first continental crust would rather be of the paleo-proterozoic age (Grant et al, 1972).

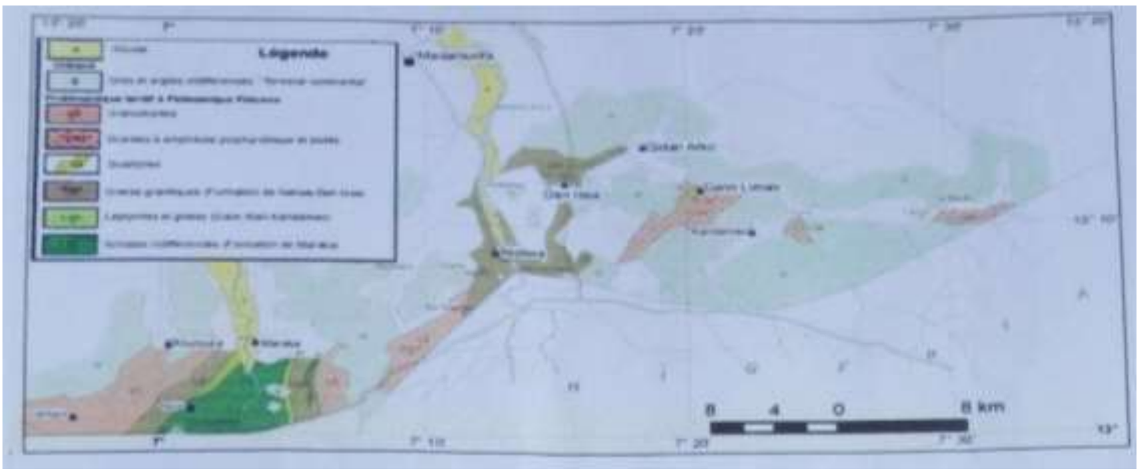

Fig. 1: Geological map of Southern Maradi, Mignon (1970)

During the period extending from the neo-proterozoic (750 Ma) to the Cambrian (500 Ma) all the base formations have been affected by the Pan-African thermo -tectonic event (Turner, 1983; Abdulsalam et al, 2002; Caby, 1987) The Pan-African Orogenesis (600 + 150 ma) was the last re-activation which affected the whole region. (Turner, 1983, Caby et al, 1991)

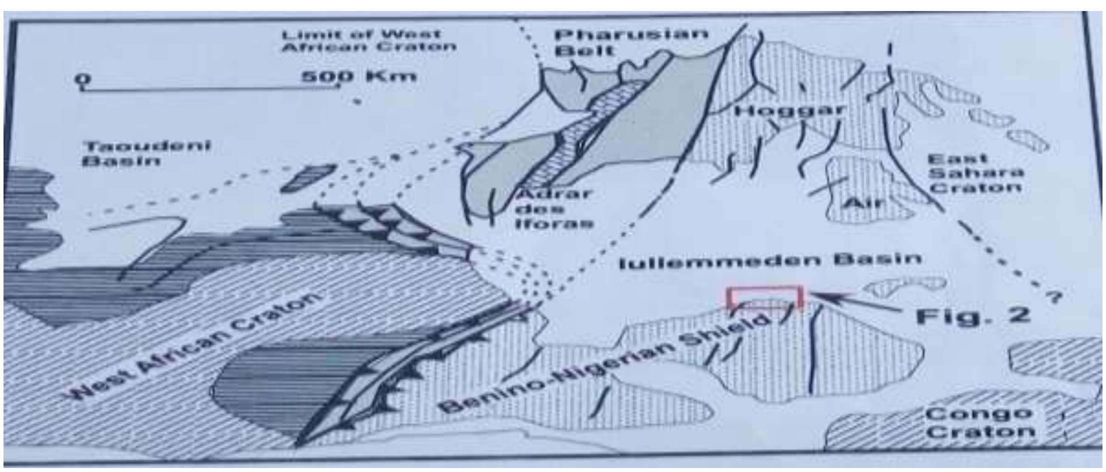

Fig. 2: Localization of study sector in the Benin-Nigeria shield of the Pan-African province (Ajibade and Wright, 1989). 1: Mesozoic and Cenozoic formations; 2: Pleistocene deposits 3: Pan–African metasediments and metavolcanics 4: Nigeria-Air-Hogger Shield 5: West African and Congolese Craton, 6: zone of study; 7: Suture zone; 8: corridor of shares.

