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GRAVITY CHARACTERISTICS OF THE PANAFRICAN OROGEN IN GHANA, TOGO AND BENIN (WEST AFRICA)

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ABSTRACT

The studied area is straddling the west-african Craton and the nigerian-beninian panafrican mobile plate.From West to East,it is composed of three large petrostructural sets which show specific gravity characteristics :the Volta Basin domain,constituted of sedimentary formations lying in a major discordance on the west-african Craton crystalline basement;it exhibits positive gravity anomalies probably linked with basic magmatic intrusions met in the basin.Next,one medial set,corresponding to the external structural unit domain of the Dahomeyide range;composed of epi- to mesozonal rocks,it shows large negative anomaly panels very likely in close relation with the tectonic overload.Finally,one eastern set,comprising gneisso-migmatitic internal units of the nigerian-beninian plate western border;it mainly outlines positive anomalies which seem to be in connection with granulitic and basic complexes encountered in places inside this area.This set includes the suture zone.

We mention in these three sets numerous gravity discontinuities which testify to the great structural complexity of the region.However,this complexity is frequently concealed or attenuated by counterbalance and smoothing phenomena.This gravity complexity increases from North to South,and is interpreted as the sign of a rise of the southern part deep zones of this sector during the panafrican event.Moreover,this complexity also might testify to an aggregation of panafrican mobile plate compartments.

INTRODUCTION

The first gravity works done(Crenn,1957)have allowed to outline an important tectonic contact between one western domain with large negative anomaly panels and known since the Grant's works(1969a)as"the west-african plate",and one eastern domain with large positive anomaly panels constituting the western border of the nigerian-beninian "mobile plate".The aim of our study is to clarify the structural evolution of the contact zone between the west-african Craton and the nigerian-beninian panafrican mobile plate,using the presently available data bank.

I- GEOLOGICAL AND STRUCTURAL FRAME

The Dahomeyide range is,from West to East,composed of :one foreland represented by non-metamorphic and not very deformed sedimentary Volta Basin formations;external units represented by epi- to mesozonal formations;internal meso- to catazonal units consisting of a set of gneisses,migmatites and varied granitoids,and including one molassic volcano-sedimentary series and the suture zone.

1- The Volta Basin

It consists of three supergroups,from the the base to the submit.

- **The lower supergroup or the Bombouaka one**.Thick of 1000m,it comprises two essentially sandstone-like groups separated by one argillosilty group.The lower group is composed of fine and mature sediments deposited in an epicontinental environment.The median group is constituted of about 1000My old sediments.It materializes a clean transgression linked with the rifting intensification.The upper group is made of filling up facies.
- **The middle supergroup or the Pendjari one**.It is thick of about 1500 to 4000m,and comprises two groups :the lower group or the Kodjari one,is constituted of the so called "tillite-barite carbonate-argillous silexite" triad.It sometimes shows internal lacunas,and in places silexites change laterally or vertically to siltstones or to phospharenites.This group indifferently lies on the various Bombouaka supergroup formations,and in places directly on the eburnean bedrock.The upper group or the Porga group,is composed of shales and rythmic siltstones with lenses and/or traces of sandstones,conglomerates and graywackes.It is of about 660My old and includes microfossils of th Vendian (Amard and Affaton,1984).
- **The upper supergroup or the Tamale one**.It lies,in a progressive discordance,on the previous supergroup.Thick of 500 to 1000m,it comprises two molassic sets.The first or the Yendi group,is argillosilty.The second or the Kebia group,is composed of polygenic conglomerates,arkoses and siltstones.Its plateform is of a fluvioglacial nature probably of the final ordovician age.

The paleosurface on which lie the Volta Basin formations is complex.It includes depressions and shoals(Ako and Wellman,1985;Affaton,1990).It gently slops down from West to East,then shows a sharp West dip in the vicinity of the Dahomeyide range,so demonstrating the dissymmetric structure of the basin and the presence of its structured eastern border.These depressions and shoals are probably governed by a set of horsts and grabens with which are in places associated volcanites and which has increased,from West to East,the deepening of the basin and the thickenning of its formations.

2- The Dahomeyide range external structural units

They appear following a submeridian trend.They are composed of the Buem,the Atacora and the Kara units.

- **The Buem structural unit**.It overthrusts the Volta Basin formations.It is formed with anchimetamorphic and tectonized equivalents of the middle and upper groups of the Bombouaka supergroup,and the Pendjari supergroup formation set.It is subdivided into a western and an eastern Buems.The western Buem consists of nappe outliers of the Volta Basin formations.It is characterized by folds,right dipping or West overfold,whose western flanks are generally laminated.The eastern Buem shows two fold phases,one microfracture dense network and one important scaling set(Affaton,1975;Simpara,1978;Affaton,1990).

- **The Atacora unit**.It consists of quartzites and schists separated by one glacial paleosurface which is materialized by tillite(Affaton,1975;1990;Affaton et al ,1980).These formations generally exhibit an eastern dip.The quarzites are considered as the equivalents of the tectonized and epimetamorphic formations of the Bombouaka supergroup ,whenever the schists might be the equivalents of the Pendjari supergroup formations.We there observe metamixtites,volcanites,cipolins and phospharenites.In places,varied basement gneisses appear as scales at the quartzite base.This unit displays four tectonic and two metamorphisme phases.

- **The Kara unit**.It outcrops mainly in the Kara region.It is essentially formed with muscovites or two mica bearing orthogneisses of the granitic origin.This unit supports in a fundamental discordance the atacorian quartzites,but also lies as a nappe or klippe on these latter.The granites from which come these gneisses are of the eburnean age(2064±90My)but are remobilized in the Panafrican(608±7My)(Affaton et al.,1978;Caen-Vachette et al.,1979).

3- The internal structural units

The area occupied by the Dahomeyide range internal structural units is composite.It consists of petrographic sets outcropping in stretchs or in more or less continuous subparallel belts,trending NNE-SSW.We there mention varied facies including migmatites, various gneisses, granulites, cipolins, micaschists, quartzites,amphibolites as well as several ante- to syn- and post-panafrican granitoid generations.These granitoids are not very frequent in the suture zone but they become more and more abundant to the East.The entire internal zone is affected by a series of submeridian tectonic unevenesses materialized by mylonitic bundles of which the most important are those of the Kandi,Alibory and Nangbeto faults.This domain is also affected by a series of grabens filled in with molassic-type volcano-sedimentary materials which are considered as contemporaneous of the Tamale supergroup formations.These formations include basic and acid volcanites with which are associated epimetamorphic or diagenetic clastic sediments.

Geochronologically,the numerous age datings obtained for the formations of these units generally give a panafrican age(Bonhomme,1982;Affaton et al.,1978;Breda,1982 and 1985).But some migmatites and orthogneisses of the Atacora unit border gave eburnean ages(2000 to 1700My) and panafrican ones(640 to 500My).These latter are interpreted as the rejuvenation ages of the concerned formations.In fact,these formations show,besides the four panafrican defomation phases,at least a foliation and traces of an anterior metamorphic deformation.

4- The suture zone

It is materialized by an alignment of a series of basic rock massifs displayed in nappes or East overthrusting the external unit formations,from the Niger border up to the Atlantic ocean(Dérouvarou,Kabyè and Djabatouré Massifs,Ahito and Agou Mounts).The rocks comprise eclogites,charnockites,pyroxenites,granulites,metagabbros,metadiorites,amphibolites,serpentinites,and talkschits.They are generally associated with paragneisses,micaschists and metaconglomerates.The basic rocks outline a granulitic or eclogitic-type metamorphism and an amphibolitic-like retromorphism.An age between 900 and 700My has been found for the protoliths of the Ahito Mount eclogites,with a 510My old retromorphosis(Bernard-Griffiths et al.,1985).The suture zone formations have undergone at least the four panafrican tectonic deformation phases already mentioned in the atacorian unit and in the Dahomeyide orogen internal units.

II- THE GRAVITY DATA AND THEIR USE

A- METHODOLOGY

1- Data sources

The data bank used in this study is from the 4718 stations established by the Institut français de recherche scientifique pour le développement en coopération(O R S T O M)(Crenn,1957),the Institut Géographique National(I G N) and the research group of the Laboratoire de Géophysique de l'Univerité Nationale du Bénin (L G - U N B) in cooperation with the geophysics laboratory of the Centre Géologique et Géophysique de l'Université des Sciences et Techniques du Languedoc(C G G - U S T L).The U N B geophysics team has made use,for the measurements,of Lacoste and Romberg and Worden Master gravity meters,of Wallace and Tiernan aneroid barometers,of 1/200000 I G N geographic maps,of a Land Rover vehicle hectometer counter,and of compass.The data relative to Ghana are from numerization and hence,they are not mentioned on the Fig.2 map.All the measured data have undergone the classical Faye,Bouguer and latitude reductions(e.g.,Sharma,1982;El-hadj Tidjani and Agbani,1988).The 2.67g/cm^{3}density has been used for the Bouguer reductuion.The Geodetic Reference System 1967(G R S 67)formula has been applied for the latitude (or normal)reduction in the International Gravity Standardization Network 1971(I G S N 71)system.We did not do any terrain reduction upon our measured data in Benin due to the very little uneven character of this area.The most likely error on the Bouguer anomaly has been estimated to 1mgal.Moreover,all the Bouguer anomaly values have undergone an isostatic reduction according to the Airy's local isostasy concept.This reduction has been made using a computer,with an initial crust thickness of 30km and a crust-mantle density contrast of 0.45g/cm^3,as recommended by Shurbet(1955) and Crenn(1957).

