Gravity analysis of the boundary between the Congo craton and the Pan-African belt of Cameroon

Jean Marie TADJOU[1)2)*)], Robert NOUAYOU[2)], Joseph KAMGUIA[1)2)], Houetchack Ludovic KANDE[1)2)] & Eliezer MANGUELLE-DICOUM[2)]

[1)] National Institute of Cartography (NIC)-Cameroon, PO Box 157, Yaounde–Cameroon.

[2)] Department of Physics, Faculty of Science, PO Box 6052, University of Yaounde I–Cameroon.

[*)] Corresponding author, jtadjou1@yahoo.fr

KEYWORDS

crustal discontinuity
spectral analysis
2D1/2 modeling
Congo craton
Moho depth
Pan-African
analysis

Abstract

A gravity-based geophysical study was performed across the southern part of Cameroon to investigate the important Precambrian boundary between the Archean Congo craton and the Pan-African metamorphic belt. The study includes analyses of results from a long section of profiles in which allochthonous Pan-African rocks have been juxtaposed against the craton. Interpretations of gravity data from these profiles, combined with 2-D spectral analysis permit deep structures to be identified and depths of major crustal discontinuities to be determine. The later allow the evaluation of the mean Moho depth in the region at around 47 km and determining variations in the crustal density across the tectonic boundary between the Congo craton and the Pan-African fold belt. 2D1/2 modeling provides images of deep structures in the region. These reveal that the crust of the Congo craton is relatively thick and consists predominantly of low-density rocks. In contrast, Pan-African belt rocks are mostly relatively dense. The images suggest that a fault zone juxtaposed the high-density Pan-African domain in the north against the low-density Archean rocks in the south, at nearly 20 km crustal depth. An explanation for the enhanced low densities is that part of the lower crust beneath the craton domain is subsiding. In this case, a probable source for the enhanced high-density rocks is Pan-African ocean margin units, as suggested by their location at the edge of the Pan-African continental block.

Eine Gravimetriestudie wurde im den Südteil Kameruns durchgeführt um die bedeutende präkambrische Grenze zwischen dem archäischen Kongokraton und dem Panafrikanischen Metamorphose-Gürtel zu untersuchen. Die Studie beinhaltet Analysen der Resultate mehrerer Längsschnitte, in denen allochthone Panafrikanische Gesteine an den Kraton grenzen. Die Interpretation der Gravimetriedaten kombiniert mit einer 2-D Sprektralanalyse erlaubt es, Tiefenstrukturen zu identifizieren and die Tiefe der bedeutendsten Diskontinuitäten zu bestimmen. Daraus ergibt sich eine Abschätzung der mittleren Moho-Tiefe von 47 km in dem Untersuchungsgebiet, und die Bestimmung der Variationen der Krustendichte entlang der tektonischen Grenze zwischen dem Kongokraton und dem Panafrikanischen Gürtel. Eine 2D1/2 Modellierung ergibt eine kartenmäßige Darstellung der Tiefenstrukturen des Gebietes. Daraus ergibt sich, dass die Kruste des Kongokratons relativ dick ist und im wesentlichen aus Gesteinen niedriger Dichte bestehen, während die Panafrikanischen Gesteine vorwiegend hohe Dichten aufweisen. Aus der Modellierung ist abzuleiten, dass eine Störung die Panafrikanischen Gesteine hoher Dichte im Norden gegen Archäische Gesteine niedriger Dichte im Süden in einer Tiefe von 20 km abgrenzt. Die auffallenden niedrigen Dichten werden dadurch erklärt, dass Teile des Kratons samt der unteren Kruste absinken. Eine wahrscheinliche Quelle für die Gesteine höherer Dichte kann die Situation eines ehemaligen Panafrikanischen Ozeanrandes darstellen, wie auch durch die Lage am Rand des Panafrikanischen Kontinentblockes nahe legt.

1. Introduction

Calculations of the power spectrum from Fourier coefficients to obtain the average depth to a disturbing surface, or the average depth to the top of a disturbing body have been used widely in geophysical studies (e.g., Spector and Grant, 1970). The underlying assumption of the hypothesis is that the shallow sources are represented by high wavenumber parts of the whole spectrum, and only deep-lying sources contribute to the low wavenumber part. The subsurface can also be divided into a number of right rectangular prisms, and the observed gravity or magnetic field is a synthesis of anomalies produced by each of the ensembles. Each prism is described by a set of parameters such as their physical dimensions (e.g. length, width, and thickness), depths, and gravity contrasts (or magnetizations). Using this method, Pal et al. (1979), for example, compiled crustal thickness maps of India based on spectral analysis of Bouguer gravity data. Poudjom-Djomani et al. (1997), Nnange et al. (2000) and Kande et al. (2006) used the same approach to determine depths to major density contrasts beneath the West African rift systems and parts of the Adamawa uplift in Nigeria and Cameroon. With the same approach, and using both new and existing Bouguer gravity data within the Congo craton and adjacent areas, Nnange et al. (2000) identified three major discontinuities within the crust in this region.

In this paper, the depths to major crustal discontinuities in the Congo craton area of Cameroon are estimated using spectral analysis of total Bouguer and gravity anomalies. These depths allow the mean depth to the Moho to be evaluated in the region, and variations in the crustal density across the major tectonic boundary between the Congo craton and the Pan-African fold belt to be evaluated. Synthesis of our data and literature data allows a modified tectonic and geodynamic model for the boundary between the Congo craton and the Pan-African belt to be proposed.

2. Geological and tectonic settings

The part of the Congo craton under study, which is known as the Ntem Complex in the Cameroon, consists predominantly of Archean rocks with some reworked and resedimented material formed in the Paleoproterozoic (Tchameni, 1997; Tchameni et al., 2001). The Archean period is dominated here by the Liberian Orogeny, which began with the intrusion of magmatic rocks from which the greenstone belts were derived. Greenstone belt formation was followed by diapiric intrusion of the Tonalite-Throngemite-Granodiorite (TTG) between 2900 and 2800 Ma, during the major tectonometamorphic phase (Tchameni, 1997; Tchameni et al., 2001). The structures formed are essentially vertically dipping and the metamorphism dominated by granulite-facies rocks that ended with an important migmatisation event, resulting in the intrusion of anatectic potassic granitoids.