The first stage consists of lineaments from the magnetic map (Figure 3) of PRDSM (2005) The ductile and major corridors of shear forms a bundle of NE-SW direction. (Figure 3 and 4) A solo meridian zone of shearing moves back in senetre, the front structures.

(Figures 3, 4) The observation of the geomagnetic map shows too that a system of late fracturization with a NW-SE direction affects this region.

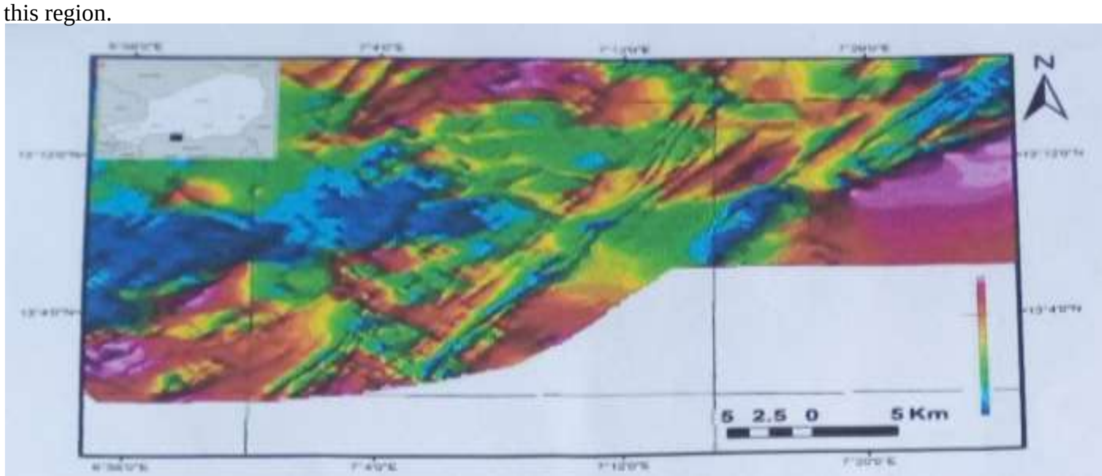

Fig. 3: Brought out from the total map of lineament, total magnetic field of south Maradi at a scale of 1/200, 000th (PRDSM, 2005) on the colours of rose representing the zones having strong magnetic intensity and the blue colour, the ones of weak magnetic intensity. The zones of average magnetic intensity correspond to slots colour from olive to yellow.

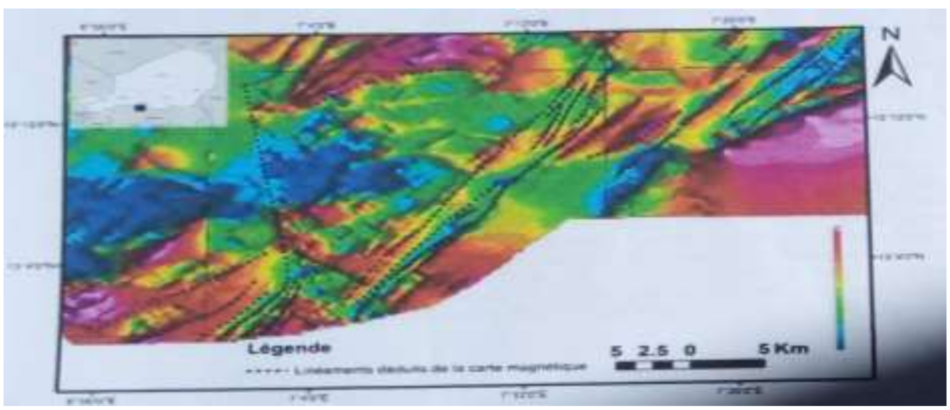

Fig. 4: Interpretation of map of total magnetic field of South Maradi (scale of 1/200000th; PRDSM, 2005)

The geological units identified by Mignon (1970) in South Maradi (Figure 1) are correlated to the geological assemblages of Northern Nigeria.

