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Paris, le 3 décembre 1964

5ème REUNION DE LA COMMISSION GRAVIMETRIQUE INTERNATIONALE

13-18 sept. 1965.

Ière CIRCULAIRE.

Mon cher Collègue,

La cinquième réunion de la Commission Gravimétrique Internationale, doit se tenir à Paris en 1965, du Lundi 13 septembre au samedi 18 septembre 1965.

Le lieu de la réunion, l'horaire exact et l'ordre du jour détaillé seront fixés dans une circulaire ultérieure.

La Commission Gravimétrique Internationale comprend en principe un délégué national par pays adhérent à l'U.G.G.I. Elle peut être appelée à prendre des décisions de détail dans certains domaines techniques ou, pour des questions plus importantes, à émettre un avis soumis pour décision à l'Assemblée Générale suivante de l'A.I.G.

Mais il est de tradition constante, et il paraît hautement souhaitable, qu'un Symposium élargi de Gravimétrie se tienne en même temps que la réunion de la Commission Gravimétrique Internationale, avec un programme plus étendu et plus adapté aux questions d'actualité. Ces travaux doivent constituer une préparation à la réunion de la Section IV GRAVIMETRIE qui doit se tenir au cours de la prochaine Assemblée Générale de l'A.I.G. Ils doivent d'ailleurs se limiter aux travaux gravimétriques proprement dits sans empiéter (si ce n'est brièvement, et à titre d'information) sur des travaux purement théoriques.

La présente circulaire qui constitue d'ores et déjà une invitation formelle, est envoyée à un certain nombre de personnes dont la liste comprend aussi bien les Délégués nationaux que d'autres géodésiens. Cette liste, qui n'est qu'un premier projet, est loin d'être exclusive. Il est au contraire instamment demandé que d'autres noms soient suggérés au Directeur du Bureau pour envoi de la présente Circulaire.

Par ailleurs, certains Délégués ou certains invités souhaiteront probablement recevoir une invitation personnelle sous une autre forme, invitation dont ils pourront faire état auprès des Autorités de leurs pays pour obtenir de ces dernières les crédits nécessaires à leur voyage et à leurs frais de séjour. Le Bureau Gravimétrique International est prêt à envoyer de telles lettres personnelles à caractère officiel, suivant les indications qui lui seront données par les personnes intéressées.

Une formule d'inscription est jointe à cette circulaire*. Les personnes qui pensent pouvoir assister à la réunion sont priées de la remplir ~~Et de la renvoyer dès à présent~~ au Bureau Gravimétrique étant entendu que, si leur engagement n'est pas formel, ils devront confirmer leur inscription deux à trois mois avant la date prévue pour la réunion.

Les questions traitées au cours de cette réunion seront celles habituellement envisagées par la Commission Gravimétrique Internationale (Réseau de 1er ordre, Mesures absolues, Bases d'étalonnage, Mesures en mer, Réseaux nationaux, Cartes d'anomalies...) Il serait souhaitable que certains problèmes nouveaux récemment soulevés soient également considérés, et dans ce but, je vous demande de bien vouloir nous faire connaître toute question que vous désireriez voir inscrite à l'ordre du jour.

En particulier, la Commission Gravimétrique Internationale aura à s'occuper de l'état d'avancement des travaux concernant la mise en cartes perforées par le Bureau Gravimétrique International, de toutes les données gravimétriques mondiales (le modèle adopté pour les cartes a été arrêté depuis la dernière réunion). On peut estimer qu'environ 100.000 cartes seront prêtes en Septembre 1965. Des mesures (notamment financières) devront être prises pour la continuation de ce travail essentiel.

Une meilleure coopération entre la Commission Gravimétrique Internationale et certaines autres organisations internationales (telles que les Commissions du Manteau Supérieur et des Mouvements récents de l'Ecorce terrestre) devra être réalisée .+

Il est instamment demandé que chaque pays fournisse un Rapport National, qui sera considéré comme un Rapport préliminaire à celui qui doit être présenté à l'Assemblée Générale suivante de l'U.G.G.I. Ce rapport pourra être établi sous forme simplifiée (Ronéo). Il serait établi à 100 exemplaires qui seront distribués aux Délégués présents à la réunion.

Espérant qu'il vous sera possible d'assister en personne à cette réunion, je vous prie, mon Cher Collègue, d'agréer l'expression de mes sentiments distingués.

* à la circulaire déjà envoyée en décembre 1964

+ voir page 25.

Paris, 3rd December 1964

Ve MEETING OF THE INTERNATIONAL GRAVITY COMMISSION

13-18th Sept. 1965

Ist CIRCULAR

My dear Colleague,

The fifth meeting of the International Gravity Commission will be held in Paris in 1965,

from Monday, 13th September until
Saturday 18th September 1965

The place of the meeting, the precise time-table and the detailed agenda, will be indicated in a later circular.

The International Gravity Commission is composed, in principle of one delegate from each member-nation of the I.U.G.G. It can be called upon to take decisions on certain technical questions, or, for the more important questions, to offer an opinion to be submitted to the General Assembly of the I.A.G. the following year.

It is a tradition, however, and it appears to be well worthwhile, that at the same time as the meeting of the International Gravity Commission, a wider Symposium on Gravity should be held, on a wider range of subjects and adapted to questions of present interest. The activities undertaken should also be a preparation for the meeting of Section IV "GRAVITY" during the next Assembly of the I.A.G. Moreover, they should be limited to questions of actual measurement of gravity without touching on its purely theoretical aspects (except briefly for informative purpose).

The present circular, which constitutes in itself a formal invitation is being sent to a certain number of people of whom some are national delegates. The present list, however, is only the first draft, and is far from being exclusive. On the contrary, it is urgently requested that the names of others to whom this circular could be sent be submitted to the Director of the Bureau.

In addition, certain delegates or people invited might like to receive a personal invitation which they could present to the appropriate Authorities of their countries in order to claim from them the expenses of their journey and their stay. The International Gravity Bureau is prepared to send such personal invitations of an official nature, according to instructions given, to anyone who may be interested.

*

A registration form is included with this circular. Those who think that they will be able to attend the meeting are requested to fill in this form and to send it, as soon as possible, to the Gravity Bureau here on the understanding that, if their commitment is not definitive, they will confirm their registration two or three months before the date fixed for the meeting.

The questions dealt with during this meeting will be those usually treated by the International Gravity Commission (International 1st order Network, Absolute Measurements, Calibration bases, Sea and Airborne Measurements, National Networks, Maps of Anomalies ...). It would be desirable, to consider, in addition, certain problems which have been encountered during these past few months, and with this in mind, I would ask you to be so kind as to let us know of any question that you would like to see included in the agenda.

In particular, the International Gravity Commission will need to consider the progress of the work of the International Gravity Bureau in putting on to punched cards all the world gravity data (the model adopted for the cards was decided upon after the last meeting). It is possible to estimate that about 100,000 cards will be ready in September 1965. Certain measures (notably financial) will need to be taken in order to ensure the continuation of this essential work.

It will be necessary to achieve a better cooperation between the International Gravity Commission and certain other international organisations (such as the Upper Mantle Committee and the Commission Recent Crustal Mouvements) +

It is urgently requested that each Country provide a National Report, which will be considered as a preliminary Report to that which will have to be presented at the next General Assembly of the U.G.C.I. This report can be presented under a simple format (Roneo). A 100 copies would be necessary, to be distributed to delegates present at the meeting.

Hoping that it will be possible for you to attend this meeting in person, I remain ...

* The circular already sent out in December 1964
+ see page 25.

INTERNATIONAL MEETINGS ON GRAVITY QUESTIONS

held

since the General Assembly of IUGG (Berkeley, Aug. 1963)

- I) - The Special Study Group n°6 for the Establishment of the Calibration Base for gravimeters in Europe has had a meeting in the rooms of the German Geodetic Research Institute, in the Bavarian Academy of Science, in Munich, on the 18th Nov. 1963, under the Chairmanship of Dr KNEISSL, Chairman of this Group.

During this Session, many questions were raised on : problems concerning instruments and ajustements, organisation problems with regard to connexion between land and sea measurements etc...

In particular, at the beginning of the meeting, the function of Vice-President was created and this was kindly undertaken by Prof. SOLAINI. This step was necessary because, for future tasks, the immediate contact with Prof. MORELLI who will prescribe the accuracy requirements and the claims to the adjustment, is necessary.

An extract of the C.R. is included later (p. 11)

- II) - A second Meeting of this same Special Study Group was held in the Institut of Topography and Geodesy of "Politecnico" in Milan (29-30 April 1964).

On this occasion, it was a joint meeting with the Members of the Special Study Group n°5 (Chairman ; Prof. MORELLI) who have been participating in the 1963 measurements on the Euro-African Calibration Line.

The aims of the 2 Groups are distinct, but in practice, many problems concern both.

A brief summary is included later (p. 20)

- III) - The Special Study Group n°16 for "The use of Gravity Anomalies in Geodesy" (Chairman : Dr. TENGSTROM) has held a small conference in Paris (29-31 July 1964) to prepare a practical investigation of different methodes of determining deflections of the vertical over irregular topographical and geological structures.

The area for testing such methods had been chosen in the Italian West Alps where a lot of astro-geodetic stations exist and where the gravity coverage is quite comprehensive. The plan for the practical investigation was to compute differences in the area by 3 methods :

- 1) Molodenskij's using free air anomalies (by Dr. BURSA, Prague),
- 2) Rudzi-reduction and restauration of reflected topography (by Dr. TENGSTROM, Upsala).

.../...

- 3) Model Earth-anomalies and restauration of the smoothed topography (by Prof. MORELLI, and Brig. GLENNIE).

Dr. TENGSTROM in collaboration with the I.G.B. has collected the material which will be used by these Groups. This material has been partially delivered and discussed during the Conference in Paris.

- IV) - Symposium on "The determination of the Figure of the Earth" held in Prague, (6-10 Oct. 1964), at the Institute of Geophysics.

This Symposium was very important because it was the first one in recent times where all schools of different opinion concerning the theories and their practical application for the Determination of the Figure of the Earth, could discuss in detail their ideas and check them against each other.

A complete text of the contributions and an abstract of the discussions will be published in the journal "Studia Geophysica et Geodaetica", 1965, n°2 (April).

We mention below only the subjects of the principal questions dealt with and the 3 Resolutions appropriate to the Gravimetric field (among the 6 Resolutions adopted at the end of the Meeting).

Principal Subjects :

- 1) The solution of the Boundary Value Problem from the Theory of potential.

Discussion on the different theories.

- 2) The Application of the Solutions of the Boundary Value Problem. The interpolation of Gravity Data. Test Areas.

Dr. TENGSTROM brought up the choice of the test area : the West Alps. Some questions were put on the suitability of this area, on the accuracy of the gravity field and on the topographical maps and gravity data necessary for commencing work. The Group (3) (Prof. MORELLI) has just begun its work.

- 3) Absolute Determinations by means of Gravity.

It is said in particular that the centre of the West Alps test area would also be suitable for determining absolute deflection and quasi-geoid height.

- 4) Basic Constants, Geometry and Gravity.

- 5) Geometric Methods for Determining the Figure of the Earth.

- 6) Miscellaneous questions :

-the best Model Ellipsoid for Geophysical Purposes,
-the Correspondance between the Shape of the Earth and certain Geophysical Phenomena.

...
Resolutions :

The Symposium....

N°I - recognising the importance of practically comparing different methods for determining gravimetric deflection-differences at the Earth's surface,

.../...

recommends, that all possible help should be given by countries, which are in possession of gravity data, necessary for such test-works. As a convenient area for beginning such a work, the Symposium recommends the already proposed area in the West Alps. The Symposium asks Dr. TENGSTROM, acting president of SSG 16 of IAG to conduct this work. It also asks all specialists of different gravimetical methods to take part in the investigations.

...
N°4 - recognizing the utmost importance of the interpolation of discrete gravity values, which must be done in all problems of gravimetical Geodesy, strongly urges that further theoretical and practical work be carried out to solve this interpolation problem in the best way.

N°5 - recognizing the great importance of proving the existence or non-existence of secular variations in the Earth's gravity field, recommends that every effort be made to solve this problem by using different methods.

...

- V) - Symposium on "The extension of the Gravity anomalies to unsurveyed areas", held in Columbus, Ohio (18-20 Nov. 1964) under the Presidency of Prof. W. HEISKANEN.

The principal questions treated were the following :

- Report on the existing gravity Material
- Extension of the Gravity Net to the Unsurveyed Areas of the Earth-Statistical Methods
- Extension of the Gravity Net to the Unsurveyed Areas of the Earth-Geophysical Methods
- External Gravity Field of the Earth.

REPORT ON THE SESSION OF THE SPECIAL STUDY GROUP N° 6

MUNICH, on November 18th, 1963,

(Extract).

Professor KNEISSL welcomes the participants stating that the Special Study Group N°6 has now really a new scope of tasks. The previous works concerning the gravimeter calibration line served only to bring the former measurements to a uniform scale. The future task is to assist Prof. Morelli in the establishment of the world gravity net-work. This task can be divided into two parts :

1) to strengthen the existing gravimeter calibration line that it may form a "corset-line" for the world gravity net ;

2) to assure the ties between the European stations of the world gravity network, and to consider whether additional measurements are necessary.

.../...

As a third task, the density of the European net should be increased thus permitting its application as test net for various adjustment methods in order to study the later adjustment of the world gravity net. This is to establish at the same time an extremely uniform network in Europe covering all European countries. Moreover the accuracy attained may become a model for other continents, being sufficient also for all scientific problems.

...

Professor Kneissl mentions the following programme points for this session :

- 1) - Gravimeter calibration line
 - a) Measurements in Europe
 - b) Proposals for the junctions to Africa
- 2) - Site of the world gravity stations in Europe
implying the question of where junction measurements are to be performed
- 3) - Checking of the existing measurements
 - a) Pendulum measurements
 - b) Line gravity measurements
 - c) Airborne gravity measurements
 - d) Sea gravity measurements along the European coasts and in the Mediterranean Sea
- 4) - Question of instrumental calibration and accuracy of the existing measurements considering the calibration
- 5) - Additional supplementary measurements and centerings
- 6) - Adjustment problems

...

Professor Morelli made some remarks and suggestions to the European gravimeter Calibration Line.

