Gravity Study of the Crust beneath the Babouri-Figuil and Mayo Oulo-Léré Sedimentary Basins, North Cameroon and South Chad

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Abstract

In this work, the crustal structure study of Babouri-Figuil and Mayo Oulo-Léré sedimentary basins was carried out through the interpretation of gravity data. These data were obtained by combining to the terrestrial gravity data those obtained from EGM2008 model. The Analysis of the terrestrial Bouguer anomaly maps revealed negative and positive anomalies. Negative anomalies would be the signature of sedimentary basins while positive anomalies would be attributed to basaltic rocks under granitic environment. To isolate anomalies due to deep structures from those due to near surface structures, we used the empirical method. This method testifies that the residual map of order 4 is an appropriate one. In order to conduct the quantitative interpretation of the combined gravity data, six profiles were drawn on the residual Bouguer anomaly map and therefore were interpreted using spectral analysis and 2.5D modeling methods. The results indicate that the mean depths of mass sources near surface of Babouri-Figuil and Mayo Oulo-Léré sedimentary basins were 1.50km and 1.55km respectively. Moreover, Babouri-Figuil is constituted of two formations of different density contrast while Mayo Oulo-Léré shows three formations. These models helped us to clarify the geological structure of the study area. The results of the present study allow greater understanding the sedimentary basin thickness.

1. Introduction

The study area located between longitudes 13° to 14°30E and latitudes 9° to 10°30N is presented in Fig. 1. It covers the Babouri-Figuil and Mayo Oulo-Léré sedimentary basins. The main studies carried out in these basins have mainly focused on geological studies. These include the works of (Allix et al. 2000; Allix and Popoff 1983; Dejax et al. 1989; Ndjeng et al. 1988; Ndjeng 1992; Colin et al. 1992; Ndjeng 1994; Brunet et al. 1988; Bessong 2012; Ntsama 2013). These works have shown that the Babouri-Figuil and Mayo Oulo-Léré sedimentary basins are two small Wealdian basins filled with continental sediments. These sediments are mostly detritics and made up of an alternation of fine sandstones, silts and indurated marls. However, from geophysical point of view in general and gravimetry in particular, the thickness of these basins is still poorly understood. The gravity data available in this area are obtained by ORSTOM (Office de Recherche Scientifique et Technique d'Outre Mer) during the various reconnaissance campaigns. The itineraries followed tracks, carrossables roads and sometimes water courses. Despite these efforts, these data are very sparse and present many gaps. A Bouguer anomaly map realized with such gaps presents many insufficiencies. Its interpretation leads to erroneous conclusions. To solve this problem, it would be appropriate to densify data by carrying out a new gravity campaign. Unfortunately, gravity campaigns are very expensive. An elegant solution to this problem consists to densify the measured gravity data by using the EGM2008 field model and making them usable (Bouba et al. 2017). These data have been reduced by using a series of corrections to eliminate the non-geological causes of gravity variations. The obtained database allowed to establish a new gravity map of the region. In this paper, we applied spectral analysis and 2D.5 modeling methods to the combined gravity data in order to determine the depth and density contrast of the crustal structure beneath the Babouri-Figuil and Mayo Oulo-Léré sedimentary basins. These methods have been used to isolate causative bodies by representing them as polygonal bodies in two dimensions (Toushmalani and Saibi 2015). Similar approaches were used successfully to improve the subsurface structure geometry of Algeria (Farhi et al. 2016; Saibi et al. 2006) mentioned the relationship between the observed gravity anomalies and the obtained models of the integrated 2D gravity interpretation technique.

2. Geological Setting

Cameroon has two types of sedimentary basins: coastal sedimentary basins located in the southwest of Cameroon and intracontinental sedimentary basins located in the northern part of the country. Many of these latter are connected to the Yola branch belonging to the Benue ditch. These are Koum, Hamakoussoum, Babouri-Figuil and Mayo Oulo-Léré basins. The Babouri-Figuil sedimentary basin and that of Mayo Oulo-Léré are small basins elongated of EW direction. They are located respectively between latitudes 9°44'-9°50' and 9°39'-9°44' and longitudes 13°44'-14°02' and 13°43'-14°28' (Fig. 2). These two basins have Wealdian facies equivalent to the Bima formations in Nigeria (Ntsama 2013).

The Babouri-Figuil sedimentary basin is the most northern of the small Cretaceous basins with continental sediment in north Cameroon. It is lengthened on nearly 45km with a width ranging from 1km towards Figuil and 8km between the villages of Babouri and Sorawel (Ndjeng et al. 1988; Ntsama 2013). It is a basin dotted with mounds and basic sandstone. Its sedimentary pile locally reaches 1500m (Danra Moh Guela et al. 2019). These sediments are constituted of fine sandstones, silts and marls. Their presence testifies the sedimentation whose origin would be linked to the indicator of many emersion phases (Ndjeng 1992). The abundance of flore and the existence of evaporation levels are present throughout the basin. The swamp environment under hot and humid climate is revealed by the abundance of Estheries whose eggs dissemination is favored by drying seasonal periods (Brunet et al. 1988). The presence of leaves and footsteps of dinosaurs have been found in Mayo-Tafal (Dejax et al. 1989).

The Mayo Oulo-Léré basin is over 50km long and less than 10km wide. It extends towards the south of Chad in the Léré area. It is separated from the Babouri-Figuil basin by granite complexes culminating at 800m of altitude. It consists mainly of silts and hardened clays. Basaltic rocks present in the sediments in form of sills set up a metamorphism of contact (Ndjeng 1994). Through on Paleoflore study, the Mayo Oulo-Léré sedimentary basin is constituted with invisible small grabens (Ntsama 2013; Guiraud and Maurin 1991). These grabens established in north-south extensive context are constituted with basaltic formations (Ndjeng 1992). Microfossils collected from this basin provides from anteaptian sedimentation.

3. Data And Methods

3.1. Gravity Data

The gravity data used in this work provide from two independent sources. One is derived from measured gravity data and the other is obtained from Earth Gravity Model EGM2008.

3.1.1. Terrestrial Gravity Data

The terrestrial gravity data used in this work were collected between 1960 and 1968 by the Office de Recherche Scientifique et Technique d'Outre-mer (ORSTOM) during various reconnaissance campaigns. These data were obtained between latitudes 9°00' and 10°30'N and longitudes 13°00' and 14°30'E. The acquisition campaigns of these data were obtained by a car, along the roads, carossable tracks and sometimes water courses. The measurements were taken every 3km. Several gravimeters (Worden and Lacoste & Romberg) were used to measure the variations of gravity. The calibration of the gravimeters was carried out on stations of the Martin network which are defined in Potsdam system. The precision on the gravity values is the order of 0.2mGal. The location of the measuring stations was determined on topographic maps by compass tracking. The average error in the position of the stations is estimated at around 200m. Altitudes were estimated using barometers and altimeters (Wallace and Thierman, Thommen). The accuracy on the values of altitude depends on the climate, the difference of altitude between the reference station, the measure point and the distance from the stations. The error on altitude of the stations can reach 10m when the weather conditions are unfavorable and 3m otherwise.

The terrestrial Bouguer anomaly map presented in Fig. 3 is plotted using the Generic Mapping Tools (Wessel and Smith 1995). This map shows two main zones of anomalies: low and high zones.

Low anomalies zones are divided into two parts. The first part located in the northern part of the study area covers the towns of Hamakoussou, Dembo, Dourbey, Guider and the entire sedimentary basin of Babouri-Figuil. In this sector, low anomalies are unevenly distributed (-65 to -35mGal). This situation would be due to the lack of terrestrial gravity data in the sector. The second part located in south of Léré is also constituted of low anomalies with a minimum that can reach − 60mGal. These anomalies would be due to the filling effect of the Pala-Lamé sedimentary basin in Chad.

High anomalies zone covers the southwest of Garoua, Lagdo and Bibémi towns and the entire area of Mayo Oulo-Léré basin. The amplitude of these anomalies is around − 25mGal with a maximum at 0mGal in the northern part of Bibémi and Mayo Oulo-Léré sector. These anomalies would be due either to the upwelling of magmatic fluids through the lithospheric fractures in the sedimentary zone or to denser rocks found on surface (Louis 1970).