Data Collection and Analysis

This research was carried out by a team of experts as shown on the paper. It involved primary data gathering which was direct visit to the field. The works of geological cover of the areas was carried out along with making of geophysical map of major structures (Figure 4) have contributed towards modifying and completing the figure 1 (the map) obtained by Mignon (1970). This procedure enabled the research to make the map of Figure 5 and beside to proceed to a geological section (Figure 6)

That involved about three (3) stages; reconnaissance survey and two other visits. The fourth stage consisted of a micro-tectonic analysis on samples collected from field and in laboratory which enabled the researcher to determine the different deformation stages. The rock samples collected based on radiometric dating were analysed at Activation Laboratory Ontario, Canada.

Review of Related Literature:

In the patterns of Crustal reactivation, previous researches have summarized many geological similarities elsewhere within African geological contexts and their different age provinces. The Precambrian Crust of West Africa appeared to have been subjected to series of essentially similar cycles of events throughout most of its history. Each cycle involves deposition of supracrustal sediments and volcanics, followed by deformation and metamorphism, basement reactivation and emplacement of granitic intrusion. The tectonic environment of each cycle must have been broadly similar throughout the region. For instance, the consistent regional trend of structures, between N-S and NE-SW point to the existence of fundamental and long-lived stress system. This is also indicated by many major faults and shear zones which have the same general N-S to NE-SW orientation throughout the region. They are often marked by the occurrence of mylonites and pods and lences of vein quartz among them. Although quartz veins are also found filling fractures and faults of any size and orientation (Wright et al, 1985).

RESULTS AND DISCUSSIONS

Geological correlations

The geomagnetic maps are well known for their relevance in linear structure's interpretation generated by tectonic contacts (Ajibade et al, 1987) Figure 7 represents the pseudo-geological map obtained from the interpretation of results of air-lifted geophysical levers Mag/spectro and Mag/EM (PRDSM, 2005) This pseudo-geological map brings structures of ductile (Schistosity/foliation, ductile shearing corridor) and brittle (fractures) The correlations achieved have enabled some corrections in the Mignon`s (1970) map in Figure 1, as regards to the main structures of deformation (Figures 5 and 6) to see the continuity of geological formations of southern Maradi with the one described in northern Nigeria.

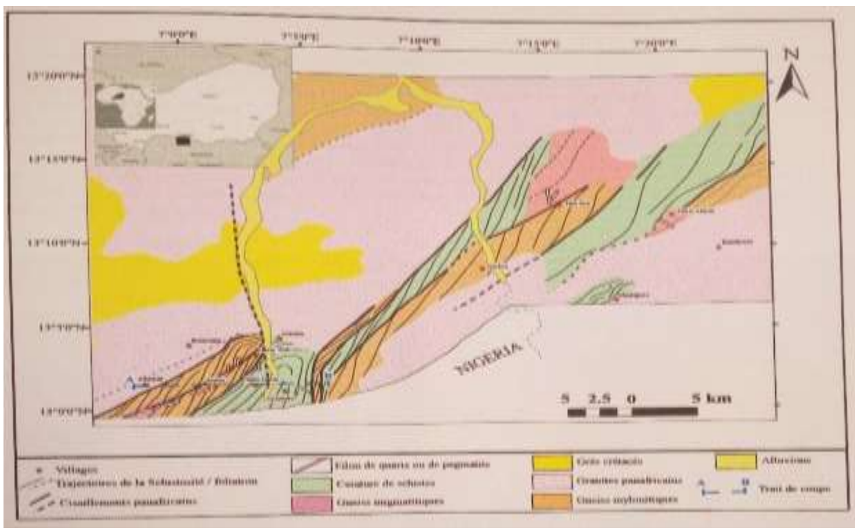

Fig. 5: Geological map of Southern Maradi compiled from geophysical (PRDMS, 2005), cartographic (Mignon, 1970) data from drilling (DRH/Maradi, 2013)

