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BUREAU GRAVIMETRIQUE INTERNATIONAL

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INFORMATIONS FOR CONTRIBUTORS

Contributors should follow as closely as possible the rules below :

Manuscripts should be typed (double-spaced) in Prestige-Elite characters (IBM-type), on one side of plain paper 21 cm x 29,7 cm, with a 2 cm margin on the left and right hand sides as well as on the bottom, and with a 3 cm margin at the top (as indicated by the frame drawn on this page).

Title of paper. Titles should be carefully worded to include only key words.

Abstract. The abstract of a paper should be informative rather than descriptive. It is not a table of contents. The abstract should be suitable for separate publication and should include all words useful for indexing. Its length should be limited to one typescript page.

Table of contents. Long papers may include a table of contents following the abstract.

Footnotes. Because footnotes are distracting, they should be avoided as much as possible.

Mathematics. For papers with complicated notation, a list of symbols and their definitions should be provided as an appendix. All characters that are available on standard typewriters should be typed in equations as well as test. Symbols that must be handwritten should be identified by notes in the margin. Ample space (1.9 cm above and below) should be allowed around equations so that type can be marked for the printer. Where an accent or underscore has been used to designate a special type face (e.g., boldface for vectors, script for transforms, sans serif for tensors), the type should be specified by a note in a margin. Bars cannot be set over superscripts or extended over more than one character. Therefore angle brackets are preferable to accents over characters. Care should be taken to distinguish between the letter 0 and zero, the letter l and the number one, kappa and k, mu and the letter u, nu and v, eta and n, also subscripts and superscripts should be clearly noted and easily distinguished. Unusual symbols should be avoided.

Acknowledgements. Only significant contributions by professional colleagues, financial support, or institutional sponsorship should be included in acknowledgements.

References. A complete and accurate list of references is of major importance in review papers. All listed references should be cited in text. A complete reference to a periodical gives author (s), title of article, name of journal, volume number, initial and final page numbers (or statement "in press"), and year published. A reference to an article in a book, pages cited, publisher's location, and year published. When a paper presented at a meeting is referenced, the location, dates, and sponsor of the meeting should be given. References to foreign works should indicate whether the original or a translation is cited. Unpublished communications can be referred to in text but should not be listed. Page numbers should be included in reference citations following direct quotations in text. If the same information has been published in more than one place, give the most accessible reference ; e.g. a textbook is preferable to a journal, a journal is preferable to a technical report.

Tables. Tables are numbered serially with Arabic numerals, in the order of their citation in text. Each table should have a title, and each column, including the first, should have a heading. Column headings should be arranged to that their relation to the data is clear.

Footnotes for the tables should appear below the final double rule and should be indicated by a, b, c, etc. Each table should be arranged to that their relation to the data is clear.

Illustrations. Original drawings of sharply focused glossy prints should be supplied, with two clear Xerox copies of each for the reviewers. Maximum size for figure copy is (25.4 x 40.6 cm). After reduction to printed page size, the smallest lettering or symbol on a figure should not be less than 0.1 cm high ; the largest should not exceed 0.3 cm. All figures should be cited in text and numbered in the order of citation. Figure legends should be submitted together on one or more sheets, not separately with the figures.

Mailing. Typescripts should be packaged in stout padded or stiff containers ; figure copy should be protected with stiff cardboard.

BUREAU GRAVIMETRIQUE INTERNATIONAL

Toulouse

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INTERNAL MATTER

GENERAL INFORMATIONS

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1. HOW TO OBTAIN THE BULLETIN

The Bulletin d'Information of the Bureau Gravimétrique International issued twice a year, generally at the end of June and end of December.

The Bulletin contains general informations on the community, on the Bureau itself. It informs about the data available, about new data sets...

It also contains contributing papers in the field of gravimetry, which are of technical character. More scientifically oriented contributions should better be submitted to appropriate existing journals.

Communications presented at general meeting, workshops, symposia, dealing with gravimetry (e.g. IGC, S.S.G.'s,...) are published in the Bulletin when appropriate - at least by abstract.

Once every four years, a special issue contains (solely) the National Reports as presented at the International Gravity Commission meeting. Other special issues may also appear (once every two years) which contain the full catalogue of the holdings.

About three hundred individuals and institutions presently receive the Bulletin.

You may :

- *either request a given bulletin, by its number (67 have been issued as December 1, 1990, but numbers 2, 16, 18, 19 are out of print).*
- *or subscribe for regularly receiving the two bulletins per year plus the special issues.*

Requests should be sent to :

Mrs. Nicole ROMMENS
CNES/BGI
18, Avenue Edouard Belin
31055 TOULOUSE CEDEX - FRANCE

Bulletins are sent on an exchange basis (free of charge) for individuals, institutions which currently provide informations, data to the Bureau. For other cases, the price of each number is as follows :

- 65 French Francs without map,

- 75 French Francs with map.

2. HOW TO REQUEST DATA

2.1. Stations descriptions Diagrams for Reference, Base Stations (including IGSN 71's)

Request them by number, area, country, city name or any combination of these.

When we have no diagram for a given request, but have the knowledge that it exists in another center, we shall in most cases forward the request to this center or/and tell the inquiring person to contact the center.

Do not wait until the last moment (e.g. when you depart for a cruise) for asking us the information you need : station diagrams can only reach you by mail, in many cases.

2.2. G-Value at Base Stations

Treated as above.

2.3. Mean Anomalies, Mean Geoid Heights, Mean Values of Topography

The geographic area must be specified (polygon). According to the data set required, the request may be forwarded in some cases to the agency which computed the set.

2.4. Gravity Maps

Request them by number (from the catalogue), area, country, type (free-air, Bouguer...), scale, author, or any combination of these.

Whenever available in stock, copies will be sent without extra charges (with respect to usual cost - see § 3.3.2.). If not, two procedures can be used :

- *we can make (poor quality) black and white (or ozalide-type) copies at low cost,*
- *color copies can be made (at high cost) if the user wishes so (after we obtain the authorization of the editor).*

The cost will depend on the map, type of work, size, etc... In both cases, the user will also be asked to send his request to the editor of the map before we proceed to copying.

2.5. Gravity Measurements

They can be requested :

(a) either from the CGDF (Compressed Gravity Data File). the list and format of the informations provided are the following :

CGDF RECORD DESCRIPTION

70 CHARACTERS

Col. 1	*Classification code - 0 if not classified*
2- 8	*B.G.I. source number*
9- 15	*Latitude (unit = 1/10 000 degree)*
16- 23	*Longitude (unit = 1/10 000 degree)*
24	*Elevation type* *1 = Land* *2 = Subsurface* *3 = Ocean surface* *4 = Ocean submerged* *5 = Ocean Bottom* *6 = Lake surface (above sea level)* *7 = Lake bottom (above sea level)* *8 = Lake bottom (below sea level)* *9 = Lake surface (above sea level with lake bottom below sea level)* *A = Lake surface (below sea level)* *B = Lake bottom (surface below sea level)* *C = Ice cap (bottom below sea level)* *D = Ice cap (bottom above sea level)* *E = Transfer data given*

25- 31	*Elevation of the station (0.1 M)* *This field will contain depth of ocean positive downward)* *if col. 24 contains 3, 4 or 5.*
32- 36	*Free air anomaly (0.1 mgal)*
37- 38	*Estimation standard deviation free air anomaly (mgal)*
39- 43	*Bouguer anomaly (0.1 mgal)* *Simple Bouguer anomaly with mean density of 2.67 - N_o terrain correction*
44- 45	*Estimation standard deviation Bouguer anomaly (mgal)*
46	*System of numbering for the reference station* *1 = IGNS 71* *2 = BGI* *3 = country* *4 = DMA*
47- 53	*Reference station*
54- 56	*Country code*
57	*1 : measurement at sea with no depth given* *0 : otherwise*
Col. 58	*Information about terrain correction* *0 = no information* *1 = terrain correction exists in the archive file*
59	*Information about density* *0 = no information or 2.67* *1 = density ≠ 2.67 given in the archive file*
60	*Information about isostatic anomaly* *0 = no information* *1 = information exists but is not stored in the archive file* *2 = information exists and is included in the archive file.*
61	*Validity* *0 = no validation* *1 = good* *2 = doubtful* *3 = lapsed*
62- 70	*Station number in the data base.*

(b) *or from the Archive file. The list and format of the informations provided are the following :*

ARCHIVE FILES

RECORD DESCRIPTION

160 CHARACTERS

Col. 1- 7	*B.G.I. source number*
8- 12	*Block number* *Col. 8-10 = 10 square degree* *Col. 11-12 = 1 square degree*
13- 19	*Latitude (Unit : 1/10 000 degree)*
20- 27	*Longitude (unit : 1/10 000 degree) (- 180 to + 180 degree)*
28	*Accuracy of position* *The site of the gravity measurement is defined in a circle of radius R* *0 = no information on the accuracy* *1 = R <= 20 M (approximately 0'01)* *2 = 20 < R <= 100* *3 = 100 < R <= 200 (approximately 0'1)* *4 = 200 < R <= 500*

5 = 500 < R <= 1000
6 = 1000 < R <= 2000 (approximately 1')
7 = 2000 < R <= 5000
8 = 5000 < R
9 ...

29 System of position
0 = unknown
1 = Decca
2 = visual observation
3 = radar
4 = loran A
5 = loran C
6 = omega or VLF
7 = satellite
9 = solar/stellar (with sextant)

30-31 Type of observation
A minus sign distinguishes the pendulum observations from the gravimeter ones.
0 = current observation of detail or other observations of a 3 rd or 4th order network
1 = observation of a 2nd order national network
2 = observation of a 1st order national network
3 = observation being part of a nation calibration line
4 = individual observation at sea
5 = mean observation at sea obtained from a continuous recording
6 = coastal ordinary observation (Harbour, Bay, Sea-side...)
7 = harbour base station

32 Elevation type
1 = Land
2 = Subsurface
3 = Ocean surface
4 = Ocean submerged
5 = Ocean bottom
6 = Lake surface (above sea level)
7 = Lake bottom (above sea level)
8 = Lake bottom (below sea level)
9 = Lake surface (above sea level with lake bottom below sea level)
A = Lake surface (below sea level)
B = Lake bottom (surface below sea level)
C = Ice cap (bottom above sea level)
D = Ice cap (bottom above sea level)
E = Transfer data given

33-39 Elevation of the station (0.1 M)
This field will contain depth of ocean (positive downward) if col. 32 contains 3, 4 or 5

40 Accuracy of elevation (E)
0 = unknown
1 = E < = 0.1 M
2 = 1 < E < = 1
3 = 1 < E < = 2
4 = 2 < E < = 5
5 = 5 < E < = 10
6 = 10 < E < = 20
7 = 20 < E < = 50
8 = 50 < E < = 100
9 = E superior to 100 M

41-42 *Determination of the elevation*
  = no information
0 = geometrical levelling (bench mark)
1 = barometrical levelling
3 = data obtained from topographical map
4 = data directly appreciated from the mean sea level
5 = data measured by the depression of the horizon (marine)
Type of depth (if Col. 32 contains 3, 4 or 5)
1 = depth obtained with a cable (meters)
2 = manometer depth
4 = corrected acoustic depth (corrected from Mathew's tables, 1939)
5 = acoustic depth without correction obtained with sound speed 1500 M/sec. (or 820 Brasses/sec)
6 = acoustic depth obtained with sound speed 800 Brasses/sec (or 1463 M/sec)
9 = depth interpolated on a magnetic record
10 = depth interpolated on a chart

43-44 *Mathews' zone*
When the depth is not corrected depth, this information is necessary.
For example : zone 50 for the Eastern Mediterranean Sea

45-51 *Supplemental elevation*
Depth of instrument, lake or ice, positive downward from surface

52-59 *Observed gravity (0.01 mgal)*

60 *Information about gravity*
1 = gravity with only instrumental correction
2 = corrected gravity (instrumental and Eotvos correction
3 = corrected gravity (instrumental, Eötvös and cross-coupling correction)
4 = corrected gravity and compensated by cross-over profiles

61 *Accuracy of gravity (e)*
When all systematic corrections have been applied
0 = E < = 0.05
1 = .05 < E < = 0.1
2 = 0.1 < E < = 0.5
3 = 0.5 < E < = 1.
4 = 1. < E < = 3.
5 = 3. < E < = 5.
6 = 5. < E < = 10.
7 = 10. < E < = 15.
8 = 15. < E < = 20.
9 = 20. < E

62 *System of numbering for the reference station*
This parameter indicates the adopted system for the numbering of the reference station
1 = for numbering adopted by IGSN 71
2 = BGI
3 = Country
4 = DMA

63-69 *Reference station*
This station is the base station to which the concerned station is referred

70-76 *Calibration information (station of base)*
This zone will reveal the scale of the gravity network in which the station concerned was observed, and allow us to make the necessary corrections to get an homogeneous system

77-81 *Free air anomaly (0.1 mgal)*

82-86 *Bouguer anomaly (0.1 mgal)*
Simple bouguer anomaly with a mean density of 2.67 - No terrain correction

87-88 *Estimation standard deviation free air anomaly (mgal)*

89-90	*Estimation standard deviation bouguer anomaly (mgal)*
91-92	*Information about terrain correction* *Horizontal plate without bullard's term* *0 = no topographic correction* *1 = CT computed for a radius of 5 km (zone H)* *2 = CT 30 km (zone L)* *3 = CT 100 km (zone N)* *4 = CT 167 km (zone 02)* *11 = CT computed from 1 km to 167 km* *12 = CT 2.5 167* *13 = CT 5.2 167*
93-96	*Density used for terrain correction*
97-100	*Terrain correction (0.1 mgal)* *Computed according to the previously mentioned radius (col. 91-92) & density (col. 93-96)*
101-103	*Apparatus used for the measurements of G* *0.. pendulum apparatus constructed before 1932* *1.. recent pendulum apparatus (1930-1960)* *2.. latest pendulum apparatus (after 1960)* *3.. gravimeters for ground measurements in which the variations of G are equilibrated of detected using the following methods :* *30 = torsion balance (Thyssen...)* *31 = elastic rod* *32 = bifilar system* *4.. Metal spring gravimeters for ground measurements* *42 = Askania (GS-4-9-11-12), Graf* *43 = Gulf, Hoyt (helical spring)* *44 = North American* *45 = Western* *47 = Lacoste-Romberg* *48 = Lacoste-Romberg, Model D (microgravimeter)* *5.. Quartz spring gravimeter for ground measurements* *51 = Norgaard* *52 = GAE-3* *53 = Worden ordinary* *54 = Worden (additional thermostat)* *55 = Worden worldwide* *56 = Cak* *57 = Canadian gravity meter, sharpe* *58 = GAG-2* *6.. Gravimeters for under water measurements (at the bottom of the sea or of a lake* *60 = Gulf* *62 = Western* *63 = North American* *64 = Lacoste-Romberg* *7.. Gravimeters for measurements on the sea surface or at small depth (submarines..)* *70 = Graf-Askania* *72 = Lacoste-Romberg* *73 = Lacoste-Romberg (on a platform)* *74 = Gal and Gal-F (used in submarines) Gal-M* *75 = AMG (USSR)* *76 = TSSG (Tokyo Surface Ship Gravity meter)* *77 = GSI sea gravity meter*
104	*Conditions of apparatus used* *1 = 1 gravimeter only (no precision)* *2 = 2 gravimeters (no precision)* *3 = 1 gravimeter only (without cross-coupling correction)* *4 = 2 gravimeters (influenced by the cross-coupling effect) with the same orientation*