The state of the European gravimeter Calibration Line is characterized by the available adjustment 1962 made by Prof. Kneissl. A weak point in the European gravimeter calibration Line is -as is often mentioned- the part north of Copenhagen.

The Meridian Line following the same course in Central Europe as the gravimeter Calibration Line is to be distinguished from the latter : north of Bad Harzburg the meridian line follows its course via Helsinki to Hammerfest, and in the south it continues in the South African meridian line. This Meridian Line as part of the world gravity net should contain only a few stations measured by means of a few select instruments (resolution of the Paris meeting in 1962).

Most of the pendulum measurements for this line are completed. The observations were performed by :

- Prof. Honkasalo and Dr. Jackson with Cambridge pendulums,
- Prof. Woollard with Wisconsin pendulums,
- Prof. Mateo (partially) with Askania pendulums,
- Prof. Solaini with Italian pendulums.

.../...

It is emphasized once more that there must be a distinction made between the European gravimeter calibration Line, and the European gravity network.

Professor Morelli thinks that sufficient measurements will be available after the completion of Professor Solaini's works in the near future.

During this year, work has been concentrated on the European-African Meridian Line, and will be concentrated on the American Meridian Line in the coming year. It is important to keep the same working method for all pendulums, and to take special care in the selection of the stations with respect to underground conditions, microseismic, and so on.

The measurements on the European-African Meridian Line always begin in the central station Rome. Northwards the line includes the stations : Bad Harzburg, Helsinki, Hammerfest ; southwards the stations Nairobi, Johannesburg and Mowbray. The stations are distributed so that the gravity differences are approximately equal. Practically, three different pendulum apparatuses were employed :

-Prof. Mateo's measurements with Askania pendulums are omitted, because he measured only the lines Teddington - Potsdam - Teddington - Rome - Nairobi, and then interrupted the measurements because of organization difficulties.

-Prof. Woodard measured the lines Rome - Nairobi - Johannesburg - Mowbray, further Rome - Bad Harzburg - Helsinki - Hammerfest, with Gulf pendulums, and back again.

-with Cambridge pendulums - the Prof. Honkasalo measured : Teddington - Helsinki - Bad Harzburg - Rome - Bad Harzburg - Helsinki - Hammerfest - Helsinki;

- and the Dr Jackson :

Rome - Nairobi - Johannesburg - Mowbray ; Mowbray - Johannesburg - Nairobi - Rome - Teddington.

- Professor Solaini measured the following lines with the Italian pendulum apparatus :

Milan - Rome - Nairobi - Johannesburg - Mowbray - Johannesburg - Nairobi - Rome - Milan .

In the coming spring, he will travel the north part of the line :

Rome - Bad Harzburg - Helsinki - Hammerfest - Helsinki - Bad Harzburg - Rome.

Professor Honkasalo states that he studied thoroughly the north part of the gravimeter calibration line. He distributed a copy with his relevant results. In essential this is a new adjustment with the values of the hitherto existing adjustment, and with new measurements, measurements which were not yet included in the hitherto existing adjustment because of their courses via the reference station Helsinki.

.../...

Even the previous values show that the weights will differ from those of the hitherto existing adjustment.

Further he points to the fact that the pendulum measurements have different degrees of accuracy. Six pendulum measurements in all combinations were executed in a net in order to study better the pendulum measurements. Moreover he points to the fact that simultaneous transport of pendulums are gravimeters eventually implies the same systematic errors for all instruments. Therefore these measurements cannot be considered, strictly speaking as independant.

Professor Morelli continues by stating that he will work on the American Meridian Line corresponding to the working method on the European-African Meridian Line. The total gravity difference on the two meridian lines is nearly the same, i.e. 5000 mGal between Hammerfest and Nairobi, and the same between Point Barrow and La Paz. Later gravimeter measurements are to be performed on the meridian lines, and thus groups equipped with LaCoste-Romberg-gravimeters have been created. Considerable influences by magnetism, drift and so on, have set in during the previous measurements with Askania, Worden, Western, and North American gravimeters. In comparison with these, the LaCoste-Romberg gravimeter has the following advantages ; over the whole range, there is only a small reading disk, the instrument has practically no drift and is not influenced by magnetic field ; reading, handling and calibration are easy.

The large type has proved better than the smaller one. The smaller type is characterized as a "geodetic type", which means "for geophysical purposes". Discontinuities with this second type are possible. The factory calibration of the instruments originally covered too few points. This factory calibration being extended, periodical and pseudoperiodical effects are also included. The factory calibration is performed by means of a supplementary mass. More tests with this instrument were carried out by Professor Morelli on the European gravimeter calibration line. There were two groups with three instruments each, and they were transported by car. All the main stations of the European gravimeter calibration line were visited.

Subsequently the measurements over the European-African Meridian Line were made with the same instruments. They were, of course, transported by aircraft. Based on the test measurements with these six instruments, there are six additional good measurements available on the gravimeter calibration line. Of course the measurements on the Meridian Line are completed by extraneous measurements, for instance those of Professor Grossmann. In 1964, the pendulum and gravimeter measurements on the European and American meridian lines will be completed.

Gravimeter measurements were performed on the meridian line by two groups with 3 LaCoste-Romberg gravimeters each. .../...

Also on the European gravimeter Calibration Line, measurements were performed with these gravimeters in order to determine the scale and the periodical errors.

On the African part of the Meridian Line, 3 only of these instruments have been used up to the present. Former measurements, for instance those of Professor Grossmann, are to be included. Additional measurements are not planned by the Italian colleagues.

Professor Morelli adds that also all pendulum groups are equipped with a LaCoste-Romberg gravimeter. Then he proposes to conclude the discussion on the world gravity net and to return to this subject only if requested. The measurements for the world gravity net should be completed in two years, thus no larger changes are possible. Prof. Kneissl concludes this part of the agenda.

Professor Honkasalo states that in Finland they are following for calibration purposes not only a line but a whole net, because the number of combinations is higher in the latter. He refers to the Finnish report for the IUGG-General Assembly in Berkeley.

Concerning the next point there arises the problem how a European gravity network can be included in the world gravity net, and which ties are already existing. Prof. Morelli states that only old measurements are available at present. There is nothing available from the new measuring groups with the LaCoste-Romberg gravimeters except a few ties, for instance with Potsdam. Hence no modern measurements are available to be included in a new adjustment. Subsequently Prof. Kneissl asks whether a coordinating plan exists for the observers, giving the stations to be observed, and the order of observations.

It is concluded that : the members of the Special Study Group N°6 will receive from Prof. Morelli a detailed plan with all junctions of the world gravity network in Europe to be measured under his own direction.

The next point on the agenda concerns the study of the European measurements to be applied to the European test gravity net. It is stated that many measurements are available which should be brought eventually into consideration. Prof. Honkasalo undertakes to give the station descriptions with coordinates, altitudes, measuring values, observers, and so on for the North part of the net. Prof. Morelli proposes that the available measurements be checked in the following way :

- Prof. Honkasalo for the Cambridge pendulums,
- Prof. Solaini for the Italian pendulums,
- Dr. Marzahn for the Askania pendulums,
- Dr J.C. Rose for the American pendulums.

.../...

At this stage of the discussion the question arises how it is possible to include the East European States in this work. There is the general view that the East European States should be included because it concerns the elaboration of the European network under the auspices of an international organization. Hence it was recommended to send a request to the appropriate East European States asking for their collaboration. Professor Morelli states that a great number of measurements were performed in all East European States, but very few connections to the measuring stations in the West are available. In the case of a participation, these countries are invited to send a delegate to the Special Study Group N°6. A corresponding agreement should be found for those West European States that are not yet collaborating.

Based on the above mentioned working method, it should be expected that all existing pendulum measurements be covered. Prof. Morelli holds the opinion that no additional measurements will be necessary.

The next discussion point is gravimeter measurements over long distances. It is stated that such measurements over long distances are available from Prof. Grossmann and Mr. Martin in France...

The Special Study Group decides to give a synopsis of the airborne gravimeter measurements in the European net and to check them critically in respect of instruments used, calibrations and so on. The examinations are taken by :

Dr. Marzahn for Prof. Grossmann's values,
Mlle Dr. Coron for Mr. Martin's values,
Prof. Morelli for the Italian values,
Prof. Honkasalo for the North European values.

After the completion of this check, the corresponding net diagrams should be drawn and presented to the next working session of the Study Group members in Milan. For the final results, the measurements of the LaCoste-Romberg gravimeters are to be included. Missing measurements are to be executed by the groups with LaCoste-Romberg gravimeters.

...

Professor Kneissl puts the question whether it is possible to consider the line gravimeter measurements which are composed of short lines. The answer is affirmative, however it is necessary to take care with the setting of the Weights. Prof. Wolf confirms this view emphasizing that a separate adjustment is necessary, thus checking the applicability of the measurements. Concerning the line gravimeter measurements there is the question : where more measurements sufficiently accurate to be included exist. In France, the measurements by Martin, and in Germany the gravimeter calibration line come into question.

.../...

In the subsequent discussion it can be decided after preliminary studies which former measurements and which modern ones can be included. The members of the Study Group are asked to consider this question for the next session. A division of work shall be made in the following way : Professor Solaini checks critically the measurements of the European gravimeter calibration line, and Professor Jelstrup the line gravimeter measurements in Norway, giving synopses and proposals for supplementary measurements. The performance on the same task for France, Spain and Portugal will be taken by Mlle Coron ; concerning the gravimeter measurements in England, Mr. Bullerwell will be asked, Professor Bruins for Holland, Mr. Jones for Belgium, and Professor Ledersteger or Dr. Mitter for Austria.

Professor Morelli proposes to adopt two stations in each of the large countries, and one station in each of the small countries for the European net ; so that the latter will not become too large.

Concerning the gravity measurements at sea, the next program point, Prof. Morelli explains that is not difficult to connect measurements with underwater gravity meters to land gravity measurements. A great number of values is available for the Italian coasts.

The state concerning sea gravimeters on ships at present is that for differences up to 6000 mgal, an accuracy of a few mgal is obtained. In Europe there exist very few such instruments : one being with the Deutsches Hydrographisches Institut, another one being in England, one in Italy and one in France. The main problems are : the calibration problem, and the problem of junctions to the harbour stations. For the Askania instruments having, as is well known, a larger drift, the calibration problem has been solved in Italy in this way : the instrument was disassembled and subsequently calibrated on the calibration line.

In any case it should be decided in the European net which harbour stations can be joined with relatively little expenditure. Mlle Coron states that Prof. Tardi is already preparing such a project, and will soon distribute a circular about existing harbour connexions. Prof. Kneissl summarizes these discussions :

The hitherto existing gravity measurements at sea do not yet contribute to the net because of their lower accuracies. However according to Prof. Morelli's proposal, harbour stations should be established for connexions to the gravity measurements at sea.

.....

Professor Kneissl begins the afternoon session with the question as to whether proposals for further line gravimeter measurements for the European Net are available. This is answered in the negative...

Professor Honkasalo asks whether new measurements are available between Bodø and Hammerfest. Prof. Morelli states that an improvement of the European gravimeter calibration line was made together with the calibration and test of the LaCoste-Romberg gravimeters. A complete line gravimeter measurement was executed there and back, but only a partial airborne gravity measurements. No drift control is existing for the airborne gravity measurements, because the measurements were broken off prematurely.

The whole distance Catania-Hammerfest was measured anew with three different equipments. With these measurements, the well known breach near Copenhagen appears. Both the results of the measurements and of the line gravimeter measurements on the North line are shown. All members of the Special Study Group N°6 will get a copy after completion. The values gained coincide very well with the provisional Italian Milligal up to Copenhagen, also with the Munich adjustment. A little difference appears but only in the scale... However the part north of Copenhagen cannot be employed in practice, it should be checked according to the general opinion. Prof. Kneissl thinks it is the task of the German authorities to perform this check. He states moreover that these new results will be of great use for the European net...

Prof. Honkasalo points to many junctions between Finland and Sweden accomplished recently.

Prof. Kneissl summarizes :

We are glad of the fine measuring results and state that the former suppositions concerning the weak point have been confirmed. The German Geodetic Commission is willing to measure again between Hamburg and Copenhagen in order to find out whether errors have come in with former measurements. If not, also the airborne gravity measurements must be checked. The measurements will make a valuable contribution to the European gravimeter Network.

Subsequently follows the discussion on the last point of the agenda, i.e. the adjustment. During the last session, Prof. Wolf presented a proposal concerning the adjustment. Meanwhile Prof. Solaini has made analogous studies in Italy. From the point of view of the adjustment, Prof. Wolf proposes to subdivide into different groups. If no systematic differences appear hereby, then the total adjustment shall follow immediately. The form of the subdivision into different groups depends on the best way of finding out systematic errors. It can be subdivided for example into pendulum measurements, line gravimeter measurements, and airborne gravity measurements, or into the European gravimeter line and other ties. A third way would be the subdivision into national nets. It is most important to start as soon as possible in order to gain experience. It is confirmed that only studies bases on the last squares method come into question. .../...

Professor Kneissl asks the question whether preliminary experience in a smaller test net could be gained. This would fail because sufficient freedom degrees must exist in order to give a sufficient background to the statistical methods. It is stated that this working method successfully applied for RETrig on the Bodensee test net, is not possible here, and that it is necessary to wait until all material is available in Europe.

Professor Honkasalo asks whether a strengthening on the line Bodø-Hammerfest is possible. Prof. Morelli answers that the gravimeters accompanying the pendulum measurements in Hammerfest could eventually carry out such measurements.

It is generally stated that preliminarily the collection of more material is necessary, and that statistical studies of the adjustment methods should be performed with this material. The quantity of the material is not too important, as Professor Wolf explains, because adjustment will probably be computed by IBM 7090 of the Technological University at Munich. Professor Kneissl emphasizes that he would welcome that different institutions compute the adjustment, as it was made for RETrig. The Italian colleagues mention that they have already the necessary programmes and, for instance, the checking computations of the airborne gravity measurements could be done in Milan. Professor Kneissl affirms that the material will be sent to all members of the Special Study Group N°6, thus enabling them to participate in the computation works.