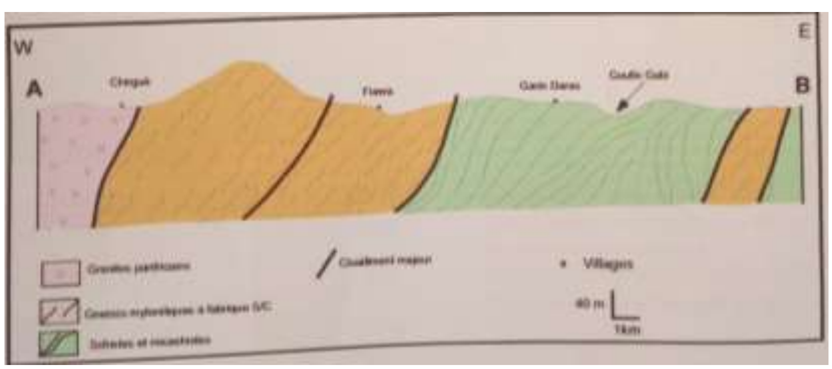

Fig. 6 geological cross section A-B (W-E) of the southern part of the study sector.

The continuity of the rock outcrops in the south of Maradi corresponds to the relative continuity of magnetic data (Figure 3; PRDSM, 2005) which stand to be a source of information about the interpretations of tectonic structures (Figures 4 and 5) The geological map of southern Maradi as claimed by Mignon (1970) does not reveal the existence of shearing zones that divided NE-SW and N-S (Figure 1). These structures exploited the outcrops which are visible on the maps of total magnetic field (Figure 4) and of magnetic interpretations (Figure 7). The shearing zones affected some wide zone that Ferre et al. (1996)

related to the late-Pan-African episode in relation to the setting up of neo-proterozoic granites (Figures 4 and 5). According to Ferre et al. (1996) these shearing zones would have controlled the setting up, and besides, deformed these granites.

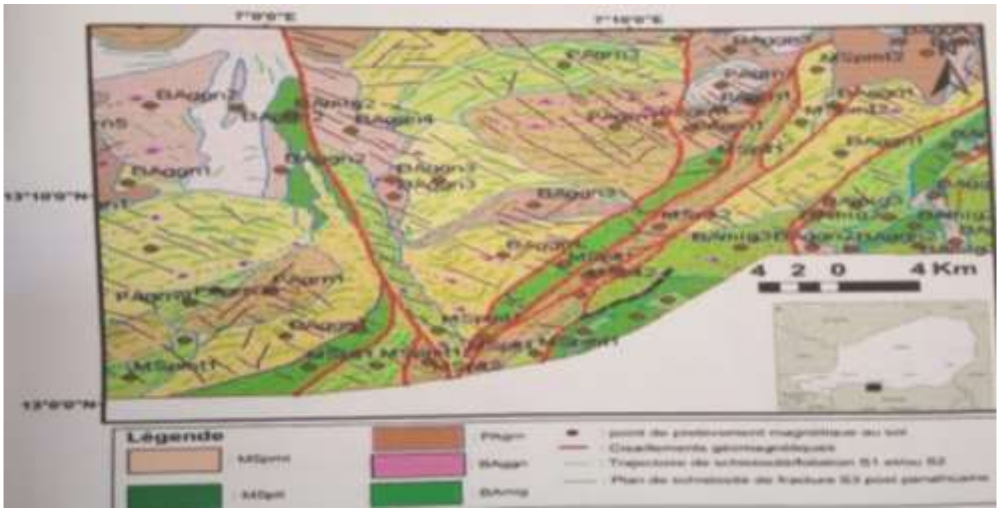

Fig. 7: map of magnetic interpretation (pseudo-geological) showing the magnetic lineaments extracted and the different geological major units. (PRDSM, 2005) BA mg: magmatic gneiss; BA ggn: granitic gneiss; PAgrn:: Pan-African granites; MSplt: Pelitic schists; MSpmt: Psammitic gneiss complexthat banded quartizite rock.