	5 = 2 gravimeters (influenced by the cross-coupling effect) in opposition *6 = 1 gravimeter (compensated for the cross-coupling effect)* *7 = 1 gravimeter non subject to cross-coupling effect* *8 = 3 gravimeters*
105	*Information about isostatic anomaly* *0 = no information* *1 = information exists but is not stored in the data bank* *2 = information exists and is included in the data bank*
106-107	*Type of the isostatic anomaly* *0.. Pratt-Hayford hypothese* *01 = 50 km including indirect effect (Lejay's tables)* *02 = 56.9 km* *03 = 56.9 km including indirect effect* *04 = 80 km including indirect effect* *05 = 96 km* *06 = 113.7 km* *07 = 113.7 km including indirect effect* *1.. Airy hypotheses (equality of masses or pressures)* *10 = T = 20 km (Heiskanen's tables, 1931)* *11 = T = 20 km including indirect effect (Heiskanen's tables 1938 or Lejay's)* *12 = T = 30 km (Heiskanen's tables, 1931)* *13 = T = 30 km including indirect effect* *14 = T = 40 km* *15 = T = 40 km including indirect effect* *16 = T = 60 km* *17 = T = 60 km including indirect effect* *6......* *65 = Vening Meinesz hypothesis "modified Bouguer anomaly" (Vening Meinesz, 1948)*
108-112	*Isostatic anomaly a (0.1 mgal)*
113-114	*Type of the isostatic anomaly B*
115-119	*Isostatic anomaly B*
120-122	*Velocity of the ship (0.1 knot)*
123-127	*Eötvös correction (0.1 mgal)*
128-131	*Year of observation*
132-133	*Month*
134-135	*Day*
136-137	*Hour*
138-139	*Minute*
140-145	*Numbering of the station (original)*
146-148	*Country code (B.G.I.)*
149	*Validity*
150-154	*Original source number (ex. DMA code)*
155-160	*Sequence number*

Whenever given, the theoretical gravity (gO), free-air anomaly (FA), Bouguer anomaly (BO) are computed in the 1967 geodetic reference system.

The approximation of the closed form of the 1967 gravity formula is used for theoretical gravity at sea level :

$$\gamma_o = 978031.85 + [\,1 + 0.005278895 * \sin^2(\phi) + 0.000023462 * \sin^4(\phi)],\ \text{mgals}$$

where ϕ is the geographic latitude.

The formulas used in computing FA and BO are summarized below.

Formulas used in computing free-air and Bouguer anomalies

Symbols used :

g	: *observed value of gravity*
γ	: *theoretical value of gravity (on the ellipsoid)*
Γ	: *vertical gradient of gravity (approximated by 0.3086 mgal/meter)*
H	: *elevation of the physical surface of the land, lake or glacier ($H = o$ at sea surface), positive upward*
D_1	: *depth of water, or ice, positive downward*
D_2	: *depth of a gravimeter measuring in a mine, in a lake, or in an ocean, counted from the surface, positive downward*
G	: *gravitational constant* ($667.2\ 10^{-13}\ m^3\ kg^{-1}\ s^{-2}) \Rightarrow k = 2 \pi G$
ρ_c	: *mean density of the Earth's crust (taken as 2670 kg* m^{-3})
ρ_w^f	: *density of fresh water (1000 kg* m^{-3})
ρ_w^s	: *density of salted water (1027 kg* m^{-3})
ρ_i	: *density of ice (917 kg* m^{-3})
FA	: *free-air anomaly*
BO	: *Bouguer anomaly*

Formulas :

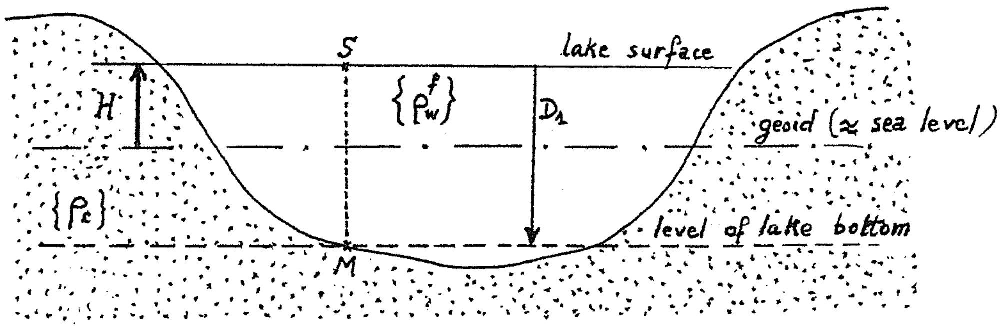
* *FA :* *The principle is to compare the gravity of the Earth at its surface with the normal gravity, which first requires in some cases to derive the surface value from the measured value. Then, and until now, FA is the difference between this Earth's gravity value reduced to the geoid and the normal gravity* γ_o *computed on the reference ellipsoid (classical concept). The more modern concept, in which the gravity anomaly is the difference between the gravity at the surface point and the normal (ellipsoidal) gravity on the telluroid corresponding point* may be adopted in the future depending on other major changes in the BGI data base and data management system.*

* *BO :* *The basic principle is to remove from the surface gravity the gravitational attraction of one (or several) infinite plate (s) with density depending on where the plate is with respect to the geoid. The conventional computation of BO assumes that parts below the geoid are to be filled with crustal material of density* ρ_c *and that the parts above the geoid have the density of the existing material (which is removed).*

---

*cf. "On the definition and numerical computation of free air gravity anomalies", by H.G. Wenzel. Bulletin d'Information, BGI, n° 64, pp. 23-40, June 1989.

For example, if a measurement g_M is taken at the bottom of a lake, with the bottom being below sea level, we have :



$$g_S = g_M + 2k\rho_w^f D_1 - \Gamma D_1$$

$$\Rightarrow \quad FA = g_s + \Gamma H - \gamma_o$$

Removing the (actual or virtual) topographic masses as said above, we find :

$$\delta g_s = g_s - k\rho_w^f D_1 + k\rho_c(D_1 - H)$$

$$= g_s - k\rho_w^f[H + (D_1 - H)] + k\rho_c(D_1 - H)$$

$$= g_s - k\rho_w^f H + k(\rho_c - \rho_w^f)(D_1 - H)$$

$$\Rightarrow \quad BO = \delta g_s + \Gamma H - \gamma_o$$

The table below covers most frequent cases. It is an update of the list of formulas published so far, which had four typing errors (for cases 2, 4, 5, 8).

It may be noted that, although some formulas look different, they give the same results. For instance BO (C) and BO (D) are identical since :

$$-k\rho_i H + k(\rho_c - \rho_i)(D_1 - H) \equiv -k\rho_i(H - D_1 + D_1) - k(\rho_c - \rho_i)(H - D_1)$$

$$\equiv -k\rho_i D_1 - k\rho_c(H - D_1)$$

Similarly, BO (6), BO (7) and BO (8) are identical.

Elev Type	Situation	Formulas
1	Land Observation-surface	$FA = g + \Gamma H - \gamma_o$ $BO = FA - k\rho_c H$
2	Land Observation-subsurface	$FA = g + 2k\rho_c D_2 + \Gamma(H - D_2) - \gamma_o$ $BO = FA - k\rho_c H$
3	Ocean surface	$FA = g - \gamma_o$ $BO = FA + k(\rho_c - \rho_w^s)D_1$
4	Ocean submerged	$FA = g + (2k\rho_w^s - \Gamma)D_2 - \gamma_o$ $BO = FA + k(\rho_c - \rho_w^s)D_1$
5	Ocean bottom	$FA = g + (2k\rho_w^s - \Gamma)D_1 - \gamma_o$ $BO = FA + k(\rho_c - \rho_w^s)D_1$
6	Lake surface above sea level with bottom above sea level	$FA = g + \Gamma H - \gamma_o$ $BO = FA - k\rho_w^f D_1 - k\rho_c(H - D_1)$
7	Lake bottom, above sea level	$FA = g + 2k\rho_w^f D_1 + \Gamma(H - D_1) - \gamma_o$ $BO = FA - k\rho_w^f D_1 - k\rho_c(H - D_1)$
8	Lake bottom, below sea level	$FA = g + 2k\rho_w^f D_1 + \Gamma(H - D_1) - \gamma_o$ $BO = FA - k\rho_w^f H + k(\rho_c - \rho_w^f)(D_1 - H)$
9	Lake surface above sea level with bottom below sea level	$FA = g + \Gamma H - \gamma_o$ $BO = FA - k\rho_w^f H + k(\rho_c - \rho_w^f)(D_1 - H)$
A	Lake surface, below sea level (here $H < o$)	$FA = g + \Gamma H - \gamma_o$ $BO = FA - k\rho_c H + k(\rho_c - \rho_w^f)D_1$
B	Lake bottom, with surface below sea level ($H < o$)	$FA = g + (2k\rho_w^f - \Gamma)D_1 + \Gamma H - \gamma_o$ $BO = FA - k\rho_c H + k(\rho_c - \rho_w^f)D_1$
C	Ice cap surface, with bottom below sea level	$FA = g + \Gamma H - \gamma_o$ $BO = FA - k\rho_i H + k(\rho_c - \rho_i)(D_1 - H)$
D	Ice cap surface, with bottom above sea level	$FA = g + \Gamma H - \gamma_o$ $BO = FA - k\rho_i D_1 - k\rho_c(H - D_1)$

2.6. Satellite Altimetry Data

BGI has access to the Geos 3 and Seasat data base which is managed by the Groupe de Recherches de Géodésie Spatiale (GRGS). These data are now in the public domain.

Since January 1, 1987, the following procedure has been applied :

(a) *Requests for satellite altimetry derived geoid heights (N), that is : time (julian date), longitude, latitude, N, are processed by B.G.I.*

(b) *Requests for the full altimeter measurement records are forwarded to GRGS, or NASA in the case of massive request.*

In all cases, the geographical area (polygon) and beginning and end of epoch (if necessary) should be given.

All requests for data must be sent to :

Mr. Gilles BALMA
Bureau Gravimétrique International
18, Avenue E. Belin - 31055 Toulouse Cedex - France

In case of a request made by telephone, it should be followed by a confirmation letter, or telex.
Except in particular case (massive data retrieval, holidays...) requests are satisfied within one month following the reception of the written confirmation, or information are given concerning the problems encountered.

If not specified, the data will be written, formatted (EBCDIC) on unlabeled 9-track tape (s) with a fixed block size. The exact physical format will be indicated in each case.

3. USUAL SERVICES B.G.I. CAN PROVIDE

The list below is not restrictive and other services (massive retrieval, special evaluation and products...) may be provided upon request.

The costs of the services listed below are a revision of the charging policy established in 1981 (and revised in 1989) in view of the categories of users : (1) contributors of measurements and scientists, (2) other individuals and private companies.

The prices given below are in french francs. They have been effective January 1, 1991 and may be revised periodically.

3.1. Charging Policy for Data Contributors and Scientists

For these users and until further notice, - and within the limitation of our in house budget, we shall only charge the incremental cost of the services provided. In all other cases, a different charging policy might be applied.

However, and at the discretion of the Director of B.G.I., some of the services listed below may be provided free of charge upon request, to major data contributors, individuals working in universities, especially students...

3.1.1. Digital Data Retrieval

. on one of the following media :
** printout.................. 2 F/100 lines*
** magnetic tape............. 2 F per 100 records*
+ 100 F per tape - 1600 BPI
(if the tape is not to be returned)

. minimum charge : 100 F.

. maximum number of points : 100 000 ; massive data retrieval (in one or several batches) will be processed and charged on a case by case basis.

3.1.2. Data Coverage Plots : in Black and White, with Detailed Indices

- *20°x 20° blocks, as shown on the next pages (maps 1 and 2) : 400 F each set.*
- *For any specified area (rectangular configurations delimited by meridians and parallels) : 1. F per degree square : 100 F minimum charge (at any scales, within a maximum plot size of : 90 cm x 180 cm).*
- *For area inside polygon : same prices as above, counting the area of the minimum rectangle comprising the polygon.*

3.1.3. Data Screening

(Selection of one point per specified unit area, in decimal degrees of latitude and longitude, i.e. selection of first data point encountered in each mesh area).

- *5 F/100 points to be screened.*
- *100 F minimum charge.*

3.1.4. Gridding

(Interpolation at regular intervals Δ in longitude and Δ' in latitude - in decimal degrees) :

- *10 F/ΔΔ' per degree square*
- *minimum charge : 150 F*
- *maximum area : 40°x 40°*

3.1.5. Contour Maps of Bouguer or Free-Air Anomalies

At a specified contour interval Δ (1, 2, 5,... mgal), on a given projection :
10. F/Δ per degree square, plus the cost of gridding (see 3.4) after agreement on grid stepsizes. (at any scale, within a maximum map size for : 90 cm x 180 cm).

. 250 F minimum charge

. maximum area : 40°x 40°

3.1.6. Computation of Mean Gravity Anomalies

(Free-air, Bouguer, isostatic) over ΔxΔ' area : 10 F/ΔΔ' per degree square.

. minimum charge : 150 F

. maximum area : 40 ° x 40 °

3.2. Charging Policy for Other Individuals or Private Companies

3.2.1. Digital Data Retrieval

. 1 F per measurement

. minimum charge : 150 F

3.2.2. Data Coverage Plots, in Black and White, with Detailed Indices

- *2 F per degree square ; 100 F minimum charge. (maximum plot size = 90 cm x 180 cm)*
- *For area inside polygon : same price as above, counting the area of the smallest rectangle comprising in the polygon.*

3.2.3. Data Screening

. 1 F per screened point

. 250 F minimum charge

3.2.4. Gridding

Same as 2.1.4.

3.2.5. Contour Maps of Bouguer or Free-Air Anomalies

Same as 2.1.5.

