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On the use of global potential field models for regional interpretation of the West and Central African Rift System

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ABSTRACT

The use in regional interpretations of the Earth Gravity Model (EGM08) and Earth magnetic model (EMAG2) is evaluated by comparison to ground gravity and aeromagnetic data in the central sector of the West and Central African Rift System (WCARS). The comparison includes upward continuation, spectral analysis and pseudogravity calculation and statistical evaluation. A correlation between EMAG2 (which contains roughly 25 km resolution aeromagnetic data in the region) and near-surface aeromagnetic data over WCARS is only true for the very low wavelength part but a strong similarity between EGM08 and ground gravity data can be confirmed. Interpretation of the EGM08 data allows identifying and confirming the position of major structural trends, and provides new information on the crustal architecture. The lineaments limiting different grabens forming the Logone Birni basin and in the southern Chad basin are identified. The results presented here show the use of EGM08 data for regional interpretations over Cameroon and adjacent countries, which can overcome the absence and sparseness of data in developing countries and remote areas.

1. Introduction

The West and Central African Rift System (WCARS) (Fig. 1) is divided into the West African Rift Subsystem (WARS) and the Central African Rift Subsystem (CARS), and is an intracontinental Cretaceous–Tertiary rift system where both strike–slip and extensional basins were formed mainly by the mechanical separation of African crustal block during the Early Cretaceous (Browne and Fairhead, 1983; Fairhead, 1986; Binks and Fairhead, 1992; Guiraud and Maurin, 1992). Significant oil discoveries have been made in sedimentary basins belonging to the WCARS (e.g., Doba Basin, Chad which led to the construction of the Chad–Cameroon pipeline). Despite the scientific and economic interest in these areas, the existing gravity data base in Cameroon and adjacent countries consists of local surveys collected in the 1960s and 1980s (Fairhead and Okereke, 1987; Poudjom Djomani et al., 1995). High resolution gravity data are mostly located in areas of high petroleum interest like the Gulf of Guinea or the main Chad basin zones and are usually the property of petroleum companies, and thus not always available for academic studies. Further, most of the area of the WCARS is covered by thick forest with few roads. Hence, the gravity data distribution is highly uneven and concentrated along major roads and tracks. Magnetic data are mostly surveyed in the 1960s. Their patchy distribution does not allow derivation of large scale interpretational models.

The compilation of a new generation of global models of the gravity and magnetic field keeps the promise to overcome the sparseness of data. We use the Earth gravitational Model EGM08 (Palvis et al., 2008) and the Earth Magnetic Anomaly Grid EMAG2 (Maus et al., 2009) to discuss the possibilities in using those global gravity and magnetic field compilation in regional mapping. The present work evaluates the EGM08 and EMAG2 in the central sector of the WCARS and the main objective is to evaluate whether the EGM08 and EMAG2 can aid in recognising major tectonic and structural elements. Consequently, this study provides a preliminary, yet reliable, assessment about the use of EGM08 and EMAG2 for future studies in Cameroon and adjacent countries.

2. Geology and tectonic background

In this section, we provide a brief review of the major tectonic features of the area of study that are relevant to the application and discussion of the new geopotential field map interpretations, in particular, the upper Adamawa plateau, the Benue Trough, and the southern Chad sedimentary basins (Fig. 1). For comprehensive

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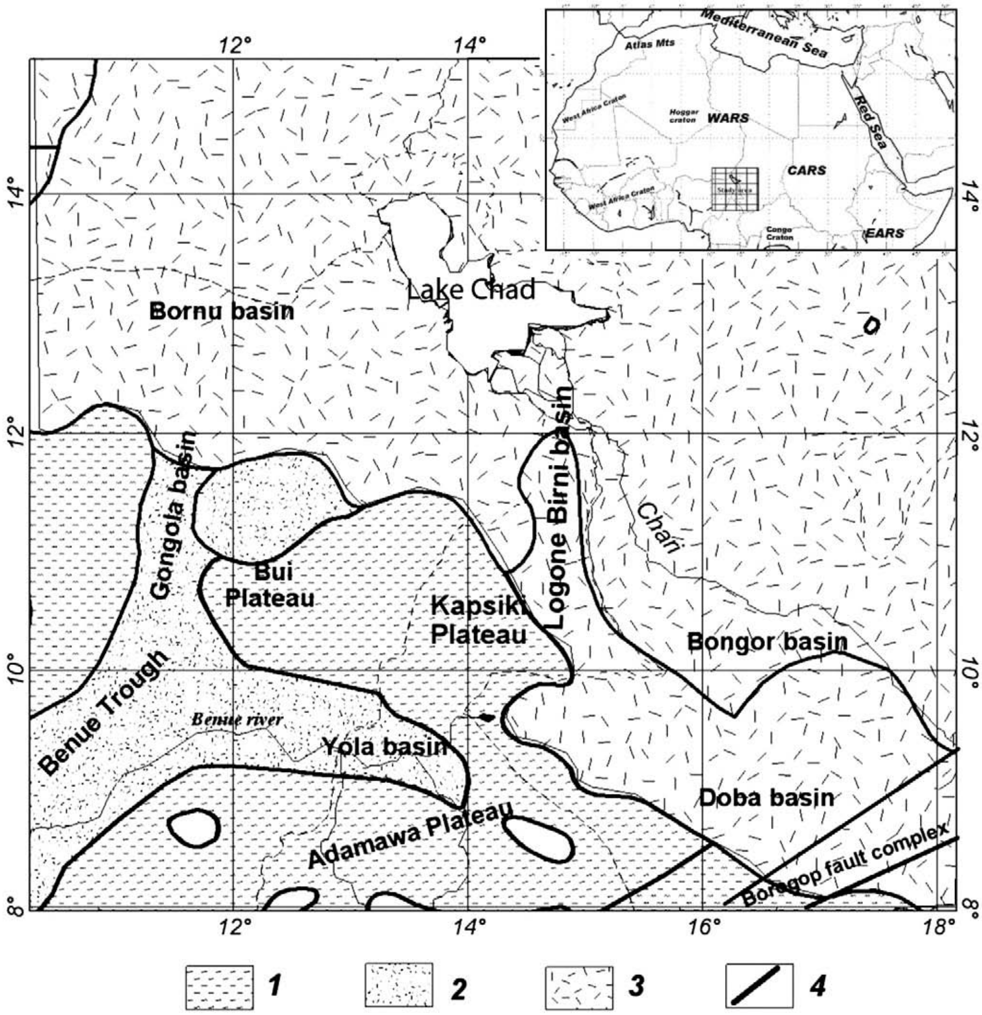

Fig. 1. Location and simplified geological map of the study area in the West and Central African Rift System (WCARS). WARS = West Africa rift system; CARS = Central African rift system; EARS = East African rift system. (1) Precambrian; (2) Early Cretaceous; (3) Tertiary–Quaternary; and (4) Faults or major structural elements.

reviews of WCARS geology and tectonics we refer the reader to Schlüter (2006); Milesi et al. (2006) and Genik (1992).

Extensional, compressional tectonism and subsidence have been the most important tectonic events in shaping the geology of the WCARS (Fairhead and Okereke, 1987). The general surface geology is mainly composed of the Precambrian basement folded by Early Cretacious to Recent sediments deposited in sedimentary basins. The Precambrian basement in the area of study is mainly outcropping in the upper Adamawa Plateau Mandara Mountains area in the Kapsiki Plateau. It is made up of migmatites and anatectites of the Mokolo unit (Ngounouno et al., 2000) and the formations of the Pan African Mobile Belt. These rocks are intruded by some granite (Dumort and Péronne, 1966) and are locally covered by continental sediments of Lower Cretaceous ages (sandstones, red mud, and conglomerates less than 20 m thick). The oldest sediments are Early Cretaceous in age with an unknown total thickness. They are made up of sand stones, mudstones, shale, clastic and limestones which rest uncomfortably on the Precambrian basement rocks. These sediments manly crop out over the Benue Trough and its side basins namely the south–north trenching, Gongola and west–east trenching, Yola. These rocks are also present in the rest of southern Chad basins (Bongor, Daba and Logone Birni) but are locally covered by Recent sediments, mostly Tertiary–Quaternary in age. Further details in local geology and relationship with the new geopotential field models for the tectonic features stated above are provided and discussed in the next sections.

3. Data and comparison

3.1. Gravity data

The ground gravity dataset is extracted from the Bouguer gravity anomaly map established by Poudjom Djomani et al. (1996) and made available by IRD (Institut de Recherche pour le Développement, France). This dataset covers the region between longitudes 13.3°E to 15.7°E and latitudes 10°N to 14°N and consists of approximately 1350 points. The measured points have a relatively even distribution throughout the study area (Fig. 2), although the data are concentrated along major roads and tracks with a station spacing of 2–5 km. All the data were tied to the IGSN71 reference system, and a density of 2670 kg/m^3 was used for the Bouguer correction.

The dataset we used was taken from the Earth Gravitational Model (EGM08) (Palvis et al., 2008). An early version, the EGM96 (Lemoine el al., 1998) is composed of surface (land, marine, and airborne) gravity data, and gravity anomalies estimated over the ocean areas from satellite altimetry. The new model EGM08 has been corrected for the long wavelength ($\geq$300 km) anomalies of satellite data (e.g. GRACE). The model provides earth's external gravitational potential by a spherical harmonic model complete to degree and order 2159, with additional spherical harmonic coefficients extending up to degree 2190 and order to 2159, this new model provides gravity data with a $5' \times 5'$ nominal resolution.