The interpretation of air-lifted geophysical data (PRDSM, 2005) in line with the works done in northern Nigeria (Ferre et al.1996) enabled to propose a map of geological correlations between the geological units of southern Maradi and those of northern Nigeria (Figure 8) It was found out that from this correlation obtained from south Maradi, just like in the north-western part of Nigeria three lithostratigraphic units can be distinguished, they are thus shown (Figure 8):

1. From the gneissic and migmatitic complex outcropping at Wali area/environ, (PRDSM, 2005), (Mignon, 1970) corresponding to the migmatitic-gneiss complex of northern Nigeria (Ajibade & Wright, 1989; Mc Curry, 1976; Abubakar, 2012) on age of 2,700 Ma to 2000 ma has been attributed/assigned to this migmatitic and gneissic complex corresponding to a more ancient substratum, forming some paleoproterozoic block of continental Crust, (Ajibade and wright, 1989)

2. A chain of schists of sourthern Maradi: the Maraka range of schist is a continuity of the Schist belt of Wonaka (North of Nigeria) The schist range of Wonaka would represent an ancient Pan-African Basin. (Turner, 1983).

3. Some Pan-African granitoids of Shirgue, likewise some mylonitic gneiss at Nidwa-Dan Issa environ (Figures 5 and 8), which are in continuity with the Older granites of Nigeria (Mignon, 1970; PRDSM, 2005; Abubakar, 2012)

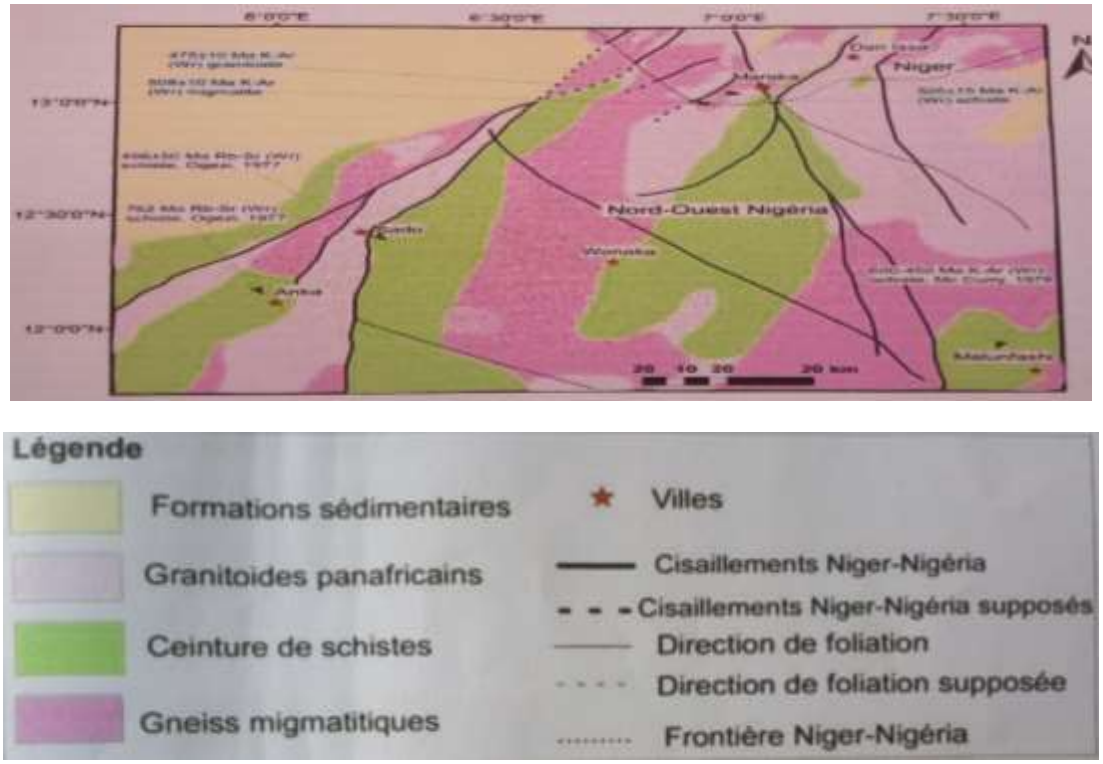

Fig. 8: Map of synthetic and geological correlation of the Nigeria shield showing the continuity between the beginning of the southern Maradi base and that of north-western Nigeria (Mignon (1970)/ PRDSM (2005; Abubakar, 2012), Talaat et al, (2010) and Caby et al. (1991)