The Paleoproterozoic evolution of the Ntem Complex is equivalent to the Eburnean orogenic cycle, characterized by intrusion of doleritic dykes; this cycle ended with a thermal or hydrothermal event at around 1800 Ma (Tchameni et al., 2001). A general feature of rocks in this region is a schistosity formed during the intense Pan-African metamorphism; this is restricted to the contact between the Ntem Complex and the Pan-African fold belt. The main Precambrian boundary between the Congo craton and the Pan-African belt consists of metasedimentary rocks lying along the northern edge of the Congo craton (Nzenti et al., 1984; 1994; 1998). These are presumed to have been deposited in a continental rift environment, based on the presence of alkaline and metavolcanic rocks of the Yaoundé and Lom successions (Nzenti et al., 1998).

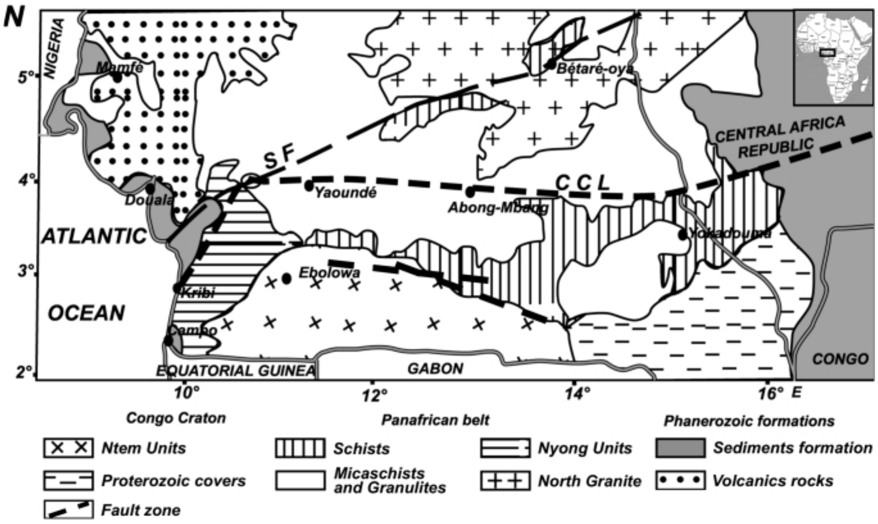

Figure 1: Geological sketch map of the southern Cameroon region. The major structural units shown are the Congo craton, the Pan-African belt, some Cretaceous to recent sediment (Mamfe, Douala-Kribi-Campo and Central Africa Republic) and volcanic rocks; SF: the Sanaga Fault; CCL: the northern Congo Craton Limit.

3. Methods of depth estimation by spectral analysis

Spectral analysis of gravity data uses the 2-D Fast Fourier Transform and transforms gravity data from the space domain to the wavenumber domain. Thus, if b(x) represents the discrete N data array of gravity data obtained by sampling a continuous profile at evenly spaced intervals Δx, the finite discrete Fourier transform of b(x) is given as:

$$B(\omega) = \sum_{0}^{N-1} b(x)\exp(-i\omega x).\Delta x \qquad (1)$$

where the capital letter refers to transform domain, i is the complex operator, ω = 2πk is the frequency and $k = \lambda^{-1}$ is the wavenumber in the x direction. The Fast Fourier Transform is obtained by summing the sequence over the number of samples. From Karner and Watts (1983) and Browne (1984), the expression of the Bouguer Slab Effect is:

$$B(k)_{z=0} = 2\pi\Delta\rho G.\exp(-2\pi kt).F(k)_{z=0} \qquad (2)$$

where $B(k)_{z=0}$ is the Fourier transform of the Bouguer anomaly profile $b(x)_{z=0}$, determined on an observational section due to a randomly distributed density contrast on an interface at a mean depth z = t; Δρ is the density contrast between two layers; F(k) is the Fourier transform of f(x), the derivation of the interface from the mean depth z; G is the gravitational constant. Thus, from equation (2) the power spectrum of B (k) is simply:

$$E = |B(k)_{z=0}|^2 = (2\pi\,\Delta\rho G)^2.|F(k)|^2 exp(-4\pi kt) \qquad (3)$$

The expected values of the power spectrum are expressed as the product of a depth factor and a size. This power spectrum exhibits intervals of wavenumbers in which the logarithm of the power varies approximately linearly with the wavenumber. The amplitude of the spectrum at any wavenumber is finite and approaches zero exponentially with increasing wavenumber. That is, the logarithm of power decreases linearly with increasing wavenumber within discrete segments of the spectrum. The slopes of these linear segments are proportional to the depths to the top of the prism creating the observed anomalies. The depth to causative mass distributions can be obtained by analyzing a plot of the logarithm of the power spectrum as a function of the wavenumber or frequency. Taking the logarithm of both sides of equation (3), one has:

$$LogE = Log\,A(k)_{z=0} \pm 4\pi kt \qquad (4)$$

where k is the wavenumber and t the depth to causative mass distribution; $A(k)_{z=0}$ refers to the amplitude spectrum. One can plot the wavenumber k against LogE to obtain the average depth to the disturbing interface. The interpretation of LogE against the wavenumber k requires the best-fit line through the lowest wavenumber of spectrum. The most commonly encountered situation is the one in which there are two ensembles of sources; deep and shallow. These ensembles are recognizable by a change in the rate of decay of the power spectrum with wavenumber. The mean ensemble depth dominates the spectrum so that a significant change in depth of the ensembles results in a significant change in the rate of decay. Then the average depth can be estimated by plotting equation (4) as:

$$h = \frac{\Delta LogE}{4\pi\Delta k} \qquad (5)$$

where h is the average depth, ΔLogE and Δk are variations of E and k respectively. The power spectrum generally has two sources. The deeper source is manifested in the smaller wavenumber end of the spectrum, while the shallower ensemble manifests itself in the larger wavenumber end. The tail of the spectrum is a consequence of high wavenumber noise.

