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BUREAU GRAVIMÉTRIQUE INTERNATIONAL

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Bulletin d'Information

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BUREAU GRAVIMETRIQUE INTERNATIONAL

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A - NOTICES NECROLOGIQUES

Mr. B.C. BROWNE

"Mr. Benjamin Chapman Browne, who had been Reader in Geodesy at Cambridge University since 1948 and a Fellow and Praelector of Trinity College since 1947, died on August 14. at the age of 57.

Browne was born on April 29. 1911. He was an undergraduate at Pembroke College, Cambridge, and took his B.A. in 1934. After a short period in the Cavendish Laboratory, where he worked with Rutherford and Oliphant, he joined the Department of Geodesy and Geophysics in 1936. With the exception of the war years, he spent the whole of his working life in Cambridge. He was Head of the Department of Geodesy and Geophysics from 1948 - 1960. His main scientific interest was the measurement of gravity on land and at sea and particularly in the improvement of instruments and in international comparisons needed to connect the gravity networks of the world.

Perhaps his best known work is the study which he made of the effect of the movements of a ship on the measurement of gravity. He pointed out that the usual treatment was inconsistent with Einstein's "Principle of Equivalence", and showed that a correction, now known as the "Browne Correction", was required. His measurements, and those of his collaborators, form a large part of those carried out on the three international comparison lines from North Cape to Cape Town, Point Barrow to Santiago and Tokyo to Melbourne, and are a permanent memorial to his skill and care. They probably represent the ultimate limit of accuracy that can be obtained by measurements with pendulums. The completion of this large task shortly before he died was a source of great satisfaction to him.

Browne took part in many expeditions at sea, not all of them connected with the measurement of gravity. In 1946, with other scientists, he took part in a 4,000 mile voyage in the submarine Tudor. For 28 days the submarine rarely left the ocean bed. The trip extended from the Bay of Biscay almost to the shetlands. On board ship he was at his best :

good humoured, optimistic, and helpful in everything. This side of his work is not adequately represented in his publications ; he played a substantial part in the International Indian Ocean Expedition and in many other enterprises whose results were published by his colleagues.

During the Second World War, the worked as an "Experimental Officer" at the Admiralty's Antisubmarine Experimental Establishment and made a substantial contribution to its work. The study of sound in the sea remained one of his interests after the war. He also played a large part in national and international committees concerned with geodesy and geophysics. He was for many years, secretary and chairman of the Geophysical Committee of the Royal Astronomical Society, chairman of the Gravity Committee of the International Association of Geodesy and of the Research Vessels Committee of the Natural Environment Research Council.

He is survived by his wife, Marjorie, whom he married in 1948, and by a son and a stepdaughter. Friends and colleagues in many countries will miss his cheerful presence, his knowledge and his kindness".

from : The Times, August 21. 1968

Mr. W.D. LAMBERT

W. . Lambert est décédé à l'age de 89 ans à l'hôpital de Washington le dimanche 24 novembre 1968. Il avait été élu Correspondant de l'Académie des Sciences de Paris pour la Section de Géographie et Navigation le 13 janvier 1947 et était né à West New Brighton (état de New-York) le 12 janvier 1879.

W.D. Lambert avait été pendant de nombreuses années Chef de la Section de Gravimétrie et Astronomie au Coast & Geodetic Survey (jusqu'en 1949). Il était Membre de l'Académie Nationale des Sciences de Washington, dont il avait été Vice-Président. Il a été Président de l'Association internationale de Géodésie de 1946 à 1951 et, à ce titre, a eu la charge de reconstituer et de remettre en marche cette importante organisation internationale qui avait été mise en sommeil pendant la deuxième guerre mondiale et avait été désorganisée par le décès en février 1946 de son Secrétaire général : le Général Georges Perrier.

W.D. Lambert était un mathématicien de grande classe qui avait enseigné les mathématiques et l'astronomie successivement aux universités du Maine et de Pennsylvanie. Lorsqu'il entra au Coast & Geodetic Survey en 1911 il servit successivement au titre de Calculateur, puis de "Senior mathematician" avant de devenir Chef de la Section de Gravimétrie et Astronomie.

Pendant la première guerre mondiale il fut lieutenant en premier, dans le Corps des Ingénieurs militaires et servit pendant 15 mois en France dont il connaissait à fond la langue et la civilisation. Il avait conservé de fidèles relations avec les familles françaises dans lesquelles il avait cantonné pendant la guerre.

Ses travaux scientifiques ont porté essentiellement sur la théorie isostatique, les mesures gravimétriques et leur réduction au géoïde, la détermination de la figure de la Terre d'après les observations gravimétriques et à l'aide des méthodes astronomiques. Mais il s'est particulièrement intéressé aux deux problèmes ci-après :

- la variation des latitudes et le mouvement de l'axe de rotation à l'intérieur même du corps terrestre (polhodie), problème pour l'étude duquel les Etats-Unis avaient installé deux observatoires fixes (Ukiah et Gaithersburg). Il a publié le fascicule correspondant à ce vaste problème dans le Handbuch der Geophysik, Berlin, 1931 ;

- les marées de l'écorce terrestre, problème sur lequel il présentait dès avant la deuxième guerre mondiale un rapport très documenté à chaque Assemblée Générale de l'Association internationale de Géodésie. A l'heure actuelle ce problème (très complexe) est étudié par un Comité spécial qui a son centre à l'observatoire de Uccle (Bruxelles). W.D. Lambert en était le Président d'Honneur et ses avis y étaient toujours écoutés avec beaucoup de considération.

Un ouvrage très important a été publié par lui en 1931 et constitue la Publication spéciale n°199 du Coast & Geodetic Survey : Formules et tables pour déterminer la forme du géoide et son effet indirect sur la gravité.

Dans les vingt dernières années de son existence il était "Consultant pour les problèmes de Géodésie" au Départment of Geodetic Science de la Ohio State University à Columbus, où le savant géodésien finlandais W. Heiskanen traitait de nombreux problèmes de Géodésie contemporaine. (The new Era of Geodesy).

On ne saurait concevoir une Notice sur W.D. Lambert sans faire état de l'aménité de son caractère et du charme de ses relations. Dans la grande famille des géodésiens s'occupant de problèmes internationaux, il ne comptait que des amis, qui ont ressenti sa disparition avec beaucoup de peine. Du moins ont-ils la consolation de voir une longue existence pleinement remplie et cela avec une parfaite dignité".

P. TARDI

B - INFORMATIONS

a) Publication "GRAVIMETRIA" - Collana di Scienze Terrestri, n°2, del Bianco Editore, Udine, 575 p, 1968, - Carlo MORELLI.

Les traités généraux sur la gravimétrie sont si peu nombreux que la parution de cet ouvrage est accueillie avec grand intérêt. Ce livre est le 2ème de la Collection des Sciences de la Terre que dirige le Prof. Morelli. Dans la même collection a déjà paru : "Oceanografia" (Prof. MOSETTI) et sont en préparation : "Sismologia" (Prof. CALOI) et "G[illegible]ica" (Prof. Mosetti).

Comme on pourra le voir dans la table des matières, ci-après, l'auteur parcourt le vaste domaine de la pesanteur, depuis les considérations théoriques conduisant à la détermination de la forme de la Terre jusqu'aux techniques de géophysique appliquée relative aux instruments, aux méthodes de réduction et d'interpolation des résultats.

Le 6ème chapitre donne un aperçu des grands phénomènes concernant l'ensemble du Globe Terrestre : l'isostasie, la dérive des continents, le mouvement des pôles...

Quelques omissions semblent regrettables :

Le pendule inversé Holweck-Lejay a été complètement passé sous silence et les gravimètres terrestres Norgaard et LaCoste seulement nommés alors que les mesures à la balance d'Eötwös ont été longuement décrites.

On aurait aimé voir citer aussi les travaux de J. Martin sur la technique instrumentale des gravimètres et ceux de R. Neumann dans le chapitre sur les réductions (méthode de la parabole).

Mais ces critiques de détail sont de faible importance devant la masse de documentation et le nombre d'applications que le lecteur trouvera dans cet ouvrage.

Nous donnons ci-dessous la table des matières :

- Funzioni armoniche sferiche.
- Calcolo del potenziale gravitazionale esterno dello sferoide terrestre.
- Equazione delle superfici equipotenziali dello sferoide terrestre.
- Campo gravitazionale esterno dello sferoide terrestre.
- Formule per l'ellissoide terrestre. Gravita normale.
- Potenziale dovuto alle irregolarita di massa.
- Teorema di Stokes. Forma della terra.
- Influenza dei corpi celesti sulla gravita.
- Bibliografia.

2°) Misura della gravita

- Misure assolute, sistemi di riferimento.
- Misure pendolari relative.
- Correzioni alle misure pendolari.
- Teoria dei gravimetri.
- Descrizione di alcuni tipi di gravimetri.
- Rettifiche ai gravimetri.
- Deriva.
- Taratura.
- Criteri operativi
- Rete gravimetrica mondiale di 1° ordine.
- Rete gravimetrica italiana.
- Bibliografia.

3°) Gravita in mare.

- Importanza e necessita delle misure.
- Premesse teoriche :
  . Errore in $\bar{a}$ quando $\theta_0 \neq 0$ (trascurando l'effetto di θ_1); correzione statica di livellazione.
  . Errore in $\bar{a}$ quando la piattaforma oscilla di un angolo θ_1; correzione dinamica di livellazione.
  . Errore in $\bar{a}$ dovuto all'effetto di accoppiamento trasversale ("cross coupling effect").
- L'apparato di Vening Meinesz per misure in sommergible.
- Gravimetri per navi di superficie.:
  . Il gravimetro LaCoste & Romberg.
  . Il gravimetro Graf-Askania Gss.
  . Impiego del gravimetro in mare.
  . Caratteristiche del gravimetro marino Graf-Askania, nuovo tipo (Gss 2).
- Misure sul fondo con gravimetri.
- Misure nei mari italiani : tecniche e risultati.
- Bibliografia.

4°) <u>Riduzione delle misure di gravita.</u>

- Riduzione in aria libera o di Faye.
- Riduzione per la piastra, o di Bouguer.
- Correzioni per le misure in mare.
- Correzione topografica.
- Correzione pe la gravita "normale γ'_o", anomalie di Bouguer.
- Riduzione isostatica :
  . Ipotesi di Pratt ed ipotesi di Airy.
  . Compensazione locale e compensazione regionale
  . Criteri di calcolo.
  . Effetto indiretto
  . Discussione delle anomalie isostatiche.
- Riduzione geologica e geologico-isostatica.
- Bibliografia.

5°) <u>Interpretazione delle anomalie di gravita.</u>

- Anomalie locali o residue.
- Campo di regionalita.
- Interpretazione quantitativa delle anomalie gravimetriche.
- Reticoli per masse infinite secondo una direzione orizzontale.
- Reticoli per masse finite.
- Il calcolatore analogico ottico.
- Altri abachi per masse infinite e per masse finite (Haun, le Roy, 1958).
- Determinazione quantitativa della massa responsabile dell'anomalia. -
- Formule per la determinazione della profondita.
- Interpretazione di una anomalia gravitazionale a cui sia sovrapposto un effetto regionale (Bulakh, 1962).
- Metodi del gradiente verticale.
- Metodi delle derivate seconde.
- Metodo delle combinazioni lineari (o analisi periodale).
- Continuazione analitica verso l'alto e verso il basso.
- Bibliografia.

6°) <u>Isostasia.</u>

- Le campagne di gravita in mare e la teoria delle correnti di convenzione.
- Prove a sostegno dell'isostasia.
- Influenza dei processi geologici sull'isostasia.
- Le anomalia di gravita in Italia.
- Deriva dei continenti.
- Variazioni di longitudine e di latitudine.
- Migrazioni dai poli.
- Bibliografia.

7°) Cenni di geodesia fisica.

- Generalizzazione di Levallois.
- Gradiente della gravita :
  . Introduzione
  . Determinazione del gradiente normale esterno.
  . Considerazioni teoriche riguardanti il gradiente anomalo.
  . Calcolo delle componenti del gradiente orizzontale dalle anomalie di Bouguer.
  . Calcolo del gradiente verticale dalle anomalie di Bouguer.
  . Calcolo dell'influsso nel gradiente della topografia.
  . Limiti del gradiente gravimetrico in quota calcolato dalle anomalie di Bouguer.
  . Calcolo in quota del gradiente anomalo dalle anomalie gravimetriche riferite alla superficie fisica della Terra.
  . Calcolo in quota di g dalle anomalie gravimetriche riferite alla superficie della Terra.
- Riduzione in aria libera secondo Ledersteger.
- Rappresentativita delle anomalie
- Ruolo dell'isostasia.
- Estensioni della correlabilita con la topografia :
  . "Model Earth" di de Graaf Hunter.
  . Analisi statistica di Neidell.
- Deduzioni e conclusioni.
- Bibliografia.

8°) Studio delle superfici di livello. Bilancia di torsione di Eötvös.

- Raggi di curvatura delle sezioni normali di una superficie di livello.
- Gradiente gravimetrico.
- La bilancia di torsione di Eötvös.
- Teoria della bilancia di torsione.
- Procedimento per il calcolo delle derivate seconde.
- Determinazione delle costanti strumentali.
- Correzioni alle derivate seconde del potenziale ricavate con la bilancia di torsione.
- Presentazione ed utilizzazione dei risultati.
- Anomalie causate da masse di forma semplice.
- Interpretazione delle misure Eötvössiane.
- Differenza di gravita fra due stazioni Eötvössiane.
- Calcolo della perturbazione locale completa.
- Bibliografia.

9°) <u>Maree terrestri.</u>

- Introduzione.
- Forze di marea.
- Espressione della forza di marea.
- Componenti orizzontale e verticale della forza di marea.
- La teoria statica e le maree del nucleo terrestre.
- Espressione generale dell'altezza delle maree generate da un corpo celeste.
- Notazioni in uso per le maree terrestri.
- Deformazioni delle superfici equipotenziali causate da effetti luni-solari.
- Numeri di love. Fattore di riduzione γ e fattore gravimetrico δ.
- Determinazioni sperimentali di γ e δ.
- Pendolo orizzontale.
- Taratura dei pendoli.
- Analisi armonica.
- Cause di perturbazione nelle maree terrestri.
- Separazione degli effetti diretti ed indiretti.
- Bibliografia.

b) Adoption par le BUREAU INTERNATIONAL des POIDS et MESURES de la valeur de g absolue

M. TERRIEN

Résolution 1 (1968)

Le Comité International des Poids et Mesures, réuni le 16 Octobre 1968,

CONSIDERANT la Résolution 11 de la XIème Conférence Générale des Poids et Mesures (1960), qui décidait de conserver provisoirement le Système gravimétrique de Potsdam et qui donnait pouvoir au Comité International des Poids et Mesures de décider du changement du Système de Potsdam lorsqu'il aura estimé que la valeur de l'accélération due à la pesanteur est connue avec une exactitude suffisante ;

CONSIDERANT que les mesures absolues les plus récentes et les rattachements effectués au moyen d'un appareil transportable de mesure absolue donnent des résultats concordants avec une précision qui semble meilleure que le millionième :

que des valeurs plus exactes de l'accélération due à la pesanteur sont devenues nécessaires dans certaines déterminations métrologiques de précision ;

DECIDE que, pour les besoins métrologiques, la valeur de l'accélération due à la pesanteur à Potsdam, qui est le point de départ de ce Système, soit prise égale à 9,812 60 m/s^2, et non plus 9,812 74 m/s^2, valeur adoptée initialement.

C - GRAVITY MEASUREMENTS AT SEA

a) Traduction d'un article russe : "BILAN DE L'EMPLOI D'UN GRAVIMETRE SUR UN NAVIRE DE SURFACE" extrait de : Etudes Gravimétriques en mer, Inst. Astr. U.R.S.S., Fac. Géol. - n° 1, p.69-75, Moscou, 1961, par GROUCHINSKY Y.P.

Introduction

Au cours des recherches gravimétriques en mer, exécutées pendant la 2ème traversée Antarctique du navire "Obi", on a étudié un prototype de gravimètre marin amorti KGOM-3 à quartz, du système de K.E. VESSELOV. Ce gravimètre se trouvait à bord du navire à côté des appareils marins à pendule, ce qui a permis de comparer ses lectures à celles des appareils pendulaires.

C'était le premier cas d'utilisation d'un gravimètre sur un navire de surface pour la détermination de la force de pesanteur au cours des travaux marins gravimétriques d'U.R.S.S.

Cette étude avait pour but : établir la possibilité d'utilisation des gravimètres de ce genre sur les navires de surface, élaborer les méthodes d'observation par gravimètre sur navire de surface, enfin, déterminer les valeurs de la force de pesanteur aux points intermédiaires entre les points mesurés par des appareils pendulaires.

