A Gravity Study of Cameroon, West Africa, and Geodynamical Implications

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SUMMARY

Gravity data available in Cameroon are used first to compute a new Bouguer anomaly map of Cameroon. Second, the rigidity of the lithosphere in Cameroon and adjacent areas is estimated in terms of the Effective Elastic Thickness (EET) by the use of the coherence function analysis. The EET map deduced from this study shows that the lithosphere is the weakest beneath the rifted and volcanic areas (14-20 km) and the highest (> 28 km) in cratonic areas. These results are discussed in the light of the geodynamic of the studied area.

A spectral analysis of the gravity data is also performed to determine the crust-mantle boundary. A map is drawn and shows a variation from 14 to 45 km of crustal thickness.

In order to better constrain this results according to the geological features, some magnetic profiles are used for 2D modelling.

INTRODUCTION

The mechanical lithosphere and the crust-mantle boundary are studied in Cameroon and adjacent areas using gravity and magnetic data.

The studied area is a part of the Central African mobile zone and also includes a part of the Congolese craton (figure 1). The later was initiated during Liberian cycle (2800 Ma) and was rejuvenated during Eburnean (2300 -1800 Ma) (Clifford, 1970). Lately, the whole area has been affected by the Pan-African cycle (600 + 100 Ma) which produced deformations, metamorphism and intrusion of abundant granitoids. During the stages of the Pan-African, important tectonic movements occured by megashear zones oriented ENE - WSW from Sudan to Cameroon (Cornacchia et Dars, 1983). This is known as the Central African Shear Zone (CASZ) which extends over about 2000 km. It is a dextral shear associated with major mylonites predating the opening of the South Atlantic Ocean (Almeida et Black, 1967).

The Adamawa uplift, in Central Cameroon, is located at the northeastern limit of the 'Cameroon Volcanic Line' (CVL) which comprises a series of Tertiary to Recent volcanoes from the Atlantic island of Annobon to the Oku mountains in Cameroon where it splits into two branches: one branch crossing the Benue trough into eastern Nigeria (Biu plateau), and the other branch running eastward to the Adamawa plateau. This uplift was formed between Late Cretaceous and Early Tertiary (Brown and Fairhead, 1983) together with the other African uplifts: Darfur, Hoggar, Tibesti and Air. The Benue trough, located at the northwestern margin of the CVL is commonly believed to be a rift feature that originated in the Cretaceous during the opening of the South Atlantic ocean (Burke et al., 1971; Benkhelil et Guiraud, 1980). It extends for some 900 km northeastward from the Niger delta basin on the northern end of the Golf of Guinea. The northeastern part consists of the Yola arm in Cameroon (Garoua) and the Gongola arm in Nigeria beneath the Chad basin.

In this study, we interpret the gravity data to determine the mechanical behaviour of the continental lithosphere by estimating the flexural rigidity, or equivalently, the effective elastic thickness of the lithosphere beneath the Adamawa uplift and adjacent areas. The approach used here is the analysis of the coherence function between the gravity and the topography as a function of the wavelength (Louden and Forsyth, 1982; Forsyth, 1985; Lewis and Dorman, 1970; Ebinger et al., 1989). An effective elastic thickness map is derived and is interpreted according to different geological features in the area.

A crustal thickness map is also derived from a spectral analysis of the data, the values are then compared to each other, again with light of the geodynamical evolution of the corresponding areas.

Some magnetic profiles are also used, in 2D modelling, to better constrain the gravity results.

THE DATA

The gravity data used in this study were acquired during several surveys carried out in Cameroon and adjacent countries by 1) ORSTOM (France) between 1960 and 1967, 2) Fairhead (1982), 3) IRGM (Cameroon) - University of Leeds (UK), DMA (Defense Map Agency) and ELF oil company (unpublished). Latitudes and longitudes were converted to (x,y) coordinates using a UTM projection. Data were then interpolated to a regular 18.5 km spacing grid using a finite element algorithm (Inoue, 1986). The total grid has 85 x 79 points. Same treatment was applied to the gravity and topographic data. From the final grid, we extracted 33 gravity and corresponding topographic squared grids (444 x 444 km).

