Hindawi
International Journal of Geophysics
Volume 2019, Article ID 9148678, 12 pages
https://doi.org/10.1155/2019/9148678

Research Article

Evidence of Major Structural Features over the Pan-African Domain in the Bertoua-Mbangue Area (East Cameroon) from a Multiscale Approach of Modeling and Interpretation of Aeromagnetic Data

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Received 11 June 2018; Accepted 29 August 2018; Published 3 March 2019

Academic Editor: Marco Bonini

The aim of this study is to investigate crustal structures from East Cameroon, using aeromagnetic data. The modeling of aeromagnetic data is conducted using the Oasis Montaj 8.0 software. The total magnetic intensity map reduced to the equator (RTE-TMI) shows important anomalies features, namely, the Northern East magnetic anomalies of high amplitude, the Southwest where very low values of the magnetic intensity were observed, and a corridor with negative values relatively high, separating the anomalies. The horizontal gradient map shows on the one hand brittle and folded structures carried out in the area of study and on the other hand various rectilinear, narrow, and short-wave anomalies that can be classified as a family of little faults. The maxima observed on the RTE-TMI maps are correlated to intrabasement contacts; and the map derived from Euler's solutions permitted to evaluate the depth of the geological accidents observed from the other filters. This map also reveals new faults with a depth greater than 5000 m. The lineaments identified in the Southwestern part could be linked to the Pan-African orogeny and seem to correspond to deep-seated basement structures, which are referred to the tectonic boundary between Congo Craton and the Pan-African orogeny belt. A $2^{3/4}$-D modeling confirmed the observations derived from the RTE-TMI and HGM maps analyses. It shows intrusive bodies composed of gneiss and porphyroid granite and some domes with their roof situated at various depths not exceeding 1800 m from the surface. The structural map of the study area shows the trending of the structural features observed, namely, NE-SW, NW-SE, ENE-WSW, and WNW-ESE, respectively, while the E-W and N-S are secondary orientation of the observed tectonic evidence. Moreover, circular anomalies observed over the area are assimilated to intrusions of high magnetic materials or to granitic domes.

1. Introduction

The area of study is a region characterized by tectonic features such as faults, folds, and important undulations. The analysis of lineaments represents an important step in geological surveying. Toteu et al. [1] qualified the studied area being geologically important due to the fact that it is crossed by the Central African Pan-African Chain and the Congo Craton.

In order to have a better understanding of the tectonic environment of the area located in the Eastern part of Cameroon that comprises 04°30′ and 05°00′ latitudes and 13°00′ and 14°00′ longitudes, the aeromagnetic method is applied through various aeromagnetic data analyses including horizontal gradient method (HGM), Euler deconvolution, and the upward continuation. This multiscale approach is very economical, fast, with a noninvasive implementation, and without impact for the environment [2–4].

The objective of this study is the reinterpretation of aeromagnetic data of the East Cameroon region with a focus on structural investigation of folds and faults based on a multiscale approach of data processing techniques and correlating linear and circular structures with regional geology; this will permit ameliorating the geological knowledge information of the area under study.

2. Geological and Tectonic Facts

A synthesis of the work of many researchers [5–7] reported that Central Africa consists mainly of granitic rocks and metamorphic rocks, which outcrop from Cameroon to Sudan.

The African continent is constituted by several stable or cratonic zones separated by mobile zones [8]. They are geological belts and rejuvenated areas [9]. The mobile zones located on the margin of the Archaean and Proterozoic orogeny constitute the foyer in which most of the African geological history is played in the sense that they experienced tangential compression and more or less vertical longitudinal accidents [8, 9].

The Pan-African formations of Cameroon belong to the mobile zone of Central Africa [10], also known as the Oubanguide chain [11, 12]. It is attached to the East to Pan-African formations of the Mozambican belt of submeridian orientation. To the West, it extends to the North of Brazil by the Sergipe range. The set forms an orogenic mega belt of E-W direction.

The Pan-African of Cameroon corresponds to a set of metamorphites and plutonites whose age varies between 800∓50Ma and 500 ∓50Ma. The Pan-African formations can be grouped into two large groups on the basis of their tectonometamorphic and lithological evolution, namely, formations inherited from an older building but restructured and partially reworked Pan-African; and Pan-African formations "sensu stricto" set up during the orogenesis. Pan-African formations inherited from an older settlement are found between the Archean Craton in the south and the northern domain of the chain [6, 13], while the Pan-African formations proper correspond to the Yaounde group, to the series of Lom and Poli.

Two large dextral mylonitic shear zones, the Sanaga Fault [14] and the Cameroon Center Shear Zone, cross Cameroon from northeast to southwest. These major shears belong to the Oubanguid setback zone [15], which continually follows from the Gulf of Guinea to the Gulf of Aden [5]. However, the Center Cameroon Shear Zone is the major element of the Adamawa tectonic bundle; it is a ductile to ductile brittle dextral shear zone striking ENE-WSW [6, 16]. It constitutes a combined system of faults continuing in RCA and East Africa. It is a mega-lineament of several hundred kilometers long, representing reefs of ancient lithospheric scale faults. These faults are replayed in dextral shear zones at the end of the Pan-African and then in the Cretaceous by creating a series of grabens. This area controlled during the neoproterozoic the establishment of many so-called "syntectonic" granites.

The basement here is relatively rigid. This ability generates brittle tectonics, where faults abound. Fields of faults, or flexures, are located in the edge of old basement [8]. The intensity of the stresses has generated two types of accidents: swellings, resulting from less intense tectonics, and faults, when the tectonic forces are greater [8].

The study area is situated within the East Cameroon region, precisely between $04^{\circ}30'$ and $05^{\circ}00'$ of latitude and $13^{\circ}00'$ and $14^{\circ}00'$ longitude (Figure 1).