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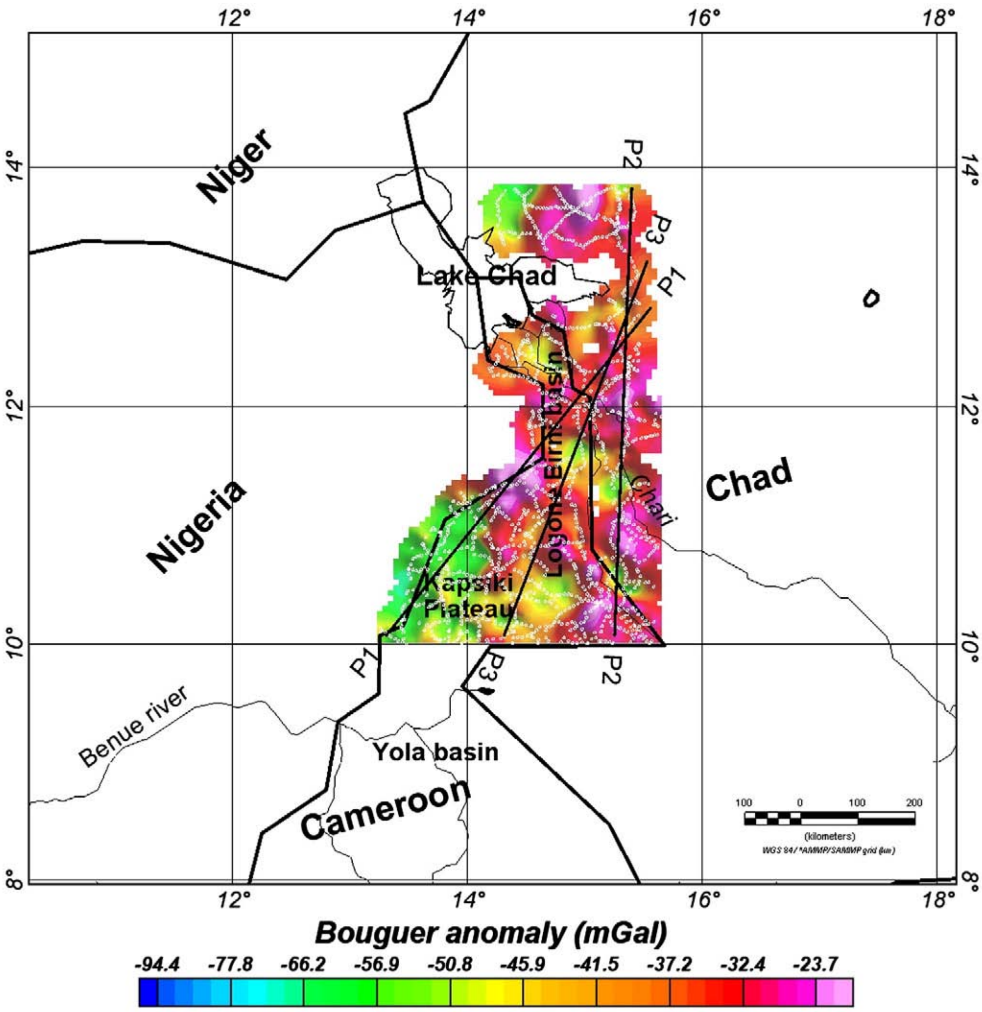

Fig. 2. Bouguer gravity anomaly map of North Cameroon, superimposed on it are gravity data distribution points (white dots) and selected profiles (P1–P3) used for the test.

We have used the spherical harmonic coefficients of the EGM08 (Palvis et al., 2008) to first derive a geoid referenced to the WGS84 spheroid and subsequently calculated the free air (Fig. 3) and the Bouguer gravity anomaly (Fig. 4) over the central sector of the WCARS, accordingly. The Bouguer correction was calculated using the ETOPO1 elevation data (Amante and Eakins, 2008) and applying the Bouguer correction with a density of 2670 kg/m^3 for the Bouguer slab using GEOSOFT software (Xcellaration Gravity, 2002). Comparing the resulting Bouguer anomalies from the two data bases shows considerable consistency in the long and short wavelength anomalies (Figs. 2 and 4). For example, the amplitude and extent of negative anomaly representing the Kapsiki Plateau, or the Logone Birni basin are also clearly visible on the EGM08 data (Fig. 4). We compare the EGM08-based and ground data along three selected profiles across northern Cameroon (Fig. 4) using a series of statistical method applied to each profile.

The statistics of this comparison are given in Table 1 and are shown in Fig. 5a–c. The maximum absolute difference in amplitude between EGM08 and ground data is about 10 mGal for the first profile with a correlation of about 0.94 while the maximum absolute difference in amplitude is about 22 mGal with a correlation of about 0.86 for the second profile and finally a maximum absolute difference in amplitude of 12 mGal with a correlation of about 0.78 for the third profile. As the maximum difference is less meaningful because of the difference in wavelength content, we have evaluated the mean amplitude difference between EGM08 and ground gravity data for each of the profiles (Table 1). This shows that the discrepancy between EGM 08 and ground gravity data is not significantly large in this part of the continent. The scatter analysis (Fig. 5a–c) enhances consistencies and offers a remarkable agreement between the EGM08 and the ground data. Naturally, the profiles from ground data depict short wavelength anomalies while the EGM08 derived data appears slightly smoothed. There are also some slight misfits in amplitude between the two data sets on each of the profiles (Fig. 5d–f). This is the result of the difference in wavelength contain. Both could be a result of various regrinding process as well. However the spatial position of the different anomalies remains the same on both maps.

As a more qualitative comparison, we use spectral analysis to quantify differences in wavelength between ground data and EGM08, and test if the result from spectral analysis is similar to that of above observations. Because any anomaly grid may be the combined result of the effects of several sources of different wavelength and direction, the logarithm of the power of the signal at each wavelength can be plotted against wavelength, regardless of direction, to produce a power spectrum (Spector and Grant, 1970). This can be used to quantitatively compare different data sets. Fig. 5g represents the plot of the radially averaged power spectrum of the ground and EGM08 data signals at each wavelength. The two curves show very similar trend. This result is consistent with the above analysis showing only a small difference between ground and EGM08 data, with the exception that the ground data naturally contain higher frequency information due to the high resolution. The EGM08 data have a spatial resolution

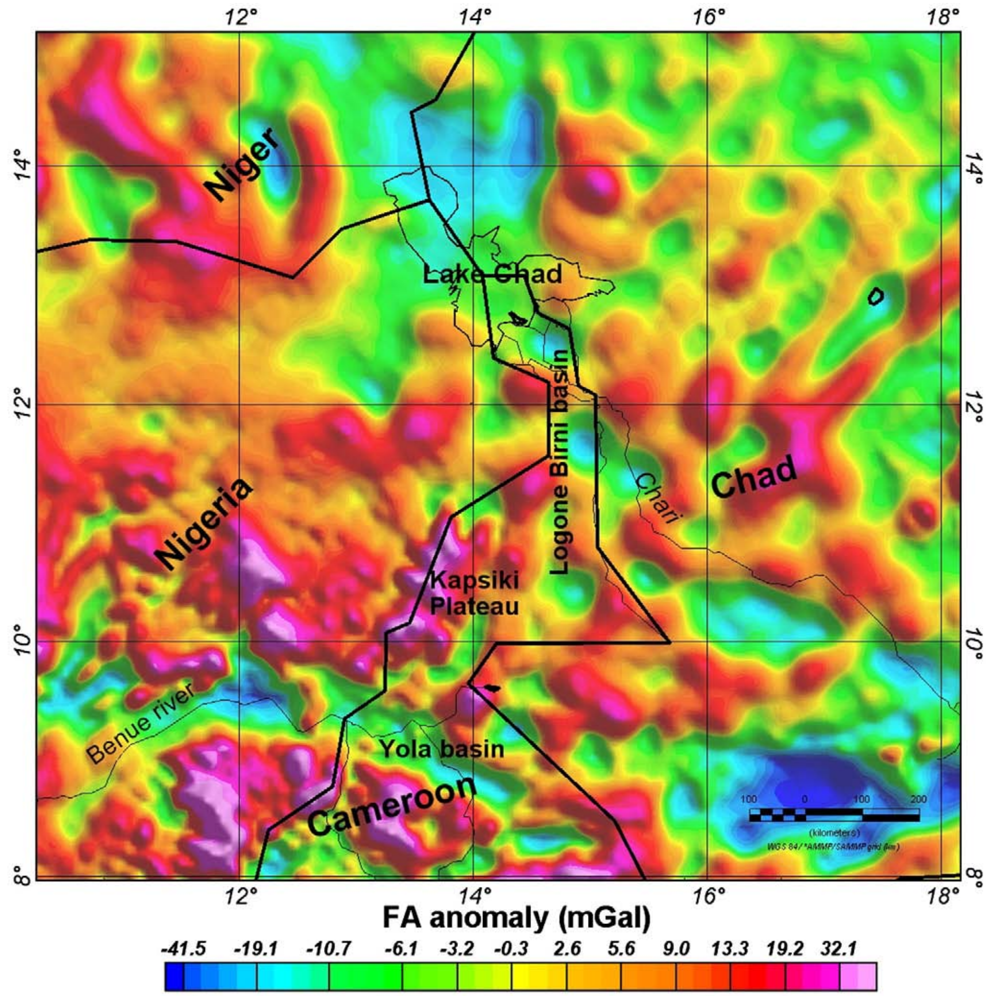

Fig. 3. Free air gravity anomaly (from EGM08) of the central sector of WCARS.

of about 9.3 km, which provides a shortest wavelength of about 19 km, whereas the resolution of ground data is about 2–5 km and provides the shortest wavelength of 4–10 km. This small difference in the wavelength content provides additional consistency in the degree of correlation between the two datasets.

