ASSOCIATION INTERNATIONALE DE GÉODÉSIE

BUREAU GRAVIMÉTRIQUE INTERNATIONAL

N° 29

Bulletin d'Information

Juillet 1972

9, QUAI St-BERNARD - Tour 14
PARIS V°

B U R E A U G R A V I M E T R I Q U E

I N T E R N A T I O N A L

Paris

-=-=-=-=-=-

B U L L E T I N D ' I N F O R M A T I O N

Juillet 1972

N°29

Subvention UNESCO - 1972
DG/2.1/414/34

T A B L E des M A T I E R E S

1ère Partie

2ème Partie

Prof. P. TARDI

Dr. S. CORON

- A -

Proceedings of the meeting at the Central Bureau of the IAG on 24th February, 1972, at 9.30 called by the President to discuss THE FURTHER DEVELOPMENT OF THE IGSN 71 AND THE SECULAR VARIATION OF GRAVITY.

Present :

- President of the IAG, Prof. Ju.D. BOULANGER, Chairman of the meeting
- Secretary General, Ing. Gen. Geogr. J.J. LEVALLOIS
- Director Adjoint of the B.G.I., Dr. S. CORON
- Director of the BIPM, Dr. J. TERRIEN
- Dr. A. SAKUMA from the BIPM
- Director of the Terrestrial Sciences Laboratory of the USAF, Mr. O.W. WILLIAMS.
- Secretary of Section III of the IAG, Prof. T. HONKASALO, Secretary of the meeting.

Prof. BOULANGER outlined the matters to be discussed at the meeting. He first asked the difference between the Potsdam system and the system of the IGSN 71 and proposed direct tying measurements between Potsdam and some European stations, especially between Potsdam and Paris. He then proposed international cooperation on global study of secular variation of gravity. The most accurate absolute gravity measurements in Paris should be tied with the others in Washington, Sydney, London, Potsdam and Tokyo. Tidal corrections are of special importance, since they vary greatly depending on locality, e.g., as much as 200 μGal between England and the Continent. The President of Section III, Gravimetry, should draw up an international plan.

Ing. LEVALLOIS remarked that this project should be approved by the IAG or IUGG assembly, not by the International Gravimetric Commission alone.

Prof. MORELLI explained that the difference between the Potsdam and IGSN 71 systems cannot be expressed by one constant. The difference in Potsdam is 14.01 mGal. In other places the differences vary depending on their connections with Potsdam.

Prof. BOULANGER said that the difference between Moscow and Potsdam has been measured many times and is now known with an accuracy greater than ± 0.015 mGal. Accurate measurements are being carried out in the Soviet Union with 5 new sets of pendulum apparatus using 10 pendulums. A set of these measurements gives an accuracy of ± 0.02 - 0.03 mGal for one back and forth measurement. He proposed that measurements be made using these instruments between

Potsdam - Paris
Potsdam - Washington
Potsdam - Tokyo
Potsdam - Sydney
Potsdam - Bad Harzburg
Potsdam - London (Teddington)

He mentioned that Prof. TORGE has suspected an error of 0.2 mGal between Paris and Bad Harzburg. On the other hand Moscow (Institute of Earth's Physics) can be considered as an excenter of Potsdam. According to Dr. SAKUMA the correction to the Potsdam value is -13.78± 0.07, but BOULANGER has computed -13.94 ± 0.06.

Dr. SAKUMA reported on the results at Sèvres during the period 1966-1972. All these measurements were carried out at the same site (A_2) each year in August, except for 1972, when they were made in February.

1966	980 925.687 mGal
1967	" .667
1968	" .651
1969	" .649
1970	" .657
1971	" .678
1972	" .710

These results show a parabolic variation of g.

He said that a similar apparatus is now under construction for Mizusawa (Japan), Uppsala (Sweden) and Nice (France). A new portable type with a measuring accuracy of ± 10 µGal is under construction in Torino (Italy) and will be ready at the end of this year.

Mr. WILLIAMS mentioned that an American portable absolute apparatus will be available in 1973.

Prof. BOULANGER proposed that a net of control stations be measured around Sèvres to separate local effects. He emphasized that the amplitude and phase differences of tidal correction have large local variations and cannot be extrapolated. It should be measured at the place where the absolute measurements are carried out.

Prof. HONKASALO proposed the measurement of a net of control stations in one line with very small gravity differences, similar to the stations in the Fennoscandian land uplift line, where 8 stations on a 1.200 km line have been measured with $\pm$ 3 µGal accuracy.

Dr. TERRIEN reported that the tidal correction is the mean of a longer observation period. Thus although the amplitudes and phase differences may not be entirely correct most of the errors are eliminated and any systematic errors must be small in the tidal correction.

Dr. SAKUMA had studied the effect of air pressure changes on his absolute gravity measurement and obtained a value of 0.6 µGal/ 10 mmHg. He would like the BIPM to be lent a recording gravimeter, who should then perform the observations.

Mr. WILLIAMS promised to lend the BIPM a gravimeter after some months.

Dr. LEVALLOIS : In France there is a long term program for measuring a net of 30-40 stations and repeating the measurements every year. This may explain some regional changes in gravity, but France is too small an area. A met of II-order stations must be measured with portable absolute apparatus in addition to the few permanent absolute stations.

Prof. BOULANGER pointed out that some stations in the equator area are necessary since the changes are expected to be greatest there. The changes are very slow, less than 0.01 mGal/year, and the reason for changes is deep, perhaps at a depth of 600-700 km. He estimated that the real accuracy may be about $\pm$ 10 µGal at permanent stations since there may be a systematic effect not yet considered. The Control Net should be observed each 5 or 10 years, and for tying measurements different types of apparatus should be used to avoid any systematic errors. Systematic errors can arise in the absolute measurements e.g. from the distance determination.

Dr. TERRIEN said that the International Commission of Weights and Measures in 1960 issued instructions on the use of the new meter definition. In theory an accuracy of 10^{-9} can be achieved. Using a special technique accuracies of 10^{-10} - 10^{-11} can be reached.

Mr. WILLIAMS stated that the NBS has also measured lengths with an accuracy of 10^{-9}. He emphasized that there are two problems in studying the secular variations of gravity.

1. Accurate measurements need good metrologists.

2. Interpretation of observations needs good geophysicists.

Prof. BOULANGER proposed that an international project be prepared according to these discussions and circulated one year before the next Assembly. He invited geodesists to come to measure in Moscow, Odessa, Murmansk and Nahotka. Moscow has been tied to Potsdam with ± 0.015 mGal accuracy, the others with ± 0.025 mGal accuracy. The USSR geodesists can measure two tyings every year with an accuracy greater than ± 0.030 mGal. He considers the tyings Potsdam-Paris, Sydney-Washington-Ottawa the most important. Soviet gravimetrists are ready to make these measurements.

Ing. LEVALLOIS mentioned that the USSR gravity values at the above stations are available at the BGI and proposed that they be added to the world gravity net. ⁂

Prof. MORELLI stated that since the observational material is unknown there is no chance of adding these measurements to the net, and only the gravity values at these stations can be added. He considered there are three possibilities for the international plan for a net of absolute station and tyings between these :

a) Inter-Union Commission on Geodynamics
b) IAG
c) ICSU

Ing. LEVALLOIS pointed out the connections between the BIPM and other laboratories. These should be used.

Prof. BOULANGER seconded Prof. MORELLI's proposal that this project be made not only by IAG or IUGG project but should be made in many other scientific Unions, such as the IUGS and IUPAP, and thus also the ICSU.

After the discussions Mr. WILLIAMS presented and distributed a Bouguer anomaly chart of Asia with 10 mGal contour intervals compiled by the USAF Aeronautical Chart and Information Center.

Ju. D. BOULANGER
President

T. HONKASALO
Secretary

⁂ Until now the B.G.I. has not yet received the U.S.S.R. gravity values.

- B -

VARIOUS INFORMATION

a) GENERAL BIBLIOGRAPHY of the EARTH TIDES

The International Center for Earth Tides has brought the whole bibliography on punched cards (1800-1971).

The information is listed accordingly to the decimal classification used for the preceeding bibliographic publications but slightly improved and completed.

The bibliography contains approximately 2,000 references.

This publication is presented by a photocopy of the listing of the punched cards.

Considering the high cost of this publication and the reduction of the ICSU funds allowed to the Permanent Services, it cannot be sent free of charge .

This new completed edition of the bibliography can be obtained against payment of three hundred fifty belgian francs (350 FB), (postage included), to Banque Lambert Luxembourg, Boulevard Grande Duchesse Charlotte à Luxembourg, Grand Duché de Luxembourg, account 112.474.51 - Mr P. MELCHIOR, International Center for Earth Tides.

from : Prof. P. MELCHIOR
Director of the International Center
for Earth Tides

b-1) A DETERMINATION OF THE VELOCITY OF LIGHT USING THE TWIN SUPERHETERODYNE PRINCIPLE.

Most of the newer electro-optical determinations of the velocity of light have been based on the modulation principle of Bergstrand. The author developed 1952-54 the "Twin Superheterodyne Principle" for electro-optical distance measuring. This modulation principle is now incorporated in the AGA instruments and the author has used a Geodimeter 8 for a new determination of the velocity of light. The present study has been made in close cooperation with the Finnish Geodetic Institute which made its base line Niinisalo-Pihnari (22219848.3 $\pm$ 1.78 mm) available for the author. The final result from two weeks of observations was $c = 299792375 \pm 60$ m/sec. The final statistical analysis has been made with the use of Wiener-Hopf filtering technique. Hypothesis testing according to Fisher and Hart is included.

Meeting of I.A.G., Moscow, 1971.

b-2) AN INSTRUMENT FOR A DETERMINATION OF THE WAVE-VELOCITY OF LIGHT

An instrument for a direct determination of the wave-velocity of light has been completed. The instrument is intended for use in combination with electro-optical distance measuring instruments.

The instrument has a weight of approximately 1100 g and dimensions 23 x 9 x 6 cm. The wave-velocity is determined as an absolute measurement with a resolution better than 10^{-6}. (The ultimate accuracy is in the order of 10^{-8}). It is estimated that the instrument can be manufactured for less than 1000 US $.

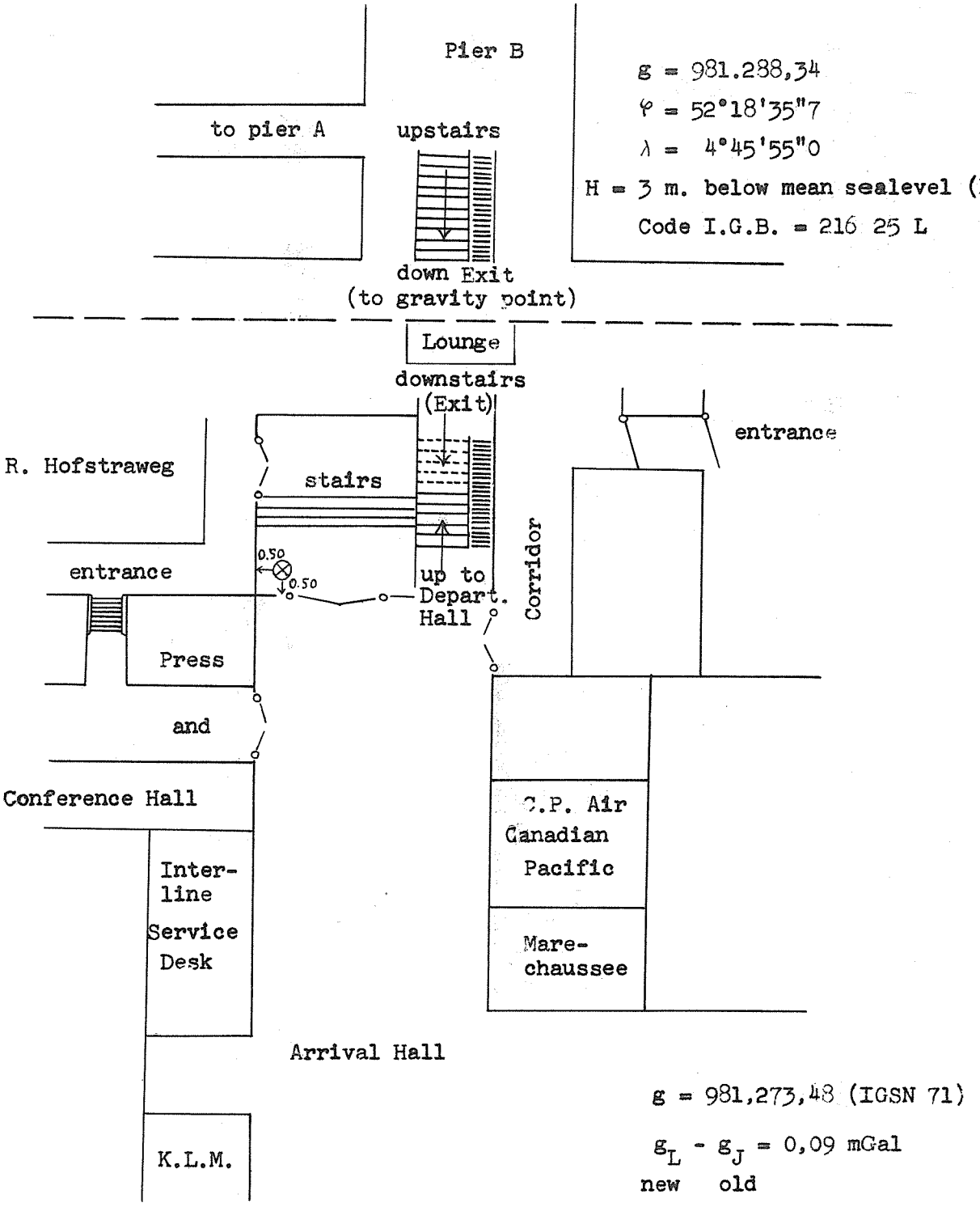
Further information concerning the instrument will not be released at the moment. Those who are interested in further information are kindly asked to notify the institute and additional information will thereafter be forwarded as soon as it will be available.

from : A. BJERHAMMAR
(letter 29.12.1971)

Gravity Station

AMSTERDAM-AIRPORT-SCHIPHOL

(new site)



Reference : G.L. STRANG VAN HEES. Technological University,
Geodetic Institute, Kanaalweg 4, Delft, Netherlands.

- C -

CARTE d'ANOMALIES MOYENNES à l'AIR LIBRE par 5° x 5°

A maintes reprises, on a demandé au Bureau Gravimétrique International des cartes d'anomalies moyennes à l'air libre, soit par 5° x 5°, soit par 1° x 1°.

Il a donc semblé utile de commencer à publier la carte d'anomalies moyennes par 5° x 5°. Cette carte tenue à jour par M.F. ESNOULT du B.G.I. est insérée à la fin du présent Bulletin d'Information.

Les anomalies à l'air libre ont été calculées par rapport aux valeurs théorique de g données par la formule internationale (1930), c'est-à-dire avec les éléments de base suivants :

Aplatissement $\alpha = 1/297$
Valeur absolue de g à Potsdam : 981 274 mGal

$$\gamma_{1930} = 978\,0490\,(1 + 0{,}005\,2884\,\sin^2\varphi - 0{,}000\,0059\,\sin^2 2\varphi)$$

Les anomalies moyennes sur cette carte sont indiquées en milligals ; leur précision est très variable suivant le nombre et la répartition des mesures dans chaque compartiment.

Sur la carte on a différencié 3 groupes de valeurs :

1) Valeurs rassemblées, calculées au mieux au B.G.I. à partir de documents très variés. (Chiffres droits).

2) Valeurs provenant du Catalogue : ACIC Reference Publication n°29 "1° x 1° Mean Free Air Gravity Anomalies", Saint-Louis, Missouri, August 1971. (Chiffres penchés).

Lorsque le nombre n des valeurs moyennes publiées par 1° x 1° était insuffisant (inférieur à 5 par compartiment de 5° x 5°), ces valeurs n'ont pas été prises en considération.