Le gravimètre a été installé dans le Laboratoire Géophysique du navire "Obi", à côté des appareils à pendule (à la hauteur de 2,8 m. au dessus du niveau d'eau). La fig. 1 (texte russe original) représente le gravimètre au Laboratoire suspendu à la cardan. Ses lectures généralement étaient faites simultanément avec celles des appareils pendulaires ; mais parfois des lectures supplémentaires au gravimètre étaient faites aux points intermédiaires entre les points mesurés par les appareils pendulaires. On a été obligé de transférer le gravimètre le 21 janvier 1957 sur un autre navire "Lena" et ce n'est que le 7 avril qu'il a été de nouveau installé sur "Obi". Ainsi, les mesures ont été faites avec le gravimètre avant son transfert à "Lena" aux mois de décembre - janvier 1956 - 1957, ainsi qu'après son retour sur "Obi". La nécessité de faire un réglage et d'ajouter le liquide n'a permis de commencer les mesures que le 14 avril. On a exécuté un cycle de mesures entre le 14 et le 25 avril ; mais aucune d'elles n'a pu être confirmée par des mesures pendulaires car pendant cette période, l'état de la mer ne permettait pas de travailler avec les appareils à pendule. Il est clair que les mesures de cette partie de la traversée, qui ne pouvaient ni être confirmées, ni ramenées à un système gravimétrique uniforme ne sont pas utilisables et peuvent seulement permettre d'élaborer la méthode de mesures et de prouver la possibilité de les faire. Du 20 au 23 avril, on a changé l'étendue de l'échelle du gravimètre pour l'adapter à la nouvelle latitude. Du 25 au 28 avril, on a exécuté une série de mesures dont une partie coïncide avec celles des appareils à pendule. Du 28 avril au ler mai, le navire se trouvait en rade des Iles des Cocotiers, le gravimètre alors a été transporté sur le rivage où il a été réglé. Ensuite, entre le mai et le 5 juin a été faite une série de mesures tantôt aux mêmes points que les mesures pendulaires, tantôt aux points intermédiaires. Pendant la dernière partie du trajet, entre Ceylan et l'Afrique, le navire ne s'est pas arrêté aussi, on a seulement fait des mesures avec le gravi mètre. Ainsi, tous les travaux avec le gravimètre peuvent être partagés en 4 parties, dont les caractéristiques sont représentées dans la table suivante :

Table 1

Secteur de la traversée	Date	Nombre de points	Nombre de mesures pendulaires	Lieu de référence
Antarctique, Mer de Deyvice	11-12,21-1	18	12	Mirny avec le contrôle à tous les points de mesures pendulaires.
Région tropicale méridionale	25-4, 1-5	8	6	Point n°66 avec le contrôle à tous les points de mesures pendulaires.
Région équatoriale, avant Colombo	2-5, 24-5	23	14	Colombo avec le contrôle à tous les points de mesures pendulaires.
Mer d'Arabie	27-5, 5-6	13	1	Colombo
Total		62	33	

On n'a pas tenu compte :

1°) de 4 points (n°1 à 4) correspondant aux moments du réglage du gravimètre ;

2°) de 14 points (n° 23 à 36) qui n'avaient pas de point d'attache,

et 3°) le point n° 45, où la mesure du gravimètre était invraisemblablement grande (50 mgal).

Caractéristiques fondamentales du gravimètre

Le gravimètre a été étudié avant le départ en expédition ; alors on a déterminé le coefficient de température et la valeur approximative de la division de l'échelle ; au retour sa valeur exacte a été déterminée.

Le coefficient de température est indiqué dans l'équation :

$$\Delta_t A = - K (t - t_o)$$

où $\Delta_t A$ est la correction due au changement de la température, $t_o = 20°$ et K = 0,602 exprimé en division du micromètre. La valeur d'une division de l'échelle, déterminée avant le départ, était égale à 24,50 mgal, et après le retour à - 23,25 mgal.

Pendant le dépouillement, on a utilisé cette dernière valeur de la division du micromètre.

On a déterminé les constantes de passage d'un trait de repère à l'autre au cours de la traversée et chaque fois que cela était possible, on a controlé l'installation des niveaux et la position du micromètre gauche fixe. Ces contrôles ont pû être faits 4 fois : au moment de l'arrêt à Mirny, pendant le débarquement sur la glace pour la vérification des appareils, pendant le débarquement aux Iles des Cocotiers et, enfin, pendant l'arrêt à Colombo.

Ci-après se trouve la table de conversion des lectures du gravimètre, faites à partir d'un certain trait de repère, en lectures, pour un autre trait de repère :

Table 2

Traits de repère	2	3	4	5	6	7
2	0	- 20,5	- 41,4	- 61,9	- 82,4	- 102,5
3	- 20,5	0	- 20,7	- 41,4	- 62,0	- 82,5
4	+ 41,4	+ 20,7	0	- 20,7	- 41,3	- 62,0
5	+ 61,9	+ 41,4	+ 20,7	0	- 20,6	- 41,4
6	+ 82,4	+ 62,0	+ 41,3	+ 20,6	0	- 20,6
7	+102,5	+ 82,5	+ 62,0	+ 41,4	+ 20,6	0

1°) Dans le sens verticalsont indiqués les traits de repère qui ont servi réellement pour les lectures ; la ligne horizontale contient les traits de repère qui donnent la conversion correspondante. L'erreur quadratique moyenne de calcul des valeurs de la table 2 est égale à ± 10, c'est-à-dire, en utilisant ces valeurs, il est possible d'introduire dans les calculs des erreurs systématiques jusqu'à 2 mgal. En règle générale, les lectures étaient faites à partir du même trait de repère ; c'est seulement dans le cas de changement de latitudes pendant la traversée et lorsque la force de pesanteur variait beaucoup qu'on était obligé de passer à un autre trait de repère.

Le déplacement du point zéro du gravimètre a été déterminé au cours des observations faites à Colombo, où le navire est resté pendant 4 jours, ainsi qu'en comparant les mesures obtenues par le gravimètre avec celles des appareils à pendule. La table 3 contient les valeurs de déplacement du point zéro du gravimètre.

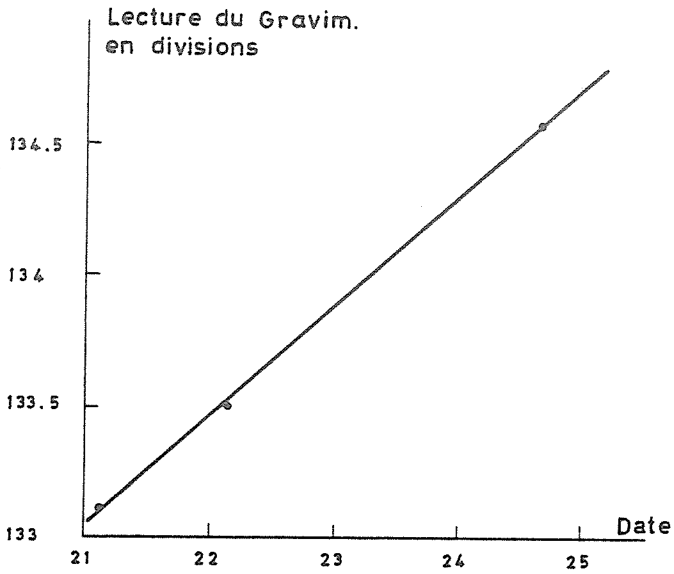
Table 3

Méthode de détermination - temps	t° moyenne	Déplacement journalier du point zéro
D'après les observations pendant 4 jours à Colombo.	31°	10,3 mgal
Par la comparaison avec les mesures faites aux différents points avec les appareils pendulaires au cours de la traversée Antarctique.	20°	4,9 mgal
Par la comparaison avec les mesures faites aux différents points avec les appareils pendulaires au cours de la traversée du Sud au Nord.	29°	12,67 mgal
Par la comparaison avec les mesures faites aux différents points avec les appareils pendulaires au cours de la traversée du Sud au Nord et d'Est en Ouest.	30°	7,8 mgal

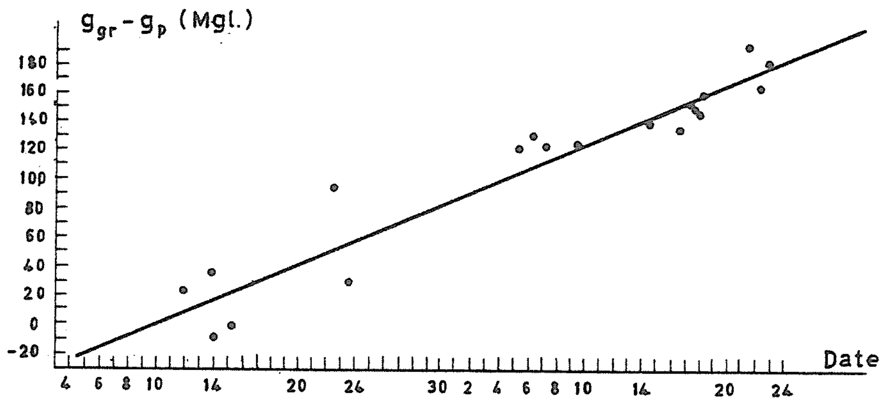
La fig. 2 représente le changement des lectures du gravimètre compte tenu du déplacement du point zéro à Colombo, et sur la fig. 3a on voit le changement de la différence entre les mesures obtenues par pendule et celles par gravimètre, conformément aux 2ème, 3ème et 4ème lignes de la table 3.

Méthode de travail avec le gravimètre

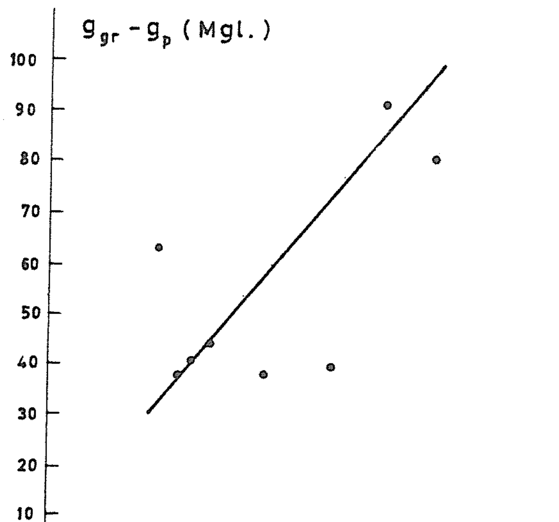
La méthode de travail avec le gravimètre, dans le cas de recherches gravimétriques en mer au cours de longues traversées, est basée sur la combinaison des mesures du gravimètre avec les mesures pendulaires. L'augmentation systématique de la différence entre les mesures faites avec le gravimètre et avec l'appareil pendulaire permet d'évaluer le déplacement du point zéro. Etant donné la faible précision des déterminations pendulaires sur les navires de surface (elle est caractérisée par l'erreur quadratique moyenne de $\pm$ 10 mgal), le déplacement du point zéro peut être considéré comme linéaire d'après toutes les comparaisons du gravimètre avec les pendules, obtenues au cours de la traversée.



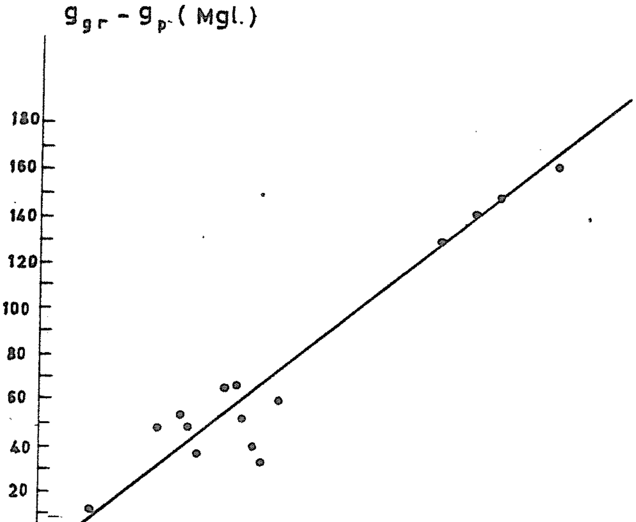
(Fig. 2)



(Fig. 3a)



(Fig. 3b)



(Fig.3B)

Ainsi, le gravimètre a été employé comme un appareil d'interpolation, seulement les valeurs de cette interpolation entre deux points successifs n'étaient pas considérées comme définitives et on faisait l'uniformisation d'après toutes les comparaisons faites au cours de la traversée.

Pour faire la mesure avec le gravimètre on le mettait en marche pendant quelques minutes : de 5 à 8. On notait toutes les positions extrêmes consécutives du pendule et on cherchait leur moyenne. Il aurait été très utile d'employer l'enregistrement automatique, par exemple photographique, car cela aurait permis d'obtenir une moyenne plus exacte et de tenir compte des fluctuations anormales du roulis. On repète cette opération 2 ou 3 fois sur le même point et on considère comme lecture définitive la moyenne de toutes. Au passage d'un point à l'autre, le gravimètre reste calé à la cardan. On le décale 30 ou 40 minutes avant le commencement des observations pour que le pendule prenne une position normale par rapport au corps de l'appareil. Au cours des mesures au gravimètre, on a noté la température de l'appareil et les indications des accéléromètres. Etant donné que le gravimètre n'en était pas muni on obtenait les valeurs des accélérations perturbantes à partir des accéléromètres des appareils pendulaires. Pour quelques points, où les indications de ces derniers n'ont pas été notées, on a admis lès corrections moyennes dues aux accélérations perturbantes et obtenues dans des conditions analogues. L'erreur introduite n'est pas grande, car dans des conditions pareilles, les valeurs des accélérations perturbantes horizontales varient peu (dans les limites de 12 à 20 mgal environ). Les perturbations verticales exercent une très faible influence sur le gravimètre, ainsi la correction correspondante a été négligée (voir Vesselov, le recueil : "La physique appliquée", n°15).

En plus des corrections dues à la variation de la température au déplacement du point de zéro et aux accélérations perturbantes, on a tenu compte généralement de la correction d'Eötvös.

La plupart des observations avec le gravimètre ont été faites en mer, quand le navire était arrêté et quand les vibrations au fond n'existaient pas. Cependant, contrairement au travail avec les appareils pendulaires, les mesures au gravimètre sont possibles malgré les vibrations pendant la marche du navire. Au cours de la traversée entre les Indes et Suez, les mesures ont été faites entièrement pendant la marche.

La comparaison des mesures du gravimètre avec celles des appareils pendulaires a été faite à 32 points.

Les différences obtenues permettent d'apprécier les mesures avec le gravimètre. En évaluant la valeur des mesures des appareils pendulaires nous avons admis pour elles l'erreur quadratique moyenne égale à ± 8 mgal. Suivant les valeurs des différences, on peut considérer les mesures du gravimètre et celles des appareils pendulaires comme ayant la même précision. Dans ce cas, l'erreur quadratique moyenne d'une mesure au gravimètre sera obtenue par la formule :

$$\varepsilon = \pm \sqrt{\frac{\Sigma d^2}{2n}} = \pm \sqrt{\frac{7097}{64}} = \pm 10{,}5 \text{ mgal.}$$

où d est la différence $g_{pend.} - g_{grav.}$, et n est le nombre de différences.

C'est précisément cette valeur de l'erreur quadratique moyenne qui doit être attribuée aux mesures avec le gravimètre sur un navire de surface. Nous estimons que l'usage de l'enregistrement photographique et l'emploi du girostabilisateur permettra d'augmenter considérablement la précision des observations.

La comparaison des anomalies de la force de pesanteur obtenues d'après les mesures avec le gravimètre et les appareils pendulaires au cours de la traversée du Sud au Nord, témoigne d'une bonne similitude des résultats.

Pour les mesures faites en mer Rouge et au cours de la traversée d'Est en Ouest on s'est servi seulement du gravimètre pendant la marche du navire. Heureusement, au cours de ce trajet le navire suivant de près l'un des itinéraires de Vening-Meinesz, ce qui a permis de comparer les mesures exécutées avec ses résultats. La similitude des résultats d'observations des diverses expéditions est bonne et on peut constater une corrélation entre la divergence des anomalies et la divergence des profondeurs. Cela confirme la conclusion concernant la possibilité des mesures avec le gravimètre de ce genre pendant la marche du navire même en présenoe des fortes vibrations.

Conclusions

Les résultats de mesures faites avec le prototype d'essai du gravimètre amorti sur le navire "Obi" permettent de faire les conclusions suivantes :

1°) Le gravimètre ainsi construit peut être employé sur les navires de surface pour la détermination de la force de pesanteur. Il est facile d'obtenir la précision de ± 10 mgal en l'utilisant, sans perfectionnements notables, comme appareil d'interpolation conjointement avec les appareils pendulaires.

