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GRAVITY SURVEYS IN SURINAM AND THE NETHERLANDS LEEWARD ISLANDS AREA 1958-1965

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INTRODUCTION

In this publication the outcome is presented of gravity measurements carried out in Surinam and the Netherlands Antilles.

The first part is a report taken from the doctorate thesis by Dr. J. VAN BOECKEL (thesis Amsterdam, 1968). The author made a detailed gravity survey in northern Surinam in the years 1958 and 1960. He travelled thousands of miles, mostly by corjaal (= canoe), and made more than 400 gravity stations along the Surinam rivers. The gravity field of northern Surinam appears to be characterized by a belt of negative anomalies in the centre of the country, and by a region of positive deviations in the western part. The author gives an explanation of the important anomalies which is based on the present knowledge of the geology of Surinam, and on a comparison with other countries of comparable tectonical structure.

The second part is a description and interpretation of gravity anomalies in the southern part of the Caribbean Sea. The author, Dr. R. A. LAGAAY, wrote a doctoral thesis (Utrecht, 1968) on his geophysical investigations on the Netherlands Leeward Islands. He carried out gravimetric and geomagnetic observations on the islands of Aruba, Bonaire and Curaçao, during the summer of 1962, at about 250 stations. Further gravity measurements at the surrounding sea were made in the Navado III project (1964–1965). The author has tried to broaden the original plan of investigations to a much wider view on the gravity of the southern Caribbean Sea. By comparing the gravity anomalies with data obtained by other authors, he has succeeded in finding an interpretation of the anomalies, and also an explanation of the mechanism which determined the crustal structure in that area.

Both authors deserve the high appreciations and thanks of the Netherlands Geodetic Commission for their important gravity work and for rewriting parts of their doctorate theses for this publication.

The Editor,
J. VELDKAMP

PART I

REGIONAL GRAVITY SURVEY OF NORTHERN SURINAM

by

J. VAN BOECKEL

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PREFACE

It is a pleasure to express my warm appreciation of all the people who enabled me to study the gravity field in northern Surinam. I am greatly indebted to Prof. Dr. J. VELDKAMP who instigated this research. Without his enthusiasm and his active interest in the geophysical investigations in Surinam, the study presented here would never have materialized. I also owe a special debt of gratitude to Prof. Dr. J. P. BAKKER for many stimulating discussions on the interpretation of the anomalies in the gravity field of Surinam.

I further express my gratitude to the Netherlands Foundation for the Advancement of Research in Surinam and the Netherlands Antilles (WOSUNA) for its ample support given to this project.

Of the many staffmembers of the Surinam Government Geological and Mining Service, who rendered their support so generously, I wish to acknowledge in particular the collaboration of Ir. H. BECKERING VINCKERS, Drs. R. CAMBRIDGE, Ir. G. DOEVE, Ir. C. VAN KOOTEN, Drs. D. LOEMBAN TOBING, Drs. L. O'HERNE, Mr. H. STÜGER, Mr. E. VAN DER KALLEN, Mr. A. VAN AERDE, Mr. M. VAN BREST, Mr. K. RAGHOENATH and Mr. A. ABRAHAMS.

During my stay at the Dominion Observatory, Ottawa, Canada many individual scientists have contributed to the progress of this research project. My sincere thanks are especially due to Dr. M. INNES, Dr. D. NAGY, Dr. J. TANNER and Mr. A. RATTEW.

Finally I wish to express my appreciation to Miss F. PERIÉ, Mr. OOSTING, Mr. SCHEPER and Mr. SMIT for their conscientious assistance in preparing the manuscript and the drawings.

J. VAN BOECKEL

SUMMARY

The aim of this monograph is to present the results of the regional gravity survey in northern Surinam. The contents of this report are divided into two parts. The first part contains a description of the gravity measurements. The second part explores the interpretational aspects of the gravity field in northern Surinam. This chapter first gives a brief account of the Surinam geology. Before passing on to the interpretation of the broader scale phenomena of the gravity field, it then continues with the examination of two small scale anomalies (near Dramhoso and Afobaka). As the gravity field in northern Surinam is dominated by a belt of intensly negative anomalies, the main part of the interpretation in chapter two is specifically devoted to the explanation of this prominent gravity deficit. Finally, the positive deviations of the gravity field in western Surinam are discussed in relation to the basement configuration of the Corantijn Basin.

For this report the author used those parts of his doctorate thesis (VAN BOECKEL, 1968) which are relevant to the regional gravity survey of northern Surinam as such. For a more comprehensive treatment of the gravity field of Surinam, in particular as regards its correlation with the geomagnetic investigations in Surinam, the reader is referred to the original thesis, which also discusses the method of interpretation applied here in more detail.

Chapter 1

GRAVITY SURVEY

1.1 The measurements

The regional gravity survey, the results of which are presented here, was preceded by other gravity measurements in Surinam. The measurements carried out are given below in chronological order:

1945 (HARDING)	A gravity measurement on the Zanderij airfield at the "runway end of first sidewalk south of operation tower". Measured value: g = 978,050.0 mgal.
1949 (VENING MEINESZ)	Gravity measurement with the pendulum apparatus of Prof. Vening Meinesz aboard H. Neth. M.S. "O 24" in Paramaribo harbour (off the landing stage of the gasworks). Value measured: g = 978,080.5 mgal.
1957 (VELDKAMP)	Gravity measurements along the Paramaribo-Dam railway track and the Marowijne River with the Askania gravimeter Gs 9 No. 70 of the Netherlands Geodetic Commission (21 stations).
1958 (VAN BOECKEL)	Gravity measurements along a track from Paramaribo up to the Surinam-British Guiana border (Saramacca canal - Saramacca - Coppename - Wayombo - Nickerie - Corantijn) and along Garnizoenspad as far as the Saramacca River and following the road from Coppenamepunt to Coronie (115 stations).
1960 (VAN BOECKEL)	A regional gravity survey in the northern part of Surinam. The area explored is situated between latitude 4° and 6° north and longitude 54° and 58° west. This territory does not comprise either the profile measurement of the gravity along the British Guiana coast from the mouth of Corantijn up to Georgetown, or those carried out in the Table Mountain area south of latitude 4° (319 stations).

1.1.1 *Reconnaissance survey 1958*

In July and August 1957 the author had the pleasure of assisting Prof. VELDKAMP in the gravity measurements along the Marowijne River and the railway track Paramaribo-Dam. The observations were important for the interpretation of the measurements carried out in 1949 by Prof. VENING MEINESZ on board H. Neth. M.S. "O 24" on the ocean off Surinam and French Guiana.

In "Measurements of Gravity in Surinam" (Gravity Expeditions 1948–1958) VELDKAMP has published the results of these measurements and interpreted them in order to obtain a more accurate picture of the trend of the gravity at the edge of the continent.

Through these, VELDKAMP has arrived at the conclusion that everywhere in the area considered, gravity in Surinam is under the normal value and that near the coast and on the ocean, its trend points to a local isostatic equilibrium. The numerical value of the free-air anomaly along a profile perpendicular to the coast is in accordance with the value to be expected from a normal crust cross-section and from a gradual transition from the continental to the oceanic crust.

From measurements along both profiles (nearly perpendicular to the coast) it has become evident that at the same latitude, gravity along the Marowijne showed a higher value than along the railway.

As the depth of the basement under the coastal sediments increases in a westerly direction down to nearly two kilometres, the author thought this decreasing tendency was likely to continue further west of the Surinam River. With a view to finding out whether the gravity field in Surinam coastal area does actually present this picture, the author proposed to continue the measurements in a westerly direction. At the proposal of Prof. VELDKAMP, the Netherlands Geodetic Commission proved to be willing to make available once more the Askania gravimeter that had already been sent back to the Netherlands in the meantime. In the period between September 26th and October 22nd, 1958, a reconnaissance survey was performed along the following profiles:

1. every kilometre along Garnizoenspad to the Saramacca River;
2. the inland water route from Paramaribo to Nickerie (along the Saramacca Canal, Saramacca River, Copename River, Wayombo River, Nickerie River);
3. the Corantijn River as far as Apoera;
4. every 5 kilometres up the road from Coppenamepunt to Coronie (terminus Burnside).

In order to obtain a clear picture of the trend of the gravity, detailed measurements were carried out in the polders of Nickerie and Coronie.

The gravity station in the Wosuna building, Paramaribo, was taken as a base station for all those performed in 1958.

Whilst the 1957 expeditions had already given grounds for supposing that the Surinam gravity field was disturbed, the 1958 reconnaissance survey led to some outstanding results. It was found that in the coastal area the trend of the anomalies was entirely determined by the clearly obvious minimum of the gravity in the Coppename River-basin.

Strange as it may be, this minimum with a lowest value of -63 mgal is joined to the west by a maximum with a highest value of $+33$ mgal situated in the area between the Corantijn and Nickerie rivers, where the basement is located at the depth of nearly two kilometres. One would not have dared to predict that an excess of gravity would be located at that point where the packet of unconsolidated sediments in the Surinam coastal region is thickest.

1.1.2 *Regional survey 1960*

The promising results of the gravity measurements in 1957 and 1958 led to the organization in 1960 of a regional gravity survey to measure a network of gravity stations in northern Surinam. The choice of locations for these stations was subject to limitations. For reasons of accessibility the majority of them were measured along the banks of rivers and creeks. The gravity profiles were pushed on upstream as far as was reasonably possible. Another reason why the gravity was measured mainly along the rivers was that our knowledge of the topography of the Surinam interior was not accurate enough to take into account topographical reductions. Performing time-consuming geodetical measurements in order to determine the height of the gravity stations was beyond the scope of this survey. If one chooses the spots of the measurements in the close vicinity of the rivers, their fall offers the most reliable hold for the calculation of the topographical heights of the points of measurement. Where gravity readings were not taken along the rivers or creeks, but over land, either the heights were so small as to be ignored, or else they were already known through topographical measurements (along the Afobaka road, the railway track to Dam and in the Table Mountain area).

Measurements begun on May 16th, 1960, along the Saramacca made it clear that along this river even larger negative deviations of the gravity than those near Kabel and the Coppename are to be found in the Mamadam Falls area. Subsequently, gravity profiles were measured along the following rivers and creeks: Coppename, Tibiti, Kabo, Wayombo, Nickerie, Falawatra, Masona, Marataka, Kapoeri, Kabalebo and Corantijn. After returning to Paramaribo a profile was measured along the then almost finished road from Paramaribo to Afobaka (the location of a hydro-electric plant in the Surinam River). Measuring of the gravity trend in the area between the Saramacca and Marowijne Rivers was next started. Profiles were measured along the Commewijne River and the Tempati, Mapane, Penninica and Cassewinica Creeks.

So far, the gravity measurements made showed that everywhere along the Surinam River gravity is of a higher value than in corresponding latitudes along the Saramacca. This justified the supposition that pushing the profile further southwards along the Saramacca would furnish interesting indications of the trend of the belt of the negatively deviating gravity. It was therefore decided to organize an expedition to the Table Mountain area, where an additional east-west profile was measured in the direction of the airstrip there. In this southern latitude too, gravity still shows a considerable deficit. This negative anomaly, moreover, continues to increase in the direction of Table Mountain. This implies that between the Table Mountain and Emma ranges and the upper Nickerie, where the positive anomaly of western Surinam begins, an area of sharply increasing gravity must be found.

The last journey of the gravity survey in 1960 led to the Coesewijne, the Cottica and the mouth of the Marowijne rivers in order to complete measurements in the eastern coastal region. These indicated that the ridge of rather high gravity, that runs parallel to the coast, is continued further to the east. In the extreme northeastern part of Surinam even a $+9$ mgal value is met.

Thanks to the willing cooperation of the Geological Survey of Guiana, it was possible, after the survey in Surinam was finished, to measure a gravity profile along the coast of Guiana from Georgetown to Springland. By using a speedboat from Springland across the Corantijn mouth and by measuring again at the Nanni Sluice (station 382) on the Surinam bank of the Corantijn River, which station had already been measured before, we were able to link measurements in Guiana directly with those in Surinam.

The measurements in Guiana revealed the gravity along the coast there to be far less disturbed than along the Surinam coast, where the gravity trend is determined by the strongly negative anomaly of -63 mgal to the west of the mouth of the Coppename. Along the coast between Georgetown and Springland only small positive or negative deviations not larger than 10 mgal are found. But a sharp gradient was recorded in the trend of the gravity in the very narrow coastal strip between Georgetown and the beach to the northeast of this town. On the assumption that this anomaly is caused by the fault that had previously been projected near Georgetown from water drilling operations, and also at the request of the Geological Survey, a further network of stations was measured in the city of Georgetown and in the near vicinity. These measurements provided indications regarding the direction of the fault.

For locations of gravity stations in Guiana, see Table V in Appendix B.

1.1.3 *Instrumentation*

Gravity measurements in 1957 and 1958 were all performed with the Askania Gs 9 No. 70 gravimeter owned by the Netherlands Geodetic Commission. In May and June, 1960 measurements were also carried out with this instrument. In June, 1960 the Worden No. 292 gravimeter, placed at our disposal for this purpose by the Bataafsche Internationale Petroleum Maatschappij, arrived in Surinam. Before the Worden was sent to Surinam it had been subjected to a performance test by Texas Instruments Inc. Houston. In the first half of July measurements were made with both the Askania No. 70 and the Worden No. 292. From the second half of July on the Askania was kept in reserve and stored in the Geological and Mining Service's air-conditioned laboratory. Therefore nearly all measurements carried out since the middle of July were made with the Worden No. 292, only the 18 stations along the upper Saramacca (to the south of the Grandam) and in the Table Mountain area were measured with the Worden No. 512 owned by the Geological and Mining Service in Surinam.

Working out of the results of the measurements made it clear that both the Askania No. 70 and the Worden No. 292 were operating reliably. In order to make a comparison with the scale-values supplied by the makers, a rather large number of stations were measured with both instruments. From these measurements it can be deduced that the scale-values of both instruments, as provided by the Askania and Texas Instruments Works respectively, are also applicable to measurements in Surinam.

Whilst it was possible to verify the scale-values of the Askania No. 70 and the Worden No. 292 by means of many comparative measurements, too few stations were measured with the Worden No. 512 for a critical assessment of the scale-value given (0.0996 mgal per scale unit). The measurements performed along the upper Saramacca with this gravimeter showed that further working out of these measurements may be based roughly on the scale-value given by Texas Instruments Inc.

1.1.4 *Network of base stations*

The relative gravity measurements carried out in 1957 by means of the Askania No. 70 were connected by VELDKAMP (1960) with HARDING's measurement on the Zanderij airfield. HARDING gives as a result of this measurement: $g = 978{,}050.0$ mgal. This Zanderij gravity station measured by HARDING with a Worden gravimeter served likewise as a primary base station for the regional survey; for all stations gravity was calculated starting from this base value of the gravity in Surinam. VELDKAMP mentions the results of the measurements of the Zanderij-Paramaribo profile. Those at Paramaribo were carried out in the Wosuna block (in the guesthouse in Tapanahony Street) and on the Stenen Trap, a triangulated point situated on the Waterkant, near Government Square. The latter point is about 1 km to the northeast of the gasworks landing stage, off which VENING MEINESZ carried out his pendulum measurements aboard H. Neth. M.S. "O 24" in 1949. VELDKAMP notes a 6 mgal difference between his gravimetrical measurement (linked up with HARDING's base at Zanderij) and the pendulum observation. Considering the possible error of the observations and the various bases on which the constants of the pendulum and the gravimeter depend, VELDKAMP does not think this difference alarming. It is highly improbable that a difference of gravity of about 6 mgal would actually exist between both stations. The trend of the anomalies in the Paramaribo area suggests that at both places gravity will be nearly equal. VENING MEINESZ (1960) gives various reasons why the accuracy of his observations has not been explicitly evaluated and refers to the estimate of a standard deviation of about 4 mgal as given by EWING and VENING MEINESZ for a typical observation. It should be pointed out that according to VENING MEINESZ, a submarine harbour observation is the most difficult to carry out.

Starting from the Zanderij primary base station, the value of the gravity was determined at the secondary base station at Paramaribo (Station 1 in the Geological and Mining Service building in Kleine Water Street).

From measurements of the Zanderij-Paramaribo profile both with the Askania No. 70 and the Worden No. 292, it can be deduced that the gravity at the secondary base station equals 978,080.0 mgal. This value was measured in room 122 of the Geological and Mining Service laboratory, the floor of this room being about two metres above ground level. For all expeditions to the interior in 1960, the initial and final measurements were performed at this point, so that all stations could be made directly referring to this secondary base station (= station 1).

In the 1958 measurements, those of station 2 (WOSUNA) were used as starting point. Through repeated measurements it became evident that there is no distinct difference between the results of the gravity readings at stations 1 and 2. As for the gravity measured, owing to this good luck, station 2 can be identified with station 1. It was accordingly possible

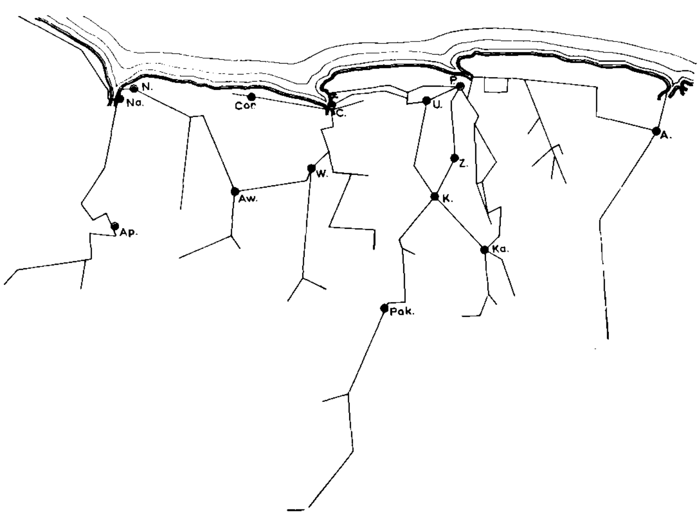

Figure 1. Network of base stations. The lines indicate the profiles, along which gravity has been measured in northern Surinam.

Table I. Locations of base stations (see also map in Figure 1)

P.	*Paramaribo* (Station 1). Geological and Mining Service, Kleine Water Street. Laboratory, room 122.
Z.	*Zanderij* (Station 132). Eastern end of first sidewalk of the secondary runway to the south of the control tower (the one on the old platform of the airfield).
A.	*Albina* (Station 25). On the concrete ledge next to the northern wall of the customhouse.
Ka.	*Kabel* (Station 136). Under the railway guesthouse on the southern side of the railway track.
K.	*Kwakoegron* (Station 133). Next to the level pole of the K.L.M. astrostation on the western side of the railway.
Pak.	*Paka Paka* (Station 185). On the bank near the landing place at about 10 metres southeast of the teacher's house.
U.	*Uitkijk* (Station 140). Sluice between Surinam river and Saramacca canal on the concrete edge of the northern lock wall.
C.	*Coppenamepunt* (Station 249). On the bank of the Coppename next to the eastern end of the ferry landing stage.
Cor.	*Coronie* (Station 262). In front of the staircase of the main entrance of the government guest-house.
W.	*Wayombo mouth* (Station 287). On the bank next to the Landsbosbeheer wharf.
Aw.	*Awarra mouth* (Station 365). On the bank next to the Landsbosbeheer wharf.
N.	*Nieuw Nickerie* (Station 339). On the bank next to the General Landing Stage situated in a direct line with Landing Street.
Na.	*Nanni Sluice* (Station 382). On the bridge across the sluice.
Ap.	*Apoera* (Station 395). On top of the bank to the west of the police post.

Table II. Gravity at base stations

Base station	Number of station	Place	g in mgals	Accuracy in mgal (in respect of the primary base)	Accuracy in mgal (in respect of the secondary base)
Z.	132	Zanderij	978,050.0	= primary base	
P.	1	Paramaribo	978,080.0	± 0.3	= secondary base
A.	25	Albina	978,084.2		± 0.2
Ka.	136	Kabel	978,009.5		± 0.3
K.	133	Kwakoegron	978,030.1		± 0.3
Pak.	185	Paka Paka	977,995.3		± 0.4
U.	140	Uitkijk	978,075.7		± 0.1
C.	249	Coppenamepunt	978,050.4		± 0.1
Cor.	262	Coronie	978,071.2		± 0.1
W.	287	Wayombo mouth	978,031.3		± 0.3
Aw.	365	Awarra mouth	978,079.4		± 0.2
N.	339	Nieuw Nickerie	978,133.3		± 0.3
Na.	382	Nanni Sluice	978,110.4		± 0.3
Ap.	395	Apoera	978,091.8		± 0.1

to have all measurements carried out in 1958 and 1960 made to refer to one secondary base station (station 1).

For the benefit of future gravity researches in Surinam, an attempt was made to set up a network of tertiary base stations (Figure 1). In order to eliminate inaccuracies as much as possible, the tertiary base stations were measured on several tours (except the one at Coronie).

For future surveys these tertiary base stations can be used as control stations. For this reason the locations of the measuring points (see Table I) are described in such a way that no misunderstanding could possibly arise. The estimated accuracy of the stated values of gravity is also mentioned (Table II).

It may be expected that during future gravity research in Surinam, so-called relative instruments (recording only differences in gravity) will be used. For the calibration of the constants of such gravimeters it is desirable to have available a base profile or a calibration line, i.e. a known and accurately measured difference of gravity between two or more stations. The scale-value in Surinam of the Askania No. 70 was evaluated several times by means of calibration and proved to be quite concordant with the scale-value of the Worden No. 292, as established shortly before by Texas Instruments Inc. Therefore it is warranted to introduce the relative measurements of a favourably situated profile as a base line. The Paramaribo-Uitkijk stretch was chosen for this purpose. Measurements of the differences of gravity between Paramaribo (station 1) and Uitkijk (station 140) resulted in a rounded-off average of 4.30 mgal. If a greater interval of gravity is preferred, the accurately measured Paramaribo-Coppenamepunt profile (29.6 mgal) may be used as a calibration line.

This establishment of a base line and a network of base stations is no more than a crude initial step in the setting up of a Surinam base network, the accuracy of which may be improved later on.

1.2 Reductions of observations

The results of the gravity measurements have been compiled in Table IV (Appendix A), while the Bouguer gravity anomaly map (Map I, inserted at the end) gives the Bouguer anomaly contours drawn on the basis of the Bouguer anomaly figures listed in this table.

For the determination of the topographical altitudes, all available data of heights have been used. In order to give some idea concerning the degree of accuracy of the altitudes of the gravity stations listed in Table IV (Appendix A), a classification of accuracy is also included. For the various classes, the following order of accuracy applies:

		corresponding effect on Bouguer anomaly
(i)	= error ± 1.00 m	± 0.2 mgal
(ii)	= error ± 2.00 m	± 0.4 mgal
(iii)	= error ± 5.00 m	± 0.8 mgal
(iv)	= error ± 10.00 m	± 2.0 mgal
(v)	= error ± 20.00 m	± 4.0 mgal

All elevations are related to the average sea level near the mouth of the Surinam River in the year 1956. This average sea level is the zero-level or Normal Surinam Level that has been introduced as the reference level for the whole of Surinam.

The altitude of the majority of the stations situated in the young coastal area has been assumed to be almost equal to that of the Stenen Trap at Paramaribo (2.5 m). As regards all stations outside this area, altitudes have been taken from geodetic measurements or evaluated with the help of the fall of the rivers. On all stations measured the elevation of the measuring point above the level of the river has always been allowed for. Regarding the elevations of the stations upstream of the falls – in cases where geodetic data were not available – the evaluated heights of the falls have also been taken into account.

The values of the theoretical or normal gravity (g_0) (listed in Table IV) have been calculated in accordance with the international gravity formula

$$g_0 = 978.049\,(1 + 0.005\,288\,4 \sin^2\varphi - 0.000\,005\,9 \sin^2 2\varphi) \text{ cm/sec}^2.$$

All Bouguer anomalies given are based on the simplified Bouguer reduction, which means that neither terrain corrections nor the curvature of the earth have been elaborated as is done when the so-called "expanded" Bouguer formula is applied.

As stated above, errors in the topographical elevations cause inaccuracies in the value of the Bouguer reduction. However, with the small differences in height between the stations, inaccuracies in the evaluation of the altitudes have little effect on the general picture of the Bouguer anomalies of the highly disturbed gravity field in northern Surinam.

1.2.1 *Isostatic reduction*

In such a flat country as the Surinam coastal area, the Bouguer anomalies themselves indicate to what extent isostatic equilibrium exists. Nevertheless, the vicinity of the Atlantic Ocean and the continental shelf (which, 180 km to the north of Paramaribo, begins to drop from 200 metres down to 4 km) is the cause of the Bouguer anomalies not being identical with the isostatic ones in the flat coastal region either. The aim of the gravity research carried out by VELDKAMP in 1957, was to obtain a better insight into the trend of the gravity on a continental shelf. In order to explain the gravity profile measured perpendicular to the coast, VELDKAMP (1960) presents a model cross-section of the crust (see Figure 2), which is

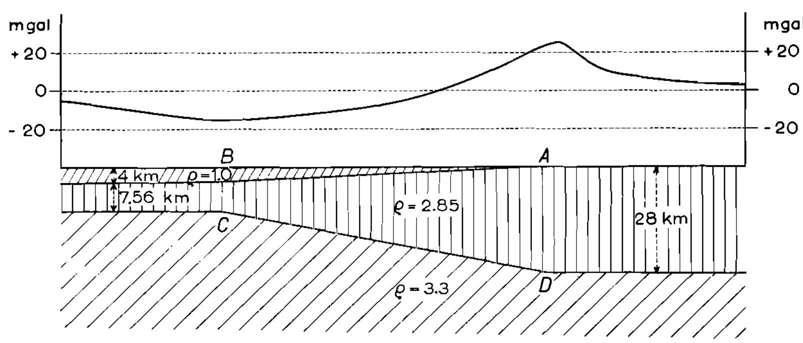

Figure 2. Model of the earth's crust, as given by VELDKAMP (1960), assuming a gradual change from ocean to continent under local isostasy. The gravity anomaly profile has been calculated after the model.

similar to the structure of a continental shelf as found by WORZEL and SHURBET. In this model the thickness of continental and oceanic crust are 28 and 7.56 km respectively, the densities of crustal and subcrustal rocks being 2.85 gm/cc and 3.30 gm/cc. A gradual dip of both the bottom of the sea and the underside of the crust over a distance of 300 km has been assumed. This implies that everywhere a local isostatic equilibrium is being supposed. VELDKAMP concludes that the deviation of the gravity calculated from this model is quite in accordance with the profile actually measured, not considering the gravity deficit over the whole area. According to theory, a maximum of +25 mgal, being caused by the inclined bottom of the crust under the ocean, has to be found at the border of the ocean. Where the ocean gradually becomes less deep, calculations result in a negative anomaly of −15 mgal.

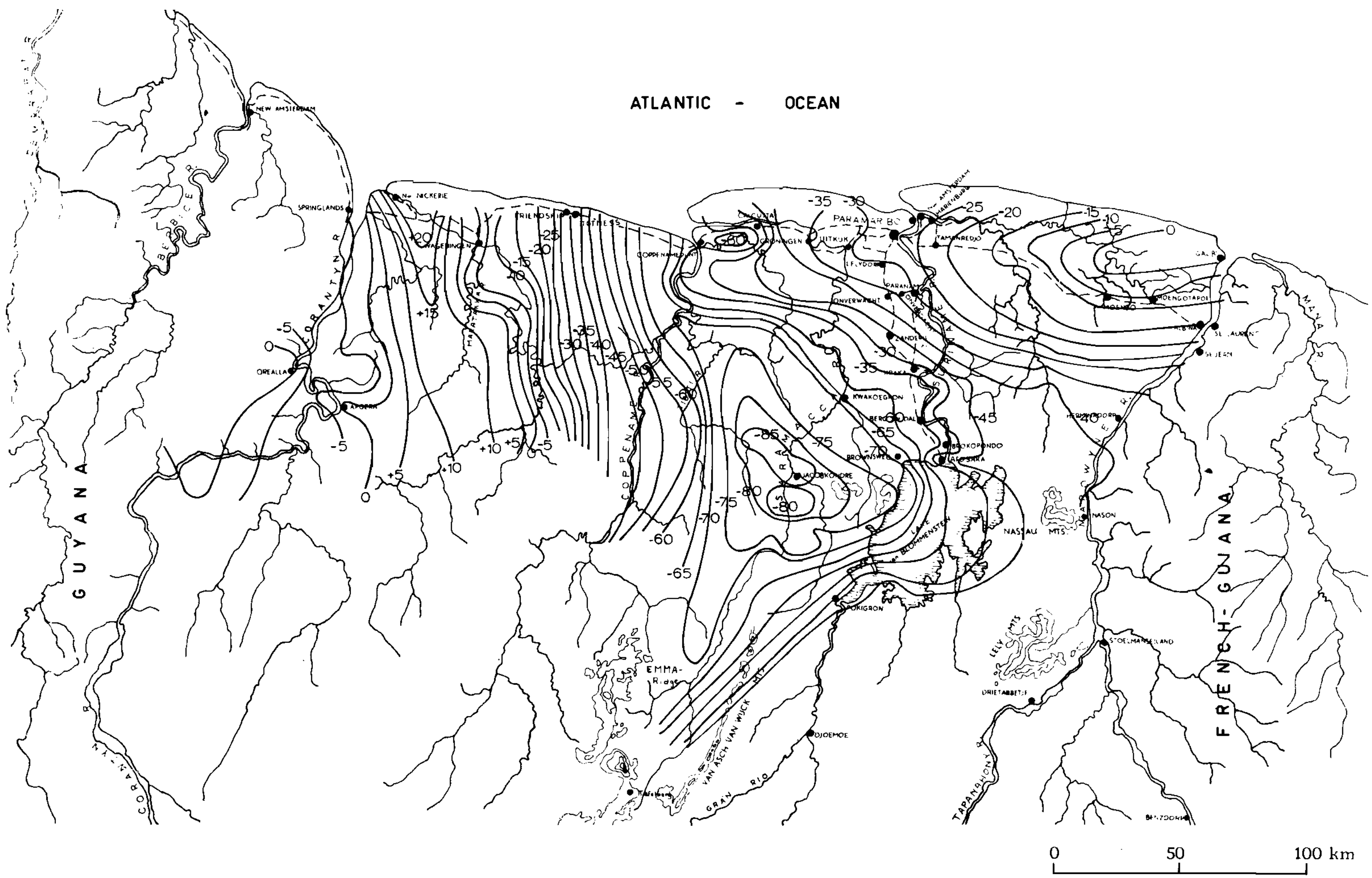

Figure 3. Isostatic anomalies in northern Surinam. (Computation of anomalies based on local Airy reductions; $T = 30$ km). Contour interval: 10 mgal.

The calculated anomalies actually appear to remain equal if a density of 2.67 gm/cc is assumed for the crust and 3.27 gm/cc for the subcrustal rock. Such a distribution of density has been used by the Isostatic Institute in Helsinki for the computation of isostatic reductions based on the Airy theory.This theory supposes isostatic equilibrium to be attained by every topographical element that is compensated by a corresponding element at the bottom of the rigid earth's crust (a root or anti-root).

VENING MEINESZ (1948) concludes from the many gravity profiles he has measured across continental shelves, that most coasts are compensated locally. This result is also to be expected, if the large difference in height of the crust on the continent and under the ocean is attributed to the sudden thinning of the sial layer close to the coast. Taking into account a flat or prismatic layer of sediments on the slope of the continental crust leads to still more refined computations. This correction, according to VELDKAMP, changes the calculated curve of the anomalies to some extent but not very much.

Considering VELDKAMP's findings, it seems quite reasonable to make use of the isostatic corrections computed by the International Institute in Helsinki to draw a sketch of the isostatic anomalies in northern Surinam (Figure 3). The influence of the surrounding topographical deviations on the surface has been taken into account, local floating equilibrium and also regional compensation of mass-deviations being assumed.

It matters little to the computation of isostatic anomalies in the Surinam coastal region whether local or regional compensation is assumed. VELDKAMP concludes, that the trend near the coast and on the ocean points to a local isostatic equilibrium.

The sketch of the isostatic anomalies outlined by Figure 3 is based on the assumption of local isostatic equilibrium. As for the stations measured by VELDKAMP, the free-air (Δg_f), the Bouguer (Δg_B) and the isostatic anomalies (Δg_i) respectively are stated in Table III, the last ones resulting from applying the topographic isostatic reductions calculated in Helsinki in the case of local compensation, that is to say R (regionality) $= 0$.

The computation of the anomalies given in Table III is based on the following formulae:

$\Delta g_f = g - g_0 + 0.3086h$ (corrected for height (h) above sea level ($0.3086h$))

$\Delta g_B = g - g_0 + 0.3086h - 0.1118h$

(corrected for height (h) above sea level and attraction of Bouguer plate ($0.1118h$))

$\Delta g_i = g - g_0 + 0.3086h - 0.1118h + b + t + C$

(corrected for height (h) above sea level and attraction of the topography ($0.1118h + b + t$) and corresponding compensation (C)).

The simple Bouguer reduction has been elaborated into the formula for Δg_B. The "expanded" Bouguer reduction ($0.1118h + b + t$) appears in the formula for Δg_i. The b-term eliminates the effect of that part of the Bouguer plate situated outside the O-zone and also introduces the correction necessary because of the curvature of the earth. The terrain correction is rendered by the t-term.