We computed the Fourier transform of the data using the algorithm of Singleton (1968). The gridded data were mirrored about their eastern and southern parts in order to avoid the edge effects.

The magnetic profiles used in this study were extracted from magnetic data of the AAMP (African Aeromagnetic Mapping Project) provided by the GETECH branch of the ULIS (University of Leeds Industrial Service, UK).

PRINCIPAL RESULTS AND CONCLUSION

The Bouguer anomaly map

The Bouguer anomaly map of Cameroon and the adjacent countries shows various features (figure 2): 1) the long wavelength negative Bouguer anomaly of about -120 mgals centered on the Adamawa massif in central Cameroon. This anomaly is oriented NE - SW near the coast (corresponds to the volcanic massifs of the CVL) and becomes E-W in the Adamawa region; 2) located at the western margin of the CVL, the Benue trough is characterised by NE-SW positive anomalies of about -40 mgals.; 3) southern Cameroon is characterized by negative anomalies which correspond to the northern part of the Congolease craton. The limit of this craton is marked by a low and regular vertical gradient of about 1 mgal/km

(Collignon, 1968) which denotes a change in crustal rocks from the north to the south; 4) the positive anomalies (40 mGals) observed in Chad may denote either the subsiding basins and grabens that initiated during Cretaceous times, either a suture zone if compared to the anomalies seen at the limit of other cratonic zones (P. Louis, 1970). These assumptions are discussed according to the EET and Moho contour maps. We can also note the signature of the CASZ in Central Africa.

The EET map (figure 3) shows that the EET is at its minimum (14-20 km) beneath the rifted and volcanic areas (e.g. Adamawa massif, Benue trough, CVL), increases to 24 km in the Precambrian belt of the CAR, and finally , is greatest (more than 28 km) in cratonic areas (Congolese craton and the so called nilotic craton in Chad). A similar study using a NS profile along the Adamawa uplift gave estimates of 20 km for the EET beneath this volcanic dome (Poudjom et al., 1992). This variation shows a relationship between the EET values and the tectonic provinces.

The crustal thickness (Tc) contour map shows a variation from 15 to about 50 km. The lower values (15-22 km) are obtained in central Cameroon on the region of the Adamawa uplift. To the North of this area, the crust is about 23 to 28 km thick. This area comprises the Yola branch of the Benue trough, were seismic refraction studies (Dorbath et al., 1984) have shown a normal crust in the south (33 km) and an abnormal crustal thickness in the north (23 km). The highest values of the crustal thickness are found in south Cameroon and corresponds to the Congolese craton. Finally, we find a crust of 14 km thick in the area of the Chad basin. This area, which was found to be strong according to the value of the EET obtained previously (36 km), is characterised here by a thin crust. This result is also discussed in light of a 2D modelling of a magnetic profile.