Lorsque le nombre des valeurs moyennes par 1° x 1° était trop peu important ($5 < n < 10$) et que l'erreur indiquée pour chaque évaluation atteignait 20 mGal (par 1° x 1°) on a généralement reporté sur la carte 2 valeurs dans chaque compartiment :
- la valeur ACIC définie ci-dessus,
- la valeur KIVIOJA définie ci-après.

3) Valeurs provenant de la publication :
"Effect of topographic masses and their isostatic compensation on the mean Free Air Gravity Anomalies of 5° x 5° surface elements" by L. KIVIOJA, Columbus, Ohio, December 1963.

Nouveaux Systèmes de Référence

En 1967, l'Association Internationale de Géodésie a adopté un nouveau Système de Référence Géodésique ($\alpha = 1/298.25$). Dans ce Système (1) la valeur de la pesanteur normale sur l'ellipsoïde choisi est donnée par :

$$\gamma_{1967} = 978\ 0318\ (1 + 0{,}0053024\ \sin^2\varphi - 0{,}0000059\ \sin^2 2\varphi)$$

En 1971, l'A.I.G. a décidé d'abandonner l'ancien système de référence de pesanteur basé sur la valeur absolue de l'unique station de Potsdam, et d'adopter comme système de référence gravimétrique mondial un nouveau réseau de pesanteur dit : Réseau Gravimétrique International Unifié 1971 (IGSN71).

Ce nouveau système de référence gravimétrique comprend environ 700 stations réparties dans le monde entier, où les valeurs de g ont été calculées par rapport aux récentes déterminations absolues de la pesanteur et compensées par différentes méthodes. La liste définitive de ces stations avec leurs valeurs de g sera publiée dans quelques mois (Bulletin Géodésique, édition spéciale, 1972). Dans le "IGSN71", la valeur absolue de g à Potsdam devient approximativement 981 260 mGal, et toutes les valeurs anciennes de g basées sur la valeur de référence de Potsdam (981 274 mGal) devront être diminuées d'une quantité voisine de 14 mGal pour être converties dans le Réseau Gravimétrique International Unifié 1971.

Conversion des anomalies dans les Nouveaux Systèmes de Référence

Pour obtenir les anomalies de pesanteur par rapport aux systèmes de référence les plus proches actuellement de la réalité physique, c'est-à-dire "correspondant aux meilleures constantes caractérisant le corps terrestre et sa dynamique" (1, p.11), il faudrait recalculer ces anomalies en considérant les références précédentes.

Exemple : $\varphi = 45°$, $h = 300$ m.

Valeur mesurée (système Potsdam) $g_P = 980\ 618$ mGal
" " (IGSN 71) $g_{IGSN} = 980\ 604$ mGal

(1) "Geodetic Reference System 1967".
Bulletin Géodésique, Edition Spéciale, 1970.

Formule 1930 = 980 629,4
Formule 1967 = 980 619,0

Anomalies à l'Air libre$_{1930}$ = 980 618 + 92,6 - 980 629,4 = + 81,2 mGal
" " " $_{1967-71}$ = 980 604 + 92,6 - 980 619,0 = + 77,6 mGal.

En retranchant 3,6 mGal à l'anomalie calculée avec la formule internationale (1930), on obtient l'anomalie dans les nouveaux systèmes.

Pratiquement, la conversion des anomalies de pesanteur (système de Potsdam, formule internationale 1930) dans le Système de Référence Géodésique 1967 et le Réseau Gravimétrique International Unifié 1971, peut être faite rapidement à l'aide d'un terme correctif, fonction de la latitude : $\Delta g = (3,2 - 13,6 \sin^2 \varphi)$ mGal.

Ce terme varie de - 10,4 mGal à la latitude de 90° jusqu'à + 3,2 mGal à l'équateur. Voir (1), p.75, colonne B dans le tableau de conversion que nous reproduisons ci-dessous :

Latitude	B	Latitude	B	Latitude	B
0°	+3,2	35°	-1,3	65°	-8,0
5°	+3,1	40°	-2,4	70°	-8,8
10°	+2,8	45°	-3,6	75°	-9,5
15°	+2,3	50°	-4,8	80°	-10,0
20°	+1,6	55°	-5,9	85°	-10,3
25°	+0.8	60°	-7,0	90°	-10,4
30°	-0,2				

.../...

L'édition de cette carte d'anomalies moyennes à l'air libre (par 5° x 5°) sera refaite en 1974 par le B.G.I.

Pour permettre de compléter au mieux cette carte d'intérêt général, le B.G.I. souhaite recevoir des observateurs et des Services Géodésiques et Géophysiques le plus d'informations possible.

Par ailleurs, le B.G.I. demande aux utilisateurs de lui envoyer toute suggestion et remarque concernant l'établissement et la présentation de cette carte afin qu'il puisse en tenir compte dans l'édition 1974.

(Prière de renvoyer la feuille rose jointe à ce Bulletin).

S. CORON
Bureau Gravimétrique International

-=-=-=-=-=-

Remarque :

Il faut bien noter que dans le cas où on adopte les nouvelles valeurs de la pesanteur (correction de - 14 mGal au Système de Potsdam ou IGSN71), les anomalies doivent être calculées, non pas avec l'ancienne formule internationale 1930, mais avec une nouvelle formule qui tient compte ou non de la modification de l'aplatissement (1/297 ou 1/298.25) :

- si les paramètres de l'ellipsoïde de référence n'ont pas été modifiés (α= 1/297), la valeur de la pesanteur théorique à l'équateur γ_E devra être changée de - 14 mGal et les anomalies de pesanteur resteront inchangées ;
- si les paramètres de l'ellipsoïde de référence sont ceux définis en 1967 (γ= 1/298.25), les anomalies de pesanteur seront modifiées comme il est dit plus haut.

- D -

EQUAL AREA BLOCKS : A PRACTICAL SOLUTION FOR THE SPHERE AND THE ELLIPSOID

by J. LAGRULA & J.M. LUBART

Abstract

Our blocks are limited by means of meridians and parallels with variable amplitude for longitude and latitude : it is a compromise between the continuity of the shape of the blocks and the easy use of the maps. The blocks are of strictly equal area for the sphere or for the ellipsoïd.

The problem of the equal area blocks for the sphere has been discussed by R.H. RAPP and examined at the U.G.G.I. General Assembly, Moscow, 1971, (Special Study Group). The various proposed solutions have been exposed in a Report (1).

They are of two categories :

1°) Blocks limited by means of meridians and parallels.

2°) Other blocks.

The second category does not suffer from the longitude - latitude asymmetry. It seems at first preferable for mathematical treatments. However, it is impossible to find a symmetrical system of coordinates in a riemannian space such as a spherical or ellipsoidal surface. The sphere being divided (icosahedron) into 20 isomorphic areas (equilateral triangles), each divided into 3 identical triangles, which are no more equilateral but only isocele, we obtain, by means of a new division into 2 parts, 120 equal area blocks (triangles no more isocele). It is the finest possible structuration. Starting from a dodecahedron we obtain the same result.

On one hand, a fine isomorphic partition of a sphere or an ellipsoid does not exist. On the other hand, the use of the available cartographical documentation is of great importance. Consequently, a practical solution of the first category may have numerous adherents.

Unfortunately, that documentation is generally sexagesimal. Furthermore, we must use equatorial blocks (1°, 5° ...), because, in our quest of equal area blocks, we are haunted by the euklidian space, and those equatorial blocks are "totems" corresponding to the euklidian cylindrical space which is tangent to our riemannian one along the equator.

The solutionsof the first category include three varieties :

1°) Blocks with constant amplitude for the latitude.
2°) Blocks with constant amplitude for the longitude.
3°) Blocks without constant amplitude.

A constant amplitude for the latitude (1) does not allow the strict equality of the areas.

A constant amplitude for the longitude (2) implies polar "triangles" of which shape differs too much from that of the equatorial blocks.

A third variety offers the best possibilities, which we may utilize in the most practical way, for example (3) in providing the values of the longitude which correspond to the borders of the maps. Another solution (4) involves very small variations of the amplitude for the latitude, and a very good continuity of the shape of the blocks from equator to the poles. But the subdivision for the longitude was not comfortable, due to the values of the numbers N of the same latitude blocks.

The subdivision for the latitude has not the same importance as for the longitude, from a practical point of view. We agree with M. DUFOUR on that opinion. However, the more continuous are the numbers N, the more approached is the local isomorphism (4).

The present solution is a compromise between that continuity and the easy use of the maps : our values of longitude are multiples of 30'. The blocks, being of strictly equal area, have exactly the same weight in statistical studies, covariances, cross covariances, integrations for spherical or spheroidal functions etc...

Concerning the ellipsoïd we have utilized the computations of the previous paper (4).

The Tables I and II show for the sphere and for the ellipsoid the values of the latitude φ and the numbers N.

B.G.I., Paris, 1972.

REFERENCES

(1) RAPP R.H. - "Equal area blocks". U.G.G.I., Moscow, 1971.

(2) LAGRULA J. - Comptes rendus, Acad. Sci., Paris, t.272, Sér. B, p.553, 1971.

(3) DUFOUR H.M. - "Considérations sur le découpage du globe terrestre en zones d'égales surfaces". U.G.G.I., Moscow, 1971.

(4) LAGRULA J. - Comptes rendus, Acad. Sci., Paris, t.273, Sér. B, p.884, 1972.

TABLE 1

SPHERE		ELLIPSOID	
φ	N	φ	N
0°	72	0°	72
5° 0'04	72	4°59'93	72
10° 2'39	72	10° 2'11	72
15° 9'55	64	15° 8'95	72
19°48'90	64	20°23'22	64
24°36'70	64	25°11'53	64
29°36'02	60	30°11'47	60
34°30'75	54	35° 6'89	60
39°11'70	54	40°21'05	54
44°12'82	50	45°25'89	48
49°16'60	45	50°21'64	40
54°19'56	40	54°53'58	40
59°24'22	36	60° 0'03	36
64°44'22	27	65°23'21	27
69°33'67	24	70°17'71	20
75° 2'34	15	74°52'44	16
79°49'28	10	79°53'41	10
85° 6'92	3	85° 8'92	3
90° 0'		90° 0'	

TABLE 2

SPHERE		ELLIPSOID	
φ	N	φ	N
0°	360	0°	360
1°	360	0°59'99	360
2° 0'02	360	2°	360
3° 0'08	360	3° 0'03	360
4° 0'19	360	4° 0'13	360
5° 0'37	360	5° 0'29	360
6° 0'65	360	6° 0'55	360
7° 1'04	360	7° 0'91	360
8° 1'56	360	8° 1'40	360
9° 2'23	360	9° 2'04	360
10° 3'07	360	10° 2'84	360
11° 4'11	360	11° 3'83	360
12° 5'35	360	12° 5'02	360
13° 6'83	360	13° 6'45	360
14° 8'57	360	14° 8'12	360
15°10'59	360	15°10'07	360
16°12'91	360	16°12'31	360
17°15'56	360	17°14'87	360
18°18'58	320	18°17'78	320
19°14'91	320	19°14'02	320
20°11'56		20°10'57	

.../...

(Continued)

20°11'56	320	20°10'57	320
21° 8'56	320	21° 7'45	320
22° 5'93	320	22° 4'69	320
23° 3'69	320	23° 2'32	320
24° 1'87	320	24° 0'34	320
25° 0'49	320	24°58'80	320
25°59'58	320	25°57'71	320
26°59'17	320	26°57'11	320
27°59'28	320	27°57'02	320
28°59'97	320	28°57'48	320
30° 1'25	320	29°58'52	320
31° 3'17	300	31° 0'18	300
32° 1'84	300	31°58'58	300
33° 1'14	300	32°57'60	300
34° 1'11	300	33°57'27	300
35° 1'80	288	34°57'63	300
36° 0'77	288	35°58'73	288
37° 0'49	288	36°58'13	288
38° 1'00	270	37°58'29	288
38°58'50	270	38°59'27	288
39°56'79	270	40° 1'12	270
40°55'91	270	40°59'96	270
41°55'93	270	41°59'67	270
42°56'91		43° 0'32	

.../...

(Continued)

42°56'91		43° 0'32	
	270		270
43°58'91		44° 1'96	
	270		270
45° 2'01		45° 4'68	
	240		240
45°59'08		46° 1'39	
	240		240
46°57'16		46°59'08	
	240		240
47°56'30		47°57'82	
	240		240
48°56'60		48°57'67	
	240		240
49°58'13		49°58'73	
	225		225
50°57'04		50°57'16	
	225		225
51°57'21		51°56'83	
	216		216
52°56'28		52°55'37	
	216		216
53°56'71		53°55'24	
	216		216
54°58'65		54°56'57	
	200		200
55°57'45		55°54'77	
	200		200
56°57'78		56°54'44	
	192		200
57°57'27		57°55'74	
	192		192
58°58'45		58°56'26	
	180		180
59°57'50		59°54'63	
	180		180
60°58'36		60°54'76	
	180		180
62° 1'22		61°56'83	
	160		160
62°58'98		62°53'81	
	160		160
63°58'70		63°52'69	
	160		160
65° 0'63		64°53'69	
	150		150
66° 0'94		65°53'05	
	144		144
67° 1'17		66°52'25	

(Continued)

67° 1'17		66°52'25	
	135		144
67°59'99		67°53'94	
	135		135
69° 1'41		68°54'34	
	120		135
69°58'52		69°57'62	
	120		120
70°58'36		70°56'67	
	120		120
72° 1'38		71°58'81	
	108		108
73° 1'31		72°57'84	
	100		100
74° 0'03		73°55'60	
	96		100
74°59'90		74°56'94	
	90		90
75°59'80		75°55'85	
	80		90
76°56'80		76°59'09	
	80		80
77°58'20		77°59'85	
	72		72
78°58'23		78°59'22	
	64		64
79°56'53		79°56'80	
	60		60
80°56'76		80°56'23	
	54		54
81°57'30		81°55'85	
	48		48
82°58'29		82°55'77	
	40		40
83°56'82		83°53'05	
	36		36
84°59'03		84°53'59	
	27		30
85°55'85		85°55'18	
	24		24
87° 0'86		86°58'93	
	15		16
87°57'94		87°58'78	
	10		10
89° 1'37		89° 1'77	
	3		3
90° 0'00		90° 0'00	

- E -

MISE AU POINT CONCERNANT LES METHODES D'EXTRAPOLATIONS STATISTIQUES DES DONNEES GRAVIMETRIQUES

L. LEBART

- Sommaire -

I - Présentation du problème

Les mesures gravimétriques ne couvrent qu'une petite partie de la surface terrestre. On possède cependant des dizaines de milliers de mesures (des centaines de milliers en réalité) dans les zones déjà explorées.

D'où l'idée d'utiliser la statistique, science réputée efficace lorsqu'il s'agit d'analyser de grands ensembles de mesures et de condenser l'information contenue dans des données éparses, d'où à priori il ne se dégage aucune régularité ou aucune autre loi que celle du hasard.

Ces méthodes statistiques ont été proposées tout d'abord par HIRVONEN, puis par KAULA, MORITZ, GROTEN, RAPP. Il s'agissait avant tout, lors de ces essais méthodologiques, de tirer des lois moyennes de données existantes, et, suivant certaines hypothèses de stabilité, de supposer ces lois valables pour les régions sans données, et par suite, de fournir des estimations des valeurs inconnues.

II - Difficultés du problème

En fait, ces tentatives, qui ne doivent leur existence qu'à l'urgence du besoin en données nouvelles, n'ont pas donné les résultats escomptés, si l'on tient compte des crédits, du temps et du nombre de publications auquel ces études ont donné lieu.

En effet, si les mesures gravimétriques ont en commun avec les ensembles statistiques généralement analysés, de constituer des "populations" riches par leurs effectifs, l'analogie s'arrête là.