From the orographic point of view, there are many types of reliefs encountered over the studied area, notably the granitic relief, which shows different forms like peaks, hills, or rounded domes. These domes are generally made of nude rocks. We can also note the presence of cristallophyllian relief, made of undulations, low hills, and compact banks.

Geologically, it belongs to the Pan-African mobile chain, which is composed of granites, schists, micaschists, and migmatites [11]. The geochronology shows rejuvenation during 500-600 Ma and the rock formations are subjected to the Pan-African tectonic event [11].

The geological formations of this domain are polycyclic and affected by three phases of the Pan-African deformations, accompanied by metamorphic recrystallization [17]. The first phase develops a schistosity S_1 which carries L_1 mineral lineation, C1 shear surfaces, S-C structures, and P_1 pleats. The second phase of deformation puts in place C2 shears, P2 pleats admitting S2 as schistosity of the axial plan, and a L2 lineation. The third phase of deformation is essentially brittle and characterized by C3 shears accompanied by P3 great undulations [17].

Recent geological studies performed by several authors [13, 16, 18–20] show the presence in the domain of high grade gneiss from the paleoproterozoic age (2100 Ma) intruded by syntectonic neoproterozoic plutonites (550 ± 50 Ma).

Figure 1 shows the various foliation and tectonic lines observed in Cameroon [1]. These foliations resulted from two major phases of deformation that are the Congo Craton and the Pan-African Channel of Central Africa. Toteu et al. [1] proposed a tectonometamorphic evolution that led to the collision model with a boundary between these two units which are located (see also [21–25]).

The geodynamic context is the one of the collisions between Congo Craton in the South and Pan-African Chain of the Central Africa. The Congo Craton extends at depth of approximatively a hundred kilometers under the Yaoundé layer [26]. The actual limit of Craton and Pan-African is the erosion limit and in the Pan-African the layer covers the Craton to the South [27].

The detailed geological map (Figure 2) of the area [28] reveals a dense hydrographic network characterized by the presence of rivers as Biatié, Bien, Kogo, Koubou, Kounié, Ndo, Ngoun, Nguinga, Njo, Séssé, Singuila, Talimbe, Toungou, Yasso, Yol, and Yong, that belong to the principal collector, namely, the Sanaga stream on one hand; on the

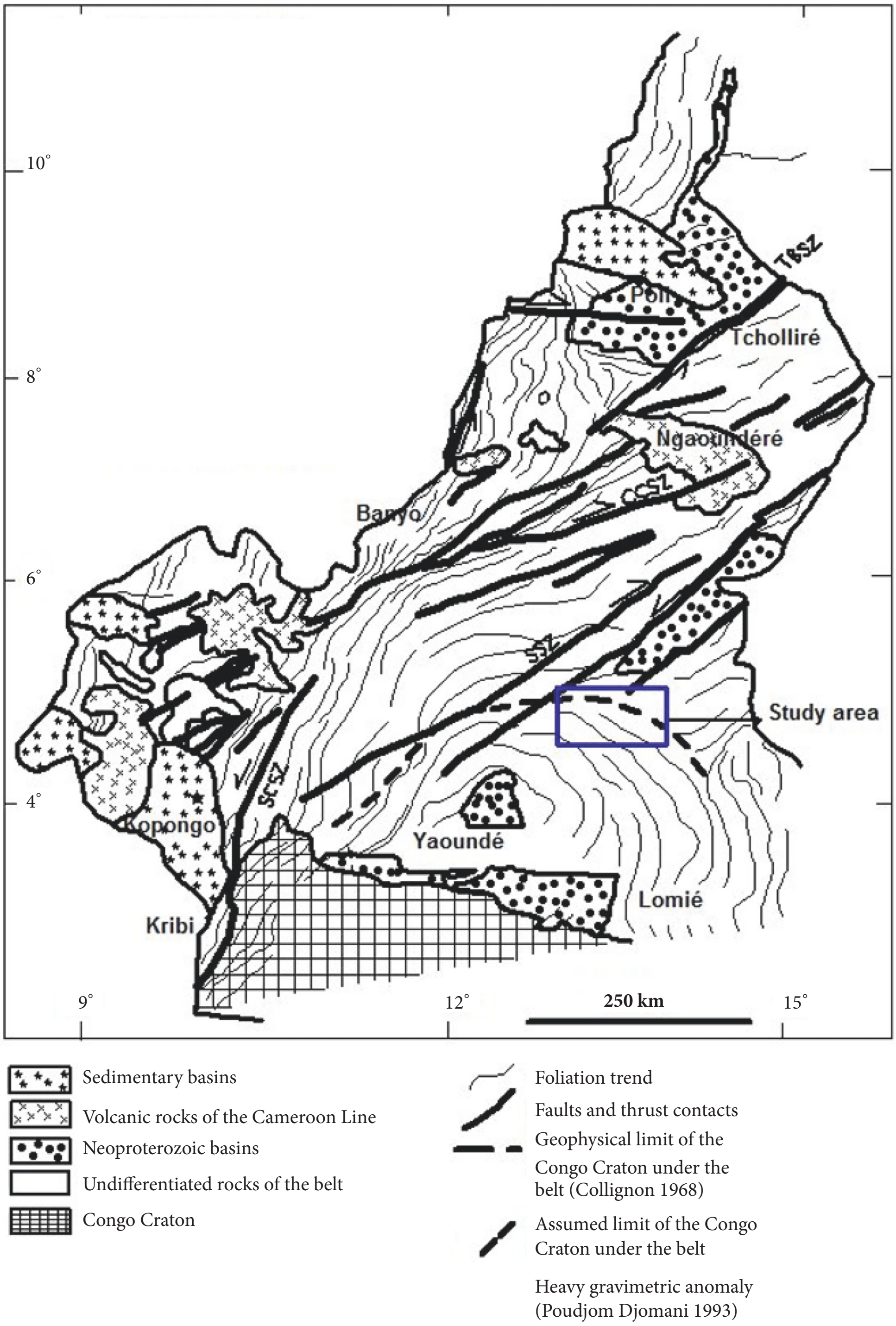


Figure 1: Foliation and lineation trends compiled from the previous geological reconnaissance maps of Cameroon at 1: 500,000 000 modified by [1].

second hand, it shows that the region is almost totally covered with migmatites, gneiss, and granites.