2°) L'usage de l'enregistrement photographique et l'emploi du stabilisateur gyroscopique ainsi que de l'accélérographe propre sont nécessaires, car cela permettra d'améliorer considérablement la précision.

3°) L'emploi des gravimètres conjointement avec les appareils pendulaires augmentera considérablement le rendement du travail.

4°) Les mesures avec le gravimètre, contrairement aux appareils pendulaires, sont possibles en cas de fort roulis et pendant la marche du navire à petite vitesse. Quant à la possibilité des mesures pendant la marche à grande vitesse, et en présence de fortes vibrations, des expériences supplémentaires sont nécessaires pour pouvoir tirer des conclusions définitives. Cependant, on peut espérer avoir une solution positive de ce problème.

5°) La précision des mesures aux 62 points gravimétriques est caractérisée par une erreur quadratique moyenne : ± 10 mgal.

b) GRAVITY MEASUREMENTS ON THE CONTINENTAL SHELF OF SURINAM

G.L. STRANG Van HEES

(Geodetic Institute of the Technical University, Delft)

Introduction

The gravity measurements have been carried out by the Geodetic Institute of the Delft Technological University with the Askania Sea gravimeter Gss-2 n°19. The instrument was equipped with an Enograph recorder, without the "Minicomp" automatic regulation. The time schedule was as follows :

The measurements were made between March 26 and April 15, 1966.

......

In both harbours, Paramaribo and Georgetown, a shore connection was made in order to check the drift of the instrument, and to connect the measurements to the world gravity system. During the whole period the instrument worked perfectly without giving any trouble.

For navigation a Decca chain was available from which the position was read every 15 minutes. Thus the Eötvös corrections could be computed with an accuracy better than 0,5 mgal. So the most important error in the measurements was due to ship movements. Previous tests of similar measurements on the Halifax testrange show that the standard deviation of the measurements varies from 2 to 6 mgal depending on the weather conditions.

Shore connection

The determination of the gravity on the jetty alongside the ship in Paramaribo was done in co-operation with the Mining and Geological Service who kindly put a Worden gravimeter at our disposal.

As base point was chosen the gravity station on the stairs near the waterside of the Gouvernements Plein with a gravity value g = 978,080.5. (See Lit. 1).

On 30 and 31 March the ship was moored to the Beekhuizen jetty and from 8 to 12 April to the O.G.E.M. jetty. For both jetties the gravity differences with the base station were - 1,4 mgal and - 0,6 mgal respectively.

So we get for the gravity on the jetty :

Beekhuizen, g = 978,079.1 mgal
O.G.E.M. g = 978,079,9 mgal

Reduction to water level gives :

Beekhuizen g = 978,080.1
O.G.E.M. g = 978,080.9

In Georgetown the gravity base was at Sproston n°1 pier, g = 978,117.9 (communicated by the British Hydrographic Department).

On berth was 0,3 mile more south at Curtis Campbell pier. Because no gravimeter was available only the normal gradient - 0,1 mgal was applied as difference between the two piers. Reduction to waterlevel gives finally :

g = 978,119.0 mgal

Scale factor

The scale factor of the instrument was determined three times on a gravimeter base line.

1. In Berlin, on the Askania base : S = 49.86
2. In England, between Londond and Edinburgh : S = 49.6
3. In the Netherlands, between Groningen and Maastricht : S = 49.5

For the measurements on the shelf of Surinam the value S = 49.6 mgal per measuring spring division (M.S.D.) was assumed.

Drift

The drift of the gravimeter was computed by comparing the instrument readings in harbour before and after the sea measurements. We got the following results :

	Date	M.S.D.	Diff.	in mgal	g	Diff.	drift
Paramaribo	30,31/3	11.290			978,080.1		
			+ 0.040	+ 2.0		+ 0.8	+ 1.2
Paramaribo	8,12/4	11.330			978,080.9		
			+ 0.877	+43.4		+38.1	+ 5.3
Georgetown	15/4	12.207			978,119.0		

So we found from 1, 8 April + 1,2 mgal drift in 8 days and from 12, 15 April + 5,3 mgal in 3 days. This last value is not very likely in comparison with the drift during the days before. Probably the base stations Paramaribo and Georgetown are not very well determined relatively. Therefore, the drift found during the first period was also applied to the measurements on 12, 13 and 14 April.

Calibration of the Enograph recorder

The results were :

30, 31 March : 4.45 ± 0.02 Chart divisions per M.S.D.
8, 12 April : 4.45 ± 0.02 Chart divisions per M.S.D.
15 April : 4.44 Chart divisions per M.S.D.

Free air anomalies

The free air anomaly is the difference between the actual gravity and the normal gravity. ($\Delta g = g - \gamma'$). To obtain the free air anomalies the following reductions were made :

1. Eötvös correction

This correction was computed from the decca positions which were fixed every 15 minutes. Also the second order correction $c = 0.0041\ v^2$ mgal, with v the ships speed in miles per hour, was applied.

2. The drift correction was assumed to be 1.2 mgal in 170 hours, or 0.1 mgal per 14 hours.

3. The normal gravity depends on the latitude ϕ and was taken from tables with gravity value of the international ellipsoid (3), according to the formula :

$$\gamma = 978{,}049.0 + 5{,}172.3 \sin^2 \phi - 5.8 \sin^2 2\phi \text{ mgal}$$

4. All gravity anomalies are referred to the gravity base station in Paramaribo (g = 978,080.5 mgal).

Literature

(1) VELDKAMP J. - "Measurements of gravity in Surinam". Gravity Expeditions 1948 - 1958. v. V, Publication of the Netherlands Geodetic Commission, Delft, 1960.

(2) Van BOECKEL J.J.G.M. - "Geomagnetic and gravimetric anomalies in the northern part of Surinam". Thesis in preparation, 1967.

(3) SCHLEUSENER A. - "Tafeln der Internationalen Normalschwere". Deutsche Geodätische Kommission, München, 1958.

Note : On the map (which is not reproduced here). are indicated :

- The steamed lines with the dates and full hour positions,
- The free air anomalies in mgal.

c) REPORT ON THE TRIALS OF THE ASKANIA SEA GRAVIMETER TYPE Gss-2 N° 11 IN R.R.S. JOHN MURRAY, MAY - JULY 1967

G.A. DAY

(Dept. of Geodesy and Geophysics, Cambridge University)

Objective

The object of the trials was to assess the suitability of John Murray for surface ship gravity measurements, and to test and gain experience with the Anschütz electrically erected gyro.

Description of John Murray

John Murray was built as an experimental stern trawler in 1963 and converted in 1967 to a research vessel. She has the following dimensions :

- Length overall : 132 ft
- Beam : 24 ft
- Gross tonnage : 441.1
- Net tonnage : 105.7
- Draft fully stored : 15 ft

The main drive is from twin - diesel engines through a gear box and variable pitch propeller. The hull form is hydroconic and the transverse metacentric height is about 2.5 ft. The natural periods of pitch and roll are both about 5 seconds. The cruising speed is 10 knots. The gravimeter compartment is part of the original fish hold and the gravimeter is about two fifths of the vessels length from forward and three feet below the water line.

Gyrostabilised platform

The meter is normally mounted on a stable platform built by Anschütz of Kiel. The stable element is a precision gyro, and previously the platform used with meter n°11 had been referenced to a mechanically (oil) erected gyro.

Recently the manufacturers have produced an electrically erected gyro with superior performance and this was available for these trials. The principal advantage of the electrically erected gyro is that it will operate satisfactorily at higher acceleration, but also it is possible to adjust the erection rate limit and the time constant of the response. In addition, if the course transducer is used, there is automatic earth rate compensation. (The west pointing error of the gyro is removed by applying erection voltages to the torque motors. The error varies with the cosine of the latitude and its components in the directions of the axes of the platform are determined from the ship's heading by a resolver). When the ship is turning a centrifugal force acts on the platform which would tilt the gyro since it attempts to align itself with the apparent vertical. To prevent the platform going off level during course alterations the gyro erection is cut off when the angle and rate of turn exceed 5° and 0.3° per second respectively.

The new gyro was installed by Anschütz engineers, who remained on board for 24 hours after leaving Plymouth. After they had disembarked the gyro failed to erect properly in the normal erection mode. It was found that the fault did not occur in fast erection and so the gyro was operated in that mode. Subsequantly another Anschütz engineer visited John Murray and adjusted the output voltage of the 400 Hz alternator but the fault persisted and for the rest of the period fast erection was used. In fast erection the erection rate limit and time constant of response cannot be varied, and the erection is not cut off automatically during course alterations. It is not considered that inability to operate in the normal erection mode significantly effects the conclusions that can be drawn from these trials.

Narrative

John Murray sailed from Plymouth on May 16th. A great many difficulties were experienced with the ship's power supplies and electrical noise, and satisfactory gravimeter operation was not achieved until the ship sailed from Dublin on May 24th. From Dublin she proceeded to the Faroe Isles and began a survey of the area between the Shetland Isles and Iceland. She returned to Plymouth on July 4 th.

Limitations of weather on gravimeter

With a moderate swell from any direction but aft, John Murray rolls and pitches heavily. With a 12 ft beam swell of 6 seconds period, rolls of 15° from the vertical were common. Under these conditions the gravimeter record was ragged. With such a swell astern the ship's motion was comfortable and the gravimeter record surprisingly smooth. During the cruise virtually the whole spectrum of weather conditions, short of a storm, were encountered and the weather was reasonably typical of the area for the time of year. Of the total of 49 days, 19 were spent in port, 11 solely sheltering from the weather (including 30 hours anchored in Saint-Ives Bay). Of the time at sea approximately two days gravimeter record (10 %) was unusable due to bad weather.

Cross-coupling errors

It is estimated that the greater part of the usable gravimeter record contains significant cross-coupling errors. For part of the cruise the beam position and fore and aft acceleration were recorded whilst steaming on a variety of courses. On two different courses typical sections of beam position and acceleration record lasting half a minute were chosen, and the average cross-coupling errors during periods of half a minute calculated. From these, cross-coupling errors on several courses have been estimated and entered in the table. The largest observed cross-coupling error of 24 mgal occurred with a 9 foot swell of 7 seconds period on the port quarter. Appreciable cross-coupling errors were present in all sea states above 3 (slight sea or swell). The directions relative to the ship's head of the main components of the waves are also shown in the table. The phase relationship of the beam motion to the surge acceleration is constant for all headings into the sea and opposite for courses going with the sea, as observed in other ships (Wall, Talwani and Worzel, 1966). It is interesting to note the decrease in cross-coupling with increase in speed at 1900 on day 154.

Vibration

Vibration at a critical frequency of 29.8 Hz was observed to cause a large deflection in this gravimeter in H.M.S. Protector (Antarctic season 1965-66). Further tests on shore have shown that the effect occurs at a number of frequencies (Report in preparation and Comolet Tirman 1965). In a small diesel driven ship it is difficult to get away from quite large vibrations.

With the gravimeter in John Murray running from a shore supply, tests were made on the effect of the ship's engines and the propellor shaft. Both main engines and the auxiliary were idled and run at full speed. All three produced a vibration which caused a deflection when idling, but at full speed the gravimeter record was unaffected. The propellor shaft running at full speed produced no deflection. The effect of the ship's speed (propeller pitch) cannot be properly observed except over a gravity range and this was not possible during this cruise. Normally the propeller pitch is altered by discreet steps by a control on the bridge. No obvious change in gravimeter output was observed when the speed was changed in this way, but on one occasion a slight adjustment of pitch in the engine room produced a disturbed gravimeter record. An exhaustive speed trial over a gravity range should be carried out as soon as possible.

Conclusion

A number of problems were encountered on this first gravity cruise and it is anticipated that most of these will have been solved before the next gravity cruise en 1968. The meter was retained on board for the cruise following the one described here and some progress has been made towards improving the environment. This includes fitting a fan to lower the temperature of the gravimeter room. However, fluctuations in temperature still cause drift in the gyro amplifier.

Operation of the gravimeter using the electrically erected gyro is feasible in John Murray but there are still some minor operational problems. However, measurement is seriously limited by weather conditions and John Murray must be considered very inefficient for operation in distant exposed waters, (32 % of the working time on this cruise was lost, for gravity measurement, due to bad weather). Even for surveys in sheltered waters it is essential to make continuous measurement of the cross-coupling errors. A speed trial should be undertaken at the earliest opportunity.

References

- WALL, TALWANI & WORZEL - "Cross-coupling and off levelling errors in gravity measurements at sea". J. Geophys. Res., 71, n°2, 1966.
- COMOLET-TIRMAN - "Quelques résultats sommaires d'études effectuées sur le gravimètre marin Askania Gss-2'.n°15 du Service Hydrographique de la Marine Française. Commission Gravimétrique Internationale, 1965.

Day/Time	Weather conditions	Main component waves			Ship's speed (knots)	Mean peak surge Accel. obs. (gals)	Estimated cross-coupling		Appearance of record
		direct relat. to ship	height (ft)	period (secs.)			mgals	phase relat.	
15.3/20.40	moderate, swell	315	5	5	8	20	12	out	smooth
15.4/09.30	mod. sea and swell	010	7.10	6	10	20	12	out	mod rough
15.4/18.50	calm sea, mod. swell	000	9	6	6	12	5	out	rough
15.4/18.55	calm sea, mod. swell	170	9	6	6	15	5	in	fairly smooth
15.4/19.00	calm sea, mod. swell	170	9	6	10	15	3	in	fairly smooth
15.5/11.50	mod., confused sea and swell	220	9	7	10	45	24	in	smooth
	slight sea and swell				10	0-5	negligible		very smooth

d) DETAILS SUR LE GEOIDE (Europe Occidentale)

Bureau Gravimétrique International

En 1967, au B.G.I., quelques recherches ont été faites afin de tester la stabilité des résultats du géoide suivant les modifications apportées aux anomalies de la pesanteur. Dans ce but, 2 programmes ont été établis :

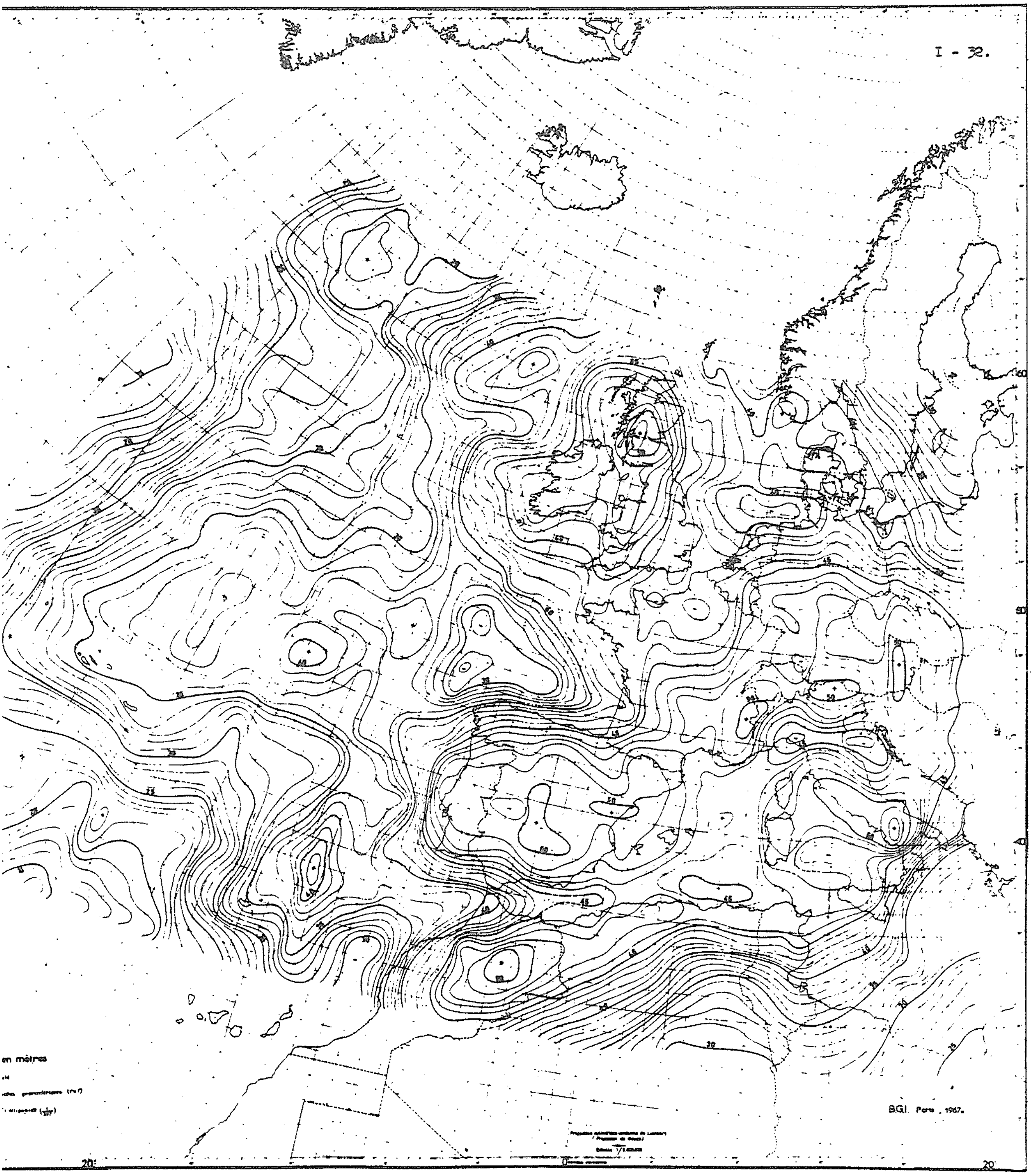
1er programme - permettant de calculer la carte mondiale du géoide à partir des anomalies moyennes par carré de 5° x 5° (2.592 carrés). Le test de ce programme sur les données de KIVIOJA (extrapolation de type géophysique) a redonné le même géoide que celui publié par ce dernier en 1964. Ce programme permettra des études empiriques sur les erreurs commises en raison de l'incertitude plannant sur de vastes zones, en particulier.