2- Elaboration of the maps

The different maps(Fig.3,4,6 and 7) have been elaborated with one software from the Golden Software Inc(U S A).For this,we've made use of the previous data bank and a regular grid of a 10km sides according to the Laporte's method(1971),in the Universal Transverse Mercator(U T M) projection and with selected parameters.We recall that choice of a 10km sides for the regular grid,de facto imposes that on the gravity maps only anomalies whose the tops of the reponsible structures are seated at depths greater than or at least equal to 10km are outlined(Sharma,1982).

B- INTERPRETATION OF THE MAPS

This mainly consists in an interpretation of the Bouguer anomaly map(Fig4)and an analysis of the gravity discontinuity main axes(Fig.5).The Bouguer anomaly map has allowed to synthetize on Fig.5 the large trends of the positive and negative axes as well as the discontinuity axes.Analysis of these documents has led to divide up the study sector into one central domain and two marginal ones.

1- Gravity characteristics of the different domains

a/ The central domain

It roughly trends NNE-SSW North of the 10th parallel and becomes submeridian South of this latitude.It consists of three zones :

- One central main gradient zone centred on the isogal line -30mgal and superimposable to the Hastings'A-B gradient zone(1983);
- One western zone centred on one large negative axis which is subdivided into three parts;
- One eastern zone centred on one large positive axis.

The -30mgal isogal line has been choosen as the central main gradient zone axis due to its regional character(Fig.4).

- The central main gradient zone is composed of three parts :

- The first part extends North of the parallel 9°30N,from Djougou to Niger.It is characterized by very close together threadlike linear isogals which suggest very steep slopes.It undergoes two small virgations,one of which is located North of the Banikoara-Dérouvarou axis,and the other NW of the circular invagination of the -20mgal isogal situated West of Sinendé.
- The second part extends South of the previous parallel,as far as the Sokodé latitude.It is characterized by more spaced threadlike and linear isogals.It undergoes one virgation South of Djougou.

. The third part of this central main gradient zone stretchs to the Badou latitude.It includes relatively close together isogals which describe a sinusoid in the vicinity of Pagala.

- **The central domain western zone** comprises three large panels centred each on a large negative axis.The northern part shows a NNE-SSW curved trend.The two others are submeridian.

. The northern panel,which is located between Dérouvarou and Boukoumbé,is in revolution around the Kouandé-Natitingou axis.The anomaly towers -70mgal.

. The central panel exhibits a rectilinear axis located between Mango and Pagala.It is in revolution around the 1°E meridian axis,with an anomaly towering -60mgal.

. The southern panel is in revolution around a meridian axis passing by West of Pagala.It is composed of two localized anomalies towering -40mgal each.

- **The central domain eastern zone** is constituted with a series of positive or lightly relative negative anomalies,very localized,generally of an elliptical shape which outlines the bidimensional character of the liable mass anomalies.But the most striking aspect of this zone is the presence of three large panels of long wavelength positive anomalies aligned on an approximately NNE-SSW axis.

. The first panel lies North of the 11th parallel.

. The second panel,which is composed of three localized anomalies,is centred on the Sinendé locality.

. The last panel,which constitutes the southern one,is the most extended.It stretchs from the parallel 9°30N up to the Atlantic ocean.It shows two gradient zones :the first,subparallel to the coast,is centred on the Savè locality;the second,trending NE-SW,passes by the Kpalimé locality.It is characterized by shorter wavelength anomalies like those encountered in the Savalou and Kétou sectors.

b/ The western domain

It lies on the Volta Basin formations.Its northern part includes one positive panel as well as very short wavelength positive anomalies in the Dapaong sector.Its southern part is characterized by threadlike isogals and the presence of one large positive panel in its eastern border.

c/ The eastern domain

It is situated North of the parallel 8°N.It displays negative nanomalies like those of the Parakou-Ségbana axis,and a series of E-W to NNE-SSW negative and positive axes.These axes stretch up to the central domain,however curving as if they were refracted at the border of these two domains;this allows to think of the existence of a big structural discontinuity between these.

2- Study of the main gravity discontinuity axes

Besides the gradient lines studied above and considered as particular discontinuity axes(Fig.4),we observe,from North to South,major discontinuity axes(Fig.5).

- **The Kandi-Banikoara axis**. Trending E-W,it separates the northern and southern panels of the central domain eastern zone,and bumps into the central main gradient axis(the -30mgal isogal).
- **The Djougou-Boukoumbé axis**. Trending E-W at East and NNE-SSW at West,it separates the positive and negative panels of the central domain eastern and western zones and stops at one gradient axis.
- **The axis South of the Dassa-Kpalimé line**. Lain in the eastern plateau of the central domain eastern zone,it seems to be subparallel to the Kpalimé gradient line at West and to the Atlantic coast at East.
- **The axis West of Bassar**. Limited by two main gradient axis,it separates the central and southern negative plateaus of the central domain western zone.
- **The Kandi-Savè axis**. Of sinuate appearance,it delimits the central and eastern domains and intersects one gradient line.It stops at the Bassar-Kpalimé axis.
- **The axis West of the Savalou-Abomey line**. Located South of the southern positive plateau of the central domain,it displays a submeridian trend and intersects the Dassa-Kpalimé axis.It delimits two sectors :one with NE-SW threadlike isogals,and the other with circular to elliptic isogals(Fig.4).
- **The Dapaong-Mango axis**. Trending NE-SW,it passes by between these localities and seems to block at North the

Djougou-Boukoumbé discontinuity axis and the Ghana main gradient axis.

- **The two last axes**. With NNE-SSW and NE-SW trends,they are entirely located in the central domain southern part.They intersect each other and seem to limit at South the Ghana main gradient axis and the Kete-Kratchi positive axis.

C- RELATIONS BETWEEN GRAVITY AND GEOLOGY IN THE DAHOMEYIDE OROGEN

The superposition of the gravity and geology maps permits to mention some coincidence between,on the one hand the large defined geological and gravity domains,and on the other hand the main gravity discontinuities and some large tectonic structures.We nevertheless notice that most of the positive anomalies outlined on the gravity map very rarely reflect the nature of the surface rocks.In order to try to understand all this,we have eastablished interpretative gravity models from four transverse profiles determined on the isostatic map and using the corresponding geological sections.

1- Modelling of the range

The isostatic reduction has been done according to the Airy's local compensation model(e.g. Sharma,1982).The resulting anomaly map is shown in Fig.6.It has been obtained by substracting fom the Bouguer anomaly map the isostatic reduction.This substraction is in fact amounted to the extraction of a -30mgal mean regional effect from the Bouguer anomalies(Fig.4,6 and 7).

Comparision of the topographic and structural map(Fig.3) with the Bouguer anomaly one(Fig.4) has permitted to notice the nearly general lack of local isostatic compensation in the study sector,except perhaps in the whole area of the Atacora structural unit where the mean height is 550m.this observation agrees with that more general made for all the West Africa where the only encountered local compensations might be associated with the Moho topography variations(Roussel and Lesquer,1991).

The modelling has been done on the basis of the continental collision model hypothesis(Affaton et al.,1991) and assuming that each profile is characteristic of collision between two crustal compartments whose densities and thicknesses are different and which are in a regional isostatic equilibrium(Thomas and Tanner,1975;Gibb and Thomas,1976).According to this assumption,the eastern crust,tectonized and magmatite injected in the Panafrican,would be thicker and heavier than the eburnean western crust(about 2000My).Hence,the main negative anomaly of the western part would be essentially linked with subduction of the western block under the eastern one;the positive anomalies in this latter would testify to the existence in depth(≥10km) of heavy and basic formations which,on surface,line in the form of scales and nappes,the suture zone,the effects of some local isostatic compensations being mirrored by the Moho topography.

On the basis of this principle and assuming bidimensional structures,characteristic of the collision orogens(Gibb and Thomas,1976),the modelling has been done using one software(de Cabissole,1989) based on the Talwani's algorithm(1959).With the lack of other data,standard values proposed by Worzel and Shurbet(1955) have been retained.So,the 2.67g/cm^3;2.72g/cm^3 and 3.12g/cm^3 density values have been respectively attributed to the western and eastern blocks and the upper mantle.In these conditions the Moho initial depth in each compartment is that already used for the isostatic reduction(30km).