In addition, michaschists and quartzites are put in evidence by [29].

Several geophysical studies have been carried out at the regional level in the Southern part of Cameroon, which corresponds to the edge of Northern Congo Craton. In that channel, Manguelle Dicoum et al. and Meying et al. [31, 32] using AMT investigations have, respectively, put in evidence a schist-granitic contact within the Congo Craton formation as a major tectonic dislocation and a SW-NE tectonic fault which seems to correlate with the Centre Cameroon Shear Zone in Akonolinga/Ayos/Nguelemendouka /Abong-Mbang area at the Southwest side of the study area. Also, these AMT

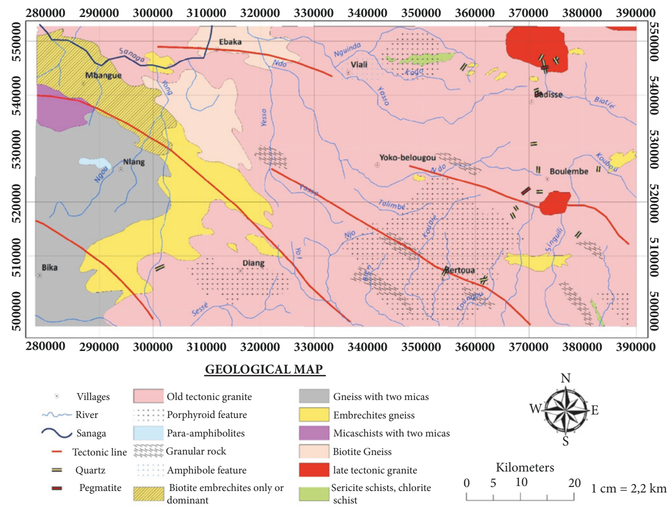


Figure 2: The geological map of the area of study (modified from [28, 30]).

surveys and interpretation have highlighted establishment links with the Central Cameroon shear zone putting in place process.

Gravity studies are carried out in adjacent areas and partly over of the area under study investigation. Tadjou et al. [33] identify many structures like contacts, dykes, fractures, and faults in the transition zone between the Congo Craton and the Pan-African Belt in Central Africa. Shandini et al. [34] put into evidence in the northern margin of the Congo Craton a deep structure, which corresponds to a classical model of collision suture of the West-African Craton and Pan-African belt. The work of [35, 36] put also in evidence a deep structure in the northern margin of the Congo Craton, which results from an active collision margin during the Pan-African orogeny. The latter also produced considerable overthrusting of the Pan-African formations onto the Congo Craton formations.

Noutchogwe et al. [37] have defined the density distribution of the crust and signature of the structures. In spite of the results obtained from other methods, a multiscale analysis using aeromagnetic data is still being necessary to be carried out in order to establish correlations with the existing results as pointed out by [37].

3. Data Acquisition

The data set used in the present study is from an aeromagnetic survey covering some parts of Cameroon territory [29]. This aeromagnetic survey was conducted in 1970 by Survair Limited (Ottawa) as part of a cooperative agreement between the Canadian and the Cameroon governments. The flying height was 235 meters, flight lines had a N-S direction with 750 meters interlines space, and the recording sensitivity of the magnetometer used was more or less 0.5 nT [29]. The final report of Paterson et al. [29] was accompanied by magnetic maps. Aeromagnetic data interpreted in this paper were extracted from one of these maps covering the study area. The total magnetic field data were continued upwards to a height of 500 meters.

4. Methodology

The treatment of data was done using many filters and operators such as horizontal gradient, upward continuation, Euler's deconvolution, and 23/4D modeling. All these filters have allowed us to perform the structural investigation in the study area.

4.1. Horizontal Gradient Method (HGM). The horizontal gradient filter enables the location of geologic contacts of bodies in the soil. The advantage of this method is its nonsensitiveness to noise provided by data during the aeromagnetic survey, because it depends only on the calculation of the primary derivatives of the magnetic field in the horizontal map [38].

This function gives a maximum above geologic contacts if the following assertions are gathered [38]:

(i) The regional magnetic field should be vertical or horizontal according to our position on the surface of the earth.

(ii) The magnetization should have the same direction with the regional field.

(iii) The geologic contacts should be vertical.

(iv) These contacts should be isolated.

(v) The magnetic sources should be thick.

The violation of the first four assertions will cause the displacement on the map of local maxima above contacts and the violation of the fifth will cause a second maximum parallel to the contact. To solve these problems, data should be transformed by the reduction operator on the poles and the analytic signal which does not depend on the magnetization directions and the magnetic field will help in the definitive choice of geologic contacts.

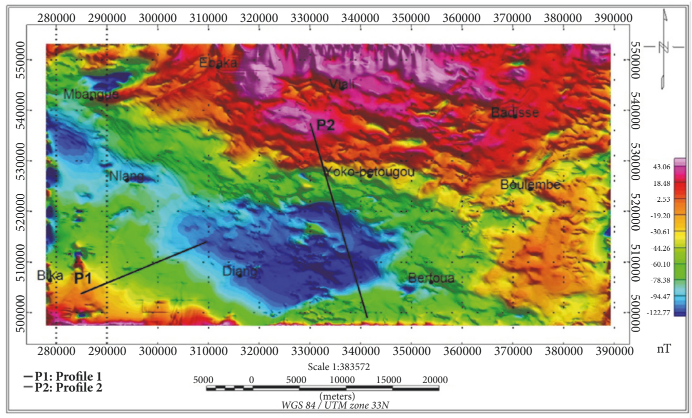


Figure 3: Total magnetic intensity map reduced to the equator.