2ème programme - permettant le calcul du géoide détaillé à partir de n'importe quelle "fenêtre" fermée de carreaux de 1° x 1°. Le calcul est donc mené avec les valeurs moyennes des anomalies gravimétriques dans des carreaux de 1° x 1° à l'intérieur de la zone à détailler et avec les valeurs moyennes des anomalies relatives à des carreaux de 5° x 5° pour tout le reste du monde.

A titre d'application, nous avons calculé le détail du géoide dans une zone allant de -35° à + 20° en longitude, et de 30° à 60° en latitude, englobant par conséquent une partie de l'Atlantique, l'Afrique du Nord et l'Europe Occidentale. Ainsi, en chaque point de cette zone, le calcul de la distance du géoide à l'ellipsoide de référence (aplatissement : 1/297) fait intervenir 1.650 valeurs moyennes de la fonction de Stokes par degré carré et 2.520 valeurs moyennes de cette fonction par carreau de 5° pour le reste du monde. (Nous avons utilisé les données de Kivioja pour le monde, et les données du B.G.I. pour l'intérieur de la zone).

Bien que les calculs aient été faits avec l'aplatissement 1/297, il a semblé utile de publier la carte du géoide détaillé dans cette zone "voir ci-joint).

Des aménagements de détail permettent de modifier ce dernier programme en vue d'un affinage plus grand des résultats.


en mètres
B.G.I. Paris, 1967.
20°
20°

Précision à attendre des géoides calculés à partir des anomalies moyennes par carreaux de 5° x 5° :

Pour donner idée de l'influence des erreurs concernant les anomalies sur la hauteur du géoide, à une latitude moyenne, on peut noter qu'une différence de 10 mgal sur un carreau entraîne une variation de la hauteur du géoide de 3 mètres, sur ce même carreau.

La diffusion de cette erreur pour les carreaux voisins se fait selon le tableau suivant :

0.2	0.3	0.4	0.4	0.4	0.3	0.2
0.3	0.4	0.5	0.6	0.5	0.4	0.3
0.4	0.5	0.8	1	0.8	0.5	0.4
0.4	0.6	1	3	1	0.6	0.4
0.4	0.5	0.8	1	0.8	0.5	0.4
0.3	0.4	0.5	0.6	0.5	0.4	0.3
0.2	0.3	0.4	0.4	0.4	0.3	0.2

Variations en mètres de la hauteur du géoide pour une variation de 10 mgal de l'anomalie du carreau central. (Carreaux de 5° x 5°, latitude 45°).

LISTE DES PUBLICATIONS

reçues au

BUREAU GRAVIMETRIQUE INTERNATIONAL

(Oct. 1967 - Sept. 1968)

CONCERNANT LES QUESTIONS DE PESANTEUR

LISTE DES PUBLICATIONS

1967

* 158 - Geogr. Surv. Inst., Bull. v.XII, Part 2, Japan, 1967.

a) TSUBOKAWA I. & K. NAGASAWA. - "Anomalous land deformation in the Niigata area before the Niigata earthquake and in the Matsushiro area". p.13-19.

b) SUZUKI H. - "On the gravity standardization program in the Western Pacific Region". p.26-27.

162 - PICK M. - "Deflections of the vertical at Potsdam". Studia Geophys. & Geod., t.11, p.383-389, Prague, 1967.

163 - RISK G.F. & M.P. HOCHSTEIN. - "Subsurface measurements on the McMurdo ice shelf, Antarctica". from : New Zealand J. Geol. & Geophys., v.10, n°2, p.484-497, 1967.

"In order to study the regimen of the McMurdo Ice shelf three holes 31, 32 and 57 m. deep, were drilled near the seaward edge of the shelf ; ice thicknesses at the drill sites were calculated to be 33, 48 and 94 m. respectively. The rate of melting at the bottom of the shelf was found to be 1 m. per year at two drill sites. The vertical density gradient in each of the holes is larger than that observed at Little America Station, and the density increases abruptly by about 0.1 g. cm^{-3} at the top of a brine-soaked layer which was estimated to be less than 6 m. thick in each hole. Temperature profiles can be explained on the assumption that the brine moves horizontally through the shelf from the seaward edge to the interior and supplies heat to the shelf by convection and by liberation of latent heat during freezing. The observed brine level in the holes is about 20 % lower than the hydrostatic level".

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* La numérotation n'est pas suivie car les publications ne se rapportant pas aux questions de pesanteur n'ont pas été indiquées.

165 - CHAPMAN R.H. - "Gravity base station network".
California Division of Mines & Geology, Sp. Rep. n°90, 49 p,
San Francisco, 1966.

"A network of gravity stations consisting of approximately 360 sites in California and adjacent states has been established in order to facilitate compilation of gravity data and to provide base stations for future gravity surveys. The LaCoste-Romberg geodetic gravity meter used for most of the survey has a large reading range, a low drift rate, and a high reading sensitivi The meter calibration was based indirectly on the North American gravity standardization range, and is believed to be accurate to at least one part in 5000. The prime base for the network was the gravity station established by Behrendt and Woollard at the San Francisco International Airport, but auxiliary bases at Palo Alto and Los Angeles were also utilized.

The observation sites, which are chiefly bench marks, were occupied in a series of loops using ground transportation, except for air ties to the Los Angeles base. Repeated observations were made at 43 key stations on different loops in order to provide an estimation of the internal accuracy of the network.

Comparative values were obtained at many of the gravity bases established in recent years by Woollard, Harrison and Corbato and others in California. The results of these ties indicate satisfactory agreement at almost all stations. Ties to the U.S. Coast and Geodetic Survey pendulum stations in the state indicate that many of the pendulum values are in error by three milligals or more.

The results of the ties and network evaluation show that most of the gravity values obtained in this study have a reliability within $\pm$ 0.10 mgal, with reference to the calibration and prime base station value used. Station descriptions and values of observed gravity, elevation, latitude, and simple Bouguer anomalies are presented".

167 - Geophys. J., R. Astr. Soc., v.14, n°1-4, 1967.
many papers, particularly :

a) MURELL S.A.F. - "An experimental study of the effect of temperature and stress on the creep of rocks, with a discussion of Earth tide damping, isostasy and mantle convection".

"This paper is based in part on a paper by the author and A.K. Misra and published in Geophys. J., R. Astr. Soc. (1965), 9, 509-535, where the experimental and theoretical results are fully described.

Measurements have been made of the creep of a number of different rocks at temperatures up to 750°C under conditions of constant compressive stress. The results show that at temperatures below about $0.2T_m$ (where T_m is the absolute temperature of melting) the creep strain in proportional to the logarithm of the time under load, and is approximately proportional to the stress and to the absolute temperature. At higher temperatures the creep rate falls off less rapidly with time, and the creep strain is proportional to a fractional power of the time, with the exponent increasing as the temperature increases and reaching a value of $\sim\frac{1}{3}$ at temperatures of about $0.5T_m$. At these temperatures the creep increases approximately as the square of the stress and possibly exponentially and it increases with temperature (T) as exp. (-U/kT), where U is an activation energy and k is Boltzmann's constant. These results are strikingly similar to those obtained in measurements on metals, and it is thought that they can be explained in an exactly similar way in terms of competing processes of strain hardening and thermally assisted processes of plastic deformation and recòvery from strain hardening. The results suggest that creep is unlikely to be of importance in the upper part of the Earth's crust but that it will be important in the lower crust and upper mantle, particularly in connection with the damping of Earth tides and with the phenomenon of isostasy. An estimate is made of the rate of steady state creep of periodotite, which is found to be within the lower limit postulated in convection theories of continental drift. Although hydrostatic pressure is known to decrease creep rates (through its influence on thermal recover) its exact influence on the creep of rocks is still a major unknown factor".

b) BLUM P.A., J. CORPEL, G. JOBERT, J. NIEVRES & A. ROUAUD. "Détermination des propriétés élastiques ou anélastiques du manteau à l'aide des charges dues aux marées océaniques". p.219-224.

"Five clinometric stations have been installed in Normandy to determine the deformation of the ground due to tidal loads in the Channel. The attraction of the water sheet is computed for every hour during the period of observation. The effect of the deformation of the ground (tilt plus variation of attraction) is evaluated and compared to the attraction of the water loads.

For an elastic body the values should be in phase and their ratio would give a mean value of the ground rigidity, varying with the distance from the coast. In fact the residues are not found exactly in phase, a result which can be attributed chiefly to an incomplete evaluation of the loads, but could be due in part to anelastic properties of the mantle".

c) MAGNITZKY V.A. - "Postglacial uplift of Scandinavia and physical nature of viscosity of the Earth's upper mantle". p.245-249.

"There are many reasons to assume isostatic readjustment taking place in the low-velocity layer. In this case postglacial uplift of Scandinavia gives the value 10^{20} - 10^{21} for viscosity in the low-velocity layer. Assuming the low-velocity layer being composed principally of Mg silicates it is possible to calculate respective viscosity due to diffusional processes. Thus for viscosity the value 10^{19} - 10^{22} was obtained which is in reasonable agreement with respective value from the uplift data".

d) ARTYSSHKOV E.V. - "On the isostatic equilibrium of the Earth's crust". p.251-260.

"A brief physical analysis of the postglacial uplift of Fennoscandia is presented. It permits one to detect the great decrease in viscosity in a relatively thin layer of the upper mantle substance. The existence of this layer, i.e. the asthenosphere, has been theoretically predicted by many authors on the basis of the fundamental principals of solid state physics. An equation of isostatic motions is derived and it has been established that they are due to the flows in the asthenosphere. The presence of the asthenosphere near the Earth's surface affects many geological phenomena. In particular, the platform motions are supported by the flows in the asthenosphere, which velocities must be of the order of 1 - 10^{2} cm/year. In conclusion some consequences of glacio-isostatic motions for periglacial regions are considered".

e) CRITTENDEN M.D. - "Viscosity and finite strength of the mantle as determined from water and ice loads". p.261-279.

"Some recent examples of transient Earth loads (Lake Bonneville, Utah ; Glacier Bay, Alaska ; northeast Greenland) indicate that both the viscosity and finite strength of the mantle are lower than is commonly presumed. A time constant (1/e) of 4000 years is estimated for Lake Bonneville, and of 1000 years for northeast Greenland. A strain rate of 10^{-14} is typical. These figures imply viscosities in a homogeneous half space ranging from 10^{20} to 10^{21} poises.

An upper limit of finite strength is set by Lake Bonneville at a few times 10^{6} dyn/cm^{2}. If mountain ranges like the Sierra Nevada or Himalaya are regarded as dynamically supported rather than static systems, this low value is not incompatible with other geologic observations".

f) ARTEMYEV M.E. - "On the character of isostatic equilibrium disturbances". p.281-286.

"The data of disturbances of the isostasy of the Earth's crust and their relation to different tectonic zones give valuable information about processes in the Earth's crust. They may be used for the evaluation of some physical parameters, for example of the asthenosphere viscosity. The last value is usually determined on this basis of the data on postglacial uplift, but there are doubts that these values can be applied to the regions with different tectonics. For this reason we have studied as a first step the character of disturbances of the isostasy in the areas of different tectonics.

It was ascertained that disturbances of the isostatic equilibrium are the result of the active geotectonic process and that isostatic forces are passive as tectonic factor. In the geological time scale the readjustment takes place instantaneously, therefore isostatic anomalies of gravity may be considered as direct indications of the modern tectonic activity.

Regular relations between isostatic disturbances and the character of the latest tectonic movements can be clearly revealed by the comparison of the isostatic anomalies maps with the schemes of Cenozoic crustal movements in the different tectonic zones. In particular, the anti-isostatic movements of the Earth's crust are very common features. The relations revealed between the isostatic gravity anomalies and tectonic movements permit us to make some conclusions about the character of internal processes in the Earth".

g) ANDERSON L. & R. O'CONNELL. - "Viscosity of the Earth". p.287-296.

"Direct and indirect estimates of the variation of viscosity with depth in the mantle indicate that a low viscosity layer exists in the upper mantle. A viscosity varying with depth can be used to reconcile the various estimates of relaxation times. If the seismic anelasticity can be used as a guide the average viscosity of the lower mantle is about 10^{23}p. Combined with previous estimates of the upper mantle viscosity this gives a relaxation time of about 3000 years for the non-equilibrium bulge of the Earth. This is close to the time from the last ice age but is much less than the 10^7 years required if the non-equilibrium bulge is due to the changing rate of rotation which requires an average mantle viscosity of 10^{26}p. If the latter value is correct the activation volume for creep is much larger than for anelasticity or the effect of a phase change in the upper mantle is more effective in suppressing creep than attenuation.

The response of a layered viscous sphere to a surface load is calculated for a wide range of parameters including the above range of estimates for lower mantle viscosity. These results can be used to estimate the decay time, or the isostatic time scale, for various sized features".

h) McKENZIE D.P. - "The viscosity of the mantle". p.297-305.

"Creep under low stresses is by diffusion and has a linear relation between stress and strain rate ; it also obeys the Navier-Stokes equation. Therefore the viscosity of the mantle may be calculated from solid state theory and also from the slow deformations of the Earth. The viscosities derived by these methods are in reasonable agreement, and both show that the viscosity of the lower mantle is $\sim 10^5$ greater than that of the upper. This high viscosity prevents polar wandering and lower mantle convection. Some suggested modifications of the viscosity depth calculations from post glacial uplift may improve their accuracy considerably".

i) RAMBERG H. - "Model experimentation of the effect of gravity on tectonic". p.307-329.

"It seems likely that many of the tectonic phenomena in the Earth's crust are generated by processes within the mantle. Our view of such a large scale tectonic phenomenon as the evolution of orogenic belts consequently ought to reflect on the theorizing of the behaviour of the mantle. The author finds it therefore approximate to present in this symposium some results from experimental model studies related to the origin of geosynclines and orogens. Some models simulating convection currents in the mantle are also discussed".

j) GROVSKY M.V. - "A state of stress in the Earth's crust and the energy of tectonic processes associated with the upper mantle". p.331-339.

"The state of stress in the Earth's crust and the energy of its plastic tectonic deformations are mainly determined by sub-crustal processes. The recorded irregularity of the rotation of the Earth can create stresses in the crust, which are 10^{10} times smaller than the stress values established independently by various methods. For this reason data on a state of stress in the crust and on the energy of its tectonic deformations represent a valuable quantitative information on the processes occuring in the upper mantle".

k) KNOPOFF L. - "On convection in the upper mantle". p. 341-346.

"Present estimates of viscosity and other pertinent parameters make it unlikely that thermal convection exists in the lower mantle. Convection may be considered from the point of view of an instability process for the upper mantle but the probable non-Newtonian nature of viscosity in the upper mantle makes this problem difficult to solve.

Criteria are suggested which evaluate the pertinence of the convection current hypothesis to the upper mantle, and which are formally independent of the viscosity. Estimates of these quantities can be obtained from the model in which Newtonian viscosity is used. The postulate is introduced that, since these quantities are independent of the viscosity, their estimates will apply, to order of magnitude, to other models of viscosity.