2- Analysis of the interpretative models

a/ Model 1 (Fig.8)

The A-A' profile outlines three compartments which overlie the central and eastern domains individualized on the Bouguer anomaly map(Fig.4).The overcompensated western compartment reflects the large negative anomalies of the central domain.It lies on the Volta Basin formations and their substratum,as well as on the Dahomeyide external srtuctural units.It is noticed beneath these latter a more important root very likely corresponding to a crust thickening(Fig.8,B and C).This thickening might at once be due to the tectonic overload resulting from the tangential movements that these units have undergone,and to the thickness of the Atacora range formations.This central compartment is undercompensated.It reflects the main gradient zone and the positive panels of its eastern border.It corresponds to the domain of the internal structural units which consists mainly of magmatites.The undercompensation of this compartment leads to think of presence in depth(≥10km) of very heavy bodies from which might come the Dérouvarou granulite-type basic complexes or the Alibory charnockites displayed along the suture zone(Breda,1982; Affaton et al.,1991).The western and central compartments clearly separates one break of slope.This reflects very likely the lapping plane of the internal units over the external ones.In the other respects,the unimodal appearance of the gravity profile in this central zone suggests that the set of rocks constituting this range part is gravimetrically homogeneous(Fig.8).This may indicate that these rocks are of the same nature as the outcropping basic complexes.

The eastern compartment outlines a relatively light overcompensation which partly lies on the Bouguer map eastern domain.This is very likely in relation with the petrographic nature of the zone which is mainly composed of migmatitic gneisses and granitoids(Perrère-Nikki and Agramarou migmatitic complexes;Affaton et al.,1978).It is noted between the central and eastern compartments one break of slope located at the level of the Kandi Fault,which seems to confirm the deep megastructure character of this latter.This fault seems to separate two petrographically and gravimetrically distinct compartments seated inside the internal structural units.

b/ The other models

Analysis of all the other models leads to similar results,with however variances due to local petrographic and gravity disturbances.

The B-B' profile (Fig.9).Its western compartment is compossed of one undercompensated western part and one overcompensated eastern part.This latter lies on the external structural units characterized by a tectonic overload more expanse than in the profile A-A' case.Analysis of the gravity model(Fig.9,B) allows to think that the overload might be responsible for the 3 to 5km crustal thickening beneath the Atacora nappes materialized by 3 to 25km thick sediments(Bayer and Lesquer,1978;Trompette,1979).In the western part corresponding to the Volta Basin and its bedrock,we notice an undercompensation.It might be explained,as suggested by Annan-Yorke(1978),and Ako and Wellman(1985) in the southern part of the basin,either by the presence of basic magmatites beneath or inside the basin sedimentary formations,or by the rise of the crust lower part .The taking place of such rocks might be penecontemporaneous of the proto-ocean development phase(Affaton,1990).

The eastern and central compartments of this profile are comparable to those of the A-A' profile.However we notice the presence of the Dérouvarou basic granulites and their southern equivalents,at the central compartment(Fig.9,A and C).The eastern compartment shows a relatively lower overcompensation than in the profile A-A'.This seems to be confirmed by the gravity model which suggests an approximately 40km thick crust,despite the counterbalance effects relative to the probable presence of heavy bodies in the zone(Fig.9,B and C).

The C-C' profile(Fig.10,A).Concerning this profile,we notice a reduction of the width of the external structural unit formations.This is very likely in connection with the nappe spit importance(more than 25km at the level of these units;Fig.1 and 10,C).This leads to a more important tectonic overload,and therefore probably to a greater underlying taking root.This apparent contradiction may be explained by a counterbalance effect due to an undercompensation very downright and relatively localized in the western part of the central zone.In fact,the central compartment comprises one relatively undercompensated western part and one highly undercompensated eastern part. The western part is superposable to the Kabyè metabasic Massif lying,according to Caby(1989),on one long wavelength gravity axis materializing the suture zone.The western compartment seems hence to be in connexion with this basic massif which so might be relatively rooted.This result seems to be in contradiction with the hypothesis looking at this massif as a nappe(Affaton et al.,1980;Caby,1989;Affaton,1990).The central compartment eastern part of this profile corresponds to the internal structural unit domain.It is there noticed the presence of two undercompensated sectors.The undercompensation seems to be in relatin with the presence of two high density contiguous bodies undelying the Savalou and Pehunco granulites(Fig.10a,C).

. At the C-C' profile level,the central compartment behaviour agrees with the geodynamical model of a collision orogen.This assumption disagrees with those from Crenn(1957) and Sagbohan(1972) which link the undercompensation uniquely with a 5 to 25km general rise of the upper mantle beneath the Dahomeyide formations.

In the other hand,presence in this central compartment of at least two high density bodies,very likely obducted during the panafrican orogeny,leads to emit two hypotheses :

1°/ We notice(Fig.10a,A) in the central compartment the existence of two breaks of slope similar to that which separates the central and western compartments and which translates the major tectonic contact between the internal and external structural units.These two breaks of slope could reflect important tectonic contacts at the level of which might be heavy bodies probably of the ophiolitic nature(Fig.10a,B).These could be the result of the splitting in two of the major break of slope indicating the panafrican suture.

2°/ The three major tectonic contacts might be independant(Fig.10b,A).This would return to assume the existence of at least three micro-continents separated by micro-oceans and collided during the panafrican event in the central compartment.This assumption rejoins that of the panafrican continental aggregation(Wright and Ajibade,1987).

The eastern compartment gravity characteristics tend to corroborate the coontinental aggregation hypothesis.In fact,it is there noticed a relatively high undercompensation,which is in contradiction with the observations done along the previous profiles characterized by an overcompensation.This undecompensation assumes an important crustal thinning already started in the eastern compartment at the level of the B-B' profile latitude.The eastern compartment might therefore represent a thinned micro-continent.This thinning would explain the granitoid abundance in the eastern domain(Fig.1).This abundance

leads to think that the Benioff plane would dip towards the East in this sector,and that the Kandi Fault might be its trace in outcropping.

. The D-D' profile(Fig 11). Its western compartment is characterized in particular by the presence of the very strongly Kete-Kratchi positive anomaly which culminates to more than 60mgal.This latter might mark,as previously mentioned,the presence of basic magmatites at the base or inside the Volta Basin sedimentary heap.This compartment is limited at the East by an overcompensation effect ascribed to the tectonic overload inside the Dahomeyide external structural units.However,this overcompensation is strongly attenuated by a counterbalance effect due to the presence of important positive anomalies in the central and western compartments.The central compartment displays characteristics similar to those of the C-C' profile,with however more pronounced undercompensation effects.Its western part indicates a positive anomaly in the suture zone,in the Atakpamé locality surroundings(Fig.4 and 5).Its eastern part shows a high positive anomaly.The two parts are separated by an overcompensation effect which very likely is linked with a tectonic overload(Fig.11,B and C).The eastern compartment is not too much different from that of the Fig.10,A.However it is there noticed one more pronounced undercompensation.

In the gravity profile interpretative models,we observe that positive anomalies are linked with heavy bodies having different dimensions and natures,of which the Kete-Kratchi ones are probably the most noticeable.The positive anomalies which are located at the lapping plane of the internal units over the external ones seem to be in connexion with the basic rocks outcropping in the suture zone.The positive anomalies of the internal unit domain are situated at the level of heavy bodies eventually represented on surface by the Savalou and Ouémé granulite outcroppings.In this model,the main overcompensation would be in closed relation with major tectonic contacts.These contacts might result from splitting in two of the suture zone major unevenness which puts in contact the west african Craton and the nigerian-beninian mobile plate.The heavy rocks outcropping at the level of these unevennesses would represent obducted basic rock scales.

In summary,the compared study of all the profiles(Fig.12) allows to outline the following:

- Three domains superimposable to the large petrographic and structural domains of the Dahomeyide panafrican orogen already defined in the structural studies are evidenced.These domains include,each,compartments showing specific gravity characteristics;they are separated some from the others by discontinuities materialized by breaks of slope.
- In the eastern compartments,the observed overcompensation effects progressively die down from North to South,as far as the 10th parallel surroundings;then they are relieved by undercompensation effects.They might result from a progressive rise,from North to South,of deep parts of the Dahomeyide orogen internal units,notably East of the Kandi fault.
- In the central compartments,the undercompensation effects are clearly more complex South of the 10th parallel,which indicates the very composite character of the internal structural units in the southern parts of these compartments.So,all is going as if the tangential tectonics importance in the northern part induces a gravity smoothing effect which suggests relatively simple structures in a complicated tectonic environment.
- In the western compartments and the western parts of the B-B′ and D-D′ profile central compartments,the neighbouring of important positive anomalies appreciably attenuates the overcompensation effects.Hence,it seems important to account for this counterbalance phenomenon in interpolating the panafrican orogen gravity data.
- The undercompensation effects of the D-D′ profile central compartment appear clearly more important than those in profile C-C′.This corroborates the assumption of a progressive rise of the panafrican southern part.Such a rise might date from the South Atlantic opening episode.

III- CONCLUSIONS AND DISCUSSIONS

Our gravity works complete those already done in this area.They allow,in particular,to specify the gravity characteristics and the structural evolution of the collision zone between the Dahomeyide panafrican orogen and the west-african Craton.The Bouguer and isostatic anomaly maps,elaborated using the available data set,have outlined three distinct gravity domains respectively corresponding to the external structural unit and foreland domains,the internal structural unit domain up to the Kandi Fault,and the sector extending East of this fault.