Concluding, Professor Morelli adds two further points to the discussion :

- 1 - The value of Bad-Harzburg lies, as is well known, about 1 mgal too high.... This point would become especially important if the East European countries could decide on a collaboration. Dr. Marzahn explains that this difference will not influence the adjustment until the last step, because the whole difference is computed only with gravity differences. This is generally approved.
- 2 - The work for the European Net will be completed in 2 years. Then the work with the Meridian Line will start with the same problems. In practice it would be disadvantageous if once again provisional values for the Meridian line were published within two years. Hence it seems better to publish all this work only as a test adjustment in order to preserve a certain consistency.

Professor KNEISSL summarizes :

We are of the opinion that all these tests and adjustments have only a provisional character, and that the European gravimeter network can be finally fixed only after the fixation of the world standard.

However, it is generally desirable that the material to be elaborated according to this report should be in the hands of the members of the Special Study Group N°6 already before the next meeting.

H. DEKER

REPORT ON THE MEETING OF THE SPECIAL STUDY GROUP N° 6

in MILAN from April 29 to 30, 1964

Agenda :

- 1- Scrutiny of the European gravimeter calibration line.
Proposals for further measurements.
- 2- Scrutiny of the gravity connexions between the European stations of the world gravity net.
- 3- Selection of international connexion lines out of the first order gravity networks of the European countries.
- 4- Results of the critical scrutinies of the existing pendulum measurements :
 - a) Professor Honkasalo for Cambridge pendulums,
 - b) Professor Solaini for Italian pendulums,
 - c) Professor Marzahn for Askania pendulums,
 - d) Dr. Rose for American pendulums.
- 5- Report on long line gravimeter measurements :
 - a) Professor Marzahn for the measurements by Grossmann,
 - b) Dr. Coron for the measurements by Martin,
 - c) Professor Morelli for the Italian measurements,
 - d) Professor Honkasalo for the North European measurements.
- 6- Resolution about the co-operation between the SSGs Nos.5 and 6.
- 7- Proposals for the transformation of SSG No.6 to a Permanent Commission of IAG.
- 8- Discussion of new publications.

To Nos. 1 to 3 :

The main problem of the SSG No.6 has been the establishment of the European gravimeter calibration line. The system now available, is sufficient for all practical purposes with regard to accuracy. Thus the functions of the SSG No.6 are accomplished. This is the reason for Professor Hirvonen's proposal to dissolve the SSG No.6 and to establish a new Permanent Commission in order to unify and compile the European gravimeter measurements. At present, the SSG No.6 has only the task to provide, from its area, the material necessary for the European-African meridian line. Moreover, as discussed formerly the European gravimeter net, together with the calibration line, is to be applied as test net for the adjustment of the world gravity network.

It must be clarified what can be employed, and the adjustment method has to be ascertained. The test net is to be of purposive and purely theoretical character. Therefore the necessary material must be compiled. Professor Solaini has been asked to do this work for the southern part, and Professor Honkasalo for the northern part. Further the two gentlemen have been asked to make proposals, based on their compilations, for stations in the test net to be employed.

Miss Dr. Togliatti (Milan), and Dipl.-Ing. Torge reported about recent work on the scope of the European gravimeter calibration line, and of the European gravity network.

A new adjustment of the calibration line has been performed in Milan, including the material gained recently. No essential changes have appeared as against the former results. The deviations compared with the values gained by Professor Marzahn have become a little smaller, however, the proper character has remained. Special studies on correlations of measurements followed this adjustment ; the relevant work is in process, some preliminary results were given. Professor Dr. Dr. Grossmann, in collaboration with Prof. Dr. Peschel, succeeded in measuring recently the gravity difference between Bad Harzburg and Potsdam. A preliminary result it gives between Bad Harzburg S I and Potsdam S 2, $\Delta g = + 95.12 \pm 0.04$ mGal in the scale of the European gravimeter calibration system.

To No. 4 :

Extensive reports about the critical scrutiny of the pendulum measurements have been presented by the Professors Honkasalo, Jackson, Mazzon, Marzahn, and Woollard. The following viewpoints have been emphasized during the discussion :

It can be seen with all pendulum measurements that the station influences have to be considered carefully. Professor Honkasalo studied the temperature influences, Ing. Martin points to microseismicity and to atmospheric pressure influences.

Because of the influence of temperature and eventual after-effects, the suggestions of Professor Woollard were agreed : to move the instruments in heated containers, the temperatures thus remaining constant not only during the measurement, but also during the whole measuring tour. According to a suggestion made by Professor Kneissl, it is considered appropriate to carry out the measurements in air-conditioned rooms. As stated immediately, this would probably be possible at all stations of the world gravity network.

In order to check microseismicity, special instruments or static gravimeters are to be set up, on principle, also using the static gravimeters for instance, to check the measurements relative to transient factors.

.../...

With a pendulum apparatus, the pendulums of which are hung out, thus being subject to variable air pressure, there appear difficulties similar to those relative to temperature. Therefore attention must be paid to the fact that the start of the measurements, or the application of measurements must be done only with the perfect certainty that the instrument is stabilized. It is agreed to study these influences more intensively. The German Geodetic Research Institute is willing to collaborate. On the other hand Professor Morelli thinks that the hitherto existing measurements on the European-African meridian line have the accuracy necessary for the world gravity network, in spite of these influences.

A few remarks about the world gravity net may be added (concerning) the conference of the SSG No.5) :

- 1) The pendulum measurements on the European-African meridian line are concluded. In 1965 measurements with the same pendulums are to be carried out on the American meridian line.
- 2) Japanese pendulum groups are to participate in the gravity measurements along the Pacific meridian line to be performed from 1965 on.
- 3) Because transportable equipment for absolute gravity determinations with the necessary accuracy can be expected shortly, the absolute gravity is to be determined also at the final points, and eventually at an intermediate point of the meridian line.
- 4) Further pendulum groups are invited to co-operate, but not without proof of the reliability of their pendulums.

To No. 5 :

Reports have been presented by Professor Marzahn, Dipl.Ing. Torge, Ing. Martin, and Miss Dr. Coron. (a)

No special aspects having been discussed, a detailed discussion followed about organisation problems. Professor Kneissl stated that it was convenient to inform the presidents of the SSGs Nos 5 and 6 before the start of new measurements in order to avoid that the same lines be measured again and again. Thus the presidents of the SSGs Nos 5 and 6 would have the occasion to suggest a modification of the programme.

A short discussion was held on adjustment. No difficulties are expected in this respect, because sufficient preparatory work has been done.

Some details have been given on the sites of several gravimetric stations ; Copenhagen., Lisbon...

To No. 6 :

No official decisions have been adopted, but it was arranged that the meetings of the two SSGs Nos 5 and 6 should be held together if possible.

(a) See page 23 : note on the measurements by Grossmann.

To No.7 :

As mentioned in No.I, Professor Hirvonen has suggested dissolving the SSG No.6 transforming it to a permanent commission. During the conference in Munich on March 6, 1964, with the General Secretary of IAG, Prof. Ing. Levallois, it was decided that the SSG No.6 has to work in the hitherto existing form until the meeting in Paris in 1965, where decisions about the transformation to a permanent commission can be adopted. If this transformation is decided, all countries will have to delegate one representative to the commission. Relevant proposals and suggestions for the organisation should be made available to the president of the SSG No.6 not later than the date of the meeting in Paris.

To No.8 :

No discussion on new publications took place.

H. DEKER

Note on the measurements by GROSSMANN :

Following a recent examination of the calibration functions of the 2 Askania-GS 12- gravimeters of the Geodetic Institute Hannover, the 3 greatest gravity differences published in Report "Results of some gravity measurements carried out in Europe and Africa with two long-range gravity meters with a changeable mass of the type Askania GS 12" presented in Berkeley 1963, must be changed.

The final values are :

Connexion	GS 12 N°85a	Gs 12 N° 130	
Roma interno - Kano	- 2239,98	-2240,10	mgal
Roma interno - Johannesburg	- 1824,09	-1824,43	"
Dakar ----- Lisboa	+ 1601,43	+1601,56	"

(Letter from Prof. GROSSMANN, 12/3/1964)

I N F O R M A T I O N

-.-.-.-.-

I) Collaboration with the UPPER MANTLE COMMITTEE (U.M.C.)

The following Report was presented to a meeting of the Upper Mantle Committee on account of this, it seems necessary for the International Gravity Commission to cooperate more closely with this Committee, either to inform it of the various international activities in the field of gravity, and the progress made, in particular, with regard to the calibration of gravimeters, the homogeneity and accuracy of the first order gravity world network :

or to know the areas where gravity surveys or connexions are desirable, taking into account work already done.

Problems Related to Gravity Requiring International Cooperation

The U.M.C. approved and referred to I.A.G. the following proposal :

"The analysis of satellite orbital perturbations has shown a pronounced region of subnormal gravity in the Indian Ocean immediately south of Ceylon and a comparable region of abnormal gravity in New Guinea - Solomon Island area. The dimensions of these two areas are very similar to those noted for the areas of anomalous magnetic field that are known to have secular variations in both magnitude and position and which are believed to be caused by convection movement within the earth. That these regional deviations in gravity may also be related to convection is suggested by abnormal heat flow in the Indian Ocean area, and a program of continuing precise gravity connections between key points in these anomalous areas and areas of normal gravity over a period of years might give significant information on convective transfer within the mantle. As there are no first order world gravity bases in either area of anomalous gravity, special sites would have to be selected and locally maintained as permanent gravity bases. The following sites could be considered for such a program : Colombo (Ceylon) New Delhi (India) Singapore (Manila P.I.) Darwin and Brisbane (Australia) Port Moresby (N.G.) Noumea (New Caledonia) and Aden (Arabia). This network of bases could be connected for closure via Perth (Australia) and Johannesburg (South Africa).

The reliability and physical significance of Gravity Anomalies :
In order to attach physical significance to gravity anomalies having a regional scale, and to understand their significance in terms of the crust

and upper mantle, as well as understand results from studies such as the one prepared above, it is essential that the measurements be free from systematic bias with latitude and elevation and be a true measure of the change in g . Such an obvious conclusion, however, can not be satisfied at the present time. Neither can it be said that we know the absolute value of gravity anywhere as yet. Where we stand on this problem at the moment is summarized below :

1. During the IGY an effort was made to (1) establish an international series of North-South lines pendulum gravity measurements using the Gulf compound quartz pendulums and the Cambridge compound invar pendulums, and (2) make relative gravity connections between the various absolute gravity sites in the world. The objective of the first was to establish a common standard for evaluating differences in calibration standard being used by different groups doing gravity work in various parts of the world, and that of the second was to determine the degree of error in the absolute Potsdam gravity datum now in use.

The results of these studies demonstrated that there were as many different gravity standards in use as there were observing groups, and it was on the basis of these results that the present IUGG standardization program involving measurements on the three of the IGY lines of observations with four sets of pendulums was established. This program involving measurements in Europe and Africa, North and South America and in the Western Pacific area, however, has one obvious defect. There will be no similar series of measurements covering India and Central Asia. The survey of India is anxious to be included in this program because the gravimeter work carried out by Woollard in this area indicates the Indian gravity standard is significantly in error. A series of 5 bases extending from Ceylon to Afghanistan would provide the start of a central-Asian line which should eventually be carried through to Novaya Zemlya.

2. The pendulum interconnections during the IGY between the absolute gravity sites at Washington (USA), Ottawa (Canada), Teddington (England), Paris (France), Bad Harzburg, ex-center for Potsdam (Germany) and Buenos Aires (Argentina) were disappointing in that there appears to be a systematic deviation as a function of gravity between the absolute and relative measurements. Furthermore, if the Russian Absolute measurements at Leningrad are included with old pre-1940 relative connections to other sites it appears there is good evidence for this systematic departure to defend one type of absolute measurement. The difference from the reversible pendulum measurements is about 2.2 mgal/1000 mgal, and that from the free-fall absolute measurements about 4.2 mgal/1000 mgal.

The error in the Potsdam datum on the basis of the reversible pendulum observations is about +12.9 mgal and on the basis of the free-fall measurements is about +10.9 mgal. This difference in values for the two types of absolute measurement is too large to permit any satisfactory adjustment in the Potsdam datum to be made at this time.

Another complicating factor brought out by the connections made in 1963 to Potsdam (by) the Dominion Observatory of Canada and the Osservatorio Geofisico Trieste is that the Bad Harzburg ex-center for Potsdam is about 0,9 mgal in error. If this error is allowed for, the error at Potsdam on the basis of reversible pendulum measurements is about + 12 mgal and on the basis of the free-fall measurements about + 10 mgal. Little by little control is being tightened, but it is clear that no further significant advance can be made until the apparent systematic deviation between relative and absolute gravity measurements is resolved.

Two things are needed at this time : (1) relative gravity connections to the Leningrad absolute gravity site where there is an apparent discrepancy of 3.8 mgal between free fall and reversible pendulum absolute measurements which may be a function of the experiment rather than faulty observations, and (2) absolute gravity connections between some of the absolute sites, preferably Washington, Teddington, and Leningrad.

At this writing the Gulf pendulums have just completed a new set of connections between Washington, Teddington and Potsdam, and these would be the logical instruments along with the Cambridge pendulums for a relative gravity connection to Leningrad if it could be arranged.

The only absolute gravity apparatus portable enough for international connections at this time is the free-fall apparatus of the National Physical Laboratory, Teddington, and possibly the new reversible pendulum apparatus of the Geodetic Institute in Potsdam, East Germany. Dr. Cook of NPL plans to connect Teddington to Ottawa and Washington this year, but it would add significantly to the experiment if a connection could be established to Leningrad also.

Although no results have been reported as yet for the New Potsdam absolute apparatus, it is obviously desirable to have this equipment used for the same connections as are planned to be made with NPL apparatus"

II) Fourth United Nations Cartographic Conference for Asia and the Far East.

During the meeting held at Manila in December 1964, the following resolution concerning the establishment of the National Gravity Base Stations in the Far East, and their connection to the First Order World Gravimetric Network, was taken :

Establishment of additional World Gravity Base Stations in the Far East :

This Conference

Noting the importance of the best value of absolute gravity in the same datum in many fields of science,

Recognizing the desirability of additional absolute gravity station, and further recognizing the availability of much improved portable relative gravity equipment,

.../...