When comparing the formulae for Δg_B and Δg_i, we see that these anomalies differ because both the expanded Bouguer reduction and the effect of the compensation of the topography have been elaborated into the Δg_i formula. Column 4 of Table III gives the difference between Δg_i and Δg_B. Going inland from the coast, this difference increases from about -6 mgal up to $+6$ mgal. It may be assumed that this trend is mainly caused by a variation

Table III. Free-air, Bouguer and isostatic anomalies for stations measured by VELDKAMP in 1957

Station	Anomalies (in mgal)			
	Δg_f	Δg_B	Δg_i	$\Delta g_i - \Delta g_B$
Paramaribo	−20.7	−21.0	−26.7	−5.7
Lelydorp	−25.3	−25.9	−31.3	−5.4
Onverwacht	−31.3	−31.9	−36.3	−4.4
Republiek	−35.4	−36.5	−40.4	−3.9
Zanderij	−40.3	−42.1	−45.3	−3.2
Kwakoegron	−60.0	−60.7	−62.0	−1.3
G. Goldplacer	−64.9	−65.9	−66.9	−1.0
Brownsberg	−61.5	−66.4	−66.5	−0.1
Kabel	−72.3	−74.2	−73.3	+0.9
Abontjeman	−58.1	−59.9	−59.1	+0.8
Sikakamp	−57.5	−59.3	−57.5	+1.8
Dam	−51.9	−55.3	−51.9	+3.4
Albina	−10.4	−10.7	−16.4	−5.7
Bigiston	−22.0	−22.5	−27.0	−4.5
Abeneko	−29.1	−29.8	−34.1	−4.3
Herminadorp	−30.7	−31.8	−34.7	−2.9
Langatabbetje	−37.7	−38.9	−40.7	−1.8
Nason	−34.4	−36.2	−36.4	−0.2
Mooisanti	−34.4	−37.1	−35.4	+1.7
Gakaba	−30.4	−34.6	−29.4	+5.2
Stoelmans Island	−32.6	−37.7	−31.6	+6.1

in the *C*-term. As a rule the *C*-term produces a negative reduction above the ocean and a positive one above the continent. Somewhere on the continental shelf the *C*-term will have to change its sign. This explains the increase of the difference $\Delta g_i - \Delta g_B$ in Surinam according to the decrease of the latitude.

In order to clarify what components the topographic isostatic reduction consists of, the numbers mentioned by VENING MEINESZ (1960), concerning the reductions applied to the pendulum measurements at Paramaribo, are given. At this station the total $\Delta g_i - \Delta g_B$ difference amounts to -5.7 mgal.

Effect of topography, zones A–O_2 (to 166.7 km) = −1.4 mgal
Effect of local compensation, zones A–O_2 (T = 30 km) = +3.6 mgal
Effect of topography and compensation, zones 18–1 (from 166.7 km to the antipod) = −8.3 mgal

Study of all these data shows clearly that the $\Delta g_i - \Delta g_B$ difference increases algebraically, when the centre of the A–O_2 zone is moved further inward. This justifies the method, applied here, by which the approximative value of the isostatic reduction in the Surinam coastal area is understood to be equal to the difference $\Delta g_i - \Delta g_B$ as deduced from the Helsinki computations (Table III). The estimate of the isostatic anomalies, as given in Figure 3, is also based on this. Table III shows that about the Nason-Brownsberg line the effects of the isostatic compensation and the topography compensate each other. Therefore in this region the Bouguer anomalies are nearly equal to the isostatic ($\Delta g_i - \Delta g_B = 0$). North of the Nason-Brownsberg line, the isostatic reduction will lower the Bouguer anomalies, by a maximum of -6 mgal in the stretch close to the coast. South of this line, isostatic correction results in the Bouguer anomalies becoming less markedly negative. This has hardly any effect on the trend of the centre of the large negative belt ranging from Kabel to the mouth of the Coppename River. On the other hand, measurements carried out along the upper Saramacca River and in the Table Mountain area are clearly influenced by the topographic-isostatic reduction. Sketching representative isostatic anomalies requires an approximate estimate of these reductions for the stations situated at higher altitudes. According to the Airy theory under a topographic element with a height h, a root of a thickness of $(2.67/0.6) \times h$ is to be found. Using the fundamental tables of Cassinis, the force of attraction of each Hayford zone is calculated for the total height of this zone. This evaluation results in an isostatic reduction of +12.4 mgal for station 202 near Table Mountain. This positive correction further increases slightly by applying the always positive terrain correction.

When the isostatic reduction of station 192 (near the mouth of the Toekoemoetoe) is approached in a similar way, an estimated average height of 100 metres of the zones *A–M* results for this station in a reduction of over +6 mgal. As for the other stations along the upper Saramacca River, it is now possible to interpolate roughly.

The isostatic corrections, roughly estimated above for the upper Saramacca, are fairly concordant with the difference $\Delta g_i - \Delta g_B$, which has already been introduced as an approximative isostatic reduction of the simple Bouguer anomalies already computed. Ideally the attraction and the compensation of the topography over the whole earth should have been taken into consideration for the stations of the upper Saramacca too. The effect of the topography and the compensation outside the *M*-zone has, however, been ignored for these stations.

This discussion deals with the question whether the pattern of the anomalies in North Surinam is fundamentally changed after the application of a probable isostatic correction, rather than with the exact data concerning the value of this correction itself. A comparison of the Bouguer anomaly map and the picture drawn of the isostatic anomalies clearly indicates that this is not the case. The differences between the Bouguer anomaly map and the isostatic anomaly map are not significant in view of all the potential errors that are incorporated in the assumptions involved in the isostatic reduction (WOOLLARD, 1962). Because of the compensation of the continental shelf effect, the anomalies in the Surinam coastal area are diminished algebraically, whilst on the other hand the anomalies of the upper Saramacca region become less markedly negative, thus making possible the closing of both the −75 and the −80 mgal contourlines in the south, which cannot be done on the Bouguer anomaly map. This last point is in fact the only interesting difference between both maps. The highly negative belt prevailing in the picture of anomalies in North Surinam assumes a more closed shape after the application of the isostatic reductions.

It has to be borne in mind that the map of isostatic anomalies is based on a hypothetical correction which, as has many times been expounded, might be only partially or not at all in accordance with the reality. The suppositions on which the system of reduction applied here is based are not, however, improbable because they are justified by a phenomenon observed at many places on the earth, namely that Bouguer anomalies generally are markedly negative in high mountain ranges and strongly positive on the oceans, a feature that could very well be understood if, for example, the crust thins from a 30 km thickness at the coast to a thickness of about 7 km at oceanic depths.

Chapter 2

DISCUSSION OF RESULTS

2.1 Interpretation method

The interpretations of gravity anomalies in northern Surinam, given in this chapter, are in the majority of cases based on a new method. The author developed this method together with D. NAGY during his stay at the Dominion Observatory, Ottawa, Canada. The procedure is based on the expression for the gravitational effect of a finite prism as derived by NAGY. Applying this expression it is possible to approximate the masses of the disturbing bodies (i.e. geological formations) by a number of prisms with the appropriate densities. This "method of prisms" enables us to compute the total attraction of all prisms representing all the geological formations of the area at any arbitrary calculation point. One can approximate the geological bodies with as many prisms as are desirable and make the grid system as detailed as necessary to draw synthetic gravity contours. Besides other potentialities this procedure makes it possible to apply what is essentially a geological correction to a wide complex area. For a description of this method, the reader is referred to VAN BOECKEL (1968).

2.2 Outline of Suriname geology

The Precambrian in Surinam is part of the Guiana Shield, one of the oldest continental parts of the world. Being the Precambrian core of South America, the Guiana Shield is comparable with other old nuclei of the earth's crust, such as the Canadian and Fenno-

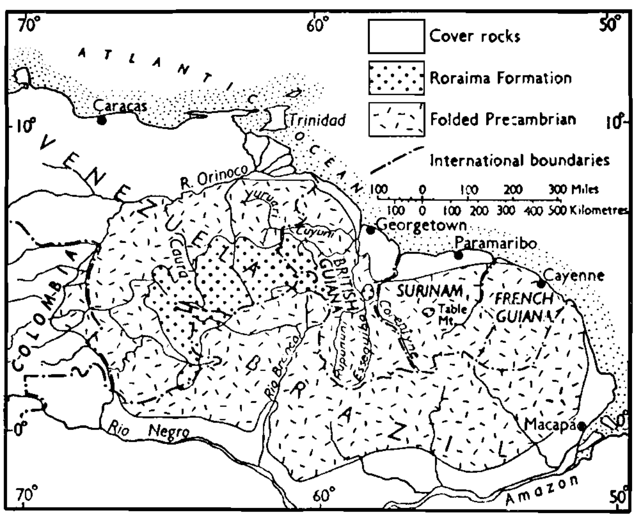

Figure 4. Outline geological map of the Guiana Shield, showing outcrop of folded Precambrian rocks and outliers of tabular Roraima formation of Proterozoic age (from McCONNELL, CANNON, WILLIAMS and SNELLING, 1964).

scandian Shields and parts of Africa, Australia, India and Russia. Ancient continental areas, like the Guiana Shield (see Figure 4) feature complex structural patterns, because of the superimposition of later structures on earlier ones. Plural metamorphism has moreover obscured the original structures. There are no fossils to be found to clarify the picture. Unfortunately most Precambrian Shields are difficult of access, many of them being covered by ice, deserts or tropical soils. In Surinam too, owing to deep weathering, much of the Precambrian geology is concealed by the extent of overburden, and structural studies are greatly hampered by the lack of good rock exposures. This unfavourable situation makes geophysical exploration almost a necessity, if further geological or structural information is wanted.

This study deals with gravity surveys in the northern part of Surinam, north of latitude 4° N. The Precambrian basal complex here consists of meta-sedimentary and meta-volcanic rocks, gneisses and granites (see Map III: Geological Sketch Map of Northern Surinam). It underlies the coastal plain in the north and crops out in the interior, where the lowland gradually passes into the hilly country and low mountains of the south.

In the centre of the country (Table Mountain and Emma Chain) there are small remnants of the essentially horizontal sediments of the Roraima Series, which were depositied in a period of tectonic rest and transgression following the sedimentation of the Rosebel Series. Judging from its outliers, the Roraima formation appears to have once covered more than one million square kilometres in the centre of the Guiana Shield (Gansser, 1954).

Compared with the age of the basal complex, the coastal area is very young. The mostly unconsolidated continental and fluviomarine deposits thicken towards the sea. The capital, Paramaribo, is situated at a location, where the sedimentary deposits are 260 metres thick. The coastal plane broadens from east to west, and the sedimentary deposits are also thickest in western Surinam, where at Nickerie the basal complex has been drilled at a depth of nearly 1500 metres.

One of the characteristics of northern Surinam is its flatness. Only in the eastern part is the monotony of the forest-covered lowland relieved by some hills, about 400–500 metres high.

From the results of the "Snellius" expedition in 1966 it was learned that the continental shelf north of Surinam is characterized by a rather flat sea bottom. Nota (1966) reports that the width of the shelf is rather great (80 miles) and that the shelf break sets in where the depth of the shelf is about 95 metres.

Many authors believe that in the complex structural pattern of Surinam two main orogenetic directions can be discerned which are related to the "Guiana" and the "Surinam" orogeneses *) respectively. The Surinam orogenesis seems to have been a process of long duration. This, together with the fact that the Surinam orogenesis is the most recent one, might be the reason why the east-west structural direction associated with the Surinam orogenesis prevails in northern Surinam. It might also account for the fact that it is mainly the structural pattern of the Surinam orogenesis that shows up in the gravity field (see Map IV: Structural Map of Northern Surinam).

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*) In the literature on the geology of Surinam the term "orogenesis" is used as a broad term designating motions during the „Guiana" and „Surinam" orogeneses resulting in folded and faulted structures and angular unconformities. In this study the term "orogenesis" is used in the same sense. Also the term "orogenic belt" is related to deep down-folding rather than to mountain building in the geographical sense.

Special reference has to be made of the occurrence of a broad zone of intense shearing and faulting in the Adampada area in western Surinam (the Bakhuis Zone).

The fact that the Roraima sandstone formation rests unconformably on the basal complex indicates that the uplift of the Paramaka massif was followed by a transgression that brought the Roraima sediments. SCHOLS and COHEN assumed on morphological and other grounds that after deposition of the Roraima, block faulting took place. Together with a system of faults, a horst and graben structure developed. The pattern of long and narrow dolerite dykes indicates that the structural lines strike north-northwest in the northeastern part and swing to a northeast direction in the western part of northern Surinam.

2.2.1 *Densities of Surinam rocks*

It is a prerequisite for the interpretation of the anomalies of the gravity in Surinam to have some information on the densities of the rock types to be found in this area. Accordingly, 168 determinations of densities were carried out. These densities were determined in the Geological and Mining Service laboratory at Paramaribo by weighing the samples in both water and the air.

The results of these measurements have been supplemented by 44 density determinations performed in 1952 at the Laboratory for Geophysics of the Delft Technological University with samples collected in the area along the Surinam River between Bosland and Kabel. These 200 or more density determinations of samples from widespread regions enable the drawing up of a table in which densities, representative of the most important rock formations in Surinam, are given. Table VI (Appendix C) gives evidence of a wide divergence in the densities found. The specific gravity of 2.51 gm/cc of the lightest Table Mountain sandstone is in marked contrast with that of 3.30 gm/cc of the heaviest sample, a pyroxenite from the Nickerie region.

2.3 The Dramhoso and Afobaka anomalies

Later in this chapter it will be tried to arrive at an interpretation of the regional pattern of the gravitational field in the northern part of Surinam. Before passing on to this interpretation of the broader scale phenomena, it is worth while first to examine the gravitational anomalies on a smaller scale. The Bemau area along the Saramacca and the region along the Surinam River between Berg en Dal and Kabel have been selected for this detailed study. The gravity measurements in these areas were deliberately made at short distances. Near both Bemau and Afobaka a distinctly positive, residual gravity anomaly was measured. Both anomalies are directly related to the higher density of the basic Paramaka formations that form the pronounced ranges of hills in these regions.

2.3.1 *The Dramhoso anomaly*

Sailing upstream the Saramacca River, the Dramhoso anomaly is found 5 km beyond the Mamadam Falls. Passing these falls, one goes through the centre of the belt of negative gravity anomalies.

In accordance with the regional trend south of this centre, the gravity anomaly should become gradually less negative. However, a short distance beyond Lemmiki the gravity profile shoots up steeply at 5 mgal/km (see Figure 5), the highest gravity value being

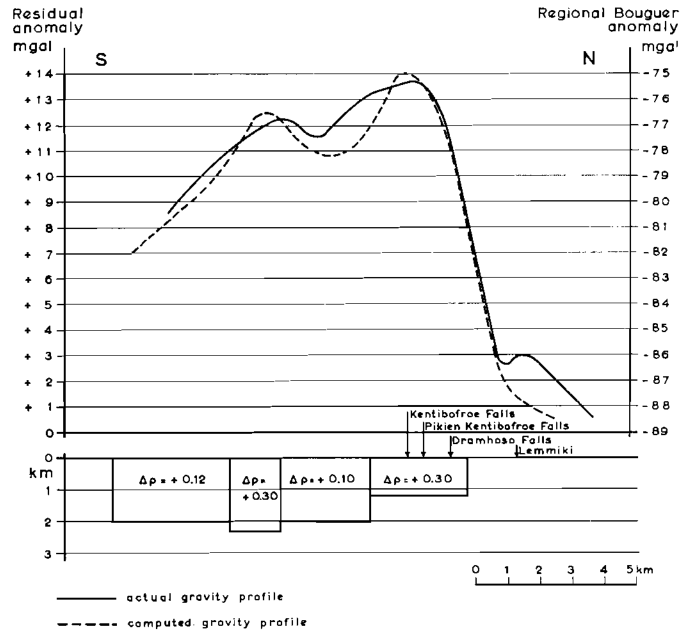

Figure 5. Bouguer gravity profile measured along the Saramacca River in the Dramhoso area. The model body giving rise to the model profile is shown in cross section. The density difference ($\Delta\varrho$) is given in gm/cc. In east-west direction the dimension of the model body is 8 km. This profile along the Saramacca River does not cross the fifth block ($\Delta\varrho = +0.30$) which extends to a depth of 2800 metres and is situated due east of the block with density difference $\Delta\varrho = +0.10$.

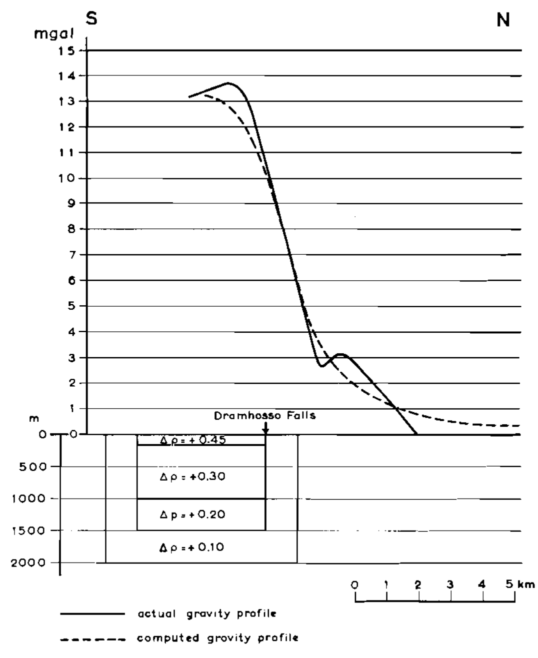

Figure 6. Model of a disturbing body with an assumed density-stratigraphy. The model gravity profile caused by this body is shown together with the actual profile of the residual gravity anomaly at Dramhoso. In east-west direction the dimension of the model body is 8 kilometres.

measured at the Pikien Kentiboffroe Fall. Farther to the south the gravity falls again.

There can be little doubt that the high gravity values here are related to the high densities of the basic to ultrabasic rocks. The density contrast needed for the calculation of a model anomaly can be derived from the table of densities of Surinam rocks (Table VI, Appendix C). For the density contrast between the biotite-granites and ultrabasic rocks found in the Dramhoso region, 0.30 gm/cc seems to be an adequate value. The Dramhoso anomaly has been analysed by dividing the region on the basis of the geology into prisms with specific density contrasts. The model profile in Figure 5 shows an optimal resemblance with the actual anomaly. This calculated profile was obtained with an arrangement of five blocks with depths varying from 1200 to 2800 metres.

Other evidence, of a geological and geomorphological nature, also indicates that the Bemau massif could well be a structure which extends to a limited depth only. This probability calls for yet another interpretation of the gravity anomaly. In Figure 6 a model is presented of a disturbing body, subdivided into segments, the densities of which decrease with depth. Directly below the basic massif, which is only 200 m deep, there is supposed to be a migmatite zone with a density of 2.95 gm/cc. For the sake of simplicity, it is assumed that below a depth of one kilometre, density decreases stepwise till at a depth of two kilometres it equals the low density of granite (2.65 gm/cc). The real mass distributions will undoubtedly be much more complicated. This model is, however, capable of showing that the 12 mgal gravity anomaly can be explained by a density-stratigraphy, which is adequate to the hypothesis that density decreases with increasing distance to the basic massif. The anomaly caused by such a model body has a maximum intensity of 13.2 mgal, which is close to the actual value, while the gradient is also analogous to the one measured in the field (see Figure 6).

Thus we already have two models fitting the Dramhoso anomaly.

There is no disguising the fact that in the latter interpretation, the density of the top layer (3.10 gm/cc) is on the high side. Moreover, no terrain corrections have been applied to the Dramhoso anomaly. If corrections are made for the rugged terrain around the gravity stations, these corrections, which are always positive, would increase the anomaly.

Summarizing one might say that both the geology and the morphology of the Bemau region can probably be explained most simply by regarding this phenomenon as a resistant block, a few kilometres thick, which has been able to maintain its position in the middle of a vast granite area.

2.3.2 *The Afobaka anomaly*

The Afobaka anomaly, which occurs in an area that is geologically well-known, is a residual positive gravity anomaly, which is superimposed on the general pattern of the negative belt (Figure 7). While all Precambrian formations in Surinam are represented in this region, the Afobaka area is tectonically relatively little disturbed.

In many aspects the Afobaka anomaly is analogous to the anomaly near Dramhoso. Both have been measured on the flanks of the great negative belt dominating the gravity pattern in northern Surinam. The steep gradients of these two anomalies occur on the side nearest to the centre of the negative belt. This is to be expected, because at that side both the negative gradient of the regional anomaly and the decrease of the local positive one are superimposed on each other. In both cases where these steep gradients are found, there

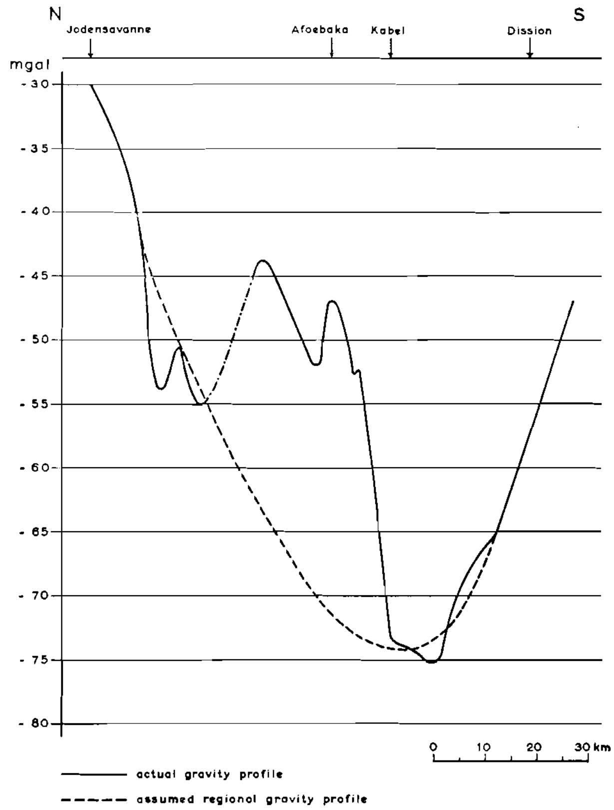

Figure 7. Bouguer gravity profile measured along the Surinam River from Jodensavanne up till Koenkoen Falls. The hypothetical regional profile which is used for the determination of the residual Afobaka anomaly (Figure 8) is included in this Figure.

is a distinct contact between heavy basic Paramaka rocks and light granodiorites (quartz diorites). Only the amplitude of the Afobaka anomaly seems to be greater than that of the Dramhoso anomaly.

As is the case with the Saramacca near Dramhoso, the Surinam River too is crossed near Afobaka by an east-west ridge of hills (Brokolonko landscape), which forms the northern boundary for the Afobaka reservoir. The entire area between Afobaka and Berg en Dal has a pronounced east-west trend, both geologically and morphologically.

From all geological evidence it is clear that the broad structure of basic Paramaka rocks is responsible for the interruption in the negative trend of gravity in this region.

Due to the steep gradient of the regional negative anomaly, in this case the determination of the intensity of the local anomaly is not as simple as with the positive anomaly near Dramhoso.

Figure 7 outlines what could be the possible shape of the regional anomaly along the Surinam River, after elimination of the local anomaly near Afobaka. The profile traced in this way has been used on a hypothetical basis to correct the Afobaka anomaly for the regional change in the gravity field. The residual Afobaka anomaly is shown in Figure 8. Although the amplitude of the anomaly has not been exactly defined, it shows roughly what requirements a model of the disturbing body has to meet. The width of the model in

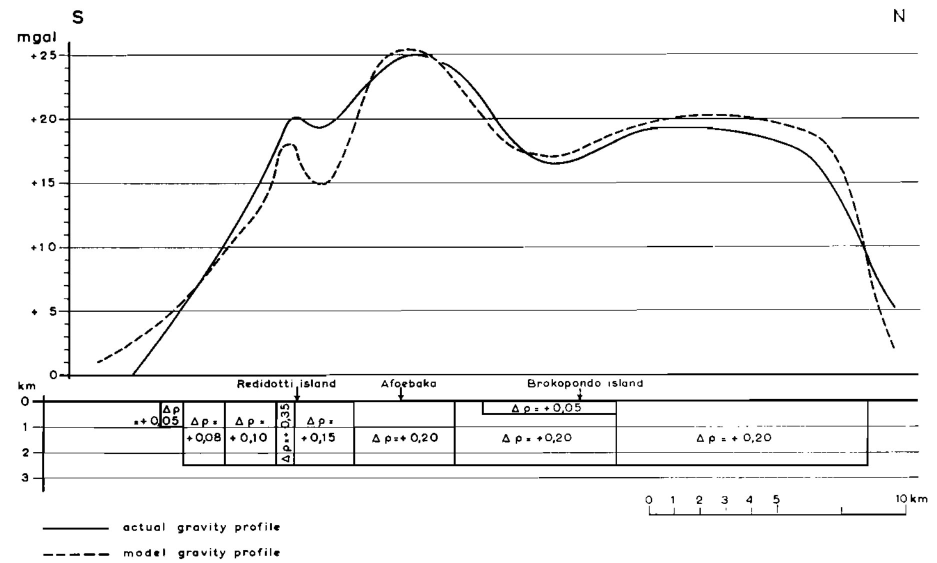

Figure 8. Actual and model residual gravity profiles at Afobaka. The model prisms, shown here in cross section, are 50 km long in east-west direction, the north-south directed profile going through the middle of the prisms. The density-contrasts indicated in the prisms are based on density determinations of 44 rock samples along the Surinam River.

the direction of the profile should be about 25 km. Such a body has to be so deep and so much heavier than the surrounding formations to produce a maximum anomaly of about 20 mgal. The isolated peak over the Afobaka ridge even rises about 5 mgal higher. It might well be caused by a local heavier segment (pyroxenite, norite) in the model body. It is fairly certain that the lower level in the centre of the anomaly near Brokopondo is associated with a lighter Rosebel formation folded in the Paramaka rocks as a syncline.

The densities of the blocks in Figure 8 are based on the density determinations of 44 samples found at the surface. Thus the arrangement of prisms represents the geological profile. All these values are considered in contrast with the density of the granites (2.65 gm/cc) surrounding these rocks. As Figure 8 shows, it appears quite possible to construct a model body that, while being in accordance with the geologic reality, gives rise to a model gravity anomaly concurrent with the actual one.

The residual gravity anomaly in Figure 8 runs perpendicularly to the strike of the geological formations, which in this model are supposed to be 50 km wide in east-west direction.

No effort has been made to match the model curve better with the actual one than is done in Figure 8. The calculated profile is based on known density contrasts and deduced depths; the discrepancies left tell us how closely the model approximates to the complex reality. The model in Figure 8 agrees fairly well with the geological profile through the same region given by HOLTROP (1962). Here too, the Paramaka formations extend to a depth of about 2.5 kilometres.

2.4 The negative belt

The gravity field in northern Surinam is dominated by a belt of intense negative anomalies.

Over land the axis of this arcuate „negative belt" extends over more than 200 km. Gravity measurements on the continental shelf, performed by STRANG VAN HEES (1966) revealed that the negative belt also protrudes over 50 km into the shelf area. This new evidence that the negative belt dominates even a substantial part of the gravity field of the continental shelf is all the more reason to assume that this gravity phenomenon indeed discloses a major structure in the continental crust of Surinam. The interpretation of the regional gravity pattern stands or falls, in fact, with the explanation for the occurrence of this gravity deficit.

The course of this negative belt closely corresponds with the dominating structural trend in northern Surinam, which is attributed to the „Surinam" orogenesis. The negative anomalies indisputably indicate a mass deficit. The problem which now arises is to explain how the "Surinam" orogenesis gave rise to a mass deficit which, even today – after say 1000 million years or more – manifests itself in the gravity field. The current view is that the gravity deficit in the case of a young mountain range is due to a light root at the base of the rigid crust. The author believes it improbable that the negative belt in Surinam is chiefly caused by such a root or the relict of it. The negative belt probably is the expression of a mass deficit caused by a voluminous granite batholith, the formation of which was linked up with the "Surinam" orogenesis. In the interpretations of the Bemau and Afobaka gravity anomalies, it is made clear that these positive deviations probably result from density contrasts occurring in the upper part of the earth's crust. These anomalies, however, are obviously superimposed on the wide regional anomaly of the negative belt. The cause of this background anomaly has to be situated deeper in the crust, as might be the case with a huge granite body partly covered by these denser formations.

The author is not alone in believing that large negative anomalies may be caused by granite batholiths. BOTT (1956) in particular has drawn attention to the characteristic occurrence of negative gravity anomalies over granite masses. To be able to compare the gravity field in northern Surinam with gravity data of other Precambrian areas, the author has made an extensive study of regional gravity anomalies over the Canadian Shield. This comparative study provides strong arguments for the interpretation presented here.

The interpretation of the negative belt starts from the established fact that the Bouguer anomalies in the Surinam coastal area cannot possibly be regarded as a consequence of the isostatic compensation of the topography. Apart from some hills (up to a height of 500 m) in the southern part, the topography is noticeably flat in the area under investigation.

In an area of low surface elevation it does not make an essential difference if one bases the interpretation of the gravity field on the Bouguer, the free-air or the isostatic anomalies. According to the classical theories, all three kinds of anomalies should be about zero if isostatic equilibrium should prevail in the northern part of Surinam.

While attributing the negative belt mainly to density contrasts inside the crust, it is of importance to learn to what depth these contrasts extend. The only indications available are provided by the course and the intensity of the gravity in the negative belt.

2.4.1 *Regional profiles*

In Figure 11 a large regional profile right across the centre of the negative belt is given. The profile in Figure 11 only covers the northeastern half of the anomalous zone. It is presented here because it penetrates into the centre and is, moreover, directed perpendicularly to the

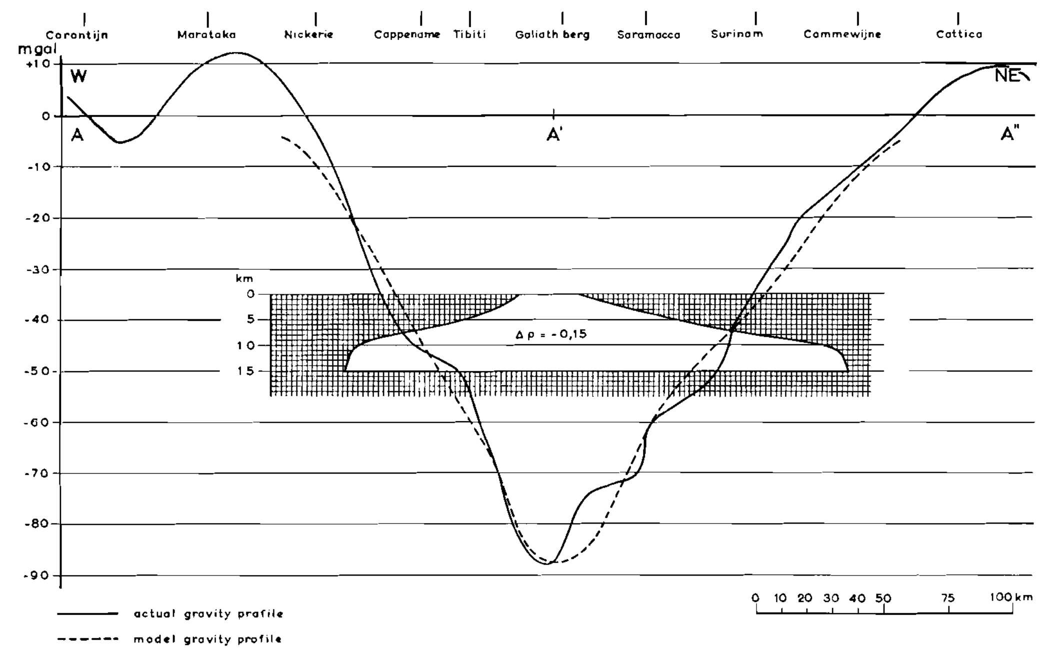

Figure 9. Bouguer gravity profile along the line *A A′ A″* (see Map I). The profile crosses the centre of the negative belt near Mount Goliath. The model of the granite batholith is shown in cross section. The model gravity profile has been determined by computing three-dimensionally the attraction of the whole granite batholith (see Figure 12).

strike of the negative belt. The course of the gravity along the Surinam coast is shown in Figure 10.

One would expect the regional profiles to be less steep in the centre than on the flanks. Figure 9 makes it clear, however, that the gradient is remarkably steep in the centre too. This indicates that part of the total anomaly in the centre must have a relatively shallow cause. The granite batholith is therefore assumed to reach up to or near to the surface.

This assumption is supported by consulting the aeromagnetic map of northern Surinam. Along both the Saramacca and the Tibiti, in the very centre of the negative belt, the author came across large granite complexes. Densities of rocks samples in this area average 2.64 gm/cc.

It can be stated that by means of the combined information of gravitational and aeromagnetic anomalies, the structural trend of the Surinam orogenic belt can be traced into the coastal areas where the Precambrian structures are hidden by a cover of sediments. The fact that the area along the axis of the negative belt is also marked by an aeromagnetic pattern that seems to be characteristic of granitic areas suggests that the abnormality in mass is situated in the upper part of the crust rather than at its base. Even though a more detailed survey might reveal many discrepancies to explain, it would not be easy, in the author's opinion, to get around the problem of explaining the aeromagnetic patterns in northern Surinam without supposing some type of an intrusive acid structure that occupies a considerable part of the crust.