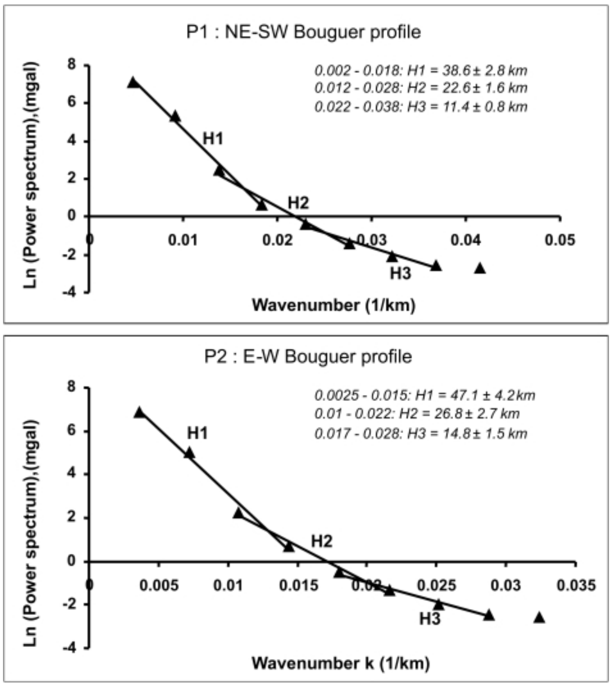

Figure 4: Power spectral analysis of gravity data. Plots of logarithm averaged power spectrum of the Bouguer gravity over the Congo craton versus wavenumber k for: NE-SW profile and E-W profile. The averaged power spectrum was calculated by means of a fast Fourier transform (FFT). Three mean depths to crustal interfaces H1, H2 and H3 in decreasing depth order have estimated from the slope of the corresponding segments.

4. Gravity data and interpretation

4.1 Gravity data and Bouguer anomaly map

Gravity data for this work were collected firstly between 1963 and 1968, during a detailed gravity survey of Cameroon and Central Africa undertaken by the Office de la Recherche Scientifique et Technique d'Outre-Mer - ORSTOM (Collignon, 1968, Louis, 1970), and secondly between 1970 and 1990, by other geophysical (gravity) campaigns (Hedberg, 1969; Albouy and Godivier, 1981; Okereke, 1984). The data were combined in this study in order to achieve a meaningful gravity data distribution within the region (Fig.2). The data set consists of 2,300 irregularly spaced gravitational acceleration values and corresponding elevation points. They were collected at 4 km intervals from all gravity stations including base stations, on all available roads and tracks in the area using Worden gravimeters (n°313 and 600) with a precision of 0.2 mGal. The gravimeter readings were corrected for drift and the gravity anomalies were computed assuming a mean crustal density of 2.67 g/cm^3. The maximum error in the Bouguer anomaly value for any of the stations due to the error in height determination is not expected to exceed 0.15 mGal.

The data were then interpolated to a regularly spaced grid using a finite element algorithm (Briggs, 1974; Inoue, 1986). An appropriate software computer program for carrying out a Kriging interpolation procedure (Golden Software Inc., 1993) was used to grid the data in this study. The resulting Bouguer anomalies were then plotted to obtain a Bouguer anomaly map (Fig.3) with contours at a 5 mGal interval. This map is broadly similar to those reported by Collignon (1968) and Poudjom-Djomani et al. (1995a).

A closer look at the Bouguer anomaly map (Fig.3) shows that, in general, low gravity anomalies occur in the centre of the area. A comparison of the main features of this map with the geological map (Fig.1) indicates that this central negative anomaly, with a minimum amplitude of approximately –100 mGal in the Bengbis zone (between Ayos and Djoum), is entirely located in schists and quartzites. The contour pattern of this anomaly indicates that to the north, east and southeast, beyond the mapped area, this body extends laterally at depth. The southwest portion of the negative anomaly occurs over outcrops of the So'o granitic rocks (Ntem Units) in the north-eastern part of Ebolowa. This anomaly may be due to an intrusion of the So'o granites within the basement of the area, which has a low negative density contrast with respect to the surrounding basement rocks. It should be recalled that although the density of granites lay between 2.50 and 2.80 g/cm^3, the So'o granite seems to have a density at the lower limit of this range. These granites extend at depth up to the

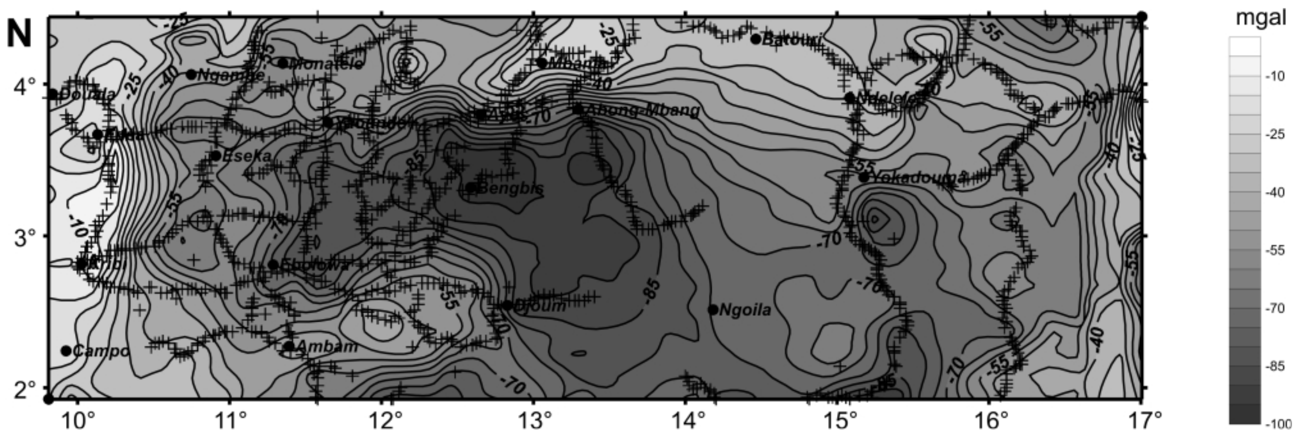

Figure 2: Gray scale image of the contoured Bouguer anomaly map and data distribution of the southern Cameroon (Intervals: 5 mGal; gray-scale unit: mGal). The map is based on gravity stations shown as crosses.

north, underlying the schists and quartzites. The association of large negative anomalies with Neogene uplift and alkaline in Africa is a common phenomenon in Africa and is interpreted as density deficiencies within the upper mantle beneath the uplifted areas (Fairhead and Okereke, 1988; Ebinger et al., 1989; Poudjom-Djomani et al., 1997; Nnange et al., 2000).