The first domain displays numerous localized positive anomaly zones of which the most characteristic are seated in the Kete-Kratchi sector(in Ghana).These anomalies are very likely linked with the existence of basic nature heavy bodies localized beneath or inside the Volta Basin sedimentary heap.

The central domain shows the classical gravity characteristics of a continental collision orogen,with two zones of large positive and negative anomalies separated by one high gradient zone.This gradient zone is centered on the suture zone along which are displayed in nappes basic rock massifs.The first zone reveals an important tectonic overload at the level of the external structural units.In the central zone,which lies on the area West of the Kandi Fault,there is one positive anomaly line which might testify to the existence of either a series of subjacent high density bodies,or a upper mantle rise.The abundance of granulitic formations or of syn- to post-tectonic granites along this line,anyhow testify to a severe magmatic and thermotectonic activity probably linked with these structures.

The compartment East of the Kandi Fault is characterized in the whole by negative anomalies with,nevertheless,some very localized positive anomalies.

All these domains include discontinuity axes which so attest the structural complexity of the Dahomeyide orogen area.

The gravity profiles have allowed to also distinguish three compartments which are partly superimposable to the Bouguer map three domains.The western compartment,overcompensated,corresponds to the external structural unit domain.It is characterized by an important crustal taking root,doubtless linked with the tectonic overload coming from the panafrican tectogenesis tangential movements.The undercompensation of its western part should be explained by the bringing into place of basic magmatites before or after the panafrican phase.The central compartment,which includes the suture zone,is characterized by an important undercompensation.This might be linked with heavy rocks represented in outcropping by basic massifs and doubtless in depth,beneath the internal units,by rocks of the same nature or by upper mantle rocks.The eastern compartment testify to some complexity which is shown by an overcompensation in the northern part and an undercompensation in the southern one.

The strong undercompensation in the compartments generally attenuates the overcompensation by a gravity counterbalance effect,which is more often translated by an attenuation of the crustal taking root mentioned through the interpretative models.This phenomenon is produced at the breaks of slope in the central compartments of the studied sector southern part.The breaks of slope themselves are the reflections of the major unevennesses separating these compartments.It is at their level that are produced the subduction-obduction phenomena due to the panafrican tangential movements.Obduction is in particular along the suture zone translated by the presence of a series of basic rock massifs.At the breaks of slope,it is materialized by the existence of subjacent high density bodies.Such an interpretation agrees,either with the hypothesis of splitting in two of the panafrican suture zone including the gravity smoothing notion in structural complexity sectors,or with that of micro-continent aggregation during the panafrican orogeny.However,it is important to mention that the increasing directional high complexity from North to South encountered in the studied area,followed by a migmatite and granite abundance,leads to think of a progressive rise of the upper mantle in the orogen southern part.This rise might start in the Paleozoic,favouring by toppling over the Iullemeden syneclisis development,and end with the South Atlantic opening.

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FIGURE CAPTIONS

Fig.1- Synthetic geological map of the Dahomeyide range. 1:eburnean basement;2:allochtonous acid orthogneisses;3:metabasic massifs of the suture zone;4:orthogneissic,paragneissic and mylonitic with acid dominant complex;5:acid and intermediate granulites;6: panafrican charnockites;7:undifferentiated migmatites;8:gneissic complex with biotite and garnet,biotite and hypersthene,and granulites with pyroxenes; 9:alkaline gneissic complex with amphiboles,pyroxenes and biotites,acid granulites,quartzites and marbles;10:mylonitic complex(gneisses,amphiboles,metagabbros mylonitized and in tectonic scales;11:lower supergroup of the Volta basin(Bombouaka);12:middle supergroup of the Volta basin(Pendjari);13:Atacora structural unit;14:western structural unit of the Buem(western Buem);15:eastern structural unit of the Buem(eastern Buem);16:upper supergroup of the Volta basin(Tamale molasse);17:panafrican molassic volcano-sedimentary formations;18:late to postpanafrican granitoids;19:Kandi paleozoic basin;20:coastal meso-cenozoic basin;21:Kandi Fault;22:major overlaps and thrusts.

Fig.2- Gravity station distribution over the Dahomeyide range.The geographical coordinates are at once in degrees and in kilometers (in the UTM projection,MO=2)

Fig.3- Topographic and structural map of the Dahomeyide range.
1:isohypses(contour interval:100m); 2:overthrusts; 3:main faults; 4:secondary faults; 5:general trends of the main structures.

Fig.4- Bouguer anomaly map. Density :2.65g/cm^3.Contour interval :10mgal. 1 :Gravity domain boundaries.

Fig.5- Main gravity trends over the Dahomeyide range.
+ + + :Main positive axes.
- - - :Main negative axes.
+ + + :Secondary positive axes.
- - - :Secondary negative axes.
-o-o- :Main gradient zones.
z- -z :Main discontinuity axis n°z.
⊡ :Locality sites.

Fig.6- Isostatic anomaly map (Airy,30km) and four transverse profiles through the Dahomeyide range. Contour interval :10mgal.

Fig.7- Superimposition of anomaly and reduction curves for each profile A-A',B-B',C-C' and D-D'.
———— :Bouguer anomaly.
-.-.-.-.-.:Isostatic reduction.
--------- :Isostatic anomaly.

Fig.8- Interpretation of the gravity profile A-A′.
A :Isostatic anomaly profile.
B :Interpretative structural model.
C :Geological section.

Fig.9- Interpretation of the gravity profile B-B′.
A :Isostatic anomaly profile..
B :Interpretative structural model.
C :Geological section.

Fig.10a- Interpretation of the gravity profile C-C′ (First hypothesis).
A :Isostatic anomaly profile.
B :Interpretative structural model.
C :geological section.

Fig.10b- Interpretation of the gravity profile C-C′ (Second hypothesis).
A :Isostatic anomaly profile.
B :Interpretative structural model.
C :Geological section.

Note:Automatic modelling in this case is possible only when supposing a progressive variation of the crustal density from West to East in the eastern part of the range.Whereas such a progressive density variation is not accounted for in the first hypothesis(Fig.10a),it here constitutes the major element.Moreover the crust thickness is more important here than elsewhere.

Fig.11- Interpretation of the gravity profile D-D′.
A :Isostatic anomaly profile.
B :Interpretative structural model.
C :Geological section.

Fig.12- Comparision of the four studied gravity profiles.