3.2. Magnetic data

The aeromagnetic data used for this test were provided by GETECH and are limited between latitudes 9° N to 13° N and longitudes 13° E to 16° E. They are part of African Magnetic Mapping Project (AMMP) dataset compiled in 1992. The data have had the International Geomagnetic Reference Field (IGRF) removed and have been upward continued to produce a 0.01×0.01 degree grid at 1000 m above the terrain. The global Earth Magnetic Anomaly Grid (EMAG2) is a compilation from available satellite, airborne and marine magnetic measurements (Maus et al., 2009). This model updates the World Digital Magnetic Anomaly Map (WDMAM) (Korhonen et al., 2007). The nominal resolution has been improved from 3 arc min (~5 km) to 2 arc min (~3 km), and the altitude observation level is decreased from 5 km to 4 km above the geoid (Maus et al., 2009). For the purpose of this study, these two data sets have been regridded to produce 5×5 km grid using the minimum curvature technique (Figs. 6 and 7). Nevertheless the input data for this region of Africa used for EMAG2 has not changed compared to the earlier WDMAM data. They are data provided by GETECH with a nominal resolution of 15 min (equivalent to about 25 km data spacing) (S. Maus, personal communication, 2009).

Visual comparison shows some similarities between the two data sets in some areas for example the Yola basin, the Kapsiki plateau and areas close to the Lake Chad can be recognised. At regional scale, some major features like the Upper Adamawa Plateau or the Upper Benue Trough can also be identified.

A comparison of the GETECH local aeromagnetic data and the EMAG2 shows that the EMAG2 is smoother in appearance and poorly resolves short wavelength anomalies due to its 25 km original data availability in this region. Overall effect of this smoothing is similar to the result of an upward continuation of low altitude data. Thus, to evaluate the effective altitude of the EMAG2 we apply the standard upward continuation to the aeromagnetic data over Cameroon. The comparison with the EMAG2 (Fig. 8a) shows that the EMAG2 field shows good correlation with the aeromagnetic upward continued at the level of 25 km (Fig. 8a and b). This means that the wavelength content in the EMAG2 model does not correlate to a magnetic model measured at 4 km height over Cameroon (and likely in other places in the world where there are similar decimated data).

Similar to the gravity data, we plotted the radially averaged power spectrum from aeromagnetic and EMAG2 fields at each wavelength (Fig. 8c). Contrary to the gravity data, the trends of the two curves are distinctly different. The energy content in the EMAG 2 data is likely to enhance the effect deeper sources on the expense of short wavelength anomalies representing shallower sources. This result is in good agreement with that obtain from upward continuation.

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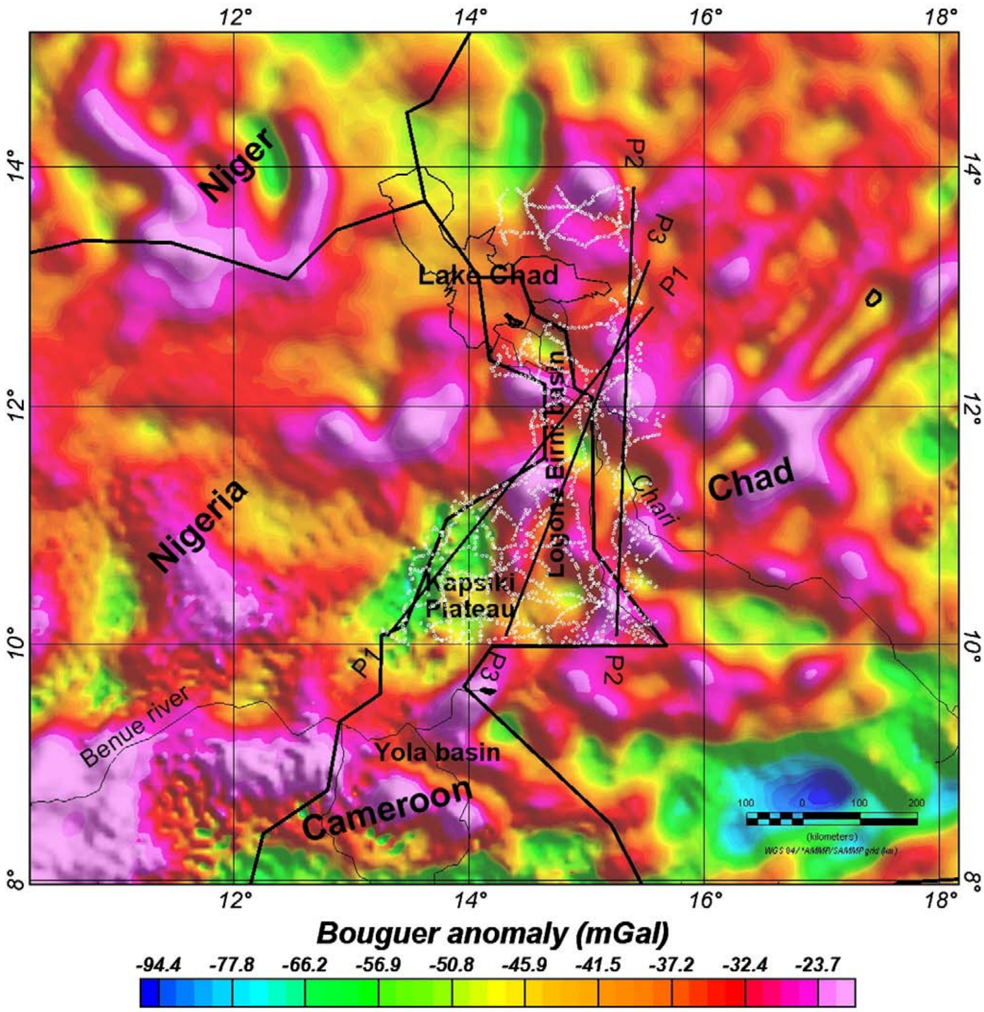

Fig. 4. Bouguer gravity anomaly map of the central sector of the WCARS derived from free air EGM08. Superimposed on it are ground gravity data distribution points (white dots) and selected profiles (P1–P3) used for the test.

4. Geological mapping

Since the early Cretaceous, two major rifts systems have developed within the Northern African continent, the Tertiary to recent rift system of East Africa and the Cretaceous to Early Tertiary rift system of West and Central Africa (WCARS) (Fairhead, 1986). The regional configuration of the West and Central African rift system consists of a series of major NNW to NW-trending extensional basins taking up the strain caused by NE to ENE orientated strike–slip motions emanating from the Gulf of Guinea (Benkhelil, 1982; Fairhead, 1986, 1988; Fairhead and Okereke, 1987 and Okereke, 1984). However, the exact location and extent of some domain boundaries of the WCARS are still unclear and they are sometimes masked by the presence of long wavelength anomalies related to mantle uplift (Fairhead, 1986; Fairhead and Okereke, 1987). Gibb and Thomas (1976) and Fountain and Salisbury (1981) showed that density contrasts caused by the juxtaposition of domains with different petrophysical properties, at locations such as geological boundaries, as well as lineaments can cause paired (positive and negative) gravity anomalies. Such paired gravity anomalies, encountered across dissimilar structural provinces worldwide (Gibb and Thomas, 1976; Subrahmanyam, 1978; Fountain and Salisbury, 1981; Mukhopadhyay and Gibb, 1981; Nyblade and Pollak, 1992).

Magnetic anomalies can be used to map the top of the basement interface. The pseudogravity transformation may be a tool for assessing basement provenance (Lyngsie et al., 2006) and it in general suppresses the short to intermediate wavelength content. We applied the pseudogravity transformation to both the aeromagnetic and the EMAG2 data and compared the results with the known geology to evaluate how these data can help assessing basement lineaments. The pseudogravity transformation can be defined as the gravity anomaly that would be observed if the magnetization distribution were replaced by a uniform density distribution. The resulting pseudogravity maps are shown in Fig. 9. The pseudogravity map from the aeromagnetic data (Fig. 9a) shows high amplitude anomalies in the Kapsiki plateau. This zone of strong anomalies is coinciding with the Precambrian aged crystalline basement in this area. However, the pseudogravity response from the EMAG2 model (Fig. 9b) shows that broad long wavelength anomalies are hard to correlate with any feature known to be present in this area. From the results given above it is clear that using EMAG2 in the central sector of the WCARS will not allow for detailed interpretation of the crustal

Table 1
Statistics for the amplitude difference and correlation coefficient (σ) between ground gravity data and EGM 08 for each profile. GD = ground gravity data.