The western and northern borders of this anomaly are characterised by very high gravity gradients, and the anomalies in the region are positive relative to their immediate surroundings. These positive anomalies occur over or near higher grade metamorphic rocks (granulites and mica-schists). The observed zones of W-E trending high gravity gradients in the north, which occur over basic intrusive rocks, suggest the existence of a suture zone between two continental blocks. These gradients seem to be indefinite in the eastern part of the study area. In the western part, the observed S-N gradients occur over the Nyong units, which are also made of basic intrusive rocks. Therefore, the presence of these gradients, coupled with high positive anomalies also suggests the existence of a suture zone in this Precambrian oceanic area.

The south-western border of the area is characterised by a relatively positive anomaly trending NE-SW that seems to correlate with the intrusion of denser materials in the crust. At the southern border of the region, the positive anomalies observed are associated with gneisses and charnockites. The latter represent a deep-rooted structure that occupies the basement of the region. This basement seems to have been affected by the tectonic folding that characterises the transition zone between the stable craton and the Pan-African fold belt.

There are two main features in the area, coupled with gravity gradients: one at the northern margin and the other at the western margin. These features (Congo Craton Limit; CCL) are both related to normal faults (Fig.1 and Fig.3). The northern fault, in addition to its obvious strike-slip displacement, has a vertical component with the hanging-wall downthrowing to the south, southeast and southwest, enclosing a wedge-shape trough (Mbom Abane, 1997; Tadjou et al., 2004). The

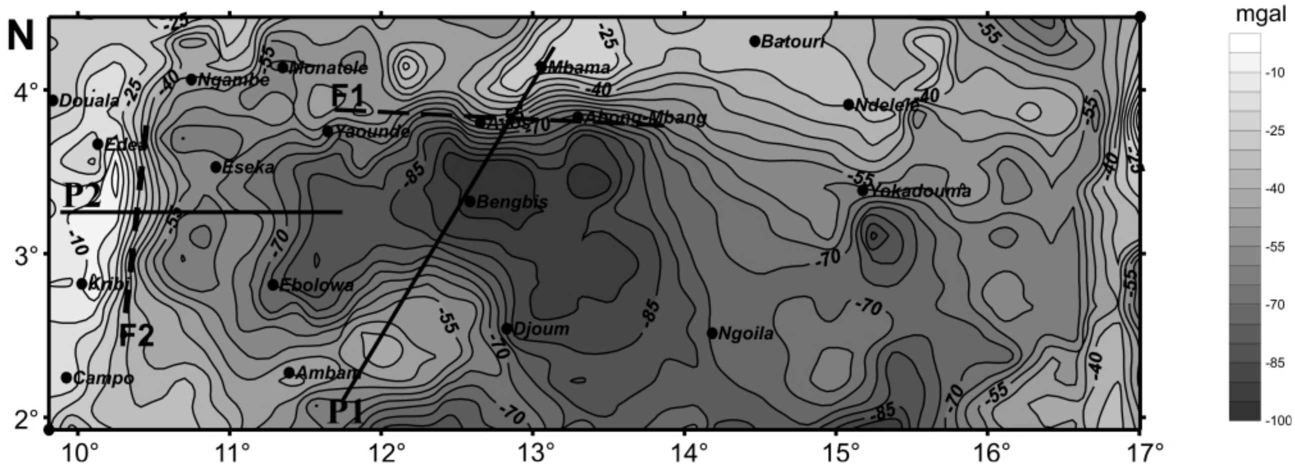

Figure 3: Gray scale image of the Bouguer anomaly map of the southern Cameroon (Intervals: 5 mGal; gray-scale unit: mGal) showing fault zones and studied profiles. Note the large negative anomalies at the centre part of the area. The geophysical limit of the Congo cration is followed in Cameroon by a W-E gravity gradient between Campo and Ngambe and N-S gravity gradient between Yaounde and Ndelele. The positive anomalies in the north and west marked the northern edge of the Congo Craton are also clearly seen. F1: Northern Fault Zone; F2: Western fault zone. P1 and P2 denote studied profiles.

western fault, near the coast, which is associated with high-gradients trending N-S, is the signature of the eastern and south-eastern marginal faults of the Douala and Kribi-Campo sedimentary basins (Njike Ngaha, 1984). This important fault seems to mark the northwestern border of the Congo Craton.

4.2 Depth estimation by spectral analysis

A qualitative interpretation of gravity anomalies was made using 2D spectral analysis of gravity anomalies over the entire area. Two plots of log average power spectrum versus wavenumber for the Bouguer fields over the region were derived from the gravity signatures (Fig. 4) to determine the depth of the anomalous sources. Three depths, assumed to correlate with lithospheric density discontinuities, have been interpreted from each Bouguer profile; these depths to density contrasts are associated with the crust-mantle interface and crustal horizons.

Depth estimates were calculated using equation (5). The area was divided into two sectors, a western and a central to east sector, within each of which the crustal structure was assumed to be approximately uniform. The middle and eastern block covers the entire negative Bouguer anomaly centered over the Congo craton and the high E-W gravity gradient observed in the northern part of the area (Fig.3). The western block covers the south-western Cameroon basement areas that consist of the high N-S gravity gradient observed between Campo and Ngambe. The curvature of the power spectrum suggests that about three linear segments or depths can be identified in the Bouguer map. The straight line of each waveband cut-off corresponds to major discontinuities within the crust in this area.