Il n'y a jamais répétition d'épreuve au sens statistique : l'anomalie à l'air libre de la pesanteur est une variable indéterminée plutôt qu'aléatoire. Il n'est pas possible en général d'affecter des possibilités aux valeurs d'une anomalie gravifique en un point d'une région non explorée, car il n'existe aucune raison de probabiliser ces valeurs à priori (comme c'est le cas lors du jet d'un dé, ou de la roulette), ou à posteriori, après l'observation de fréquences (comme par exemple pour les prévisions de mortalité) ...

Il va donc falloir faire des hypothèses restrictives sur la répartition de ces anomalies.

L'hypothèse la plus couramment retenue est malheureusement peu vraisemblable, mais elle présente l'avantage d'avoir donné lieu à de nombreux développements dans d'autres branches de la physique. C'est l'hypothèse de stationnarité.

La loi de probabilité de deux valeurs d'anomalie de la pesanteur situées à une distance r ne dépend que de r.

Cette condition suppose réalisée l'isotropie de la répartition des anomalies. Il est évident que cette contrainte est assez draconienne, et que la répartition des anomalies dans les zones déjà connues ne satisfait pas aux conditions de régularité dictées par ces hypothèses.

III - Revue des travaux antérieurs

Il semble que les premiers travaux de statistique appliqués à la géodésie soient dus à "DE GRAAF-HUNTER", en 1935. Il s'agissait alors d'un travail empirique sur les erreurs d'interpolation sans véritable inférence statistique, mais cependant d'un grand intérêt. Il a ainsi défini "l'erreur de représentation" E comme la racine carrée de la moyenne quadratique des différences entre une valeur et la valeur moyenne des observations autour de ce point.

Les travaux "DE GRAAF-HUNTER" ont été repris par HIRVONEN en 1956 avec un volume de données beaucoup plus considérable. Celui-ci a ensuite calculé, puis représenté graphiquement les fonctions g (s), donnant, pour chaque valeur de s (représentant ici la longueur du côté d'un carré), la valeur g (s) de la racine de la moyenne quadratique des anomalies, cela pour des carrés allant de 10 km de côté jusqu'à 30°.

Jusqu'ici, ces travaux étaient du domaine de la statistique descriptive. HIRVONEN a inauguré les travaux de statistique mathématique en calculant l'autocorrélation des anomalies situées à une distance r, et en traçant les corrélogrammes correspondants.

En 1957, KAULA publie des travaux analogues, puis en 1959, il utilise certains résultats relatifs aux Chaînes de Markov pour faire des essais d'extrapolation. Rappelons qu'un processus est Markovien si sa loi de probabilité en t + 1 ne dépend que de son état à l'instant t, quels qu'aient été ses états antérieurement à cet instant.

Transposée à l'étude des anomalies, cette notion revient à supposer que la valeur d'une anomalie ne dépend que des anomalies immédiatement voisines, et que les valeurs situées au-delà d'une valeur connue n'apportent aucune information supplémentaire. Bien qu'originale, cette méthode ne conduit pas à des résultats probants.

En 1962, HIRVONEN et RAPP publient des études de corrélogrammes calculés sur des mesures faites en Finlande et dans l'Ohio. RAPP propose une forme analytique polynomiale pour la covariance (en fonction de la distance).

En 1962, MORITZ propose une théorie (qui n'est autre que la régression multiple) pour prédire les anomalies dans les zones où l'on a déjà quelques mesures, ainsi qu'une estimation de l'erreur commise. Il améliore son modèle en 1963 en considérant comme variable explicative de la valeur d'une anomalie en un point, non seulement les valeurs des anomalies au voisinage de ce point, mais les valeurs des altitudes au voisinage, et au point lui-même. Cette estimation fait intervenir les fonctions suivantes : autocorrélation des anomalies, corrélation entre une anomalie en un point, et l'altitude d'un point situé à la distance r, enfin, corrélation entre anomalie et altitude au même endroit.

Cette méthode, bien que classique en statistique, semble avoir été retrouvée par MORITZ lui-même. Elle s'applique également à la prédiction des anomalies moyennes.

En 1964, RAPP applique ces méthodes pratiquement, et conclut que les dix points les plus voisins sont, à l'intérieur d'un carreau de 5° x 5°, suffisants pour donner une précision convenable. (En d'autres termes, les résultats ne sont pas améliorés si l'on prend plus de dix points).

Une méthode de prédiction plutôt analytique que statistique a été suggérée par KIVIOJA en 1962, qui a proposé des prolongements utilisant des développements en séries de Fourier (pour les profils), ou des ajustements par des fonctions développables en harmoniques sphériques.

La plupart des recherches actuelles dans ce domaine visent à trouver de nouveaux ensembles de variables aisément mesurables corrélés avec les anomalies. Il sera donc de plus en plus difficile de distinguer prédictions statistiques et prédictions géophysiques des anomalies.

IV - Principaux résultats techniques

1°) Méthode de prédiction par régression multiple

L'anomalie gravimétrique est considérée comme une fonction aléatoire des coordonnées d'un point, dont on ne connaîtrait qu'une seule réalisation. L'hypothèse stationnaire stipule que la loi du couple $(\Delta g_i, \Delta g_j)$ ne dépend que de la distance d_{ij} des points i et j.

Si $\Delta\bar{g}$ désigne l'anomalie moyenne d'une zone, la covariance du couple $(\Delta g_i, \Delta g_j)$ s'écrit :

$$C = \int (\Delta g_i - \Delta\bar{g})\ (\Delta g_j - \Delta\bar{g})\ d\Omega = c\ (d_{ij})$$

Empiriquement, cette covariance se calcule en sélectionnant par un procédé automatique tous les couples de points situés à la même distance d, et en effectuant les produits deux à deux des écarts des anomalies par rapport à la moyenne.

On refait le calcul pour différentes valeurs de d, pour obtenir l'allure de la courbe C (d). Les formules permettant la prédiction se retrouvent aisément : supposons que la valeur à prédire x soit une combinaison linéaire des n valeurs les plus proches :

$$x = \sum \alpha_i \, x_i$$

Cherchons les valeurs des coefficients αi tel qu'en moyenne l'erreur quadratique sur x soit la plus faible possible, c'est-à-dire telle que :

$$E\,(x - \sum \alpha_i \, x_i)^2 \text{ soit minimum,}$$

le symbole E (t) désignant l'Espérance mathématique de ..

Dérivant cette expression par rapport à α_j :

$$\frac{\partial}{\partial \alpha_j} \left[E\,(x - \sum \alpha_i \, x_i)^2 \right] = -\,2\,E\,(x - \sum \alpha_i \, x_i)\, x_j = 0$$

par suite de la linéarité de l'opérateur E :

$$E\,(x \; x_j) - \sum \alpha_i \, E\,(x_i \; x_j) = 0$$

si l'on désigne par α le vecteur colonne des valeurs des α_j, par M la matrice des covariances de terme général E $(x_i \; x_j)$, par C le vecteur ayant pour composante E $(x \; x_j)$, on peut écrire:

$$C = \alpha' \, M \qquad (\alpha' \text{ désignant le transposé de } \alpha)$$

d'où, (M étant en général définie positive)

$$\underline{\alpha' = M^{-1} \, C}$$

Tous les éléments de M et de C sont connus dès lors que l'on s'est fixé la position du point où l'on cherche la prédiction, car les termes E $(x_i \; x_j)$ et E $(x \; x_j)$ ne sont autres que les moments du second ordre d'observations, qui sont supposés ne dépendre que de d_{ij} (distance de deux points connus entre eux) ou des distances du point x aux différents points connus.

En fait, cette méthode a le défaut de donner systématiquement un résultat dans tous les cas, ce résultat n'ayant une signification que dans un petit nombre de cas.

Il est facile de vérifier que malgré la démarche analytique relativement complexe (chaque prédiction demande, si l'on considère que les dix points les plus proches ont une influence non négligeable, une inversion de matrice 10 x 10, qui peut durer plusieurs secondes même sur un bon ordinateur), cette méthode de prédiction ne fait que réaliser une interpolation proportionnelle.

Signalons qu'elle n'est valable que pour une distance inférieure à 50 km, au-delà de laquelle les corrélations s'évanouissent. Signalons également qu'il y a intérêt à calculer des corrélogrammes régionaux (plusieurs fonctions C (d), pour les régions montagneuses, maritimes, plates). Cela revient à améliorer l'hypothèse stationnaire, en énonçant :

"La liaison entre deux anomalies ne dépend que de la distance dans une zone géographique homogène".

Quels sont donc les avantages de cette méthode ? Elle permet essentiellement d'enrichir les zones déjà légèrement explorées, sans entrainer de manipulation ni d'estimations subjectives.
Il serait illusoire de vouloir l'appliquer en vue de déterminer les valeurs des anomalies dans des zones totalement inexplorées.

2°) Méthodes faisant intervenir les altitudes

Au paragraphe précédent, nous avons considéré que les variables explicatives étaient des anomalies x_i. Le modèle n'est pas rendu plus compliqué si certains des x_i désignent non pas des anomalies mais des altitudes.

La matrice M contient alors des termes tels que : E $(x_i\ h_j)$, soit : "corrélation entre l'anomalie en i et l'altitude en j".
Il importe donc d'avoir établi précédemment les formules donnant C_{xh} (d) : corrélation entre l'anomalie et l'altitude de deux points distants de d, et en particulier la valeur de cette fonction pour d = 0 (valeur en général assez bien connue).

Ici encore, il apparaît peut raisonnable de supposer que les anomalies dépendent partout de la même façon de l'altitude.

Des études sont en cours au B.G.I. pour étudier précisément cette régionalisation de la dépendance entre anomalies et altitude. Les résultats, s'ils sont probants, permettront d'améliorer l'hypothèse de stationnarité, en une hypothèse de stationnarité locale.

Ainsi, la matrice de covariance de (a_1, h_1, a_2, h_2), où a_1, a_2 désignent les anomalies aux points 1 et 2, h_1 et h_2 les altitudes aux points 1 et 2, n'est supposée ne dépendre que de la distance des points 1 et 2 seulement dans des zones restreintes, homogènes du point de vue du relief, ou d'un point de vue tectonique.

Ainsi amélioré, le modèle permettra des estimations dans des zones non explorées, puisque figure l'altitude parmi les variables explicatives, ainsi que la catégorie géographique, tectonique, géologique de la région.

Il reste bien sur à faire un travail de classification et d'analyse des régions ; à chacune des régions (mettons dix types de "paysages" sur toute la surface du globe) correspondra un corrélogramme d'anomalie, un corrélogramme d'altitude, et un corrélogramme croisé anomalie - altitude, et par suite, une méthode optimum de prédiction.

3°) Quelques résultats sur les méthodes de régression multiple

Les corrélogrammes obtenus ont été ajustés à des fonctions du type "loi de Cauchy" ou "loi de Laplace-Gauss" par la méthode des moindres carrés.

Pour une distance $d \leqslant 30°$, on a des formes analytiques du type

$$C(d) = C(0) / (1 + c^2 d^2) \quad \text{ou}$$

$$C(d) = C(0) \exp. \left\{-c^2 d^2\right\}$$

Les résultats des prédictions effectuées sur des zones déjà explorées, à titre de vérification sont les suivants :

- Si l'on connait beaucoup d'anomalies voisines de celle à prédire, il n'est pas nécessaire de tenir compte de chacune de ces anomalies (il y a redondance d'information par suite de l'autocorrélation des anomalies).
- Seules les anomalies les plus proches présentent de l'intérêt. (Il y a un "effet d'écran" markovien, au sens où KAULA utilisait ce mot).
- Les prédictions n'ont que peu de valeur pour les grandes distances.

4°) Méthodes de prédiction par analyse statistique globale

Lors de l'emploi des méthodes précédentes, la distance de deux points où sont mesurées des anomalies a été utilisée, mais les coordonnées d'un point ne sont jamais intervenues, et les méthodes s'appliquaient comme si les diverses anomalies étaient situées sur un plan.

Une étude statistique globale, faisant intervenir les développements de fonctions en harmoniques sphériques, a l'avantage d'être plus synthétique, et de pouvoir être rapprochée de résultats obtenus à partir des expériences de géodésie spatiale.

Les travaux entrepris dans cette direction de recherche sont principalement le fait de KAULA (Institute of Geophysics and Planetary Physics, University of California, Los Angeles) et de KIVIOJA (Purdue University). La plupart des publications d'analyses statistiques globales mettent en jeu des hypothèses non vérifiées par la distribution des anomalies. Comme la stabilité des résultats en cas de déviation des hypothèses n'est pas étudiée (et serait extrêmement complexe à étudier, à moins de faire intervenir de nouvelles hypothèses...) les résultats sont à manier avec la plus grande suspicion.

Ces auteurs concluent également à la nécessité de faire intervenir des variables exogènes comme l'épaisseur de la croûte terrestre ou les courants de chaleur (heat flow).

Les variables explicatives doivent être faciles à mesurer, ce qui restreint considérablement le choix du statisticien.

L'apport de la statistique aux méthodes globales est insignifiant par rapport à l'apport des mesures provenant des observations des anomalies des trajectoires des satellites.

En effet, les développements en harmoniques sphériques conduisant à des calculs raisonnables ne permettent que de mettre en évidence des ondulations extrêmement étendues, alors que l'information gravimétrique, là où elle existe, est extrêmement dense, et inadaptée à ce genre de traitement. Par contre, l'observation des satellites est parfaitement compatible avec cette formalisation, et réussit précisément là où les méthodes de régression échouent - prédiction dans de vastes zones totalement inexplorées.

5°) Méthodes de prédiction n'utilisant pas la Statistique

Bien que le titre de la note semble en contradiction avec celui de ce paragraphe, nous allons exposer brièvement les autres méthodes de prédiction, et cela pour deux raisons :

1 - Si ces méthodes ne sont pas appelées statistiques, c'est que les spécialistes de la Géophysique et de la Géologie ne sont pas en général en mesure d'apprécier les services que la statistique peut rendre à leur propre discipline.

2 - Par suite de la prise en compte de variables explicatives nouvelles, dans les modèles de régression multiple, il est de plus en plus artificiel de séparer méthodes statistiques et géophysiques. Les deux principales méthodes de prédiction sont celle de MM. STRANGE et WOOLLARD (méthode purement géophysique) et celle de MM. KIVIOJA, LAMBERT (réductions isostatiques).

Il est vraisemblable que les développements récents de la Statistique, permettant d'intégrer dans un même modèle explicatif un très grand nombre de variables vont contribuer à fondre ces démarches distinctes en un seul procédé de prédiction.

A) Corrélation avec les variables géophysiques et géologiques

Ces études ont été réalisées principalement par G.P. WOOLLARD & W.E. STRANGE, à l'"Hawaii Institute of Geophysics".

Voici quelles sont les conclusions auxquelles ils arrivent pour la prédiction des anomalies à l'air libre en zones totalement inexplorées.

1) Déterminer les altitudes moyennes par carreau de 1° x 1°.

2) Utiliser la relation : AL = 60 h + 13 mGal pour des altitudes inférieures à 250 m. près des côtes (h est exprimé en km).

la relation : AL = 7,8 h - 3 mGal pour des altitudes comprises entre 250 m. et 1800 m.

la relation : AL = 38 h - 58 mGal pour des altitudes comprises entre 1800 et 3000 m.

3) Diviser la zone à renseigner en régions homogènes géologiquement, suivant la classification ci-dessous, et appliquer les corrections correspondantes :

	Correction à la prédiction
a - Chaines de montagne :	
Mesozoïque ou plus jeune	- 10 mGal
Paléozoïque ou plus ancienne	0
b - Zones de soulèvement eustatique	- 15
c - Boucliers, avec orogènèse surimposée	- 30
avec bassin surimposé	+ 20
d - Volcanisme tertiaire	- 10
e - Fossés (graben) ou bassins à parois escarpées	- 40
Horsts	+ 30
f - Batholithes granitiques	- 50
g - Aires de sédimentation géosynclinales	- 15
h - " " avec basalte	+ 40
i - Fossés d'effondrement en zone plate	- 100
j - Horsts en terrain plat	+ 40
k - Petits horsts et grabens, granites, etc...	± 20

4) On calcule une correction de variation de masse locale par la formule $\Delta g = 99\ h$ (h toujours en km.), où h est la différence entre l'altitude de la station et l'altitude moyenne de la région de 2° x 2° qui contient la station.