GD-EGM08	Min (mGal)	Max (mGal)	Mean difference (mGal)	Correlation Coefficient (σ)	Std.Dev. (mGal)
Profile 1	−10	10	−0.31	0.94	5
Profile 2	−22	8	−4.40	0.86	7
Profile 3	−12	12	−2.80	0.78	5

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structure due to the low resolution of the data in this region, although the majority of magnetic signal is generated at crystalline (igneous or metamorphic) basement level. From seismic determination the maximum depth of top of the basement interface in the central sector of the WCARS is about 7 km (Genik, 1992). Further, the pseudogravity map obtained from aeromagnetic data (Fig. 9a) shows a consistency

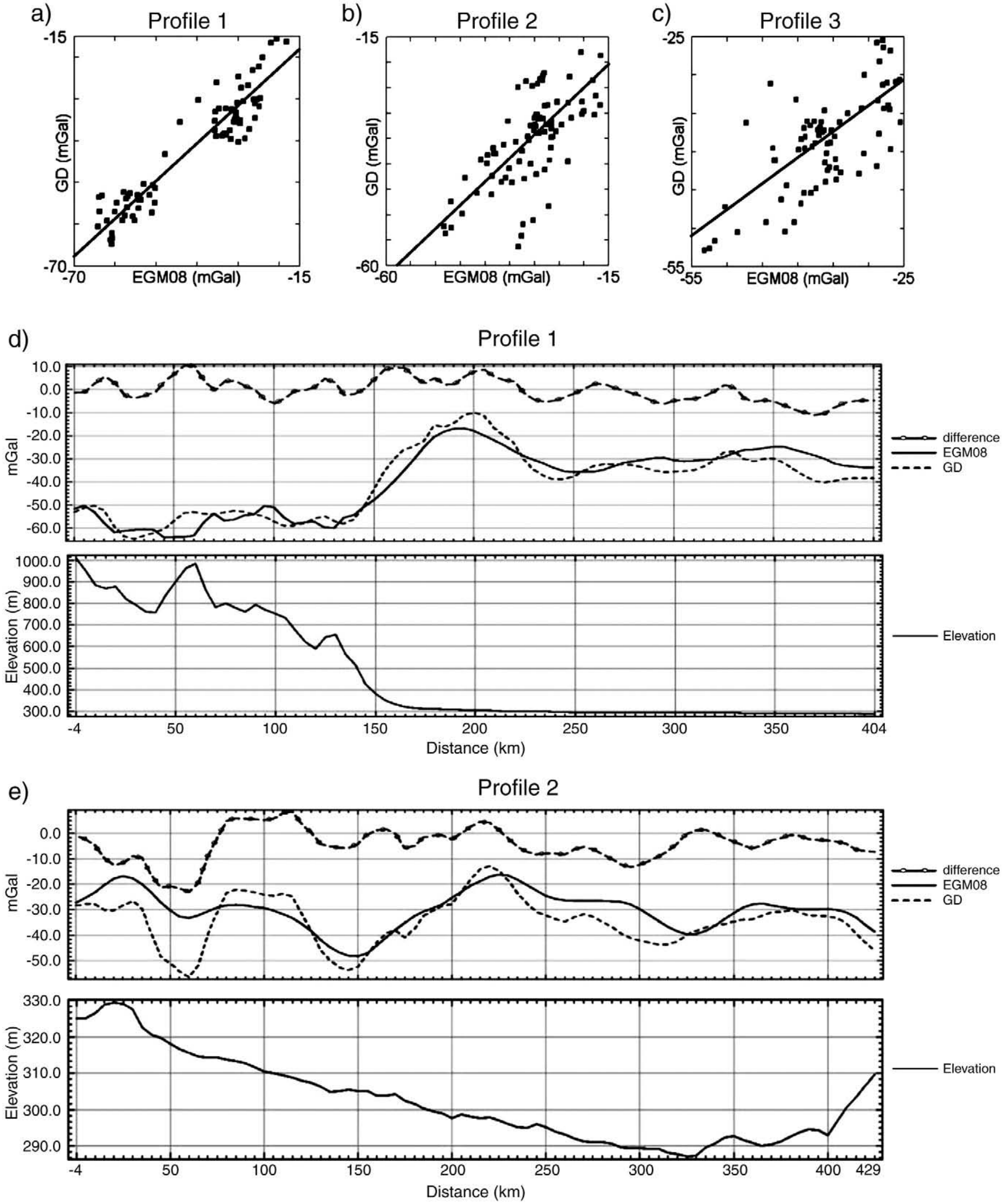
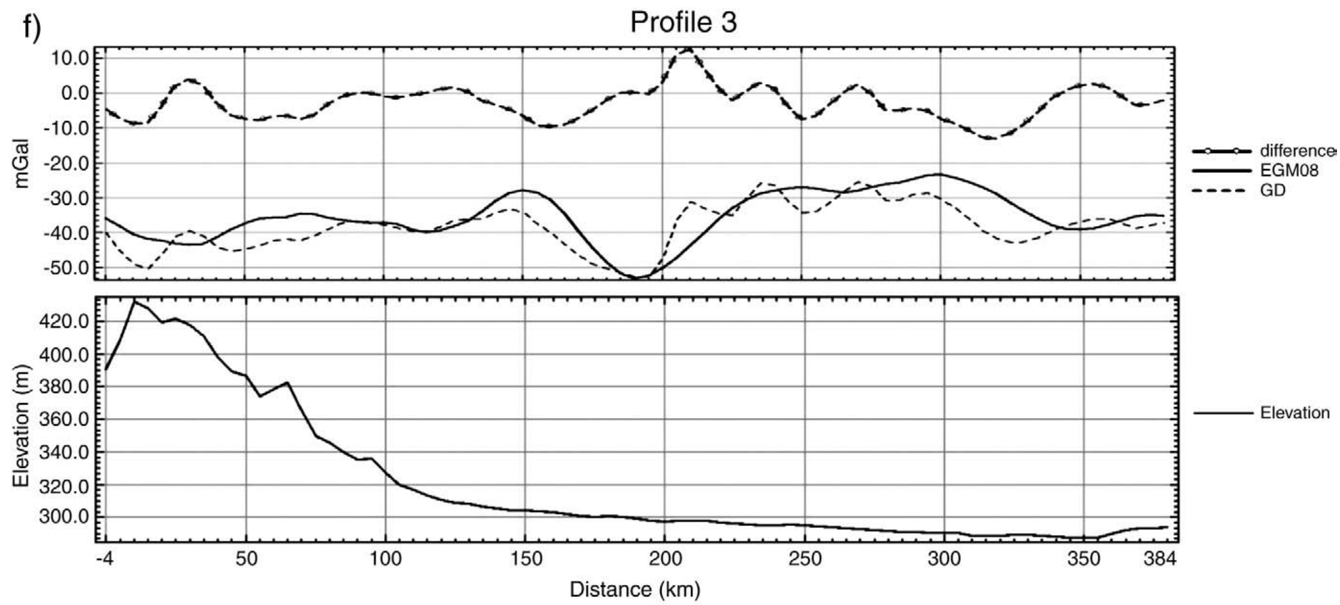


Fig. 5. Comparison of ground gravity data with EGM08 for each profile. Location of profiles shown in Figs. 2 and 4. (a–c) Scatter analysis between ground gravity data and EGM08 for each profile. (d–f) Three gravity profiles on EGM08 and ground gravity data (GD) with the topography across the northern Cameroun. Difference = GD-EGM08. g) Comparison of the radially average power spectra calculated from ground gravity data with EGM08 fields by averaging the Fourier amplitudes.



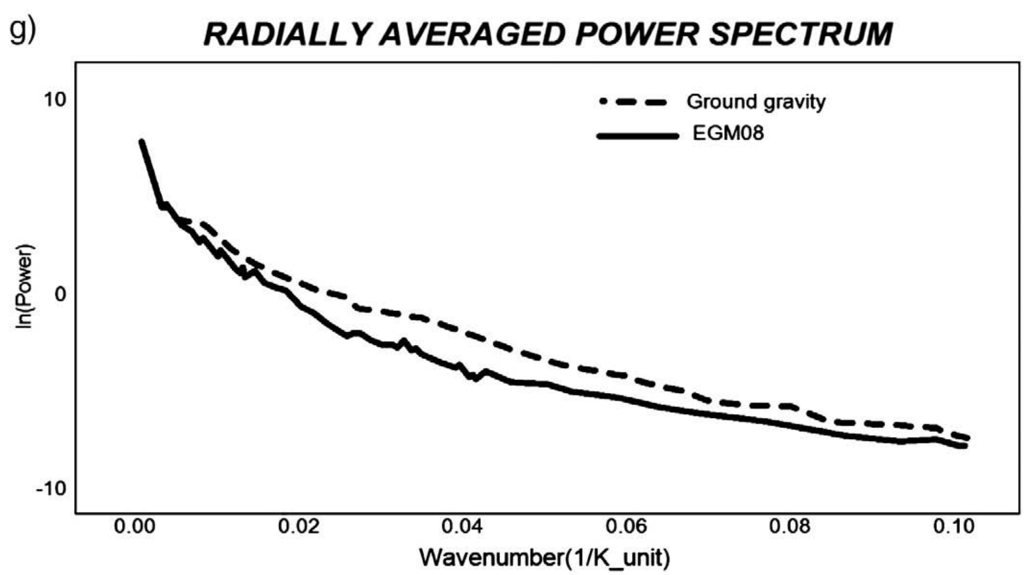


Fig. 5 (*continued*).

with surface geology whereas the pseudogravity anomaly obtained from EMAG2 (Fig. 9b) does not allow for detailed structural interpretation due to the low resolution. Therefore, EMAG2 is not suitable for any top basement mapping in the central sector of the WCARS opposed to aeromagnetic data. However, the EMAG2 data roughly define the boundaries between the basement units like the Kapsiki plateau and the sediment dominated units as the Logone Birni Basin can be distinguished.

To enhance lateral boundaries of density contrast in potential field data, we calculated the horizontal gradient of the Bouguer gravity anomaly which was derived from EGM08 in the central part of the WCARS and their tectonic relationships, with a focus on the Logone Birni basin (LBB) where structural and lineament information are not available. The amplitude of the horizontal gradient (Cordell and Grauch, 1985) is expressed as: $HG=\sqrt{\left(\frac{\partial g}{\partial x}\right)^2+\left(\frac{\partial g}{\partial y}\right)^2}$ where $\frac{\partial g}{\partial x}$ and $\frac{\partial g}{\partial y}$ are the horizontal derivatives of the gravity field in the x and y directions.