Judging from the geometry of the negative belt, it seems reasonable to assess the dis-

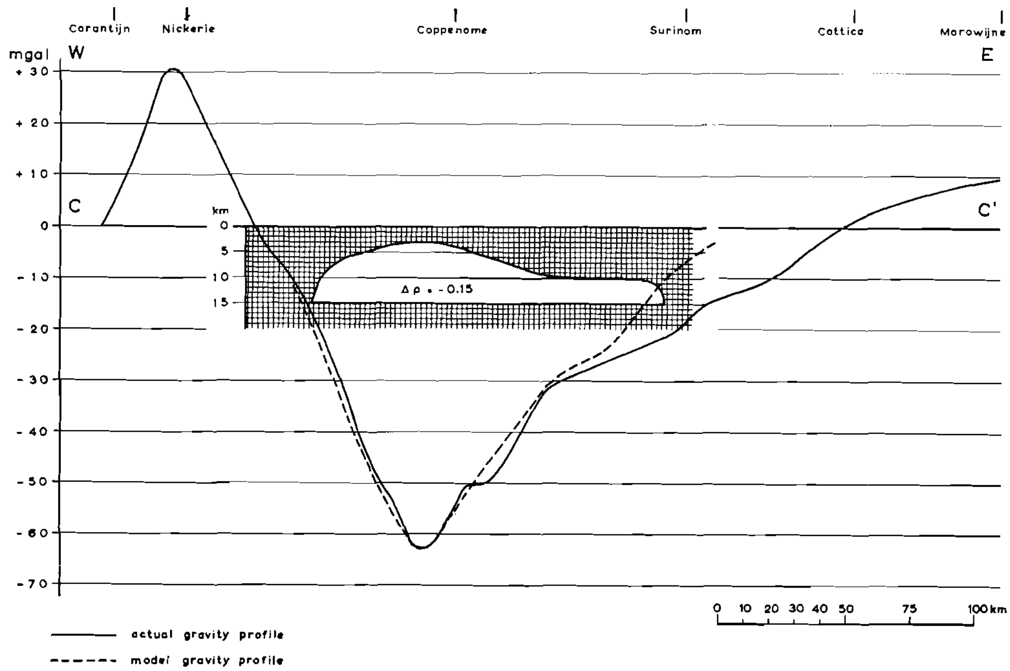

Figure 10. Profile showing the course of gravity along the Surinam coast from Galibi to Springland. An attempt has been made to explain essentially the conspicuous negative part of the anomaly by the model body given in cross-section. In north-south direction the model body, giving rise to the model gravity profile, is 160 km wide. The positive anomaly in the Nickerie area will be dealt with in section 2.5.

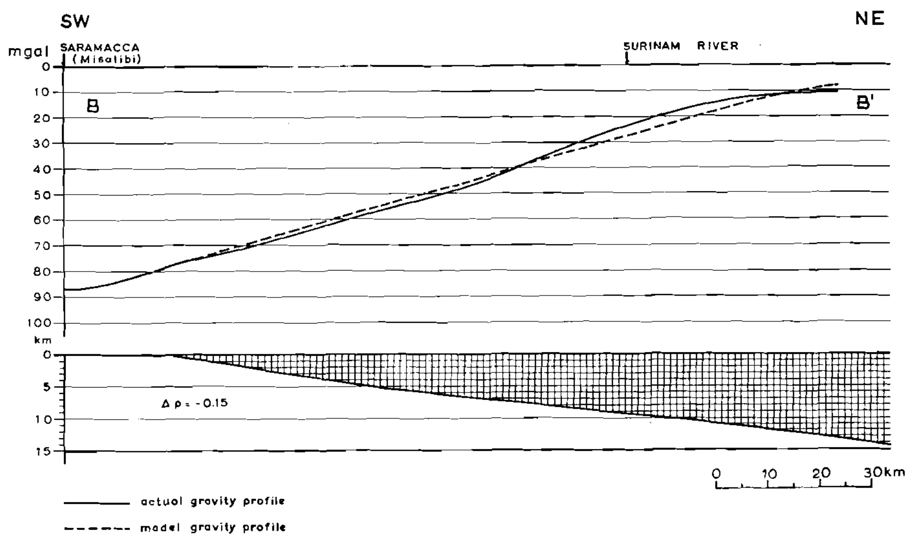

Figure 11. Bouguer gravity profile across the northern part of the negative belt along the line *B B'* (see Map I). The direction of the profile is perpendicular to the strike of the negative belt. The model body giving rise to the model gravity profile is shown in cross-section. In the direction perpendicular to the profile, the model body is 200 km wide. To present a clear picture of the true shape of the model granite batholith, the horizontal and vertical scales are identical. The dip of the granite batholith surface is not more than 7° for the greater part.

turbing body initially as a rectangular batholith measuring 200×100 km^2. The density of the granite batholith is supposed to differ from the density of the material enclosing it by −0.15 gm/cc. A maximum intensity between −85 and −90 mgal for a batholith of this size corresponds with a depth of the batholith floor of 15 km. Based on this figure, efforts were made to find a shape for the batholith with such a maximum depth. To match the gradient of the model with the gradient of the actual profile in Figure 11 it was found to be necessary to give the model batholith a dome-like shape. Should the granite batholith be bounded by vertical walls, the gravity profile would feature gradients much steeper than the actual ones and, moreover, a broad and flat minimum in the centre of the anomaly.

Applying the method of prisms ((VAN BOECKEL, 1968), it was found that a batholith body like that drawn in cross section in Figure 11 produces a profile very similar to the actual one.

Due to the ambiguity in gravity interpretation, many more models can be thought of which will produce anomalies comparable with the negative belt. The width of the area in the centre of the anomaly, where the model of the granite batholith reaches the surface, is based on the aeromagnetic data. There are two variables, the effects of which are inseparable. It is possible to match the intensities of model and actual anomalies by changing either the depth (here 15 km) or the density $\Delta\varrho$ (here −0.15 gm/cc) of the disturbing body. The estimation of the density contrast is founded on a density of 2.65 gm/cc for the granite and an average density of 2.80 gm/cc for Precambrian rocks.

That the body of relatively low density causing the negative belt extends to great depths may be taken for granted. The depth of the disturbing body can only be considerably less, if an improbably high value is assumed for the density contrast.

2.4.2 *Topography of granite batholith*

With the method of prisms it is possible to calculate a synthetic gravity field over practically every geological structure. The method of prisms seems to be the most appropriate procedure to use and find out more about the geometry of the supposed granite batholith in northern Surinam.

Based on the results of the interpretations of several gravity profiles in the last section a batholith model was built up with 88 prisms. The prisms all had the same density difference (−0.15 gm/cc) with respect to the average density (2.80 gm/cc) of the Precambrian rocks in this area. The effects of all prisms were calculated in points of a grid system of 250 by 300 km covering the area of the negative belt. Thus a synthetic gravity field was acquired, which could be compared with the actual gravity field in Surinam. Based upon the differences between the calculated and measured values, modifications were made in the configuration of prisms until with an arrangement of a total of 100 prisms the gravity field calculated was congruent with the actual one. Based on this configuration of 100 prisms, in Figure 12 the depth contours are drawn of a granite batholith. With a density difference of 0.15 gm/cc, this batholith produces a gravity anomaly, the contours of which are in fair accordance with the gravity pattern of the negative belt. Figure 9 shows a comparison of the actual profile with the calculated profile along the same line across the model batholith. Bearing in mind the ambiguity of every gravity interpretation, we now have at least a model available that accounts for the perturbation in the gravity field in northern Surinam; a model that is based on the exact computation of the attraction of a three-dimensional body made up of 100 prisms.

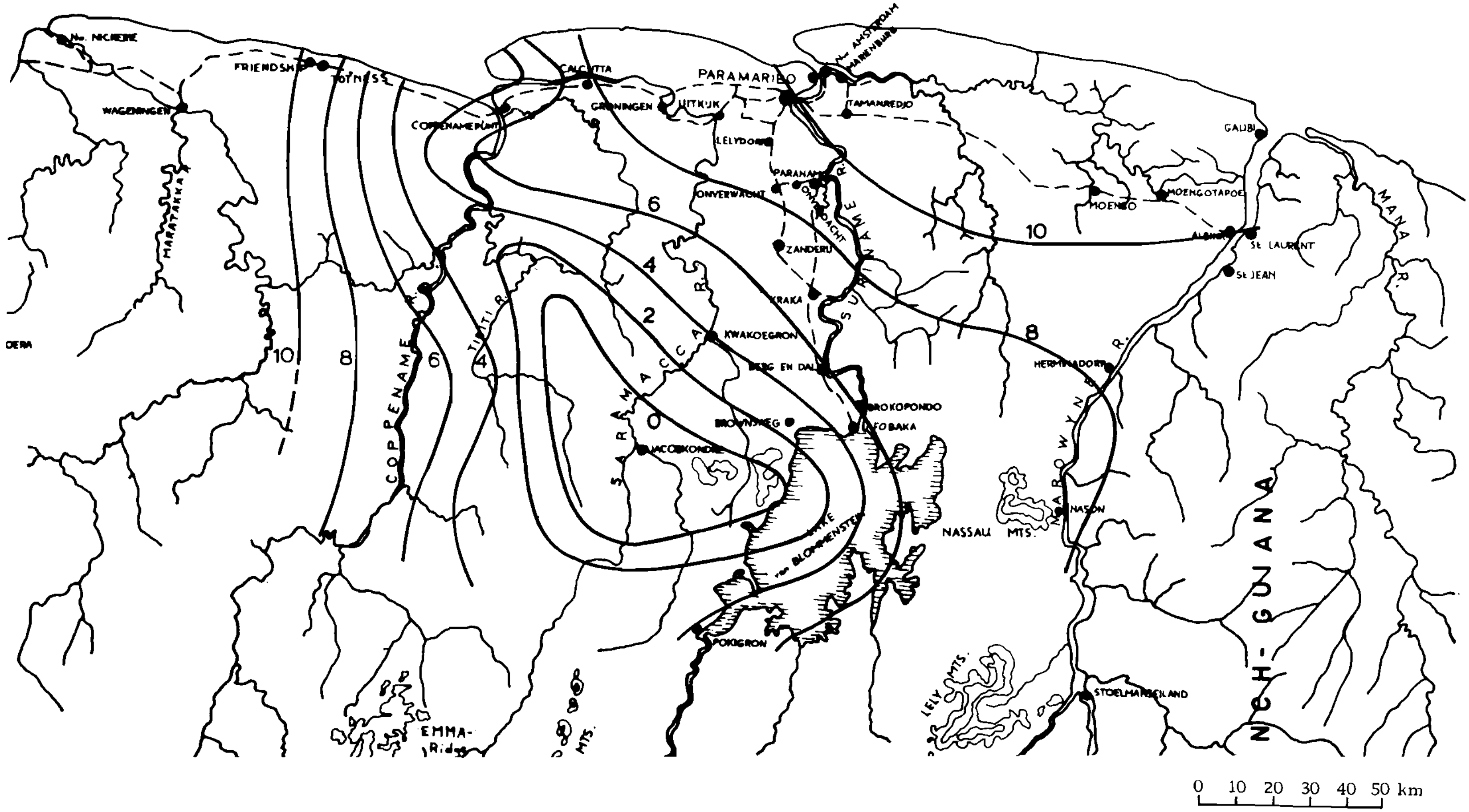

Figure 12. Topography of granite batholith. The depth and contours of upper surface of the model batholith are indicated by isohypses at every two kilometres. The overall depth of the bottom of the batholith is 15 km. The density contrast is −0.15 gm/cc. The greater part of the negative belt can be explained by the occurrence of a batholith of this shape. The gravitational attraction of this model batholith has been computed with the three-dimensional method of prisms.

2.4.3 *A granite batholith as a cause*

In the previous section an attempt has been made to explain the phenomenon of the negative belt by using a quantitative interpretation method. The results allow of explaining the intense anomaly not with variations in the thickness of the crust but with horizontal variations in its density. These considerations lead to the supposition that the strong negative anomaly is brought about by the plutonic core of an old orogenetic system which, on completely different grounds, has been recognized as the "Surinam" orogenesis. The negative anomaly would then be produced by the density-contrast between the batholitic granite mass and the denser country rocks (gneisses, meta-sediments, meta-volcanics).

Both the fact that granitic intrusives are characterized by local gravity minima throughout the world (WOOLLARD, 1962), as well as the fact that the mean density of crystalline rocks is greater than the mean density of granites, can only be understood if we abandon the idea of the crystalline basement complex being granitic. This consideration has a direct bearing on the way the "geologic correction" is commonly applied. That granites were usually not considered as masses of anomalous low density, starts from the original estimate of 2.67 gm/cc for the standard density of the crust. As only sediments do have densities significantly lower than 2.67 gm/cc, the geologic correction was, and is, still mostly applied in case of sedimentary basins. This policy caused that addition of the geologic correction to measured gravity values did not depict such local mass deficiences as granite bodies. Thus, interpreters started to look for anomalous masses deeper down, while the actual causes could well be situated near to the surface of the bedrock. Confusion arising from this restrictive application of the geologic correction would be avoided by relating the definition of this correction not to a crustal density of 2.67 gm/cc, but to the actual mean density of crustal rocks.

The geology of the area where the negative belt is encountered indicates that the granite batholith must have intruded into a complex of meta-sedimentary and meta-volcanic rocks. The negative belt should thus mainly be the consequence of a direct density contrast between the batholith of massive granite with a low density (2.65 gm/cc) and surrounding rock formations of an average density equal to the mean density of Precambrian rocks (2.80 gm/cc). The country rocks could be "granites" with a higher density, gneisses and meta-sedimentary and meta-volcanic Paramaka and Rosebel formations.

There are granite bodies in other parts of the world, which are also associated with prominent negative gravity anomalies. REICH (1932) was one of the first to point out that the observed negative Bouguer anomalies, associated with the Precambrian Rapakivi granites in Finland, require a thickness of 12 km of granite to explain the gravity deficit. BOTT (1956) takes it for granted that negative anomalies coinciding with granite intrusions are essentially caused by the relatively low density of the granite. According to his ideas, the density contrast, as determined with surface samples, has to extend to a depth of 10 km or more to explain the intensities of the anomalies. This all means that the crust should retain its complexity to great depths. HOWELL (1959) thinks the large volumes of the observed batholiths suggest the size of the individual bodies may become larger as one goes down into the earth, but how far this simplification of the structure goes is unknown. According to seismic results published by WOOLLARD (1962), granitic intrusive bodies, although characterized by marked negative anomalies, are apt to have subnormal values of crustal thickness if the crust is defined by the Moho-discontinuity. This author thinks in case of major granite intrusions, it might even be an undefined, as yet, sub-Moho layer, extending down to a depth

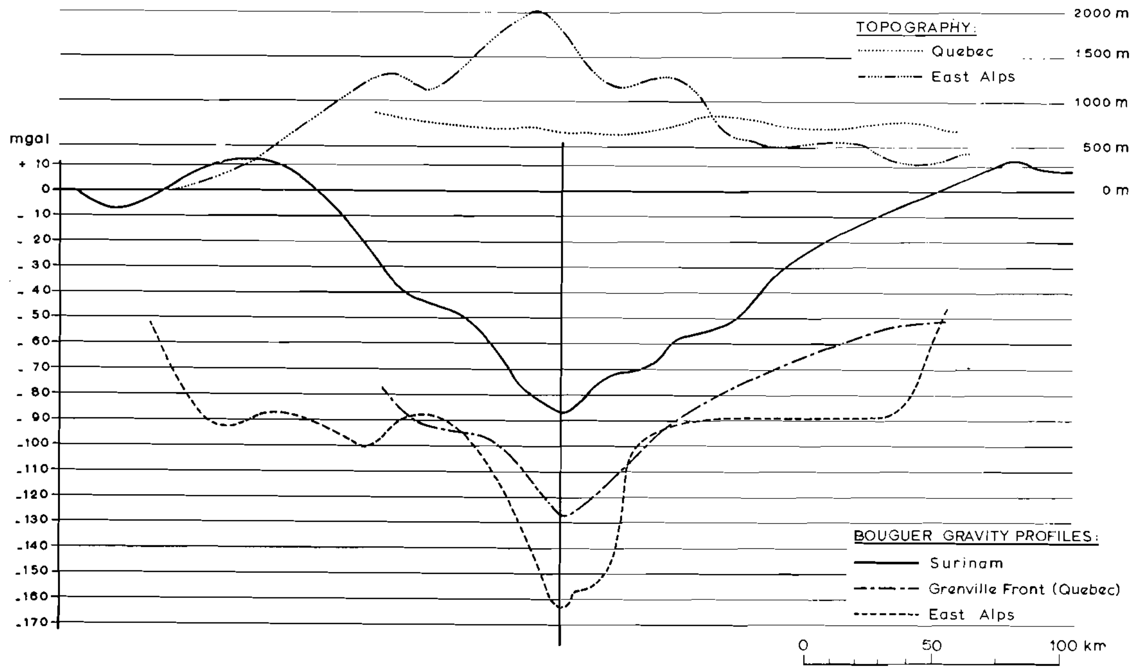

Figure 13. Comparison of Bouguer gravity profiles across the negative belt in Surinam (Profile *A A′ A″*), through the negative anomaly near the Grenville Front in Central Quebec (INNES) and through the negative anomaly in the eastern Alps (HOLOPAINEN) respectively. The topographical profiles of the eastern Alps and Central Quebec are also shown in the upper part of this Figure. Because of the inconsiderable relief in the Surinam coastal region, the profile of elevations in that area might as well be taken as to coincide with the zero-plane.

of about 60 kilometres, that is controlling the gravity field.

GARLAND (1964) summarizes his ideas about the gravity pattern in the Canadian Maritime Provinces by noting that the general coincidence of the negative anomalies with the larger granite masses of southern Nova Scotia strongly suggest that the granite itself is responsible for at least a part of the negative anomalies.

The study made by INNES (1957) of gravity and isostasy in Central Quebec is most instructive in relation to the problem presented by the Surinam negative belt. Near the Grenville Front, i.e. the boundary between the Superior and the Grenville provinces, INNES discovered a belt of intense negative gravity anomalies. The maximum Bouguer anomaly is −120 mgal, the maximum isostatic anomaly −75 mgal. These anomalies are thought to be associated with large masses of non-exposed intrusive granite.

It makes sense to extend the comparison made by INNES between the Bouguer profiles across the Alps and across the negative anomaly in Central Quebec farther to a profile across the negative belt in Surinam. Figure 13 shows the striking resemblance of these profiles, especially as regards their lateral extent. The profiles across the Canadian and Surinam negative belts both feature in the centre a gravity value about 80 mgal lower than in the surrounding areas.

In the eastern Alps the amplitude of the Bouguer anomaly is twice as large as that of the Surinam and the residual Central Quebec profile. Here we are dealing, however, with a young orogenesis. Part of the gravity deficit may therefore be attributed to a thickening of the crust. Figure 13 shows HOLOPAINEN's Bouguer profile across the eastern Alps. In contrast to the Surinam and Central Quebec profiles, in the central area of the eastern Alps there is a remarkably sharp decrease in gravity, giving rise to a central anomaly of more than −70 mgal, superimposed on a regional level of −90 mgal. If it is assumed that – as in Surinam – in the eastern Alps too, about 80 mgals of the total amplitude is caused by a density contrast between the plutonic core and country rock, then the thickening of the crust might give rise to another deficit of 80 mgal. This thickening puts the material of the crust in an environment (the mantle) which is taken to be 0.6 gm/cc heavier. This lateral inhomogeneity at the base of a 30 km thick crust will cause a gravity anomaly of −80 mgal at the surface if the thickening amounts to about 4.5 km.

Comparison of gravity surveys over young and old mountain ranges makes it clear that part of the gravity deficit currently attributed to crustal thickening might definitely be explained by horizontal variations in crustal density. In other words, the fact that an isostatic anomaly ultimately appears to go to zero is no decisive criterion for the adequacy of the isostatic reduction method applied. It may be that for the sake of this ideal the roots under the young mountain ranges were taken too large.

2.4.4 *Relict of a mountain root*

What conclusions are to be drawn – in the light of this discussion – from the occurrence of the large negative anomaly in the Surinam part of the Guiana Shield? The question is put whether one could also conceive this anomaly as originated by a relict of an old mountain root still situated at the base of the crust. The mountains of the orogenic system have been completely removed by erosion, but the associated root should still exist. It is improbable, however, that the mountain root should not have disappeared in the course of the enormous time since the Precambrian period as a result of melting, dispersion and isostatic upheaval. This is the more unlikely if calculations are based on the figure given by VENING MEINESZ (1958) for the rate of readjustment of isostatic equilibrium. If the value derived from the postglacial uplift of Fennoscandia is applicable to the roots of Precambrian mountain systems, then the isostatic deviation brought about by the Surinam orogenesis should have been reduced to $1/e$ of its value in a period of the order of ten thousand years. As VENING MEINESZ says, the root below the normal depth of the Moho discontinuity must assume the temperature and viscosity normally present at that depth. This process, called "melting", must lead to the flattening of the root and its spreading under the foreland of the range. VENING MEINESZ mentions the possibility that a slight inclination of the Moho discontinuity can still be maintained, because an elastic limit has to be overcome before subcrustal flow can start.

Model calculations show that it is also possible to construct a disturbing body at the base of the crust that – except for the steep gradient in the centre of the anomaly – accounts for the perturbation in the gravity field (see Figure 14).

With the gravity field as the only available information, one cannot deny the existence of a relict of a mountain root. This does not mean, however, that on the ground of the gravity data one is *a priori* obliged to give preference to an explanation of the negative belt involving a mountain root. If there is any relict of a root beneath the crust, then this mass anomaly is, as the author thinks, likely to be of minor importance as a cause of the gravity anomaly.

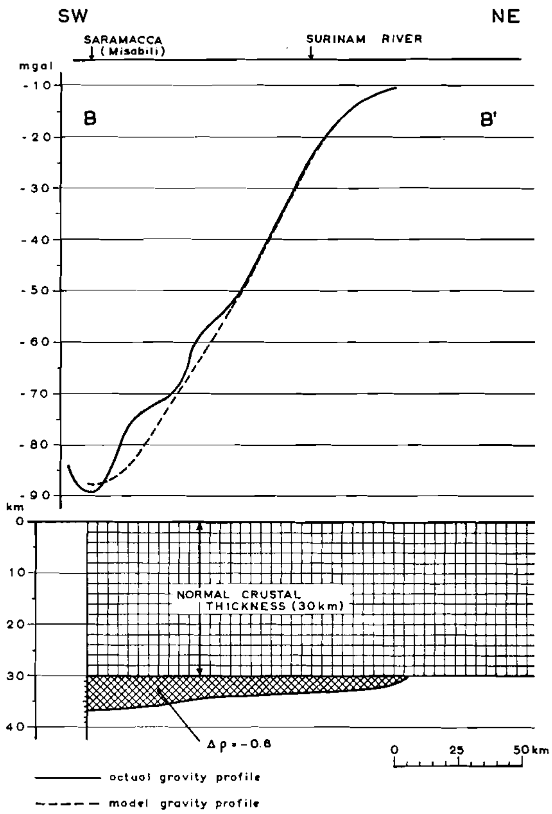

Figure 14. Comparison of the model gravity profile, due to a model root at the base of a 30 km thick crust, with the actual Bouguer gravity profile along the northern part of the negative belt along the line *B B'*. The direction of the profile is perpendicular to the strike of the negative belt. The attraction of the model root has been calculated with the three-dimensional computer method of TALWANI and EWING (1960).

One wonders whether also a heterogeneity of the mantle could be the cause of the anomaly. Processes in the mantle, however, are expected to be complicated functions of at least temperature, pressure and time, which makes it hardly possible to give a realistic interpretation based on the quantitative gravitational effects of processes at such great depths.

WOOLLARD (1962) is of the opinion that regional gravity anomalies, which feature the same departures in sign over areas of 250 kilometres or more in width, suggest a true isostatic unbalance that intuitively can be explained only in terms of unknown forces that prevent regional equilibrium from being achieved between the crust and the mantle or from the crust and the mantle having regional differences in strength.

The surprising about the Surinam negative belt is that this large gravity deficit occurs in an area where there is no sign of a mountain belt in the topographical sense. Here the mountain range has been removed and erosion has now exposed the orogenic belt in cross section.

2.5 The Corantijn basin

Another prominent phenomenon on the gravity map of northern Surinam is the high positive anomaly over the polders of Nickerie and Wageningen. The highest gravity values have been measured just here, where the Precambrian basement is covered with a 2 km thick mass of mostly young unconsolidated sediments (see Map IV: Structural map of Northern Surinam). According to HEDBERG (1936), the density of sediments will increase with the depth from about 2.00 gm/cc at the surface to almost 2.50 gm/cc two km down. Taking 2.30 gm/cc as an average density, the sediments can be concluded to weigh about 0.5 gm/cc less than the rocks of the crystalline basement. If in the area of the positive Nickerie anomaly the depth of the basement is on an average 1500 m, the geological correction should amount to some +30 mgal. To add this geological corrrection straight away to the actual anomaly does not, however, seem to be realistic, because this correction implies that the profile of the crust should be "normal" if the whole Corantijn basin were to be filled up with crystalline rocks instead of a sedimentary formation. This is quite a question. Instead of being a mass deficit, the sedimentary materials may even be interpreted as an extra load on a crust otherwise in isostatic equilibrium.

A problem like the gravity field in the Corantijn basin has so many unknown aspects that however carefully hypotheses are built up, these will always remain highly speculative. The established facts, on which an explanation must be based, are the following:

1. The Corantijn basin shows positive gravity anomalies almost everywhere. The peak values occur along the coast near Nieuw Nickerie; to the west of this maximum, gravity drops to values normal for this latitude.
2. There is an enormous gap between the ages of the young sediments filling the basin and the Precambrian basement. Features such as lignite and fine sands, which have been met in drill cores, might, according to NOËL-PATTON (1937), suggest that the top layer was at times above sea level.
3. Applying the BOTT and SMITH (1958)-method we learn that intensity and gradient of the Nickerie anomaly point to a maximum depth of 7 km to the top of the disturbing body.
4. In the east the Corantijn estuary is bounded by northeast-southwest directed faults and in the west by faults striking northwest-southeast (see Map IV: Structural Map of Northern Surinam).

The deepest point of the basement is near Whim (British Guiana), where the basement rocks are overlain by 2225 metres of young sediments. The gravity in this area is remarkably normal, as was found during the additional survey the author made along the coast of British Guiana. Thus, as it looks now, there is no obvious relationship between the perturbations in the gravity field and the deep trough of sediments deposited in – as MCCONNELL (1959) describes it – "a downfold of the basement rocks in a wide bow-shaped formation facing north-northeast and more or less bisected by the lower course of the Berbice River".

The given fact that the positive Nickerie anomaly does not lie over the region where the thickness of sediments is greatest, makes it less probable that the sediments cause the positive anomaly because they are an extra load on the crust. The small extension of the Nickerie anomaly does not fit such an explanation either. The cause of the anomaly has to be sought in the basement itself, probably in the uppermost kilometres.

Because there are no gravity stations in the swampy coastal area between the Corantijn and Marataka Rivers, it is not possible to draw a reliable contour pattern for that area.

The gravity values measured warrant the supposition that the gravity field in Western Surinam features a more or less symmetrical north-south ridge of positive anomalies. Should this be the case, then the more regional positive gravity anomaly, extending south of Nieuw Nickerie across the western part of the gravity map of northern Surinam, could reasonably be explained by a 3 km deep synclinal structure of basic intrusive, meta-sedimentary or meta-volcanic rocks with a density contrast of +0.15 gm/cc with respect to the surrounding formations. The strike of the three-dimensional synclinal model of these Paramaka-type rocks is considered to be the same as that of the contours of the positive gravity belt. Figure 15 shows the dimension and the form of the model with the gravity profiles belonging to it.

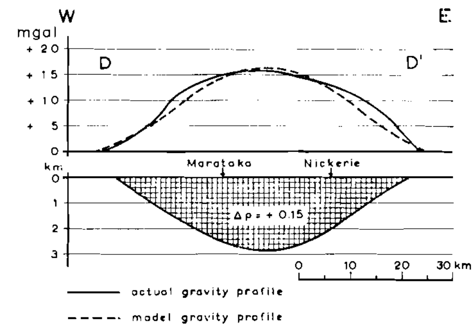

Figure 15. Bouguer gravity profile across the positive ridge in western Surinam. The model is a synclinal structure, which is 100 km wide in north-south direction.

One of the many possible explanations for the more local anomaly in the direct environment of Nieuw Nickerie is to ascribe this anomaly to a basic complex preserved in a synclinal downwarp in the Precambrian basement under Nickerie. Thanks to the gravity measurements made during the Continental Shelf Expedition "Snellius", it became clear that the steep gradient in the gravity field to the southwest of Nickerie belongs to the slope of a much wider positive anomaly which stretches out much farther to the northeast (see Figure 16). Measurements performed at sea by STRANG VAN HEES (1967) show that Nieuw Nickerie is situated at the southeastern edge of a 70 km long, more or less elliptical, anomaly. It seems that this anomaly is part of a belt of positive gravity anomalies, which runs across the western part of Surinam until in the neighbourhood of Nieuw Nickerie it shifts to the northeast, while on the continental shelf this belt trends more and more eastward. With this new information available, it seems more reasonable to explain the positive anomaly in the Nickerie area as the slope of an anomaly with a maximum intensity of about +45 mgal. This anomaly, the centre of which should be located 30 km to the northeast of Nieuw Nickerie, could be explained by a 4 km thick basic to ultra-basic rock formation that features a density difference of +0.30 gm/cc and starts from the top of the bedrock, situated at a depth of two kilometres below the coastal sediments.

There is no point in going deeply into the isostatic aspects of the evolution of the Corantijn basin. Who can tell what the reaction of crust and substratum would be in this disturbed area of the earth's crust, which should be considered as a zone of weakness on account of it being part of a continental margin in the first place.

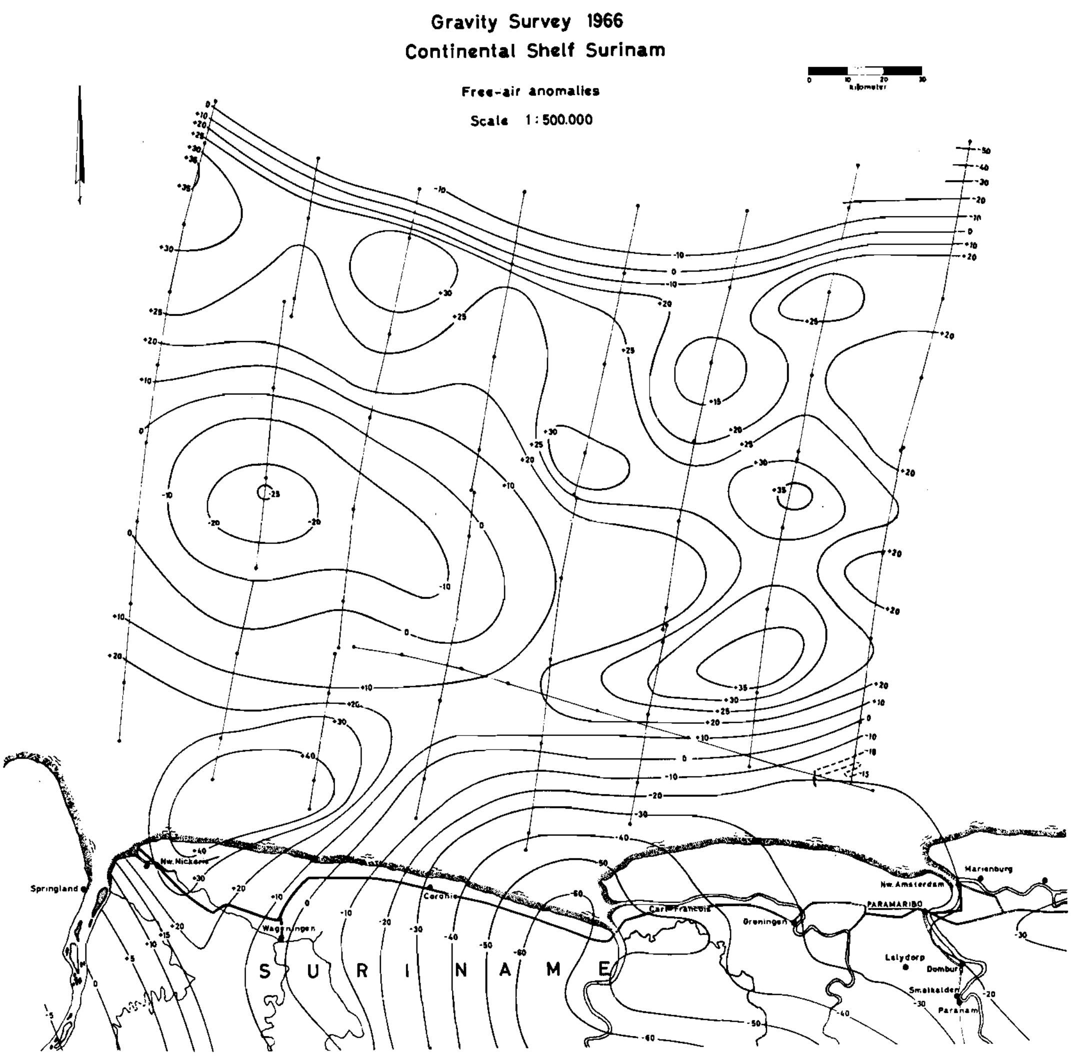

Figure 16. This picture of the gravity pattern over the continental shelf and the coastal area of Surinam results from a combination of the outcome of the over-land gravity surveys, dealt with in this thesis, together with the preliminary free-air anomaly pattern as measured by STRANG VAN HEES (1967) on the continental shelf during the Snellius expedition. Incorporation of the off-shore measurements shows the negative belt protruding quite far into the continental shelf area, while, at the same time, it reveals that the positive anomaly near Nickerie actually has its maximum out at sea.