The estimates of the time necessary to set up stable convection and the gravity anomaly expected over a convecting mantle are consistent with the hypothesis of convection in the upper mantle. The estimates of the depression of the geoid over a rising current and of the horizontal scale of the convection cells appear to yield results inconsistent with convection in the upper mantle".

l) LYUSTIKH E.N. - "Criticism of hypotheses of convection and continental drift". p.347-352.

"The computations of mantle convection involve assumptions too far from reality and are misleading therefore· Besides, such computations must involve spherical harmonics of several different orders, not of a single one. The order of spherical harmonic does not determine exactly the number of convection cells. Mathematical analysis of the Earth's relief cannot provide definite information about the past and present convection. If the Earth has an iron core which grows, any convection is impossible· Most of the evidence in favour of continental drift in invalid. The mid-ocean ridges are not axes of rising convection currents. Both the convection hypothesis and the drift hypothesis are doubtful and need a more reliable basts".

m) WEERTMAN J. - "The effect of a low viscosity layer on convection in the mantle". p.353-370.

"In this paper we attempt to find a solution of the following problem. It appears reasonable to expect that if thermal convection occurs in the Earth's mantle, it may also occur within the Moon and Mars. The dimensions of these latter two bodies are comparable to the thickness of the Earth's mantle.

Presumably the amount of radioactive heat generated per unit mass is similar in all three bodies. Yet the surface morphology of the Earth, which many scientists believe arises ultimately from mantle convection, differs markedly from that of the Moon or Mars. The explanation advanced here for this difference is based on the effect produced on convection in the mantle by the presence of a low "viscosity" or low creep strength layer. It is assumed that the low velocity layer of the mantle is such a low creep strength layer. A low viscosity layer changes the amount of "coupling" between the outer crust and mantle convection. (The crust is "coupled" if mantle convection produces stresses in the crust which are large enough to deform it plastically. The crust is "decoupled" from the mantle if these stresses are insufficient to produce plastic deformation). The theory assumes that the viscosity or creep strength is essentially zero in the low viscosity layer. The analysis is similar to that developed earlier for the calculation of stresses within the mantle. We find that the deeper within the mantle lies the low viscosity layer the greater is the coupling of the outer crust to be mantle convection currents. If the low creep strength layer lies close to the surface the outer crust is decoupled from the interior. According to the literature the depth of the low velocity layer is determined by the temperature and pressure profiles within the mantle. If the temperature profile were kept constant but the pressure reduced by changing g, the gravitational acceleration, the low velocity zone would be moved to a level closer to the surface. It is proposed that because of this interdependence between temperature, pressure and depth of the low velocity layer, the low velocity layers in Mars and the Moon (if such layers exist in these bodies) lie much closer to the surface than does the corresponding layer in the Earth. Hence the outer crusts of Mars and the Moon are more nearly decoupled from the interior than in the Earth's crust".

n) RUNCORN S.K. - "Flow in the mantle inferred from the low degree harmonics of the geopotential". p.375-384.

"Flow in the Earth's mantle is inferred from continental drift. Its distribution may be obtained from the pattern of zones of compression and tension in the Earth's crust and from the low harmonics of the geopotential. The origin of the flow is held to be convection. The depth to which the flow extends will be discussed. The relation of the flow to the earthquake mechanism will be considered".

o) OROWAN E. - "Island arcs and convection". p.385-393.

"If island arcs are the outcrops of compressive faults, they cannot be products of a uniform field of compressive stress because their symmetry is lower. The polarity of the curvature, however, is provided if the compression is of convective origin. Incipient faulting is then followed by a convergence of the convective flow towards the fault, causing a convergence of the initially parallel stress trajectories. Since the fault propagates at right angles to the trajectories of maximum compressive stress, its coutcrop becomes an arc convex towards the upstream side.

In oceanic compressive faults due to convection the two conjugate fault planes are not equivalent because overthrusting of the downstream side by the upstream side would lead to the accumulation of a thick crust which would inhibit the progress of faulting along the plane, and because underthrusting is lubricated by decomposing serpentine, fluxed balalt... This seems the reason why apparently in all long-lived oceanic compressive faults the upstream (usually the oceanward) side underthrusts the downstream side".

p) BOTT M.H.P. - "Terrestrial heat flow and the mantle convection hypothesis". p.413-428.

"The paper aims to show that the distribution of terrestrial heat flow is consistent with the mantle convection hypothesis provided that certain restrictions are placed on allowable patterns of convection. Some objections to convection are first discussed.

Numerical experiments have been carried out on the loss of heat from the upper surface of a mantle convection cell, assuming a simplified flow pattern. The results are compared with observed heat flow. Subject to the assumptions of the models, the results suggest that sub-oceanic mantle convection currents, if they exist, are overlain by a layer 50 - 100 km thick which is stationary or moves much less rapidly. This appears to rule out the mechanism of continental drift by ocean floor spreading as suggested by Dietz ; continental drift affecting the overlying layer must occur at a much lower velocity than the convection current. If thermal diffusivity remains approximately constant with depth the velocity near the upper surface of the convection cell needs to be at least about 20 cm/y to explain the uniformity of heat flow, but if radiative conduction becomes dominant a lower velocity would be acceptable.

The experiments have been extended to a convection cell flowing beneath a continental margin. The results suggest that the approximate equivalence of oceanic and continental mean heat flow can best be explained if convection currents are generally present beneath oceans but absent beneath continents, unless the continental crust has a much lower radio-activity than is normally supposed. The anomalous low heat flow of Pre-Cambrian shields suggests absence of convection in the mantle beneath since the Pre-cambrian.

Conditions particularly favourable to large-scale partial fusion of the upper mantle occur in the topmost section of a rising convection current. This should result in abundant igneous activity and local areas of anomalously high heat flow. This supports the view that ocean ridges overlie uprising convection currents. Belts of relatively low heat flow adjacent to the ocean ridges are difficult to explain if the convecting mantle behaves as a Newtonian viscous fluid, but are explicable on the non-Newtonian model of convection recently suggested by Orowan".

169 - WORLD DATA CENTER A. - "Airglow - Ionosphere - Aurora - Cosmic Rays - Geomagnetism - Solar activity".
Catalogue of data received by W.D.C. A for the period
1 July 1957 - 30 June 1967, 1967.

170 - WORLD DATA CENTER A. - "Gravity - Tsunami - Seismology - Longitude & Latitude - Meteorology".
Catalogue of data received by W.D.C. A during the period
1 July 1957 - 30 June 1967, 1967.

171 - MELCHIOR P. - "Marées terrestres".
Bull. Inf. n°49, p.2149-2228, 1967.

172 - COOK A.H. - "The motion of artificial satellites in the gravitational field of Earth".
Pub. della Comm. Geod. Italiana, Memorie n°18, 138 p, 1967.

"My purpose in these lectures is to show how from observations of the motions of artificial satellites we may derive the external gravitational potential of the Earth, and although for most of the time I shall be describing theories of satellite orbits, I shall not be trying to give a complete account of such theories. Such a complete account would describe, I think, all the methods that could be used to enable one to determine at any future time the motion of a satellite from initial conditions and from the known forces acting on it. That is a more ambitious program than we require to determine the Earth's potential from observations of artificial satellites ; and my lectures are restricted to this latter aspect of theories of satellite orbits. Even in this restricted range I shall not attempt to discuss all theories, but I shall endeavour in my selection to cover those which I think are

of the greatest

historical importance and I shall also try to bring out those aspects of the subject which lead to further developments and in particular to theories of orbits about the Moon.

The first two lectures contain fairly elementary matter, for I propose to put together in them a number of general ideas and particular results that we shall want in the later lectures, instead of having to introduce them from time to time in the course of individual lectures".

177 - HARRISON J.C. - "Gravity measurements in the Northern Continental borderland area off Southern California".
Univ. California, Inst. Geophys. & Planetary Physics,
Interim Rep. n°1, 44 p, Los Angeles, 1960.

178 - HARRISON J.C. - "Gravity measurements in the Southern Continental borderland west of Baja California".
Univ. California, Inst. Geophys. & Planetary Physics,
Interim Rep. n°2, 61 p, Los Angeles, 1961.

179 - CORBATO C.E. & M.D. HELFER. - "Gravity measurements on the cruise of the U.S.S. Gear, October 23 - 27, 1961".
Univ. California, Inst. Geophys. & Planetary Physics,
Interim Rep. n°3, 19 p, Los Angeles, 1962.

180 - HELFER M.D. - R. von HUENE & M. CAPUTO. - "Gravity survey of the Santa Barbara Channel with the U.S.S. Rexburg".
Univ. California, Inst. Geophys. & Planetary Physics,
Interim Rep. n°4, 16 p., Los Angeles, 1962.

181 - HELFER M.D. - M. CAPUTO & J.C. HARRISON. - "Gravity measurements in the Pacific and Indian Oceans, Monsoon expedition 1960-61".
Univ. California, Inst. Geophys. & Planetary Physics,
Interim Rep. n°5, 37 p, Los Angeles, 1962.

Cartes du BUREAU de RECHERCHES GEOLOGIQUES et MINIERES
établies en 1967 :

- Carte de la France, échelle 1/2.000.000°, densité 2,3 - 2,7, inventaire des prospections gravimétriques, 8 feuilles.

- Cartes de la France, échelle 1/200.000°, densité 2,3 :

  n° 19, Saverne.
  n°28-36, Strasbourg - Mulhouse.

- Carte sur fond géologique, échelle 1/320.000°, n°21, La Rochelle.

- Cartes de la France, échelle 1/80.000°, densité 2,7 :

  n°37-26, Sarreguemines,
  n°38 , Wissembourg,
  n°54 , Saverne
  n°55 , Lauterbourg,
  n°71, , Strasbourg,
  n°86 , Colmar,
  n°101 , Mulhouse,
  n°115 , Ferrette,
  n°233-245, Montpellier.

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1968

1 - GARLAND G.D. - Chronique de l'U.G.G.I.
n°69, p.129-176, 1967.

2 - GARLAND G.D. - Chronique de l'U.G.G.I.
n°70, p.177-224, 1967.

3 - GARLAND G.D. - Chronique de l'U.G.G.I.
n°71, 48 p, 1968.

6 - Bulletin Géodésique n°86, 1967.

a) LEVALLOIS J.J. - "Assemblée Générale de l'A.I.G., Lucerne 1967". Rapport du Secrétaire Général. p.311-330.

b) I.A.G. - Report on the third meeting of the Western European sub-commission of the International Commission for Artificial Satellites. (Venice, May 1967) p.483-484.

c) HEISKANEN W.A. & H. MORITZ - "Physical geodesy". p.491-492.

"Cet ouvrage théorique important traite du champ de gravité terrestre, de ses nombreuses applications en géodésie, et de leur développement actuel. Il est destiné aux étudiants et aux techniciens de l'enseignement supérieur".

7 - Bulletin Géodésique n°87, 1968.

a) TENGSTROM E. - I.A.G. Conferences on the normal spheroid and the figure of the Earth (SSG 16), and on recent research on atmospherical refraction for geodetic purposes (SSG 23), held in Vienna (March 14 - 17, 1967). p.23-32.

b) HYTONEN E. - "Report on progress of the absolute gravity measurements with long wire pendulum". p.95-96.

c) ARNOLD K. - "An attempt to determine the unknown parts of the Earth's gravity field by successive satellite passages". p.97-102.

d) HEIFETZ M.E., B.M. MALAHOV & V.P. TEREHOV. - "Sea surface pendulum measurements made by Laboratory of gravimetry of the Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography of the U.S.S.R". p.103-106.

e) RAPP R.H. - "The computation of gravity at elevation on a large scale". p.107-113.

8 - ELSTNER C. - "Relative pendelmessungen zwischen Potsdam - Helsinki und Ivalo".
Deutsche Akad. Wissensch., Geod. Inst. Potsdam, n°17, 19 S, Berlin, 1968.

17 - HOCHSTEIN M.P. - "Pressure ridges of the McMurdo ice shelf near Scott base, Antarctica".
from : New Zealand J. Geol. & Geophys., v.10, n°4, p.1165-1168, Wellington, 1967.

18 - FISHER R.G. - "Shallow heat survey of Taupo Borough and adjacent country".
from : New Zealand J. Geol. & Geophys., v.8, n°5, p.751-771, 1965.

"A shallow heat survey of the Taupo Borough and the adjacent country was made over the period 1958-64. The estimated natural heat flow of 25,000 kcal/sec. is approximately 25 % that of Wairakei measured in 1958".

19 - REINHART E. - "Lotabweichungen aus sichtbaren Massenberechnet mit Hilfe einer Rechenanlage für das Basis vergrösserungsnetz Heerbrugg".
D.G.K., Reihe C, H. n°114, 84 S, München, 1968.

21 - BOTT M.H.P. & P. SCOTT. - "Recent geophysical studies in South-West England".
from : Present views on some aspects of the Geology of Cornwall and Devon. p.25-44, 1964.

22 - BURSA M. - "Theoretical and practical achievements in determining the figure of the Earth and its external gravitational field". 1963 - 1967".
Research Inst. Geod., Praha, paper presented at the XIV General Assembly of the I.U.G.G., Lucerne, 1967, 56 p, 1967.

24 - ROKSANDIC M.M. - "An outline of the geotectonic districts of the Adriatic Sea".
from : Bull. Inst. Geol. & Geophys. Res., Ser. A, n°22/23, 14 p, Beograd, 1964/65.

25 - ROKSANDIC M.M. - "Nature géotectonique de la Méditerranée à la lumière des données géophysiques".
Inst. Recher. Géol. & Géophys., Ser. C, t.VII, p.93-100, Beograd, 1966.

26 - ROKSANDIC M.M. - "Structures profondes et superficielles des Dinarides externes et de l'Adriatique".
Inst. Recher. Géol. & Géophys., Sér. C, t.VII, p.101-161, Beograd, 1966.

29 - MELCHIOR P. - "Marées terrestres"
Bull. Inf. n°50, p.2230-2315, 1968.

31 - BONATZ M. - "Gravimetric Earth tide recording with Askania gravimeter GS 11 or 12 by electronic amplification of the gravimeter signal".
Presented at the XIV General Assembly of I.U.G.G.,
Inst. Theor. Geod., Univ. Bonn, Typewritten text, 5 p, 1967

32 - BONATZ M. - "Untersuchungen elastischer nachwirkungen am Askania gravimeter GS 11 n°116".
from : Studia Geophys. & Geod., n°11, p.164-182, 1967.

34 - MONTAG H. - "Bestimmung rezenter Niveauverschiebungen aus langjährigen Wasserstandsbeobachtungen der südlichen Ostseeküste".
Deutsche Akad. Wissensch Berlin, Geod. Inst. Potsdam, n°15, 139 S, 1967.

36 - INSTITUT ROYAL METEOROLOGIQUE DE BELGIQUE. - "Jaarboek, résultats des observations des marées terrestres en 1964-1965". 188 p, Bruxelles, 1967.

37 - ROSS D.I. - "Geophysics data report 1967-1-D, Monaco cruise BIO BAFFIN 07-67, April - May 1967". Inst. Ocean. Bedford, 110 p, Dartmouth, 1967.

"From April 5 to May 8 CSS BAFFIN ran two lines across the North Atlantic (Latitudes 41°30'N and 38°30'N) on her way to and from the IXth International Hydrographic Conference held at Monaco. A complete report of the cruise is given in B.I.O. Report 168. The Hydrographers on board operated a magnetometer on both Atlantic crossings and punched five-minute bathymetry values on paper tape using a Friden flexowriter. This report is a summary of the magnetic field and bathymetry data obtained".

38 - TANNER J.G. - "An automated method of gravity interpretation". Contr., v.7, n°24, 9 p, from : Geophys. J. R. Astr. Soc., n°13, p.339-347, Ottawa, 1967.

"The interpretation of an observed gravity anomaly in terms of an anomalous mass with irregular outline and with uniform density contrast requires the solution of a non-linear problem. It is possible to iterate this non-linear problem by means of a linear approximation, provided some assumption is made about one of the surfaces of the anomalous mass. This paper gives such a method.

If there are m observations of a gravity anomaly and if the anomalous mass is assumed to be subdivided into n two-dimensional rectangular blocks ($n \leq m$) then a set of linear equations can be solved - directly if $m = n$, and by least squares if $m > n$ - to give a system of blocks of variable density constrast which satisfy, or nearly satisfy in the case of the least squares solution, the observed gravity anomaly. These blocks are then transformed to give blocks of uniform density contrast. Because the gravity effect is non-linear the transformed blocks will not usually satisfy the observed anomaly. It is, therefore, necessary to adjust the model using the same general method.

Two computer programs applying respectively to structures with inward dipping contacts and to structures with outward dipping contacts have been developed. The formulae used in the programs apply to two-dimensional structures, but three-dimensional structures are approximated by end corrections".