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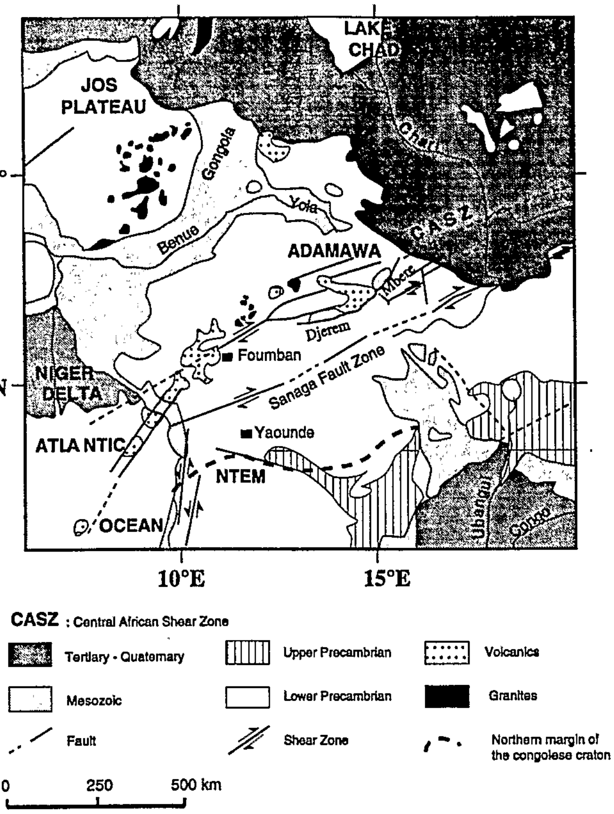


Figure 1: Geological map of the studied area.

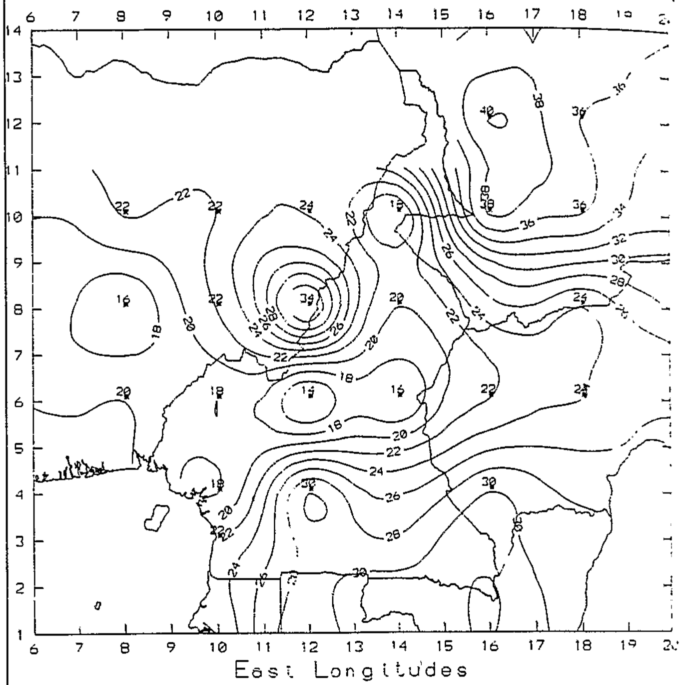
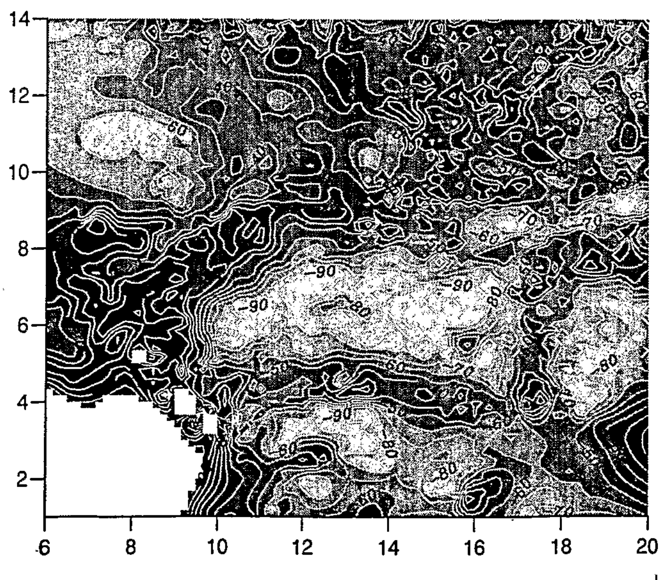


FIGURE 3: ELASTIC THICKNESS MAP OF CAMEROO

FIGURE 2: BOUGUER_ANOMALY



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