3.1.2. Data from EGM2008

In this part, gravity data were obtained using the Earth Gravity Model. This model provides more informations on the Earth's gravity field for various geophysical applications (Palvis et al. 2008; Bonvalot et al. 2012). Its utilization is advantageous because it possesses: (1) harmonic coefficient up to degree and order 2190 (Weiyong and Rummel 2013). (2) Good spatial resolution and good ability to provide gravity data. (3) Spatial resolution of 5 arcminutes corresponding to a wavelength of 9km, approximately

6 times more resolution than other models. (4) Gravity data over the entire Earth, data obtained from disturbance analyzes of satellite trajectories and data from satellite altimetry over the oceans (Palvis et al. 2012). (5) Gravity data are freely obtained. (6) It provides more information on the areas devoid gravity data and geologically inaccessible. This model has been used in the localization of coal deposits in India, in the mapping of cratons and in the delineation of geological discontinuities in sedimentary basins (Jitendra and Pala 2015). According to (Bouba et al. 2017; Kamguia et al. 2007; Abate Essi et al. 2017) EGM2008 gravity data and terrestrial ones have the same precision; so they are stackable and can be superimposed. Data from this model are combined with terrestrial data in order to increase their density. Bouguer's correction is obtained by taking an average density of 2.67g/cm^3. The densified gravity data thus obtained have permitted to establish a new Bouguer anomaly map by joining points having the same anomaly value (Fig. 4). For objectivity reasons, the Bouguer anomaly map is plotted by computer using the Generic Mapping Tools software (Wessel and Smith 1995). This map is interpreted in two gravity zones.

The first zone located in the northern part of the study area, consists of a large low domain (-60mGal) visibly more developed than on terrestrial simple Bouguer anomaly map. It is in this area that Babouri-Figuil sedimentary basin is located. The Examination of this map shows that this basin tends to evoke the mark of sedimentary fill. We would imagine a lake basin where water courses brought their alluvium while the volcanoes spread their lavas. These anomalies may be due either to the collapse of sedimentary block or to the local thickening of sedimentary series generated by the depression of the basement roof. In south of Léré, we observe negative anomalie zone of -60mGal. These anomalies can be due to sediments deposits in this area.

The second zone extends from Garoua town to Léré in Chad and up to Bibémi. This zone includes the Mayo Oulo-Léré sedimentary basin. It is characterized by high and positive anomalies. These anomalies could correspond to the intrusion of basaltic rocks under the sedimentary basin. However, the orientation of the isoanomal lines does not coincide perfectly with the basin direction. It suggests that, the intrusion would have been favored by tectonic process. The first and second domains are separated by strong gradient, which would result from discontinuities between crustal formations, such as faults, flexures or contacts of intrusive rocks.

3.2. Method

3.2.1. Regional/Residual separation

In Benue sedimentary trough, the third-order of polynomial surface of regional anomaly has used (Kamguia et al. 2005). Such choice cannot be justified when we considered detailed interpretation of the basement. It is therefore necessary to define a criteria for choosing the regional surface which takes into account the variations of the gravity field in all directions. In this study we used the empirical method of (Zeng et al. 2007). This method permits us to determine a regional anomaly which presents the best resemblance to the prolonged Bouguer anomaly at optimum altitude. The degree of resemblance between two gravity fields g_1 and g_2 is determined by the correlation factor calculated by using the formula proposed by (Abdelrahman et al. 1989):

$$r_{g_1,g_2} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} g_1(x_i,y_j)g_2(x_i,y_j)}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N} g_1^2(x_i,y_j)\sum_{i=1}^{M}\sum_{j=1}^{N} g_2^2(x_i,y_j)}} \qquad (1)$$

where *M* and *N* are the number of sampling data along *x*-direction and *y*-direction respectively. Figure 5a shows the curve giving the variation of the correlation factor as a function of continuation heights. It is an increasing curve which presented a maximum deflection noted C at a certain continuation heights. This deflection is given by the gap between the curve of the correlation factor and the line joining the two ends of the curve. In Fig. 5b, we plot the curve giving the variation of the deflection C at each altitude as a function of continuation heights. This curve passes through a maximum altitude Hm = 25km called optimum altitude of upward continuation of the Bouguer and also corresponds to the depth of investigation in the region. For the choice of the regional degree, we calculated the coefficients of correlation between the upward continuation of the Bouguer map at 25km and the regional anomaly maps for different degrees (Fig. 5c). We find that the upward continuation of the Bouguer map at optimal altitude present a maximum correlation with the regional anomaly map of order 4. Thus, residual anomaly map of degree 4 will essentially highlight the gravity effect of shallow structures in the study area.

3.2.2. Power Spectrum Analysis

The Spectral analysis is a method that permits to define the planes of separation between several structures of different densities. When we plot the logarithm of gravity energy as function of frequency, the spectral curve has two slopes. The first slope located in the low frequencies corresponds to the deep structures. The second slope located in the high frequencies corresponds to the near surface structures. The average depths of gravity anomalies sources can be estimated from the relationship (Gerard and Griveau 1972; Dimitriadis et al. 1987):

$$h = \frac{\Delta(LogE)}{4\pi\Delta(n)} \qquad (2)$$

where $\Delta(LogE)$ is the variation of the logarithm of the energy spectrum; the interval of frequency. These depths permit to constrain the 2D1/2 modeling and assimilate the geological structures to the reality. The average error on each gravity profile is estimated at 5% of the obtained depth (Bouba et al. 2017; Nnangue et al. 2000).

3.2.2. 2D1/2 Modelling

The Modeling consists to calculate the theoretical anomaly from simple shape of the structure of model and to compare it to observed anomaly. The best obtained model is that which corresponds to the structure whose calculated anomaly is assimilated to the observed anomaly by adjustment (Poudjom-Djomani 1993). In this part, 2D1/2 modeling is obtained by using Grav2DC software based to algorithm of (Cooper 2004; Talwani et al. 1959). This modeling was carried out by taking into account the depths calculated by spectral analysis, the geology of the region and the density contrast of the anomalies sources. The density contrast is calculated from the formula, $C_i = d_0 - d_i$ where $d_0 = 2.65g/cm^3$ is the average density of the granites, d_i is the average density of the ith formation (Noutchogwe et al. 2006).

4. Results

4.1. Presentation of New Residual Bouguer Anomaly map

The residual anomaly map presented in Fig. 6 shows two anomaly sectors: positive sector and negative sector.

The first sector is located in west of Garoua, northeast of the study area and east of Dourbey. The values of anomalies are between (0 to 15mGal). It would be due to the presence of heavy rocks in granitic environment. The analyze of this map also shows another positive sector which extend from Bibémi to Léré in Chad and include the Mayo Oulo-Lére sedimentary basin which is located inside positive anomaly zone (15 to 35mGal). These anomalies show that the Mayo Oulo-Léré basin does not have the morphology of sedimentary basin. It would correspond to a lake basin with a spectacular rise of heavy rocks probably basaltics.

The second sector is constituted of negative anomalies. These anomalies are located in south of Garoua and around Dourbey where the Babouri-Figuil sedimentary basin is located. The values of these anomalies are between − 15 and − 5mGal. This could correspond to the sedimentary deposits of the Garoua trough in general and the Babouri-Figuil basin in particular. This basin constituted essentially of sandstone would be linked to the Benue trough. The Analysis of the map shows also another negative sector located in south of Léré on Cameroon-Chad border. In this sector the minimum value of anomalies is -25mgal. This would indicate the presence of weak formations compared to the surrounding formations.