For the deepest discontinuity, the mean depth estimates for the NE-SW Bouguer profile is 38.6 ± 2.8 km. For E-W profiles, the depth estimate is 47.1 ± 4.2 km. The deeper horizon (47 km), which may reflect the Moho depth in the areas, agrees very closely with the result (48 km for the Moho) obtained from gravity modelling (Boukéké, 1994; Tadjou, 2004). The 38.6 km obtained for the area of the Congo Craton also agree closely with 35 ± 3 km thickness of the crust estimated from spectral analysis of gravity data (Nnange et al., 2000) in the southern Cameroon area. These depths represent the mean depth of the crust/mantle interface discontinuity in the region.

Depth estimates of 22.6 ± 1.6 km and 26.8 ± 2.7 km obtained respectively for the NE-SW and E-W Bouguer profiles, may possibly correspond to an intracrustal density discontinuity, or, for the E-W profile, it may indicate that the crustal thickness varies within the region. The 26.8 km depth may reflect the thickness of the crust in the coastal zone, while the depth of 22.6 km represents the depth of density discontinuity beneath the northern edge of the Congo Craton in Cameroon. This discontinuity may be caused by an intrusion of dense materials in the crustal basement. This intrusion marks the northern border of the Congo Craton.

The shallowest depths obtained from the Bouguer profile are 11.4 ± 0.8 km and 14.8 ± 1.5 km. These may be due to intra-basement density variations associated with the northern margin of the Congo craton, or to the uplift of the upper mantle in the western and northern part of the area.

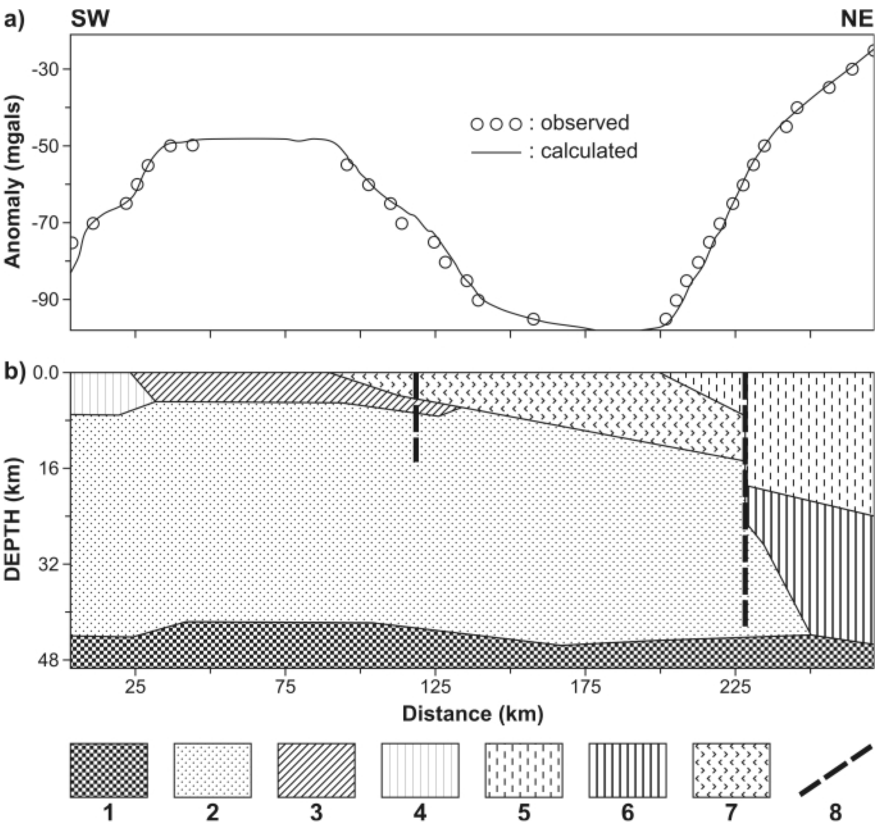

Figure 5: Bouguer gravity model of NE-SW profile of Fig. 3. The upper panel shows calculated and observed Bouguer gravity, and lower section shows the preferred model distributions.
(a) Observed and theoretical Bouguer anomaly due to 2D1/2 synthetics models.
(b) Synthetics and inferred structures of the northern edge of the Congo craton: 1 : Upper Mantle d1=3.20 g/cm^3; 2 :Southern Crust (Congo craton) d2=2.67 g/cm^3; 3 :Charnockites (Craton) d3=2.90 g/cm^3; 4: Gneiss (Craton) d4=2.75 g/cm^3; 5 : Northern crust (Pan-African belt) d5=2.70 g/cm^3; 6 : Granulites d6= 2.90 g/cm^3 (deep structure in Pan-African belt); 7 : Granites d7=2.57 g/cm^3(Craton); 8 : Proposed fault.

5. Discussion

The depths to major crustal discontinuities in the Congo Craton are estimated using spectral analysis of total Bouguer gravity anomalies. These allow the mean depth of Moho in the region to be evaluated and contribute to the determination of variations in the crustal density across the major tectonic boundary between the Congo Craton and the Pan-African fold belt. There are significant changes in the character of the spectrum when one moves from deeper to shallower sources. According to the results obtained in our study, the crustal thickness beneath the northern edge of the Congo Craton varies from 25 km in the west to 32 km in the north and 47 km in the centre of the craton. The magnitude of the gravity gradients observed in the west and north of the study area is probably a result of a transition to normal crustal thicknesses (greater than or equal to 33 km thick). The depth of 47 km obtained from the deeper source corresponds to the average Moho depth of the Congo Craton. The Moho becomes shallower in the western and northern parts of the area, where it lies at about 32 km.