Signalons que ces méthodes ont donné, lors d'une expérience sur des données connues aux U.S.A. une approximation meilleure que ± 8 mGal dans 50 % des cas, et meilleure que ± 20 mGal dans 90 % des cas.

Ces chiffres sont cependant optimistes car les prédictions géologiques ont été faites dans des régions où la géologie est exceptionnellement bien connue. Ce n'est pas le cas des fonds sous-marins, par exemple. De plus, ce sont ces mêmes régions qui ont conduit à la classification ci-dessus, et à évaluer les corrections.

B) Prédiction par compensation isostatique des masses

Ces méthodes ont été utilisées par KIVIOJA pour calculer les 2592 valeurs moyennes des anomalies qui ont été utilisées par le B.G.I. pour calculer le géoïde mondial, et qui sont encore utilisées, faute de mieux, pour compléter les données en dehors de "fenêtres" où l'on a une bonne connaissance de ces anomalies.

Le principe de la méthode, bien connu, consiste à donner la valeur 0 à toute anomalie isostatique inconnue à priori, puis à appliquer la correction isostatique en sens inverse pour restituer une anomalie à l'air libre. (Correction calculée dans le système d'Airy-Heiskanen, T = 30 km.).

V - Le point des recherches actuelles et la direction des recherches futures.

Si le but final est la recherche des anomalies, la voie de recherche toute tracée semble être une méthode statistique multidimensionnelle qui intégrerait toutes les tentatives précédentes.

Pourquoi une telle méthode n'a-t-elle jamais été appliquée ? D' une part, parce que jusqu'à ces dernières années, les méthodes de calcul étaient trop artisanales pour permettre de traiter beaucoup de variables simultanément (raison pour laquelle les modèles statistiques eux-mêmes étaient simplistes).

D'autre part, parce que le nombre de disciplines intéressées est trop grand, et que la dispersion des Laboratoires exclut la possibilité d'une collaboration étroite.

Ainsi, un modèle combinant les travaux de WOOLLARD et de MORITZ, s'apparentant aux modèles dits "d'analyse de la covariance" en statistique est à l'étude au B.G.I.

L'anomalie s'écrirait :

$$A = \Sigma \lambda_{ik} h_i + \mu_k h + \alpha_k + \beta$$

où les λik sont des coefficients qui dépendent du paysage géo-tectonique k, et du point i environnant le point cherché.
(Les paramètres dépendant de k seraient variables selon l'aspect géo-tectonique des régions).

Si cependant le but final n'est pas la recherche des anomalies par elle-même, mais la recherche de fonctions de ces anomalies, il n'est pas indispensable de prédire les anomalies : on peut faire une prédiction directe de la fonction.

Prenons le cas d'un calcul de géoïde par la formule de Stokes :

$$H = \frac{1}{4\pi ga} \int \Delta g \, f(\psi) \, d S.$$

Ce calcul se fait en prenant pour surface élémentaire le carreau de 1° x 1° et, pour les zones éloignées, le carreau de 5° x 5°.

Si l'on se propose de calculer H en chaque point de la terre, il est évident que la connaissance de Δg en chaque point de la terre est requise, car on passe des anomalies au géoïde par une transformation linéaire, non singulière (on peut reconstituer les anomalies à partir du géoïde).

Mais dans certains cas, on n'a besoin de connaître le géoïde que sur une partie de la surface terrestre.

Il existe de nombreuses "anomalies" possibles pour les zones inexplorées, qui donnent la même valeur du géoïde en cette partie limitée de la surface terrestre. Dans ce cas, la connaissance de la totalité des anomalies ne devrait pas être nécessaire.

Il serait plus efficient, plutôt que de chercher une estimation qui minimise le carré de l'erreur sur l'anomalie, de chercher des estimations qui minimisent le carré de l'erreur sur le géoïde calculable à partir de celles-ci.

Ainsi, on obtiendrait bien la valeur optimum de la grandeur cherchée, sans se soucier des valeurs correspondantes des anomalies.

Le problème n'a pas de solution analytique simple, mais une solution par simulation est envisageable, compte tenu du programme de calcul de géoïde existant. Il est vraisemblable que de telles études seront complétées à l'avenir au B.G.I.

B.G.I., 1968.

LISTE DES PUBLICATIONS

reçues au

BUREAU GRAVIMETRIQUE INTERNATIONAL

(Septembre 1971 à Février 1972)

CONCERNANT LES QUESTIONS DE PESANTEUR

LISTE des PUBLICATIONS

National Reports (A.I.G.) presented at the XV General Assembly of U.G.G.I., Moscow, 1971.

Argentina
Australia
Austria
Belgium
Canada
Czechoslovakia
Denmark
Finland
France
German Democratic Republic
German Federal Republic
Greece
Hungary
Indonesia
India
Iran
Ireland
Italy
Japan
Mexico
Morocco
Nigeria
Netherlands
New Zealand
Norway
Poland
Portugal
Rhodesia
Rumania
Sweden
Thailand
Turkey
United Kingdom
United States
U.S.S.R.
Yugoslavia

National Reports (Upper Mantle Project)

542 - NATIONALKOMITEE für GEODÄSIE & GEOPHYSIK der D.D.R.
55 p, Berlin.

543 - THE DANISH NATIONAL COMMITTEE
Progress Report for Denmark, 1964-1971, 12 p, Copenhagen.

544 - NATIONAL COMMITTEE of IUGG/URSI, Nigeria.
Final Report of the Nigerian Upper Mantle Committee, 3 p.

545 - NETHERLANDS COMMISSION
Final Report, 43 p.

546 - LAMBERT B.P. - "Geodetic surveying in Antarctic, 1967-1970".
Sci. Com. Antarctic Res., 22 p.

547 - BANKWITZ P. - "Geological explanations to recent movements in the GDR".
Nat. Kom. Geod. & Geophys. D.D.R., 9 p.
Presented at the XV General Assembly of IUGG, IAG, Moscow, 1971.

On the basis of new geodetic data and geological observations it was possible to widen the knowledge about recent movements. The exact position and the specific character of faults could be determined. Without geodetic methods this knowledge is difficult to obtain.

Up till now, horizontal movements are evident only in the south-eastern area. There, and in the north-western part, zones of recent activity form a block structure. By co-ordinating relevellings, retriangulations and geologic observations, it was possible in certain places to decide the specific character of recent active faults in our rather quiet seismic region.

548 - WIRTH H.W. - "Isostasy and deformations of the equipotential surfaces in the Earth's interior".
Nat. Kom. Geod. & Geophys. D.D.R., 5 p.
Presented at the XV General Assembly of IUGG, IAG, Moscow, 1971.

549 - BYL J. - "Results of tilt observations at Potsdam".
Nat. Kom. Geod. & Geophys. D.D.R., 6 p.
Presented at the XV General Assembly of IUGG, IAG, Moscow, 1971.

Besides these interesting facts we have found furthermore a distinct yearly period in the instrumental drift, which shows a predominant NS-direction and which stands in good agreement both with the nearer tectonic structure and the morphology of the station.

550 - SCHULER R., G. HARNISCH, H. FISCHER & R. FREY - "Absolute Schweremessungen mit Reversionspendeln in Potsdam 1968-1969".
Deutsche Akad. Wissens. Berlin. Veröff. Zentralinst. Physik der Erde, n°10, 193 S, Potsdam, 1971.

A new absolute determination of the acceleration due to gravity was made at the former Geodätisches Institut Potsdam (since 1969 part of the Zentralinstitut Physik der Erde), using the reversible pendulum method. Measurements with two apparatus yielded a g value of

$$g = (981{,}260\ 1 \pm 0{,}000\ 3)\ \mathrm{cm.s^{-2}},$$

which refers to the double pillar SO in the Pendelsaal corresponding to a deviation of - 13,9 mGal from the reference level of the Potsdam system, based on the measurements of KUHNEN and FURTWANGLER (1898-1904). Beside essential theoretical fundamentals of the reversible pendulum method the publication presented

here includes a detailed description of facts concerning the devices which have been used, their results, and the way of interpretation. In addition the determinations of absolute gravity since the work of KUHNEN and FURTWANGLER are summarized and compared with the results from the recent reversible pendulum measurements performed at Potsdam.

551 - C.N.E.X.O. - Rapport annuel 1970.
60 p, Paris, 1971.

552 - RECHENMANN J. - "Cartes gravimétriques du Niger".
ORSTOM, Notice explicative n°36, 11 p, 1969.

La Mission Géophysique de l'ORSTOM a effectué, à la demande du Gouvernement de la République du Niger, et dans le cadre d'une convention, le levé gravimétrique de reconnaissance du territoire du Niger, au cours des années 1962 à 1965.

Cette note présente les résultats, publiés sous forme de cartes au 1/1.000.000, de ces campagnes gravimétriques. Elle rappelle brièvement comment les travaux ont été conduits sur le terrain, ainsi que la méthode de calcul des anomalies de Bouguer. Celles-ci sont présentées sur cinq cartes au 1/1.000.000 (hors texte) :

Niger Ouest
Niger Centre
Niger Sud-Est
Niger Nord-Est
Niger Nord-Ouest

Les interprétations géologiques des anomalies gravimétriques ayant fait l'objet de publications antérieures (6.7.8.9) ne sont pas présentées dans cette zone.

A l'occasion de ces levés gravimétriques, le réseau des bases magnétiques au Niger a été complété. De plus, la composante verticale Z, du champ magnétique terrestre, a été mesurée à chaque point gravimétrique.

554 - STACEY R.A. - "Interpretation of the gravity anomaly at Darnley Bay, N.W.T.".
from : Canadian J. Earth Sci., v.8, n°8, 6 p, 1971.

The almost circular gravity anomaly which lies at the head of Darnley Bay on the Arctic coast 400 km east of the Mackenzie Delta, has a radius of 50 km with Bouguer values rising 130 mGal above the background field . It is concluded that the anomaly is due to a basic or ultrabasic body in the form of a truncated cone (which may narrow towards the surface or downwards), lying at a comparatively shallow depth within the Proterozoic sediments. Having obtained a feasible configuration for the body, the influence it may have had on the deposition of later proterozoic and early paleozoic sediments is discussed in speculative terms.

555 - BONATZ M., P. MELCHIOR & B. DUCARME - "Station Longyearbyen (Spitsbergen), mesures faites dans les trois composantes avec 6 pendules horizontaux VM et trois gravimètres Askania". Obs. Royal de Belgique, Bull. d'Obs. : Marées Terrestres, v.IV, fasc. 1, Section Géodynamique, 110 p, 1971.

556 - BONATZ M. & P. MELCHIOR - "Erdgezeitenregistrierungen in der Arktis. International Astro-Geo-Project Spitzbergen 1968/70". Obs. Royal de Belgique, Comm. Sér. B, n°58, Sér. Geophys. n°102, Zeits. Vermesswes. 96, Heft 7, S.305-309, 1971.

Some partial-tides in the horizontal earth-tide-spectrum can synchronously in both main direction practically only be measured in the proximity of the poles. For vertical component the fortnightly moon-wave there reaches one maximum which, with modern technics, seems possible to be measured. The aim of an international expedition to Spitzbergen (φ = 78°N) in 1969/70 was the observation of these waves. It is reported about the performance of the research work and some ideas are given on the results of measurements and the first results of harmonic analysis.

557 - MELCHIOR P. - Marées terrestres. Bull. Inf. n°61, p.3001-3111, Bruxelles, 1971.

558 - LAW L.K. & R.P. RIDDIHOUGH - "A geographical relation between geomagnetic variation anomalies and tectonics". Canadian J. Earth Sci., v.8, n°9, p.1094-1106, 1971.

A world review of the available geomagnetic variation data, with a standardized presentation of results from North America and Europe, shows that there is a geographical relation between inland geomagnetic variation anomalies and tectonic features. Particularly evident in North America is a correlation between anomalies and the edge of the stable craton. Other anomalies are situated along fold belts (eastern Canadian Arctic) and rift-fault zones (Rhine Graben, Iceland).With the exception of that in Japan, all reported anomalies are shown to occur within these three tectonic categories. In terms of plate theory, these categories and the island arc system related to Japan are characteristic of past or present plate boundary zones. A close association between plate margins and geomagnetic variation anomalies is thus implied.

559 - USAF, AERONAUTICAL CHART & INFORMATION CENTER - Quarterly accession list, 1 July - 30 Sept. 1971.
DoD Gravity Library, 10 p, St-Louis, 1971.

560 - ACCADEMIA NAZIONALE DEI LINCEI - Paolo DORE : discorso commemorativo pronunciato del Linceo Luigi Solaini nella seduta ordinaria del 20.2.71. Celebrazioni Lincee 44, 13 p, Roma, 1971.

561 - RECHENMANN J. - "Cartes gravimétrique et magnétique du Nord Mauritanie".
ORSTOM, Notice explicative n°46, 6 p, 1971.

Cette note présente les résultats de la campagne 1960-1961 effectuée dans le nord de la Mauritanie et qui ont été publiés sous la forme de cartes à 1/1.000.000 :
- Carte gravimétrique "Nord Mauritanie",
- Nord Mauritanie. Magnétisme. Anomalies de Z.

Les résultats des campagnes qui ont porté sur les régions occidentale et méridionale de la Mauritanie, ainsi que les mesures effectuées au Sénégal, ont été publiés dans un même rapport afin de préserver, au niveau des interprétations, l'unité géologique du bassin sédimentaire du Sénégal. (Voir - CRENN Y & J. RECHENMANN, Cahier ORSTOM, Sér. Geophys., n°6, Paris, 1965).

562 - WORLD DATA CENTER B.1, U.S.S.R. - Six-monthly catalogue of data on Seismology and Gravity received during the period July 1 - December 31, 1970. 24 p, Moscow, 1971.

This Catalogue contains information about the observational data on Seismology and Gravimetry received by WDC B.1 for the period from July 1 to December 31, 1970.
But if data from a station has been continually sent to the WDC B, the whole period of the available results of observations is shown in the catalogue.

CENTRE NATIONAL de la RECHERCHE SCIENTIFIQUE - Bulletin signalétique 120 : Astronomie, Physique Spatiale, Géophysique.

563 - n°10, p.485-566, Paris, 1971.

564 - n°11, p.567-616, Paris, 1971.

565 - n°12, p.617-693, Paris, 1971.

566 - CANADIAN HYDROGRAPHIC SERVICE - Gravity, Free-air anomaly map, Marine Science Branch, Dept. Energy Mines & Resources, Map n°14938 B, Atlantic Ocean, scale : 1/250.000, Ottawa, 1971.

BUREAU of MINERAL RESOURCES, Canberra, Australia - Bouguer anomaly maps, scale : 1/500.000.

567 - n°G.69-113-1, Medusa Bank (W.A.), 1962.

568 - n°D.52/B2-3(R), Fog Bay (N.T.), 1970.

569 - n°D.52/B2-5(R), London Derry (W.A.), 1970.

570 - n°D.52/B2-1(R), 1968.

571 - n°D.52/B2-6(R), 1970.

572 - n°D.52/B2-2(R), 1970.

573 - GEOPHYSICAL INSTITUTE, Japan - To the memory of Professor Emeritus Mankichi HASEGAWA.
Sp. Contr. n°10, 184 p, Kyoto Univ., 1970.

574 - INSTITUT für ANGEWANDTE GEODASIE - Nachrichten aus dem Karten & Vermessungswesen".
Reihe II, Deutsche Beitrage in fremden Sprachen, H.n°26, 17 S, Frankfurt, 1970.

575 - COOK A.H. - "The moments of inertia and the density distribution of the Moon".
from : Mon. Nat. R. Astr. Soc., n°150, p.187-194, 1970.