4.2. Estimation of Mean Depth of Density Interfaces

In this part, we used the spectral analysis to determine the depths of geological structures source of anomalies. Six profiles P1, P2, P3, P4, P5 and P6 have been traced on densified residual Bouguer anomaly map. P1, P2 and P3 were plotted on Babouri-Figuil sedimentary basin and P4, P5 and P6 on Mayo-Oulo-Léré sedimentary basin. All these profiles are executed perpendicularly to the main elongation of the structure to be studied. When we plot the energy spectrum logarithm as a function of frequency, the spectral curve presents two characteristic slopes. The first slope located in the low frequencies corresponds to the deep structures. The second slope which represents the high frequencies corresponds to the bodies near surface.

In Babouri-Figuil sedimentary basin, two major discontinuities have been obtained by spectral analysis on profiles P1, P2 and P3 (Fig. 7).

The first discontinuity corresponds to deep structures with depths estimated at 4.70km, 4.55km and 5.46km respectively for profiles P1, P2 and P3. These depths could correspond to the sediment-granite contact zone. The second discontinuity is associated with bodies near surface. The estimated depths are: 1.48km, 1.44km and 1.58km respectively for profiles P1, P2 and P3. The average value of depth in this basin is around 1.50km. This result agrees with those obtained by (Schowoerer 1965; Ndjeng and Brunet 1998). According to these authors the depth of the sedimentary series does not exceed 1500m. Therefore the boundary between the lower crust and the upper crust of Babouri-Figuil sedimentary basin would be shallow.

In Mayo-Oulo-Léré sedimentary basin, two major discontinuities have been obtained on profiles P4, P5 and P6 (Fig. 8).

The first discontinuity possesses the following depths 4.27km, 4.62km and 5.32km. These depths could correspond to the crust-mantle interface. The second discontinuity presents the following depths 1.48km, 1.54km and 1.72km. These depths are associated with intracrustal structures with an average depth of 1.55 km. This value probably corresponds to the near surface layer. It indicates that the Mayo Oulo-Léré basin would be deeper than that of Babouri-Figuil.

4.3. Density and Density Contrast of Structures

To determine the characteristics and shapes of geological structures of suspected bodies in Babouri-Figuil and Mayo oulo-Léré sedimentary basins, six profiles were modelized. P1, P2 and P3 of SE-NW direction were modelized in Babouri-Figuil sedimentary basin and P4, P5 and P6 of SW-NE direction in Mayo Oulo-Léré. The average densities of sediments, granites and basaltic rocks present in the study area are respectively: 2.45g/cm^3; 2.65g/cm^3; 3g/cm^3 (Telord et al.1990). The corresponding density contrasts are respectively: -0.2g/cm^3, 0g/cm^3 and 0.3g/cm^3. In Babouri-Figuil sedimentary basin, we obtain three models of structures corresponding to profiles P1, P2 and P3. These models are constituted of two formations of different density contrast (Fig. 9).

- The first formation has density contrast and density respectively – 0.2g/cm^3 and 2.45g/cm^3. This formation is present throughout the profile. Its depth varies and reaches a spectacular value of 5km, this formation would probably be responsible for a vast zone of negative Bouguer anomaly observed in the sedimentary basin. The density contrast associated with this formation permits to identify along the continental sediments.

- The second formation with density of 2.65g/cm^3 is associated to granites. It constitutes the substratum of the basin and it is presented as a rooted structure that extends to great depth.

In Mayo Oulo-Léré sedimentary basin, we obtain three models corresponding to profiles P4, P5 and P6. These models are constituted of three formations of different density contrast (Fig. 10).

- The first formation of density contrast − 0.2g/cm^3 has an average density of 2.45g/cm^3. It is associated with continental sediments. This formation is present throughout the profile. It depth varies and reach a maximum depth of 3km.

- The second formation with an average density of 2.65g/cm^3 is associated to granites. The depth is an extension of this formation probably constitutes the substratum of the basin.

- The third formation with density contrast of + 0.3g/cm^3 has an average density of 2.95g/cm^3. It is associated with basaltic rocks. To the SW of the profile, these basalts are near surface. The roof of this formation is decreasing and stabilizes at 1.5km. This roof drops to a depth of 3km to the NE of the profile. This formation would be formed during the cooling of magma inside the earth's surface during the volcanic eruption.

5. Discussion

Empirical method of Zeng allows us to determine a regional anomaly which presents the best resemblance to the prolonged Bouguer anomaly at optimum altitude. This method testifies that the residual map of order 4 used in this work is an appropriate one. Negative anomalies observed on this residual map are due to the sedimentary cover while positive anomalies can be explained by the presence of basaltic rocks that were brought up tectonically to the surface. According to the spectral analysis, the depth in the negative anomaly (Babouri-Figuil) and positive anomaly (Mayo Oulo-Léré) is very close. This is because the two basins are similar and shallow. The mean depths of Babouri-Figuil and Mayo Oulo-Léré sedimentary basins were 1.50km and 1.55km respectively. These results agree with those obtained by (Ntsama 2013). According to these authors, Mayo Oulo-Léré and Babouri-Figuil are small shallow Cretaceous basins filled with continental sediments and which depths do not exceed 1600m. For 2.5D subsurface modeling, the structure of the Babouri-Figuil and Mayo Oulo-Léré presents many similarities in the composition of the upper crust when we observe profile P1 to P6. Some constraints and other geological considerations linked with the tectonic features of these basins were combined to build an accurate model for each profile. These constraints have been adopted to build the model corresponding to each anomaly such as the densities of anomalous masses. Densities have been either superior or inferior to the enclosing bed density, which was supposed to have homogenous mean density of 2.67g/cm^3 for the Babouri-Figuil and Mayo Oulo-Léré. The mean densities of rocks present in the study area like granites, basaltics rocks and sedimentary formations were respectively supposed to be 2.65; 3; 2.45 g/cm^3 (Telford et al. 1990; Zanga-Amougou et al. 2013). The interpretation of these models showed the presence of granites, basaltic rocks and sedimentary covers. Sedimentary formations have variable thickness with the maximum of about 5km found in Babouri-Figuil and around 3km in Mayo Oulo-Léré sedimentary basin. The outflows of these sediments confirm the hypothesis showed in geological map. The following formation is constituted of granites. These granites are very abundant in the study area and their thickness are increasing in Babouri-Figuil and decreasing in Mayo Oulo-Léré sedimentary basin. This could indicate that the uplift of granites is most significant in Babouri-Figuil. These models showed also basaltic rocks that generate positive residual anomaly. The origin of these rocks is found at great depth; it has cooled down and could not reach the earth's surface. These results are compatible with the findings of (Kamguia et al. 2005) and the scheme proposed by (Ndjeng et al. 1988) to explain the mechanism of magmatologic establishment of lavas in the Babouri-Figuil and Mayo-Oulo-Léré.

6. Conclusions

This work is based on the analysis and interpretation of combined gravity data of Babouri-Figuil and Mayo Oulo-Léré sedimentary basins. The obtained new gravity anomaly map shows different geological structures partially or totally masked by the sedimentary cover. This map shows strong link between positive anomalies with basaltic rise and between negative anomalies with sedimentary deposits. For the choice of the residual anomaly we used the empirical method of Zeng. This method shows that the residual Bouguer anomaly map of order 4 is the best for an interpretation of crustal structures. The spectral analysis carried out in Babouri-Figuil and Mayo Oulo-Léré sedimentary basins permit to determine the major discontinuities. The mean values of 1.50 km and 1.55 km are the new depth values obtained for future studies in these basins. The 2.5D modeling of the sources of residual anomalies highlights the structures having different densities or densities contrast. The various models show that Babouri-Figuil sedimentary basin is constituted of continental sediment which is situated on granitic environnement. The Mayo Oulo-Léré sedimentary basin is constituted of sediments, basaltic rocks and granitic basement. For the future investigation we will use the 3D inversion, Horizontal Gradient Analysis and Euler deconvolution methods to improve and consolidate our results.

Abbreviations

EGM2008
Earth Gravitational Model 2008
ORSTOM
Office de Recherche Scientifique et Technique d'Outre Mer
BGI
Bureau Gravimétrique International
NGIA
National Geospatial-Intelligence Agency
USA
United States of America
ICGEM
International Centre for Global Earth Models

Declarations

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Authors Contributions

BS, AB, VO and LY designed the study area, proposed the methodology, analyzed and interpreted the gravity data by using various advanced processing techniques in consultation with JK and EMD. The manuscript was jointly prepared by BS, AB, VO, LY, JK and EMD. All authors realized maps, discussed the results and contributed to the writing of the manuscript. All authors read and approved the final version of manuscript.