4.2. Upward Continuation. This operation transforms the initial magnetic field by applying a low passed filter that attenuates short wavelengths while amplifying high wavelengths. We distinguish two types of extensions [39], namely, the upward continuation, which attenuates the amplitude, and a smoothing, which is a transformation that takes the anomaly from the altitude z = 0 to the altitude z >0. This operator corresponds to a low frequency filter that permits to attenuate anomalies of great wavelength.

4.3. Euler's Deconvolution. It is used as a filter that permits to localize sources of anomalies. This method was described by [40–43].

4.4. Modeling. The modeling consists of in fitting the observed anomalies and computed curve based on bodies representing the possible geological units present in the subsurface [44].

5. Results

5.1. Total Magnetic Intensity Anomaly Reduces to the Equator Map. The total magnetic intensity reduced to the equator (RE-TMI) map (Figure 3) analyses, permitted to interpret the deep structures, but it has the disadvantage of having a background noise generated by the wavelengths. In theory, the reduction at the equator transforms an anomaly caused by a body subjected to a magnetization having an inclination different from zero, into another anomaly, which is associated with the same body if the inclination of the magnetization is zero. From the spatial representation point of view, the anomaly passes from any form to a characteristic symmetric form, with a central latitudinal lobe surrounded in North and South by two lobes of opposed sign to the first [3]. The main sources of magnetic anomalies are assumed to depend on the magnetic properties of the basement [3].

The reduction to the equator has been computed using the values of the magnetic inclination and declination respectively (Im = -13.98°; Dm = -5.33°), on 1st January 1970 for the area located between latitudes 4°30 N and 5°00 N and longitudes 13°E and 14°E.

In Figure 3, a relatively good correlation between the observed anomalies and the geology of the study area was noticed. Granites mapped by Gazel [30] and Gazel et al. [28] in the North might be characterized by the great and medium amplitudes reaching 43.06 nT. The micaschists could be characterized by low amplitudes reaching -122.77 nT. Granites and micaschists might be separated by gneiss rocks, characterized by magnetic anomalies with amplitudes ranging between -78.38 nT and -30.61 nT.

The anomaly map of the total magnetic field reduced to the equator (Figure 3) shows almost symmetrical anomaly. The negative anomalies have moved to the Southeast, suggesting that these anomalies were probably associated with the body having a well-induced behavior.

The area of study shows a magnetic relief perturbed by many anomalies. It is divided into three main magnetic domains. The North and East parts are characterized by elevated values of the magnetic field ranging between -2.53 nT and 43.06 nT, with the Western and Southern parts characterized by very weak values ranging between -78.38 nT and -122.77 nT of the magnetic field. Also, there is a domain, constituted of the intermediate values, which takes all of the NW-SE diagonal ranging between -44.26 nT and -78.38 nT. This intermediate domain forms a corridor which seems to properly correspond to the tectonic line emphasized on the geologic map. At the Northwest side, we can equally note the presence of lineament trending ENE-WSW that could well be linked to the Sanaga river fault.

The RTE map shows a contrast that is assimilated to a channel between the Pan-African Mobile Belt (PAMB) of Central Africa and the Congo Craton. Thus, the Northeastern part characterized by the positive anomaly values seems to correspond to the PAMB, while the Western part constituted by negative anomalies would mark the Craton Congo. The two zones are separated by a transition subarea dominated by relative negative low values of magnetic anomalies

The transitional subarea delineated between the Congo Craton and the PAMB is oriented SE-NW and it is in

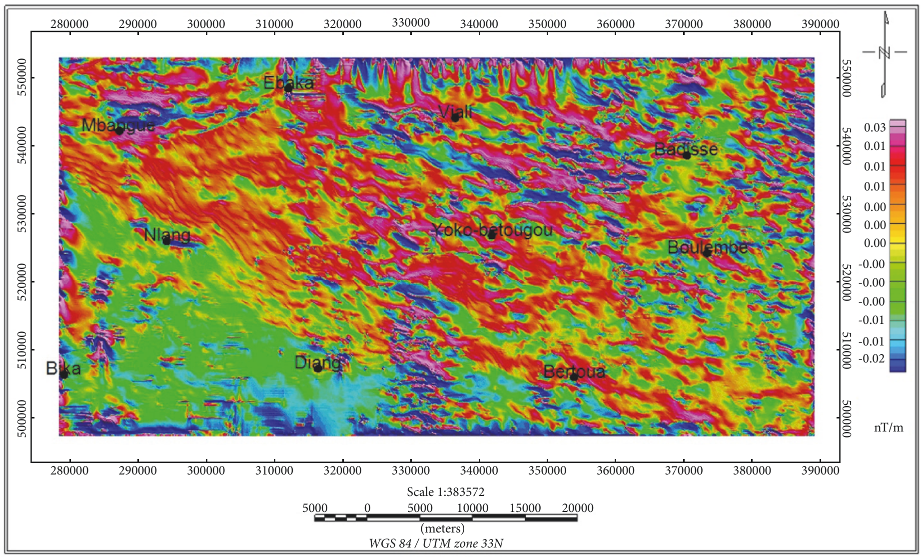


Figure 4: Horizontal gradient map.

coherence with the tectonic line identified by geological setting [5, 28, 30].

The tectonic facts put in evidence through the qualitative analysis of the RTE map (Figure 4) are witnessing the fact that the study area has been affected by intense folding events.