39 - DOHR G. & K. FUCHS. - "Statistical evaluation of deep crustal reflections in Germany".
Geophys., v.XXXII, n°6, p.951-967, 1967.

"By a routine method of observation during exploration reflection measurements, sufficient data were compiled to allow significant statistical conclusions concerning deep crustal reflectors. The appearance of deep crustal reflections differs considerably from that of reflections from shallow sedimentary beds. They correlate only over short distances, seldom more than a few kilometers. The reflection times display quite a scatter, even over small areas. In many cases the reflected signal is typically broadened to continue over a few cycles. Following this reflection band along a profile, the main energy is frequently shifting from one phase to another until finally it disappears completely. A new method of wide angle reflection observations using a common reflection point technique was used to support and confirm results of the statistical analysis".

40 - DOBACZEWSKA W. - "Théorie de la solution du problème fondamental de la géodésie satellitaire".
Komitet Geod. Polskiej, Akad. Nauk, Geod. i Karto., t. XVI, n°4, p.213-262, 1967.

"Cette étude est consacrée au problème de jonction des réseaux géodésiques au système universel par rapport au centre de la masse de la Terre et à son axe de rotation. On a présenté les systèmes spatiaux de géodésie cosmique, ainsi que l'orientation de ces systèmes dans le globe terrestre et par rapport aux étoiles. On a donné les méthodes satellitaires de l'inclinaison de l'ellipsoide de référence par rapport au système terrestre, les méthodes satellitaires de détermination des coordonnées du centre de la masse de la Terre dans le système géodesique ainsi que la méthode de liaison de deux réseaux de triangulation classique au moyen de l'observation synchronisée des satellites artificiels".

41 - ROBERTSON E.I. - "Bouguer anomaly map of Viti Levu, Fiji".
from : New Zealand J. Geol. & Geophys., v.10, n°5, p.1309-1313, Wellington, 1967.

"The Bouguer anomaly map of Viti Levu in the Fiji Group consists essentially of a gravity "low" surrounded by gravity "highs". The "low" can be explained partly by the effect of the younger rocks which have a specific gravity 0.4 g/cm^3 less than the older rocks (Lower Tertiary), and partly by a relative thickening of the crust by about 10 km. The average crustal thickness is about 30 km which supports the geological evidence that the Fiji islands are continental".

42 - HERMANOWSKI A. - "Vertical displacements of local points in aveal leveling nets of high precision determined on base of periodical observations".
Politechnika Warszawska, Zeszyty Nauk. n°171, Geod. n°21, 60 p, Warszawa, 1967.

"In this work the vertical movements of the Earth's crust having local and centurial character, have been defined according to the geodetical point of view. These definitions allow the separation, by means of periodical leveling observations of high precision of points liable to vertical movements of centurial character only and to compute the size of local movements in reference to them.

Assuming, that all material points of Earth's crust are in permanent move the idea of the stability of the ground, according to the architector's point of view have been introduced, what permitted a very high precision in the determination of a constant level datum for whole period of building and exploitation of the object.

Founded on elaborated definitions and assumptions, the completely original method of compensation of field data and the computation of vertical displacement has been worked out. The new method of compensation is very useful especially in that case when computing vertical displacement of points of areal leveling nets, spread over large territories (of a size of about 20.000 km^2). This is valid for mining territories too. The same method may also be applied when municipal leveling nets have to be brought up to date or when determining vertical displacements of bases of big water constructions resp. industrial constructions, during periods of building and exploitation".

46 - Geophysical Journal of the Royal Astronomical Society, v.12, n°5, p.449-544, 1967.

a) WITTE L. - "Truncation errors in the Stokes and Vening Meinesz formulae for different order spherical harmonic gravity terms". p.449-464.

"A detailed analysis of truncation errors in the Stokes formula integration, using Molodenskii's method, shows the mode of dependence of the errors on the spherical harmonic components of Δg of different order. The results indicate that significant reduction in the truncation errors can be achieved by adopting a reference model for normal gravity of higher order than that based on the International Ellipsoid. Particularly, the use of a seventh order reference model combined with truncation at the first zero crossing of the Stokes kernel function appears very promising. The treatment of truncation errors for deflection of the vertical as given by Molodenskii et al.. and Hirvonen & Moritz yields results for deflections as derivatives of geoidal heights explicitly obtained from Stokes formula. These errors can be reduced by the same techniques as suggested for the Stokes integration. The truncation error behaviour of the Vening Meinesz formulae is shown to be different. An adaption of Molodenskii's approach using an expansion of the truncated deflection of the vertical kernel function in terms of associated Legendre polynomials of first order provides a means for spherical harmonic analysis of the truncation errors in the Vening Meinesz formulae".

b) JEFFREYS H. - "A completeness theorem for expansion of a vector function in spherical harmonics". p.465-468.

"A proof is given that the F, G, H notation is adequate for expressing a vector function in a sphere in terms of spherical harmonics, subject to convergence conditions ; that is, the terms are linearly independent (and can in fact be made orthogonal) and form a complete set such that no non-zero set of components expansible over spheres can be orthogonal to all of them".

47 - KOCH K.R. - "Successive approximation of solutions of Molodensky's basic integral equation".
AFCRL 67-0506, Dept. Geod. Sci. Rep. n°85, Rep. n°14, 34 p, Columbus, 1967

"This report is concerned with the successive approximation of the solutions of linear integral equations by electronic computers. An application is given by the approximation of Molodensky's basic integral equation. By a mathematical model Molodensky's solution of the basic integral equation is compared with the successive approximation of this integral equation. It is shown that the successive approximation is preferable".

48 - Geophysics, v.XXXII, n°5, 1967.

a) SAHA S.N. - "An electromagnetic analog method for computing gravity and magnetic effects of two dimensional bodies". p.833-852.

"An analog method can provide quick and accurate computation of gravity and magnetic anomalies arising from bodies in the form of horizontal cylinders of any arbitrary cross section and polarization. It has been possible to simulate the gravitational and magnetic fields of such a body by a current system flowing along a set of parallel wires. The underlying principle is that the magnetic field due to current in a long straight wire is mathematically similar to the gravitational field due to a line mass of uniform density. This similarity has been extended to the magnetic case, since the currents in the opposite directions reproduce the fields due to positive and negative line poles.

Comparison of the simulated field for some simple bodies has been made with theoretically computed values. Generally, these agreed within less than 3 % error. In the case of the magnetic analog it has been possible to reproduce the field for any direction of polarization perpendicular to the strike.

It is also possible to simulate the effects of density changes or changes in susceptibility contrast and in permanent magnetism. The method may be extended to the measurement of magnetic field components for any direction of strike of the body. Torsion balance quantities may be simulated as well as simple field quantities".

b) ROY A. - "Convergence in downward continuation for some simple geometries". p.853-866.

"Laplacian fields can be continued either by the use of Taylor series, or by spectral analysis and synthesis. While the first method is applicable to mon-Laplacian fields as well, the second, as it is presently developed, is not. The convergence properties of downward continuation by these methods have been investigated for some source geometries that frequently occur in nature. The cases treated include gravity, magnetic, electrical and electromagnetic fields. When the spectral method is used, the boundary between regions of convergence and divergence is always a plane that is parallel to the plane of observation. With the Taylor series method, on the other hand, the boundary is a hyperboloid or a combination of hyperboloids. The position of these boundaries - plane or hyperboloid - depends upon the shape of the anomaly-causing body. For bodies with corners and edges, the plane passes through the shallowest corner or edge, or there is a hyperboloid apexed at each corner or edge so that the outermost envelope constitutes the boundary of convergence. For smooth bodies, like spheres and cylinders, these boundaries are positioned at some internal point, which, in the case of artificial-field methods, may correspond to an image. For instance, for the gravity effect of a sphere or a two-dimensional horizontal circular cylinder, or their magnetic and electrical effects under the influence of a uniform primary field, the plane or the hyperboloid passes through or is apexed at the center or the axis, as the case may be.

The results of this paper provide the theoretical justification for using the method of continuation in interpretation of mining geophysical data, as reported empirically earlier".

c) NEGI J.G. - "Convergence and divergence in downward continuation". p.853-866.

"The paper reports solutions for some unanswered questions regarding the properties of the downward continued field for some simple source configurations. The radii of convergence, the conditions for predicting presence or absence of singularities on the boundary of the region of convergence and the equations for the boundary curves for the regions of convergence and divergence for arbitrary values of x are obtained from Taylor series representations of the fields of line and strip sources. The results provide useful connections in the discussion of some pertinent convergence and divergence characteristics of downward continuation".

49 - PAUL M.K. - "A method of computing residual anomalies from Bouguer gravity map by applying relaxation technique". Geophys. v. XXXII, n°4, p.708-719, 1967.

"A new method of computing residual anomalies for gravity prospecting data from a Bouguer gravity map has been evolved.

In arriving at the proposed method, we have a first examined the behavior of the regional gravity field from an analytical point of view. With the concepts acquired therefrom in mind, we consider the case of square grids with such separation of stations that in an elementary area, formed by joining the four nearest stations around a central station, the regional field may be represented by a linear function of the Cartesian coordinates in the horizontal surface of observation. Making use of the formal relationship between the residual, regional and Bouguer gravity values, we have been able to formulate in this case a set of simultaneous linear equations - one for each station of observation - with the residual values at the grid corners as the unknowns in the left hand sides of these equations and some linear function of the Bouguer values at the grid corners as the known quantities in the right hand sides. With some plausible estimates of the residual values at the stations on the boundaries at hand, these equations can be solved efficiently with the aid of the relaxation technique as has been exemplified in the cases of theoretical model as well as field data".

50 - BURSA M. - "Fundamentals of the theory of geometric satellite geodesy".
Inst. Geophys. Acad. Tchecos. Sci., Geofys. Sbor. n°24, p.25-74, 1966.

"The meaning of the term "satellite geodesy" has not yet been exactly defined. Here we practically identify it with the field in which the problems and tasks of basic geodesy from observations of the positions of objects (as a rule artificial) in near cosmic space are solved. At the same time, none of the consideration or derivations lose their validity if instead of the Earth we consider some other "basic" body for which the problems are solved, e.g. the Moon.

Near cosmic space is taken here to mean only the surroundings of the basic body up to a distance from the surface equal to a part or several units (tens) of the radius of the body. In this near cosmic space there are assumed to be objects, the positions of which can be observed. These may be :

a) artificial satellites,

b) artificial marks (high altitude flashes) that are "static", i.e., artificial objects which are not orbiting and are usually carried by balloons or rockets,

c) natural satellites (the Moon if the Earth is considered).

Although satellite geodesy is regarded as a new field, work done in the last century or even earlier can be found that fits into the field as defined above.

In 1768, a paper appeared by I.A. Euler which theoretically solves the problem of determining the form of the Earth's meridian from simultaneous observations of the position of the Moon at stations located in the meridian being investigated".

51 - Geophysical Journal of the Royal Astronomical Society, v.14, n°5, 1968.

a) VICENTE R.O. - "The possibilities of detecting motions of the crust". p.475-478.

"The precision of astronomical and geodetic methods that can be employed for the detection of any movements of the crust is discussed. The rates of continental drift proposed by several authors are shown to be below the precision of present day methods. The denominated difference methods, some of them not yet tried out, might give quicker results. The difficulties encountered in extrapolating the results found for short periods of time are pointed out".

b) NEWTON R.R. - "A satellite determination of tidal parameters and Earth deceleration". p.505-540.

"This paper uses perturbations in the inclination and in the longitude of the node for four nearly polar satellites to find values of the tidal number k and of the phases for the lunar and solar semi-diurnal tides. In order to obtain the desired accuracy, it was necessary to include the following perturbations in the analysis : differences between UT2c and UT1,
: the motions of the true coordinate systems of date, including the rotation of the ecliptic,
: atmospheric drag,
: radiation pressure, including radiation scattered or emitted by the satellite and including radiation scattered by the Earth as well as direct sunlight,
: the atmospheric tide,
: the gravitational perturbations produced by the Sun and Moon, and: the perturbations due to the zonal gravity harmonics.

For many of these, existing perturbation procedures are not accurate enough, and new methods were devised. The new methods are described. By-products of the perturbation analysis include a small change in the method of inferring wind velocities from orbital data at altitudes around 600 km, and a substantial change in the value of the estimated torque due to the atmospheric tide.

The value found for the ratio of lunar to solar tidal friction torques is considerably greater than that given by an existing model, but is closer to the value generally given for linear friction than to that for non-linear friction. This does not imply that the friction is linear. It is shown that the relation between the torque ratio and the type of friction depends upon an unknown parameter of the oceans. Over a large range of this parameter, which includes plausible values, the ration of the friction torques is independent of the law of friction.

The value found for k is 0.336 ± 0.028. The deceleration of the Earth's rotation due to the combination of the gravitational and atmospheric tides is estimated to lie between 16.8 and 21.4 parts in 10^{11} per year. This is lower than other recent estimates and is in better agreement with the value deduced from ancient eclipses".

52 - NASSAR AL-SADI H. - "A gravity investigation of the Pickwell Down Sandstone North Devon".
from : Geol. Magazine, v.104, n°1, p.63-72, Baghdad, 1967.

"The area to the north of Barnstaple (North Devon) was covered by a detailed gravity survey. The main gravity gradient of the Bouguer anomaly map (estimated to be 1.2 mgals per mile) confirmed the conclusions drawn by Bott et al.. (1958), who attributed it to a basin of possibly Carboniferous sediments and/or Old Red Sandstone, about 4 miles thick, separated from the outcropping Devonian rocks by an assumed thrust plane.

A negative residual gravity anomaly is located over the outcrop of the Pickwell Down Sandstone. Analyses of the anomaly show that it is caused by the southwards dipping belt of sandstone and that the angle of dip of the formation decreases with depth. At a depth of about 2 miles the formation becomes nearly horizontal. Alternatively, it may terminate against an assumed thrust plane underlying the whole outcropping Devonian.

The aeromagnetic map of the area shows an elongated magnetic "high" following the outcrop of the Morte Slates. The anomaly is probably caused by near surface, highly magnetized rocks in association with the Morte Slates".

54 - HARRISON J.C. & F.N. SPIESS. - "Gravity measurements in the Gulf of California".
Inst. Geophys. & Planetary Physics, Interim Rep. 0, 99 p,
Univ. California, Los Angeles, 1961.

55 - HELFER M.D. - M. CAPUTO & R.L. FISHER. - "Gravity measurements in the Indonesian Archipelago, Jan. 1963 - Feb. 1963 (R/V ARGO)". Inst. Geophys. & Planetary Physics, Interim Rep. n°6, 15 p, Univ. California, Los Angeles, 1963.

58 - BERKHOUT A.W.J. & L.W. SOBCZAK. - "A preliminary investigation of gravity observations in the Somerset and Prince of Wales Islands, Arctic Canada with map".
Dom. Obs., Grav. map Ser., 10 p., Ottawa, 1967.

"Au cours du printemps et de l'été de 1965, quelque 750 observations gravimétriques ont été faites dans la région des iles Prince-de-Galles et Somerset. La carte des anomalies de Bouguer, dressée à partir de ces données, montre une série de hauts et de bas bas à direction nord dans le centre et le sud de la région. Ces anomalies sont attribuées à des variations de densité dans les roches de fond cristallines. Deux hauts gravimétriques locaux dans l'ouest de l'île Prince-de-Galles seraient des indices d'intrusions basiques assez près de la surface".

59 - ROSS D.I. - "Storage and retrieval of geophysical data".
Inst. Ocean., Bio Computer note 67-3-C, 79 p, Dartmouth, 1967.

"The use of digital recording techniques in the acquisition of marine geophysical data has made it imperative that a reliable and efficient data storage and retrieval system be set up. The present note describes the system set up by the marine geophysics group at Bedford Institute of Oceanography. It is intended primarily as a manual for personnel using the data collected. The facility for retrieving data quickly from the system has already proved the usefulness of the system and justified the time involved in developing it".

60 - WOLF H. - "F.R. HELMERT und die moderne Geodäsie".
Z. Wermessung., t.92, H.n°7, S.237-240, Bonn, 1967.

"50 years after Helmert's decrease we may recognize the eminent importance of his utmost significant and fundamental ideas and his most successful investigations in all fields of Geodesy. The following concepts obviously are due to Helmert : The conception of "economic surveys" (in his doctor's thesis), of "equivalent" observations (in close connection to the "correlated" observations), the Pranis Pranievitch method, our method of simultaneous adjustments of angles and distances. Pearson's "ChiSquare" distribution, the projection of the topographic point onto the ellipsoid (cf. Hotine), Helmert's formulae of ellipsoidal Geodesy, Helmert's orthometric heights, his method of astronomic leveling, Hayford's "area method" for best-fitting ellipsoids, his "condensation method" for gravity reductions, his moon parallaxe formulae etc... Under his supervision in the Potsdam Geodetic Institute the known absolute gravity value was determined, investigations for Earth tides were performed, the conception of the European Triangulation Net was born and the ratio of the "International Meter" to the older "Legal Meter" was numerically fixed ; an abundance of ideas being so much efficacious certainly also for ever future time".