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Availability of data and materials

The terrestrial gravity and EGM2008 data use in this study are available respectively, at the BGI (Bureau Gravimétrique International): https://bgi.obs-mip.fr/dataproducts/ and ICGEM (International Centre for Global Earth Models): http://icgem.gfz-potsdam.de/home

Conflicts of Interest

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

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Figures

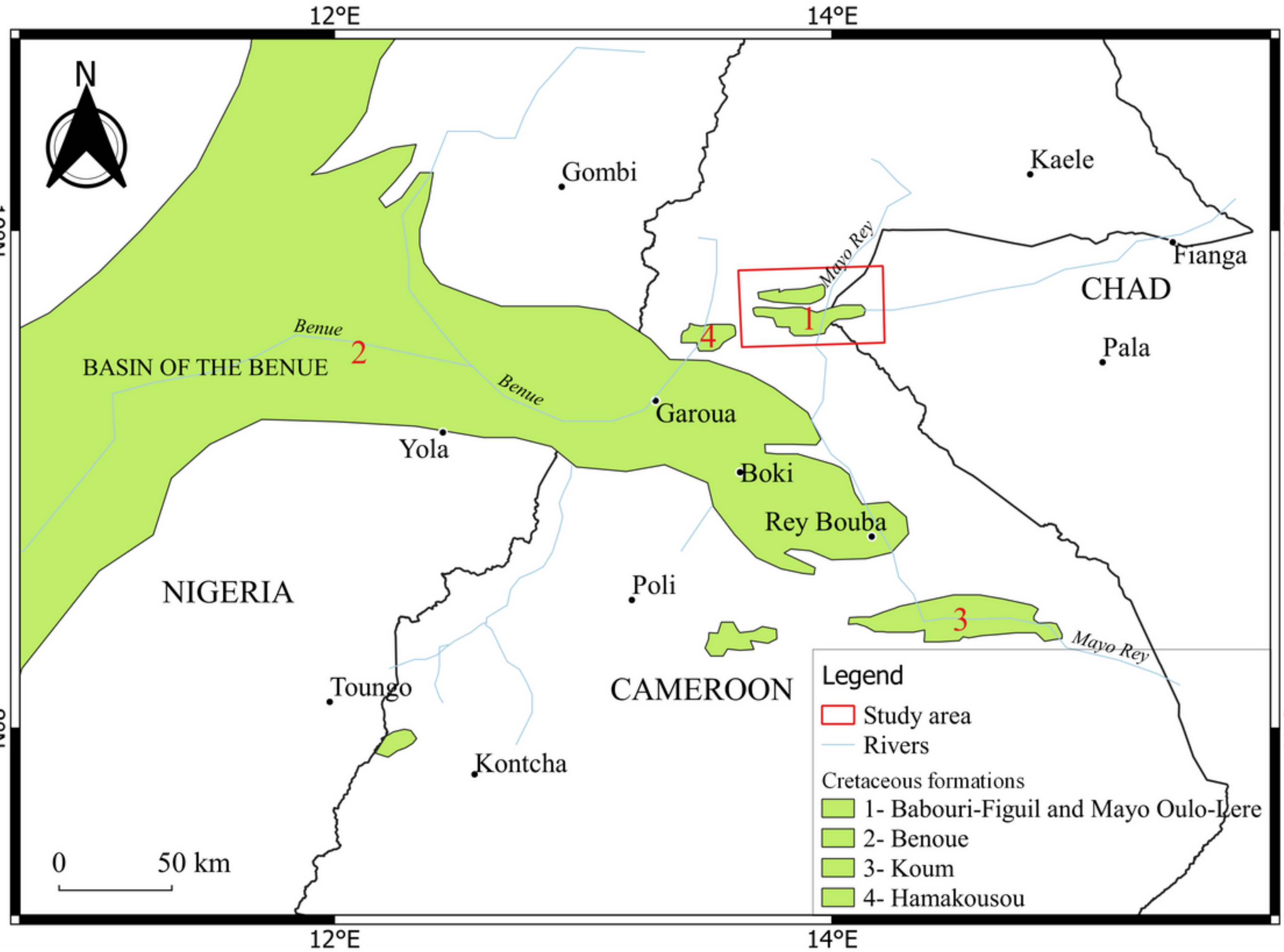

Figure 1

Location map of Babouri-Figuil and Mayo Oulo-Léré sedimentary basins, modified after (Bessong 2012).

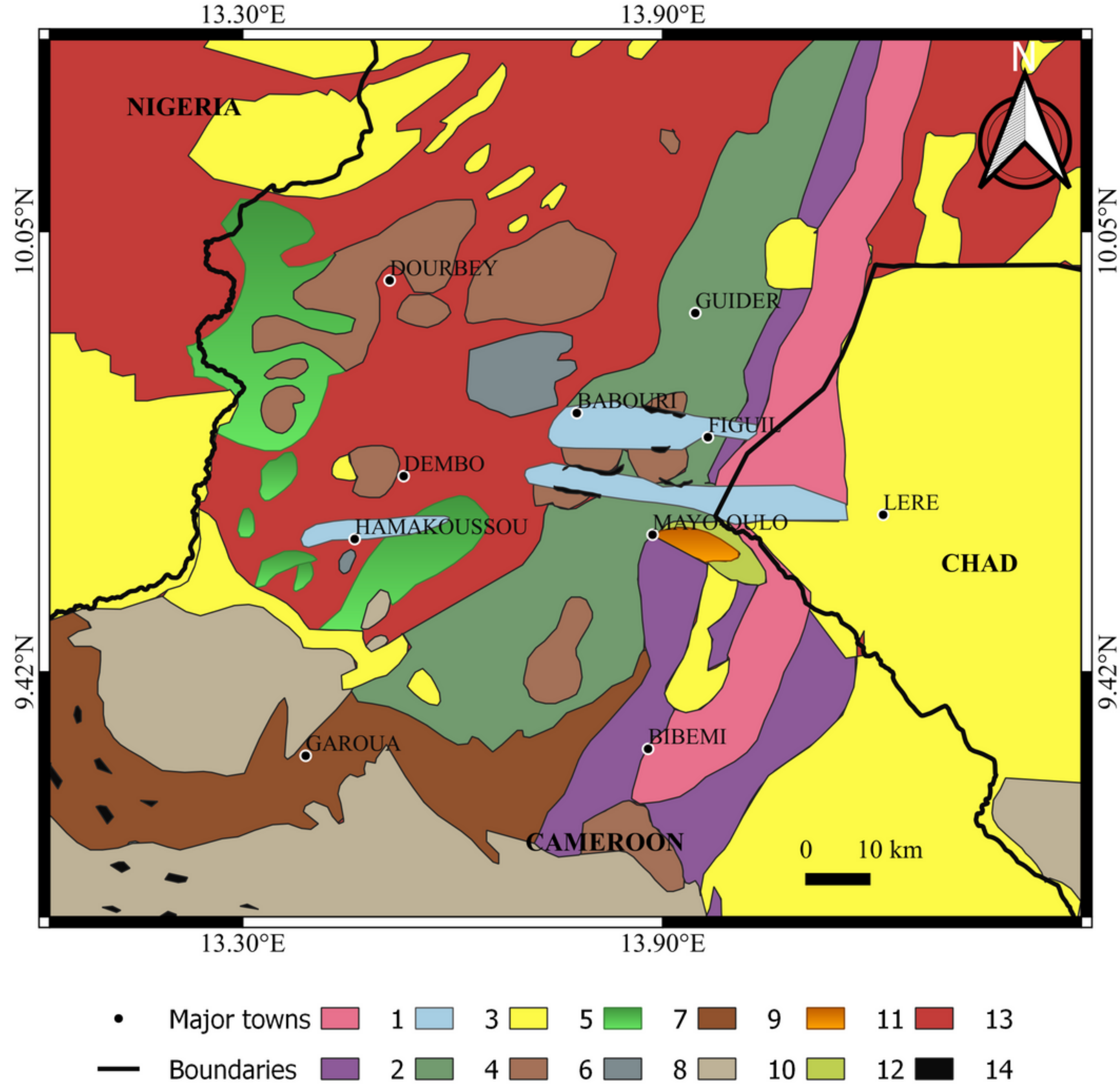

Figure 2

Geological map of the study area (modified from (Abubakar et al. 2018; Abate Essi et al. 2019): **1:** Mica Schist. **2:** Lower Gneiss. **3:** Sedimentary Formations. **4:** Embrechites Migmatic. **5:** Old Syn Tectonic Granitoid. **6:** Late Syn-tectonic Granitoid. **7:** Anatexites Granitoid. **8:** Post-Tectonic Granitoid **9:** Quaternary Alluvium. **10:** Cretaceous Benue Sandstone. **11:** Plio-pleistocene. **12:** Conglomerates (Sandstone and lavas). **13:** Anatexites Migmatic. **14:** Basalt.