5.2. Horizontal Gradient

5.2.1. Analysis of the Horizontal Gradient Map. Total horizontal derivative filter is an effective tool in detecting edges of magnetized structures [45, 46] and it tends to accentuate shallow anomalies. The horizontal gradient anomaly map (Figure 4) reduced to the equator (RTE) confirms with precision the presence of brittle and folded structures as portrayed in previous geological studies carried out in the area under study. Various anomalies such as rectilinear, narrow, and short-wave anomalies can be classified as a family of little fractures. Anomalies present undulated forms characterize the intensity of the wave that has taken place in the area. The small anomalies trend (Figure 4) is in accordance with the rosette (Figure 6(b)) and shows, respectively, WSW-ENE, WNW-ESE, SW-NE, SE-NW, and E-W directions. Several zones of strong gradient anomalies having a high magnetic susceptibility contrast are also put in evidence. A SW-NW trending tectonic line crosscuts Badissé and extends for several kilometers to the North.

However, this simple HGM map does not allow us to summarize well the main limits between contacts; therefore the horizontal gradient of upward continuation is used, to enhance the quality of the information related to the contact among geological formations.

5.2.2. Maxima Horizontal Gradient of Upward Continuation Map. The horizontal gradient is the best way to localize geological contacts in the basement, especially faults by determining their track, dip and their degree of importance [47, 48]. Indeed, the limit between two blocks characterized by different susceptibilities is underlined by the line representing the local maxima value of this gradient. The magnetic anomaly situated above a vertical contact is materialized by a curved line with a minimum on the side of the rocks with weak susceptibility and a maximum on the side of the rocks with higher susceptibility. The inflexion point of the curve is located at the balance point of this contact, thus materializing the maximum of the horizontal gradient [48, 49].

Figure 5 shows the superimposition of the horizontal gradient reduced to the equator map of maxima and the upward for 1 km, 2 km, and 3 km. A structural complexity marked by the alignment of the maxima is observed; it suggests the existence of many linear structures that affected basement rocks. The configuration of these maxima brings out various structural directions which are ESE-WNW, ENE-WSW, NW-SE, NE-SW, and E-W. These are most important structural directions which reveal the presence of deformations at the local and regional scales and are characterized by folds, faults, and fractures that follow the above-mentioned structural trends.

The map of Figure 5 shows anomalies associated with continuous geological contacts. Figure 6 also shows anomalies following the WNW-ESE, ENE-WSW, NW-SE, and E-W trends. These anomalies correspond to areas of magnetic contacts and could be characterized by diverging magnetic susceptibility values, associated with folds, fractures, and faults. Two major categories of contacts are distinguished, namely,

(i) the rectilinear high intensity contacts observed over several kilometers and representing fault signature,

(ii) the circular contacts.

Some contacts of the latter category are found at Viali, Ebaka, Mbangue, and North of Bertoua and they are characterized by intrusive rocks.

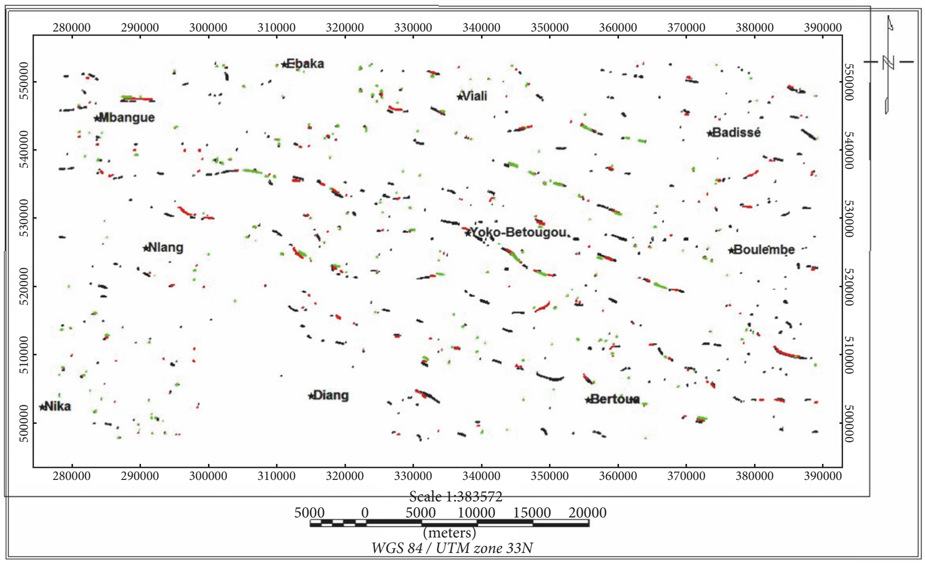


Figure 5: Superposition of maxima of horizontal gradient of RTE upward continued to 1 km, 2km, and 3 km.

The structural map of Figure 6(a) displays the lineament synthesis obtained from superimposing of maps of local maxima extended horizontal gradients maps up to 1000m, 2000m, and 3000m distance. It summarizes the essential lineaments highlighted over the study area.

It reveals lineaments with three major trends, which are NE-SW, NW-SE and E-W, respectively. The NW-SE direction is the dominant.

5.2.3. Euler Map. Euler solutions were calculated according to the following parameters: structural index is 0, tolerance is 10, while the window size is 15. The structural index equal to 0 allows highlighting the observed magnetic contacts over the study area.

A similarity between the Euler solutions map (Figure 7) and the magnetic lineaments obtained from the horizontal gradient map (Figure 4) is noticed.

The fault identified at the Northwest of Mbangue area is highlighted through a clustering solution that coincides with the directions of lineaments observed on the structural map (Figure 6(a)). Badissé's structural line is also put in evidence on Euler's map. The general trend of weaknesses within the subarea where potential ores mineralizations can be found is linked to the regional tectonic deformations of rocks encountered in the Mbangue-Bertoua area.