Values of the moment of the Moon's inertia ratios A/Mr_o^2, B/Mr_o^2 and C/Mr_o^2 are calculated from a least squares adjustment of data concerning the gravitational potential and the physical librations. The best values are :

$$C/Mr_o^2 = 0.3950$$

$$A/Mr_o^2,\ B/Mr_o^2 = 0.3948$$

all with a standard deviation of 0.003.

The sources of uncertainty of the data are discussed and the importance of new types of observation of the librations is emphasized. The bearing of the results upon the distribution of density in the Moon is considered.

576 - INSTITUT für ANGEWANDTE GEODASIE - Nachrichten aus dem Karten und Vermessungswesen.
Reihe II : Deutsches Beiträge in fremden Sprachen, H.n°28, 64 S, Frankfurt, 1971.

a) BREIN R. - "An instrument for precise measurements of small differences of the gravity".
p.5-9.

The accuracy of gravity measurements should be improved for the purpose of physical research of gravity, for the registration of Earth tides and for the study of secular gravity variations.

The best results were obtained by gravimeters using the Galitzin system of seismic meters. The experiences in measuring small differences of gravity demonstrate that unsteady results are mainly caused by the complicated mechanics of these systems. On the other hand, the physical characteristics of good gravimeter springs enable an improvement of the accuracy obtained up to date.

These facts led to the construction of an instrument on the base of the vertical spring balance. This mechanical most simple gravimeter system has some disadvantages. It is very insensible with regard to gravity differences and sensitive with regard to seismic perturbations. Experiments carried out with a capacitance bridge show that a change of 1 μGal can be indicated with that device. The elimination of seismic perturbations is carried out by air damping of the capacitor of the capacitance device and by electronic integration. The value of damping can be regulated in great limits by simple electronic elements.

The gravity differences are measured by an electromagnetic spring. This mechanically simple device is used successfully since some years for registration of earth tides. The testing instrument has a gravimeter spring with a length of 10 cm. Experiments are planned with a 5 cm-spring.

b) HEITZ S. & G. SOLTAU - "Possibilities for the geophysical research of the Nördlinger Ries by the use of astro-geodetic deflections of the vertical".
p.23-27.

For the investigation of the mass deficiency under the Nördlinger Ries astrogeodetic deflections of the vertical were determined. A procedure for the evaluation of these deflections is discussed and a comparison of the results with those of some models derived from gravity measurements is carried out.

577 - PAVONI N. - "Zonen lateraler horizontaler Verschiebung in der Erdkruste". (Zones de déplacements horizontaux latéraux dans la croûte terrestre et conséquence pour la tectonique globale).
Mit. Inst. Geophys. n°49, 1971.
Geol. Rundschau, Bd 59/1, S.56-77, 1969

L'analyse tectonique des systèmes de failles de décrochement actives pendant le Cénozoique fournit des indications sur la direction de la composante horizontale de la pression maximale dans la lithosphère continentale. On constate que cette direction s'accorde avec celle déduite des investigations séismologiques.

Un intérêt particulier est porté au mécanisme des grandes failles transversales qui coupent les dorsales médio-océaniques. L'hypothèse proposée est que, contrairement à la conception actuelle, les dorsales médio-océaniques se situent là où, sous la lithosphère, dans l'asthénosphère, la composante horizontale de la vitesse de mouvement de matériel du manteau est la plus grande. Cette hypothèse explique les structures caractéristiques des dorsales océaniques, aussi bien le cisaillement intensif des dorsales par les failles transversales que le changement brusque de direction des anomalies magnétiques.
...

Deux centres géotectoniques sont indiqués, l'un à 10° E/0° N en Afrique centrale, l'autre à 170°W/0°N dans le Pacifique central. Il faut supposer qu'on a sous la lithosphère un mouvement du manteau de ces centres vers l'extérieur, dont la composante horizontale de la vitesse atteint un maximum à 50 - 60 degrés de distance de ces centres.

578 - USAF, AERONAUTICAL CHART & INFORMATION CENTER - Quarterly accession list, 1 Oct. - 31 Dec. 1971.
DoD Gravity Library, 8 p, St-Louis, 1971.

579 - KUIPER G.P. - "Support of AFCRL lunar laser field unit".
AFCRL-71-0469, Final Rep., 20 p, 1971.

The procedures described are used in the construction & development of a 60-inch aperture lunar laser telescope at low cost. These procedures were based on a previous development at this laboratory of inexpensive photometric telescopes of 60-inch aperture. The adaptation of these techniques to the more severe requirements of a lunar laser telescope has presented difficult problems. In addition, a modified telescope mounting had to be constructed, a special guider, and a dome with associated living quarters located on Mt. Lemmon, elev. 9170 ft. The initial construction and installation was on site II, Catalina Observatory, elev. 8400 ft. 35 miles from the University and 8 miles E. of Mt. Lemmon. ...

580 - KENT P.E., J.A. HUNT, M.A. & D.W. JOHNSTONE - "The geology and geophysics of coastal Tanzania".
Inst. Geol. Sci., Geophys. Paper n°6, 101 p, 1971.

The paper describes the stratigraphy and distribution of the Mesozoic and Tertiary rocks of the Indian Ocean coast zone of Tanzania on the basis of surface mapping, geophysical surveys and 52 exploratory boreholes, and discusses the structure of the continental margin in relation to sedimentary history, continental drifting and rift valley origins.

...

Comparison of topography, surface geology and geophysical definition of deep structure shows that on the large islands the known fold and fault structures have developed progressively throughout Tertiary times. This contrasts with the inland edge of the coastal basin, where faults with several thousands of metres in vertical displacement ended their activity during the jurassic.

Although the coastal basin is some 500 miles (800 km) distant from the inland rift-valley zone in a different overall environment, the history of fault movement is closely similar, and the stress conditions in the coastal region do not appear to have been historically different from those of the rifts. It is noticeable that there is an absence of compressional structures, and the pattern of faulting indicates predominantly vertical movement with an absence of transcurrent displacement in post-palaeozoic times.

Despite the long-continued history of subsidence and faulting there is no evidence of the major distension which might have been expected from current theories of rift valley/ocean ridge development, or from stretching taking place as the Indian Ocean progressively opened, and there is an almost complete absence of igneous activity. These facts have to be taken into account in consideration of world tectonics.

581 - KOMITET GEODEZJI POLSKIEJ, AKADEMII NAUK - Geod. i Kart., t.XX, Z.3, 250 p, Warszawa, 1971.

...

a) BARLIK M. - "De la solution du problème de Bjerhammar sur les terrains montagneux".
p.183-192.

Dans cet article on traite des propositions émises par nombre d'auteurs comme solution du problème de Bjerhammar en géodésie dynamique pour les terrains à grandes dénivellations et à grande élévation au-dessus du niveau de la mer. L'auteur préconise la réduction du terrain et l'application d'une surface de référence auxiliaire afin de procéder au calcul de l'anomalie Δg réduite à cette surface. L'anomalie de Bjerhammar sur la surface de la Terre, complétée par la réduction au terrain, forme la première approximation pour les itérations ultérieures comme solution de l'équation intégrale.

b) BARLIK M. & A. CZARNECKI - "Graduation des gravimètres type GAK 7T et Sharpe CG par la méthode d'inclinaison, au Laboratoire Gravimétrique de l'Ecole Polytechnique de Varsovie".
p.199-207.

Les auteurs ont procédé à l'étalonnage des gravimètres par la méthode d'inclinaison en utilisant le théodolite astronomique Wild T4, spécialement adapté à ce but par l'Institut de Géodésie Supérieure et d'Astronomie Géodésique. On a mis en oeuvre des programmes d'observations et des procédés de calcul inconnus jusqu'alors dans le domaine scientifique. Des mesures ont été prises aux températures de 20°C, 5°C, et ensuite de 20°C.

Les résultats de la graduation sont indiqués. Les erreurs relatives de graduation, calculées à la base des erreurs moyennes ont été de :
- $(2,0 - 8,4)\ 10^{-4}$ pour les gravimètres GAK 7T.
- $(0,8 - 2,3)\ 10^{-4}$ pour les gravimètres Sharpe CG.

Les variations du coefficient de l'équation gravimétrique dans l'intervalle de température de 5°C à 30°C ont été de :
$(7,5 - 9,2)\ 10^{-4}$ mgl/1°C pour les gravimètres GAK 7T
$(3,6 - 4,4)\ 10^{-4}$ mgl/1°C pour les gravimètres Sharpe CG.

On a constaté que la variation du coefficient de l'équation gravimétrique avec le temps est de l'ordre de :
1.10^{-3} pour les gravimètres GAK 7T
3.10^{-6} pour les gravimètres Sharpe.

L'ensemble des études a prouvé que les instruments Type 7T se prêtent moins aux mesures gravimétriques de précision que les instruments Sharpe CG.

C.N.E.X.O. - Bulletin d'Information.

582 - n°31-32, 16 p, Paris, Août 1971.

583 - n°33, 17 p, Sept. 1971.

584 - n°34, 16 p, Oct. 1971.

585 - n°35, 21 p, Nov. 1971.

586 - n°36, 11 p, Déc. 1971.

587 - n°37, 11 p, Janv. 1972.

588 - n°38, 13 p, Fév. 1972.

589 - n°39, 13 p, Mars 1972.

590 - AERONAUTICAL CHART & INFORMATION CENTER - World relative gravity reference network : North America, Canada and Mexico.
Ref. Pub. n°25, 860 p, Saint-Louis, 1970.

One of the basic problems of gravimetry is the standardization of available data on a world-wide basis. To assist geodesists in the field, ACIC has collected the various networks and base station data and adjusted them to a homogeneous datum and scale. To enable observers to recover these stations, descriptions and/or sketches are presented in addition to the adopted gravity values.

In this publication are reported sketches of United States (conterminous U.S. and Alaska), Canada and Mexico.

The datum for the adjusted gravity values was fixed by the gravity values of the U.S. National Gravity Base Net. An interval of 1228.48 mgals on the American Calibration Line, between Houston A and Great Falls A, set the scale for the adjustment.

In Canada, the gravity values and estimated accuracies are relative to the National Reference Station at Ottawa (ACIC 0109-0, IGB 15255A). For the sites in Mexico, the gravity values and estimated accuracies are relative to the pendulum station in Mexico City (ACIC 0150-0, IGB 04699A). Gravity values and estimated accuracies for sites in Alaska and the United States are relative to the Commerce Building Pier at Washington, D.C. (ACIC 0165-0, IGB 11687A).

591 - AERONAUTICAL CHART & INFORMATION CENTER - World relative gravity reference network : Europe.
Ref. Pub. n°25, 310 p, Saint-Louis, 1971.

The European area for this publication consists of Albania, France, Austria, Azores, Belgium, Bulgaria, Czechoslovakia, Denmark, Finland, Germany (East), Germany (West), Greece, Hungary, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Netherlands, Norway, Poland, Portugal, Rumania, Spain, Sweden, Switzerland, United Kingdom, and Yugoslavia.

The adopted gravity values and estimated accuracies are relative to Potsdam (g = 981.274 mgal). The scale is the same as that adopted for the North American Area.

592 - AERONAUTICAL CHART & INFORMATION CENTER - 1° x 1° mean free-air gravity anomalies.
Ref. Pub. n°29, 190 p, Saint-Louis, 1971.

The gravity anomaly information furnished in this report has been computed from data held in the DoD Gravity Library.

This publication contains a set of 1° x 1° mean free-air anomaly (MFAA) values for portions of the world where sufficient gravity data is available for anomaly computation. The values are referred to the International Ellipsoid and represent the mean values of anomalous gravity within a surface area one degree in latitude by one degree in longitude. Whenever possible, the MFAA values were developed directly from observed gravity data. Mean anomaly values in ocean areas were computed from point free-air anomalies, and mean anomaly values over land areas were computed using point Bouguer anomalies plus 1° x 1° mean elevations. In some areas of sparse or no observed gravity coverage, the mean anomalies were determined using gravity-geophysical correlation prediction techniques. MFAA Standard errors (1σ) were determined as a function of the density, distribution, and accuracy of the observed gravity data. The available 1° x 1° MFAA values and standard errors are listed in milligals, in tabular form, on facing pages. Each page of the data table represents an area of 20° in latitude by 20° in longitude, with page 1 commencing at 90°N and 0°E.

593 - ANTHONY D. & R.M. PERRY - AFCRL's experimental aerial gravimetry program".
AFCRL-71-0411, Env. Res., Papers n°366, 32 p, Bedford, 1971.

Between December 1965 and March 1968 AFCRL conducted a series of experimental aerial gravity measurements to determine the feasibility of large scale aerial gravity surveys. This report gives the results of the program and includes :

1. Program background.
2. Instrumentation description including the four gravimeters tested.
3. Upward continuation of gravity methods and evaluation in the test area.
4. Data processing procedures including corrections and smoothing methods applied.
5. Representative sample profiles.
6. Accuracy achieved in terms of profile and mean anomalies.
7. Other aerial gravity tests and studies including helicopter gravity tests, a systems analysis of aerial gravimetry, and gravimetry by means of gradient measurements.

594 - A.I.G., Bulletin Géodésique n°101, p.232-342, Septembre 1971.

a) GRAFAREND E. & W. NIEMEIER - "The free non-linear boundary value problem of physical geodesy".
p.243-262.

Crustal data of surface elevations and depth of Moho (and densities) can be utilized to form model-earth anomalies. These model-anomalies can closely approximate the free-air anomaly field of the earth, and could thus be used to predict the latter.

A review of several such models is presented, with some elaboration on model developments, procedures, data analysis and accuracies.

One of the models approaches a prediction accuray of ± 10 mgal for 5° x 5° mean free-air anomalies, whose r.m.s. value was about 30 % higher.

b) SHARNI D. - "Model anomalies for the Earth from crustal data".
p.299-317.

Within potential theory of Poisson - Laplace equation the boundary value problem of physical geodesy is classified as free and non-linear. For solving this typical non-linear boundary value problem four different types of non-linear integral equations corresponding to singular density distributions within single and double layer are presented. The characteristic problem of free boundaries, the problem of free surface integrals, is exactly solved by metric continuation. Even in the linear approximation of fundamental relations of physical geodesy the basic integral equations become non-linear because of the special features of free surface integrals.

c) MORRISON F. - "Density layer models for the geopotential".
p.319-328.

Spherical harmonic representation of the geopotential suffers from convergence problems in both the mathematical and numerical senses ; it also is not suitable for use with the terrestrial gravity data, which is distributed very unevenly over the surface of the earth. Of the alternative mathematical models, the simple density layer offers the most mathematical and computational simplicity and avoids the problems associated with spherical harmonics, in practice low order spherical harmonic models have been combined with a density layer for a complete model of the geopotential. Results from satellite data alone and from combinations of satellite and gravity measurements have been published already, improved models will be obtained as new data become available.

d) GOGUEL J. - "Bouguer au Chimborazo".
p.329-334.

e) ANDERSSON F. - "On the absolute determination of the deflections of the plumb-line".
p.335-340.

595 - A.I.G., Bulletin Géodésique n°102, p.346-468, Décembre 1971.
XVème Assemblée Générale, Moscou, p.349.

MARUSSI A. - Presidential address, p.351.

LEVALLOIS J.J. - Rapport du Secrétaire Général, p.359.

LOUIS M. - Compte-rendu des séances du Comité Exécutif, du Conseil de l'Assemblée, p.375.

Voeux et recommandations, p.391.

Comptes-rendus résumés des séances des sections par les secrétaires des sections, p.415.

596 - A.I.G., Bulletin Géodésique n°103, p.1-127, Mars 1972.

a) CHAPRONT-TOUZE M. - "Détermination locale des anomalies de gravité et hauteur du géoïde à l'aide d'observations de satellites artificiels". p.47-62.

Le potentiel terrestre, harmonique à l'extérieur de la surface terrestre, admet un développement en harmoniques sphériques, convergeant à l'extérieur d'une sphère contenant intérieurement la Terre.