Local peaks in the magnitude of the horizontal gradient give the locations of the large density contacts. The steepest horizontal gradient of a gravity anomaly will be located directly over the edge of the body if the edge is vertical and far away from any other edge or source (Thomas et al., 1992).

Fig. 11 presents the computed horizontal gradient of the gravity field of the central segment of the WCARS together with the established structural domain boundaries. A closer examination of the gravity anomaly and the horizontal gradient maps shows that the study area can be divided into five regions based on anomaly trend, wavelength and amplitude (Figs. 10 and 11).

Region one (GD I), the upper Adamawa Plateau in central Cameroon is underlain by Precambrian basement and has been uplifted by up to 1 km relative to the surrounding area during the Tertiary. The basement consists mainly of formations of the Pan African Mobile Belt. It is characterised by a large negative Bouguer anomaly in the southern part and positive anomaly to its northern part, which is orientated roughly E–W, and is charactarized by a strong gravity gradient with a magnitude generally exceeding

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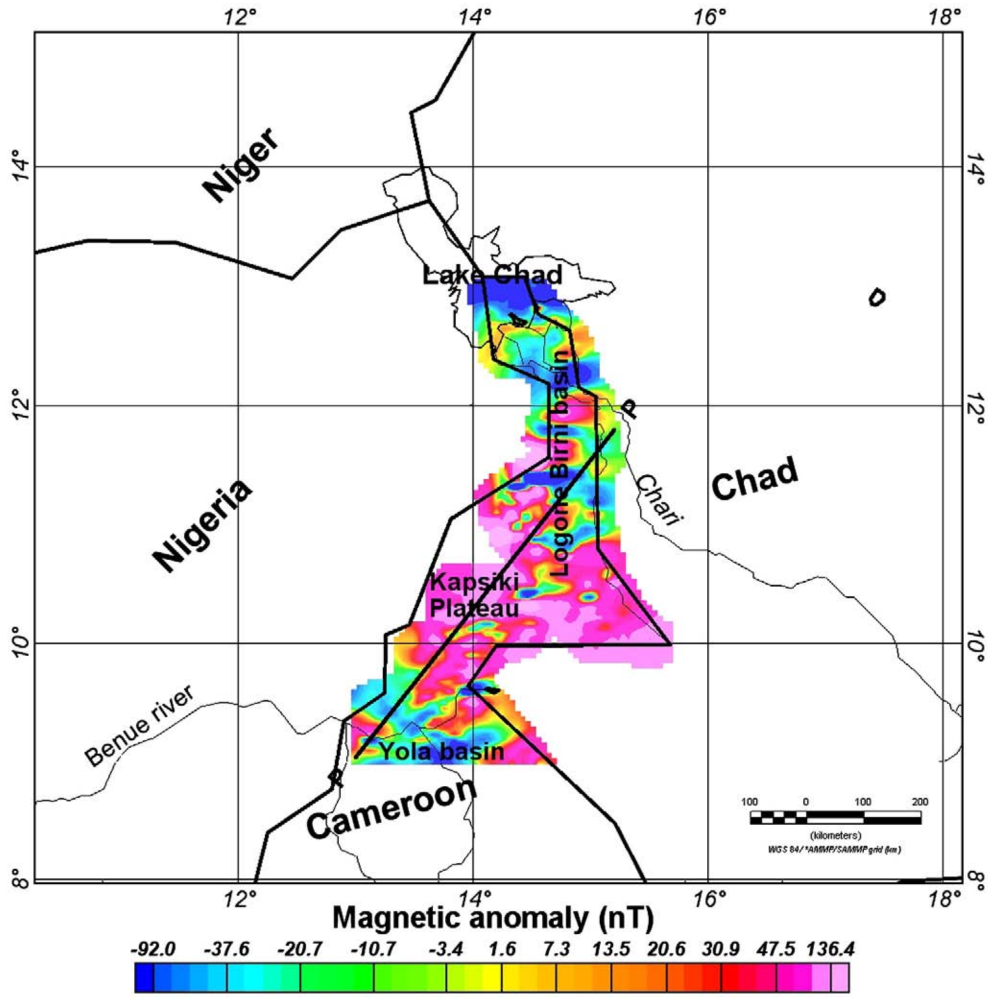

Fig. 6. Aeromagnetic anomaly map of North Cameroon, superimposed on it is the selected profile (P) used for the test.

2 mGal/km. This suggests the presence of dense material in the subsurface, consistent with the presence mainly gneiss, granite and charnockite rock types forming the Precambrian basement, but intrusion by mafic plutonic or volcanic rocks such as basalt in the basement rocks is also possible. The plateau is constructed from a series of lava flows with most recent activity represented by strombolian cinder cones south of Ngaoundere (Tendjim, 1986; Nono et al., 1994). This region is part of the Cameroon volcanic line (CVL) and which has been active since the Cenozoic. In the continental sector, its activity includes emplacement of plutonic complexes (more than 60) and volcanic eruptions (Ngako et al., 2006).

Region two (GD II), coinciding with the Kapsiki Plateau can be seen as the northern continuation of (GD I) as both they show roughly similar geology and gravity properties and belong to the CVL, although split by the failed arm of the Benue Trough. The geology of this region consists of the Precambrian basement made up of migmatites and anatectites of the Mokolo unit (Ngounouno et al., 2000). These rocks are intruded by some granite (Dumort and Péronne, 1966) and are locally covered by continental sediments of lower Cretaceous ages (sandstones, red mud, and conglomerates less than 20 m thick). The most prominent anomaly within the Kapsiki Plateau is the large negative gravity anomaly that occurs at the Mandara mountainous area and is locally bounded by relative gravity highs. This anomaly that occurs over the granitoid lithology may denote the presence of less dense granite, while the small scale scattered highs on the horizontal gradient map might be caused by more mafic necks known to be present in those areas. In the Kapsiki Plateau, numerous necks are located at the intersection of submeridian fractures (N–S, N170° and N20°), known as Pan African directions, which are probably older but were reworked during the Phanerozoic and, especially in the Cretaceous (Moreau et al., 1987). The short wavelength character of the horizontal gradient is an indication that these sources are relatively shallow and small in size.

Region three (GD III) is mainly composed of the Middle and Upper Benue Trough with its side rifted basins (Yola and Gongola), and the Bui Plateau. The Benue Through is a sinistral wrench fault zone made of a series of en echelon basins filled with marine Cretaceous sediments of Albian and younger age (Benkhelil, 1982; Benkhelil et al., 1988; Maurin et al., 1986). It can be traced northwards from the Gongola Rift into Lake Chad region where it is covered and obscured by Tertiary to Recent lacustrine sediments (Fairhead and Green, 1989). The geology of the Benue Trough, and particularly the Upper Benue Trough, is well summarized by Petters and Ekweozor, 1982; Benkhelil, 1982; Dike, 1993, 2002; Obaje, 1994; Zaborski et al., 1997; Zaborski, 2000, 2003; and Abubakar et al., 2008. The oldest sediments consist of continental deposits of the Late Jurassic to Albian Bima Formation which rest unconformably on Precambrian basement rocks. The most prominent feature (Figs. 10 and 11) is the broad positive NE–SW trending Bouguer anomaly that coincides with the axis of the trough. The maximum

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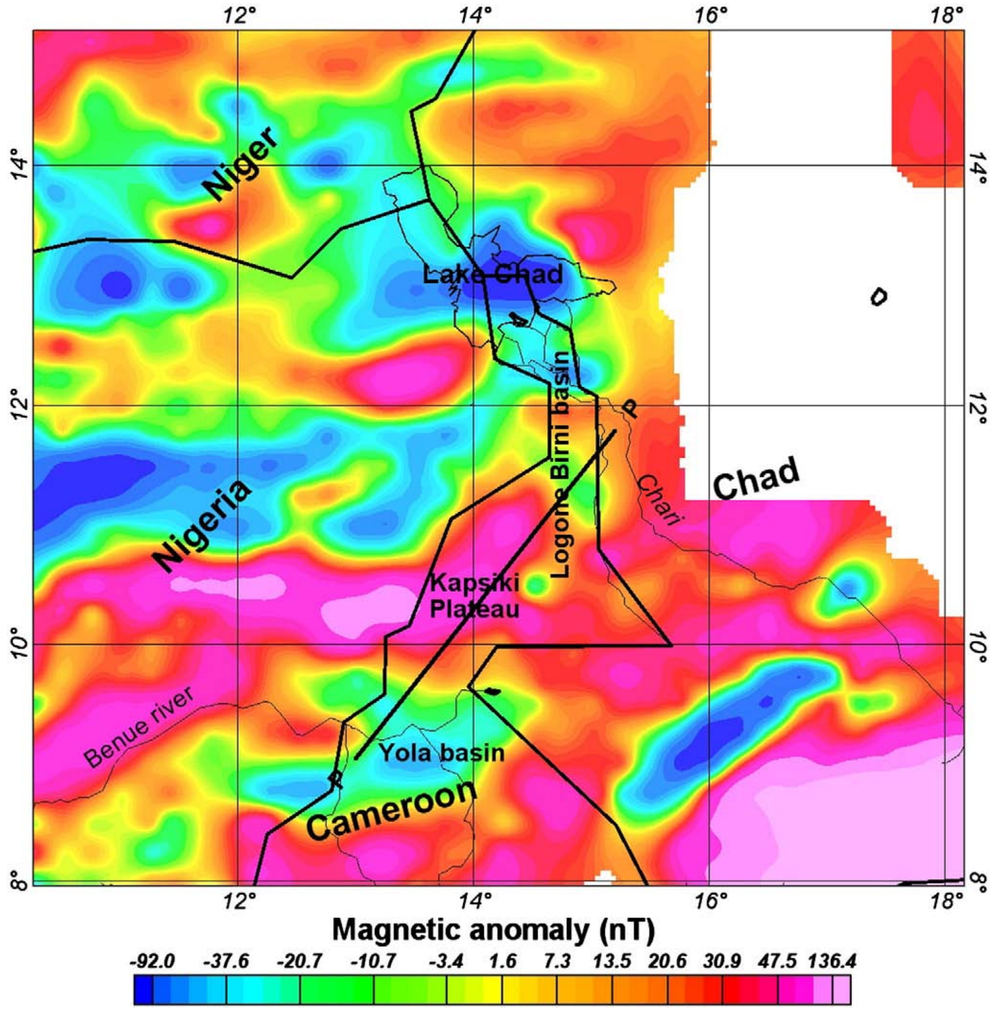