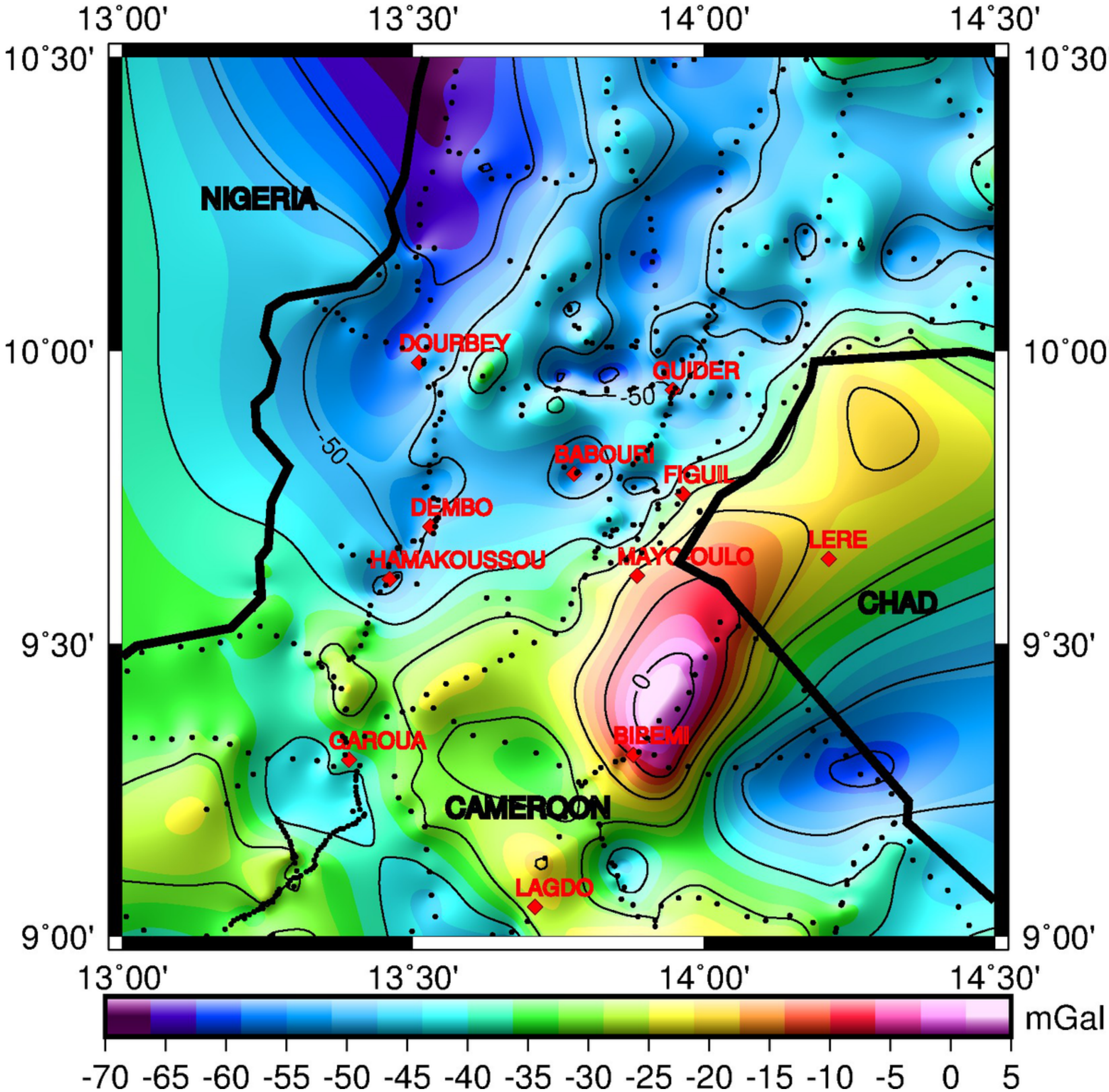

Figure 3

Bouguer anomaly map of the region obtained by using terrestrial gravity data

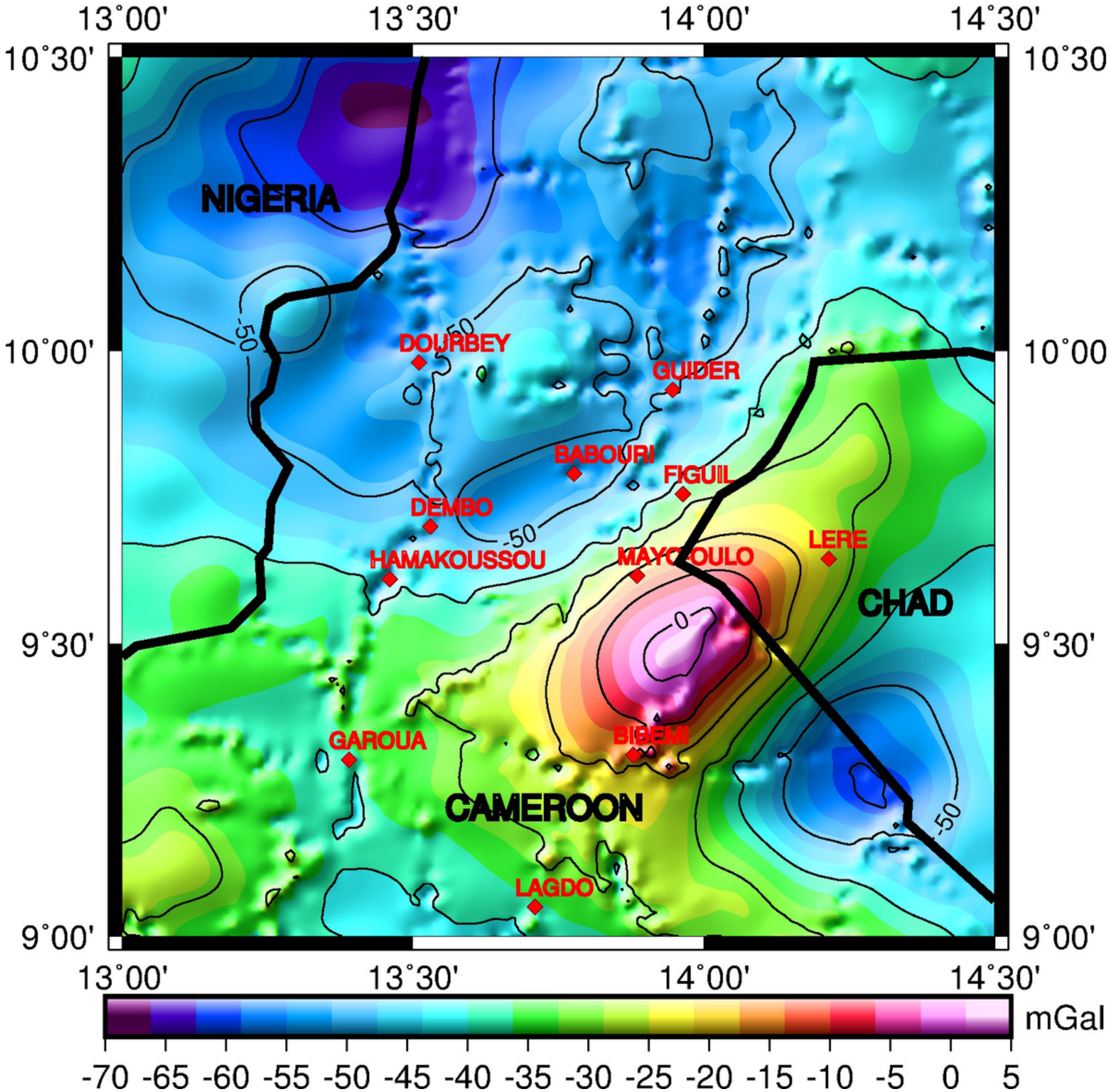

Figure 4

Bouguer anomaly map of the region obtained after combined terrestrial gravity data and EGM2008 model.