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APPENDIX A

Table IV. Tables of free-air and Bouguer anomalies for all gravity stations in Surinam (for the location of the gravity stations, see map II)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
1	Paramaribo (G.M.D.)	978 080.0	978 102.0	2.5 (i)*	−21.2	−21.5
2	Paramaribo (WOSUNA)	978 080.0	978 101.9	2.5 (i)	−21.1	−21.4
3	Paramaribo (Harbour)	978 080.0	978 102.0	2.5 (i)	−21.2	−21.5
4	Meerzorg	978 080.9	978 101.7	2.5 (i)	−20.0	−20.3
5	Jagtlust	978 082.0	978 101.7	2.5 (i)	−18.9	−19.2
6	Belwaarde	978 082.4	978 102.5	2.5 (i)	−19.3	−19.6
7	Nieuw Amsterdam	978 080.9	978 103.0	2.5 (i)	−21.3	−21.6
8	Marienburg	978 081.4	978 103.0	2.5 (i)	−20.8	−21.1
9	Alkmaar	978 085.8	978 102.6	2.5 (i)	−16.0	−16.3
10	Spieringshoek	978 086.8	978 102.7	2.5 (i)	−15.1	−15.4
11	Taman Redjo	978 085.7	978 101.2	2.5 (i)	−14.7	−15.0
12	Orleanakreek	978 088.5	978 101.2	2.5 (i)	−11.9	−12.2
13	Commetewanakreek	978 088.5	978 101.1	2.5 (i)	−11.8	−12.1
14	Alliance	978 089.5	978 103.1	2.5 (i)	−13.6	−13.9
15	Ephrata	978 093.7	978 102.4	2.5 (i)	− 7.9	− 8.2
16	Beetre	978 095.3	978 102.6	2.5 (i)	− 6.5	− 6.8
17	Zandplaat	978 104.9	978 101.7	2.5 (i)	+ 4.0	+ 3.7
18	Calibo	978 105.0	978 101.3	2.5 (i)	+ 4.5	+ 4.2
19	Pikien Santi	978 108.9	978 101.1	2.5 (i)	+ 8.6	+ 8.3
20	Coermotibomonding	978 108.9	978 100.4	2.5 (i)	+ 9.3	+ 9.0
21	Ricanaumonding	978 104.6	978 099.3	2.5 (i)	+ 6.1	+ 5.8
22	Moengo	978 097.6	978 098.1	8.0 (ii)	+ 1.7	+ 0.9
23	Moengo	978 097.0	978.098.1	8.0 (ii)	+ 1.2	+ 0.3
24	Moengotapoe	978 097.9	978 097.6	6.5 (i)	+ 2.3	+ 1.6
25	Albina (douane)	978 084.2	978 096.2	2.5 (i)	−11.2	−11.5
26	Albina (G.M.D. camp)	978 085.1	978 096.4	2.5 (i)	−10.5	−10.8
27	Tapoehoekoe	978 087.6	978 096.8	2.5 (i)	− 8.4	− 8.7
28	Wanekreek	978 097.3	978 098.7	2.5 (i)	− 0.6	− 0.9
29	Langamankondre	978 104.5	978 099.9	2.5 (i)	+ 5.4	+ 5.1
30	Galibi	978 109.7	978 100.6	2.5 (i)	+ 9.9	+ 9.6
31	Bigiston	978 071.0	978 094.7	4.8 (ii)	−22.1	−22.6
32	Abeneko	978 062.0	978 093.0	6.6 (ii)	−29.0	−29.7
33	Herminadorp	978 057.0	978 090.8	5.4 (ii)	−32.1	−32.6
34	Langatabbetje	978 047.0	978 088.7	11.4 (ii)	−38.2	−39.4
35	Nason	978 046.0	978 085.4	16.1 (ii)	−34.4	−36.2
36	Mooisanti	978 041.0	978 083.4	24.5 (ii)	−34.8	−37.5
37	Gabaka	978 038.0	978 080.1	38.5 (ii)	−30.2	−34.4
38	Stoelmanseiland	978 032.0	978 078.8	46.6 (iii)	−32.4	−37.5
39	Slootwijk	978 090.2	978 102.2	2.5 (i)	−11.2	−11.5
40	Blekerwaar	978 091.0	978 102.2	2.5 (i)	−10.4	−10.7
41	Kraskreek	978 091.2	978 102.2	2.5 (i)	−10.2	−10.5
42	Pinica	978 093.8	978 101.3	2.5 (i)	− 6.8	− 7.0
43	Oost-West verbinding	978 093.2	978 100.7	2.5 (i)	− 6.7	− 7.0
44	Potribo	978 092.0	978 100.4	2.6 (i)	− 7.6	− 7.9
45	Destommesburg	978 088.2	978 099.4	3.1 (i)	−10.2	−10.6
46	Rozenbeek	978 090.0	978 099.0	3.3 (i)	− 8.0	− 8.3
47	Godo	978 089.7	978 098.6	3.5 (i)	− 7.8	− 8.2
48	Djakkikreek	978 086.9	978 097.8	4.0 (i)	− 9.7	−10.1

* For legend see page 17

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
49	Martampoeka	978 085.6	978 097.1	4.5 (i)	−10.1	−10.6
50	Sapende	978 081.4	978 096.3	4.9 (i)	−13.4	−13.9
51	Penninicamonding	978 076.7	978 095.7	5.3 (i)	−17.4	−18.0
52	Godo-Rai	978 075.0	978 095.4	5.5 (i)	−18.7	−19.3
53	Java	978 068.5	978 094.6	5.9 (i)	−24.3	−24.9
54	Kamp Bruynzeel I	978 056.8	978 093.7	6.5 (i)	−34.9	−35.6
55	Poitehede	978 056.2	978 093.1	6.9 (i)	−34.8	−35.5
56	Doorsnee	978 053.9	978 092.0	7.4 (i)	−35.8	−36.6
57	Kamp Bruynzeel II	978 052.5	978 091.1	7.8 (i)	−36.2	−37.0
58	Kopi-ondro	978 063.3	978 093.8	6.3 (i)	−28.5	−29.2
59	Konkongo	978 057.2	978 093.1	6.6 (i)	−33.8	−34.6
60	Groenkreek	978 068.2	978 094.6	6.3 (i)	−24.4	−25.1
61	Boven Pondokreek	978 062.0	978 094.1	6.6 (i)	−30.0	−30.7
62	Ningre Peprekondre	978 080.3	978 096.0	5.5 (i)	−14.0	−14.6
63	Bamboe	978 077.3	978 095.5	5.7 (i)	−16.4	−17.1
64	Herstellingskreek	978 084.9	978 097.6	4.0 (i)	−11.5	−11.9
65	Copie	978 080.0	978 096.4	5.0 (i)	−14.8	−15.4
66	Domburg	978 078.7	978 099.7	2.5 (i)	−20.2	−20.5
67	Waterland	978 080.3	978 099.2	3.5 (i)	−17.8	−18.3
68	Klein Chatillon	978 075.7	978 099.0	2.8 (i)	−22.5	−22.7
69	Paranam	978 073.5	978 098.1	3.0 (i)	−23.7	−24.0
70	Groot Chatillon	978 074.2	978 098.4	3.3 (i)	−23.2	−23.5
71	Berendslust	978 074.5	978 098.0	3.8 (i)	−22.3	−22.7
72	Bergen op Zoom	978 072.4	978 096.9	4.5 (i)	−23.1	−23.6
73	Esthershust	978 068.1	978 096.6	5.0 (i)	−26.9	−27.5
74	Carolina	978 064.0	978 095.3	6.0 (i)	−29.4	−30.1
75	Jodensavanne	978 063.0	978 095.0	6.5 (i)	−30.0	−30.7
76	Suhoza of Agila	978 053.7	978 093.8	7.0 (i)	−37.9	−38.7
77	Phedra	978 046.7	978 093.4	9.0 (i)	−43.9	−44.9
78	Rama	978 038.3	978 093.2	10.0 (i)	−51.8	−52.9
79	La Providence	978 039.0	978 092.4	10.2 (i)	−50.2	−51.4
80	Moederzorg	978 035.4	978 092.0	10.4 (i)	−53.4	−54.5
81	Reinsdorp	978 037.9	978 091.2	10.6 (i)	−50.0	−51.2
82	Berg en Dal I	978 037.0	978 090.4	10.8 (i)	−50.1	−51.2
83	Mao Tapoe	978 036.4	978 090.1	11.5 (ii)	−50.1	−51.4
84	Sesebiase	978 043.2	978 090.5	13.0 (ii)	−43.2	−44.7
85	Mawassi	978 042.8	978 090.5	12.4 (ii)	−43.9	−45.2
86	Aganjakondre	978 043.8	978 090.2	11.6 (ii)	−42.8	−44.1
87	Bosland	978 040.6	978 089.5	11.8 (ii)	−45.2	−46.5
88	Brokopondo	978 036.1	978 089.0	12.0 (ii)	−49.2	−50.5
89	Balin Soela	978 034.1	978 088.5	12.4 (ii)	−50.6	−51.9
90	Suralcokamp	978 035.3	978 088.4	12.5 (ii)	−49.2	−50.6
91		978 037.1	978 088.4	12.5 (ii)	−47.4	−48.8
92	Nieuw Star eiland	978 038.6	978 088.3	12.6 (ii)	−45.8	−47.2
93	Afoebaka	978 038.2	978 088.1	12.6 (i)	−46.0	−47.4
94	Koffiekamp	978 031.3	978 087.7	14.0 (ii)	−52.1	−53.6
95	Prangapasieval	978 031.9	978 087.5	13.3 (ii)	−51.5	−52.9
96		978 031.3	978 087.4	13.6 (ii)	−51.9	−53.4
97		978 025.7	978 087.4	13.8 (ii)	−57.4	−58.9
98		978 021.9	978 087.3	14.2 (ii)	−61.0	−62.6
99	Julianaweg	978 020.6	978 087.3	15.2 (ii)	−62.0	−63.7
100	Maripasoela	978 018.2	978 087.2	15.4 (ii)	−64.2	−65.9

Table IV (continued)

No.	Station		Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
101	Janifoetoe		978 015.2	978 087.2	15.5 (i)	−67.2	−68.9
102	Fitji-Soela		978 011.5	978 086.8	15.8 (i)	−70.4	−72.1
103	Kabel-landing		978 010.1	978 086.7	16.0 (i)	−71.6	−73.4
104	Kentoegron island		978 007.9	978 085.9	17.0 (i)	−72.7	−74.6
105	Lombé		978 006.6	978 085.6	18.0 (i)	−74.4	−76.4
106	Gansee		978 006.7	978 085.3	18.5 (i)	−72.9	−74.9
107	Bedoti		978 012.4	978 084.6	19.5 (ii)	−66.2	−68.3
108	Bakra-opposton		978 013.4	978 084.1	21.0 (ii)	−64.2	−66.5
109	Grankreek I		978 019.6	978 083.1	23.0 (ii)	−56.4	−58.9
110	Dission		978 020.4	978 082.8	25.0 (ii)	−54.6	−57.4
111			978 024.7	978 082.6	27.0 (ii)	−49.5	−52.5
112			978 027.8	978 082.3	29.0 (ii)	−45.5	−48.7
113			978 029.0	978 082.1	31.0 (ii)	−43.5	−46.9
114	Koenkoenval		978 026.9	978 081.7	34.0 (ii)	−44.3	−48.0
115	Adawi		978 021.4	978 081.8	35.0 (iii)	−49.5	−53.4
116	Lorrieval		978 020.4	978 081.7	39.0 (iii)	−49.2	−53.5
117	Grankreek II		978 019.9	978 082.9	24.0 (ii)	−55.6	−58.2
118	Grankreek III		978 019.2	978 082.6	25.0 (ii)	−55.6	−58.4
119	Weg Paranam-Afobaka:	km 5	978 066.6	978 096.7	4.8 (i)	−28.6	−29.1
120		km 10	978 063.4	978 096.0	7.5 (i)	−30.7	−31.4
121		km 15	978 057.6	978 095.5	11.0 (i)	−34.5	−35.7
122		km 20	978 049.2	978 094.8	21.2 (i)	−39.0	−41.4
123			978 036.0	978 093.9	36.7 (i)	−46.6	−50.5
124			978 027.0	978 092.7	35.8 (i)	−54.6	−58.5
125	Marechalkreek		978 034.8	978 091.8	8.3 (ii)	−54.4	−55.3
126	Klaaskreek		978 035.7	978 090.9	7.6 (ii)	−52.8	−53.7
127	Berg en Dal II		978 036.2	978 090.4	12.5 (i)	−50.3	−51.7
128	Compagniekreek		978 027.2	978 089.1	17.6 (ii)	−56.5	−58.4
129	Lelydorp		978 072.5	978 099.5	5.8 (i)	−25.2	−25.8
130	Onverwacht		978 065.0	978 097.8	4.7 (i)	−31.3	−31.9
131	Republiek		978 057.5	978 096.1	10.0 (i)	−35.5	−36.6
132	Zanderij		978 050.0	978 095.4	16.3 (i)	−40.3	−42.1
133	Kwakoegron		978 030.1	978 092.1	6.4 (i)	−60.1	−60.8
134	Guyana Goldplacer		978 022.5	978 090.2	9.3 (i)	−64.8	−65.8
135	Brownsweg		978 013.0	978 088.2	44.3 (i)	−61.5	−66.3
136	Kabel (station)		978 009.5	978 086.8	17.6 (i)	−71.9	−73.8
137	Abontjeman		978 023.0	978 086.1	16.6 (i)	−58.0	−59.8
138	Sikakamp		978 021.5	978 084.4	16.1 (i)	−57.9	−59.7
139	Dam		978 021.5	978 083.1	31.4 (i)	−51.9	−55.3
140	Uitkijk		978 075.7	978 101.1	2.5 (i)	−24.6	−24.9
141	Santigron		978 067.5	978 099.0	2.5 (i)	−30.7	−31.0
142	Manjaboom		978 064.6	978 099.0	2.5 (i)	−33.6	−33.9
143	Dam Parra		978 062.0	978 098.6	2.6 (i)	−35.8	−36.1
144	Vier Hendrikken		978 059.0	978 098.0	2.8 (i)	−38.1	−38.4
145	Totikamp		978 053.4	978 097.2	3.0 (i)	−42.9	−43.2
146	Locuskreek		978 047.4	978 096.6	3.2 (i)	−48.2	−48.6
147	Gr. Makkakreek		978 044.4	978 096.1	3.3 (i)	−50.7	−51.0
148	Blakawattrakreek		978 041.2	978 095.5	3.7 (i)	−53.1	−53.6
149	Gr. Poikakreek		978 037.6	978 094.9	3.9 (i)	−56.1	−56.5
150	Moeriekreek		978 036.9	978 094.3	4.2 (i)	−56.1	−56.6
151	Surocto		978 037.5	978 094.9	5.9 (i)	−55.6	−56.2
152	Weg Zanderij		978 034.6	978 094.4	5.1 (i)	−58.2	−58.8

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
153	Houthakkerskamp	978 038.6	978 093.5	5.3 (i)	−53.2	−53.8
154	Maripaston	978 035.9	978 093.2	4.5 (i)	−55.9	−56.4
155	Makkakreek	978 022.6	978 091.7	5.3 (i)	−67.4	−68.0
156	Sabanpassie	978 019.2	978 091.4	5.6 (i)	−70.5	−71.1
157	Ketti-Ketti	978 017.2	978 091.3	5.9 (i)	−72.3	−72.9
158	Moeroe-Moeroekreek	978 017.0	978 090.9	6.2 (i)	−72.0	−72.7
159	Doorsnee	978 017.4	978 090.6	6.3 (i)	−71.2	−71.9
160	Lokso-harti	978 011.8	978 090.3	6.7 (i)	−76.4	−77.2
161	Bottrikoesanti	978 005.7	978 089.1	7.7 (i)	−81.0	−81.9
162	Toboeka	977 998.5	978 088.2	8.0 (i)	−87.2	−88.1
163	Missalibi	977 996.4	978 087.2	10.6 (i)	−87.5	−88.7
164	Oemakondre	977 996.7	978 087.1	18.0 (i)	−84.8	−86.8
165	Lemmiki	977 997.0	978 086.8	19.0 (i)	−83.9	−86.0
166		977 996.9	978 086.7	19.3 (i)	−83.8	−85.9
167		978 000.8	978 086.7	19.4 (i)	−79.9	−82.0
168	Dramhoso	978 003.1	978 086.6	19.8 (i)	−77.4	−79.5
169		978 004.8	978 086.6	20.4 (i)	−75.5	−77.7
170		978 006.6	978 086.5	20.8 (i)	−73.5	−75.7
171		978 006.8	978 086.4	21.2 (ii)	−73.0	−75.4
172		978 006.6	978 086.4	22.0 (ii)	−73.0	−75.4
173		978 005.4	978 086.1	22.5 (ii)	−73.7	−76.2
174	Limbawatra	978 004.2	978 086.0	23.0 (ii)	−74.7	−77.2
175	Hedoti	978 004.5	978 085.8	23.5 (ii)	−74.0	−76.6
176	Pajakreek	978 003.8	978 085.7	24.0 (ii)	−74.5	−77.1
177	Godongron	978 002.7	978 085.6	25.0 (ii)	−75.1	−77.9
178	Kwattahede	977 997.7	978 085.3	30.0 (ii)	−78.3	−81.6
179	Bradiwatra	977 996.2	978 084.6	34.0 (ii)	−77.9	−81.6
180	Makajapingo	977 990.1	978 083.8	42.0 (ii)	−80.7	−85.3
181	Bigibodi	977 992.9	978 083.4	42.0 (ii)	−77.5	−82.1
182	Warnakomotonafaja	977 995.8	978 083.1	45.0 (ii)	−73.3	−78.3
183	Loewiedam	977 999.3	978 083.2	50.0 (ii)	−68.4	−73.9
184	Kokkoporokansian	977 995.3	978 083.1	56.0 (ii)	−70.4	−76.6
185	Pakka-Pakka	977 995.3	978 082.8	62.0 (i)	−68.3	−75.1
186	Brokobotoval	977 993.9	978 081.5	72.0 (ii)	−65.3	−73.3
187	Grasisoela	977 989.6	978 080.7	80.0 (ii)	−66.3	−75.1
188	Wittistonsoela	977 986.3	978 080.1	88.0 (iii)	−66.9	−76.4
189	Granmankondre	977 981.1	978 079.3	98.0 (iii)	−67.8	−78.7
190	Vertrouwen	977 980.8	978 078.4	100.0 (iv)	−66.6	−77.6
191	Alikiabakoeba	977 977.6	978 077.5	101.0 (iv)	−68.6	−79.7
192	Toekoemoetoe	977 976.9	978 076.5	105.0 (iv)	−67.0	−78.6
193	Loewiefoenda	977 977.3	978 076.3	106.0 (iv)	−66.1	−77.8
194	Granpoe	977 980.8	978 075.5	108.0 (iv)	−61.2	−73.1
195	Lawaaidam	977 986.1	978 074.8	110.0 (iv)	−54.6	−66.7
196	Afintinjaminjamfoenda	977 991.0	978 074.1	117.0 (iv)	−46.8	−59.7
197		977 990.7	978 073.2	120.0 (iv)	−45.3	−58.5
198		977 988.6	978 073.1	125.0 (iv)	−45.7	−59.5
199		977 986.4	978 073.1	125.0 (iv)	−47.9	−61.7
200		977 979.6	978 071.6	130.0 (v)	−51.7	−66.0
201		977 979.6	978 071.3	132.0 (v)	−50.8	−65.3
202	Airstrip Tafelberg	977 939.2	978 071.0	232.0 (iii)	−59.9	−85.4
203		977 938.3	978 071.0	236.0 (iv)	−59.5	−85.5
204		977 939.0	978 071.0	232.0 (iv)	−58.8	−85.6

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
205		977 941.0	978 071.0	232.0 (iv)	−58.1	−83.6
206		977 942.1	978 071.0	229.0 (iv)	−57.9	−83.1
207	Toekoemoetoe	977 974.8	978 076.5	108.0 (iv)	−68.2	−80.1
208	Sjampassie	977 997.7	978 087.4	8.5 (ii)	−87.1	−88.0
209	Tjoemboepassie	977 999.8	978 087.4	8.8 (ii)	−84.9	−85.8
210	Tjow-Tjowvallen	977 999.2	978 087.1	10.0 (ii)	−84.8	−85.9
211	Paramaribo	978 080.8	978 102.1	2.5 (i)	−20.5	−20.8
212	Garnizoenspad km 4	978 080.6	978 102.2	2.5 (i)	−20.8	−21.1
213	km 6	978 080.0	978 102.3	2.5 (i)	−21.5	−21.8
214	km 9	978 079.8	978 102.4	2.5 (i)	−21.8	−22.1
215	km 12	978 079.2	978 102.4	2.5 (i)	−22.4	−22.7
216	km 15	978 077.4	978 102.5	2.5 (i)	−24.3	−24.6
217	km 16	978 077.0	978 102.5	2.5 (i)	−24.7	−25.0
218	km 17	978 076.1	978 102.5	2.5 (i)	−25.6	−25.9
219	km 17.8	978 076.0	978 102.5	2.5 (i)	−25.7	−26.0
220	km 19	978 075.7	978 102.6	2.5 (i)	−26.1	−26.4
221	km 20	978 075.5	978 102.6	2.5 (i)	−26.3	−26.6
222	km 21	978 075.3	978 102.6	2.5 (i)	−26.5	−26.8
223	km 22	978 075.5	978 102.6	2.5 (i)	−26.3	−26.6
224	km 23	978 075.7	978 102.5	2.5 (i)	−26.0	−26.3
225	km 24	978 075.5	978 102.5	2.5 (i)	−26.2	−26.5
226	km 25	978 074.9	978 102.4	2.5 (i)	−26.7	−27.0
227	km 26	978 074.9	978 102.4	2.5 (i)	−26.7	−27.0
228	km 27	978 074.7	978 102.3	2.5 (i)	−26.8	−27.1
229	km 28	978 074.2	978 102.3	2.5 (i)	−27.3	−27.6
230	km 29	978 073.9	978 102.2	2.5 (i)	−27.5	−27.8
231	km 30	978 073.9	978 102.2	2.5 (i)	−27.5	−27.8
232	km 31	978 073.8	978 102.1	2.5 (i)	−27.5	−27.8
233	km 32	978 073.4	978 102.1	2.5 (i)	−27.9	−28.2
234	km 33.3	978 072.9	978 102.0	2.5 (i)	−28.3	−28.6
235	Weg naar Zee I	978 080.5	978 102.8	2.5 (i)	−21.5	−21.8
236	II	978 080.8	978 103.1	2.5 (i)	−21.5	−21.8
237	III	978 081.4	978 103.4	2.5 (i)	−21.2	−21.5
238	La Poule	978 074.8	978 100.8	2.5 (i)	−25.2	−25.5
239	Groningen	978 072.2	978 101.3	2.5 (i)	−28.3	−28.6
240	Driesprong	978 072.3	978 101.8	2.5 (i)	−28.7	−29.0
241	Sarah Maria	978 071.5	978 102.3	2.5 (i)	−30.0	−30.3
242	La Prévoyance	978 070.7	978 102.7	2.5 (i)	−31.2	−31.5
243	Tijgerkreek	978 070.5	978 102.2	2.5 (i)	−30.9	−31.2
244	Bombay	978 067.9	978 102.7	2.5 (i)	−34.0	−34.3
245	Calcutta	978 065.0	978 102.6	2.5 (i)	−36.8	−37.1
246	Carl François	978 055.6	978 102.2	2.5 (i)	−45.8	−46.1
247	km 85	978 051.9	978 101.8	2.5 (i)	−49.1	−49.4
248	km 90	978 049.3	978 101.7	2.5 (i)	−51.6	−51.9
249	Coppenamepunt	978 050.4	978 101.3	2.5 (i)	−50.1	−50.4
250	Weg naar Coronie	978 045.6	978 100.8	2.5 (i)	−54.4	−54.7
251		978 040.6	978 101.0	2.5 (i)	−59.6	−59.9
252		978 037.5	978 101.3	2.5 (i)	−63.0	−63.3
253		978 038.7	978 101.5	2.5 (i)	−62.0	−62.3
254		978 039.1	978 101.6	2.5 (i)	−61.7	−62.0
255		978 043.7	978 101.8	2.5 (i)	−57.3	−57.6
256		978 049.4	978 102.0	2.5 (i)	−51.8	−52.1

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
257	Weg naar Coronie	978 053.1	978 102.3	2.5 (i)	−48.4	−48.7
258		978 057.6	978 102.5	2.5 (i)	−44.1	−44.4
259		978 062.9	978 102.7	2.5 (i)	−39.0	−39.3
260		978 066.1	978 102.8	2.5 (i)	−35.9	−36.2
261		978 069.7	978 102.8	2.5 (i)	−32.3	−32.6
262		978 071.2	978 103.0	2.5 (i)	−31.0	−31.3
263		978 077.0	978 103.1	2.5 (i)	−25.3	−25.6
264		978 078.4	978 103.2	2.5 (i)	−24.0	−24.3
265		978 081.1	978 103.3	2.5 (i)	−21.4	−21.7
266		978 085.7	978 103.4	2.5 (i)	−16.9	−17.2
267		978 073.1	978 103.4	2.5 (i)	−29.5	−29.8
268		978 071.2	978 103.4	2.5 (i)	−31.4	−31.7
269		978 068.7	978 102.5	2.5 (i)	−33.0	−33.3
270		978 070.7	978 102.7	2.5 (i)	−31.2	−31.5
271		978 068.0	978 103.2	2.5 (i)	−34.4	−34.7
272	Flamingokreek	978 051.9	978 102.7	2.5 (i)	−50.0	−50.3
273	Vissersdorp	978 050.6	978 101.7	2.5 (i)	−50.3	−50.6
274	Coesewijnemonding	978 052.7	978 100.8	2.5 (i)	−47.3	−47.6
275	Coesewijne	978 044.8	978 101.2	2.5 (i)	−55.6	−55.9
276	Coesewijne	978 044.4	978 101.4	2.5 (i)	−56.2	−56.5
277	Coesewijne	978 048.3	978 101.6	2.5 (i)	−52.5	−52.8
278	Kalebaskreek	978 051.8	978 099.1	2.5 (i)	−46.5	−46.8
279	Peruviakreek	978 046.4	978 098.9	2.5 (i)	−51.7	−52.0
280	Karani	978 043.5	978 097.7	3.0 (i)	−53.3	−53.6
281	Tibiti-Bruynzeel	978 038.7	978 097.0	3.5 (i)	−57.2	−57.6
282	Goede Hoop II	978 029.8	978 096.8	3.5 (i)	−65.9	−66.3
283	Goede Hoop I	978 029.8	978 096.8	3.5 (i)	−65.9	−66.3
284	Coppename (308)	978 024.3	978 096.0	4.0 (i)	−70.5	−70.9
285	Coppename	978 027.0	978 096.0	4.5 (i)	−67.6	−68.1
286	Houthakkerskamp	978 032.3	978 095.7	4.5 (i)	−62.0	−62.5
287	Wayambomonding	978 031.4	978 095.2	7.0 (i)	−61.6	−62.4
288	Onobissimonding	978 036.7	978 093.4	6.3 (ii)	−54.8	−55.4
289	Heidoti	978 043.7	978 092.1	7.0 (ii)	−46.2	−47.0
290	Tjakka-Tjakkaston	978 044.7	978 091.3	8.0 (ii)	−44.1	−45.0
291	Bitagron	978 040.3	978 090.7	9.0 (ii)	−47.6	−48.6
292	Kaaimanston	978 042.3	978 089.7	10.5 (ii)	−44.1	−45.3
293	Mooiston	978 041.6	978 088.2	12.5 (ii)	−42.7	−44.1
294		978 035.7	978 086.3	14.0 (ii)	−46.3	−47.8
295	Kwamakreekmonding	978 035.8	978 085.6	15.0 (ii)	−45.1	−46.6
296	Raleighvallen	978 027.5	978 083.8	17.5 (ii)	−50.9	−52.8
297	Gran Stonkreek	978 033.2	978 096.3	4.0 (i)	−61.9	−62.3
298	Asafirikondre	978 026.6	978 096.0	4.3 (i)	−68.1	−68.5
299	Sabana	978 023.7	978 094.5	5.5 (i)	−69.1	−69.7
300		978 022.3	978 095.0	6.8 (i)	−70.6	−71.3
301	Kabokreek	978 021.1	978 094.9	7.0 (i)	−71.6	−72.4
302		978 020.7	978 094.0	7.6 (i)	−70.9	−71.6
303		978 021.4	978 093.3	8.1 (i)	−69.3	−70.2
304	Simariembo	978 027.3	978 092.2	9.4 (i)	−62.0	−63.0
305		978 030.1	978 091.7	10.3 (ii)	−58.4	−59.5
306	Fesihede	978 032.7	978 091.1	10.6 (ii)	−55.1	−56.3
307	Tebesa	978 034.0	978 090.1	11.3 (ii)	−52.6	−53.9
308		978 028.7	978 089.7	11.7 (ii)	−57.4	−58.7

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
309		978 022.3	978 090.0	12.1 (ii)	−63.9	−65.3
310	Bigi Soela	978 013.5	978 090.0	15.5 (ii)	−71.7	−73.4
311		978 009.9	978 089.9	15.8 (iii)	−75.1	−76.8
312		978 004.9	978 089.9	16.1 (iii)	−80.0	−81.8
313		978 003.6	978 089.7	16.3 (iii)	−81.0	−82.8
314		977 997.6	978 089.3	16.7 (iii)	−86.5	−88.4
315		977 996.5	978 089.2	16.8 (iii)	−87.5	−89.3
316		977 997.6	978 089.2	17.0 (iii)	−86.3	−88.2
317		977 996.1	978 089.2	17.2 (iii)	−87.8	−89.7
318		978 003.9	978 088.5	17.6 (iii)	−79.1	−81.1
319		978 001.9	978 088.3	17.8 (iii)	−80.9	−82.8
320	Kabokreek	978 020.4	978 095.7	7.1 (i)	−73.1	−73.9
321		978 021.8	978 094.9	7.2 (i)	−70.9	−71.6
322		978 021.7	978 094.8	7.4 (i)	−70.8	−71.6
323		978 018.2	978 094.2	7.7 (i)	−73.6	−74.5
324		978 018.0	978 094.2	7.8 (i)	−73.8	−74.6
325	Kwamakreek	978 029.8	978 085.3	18.0 (iii)	−49.9	−52.3
326		978 023.2	978 084.9	22.0 (iii)	−54.9	−57.3
327		978 017.2	978 084.6	27.0 (iii)	−59.0	−62.0
328		978 015.0	978 084.6	30.0 (iv)	−60.3	−63.6
329		978 038.4	978 094.3	5.5 (ii)	−54.2	−54.8
330	Corneliskondre	978 045.5	978 093.6	6.5 (ii)	−46.1	−46.8
331	Wayambo	978 048.8	978 093.2	6.3 (ii)	−42.4	−43.1
332	Boscokaboeia	978 050.4	978 093.3	8.5 (ii)	−40.3	−41.2
333	Venloo's dorp	978 056.6	978 093.5	7.0 (ii)	−34.7	−35.5
334	Donderskamp	978 067.7	978 094.1	7.8 (ii)	−24.0	−24.8
335	Concessie Arawarra	978 072.6	978 093.5	8.0 (ii)	−18.4	−19.3
336	Wayambo-Arawarra	978 072.1	978 093.2	8.2 (ii)	−18.6	−19.5
337	Fossibergi	978 072.8	978 092.5	8.5 (ii)	−17.1	−18.0
338	Fossibergi	978 070.5	978 092.3	8.7 (ii)	−19.1	−20.1
339	Nieuw Nickerie	978 133.3	978 104.3	2.5 (i)	+29.8	+29.5
340		978 131.2	978 104.4	2.5 (i)	+27.6	+27.3
341		978 129.9	978 104.6	2.5 (i)	+26.1	+25.8
342		978 128.0	978 104.6	2.5 (i)	+24.2	+23.9
343	Nickerie Airstrip	978 124.5	978 104.5	2.5 (i)	+20.8	+20.5
344	Waldeck	978 128.1	978 104.3	2.5 (i)	+24.6	+24.3
345	Claraweg	978 125.4	978 104.3	2.5 (i)	+21.9	+21.6
346		978 116.4	978 103.9	2.5 (i)	+13.3	+13.0
347		978 122.4	978 103.8	2.5 (i)	+19.4	+19.1
348	Clarasluis	978 113.4	978 103.5	2.5 (i)	+10.7	+10.4
349		978 117.3	978 103.6	2.5 (i)	+14.5	+14.2
350		978 119.9	978 103.6	2.5 (i)	+17.1	+16.8
351	Nickerie-watertoren	978 131.7	978 104.3	2.5 (i)	+28.2	+27.9
352		978 134.2	978 104.3	2.5 (i)	+30.7	+30.4
353		978 137.6	978 104.3	2.5 (i)	+34.1	+33.8
354	Paradise	978 136.0	978 103.5	2.5 (i)	+33.3	+33.0
355	Hazard	978 137.3	978 104.1	2.5 (i)	+34.0	+33.7
356	Henar	978 129.8	978 102.6	2.5 (i)	+28.0	+27.7
357	Bombay	978 116.5	978 101.7	2.5 (i)	+15.6	+15.3
358	Wageningen	978 105.3	978 100.8	2.5 (i)	+ 5.3	+ 5.0
359	Koffiemakkakreek	978 094.5	978 100.7	2.9 (i)	− 5.3	− 5.6
360	Karapanakreek	978 095.6	978 098.7	3.5 (i)	− 2.0	− 2.4