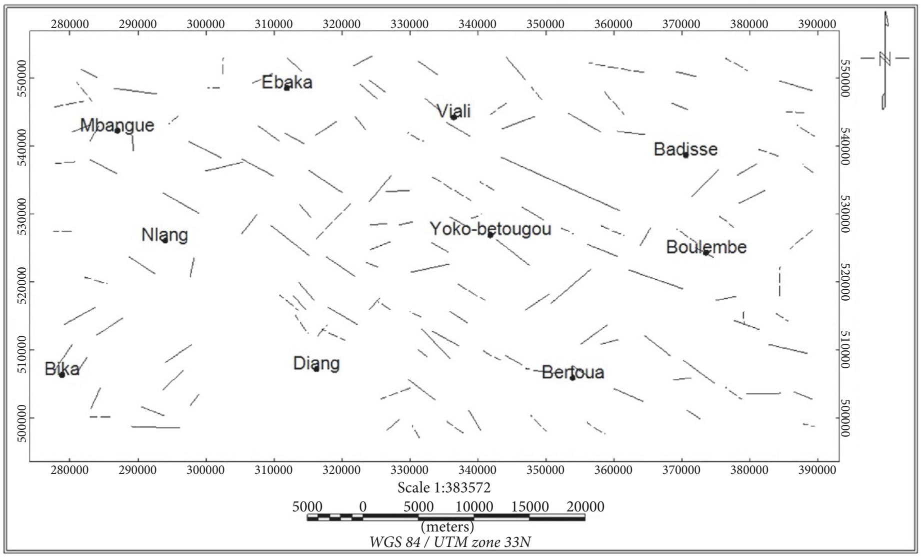
The Southwestern area has few solutions and too little magnetic contacts, which means it is stable and the tectonic activity intensity is very low. It seems to correspond to the Congo Craton. The rest of the map has a many solutions which imply existence of a broad set of linear contacts. The contacts may be associated with granitic rocks remobilization. These linear contacts follow the same group of trends revealed by the HGM analyses and they are NE-SW, NW-SE, and E-W. Notably, they have the same general direction as the Central Cameroon shear zone (CCSZ).

On this map (Figure 7), it is noted that the alignment of the solutions indicates other new faults at Southern and Southeastern parts of the study area. The Euler solutions map better distinguishes intrusive bodies from deep faults. Thus, the Southwestern zone is the site of the very deep faults, whereas the Southern part is faulted to about 3000 m depth. The rectilinear and continuous alignment of Euler's solutions characterizes geological accidents in the cratonic basement. The major direction here is WNW-ESE while the secondary directions are NW-SE, E-W, and NE-SW.

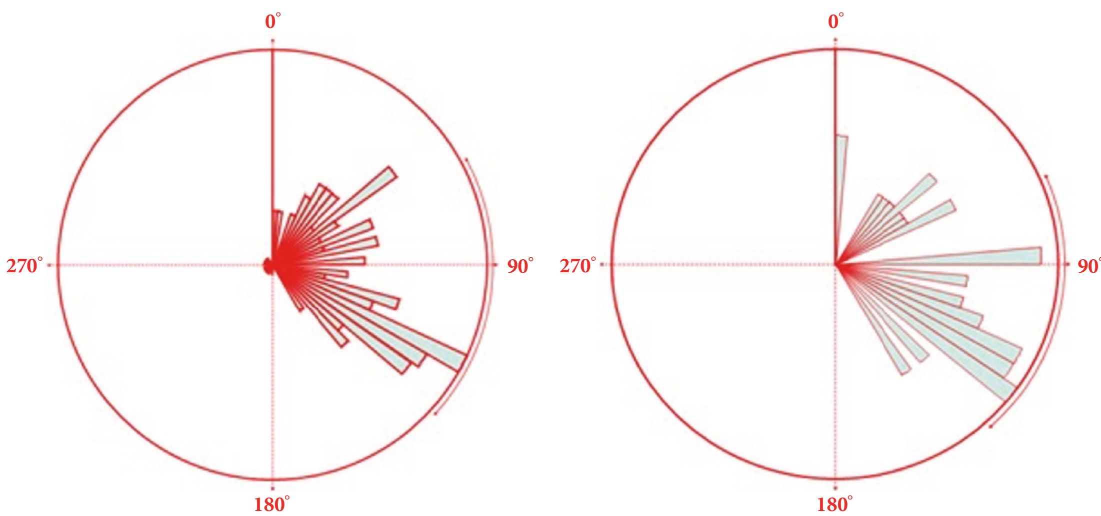
The deepest geological accidents are WNW-ESE and NW-SE, with depths of more than 14000 m, and are located in the Southwestern part of the study area, which is covered by two mica gneiss and granites.

The absence of these contacts in the preceding maps justifies the deep nature of these structural tectonic facts. The compact form of Euler's solutions around Mbangue suggests an intrusion of buried material of about 3000 m deep. Linear contacts observed in the Southern area reflect discontinuities like faults which have depth ranging from 3000 m to 14000 m; the semicircular forms could reflect intrusion of materials at depths up to 5000m.

5.3. $2^{3/4}$-D Modeling. Theory and application of modeling the source body of this study were performed by the Oasis Montaj's GM-SYS module 8.0 that permits forward modeling of magnetic data to obtain the optimal fit of the generated source model to the observed data. GM-SYS is based on the algorithms described by [50, 51]. The calculated responses change iteratively with the change of the model parameters, particularly the magnetic susceptibility. The two selected profiles are thus modeled using the forward modeling of the GM-SYS to predict the shape and mean depth of the shallow horizontal pipe. Figures 8(a) and 8(b) present the GM-SYS application of the modeled profiles based on the input model



(a) Structural map of the study area



(A) (B)

(b) (A) Rose diagram of the major lineament orientations. (B) Rose diagram of the minor lineament orientations

Figure 6

parameters and the automatic iteration procedure. They are depicting the shape and the depth of the pipe source as evident from the consistency between the observed and the calculated field curves occurred at different depth values.