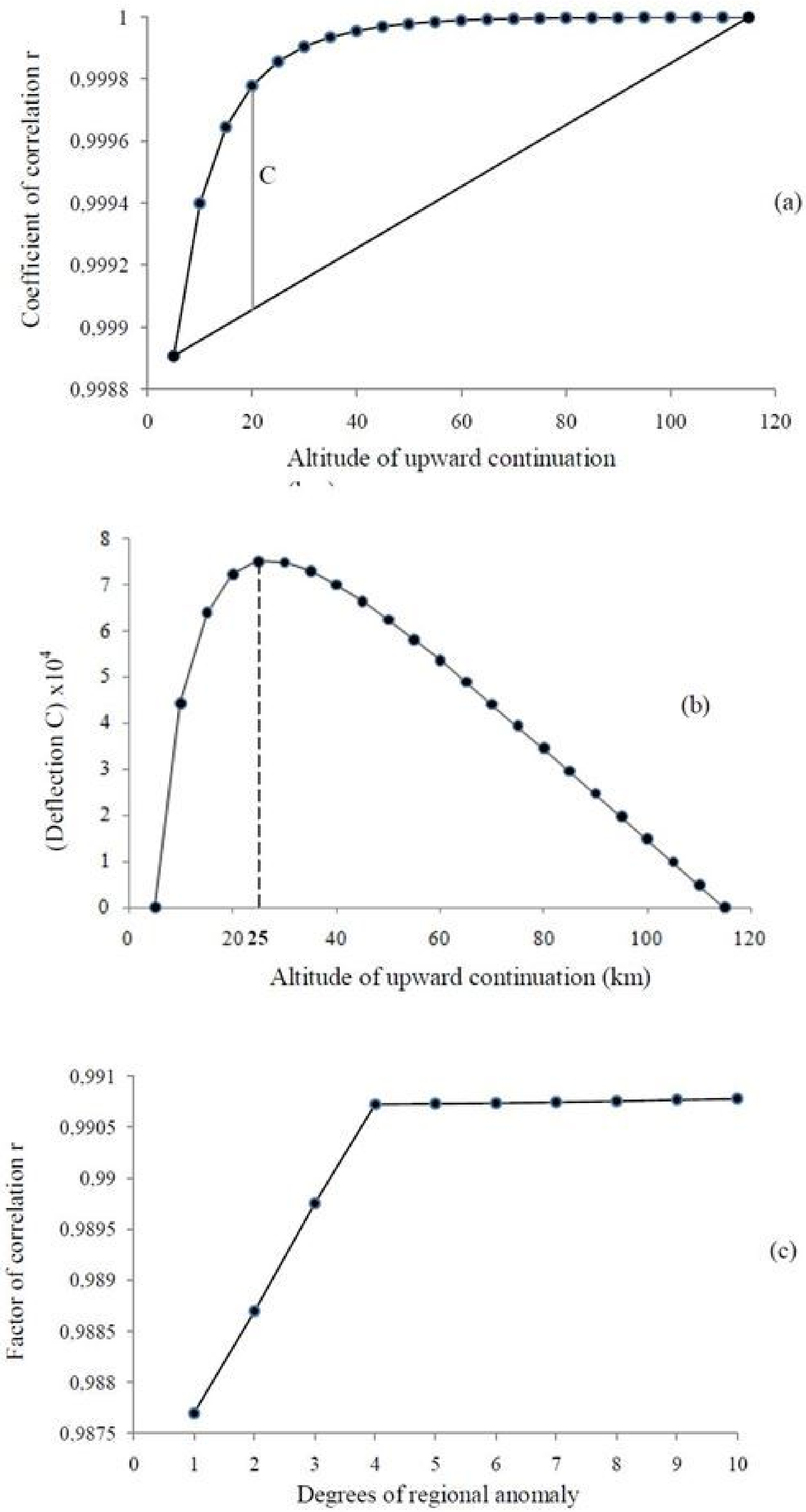

Figure 5

Optimum upward-continuation height by the method of (Zeng et al. 2007). **(a)** Cross-correlation between two successive upward continuated as a function of the continuation height, **(b)** the deflection C of the cross-correlation curve and **(c)** the factor of correlation according to the degrees of regional anomaly.