Two selected profiles (Fig.5 and Fig.6), trending approximately perpendicular to both the gravity contours and the geological structures, were modeled using the IGAO2D1/2 computer program (Chouteau and Bouchard, 1993). Interpretation of these profiles has shown that the structures responsible for the negative anomalies in the area are less dense than the upper mantle. The maximum vertical thickness of the rocks is estimated to reach 48 km, interpreted as the maximum thickness of the crust in this region. Because of two dimensionalities, this value may be slightly underestimated. If the true density is greater than the adopted density of 2.67 g/cm^3, the depth will increase. It can be noted that the maximum thickness of the Pan-African belt exceeds 30 km in the northern sector (Fig.5), so we suppose a granulite body of about 20 km thickness below the metamorphic rocks, of which the granitic gneisses, schists and micaschists may be an exposed part. The cratonic rocks continue at depth to the north, underlying the Pan-African units.

The western zone (Fig.6) consists of a positive anomaly, probably due to basic intrusions. Such doming might also correspond on the surface to syenites and granulites observed at the border of the structural unit. The central part, which mainly corresponds to the transitional zone between the Congo Craton and the Pan-African belt, comprises Archean Paleoproterosoic greenstones (2.75 g/cm^3). This zone outlines an important crustal root due to the tectonic overload; it also links to the presence of low-density masses, represented by Nyong units. The eastern part, which belongs to the cratonic domain, is downthrown to the east. This might be associated with progressive mantle rise from east to west. The thicknesses of the crust also decreases from east to west (47 km in the east to 32 km in the west). Two-dimensional models of the lower crust-upper mantle were obtained in the same area, assuming a density contrast of 0.52 g/cm^3 between the upper mantle and the lower crust (Tadjou, 2004). In these models, which were obtained from the isostatic gravity profiles trending N-S on the isostatic map, the thickness of the crust was approximately 33 km in the north, whereas an approximately 48 km thick crust was inferred for the central and eastern end of the area.

Our moho thickness results can be interpreted in terms of thinning of the crust in the west of the region due to lithospheric stretching, due to upwelling of the upper mantle as a result of isostatic compensation. Since the anomaly decreases from the west and north towards the south (Fig.3), it is probable that the crust beneath the region thins to the west (due to a former transition to oceanic crust) and the north. The density contrast between the upper mantle and the crust

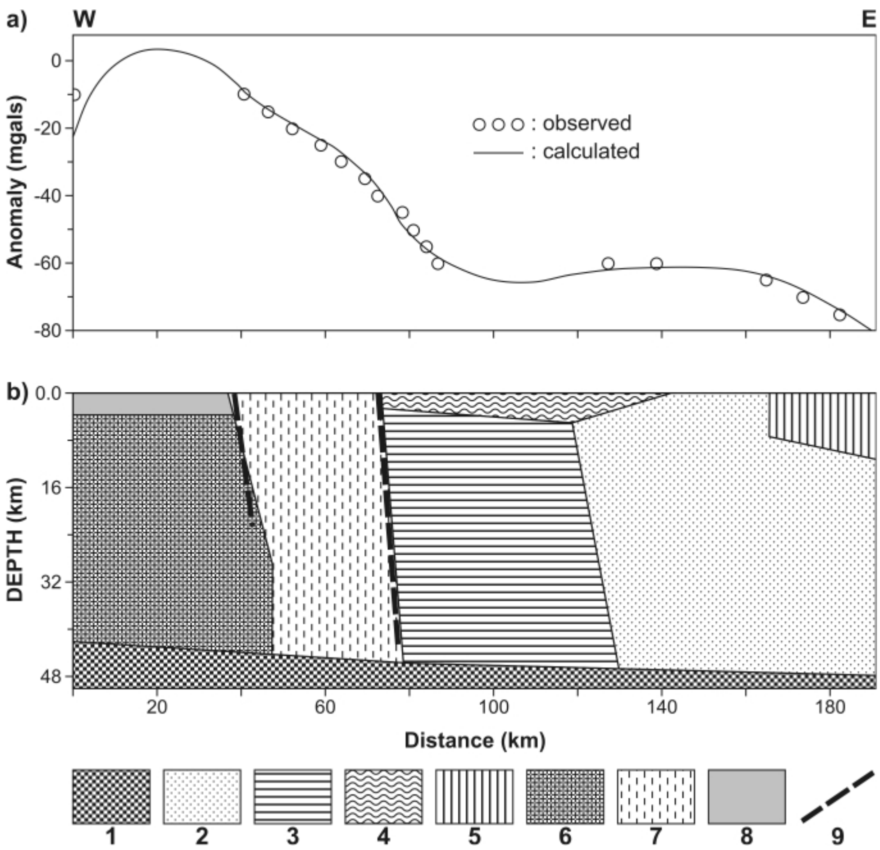

FIGURE 6: Bouguer gravity model of E-W profile of Fig. 3. The upper panel shows calculated and observed Bouguer gravity, and lower section shows the preferred model distributions.
(a) Observed and theoretical Bouguer anomaly due to 2D1/2 synthetics models.
(b) Synthetics and inferred structures of the northern edge of the Congo craton: 1 : Upper Mantle d1=3.20 g/cm^3; 2 : Ntem units (Congo craton) d2=2.67 g/cm^3; 3 :Nyong units (Eburnean) d3=2.70 g/cm^3; 4: Archean to paleoproterozoic greenstone (Craton) d4= 2.75 g/cm^3; 5 : Gneiss (Craton) d5=2.75 g/cm^3; 6 : syenite (deep structure in Pan-African belt) d6=2.90 g/cm^3; 7 : Granulites d7= 2.90 g/cm^3 (deep structure in Pan-African belt); 8 :phanerozoic cover d8=2.5 g/cm^3; 9 : Proposed fault.

might therefore be very low beneath the Precambrian oceanic zone, compared to density contrasts between a normal upper mantle and the continental crust. Using spectral analysis of new gravity data in Cameroon, Nnange et al. (2000) obtained three major density discontinuities in the crust beneath the Congo Craton area (the first at 13 km for the upper crust, the second at 25 km for the mid-crust and the third at 35 km for the crust-mantle interface). These results are consistent with those obtained is this study. The depth of the mantle-crust interface beyond the Congo Craton seems to correlate with the results of the studies of Poudjom et al. (1995b) who use the elastic effective thickness to obtain a value of 40 km for the Congolese Craton crust. In their study, they investigate the relationship between these tectonic features and the flexural rigidity of the lithosphere in the Cameroon, in terms of effective elastic thickness (Te), by using a coherence function analysis. The Te contour map deduced from their study shows a good relationship between tectonic provinces and the rigidity of the lithosphere; the minima (14-20 km) lie beneath active rifted and volcanic areas, and maxima (40 km) correspond to Archean reworked units in the Congo Craton. Our estimate of crustal thickness is also in good agreement with depth estimations from seismic refraction measurements associated with undisturbed craton (Michael and William, 2001), which is relatively thin (35–40 km).