61 - BOTT M.H.P. - "The deep structure of the Northern Irish Sea, a problem of crustal dynamics".
from : Colston papers, v.XVII, p.179-204, Durham, 1965.

"Gravity investig·tions of the northern Irish Sea show negative anomalies of 20 - 40 mgal amplitude superimposed on a relatively high regional Bouguer anomaly.

The negative gravity anomalies are attributed to deep sedimentary basins as follows :

- the Stranraer Basin occupying Luce Bay and the Stranraer neck,
- the Solway Firth Basin between southern Scotland and the Isle of Man,
- the Manx-Furness Basin between Lancashire and the Isle of Man,
- the Peel Basin west of the Isle of Man.

Carboniferous and Permo-Triassic rocks probably form much of the infill of these basins, which have thicknesses of the order of 1-6 km. The aeromagnetic maps recently published by the Geological Survey of Great Britain confirm that the magnetic basement is deep beneath the Solway Firth and western Manx-Furness Basins. A sharp magnetic anomaly in the Manx-Furness Basin, west of Morecambe Bay, with east-south-easterly elongation is interpreted as a thick sill or belt of lavas dipping northwards and possibly faulted ; it has southerly magnetization which is consistent with a Carboniferous or Permian age.

The high regional Bouguer anomaly may be interpreted as a denser or thinner crust beneath the north-eastern Irish Sea. A recent United Kingdom Atomic Energy Authority (U.K.A.E.A.) seismological experiment based on Eskdalemuir yielded a crustal thickness of 23-24 km beneath the north-eastern Irish Sea in contrast to 27-28 km beneath southern Scotland, confirming quantitatively the regional gravity interpretation.

A negative magnetic anomaly of -160 gamma amplitude and 40 km. width lies between the Isle of Man and southern Scotland. This Solway magnetic anomaly is interpreted as a deep-seated contrast in magnetization extending through much of the crust, suggesting an apparent block-structure for the crust beneath the northern Irish Sea. This could be caused by a dyke-swarm of late-Palaeozoic or earlier age penetrating the crust.

The positive regional gravity anomaly represents an excess load above the Moho. This causes a stress-distribution supplementary to the large horizontal tensions and compressions which affect the crust and upper mantle. The supplementary stress-system reinforces any horizontal tension in the underlying upper mantle and reduces it beneath the adjacent belts. This explains the vulnerability of positive isostatic regions to normal faulting and dyke-intrusion ; the normal faulting accounts for the prominence of large sedimentary basins. The northern Irish Sea and the Midland Valley of Scotland provide good examples of this association of positive anomalies, faulting, sedimentary basins and dyke-swarms during periods of tension.

The subsidence of the basins is attributed to the continuing isostatic uplift of the Caledonian and possibly Hercynian mountain-ranges as they suffer denudation. It is suggested that complementary ductile inflow within the upper mantle draws material from beneath the adjacent regions causing acute subsidence. Denudation provides the sedimentary infill".

62 - McLEAN A.C. - "A gravity survey in Ayrshire and its geological interpretation".
Trans. R. Soc., v. LXVI, n°10, p.239-265, Edinburgh, 1966.

"Bouguer anomaly maps covering most of Ayrshire at a density of about one station per sq. km., show a close relationship between anomalies and the distribution of the Upper Palaeozoic rocks in the area south of the Inchgotrick Fault, but are less clearly interpreted to the north, where thick dense igneous masses are present.

In central and south Ayrshire the gravity field may be largely interpreted in terms of the known density-contrasts at the interfaces separating Upper and Lower Old Red Sandstone, and Lower Old Red Sandstone and Lower Palaeozoic rocks. The major structure, the Mauchline Basin, is reflected clearly in the largest anomaly, and there is evidence of a culmination of its south-western limb near Kirkoswald. The important N.E.-S.W. faults also give rise to large anomalies, which may be connected with the known geology. It is inferred that they moved as normal faults in Carboniferous times, and that the adjacent synclines are essentially sags associated with the fault displacements. There is geophysical evidence that both the Southern Upland and Kerse Loch Faults existed in Middle O.R.S. (proto-Armorican) times. It is concluded that a hypothesis of N.-S. Armorican stress is not valid in south Ayrshire.

In north Ayrshire, many of the anomalies are best explained by changes of thickness of the Millstone Grit lavas and of the Clyde Plateau lavas, and by the presence of thick dolerite intrusions. Additional evidence is needed, however, before final conclusions may be drawn".

63 - McLEAN A.C. & I.R. QURESHI. - "Regional gravity anomalies in the Western Midland Valley of Scotland".
Trans. R. Soc., v. LXVI, n°11, p.268-283, Edinburgh, 1966.

"In the western Midland Valley of Scotland and the neighbouring areas of the south-western Grampians and Southern Uplands, the regional Bouguer anomalies may be resolved into a westerly-rising component similar to that prevailing throughout western Scotland, and a broad high over the central zone of the graben with marked decreases towards the bordering mountains.

When allowance is made for the contribution to the gravity anomalies of the light Upper Palaeozoic rocks within the graben, the adjusted values outline an accentuated high over the graben with a drop of 25 - 30 mgal from the maximum to the northern limit of the area and with a corresponding drop to the south. In a profile normal to the major geological structure, the shape of the high approximates to a parabola with its apex 5 miles north-west of the Inchgotrick Fault.

These regional changes may best be explained by a thickening of the Upper Crustal Layer under the Grampians and Southern Uplands, most probably by the addition of thick Lower Palaeozoic and Dalradian geosynclinal deposits. Thicknesses of the order of 17,000 ft., additional to those under the Midland Valley, are required to account for the gravity changes. The relative attenuation of the succession in the Midland Valley area, implies that the area of the graben was already a crustal entity in pre-Upper Palaeozoic times.

The anomalies accord qualitatively with isostatic compensation of topography. The predominant high positive background values, have, however, no significance pecular to the graben area".

65 - SHERIFF R.E. - "Glossary of terms used in geophysical exploration". Geophys. v. XXXIII, n°1, p.183-228, 1968.

"More than a decade ago, the American Geological Institute prepared a Glossary of Geology and Related Sciences, which became a standard for terminology in most major fields of the earth sciences. A committee of the Society of Exploration Geophysicists under Dr. R.A. Geyer's chairmanship was given responsibility for the entries on geophysics included in this publication.

The AGI is now revising and enlarging its glossary and a new edition is expected to be published in 1968. The SEG has again been asked to contribute the material on geophysics. As with most other technical fields, the number of terms in solid-earth geophysics, particularly those aspects involved with exploration, has increased at an explosive rate and an adequate revision of the earlier material becomes a major undertaking.

It is a most fortunate coincidence that when the SEG was asked by the AGI to provide a revised glossary of geophysical terms, Dr. R.E. Sheriff of Chevron Oil Company had just completed the draft of a geophysical glossary which he had prepared independently for circulation within his own company. Upon examining Dr. Sheriff's material, the SEG Committee members assigned to prepare the geophysical entries for the AGI's new edition decided that his glossary could, with some minor modifications, serve as the SEG's contribution to the AGI effort. Because of the large variety of technical specialities represented in exploration geophysics, it was decided to handle Dr. Sheriff's glossary in somewhat the same way as technical papers submitted for publications in scientific journals. The material was divided into ten categories and all entries in each category were sent to an expert in the field concerned for review and editing. These categories are as follows : gravity, magnetics, electrical prospecting, seismic fundamentals, seismic field operations, seismic interpretation and data processing, digital technology, seismic refraction, seismic instrumentation and position location. The efforts of the following referees in reviewing the material are acknowledged with sincere appreciation.: J. Allingham, C.M. Clark, C.H. Dix, L.W. Gardner, G.V. Keller, J.A. Long, G.S. McKenzie, F.A. Van Melle, M. Slavin III, and Isidore Zietz.

The present preliminary publication of the geophysical entries for the larger AGI glossary should make it feasible for individuals competent in various technical fields to review the material and suggest corrections before it is finally submitted to the AGI later in the year. In this sense we would be making a semi-final draft of our entries accessible for proofreading by a much wider group of knowledgable geophysicists than we could otherwise reach"...

66 - KOCH K.R. - "Determination of the first derivatives of the disturbing potential by Green's fundamental formula".
AFCRL 67-0616, Rep. n°90, Sci. Rep. n°15, 42 p, Columbus, 1967.

"Simplified evaluations of the first derivatives with respects to an arbitrary direction of the potential of a simple layer and a double layer are given. The obtained formulas are used to differentiate Green's fundamental formula, which follows from Green's identities. They are checked by another method of differentiation.

An application of the derivative of Green's formula in geodesy leads to a linear integral equation for the derivative of the disturbing potential with respect to the earth's normal. Using a method due to Molodensky, the integral equation is transformed into an integral formula. This formula yields the first derivatives of the disturbing potential at the earth's surface with respect to an arbitrary direction, if the free-air anomalies and the disturbing potential are known at the earth's surface".

69 - VALLIANT H.D., I.R. GRANT & J.W. GEUER. - "A temperature control system for the canadian pendulum apparatus".
Dom. Obs., Pub. v. XXXVII, n°1, 10 p, Ottawa, 1967.

"A temperature control system has been developed for use with the Canadian Pendulum Apparatus for relative gravity measurements. This system, which maintains the pendulums at a constant temperature at 40.00°C, consists of three major components : a vacuum enclosure in which to house the pendulums ; an electronic thermometer to measure their temperature ; and an electronic thermostat to maintain a constant temperature. Extensive testing of the system indicates that the temperature of the pendulums may be measured with an accuracy of ± 0.01°C and that the electronic thermostat has a stability of about 0.002°C when the vacuum chamber is kept continuously closed. Under normal operating conditions, when the pendulum case is opened regularly to change pendulums, the observed temperature fluctuations amount to a maximum of ± 0.025°C. As small corrections may be applied to the pendulum periods to compensate for these temperature fluctuations, the error in gravity due to temperature effects never exceeds 1/6 mgal".

70 - VAILLANT H.D. - "An electronic system for measuring pendulum periods".
Dom. Obs., Pub. v. XXXVII, n°2, p.15-19, Ottawa, 1967.

"An electronic system for measuring the period of freely swinging pendulums has been developed for use with the Canadian Pendulum Apparatus. Extensive testing with an electrically generated test signal suggests that the error in determining the mean period of a one-second pendulum, averaged over 1200 seconds, does not exceed 100 and may be as low as 13 ns. Further testing with actual pendulums indicates that the measured periods, for a group of 3000 second observations, have a standard deviation of 600 ns. It is believed that this increased error is due to some factor associated with the pendulums, such as the effects of microseisms, knife-edge effects, or the dimensional stability of the pendulums themselves".

71 - FUJITA N. - "G.S.I. Airborne magnetometer and geomagnetic studies on aeromagnetic survey".
Bull. Geogr. Surv. Inst., v. XIII, Part 1, p.1-69, 1968.

"Entre 1961 à 1965, les trois composantes du champ magnétique au Japon ont été mesurées en avion par l'Institut japonais de Géographie (Geographical Survey Institute) suivant le projet du "World Magnetic Survey" (W.M.S.). En 1965, le champ total a été mesuré au dessus de la région sud du Kanto, suivant l'"Upper Mantle Project" (U.M.P.). La relation entre l'anomalie magnétique et la chaleur de fluage ou l'anomalie de Bouguer n'est pas très forte".

73 - GARCIA COGOLLOR A. - "Introduccion al estudio gravimetrico de Fernando Poo".
Inst. Geogr. Catastral, 95 p, Madrid, 1967.

76 - KRZEMINSKI W. - "Organisation et les débuts des travaux de la Commission des Académies des Sciences des pays socialistes pour l'étude en commun du problème complexe "Recherches géophysiques planétaires".
Kom. Geod. Polskiej, Akad. Nauk., Geod. i Karto., t. XVII, n°1, p.79-81, Warszawa, 1968.

77 - CANN J.R. - "Geological processes at mid-ocean ridge crests".
Geophys. J., R. Astr. Soc., v.15, n°3, p.331-341, 1968.

"A simple model of mid-ocean ridge structure is developed from the hypothesis of ocean floor spreading using the most recent published information. This model accounts for the differences between the Mid-Atlantic Ridge and the East Pacific Rise in a way consistent with the known features of other parts of the ridge system, and leads to conclusions about the form of the uprising currents in the mantle and the constitution of layer 3".

79 - REICHENEDER K. - "Zur übertragung des Potsdamer Schweresystems". Deutsche Akad. Wissensch., n°31, 72 S, Berlin, 1968.

"The exact knowledge of gravity gradient on the pillars for measuring gravity is necessary to transfer the Potsdam fundamental data to the other sites in the Geodetic Institute. These gravity gradients are here found out by the computed gravitation of all the masses sharing the erection of the Geodetic Institute. It was possible to determine the gravity in the sites with a mean uncertainty of ± 0,0045 mgal, compared with the precise measurement by a Sharp-Gravimeter".

80 - LONG R.F. - "Air Force Cambridge Research Laboratories," report on research for the period July 1965 - June 1967". AFCRL 68-0039, 342 p, Bedford, 1967.

"This is the fourth in a series of reports issued every two years covering the research programs of the AFCRL. The report was written for the Air Force and DoD managers of research and development. We have made certain suppositions with respect to this audience and one of these is that it is technically informed to a marked degree. Through formal scientific and technical training,

and through long association with military R&D programs, the military R&D manager brings considerable sophistication to his evaluation of the merit of certain programs. In addressing this audience, there is no need to dwell unduly on the connection between investigation and its relevance to enhanced Air Force capability. Although we often state these connections explicitly, just as often we assume the connections to be implicit. Another supposition is that the reader has a general awareness of the state of the art in a particular field. We therefore undertook to discuss the various programs at AFCRL in sufficient technical depth to permit the reader to make fine distinctions between these programs and related programs conducted elsewhere. Curiously, one discovers that after establishing the various assumptions, guides, and criteria for a report meaningful to the military R&D manager, the criteria have equal validity to a much broader class of reader. This report may be of interest and value to all those who may wish to obtain a reasonably complete account of research programs of the AFCRL and of the progress made under these programs during the period July 1965 through June 1967".

81 - HEARST J.R. - "Terrain corrections for borehole gravimetry". Geophys., v. XXXIII, n°2, p.361-363, 1968.

"Computer program for the application of terrain corrections. A list of the Fortran program is available upon request... Measurement of density".

700 - MITTERMAYER E. - "Eine nichtiterative Lösung der 1 geodätischen Hauptaufgabe auf den Rotationsellipsoiden von Bessel, Hayford und Krassowsky für geodätische Linien beliebiger Länge".
D.G.K., Reihe C, dissertationen, H. n°116, 35 S, München, 1968.

730 - MORITZ H. - "Kinematical geodesy".
AFCRL-67-0626, Rep. n°92, Sci. Rep. n°16, 65 S, Columbus, 1967.

"With the use of moving instruments, such as airborne gravimeters which are often related to precise inertial stabilization systems, the essentially statical character of geodesy begins to be enlarged by kinematical features. The potential of gravity, combining gravitational attraction and centrifugal force, is no longer adequate for kinematics, but other inertial forces of Coriolis type must also be considered.

The main purpose of the present paper is an investigation of the geodetic aspects of the interrelation of gravitational and inertial forces and their separation by means of structural differences in their respective fields. For a deeper insight, the general theory of relativity is indispensable ; it also furnishes convenient mathematical techniques.

The extraction of purely gravitational effects is possible with second and third derivatives of the potential ; therefore geodetic applications of these quantities are discussed, integral formulas similar to Stokes's integral being given for this purpose".

760 - KOCH K.R. - "Orbit perturbations of artificial Earth satellites as functions of gravity anomalies and differential corrections of orbit and station coordinates".
AFCRL-68-0163, Rep. n°96, Sci. Rep. n°17, 35 p, Columbus, 1968.

"In the first part of this report the orbit perturbations of an artificial earth satellite are given as functions of the gravity anomalies by means of Stokes' formula. To compute the perturbations, the perturbed equations of motion are integrated numerically and the usual integration technique is applied for Stokes' formula by dividing the surface of the earth into surface elements in which the gravity anomaly and Stokes' function are regarded as constants. In a numerical example orbit perturbations are computed for three satellites with different orbital elements from mean anomalies of different sizes of surface elements to determine the influence of the sizes of surface elements on the orbit perturbations.