Realizing that this field of activity lies within the province of the International Union of Geodesy and Geophysics (IUGG),
Invites that the IUGG consider the establishment of the additional World Gravity Base stations in the Far East, including but not limited to Manila, Bangkok, and Djakarta,
Recommends the consideration of the stated willingness of the Governments of Japan and the Philippines to participate in such connections, and,
Recommends further that the various countries of this region consider the establishment of National Gravity Base Stations which in turn would be referenced to the stations of the World Gravity Base Net.

III) Problems of the Special Study Group 5 "The First Order World Network"
(Circular letter from Prof. MORELLI, Chairman)

PRESENT SITUATION (11 January 1965)

1. Gravimeter measurements. -----

1.1. US, Naval Oceanographic Office (U.S.N.O.O.) is going to forward the observations realized in 1964 with ten LC&R meters on the N.A.C.L. ; the report on measurements made in 1963 on the E.C.L. (G2, g5, g15 meters) is nearly completed and will be sent within a few weeks (letter dated Dec. 29, 1964).

Project MAGNET ties will possibly be executed in future with more than one meter, as previously. Observed data concerning the first six trips have been furnished ; data related to the last trip are under process and will be forwarded at the the earliest possible date (from the same letter as above) . Project MAGNET is assumed to provide a lot of very essential transversal connections between the main calibrations lines for the F.O.W.G.N. therefore, any possible strengthening in accuracy is highly recommended.

Investigations about inverse correlation between drift and gravity changes on LC&R meters could be made through manufacturer's calibration arrangement as proposed by U.S.N.O.O. : recent N.A.C.L. data seem to be favourable to the hypothesis of this effect.

1.2 A.P.C.S., 1381st G.S.S. 1964 gravity trip on the European Africa Calibration Line (E.A.C.L.) is still classified, due to D.I.A. instructions. A revised version of these instructions has been solicited and it is hoped that this will allow the data to be released but, in any case, not prior to Jan. 15, 1965, according to a letter dated Dec. 15, 1964. The same letter communicates that 1961 southeast Asia gravity measurements will be reprocessed and included in the report covering the West Pacific Calibration Line measurements recently made.

1.3. Prof. Grossman (with letter of Dec. 15, 1964) reworked the gravity connections made through 1958-64 on E.A.C.L. with Askania meters and forwarded the values obtained in the hypothesis of a linear drift (uncorrelated data). A comparison of this new computation shows good agreement with G3

and G1 measurements on E.A.C.L. (1963), the latter having greater spread in values ; some disturbances are still present in the higher gravity values (up to Bodo) as also shown by the previous computation of the Grossmann's measurements.

1.4. Dominion Observatory 1962-1963 gravity trip in Europe and the Americas is now going to be reprocessed by Dr. Hamilton in order to produce a final paper on it. However, it is in the programme that the same trip be recomputed by S.G.5. ; therefore, all the data missing in the preliminary report, i.e. those concerning Argentina Calibration Lines have been requested from Dr. Hamilton and Prof. Baglietto. The latter has been asked to give permission to Dr. Hamilton for releasing these data as they had originally to be handled only by Prof. Baglietto as from an agreement reached during Hamilton's visit in South America. It is hoped to have these data within the present month.

1.5. Prof. Woollard's group that executed pendulum measurements on N.A.C.L. in 1964 has probably employed one (or more?) gravimeters in conjunction with pendulums. Dr. Szabo has been asked (letter dated 11 Jan 65) to intervene in order to get the complete data available to S.G.5 for analysing and eventually reworking. It is also hoped to obtain complete gravimeter data covering LCR-G1 measurements on N.A.C.L. in 1961 and 1962., for comparisons related to the change in scale factor.

2. Pendulum measurements

2.1. Dr. Szabo anticipated (letter dated 21Dec. 1964) that the pendulum observations in 1964 on NACL could be forwarded for internal use by all the intervening groups within March 1965, so that, after a period of about one month for revising and comments, a restricted meeting could be arranged to discuss the ideas about the way to adopt in reductions of pendulum observations. This meeting should give the primary standpoints in the bearing of the future efforts toward a conclusive goal.

2.2. S.G.5 invites all participants in pendulum measurements to furnish all the details about observations in order to allow discussions a re-computations : only the 1963 Cambridge trip, of those made on the E.A.C.L. is published (as a preliminary report) complete with all the observed data, constants and computations.

IV) Recent information on the Sea Gravity Measurements.

Geophysical study at the mouth of the "Rio de La Plata ":

About one hundred stations have already been measured, with an under water gravity meter, by the Institut of Geodesy ("Facultad de Ingenieria" Buenos Aires)

(letter from Pr, Ing. Baglietto, Nov. 1964.)

Exploration of the North Atlantic :

a) Sea Gravity observations at the surface were made on board the H.M.S. Vidal during April 1964 ; from the North of Ireland to the Strait of Gibraltar.

The measurement profiles are approximately :

- along the 56th parallel between 7°30' and 12° W.G.
- along the 11th30' meridian between 56°N. and 35° N (see Fig.2,p.40)
(from Mr. Browne, Aug. 1964)

b) In the scope of the Navadoppoject, the Royal Netherlands Navy participates in an oceanographic exploration of the North Atlantic together with the Navies of Great Britain and the United States.

This exploration is executed from 26th November 1964 till 17th September 1965 on board the recording ship Hr. Ms. "Snellius" of the Netherlands Hydrographic Service.

The Geodetic Institute of the Delft Technicological University takes part in this expedition with a newly bought Askania Seagravimeter. Due to a delay in delivering the observations are being made till May 1965 with an Askania instrument which has been kindly lent for that purpose by the Geophysic Department of the Cambridge University. The measurements are arranged in profiles every 3° degrees from 22° to 55°N Latitude.

About 14 coastal reference stations on both sides of the profiles are included in the observational scheme (letter from Prof. Bruins, 19th Jan 65).

c) The "Service Hydrographique de la Marine, France" made in 1964 a gravimetric survey on board the "Paul Goffeny" in the Northern Atlantic, with the Askania gravimeter Gss2-n°15.

On the other hand, the survey begun in 1963 in the "Golfe de Gascogne" on board the hydrographic ship "Amiral Mouchez" was continued in 1964.

Exploration of the Mediterranean Areas

a) The "Service Hydrographique de la Marine, France" on board the "Paul Goffeny" made some observations near the "Ile du Levant", with the same gravimeter Askania.

b) The Osservatorio Geofisico Sperimentale, Trieste" continued its systematic study of the Mediterranean Areas. In the following Annexe, recent cruises made in cooperation with Saclant ASW Research Center (Fig. I).

A general view of gravity measurements with remotely controlled Western gravimeters is also given in this Annexe.

V) Some details on the principal World Gravimetric Stations :

a) The I.G.B. has established a "Sketch-Library" of the principal World

Gravimetric Stations, from publications received and supplementary information given by observers, as had been announced in the Report presented at Berkeley.

The classification code is that which is used for the reference stations put on punched -cards, by the I.G.B. (square of 10 degrees ...),

At the present time, the sketch-library includes about 1400 sketches. Modifications will be made as they are notified to the IGB.

The I.G.B. would like to thank all those to whom it is indebted for its up to date sketch-library which will enable us to supply any details requested.

b) A Catalogue of pendulum stations and excenters for the First Order World Gravity Net and principal related stations was prepared at the Osservatorio Geofisico Sperimentale (Trieste), through the kind cooperation of all the Members of Special Study Group n°5.

It was distributed in provisional form to the interested people to facilitate their work but also to allow their controls and complementary ties.

A first publication with regard to the stations of Europe and Africa has been undertaken by the I.G.B.

c) In addition, the I.G.B. is preparing a special publication concerning only the stations suitable for the connexion of measurements at sea, as it was indicated in the circular of Jan. 1964 "Rattachement des mesures en mer au Réseau Gravimétrique International de 1er ordre".

ANNEXE

SUMMARY REPORT ON SEA GRAVITY
IN THE MEDITERRANEAN AREA 1953-1964
(C. MORELLI)

1. Preface

In the Paris, Sept. 1962 Meeting of the International Gravity Commission, a resolution was approved recommending a rapid exchange of information between people working at sea-gravity.

Also for the reason that bottom measurements are very effective for control of the real accuracy of the ship gravity-meters, a brief summary is first of all here given of the work done by the Osservatorio Geofisico Sperimentale, Trieste (Italy) in this field.

2. Bottom measurements (with remotely controlled Western gravimeters)

The continental shelf around the coasts of the Italian peninsula and the islands of Sicily and Sardinia have been covered by 3453 stations made with remotely controlled Western gravity-meters during the years from 1953 to 1961.

These gravity bottom measurements around Italy may be divided as follows :

- 1839 stations in Adriatic Sea ;
- 263 " in Jonian Sea ;
- 582 " in Thyrrenian Sea ;
- 451 " in the Sicily Seas ;
- 318 " around Sardinia.

Positions have been generally determined by means of radar controls on the coasts, or chains of reflecting buoys when far from the coasts. Precisions are varying from ± 50 to ± 200 meters accordingly to distances from the coasts.

The average spacing of the stations varies from 1 station each 4 square kilometers on the coastal area from Po River to Ancona to 1 station each 50 or 100 square kilometers if near or far from the coasts in the other areas.

The gravity values are referred to 94 harbour base stations connected to the Italian Gravity Fundamental Net, and the precision for the bottom stations could be claimed to be within 0.2 ± 0.3 mgals ; gravimeter readings have been always taken to the nearest 0.01 mgal.

All the measured data, including their reduction to Bouguer anomalies, are collected under two recent papers that summarize all the work done (Ciani, Gantar, Morelli, 1960 ; Gantar, Morelli, 1962).

In these papers it has been assumed as reference gravity value the Italian Fundamental Net station in Rome (Pac. of Eng., outside) with $g = 980,363.22$ gals.

The only area where gravity data lack is that comprised between the Yugoslavian coasts and their territorial water limits ; it is therefore advisable to get an arrangement with Yugoslavian Authorities to cover the missing zone, completing in such way all the possible bottom gravity survey (till the depth of ab. 200 meters) on the Adriatic Sea.

The gravity survey of the Italian seas by means of bottom measurements is fully described in publications (1954 - 1962).

3. Surface measurements (with Graf-Askania sea-gravimeter).

The first tests about the performance in the ship-mounted gravimeter continuous profiling were carried out, at the end of 1959, on the hydrographic Vessel " Staffetta " (1400 tons), in cooperation with the Istituto Idrografico della Marina, Genova and with the Deutsches Hydrographisches Institut, Hamburg. A Graf-Askania sea-gravimeter Gss-2(n° 5), belonging to the latter institution, has been employed in this experimental cruise and the tests concerned were planned to compare surface and bottom (precise) measurements as well as to investigate the general behaviour of the instrument itself and with respect to the sea conditions. In spite of several defects pointed out, the results seemed fully promising so that in 1961 a new (improved) model Gss-2 Graf-Askania sea-gravimeter (n°13) has been purchased by the Osservatorio Geofisico Sperimentale, utilizing funds placed at disposal by the Italian Ministry of Public Instruction.

The response and the behaviour of this new model have been checked at laboratory (Morelli, 1961 ; Gantar, Morelli, Pisani, 1962) and on sea (Allan, Dehlinger, Gantar, Harrison, Morelli, Pisani, 1962) during the first cruise carried out in 1961, when the Gss-2 gravimeter was utilised together with a LaCoste & Romberg model of the U.S. Office of Naval Research. This cruise (named COSSACK) and the forthcoming ones, have been performed on board the "ARAGONESE", a 3000-ton converted freighter, of the Saclant ASW Research Center that therefore provided navigation and carried (Dr. Allan) the magnetic part of a combined gravimetric and magnetometric program in the Mediterranean Sea.

The cruise COSSACK being developed also on areas where bottom precise measurements exist, a direct comparison has been possible between Askania and LaCoste & Romberg surface and these bottom gravity values : conclusions

claim a precision of ± 3 mgals, provided that sea conditions are smooth and navigation data precise to allow the Eötvös correction to be computed within 2 mgals. The Askania meter works at sea conditions rougher than those at which the LaCoste-Romberg gives useful records. Anyway, improvements were consequently made on both meters.

But for the first time it was possible to compare the two instruments driven within a good positioning system, against very accurate bottom measurements : the comparison was therefore not only relative, but also absolute. It indicated that :

- discrepancies between the two instruments increased as the Browne correction increased ;
- the LaCoste & Romberg values were always higher ;
- errors were mainly due to the LaCoste & Romberg gravity-meter.

The reason was explained as errors in horizontal accelerometers correction for longer forcing periods.

Always in cooperation with Saclant ASW Research Center, two other cruises have been carried out on the "Aragonesa" in 1961 (CORSAIR and CONCRETE), two in 1962 (CODICIL and CORINTH), four in 1963 (CONCORD, CORAN CORNET, COCKTAIL), one in 1964 (COALESCE) and one in 1965 (COBWEB).

At the end of 1964, the research ship "BANNOCK" of the Consiglio Nazionale delle Ricerche became available for these measurements ; unfortunately, the Loran C of Saclant was defective, so that the cruise (BABY) was necessarily modified to be operated with radar. From 1962, the new model of stabilized platform has been employed.

The state of the profiles run in the Mediterranean Sea up to Jan. 1965 is reported in Fig. 1 (page 39). The degree of detail in the grids of profiles is rather varied on the different areas ; some of these will be further crossed by other profiles during the future approaches to new planned areas : for this reason, some parts of the work just done have not to be considered at their final stage. As soon as the final routes are obtained from the navigators, Free air and Bouguer anomalies with terrain correction will be published.

With reference to Fig. 1 some further information is given in the following about the cruises completed up to date :

COSSACK (July 14 to August 8, 1961). Intended for experimental purposes, this cruise is well divided into two parts : some test profiles in La Spezia Gulf and then the coverage from La Spezia to Elba Island and from Elba to Giglio and Montecristo Islands, and some comparison profiles along the Southern coasts of Sicily where detailed and precise bottom measurements exist.

CORSAIR (September 1 to 23, 1961). It consists of two parts : the western

coastal area of Corsica and Sardinia, and the eastern area south of Elba Island till the parallel of Bonifacio Mouths.

CONCRETE (October 17 to December 16, 1961). Well divided in two parts, this cruise covers an area of the central Mediterranean Sea between Crete Island and the African Coasts and the Red Sea (Aqaba Gulf included).

CODICIL (August 3 to September 9, 1962). After covered a limited area in the Gulf of Genoa toward Corsica, this cruise furnished the systematic coverage of the Sicily Channel.