Fig. 7. Magnetic anomaly map of the central sector of the WCARS derived from EMAG2, superimposed on it is the selected profile (P) used for the test.

amplitude of this anomaly is about 5 mGal, similar but smaller type of anomaly has been mapped near the Bui Plateau area. Fairhead and Okereke (1987) and Benkhelil et al. (1988) interpreted this anomaly as shallow basement. An alternative interpretation is that this anomaly may be the surface manifestation of upper-mantle-derived material (intrusion) in the crust, probably due to Cenozoic magmatism of alkaline that widespread in West and Central Africa (Wilson and Guiraud, 1992). This interpretation is supported by magnetic studies (Shemang et al., 2001). The signature of this anomaly is also clearly observed on the horizontal gradient map but does not extend to the north to the Gongola Basin or northeast to the Yola rift where it is characterized by low gradient reflecting the presence of low density sediment. The gravity field over the Gongola Basin rift indicate that the rift negative anomaly is well defined and can be traced in areas where the Tertiary to recent sediments completely cover the Cretaceous rifts basins (Fairhead and Green, 1989). Seismic refraction studies across the Yola rift (Stuart et al., 1985) are consistent with the negative Bouguer anomaly been caused by up to 4000 m sedimentary thickness.

Region four (GD IV) mainly contains Cretaceous non-marine and marine clastics (3000–6000 m) and minor Palaeozoic to Jurassic pre-rift non-marine sediments of the Chad basin (Genik, 1992), which rest directly on top of the basement (Olugbemiro et al., 1997). This area is characterized by a relatively smooth gravity field which is also visible on the horizontal gradient map. The most significant anomaly in this part is a wide arcuate elongated minimum gradient that occurs north to south west of Lake Chad. This anomaly follows the southern trend of the Termit basin that coincides with the Bornu basin. This anomaly character probably suggests that the basement in the Bornu Basin is almost flat and its structural style might be less complex compared to its counterparts Doba or Termit where the basins are associated with extensional, rotated, large normal faults blocks and transpressional inverted anticlines (Genik, 1992). Farther west, this minimum extends beyond the proposed basin extent, that implies it might extend a few kilometres westward and there might exist some connection between the Bornu and the Gongola basin.

Region five (GD V) is an area that contains short wavelength gravity anomalies alternating between highs and lows and consists mainly of the Logone Birni, the Bongor, the Doba basins and adjacent areas. The anomalies are variable in lateral extent and amplitude and probably reflect the spatial distribution of sub-basins, half grabens and strike slip-faults structures. The southern Chad basins correspond to a wide group of rifts associated with the Central African Shear Zone, a continental-scale fault zone that extends from western Cameroon to eastern Sudan (Browne and Fairhead, 1983). The gravity lows in the Bongor and with the Doba basin are mainly NW–SE trending and occur over Early Cretaceous, predominantly continental siltstones, mudstones, shales and

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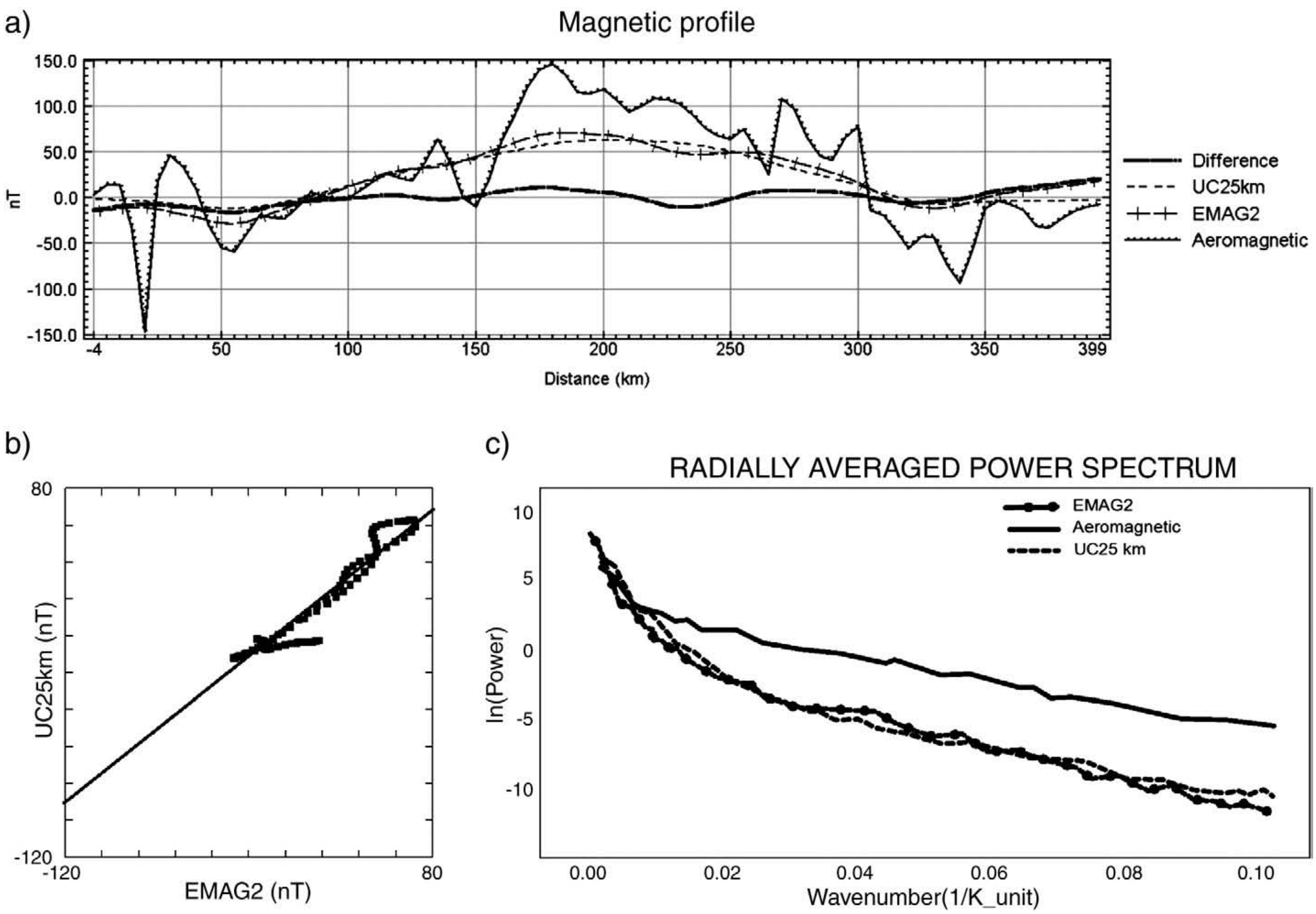

Fig. 8. a) Magnetic profile on EMAG2, aeromagnetic anomaly and its upward continuation (UC) fields at 25 km. Difference = UC25 km-EMAG2. b) Scatter analysis between EMAG2 with UC25 km for the magnetic profile. Location of the profile shown in Figs. 6 and 7, note the close similarities between EMAG2 and UC25 km. c) Comparison of the radially average power spectra calculated from EMAG2, the aeromagnetic field and the aeromagnetic upward continuation field at 25 km (UC25 km). Note the strong resemblance between EMAG2 and (UC25 km). The aeromagnetic field exhibits a clear different trend from the two other curves.

sandstones (Genik, 1992). These units are more than 7000 m thick and the anomaly extend suggests that the basement is deeper compare to adjacent areas. Similar but smaller types of anomalies can be observed in the Logone Birni basin northwest to the Bongor and the Doba basins. The stratigraphic succession of this area is poorly constrained. However, the evolution of the LBB follows the tectonic process that took place in the WCARS, as described by Browne and Fairhead, 1983; Binks and Fairhead, 1992; Guiraud and Maurin, 1992 and Genik, 1992. From the gravity and aeromagnetic interpretation, the LBB can be subdivided into three sub-basins from north to south: the Makary Subbasin or Northern Logone Birni Basin (NLBB), the Zina Subbasin or Central Logone Birni Basin (CLBB) and the Yagoua Subbasin or Southern Logone Birni Basin (SLBB). The Makary and Zina subbasins are separated by the Kousseri Platform (Manga et al., 2001), and there are strong similarities between the LBB and adjacent basins namely the Bongor and the Doba basin (National hydrocarbon Coorperation, 2002). Consequently, the negative anomalies from the LBB can be attributed to the presence of half grabens containing Early Cretaceous to Recent continental siltstones, mudstones, shales and sandstones of unknown total thickness. This interpretation based on the combined seismic profiles (Genik, 1992) as well as the exposure of thick sandstones rocks that crop out in those areas. The overall trend of the anomalies of this area is better seen on the horizontal gradient map (Fig. 10). No crystalline basement outcrops are present in this part of the study area. As expected, the maxima occur over basin ridges that are known to be present and confirm the asymmetric character of the Bongor and the Doba basins. The Borogop fault zone is also visible. Structures in these basins are preliminary extensional rotated faults blocks of Early Cretaceous rifting phase. Transpressional anticlines of Santonian age are also present and form good hydrocarbon traps (Genik, 1992). In some cases, however, the maxima define other alignments of gradients that are harder to delineate on the Bouguer gravity anomaly map and even define on structural maps. In particular, the block of linear belts trending NE–SW towards the north eastern part. Structure within the basement is suspected to strongly influence the location of faulting within the sedimentary cover and several horsts and tilted blocks have been mapped in these areas (Genik, 1992). The positive gradient is therefore interpreted has shallow basement anticline and the NE–SW trend of these maxima are parallel to the Pan-African which has generated dextral wrenching on a regional scale (Maurin et al., 1986). Similar observation is made for the Benue Trough where reactivation in a senestral sense has occurred in Cretaceous times and has extended the fault zone into the lower to Middle Cretaceous sediment cover (Fairhead and Green, 1989). Such type of elongated linear belts of gradients maxima are also common on the LBB and probably indicate bounds between different grabens that form this basin. As an additional source of information to this analysis, near surface, local anomalies were