The negative Bouguer anomalies observed over the entire region can thus be attributed to the thickness of the crust associated with a granitic intrusion with a low density contrast beneath the centre of the region. This intrusion must have caused the subsidence of the basement along the northern border of the craton. The positive anomaly of the Pan-African series can be interpreted in terms of a shallower basement or the intrusion of igneous rocks, combined with an excess crustal thinning beneath the north and west of the area. The extensive linear form of the anomaly, coupled with the consistent nature of gradients along its flanks, suggest the presence of two crustal blocks of different mean densities and thicknesses separated by a suture formed by plate collision. Analyses of aeromagnetic data (Nnange, 1991) show that this anomaly may be due to subsurface pip-like intrusions. This positive anomaly, coupled with gravity gradients is supposed to be the effect of a plate suture (Bayer and Lesquier, 1978).

The high gravity anomalies that outline the boundary are probably the expression of northwards-dipping mafic rocks, reflecting a Pan-African suture. The proposed suture line is the tectonic boundary between the Pan-African units and the Congo craton and is marked by a major density discontinuity penetrating the crust. This margin may have been a product of intra-continental collision. Our interpretations also suggests thicker Pan-African metamorphic rocks compared to the adjacent craton and the presence of dense allochthonous rocks, i.e. granulites and syenites within the Pan-African fold belt. The presence of these allochthonous rocks supports the idea of a subduction origin of the boundary between these units.

6. Conclusion

Two general observations were made concerning gravity anomalies within and at the boundaries of the Congo Craton: first, anomalies within the craton area, except in the south-eastern and northern parts, are negative relative to those in the adjacent zones; second, various anomalies are separated by high gravity gradients, which suggest major fault zones along the boundaries. Based on these observations, the zone is probably a subsided or rifted area in which the subsidence might have been accompanied by intrusion of low-density rocks with a thickness of about 20 km. This intrusion has caused north-trending faulting. The block-faulting might have resulted in the formation of the graben; the fault zone juxtaposed the high density rocks of the Pan-African domain in the north against low density Archean rocks in the south, in the upper 20 km of the crust.

2-D spectral analysis permits us to determine deep structures and depths to major crustal and Moho discontinuities. Deep structures consist of high-density rocks (granulites) of the Pan-African domain in the north and high-density rocks (charnockites) in the south. This study also enables us to infer the mean depth of Moho in the region at 47 km and to determine variations in crustal density across the tectonic boundary between the Congo craton and the Pan-African fold belt. The detailed interpretation shows that magmatic rocks within the zone occur at the margins of faulted blocks. These magmatic rocks are probably a direct consequence of block faulting of the basement rocks in the area. The gravity study also suggests that the northern margin of the Congo Craton is a product of convergent collision, as has been suggested for the eastern margin of the West-African craton and the Pan-African belt. These collisions caused considerable overthrusting of the Pan-African units onto the Congo Craton.

Acknowledgments

We thank IRD-Cameroon (Institute de Recherche pour le Developement) for acquiring and for letting us use the gravity data. We are grateful to M. Chouteau and K. Bouchard (Laboratoire de Géophysique Appliquée, Département de Génie Minéral, Ecole Polytechnique de Montréal, Canada) for letting us use their 2D1/2 modeling software program. This work is funded by the National Institute of Cartography-Cameroun.

References

Albouy, Y. and Godivier, R., 1981. Cartes gravimétriques de la République Centrafricaine. ORSTOM (Office de la Recherche Scientifique et Technique d'Outre-Mer, France), 80 p.

Bayer, R. and Lesquier, A., 1978. Les anomalies gravimétriques de la bordure Orientale du craton Ouest Africain: géométrie d'une suture PanAfricaine. Bulletin de la Société Géologique de France, XX, 863-876.

Boukéké, D. B., 1994. Structures crustales d'Afrique Centrale déduites des anomalies gravimétriques et magnétiques: le domaine précambrien de la République Centafricaine et du Sud Cameroun. Thèse de Doctorat, Université de Paris Sud, 263p.

Briggs, I. C., 1974. Machine contouring using minimum curvature. Geophysics, 39, 39-48.

Browne, S. E., 1984. Gravity studies in the Sudan: A tectonic interpretation for some rifted sedimentary basins. Ph.D thesis, University of Leeds, UK, 249p.

Chouteau, M. and Bouchard, K., 1993. IGAO 2D1/2 version 28/7/1993. Laboratoire de Géophysique Appliquée, Département de Génie Minéral, Ecole Polytechnique de Montréal, Canada.

Collignon, F., 1968. Gravimétrie de reconnaissance de la République Fédérale du Cameroun. ORSTOM (Office de la Recherche Scientifique et Technique d'Outre-Mer, Paris, France), 35 p.

Ebinger, C. J., Bechtel, T. D., Forsyth, D. W. and Bowin, C. O., 1989. Effective elastic plate thickness beneath the east African and Afar domes. Journal of Geophysical Research, 94, 2883-2890.

Fairhead, J. D. and Okereke, C. S., 1988. Depths to mayor density contrast beneath the West African rift system in Nigeria and Cameroon based on the spectral analysis of gravity data. Journal of African Earth Sciences, 7, 769-777.

Golden Software Inc., 1993. Winsurf version 7.0, Colorado USA.

Hedberg, J. D., 1969. A geological analysis of Cameroon trend. Ph.D thesis Princeton University, NJ, USA, 154 p.

Inoue, H., 1986. A least-squares smooth fitting for irregularly spaced data: finite element approach using the cubic B-spline basis. Geophysics, 51, 2051-2060.