CORINTH (October 10 to November 13, 1962). In the Southern area of Aegean Sea, from Crete to 37°N, with additional profiles South of Crete (see CONCRETE, 1961).

CONCORD (February 1 to 25 , 1963). In Aegean Sea from 37°N to 39°N.

CORAN (March 2 to 14, 1963). As completion of the survey in Ligurian Sea (See CODICIL, 1962) toward West till 7° E Gr. and toward South till 43°N.

CORNET (August 1 to 17, 1963). In the Thyrrhenian Sea from North to ab. 40° parallel. Beginning with this cruise, the position of the ship has been determined with Loran C.

COCKTAIL (October 31 to November 22, 1963). Was planned to extend the survey of the Thyrrhenian Sea till the coasts of Sicily. A damage occurred to gyro-stabilized table caused the lost of 5 days of recording, as the Sea conditions were very rough and the gimbal suspended meter did not furnish useful data.

COALESCE (June 8 to July 3, 1964). As completion of the survey in Thyrrhenian Sea and Aegean Sea.

BABY (m/s "Bannock" nov. 11 to Dec.20, 1964). Surveyed area :

- coasts of Gulf of Lions till 20-25 miles offshore ;
- spanish coasts, north of Baleares Islands, till latitude 39° and longitude 3° 45' East.;
- southern Adriatic and northern Ionian Seas from latitude 42° 30' to latitude 39° 25' (Gulf of Taranto included) and coastal strips along calabrian peninsula till Capo Spartivento.

COBWEB (in cooperation with Saclant ASW, Jan. 5 to 21, 1965). Surveyed area: Gulf of Lions, where previous surveys have been completed till latitude 41° 30'.

4. Improvements made by O.G.S. in the Graf-Askania sea-gravimeter.

The first cruises on board the "Aragonese" gave the possibility to

investigate the behaviour of the equipment also besides from the precision gained up and deriving from the intrinsic possibilities of the gravimeter itself. Some modifications became therefore advisable to improve the response of the electronic parts, especially in view of reducing the following defects :

- excessive influence of the power supply frequency on the amplifier gain ;
- different "zero" positions on the record for "Eichung" and "Messung" settings ;
- progressive loss of gain in the amplifier that causes a time variation of the scale factor on the records.

Accordingly to the above suggestions, the O.G.S. - Trieste has planned and realized a new more compact amplifier assembly in which two identical chopper-amplifier sets are at disposal of the operator (one for spare) keeping unmodified the former size of the rack.

These new chopper-amplifiers, realized on a completely modified circuit, were studied to offer the following fundamental advantages :

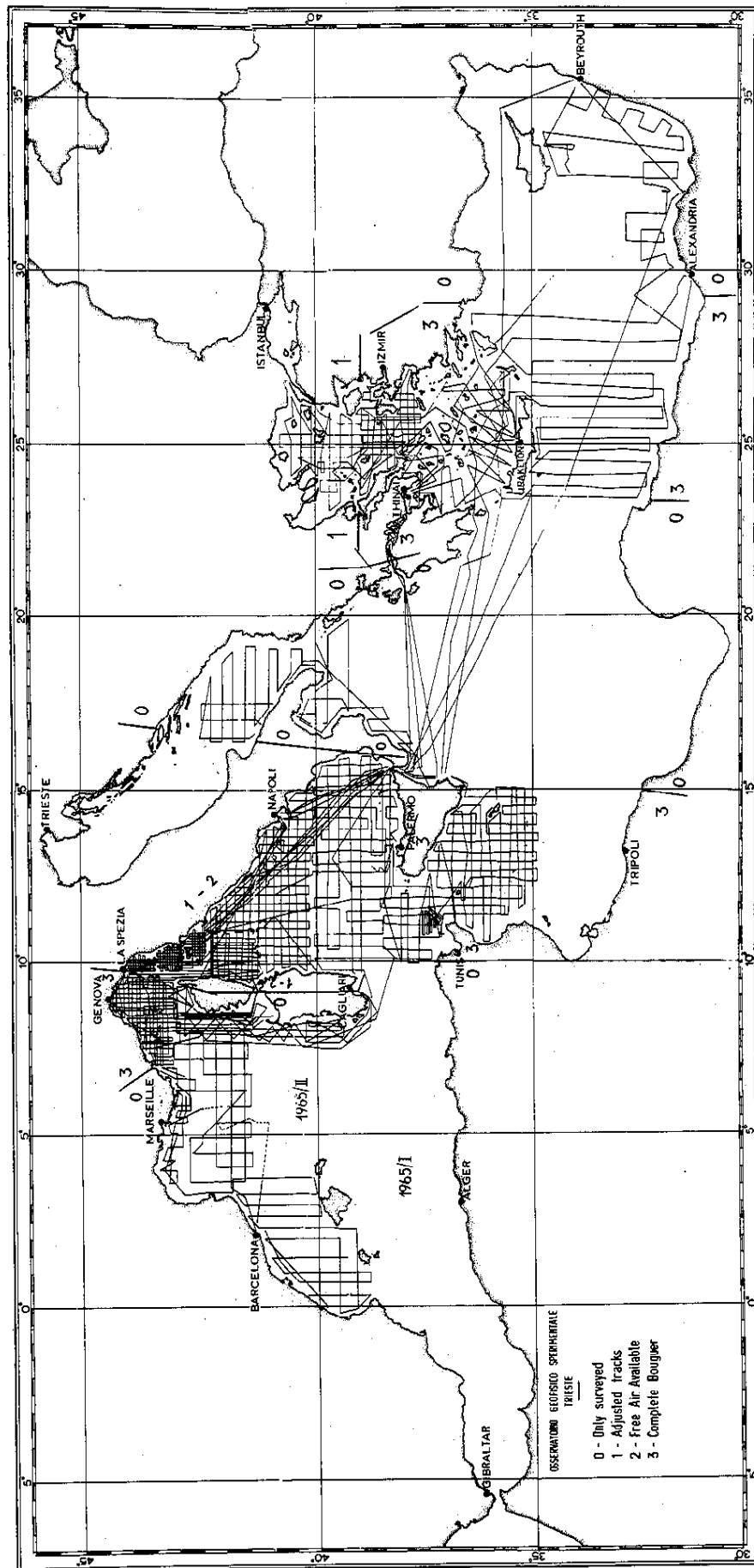
- little influence of the power supply frequency on their gain ;
- "hum" balance that allows to maintain the "zero" point on the recorder in each panel measurement position ;
- manual control of the gain in order to compensate the loss of amplification against time ;
- easy and quick changement of the operating amplifier set for repairing without any interruption in the records.

The original recording system of the Askania Sea-gravimeter has been radically improved by replacing the original recorder with a new type of recorder, having a higher sensibility and an input impedance of the same order of that of the photocell output, through an embodied convenient amplifier. A new filtering device for cutting down high frequency variations is also applied. This new recording system has been adopted from cruise COCKTAIL.

5. Accuracy.

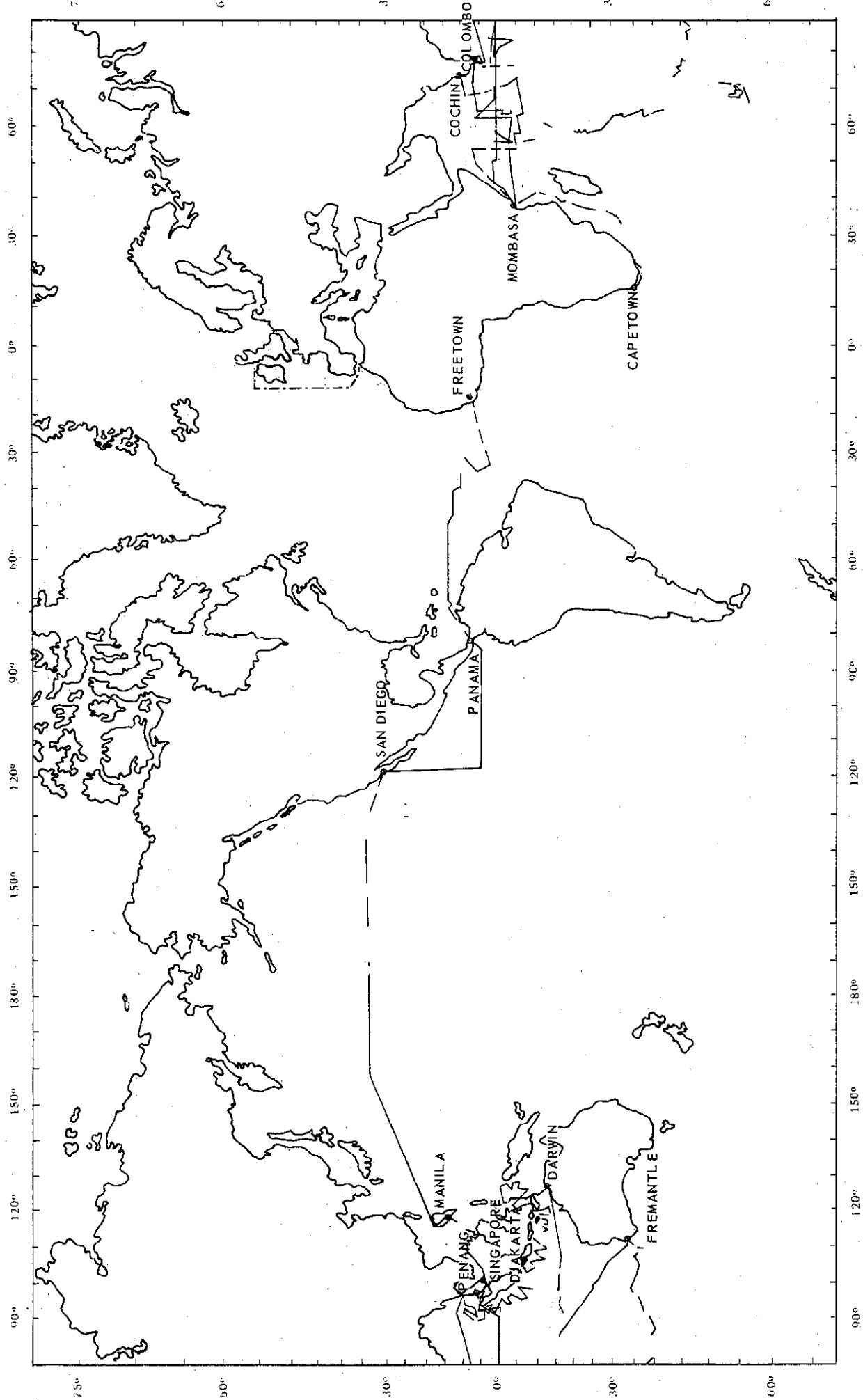
From the experience of the hitherto realized comparisons in the crossings and against bottom measurements (where available), the mean values of the observed differences with good navigational systems are :

with Loran C	:	\pm 2.1	mgls
with radar	:	\pm 3.6	mgls



MESURES de PESANTEUR en MER

Fig. 1. - Vue d'ensemble des profils gravimétriques (et magnétiques) mesurés à la surface de la mer de 1961 à 1965.
« OSSERVATORIO GEOFISICO SPERIMENTALE, TRIESTE et
SACLANT A. S. W. Research CENTER »



MESURES de PESANTEUR en MER

Fig. 2. - Principales croisières gravimétriques 1962-1964

Etats-Unis (UCLA) : LUSIAD Expedition (Mai 1962 - Août 1963) —

GREAT BRITAIN : H. M. S. Vidal (Août 1964) - - -

MESURES de la PESANTEUR en MER

APPAREILS et RESULTATS

A - APPAREILS

- *52 - ACAD. USSR. - Le gravimètre en quartz (GAL-P) pour mesures en mer avec l'équipement spécial PNU-5. Institut de Physique, Moscou, 1961, 2p.

Description sommaire.

- 53 - ALLAN T.D. and the others - Comparison of Graf-Askania and LaCoste-Romberg Surface-Ship Gravity Meters. J. Geoph. Res., 1962, 67, n°13, p. 5157-5162.

"Graf-Askania and LaCoste-Romberg surface-ship gravity meters were installed on the Sacant ASW Research Center's R.V. "Aragonese", and performance of the two instruments was compared during a 3-week cruise. Known bottom-meter gravity anomalies in portions of the surveyed area provided checks on the accuracy of the measurements. Differences with respect to meters drift, uniformity of calibration factor, reliability of measurements in calm seas and in moderately rough seas were investigated. Good results were obtained with both meters in calm seas. The Graf-Askania platform permitted reliable measurements to be made in moderate seas. The LaCoste-Romberg measurements were in error because of inadequate response of the accelerometers to long-period components of ship motion. The drift rate of the LaCoste-Romberg meter was negligible, its calibration factor did not vary significantly with time, and the time lags caused by the ship's motion were short. The Graf-Askania meter had a relatively large drift rate, and the time lags were relatively long".

- 54 - BOULANGER Yu.D. - Gravimètre en quartz pour mesures en mer (description). Acad. USSR, 1962, 5, p.88-89, (russe).

- 55 - BOWER DONALD R., WATT PETER A. - The Second-Order Errors of Sea-Surface Gravity Measurements. J. Geoph. Res., 1963, 68, n°1, p. 245-250.

.../...

* Ces articles font suite à ceux indiqués dans le Bulletin d'Information, Avril 1962, Bureau Gravimétrique International.

"An analysis of the effect of a continuous acceleration spectrum on the performance of a sea gravimeter is made. When a continuous rather than a discrete spectrum is assumed second-order errors due to acceleration product terms become more complex. In particular, the second-order correction which must be applied to the reading of a gimbal-mounted gravimeter is disturbed from the constant value previously found when sinusoidal ship motion was assumed. This disturbance is in the form of very-long-period "noise" which has, in a typical case, a rms value of $1/7$ of the constant value. It is shown also that very-long-period "noise" is present in the reading of a vertically stabilized gravimeter owing to a cross-coupling effect and that it occurs whether or not the beam displacement and the horizontal accelerations are correlated. Finally the possibility of errors being caused by nonlinear ship response is discussed. The purpose of the paper is to identify and describe from a statistical standpoint some of the factors determining the reliability of gravity measurements made at sea"

- 56 - BOWER D.R. and WATT P.A. - Some theoretical Comments on the Measurements of Gravity at sea. Paper presented at the 43th Annual Meeting, Amer. Geoph. Un., Washington D.C., April 25-28, 1962.
C.R. : J. Geoph. Res., 1962, 67, n°9, p. 3544.