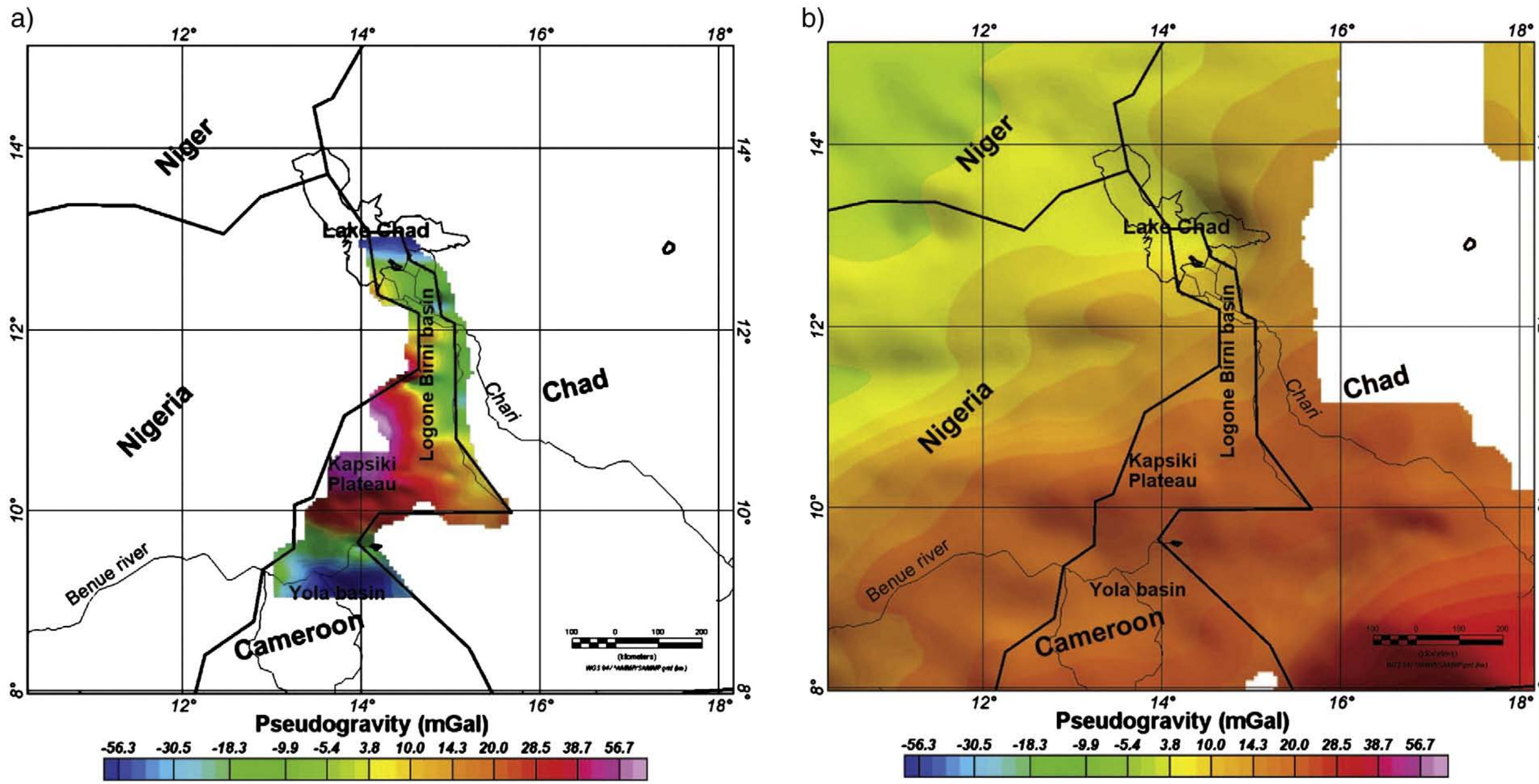

Fig. 9. Pseudogravity anomaly field of the aeromagnetic data (a) and EMAG2 (b). There are clear differences between the two signals over the Kapsiki Plateau where the basement is suppose to be close to the surface. The strong anomaly from the aeromagnetic data is more consistent with the geology, whereas the anomaly from EMAG2 shows very weak character.

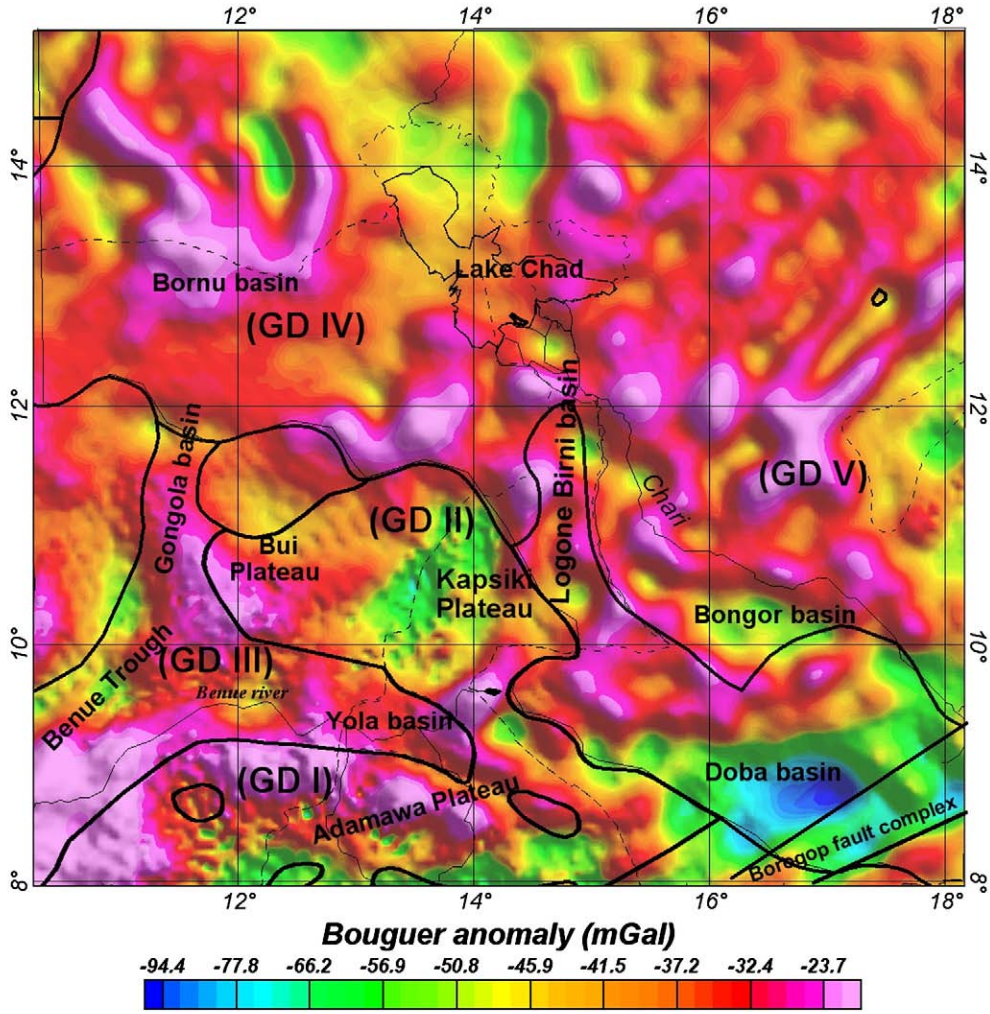

Fig. 10. Bouguer gravity anomaly map of North Cameroon and surrounding areas and the known major structural lineaments. Numbers (G I–V) are different gravity domains.

isolated by wavelength filtering. A high pass filter was constructed such that anomalies at wavelength larger than 150 km were strongly suppressed (Fig. 12). In theory, such a wavelength filter implies that sources below the crust are not longer present in the data. Hence the dominating effect of the density contrast at the crust–mantle boundary is attenuated. As a result, the extent and delimitation of different rift basins like the Doba, Bongor, Yola and the LBB were clearly emphasized. However, although the high pass filter add further contrast in the gravity signature of some of the rift basins, some other places away from these basins cannot be well constrained from Fig. 12 and hence may misguide the interpretation. The map presented in Fig. 13 may be regarded as a structural map of the central sector of the WCARS, with each linear segment of gravity gradient representing the boundary between rock packages with contrasting densities.