5.3.1. Profile 1. The magnetic profile P1 is located between Bika and Diang localities with the following boundaries [(284667.7 m; 503521.9m) and (309577 m; 513826.4 m)] with a total length of 19 km. It crosscuts a medium to low amplitude magnetic anomaly under ENE-WSW direction. This profile crosses successively from WSW to ENE two mica gneiss, embrechits gneiss, granite, and porphyroid granite. Figure 8(a) presents a structural model of this study. This model presents a superposition of the calculated curve (solid line) generated from the subsurface magnetic bodies on the measured curve (dotted line) inferred from magnetic data.

The study of the model exposes that the area surrounding the profile is influenced by the magnetic effect of rocks intrusion such as gneiss, embrechits, and pophyroid granite. The basement is a granite characterized by a magnetic susceptibility of 23.10^3 SI. Meanwhile the intrusive bodies of gneiss, embrechists, and porphyroid granite have magnetic susceptibility contrast which are 12.103 SI, 28.103 SI, and 45.103 SI and are located approximatively at 500, 300, and 1800 m depth, respectively. These intrusions are interpreted as the uplift of basement in the region during Pan-African orogeny [8].

5.3.2. Profile 2. The magnetic profile P2 (Figure 8(b)) is located between Yoko-Betougou and Bertoua localities with the following boundaries [(330023.8 m; 537275.3m) and (341342.6 m; 498815.9 m)] with a total length of 43 km. It

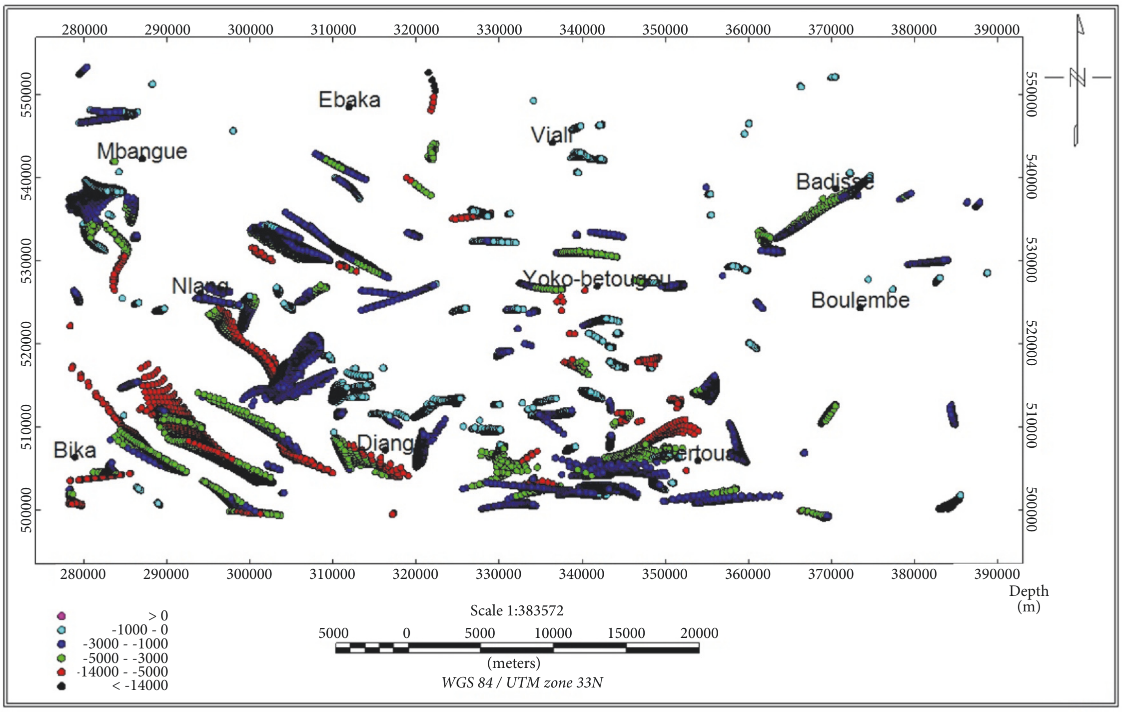
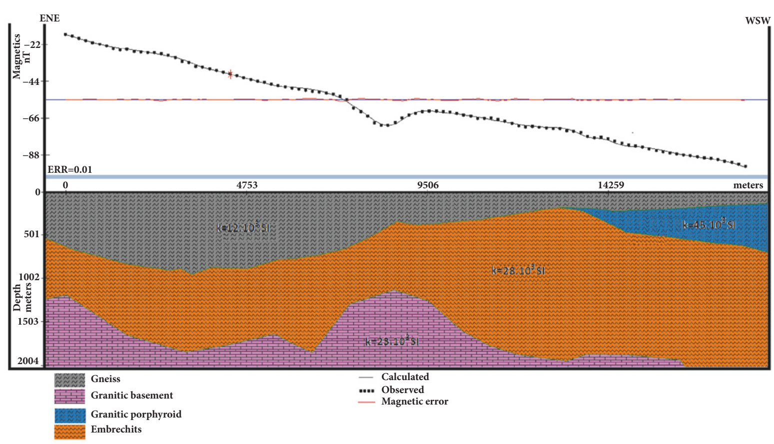
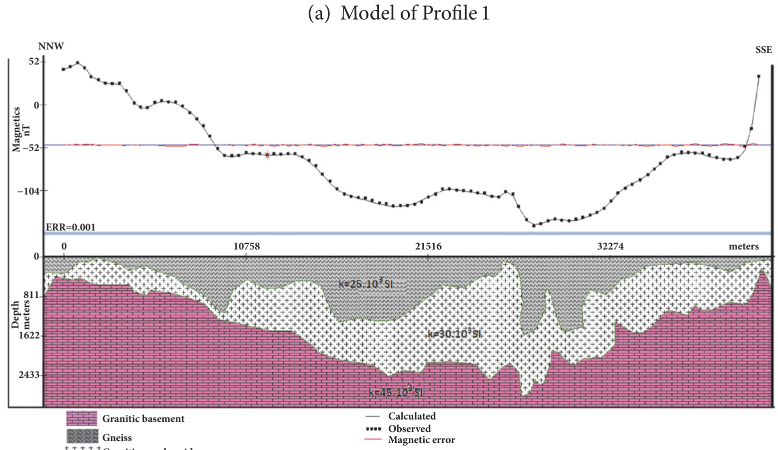