Les satellites ont permis le calcul des coefficients J_n, $C_{n,k}$, $S_{n,k}$ jusqu'à un ordre élevé et la représentation effective du potentiel terrestre sous forme d'une somme finie d'harmoniques sphériques.

Une telle représentation est globalement satisfaisante en altitude, mais lorsqu'on la prolonge à la surface terrestre, elle ne permet pas d'obtenir les détails fins que donne la gravimétrie.

Nous avons étudié une méthode destinée à obtenir, par l'observation de satellites artificiels, des détails fins du potentiel terrestre, mais uniquement sur une petite région de la surface terrestre, et sous forme numérique.

Un calcul, pour quelques passages du satellite D 1D, nous a montré que les résidus laser déduits théoriquement, par cette méthode, d'anomalies à l'air libre sur la région S, fournies par le Bureau Gravimétrique International, restaient inférieurs à 1 mètre.

La précision des observations laser est donc encore insuffisante pour que cette méthode puisse conduire à des résultats sur la structure fine du potentiel terrestre.

b) BUCK R.J. & J.G. TANNER - "Storage and retrieval of gravity data". p.63-84.

At the Earth Physics Branch in Ottawa, storage and retrieval of gravity data has progressed from the pencil and paper system used until the late 1950's to the current file-oriented gravity library operated on a large, high speed computer.

The current system is user-oriented and tends to be complex internally to preserve a simple and convenient interface to the user.

The results of approximately 150.000 gravity measurements are contained on the main output file : the principal facts file. These observations are mainly those of the Earth Physics Branch, but a small percentage have been provided by commercial geophysical companies, other government agencies and universities. Current plans call for more emphasis on extending the system to serve as a national library for gravity and related data.

Data reduction within the system is a partitioned process which employs a static model as a basis for the computations. Only a relatively minor change is required to develop a dynamic model for data reduction by eliminating the partitioned fashion in which field data are reduced. The capability of recognizing and computing accurately the magnitude of changes in the value of gravity and their geographic distribution will be a tremendous asset to studies of the dynamics of the earth.

c) LEVALLOIS J.J. - "Le système géodésique de référence 1967 et le calcul des anomalies de la pesanteur".
p.85-92.

d) XVème Assemblée Générale de l'A.I.G. - Liste des délégués et invités.
p.97-127.

597 - FLEISCHER U. - "Gravity surveys over the Reykjanes ridge and between Iceland and the Faeroe Islands".
Marine Geophys. Res. n°1, p.314-327, Hamburg, 1971.

A regional survey of the southern Reykjanes Ridge (52°N to 57°N) shows an irregular topography : a rift valley which is only partly recognizable as such, with varying azimuth and some fracturezone-like interruptions. The survey also comprised gravity and magnetic measurements.

The course of the axis as well as the perpendicular fractures show up well in the free air anomalies as relative troughs within an area of positive free air gravity. There is no indication of density variations within the topographic masses.

The anomaly pattern of total magnetic intensity indicates the exact position of the rift axis and a bifurcation at about 55°N. From the parallel magnetic anomalies south of 55°N a spreading rate can be deduced of 1.10 cm/yr perpendicular to the rift axis This spreading rate is at the same time the plate movement involved.

A survey of the Iceland-Faeroe Ridge with a 3-5 miles grid shows large gravity and magnetic anomalies over a smooth topography, indicating large pockets of light material, probably of volcanic origin. These areas have normal magnetization. Positive gravity anomalies forming a ring structure along the 200 m isobath are characterized by reversed magnetization.

The dissimilarity in morphology, seismicity and inner structure between the two ridges that intersect in Iceland suggest that there is no relation between the two phenomena.

POLITECHNIKA WARSZAWSKA - Prace Nauk.

598 - Geod. n°9, 103 p, 1971.

599 - Geod. n°10, 56 p, 1971.

600 - Geod. n°11, 50 p, 1971.

601 - KOMITET GEODEZJI POLSKIEJ, Akademii Nauk.
Geod. i Kart. t.XX, Z.4, p.250-340, Warszawa, 1971.

602 - BARLIK M. & A. CZARNECKI - "Détermination des variations de l'équation du gravimètre GAK 7T".
Geod. i Kart. t.XXI, Z.1, p.47-52, Warszawa, 1971.

Au Laboratoire Gravimétrique de l'Ecole Polytechnique de Varsovie on réalise depuis plus d'un an des examens détaillés des gravimètres géophysiques du type Sharpe CG et GAK 7T.

L'article présente les résultats de l'examen du gravimètre GAK 7T, construit en U.R.S.S. dans le domaine des variations de l'équation du gravimètre en fonction du temps, des changements thermiques et des variations de l'équation dépendant de la position de travail de la vis de réglage du gravimètre.

603 - BLUNDELL D.J., F.J. DAVEY & L.J. GRAVES - "Sedimentary basin in the South Irish Sea".
Nature, v.219, n°5149, p.55-58, 1968.

604 - COOK A.H. - "The solid ground of nature".
Univ. Edinburgh, Physics Bull., v.21, p.345-351, 1970.

605 - COOK A.H. - "The Earth as a planet".
Univ. Edinburgh, Lecture n°45, 22 p, 1970.

Many of man's most distinctive characteristics are closely connected with his being a land animal. We are as we are because the Earth can sustain stresses other than a purely hydrostatic pressure, so allowing solid rock to appear about the seas ; and because land is continually regenerated by geological processes. Geophysicists seek to understand the nature of the material of the Earth that permits these creative irregularities and the physics of the processes that generate them but they are inhibited by ambiguities due to the fact that they can observe only now and only at the surface of the Earth.

Comparisons with other planets may help in understanding the Earth and some of the comparisons that can now be made are summarised.

Geophysics is a proper subject for study in a University because of its practical utility, because it enlarges our appreciation of the implications and limitations of political and technical activities and because of the intellectual excitement of understanding our world.

606 - COOK A.H. - "The mechanical properties of the Earth, Moon and Planets".
Proc. Roy. Inst. Gt. Br., v.43, n°202, p.464-479, 1970.

607 - COOK A.H. - "The dynamical properties and internal constitutions of the Earth, the Moon and the Planets".
from : Quart. J., R. Astr. Soc., v.12, p.154-168, 1971.

As a consequence of the launching of artificial satellites, of the development of lunar and planetary radar and of the use of large computing machines, we now have a far more extensive and deeper knowledge of the dynamics of the planets than we had a decade ago. The aim of this lecture is to show how information about the internal constitutions of the planets may be inferred from their dynamical properties coupled with knowledge of the behaviour of solids under very high pressures.

608 - INSTITUTO PANAMERICANO de GEOGRAFIA e HISTORIA, Comision de Cartografia. Revista Cartog. n°20, 194 p, Buenos Aires, 1971.

609 - CHOWANSKA-OTYS D. - "Laboratory calibration of narrow-range sharpe gravimeters by the tilting method".
Prace Inst. Geod. i Kart., t.XVIII, Z.2(43) , p.107-133, Warszawa, 1971.

In poland, until recently, there was exclusively used the one method, namely the calibrating was carried out on a gravimetric base. Recently has been applied the calibration of gravimeters by the tilting method too, using the devices and methodics worked out in the Department of Experimental Gravimetry of the Institute of Earth Physics of USSR Academy of Science. In the paper, there has been presented the essence and advantages of this method in comparison with the calibrating on a gravimetric base. There have been described in detail the adjustings of the device, which must be done before measuring.

Within an international scheme, on February and March of 1970, in Poland there were carried out the calibrating of three wide-range gravimeters and four narrow-range prospecting Sharpe gravimeters by means of the tilting method.

The narrow-range gravimeters n°135, 182, 184 and 233 were calibrated by means of a device UEGP. The calibrating was carried out accordingly to the formula (3). The program of measurements was worked out in such a way that the range of a gravimeter of about 100 mgals (1000 divisions) was examined at intervals of 100 divisions.

All these gravimeters were calibrated in Warsaw at the temperature of Moreover, the gravimeter n°135 was calibrated at the temperature of + 35°C. The gravimeter n°184 was examined at the temperature of + 20°C, and next at the temperatures of + 5°C and + 35°C in Warsaw, at the temperature of + 20°C in Zakopane (860 m above s.l.) and at the temperature of + 20°C in the meteorological station on the Kasprowy Wierch (1989 m above s.l.), and again in Warsaw at the temperature of + 20°C.

The results of observations carried out in the separate measuring series, were adjusted by the method of the least squares using a computer GEO. As a result of the adjusting there was obtained a value of a gravimeter coefficient k (in miligals per division) for a considered measuring serie, and a correction due to non-linearity of a scale f(n) (in miligals) for a considered gravimeter reading, and the mean square error of these values Mf(n). On this basis the values of f(n) and Mf(n) which correspond to the gravimeters readings in specified thermic and barometric conditions of measurement, have been calculated. The results have been presented on diagrams and tables.

It is evident, from these calibrating, that the functions f(n) determined for the gravimeters n°135, 182 and 233, oscillate around

the horizontal axis ; at the same time the amplitudes of these oscillations do not exceed the value of determination error of f(n) multiplied by three.

In the case of the gravimeter n°184, the mean value of f(n) is a second order function. The values of the f(n) considerably exceed the errors of their determination. The obtained result make it possible to suggest the necessity of limitation of measuring range of this gravimeter to the divisions 250 $\pm$ 700 what correspond, in this case, to the possibility of measuring the differences Δ g to 54 mgals.

610 - KOCH K.R. & S. LAUER - "Automation der Isoliniendarstellung mit Hilfe des Wiener und des Kalman-Filters".
Mit. Inst. Theor. Geod. Univ. Bonn, n°2, 14 S, 1971.

A method for automatic plotting of contour lines from data points is discussed. It consists of two parts, the determination of points on the contour line and the representation of the contour line by low order polynomials. The first part is solved by a combination of linear interpolation and least squares prediction by means of the Wiener filter, while the coefficients of the polynomials for the representation of the contour line are determined by a modified Kalman filter.

611 - SCHRADER B. - "Beiträge zur Entwicklung der Elektronischen Datenverarbeitung in der Geodäsie".
D.G.K., Reihe C : Dissert., H.n°160, 79 S, München, 1971.

612 - NITTINGER J. & H. LUCHT - "North West European Lowlands Levelling (NWELL)".
D.G.K., Reihe B : Angew. Geod., H.n°184, 119 S, München, 1971.

After the year 1945 levellings of high precision have been carried out in the countries of Belgium, Denmark, the Netherlands as well as in the coastal regions of the German Federal Republic. Because of a great scientific and economical interest in the study of recent crustal movements the compilation of the NWELL was decided at the IUGG in Berkeley, 1963. In order to deal with this project a special working group has been set up.

The NWELL net is limited in Belgium near Ostende and extends into Denmark until North Jutland. The Dutch and German parts of the net reach in average more than 150 km deep into the country. The net contains 119 polygons.

Reference point is a group of 5 underground benchmarks near Wallenhorst/Osnabrück. Its stability is discussed in a new geological study.

The national benchmarks as well as the observation - methods etc... used by the participating countries are described by the scientists working in these particular countries.

The data are transformed into geopotential units, adjusted and represented in tables and in a map.

The accuracy of the data and the possible significance of height differences resulting from compared heights after relevelling the whole net is estimated. In the mean coastal part the fact "subsidence" or "lifting" may be proved significantly (one sided test, testlevel 95 %) if the amount of movement in question will exceed 0,5 mm/year (in relation to the inland) during the period from 1950 (epoch of observations) to the year 2000.

The publication of the NWELL gives a unified base for a later research on recent crustal movements in North West Europe.

613 - MURPHY T., D.G.G. YOUNG & P.M. BRUCK - "The post-dalradian strata along the north west coast of Lough Foyle, Inishowen, Co. Donegal". Proc. Roy. Irish Acad., v.71, Section B, n°12, p.171-181, Dublin, 1971.

A steep linear gravity gradient, trending north-east, occurs along the north-west coast of Lough Foyle. This gradient is directly related to the presence of a belt of low-density red beds originally mapped as Lower Carboniferous (Upper Calciferous Series). These rocks are fault-bounded from the Dalradian strata which make up most of Inishowen. Geophysically, a density differential of 0.35 g/cm^3 between the Dalradian and the more recent beds confirms a measured thickness of 1100 m for the post-Dalradian strata. In contrast, the available information indicates that the Lower Carboniferous succession in the north of Ireland is much thinner than this, having an observed development of approximately 300 to 400 m. There is no evidence to suggest that it in any way approaches the thickness required to explain the observed gravity anomaly.

Further to the north-east a gravity gradient exists near Magilligan Point on the opposite side of the Lough. A borehole here has proved the existence of strata the bulk of which is Trias and Carboniferous with the younger rocks forming the dominant component. Similarity of the gravity features in the two areas suggests that the post-Dalradian succession under discussion can be expected to resemble that observed in the borehole.

A separate linear gravity gradient of similar trend occurs on the southern shore of the Lough near Eglinton. A comparable geological situation probably exists here with Triassic strata fault-bounded against the Dalradian.

614 - DEUTSCHES HYDROGRAPHISCHES INSTITUT - Forschungsschiff "Meteor" der Deutschen Forschungssemeinschaft und des Deutschen Hydrographischen Instituts.
Fahrt n°20, 21 April - 30 Juli 1970, 52 S, 1971.

Etude d'océanographie physique portant sur l'étendue marine comprise entre l'Islande et les Iles Faroë, et comprenant des recherches géologiques, géochimiques et géophysiques.

Gravimétrie :

Des mesures gravimétriques ont été faites avec un gravimètre Askania. On peut en conclure que la partie N.W. de la zone prospectée est calme (sous-sol homogène) tandis que près des Faroë, il y a des structures "agitées".

Une partie des résultats a été publiée.

615 - BOTT M.H.P. - "Geophysical investigations of the northern Pennine Basement rocks".
Proc. Yorkshire Geol. Soc., v.36, Part 2, n°9, p.139-168, 1967.

Gravity and magnetic surveys show the presence of the following major basement features beneath the Lower Carboniferous rocks of the northern Pennines :

1) the Devonian Weardale Granite underlies the Alston Block and has been reached by the Rookhope borehole ;
2) a belt of east-southeasterly trending magnetic basement rocks underlies the southern half of the Askrigg Block at shallow depth and extends laterally beyond the block at greater depth ;
3) the postulated Wensleydale Granite underlies the Askrigg Block centrally and pierces the northern flank of the magnetic basement rocks ;
4) gravitationally and magnetically featureless basement rocks (possibly Lower Palaeozoic overlain by thick Carboniferous) occur between the blocks ; and
5) the basement is relatively shallow beneath the Alston and Askrigg blocks but deepens rapidly with associated thickening of the Lower Carboniferous rocks across the following hinge-lines- Ninety-Fathom-Stublick fault line, Lunedale-Butterknowle fault line, Stockdale monocline, and (from geological evidence) Craven fault belt.

Since the basement is overlain by a particularly well studied cover of Carboniferous rocks, the northern Pennines provide a unique demonstration of the influence of granites on the structural history long after consolidation. The basement features, which both include granites, have exerted close control of major and minor faulting, doming and uplift, basin formation and distribution of mineralization.

This is attributed to :
1) the relatively greater "strength" of the granites and magnetic basement rocks,
2) the supplementary stress systems set up by the low density granites and by the topographic irregularities, and
3) incipient jointing in the Weardale Granite providing an easy upward passage for mineralizing solutions.

616 - HYDROGRAPHER OF THE ROYAL NETHERLANDS NAVY - "Scientific investigations on the shelf of Surinam, H. NL.M.S. Luymes 1969". Hydrog. Newsletter, Sp. Pub. n°6, 53 p, 1971.

This publication is a report about scientific investigations on the shelf of Surinam. The first report of similar investigations appeared in the year 1967 in an issue of the Hydrographic Newsletter (Special Publication Number 5).

Whereas the first report only concerned the western part of the shelf, the present publication is a result of further studies carried out on the eastern part of the Surinam Shelf. They could be realized owing to the hospitality and co-operation, which the Royal Netherlands Navy offered to a number of scientists.

a) STRANG van HEES G.L. - "Gravity measurements on the continental shelf of Surinam".
p.11-12.