3.2.6. Computation of Mean Gravity Anomalies

Same as 2.1.6.

3.3. Gravity Maps

The pricing policy is the same for all categories of users.

3.3.1. Catalogue of all Gravity Maps

printout : 200 F

tape : 100 F (+ tape price, if not be returned)

3.3.2. Maps

. Gravity anomaly maps (excluding those listed below) : 100 F each

. Special maps :

Mean Altitude Maps

FRANCE (1: 600 000) 1948 6 sheets 65 FF the set
WESTERN EUROPE (1:2 000 000) 1948 1 sheet 55 FF
NORTH AFRICA (1:2 000 000) 1950 2 sheets 60 FF the set
MADAGASCAR (1:1 000 000) 1955 3 sheets 55 FF the set
MADAGASCAR (1:2 000 000) 1956 1 sheet 60 FF

Maps of Gravity Anomalies

NORTHERN FRANCE, Isostatic anomalies
(1:1 000 000) 1954 55 FF
SOUTHERN FRANCE, Isostatic anomalies
Airy 50 (1:1 000 000) 1954 55 FF
EUROPE-NORTH AFRICA, Mean Free air
anomalies (1:1 000 000) 1973 90 FF

World Maps of Anomalies (with text)

PARIS-AMSTERDAM, Bouguer anomalies
(1: 1 000 000) 1959-60 65 FF
BERLIN-VIENNA, Bouguer anomalies
(1: 1 000 000) 1962-63 55 FF
BUDAPEST-OSLO, Bouguer anomalies
(1: 1 000 000) 1964-65 65 FF
LAGHOUAT-RABAT, Bouguer anomalies
(1: 1 000 000) 1970 65 FF
EUROPE-AFRICA, Bouguer Anomalies

(1:10 000 000) 1975 180 FF with text
120 FF without text

EUROPE-AFRICA, Bouguer anomalies
Airy 30 (1:10 000 000) 1962 65 FF

Charts of Recent Sea Gravity Tracks and Surveys (1:36 000 000)

CRUISES prior to	*1970*	*65 FF*
CRUISES	*1970-1975*	*65 FF*
CRUISES	*1975-1977*	*65 FF*

Miscellaneous

CATALOGUE OF ALL GRAVITY MAPS

listing	*200 FF*
tape	*300 FF*

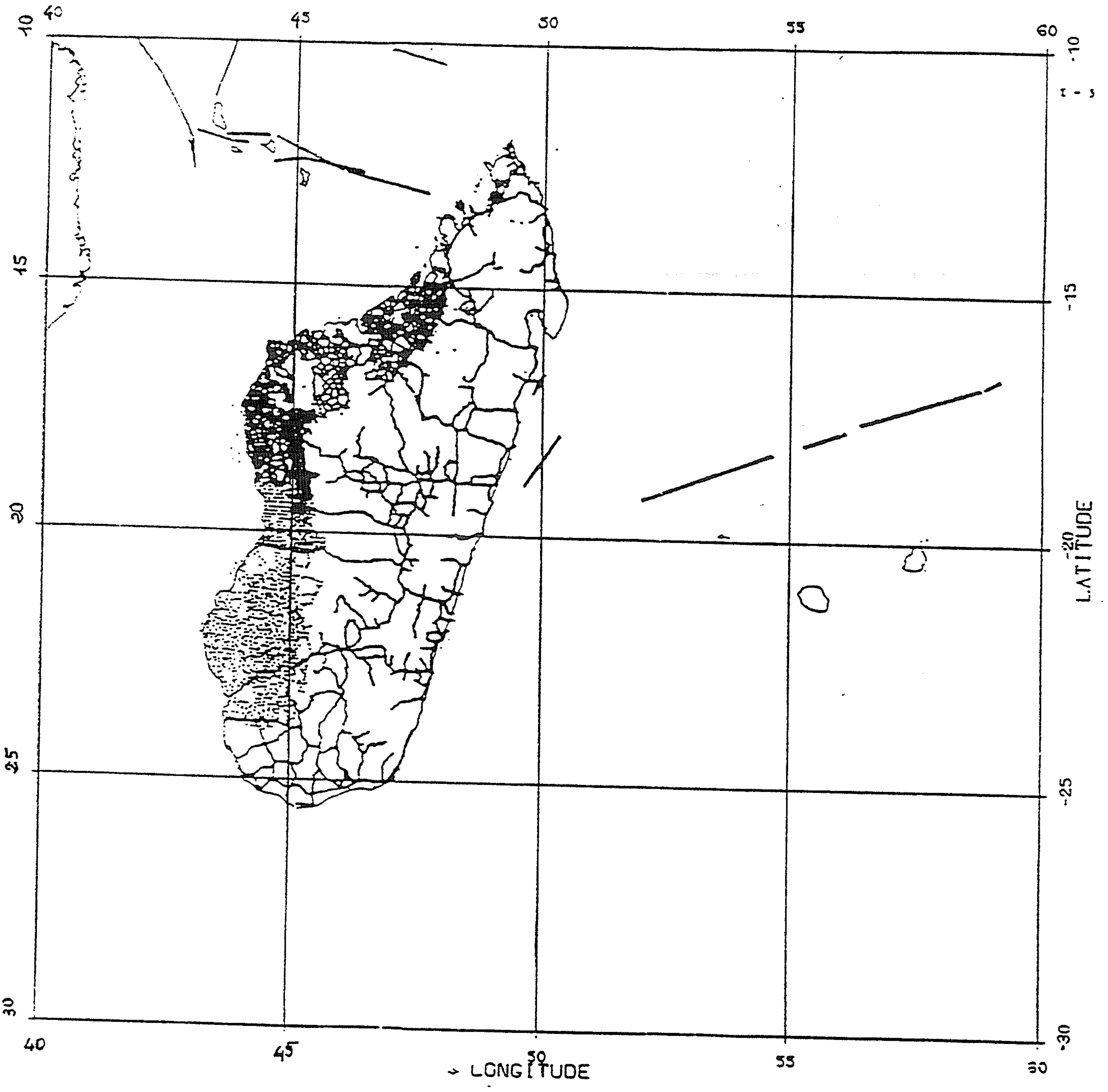
THE UNIFICATION OF THE GRAVITY NETS
OF AFRICA (Vol. 1 and 2) 1979 150 FF

. Black and white copy of maps : 150 F per copy

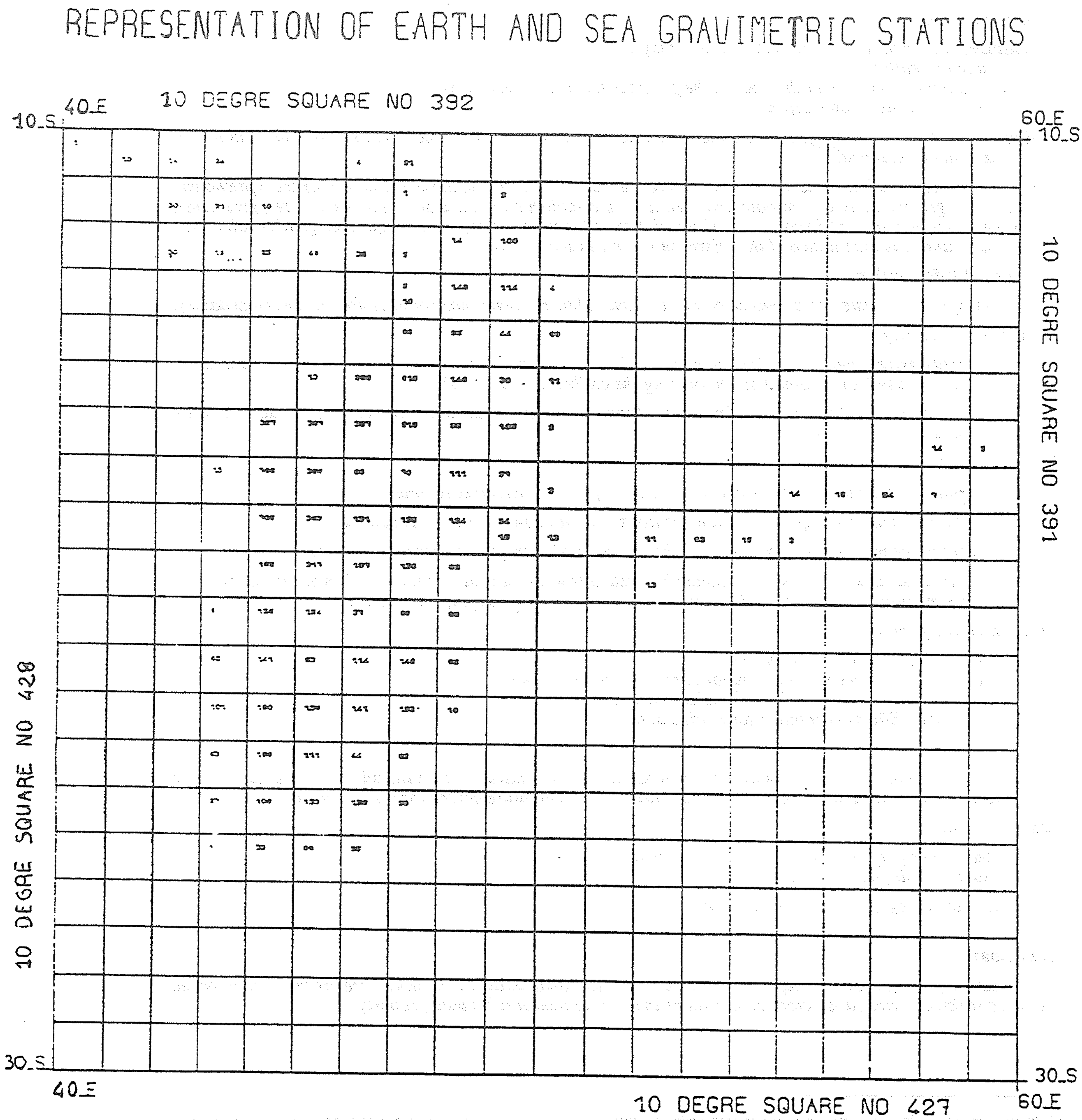
. Colour copy : price according to specifications of request.

Mailing charges will be added for air-mail parcels when "Air-Mail" is requested)

Map 1. Example of data coverage plot



Map 2. Example of detailed index (Data coverage corresponding to Map 1)



4. PROVIDING DATA TO B.G.I.

4.1. Essential Quantities and Information for Gravity Data Submission

1. *Position of the site :*

   - latitude, longitude (to the best possible accuracy),
   - elevation or depth :
   *. for land data : elevation of the site (on the physical surface of the Earth)***
   . for water stations : water depth.

2. *Measured (observed) gravity, corrected to eliminate the periodic gravitational effects of the Sun and Moon, and the instrumental drift****

3. *Reference (base) station (s) used. For each reference station (a site occupied in the survey where a previously determined gravity value is available and used to help establish datum and scale for the survey), give name, reference station number (if known), brief description of location of site, and the reference gravity value used for that station. Give the datum of the reference value ; example : IGSN 71.*

4.2. Optional Information

The information listed below would be useful, if available. However, none of this information is mandatory.

. Instrumental accuracy :

- *identify gravimeter (s) used in the survey. Give manufacturer, model, and serial number, calibration factor (s) used, and method of determining the calibration factor (s).*
- *give estimate of the accuracy of measured (observed) gravity. Explain how accuracy value was determined.*

. Positioning accuracy :

- *identify method used to determine the position of each gravity measurement site.*
- *estimate accuracy of gravity station positions. Explain how estimate was obtained.*
- *identify the method used to determine the elevation of each gravity measurement site.*
- *estimate accuracy of elevation. Explain how estimate was obtained. Provide supplementary information, for elevation with respect to the Earth's surface or for water depth, when appropriate.*

. Miscellaneous information :

- general description of the survey.
- date of survey : organization and/or party conducting survey.
- if appropriate : name of ship, identification of cruise.
- if possible, Eötvös correction for marine data.

. Terrain correction

Please provide brief description of method used, specify : radius of area included in computation, rock density factor used and whether or not Bullard's term (curvature correction) has been applied.

. Isostatic gravity

Please specify type of isostatic anomaly computed.
Example : Airy-Heiskanen, T = 30 km.

. Description of geological setting of each site

4.3. Formats

Actually, any format is acceptable as soon as the essential quantities listed in 4.1. are present, and provided that the contributor gives satisfactory explanations in order to interpret his data properly.

**Give supplementary elevation data for measurements made on towers, on upper floor of buildings, inside of mines or tunnels, atop glacial ice. When applicable, specify wheter gravity value applied to actual measurement site or it has been reduced to the Earth's physical surface (surface topography or water surface).
Also give depth of actual measurement site below the water surface for underwater measurements.

***For marine gravity stations, gravity value should be corrected to eliminate effects of ship motion, or this effect should be provided and clearly explained.

The contributor may use, if he wishes so, the BGI Official Data Exchange Format established by BRGM in 1976 : "Progress Report for the Creation of a Worldwide Gravimetric Data Bank", published in BGI Bull. Info, n°39, and recalled in Bulletin n°50 (pages 112-113).

If magnetic tapes are used, contributors are kindly asked to use 1600 bpi unlabeled tapes (if possible), with no password, and formated records of possibly fixed length and a fixed blocksize, too. Tapes are returned whenever specified, as soon as they are copied.

Part II

DIRECTING BOARD OF BGI
August 14, 1991
IUGG Vienna, 20th General Assembly

Minutes of the
DIRECTING BOARD OF
THE BUREAU GRAVIMETRIQUE INTERNATIONAL

August 14, 1991 - Vienna IUGG 20th General Assembly

AGENDA

1. Welcome and Opening Remarks .... Tanner
2. Reports
   (a) Report of the Director of BGI .... Balmino
   (b) Working Group 1 .... McConnell
   (c) Working Group 2 .... Boedecker
   (d) Working Group 5 .... Poitevin
   (e) Working Group 6 .... Boulanger
   (f) Working Group 7 .... Wenzel
3. Membership of the Directing Board .... Tanner, all
4. Membership of Working Groups .... All
5. Other Business
6. Date and Time of Next Meeting
7. Adjourn

Present : Tanner (Chairman), Balmino, Boedecker, Chief Coker, Courtier, Faller, Mäkinen, Marson, Medvedev, Morelli, Nakagawa, Poitevin, Torge, Tscherning, Wenzel.

1) Tanner extended a warm welcome to the Board, the new President of the Commission, Marson, and the new President of the Association, Torge.

2) <u>Report of the Director of BGI</u> (Balmino)

* The contribution of the BGI to the GEBCO project is complete with the production of 11 maps.