"A theoretical study of the effect of a continuous acceleration spectrum on the performance of a sea gravimeter is made. When a continuous rather than a discrete spectrum is assumed, second-order errors due to acceleration - product terms become more complex and difficult to correct. In particular, the Browne correction, which must be applied to the reading of a gimbal-mounted sea gravimeter, is disturbed from the constant value previously found by assuming simple sinusoidal ship motion. This disturbance is in the form of a very-long-period "noise" which has, in a typical case, a rms value of $1/7$ of the constant value. Thus the correction apparatus must not only reproduce the dc Browne error but this low-frequency "noise" as well. The problem of ensuring that both gravimeter and correction apparatus will have the same frequency and phase response is examined here. Several examples are given with particular reference to the possible errors due to the differences between the gravimeter filter and the filter applied to the correction apparatus".

- 57 - DEHLINGER P. and YUNGUL S.H. - Experimental Determination of the reliability of the LaCoste and Romberg Surface-Ship Gravity Meter S-9.
J. Geoph. Res., 1962, 67, n°II, p. 4389-4394.

"The LaCoste and Romberg surface-ship gravity meter S-9 has been used to measure gravity at sea on the research vessels "HIDALGO", "VERA" and "ARAGONESE". Tests were made to determine reliabilities of gravity recordings with underdamped and overdamped horizontal accelerometers in the meter system. The tests included hovering over a bottom gravity meter, making measurements over areas of known gravity making measurements at different ship speeds and headings with respect

to the waves past offshore petroleum platforms where gravity is known, comparing gravity at intersections of profiles and along reversed profiles, and making measurements while inducing sinusoidal (fish-tailing) and saw-tooth (yaw) ship motions. It was observed that:

- (1) the meter drift rate was less than 1 mgal in several months ;
- (2) successive measurements in harbours could be repeated within 1 mgal
- (3) the calibration factor supplied by the manufacturer was quite accurate
- (4) the reliability while havoring (not drifting) in even moderately rough seas was within 4 mgal,
- (5) the meter readings were accurate at very low Browne corrections but under normal cruising conditions, when moderate to large Browne corrections were indicated by the horizontal accelerometers, appreciable errors in gravity recordings were obtained, primarily due to long-period horizontal motions to which the particular accelerometers used did not respond completely. An empirical curve relating error in gravity to measured Browne correction was obtained. This curve has been used to correct gravity recorded on the "HIDALGO" ; recordings thus corrected were reliable to within approximately \pm 10 mgal. The horizontal accelerometer characteristics have been modified since these tests".

- 58 - FLEISHER U. and FRITSCH J. - Three years Experience with an Askania Sea Gravimeter after Graf. Paper presented at the 43th Annual Meeting, Amer. Geoph. Un., Washington D.C., April 25-28, 1962.
C.R. : J. Geoph. Res., 1962, 67, n°9, p.3558.

"The developments of the Askania sea gravimeter and the Anschütz stabilization have been tested continuously at the German Hydrographic Institute. In 1960 and 1961 the improved gravimeter and the latest platform could be used on several cruises between the North Sea and the gulf of Aden. After an initial value of several milligals per day, the drift of the gravimeter was sufficiently constant and less than 0.6 mgal/day, depending in size and sign on special conditions. Good constancy was found for the milligal equivalent of the measuring spring. However, the sensitivity to the small deviations that are measured as amplified photocurrent did vary at times. Results of different calibrations are shown. A cross-coupling or similar effect was found to be less than 10^{-4} times the vertical accelerations. Measured deviations in gravity at one point, in dependence of the angle between ship and sea movement, are discussed. Using Decca navigation, the mean error of a single measurement at moderate sea is almost 3 mgal ; comparisons between two gravimeters on a long profile and two examples of a surveyed area are presented".

- 59 - FRITSCH J. - Erfahrungsbericht über Messungen mit dem Askania-Seegravimeter Sonderdruck aus der Deutschen Hydrographischen Zeitschrift, 1962, 15, n°4, S. 142-173, (résumé allemand, anglais, français).

"After several general introductory considerations on sea ...

gravimetry, a report on measurements is given obtained with the Askania-seagravimeter. The effect of disturbances on the measuring value is theoretically investigated. The results of these investigations are compared with the values obtained by way of experiment. The cross coupling effect is, before all, made the subject of investigations on so-called "star cruises" by measuring the horizontal and vertical acceleration. These investigations show that up to state of sea 5 the cross coupling effect lies within the order of magnitude of other disturbing effects that are limiting the measuring accuracy of the Askania-seagravimeter to 2-3 mgal. It will be useful to average the values of the ship's courses on her ways out and back while on measuring cruise".

- 60 - GANTAR C. - Tables of Eötvös correction to continuous sea gravity measurements for Mediterranean sea latitudes. Boll. Geof. Teor. Appl., 1962, IV, n°13, p. 37-46.

"The values employed for Eötvös correction to the surface sea gravity measurements made by Osservatorio Geofisico Sperimentale di Trieste have been tabulated in the latitude interval of Mediterranean Sea (30° to 45° N)".

- 61 - GANTAR C., MORELLI C. & PISANI M. - Experimental Study of the Response of the Graf-Askania Gss2 n°13, Sea gravity Meter. J. Geoph. Res., 1962, 67, n°11, p. 4411-4419.

"The Osservatorio Geofisico Sperimentale has made laboratory tests to determine time lag of the Graf-Askania Gss2, n°13, gravity meter and the corrections for attenuations of gravity anomalies, measured in a ship at sea, due to the high damping of the beam. Amplitude attenuation and time lag characteristics of meter 13 were established for different forms of gravity variations. Practical procedures have been developed for making corrections to measurements ; they have applied successfully to the results of one survey. It is recommended that each Gss2 meter be similarly tested to determine its attenuation and time-lag characteristics".

- 62 - GLICKEN M. - Eötvös corrections for a moving gravity meter. Geophysics, 1962, 27, n°4, p. 531-533.

"When making gravity measurements with a moving meter, the Eötvös correction is often the limiting factor in the precision of the entire system. Nomograms are presented showing the error to be expected in the Eötvös correction for errors of various sizes in the determination of ground speed, heading, and latitude of the vehicle".

- 63 - GEOGRAPHICAL SURVEY INSTITUTE-TOKYO - Tokyo Surface Ship Gravity-Meter. 18p. + figures, {duplicated text.}

"In the "Tokyo Surface Ship Gravity Meter" which was designed

in 1960 and completed in 1961, a dynamic gravity meter mounted directly on the gimbals stabilized by a vertical gyroscope, is kept vertically. Variations in the vertical acceleration are converted to frequency variations through a dynamic gravity meter and are digitally recorded on punched tapes.

....

The Tokyo surface Ship Gravity Meter consists of the following parts :

- 1) dynamic gravity meter
- 2) exciting amplifier
- 3) gyroscope and gimbals
- 4) mercury levels IX and IY
- 5) erection circuits
- 6) torque motors tX and tY
- 7) temperature regulated housing provided with thermo-elements
- 8) interchanging frequency counter and
- 9) tape puncher".

- 64 - GRAF A. - The measurement of the Browne-Effect by gyroscope. Typed paper presented to the Internat. Gravity Com., 1962, 3p.

"First measurements of the apparent vertical for determination the Browne-Effect with gyros have been made. The results show, that the records are reliable and useful for this purpose. Two different types of gyros have been used. The measuring range of both types has to be enlarged to meet the problem. Till now the range is only $\pm 1,7$ degree for the angle-measurement, that means about ± 30000 mgal for the horizontal acceleration. Twice as much is needed. Principally there is no difficulty for such an extension. The air driven gyro measured very good linear. The electrically driven gyro showed an unlinear response. The inductive measuring device has to be linearised for an easier reading".

- 65 - GRAF A. - Die Bestimmung des Browne-Effektes durch Messkreisel. Deut. Geod. Kom., Reihe B, n°92, 1963, 3 S.+fig.(10 S.)

- 66 - GRAF A. - Das Vertikalpendel anstelle des Horizontalpendels für die Registrierung der Gezeiten und von kleinsten Neigungen. Deut. Geod. Kom. Reihe B, Angewandte Geod., n°104, 1963, 13 S.

"The advantages of a recording vertical pendulum for measuring tides and small inclinations in comparison with horizontal pendulums are discussed. A vertical pendulum with two components has been built by the author. It can be lowered in a borehole and adjusted by servomotors. A record in a 18-feet borehole shows that the disturbances by temperature and air pressure changes are of smaller size than the tide amplitudes. Therefore the author believes, that a borehole of 100 feet in depth should be sufficient for undisturbed measurements".

- 67 - HAALCK H. - Das Aneroid-Seegravimeter. Gerlands Beitr. Geophys., 1963, 72, n°2, S. 89-102.

"Es wird die Entwicklung eines Gravimeters beschrieben, welches in erster Linie für Messungen auf fahrenden Schiffen gedacht ist. Das Instrument besteht in seinem Grund-prinzip aus 2 Teilen, einem Quecksilber- und einem Aneroidbarometer, welche über eine kleine Luftbrücke miteinander verbunden sind. Das Quecksilberbarometer ist von dem Gewicht der Quecksilbersäule anhängig, also der Grösse der Schwerebeschleunigung "g", das Aneroidgravimeter lediglich von der elastischen Widerstandskraft der Aneroiddosen. Infolgedessen ergibt die Differenz der beiden Drucke (also die Verschiebung der beiden Messmenisken) ein Mass für die Änderung der Schwerebeschleunigung.

Aus der Theorie des Instruments, die ausführlich angegeben wird, ergibt sich, welche Dimensionen das Instrument besitzen muss, damit es die nötige Empfindlichkeit erreicht, und sodann, in welchem Verhältnis die einzelnen Teile zueinander stehen müssen, damit sich der Einfluss von Temperaturänderungen gerade kompensiert; es wird bei einer Höhe der Quecksilbersäule von 76 cm ein System von 120 Aneroiddosen benutzt. Zur Erreichung einer gleichmässigen Temperatur dient ein Thermostat. Die experimentelle Bestimmung des Skalenwertes, welche durch kleine Neigungen des Instruments nach verschiedenen Richtungen hin erfolgt, ergibt bei nicht schwankender Aufstellung eine Genauigkeit von etwa 1/100 mgal pro mm Zeigerausschlag. Die Dämpfung besteht im Prinzip darin, dass der Querschnitt der Verbindungsrohre an einer Stelle so verengt wird, dass die Durchflusszeit stufenweise verändert werden kann (praktisch ist die zweckmässigste Stufendämpfung noch nicht genügend ausprobiert; doch bestehen keine prinzipiellen Schwierigkeiten)".
*Die Beobachtungsbedingungen bei Messungen auf See werden ausführlich diskutiert".

- 68 - MORELLI C. - Nuove esperienze con il gravimetro marino Graf-Askania. Oss. Geof. Sper. Trieste, Pub. n°121b, 33p., 1961.

"Heavier damping in the new type of the Graf-Askania Sea Gravimeter introduces a considerable time lag and amplitude reduction of the instrument registration. Laboratory experiments have been therefore performed with the instrument Gss2 n°13 of the Oss. of Sper. in Trieste to study the response of the Instrument to different anomalies of simple form (sudden, linear, sinusoidal, single and composite gravity changes).

Results indicate a time constant of 405 sec., and an attenuation ratio varying from 0.43 for 15 min. period to 0.95 for 100 min. period.

Moreover, indication lag and attenuation ratio do not depend from the amplitude of the gravity variation,

...

For composite sinusoidal variations it has been experimentally verified that the gravity variations registered are equivalent to the algebraic composition of the sinusoidal components, each considered with his own indication lag and his own attenuation ratio.

On this results a simple method has been developed for the elaboration of the Graf-Askania sea-gravimeter registrations. It consists in the assimilation of the registered variation to the simple cases above discussed or in the decomposition of it in two or more of them ; each components is thereafter corrected in accordance with the above mentioned experimental results.

Nomograms are presented for the practical use of this method, which has already been experimented with good success".

- 69 - ORLIN Hyman - Operational evaluation of LaCoste & Romberg air-sea gravity meters S-II and S-I2 aboard US Coast & Geodetic Survey vessels. Prepared for the XIII General Assembly, UGGI, Berkeley California, 1963, 5p.

"To obtain the best possible operational comparison of LaCoste-Romberg Air-Sea gravity meters, the Survey, in conjunction with the U.S. Naval Oceanographic Office, has established an "Evaluation Range in the San Francisco Area". The gravity meters S-II and S-I2 were tested over this range : the test involved a series of 10-mile lines constituting cartwheels...

The error data are tabulated and analysed (grav. S-I2). It is evident that this meter undercorrects for long period horizontal accelerations, that the mean square error for uncorrected data is of the order of 14 mgal and for corrected data of the order of 6 mgal, and that all the data indicate a positive bias. This bias can be reduced to the order of 1 or 2 mgal by application of a suitable correction based upon the filtered horizontal accelerometer traces".

- 70 - POPOV E.I. - Détermination de l'accélération de la pesanteur avec un gravimètre GAL dans un sous-marin. Travaux de l'Inst. de Phys. du Globe n°24 (I9I), Recherches sur les gravimètres, Moscou, 1962, p. 85-II6.

"L'analyse des erreurs permet les conclusions suivantes :

I - La précision des déterminations est limitée :

- a) par les erreurs dues aux courants qui n'ont pas été pris en considération : jusqu'à ± 4 mgal
- b) par les erreurs de déterminations d'emplacement au moment des observations : jusqu'à ± 4 à 5 mgal
- c) par les erreurs sur la profondeur de la mer au point d'observation, dans le calcul des anomalies de réduction de Bouguer : jusqu'à ± 10 à 15 mgal aux grandes profondeurs.

II- La précision des observations de la pesanteur par gravimètres "GAL" dans un sous-marin, est caractérisée par les erreurs quadratiques moyennes suivantes :

- a, anomalies de Faye : en moyenne pour un point ± 3 à 4 mgal
- b) anomalies de Bouguer : en moyenne, pour un point ± 4 à 5 mgal;
dans les zones de grande profondeur jusqu'à ± 10 à 15 mgal.