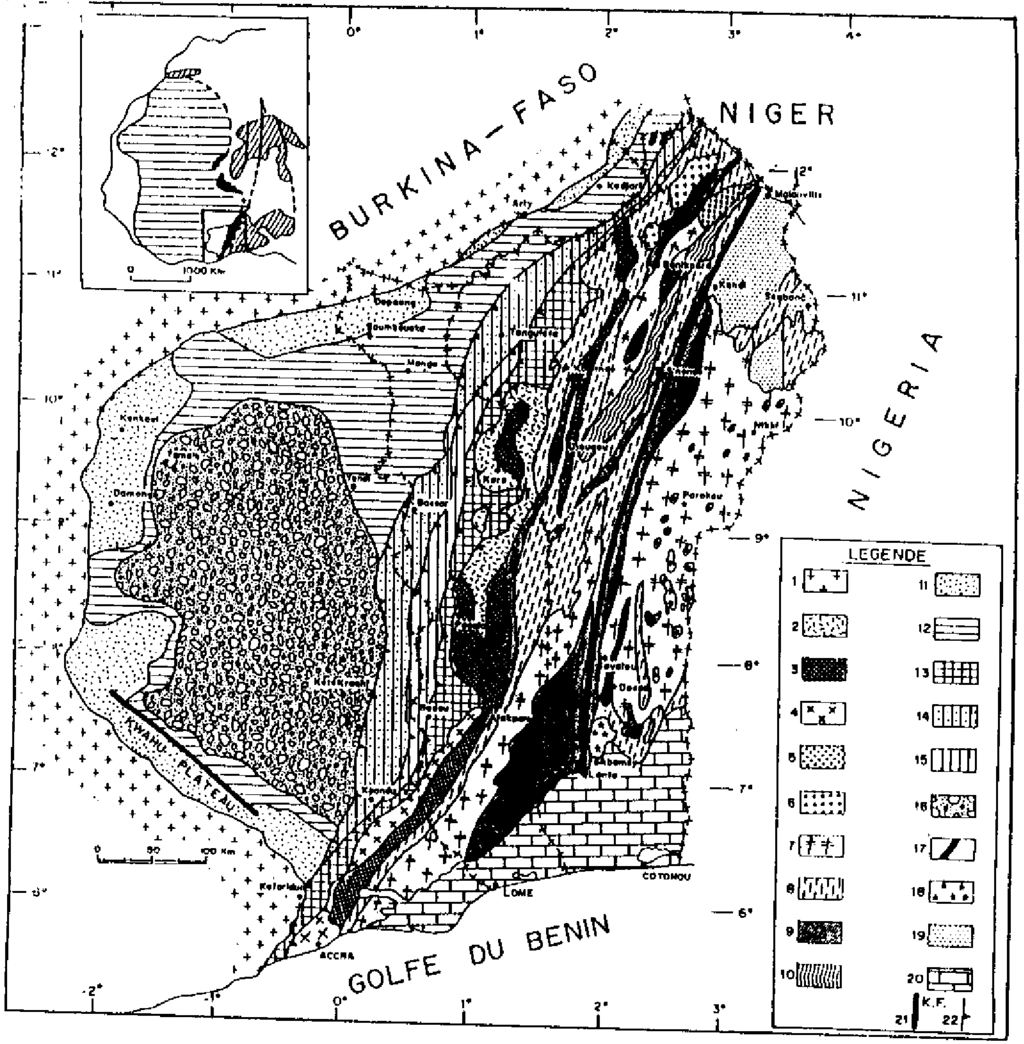


Fig. 1

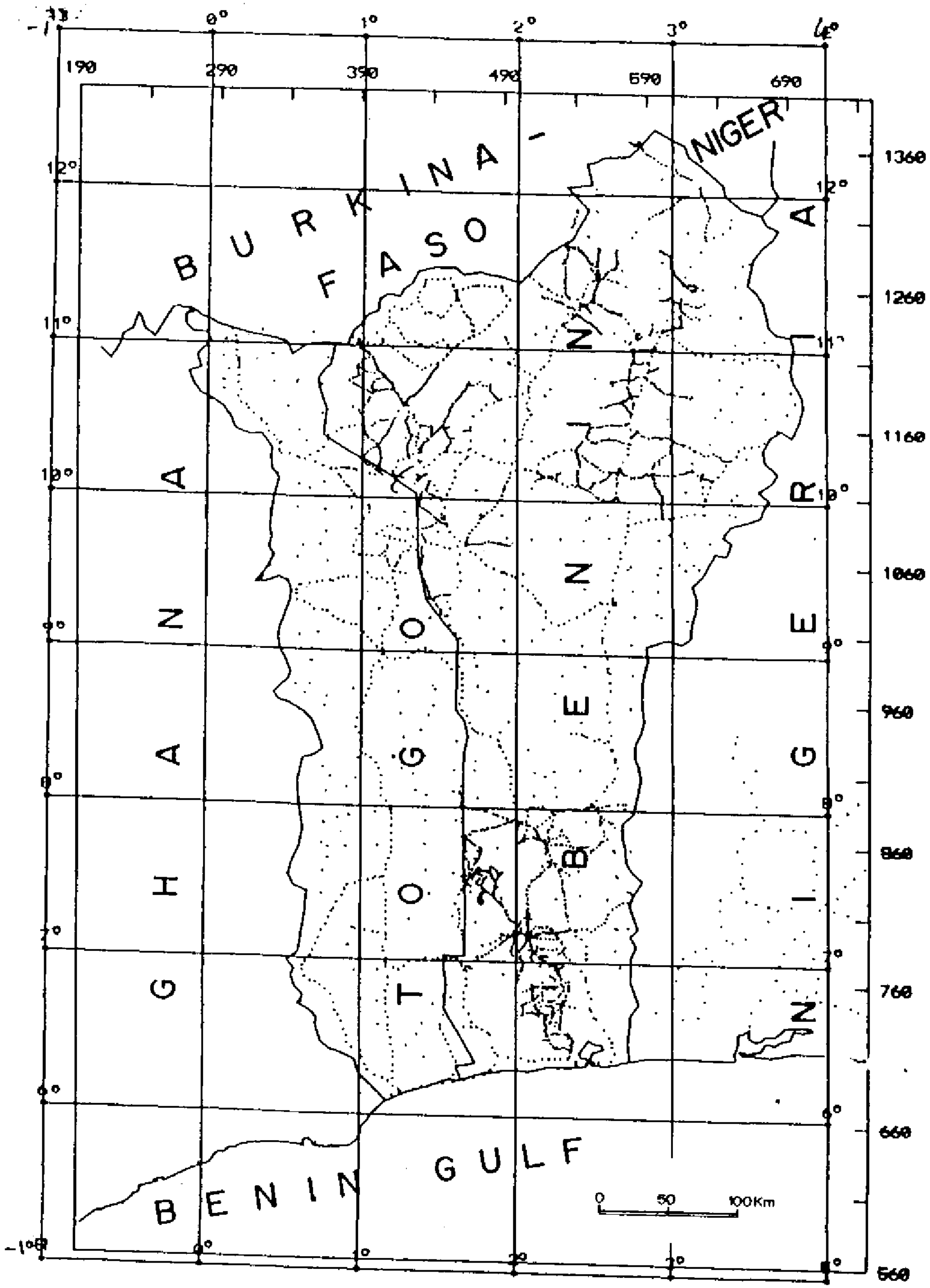


Fig. 2 _ Gravity station distribution over the Dahomeyide range
The geographical coordinates are at once in degrees and kilometers (in the U.T.M. projection)