Kande, H. L., Manguelle-Dicoum, E., Tabod, C. T. and Njandjock, N. P., 2006. The crustal structure along the Mbere Trough in South Adamaoua (Cameroon) from spectral analysis and garvity modelling. Global Journal of Pure and Applied Sciences, 12, 111-117.

Karner, G. D. and Watts, A. B., 1983. Gravity anomalies and flexure of the lithosphere at mountain ranges. Journal of Geophysical Research 88, 10 449 – 10 477.

Louis, P., 1970. Contribution géophysique à la connaissance géologique du bassin du lac Tchad. Mémoire ORSTOM (Office de la Recherche Scientifique et Technique d'Outre-Mer, France) 42, 312 p.

Mbom Abane, S., 1997. Investigations géophysiques en bordure du craton du Congo et implications structurales. Thèse de Doctorat d'état ès Sciences. Université de Yaoundé, Cameroun, 180 p.

Michael, E. P. and William, R. W. 2001. Crust and upper-mantle structure of North Africa, Europe and the Middle East from inversion of surface waves. Geophysical journal international, 154 (2), 463 – 481.

Njike Ngaha, P. R., 1984. Contribution à l'étude géologique stratigraphique et structurale de la bordure du bassin Atlantique du Cameroun. Thèse de Doctorat 3e cycle, Université de Yaoundé I, Faculté des Sciences, Cameroun, 131 p.

Nnange, J. M., 1991. The crustal structure of the Cameroon volcanic line and the Foumban shear zone based on gravity and aeromagnetic data. Ph.D. dissertation, Univ. Leeds, U.K, 242 p.

Nnange, J. M., Ngako, V., Fairhead, J. D. and Ebinger, C. J., 2000. Depths to density discontinuities beneath the Adamawa Plateau region, Central Africa, from spectral analysics of new and existing gravity data. Journal of African Earth Sciences. 30, 887-901.

Nzenti, J. P., Barbey, P., Jegouzo, P. and Moreau, C., 1984. Un nouvel exemple de ceinture granitique dans une chaîne protérozoïque de collision : les Migmatites de Yaoundé au Cameroun. Académie de Science de Paris, II, 299, 1187-1199.

Nzenti, J. P., Barbey, P., Bertrand, J. M. and Macaudière, J., 1994. La chaîne panafricaine au Cameroun : cherchons suture et modèle ! In SGF édit, 15e Réunion des sciences de la Terre, Nancy, France, p 99.

Nzenti, J. P., Barbey, P. and Tchoua, F. M., 1998. Evolution crustale au Cameroun: éléments pour un modèle géodynamique de l'orogenèse néo protérozoïque. Ed. Géocam Presses Universitaires de Yaoundé, 2, 397-407.

Okereke, C. S., 1984. A gravity study of the lithospheric structure beneath the West Africa rift system in Nigeria and Cameroon. Ph.D dissertation, Univ. of Leeds, U. K. 272 p.

Pal, P. C., Khurana, K. K. and Unikrishman, P., 1979. Two examples of spectral approach to source depth estimation in gravity and magnetic data. Pure and Applied Geophysics, 117, 772-783.

Poudjom-Djomani, Y. H., Diament, M. and Albouy, Y., 1992. Mechanical behaviour of the lithosphere beneath the Adamawa uplift (Cameroon, West Africa) based on gravity data. Journal of African Earth Sciences, 15, 81-90.

Poudjom-Djomani, Y. H., Legeley-Padovani, A., Boukéké, D. B., Nnange, J. M., Ateba-Bekoa, Albouy, Y. and Fairhead, J. D., 1995a. Levés gravimétriques de reconnaissance du Cameroun. ORSTOM (Office de la Recherche Scientifique et Technique d'Outre-Mer, France), 38 p.

Poudjom-Djomani, Nnange, J. M., Diament, M., Ebinger, C. J., Fairhead, J. D. 1995b. Effective elastic thickness and crus-tal thickness variations in west central Africa inferred from gravity data. Journal of geophysical research, vol. 100, no B11, 22047-22070.

Poudjom-Djomani, Y. H., Diament, M. and Wilson, M. 1997. Lithospheric structure across the Adamaoua plateau (Cameroon) from gravity studies. Tectonophysics, 275, p 317-327.

Spector, N. and Grant, F. S., 1970. Statistical models for interpreting aeromagnetic data. Geophysics 35, 293-302.

Tadjou, J. M., 2004. Apport de la gravimétrie à l'investigation géophysique de la bordure septentrionale de Craton du Congo (Sud-Cameroun). Thèse de Doctorat/Ph.D, Univ. Yaoundé I, 178 p.

Tadjou, J. M., Manguelle-Dicoum, E., Tabod, C. T., Nouayou, R., Kamguia, J., Njandjock, N. P. and Ndougsa, M., T., 2004. Gravity modelling along the northern margin of the Congo craton, South-cameroon. Journal of the Cameroon Academy of Sciences, 4, 51-60.

Tchameni, R., 1997. Géochimie et géochronologie des formations de l'archéen du paléoprotérozoïque du Sud Cameroun (groupe du Ntem, Craton du Congo). Thèse de Doctorat, Université d'Orléans. France. 320p.

Tchameni, R., Nsifa, N. E. and Shang, C. K., 2001. Le magmatisme archéen du complexe du Ntem (Sud Cameroun) : Implications sur l'évolution crustale du Craton du Congo. Journal of the Geoscience Society of Cameroon. 1/1, p 125.

Received: 17. January 2008
Accepted: 10. January 2009

J. M. TADJOU[1)2)*)], R. NOUAYOU[2)], J. KAMGUIA[1)2)], H. L. KANDE[1)2)] & E. MANGUELLE-DICOUM[2)]

[1)] National Institute of Cartography (NIC)-Cameroon, PO Box 157, Yaounde–Cameroon.

[2)] Department of Physics, Faculty of Science, PO Box 6052, University of Yaounde I–Cameroon.

[*)] Corresponding author, jtadjou1@yahoo.fr