* BGI now has the University of Leeds Industrial Services (ULIS) data sets for Africa and South America and will also participate with ULIS in projects covering South East Asia and Europe to the Urals. The ULIS data is confidential and available only for internal use by BGI.

Board members were urged to encourage direct donation of data to BGI for release to the scientific community.

* The volume demand on BGI data base in response to the development of the 1 cm geoid was not considered to be a problem with a 4 km spacing.

* The change over BGI data base to the new IBM will be transparent for users. The use of ORACLE in place of the old system should be in operation in November 1991.

* The data base now contains 4 million point gravity values. Data will soon be added from Poland, Hungary and Rumania. The Canadian data set is still inhomogeneous.

* A sophisticated data validation system (VERSET/DIVA) has been developed and is in use.

* The volume of requests for BGI data and services has increased by 50 % over the previous period.

3) WG1 - Data Processing (McConnell)

* The 5' x 5' gravity map of the world is ready for publication by BGI.

The Board felt this was an important achievement and hoped updated versions would be produced when appropriate. Tanner will congratulate the WG1 and the GSC, and discuss future maintenance of the map.

4) WG2 - World Gravity Standards (Boedecker)

* The IAGBN working standards for data processing, station documentation and observations continue to evolve. In particular, storage of each drop is now recommended.

* Observations have now been made at 23 of the 36 IAGBN-A stations. There has been little activity in mainland Africa, India, Arabia or Australia.

. Members were urged to convince Australian colleagues of the need for absolute observations.
. The African delegates to the IUGG will discuss the formation of bi-lateral agreements with institutions operating absolute gravimeters on the 15th August.

* A bi-lateral agreement between Algeria and the University of Trieste has been signed for the establishment of 11 absolute gravity sites.

* Observations have been made at over 150 IAGBN-B stations worldwide. All institutions operating absolute gravimeters are urged to send observation data to BGI and to occupy IAGBN-A stations whenever and wherever possible.

Proposal : WG2 establishes simple procedures for the delivery of absolute gravity data.

* The predicted future precision of GPS will be of great importance if the International GPS Geodynamics Service sites can be collocated with IAGBN stations.

5) WG6 - Intercomparison of Absolute Gravimeters (Boulanger)

* Boulanger has suggested that Marson take the chair of WG6.

Accepted.

* The future of international absolute gravimeter intercomparisons was discussed.

Proposal : WG6 determines methodology and locations.

6) WG7 - Computation of Mean Gravity Anomalies (Wenzel)

* Procedures for the production by BGI of the 5' x 5' free air gravity anomaly data set were approved. The processing software has been transferred to BGI.

The Board felt that, as the objectives have been fully met, WG7 can now formally close.

7) WG5 - Monitoring of Non-Tidal Gravity Variations (Poitevin)

* The Walferdange workshop on the intercomparison between absolute and superconducting gravimeters was most successful and the proceedings have been published (distribution is done by BGI).

* A number of teams are now starting intercomparisons. WG5 is proceeding to collect data from these events. Positive responses for the release of superconducting gravimeter data have not yet been received from Canada or Japan.

* There is a potential conflict between the overlapping terms of reference for WG5 and the SEDI group.

The Commission President will resolve this question at the Association level.

8) Membership of the Directing Board (1991-1995)

Proposal : Working Groups should be represented on the Board with voice but without vote.

Agreed.

Voting Members :

IGC President	Marson
IGC Vice-President	Mäkinen
BGI Director	Balmino
Section III President (Gravity)	Wenzel
Elected by commission membership	Faller
	Tscherning
	Groten
	Medvedev

Non-voting Members :

Chairmen of Working Groups	McConnell
	Boedecker
	Poitevin
Secretary	Courtier

Ex-Officio :

President of the Geoid Commission	Sünkel
FAGS representative	Kovalevsky

9) Next Meeting

The next meeting will take place in Toulouse during 1992 and will be collocated with a Working Group workshop.

BUREAU GRAVIMETRIQUE INTERNATIONAL
Activity Report
(April 1, 1987 - March 31, 1991)

The Bureau Gravimétrique International (B.G.I.) is one of the offices of the Federation of Astronomical and Geophysical Services (F.A.G.S.). It was created in 1951 by the International Association of Geodesy (I.A.G.), with the main purpose of collecting, on a worldwide basis, all gravity measurements and pertinent informations about the gravity field of the Earth. BGI is located in Toulouse since 1980. It is supported by five national organisations : the Centre National d'Etudes Spatiales (C.N.E.S.), the Centre National de la Recherche Scientifique (C.N.R.S.), the Institut Géographique National (I.G.N.), the Institut National des Sciences de l'Univers (I.N.S.U.) and the Bureau de Recherches Géologiques et Minières (B.R.G.M.).

The gravity data base, which contains about 4 million measurements, is managed by B.G.I. and is at the disposal of the international scientific community. Among offered services, are the provision of point gravity measurements, of mean and gridded values. These services may be provided free of charge to data contributors, researchers and students. BGI also ensures the collection of gravity maps and gravity reference station descriptions used for the adjustment of new gravimetric surveys. It publishes twice a year a Bulletin d'Information.

B.G.I. continues its data collection activities especially in the framework of large regional projects, in order to densify the world data coverage, and has put emphasis on the validation of received measurements, so as to improve the quality of the delivered information.

In Geodesy, gravity values play a great part in the modeling of the Earth gravity field, which is of permanent use for the computation of precise satellite orbits. It is also an essential information for the definition of the ocean mean surface used for the study of the global circulation.

In Geophysics, the interpretation of the gravity field anomalies allows to study density variations in the lithosphere or the mantle, with applications in oil and mineral prospecting.

1. MEETINGS AND CONFERENCES ORGANIZED

BGI	Directing Board meetings :	
	Vancouver :	August 8, 1987
	Paris :	June 21-22, 1988
	Edinburgh :	August 8, 1989
	Toulouse :	September 10, 1990
IGC	Special meeting :	
	Edinburgh :	August 5, 1989
IGC	13th general assembly :	
	Toulouse :	September 11-14, 1990
Workshop on validation of land gravity data		
	Toulouse :	October 17-19, 1989

2. SPECIAL PROJECTS OR EVENTS

2.1. GEBCO Project

BGI has been taking part in the GEBCO hydrographic project since 1983. Its role was to produce files of the contour lines of the world bathymetry for future use in geophysics (see IGN Technical note n° 130). Five maps were digitized (5-13, 5-14, 5-15, 5-16, 5-18) prior to 1987. One person was assigned in 1987 by the Institut Géographique National to work full time on it. BGI completed the Northern Europe sheet (5-01) in 1987, the North Atlantic (5-04), Central Atlantic (5-08), and North Polar sheet (5-17) in 1988. The course of this effort was interrupted in 1989 and restarted in October 1990. Then the two sheets for the North and Central Indian oceans (5-05 and 5-09) were produced. The contribution of the Bureau and IGN to the project therefore consists in eleven files (out of eighteen) and is considered to be terminated.

2.2. African Gravity Project (AGP)

This project was formulated in 1985 by geophysicists D. Fairhead of the University of Leeds (U.K.) and A. Watts of Lamont Doherty Geological Observatory. The goal was the compilation of all available private and public domain gravity data for Africa to derive a map of the gravity field of the African continent and its continental margins. The project was managed by the University of Leeds Industrial Services (ULIS) and sponsored by 16 oil companies. The Bureau participated in 1986-1987 by bringing its data base over that region. It is now also responsible for the archival of all the AGP data and received in addition the files of the produced grid values of free-air, Bouguer anomalies and elevations at 5' resolution both in longitude and latitude, for internal use in validating future acquisitions of data from Africa. Maps are being sold since early 1991 and the grids should be released in 1998.

2.3. South American Gravity Project (SAGP)

BGI was also involved with ULIS (see above) in their South American gravity compilation project on the same basis as the African project. In addition, BGI brought its expertise and validated the initial data set (about 70 000 gravity observations) over this continent, providing them to the project in spring 1989. The project terminated in April 1991 (but final products will be made later in the course of 1991).

2.4. Other Regional Gravity Projects

ULIS made new plans in 1990 for projects similar to the ones above mentioned, in South-East Asia (SEAGP) and in Europe, including the Eastern countries and USSR, up to Ural (WEEGP). BGI will also be involved in these activities. SEAGP is likely to start in mid 1991. Of special interest is WEEGP since it could be combined with the efforts of the Sub-Commission for the Geoid in Europe (of the International Commission for the Geoid).

2.5. Participation in ICL/CC5 Activities

BGI contributed to the compilation of the catalogue of data centers and data bases, established by the Institute of Physics of the Earth (Moscow) by sending circulars and questionnaires and homogenizing the informations. A first catalogue was presented in Suzdal (Nov. 1988) and later updated.

The Director of the Bureau represents the International Gravity Commission on CC5.

3. SERVICE ACTIVITIES

3.1. Data Base Software Development

Most BGI software have been running on CDC Cybers since 1980. The data base management programs were developed internally ten years ago. A new Cyber 990 was installed at CNES at the end of 1987. Changeover from NOS/BE to NOS/VE operating system required major software to be rewritten. This work was completed at the end of 1988. The data base and its system were again re-installed on a newer CYBER 992 in December 1988. The graphic language change required to rewrite many pieces of software, in 1989.

The Bureau has developed a new simple software for the data base management of regional data sets, for instance in the framework of the AGP and SAGP projects (cf. § 2.2 and 2.3). This can run on a small computer and might allow a faster merging of new sources and ensure better protection against loss of operational continuity.

In addition, the existing software was upgraded in 1990 and its performances improved when adding new sources. Subsequently, it could be made more user friendly, as well as better protected against misusage. However, instead of putting more efforts from BGI staff and following the availability of the ORACLE software on a main frame IBM 4381 at CNES, it was decided in early 1991 and after extensive satisfactory testing to discontinue the usage of our software and switch to ORACLE (level 6). This should be fully operational in the fall of 1991. Attention was exerted to ensure no interruption in the services.

3.2. Data Collection

The data base to-day contains about four million point gravity values in 3000 sources. The main new land sources acquired can be found in the Edinburgh report (B.I. n° 65, Dec. 1989). Large marine data sets (e.g. from Lamont Doherty Lab.) have since been merged. It remains more than a quarter million points to be added ; as said above, this has been a very slow process due to the characteristics of the software (until it was upgraded).

New catalogues have been produced (last update : Sept. 4, 1990) and are available on request :

. General coverage of gravity data per 20 x 20 degrees area

. Index catalogue of data distribution : statistics per degree square, mean value, standard deviation.

3.3. Data Validation

It was decided in 1987 to put an emphasis on the quality of the data redistributed by BGI. The Bureau had to acquire or/and to develop some tools to validate the point gravity measurements in its data base, starting with the land observations.

Two automated software, PFATES and GEOGRID, were received from Prof. Wenzell (Univ. of Karlsruhe - previously at IFE, Hannover) and from Pr. Tscherning (Univ of Copenhagen) respectively, which allow a fast first stage editing. An automatic validation tool (SYSTEVAL) was developed from them.

A sophisticated new system (VERSET/DIVA) for finer data validation using statistical techniques and interactive graphics has been developed (cf. Technical Note n° 10).

The Workshop organised by BGI in October 1989 focused on discussing methodology, algorithms, software hints... used in different centers, and demonstrations of BGI capabilities were performed successfully in real time. The full report appeared in the Bulletin d'Information n° 65.

In 1990, all land data were validated on a one by one source basis by means of the SYSTEVAL software. Data over South America, Spain, Belgium benefited from a finer validation by VERSET (it is much more man-power consuming) ; VERSET will be used on request on other data sets in the future. It also remains to intercompare overlapping sources. Plans are made to install similar software for the validation of marine data especially to solve for cross-over minimization parameters ; a workshop on this topic could be held in the spring of 1992.

3.4. Requests

The bureau has received and satisfied 94 requests for data and services in 1988, 75 in 1989, 110 in 1990 and 70 for the first four months in 1991. This corresponds to a mean increase of ≈ 150 % with respect to the last four year period of time. This activity presently employs one person more than half-time.

3.5. Bibliography

Compilation of the gravity bibliography continues. The digitization of the old bibliography, prior to 1980, has also been undertaken ; this is a huge work which is performed by the BGI secretary, with an additional temporary help since February 1991. A file is now available on floppy disk.

This data base is resident on hard disk on a P.C. and managed by means of the ORACLE software (new version installed in August 1990).

3.6 Miscellaneous

- training of students and visitors : data validation procedures, graphics
- compilation of absolute measurements : difficult (agencies do not answer to our request for data and facts).
- status of IGSN 71 stations : partially established, from reports of European and North-Pacific Sub-commissions, presented in Edinburgh in 1989.
- Update of map file and new catalogue : 100 maps added in 1989-1990.
- Update of reference station file : 1042 stations added in 1990 (microfiching in progress).
- Preparation, realization of a folder publicizing the role, activities and services of BGI ; distributed at the Vancouver IUGG general assembly (to be updated in 1991).
- Announcement (advertising) in EOS, in Dec. 1987.

4. SPECIFIC ACCOMPLISHMENTS

4.1. 5' x 5' Gravity Map of the World

The Bureau and WG1 members (at GSC) have prepared a 5' x 5' gravity map of the whole world. BGI produced the part of the basic grid over land areas (Bouguer anomalies) while GSC prepared the oceanic part (free-air). It will be published at the end of 1991.

4.2. Geoid over Gibraltar

Computation of a gravimetric geoid over the straight of Gibraltar area (before the establishment of the International Geoid Service), in the context of the fixed link project. Results were presented at the second Symposium devoted to this project in March 1989. Geoid heights were in good agreement with satellite Doppler and survey derived quantities at control points.

5. EVALUATION OF THE WORKS

6. PUBLICATIONS

Bulletin d'Information :		June 1987 (n° 60) 125 pages	
		Dec. 1987 (n° 61) 170 pages	
		June 1988 (n° 62) 165 pages	
		Dec. 1988 (n° 63) 108 pages	
		June 1989 (n° 64) 59 pages	
		Dec. 1989 (n° 65) 168 pages	
		June 1990 (n° 66) 63 pages	
		Dec. 1990 (n° 67) 219 pages	
BGI holdings,	Data Base Coverage :	Aug. 5, 1987	
		Aug. 5, 1989	
		Sept. 4, 1990	
	1° x 1° statistics of gravity measurements :		Aug. 5, 1989
			Sept.4, 1990
	catalogue of Maps :		Sept. 4, 1990

Other :

Balmino G., D. Lamy, M. Sarrailh, D. Toustou, N. Valès : Calcul d'un géoide gravimétrique sur le détroit de Gibraltar, Int. Symp. on a fixed link over the Gibraltar straight, Proceedings, Madrid, 1989.