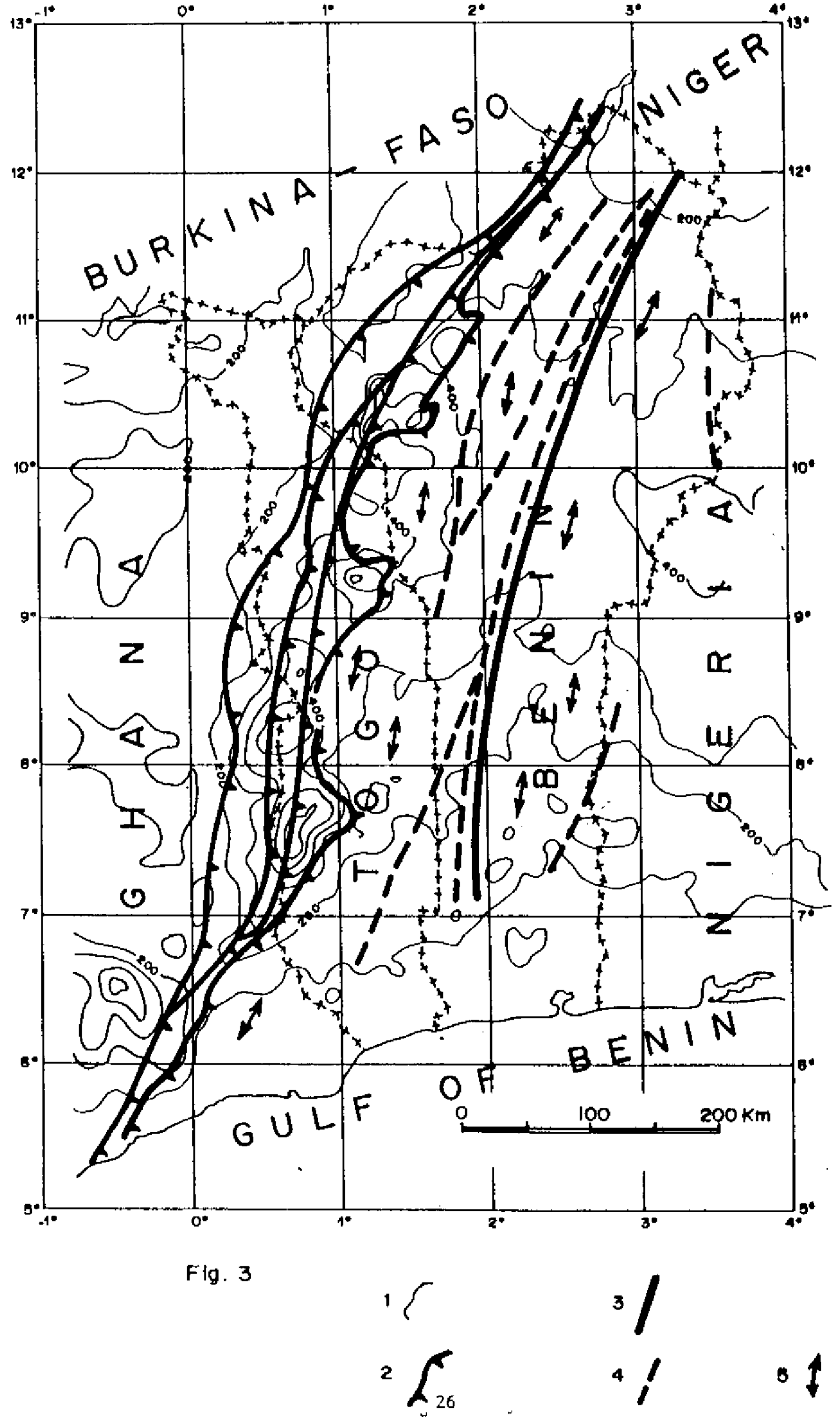


Fig. 3

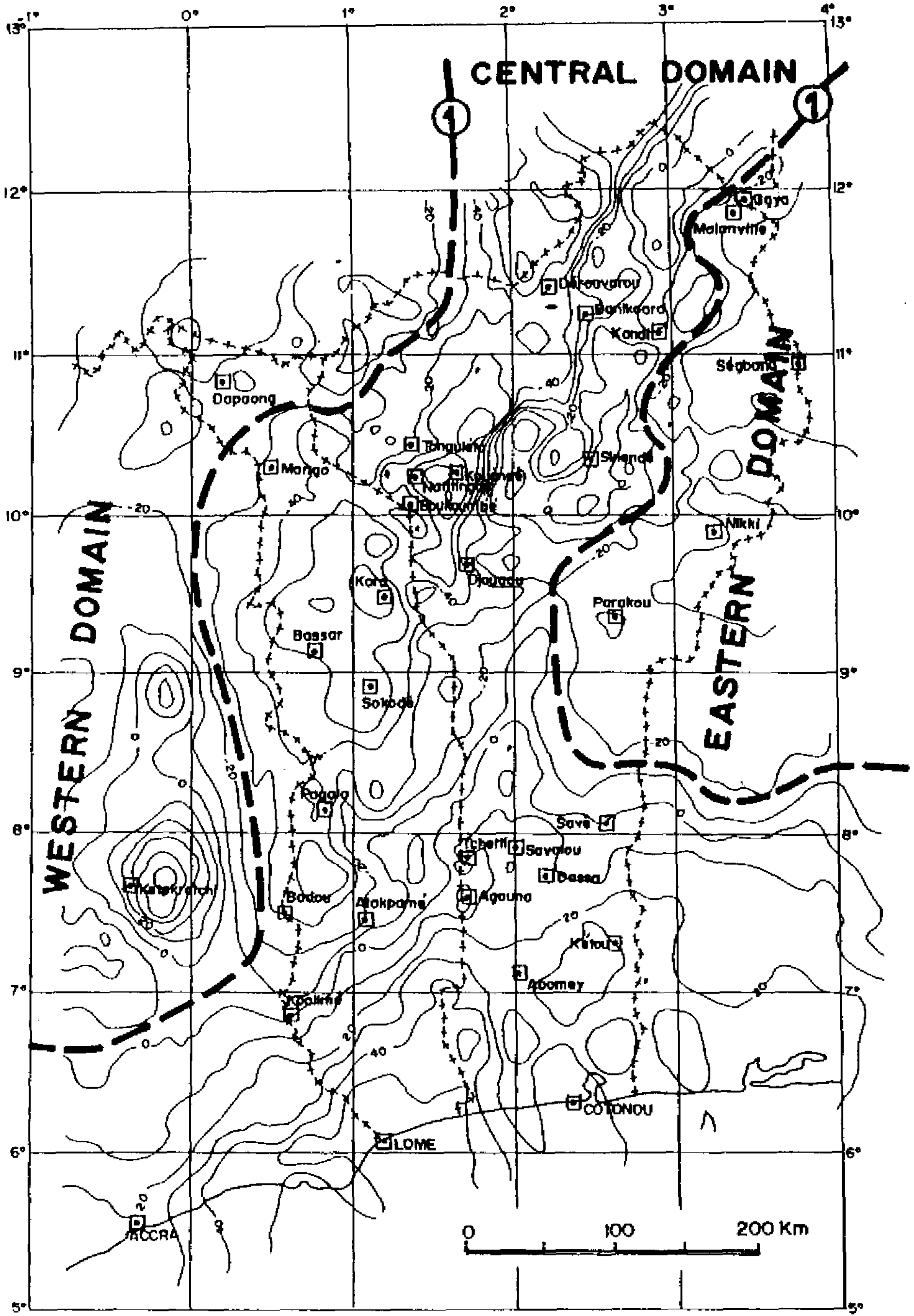


Fig. 4 _ Bouguer anomaly map. Density = 2.67g/cm^3, Contour interval = 10 mgal

1 : Gravity domain boundaries

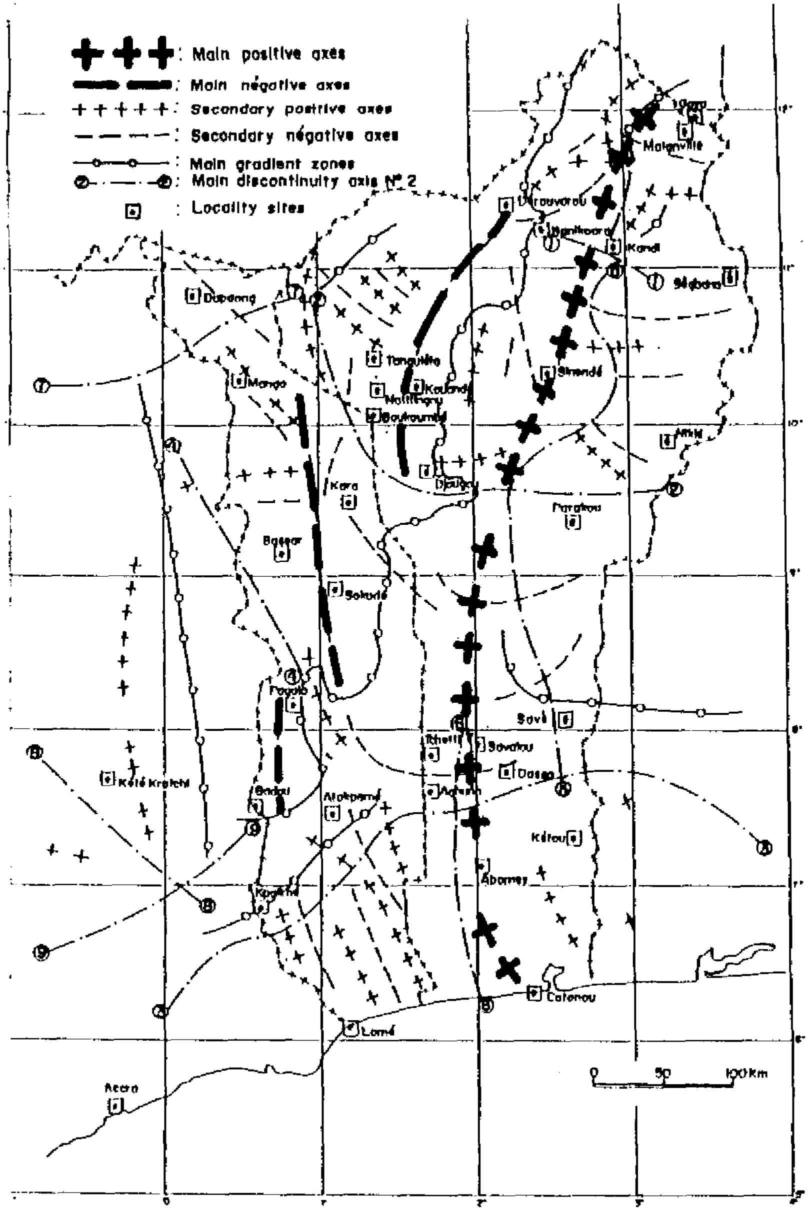


Fig. 5 _ Main gravity trends over the Dahomeykide range

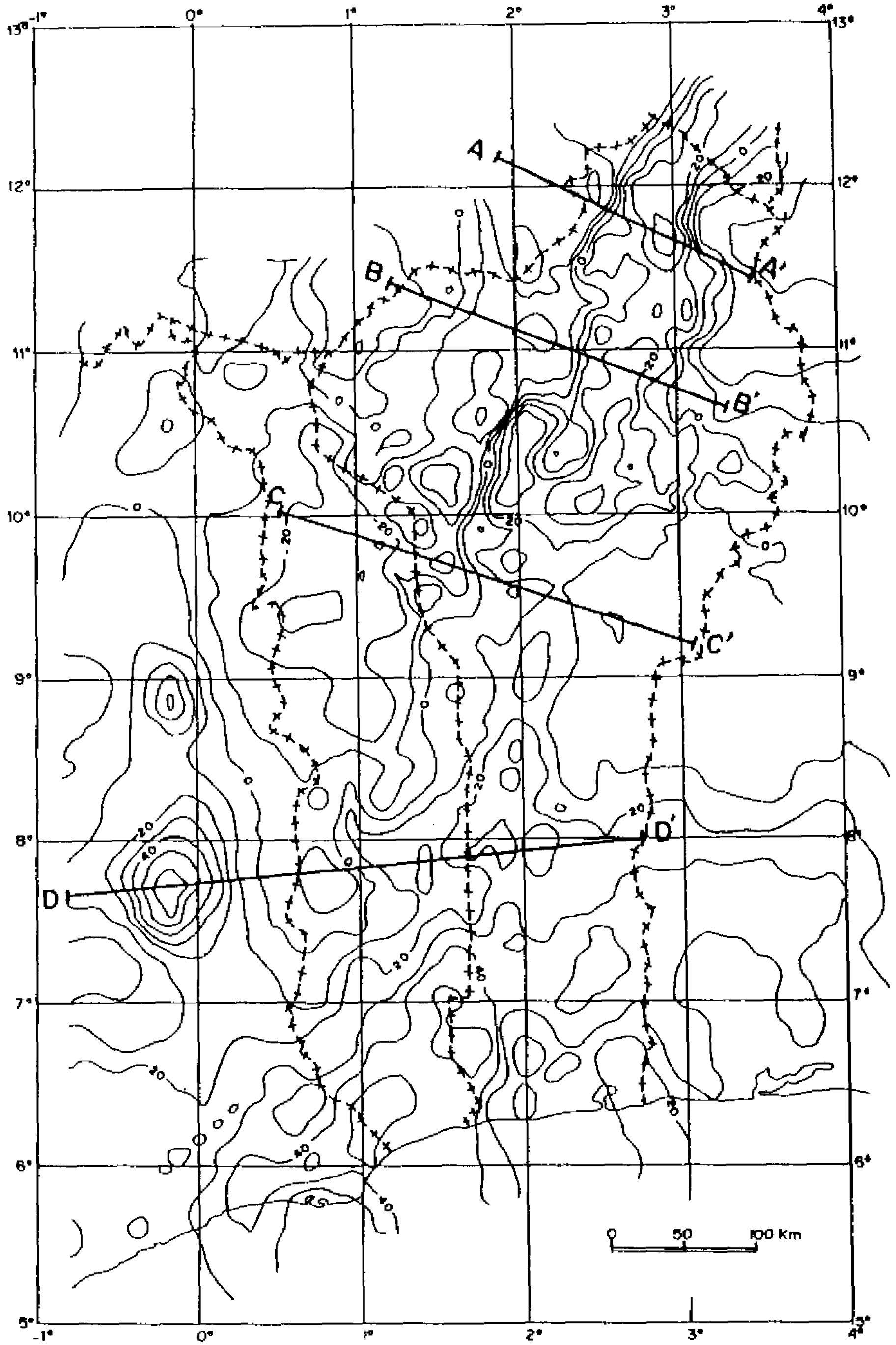