Les erreurs instrumentales des gravimètres ne dépassent pas $\pm 1,4$ mgal. On peut considérer comme suffisante la précision instrumentale des gravimètres GAL pour les mesures en sous-marin.

III - A l'aide d'un groupe de 5 à 8 gravimètres GAL en sous-marin, on peut enregistrer des variations de la pesanteur de l'ordre de 1500 à 2000 mgal sans revenir pendant 3 ou 4 mois au point de départ. Dans ces conditions, si les appareils sont bien thermos-tatisés, les erreurs instrumentales n'affecteront pas la valeur de la pesanteur observée de plus de ± 2 à 3 mgal, au point le plus "faible".

- 71 - POPOV E.I. - The duration of Observations with Heavily Damped Gravity Meters on a Mobile Base. Bull. Izvestiya, January 1963, Acad. Sci. USSR. C.R. : Geophysics 1963, XXVIII, n°2, p. 345.

"The author suggests a method for the evaluation of the necessary recording duration for the observations by means of gravity meters on a mobile base. As a result of the processing of the recordings made aboard submarines, surface vessels and aircraft, some representative values are obtained. The article describes a new method for the processing of the records from gravity meters by means of an integrator ; this method makes it possible to shorten the duration of the observations considerably".

- 72 - PYRKIN Yu.G. - Autonomous electrovane for the registration of deep currents velocity. Acad. Sci. USSR, Geophys. Bull., 1962, n°11, p.43-46, (texte en russe).

- 73 - ROMANIOUK V.A. - Détermination de l'accélération de la force de pesanteur au moyen d'un gravimètre placé sur une base mobile. Travaux de Inst. Phys. Globe, Moscou, 1961, n°18 (135), "Recherches sur la gravimétrie expérimentale en mer", p. 3-97

- 74 - ROMANIOUK V.A. - Détermination du coefficient d'amortissement d'un gravimètre fortement amorti. v. n°73, p. 125-132.

- 75 - ROMANIOUK V.A. - Observations avec des pendules placés sur une plateforme gyro-stabilisée. v. n°73, p. 132-137.

- 76 - ROMANIOUK V.A. & MIKICHA A.M. - Influence de la forme géométrique de l'arête du couteau du pendule sur le mouvement pendulaire. v. n°73, p. 98-124.

"La méthode d'étude utilisée permet d'établir avec tout le

degré de précision voulu, l'équation différentielle d'un pendule à couteau cylindrique de forme quelconque. On ne tient pas compte de la déformation de l'arête ni du support sous l'effet du poids propre du pendule.

Nous avons examiné deux cas de définition de l'arête du couteau : équations en coordonnées cartésiennes et polaires. Le problème a été étudié à fond dans le cas où l'équation de la courbe est donnée paramétriquement en coordonnées rectangulaires, le paramètre étant l'angle d'écart du pendule. Dans le cas où la courbe de l'arête du couteau est définie en coordonnées polaires, nous avons établi des formules permettant de ramener ce problème au problème précédent.

Nous avons déterminé les termes correctifs concernant l'influence de la géométrie du tranchant sur la période du pendule. La comparaison des formules de correction de la période du pendule antérieurement utilisées (pour un couteau cylindrique circulaire) et des formules trouvées, montre que la formule classique peut conduire à des erreurs notables. Les erreurs possibles ont été calculées pour certaines formes du tranchant ; elles peuvent atteindre $10 \cdot 10^{-7}$ s.

La correction devant être apportée à la période du pendule, provenant de l'influence du paramètre δ_4 présente un caractère systématique ; elle est analogue à la correction d'amplitude. Des cas peuvent se présenter où l'influence du correctif d'amplitude et celle du paramètre δ_4 se compensent. La période du pendule ne dépend plus alors de l'amplitude.

Plusieurs chercheurs ont indiqué que la correction d'amplitude ne tient pas toujours compte totalement de la relation entre la période du pendule et l'amplitude. Cette discordance peut s'expliquer par l'influence de la géométrie de l'arête du couteau sur la période.

- 77- SAGITOV M.U. & MARCHUK G.D. - The Eötvös correction for currents during gravity determinations at sea, Acad. Sci. USSR Geophys. Bull. n°II, Moscou, 1962, p.40-42, (texte en russe).
- 78 - SCHULZE Reinhard. - Automation of the sea Gravimeter Gs-2, J. Geoph. Res., 1962, 67, n°9, p 3397-3401.

"The latest improvement in the sea gravimeter after Graf led to a servo control for setting the measuring spring so that the measuring boom is always held in the zero position over an average period of time. The setting of the measuring spring is recorded by means of a potentiometer, the recorder, and a counter. Thus the direct measuring is extended to approximately 7000 mgal. Lags in recording caused by the extreme heavy damping, as well as reductions in the gravity amplitudes of interest, have been almost entirely eliminated with the automatic servo control. In addition, considerable simplification in operation and data evaluation has been achieved, with a possibility for electronic data reduction".

- 79 - TOMADA Y. & KANAMORI H. - Tokyo Surface Ship Gravity Meter - I. Geophys. Notes, 1962, 15, n°2, p. 116-145.
C.R. : Geophysics, 1964, XXIX, n°1, p. 124-125 (NETTLETON L.L.).

"The gravity measuring part of this ship's gravity meter is a "dynamic" instrument which measures changes in frequency in a vibrating ribbon due to changes in weight of a mass supported by the ribbon. The ribbon, of beryllium copper, is 0.015 mm thick by 0.17 wide and is only 30 mm long and vibrates at a frequency of about 1,800 cps with an effective weight of about 25 grams. The loading mass is a yoke attached by a cross spring to prevent lateral motion. The damping is extremely small : with ambient pressure of 10^{-5} mm of mercury the "Q" value is 25,000. The gravity instrument is mounted on a gyroscopically controlled stabilized platform.

The advantages claimed for the frequency-type gravity meter are :

1. Wide dynamic range as gravity variations of almost 100 per cent can be measured.
2. Digital output as the output signal is frequency modulated.
3. Known sensitivity ; since frequency as well as frequency variations are measured, the ratio $\Delta f/f$ corresponds with $\Delta g/g$.
4. Mechanical stiffness so that the meter is free from effects of cross-coupling between horizontal and vertical acceleration.

The paper contains only a very short remark about actual tests of the instrument on a ship and states that tests over short periods were made in June and August 1962."

- 80 - TSUBOI C. & KANAMORI H. - Continuous Measurements of Gravity on Board a Moving Surface Ship...., Proc. Jap. Acad., 1961, 37, p. 571-576.
C.R. : Geophysics, 1962, XXVII, n°5 p. 728 (KAYTON M.)

"The Geophysical Institute of the University of Tokyo, in collaboration with the Japanese Hydrographic Office, reports the measurement of gravity at sea using a vibrating-string gravimeter (accelerometer). The authors claim an overall measurement accuracy of 3-5 mgal, apparently in shallow water".

- See also n° 79.

- 81 - WORZEL J.L. and DEHLINGER P. - Comparison of Graf and LaCoste-Romberg Sea Gravimeters, Paper presented at the 43th Annual Meeting, Amer. Geoph. Un., Washington D.C., April 25-28, 1962.
C.R. : J. Geoph. Res., 1962, 67, n°9, p.3611.

"The latest models of the Graf sea gravimeter and the LaCoste-Romberg sea gravimeter were installed, adjacent to each other, on R.V. VEMA in the fall of 1960. Comparison measurements were made with the two meters on a cruise from New York via Bermuda to Puerto Rico, to Key West, and to Galveston Texas.

Owing to instrumental difficulties, useful comparison measurements were obtained for only three crossings of the Puerto Rico trench. The first such crossing was planned to follow the line of submarine pendulum measurements made on USS. DIABLO, so that comparisons could be made with the previous pendulum measurements. Both meters show the major details of this gravity structure in agreement with the pendulum data. In detail there are differences between the two meters, and between each meter and the pendulum data. These differences and the sources and magnitudes of errors are discussed".

- 82 - WORZEL J.L. & TALWANI M. - Investigations of the Cross-coupling Effect of the Graf Sea Gravimeter. Paper presented at the 43th Annual Meeting Washington D.C., April 25-28, 1962.
C.R. : J. Geoph. Res. , 1962, 67, n°9, p. 3611.

"Two early-model Graf gravimeters were mounted with beams pointed in opposite directions on the same stable platform on USS "COMPASS ISLAND". Only very small effects that could be attributed to cross-coupling were observed, although the high drift rate of one meter makes the results less conclusive than would be desired. Three-component accelerometer records have been obtained on USS "COMPASS ISLAND" and on R.V. VEMA. Analysis of the analogue records for a number of sea conditions shows that these ships rarely move in circular orbits and never for more than a minute or so at any one time. In general there is poor correlation of amplitude and phase between the vertical and horizontal accelerations. An analogue model of the Graf sea gravimeter is being made with the objective of determining the cross-coupling term from extensive magnetic tapes of the accelerometer records for many sea conditions for R.V. "VEMA".

B) GENERALITES et RESULTATS

- 83 - BOTT M.H.M. - A gravity survey off the coast of North-East England. Proc. of the Yorkshire Geol. Soc., 1961, 33, Part I, n°1, 20p. + 1 carte.

"During summer 1959, seventy-five gravity measurements were made off the Durham coast, north-east England, using an underwater gravimeter. The Bouger anomalies are interpreted as indicating the pattern of Lower Carboniferous sedimentation associated with the seaward extensions of the Ninety Fathom and Butterknowle Faults".

- 84 - CAPUTO M. - Gravity surveys at sea by the Institute of geophysics at UCLA. Inst. Geoph. Planetary Phys. Univers. of California, 1963, typewritten text, presented to the XIII General Assembly UGGI, Berkeley 1963, 13 p.

"On the gravity surveys at sea made for the past five years by the Marine Gravity Project of the Institute of Geophysics at UCLA ; approximately 80 000 miles of track have been measured.

.../...

Widely spaced tracks make up the majority of the mileage (20,000 miles in the Pacific Ocean, 24,000 in the Indian Ocean, 2,000 in the South China Sea and 4,000 in the Atlantic Ocean) but 3 areas have been surveyed in detail (Gulf of California, California borderland, Indonesian archipelago).

Free air anomalies have been published in interim reports on the results of the various cruises".

- 85 - CAPUTO M. , HARRISON J.C., ROLAND Von HUENE, & HELFER M.D. - Accuracy of Gravity Measurements off the Coast of Southern California. J. Geoph. Res. 1963, 68, n°10, p. 3273-3282.

"Two hundred and thirty-one track intersections obtained on eight surface-ship gravity traverses in the continental borderland off southern California have been analyzed to evaluate the over-all consistency of the surveys and to search for possible consistent errors among them. The over-all accuracy of the data is such that the mean discrepancy at an intersection is 6.8 mgal and the discrepancy is less than 7 mgal at two-thirds of the crossings. Elimination of intersections where the discrepancy in sounding exceeds 90 meters improves these figures significantly. Any constant differences between the surveys do not exceed about 2 mgal".

- 86 - CAPUTO M. , MASADA R., HELFER M. & HAGER C.L. - Gravity measurements in the Atlantic, Pacific, and Indian Oceans May 1962 - Aug. 1963 (R/V ARGO). Inst. Geoph. Planetary Phys. Univers. of California, Los Angeles, Interim Report n°7, 1964, 19 p.

"This report is a compilation of the gravity data collected in the Atlantic, Pacific, and Indian Oceans from May 1962 to August 1963, during the Scripps Institution of Oceanography's Lusiad expedition. During the 15 month operation of the sea water (LaCoste-Romberg Sea Meter # 3), 19,837 measurements were made over 45,643 miles of track. The main area of study was the Indian Ocean where two-thirds of the measurements were made. An estimate of the accuracy of the data was accomplished by comparing gravity values at crossings and parallel tracks.

The drift of the sea meter was checked with the LaCoste-Romberg Geodetic Meter DL I at 17 ports throughout the cruise : the drift rate averaged - 0,072 mgal/day over the entire cruise".

- 87 - CORBATO C.E. & HELFER M.D. - Gravity measurements on the Cruise of the U.S.S. Gear, October 23-27, 1961. Inst. Geoph. & Planetary Physics, Interim Report, 1962, Los Angeles, 19p.

"Additional measurements in Northern Borderland area 32°30' 34°30'N, 121°30, 118°W (off the coast of Southern California.)

but with two expansions beyond the continental slope ; 495 measurements at 2 mile intervals.

Port connections : San Pedro (California).

Free air anomalies are tabulated.

32 crossings including crossings of previous surveys (mean difference 5.6 mgal)".

- 88 - DRAKE C.L. & GIRDLER R.W. - A Geophysical Study of the Red Sea. Geoph. J. the R. Astr. Soc., 1964, 8, n°5, July 1964, p. 473 - 475.

"A description is given of the bottom topography seismic refraction profiles, magnetic and gravity observations in the Red Sea. The deep trough along the centre is associated with positive Bouguer gravity anomalies, large magnetic anomalies and seismic velocities of 7.1 km/s. It appears that this represents a fissure in the continental crust, partly filled with basic, igneous material. A structural map, based on all the geophysical evidence, has been prepared and it is suggested that the complex Red Sea rift was formed as a result of crustal tension. Finally, a discussion is given of the Red Sea as part of the world rift system".

- 89 - FLEISCHER U. - Surface-Ship gravity measurements in the North Sea. Geophysical Prospecting, 1963, XI, n°4, p. 535-549, C.R. : Geophysics, 1964, XXIX, n°1, p. 147.

"Modern marine gravimeters enable us to measure gravity at sea with a mean error of 2 to 5 mgal depending on sea conditions and navigational accuracy.

Good results could be obtained, even in rough seas, by means of Graf's ASKANIA-Sea Gravimeter mounted on an ANSCHUT gyro-stabilized platform.

When a DECCA Navigator System is used, the gravity measured at the points of intersection agrees within 5 mgal at wind-force Beaufort 4 and vertical accelerations of about 60,000 mgal.

The southern North Sea has been surveyed with VFS "GAUSS", the research vessel of the German Hydrographic Institute, Hamburg. Since 1959, about 4,000 miles of continuous gravity measurements combined with simultaneous magnetic measurements have been carried out in this area. Here nearly all remote-control gravimeter stations of the Netherlands Geodetic Commission were passed once or several times. Hence, they could be used as basic points. However, there are a few cases in which the Dutch data could not be confirmed.