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
361		978 091.7	978 097.5	4.0 (i)	− 4.6	− 5.0
362		978 104.8	978 096.6	4.8 (i)	+ 9.7	+ 9.2
363	Tapoeripa	978 097.2	978 094.2	5.8 (i)	+ 4.8	+ 4.2
364		978 084.5	978 094.6	6.5 (i)	− 8.1	− 8.8
365	Arawarramonding	978 079.4	978 093.7	7.0 (ii)	−12.1	−12.9
366	Boven-Venlookanaal	978 085.2	978 091.5	10.0 (ii)	− 3.2	− 4.3
367	Oud Suroctokamp	978 087.0	978 090.6	10.5 (ii)	− 0.3	− 1.5
368		978 092.4	978 089.6	12.5 (ii)	+ 6.7	+ 5.3
369	Baas Bartval	978 100.8	978 089.1	13.5 (ii)	+15.9	+14.4
370	Mimmiekreek	978 099.3	978 088.7	15.0 (ii)	+15.3	+13.6
371		978 095.2	978 088.5	16.0 (ii)	+11.7	+ 9.9
372	Falawatra	978 096.1	978 089.7	11.2 (iii)	+ 9.9	+ 8.6
373		978 091.8	978 089.1	12.0 (iii)	+ 6.3	+ 5.1
374		978 087.2	978 088.6	12.4 (iii)	+ 2.4	+ 1.0
375		978 080.0	978 088.4	13.2 (iii)	− 4.3	− 5.8
376	Cupido	978 101.0	978 099.1	3.2 (i)	+ 2.9	+ 2.5
377	Maratakka	978 108.7	978 096.2	4.8 (i)	+14.0	+13.5
378		978 109.3	978 094.6	5.4 (i)	+16.4	+15.8
379		978 106.7	978 093.7	5.7 (i)	+14.8	+14.1
380		978 104.2	978 092.7	6.3 (ii)	+13.4	+12.8
381		978 104.1	978 092.4	6.5 (ii)	+13.7	+13.0
382	Nannisluis	978 110.4	978 103.1	2.5 (i)	+ 8.1	+ 7.8
383	Papegaaieneiland	978 110.4	978 103.1	2.5 (i)	+ 8.1	+ 7.8
384		978 100.3	978 100.7	2.5 (i)	+ 0.4	+ 0.1
385	Ikobikreek	978 098.5	978 098.8	3.5 (i)	+ 0.8	+ 0.4
386	McLeman	978 096.7	978 097.7	2.5 (i)	− 0.2	− 0.5
387		978 089.3	978 097.2	4.7 (i)	− 6.4	− 7.0
388		978 087.0	978 096.0	3.0 (i)	− 8.1	− 8.4
389	Orealla	978 097.1	978 093.2	5.8 (i)	+ 5.7	+ 5.1
390	Separoeta	978 082.8	978 092.0	6.4 (i)	− 7.2	− 7.9
391	Glasgow	978 084.0	978 091.7	11.5 (ii)	− 4.1	− 5.4
392	Wakai	978 085.9	978 092.7	5.0 (ii)	− 5.2	− 5.8
393	Wasjabo	978 086.2	978 091.5	5.6 (ii)	− 3.6	− 4.2
394	Wasjabokreek	978 087.3	978 091.2	9.0 (ii)	− 1.1	− 2.1
395	Apoera	978 091.8	978 091.0	11.0 (ii)	+ 4.2	+ 3.0
396	Apoerakreek	978 086.3	978 090.7	9.2 (ii)	− 1.5	− 2.6
397	Corantijn	978 082.0	978 090.1	6.1 (ii)	− 6.2	− 6.9
398	Savanne	978 082.1	978 091.2	8.0 (ii)	− 6.6	− 7.5
399	Matapi	978 079.8	978 088.6	8.7 (ii)	− 6.1	− 7.1
400		978 077.7	978 088.4	8.4 (ii)	− 8.1	− 9.0
401		978 081.5	978 088.5	9.1 (iii)	− 4.2	− 5.2
402		978 081.4	978 088.3	10.3 (iii)	− 3.7	− 4.8
403		978 082.8	978 088.3	10.8 (iii)	− 2.2	− 3.3
404	Cowfalls	978 092.2	978 088.2	11.4 (iii)	+ 7.5	+ 6.2
405		978 089.7	978 087.8	12.0 (iii)	+ 5.6	+ 4.3
406		978 083.6	978 086.9	12.5 (iii)	+ 0.6	− 0.8
407	Kabalebo	978 080.3	978.086.9	10.6 (iii)	− 3.3	− 4.5
408		978 075.7	978 085.6	12.0 (iii)	− 6.2	− 7.5
409	Kapoerikreek	978 085.1	978 092.6	5.5 (ii)	− 5.8	− 6.4
410		978 083.9	978 092.5	5.8 (ii)	− 6.8	− 7.4
411		978 086.2	978 092.7	6.0 (ii)	− 4.6	− 5.3
412	Guiana B 21	978 106.0	978 103.4	2.5 (i)	+ 3.4	+ 3.1

Table IV (continued)

No.	Station	Observed gravity g	Normal gravity g_0	Elevation (metres)	Free-air anomaly (mgal)	Bouguer anomaly (mgal)
413	Guiana B 20	978 110.5	978 104.3	2.5 (i)	+ 7.0	+ 6.7
414	B 19	978 117.2	978 105.8	2.5 (i)	+12.2	+11.9
415	B 18	978 110.6	978 107.6	2.5 (i)	+ 3.8	+ 3.5
416	B 17	978 113.9	978 108.9	2.5 (i)	+ 5.8	+ 5.5
417	B 16	978 109.5	978 109.9	2.5 (i)	+ 0.4	+ 0.1
418	B 15	978 107.6	978 110.8	2.5 (i)	− 2.4	− 2.7
419	B 14	978 106.3	978 110.8	2.5 (i)	− 3.7	− 4.0
420	B 13	978 110.8	978 110.3	2.5 (i)	+ 1.3	+ 1.0
421	B 11	978 111.9	978 111.4	2.5 (i)	+ 1.3	+ 1.0
422	B 10	978 114.5	978 113.0	2.5 (i)	+ 2.3	+ 2.0
423	B 9	978 114.0	978 114.1	2.5 (i)	+ 0.7	+ 0.4
424	B 8	978 109.8	978 115.4	2.5 (i)	− 4.8	− 5.1
425	B 7	978 106.9	978 116.4	2.5 (i)	− 8.7	− 9.0
426	B 6	978 110.7	978 117.8	2.5 (i)	− 6.3	− 6.6
427	B 5	978 111.3	978 119.5	2.5 (i)	− 7.4	− 7.7
428	B 4	978 112.8	978 120.3	2.5 (i)	− 6.7	− 7.0
429	B 3	978 115.9	978 121.1	2.5 (i)	− 4.4	− 4.7
430	B 2	978 113.4	978 121.7	2.5 (i)	− 7.5	− 7.8
431	B 1	978 122.9	978 121.3	2.5 (i)	+ 2.4	+ 2.1
432	Georgetown (Waterworks)	978 121.5	978 121.3	2.5 (i)	+ 1.0	+ 0.7
433	(Seewall-Vig)	978 113.5	978 121.3	2.5 (i)	− 7.0	− 7.3
434	(Pike-Stanley)	978 115.7	978 121.3	2.5 (i)	− 4.8	− 5.1
435	(Sandy Bab-Stanley)	978 117.5	978 121.3	2.5 (i)	− 3.0	− 3.3
436	(Repentir)	978 122.6	978 121.3	2.5 (i)	+ 2.1	+ 1.8
437	(Ruimveldt)	978 121.8	978 121.3	2.5 (i)	+ 1.3	+ 1.0
438	(Hadfield-Lodge)	978 122.7	978 121.3	2.5 (i)	+ 2.2	+ 1.9
439	(Duncan)	978 118.5	978 121.3	2.5 (i)	− 2.0	− 2.3

APPENDIX B

Table V. Locations of gravity stations in Guiana

Station	Description of locality	Latitude-N	Longitude-W
B 1	Geological Survey Office - Georgetown	6° 48′ 24″	58° 09′ 09″
B 2	Carib (Bel Air)	6° 49′ 40″	58° 07′ 12″
B 3	Lusignan Community Centre	6° 47′ 58″	58° 02′ 15″
B 4	Junction of Enmore & Herslington	6° 45′ 54″	57° 59′ 12″
B 5	Mile Post 22	6° 43′ 06″	57° 55′ 54″
B 6	Mile Post 31	6° 38′ 18″	57° 51′ 48″
B 7	Mile Post 38	6° 34′ 18″	57° 47′ 56″
B 8	Mile Post 45 - Profit	6° 31′ 30″	57° 43′ 30″
B 9	Mile Post 51	6° 27′ 42″	57° 39′ 27″
B 10	Mile Post 57 - Hopetown	6° 24′ 00″	57° 36′ 06″
B 11	Mile Post 63	6° 19′ 24″	57° 34′ 42″
B 13	Government House-New Amsterdam	6° 15′ 07″	57° 31′ 06″
B 14	Mile Post 46 (To Skeldon)	6° 17′ 18″	57° 29′ 09″
B 15	Mile Post 41	6° 17′ 42″	57° 24′ 32″
B 16	Mile Post 35	6° 14′ 48″	57° 20′ 34″
B 17	Mile Post 28	6° 11′ 48″	57° 15′ 36″
B 18	Mile Post 22	6° 07′ 33″	57° 12′ 30″
B 19	Mile Post 15	6° 01′ 57″	57° 10′ 27″
B 20	Mile Post 9	5° 57′ 04″	57° 08′ 52″
B 21	Mile Post 6	5° 54′ 42″	57° 08′ 48″

APPENDIX C

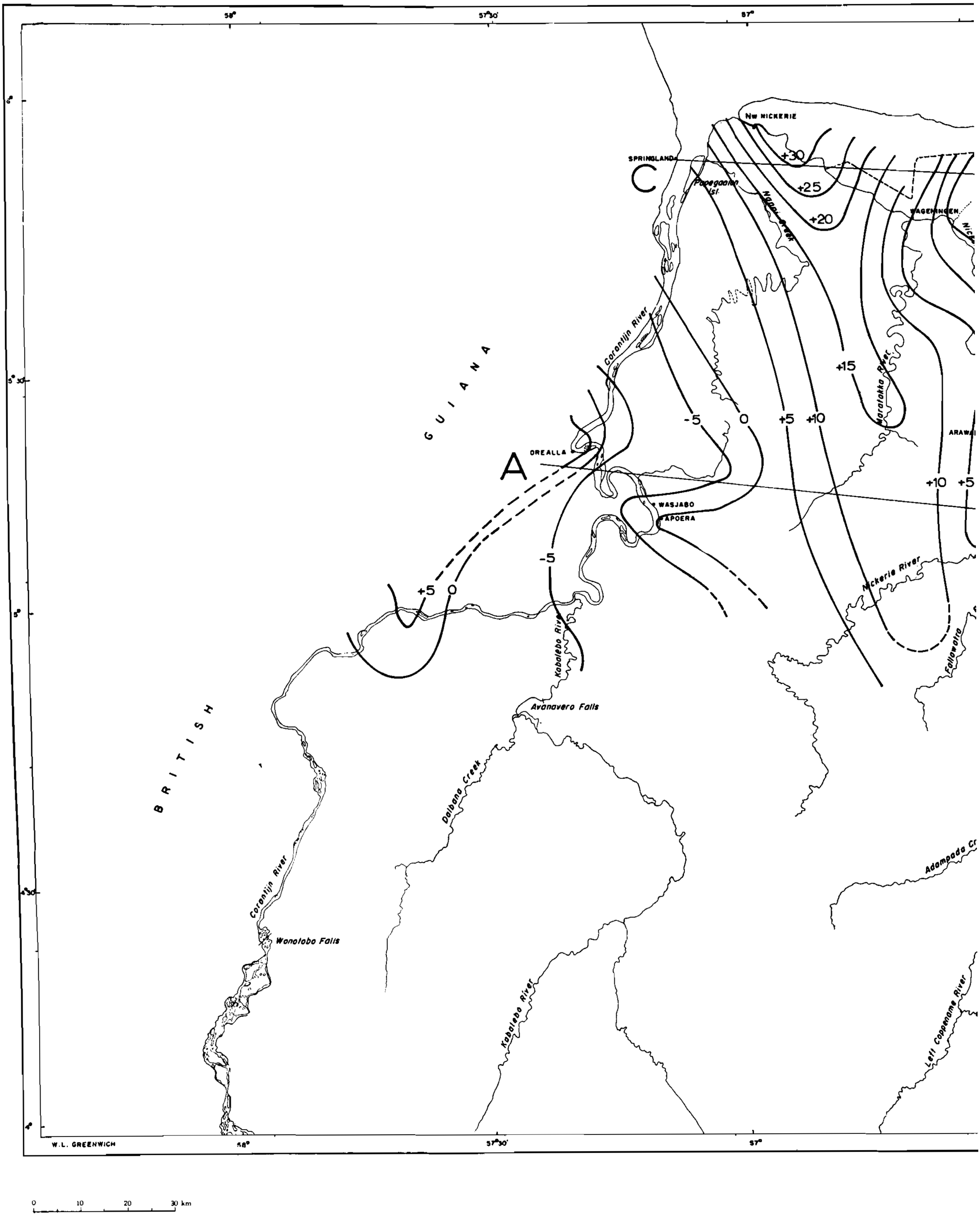
Table VI. Densities of Surinam Rocks

Rock formation	Average density (gm/cc)	Rock formation	Average density (gm/cc)
Roraima sandstone	2.58	Subgrauwacke	2.64
Granite	2.64	Grauwacke	2.72
Biotite granite	2.64	Chlorite schist	2.86
Granodiorite	2.61	Talc schist	2.87
Biotite granodiorite	2.68	Hornblende	2.88
Biotite quartzdiorite	2.66	Amphibole rocks	3.00
Tonalite	2.72	Epidiorite	3.05
Rhyolite	2.64	Dolerite (old)	2.86
Quartzite	2.66	Dolerite (young)	3.04
Gneiss	2.66	Gabbro	3.04
Biotite gneiss	2.80	Norite	3.01
Hornblende gneiss	2.83	Pyroxene diorite	3.03
Granulites	3.03	Pyroxenite	3.25

Map I

Bouguer gravity anomaly map of Northern Surinam

(contour interval: 5 milligal)


58°
57°30'
57°
6°
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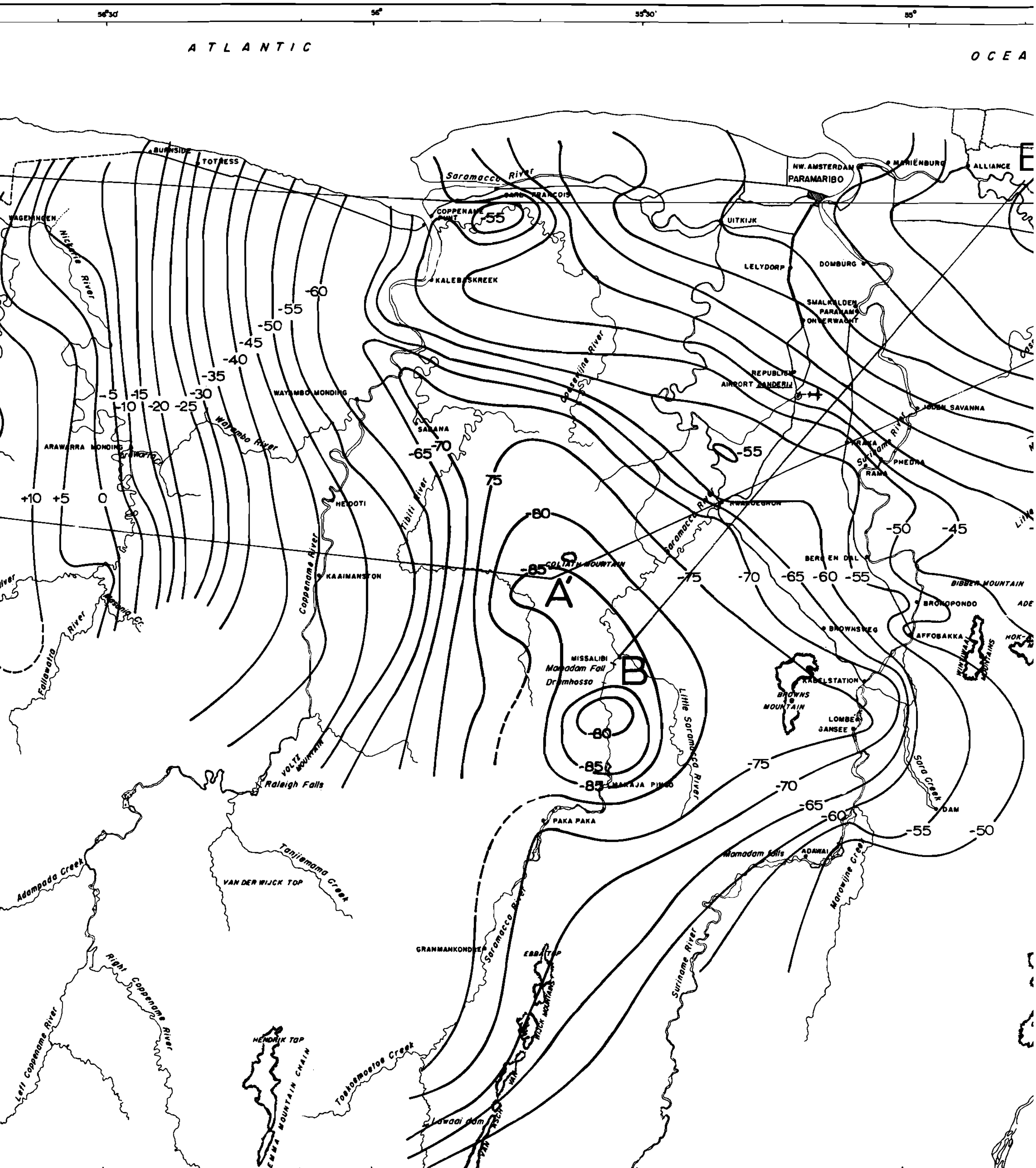
4°30'
4°
Nw NICKERIE
SPRINGLAND
C
Papegaaien Isl.
Nanni Creek
+30
+25
+20
+15
+10
+5
0
-5
WAGENINGEN
Corantijn River
G U I A N A
B R I T I S H
Maratakka River
AREALLA
A
WASJABO
APOERA
Nickerie River
Kabalebo River
Avanavero Falls
Dalbana Creek
Fallawatra
Adampada Cr.
Wonotobo Falls
Left Coppename River
W.L. GREENWICH
0 10 20 30 km



56°30'
56°
55°30'
55°
ATLANTIC
OCEA
BURNSIDE
TOTNESS
WAGENINGEN
Nickerie River
Saramacca River
COPPENAME PUNT
KALEBASKREEK
NW. AMSTERDAM
PARAMARIBO
MARIËNBURG
ALLIANCE
UITKIJK
LELYDORP
DOMBURG
SMALKALDEN
ONVERWACHT
REPUBLIEK
AIRPORT ZANDERIJ
JODEN SAVANNA
Suriname River
PHEDRA
RAMA
WAYAMBO MONDING
Wayambo River
ARAWARRA MONDING
SABANA
Coesewijne River
HEIDOTI
Tibiti River
Coppename River
KAAIMANSTON
GOLIATH MOUNTAIN
BERG EN DAL
BIBBER MOUNTAIN
BRONOPONDO
BROWNSWEG
AFFOBAKKA
MISSALIBI
Mamadam Fall
Dramhosso
KABELSTATION
BROWNS MOUNTAIN
LOMBE
GANSEE
Little Saramacca River
Fallawatra River
Raleigh Falls
VOLTZ MOUNTAIN
PAKA PAKA
Sara Creek
DAM
Mamadam falls
ADAWAI
Marowijne Creek
Tanjiemama Creek
VAN DER WIJCK TOP
Adampada Creek
Right Coppename River
Left Coppename River
GRANMANKONDRE
Saramacca River
EBBA TOP
Suriname River
HENDRIK TOP
EMMA MOUNTAIN CHAIN
Toekoemoetoe Creek
Lawaai dam
A'
B
E
+10
+5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
75
-80
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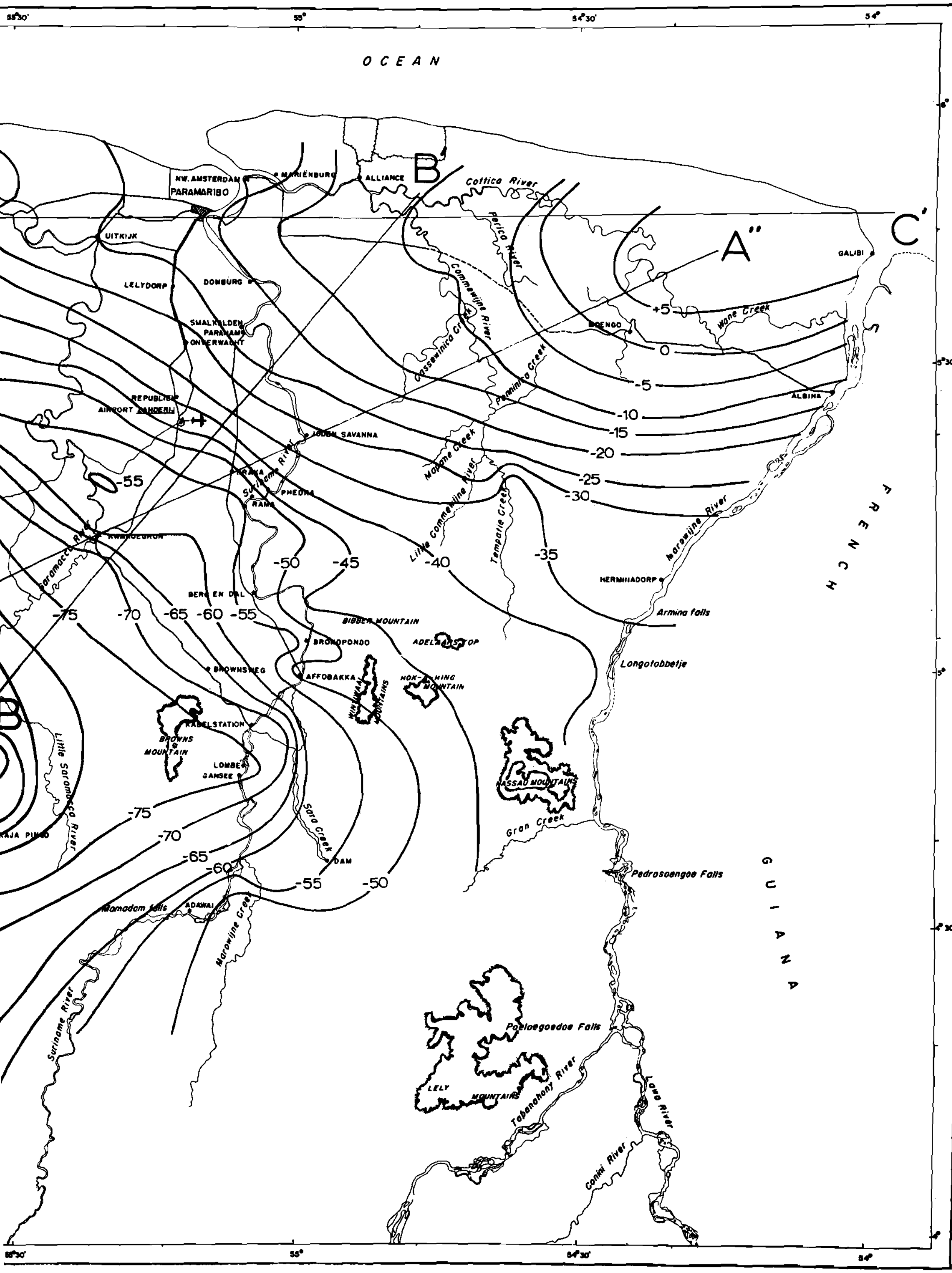
-65
-60
-55
-50



OCEAN
FRENCH
GUIANA
PARAMARIBO
NW. AMSTERDAM
MARIËNBURG
ALLIANCE
UITKIJK
LELYDORP
DOMBURG
SMALKALDEN
PARAHAMS
ONVERWACHT
REPUBLIEK
AIRPORT ZANDERIJ
JODEN SAVANNA
PHEDRA
RAMA
KWAKOEGRON
BERG EN DAL
BROKOPONDO
BROWNSWEG
AFFOBAKKA
KABELSTATION
BROWNS MOUNTAIN
LOMBE
GANSEE
BIBBER MOUNTAIN
ADELAARSTOP
HOK-A-HING MOUNTAIN
NASSAU MOUNTAINS
LELY MOUNTAINS
MOENGO
ALBINA
GALIBI
HERMINADORP
Armina falls
Longotobbetje
Pedrosoengoe Falls
Poeloegoedoe Falls
Mamadam falls
ADAWAI
DAM
Cottica River
Perica River
Commewijne River
Cassewinica Creek
Peminica Creek
Wane Creek
Mapane Creek
Little Commewijne River
Tempatie Creek
Marowijne River
Suriname River
Saramacca River
Little Saramacca River
Sara Creek
Gran Creek
Tapanahony River
Lawa River
Coeroeni River
A''
B'
C'
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-10
-15
-20
-25
-30
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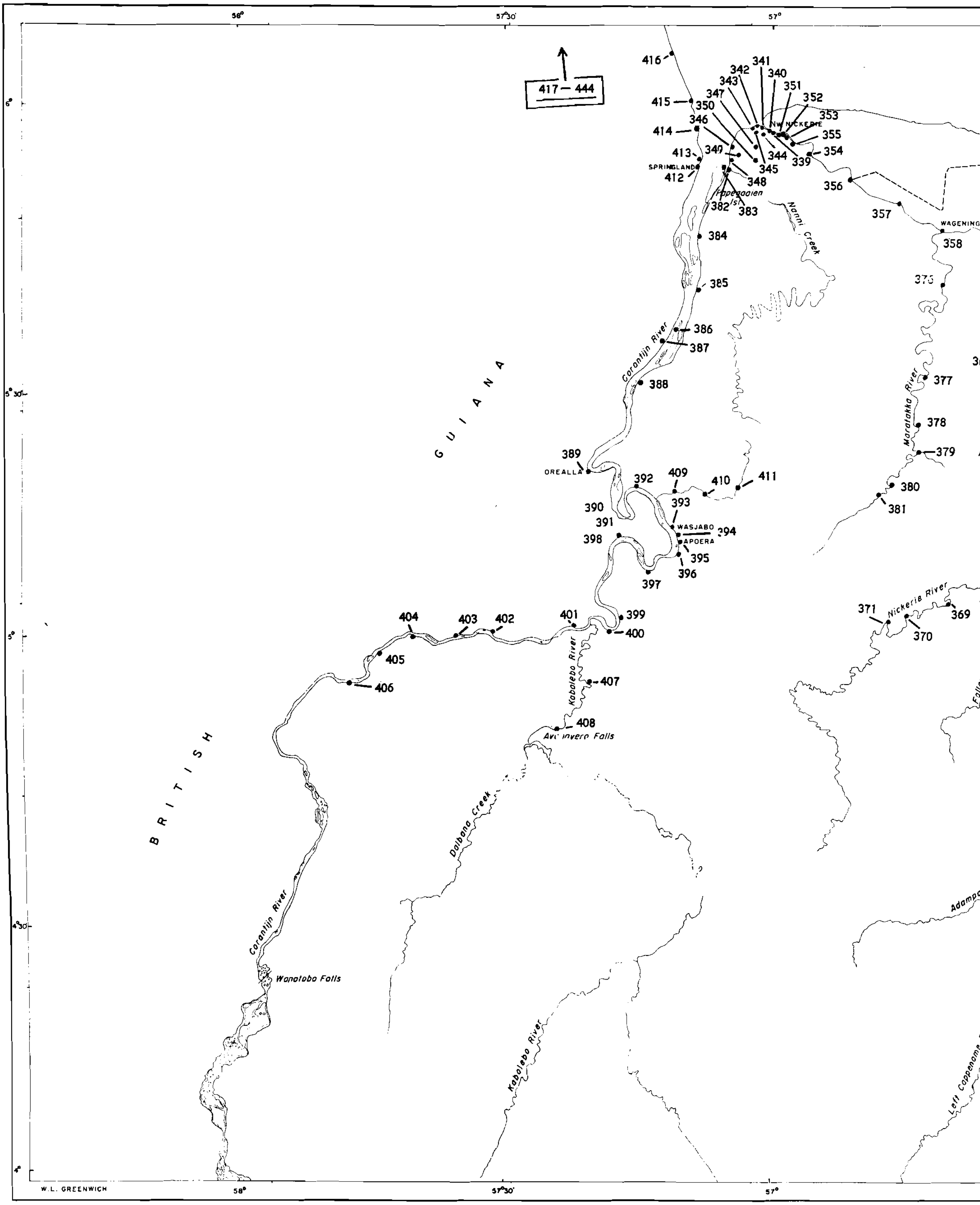
-40
-45
-50
-55
-60
-65
-70
-75
55°30'
55°
54°30'
54°
6°
5°30'
5°
4°30'
4°

Map II

Locations of gravity stations in Northern Surinam

(tables of free-air and Bouguer anomalies for all gravity stations in table IV (Appendix A)