Toustou, D. : Numérisation de la carte GEBCO au Bureau Gravimétrique International, Bull. d'Information de l'IGN, n° 130, 1988.

Toustou, D., M. Sarrailh : Chaîne de validation interactive de données gravimétriques DIVA, Technical Note n° 10, April 1989.

Report of Working Group 1 (Data Processing)
to the
Meeting of the BGI Directing Board
Vienna, Austria; August,1991

Chairman: R.K.McConnell

A. Bouguer Gravity Map of the World

Over the past year the 1:50,000,000 Bouguer Gravity Map of the World compiled from BGI data holdings was completed at the Geological Survey of Canada.

The map was intended to illustrate the extent of gravity holdings at the International Gravity Bureau (IGB) as of June, 1990. These data were contributed to the Bureau over the past 40 years by member countries of the International Gravity Commission of the International Association of Geodesy.

The basic data set over land was a 5' x 5' Bouguer anomaly grid compiled by M. Sarrailh of the IGB from 1,831,056 discrete observations derived from 2233 sources. The grid values were computed as simple arithmetic means weighted as the inverse square of the distance to a radius of 20'. Over oceanic areas the basic data set was a 15' x 15' satellite altimetry based Free air grid (Balmino et al., 1987). All data are referred to IGSN71 datum. Bouguer anomalies were computed on GRS67 using a rock density of 2670 kg/m^3 on land and densities of 2990 kg/m^3 and 1030 kg/m^3 for rock and water respectively over the oceans.

The 15' x 15' satellite Free air grid was used in conjunction with the ETOPO5 5' x 5' ocean bathymetry grid, obtained from the National Geophysical Data Center in Boulder, USA, to compute a 15' x 15' Bouguer grid for oceanic areas. This grid was combined with the 5' x 5' land data and regridded to 30 x 30 km on a Van der Grinten projection. Gridding was done by the minimum curvature method with a search radius of 60 km. Computations associated with map compilation were done by J.D. Rupert of the Geophysics Division, Geological Survey of Canada, Ottawa.

700 copies of the map were shipped to BGI in May, 1991

B. Marine Gravity Processing Workshop

BGI is currently developing software for marine gravity data processing. A workshop on this subject, tentatively planned for the spring of 1991, has been delayed until mid-1992.

International Association of Geodesy
Bureau Gravimetrique International

- Working Group 2 (WG2) : World Gravity Standards -

Activity report 1987 - 1991

0 Introduction

The work of WG2, based on the terms of reference as published 1988 (*WG2 1988*a) was supported by:

D.E. Ajakaiye, Yu.D. Boulanger, J.E. Faller, H. Hanada, J. Mäkinen, I. Marson, K. McConnell, G. Peter, G. Balmino, A. Kiviniemi, I. Nakagawa, H. Roeder, H.-G. Wenzel.

The activities of WG2 were reported repeatedly, e.g. (*WG2 1989*); they include:

1 Standardization:

For the 'International Absolute Gravity Basestation Network (IAGBN)', WG2 published, after the previous basic proposal by *Boedecker/Fritzer* (*1986*), including e.g. site selection criteria,

- Absolute Gravity Observations Data Processing Standards and Station Documentation (*WG2, 1988b*)
As was emphasized from the beginning, all standards are working standards which have to be updated from time to time. For the above standards an update is necessary in the near future in particular with respect to the earth tide reduction.

- Absolute Gravity Observations Documentation Standards (*WG2, 1991*)
In the preceding discussion one major point was the question whether all single drops should be stored or some representative 'normal' observations. Finally it was decided to recommend the storage of each drop, because the total amount of data is not that big compared to other types of geodetic observations and because different instruments would lead to different preferences for 'normal observations'.

2 International Absolute Gravity Basestation Network IAGBN

2.1 Advancement of IAGBN-A:

In the original proposal (*Boedecker/Fritzer* 1986), 36 station locations worldwide had been named 'IAGBN subset A'.
Of these, the following 17 had been prepared and observed by at least one absolute meter; the station documents were published in *WG2 1989*: **Penticton, Yellowknife, Schefferville** (Canada), **Tucson, Fort Davis, International Falls, Rolla, Great Falls** (USA), **Nuuk** (Greenland), **St. Elena Uairen** (Venezuela), **Brasilia** (Brazil), **Tandil** (Argentine), **Sodankylä** (Finland), **Wettzell** (Germany), **Antananarivo** (Madagascar), **Nanning, Beijing** (China).

Additonal stations:
Madrid /Valle de los Caidos (Spain) had been observed earlier; station description attached.
Syowa (Antarctica) has been prepared, observations are carried out in 1991 by Japanese; station description attached.
Fairbanks (USA/Alaska): Station has been prepared and observed by US-NGS; station description attached.
McMurdo (Antarctica): Station 'Terra Nova Bay' close to McMurdo Base, has been prepared and observed by Italians in 1991; station description will be available soon.
Moscow (USSR) and
Novosibirsk (USSR): Absolute station observations will be published in the 1991 IAG National Report of the USSR. It is expected that station descriptions will be available and it is hoped that observation campaigns by foreign groups will be possible in the near future.
Midway (USA): Midway has not been observed yet, but the US have carried out observations at the (geologically) younger islands of Kauai, Maui and Oahu in the Hawaii island arc. It has to be checked, whether one of these may qualify for a IAGBN-A station or whether an observation on Midway can be expected.

Of the remaining stations, the locations in Australia have been visited; reconnaissance report available. Further action would require the support of Australian bodies; so far, there was no positive response.
For New Zealand, a lack of funds was reported.
For four proposed stations in mainland Africa, no action took place; a station in Madagascar had been observed earlier by Russians. For Tamanrasset (Algeria), Bamako (Mali) and Gabarone (Botswana), initial contacts and information exist which did not lead to activities so far.
For Kerguelen (France) in the South Indian Ocean, Prof. Louis (Montpellier) had been contacted but did not respond. Information on local facilities exist and are positive.
Despite some correspondene, there seems to be little hope for observations in India and Arabia in the near future.

2.2 Advancement of IAGBN-B

A great number of absolute observations worldwide have been carried out and published.
A listing of the BGI holdings presents about 150 absolute stations as of 1987.
Personal reports received recently present:

G. Peter / US-NGS: Absolute observations at 12 stations worldwide and at 49 stations in the US 1987..91.
I. Marson / Trieste and IMGC / Torino: 7 new stations (predominantly at laser- and VLBI-sites) in Italy and Antarctica.
A. Kopaev / Univ. Moscow: 7 absolute base stations in the USSR will be published in the 1991 USSR National Report for the IAG Vienna.
R. Roeder / IfE Hannover: Observations at 37 stations worldwide 1987..91.
J. Liard / EMR Ottawa: Observations at about 25 stations in Canada should be available by now.
M. Ooe / NAO Mizusawa: Observations at 11 stations in Japan since 1982.
J. Mäkinen / FGI Helsinki: Observations at 14 stations worldwide 1987..90.
D. Ruess / ÖBEV Vienna: Numerous stations, predominantly in Austria.

The numbers include also observations at IAGBN-A stations; the list is not complete.

Groups doing absolute observations are asked to report their results and station descriptions for IAGBN-A to WG2, all obervation data and the descriptions for IAGBN-B directly to the BGI, using the standards developed by this Working Group. As of September 1990, the Director BGI reported poor response to his request for absolute data.

Please send your absolute observation data to BGI, observing the standards.

Colleagues from various contries are interested to have absolute observations in their country and shall provide local support, e.g. Mongolia, Egypt and Libya.

In general, the advancement of IAGBN has been beautiful even more because the results of the absolute meter comparison campaigns show an improved agreement between different instruments; this should be an indication also of improved accuracy.

For this reason, the efforts put into experiments and comparisons in the past, now should be put into more observation activities at IAGBN stations, which also permit comparisons between different meters.
Therefore, on behalf of WG2, I

CALL FOR OBSERVATIONS AT IAGBN-(A) STATIONS.

In particular, Africa needs absolute observations, because there is no absolute gravity meter on the whole continent.

3 Cooperation with the International GPS Geodynamics Service (IGS)

From the very beginning it has been claimed that the IAGBN sites also be monitored for geometric changes in a global network, therefore one site selection criterion was the link to a space geodetic site. This viewpoint gains new importance with the IGS project and WG2 has recommended for the IGS stations site selection to give preference to existing IAGBN stations. C.f. copy of a letter to prof. I.I. Mueller attached.

4 Maintenance of IGSN71 / Regional Networks

A revision of IGSN71 stations is underway, guided by the regional subcommissions of the International Gravity Commission; details can be found in the reports of the regional subcommissions and the BGI-director.
In accordance with the policy of the IGC since the early 1980's and in view of the increasing number of precise absolute observations available worldwide, no readjustment or renewal of the IGSN is envisaged in order to provide world gravity standards. Instead, national and regional networks are continuously updated and improved. Examples for extended works are US, China, Europe. Despite a few activities, the situation in Africa appears unsatisfactory.

Gerd Boedecker, Chairman Working Group 2, BGI

References:

Boedecker, G.; Fritzer, T.: IAG-SSG 3.87: International Absolute Gravity Basestation Network, Status Report March 1986. Veröff. Bayer. Komm. f. d. Internat. Erdmessung, Astr.-Geod. Arbeiten Nr. 47, München 1986

WG2 1988a: Terms of Reference, BGI Working Group 2 - World Gravity Standards, as revised June 24,1988. BGI-Bull. d'Information no. 63, 1988, p. 29.

WG2 1988b: International Absolute Gravity Basestation Network (IAGBN) - Absolute Gravity Observations Data Processing Standards and Station Documentation. BGI-Bull.d'Information no 63, 1988, p. 51..67.

WG2 1989: Status Report on the "International Absolute Gravity Basestation Network". BGI-Bull. d'Information no. 65, 1989, p. 50..71.

WG2 1991: Absolute Gravity Observation Documentation Standards. BGI-Bull. d'Information no. 68, 1991, p. 76..78.

Enclosure:
- 3 descriptions of IAGBN-A stations not published so far.
- Copy of a letter to prof. I.I. Mueller re. IAGBN-IGS

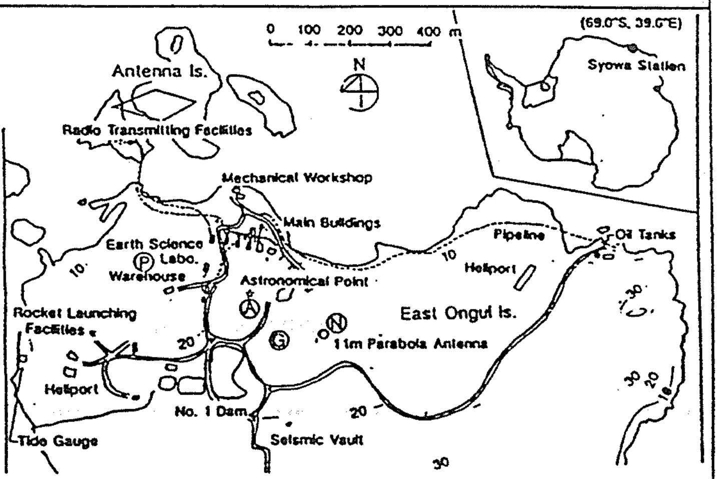
International Absolute Gravity Basestation Network (IAGBN)

Station Location: Syowa Station Country: Antarctica.

φ= 69° 00'19"S λ= 39° 34'52"E H= g=

Overview / Access / Outside View / Topo Map

The absolute gravity station is located in the gravity observation hut at Syowa Station, East Ongul Island, Antarctica. G shows the planned location of the hut in Syowa Station. Access to the station can be done at present only by the Icebreaker "Shirase", which transports the Japanese Antarctic Research Expedition.



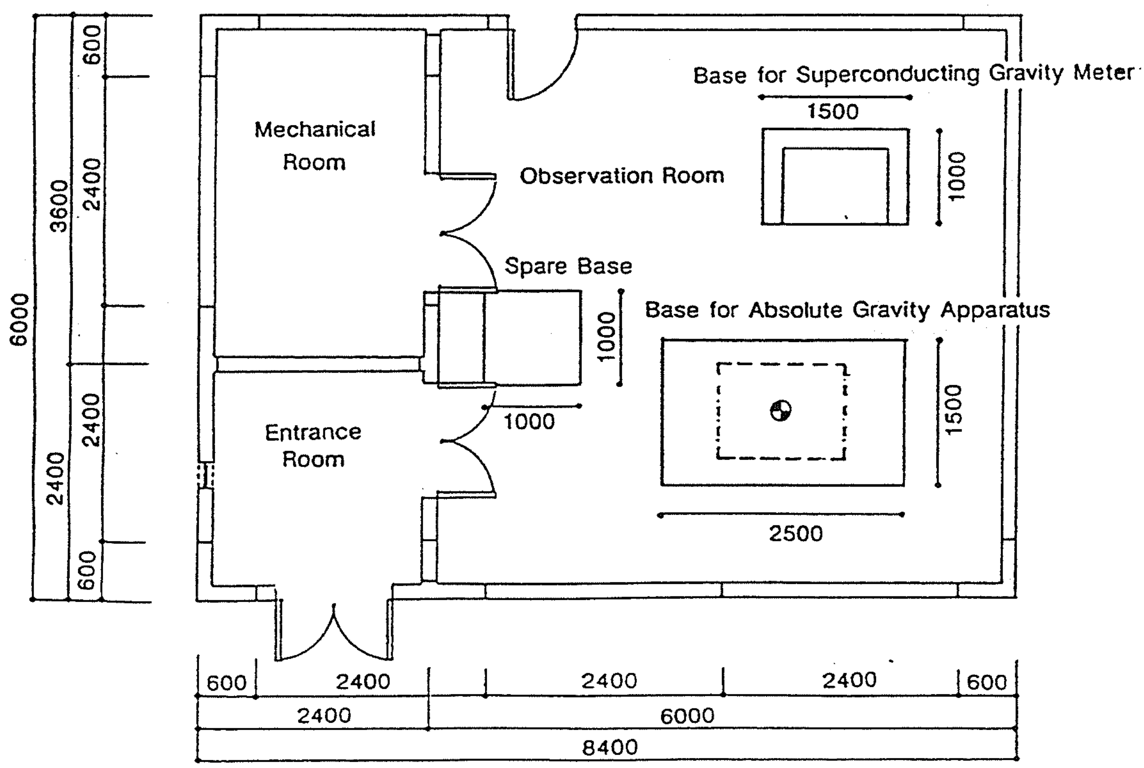
Remarks / Station Identity / Contact

The hut is under construction at the date of 20 January 1991. The planned hut has the concrete base of 2.5 m by 1.5 m for the absolute gravity apparatus, with a marble plate of 1.0 m by 1.4 m placed at the center of the base. At the center of the plate, brass disk of 8 cm diameter with a cross is buried. Station designation is IAGBN(A) SYOWA STATION JARE32 1991.