The gravity measurements of the second part of the exploration of the continental shelf were carried out from March 22 to April 3 1969 with the Askania sea gravimeter GSS-2, n°19.

The gravity measurements were linked up with the gravity base station in Paramaribo. The drift of the instrument has also been checked.

b) COLLETTE B.J., J.A. SCHOUTEN, K.W. RUTTEN, D.J. DOORNBOS & W.H. STAVERMAN - "Geophysical investigations off the Surinam coast".
p.17-24.

The results are given of a geophysical survey (seismics, magnetics, gravity) off the Surinam coast. This survey was planned in addition to the previous gravity and magnetic measurements, and covers both the continental shelf and the adjoining Guiana marginal plateau. A total of 8 continuous seismic reflection profiles have been made. These profiles show a large accumulation of prograding sediments. The gravity measurements made on 5 of the 8 tracks indicate, however, that this description of the plateau is inadequate with regard to the structure of the underlying crust. Either the Guiana plateau is lying over a slab of continental crust, or a huge thickness of sediment is present accounting for the mass deficiency.

To explain the isostatic "overcompensation" we have to assume a process affecting the equilibrium position of the continental margin. A further study of the problems follows, which will include an evaluation of the magnetic results.

Isostatic anomalies map (Airy, 30 km).

617 - WEILL G.M. - Rapport national sur les travaux français exécutés de 1967 à 1970.
Comité National de Géodésie & Géophysique, 342 p, Paris, 1971.

a) CORON S. - "Activité du B.G.I., Paris".
p.69-71.
...

618 - SAXOV S. & G. LIND - "The establishment of a gravity base net in Bohusläin with adjacent areas".
Sveriges Geologiska Undersokning, Ser. C.NR 657, Arsbok 65, n°3, 20 p, Stockholm, 1971.

A gravity base net has been established in Bohusläin and adjacent areas with a view to function as fundamental basis for a regional gravimetric survey with the purpose of studying the granitic problem in relation to gravity.

619 - SAXOV S. - "Additional gravity observations in the Faroe Islands".
Annal. Societ. Scient. Faeroensis 19. bok. Torshavn, p.9-19, 1971.

By inspection of the map previously established (1969) it was found worthwile to make a denser net of gravity in different areas, first of all in Mykines-Vagar, secondly in the southern part of Streymoy, and thirdly in Sandoy. In connection with other geophysical work a visit was paid to the islands in June - July 1970. Worden Master gravimeter n°779 was employed.

620 - GARLAND G.P. - Chronique de l'U.G.G.I., n°82, 48 p, Avril 1971.

a) Geodynamics project, p.1-3.
...

621 - GARLAND G.P. - Chronique de l'U.G.G.I., n°83, 64 p, Mars 1972.

a) Officers for the period 1971-1975 (list).
...

622 - SOCIETE HELVETIQUE des SCIENCES NATURELLES - Procès-verbal de la 117ème séance de la Commission Géodésique Suisse tenue à l'Ecole polytechnique fédérale à Zurich le 18 Juin 1971, avec des extraits des rapports sur l'activité de l'année 1970.
90 p, 1972.

623 - PENTTILA E. - "Crustal structure in Fennoscandia from seismological and gravimetric observations".
Pub. Isost. Inst. I.A.G. n°51, 38 p, Helsinki, 1972.
from : Annales Acad. Scient. Fennicae, Ser. A, III. Geol.-Geog. 110.

The structure of the Earth's crust in Fennoscandia, studied by refraction seismic methods is discussed. The thickness of the crust is generally 35 - 40 km, but greater in the region of the Gulf of Bothnia, less at the Norwegian coast. Three main types of structure are discussed, in which the ratios of the thicknesses of the granitic and basaltic layers are 2.2, 1.1 and 0.6. On the basis of correlations found between these structures and free air gravity anomalies, free-air anomaly map was used to construct a crustal-thickness map of Fennoscandia. The crust is assumed to be two-layered and homogenous and the possible inhomogeneity of the material under the crust has not been taken into account.

624 - HORNAL R.W. & J.B. BOYD - "Gravity measurements in the Slave and Bear structural provinces, Northwest territories with maps :
N° 89 - Artillery Lake
N° 90 - Rae
N° 91 - Camsell River
N° 92 - Upper Back River
N° 93 - Bathurst Inlet
N° 94 - Cambridge Bay
N° 95 - Dolphin and Union Strait".
Earth Physics Branch, Grav. map Ser., 12 p, Ottawa, 1972.

Some 4,700 gravity observations were used to compile seven Bouguer anomaly maps at a scale of 1:500,000 covering an area of the Canadian Shield bounded by latitudes 62° and 70°N and longitudes 104° and 120°W. An eighth map within these boundaries has previously been published (Hornal, 1968). The area includes the Bear and Slave Structural Provinces and portions of the Churchill Structural Province and the Interior Plains.

Gravity highs occur over the basic volcanics of the Yellowknife Group. A 30 mGal gravity high over the East Arm of Great Slave Lake is associated with basic intrusions beneath or within the sediments of the Great Slave Supergroup. A steep gravity gradient, extending from Artillery Lake to the Western River at the boundary between the Slave and Churchill Structural Provinces, is attributed to a density contrast between basement gneisses in the Churchill Structural Province and a large granite batholith in the Slave Province. A continuation of the Coppermine River High over large areas of western Victoria Island may indicate the northward extension of the basaltic flows of the Coppermine River Group beneath the Paleozoic sediments. Local gravity lows in excess of 20 mGal are underlain by the Dubawnt sandstone and the sandstones of the Parry Bay Formation.

625 - GOODACRE A.K., R.V. COOPER & J.R. WEBER - "Results of reconnaissance gravity surveys of Hudson Bay with maps :
N° 112 - Hudson Bay North
N° 113 - Hudson Bay South".
Earth Physics Branch, Grav. map Ser., 18 p, Ottawa, 1972.

The results of 821 underwater gravity observations and about 4,000 km of sea-surface gravity profiles in Hudson Bay are presented in the form of two Bouguer anomaly maps. Analysis of the gravity data indicates that random errors of about $\pm$ 3 mGal exist in the sea-surface and underwater gravity measurements. These errors are due mainly to random errors in navigation and bathymetric determinations, but part of the random error in the sea-surface gravity meter readings may be due to off-level platform errors and cross-coupling errors. Systematic errors in the gravity data should be generally small but they may be as great as 2 or 3 mGal in the eastern and northeastern parts of Hudson Bay where distortions in the electronic navigation system pattern were greatest. Unexplained constant shifts of 5 mGal or more occurred in six surface gravity profiles.

The Bouguer anomaly field of Hudson Bay shows no obvious correlation with the depth of the crust-mantle boundary, but it shows a partial correlation with the configuration of the Hudson Bay sedimentary basin as derived from magnetic and seismic data. The primary sources of variations in the Bouguer anomaly field are density variations within the Precambrian crystalline basement. The broad, regional gravity low over Hudson Bay may be a consequence of crustal loading during Pleistocene glaciation.

626 - SRIVASTAVA S.P. - "Geophysical data collected during Hudson-70, phase VII off British Columbia, Canada".
Atlantic Ocean. Lab., Bedford Inst., AOL Data Ser. n°71-5-D, 295 p, Dartmouth, 1971.

A geophysical survey was conducted off Vancouver and Queen Charlotte Islands over a four-week period (July 12 to August 5, 1970) as part of Hudson-70 expedition. The Hudson-70 expedition was organized as part of the Canadian contribution to the International Decade of Oceanographic Exploration. The geophysical survey was conducted to study the subsurface structure across the continental margin off the British Columbia coast and in the deep ocean basins. The present report contains descriptions of the various measurements made during this cruise and the data collected.

The measurements were made on board two ships, C.S.S. Hudson and C.N.A.V. Endeavour. A two-ship seismic refraction experiment was conducted in the deep ocean basin with C.N.A.V. Endeavour as the shooting ship and C.S.S. Hudson as the receiving ship. The measurements on board C.S.S. Hudson included gravity, magnetic, bathymetry, seismic reflection, heat flow, coring and bottom photography, while those on board C.N.A.V. Endeavour included seismic reflection, bathymetry and dredging.

The report has been divided into two main parts ; one containing the data collected on board C.S.S. Hudson and the other containing the data collected on board C.N.A.V. Endeavour. Each of these parts has been subdivided into various sections each dealing with a type of measurement made during the cruise.

Table 2 contains day, time (GMT), latitude, longitude (degrees), depth (fathoms), total magnetic field (T.F. in gammas corrected for diurnal variation), magnetic anomaly (M.A. in gammas, corrected for diurnal variation), Eötvös correction (milligal), free-air anomaly (F.A. using Askania gravimeter, in milligal), free-air anomaly (VSA using Vibrating String accelerometer, in milligal) and Bouguer anomaly (B.A. in milligal based on VAS values for every ten-minute interval). Places where data was missing or was unreliable are indicated by a star.

627 - GLADSTONE O. - "About the preparation of a gravity map of the Western section of Cuba at a 1:100.000 scale".
Univ. Havana, 12 p, Cuba, 1971.
(Presented at the XV General Assembly of the IUGG, Moscow 71).

This paper briefly describes a compilation of gravity data concerning an area of approximately 40000 square kilometers in the western section of Cuba, taking into account gravity surveys performed from 1929 to the present day.

It also emphasizes the whole cooperation that has prevailed among the Cuban Ministry of Mines, Fuel, and Metallurgy, the Cuban Institute of Geodesy and cartography, the Institute of Geophysics of the Academy of Sciences of Cuba, and the School of Geophysical Engineering of the Faculty of Technology of the University of Havana. This cooperation has assured the achievement of this study.

628 - KNOPOFF L. & J.C. BELSHE - "Gravity observations of the Dead Sea Rift". Univ. California, Inst. Geophys. Pub. n°476, p.5-14, Los Angeles

The Dead Sea Rift zone has been explored by means of a gravity survey. The interpretation of the data shows that the Dead Sea Rift may be different from the East African and Red Sea types. The results show that the Jordan River Valley overlies the contact between the continent represented by Arabia to the east and the ocean to the west. The thinner oceanic crust continues across the Levantine coast and terminates at the Dead Sea. After the regional gravity anomaly is removed under the assumption that the two blocks are in contact, no significant residual remains. Thus, the Dead Sea Rift is very likely a bearing surface for the motions associated with the formation of the Red Sea.

629 - PEKERIS C.L. - "Geophysics, pure and applied". Geophys. J. R. Astr. Soc., v.1, n°3, p.257-261, 1958.

630 - PICARD L. - "The quaternary in the Northern Jordan Valley". The Israel Acad. Sci. & Humanities. Proc., v.1, n°4, 37 p, Jerusalem, 1963.

631 - PICARD L. - "The geological evolution of the Quaternary in the Central Northern Jordan Graben, Israel". Geol. Soc. America, Sp. Paper 84, p.337-366, Jerusalem, 1965.

During the Quaternary the Jordan rift valley, 10 km wide, constituted a main accumulative basin for river deposits and lavas derived from the adjacent uplifted mountains of East Galilee and Hauran-Golan. The Quaternary clastic and volcanic fills interfingered with sediments of graben lakes in at least three major cycles. The thickness of the Quaternary fluvial-limnic-volcanic fill attains many hundred meters...

632 - MAY P.R. - "Gravimetric estimation of depth to aquifers in the Hazeva area, Arava Valley, Israel".
Israel J. Earth Sci., v.17, p.30-43, 1968.

Aquifers in the Judea limestone extend from outcrops on the Negev uplands into the Hazeva area in the Arava Valley ; and form a continuous artesian system eastward to the western border fault of the Dead Sea graben. A gravity survey shows that the Hazeva area is part of a shallow intermontane basin in which the Judea limestone lies at depths of from less than 100 m in the southwest to 450 m on the east along the border fault of the Dead Sea graben. Within the graben the Judea limestone lies at depths of greater than 1000 m. Between coordinates 018 and 031 north, the western border fault extends approximately north- south along coordinate 177 east, and is mostly concealed beneath Tertiary and Quaternary sediments. On the northwest the Hazeva basin is bounded by a vertical or high-angle thrust fault, and on the southwest by the unfaulted uplift of the Shezaf dome.

Depth estimations are made at six localities along the bounding faults by direct computation of the parameters of the fault anomaly, namely, the total anomaly caused by the fault, and the maximum residual gradient. The principal density interface in the geologic column occurs at the top of the Judea limestone. The density contrast between the Judea limestone and overlying rocks was determined from outcrops to be 0.5 gm/cm3. This contrast is assumed to be uniform throughout the area.

633 - MITROVIC V. & M. GRASIC - "Gravimetrical calibration measurements in 1967 and 1969".
Savezna Geodetska Uprava, p.21-35, Beograd, 1971.
Presented to the IAG at the XV General Assembly of the IUGG, Moscow, 1971.

634 - SIGL R. - Report on the Symposium on coastal geodesy held in Munich 20th - 24th July 1970.
IUGG, IAG, Sp. Study Group 2.22, 643 p, Munich, 1970.

a) KOCH K.R. - "Gravity values for continental shelf areas from satellite altimetry".
p.567-571.

By satellite altimetry the height of a satellite above the surface of the sea can be measured. If variations with time are filtered out of the data and if the altitude of the satellite above a known reference surface derived from the tracking data is subtracted, the geoid undulations with respect to the reference surface are obtained. These undulations can be converted into gravity anomalies by means of Stokes' formula and its inversion.

To determine gravity values for continental shelf areas, the adjacent land masses have to be covered with gravity anomalies, and equations more accurate than Stokes' formula have to be applied. These are readily obtained if the gravity field of the Earth is expressed by the potential of a simple layer. On the basis of this approach a method is outlined for the simultaneous analysis of the altimeter measurements, the gravity values, and the tracking data of the satellite carrying the altimeter.

b) KICK W. - "State of knowledge in glacial eustasy". p.573-580.

Geological studies make clear that the level of the oceans in the Late Glacial was by 90 to 150 m lower than today. They show that the succeeding recession of the ice (17 500 to 5 500 B.P.) has been accompanied by a simultaneous rising of the sea-level at rates of 7 to 18 mm/yr. At least during this period the glacier variations had been the decisive cause of world-wide sea-level variations. Of the several great Pleistocene ice sheets the Antarctic and the Greenland Sheet have survived until the present day. Besides these a mountain glaciation contains only one hundredth of the masses of these two ice sheets ; but the amount of the varying mass of this tiny part of the Earth's ice is comparable to that of the Antarctic or Greenlandic ice. Photogrammetric measurements of the mean level variations of 8 test glaciers in the Eastern Alps for the period from 1920 to 1950 have shown a loss of 0,56 m/yr of water equivalent, a result which for good reasons is understood to be representative of the whole area of the Eastern Alps. A recession of all mountain glaciation at the same rate would cause a rise of ocean-level by 0,9 mm/yr which is however a maximum value rather than an average one. According to recent calculations the Greenland Ice Sheet is supposed to contribute to a rise of the sea-level by 0,3 mm/yr. The mass balance of the Antarctic Sheet which is still based on too small a number of data is thougth to cause a lowering of the ocean-level by 1 - 2 mm/yr. More reliable values will be available after the International Hydrological Decade, i.e. after 1974 ; but even then our knowledge of the Antarctic variation rate may not yet be a definitive one. The variation of the Antarctic ice is supposed to be determined by its margins touching the ocean and thus to depend on ocean-level changing and not vice versa.

Recent data and their reliability are discussed in detail and secondary factors mainly reducing the glacial effect are summarized.

c) KIZAWA T. - "Recordings with Askania gravimeters before and after important earthquakes".
p.613-614.

During the many years of earth-tide observations with the Askania gravimeter Gs 12 n°161 and the photoelectric follow-up recorder made by Dr. LANGE I observed interesting extraordinary phenomena before and after important earthquakes which are likely to refer to impending strong earthquakes but which are almost unknown.

d) BHATTACHARJI J.C. - "A geodetic and geophysical study of the Koyna earthquake region".
p.615-634.