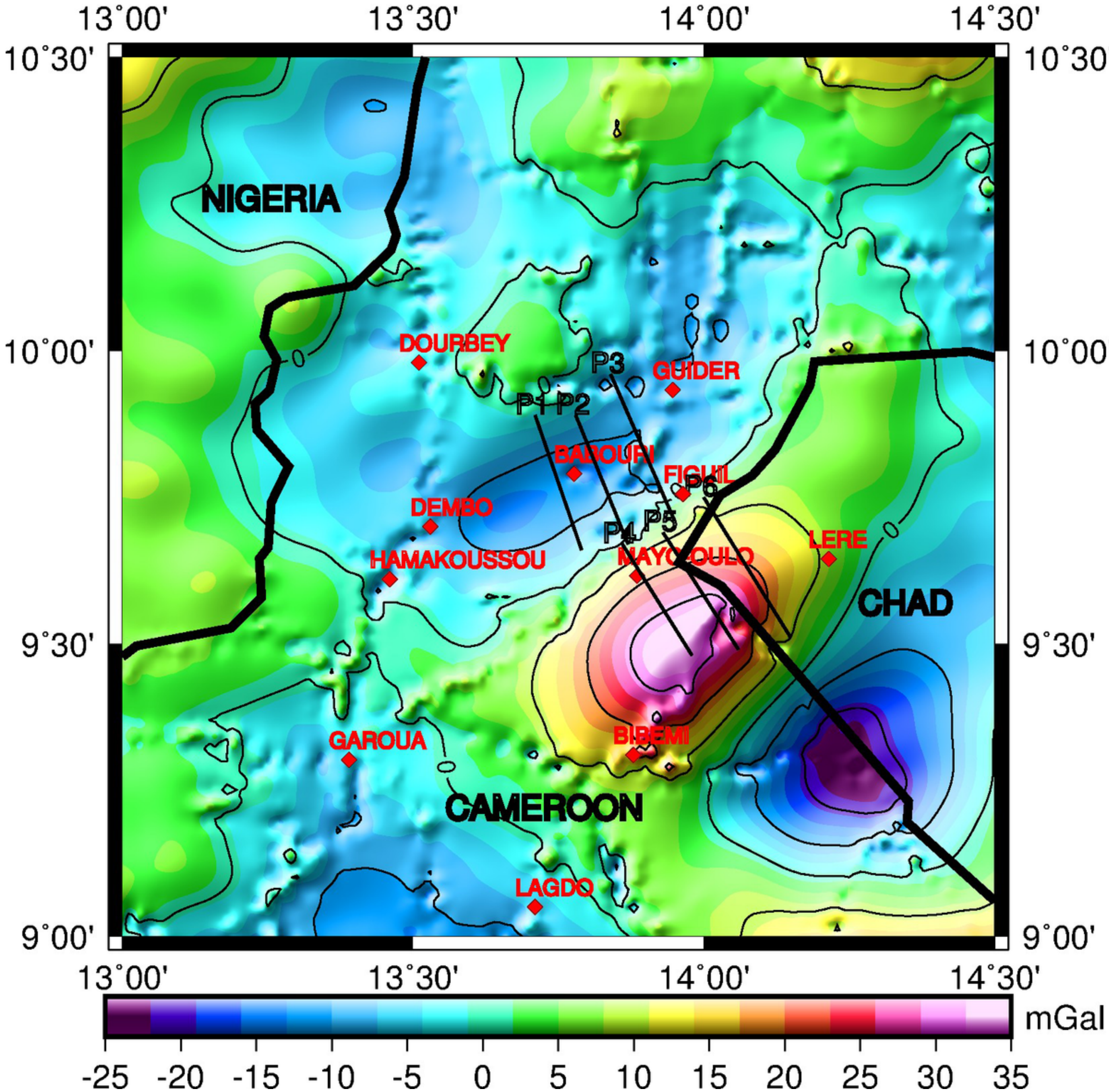

Figure 6

Fourth-order of residual Bouguer anomaly map of the region obtained after combined terrestrial gravity data and EGM2008 model.

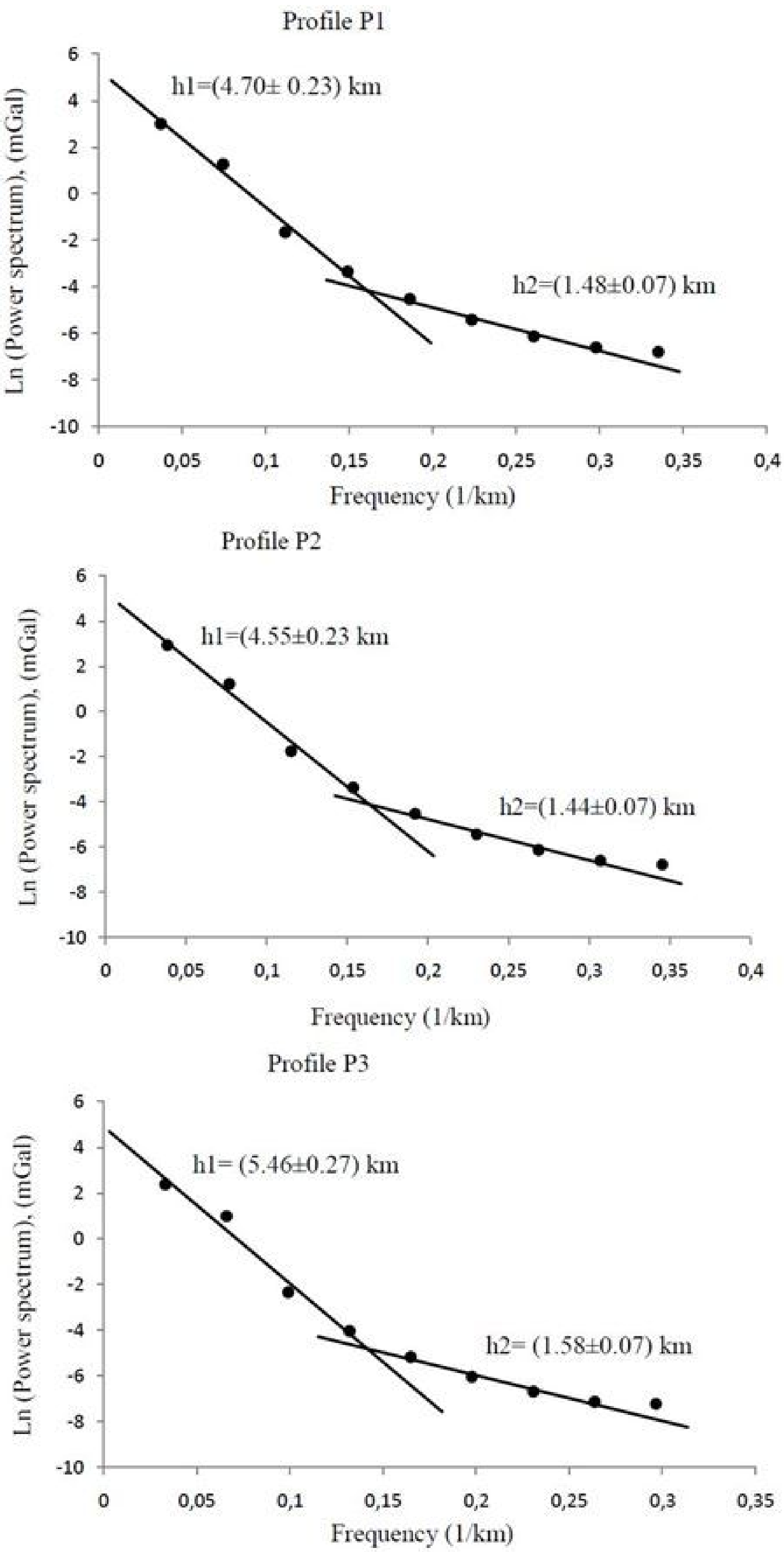

Figure 7

Power spectrum of profiles P1, P2 and P3 from spectral analysis program of Babouri-Figuil basin.