Station contact: Earth Sciences Division
National Institute of Polar Research,
Kaga 1-9-10, Itabashi-ku, Tokyo 173
Tel 3962-4711 Telefax 3962-5741

Detailed Sketch (North? Station Marker?) / Photograph

Door direction to the Entrance Room may be changed depending on the construction condition.



Date / Author 20 January 1991, Kazuo Shibuya

International Absolute Gravity Basestation Network (IAGBN)

tation Location: VALLE DE LOS CAÍDOS (madrid) Country: SPAIN

= 40º 38' 57" N λ= 4º 08' 36" W H= 1212,4 m. g= 9.79884900 m.s^{-2}

)verview / Access / Outside View / Topo Map

The station is located at the gravity laboratory Valle de los Caídos, placed 45 km. north-west from Madrid. It has a very good access by car.

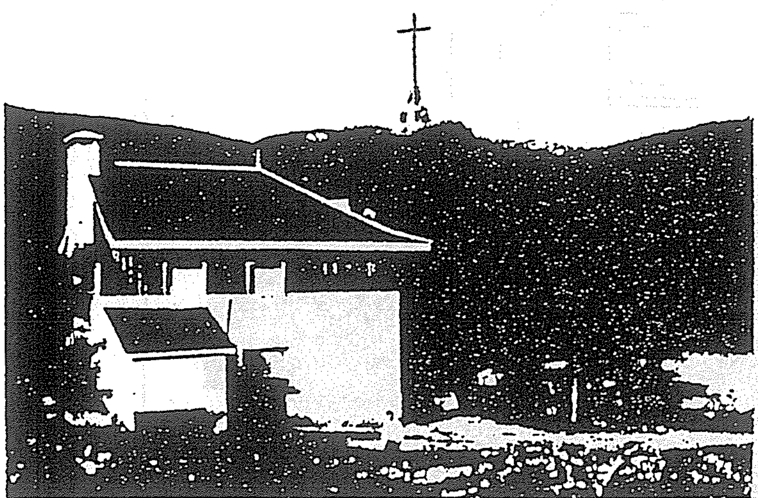
{emarks / Station Identity / Contact

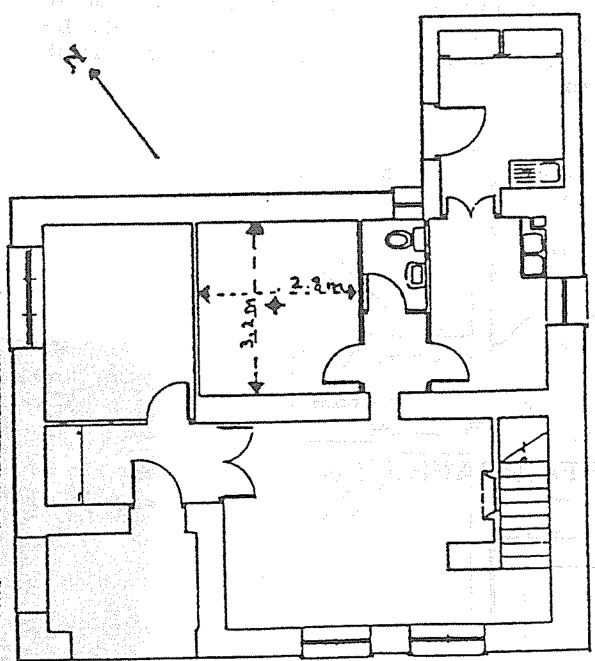
Absolute Gravity Station nº 002

Dr. R. Vieira
Instituto de Astronomía y Geodesia
Facultad de Ciencias Matemáticas
28040 MADRID
SPAIN

Tel. (91) 3 94 45 86
FAX. (91) 5 43 94 89
TELEX. 41802 UCMATE

)etailed Sketch (North? Station Marker?) / Photograph





Date / Author Enero 1991 Dr. R. VIEIRA

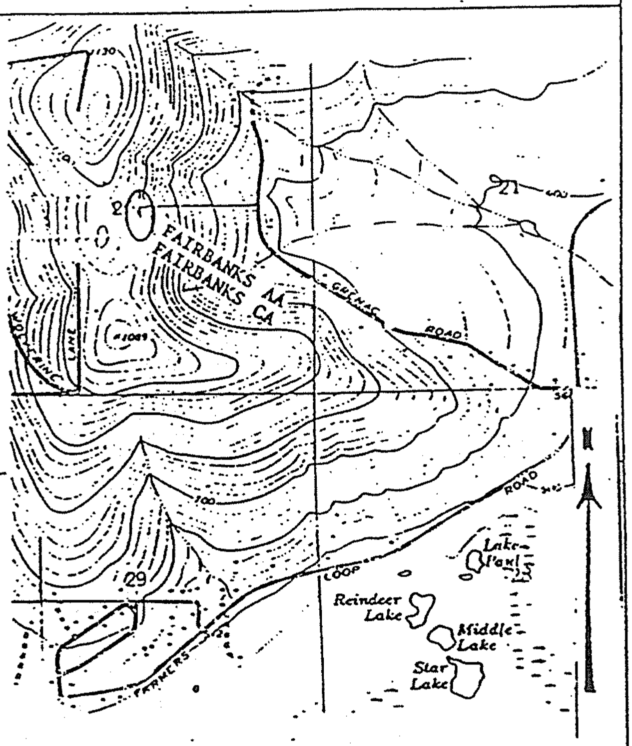
International Absolute Gravity Basestation Network (IAGBN)

Station Location: Fairbanks, Alaska — Country: United States of America

φ= 64° 53" 57" N — λ=147° 47' 41" W — H= 314 m — g=982 198 148 x $10^{-8}ms^{-2}$

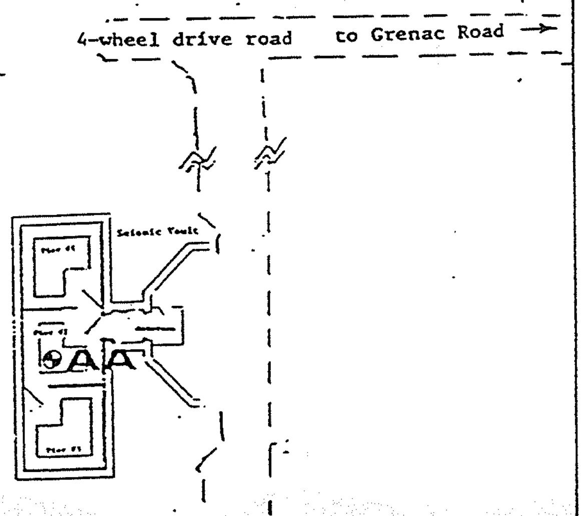
Overview / Access / Outside View / Topo Map

Station is at the USGS College Observatory Seismic Vault. From the intersection of routes AK 2 (Richardson Hwy.) and AK 3 (Parks Hwy.), go west on AK 3 for 3.5 miles (mi) to University Ave. Turn north and go 6.4 mi. Turn left on Grenac Road. Go 1.0 mi and turn left up a dirt road 0.35 mi to station on left.



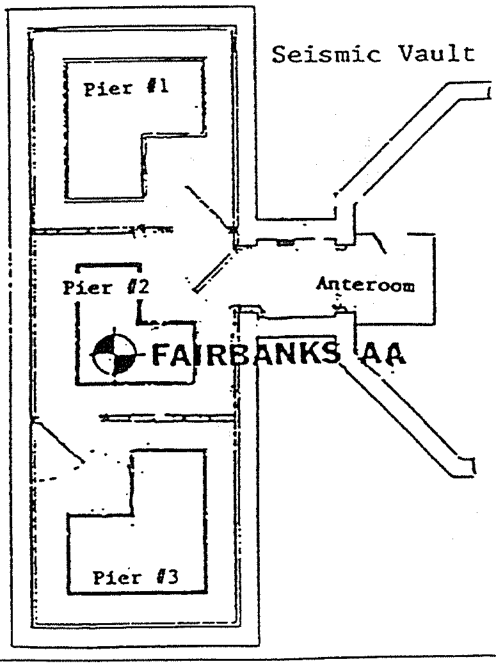
Remarks / Station Identity / Contact

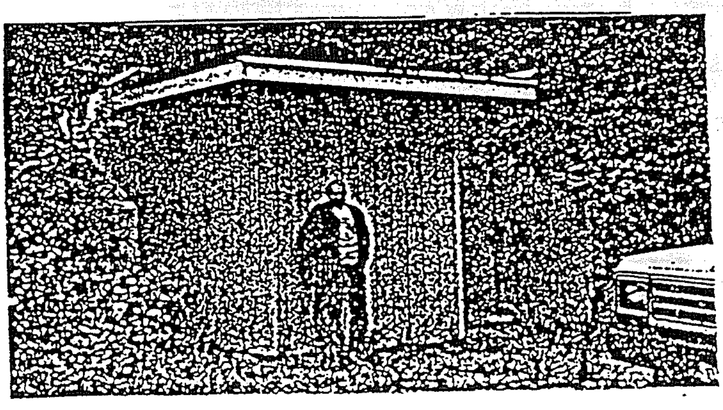
Contact USGS Magnetic Observatory at 907-479-6146. Station designation is FAIRBANKS AA. The station mark is a 3/4" brass disk set by NOAA/NGS.



Detailed Sketch (North? Station Marker?) / Photograph

Station is in seismic vault on top of Pier #2 in central room, 1.8 m west of east wall, 1.0 m north of south wall, 0.52 m SW of interior corner of raised, isolated, L-shaped pier and over mark epoxyed flush into pier.





Date / Author 10 September 1990 Bernard/Winester

International Association of Geodesy

[IN]TERNATIONAL GRAVITY COMMISSION - WORKING GROUP II: WORLD GRAVITY STANDARDS

Prof. Dr. Ivan I. Mueller
Dept. of Geodetic Science and Surveying
The Ohio State University
1958 Neil Ave.
Columbus - Ohio - 43210-1247

March 12th 1991

Re: International GPS Geodynamics Service (IGS)

Dear Prof. Mueller,

I refer to the 'Call for Participation' dated February 1., 1991.

My comments shall contribute to the question of 'Observatories' and to the application to global geodynamics; I shall not comment on the 'Data and Analysis Centers' or the 'Central Bureau'.

The more a network for geodynamic studies becomes a really global one, the more it is possible to take into consideration not only tangential position changes such as plate motions but also radial deformations. If one wants to relate these to geophysical processes, it is necessary to take into account also gravity (changes). This is one of the objectives of the 'International Absolute Gravity Basestation Network' IAGBN.

The idea of IAGBN orginates from Levallois, Mather, Uotila and many others, a proposal including objectives, rationale, station selection criteria and proposed station set of 36 stations was submitted to the IGC and IAG and endorsed 1989. More than 50% of the sites were observed, currently observations are underway in the Antarctic by Japanese and Italians. At various stages reconnaissance and/or talks are underway for additional stations. For your convenient information, I again send you reports on IAGBN.

As I see it, IAGBN and IGS-projects are

- similar in that both provide services to the respective observation system (IGS: GPS; IAGBN: gravimetry) but also offer investigation facilities to global geodynamics (IGS: position changes; IAGBN: gravity changes).

- complementary in that IGS should include gravity variations monitoring and IAGBN should include position monitoring.

- parallel in that they are both aiming at a reasonably global coverage with a limited number of stations

- parallel in that at least for a subset of IGS the more stable parts of the crust should be selected as was the case for IAGBN

- different in that permanent GPS observatories require data links to analysis centers etc., whereas the observations frequency and data quantity of absolute gravity observations is quite low.

Consequently, I offer, through this Working Group II, a link for the exchange of data and information to the gravimetric community as far as global reference networks are involved.

Kind regards

G. Boe.

Dr.-Ing. Gerd Boedecker

c/o Bayerische Akademie der Wissenschaften, Marstallplatz 8, D-8000 München 22, Germany F.R.

Phone (089) 23031212 Telex 5 213 550 dgfi d EARN/BITNET nodeDM0LRZ01 idA2101AB

REPORT OF THE IGC - WORKING GROUP V :
MONITORING OF NON-TIDAL GRAVITY VARIATIONS

PREPARED FOR
THE XXTH GENERAL ASSEMBLY OF THE IUGG
VIENNA, AUGUST 11-24, 1991

BY

Ch. POITEVIN

CENTRE DE GEOPHYSIQUE INTERNE (CGI)

OBSERVATOIRE ROYAL DE BELGIQUE

AVEVUE CIRCULAIRE, 3

B-1180 BRUXELLES

BELGIUM

Introductory Note

This report has been prepared for the XXth General Assembly of the IUGG in Vienna, 1991. It will be distributed during the meeting of the Directing Board of the International Gravity Commission which will be held during this Assembly. It will be sent to all members of WG5 and the informed persons as part of Circular Letter n° 6.

It comprises:

- this introductory note;
- the one (and a half) page report requested by the IGC;
- Seven reports prepared thanks to the willingness of some WG-members. They are presented in their original form in order to respect the integrity of the ideas of their authors that a synthesis could not achieves;
- For information, a report prepared by the IFE-Hannover for the IGC-WG II that can be interesting for WG 5 (Bis repetita placent, Haec decies repetita placebit);
- The table of contents of the proceedings of the workshop (annex 1): "Non Tidal Gravity Changes: Intercomparison between absolute and superconducting gravimeters" that has been sent to each of you (800 copies) at the beginning of August 1991 (So, please, wait until September before to ask for your own copy if you did not yet receive one);
- An updated list of IGC-WG5 members (annex 2);
- An updated list of informed persons (annex 3).

Before to close this introductory note, I would like to inform you about some news which have not been communicated as activity reports:

- There is now a superconducting gravimeter in Italy and they are organizing their first intercomparison using the IMGC instrument;
- Some new improvements have been performed on the superconducting gravimeters. The mailing list of WG5 has been sent to the maker GWR in order that everybody be informed in the future.

I think that the IUGG G.A is the opportunity to organize an informal meeting to decide the future of the WG5. An information sheet will be distributed in your pigeon box at the beginning of the G.A. with all the informations.

At last, I would like to thank all my colleagues who have contributed to this report. I hope that their action will contribute to the reinforcement of the gravimetric community.