58°
57°30'
57°
6°
5°30'
5°
4°30'
4°
W.L. GREENWICH
417 — 444
BRITISH GUIANA
NW NICKERIE
SPRINGLANDS
Papegaaien Isl.
Nanni Creek
WAGENINGEN
Corantijn River
Maratakka River
OREALLA
WASJABO
APOERA
Nickerie River
Kabalebo River
Dalbana Creek
Wanatobo Falls
Adampa
Left Coppename
416
415
414
413
412
341
342
343
340
347
351
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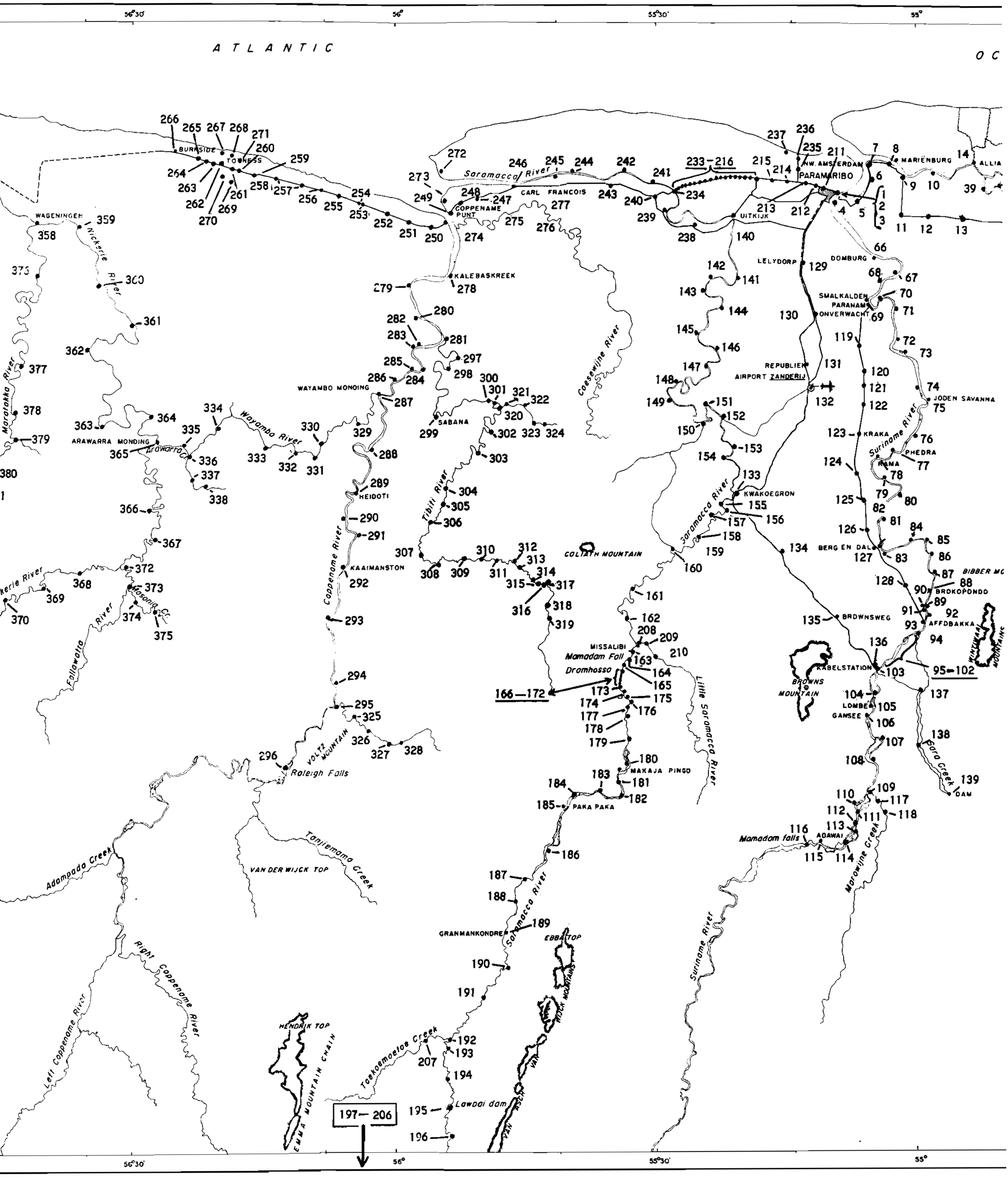
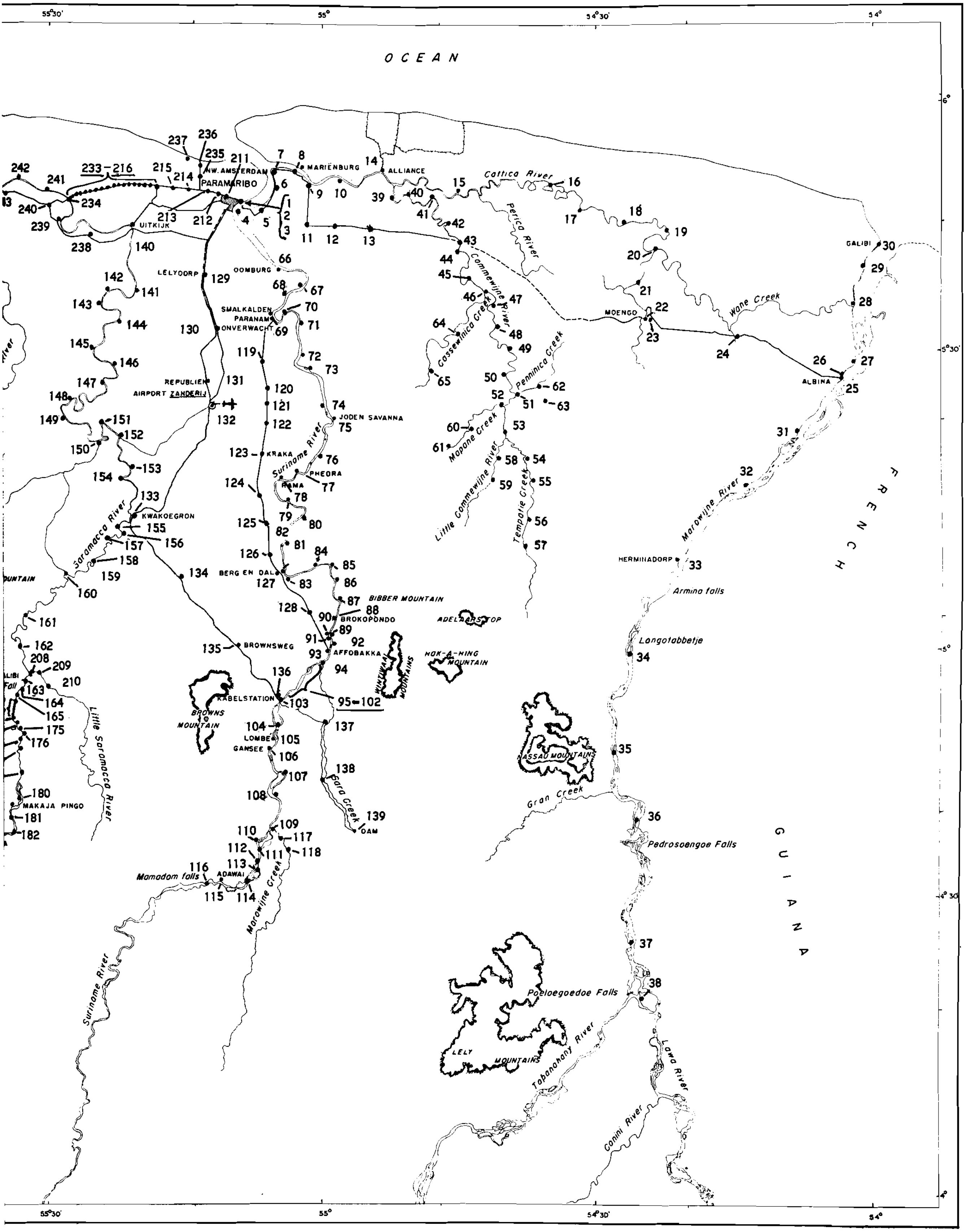
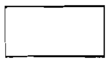
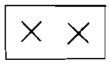
0 10 20 30 km

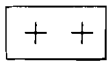

56°30'
56°
55°30'
55°
ATLANTIC
OC
BURNSIDE
TOTNESS
WAGENINGEN
Nickerie River
Saramacca River
CARL FRANCOIS
COPPENAME PUNT
NW. AMSTERDAM
PARAMARIBO
MARIËNBURG
ALLIA
UITKIJK
LELYDORP
DOMBURG
SMALKALDEN
PARANAM
ONVERWACHT
KALEBASKREEK
REPUBLIEK
AIRPORT ZANDERIJ
WAYAMBO MONOING
SABANA
Wayambo River
ARAWARRA MONDING
Arawarra Cr.
Coesewijne River
Tibiti River
Maratakka River
HEIDOTI
KAAIMANSTON
Coppename River
GOLIATH MOUNTAIN
Saramacca River
KWAKOEGRON
BERG EN DAL
BROWNSWEG
KRAKA
JODEN SAVANNA
PHEDRA
RAMA
Suriname River
BIBBER MO
BROKOPONDO
AFFOBAKKA
KABELSTATION
BROWNS MOUNTAIN
WILHELMINA MOUNTAINS
LOMBE
GANSEE
Sara Creek
DAM
MISSALIBI
Mamadam Fall
Dromhosso
166—172
Little Saramacca River
MAKAJA PINGO
PAKA PAKA
Nickerie River
Followatta River
Mosonia Cr.
VOLTZ MOUNTAIN
Raleigh Falls
Tanjiemama Creek
VAN DER WIJCK TOP
Adampada Creek
Right Coppename River
Left Coppename River
GRANMANKONDRE
EBBA TOP
VAN ASCH VAN WIJCK MOUNTAINS
HENDRIK TOP
EMMA MOUNTAIN CHAIN
Toekoemoetoe Creek
Lawbai dam
197— 206
Suriname River
Mamadam falls
ADAWAI
Marowijne Creek

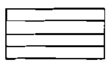

OCEAN
PARAMARIBO
NW. AMSTERDAM
MARIËNBURG
ALLIANCE
Cottica River
Perica River
Commewijne River
Cossewinica Creek
Pennininca Creek
Mapane Creek
Little Commewijne River
Tempatie Creek
MOENGO
Wane Creek
GALIBI
ALBINA
UITKIJK
LELYDORP
OOMBURG
SMALKALDEN
PARANAM
ONVERWACHT
REPUBLIEK
AIRPORT ZANDERIJ
JODEN SAVANNA
KRAKA
PHEDRA
Surinome River
Saramacca River
KWAKOEGRON
BERG EN DAL
BIBBER MOUNTAIN
BROKOPONDO
AFFOBAKKA
ADELAARSTOP
HOK-A-HING MOUNTAIN
NIEUW MOUNTAINS
BROWNSWEG
KABELSTATION
BROWNS MOUNTAIN
LOMBE
GANSEE
Sara Creek
DAM
Mamadom falls
ADAWAI
Marowijne Creek
MAKAJA PINGO
Little Saramacca River
Marowijne River
HERMINADORP
Armina falls
Langotabbetje
NASSAU MOUNTAINS
Gran Creek
Pedrosoengoe Falls
Poeloegoedoe Falls
LELY MOUNTAINS
Tapanahony River
Lawa River
Coeroeni River
FRENCH
GUIANA
55°30'
55°
54°30'
54°
6°
5°30'
5°
4°30'
4°

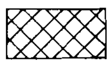
LEGEND

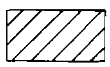

Coastal sediments overlying the Precambrian basement to the north


Mainly granites


Mainly quartz diorites and tonalites, locally migmatites


Armina and Rosebel: predominantly metamorphosed sediments (quartzites, greywackes, phyllites, micaschists etc.)


Paramaka: meta-sediments, meta-volcanics (metamorphosed intermediate, basic and ultrabasic intrusive and extrusive rocks)

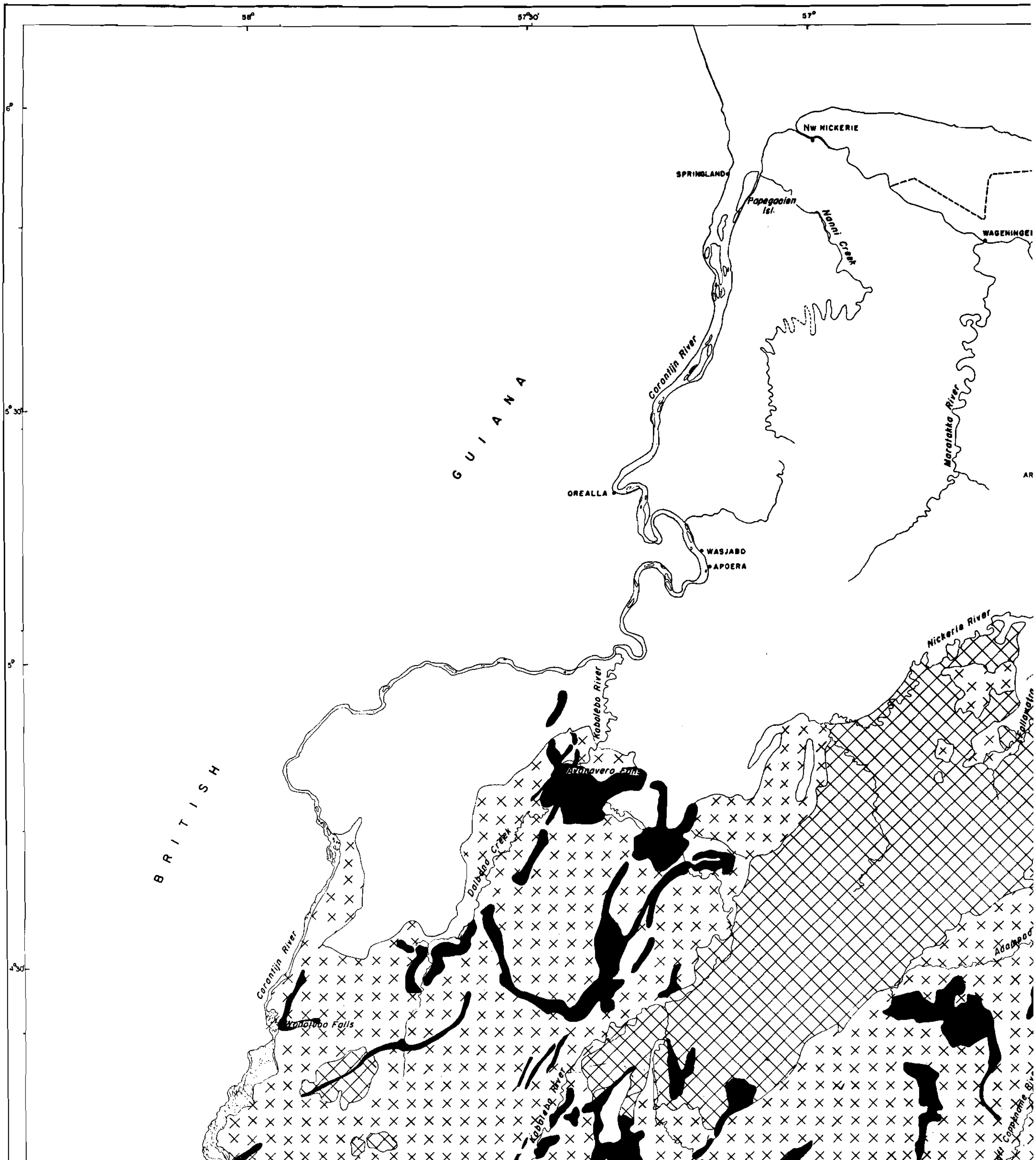

Adampada-Falawatra; mainly pyroxene gneisses and granulites with locally granitic intrusions


Younger Basic Intrusives

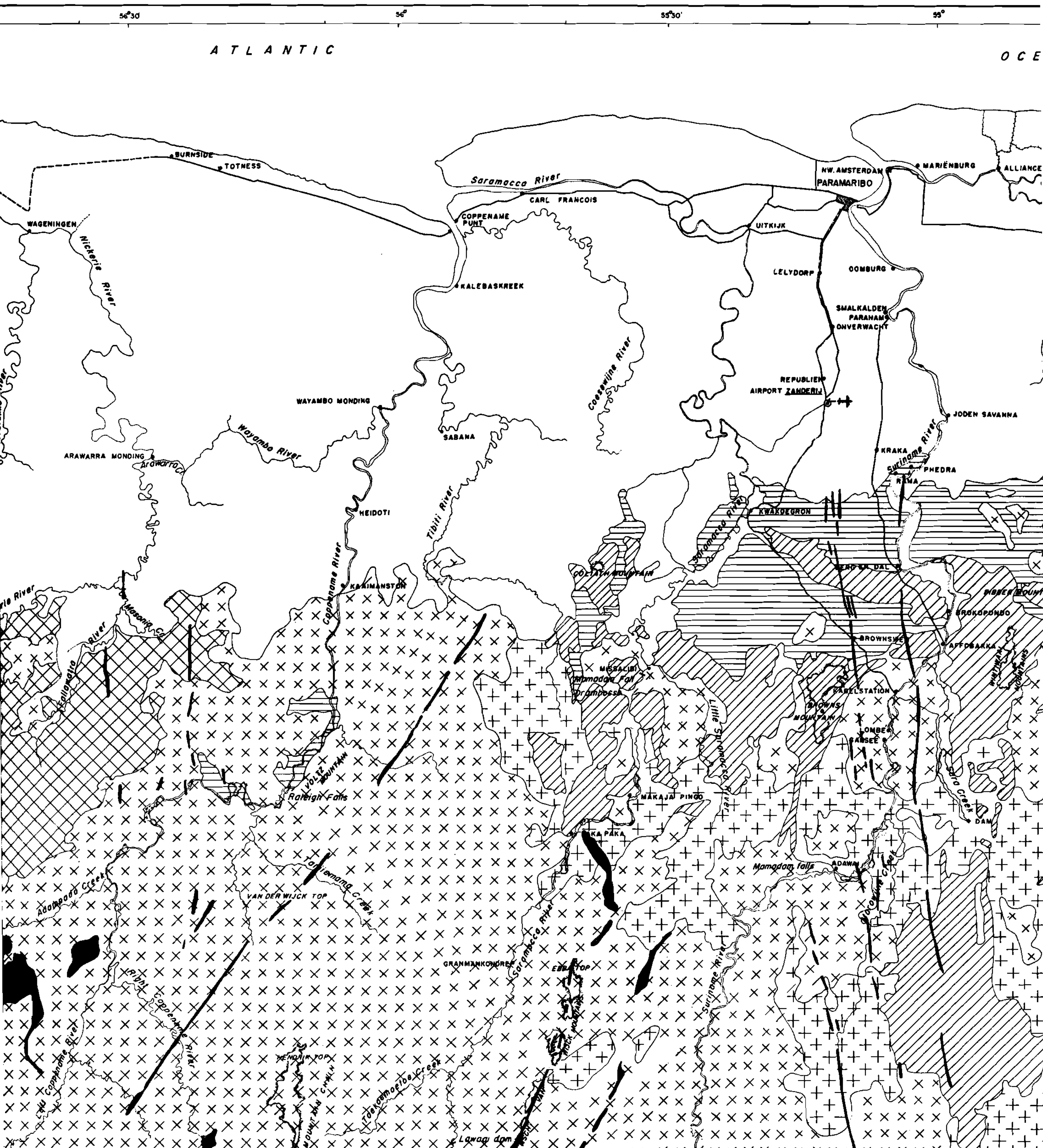
Map III

Geological sketch map of Northern Surinam

This sketch map is based entirely on the photo-geological map presented by O'HERNE in 1966 on the occasion of the Seventh Guiana Geological Conference.



58°
57°30'
57°
6°
5°30'
5°
4°30'
4°
Nw NICKERIE
SPRINGLAND
Papegaaien Isl.
Nanni Creek
WAGENINGEN
Corantijn River
Maratakka River
G U I A N A
B R I T I S H
OREALLA
WASJABO
APOERA
Nickerie River
Kabalebo River
Dalbana Creek
Corantijn River
Kabalebo Falls
Kabalebo River
Coppename River
W.L. GREENWICH
0 10 20 30 km



56°30'
56°
55°30'
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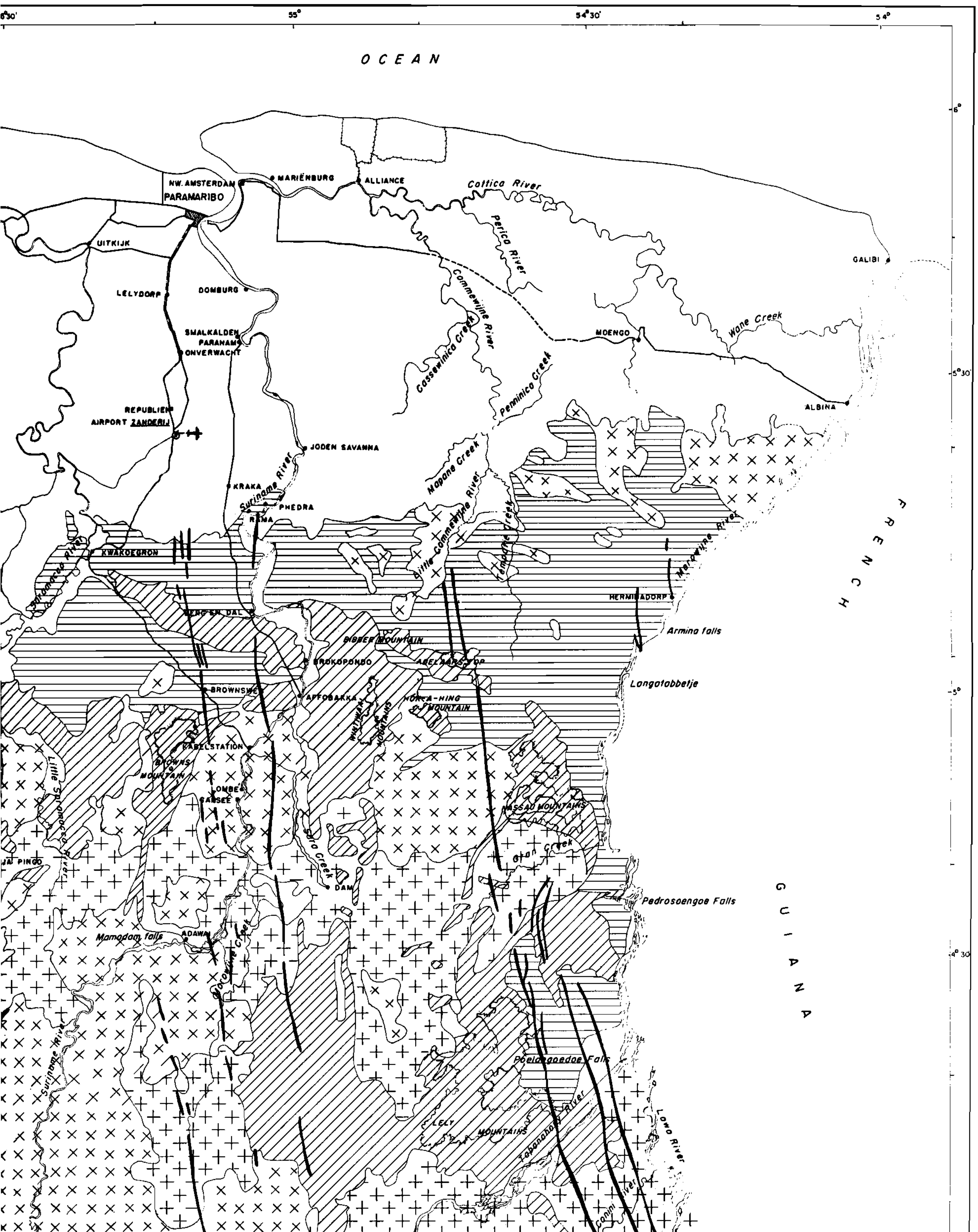
ATLANTIC
OCE
BURNSIDE
TOTNESS
WAGENINGEN
Nickerie River
Saramacca River
CARL FRANCOIS
COPPENAME PUNT
KALEBASKREEK
NW. AMSTERDAM
PARAMARIBO
MARIËNBURG
ALLIANCE
UITKIJK
LELYDORP
OOMBURG
SMALKALDEN
PARANAM
ONVERWACHT
REPUBLIEK
AIRPORT ZANDERIJ
Coesewijne River
WAYAMBO MONDING
Wayambo River
SABANA
ARAWARRA MONDING
Arawarra C.
HEIDOTI
Tibiti River
Coppename River
KWAKOEGRON
JODEN SAVANNA
KRAKA
Suriname River
PHEDRA
GOLIATH MOUNTAIN
KARIMANSTON
BROKOPONDO
AFFOBAKKA
BROWNSWEG
KABELSTATION
BROWNS MOUNTAIN
LOMBE
SAKSEE
VOLTZ MOUNTAIN
Raleigh Falls
MISSALIBI
Mamadam Fall
Drambossa
Little Saramacca River
MAKAJA PINGO
PAKA PAKA
Mamadam falls
ADAWAI
Sara Creek
DAM
VAN DER WIJCK TOP
Tanjiemama Creek
Adampada Creek
Right Coppename River
Left Coppename River
GRANMANKONDRE
EBBA TOP
HENDRIK TOP
Toekoemoetoe Creek
Lawa dam

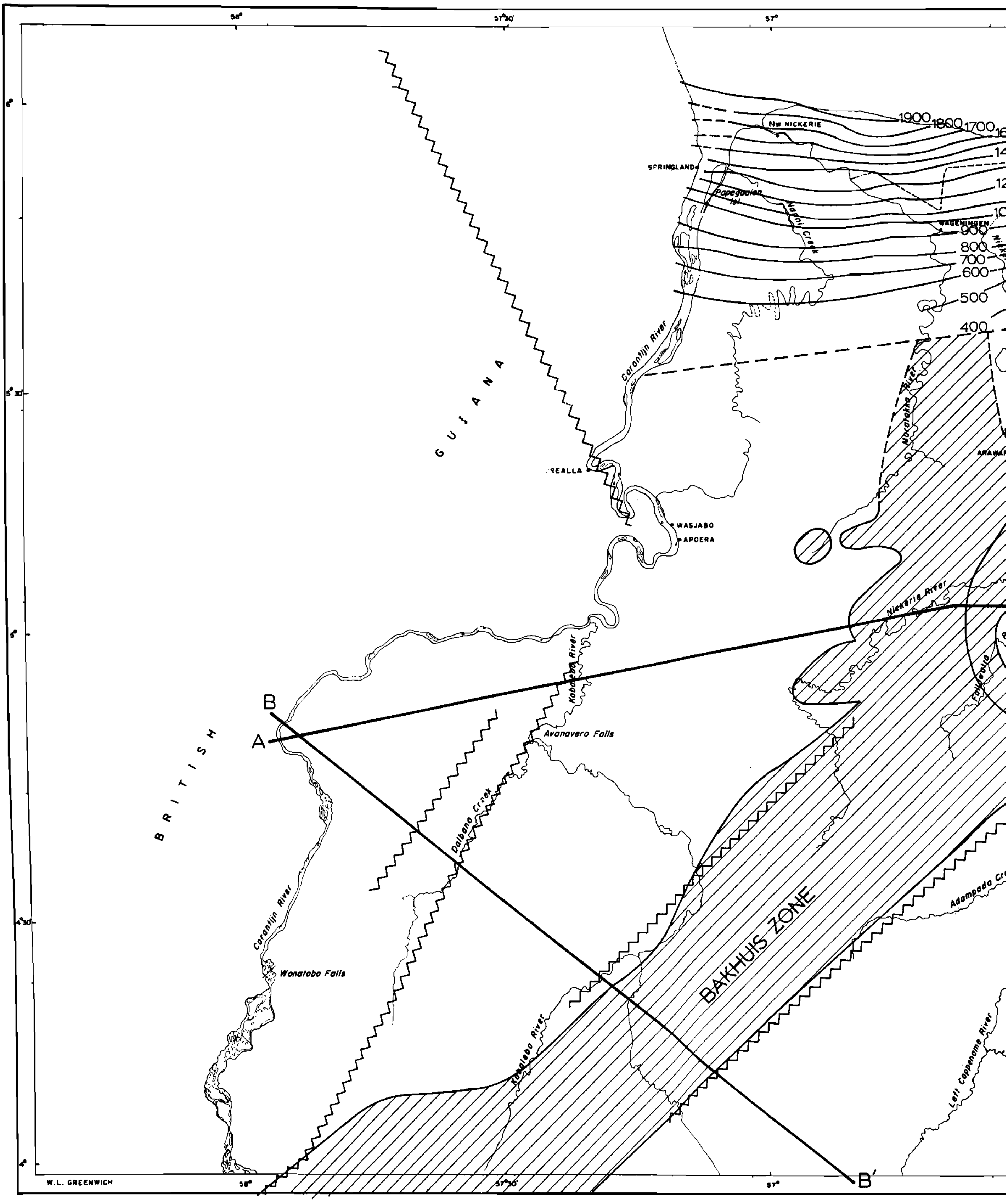


55°
54°30'
54°
OCEAN
6°
5°30'
5°
4°30'
3°
NW. AMSTERDAM
PARAMARIBO
MARIËNBURG
ALLIANCE
Cottica River
Perica River
Commewijne River
Cassewinica Creek
Penninica Creek
Wane Creek
GALIBI
MOENGO
ALBINA
UITKIJK
LELYDORP
DOMBURG
SMALKALDEN
PARANAM
ONVERWACHT
REPUBLIEK
AIRPORT ZANDERIJ
JODEN SAVANNA
KRAKA
PHEDRA
RAMA
Suriname River
Saramacca River
KWAKOEGRON
Mapane Creek
Little Commewijne River
Tempatie Creek
Marowijne River
HERMINADORP
Armina falls
Langatabbetje
FRENCH
GUIANA
BERG EN DAL
BROKOPONDO
BROWNSWEG
AFFOBAKKA
KABELSTATION
BROWNS MOUNTAIN
LOMBE
GANSEE
Little Saramacca River
Sara Creek
DAM
NASSAU MOUNTAINS
Gran Creek
Pedrosoengoe Falls
Mamadam falls
ADAWAI
Poelegoedoe Falls
LELY MOUNTAINS
Tapanahony River
Lawa River
Coeroeni River

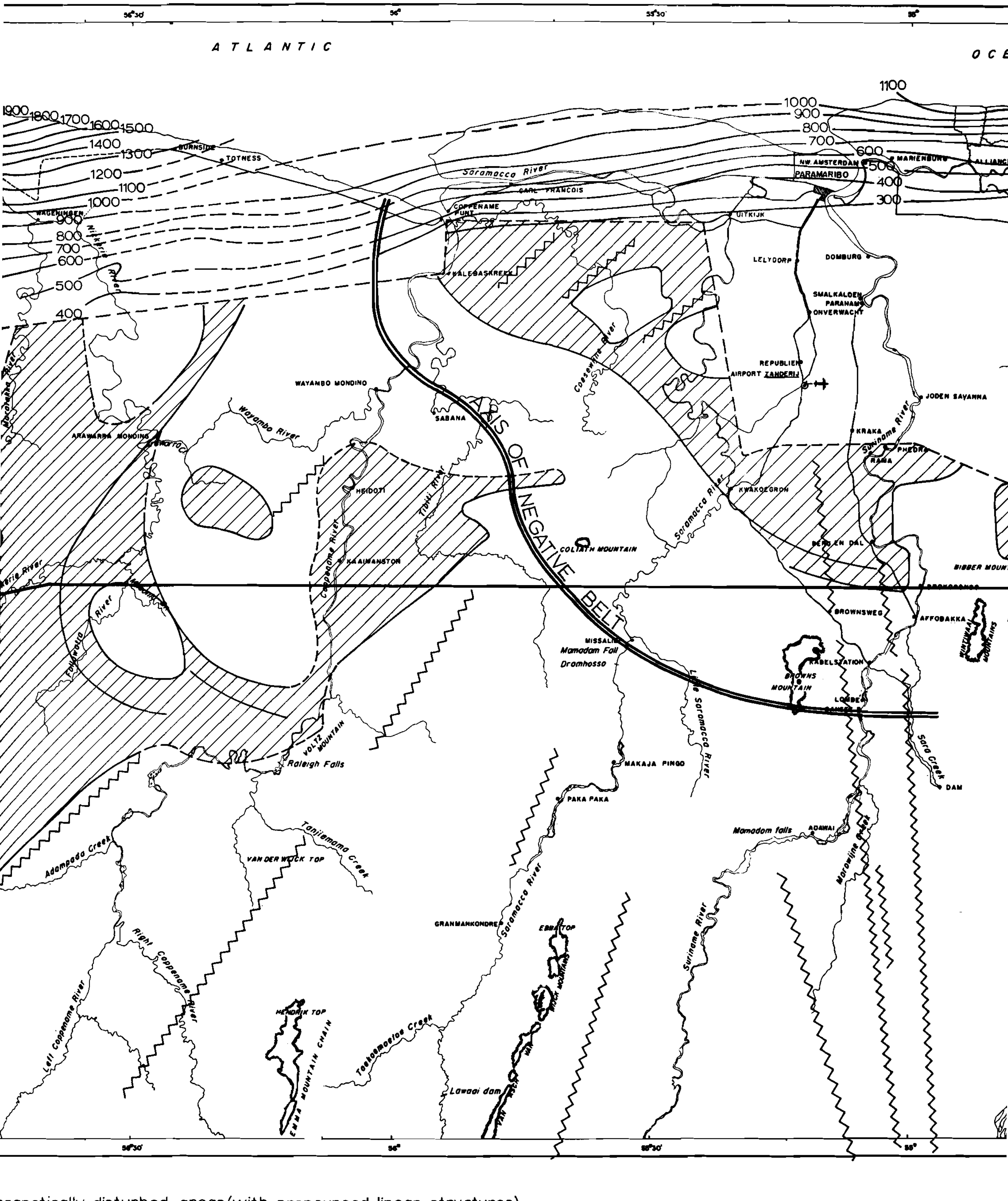
Map IV

Structural map of Northern Surinam

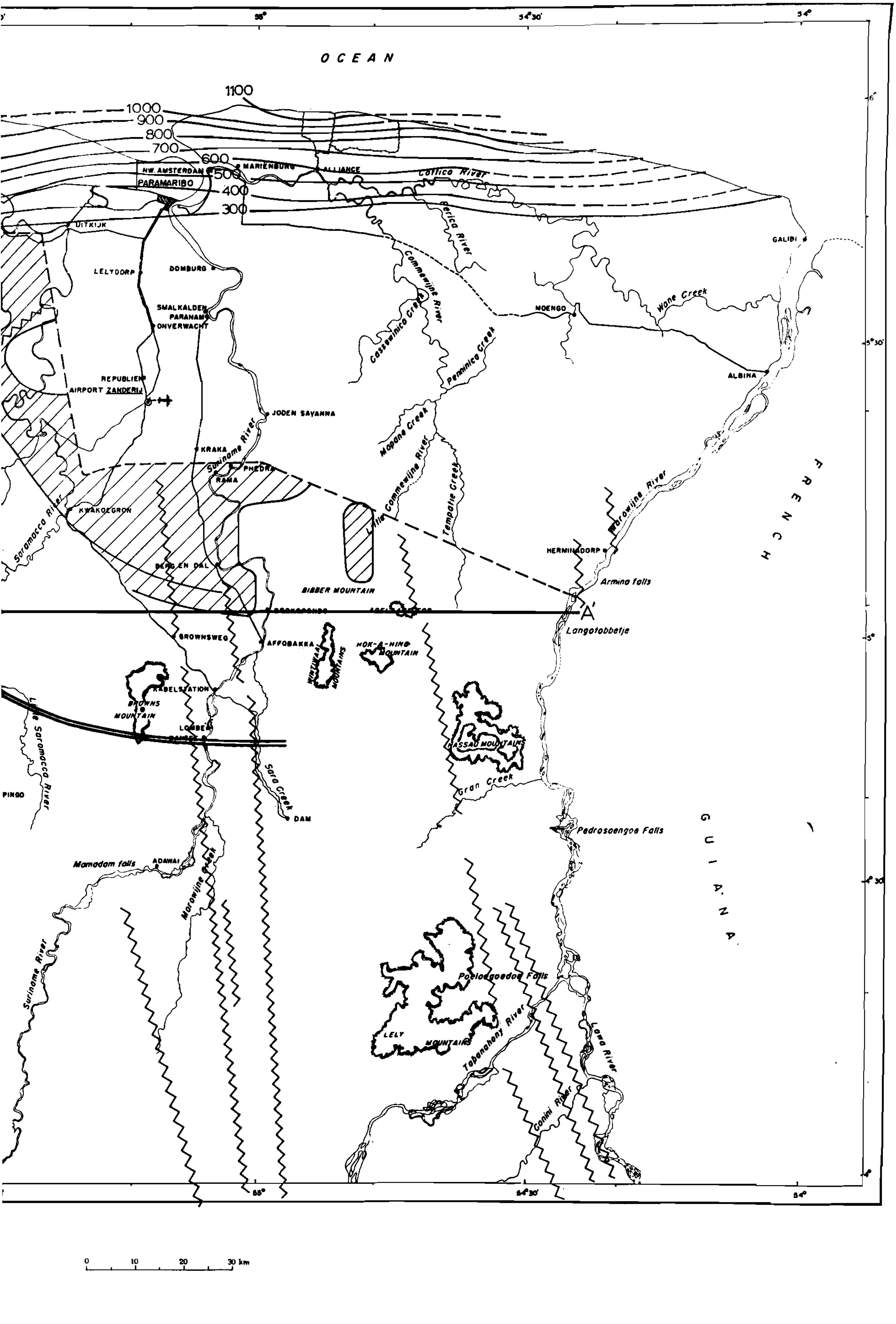
This sketch of the geological structure is based on the results of the geomagnetic and gravitational investigations, while the structural pattern has been complemented by some fault lines and dolerite dykes taken from O'HERNE's photo-geological map (see Map III). The contour lines of the depth of basement below the coastal sediments are based on the results of seismic surveys. The aeromagnetically disturbed regions of northern Surinam only extend over an area which is bounded on the north by a dotted line indicating the part of northern Surinam covered by the aeromagnetic surveys of 1959 and 1963.