5. Conclusions

Evaluation tests based on a statistical analysis, upward continuation, spectral analysis and pseudogravity transformation of magnetic data have been carried out between newly available global potential field models and ground data. Our analysis shows that EMAG2 may be helpful for first order regional geological mapping, as major geologic feature can be identified. However, the absence of short to intermediate wavelengths content in the EMAG2 data in the study area hinders the interpretation of shallow source anomalies, which requires a high resolution or needs to be spatially well extended. We find that the EMAG2 in the regions where the original data were limited to 15 min (equivalent to about 25 km data spacing) is rather equivalent to a data set observed at an altitude of 25 km than 4 km (Fig. 8a and b), which is the nominal height above the reference as stated in the WDMAM map description (Maus et al., 2009). This means that the wavelength content in the EMAG2 model does not correlate to a magnetic model measured at 4 km height over Cameroon.

A variety of tests have revealed a strong correlation between EGM08 and ground data for all wavelengths, which are found in both datasets. The EGM08 data were used to determine Bouguer gravity anomalies and to map major structural trends of the central sector of the WCARS. The results do not provide an unequivocal explanation of the origin of the WCARS but are in good agreement with a variety of precedent studies and assisted in the recognition of new major geophysical boundaries, which provides constraints on the crustal architecture, as is the case of the Logone Birni basin (LBB) where different graben limits have been clearly identified. The results presented herein provide a promising testament for the future use of EGM08 for gravity applications over Cameroon and adjacent countries and can help to solve major data problems very common in developing countries.

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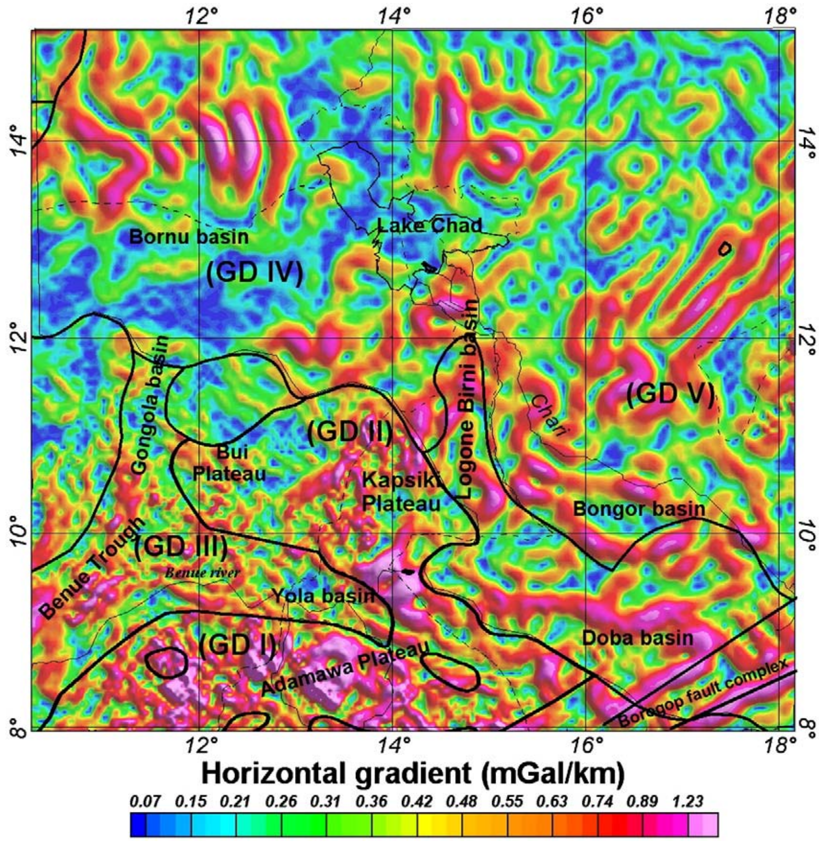

Fig. 11. Horizontal gravity gradient anomaly map of North Cameroon and surrounding areas.

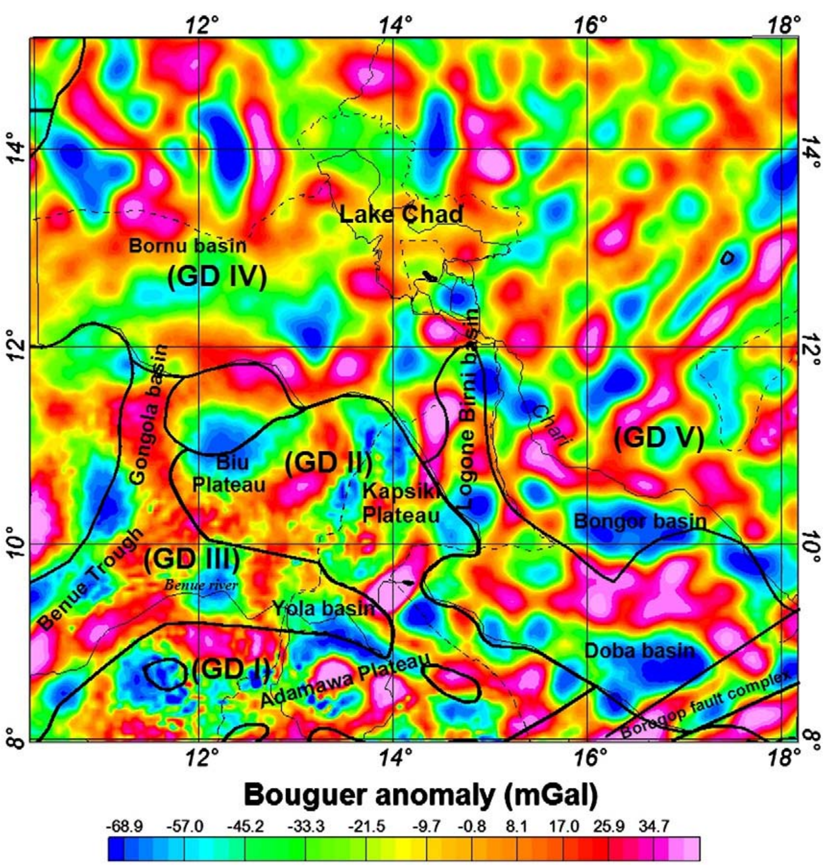

Fig. 12. Residual gravity anomaly obtained from application of a high-pass filter (cut-off wavelength 200 km) to the Bouguer gravity anomaly field. The extent and delimitation of different rift basins like the Doba, Bongor and the LBB are easily visualized.

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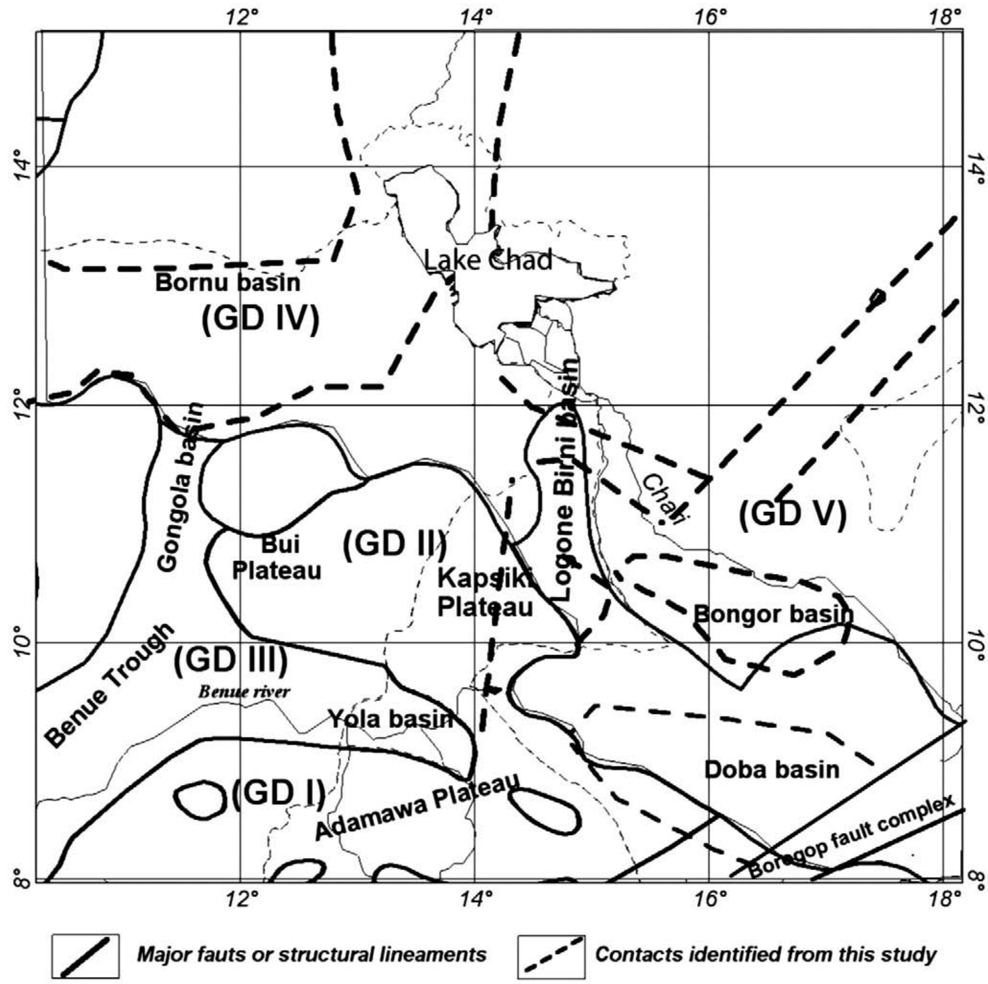

Fig. 13. Graphic representation of the major gravity domains derived from horizontal gradient and the gravity fields.

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