Gneissic and Migmatitic Complex

The gneissic and migmatitic complex are characterized by a migmatitic and undulating texture with sub-linear (Daniel, 2004; PRDSM, 2005) underlining an irregular contact (Figure 3) with Pan-African granites (Figure 8) The strong magnetic intensity as well as the undulating textures help to interprets the geochronology (dating) of the migmatites. The rocks of greissic, migmatitic complex correspond to a protoliths of quazofeldspathic rocks of paleoproterozoic period which was been reshaped during the Pan-African event, as testified by the radiometric ages obtained on total rock through the K/Ar method.

Indeed, the age of the last ductile formations having affected the rocks of this complex are 475+10 Ma regarding the gneiss of Wali environ/area and 580+10 Ma for the outcrops around Shirgue village.

The meta-volcano sedimentary schists intruded into the gneissic and migmatitic complex. At later stages, both were intruded by Pan-African granitoids. The eruptive rocks of the gneissic and migmatitic complex which show numerous enclaves of restites (biotite) and some unisepac folds showing some signs of beginning of a partial fusion. These observation are in line with those achieved by Abubakar, (2012) in the Zworoko and Afao sector, where the researcher brought some deformational structures of interior structural level among others. Some ductile shearing affecting some disharmonious foliations and folds. According to Grant et al (1972) and Abubakar (2012), the metamorphism would be of the amphibolite facie types. The migmatitic gneiss presence in these two regions (Southern Maradi and Northern Nigeria) would implicate a metamorphism of highest grade to reach the granulite facies (Soumalia & Konate, 2005)

Metasedimentary schists

The chain of metasedimentary schist shows a linear texture associated with broad zones of shearing with a strong magnetic intensity close to those of the pelitic schist and quartzite schist. One should note that in the southern Maradi, the formations of striped (with ribbons) and ferriginous quartzites (BIF) described in the northern Nigeria sector are not observed. The greyish-colored schist contain some sericite flakes, biotite and muscovite. The schistosity/foliation has average orientation of N20^o to N50^o. Locally, these schist and quartz exuates were refolded with self-insorted granites (Figure 4) In the north-western Nigeria the schist belt are directed in NNE direction would be neo-proterozoic layer, deformed and metamorphosed in the green schist facies (Abubakar, 2012)

*Pan-African Granite*s

The Pan-African Older granites are differentiated according to their textures which is magnetic and have been sub-linear (more or less deformed) and the intensity of the magnetic field they create, which indicates their synthetic and post-tectonic character (PRDSM, 2005) The outcrops are represented by some orthogneiss injected with aplite and/or with pegmatite, showing a mylonitic foliation globally directed in N25º direction. The Pan-African granitoids known as older granites of northern Nigerian, have some plutons of tonalite, granodiorite, diorite, syenite and charnokite, generally from synthetic to post-tectonic time (Konate, 1996) Prominent among these granitoids plutons manifest a radiometric age between 750Ma to 450Ma (Soumalia & Konate, 2005)

CONCLUSION

The Eburnean phase D1 was characterized by a metamorphism in the amphibolite facies with a complex plutonism marked locally by the formation of migmatitic gneiss. As in the genesis part of Liptoko, this ductile and major phase D1, related to the general shortening NW-SE brought the development of schistosity/foliation with an average $N5^0$ orientation. This was later affected by a mylonitization episode related to the working of some pronounced shearing corridors with $N50^0$ orientation, which would be associated with the setting up of the granitoids.

The Pan-African phase D2 varies from ductile to semi-ductile is marked by a schistosity/foliation through pure flattening with a $N20^0$ to N50º orientation, strongly straightened. This schistosity/foliation, which affects the schist and the Pan-African granitoids was related to an average direction of E-W to NW-SE shortening. It was continued by a right mylonitization episode. The contribution of some new radiometric data has enabled to precisely prediction of late Pan-African age of this ultimate episode of semi-ductile deformation (506 to 475 Ma).

Phase D3 that came later was eventually brittle and was characterized by two episodes of fracture schistosity of $N35^0$ to $N120^0$ and $N40^{0.}$

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