The results are given as a free air isogram map covering the area between the meridian of Greenwich and 8 degrees east, and between 54 degrees and 56 degrees latitude, with decreasing density of the measurements from east to west".

- 90 - GANTAR C. & MORELLI C. - Misure di gravità sul fondo dei mari intorno alla Sardegna con gravimetro telecomandato, Boll. di Geof. teor. ed. App., 1962, IV, n°15, p. 286-299.

"Observed and reduced gravity values of 318 measurements made at the bottom of the seas around Sardegna with remotely controlled gravimeter are here presented. Maximum depth is 190 meters".

- 91 - HARRISON J.C. - Gravity measurements in the Northern continental Borderland Area off Southern California, 1958-59, Inst. Geoph. & Planetary Physics Univ. Calif, Los Angeles, 1961, Interim Report, 4p. + tab/ and map.

"Area lies between 32° and 34°N. and 117° and 120° W.G. The survey was made, with a LaCoste-Romberg surface ship gravity meter (#3), on board the U.S.S. Butternut, AN-9 in 1959 (809 stations)

- 977 gravity values (including measurements on R.V. Horizon in 1958) at 2 mile intervals, relatively evenly spaced east of 119° W ;
- Few measurements S.W. of 119° W, 33° N
- Port connections = Long Beach (California)
- Free air and Bouguer anomalies
- 41 crossings (mean difference 4.9 mgal)".

- 92 - HARRISON J.C. - Gravity measurements in the Southern continental Borderland West of Baja, California, 1959, Inst. of Geoph. & Planetary Phys. Univ. Calif., Los Angeles, 1962, Interim Report, 6p. + tab. and map,

- " Area lies between 28° and 32°30' N and 114° 30' and 119°30' W, G.
- 1609 gravity values at 2 mile intervals, about 2/3 rds. of them north of 30° 30'N. port connections : San Diego (California).
 - Free air and Bouguer anomalies are listed. Maps of free air anomalies.
 - 32 crossings (mean difference 5.3 mgal)".

- 93 - HARRISON J.C. & SPIESS F.N. - Gravity measurements in the Gulf of California, 1959, Inst. Geoph. & Planetary Physics, Univ. Calif., Los Angeles, 1961, Interim Report, 11p. + tabl. and maps.

" 32 crossings of Gulf ; 2078 gravity stations at 2 mile intervals in Gulf and near mouth of Gulf.

Port connections : San Diego (Calif.) and Mazatlan, La Paz, Guaymas, San Felipe (Mexico). Free air and Bouguer anomalies.

Data checked at 27 locations with underwater meter (mean difference : 2.7 mgal \pm 1.5) and at 9 locations with geodetic meter (mean difference : 1.1 mgal \pm 2.6)".

- 94 - HELFER M.F., Von HUENE R. & CAPUTO M. - Gravity survey of the Santa Barbara Channel with the U.S.S. Rexburg, 1962. Inst. Geoph. & Planetary Physics, Univ. Calif. Los Angeles, 1962, Interim Report, 16 p. + map.

"458 gravity measurements : 118 on the way to the Channel from San Diego at 2 mile intervals and 340 in the Santa Barbara Channel. 13 N-S lines, 4 E.W.

Port Connections : San Diego (Calif.)

Free air anomalies

81 crossings including crossings of previous surveys (mean difference 3.9 mgal)".

- 95 - HELFER M.D., CAPUTO M. & HARRISON J.C. - Gravity Measurements in the Pacific and Indian Oceans Monsoon Expedition 1960, 1961. Inst. Geoph. and Planetary Physics, Univ. Calif. Los Angeles, Nov. 1962, Interim Report, 42p. + maps.

"37 000 miles cruise with 7 009 gravity measurements in portions at 2 mile intervals across the Pacific Ocean and the Indian Ocean.

Port connections : San Diego (Calif.), Honolulu (Hawaii) Cairns and Darwin (Australia), Jakarta (Indonesia), Port Louis (Mauritius), Freemantle and Hobart (Australia), Papeete (Tahiti) San Diego (California).

Free air anomalies.

13 crossings (mean difference ; 6.5 mgal)".

- 96 - HENDERSON G.C. - Preliminary study of the crustal structure across the Campeche escarpment from gravity data. Geophysics, 1963, XXVIII, n°5, p. 736-744, 3 figs.

"A possible structure of the earth's crust across Campeche Escarpment, Gulf of Mexico, was resolved by utilizing the gravity measurements made on the A & M College of Texas Research Vessel HIDALGO and by combining these data with published seismic information. The LaCoste-Romberg surface-ship gravity meter S-9 of A & M College, owned by the Office of Naval Research, was the gravity instrument used. The method used effectively reduces an infinite number of possible structures to a few possible structures. A total of 915 km of continuous gravity profile was traversed from June 29 to July 1, 1961. Accuracy of the gravity profiles appears to be satisfactory for this kind of crustal investigation. This report is intended as a basis for further studies : no attempts were made to ascertain the geologic events in detail. From this investigation it appears that the escarpment is nontectonic in origin, although the possibility of a crustal fault below the escarpment cannot be ignored".

- 97 - Von HUENE Roland and HAGER C.L.
Gravity Data from two Cruises Aboard the USNS CHARLES H. DAVIS (AGOR-5),
Inst. Geoph. Planetary Phys. Univ. Calif. Los Angeles, Interim Report
N° 8, Dec. 1964, 8 p. + maps.

" A listing of gravity observations made in the Santa Barbara Channel, in several sections of the Northern Continental Shelf and off Santa Catalina Island. The area near Santa Catalina is suitable for a future gravity meter calibration range. Observations made from Nov. 1963 to Jan. 1964. (LaC.-R. gravity meter # 3)".

- 98 - LONCAREVIC B.D. - Sea Gravity base stations, U.M.S. OWEN 1961-1962.
Dept. Geod. & Geoph., Cambridge 1962, 3p. + 9 sketch.

"This preliminary Report contains the principal facts regarding gravity base stations round the North Western part of the Indian Ocean. These stations were established during the 1961-62 cruise of H.M.S. OWEN and were used in the subsequent reduction of sea gravimeter readings.

The accuracy of connexions of all stations except Port Victoria and Gan is better than $\pm 0,2$ mgal.

Sketches of Devonport, Aden, Lamu (Kenya), Mombasa, Karachi, Bombay, Port Victoria (Seychelles), Gan (Addu Atoll), Port Louis (Mauritius).

- 98^{bis} - LONCAREVIC B.D. & MATTHEWS D.H. - Bathymetric, Magnetic and gravity Investigations H.M.S. Owen 1961-1962. Admiralty Marine Science Publication, 1963, n°4 —. Part I : texte (43p.+figures.) - Part II : Profiles (35prof. + chart).

Part I "The first 5 chapters deal with navigation, bathymetry, and magnetism measurements.

The 6th Chapter deals with Gravity Measurements ; the observations were made with a shipborne sea gravimeter Gss 2-II Askania and a gyrostabilized platform Anschütz.

The accuracy of the measurements reported here is about 5 mgal. The calibration of the gravimeter was performed over the Geological Survey Long Calibration Line.

The sea measurements were connected at the gravity base stations situated in harbours, with a Worden Master gravimeter. Calculated free air anomalies were plotted and compared with the original traces and where necessary smoothed. These smoothed anomalies are presented in Part II of this publication.

Part II Explanation of Profiles
Profiles
Track Chart and Profil Index.

- 99 - MORELLI C. - Gravity survey of the continental shelf around Italy.
(with an appendix on the magnetic survey of Southern Italy). Extrait des Rapports et Procès-Verbaux des réunions de la C.I.E.S.M.M., 1962, XVI, fasc. 3.

"Statistical data on the different gravity surveys around the Italian coasts realized from 1953 to 1960 by the Osserv. Geof. Sp. of Trieste ; (3453 stations observed with an underwater gravity meter)".

- 100 - ORLIN H., JONES R.B., FANNING K.F., GAROUTTE S.K. - Sea gravity phase - Oceanographic Equipment Evaluation Range - San Francisco, California.
U.S. Department of Commerce, U.S. Naval Oceanographic Office, 1962,
24 p. + maps.

"This report concerns an ocean gravity meter test range established in April and May 1962 by means of a cooperative survey by the Coast and Geodetic Survey... This range was established to facilitate operational tests and evaluations of continuous reading sea gravity meters. The range consists of 127 underwater gravity stations spaced over a 700 sq. mile area in the approaches to San Francisco, California. The report summarizes the operation and data obtained during the survey including a number of gravity ties made between existing stations in the San Francisco area. Tables of gravity data and bathymetry and gravity contoured charts of the range are included".

- IOI - TALWANI Manik. - Gravity Measurements on HMS Acheron in South Atlantic and Indian Oceans. Bull., Geoph. Soc. Amer., 1962, 73, p. II7I-II82.

"About 40 gravity observations were made by means of the Vening Meinesz pendulum apparatus aboard the British submarine HMS ACHERON in 1959.

Features over which the gravity measurements were made included the Walvis Ridge, the Continental margin of Capetown, the Mozambique Channel, and the seismically active Mid-Indian Ridge".

- IO2 - TALWANI M., HEEZEN B.C., WORZEL J.L. - Gravity anomalies physiography and crustal structure of the Mid-Atlantic Ridge. Pub. Bureau Central Séism. Int., 1961, Sér. A, Trav. Sci., n°22, p. 8I-II2 (Ass. Génér. Helsinki, 1960).

"In 1958 a Graf sea gravimeter was used aboard the U.S.S. Compass Island to obtain continuous gravity measurements across the Mid-Atlantic Ridge. The entire Mid-Atlantic Ridge is characterized by small positive free-air anomalies which for the most part, range from zero to + 50 mgal. The ridge is thus, apparently, nearly in isostatic compensation, departures being on the side of under-compensation. Bouguer anomalies are systematically smaller over the ridge than over the ocean basins. Minimum values are found over the crest provinces.

A median rift valley associated with the mid-Atlantic seismic belt was found in earlier work to show a large positive magnetic anomaly. The free-air anomalies on the U.S.S. Compass Island gravity profile show a 50 mgal minimum over the rift valley. However this disappears in the Bouguer anomaly, showing that it was associated only with the rugged topography.

Assuming a general structure of the ridge based on seismic refraction studies, three possible sections are presented to show how the structure changes under the crest provinces to provide the necessary isostatic compensation. These structures are discussed in light of the other geophysical anomalies associated with the crest provinces in general and the rift valley in particular".

- I03 - UNIVERSITY OF CALIFORNIA - Gravity surveys at sea, Inst. of Geoph., UCLA, (report to the meeting of the Int. Grav. Commission, Paris, sept. 10-15, 1962), 1962.

Liste des principales campagnes et étude de leur précision.

- I04 - U.S. NAVAL OCEANOGRAPHIC OFFICE - Gravity meter operational check range Rhode Island Sound Area, Marine Sciences Department, Washington 25, D.C., June 1962, Unpublished Manuscript (Rep. n°GI-62)

"A gravity meter operational check range has been established at sea in the Rhode Island Sound area. Although not as extensive as originally planned, this range provides an area of known gravity 14 miles north-south and 30 miles east-west with a central area of approximately 225 square miles. This range is believed adequate to allow testing and evaluating sea gravity meters over an area of known gravity under actual survey conditions.

An outstanding feature of this range is its location which makes it convenient for use by ships departing and returning to ports on the northeast coast of the U.S."

- I05 - U.S. NAVAL OCEANOGRAPHIC OFFICE - Gravity meter evaluation and training range, Chesapeake Bay, Marine Science Department, Washington 25, D.C., June 1962, Unpublished Manuscript (Report G-2-62).

"This report concerns the establishment of a gravity meter evaluation and training range in Chesapeake Bay. The value of gravity was observed at 22 positions located between Cove Point and Point Lookout. Results and values obtained are given.

A gravity meter-evaluation and training range with a high order of accuracy has been established in the Chesapeake Bay and Patuxent River. Gravity meters may be tested over a range of 8 miles east-west and more than 25 miles north-south. This Range affords a fairly rapid and inexpensive opportunity for the Gravity Branch to evaluate gravity meter operation and train personnel".

- I06 - U.S. NAVAL OCEANOGRAPHIC OFFICE - Costal gravity survey, Eastern Puerto Rico, Marine Science Department, Washington 25 D.C., April 1963, Unpublished manuscript (Report G-2-63).

"A free air anomaly chart of the eastern tip of Puerto Rico and Vieques Sound is presented, along with a tabulated list of land gravity observations in eastern Puerto Rico and adjacent islands.

This survey was accomplished during the fall of 1961 in conjunction with an underwater gravity survey in Vieques Sound.

Two LaCoste and Romberg gravity meters were used".

- IO7 - WORZEL J. Lamar - Report on Gravity Measurements at Sea for the IUGG at Berkeley August 1963 reproduced in the Bull. d'Inf., B.G.I., Paris, 1963, n°5, p.17-25.

This report covers the gravity measurements at sea since the fall of 1960.

- IO8 - YUNGUL S.H. and DEHLINGER Peter. - Preliminary Free-Air Gravity Anomaly Map of the Gulf of Mexico from Surface-Ship Measurements and Its Tectonic Implications. J. Geoph. Res., 1962, 67, n°12, p. 4721- 4728.

"Free-air gravity anomalies have been obtained aboard the R.V. "HIDALGO" in the Gulf of Mexico with a LaCoste and Romberg Surface-ship gravity meter. The data obtained are along several profiles in portions of the western Gulf of Mexico, across the West Florida escarpment, and east of Yucatan. The accuracy of measurements is estimated to be within ± 12 mgal. A preliminary map of free-air anomalies is presented and some of its crustal structural implications are discussed, particular reference being made to a profile from the Yucatan Peninsula to Beaumont, Texas. Free-air anomalies obtained in the main basin of the Gulf display fairly large variations from -60 to + 40 mgal. The gravity data are in agreement with those published by Vening Meinesz and Wright on the basis of their 1928 submarine pendulum measurements if certain corrections are made to their measurements, but they are in large disagreement with one pendulum measurement. The gravity meter data indicate, contrary to former opinions based on too few data and speculations, that the main basin of the Gulf is nearly in isostatic equilibrium".

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