Fig. 6 _ Isostatic anomaly map (Airy, 30Km) and four transverse profiles through the Dahomeyide range

Contour interval = 10 mgal

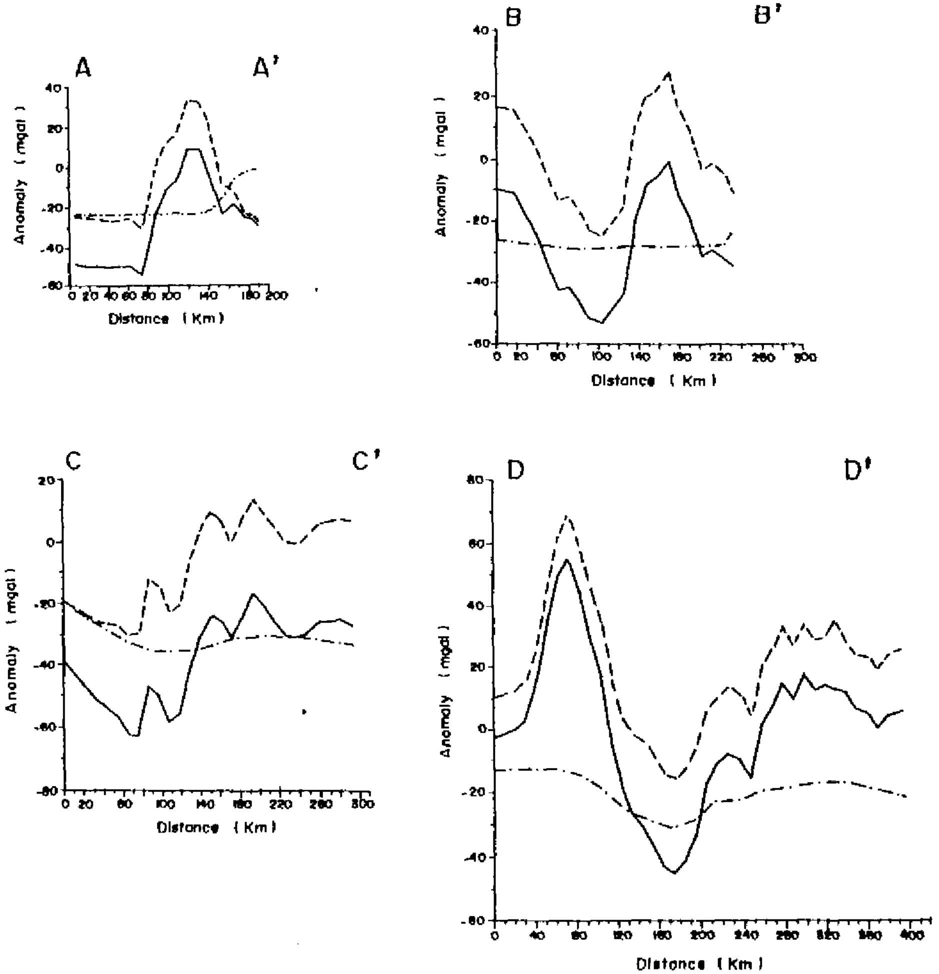


Fig. 7 _ Superimposition of anomaly and reduction curves for each profile A-A', B-B', C-C' and D-D'.

———— : Bouguer anomaly
-·-·-·-·- : Isostatic reduction
- - - - - - : Isostatic anomaly