Axis of negative belt(negative gravity anomalies)
Structural lines(main faults and dolerite dykes)
Aeromagnetically c
—1100— Countour lines of c



agnetically disturbed areas(with pronounced linear structures)
our lines of depth of basement below coastal sediments


OCEAN
1100
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900
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300
NW. AMSTERDAM
PARAMARIBO
MARIENBURG
ALLIANCE
Cottica River
Perica River
Commewijne River
Cassewinica Creek
Penninica Creek
Mapane Creek
Little Commewijne River
Tempatie Creek
UITKIJK
LELYDORP
DOMBURG
SMALKALDEN
PARANAM
ONVERWACHT
REPUBLIEK
AIRPORT ZANDERIJ
JODEN SAVANNA
KRAKA
Suriname River
PHEDRA
RAMA
KWAKOEGRON
Saramacca River
BERG EN DAL
BIBBER MOUNTAIN
BROWNSWEG
AFFOBAKKA
HOK-A-HING MOUNTAIN
WINTIWAAI MOUNTAINS
KABELSTATION
BROWNS MOUNTAIN
LOMBE
Little Saramacca River
Sara Creek
DAM
PINGO
Mamadam falls
ADAWAI
Marowijne Creek
Surinama River
NASSAU MOUNTAINS
Gran Creek
MOENGO
Wane Creek
GALIBI
ALBINA
Marowijne River
HERMINADORP
Armina falls
A'
Langatabbetje
Pedrosoengoe Falls
Poeloegoedoe Falls
LELY MOUNTAINS
Tapanahony River
Gonini River
Lawa River
FRENCH
GUIANA
55°
54°30'
54°
6°
5°30'
5°
4°30'
4°
0
10
20
30 km

PART II

GRAVITY ANOMALIES IN THE NETHERLANDS LEEWARD ISLANDS AREA – A SUMMARY

by

R. A. LAGAAY

CONTENTS

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PREFACE

In 1962 a gravimetric and geomagnetic survey was carried out in the Netherlands Leeward Islands Aruba, Bonaire and Curaçao and in 1964–1965 this survey was extended to the sea surrounding these islands. The following is a summary of the gravity results described more fully in: R. A. LAGAAY, Geophysical Investigations of the Netherlands Leeward Antilles (1969).

The initiative to the gravity survey in Aruba, Bonaire and Curaçao has been taken by Prof. VELDKAMP and the measurements were carried out by the author in the period May–September 1962.

The observations on the islands could not have been possible without the co-operation of many. The Head of the Cadastral Survey Department of the Netherlands Antilles at Willemstad, Curaçao, Ir. J. MEUTER, generously provided transport facilities and assistance during the measurements. Special mention is made of the assistance of Ir. J. DIJKHOUT and Mr. E. DE SERA, the latter from KLM-Aerocarto, during the measurements on Aruba and Bonaire respectively. Gratefully acknowledged are Dr. I. KRISTENSEN, then Director of the Caribbean Marine Biological Institute, and Dr. E. J. VAN DER KUIP, then Head of the Veterinary Department of Aruba, who were of much help in various ways.

The government of the Netherlands Antilles, and the local governments on the islands are thanked for their co-operation in obtaining access to the various private properties on the islands, and providing various indispensable facilities for the survey. In this respect the Head of the Technical Economic Council of the Netherlands Antilles, Dr. P. C. HENRIQUEZ, has been very helpful.

In 1964–1965 the Hydrographer of the Royal Netherlands Navy, Rear Admiral Ir. W. LANGERAAR, allowed H. Neth. M.S. "Snellius", in addition to her task in the NAVADO III-expedition, to sail courses around the Netherlands Antilles during which the continuous gravity measurements were made used in this study.

The officers of H.Neth.M.S. "Snellius" were at that time:
Lieutenant Commander F. BRABANDER, Commanding Officer
Lieutenant Commander J. P. H. HUIJSKENS, Project Co-ordinator
Lieutenant A. KAMP, Executive Officer
Lieutenant A. J. A. SCHOEVERS, Chief Engineer
Lieutenant L. H. VAN OPSTAL, Navigator
Lieutenant P. B. VAN DE CLOOSTER BARON SLOET TOT EVERLO
Lieutenant L. B. CORNELISSE
Lieutenant T. R. DEELDER
Lieutenant K. J. VAN MEEL
Lieutenant W. M. D. VOGT
Lieutenant R.N.N.R. J. S. A. VAN DER LINDEN, Surgeon
Sub Lieutenant R.N.N.R. R. E. M. G. LA GRANGE
Observers on board were Ir. G. L. STRANG VAN HEES, Ir. T. J. POELSTRA of the Geodetic Institute of the Delft University of Technology and Dr. B. J. COLLETTE and Mr. J. A. SCHOUTEN of the Vening Meinesz Laboratory at Utrecht. Thanks are due to Prof. Ir. G. J. BRUINS for his permission to use the sea-gravimeter of the Delft University of Technology.

The computing programme for the reduction of the gravity observations was made together with Dr. B. J. COLLETTE. Assistance was kindly given by Mr. E. M. J. BERTIN and Mr. G. J. A. JANSEN of the Electronic Computing Centre at Utrecht. Discussions on the geology of the Caribbean with Prof. Dr. M. G. RUTTEN, Prof. Dr. H. J. MAC GILLAVRY, Dr. J. H. WESTERMANN, Mr. D. J. BEETS and Mr. P. H. de BUISONJÉ were very much appreciated by the author.

Financial support for the survey was provided by the Netherlands Foundation for Advancement of Research in Surinam and the Netherlands Antilles (WOSUNA) and the Netherlands Organization for the Advancement of Pure Research (ZWO).

To all those who contributed with their generous help to the preparation of this work the author offers his heartfelt thanks. With particular gratitude Dr. B. J. COLLETTE is mentioned for many stimulating discussions and his most generously offered co-operation.

R. A. LAGAAY

Chapter 1

PENDULUM STATIONS

In previous years a fairly large number of gravity measurements has been made in the southern part of the Caribbean Sea, see Figure 1. The earlier gravity measurements were made with the pendulum apparatus during cruises of Netherlands and American submarines. The first gravity observations in the Caribbean area were carried out by VENING MEINESZ (1934) during a cruise of H.Neth.M.S. "K XIII" in 1926. In the southern Caribbean 5 stations were occupied (numbers 71–75), of which station 73 is located in what is now known as a zone of negative anomalies off the north coast of the South American continent. Station 71 is situated in the harbour of Willemstad, Curaçao, and gives evidence of the large positive anomaly in that area, which is part of the positive zone coinciding with the Netherlands Leeward islands. A second gravity expedition was undertaken by VENING MEINESZ (1948) on board H.Neth.M.S. "O XII", which in 1937 occupied 8 gravity stations (816–823) in the southern Caribbean.

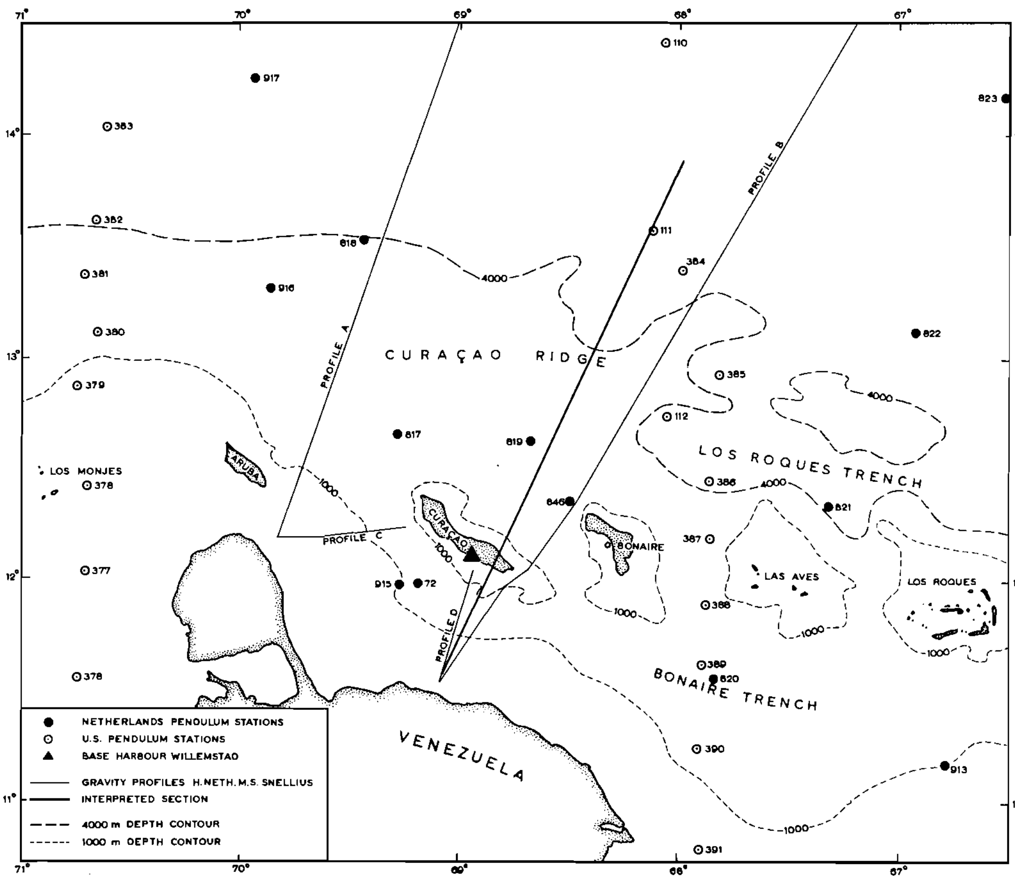

Figure 1

During a cruise of U.S.S. "Barracuda" from Coco Solo to Port of Spain 14 observations were made (serial numbers 104–117) (EWING, 1937 and HESS, 1937). In 1947 fifty two observations, located on profiles that are approximately normal to the north coast of South America, were carried out on board U.S.S. "Conger" (serial numbers 359-410) (EWING, WORZEL and SHURBET, 1957). The isostatic reductions of the gravity measurements during the cruises of U.S.S. "Conger" and U.S.S. "Barracuda" were carried out by KÄRKI and PAANANEN (1961).

The last pendulum stations in the area were made during cruises of H.Neth.M.S. "O 24" (1949), H.Neth.M.S. "Tijgerhaai" (1951) and H.Neth.M.S. "Walrus" (1957). Stations 845–849, 907–918, 954 and 1017–1032 of these cruises are located in the southern Caribbean (BRUINS, DORRESTEIN, VESSEUR, BAKKER and OTTO, 1960).

The fairly large number of gravity observations enables one to construct an anomaly map as has been done by DE BRUYN (1951). DE BRUYN did not yet have at his disposal the data of the "Conger" cruise and the Netherlands cruises of 1949–1957, so that large parts of his map were left blank. DE BRUYN (1951), HESS (1938) and VENING MEINESZ (1964) interpreted the pattern of gravity anomalies in the Caribbean area. The region of the Netherlands Leeward Antilles is referred to briefly in these studies; it is generally thought by these authors that plastic buckling of the crust brought about the zone of negative anomalies in the southern Caribbean. HAMBLETON interpreted a gravity and seismic profile at 68 °W. His section appeared in WORZEL's book (1965, figure 16) who prefers crustal extension to be responsible for the formation of trenches and negative anomaly belts.

Chapter 2

THE OBSERVATIONS

2.1 Observations on the islands (1962)

In the period from May to August 1962 over 250 stations were occupied on Aruba, Curaçao and Bonaire. The observations were made with the North American Gravimeter No. 105. The stations were located on or close to bench-marks of the Cadastral Survey Department of the Netherlands Antilles, so that geographical co-ordinates could be obtained from the grid co-ordinates of the bench marks.

These co-ordinates were provided by the Cadastral Survey and K.L.M. Aerocarto at Delft. The (y,x) grid of the islands (1963 map issue) based on the Universal Transverse Mercator Projection on the international spheroid, was converted into geographical co-ordinates (φ,λ) using the relations:

$$30.73(\varphi_c-\varphi) = y_c-y$$
$$30.19(\lambda_c-\lambda) = x-x_c$$

where (φ_c,λ_c) and (y_c,x_c) are the geographical and grid co-ordinates of the reference point of the map grid respectively, expressed in seconds and metres. The new co-ordinates of the islands appeared to be shifted with respect to those given on the old topographic maps of 1911. As a result the geographical co-ordinates for the pendulum harbour station Curaçao III, as determined from the new topographic maps, (12°07′11.0″ N - 68°55′46.0″ W), differ from the co-ordinates given earlier (12°06′45″N - 68°55′26″W).

The distance between the gravity stations was as a rule about 1 km. The selection of the site of the stations was limited by the accessibility of the terrain and by the presence of bench-marks. The observations were made with the assistance of a surveyor of the Cadastral Survey Department.

Before and after the survey the scale factor was determined in the tower of the Meteorological Institute at De Bilt, giving a value of 0.09000 mgal /division, no change occurring in the interval. The drift of the N.A.G. No. 105 was generally small. Calculated from periods of 96 hours it appeared to be about 0.001 scale unit per hour. Rough transport conditions sometimes produced jumps; if such a jump occurred, the stations were reoccupied.

All values refer to the pendulum station Curaçao III (BRUINS, DORRESTEIN, VESSEUR, BAKKER and OTTO, 1960; our station No. 7). This station is situated in the Diesel-engine room of the naval base Parera, Willemstad, Curaçao. Pendulum observations have been carried out at the site during two cruises, giving the following values:

Station	Serial number	Year	Gravity in mgal
Curaçao III	845	1949	978 441
	914	1951	978 442

The value used for the observations in the Antilles is 978 441 mgal

2.2 Observations at sea (1964-1965)

At the request of the author H.Neth.M.S. "Snellius" made two approximately north-south running traverses in the Caribbean Sea; one through the Aruba-Curaçao passage and one through the Curaçao-Bonaire passage (see Figure 1). The gravity measurements were made within the framework of in the Navado III-project (1964–1965). The instrument used was the Askania sea-gravimeter Gss 2-No. 19 of the Geodetic Institute at Delft.

The observations were corrected for instrumental drift and for the Eötvös effect. The Eötvös effect was computed assuming constant speed and course between successive navigational fix points. Under normal conditions the accuracy in the Eötvös correction was about 4 mgal. The error in the Eötvös correction for the traverse Curaçao-Venezuela-Bonaire/Curaçao passage is however greater because of troubles with the ship's gyrocompass and radar. On this traverse (lines *D* and *B* in Figure 1) the accuracy of the navigation was estimated by the navigation officer to be ± 2 nautical miles. The estimated accuracy at the endpoint of the track is ± 7 nautical miles. This means that the error in the Eötvös correction for this traverse is less than 10 mgal, which is acceptable for our interpretation of the gravity data. The cross-coupling effect has not been measured. The sea was calm during the measurements.

Chapter 3

THE REDUCTIONS

3.1 General

For the computation of the free-air anomalies, Bouguer anomalies and isostatic anomalies the normal procedure (cf. HEISKANEN and VENING MEINESZ, 1958) was used with the exception of the reduction for the land stations. These latter reductions were computed, using an electronic computer. The isostatic anomalies are based on the Airy-Heiskanen system, with a crustal thickness of 30 km and local compensation. A curstal density of 2.67 gm/cc and a mantle density of 3.27 gm/cc were used.

3.2 Reduction of the observations on land

The major advantage of the use of an electronic computer lies in the time saved, since topographic heights need to be read only once and not, as in conventional zone chart method, for each station separately. The method is only advantageous for areal surveys, and not for the reduction of widely-spread measurements. The programme utilized for the computations is an extension of the one described by BOTT (1959) for the terrain corrections.

A complete discussion of the method appeared in LAGAAY (1969). The topography is divided in a grid of equal squares of which the average height is estimated. The gravitational effect of a square can be represented by that of a segment of a hollow cylinder. Formulae were thus derived for the computation of the topographic and isostatic corrections, with the exception of the area closer than 1 km around the station, for which the zone chart method must be used. The corrections for topography and its compensation for the zones 18–1 were read from the world reduction maps of KÄRKI, KIVIOJA and HEISKANEN (1961) for the Airy-Heiskanen system $T = 30$, $R = 0$. The error resulting from the computer method is estimated not to exceed 5%.

Tables 1, 2 and 3 contain for each island:

1. Station number
2. Latitude
3. Longitude
4. Station height in metres
5. Free-air anomaly
6. Bouguer anomaly, including topographic corrections for the zones $A - O_2$.
7. Isostatic anomaly ($T = 30$, $R = 0$).

The anomalies are given with regard to normal gravity values according to Cassinis' formulae.

3.3 Reduction of the observations at sea

The normal value of gravity and the Eötvös effect were computed at the navigational fixes by linear interpolation of these values. The free-air anomaly curve was obtained by graphical interpolation.

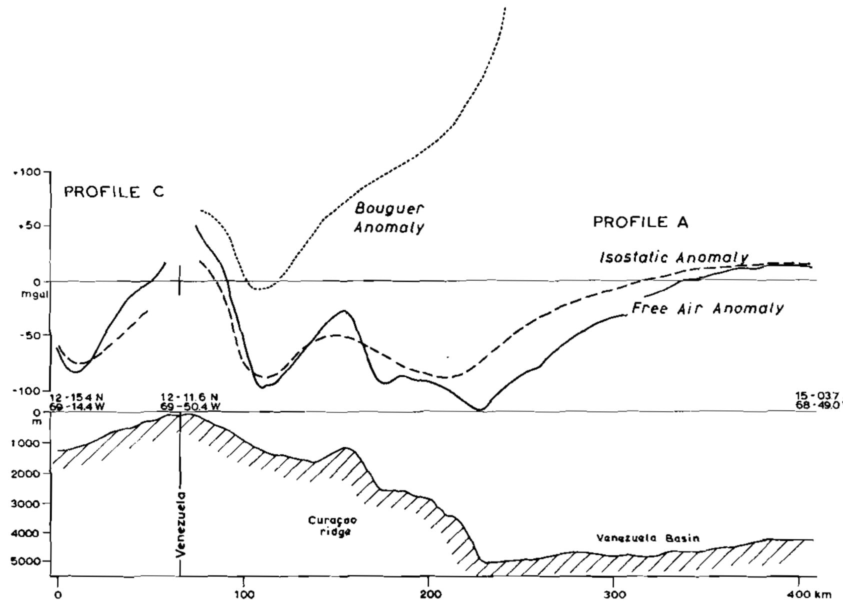

Figure 2

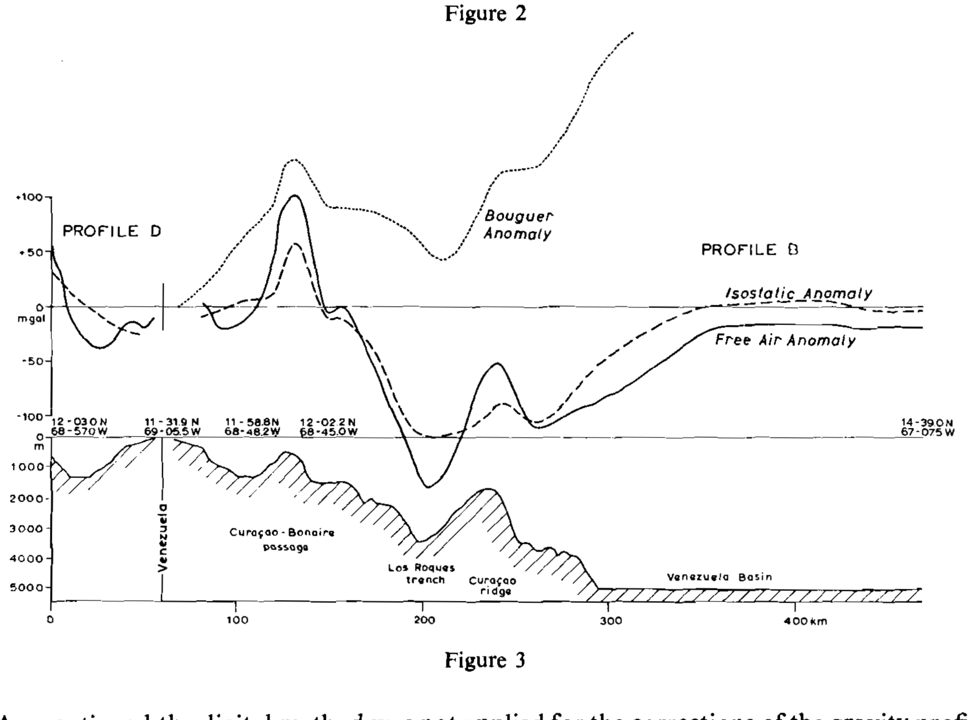

Figure 3

As mentioned the digital method was not applied for the corrections of the gravity profiles at sea, since the method is only of advantage for areal surveys. The topographic corrections and the correction for the compensation were computed with the aid of the tables of LEJAY (1947, topographic correction for the zones A to O_2), of VENING MEINESZ (1941, correction for the compensation for the zones A to O_2) and the isocorrection charts of KÄRKI, KIVIOJA and HEISKANEN (1961, topography and compensation for the zones 18–1). The complete correction curve along the ship's track was obtained by graphical interpolations. The corrections for the nearby zones were computed for a larger number of points along the track than for the zones farther away. The corrections for zones *A–H* were computed every 7 miles, for zones *I–L* every 14 miles, for zones M–O_2 every 20 miles and for zones 18–1 every 30 miles.

The gravity anomaly profiles based on the observations on board H.Neth.M.S. "Snellius" are presented in Figures 2 and 3. The curves of free-air anomalies, Bouguer anomalies (topographic correction out to zone O_2) and local isostatic anomalies are given together with the bathymetry. With regard to the bathymetric profile it is noted that the depths have been corrected for the speed of sound in water by means of Matthew's tables (1939).

The free-air anomalies for the traverse through the Curaçao-Aruba passage (Figure 2) have been computed by Ir. G. L. STRANG VAN HEES of the Geodetic Institute at Delft.

Table 4 contains:

1. Indication of profile
2. Latitude
3. Longitude
4. Seadepth in metres
5. Free-air anomaly
6. Bouguer anomaly, including topographic corrections for the zones A–O_2
7. Isostatic anomaly ($T = 30$, $R = 0$)
8. Effect of topography, zones A–O_2
9. Local Airy reduction, effect of compensation, zones A–O_2, $T = 30$
10. Local Airy reduction, effects of topography and compensation, zones 18–1, $T = 30$

Chapter 4

INTERPRETATION

The area of the Netherlands Leeward Islands forms part of the southern Caribbean zone of gravity anomalies (VENING MEINESZ, 1964). This zone stretches from east of the island of Grenada along the coast of Venezuela in a direction of about 100° to the Goajira peninsula, then turns around this peninsula, continues in a direction of 55° and seems to end abruptly off the delta of the Magdalena river. With some offset to the west the anomaly belt may then be followed on land along the Magdalena and Cauca river basins in Columbia, but in that area it becomes more patchy. Largest negative values in the belt are found north of Los Roques (−148 mgal) and west of Goajira (−118 mgal). Adjoining at the southern flank of the negative belt runs a belt of positive anomalies. This zone coincides with the Netherlands Antilles and turns further westward into Goajira. Anomaly values of more than +100 mgal are present on the island of Curaçao.*).

An important observation can be made concerning the relations of the bathymetry and the isostatic anomalies: the anomalies do not strictly follow topographic trends, as demonstrated by the positive zone which in one part coincides with the Netherlands Antilles and in another part with the Bonaire trench.

The section interpreted runs across Curaçao and is about perpendicular to the anomalies.**) The result of the isostatic interpretation is given in Figure 4. The structures are assumed to be two-dimensional

From north to south it shows:

a. A thick layer of material of low density, presumably sediments, beneath the main negative anomaly. The thickness of this layer was inferred after some modification from HAMBLETON's data at 68 °W. The lower boundary of the crust is too low with respect to its normal position (short-dashed line). The long-dashed line gives the equilibrium position of the crust with the interpreted inhomogeneities, so that the difference between this line and the given underside of the crust is a measure for the deviation from isostatic equilibrium. Remarkable in this respect is that the Aves islands, lying in this zone, have been subject to subsiding movements since Lower Miocene (DE BUISONJÉ, 1964). Forces therefore act which since that time more than counterbalanced the upward forces of the anomalous masses and at present at least sustain the anomaly. Computed over a column of 30 km the vertical component of these forces is about 5% of the total pressure.

A shallow body of higher density and a raising of the crustal interfaces parallel to the outline of the Curaçao ridge explain the secondary bulge in the negative anomaly. It is noted that the position of the shallow body could as well be deeper than given here.

b. A body of high density material produces part of the positive anomaly of Curaçao. This body is identified with the basic volcanics forming the core of the islands. Its thickness

*) From the isostatic anomaly maps of the islands (cf. LAGAAY, 1969) it appears that all gravity maxima occur above outcrops of Cretaceous basic volcanics (cf. BEETS, in press). It is therefore tentatively inferred that the large positive anomalies of the islands are related to the occurrence of high density volcanics near the surface.

**) A detailed map of local isostatic anomalies in the area of the Netherlands Leeward Islands is given in LAGAAY (1969) together with a bathymetric chart (figures 13 and 12 respectively).

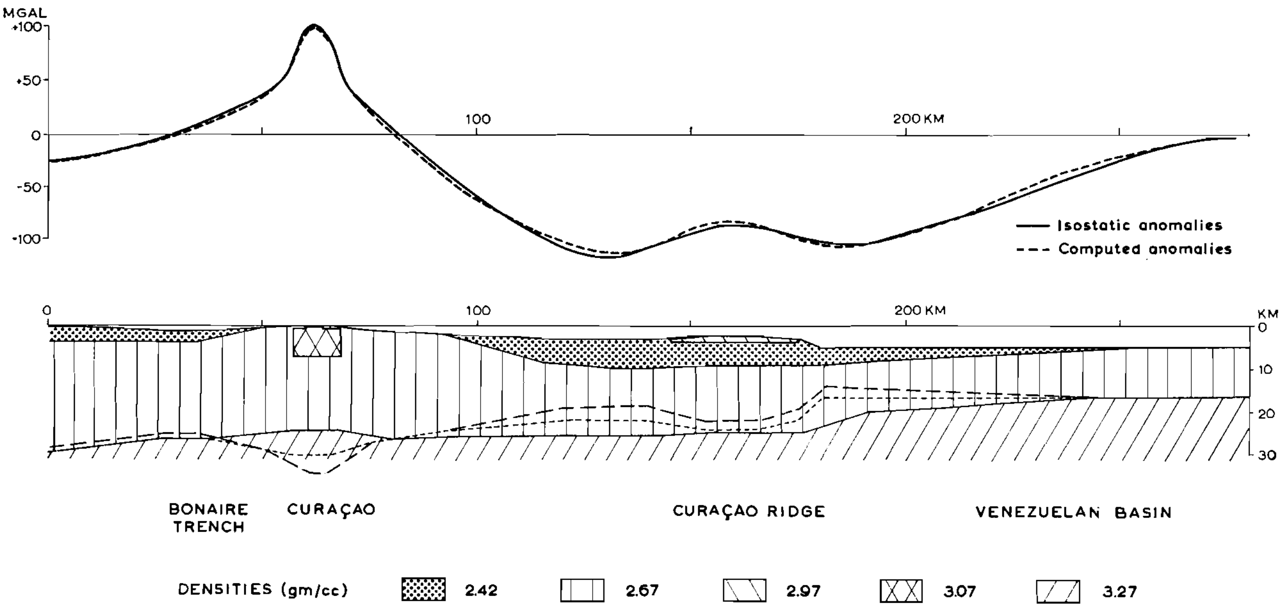

Figure 4

compares with the geological estimate of PIJPERS (1933). The underside of the crust being raised above its equilibrium position produces the additionally required positive effect.

In contrast to the islands in the negative zone, Aruba, Curaçao and Bonaire have been subject to rising movements. This again demonstrates the presence of forces counterbalancing the force of the anomalous masses.

c. Beneath the negative anomaly of the Bonaire trench a layer of low density material occurs, of which only the northern part is shown in Figure 4. It is 80 km wide and 3.5 km thick. Its presence is suggested by HAMBLETON's data and the sedimentary Falcón- and Gulf of Venezuela basins which lie in the same zone of negative anomalies. The underside of the crust beneath the Bonaire trench has been slightly lowered beneath its equilibrium position.

The general structure of the section can best be described as a wave-like deformation; the areas beneath the negative anomalies being depressed (with thick secondary sedimentary fills in the downwarps) and the area beneath the positive anomaly being raised above equilibrium. This deformation affects the transition between the oceanic Venezuelan basin and the South American continent. There are no indications of crustal thickening or thinning.

As regards the mechanism of deformation neither the plastic buckling hypothesis (VENING MEINESZ, 1934) nor the tension hypothesis (WORZEL, 1956, VAN BEMMELEN, 1958) presents a satisfactory explanation of the features found in the area studied. With plastic buckling one would expect some sign of crustal thickening, with regard to the tension hypothesis it can be demonstrated that a simple graben structure beneath the negative zone (north of Curaçao) would not produce anomalies of sufficient magnitude.

The mechanism preferred is one of shearing, possibly combined with some overriding in a direction normal to the belt (VENING MEINESZ, 1948). The asymmetry of the negative anomaly and the Los Roques trench is suggestive of this mechanism which is also held responsible for the in many respects resembling anomaly belt off the west coast of Sumatra (cf. COLLETTE, 1954). The upward bulge in the layering beneath the negative zone may represent a secondary reaction of the crust to continued downbending under increasing compression. The direction of the stress field needed for this shearing mechanism may be inferred from the system of transcurrent faults in northern South America (cf. HOSPERS and VAN WIJNEN, 1959). Here, the Oca-El Pilar right-lateral fault runs in a direction of 90°–100° along the northeast coast of Venezuela. The great fault, a left-lateral strike slip, runs along the Colombian Cordillera Central in a direction of 330–350°. According to Anderson's fault theory, the direction bisecting the compressed segment between these major strike slips indicates the direction of the horizontal compressive stress, which would thus be approximately 125°. Assuming that the negative anomaly zones – which have about the same direction as the faults and presumably were active at the same time – are due to the same stress field, it is concluded that the deformation of the crust in the southern Caribbean is due to a compressive stress in a general northwest-southeast direction. Movement of the South American continent in a northwesterly direction may have been the reason for this stress field.

A matter of much dispute has been the question whether negative anomaly zones represent early stages in mountain building. This question has been reviewed by TALWANI (1964). Here the position of the crust beneath the anomaly belt is discussed, assuming that the crust is allowed to reach isostatic equilibrium. In VENING MEINESZ' view relaxation of the stress on the subsided and plastically thickened crust in a negative zone would produce a high mountain range. However, due to the circumstance that no crustal thickening occurred in the southern Caribbean zone, the depression being filled with large amounts of sediments, only a shallow submarine ridge of about 1 km depth would be formed upon readjustment of isostatic equilibrium. Calculations on models given in the literature show that the "mountain embryo" hypothesis is also invalid for the other negative zones in the Caribbean (Puerto Rico Trench, Barbados ridge, East Venezuelan basin, Maracaibo basin). The island of Barbados itself would be slightly raised to some greater height. In the latter two areas topographic elevations of small height would be formed. It is interesting to note here that with RAITT's observation (1967) of a thick sedimentary layer in the Java trench, there also only a low submarine ridge would be formed upon reaching equilibrium.