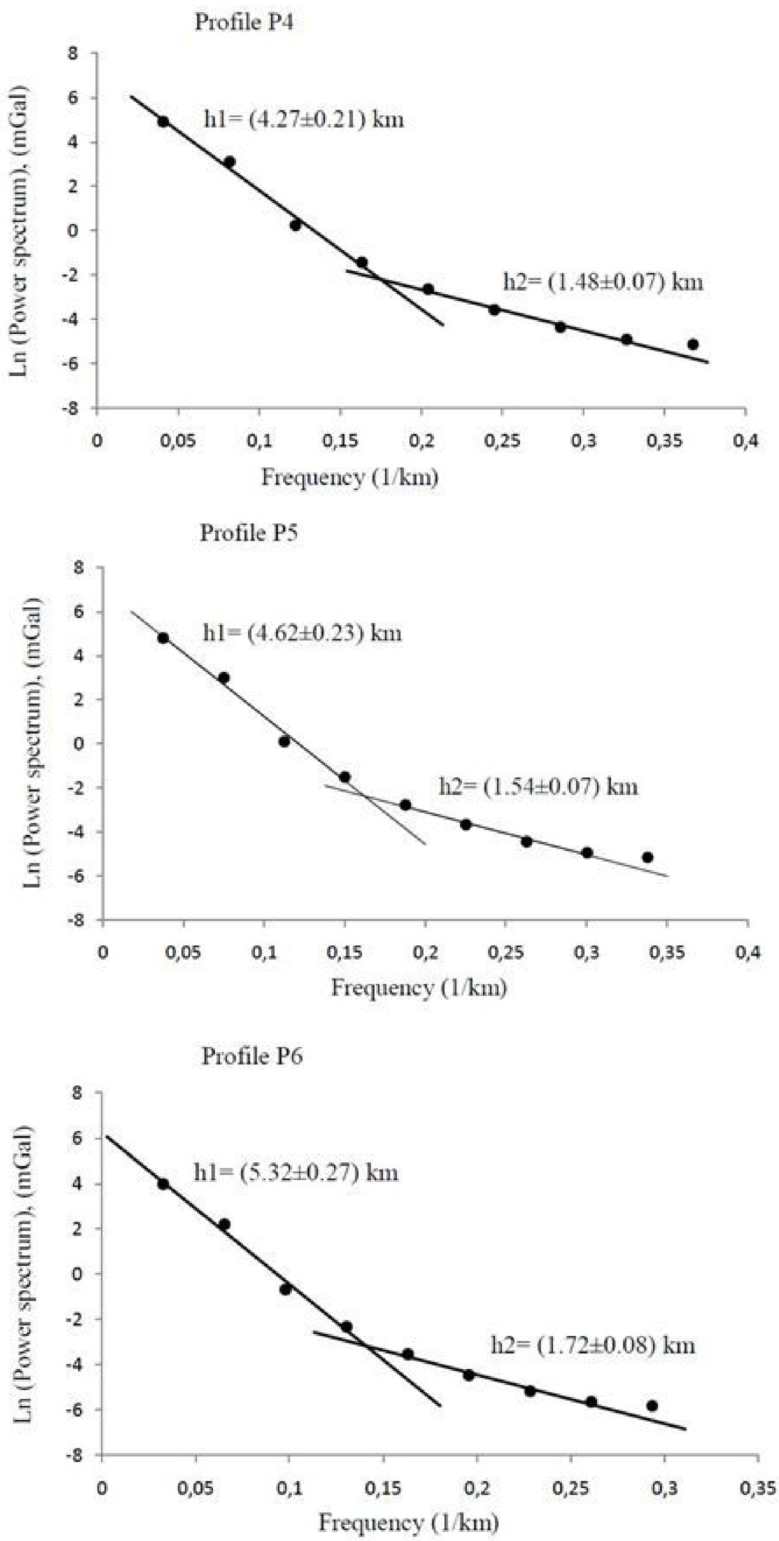

Figure 8

Power spectrum of profiles P4, P5 and P6 from spectral analysis program of Mayo Oulo-Léré basin.

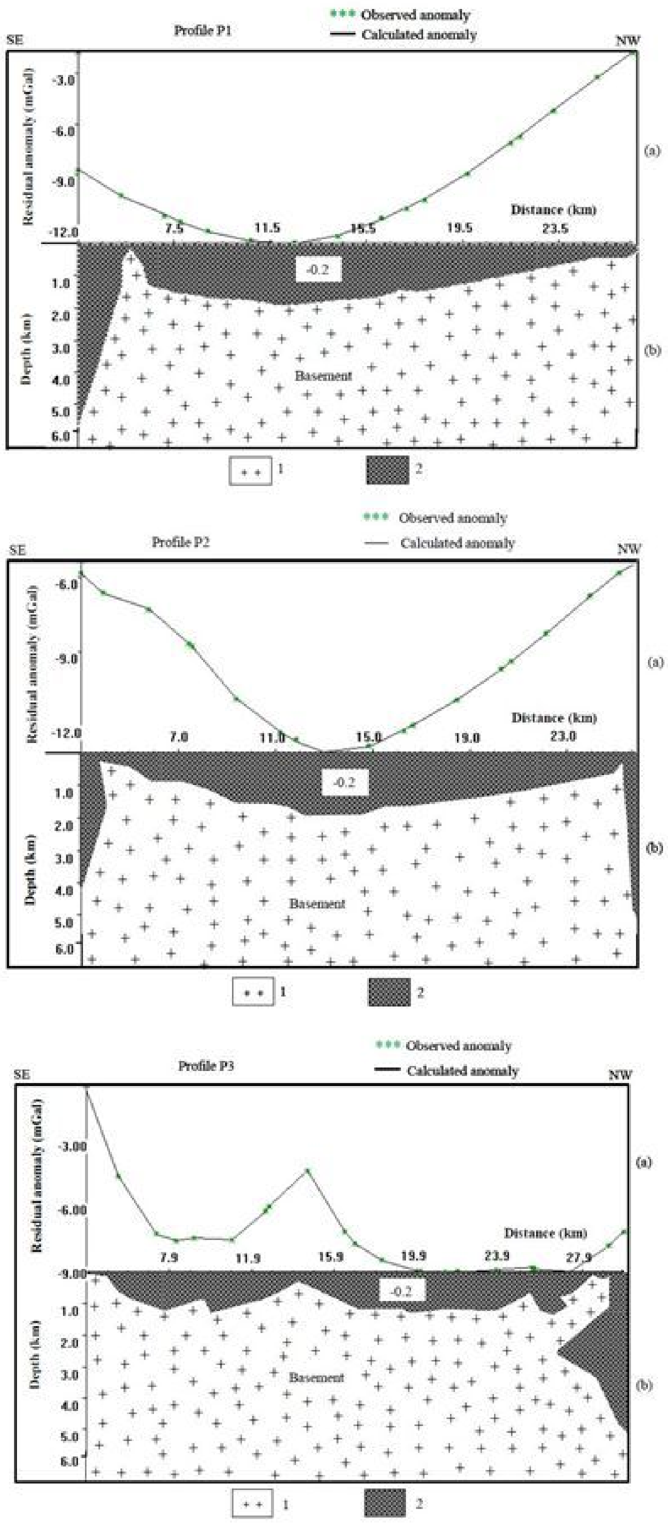

Figure 9

Crustal model of profile P1, P2 and P3 of Babouri-Figuil basin

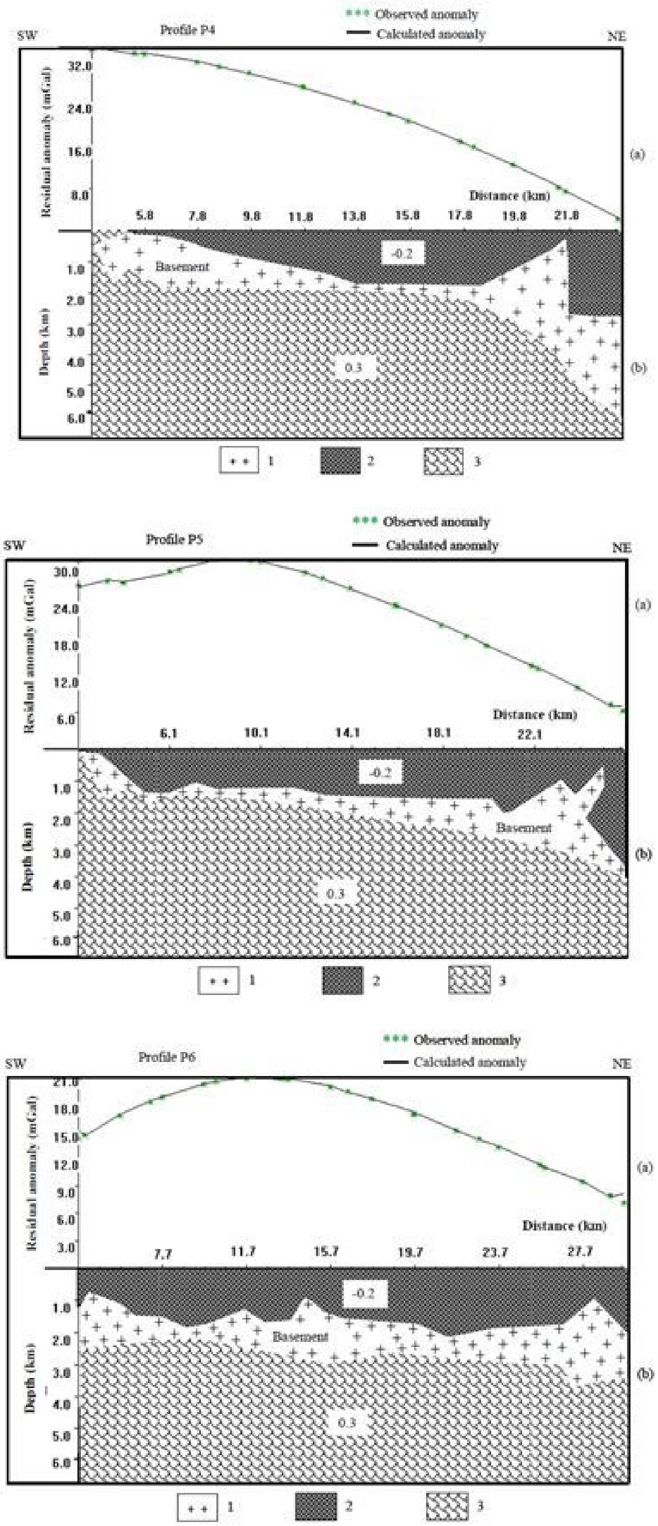

Figure 10

Crustal model of profile P4, P5 and P6 of Mayo Oulo-Léré basin

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