In the second part it is assumed that the gravity field of the earth is well known from gravity anomalies. To obtain a precise orbit of a satellite by these data, a method using differential corrections is given to compute more accurate orbital elements and more accurate coordinates of the tracking stations, whose observations determine the orbit".

770 - ROSS D.I. & D.M. PORTEOUS - "Geophysics data report 1968-1-D, Caribbean cruise, Baffin 03-68, Jan.- March, Part 1". Atlantic Ocean. Lab., Bedford Inst., 50 p, Dartmouth, 1968.

"This is one of the geophysics data reports giving a summary of observations collected on cruises of ships operated from the Bedford Institute. Complete cruise data will be supplied in standard digital format on request to suitable institutions for scientific purposes by appropriate arrangements. Free distribution of this report is indicated in the Appendix. Other institutions will be included on request. On citing this report in a bibliography the title should be followed by the words "Unpublished manuscript", in accordance with accepted bibliographic custom".

780 - MELCHIOR P. - "Marées terrestres". Bull. Inf..n°51, p.2317-2395, Bruxelles, 1968

790 - MELCHIOR P. & J.W. Van GILS. - "Rapport national concernant la séismologie et la physique de l'intérieur de la Terre, 1960 - 1967". Obs. R. Belgique, Comm. Ser. B, n°19, Ser. Geophys. n°81, 16 p, Présenté à la XIVème Assemblée Générale de l'U.G.G.I. à Zurich, 1967.

800 - MELCHIOR P. - "Contribution apportée par les marées terrestres dans l'étude de la rotation de la Terre". Obs. R. Belgique, Comm. Ser. B, n°25, Ser. Geophys., n°84, p.71-76, Bruxelles, 1968.

"Three aspects of the experimental study of earth-tides present a direct interest for the study of the rotation of the Earth. These are the experimental determination of the Love numbers and the dynamical effects of the liquid core on nutations of the principal axis of inertia ; the delay of earth-tides ; and the drift of horizontal pendulums".

810 - JEFFREYS H. & R.O. VICENTE. - "The energy of elastic strain in the Earth". Obs. R. Belgique, Comm. Ser. B, n°26, Ser. Geophys. n°85, from : Bull. Acad. R. Belge, Cl. Sci., v. LIII, n°9, p.925-933, Bruxelles, 1967.

82 - GARLAND G.D. - "Chronique de l'U.G.G.I." n°72, p.49-100, 1968.

83 - FISCHER I. & M. SLUTSKY. - "A preliminary geoid chart of Australia".
from : The Australian Surveyor, 8 p, Washington, 1967.

93 - PICK M. & I. POLA. - "The figure of the Earth in the West Alps". Geophys. Inst. Czechosl., Acad. Sci., Stud. Geophys. Geod., n°12, p.136-148, Prague, 1968.

94 - WOLF H. - "Der Beitrag der Geodäsie zur Problematik der Mohorovicic Diskontinuität". Sonder., Z. Vermesswes., H.n°5, S.172-175, 1968.

"The contribution of geodetic activity to the investigation of the shape of the Moho-discontinuity is considered : measured values of the deflections of the vertical and gravity anomalies are to be compared with computed values from substructural features. Samples concerning the "Rhein-Graben" and the Bavarian molasse region are given. Using recent crustal movements from levelings for Moho-purposes in a certain sense the 2nd derivatives must be computed, along with their significance as the most important problem".

95 - I.C.S.U. - "Survey of the activities of ICSU scientific Unions, special and scientific Committees and Commissions of ICSU". In the field of scientific information during the year 1967. ICSU Abstracting board, 312 p, 1967

96 - RODDE A. - "Simultanbestimmungen der Lotabweichungskomponenten ξ und η mit dem Prismenastrolabium".
D.G.K., Reihe B, Angew. Geod., H. n°162, 107 S, Frankfurt, 1968.

97 - ARAKAWA H. - "Statistical data for earthquakes and seismological data for special earthquakes".
Meteo. Res. Inst., Rep. of the Natural Earthquake Discipline for the UMP, 455 p, Tokyo, 1968.

98 - FLEISCHER U. - "Untersuchungen an Kreiselanlagen und an zwai antiparallel aufgestellten Seegravimetern vom Typ Gss2".
Askania Warte, H. 71, 20 S, Berlin, 1968.

99 - REICHENEDER K. - "Bedeutung und Entwicklung der absoluten Schwerebestimmung".
Sond. Osterr., Z. Vermesswes., n°2, 16 S, Wien, 1968.

101 - RAPP R.H. - "A method for the combination of satellite and gravimetric data".
AFCRL-68-0195, Rep. n°101, Sci. Rep. n°19, 71 p, Columbus, 1968.

"A set of 2261 5° x 5° mean anomalies was used alone and with satellite determined harmonic coefficients of the Smithsonian Institution to determine the geopotential to various degrees, the highest being n = 14. The results of these solutions were used to form a global 5° x 5° anomaly field referred to the International Gravity Formula.

A by-product of this investigation was a value of equatorial gravity of 978.0463 gals in the Potsdam system or 978.0326 gals in an absolute system if - 13,7 mgals is taken as the Potsdam correction. Combining this value of γ_E with f = 1/298.25, KM = 3.986088 x $10^{20} cm^3/sec^2$, the consistent equatorial radius was found to be 6378141 m.".

102 - KOCH K.R. - "Model computations for different solutions of the geodetic boundary value problem".
AFCRL-68-0164, Rep. n°102, Sc. Rep. n°18, 35 p, Columbus, 1968.

"To solve the boundary value problem of physical geodesy, the perturbing potential is usually expressed by the potential of a simple layer. By introducing this expression into the boundary condition, Molodensky's basic integral equation is obtained ; the solution of which enables us to compute the perturbing potential and its first derivative. To check the results of this method, Green's formula can be used. After transforming this formula and its derivative by a method, due to Molodensky, a linear integral equation for the disturbing potential is obtained. With the solutions of this integral equation, the first derivative of the disturbing potential can be computed from the transformed derivative of Green's formula.

For a model consisting of a cone on a plane the basic integral equation and the integral equation of Green's formula are solved by successive approximation with a computer. The solution of the basic integral equation is also obtained by Molodensky's method. These three solutions are compared for different inclination angles of the surface of the cone. The results agree very well for small inclination angles, but the approximations don't converge for greater inclination angles. The reason has to be sought in the errors of numerical integration, by which the integration over the surface of the model is solved".

103 - SCHULER R. - "Die Störung der Bewegung von Schwerependeln durch ihre Lagerung".
D.G.K., Geod. Inst., Arbeiten n°18, 140 S, Potsdam, 1968.

104 - FISCHER H. - "Uber den Einfluss elektrostatischer Felder auf die Periode von Schwerependeln".
D.G.K., Geod. Inst., Arbeiten n°20, 72 S, Potsdam, 1968.

"On the application of uncoated quartz pendulums the magnitude of a possible charge on the pendulums is reduced to an amount, which do not troublesome influence the frequency of the pendulums. In confirmity with the arrangement of the pendulums the magnitude of this allowed residual of the charge is approximately calculated by means of relations stated in this work. Experimental results from a 1-pendulum-apparatus are given. Methods of the measurement of plane charge are shown".

105 - HAMMOND J.A. & J.E. FALLER. - "Laser interferometer system for the determination of the acceleration of gravity".
from : IEEE J. Quantum Electronics, v. QE-3, n°11,
p.597-602, 1967.

"A system is described for determining the acceleration or gravity using a stabilized He - Ne laser as the light source in a Michelson-type interferometer which incorporates a freely falling corner reflector as one of its mirrors. The method effectively utilizes the most precise standards presently available for the measurement of length and time and is capable of an accuracy of better than 5 parts in 10^8".

109 - SCHWEIZ. GEOD. KOMM. - "Astronomisch-geodätische, Arbeiten in der Schweiz".
Lotabweichungen, Geod. & Meereshöhen in dern Schweizer Alpen, Band 26, 147 S, 1967.

110 - VESTINE E.H. & A.B. KAHLE. - "The Westward drift and geomagnetic secular change".
Geophys. J.R. Astr. Soc., v.15, n°1 & 2, p.29-37, 1968.

"Short-term fluctuations in the length of the day on the order of a decade are discussed in relation to fluctuation in westward drift of the outer part of the Earth's core.

Decreases in the Earth's rotation rate noted near 1910 and 1965 are shown to be correlated with decreases in westward drift of the Earth's magnetic eccentric dipole, which probably originates fairly deep within the Earth's core. If the outer 200 km. thickness of the core moves approximately as does the eccentric dipole field, the changes in angular momentum implied for this part can explain the observed changes in the length of the astronomical second, on the basis of conservation of angular momentum. Other estimates of westward drift in the core based on higher-degree harmonic terms give a lower westward drift, and also seem to show less precision in the estimates of flow in the core. These discrepancies are unexplained".

111 - COOK A.H. - "The polar flattening and gravity formula in the geodetic reference system 1967".
Geophys. J.R. Astr. Soc., v.15, n°4, p.431-433, 1968.

"The International Union of Geodesy and Geophysics, at its General Assembly of 1967, adopted a new geodetic reference system, the Geodetic Reference System 1967, in which the parameters defining the external gravitational field of the Earth are the same as those adopted by the International Astronomical Union in 1964 for the system of astronomical constants. The values are :

Equatorial radius,	a : 6 378 160 m.
Coefficient of second zonal harmonic in potential,	J_2 : 1 0827x10^{-3}
Product of mass and gravitational constant, GE	: 3.98603x$10^5 m^3 s^{-2}$.

The resolutions in which these parameters were adopted left to subsequent publication the additional parameters of the corresponding sea-leval equipotential surface, namely the polar flattening, f, and the coefficients in the formula for the variation of gravity at sea-level. My aim in this note is to collect a number of variants of the relevant formulae and to give the numerical values.

The values from the third order formulae are :

$$f = 3.35292 \times 10^{-3}, \quad \frac{1}{f} = 298.247.$$

If the value of gravity is expressed in the form

$$g = g_e \,(1 + \beta_1 \sin^2 \phi + \beta_2 \sin^2 2\phi + \beta_3 \sin^2 \phi \sin^2 2\phi),$$

where ϕ is the geographical latitude (see Cook, (1959) for the third order terms), the expressions for the coefficients are :

$$\beta_1 = \frac{5}{2} m - f + \frac{15}{4} m^2 - \frac{17}{14} fm - \frac{1}{98} f^2 m - \frac{3}{4} fm^2 + \frac{45}{8} m^3,$$

$$\beta_2 = \frac{1}{8} f \left(f - 5m + \frac{17}{7} fm - \frac{15}{2} m^2\right),$$

$$\beta_3 = - \frac{1}{8} f^2 \left(\frac{15}{2} m - f\right),$$

where m is, as before, $a^3 \omega^2 (1 - f)/GE$.

The expression for g_e was given earlier. The numerical values are :

$$\beta_1 = 5.30236 \times 10^{-3}$$
$$\beta_2 = 5.850 \times 10^{-6}$$
$$\beta_3 = 3.2 \times 10^{-8}$$
$$g_e = 978.0309 \text{ cm s}^{-2}.$$

115 - Geod. Geoph. Veröff. R. III, H.7, 1968.

a) ELSTNER C. & H. WIRTH. - "Relative Schweremessungen zwischen Potsdam und Antarktika". 30 S.

b) LINDNER K. & H. WIRTH. - "Bericht der DDR Teilnehmergruppe an der 10, Sowjetischen Antarktisexpedition überwinterung 1965". S. 31-66.

119 - GIBB R.A. - "The densities of Precambrian rocks from northern Manitoba".
Contr. Dom. Obs., v.8, n°15, 6 p, Ottawa.
from : Canadian J. Earth Sci., v.5, n°3, 1968

"To assist in the interpretation of gravity anomalies in northern Manitoba and northeastern Saskatchewan, a part of the western Canadian Shield, the average densities of 2004 Precambrian rock samples, grouped according to rock type, are tabulated. Relatively positive anomalies may be expected over greenstone belts (2.85 g/cm3), sedimentary gneisses (2.79 g/cm3), granulites (2.73 g/cm3), and mafic to ultramafic intrusions - diorite (2.77 g/cm3), gabbro (3.00 g/cm3), and peridotite (3.19 g/cm3), whereas negative anomalies may be expected over granitic rocks (2.64 g/cm3). These results are consistent with results from other areas. The average composition of a slab of surface rock in this part of the western Canadian Shield is shown to be granodioritic with an average density of 2.67 g/cm3".

120 - GIBB R.A. - "A geological interpretation of the Bouguer anomalies adjacent to the Churchill-Superior boundary in northern Manitoba". Contr. Dom. Obs., v.8, n°16, 15 p, Ottawa.
from : Canadian J. Earth Sci., v.5, n°3, 1968.

"The Bouguer anomaly map of northern Manitoba and part of northeastern Saskatchewan was updated by a gravity survey in 1965. Density determinations of some 2000 Precambrian rock samples provide a sound basis for interpretation of the Bouguer anomalies in terms of relatively near-surface mass distributions in the upper crust. In some parts of the area there is excellent correlation between the surface rocks, their densities, and the Bouguer anomalies. The Nelson River gravity high outlines a belt of dense granulites. To the northwest three gravity lows are interpreted as the gravity effects of granitic intrusions, of which one is exposed at Split Lake and the others are largely subjacent, although their presence is supported by the occurrence of numerous mappable stocks of granite within the gravity lows. The Nelson River gravity high is separated from these lows by a steep gravity gradient, which marks a boundary between rocks of predominantly different ages (Hudsonian and Kenoran) between latitudes 54° N and 56° N. Age determinations are consistent with an interpretation of the Pikwitonei subprovince as an inlier of Kenoran age within the Churchill Province. The main Churchill-Superior boundary may then be moved south to what is at present the southern limit of the Cross Lake sub-province, which is a return to approximately the position originally selected by M.E. Wilson".

122 - SIMON D. - "Elastische Nachwirkungen an einem Askania-Gravimeter Gs-11".
from : Marées Terrestres, Bull. Inf. n°44, p.1759-1774, 1966.

123 - Boll. Geof., teor. appl., v. X, n°37, 1968.

a) GROTEN E. & E. REINHART. - "Gravity prediction in mountainous areas". p.28-43.

"Regression of gravity anomalies with elevation is studied in the Northern Alps. It is shown that the regression coefficient varies even withing small areas ; further, it was found that linear correlation is much higher if free air anomalies are corrected for terrain effect. Since this effect has mostly systematic character regression coefficients derived from "terrain-corrected" anomalies are different from those obtained from simple anomalies. The deviations can be remarkable. For mean gravity anomaly terrain corrections are important only for anomalies of blocks smaller than 20 km x 20 km".

b) MORITZ H. - "Mass distributions for the equipotentialellipsoid". p. 59-65.

"The subject of this paper is the determination of regular mass distributions for the equipotential ellipsoid. A very general solution of this problem is given, and a particular solution, corresponding to a homogeneous core with a nearly-homogeneous mantle, is studied".

c) NORINELLY A. & G. FINZI-CONTINI. - "Un simulatore fotoelettrico per l'interpretazione gravimetrica di strutture bi-E tridimensionali". p. 66-87.

"A photo-electrical analog simulator which is able to plot profiles of gravitational anomalies both for bi- and tri-dimensional structures is described.

For the case of bi-dimensional structures, the apparatus is made up of a net of as many elementary electrical circuits or equal resistances as photo-sensitive devices. Each resistance value simulates a vertical gravity contribution to which it is proportional. All the electrical circuits are connected in series. The photo-electric devices, conviently arranged on a limited portion of the Hubbert's graticule, can pilot intermediate circuits, which, when illuminated, are able to by-pass the above mentioned elementary electrical circuits. Therefore, when the resulting photo-electrical graticule is illuminated, it is possible to control the number of the photo-sensitive devices illuminated by a mere piece of hard paper simulating a given structure.

Consequently, the value of the electrical net resistance will also change in connection to the simulated structure shape and to its position relative to the graticule. When the net is fed by a direct current, the value of which must remain constant, the voltage we will measure at the net terminals will be proportional to the net resistance and, hence, to the vertical gravitational effect of the simulated structure.

Finally, by properly moving the simulated structure in a straight line and by feeding an XY registrator, we will have a voltage profile, that will be read in gravity units, through the analogy on which the simulator is based.

If one, according to the theoretical principles of a previous paper of one of the present writers, changes the resistances values of the elementary circuits, the simulator will plot profiles of gravimetrical anomalies caused by tri-dimensional structures to this aim additional circuits are added, which allow the simulator to work for tri-dimensional structures. They are made up of auxiliary resistance nets and of special circuits equipped with semiconductors. These nets and circuits are by-passed via the same photo-sensitive devices working on the bi-dimensional case.