C. POITEVIN
Chairman WG5
August 8, 1991.

Report of the IGC-WG5: "Monitoring of Non-Tidal Gravity Variations"

The IGC-WG5 was created during the XIXth IUGG General Assembly in 1987. The IAG resolution n°4 has been adopted at that time to support the work of WG5.

The Terms of Reference of the IGC-WG5 are in brief:

"to link together the existing and future superconducting gravimeters in a network monitored by absolute gravimeters in order to study residuals, after removal of the tides, for geophysical interpretation, leading to the monitoring of non-tidal gravity variations at a global scale".

The basic ideas underlying the creation of IGC-WG5 refer to the fact that there exists now two kinds of high precision gravimeters:

- the absolute gravimeters (AG) which now reach a precision of 10^{-9} and are transportable;

- the superconducting relative gravimeters (SCG) which are site-fixed reaching a long term precision of 10^{-9} and measuring continuously. The main advantage compared to spring gravimeters being a very low and quite regular drift.

(More details can be found in: Rep. IGC-WG5, Bull. Inf. BGI N°67, pp 45-58, Dec. 1990).

A direct collaboration has been established between different teams to intercompare AG with SCG, for instance: in Canada, in USA (in cooperation with Germany), in Europe (Finland, Germany, Belgium, France). A sub-WG5 has been created in Japan (3 AG, 5 SCG). Most of these experiments are in the starting stage.

An informal meeting of WG5 took place in Walferdange (G.-D. Luxemburg) in December 1987 (17 participants) and has been reported in the circular letter n°2 of the WG.

In collaboration with the European Centre for Geodynamics and Seismology (ECGS), the IGC-WG5 organized in September 1990 a 3-days Workshop (35 participants, 18 communications) entitled: "Non Tidal Gravity Changes: Intercomparison between absolute and superconducting gravimeters". The proceedings of this workshop (250 pg.) has been distributed at the end of July to all the persons of the IGC-WG5 and the BGI mailing lists, spare copies are available on request* (800 copies).
These proceedings are representative of the scientific works of the IGC-WG5 members (see Table of Contents in annex 1).

Considering the high scientific level and the success of this Workshop, a second one is scheduled for 1992 or 1993.

Another way of communication amidst the WG is by means of circular letters. During its last annual meeting on September 1990 in Toulouse, the Directing Board of the BGI asked "that WG5 collect data from sites where colocated superconducting and absolute gravimeter measurements have been made and to take appropriate action to ensure that these data are preserved in a central location for posterity". The IGC-WG5 Circular letter of February 28, 1991 is a first attempt to clarify this matter . The answers show that absolute gravity measurements could easily be released (Finland, Germany, USA, China) while it seems more difficult to obtain for the superconducting data (Canada, Japan). The data exchange format remains one of the first problem to solve.

At last, a project proposed by our Canadian colleagues, the Global Geodynamics Project (GGP) presented during the WG5 workshop, deserves a special attention as it meets some objectives of the IGC-WG5 (see proceedings of the workshop). This project will be discussed during the IUGG General Assembly in Vienna. It is hoped that most of the WG5 members will participate to the discussion.

C. POITEVIN
Chairman IGC-WG5.

June 15, 1991.

to : Secretariat ECGS c/o Mrs JEAN
Observatoire Royal de Belgique
Avenue Circulaire , 3
B - 1180 Bruxelles Belgium

CSGI project - D. Crossley, McGill University

Report for Canadian Geophysical Bulletin, 1990

also proposed as :

Activity Report 1987-1991 to IGC-WG 5

The CSGI (Canadian Superconducting Gravimeter Installation) is a cooperative project between a consortium of Canadian universities (principally McGill, University of Western Ontarion and Saskatchewan) and the GSC (principally the Geodynamics Division, Ottawa). The project runs a GWR superconducting gravimeter at the Canadian Absolute Gravimeter Station (CAGS) in Cantley, Que. in the Gatineaux Hills north of Ottawa.

The instrument began operating on 7 November, 1989. There were initial problems with the recording software which have now been successfully resolved. We currently sample gravity at 1s intervals, with a time accuracy of about a millisecond. This can be compared with the instrument at Wettzell (operated by the Institute for Applied Geodesy, Bavarian Forest, Germany) which has a sample interval of 10s, with a timejitter of 1sec. We sample the atmospheric pressure at 0.1Hz, and 29 other environmental and instrumental parameters are recorded every one minute.

The unique character of the CSGI is that it is a cooperative effort, with several groups across Canada having ready access to the raw data. As a direct consequence, we were able to undertake a wide range of investigations, individually and in cooperation, very shortly after the data acquisition began. In addition the CSGI project has been integrated into the Canadian absolute gravity programme in the Geophysics Division of the GSC through a campaign of simultaneous observation for several months each year. The two instruments together provide a gravity reference system of very high quality.

Current CSGI Projects

1. **Earthquake Studies** (University of Western Ontario).The SG is a highly sensitive accelerometer. A large number of normal modes have been identified and decay rates plotted. Q for individual modes has been calculated. The present aim is to establish the lower bound on earthquake magnitude for normal mode excitation and to search for the gravity signatures of slow and silent earthquakes.

2. **Calibration with Absolute Gravimeter** (Geological Survey of Canada). One long calibration run with the JILA-2 Absolute Gravimeter concluded in March, 1990. Analysis of both datasets have provided a set of calibration constants, based on prominent tidal peaks. We are currently re-analysing the data to determine the improvement in calibration confidence interval with the length of comparison time between the two instruments.

3. **Theoretical Earth Tides** (University of Saskatchewan) The theory of the fluctuations of the mutually attractive force between the Earth and neighbouring massive bodies have been refined to provide theoretical values to the 60 nanogal level in support of the analysis of CSGI data.

4. Core Oscillations (York University, McGill University, Memorial University). These studies aim at providing the periods and amplitudes of internal gravity oscillations and wobble modes of the core for realistic Earth models.

Data Repair and Reduction

To date this has been carried out at 2 centres, the University of Western Ontario (UWO) and Geological Survey of Canada (GSC). Protocols have been developed both at UWO and the GSC to repair missing or rejected sections of a time series. The rejected sections are primarily due to clipping and non-linearity induced by large surface waves due to earthquakes. The UWO repair method is novel in that it attempts to produce a continuous series, with minimum effect on the amplitude spectrum. At UWO and McGill University, data recording and transmission software is being been developed. Currently the raw data is being placed on line from McGill University for Canadian access.

Status and Future

The CSGI Infrastructure Grants from NSERC has just been renewed for another 3 years, thus ensuring the continued operation of the installation. We are planning to install a WORM archival system for the raw and processed data and to finish documenting the elaborate data acquisition system that was written for this project.

A new global gravity monitoring programme is being prepared, the GGP (Global Geodynamics Project) and it is expected to be endorsed as a project of SEDI (Study of the Earth's Deep Interior) at the IUGG in Vienna this summer. This project will coordinate the 11 existing and any future SG instruments into a global 6-year campaign to monitor the gravity field with very high precision. The main scientific objectives of GGP are the search for internal gravity waves in the Earth's core, refinement of the position of the rotation pole, quantification of the effects of global atmospheric pressure loading and mass re-distribution on the solid Earth, searching for slow and silent earthquakes, and analysing the gravity changes associated with tectonics, sea-level changes and post-glacial rebound.

OVERVIEW OF ABSOLUTE MEASUREMENTS OF THE GRAVITY ACCELERATION IN CHINA

Guo by Youguang

National Institute of Metrology - Beijing

Proposed as : Activity Report 1987-1991 to IGC-WG 5

During these four last years the NIM-II transportable absolute gravimeter has been improved in our laboratory. An iodine stabilized He-Ne laser, instead of Lamb deep stabilized He-Ne laser, has been used as the light source in our Michelson interferometer and provided a length standard. In order to reduce the effect of background disturbance a new method for processing data has been developed. With the improved absolute gravimeter NIM-II, we participated in the Third International Comparison of Absolute Gravimeters at the BIPM. The intercomparison results gives a value for the average of all measurements which differs from our transferred value by 6μGal. It is better than our results in the Second International Comparison of Absolute Gravimeter.

After the Second ICAG absolute measurements of the gravity acceleration made a beginning with the NIM-II absolute gravimeter in China. During the last few years the instrument was driven a total distance of approximately 28000 Km(more than half of the distance was by small van, the other by train). About twenty five absolute gravity stations have been established which are located in Xinjiang, Yunnan, Heilonjiang, Jilin, Liaoning, Zhejiang, Jiangsu etc. province and Shanghai city. The uncertainties of around $1\times10^{-7}m/s^2$ have been attained at each of these stations. A comparison with results from observations performed with the Germanic JILAG-3 absolute gravimeter showed a good agreement in five stations. The gravity differences between these results with two kind of absolute gravimeter are less 11μGal in five station. There is another comparison between these results obtained with our NIM-II instrument and Finish JILAD-5 absolute gravimeter. The results showed a good agreement too in three stations (less than 13μGal). At the same time a long gravity calibration line has been set up which from Harbin through Beijing to Kunming has the gravity difference $2291\times10^{-5}m/s^2$. The NIM-II absolute gravimeter also has been used for establishment of two short gravity calibration lines on the mountains. One is located near by Beijing (246×10^{-5} m/s^2), another is located near by Kuming ($116\times10^{-5}m/s^2$).

In order for investigation in earthquake prediction the monitoring of non tidal gravity variations has been made with NIM-II absolute gravimeter at Xiangshan station in the vicinity of Beijing. We have collected the data of absolute gravity from 1986 to 1990.

But I regret very much, this project and all measurements of absolute gravity with NIM-II instrument in China went to a stop for lack of finance in 1991. Because my laboratory belong to the National Institut of Metrology. Now we have no a chance to get money for investigation in geophysics.

Absolute gravity determinations at Xiangshan station
ϕ=39.9° λ=116.2° H=164m EH.h=0 dg/dh=275

No	Epoch	C g (μgal)	Depth of ground water
1	1986/03/11	980 129 252	
2	1987/07/21	980 129 278	
3	1987/08/26	980 129 271	
4	1987/09/28	980 129 277	
5	1988/03/13	980 129 275	
6	1988/03/14	980 129 270	
7	1988/04/23	980 129 259	
8	1988/05/13	980 129 265	
9	1988/06/17	980 129 272	
10	1988/08/25	980 129 282	2.68 m
11	1988/09/06	980 129 276	3.89 m
12	1989/07/29	980 129 280	
13	1989/08/15	980 129 273	5.15 m
14	1989/09/15	980 129 281	5.73 m
15	1989/10/18	980 129 281	7.44 m
16	1989/12/28	980 129 278	
17	1990/05/31	980 129 258*	
18	1990/09/30	980 129 282	6.08 m
19	1990/10/12	980 129 286	
20	1990/11/20	980 129 288	8.59 m
21	1990/12/03	980 129 286	
22	1990/12/21	980 129 289	9.14 m
23	1991/01/18	980 129 272	9.58 m

1. * With JILAG-3 absolute gravimeter.
2. No polar motion correction and air pressure correctionapplied.
3. Depth of ground water is from the surface of the ground to the suface of the ground water.

Table:( ) Comparison of NIM-II observation with observation by IMGC and JILAG-5

Station	NIM-II			IMGC				JILAG-5			
	Epoch	g (μgal)	dg/dH (μgal/m)	Epoch	g (μgal)	dg/dH (μgal/m)	Δg (μgal)	Epoch	g (μgal)	dg/dH (μgal/m)	Δg (μgal)
Beijing (IAGBN)	86.3	980 110 564	-223.7 [1]	81.8	980 110 567 [2]		-3	90.5 90.6	980 110 577	-240 [2]	-13
Nanning (IAGBN)	83.10	978 745 984 [3]	-305 [2]	81.9	978 745 951 [2]		+33	90.6	978 745 987	-302 [2]	-3
Kunming	86.3	978 347 717	-252 [2]	81.10	978 347 749	-252 [2]	-32	90.6	978 347 707	-252 [2]	+10
Guangzhou	83.10	978 815 655 [3]	-305 [2]	81.10	978 815 709	-305 [2]	-54	90.6	978 815 675	-305 [2]	-20
Harbin	87.7	980 637 626	-286 [2]					90.5	980 637 683	-286 [2]	-12

1. IfE gradient used
2. Taken from Dr. Zou (RISM, China)
3. With NIM-I absolute gravimeter
4. No polar motion corection and no air pressure correction applied

WORK RELATED TO IGC WG 5

By J. Mäkinen from 1987 to 1990 (1991)

Geodeettinen Laitos

1. Absolute/superconducting comparisons

Absolute gravity was measured with the JILAG-5 at the superconducting sites Brussels and Strasbourg in April/May 1989, December 1989, September 1990, and April 1991. All these measurements were referred to the absolute station Clausthal (FRG). The observations at Strasbourg can also be used to calibrate the superconducting gravimeter there. An attempt was made to detect a possible variation in the vertical gradient of gravity at Strasbourg (negative result, not published).

2. The gravity effect of subsurface water

was studied in unconfined aquifers in sand/silt and silt/clay soils, using relative gravimeter (LCR). The importance of soil moisture content (as opposed to groundwater alone), and the inadequacy of precipitation as the sole explanatory variable were brought out. In sand/silt soil the observed gravity variations were well explained by observed water storage variations. In silt/clay soil, bafflingly, this failed. The gravity and gradient effects of surface water (snow) were pointed out /1/2/3/.

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2. J. Mäkinen and S. Tattari: The influence of variation in subsurface water storage on observed gravity. The XI International Symposium on Earth Tides, Helsinki, Finland, July 31 to August 5, 1989.

3. J. Mäkinen and S. Tattari : Subsurface water and gravity. Workshop "Non tidal gravity changes". Intercomparison between absolute and superconducting gravimeters. Walferdange (Luxembourg), September 5-7, 1990.

ACTIVITY REPORT 1987-1991 TO IGC-WG 5

by

G. Peter

National Geodetic Survey - U.S.A.

In about October 1989, John Goodkind's (UCSD-SG) and Bernd Richter's superconducting gravimeter (IFAG-SG) have been installed at the Richmond, Florida (just south of Miami) site. We have made two six-days-long comparison observations between these instruments and the NGS JILAG-4 absolute gravimeter (AG); one in March 1990, and one in September 1990. As the ground water table change between the two measurement periods was too small to account for it, most likely the moisture content changes of the "soil" above the water table caused an increase of gravity of about +6 μGal in this time interval (SG detected +6.0 μGal, the AG +7.8 μGal). The UCSD-SG instrument was shut down several times between the comparisons due to various problems, and our AG meter may also had a small laser drift during the first comparison (the laser had to be replaced after this station occupation). John Goodkind reported these results at your Luxembourg Workshop. We will be repeating the comparison in June 1991, and we expect that both the SG and the AG gravimeter will be in better condition at that time. Also, we now have a detailed water table and soil profile moisture monitoring program in place. We plan to write paper on the change of gravity observed with both instruments, with particular emphasis on the hydrology.