The southern Caribbean arc can better be seen in the light of continental drift. Movement of South America deformed the northern continental margin which is of the type that is found off the east coast of North America, but undeformed in that area (DRAKE et al., 1959). This interpretation would evidently not hold for the Lesser Antilles arc which on both sides is bounded by oceanic basins. The structure of this arc is characterized by crustal upwarps and downwarps, volcanicity on the islands and relatively abundant seismicity (SYKES and EWING, 1965). These features suggest that the Lesser Antilles form the region where Atlantic crust is transported downward by underthrusting, thereby compensating for the formation of new crust at the Ridge (see OLIVER and ISACKS, 1967, on the Tonga trench). Volcanicity and seismicity are notably absent in the southern Caribbean arc.

In view of the above said, it seems significant that the Mio-Pliocene is an active period in the formation of the Caribbean structures and anomaly zones as well as in the formation of the Mid Atlantic ridge (cf. COLLETTE et al., in press).

Under influence of the east-west spreading of the Atlantic Ocean floor, the compressive stress in the area of the Lesser Antilles must have an approximately westward direction. This relation is evidently not as simple for the area of the southern Caribbean and northern South America. In this area also a westward direction would be expected, but a northwestward directed compressive stress was found. It is suggested that this deviation is due to the counterdirected influence of the roughly east-north-eastward spreading of the South Pacific Ocean floor.

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APPENDIX

Table 1. Gravity observations on Aruba

Station number	Latitude N φ	Longitude W λ	Station height, m	Anomalies in milligal free-air	Bouguer	isostatic ($T=30$, $R=0$)
1	12° 30′ 02.9″	69° 57′ 00.4″	67.2	+ 97.8	+93.7	+38.9
2	12° 29′ 53.8″	69° 56′ 30.2″	77.0	+101.9	+98.0	+42.9
3	12° 29′ 48.8″	69° 54′ 53.8″	41.6	+ 98.9	+98.0	+41.2
4	12° 28′ 30.3″	69° 53′ 29.8″	28.9	+ 95.7	+96.2	+39.6
5	12° 29′ 56.1″	69° 56′ 08.5″	65.7	+102.0	+98.7	+43.1
6	12° 27′ 19.9″	69° 54′ 07.2″	59.9	+ 84.2	+80.8	+26.7
7	12° 28′ 41.1″	69° 58′ 46.7″	11.7	+ 53.4	+54.5	+ 3.6
8	12° 31′ 21.7″	70° 02′ 24.1″	2.2	+ 45.0	+47.2	− 3.8
9	12° 31′ 16.4″	70° 01′ 01.7″	17.1	+ 65.2	+65.7	+13.6
10	12° 30′ 53.5″	69° 59′ 30.3″	24.0	+ 80.8	+80.8	+27.7
11	12° 30′ 29.4″	69° 58′ 11.9″	50.3	+ 88.8	+86.1	+32.8
12	12° 31′ 07.1″	70° 00′ 32.0″	20.8	+ 74.1	+74.3	+21.8
13	12° 30′ 17.6″	70° 01′ 22.1″	3.4	+ 41.2	+43.2	− 7.3
14	12° 29′ 43.7″	70° 00′ 41.8″	4.5	+ 42.0	+44.0	− 6.4
15	12°29′ 19 .1″	69° 58′ 32.4″	44.1	+ 78.8	+76.5	+24.5
16	12° 28′ 54.8″	69° 58′ 02.1″	1.1	+ 74.9	+77.4	+25.4
17	12° 29′ 52.0″	69° 58′ 38.9″	30.2	+ 82.8	+82.1	+29.5
18	12° 31′ 05.2″	69° 58′ 43.7″	33.0	+ 86.2	+85.4	+31.1
19	12° 31′ 57.1″	69° 58′ 41.1″	47.8	+ 94.1	+92.0	+36.4
20	12° 32′ 58.6″	69° 58′ 39.2″	20.8	+ 92.5	+93.7	+36.6
21	12° 32′ 25.8″	69° 58′ 37.7″	31.4	+ 93.1	+92.9	+36.5
22	12° 31′ 47.3″	70° 01′ 47.2″	11.2	+ 65.0	+66.2	+14.1
23	12° 32′ 08.8″	70° 01′ 26.2″	18.2	+ 78.9	+79.5	+26.7
24	12° 32′ 31.1″	70° 01′ 04.2″	26.4	+ 85.1	+84.8	+31.1
25	12° 33′ 27.6″	70° 00′ 27.3″	31.3	+ 92.9	+92.5	+36.7
26	12° 34′ 07.8″	69° 59′ 42.2″	6.8	+ 90.8	+93.8	+36.1
27	12° 33′ 41.6″	70° 00′ 11.5″	52.0	+ 95.4	+92.9	+36.5
28	12° 32′ 56.3″	70° 00′ 42.1″	26.2	+ 90.8	+90.7	+36.0
29	12° 32′ 20.0″	70° 02′ 11.4″	12.4	+ 68.8	+69.9	+17.3
30	12° 33′ 12.2″	70° 02′ 36.0″	5.8	+ 68.2	+70.1	+16.9
31	12° 33′ 59.1″	70° 02′ 09.0″	3.7	+ 77.2	+79.5	+24.8
32	12° 34′ 16.9″	70° 02′ 40.7″	2.2	+ 67.7	+70.2	+15.5
33	12° 33′ 43.2″	70° 03′ 16.0″	1.6	+ 60.7	+63.1	+ 9.8
34	12° 31′ 54.3″	70° 01′ 40.3″	13.5	+ 70.0	+71.0	+18.6
35	12° 29′ 16.5″	70° 00′ 00.4″	5.3	+ 46.0	+47.8	− 2.6
36	12° 27′ 55.0″	69° 57′ 52.3″	2.9	+ 48.1	+50.3	0.0
37	12° 27′ 09.6″	69° 57′ 00.1″	2.5	+ 46.2	+48.5	− 1.8
38	12° 27′ 32.6″	69° 56′ 34.9″	40.8	+ 68.8	+67.1	+15.9
39	12° 26′ 54.9″	69° 55′ 33.5″	15.1	+ 55.4	+56.4	+ 4.9
40	12° 27′ 12.6″	69° 54′ 45.8″	55.3	+ 77.6	+74.3	+21.0
41	12° 26′ 26.2″	69° 53′ 54.5″	29.4	+ 67.5	+67.1	+13.8
42	12° 26′ 12.2″	69° 54′ 32.4″	9.4	+ 50.3	+52.0	+ 0.3
43	12° 28′ 08.4″	69° 54′ 49.0″	76.6	+ 90.9	+85.6	+31.1
44	12° 28′ 31.4″	69° 54′ 53.9″	72.0	+ 93.4	+88.6	+33.7
45	12° 28′ 49.4″	69° 54′ 46.8″	70.5	+ 95.8	+91.3	+35.8
46	12° 27′ 37.9″	69° 54′ 43.7″	52.2	+ 84.0	+81.2	+27.3
47	12° 27′ 32.0″	69° 53′ 47.1″	53.5	+ 86.1	+83.4	+28.7
48	12° 27′ 55.3″	69° 53′ 32.0″	43.0	+ 91.7	+90.4	+34.7

Table I (continued)

Station number	Latitude N φ	Longitude W λ	Station height, m	Anomalies in milligal		
				free-air	Bouguer	isostatic (T=30, R=0)
49	12° 29′ 07.1″	69° 53′ 51.3″	9.1	+93.9	+96.7	+39.6
50	12° 29′ 46.9″	69° 54′ 16.6″	8.0	+94.2	+97.4	+39.9
51	12° 29′ 28.7″	69° 54′ 18.9″	27.8	+96.9	+97.7	+40.6
52	12° 29′ 13.4″	69° 54′ 28.5″	41.6	+97.8	+96.8	+40.2
53	12° 26′ 55.4″	69° 54′ 55.7″	24.0	+62.2	+62.3	+10.1
54	12° 25′ 59.1″	69° 55′ 17.8″	1.3	+35.9	+38.5	−12.1
55	12° 26′ 28.5″	69° 55′ 38.3″	0.2	+42.4	+45.0	− 5.9
56	12° 26′ 45.8″	69° 55′ 36.1″	10.4	+48.6	+50.1	− 1.2
57	12° 25′ 58.7″	69° 54′ 20.8″	10.5	+49.3	+50.9	− 0.7
58	12° 26′ 05.4″	69° 52′ 36.3″	18.2	+77.7	+78.8	+24.7
59	12° 24′ 59.0″	69° 52′ 08.0″	3.2	+76.1	+79.2	+26.9
60	12° 25′ 24.5″	69° 53′ 12.4″	17.0	+63.9	+64.9	+12.7
61	12° 25′ 35.8″	69° 52′ 38.1″	21.4	+74.1	+74.8	+21.2
62	12° 29′ 55.9″	69° 59′ 49.7″	7.2	+63.0	+64.6	+13.1
63	12° 30′ 30.3″	69° 59′ 05.1″	24.1	+82.1	+82.1	+29.1
64	12° 31′ 36.0″	69° 59′ 41.5″	37.2	+85.5	+84.1	+30.2
65	12° 32′ 08.5″	70° 00′ 22.7″	36.7	+86.6	+85.3	+31.3
66	12° 32′ 35.2″	69° 59′ 40.4″	45.0	+93.8	+91.8	+36.4
67	12° 33′ 01.0″	69° 58′ 52.9″	14.1	+92.0	+94.5	+37.6
68	12° 32′ 46.5″	69° 57′ 44.5″	8.0	+91.4	+94.5	+36.5
69	12° 31′ 24.0″	70° 02′ 42.3″	2.0	+41.5	+43.6	− 7.1
70	12° 32′ 45.1″	70° 03′ 36.2″	2.3	+49.6	+51.8	0.0
71	12° 35′ 04.8″	70° 02′ 41.3″	1.0	+75.0	+77.8	+21.4
72	12° 36′ 14.2″	70° 03′ 03.5″	3.9	+86.4	+89.1	+31.5
73	12° 37′ 25.2″	70° 03′ 17.5″	3.7	+87.9	+91.2	+31.4
74	12° 36′ 01.8″	70° 02′ 24.7″	2.0	+88.7	+91.6	+33.7
75	12° 35′ 01.7″	70° 02′ 08.9″	6.7	+88.5	+90.8	+34.0
76	12° 34′ 16.9″	70° 02′ 14.0″	3.5	+77.6	+80.0	+24.3
77	12° 33′ 16.4″	70° 01′ 49.6″	14.5	+82.9	+84.1	+29.9
78	12° 31′ 24.8″	70° 02′ 05.4″	4.1	+50.6	+52.5	+ 1.2
79	12° 32′ 28.0″	70° 02′ 53.0″	4.4	+56.7	+58.6	+ 6.6
80	12° 36′ 53.5″	70° 02′ 36.6″	4.8	+87.5	+90.4	+30.9
81	12° 35′ 16.8″	70° 01′ 22.2″	20.9	+91.6	+92.8	+35.0
82	12° 34′ 32.0″	70° 01′ 21.2″	29.0	+93.1	+93.0	+36.1
83	12° 27′ 25.8″	69° 52′ 56.8″	11.8	+85.1	+87.3	+31.5
84	12° 26′ 34.2″	69° 52′ 39.7″	11.6	+79.2	+81.1	+26.3
85	12° 32′ 03.8″	70° 03′ 10.5″	2.5	+45.7	+47.8	− 3.4
86	12° 30′ 19.7″	70° 00′ 39.5″	18.7	+54.2	+54.6	+ 3.3
87	12° 28′ 49.3″	69° 58′ 42.9″	21.8	+63.4	+63.4	+12.3
88	12° 26′ 41.6″	69° 54′ 50.2″	18.7	+57.8	+58.5	+ 6.5
89	12° 26′ 08.2″	69° 53′ 57.4″	15.3	+58.8	+59.9	+ 7.5

Table 2. Gravity observations on Curaçao

Station number	Latitude N φ	Longitude W λ	Station height, m	Anomalies in milligal		
				free-air	Bouguer	isostatic (T=30, R=0)
1	12° 07′ 45.3″	68° 58′ 07.0″	3.0	+144.4	+152.6	+ 76.8
2	12° 08′ 41.4″	68° 50′ 23.1″	33.8	+164.8	+167.6	+ 85.1
3	12° 16′ 43.7″	69° 03′ 49.3″	20.0	+132.9	+137.3	+ 51.9
4	12° 22′ 11.9″	69° 09′ 23.2″	10.6	+115.8	+132.8	+ 41.8
5	12° 07′ 03.3″	68° 57′ 20.6″	2.4	+140.8	+150.8	+ 75.3
6	12° 06′ 57.5″	68° 55′ 35.5″	37.8	+161.0	+163.7	+ 87.3
7*	12° 07′ 11.0″	68° 55′ 46.0″	2.0	+165.9	+172.3	+ 95.4
8	12° 06′ 39.0″	68° 53′ 12.5″	15.1	+173.0	+177.1	+ 99.5
9	12° 06′ 33.0″	68° 51′ 20.7″	22.9	+175.5	+178.7	+ 99.8
10	12° 04′ 16.0″	68° 51′ 02.4″	1.4	+158.5	+167.1	+ 90.7
11	12° 05′ 44.7″	68° 50′ 05.7″	7.1	+173.7	+178.8	+100.0
12	12° 07′ 09.8″	68° 50′ 51.3″	22.8	+173.5	+176.8	+ 96.6
13	12° 08′ 09.0″	68° 53′ 03.1″	30.8	+171.6	+173.8	+ 94.3
14	12° 07′ 40.0″	68° 54′ 02.2″	3.5	+165.7	+170.8	+ 92.6
15	12° 05′ 39.0″	68° 53′ 57.5″	0.6	+154.2	+162.7	+ 86.8
16	12° 08′ 37.0″	68° 54′ 21.0″	7.5	+164.1	+168.8	+ 89.6
17	12° 09′ 34.3″	68° 56′ 10.0″	36.8	+160.3	+162.0	+ 82.7
18	12° 11′ 41.6″	68° 56′ 03.3″	7.6	+126.7	+133.6	+ 50.2
19	12° 09′ 32.2″	68° 54′ 49.4″	36.1	+160.3	+162.0	+ 81.5
20	12° 09′ 15.5″	68° 53′ 22.2″	29.3	+162.8	+165.4	+ 84.1
21	12° 10′ 53.1″	68° 51′ 13.4″	9.2	+128.4	+136.3	+ 50.1
22	12° 08′ 11.4″	68° 48′ 20.8″	4.5	+151.7	+159.2	+ 75.7
23	12° 10′ 33.6″	68° 58′ 07.4″	35.5	+155.9	+158.0	+ 77.7
24	12° 10′ 44.2″	68° 57′ 40.2″	53.1	+155.0	+155.2	+ 74.4
25	12° 08′ 18.0″	68° 57′ 05.8″	10.1	+162.0	+166.9	+ 89.8
26	12° 06′ 20.8″	68° 47′ 17.8″	5.7	+162.7	+170.3	+ 88.6
27	12° 05′ 40.2″	68° 46′ 44.1″	6.4	+162.8	+171.2	+ 89.9
28	12° 03′ 04.4″	68° 44′ 52.4″	1.4	+147.5	+157.0	+ 77.0
29	12° 03′ 59.3″	68° 45′ 14.2″	3.7	+157.3	+166.0	+ 85.7
30	12° 07′ 13.6″	68° 47′ 53.0″	6.7	+162.3	+169.3	+ 86.9
31	12° 02′ 46.8″	68° 47′ 11.6″	3.0	+155.4	+164.5	+ 86.9
32	12° 03′ 03.3″	68° 46′ 39.6″	2.4	+154.6	+163.6	+ 85.4
33	12° 04′ 17.0″	68° 50′ 25.0″	21.2	+171.1	+177.9	+101.1
34	12° 05′ 40.3″	68° 49′ 06.2″	50.7	+176.1	+177.9	+ 98.4
35	12° 04′ 14.3″	68° 48′ 25.1″	29.9	+172.1	+175.4	+ 97.1
36	12° 03′ 02.5″	68° 49′ 01.3″	1.7	+153.7	+163.9	+ 87.4
37	12° 10′ 29.0″	68° 55′ 44.5″	25.6	+151.4	+154.6	+ 73.6
38	12° 11′ 00.2″	68° 55′ 56.0″	57.8	+144.2	+144.5	+ 62.0
39	12° 11′ 20.2″	68° 59′ 31.5″	43.0	+145.5	+147.1	+ 66.6
40	12° 12′ 39.8″	69° 00′ 55.2″	67.5	+137.3	+136.7	+ 55.4
41	12° 13′ 03.1″	69° 02′ 43.5″	21.5	+130.1	+134.5	+ 53.9
42	12° 13′ 28.3″	69° 05′ 08.6″	1.0	+119.2	+129.7	+ 49.7
43	12° 15′ 35.5″	68° 04′ 21.8″	48.2	+131.7	+133.0	+ 49.8
44	12° 14′ 55.3″	68° 02′ 48.6″	83.9	+131.7	+129.3	+ 46.0
45	12° 16′ 50.2″	69° 02′ 58.0″	8.5	+126.2	+132.8	+ 46.6
46	12° 15′ 07.9″	69° 01′ 50.5″	8.7	+119.7	+126.2	+ 41.9
47	12° 14′ 20.5″	69° 01′ 02.5″	5.6	+118.5	+125.4	+ 41.8
48	12° 13′ 02.8″	68° 59′ 31.2″	5.5	+120.3	+127.0	+ 44.1

*) Station No. 7 has the location of the pendulum station Curaçao III.

Table 2 (continued)

Station number	Latitude N φ	Longitude W λ	Station height, m	Anomalies in milligal		
				free-air	Bouguer	isostatic (T=30, R=0)
49	12° 08′ 42.4″	68° 59′ 44.6″	4.4	+136.2	+147.4	+ 70.8
50	12° 14′ 20.3″	69° 02′ 14.8″	72.8	+131.1	+129.9	+ 47.1
51	12° 19′ 52.8″	69° 03′ 21.5″	9.5	+145.3	+153.3	+ 61.4
52	12° 19′ 48.1″	69° 05′ 16.8″	50.3	+141.9	+143.8	+ 53.7
53	12° 17′ 54.2″	69° 05′ 04.7″	35.9	+136.7	+139.5	+ 53.0
54	12° 18′ 25.1″	69° 06′ 15.9″	41.3	+133.9	+136.4	+ 49.9
55	12° 16′ 29.1″	69° 07′ 41.8″	1.0	+101.0	+112.7	+ 29.9
56	12° 16′ 13.9″	69° 05′ 35.6″	25.4	+125.1	+129.4	+ 46.0
57	12° 09′ 19.0″	68° 58′ 41.3″	17.0	+157.3	+161.8	+ 84.0
58	12° 10′ 41.6″	69° 00′ 42.7″	32.4	+137.3	+142.4	+ 63.6
59	12° 09′ 54.3″	68° 59′ 25.2″	2.1	+151.6	+157.9	+ 79.3
60	12° 20′ 10.1″	69° 08′ 54.5″	12.0	+115.1	+125.6	+ 37.7
61	12° 21′ 05.8″	69° 08′ 38.5″	40.6	+127.4	+133.9	+ 44.2
62	12° 22′ 40.2″	69° 09′ 03.3″	7.5	+130.6	+142.8	+ 50.1
63	12° 22′ 14.7″	69° 06′ 59.1″	15.3	+143.6	+151.7	+ 58.1
64	12° 20′ 50.8″	69° 06′ 10.2″	18.7	+138.9	+144.9	+ 53.5
65	12° 21′ 25.5″	69° 04′ 19.1″	7.6	+146.7	+155.1	+ 61.2
66	12° 23′ 29.7″	69° 09′ 32.8″	9.5	+128.7	+145.6	+ 51.1
67	12° 15′ 09.3″	69° 06′ 19.3″	1.5	+110.4	+122.7	+ 41.1
68	12° 20′ 00.7″	69° 06′ 37.8″	64.5	+140.9	+141.5	+ 52.0
69	12° 19′ 52.2″	69° 07′ 03.0″	64.5	+139.8	+140.7	+ 51.6
70	12° 09′ 51.0″	68° 54′ 55.3″	21.6	+155.7	+159.1	+ 78.1
71	12° 17′ 13.7″	69° 06′ 56.7″	12.9	+119.5	+125.9	+ 41.6
72	12° 18′ 46.4″	69° 08′ 25.5″	9.0	+118.1	+126.5	+ 40.7
73	12° 17′ 57.2″	69° 05′ 36.5″	58.6	+137.0	+137.6	+ 51.5
74	12° 18′ 12.8″	69° 03′ 13.0″	8.3	+130.3	+137.8	+ 49.4
75	12° 07′ 40.4″	68° 56′ 53.3″	5.5	+159.8	+165.7	+ 89.3

Table 3. Gravity observations on Bonaire

Station number	Latitude N φ	Longitude W λ	Station height, m	Anomalies in milligal		
				free-air	Bouguer	isostatic (T=30, R=0)
1	12° 07′ 01.0″	68° 17′ 33.9″	2.9	+162.7	+171.1	+76.7
2	12° 05′ 10.8″	68° 16′ 47.1″	1.7	+164.5	+172.2	+79.9
3	12° 30′ 48.8″	68° 16′ 47.8″	4.5	+160.5	+169.1	+78.2
4	12° 01′ 44.1″	68° 14′ 56.1″	2.0	+162.3	+171.0	+81.0
5	12° 07′ 54.1″	68° 14′ 33.4″	3.2	+170.6	+177.3	+80.5
6	12° 06′ 19.3″	68° 14′ 21.1″	1.4	+170.6	+177.2	+82.4
7	12° 05′ 52.4″	68° 14′ 04.4″	0.8	+170.6	+177.4	+83.0
8	12° 08′ 07.3″	68° 15′ 54.5″	6.1	+166.8	+173.1	+76.9
9	12° 06′ 20.0″	68° 13′ 11.2″	1.0	+168.4	+175.8	+80.2
10	12° 09′ 51.8″	68° 12′ 41.0″	17.4	+174.0	+180.4	+79.4
11	12° 09′ 55.4″	68° 15′ 33.2″	16.9	+177.2	+182.8	+83.6
12	12° 10′ 21.1″	68° 14′ 14.7″	20.2	+179.1	+184.7	+83.9
13	12° 11′ 05.8″	68° 12′ 51.5″	0.3	+161.3	+170.0	+66.9
14	12° 11′ 36.4″	68° 15′ 44.3″	26.5	+168.6	+174.0	+71.9
15	12° 14′ 45.7″	68° 17′ 23.0″	10.8	+144.1	+155.2	+46.8
16	12° 14′ 38.7″	68° 19′ 20.5″	10.0	+151.6	+161.4	+54.0
17	12° 13′ 35.3″	68° 16′ 41.1″	43.0	+147.1	+152.4	+46.2
18	12° 09′ 38.4″	68° 16′ 12.6″	4.0	+164.4	+171.8	+72.9
19	12° 10′ 11.3″	68° 16′ 06.6″	15.8	+173.2	+179.0	+79.6
20	12° 10′ 56.6″	68° 16′ 05.6″	10.2	+176.1	+182.9	+82.2
21	12° 12′ 42.7″	68° 16′ 10.6″	48.4	+154.5	+158.3	+54.2
22	12° 14′ 32.8″	68° 17′ 04.6″	8.8	+142.8	+153.5	+45.5
23	12° 14′ 55.4″	68° 18′ 40.4″	9.8	+146.1	+156.8	+48.5
24	12° 14′ 28.9″	68° 20′ 32.4″	38.5	+159.4	+166.3	+59.5
25	12° 14′ 30.5″	68° 21′ 15.5″	23.7	+162.6	+173.1	+66.4
26	12° 14′ 24.3″	68° 22′ 01.9″	1.0	+167.7	+179.4	+73.0
27	12° 14′ 24.3″	68° 20′ 15.8″	61.1	+159.7	+164.2	+57.5
28	12° 12′ 07.3″	68° 15′ 47.0″	49.6	+163.1	+166.8	+63.2
29	12° 11′ 17.8″	68° 15′ 52.4″	17.5	+174.1	+180.3	+78.8
30	12° 10′ 25.7″	68° 17′ 10.9″	3.7	+156.9	+164.7	+65.3
31	12° 11′ 29.1″	68° 17′ 37.8″	4.7	+156.0	+164.4	+63.4
32	12° 12′ 08.5″	68° 18′ 22.0″	3.7	+152.8	+162.8	+60.8
33	12° 13′ 17.2″	68° 20′ 43.6″	13.4	+153.3	+165.6	+62.0
34	12° 12′ 36.2″	68° 18′ 56.8″	5.0	+151.7	+162.1	+59.3
35	12° 14′ 32.8″	68° 21′ 40.8″	13.5	+166.4	+176.3	+69.5
36	12° 14′ 43.9″	68° 21′ 55.6″	8.9	+167.1	+177.8	+70.6
37	12° 15′ 06.2″	68° 22′ 34.3″	7.6	+167.7	+179.2	+71.3
38	12° 15′ 14.3″	68° 23′ 25.0″	17.0	+170.3	+182.0	+73.7
39	12° 15′ 31.2″	68° 24′ 27.4″	9.3	+166.1	+182.0	+73.0
40	12° 16′ 00.6″	68° 24′ 42.9″	0.4	+156.8	+175.6	+65.4
41	12° 12′ 30.7″	68° 15′ 33.4″	40.0	+156.0	+160.6	+56.7
42	12° 06′ 45.8″	68° 17′ 08.1″	0.7	+163.6	+171.0	+76.8
43	12° 12′ 19.3″	68° 14′ 49.5″	35.0	+156.8	+161.9	+57.8
44	12° 11′ 49.7″	68° 13′ 25.9″	23.8	+156.4	+162.8	+58.7
45	12° 12′ 53.9″	68° 11′ 43.8″	4.7	+135.4	+146.9	+39.0
46	12° 12′ 02.6″	68° 12′ 20.2″	4.7	+141.6	+151.1	+45.6
47	12° 11′ 25.0″	68° 13′ 01.2″	22.4	+157.7	+164.2	+60.2
48	12° 11′ 31.2″	68° 12′ 32.7″	4.7	+151.0	+159.8	+55.6
49	12° 08′ 37.3″	68° 15′ 30.3″	8.1	+169.9	+176.0	+78.8
50	12° 04′ 51.6″	68° 13′ 48.2″	3.4	+176.7	+183.5	+90.3
51	12° 04′ 04.7″	68° 13′ 31.9″	3.1	+182.6	+189.6	+97.0

Table 3 (continued)

Station number	Latitude N φ	Longitude W λ	Station height, m	Anomalies in milligal		
				free-air	Bouguer	isostatic ($T=30$, $R=0$)
52	12° 02′ 51.2″	68° 13′ 29.0″	1.7	+178.1	+185.7	+94.0
53	12° 01′ 52.8″	68° 14′ 07.3″	10.5	+170.2	+178.3	+87.7
54	12° 02′ 26.1″	68° 15′ 40.7″	1.5	+162.0	+170.0	+80.0
55	12° 14′ 45.8″	68° 20′ 03.4″	22.1	+154.4	+163.1	+55.6
56	12° 15′ 28.2″	68° 20′ 19.1″	9.5	+151.2	+162.3	+53.2
57	12° 16′ 05.1″	68° 20′ 19.6″	5.0	+145.4	+158.2	+47.7
58	12° 16′ 39.1″	68° 21′ 18.2″	4.4	+145.7	+159.8	+48.0
59	12° 18′ 10.4″	68° 22′ 17.7″	9.8	+131.7	+150.0	+33.7
60	12° 18′ 22.1″	68° 23′ 49.1″	5.0	+128.1	+149.8	+33.2
61	12° 17′ 16.3″	68° 21′ 45.6″	10.7	+141.6	+156.3	+42.6
62	12° 17′ 26.9″	68° 22′ 06.8″	27.7	+142.6	+156.1	+41.8
63	12° 17′ 17.1″	68° 22′ 36.4″	41.1	+148.2	+160.0	+46.4
64	12° 17′ 11.5″	68° 23′ 19.0″	49.0	+149.6	+161.1	+47.6
65	12° 17′ 07.9″	68° 23′ 48.6″	28.0	+151.7	+165.8	+52.4
66	12° 17′ 11.3″	68° 24′ 06.2″	11.5	+147.7	+164.4	+50.9
67	12° 17′ 05.1″	68° 24′ 42.0″	7.5	+144.9	+165.2	+51.9
68	12° 14′ 15.4″	68° 20′ 04.7″	34.0	+156.9	+163.9	+57.5
69	12° 13′ 59.4″	68° 20′ 31.0″	106.0	+163.2	+163.1	+57.4
70	12° 10′ 13.0″	68° 18′ 07.1″	1.5	+150.9	+159.4	+60.9
71	12° 09′ 56.8″	68° 17′ 40.8″	1.4	+153.6	+161.5	+63.2
72	12° 09′ 33.2″	68° 17′ 28.5″	1.4	+154.6	+162.8	+65.1
73	12° 09′ 42.3″	68° 18′ 05.7″	3.0	+152.4	+160.2	+62.5
74	12° 09′ 59.2″	68° 17′ 04.2″	0.6	+157.2	+165.0	+66.4
75	12° 08′ 51.1″	68° 15′ 50.4″	2.3	+165.4	+172.3	+74.9
76	12° 09′ 17.7″	68° 15′ 02.9″	13.7	+177.2	+183.0	+84.4
77	12° 09′ 22.4″	68° 14′ 31.6″	17.0	+183.7	+189.3	+90.3
78	12° 09′ 14.3″	68° 13′ 57.4″	19.0	+184.5	+189.9	+90.7
79	12° 09′ 13.6″	68° 12′ 40.6″	10.0	+178.1	+184.9	+84.8
80	12° 09′ 43.5″	68° 13′ 20.6″	16.9	+179.0	+185.2	+84.8
81	12° 09′ 18.7″	68° 15′ 34.3″	8.5	+172.2	+178.6	+80.3
82	12° 09′ 22.5″	68° 16′ 15.2″	2.2	+161.7	+168.9	+70.8
83	12° 09′ 19.4″	68° 11′ 55.1″	3.8	+164.7	+173.1	+72.3
84	12° 08′ 28.2″	68° 13′ 14.3″	14.0	+184.3	+190.2	+91.7
85	12° 07′ 38.4″	68° 13′ 33.6″	0.8	+175.4	+182.5	+85.4
86	12° 06′ 58.6″	68° 13′ 00.6″	0.9	+178.1	+185.3	+88.7
87	12° 01′ 44.3″	68° 14′ 36.3″	0.6	+165.4	+173.9	+83.7
88	12° 09′ 10.1″	68° 16′ 29.0″	2.0	+160.5	+168.0	+70.4

Table 4. Gravity observations in the Caribbean Sea

Profile	Latitude N φ	Longitude W λ	Depth, m	Anomalies in milligal			Corrections* in 0.1 milligal		
				free air	Bouguer	isostatic (T=30, R=0)	topog.	R=0	
								comp. $A-O_2$	$t+c$ 18−1
A	15° 03.7′	68° 49.0′	4322	+ 10	+307	+ 12	+2969	−2666	−283
	14° 10.0′	69° 07.8′	4836	− 35	+289	− 8	+3239	−2702	−262
	13° 29.7′	69° 22.9′	3943	−112	+156	− 85	+2679	−2175	−235
	13° 16.2′	69° 26.7′	2900	− 91	+114	− 83	+2049	−1740	−228
	12° 49.4′	69° 36.1′	1577	− 46	+ 53	− 53	+ 990	− 856	−205
	12° 29.2′	69° 43.2′	940	− 65	− 4	− 79	+ 608	− 570	−175
	12° 22.5′	69° 45.5′	510	+ 15	+ 50	− 9	+ 350	− 417	−175
C	12° 11.6′	69° 50.4′	48	+ 27	+ 28	− 6	+ 11	− 178	−160
	12° 11.6′	69° 41.0′	350	− 2	+ 22	− 28	+ 246	− 343	−160
	12° 15.4′	69° 14.4′	1244	− 60	+ 19	− 56	+ 781	− 566	−180
D	12° 03.0′	68° 57.0′	713	+ 55	+104	+ 34	+ 489	− 537	−170
	11° 46.5′	69° 02.0′	1348	− 23	+ 66	+ 8	+ 887	− 420	−155
	11° 31.9′	69° 05.5′	53	− 9	− 5	− 31	+ 40	− 126	−130
B	11° 58.8′	68° 48.8′	896	+ 30	+ 78	+ 9	+ 483	− 524	−170
	12° 02.2′	68° 41.8′	604	+101	+139	+ 58	+ 380	− 636	−170
	12° 20.5′	68° 29.2′	2041	− 47	+ 87	− 36	+1340	−1049	−180
	12° 34.4′	68° 21.2′	3435	−167	+ 51	−118	+2182	−1484	−205
	12° 48.2′	68° 13.1′	1802	− 64	+ 93	−104	+1567	−1748	−220
	13° 15.9′	67° 56.7′	4726	− 90	+209	− 58	+2993	−2435	−235
	13° 43.6′	67° 40.3′	5063	− 24	+315	− 1	+3392	−2916	−250
	14° 11.3′	67° 23.9′	5070	− 15	+329	+ 7	+3440	−2951	−270
	14° 39.0′	67° 07.5′	5066	− 18	+327	− 3	+3455	−3021	−284

* The corrections have been interpreted as corrections to measured gravity.