FIGURE 7: Euler solutions map.



(a) Model of Profile 1



(b) Model of Profile 2

FIGURE 8

crosscuts a low to high amplitude magnetic anomaly following a NNW-SSE direction. This profile crosses successively from NNW-SSE three geological formations, namely, gneiss, granite, and porphyroid granites.

In the model, it is considered that the basement is granitic with a magnetic susceptibility of 45.103SI. Thus, intrusive bodies are gneiss and porphyroid granite with magnetic susceptibility contrast is 25.103 SI and 30.103 SI and is located approximatively at 300 and 1000 m depth, respectively. This magnetic profile presents some discontinuities sprung from intrusions. These intrusions were put in place during the thrusting of the Pan-African Fold Belt over the Congo Craton [8].

6. Discussion

The RTE-TMI map presents three important anomaly sectors, namely, the Northern East characterized by magnetic anomalies of high amplitude, the Southwest where very low values of the magnetic intensity are observed, and a corridor with negative values relatively high, separating the two sectors. This distribution of magnetic anomalies correlates with the geological observations [28, 30], in which granites and migmatites are, respectively, found in the Northeast and Southeast, while gneiss rocks are identified in the corridor. The big corridor separating the two subareas seems to correspond to the tectonic line highlighted by [28]. The structures responsible for these anomalies seem to be located deep in the crust and are probably intrusive bodies with high magnetic properties.

From the tectonic point of view, the horizontal gradient anomaly map (Figure 5) has enabled us to observe many undulated anomalies having short wavelength. The latter could be correlated to structural formations such as folds and foliations. Their origin can be linked to ductile deformations of the basement related to Huronian orogeny as stated by [52]. Generally, the structural deformations are directed WSW-ENE, ESE-WNW, SE-NW, SW-NE, and E-W. From a regional scale, the fold systems trending NE-SW and NW-SE are in accordance with the directions highlighted in geological investigations focused on the deformation history of the Neoproterozoic Central African Belt in Southern Cameroon by [52], in adjacent areas situated below the present study area. These aligned, short wavelength anomaly dispositions show the presence of other structural features such as fault. In addition, the observed tectonic features have linkage with fault and fold lines oriented NW, SW-NE, WNW-ESE, WSW-ENE, and W-E, as identified by geophysical surveys carried out in gravity [9, 32, 53, 54] and aeromagnetic [3] in areas situated below the current study area.

The horizontal gradient map with upward prolongated values shows four main families of lineaments directed, respectively, ENE-WSW, ESE-WNW, NW-SE, and NE-SE. The NE-SW trend is the outcome of compression which has occurred along the NW-SE axis during regional neoproterozoic metamorphism. This structural trend seemingly resulted from the collision of the Pan-African Chain and the Congo Craton, as proposed by some authors [1, 55]. The ENE-WSW and NE-SW trends correspond to the Central Cameroon Shear zone [1].

Euler's deconvolution anomaly map presents a cluster of solutions to the South of the studied area. The solutions observed to the West of Bertoua may be associated with small scale anomalies or structural deformations. This map also reveals new faults with a depth greater than 5000 m. The lineaments identified in the Southwestern part could be linked to the Pan-African orogeny and seem to correspond to deep-seated basement structures, which are inferred to represent the tectonic boundary between the Craton and the Pan-African as being stated by [1].

The lineaments with a NW-SE and ESE-WNW trends seem to correlate with those resulted from the Pan-African orogeny and correspond to the limit between the Central Africa Pan-African Chain and the Congo Craton, as evidenced by Basseka et al. [35] in gravity analysis investigations. These trends also correspond to those identified on the Adamawa plateau [37], as well as in the survey carried out by Dumont et al. [9] who identified the Central Cameroon shear zones.

7. Conclusion

The results highlighted from the present study have enabled improvement of the geological and geophysical information of the studied areas. Various linear structures as lineaments and tectonic lines were identified. They are principally oriented ESE-WNW, ENE-WSW, NE-SW, and NW-SE, some with a lower frequency trend E-W and N-S. The observed structural features (faults; folds) confirm the intense tectonic movements that occurred over the area. Heavy magnetic materials and granite domes that correspond to huge circular anomalies are put in evidence. All these identified structural elements are in accordance with the results obtained from previous geological and geophysical surveys [3, 9, 32, 37, 54] carried out in the study area and neighbouring zones. The study area, although located on the Pan-African chain, could be seen as the fingerprints of the Congo Craton due to the observed NW-SE trend of structural features. A $2^{3/4}$-D modeling has confirmed the observations derived from the RTE-TMI and HGM maps analysis. It shows intrusive bodies composed of gneisses and porphyroid granites and domes with their roof situated at various depths not exceeding 1800 m from the surface.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This work was carried out at the University of Yaoundé I, Cameroon, as part of first author's Ph.D. studies.

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