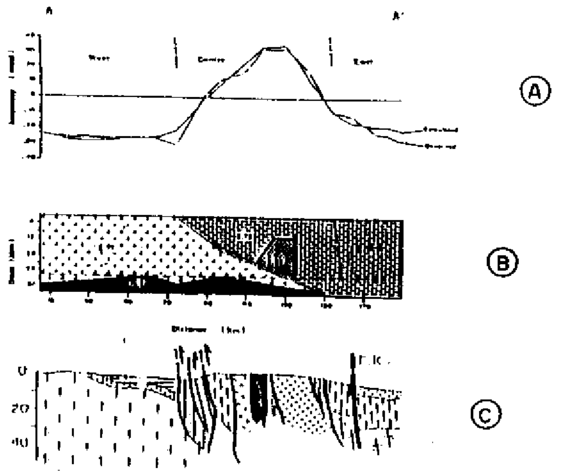


Fig. 8

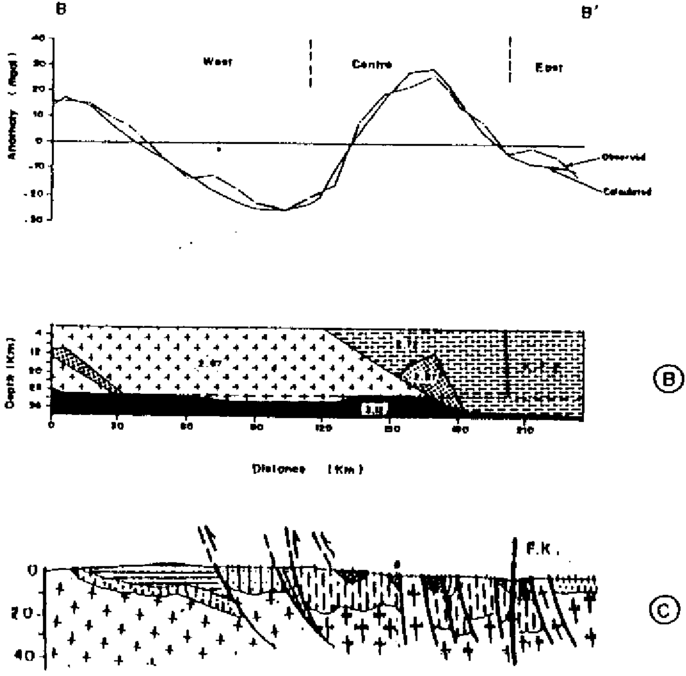


Fig. 9

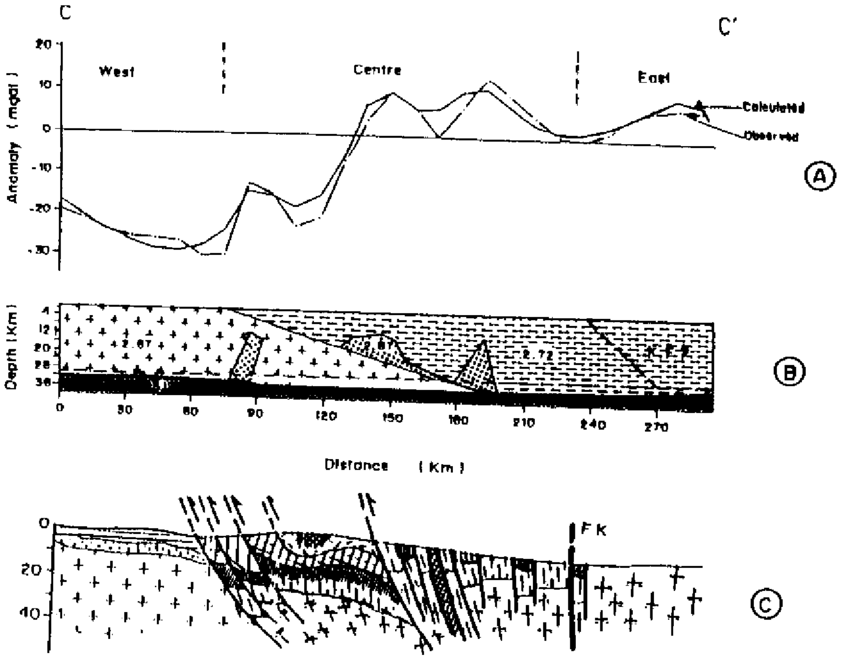


Fig. 10a

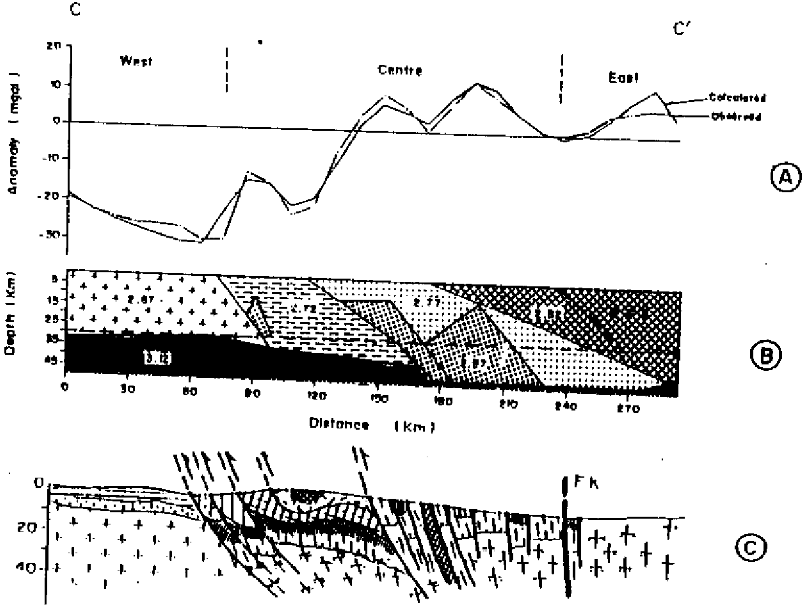


Fig. 10b

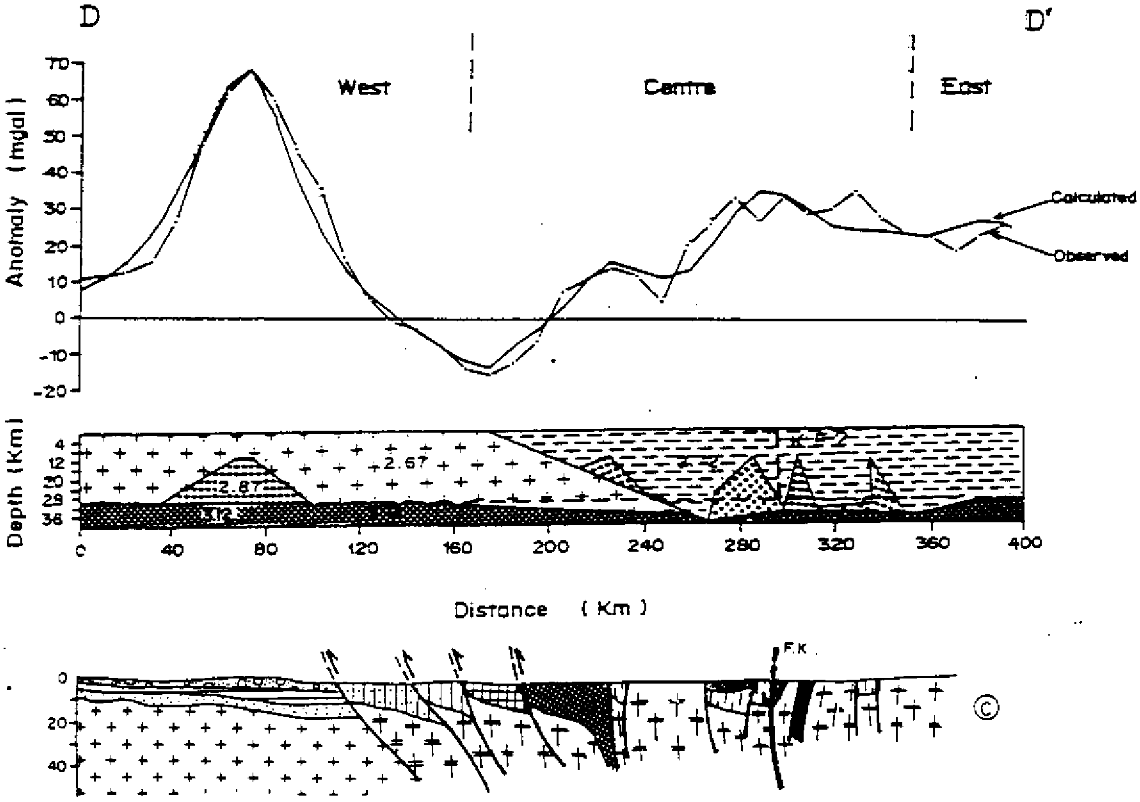
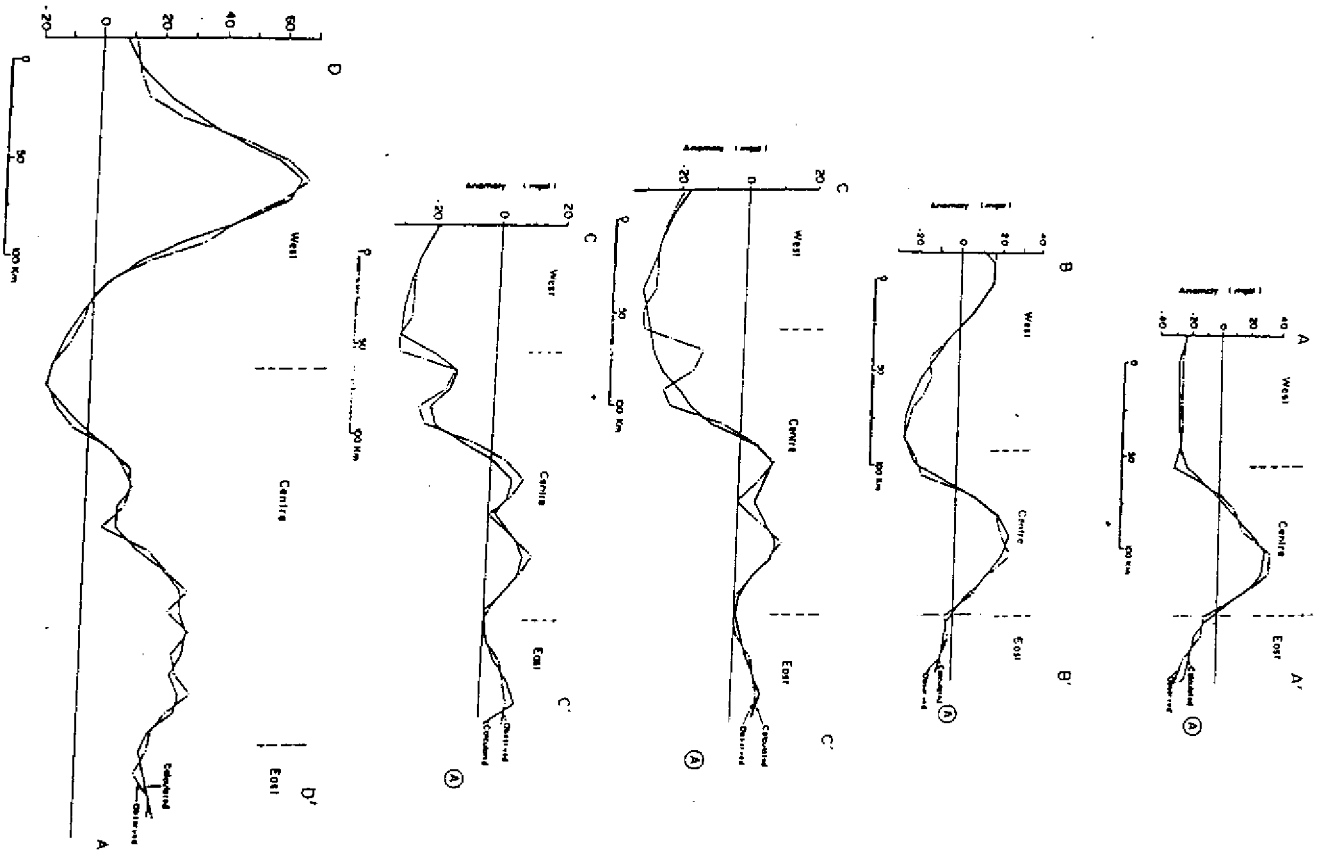

D
D'
West
Centre
East
Calculated
Observed
Anomaly (mgal)
70
60
50
40
30
20
10
0
-10
-20
Depth (Km)
4
12
20
28
36
2.67
2.87
3.12
0
40
80
120
160
200
240
280
320
360
400
Distance (Km)
F.K.
0
20
40
Ⓒ

Fig. 11


D
D'
A
West
Centre
East
Calculated
Observed
-20
0
20
40
60
0
50
100 Km
Anomaly (mgal)
C
C'
B
B'
A
A'
Ⓐ

F I G. 12