The recent earthquake at Koyna, in India, came as a surprise to earth-scientists as the site is located in the Indian Peninsular shield which is traditionally referred to as an ancient stable block. It is thus very difficult to pronounce any opinion about it until the area affected by this earthquake is fully investigated. A comprehensive geodetic and geophysical study of the region is, therefore, made in this paper with a view to throwing further light on the subject.

The results of geodetic triangulation, trilateration and levelling works, and the geomagnetic, plumb-line deflection and gravimetric observations carried out before and after the recent earthquake, over the Koyna region, are discussed in detail. These provide ample indications regarding not only the prevailing condition of isostatic imbalance in the region and the easterly trend of the recent crustal movement along the western coast, but also the existing deepseated fault belt now revealed in between the West Coast and the continental divide, right from Ratnagiri to the north of Bombay. It is then concluded that the chances of these factors having a significant bearing on the recent Koyna earthquake, can not be completely ruled out.

635 - KNEISSL M. - "Beiträge aus der Bundesrepublik Deutschland zur Vorlage bei der XV. Generalversammlung der Internationalen Union für Geodäsie und Geophysik vom 30. Juli bis 14. August 1971 in Moskau".
D.G.K., Reihe B : Angew. Geod., H.n°188, 98 S, München, 1971.

a) EHRNSPERGER W., M. NABAUER, H. SEIFERS & H. WOLF - "Investigations on the strength of figure in a European satellite Network using fictitious satellite positions in heights of 1200 kms and 4000 kms".
p.5-22.

The investigations are based on a European satellite network, consisting of 15 stations as proposed by Prof. RINNER (Exgeos Projekt).

About 50 fictitious subsatellite points are scattered nearly uniformly over and around the region of these stations. Now a satellite triangulation is performed first assuming all satellite heights to be 1.200 kms (Echo), then to be 4.000 kms (Pageos). Into these two networks direction observations to a smaller number of fictitious satellite positions all in a height of 4.000 kms are involved. Finally, distances of ground stations observed by terrestrial methods and laser distances to the fictitious satellite positions, both of various precision, are introduced into the adjustment.

Since exclusively the strength of figure is considered here, the results of the computations consist in the standard deviations of the adjusted coordinates only and not in the values of these coordinates. These results from the individual steps of the adjustment are compared and briefly discussed.

b) GRAFAREND E. - "A combined gravimetric-astrogeodetic method for telluroid and vertical deflection analysis".
p.23-36.

The classical computation of height anomalies or of vertical deflections is based on G.G. Stokes or F.A. Vening Meinesz integrals, if gravimetric anomalies or vertical deflections are given. In modern theories, initiated by T. KRARUP (1969) and H. MORITZ (1970), these signals are classified as random functions and are predicted in a total operation, following the A. KOLMOGOROV and N. WIENER prediction theory within stochastic processes. Physical information of the system is concentrated in the correlation functions of height anomalies, vertical deflections and gravity anomalies. Here a total analysis of information matrices is presented for predictions of undulations and deflections. ...

c) LAUER S. - "Kovarianzen, poxer-spektren und prädiktionen im lokalen Schwerefeld".
p.37-49.
...

636 - SIGL R. - "Activity of the Special Study Group n°22 linked to Section II of I.A.G. 1967-1971".
(Comparison in space for heights of mean sea level, determination of secular movements between land and sea).
D.G.K., Reihe B : Angew. Geod., H.n°190, 51 S, München, 1971.
Presented to the XVth General Assembly of IUGG at Moscow, 1971.

The first part reports about administrative affairs of the Special Study Group (SSG) and recalls some resolutions of 1967, guiding the work in the last four years. The close co-operation with the permanent Service for Mean Sea Level is illustrated by the discussion about the introduction of local reference for tide gauges.

Further a short report about the meeting of SSG during the Symposium on Recent Crustal Movements at Leningrade, May 1968 and a detailed review of the Symposium on Coastal Geodesy at Munich, July 1970 are given. Finally, additional works arisen from the field of the SSG, are adduced and supplemented by Japanese titles.

637 - WITTE B. - "Berechnungsverfahren für die Bestimmung des Erdschwerepotentials aus Doppler-Beobachtungen mit Hilfe des Modells einer einfachen Schicht".
D.G.K., Reihe C : Dissert., H.n°167, 45 S, München, 1971.

Le potentiel de la Terre est représenté par une couche simple à densité variable d'une région à l'autre. Les valeurs de cette densité sont fixées, pour 104 éléments de surface à l'aide de l'observation de l'effet Doppler, et l'on décrit les méthodes de calcul de la densité. On emploie des procédés d'intégration numérique pour calculer les orbites des satellites à partir de l'effet Doppler. On représente en détail l'influence du champ de la pesanteur sur l'orbite, ainsi que l'effet luni-solaire et l'influence de la pression atmosphérique. On combine les contributions de divers satellites pour fixer les densités des 104 éléments de surface.

638 - SCHWARZ K.P. - "Numerische Untersuchungen zur Schwerefortseizung".
D.G.K., Reihe C : Dissert., H.n°171, 72 S, München, 1971.

Le présent travail concerne le prolongement vers le bas de valeurs gravimétriques obtenues en avion à une certaine altitude. La méthode itérative proposée est beaucoup plus rapide que les méthodes antérieures.

639 - MIHELCIC M. - "Uber eine Theorie zur Simultanauswertung von fluggravimetrischen und terrestrische-gravimetrischen Messungsdaten".
D.G.K., Reihe C : Dissert., H.n°172, München, 1972.

640 - WOLF H. - "Aquivalente und korrelierte Beobachtungen".
Jeodezi Bulteni, Sayi 4, Cilt 1, p.185-191, Turkay, 1971.

641 - U.S.A.F. AERONAUTICAL CHART & INFORMATION CENTER - Quarterly accession list, Jan. 1 - Mar. 31, 1972.
DoD Gravity Library, 13 p, Saint-Louis, 1972.

642 - QURESHI I.F. - "Gravity measurements in the North-eastern Sudan and crustal structure of the Red Sea".
Geophys. J. R. Astr. Soc., v.24, p.119-135, 1971.

Gravity measurements made in the Sudan over a part of the Red Sea coastal plain and along a profile between Atbara and Suakin are described. Bouguer anomalies over the coastal plain are similar to those observed at continental margins off north-east America. These anomalies, taken together with those observed by other workers and corrected for shallow density variations, show the existence of a regional anomaly with a maximum at about + 140 mGal over the Red Sea axis and a minimum at about - 82 mGal over the Red Sea Hills. Assuming symmetry about the axis, the regional anomaly is interpreted in terms of two crustal models. Feasibility and significance of these models is discussed in the light of other geophysical information. It is concluded that a separation in the axial trough of the Red Sea was preceded by a drastic thinning of the continental crust.

643 - ALLAN T.D. & C. MORELLI - "A geophysical study of the Mediterranean Sea".
Boll. Geof teor. appl., v.XIII, n°50, p.99-142, Juin 1971.

During the period 1961-65 co-operative cruises between Saclant ASW Research Centre, La Spezia and the Osservatorio Geofisico Sperimentale, Trieste resulted in an extensive coverage of bathymetric, magnetic field and gravity measurements over all of the Western and part of the Eastern Mediterranean. The results of those surveys are presented as a series of 36 charts covering a total of 9 areas - 7 adjacent areas in the Western Mediterranean and 2 in the Eastern Mediterranean. For each area contour charts of free-air and Bouguer gravity, total magnetic field, and bathymetry have been constructed at a uniform scale of 1:750,000.

A qualitative interpretation of the tectonics of the Mediterranean region is attempted in the light of the more recent theories of sea-floor evolution. Consideration is given not only to the magnetic and gravity results but also to other types of geophysical measurements made recently by other institutes.

It is shown that there are distinctive differences in the tectonic processes over the Mediterranean region. Although almost all Mediterranean crust is considered to be "transitional" it is shown that the Eastern Mediterranean crust is closer to continental crust while the Western Mediterranean crust (under the Balearic Basin) is closer to oceanic.

No patterns of magnetic lineations as distinctive as those over the ridges of the major oceans have been detected in the Mediterranean. Only in the northern Aegean does the geophysical evidence indicate the evolution of a spreading sea-floor. For the rest of the Mediterranean, oceanic crust appears to have been either completely destroyed or is presently in the process of destruction.

644 - GRUSHINSKY N.P. & N.B. SAZHINA - "The gravitational field and the geoid of Australia".
J. Geol. Soc. Australia, v.18, Part 3, p.183-199.
Australian National Univ. Pub. n°199, Sydney, 1971.

A map of the geoid in Australia and surrounding oceanic areas has been produced on a scale of 1:5 M. There are two variants, both of which employ Bouguer anomalies for the land areas. For the ocean areas in the first variant, anomalies have been obtained as the difference between the observed and theoretical values of gravity at sea level. In the second variant, a correction has been introduced to reduce the density of the water layer to the average density of the Earth's crust. The height of the geoid in Australia is calculated in the same way. The effect of distant zones has been allowed for in accordance with the data of Kozai (1967) and Köhnlein (1967), and a high precision for the geoid height for Australia has been obtained. Discrepancies between the new data and the observations of Mather (1969) amount to + 2 m for the regions investigated and $\pm$ 4 m for the entire continent. Coordinates have also been obtained for the centre of the Australian ellipsoïd relative to the centre of the Earth's mass.

645 - VEROFFENTLICHUNG DER BAYERISCHEN KOMMISSION für die INTERNATIONALE ERDMESSUNG der Bayerischen Akademie der Wissenschaften.
Astr.-Geod. Arb. H.n°28, 49 S, München, 1971.

a) SIGL R. - "Bericht über die Entwicklung des Sonderforschungsbereiches 78 Satellitengeodäsie und die Arbeiten 1970 der Gruppe A "Dynamische Methode".

b) KNEISSL M. - "Bericht über die Arbeiten 1970 der Gruppe B "Geometrische Methode".

646 - EBERHARD O. - "Ergebnisse der Erdgezeitenbeobachtungen 1961 - 1968 in Berchtesgaden der Abt.I des Deutschen Geodätischen Forschungsinstituts".
D.G.K., Reihe B : Angew. Geod. H.n°70/Teil III, 24 S, München, 1971.

647 - MORITZ H. - "Series solutions of Molodensky's problem".
D.G.K., Reihe A : Höhere Geod., H.n°70, 92 S, München, 1971.

The present report is intended as a systematic and fairly comprehensive exposition of recent work on a new approach to Molodensky's problem.

The present work may be considered as a continuation of an earlier report (MORITZ, 1968), in which we have extensively considered and compared various linear solutions of Molodensky's problem, showing their equivalence.

There exists, however, a more elementary approach through analytical continuation by means of power series. This method has been employed in (MORITZ, 1968, Part B) to derive the linear solutions. In (MORITZ, 1969c,1970 a, b) it has been extended to approximations of an arbitrary order, leading to a complete series solution of a new type, equivalent to the Molodensky series but simpler and practically more convenient. A similar idea was presented independently by MARYCH (1969 a, b).

The present report represents a detailed exposition of the method of analytical continuation for the use of Molodensky's problem. In Part A we shall derive the corresponding series solution and show its equivalence to the Molodensky series.

Part B is devoted to the mathematical structure of the problem.

648 - WOLF H. - "Gruppenweise Höhenregressionen von Bouguer-Anomalien als Hilfsmittel zur Schwere - Prädiktion".
Mit. Inst. Theor. Geod. Univ. Bonn, 16 S, Bonn, 1971.

Starting with gravity predictions the regression between free-air anomalies and elevations hitherto has been used for the trend-elimination. Objections, however, have been raised against this procedure because of the lack of geophysical significancy. Here, therefore, a procedure is shown of how to succeed, considering geophysical or geological data, too, by subdividing the Bouguer anomalies with respect to their regional occurance. For demonstration purposes a sample is added as to the gravity measurements on the volcanic Rodderberg-hill.

649 - HAVERLAND W.D. - "An analysis of variational equations for the direct evaluation of the Earth's gravity field".
AFCRL-71-0421, Rep. n°161, Sci. Rep. n°16, 95 p, 1971.

The variational equations, proposed by Obenson and proposed by Rapp, which are used to generate observation equation coefficients in the direct combination of satellite and gravimetric data are critically reviewed. Each procedure is tested with respect to accuracy as a function of step size, integration procedure, and orbit time. The two procedures are combined into a single program that combines the best features of the original proposals.

The study concludes that if an orbit arc of less than 15 hours is being considered, RAPP's method with a fixed fourth order predictor and a fifth order corrector gives the best results. If orbit arcs greater than 15 hours are being used, the combine solution composed of a fixed fourth order predictor and a fifth order corrector for anomaly integration and OBENSON's method for element integration gives the best results.

650 - MEISSL P. - "Preparations for the numerical evaluation of second order Molodensky-type formulas".
AFCRL-71-0608, Rep. n°163, Sci. Rep. n°18, 72 p, 1971.

A set of formulas proposed by MORITZ and constituting a second order solution of Molodensky's problem has been transformed in a way that the resulting formulas are numerically tractable. The difficulty in the original formulas arose from the occurence of singular integrals. Their regularization introduces derivatives of gravity anomalies and terrain heights and necessitates a numerical differentiation procedure. Spline function interpolation has been chosen to deal with this. The existing truncation theory has been extended to cover more sophisticated truncation procedures as well as a succession of heavier and heavier smoothed versions of the integrand.

651 - BULGARIAN ACADEMY of SCIENCES - Abstracts of Bulgarian scientific literature : Mathematics, Physics, Astronomy, Geophysics, Geodesy".
v.VIII, n°2, July - December, 22 p, Sofia, 1971.

652 - BURSA M. - "Effect of removed topography and condensation on deflections of the vertical on the territory of Czechoslovakia".
Travaux Inst. Geophys., Acad. Tchecosl. Sci., n°302-318, v.XVII, p.45-64, Praha, 1972.

In order to determine the components of the deflections of the vertical ξ , η on the physical Earth's surface with a high accuracy (standard error of the order of several tenths of a second of arc), special attention must be devoted to the effect of topographical masses, especially in mountain regions. So far, two methods have been worked out : the method of indirect interpolation and the method of removing and restoring the topography. Especially suitable, with a view to practical applications, seems to be the alternative eliminating the linear term, which can be interpreted as removing and restoring practically all topographical masses above sea level, or condensing these masses to a horizontal plane (the surface $H = H_o$) at the normal height H_o of the point investigated.

This method was applied to the whole territory of Czechoslovakia, and the results obtained are discussed in this paper. The deflections of the vertical, after eliminating the effect of topographical masses can be interesting from a geophysical and geological point of view. Their general representation is mentioned in relation to the axes of zones of increased macroseismic mobility, derived by statistical analysis of earthquake propagation, which are in a good agreement with the principal tectonic dislocation zones. The correlation is quite evident and the general picture obtained will serve to a detailed study of partial regions, for which discrete values with a considerably larger density of distribution are being prepared.

653 - GATTI R., G. GALLO, J. SUNOL, P.C. CORONA & H.P. DIAZ - "Observaciones gravimetricas en la Provincia de Buenos Aires, Año 1967".
Obs. Astr. Univ. Nac. La Plata, Ser. Geod., t.VIII, 42 p, La Plata, 1970.

654 - VALLIANT H.D. - "A canadian network of gravity measurements with pendulums".
Geophys. J. R. Astr. Soc., v.23, p.543-555, 1971.

From 1968 to 1970, the Canadian pendulum apparatus of the Earth Physics Branch (formerly Dominion Observatory) was used to establish a network of gravity stations within Canada to provide scale control for the Canadian gravimeter net. The pendulum network, adjusted by the method of least squares, has a standard deviation of 0.12 mGal. Agreement with Faller's absolute apparatus to - 23 ppm in scale is noted.

ANOMALIES MOYENNES DE LA PESANTEUR - 5°x5°