NGS also visited Japan in February-March 1991, and we had a two-days-long comparison with the Japanese owned GWR SG (and with several other AGs at Esashi. I was told by Dr. Hanada that his colleague, Dr. Tsubokawa will report the comparison to you. The Esashi site is seismically very quiet, and our AG data were spectacular.

Activities of IFAG during 1987-1991 concerning WG 5

by B. Richter

- Installation of TT40 in Miami, parallel registration with SCG-A (Goodkind's instrument, UCSD).
- Installation of TT60 at the satellite observation station Wettzell, Baverian Forest.
- Improvement of the calibration system for SC-gravimeter using the method of artificial accelerations; achieved accuracy 10-4.
- Test of prototype of a portable small SC-gravimeter; measuring system downscaled by the factor of 2; weight 35 kg; height 70 cm; diameter 50 cm.
- Development of new registration system for PCs, OS QNX-PC realtime operational system - data acquisition: gravity signal every 10 seconds, environmental channels (air pressure, temperature, etc.) every 30 - 120 seconds, data links to main fraime computers.

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Report of the Japanese Sub-Working Group for the IGC-WG5 during the Period of 1988-1991

Tsuneya TSUBOKAWA

(National Astronomical Observatory Mizusawa)

In Japan, the National Astronomical Observatory Mizusawa (NAOM) and the Geographical Survey Institute (GSI) are engaging in absolute gravimetry with their absolute gravimeters. On the other hand, 5 GWR superconducting gravimeters (SCGs) altogether are, as of May 1991, in operation in 3 institutes; Kyoto University, University of Tokyo and NAOM.

The NAOM has made absolute gravity measurements at 5 stations in Japan with three types of absolute gravimeters developed by themselves, during the period concerned [1]. The first model has worked since 1978 with the standard deviation of about 10 μGals for a single drop at Esashi. The second one took part in the Third International Comparison of Absolute Gravimeters held at BIPM in November 1989, soon after the completion. This gravimeter gave almost the same value as the mean of the other 9 absolute gravimeters participated [2]. The second gravimeter has achieved further improvements, especially for a release mechanism, since the Comparison. A direct comparison of this gravimeter with that of the National Geodetic Survey (NGS) was made at Esashi station in March 1991. The difference obtained with two absolute gravimeters (NGS-NAOM) was 27 μGals. The NAOM has also developed the third absolute gravimeter with a rotating vacuum pipe, for realizing long-term continuous observations. A test of one-week continuous observations with this gravimeter has succeeded in March 1991. The amplitude of four principal components of gravity tides have been determined using the data obtained. Developments of the gravimeter are going on for detecting the secular or long period gravity changes.

The GSI has carried out absolute gravity measurements at 5 stations with the transportable absolute gravimeter of modified Sakuma-type during this period. The precision of absolute values obtained was better than 10 μGals. Repeated gravity measurements at Tsukuba have revealed that the repeatability of the gravimeter was better than 8 μGals. Results of the direct comparison with the NGS absolute gravity meter at Tsukuba showed an excellent agreement within 1 μGal. The GSI has also conducted relative gravity surveys for the first-order gravity network, which consists of about 300 gravity stations and is linked to 13 absolute gravity stations. Those surveys are to be repeated every 5-7 years to detect possible gravity changes due to vertical crustal movements [3, 4].

A new absolute gravity station has just established in January 1991 at Syowa Base, Antarctica. The station corresponds to the proposed one in the A-set stations of the International Absolute Gravity Basestation Network (IAGBN). The first series of absolute gravity measurements there is to be executed by the GSI with its gravimeter in January 1992. The second series will be made by the NAOM with 2 absolute gravimeters of their second and third models in January 1993.

Department of Geophysics, Kyoto University, installed 2 SCGs (Model TT-70 Nos. 8 and 9) by turning to the direction of 90 degrees in the same room at the Department in July 1988. Continuous observations with these SCGs have continued for precise investigations on the tidal change of gravity. Non-tidal gravity changes accompanied with atmospheric pressure changes were also investigated using them [5].

The NAOM continued tidal observations with the SCG (Model TT-70 No. 7) at the Esashi Earth Tides Station in February 1988 - August 1989. However, the repair of the gravity sensing unit required the interruption of records for about one year. The observations restarted in October 1990. Compared with the previous records, records obtained by the repaired sensing unit showed a good quality with a very low drift rate.

Ocean Research Institute, University of Tokyo has conducted SCG observations with TT-70 No. 11, at Kakioka since October 1989. The main objective of the observations is to detect the gravity changes associated with the free oscillations of the earth. The observations are scheduled to be continued at least for 3 years.

An observation project in Antarctica using a SCG is promoted by four institutes in Japan. The SCG (Model TT-70 No. 16) and a helium liquefier to be used for this project have tested, soon after the installation in the gravity room at the NAOM in March 1991. The test of the liquefier was accomplished in the beginning of May. The liquefier has proved to be efficient to make enough amount (100 liters) of liquid helium necessary for setting up the SCG in Antarctica.

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Activity Report to IGC-WG V
1987 - 1991

by H.-G. Wenzel, Geodätisches Institut, Universität Karlsruhe

1 Feasibility Study for the Calibration of a Superconducting Gravimeter by Parallel Recording with an Absolute Gravimeter

In order to investigate the possibility of calibrating a superconducting gravimeter by parallel recording of earth tides with an absolute gravimeter, a two days experiment of continous absolute gravity observations (one drop every 12 secs) has been performed in December 1987 at Institut für Erdmessung, Universität Hannover, with the free fall absolute gravimeter JILAG-3. The observations have been performed during the weekend with medium tidal variation (900 nm/s^2 peak to peak) and wind induced microseismic noise of about 700 nm/s^2 standard deviation per drop. By averaging over 400 drops, the standard deviation is decreasing to 30 nm/s^2. The rms discrepancy to tides computed from the CTED tidal potential development using observed tidal parameters was 20 nm/s^2. The adjustment of a linear scale factor between the absolute gravity observations and the computed tides gave a standard deviation of about 1% for the scale factor, showing that the capability of present day (1987) absolute gravimeters of JILAG type to calibrate a superconducting gravimeter is only 1% under similar conditions.

Reference : WENZEL, H.-G. : Results of a Test Experiment to Record Tides with an Absolute Gravimeter. Presented to 66th JLG Meeting Walferdange, March 14-15, 1988.

2 Calibration of the Strasbourg Superconducting Gravimeter TT60 by Parallel Recording with LCR Model G Gravimeters

In 1990, an experiment has been carried out to calibrate the superconducting gravimeter TT60 at Strasbourg (Institute du Physique du Globe, Strasbourg). Two LCR gravimeters model G with SRW electrostatic feedback (Geodätisches Institut, Karlsruhe) have been set up in parallel with the superconducting gravimeter for 6 months to record the gravity variation due to earth tides and atmospheric pressure. The signals of all three gravimeters plus that of a barometer have been recorded with 5 minute sample rate using two different digital data acquisition systems. The feedbacks of the LCR gravimeters have been calibrated before and after the experiment at Hannover vertical gravimeter calibration line. The experiment is currently under evaluation, no results available.

3 Calibration of the Bad Homburg Sperconducting Gravimeter TT100 and two LCR Model G Gravimeters on an Acceleration Platform

In March 1991, an experiment has been started to simultaneously calibrate the new small size superconducting gravimeter TT100 (Institut für Angewandte Geodäsie, Frankfurt) and two LCR model G gravimeters with SRW electrostatic feedback (Geodätisches Institut, Karlsruhe) on an acceleration platform at station Bad Homburg. The feedbacks of the LCR gravimeters have already been calibrated on the Hannover vertical gravimeter calibration line. The experiment is currently in operation, no results available.

Hans-Georg Wenzel, 10.4.1991

For information to IGC - WG 5

Absolute Gravimetry

Activities of Institut für Erdmessung (IfE) 1987-1991
Report to IAG-IGC Working Group II

Instrumental investigations and developments of JILAG-3

To improve repeatability and accuracy of observations with the absolute gravimeter JILAG-3, technical investigations have been performed. The optical base was readjusted in early 1988 resulting in a +0.22 μms^{-2} correction for gravity observations performed with the instrument in 1986 and 1987, cf. *Torge et al. 1989*. Laser frequency variations due to temperatures different from the calibration temperature is corrected by an appropriate reduction function since summer 1988, allowing the employment of JILAG-3 at temperatures between 20 and 25°C without loss of accuracy due to this effect. Floor recoil effects, caused by the dropping procedure, require hardware and software improvements which are in process at present time. Comparisons of JILAG-3 results with independent gravity data showed a long term accuracy of ±0.07...0.1 μms^{-2}, cf. *Torge 1990b*.

Absolute gravimetry campaigns

In 1987/88 gravity observations have been carried out on the Faeroer Islands (one abs. station) and in Iceland (five realible abs. stations, geodynamics), cf. *Torge 1989*. In 1988 three absolute stations were observed in Greenland (fundamental network, IAGBN), in co-operation with the *Danish Geodetic Institute*. The same year a gravity campaign was performed in Venezuela (six abs. stations, geodynamics, fundamental network), cf. *Drewes et al. 1991*. In 1989 three absolute measurements were carried out in Argentine (fundamental network, IAGBN, geodynamics), seven in Brazil, and two in Uruguay, in co-operation with several institutions (*Universidade de Buenos Aires; Universidade Federal do Parana, Curitiba; Servicio Geografico Militar, Montevideo*). In a joint project with the Institute of Seismology (IoS), Wuhan/China, a gravity control system has been established in the Yunnan earthquake region in 1990 (37 gravity stations, six of them absolute, geodynamics) and was supplemented by four absolute stations in Wuhan and Beijing, cf. *Torge et al. 1990a*. The absolute gravity stations have been connected to national and international networks by relative observations, whenever feasible. Reobservations of a few stations and the extension of the absolute gravity net in South-America are scheduled for autumn 1991 (Argentine: 2 existing stations plus 2 or 3 new ones, Brazil: 1 or 2 + 1 or 2, Uruguay: 2 + 1); the Yunnan control net shall be reobserved and enlarged by one or two absolute sites in spring 1992. New stations will be observed in Germany (2) and in the Netherlands (3) already in summer/autumn 1991.

Within the frame of the different research projects, IfE contributed to the establishment of the International Absolute Gravity Basestation Network IAGBN by performing absolute gravity observations with JILAG-3 at five stations of subset A and four stations of subset B (subsets defined in *Boedecker and Fritzer 1986)*. Included are one station in Godthab/Greenland (1988), three stations in South America (Tandil/Argentine 1989, Brasilia/Brazil 1989, Sta. Elena/Venezuela 1988), cf. *Gemael et al. 1990* and *Drewes et al. 1991*. In Germany, a gravity determination was carried out at the fundamental satellite observation station Wettzell (1989).

From subset B the stations Sèvres/France, Bruxelles/Belgium (1987 and 1989), c.f. *Poitevin 1990*, Potsdam/Germany (1988 and 1990), cf. *Torge et al. 1990b*), and Beijing/China (1990), cf. *Torge et al. 1990a*, have been observed within the past four years. Results are summarized in the table below. The accuracy of the values at floor level is estimated to be 0.1 μms^{-2} or a little bit better.

Absolute gravity determinations by IfE at IAGBN stations

IAGBN A	Number IAGBN/IfE	n	ref.h [m]	dg/dh [μms^{-2}/m]	$g_{ref.h}$ [μms^{-2}]	Δg [μms^{-2}]	g_{floor} [μms^{-2}]
Sta. Elena[1]	3001/0040	1721	0.803	2.969	9 778 218.459	2.384	9 778 220.84
Nuuk (Godthab)[1]	3107/1072	1468	0.802	-	9 821 904.302	2.245	9 821 906.55
Tandil[1]	3114/0322	1627	0.810	2.980	9 799 041.189	2.414	9 799 043.60
Brasilia	3212/0122	1441	0.808	2.478	9 780 485.973	2.002	9 780 487.98
Wettzell	0205/0162	3404	0.808	3.329	9 808 354.370	2.690	9 808 357.06
IAGBN B	**Number IAGBN/IfE**	**n**	**ref.h [m]**	**dg/dh [μms^{-2}/m]**	**$g_{ref.h}$ [μms^{-2}]**	**Δg [μms^{-2}]**	**g_{floor} [μms^{-2}]**
Sèvres (at A1)	—/0111	1436	0.795	-	9 809 257.290	2.572[2]	9 809 259.86
(at A3)		3156	0.801	-	9 809 256.885	3.127[2]	9 809 260.01
Bruxelles (6/87)	—/2002	5335	0.812	2.873	9 811 164.486	2.333	9 811 166.82[3]
(12/89)		5222	0.811	2.873	9 811 164.337	2.330	9 811 166.67[3]
Potsdam (1/88)	—/0014	4410	0.804	2.590	9 812 614.611	2.100	9 812 616.71
(1/90)		3113	0.839	2.590	9 812 614.411	2.191	9 812 616.60
Beijing	—/1003	1564	0.821	2.241	9 801 103.885	1.840	9 801 105.72

n: Number of drops used for the determination of gravity,
ref.h: Referenz height above floor level.
Δg: Gravity difference between the instrument's reference point and a station mark. Since the reference point is not vertically above the mark in any case, Δg may differ from the factor *ref.h x dg/dh*.

[1] Stations Sta. Elena (instead of Boa Vista) and Nuuk (Godthab) (instead of Sisimiut (Holsteinsborg)) were choosen because of logistical purposes, Tandil (instead of Mar del Plata) was choosen, because it is an earth tide station which is located more far from the coast.

[2] Centering to station Sèvres A according to *Becker et al. 1990*. At the other stations gradients and gravity differences for centering were observed with LCR G-298 and G-709, in Wettzell additionally with G-793 and G-854 (all equipped with SRW-feedback); in Beijing G-853 equipped with a SSB-feedback was employed together with G-298 and G-709.

[3] The gravity difference to Bruxelles A is +6.04 μms^{-2} yielding there 9 811 172.86 μms^{-2} for the observation in 1/88 and 9 811 172.71 μms^{-2} for 12/89.

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ANNEX 1

Proceedings of the Workshop:
Non Tidal Gravity Changes:
Intercomparison between absolute and
Superconducting gravimeters.

AN OVERVIEW

Proceedings of the Workshop: Non Tidal Gravity Changes: Intercomparison between absolute and superconducting gravimeters

September 5th to 7th, 1990
WALFERDANGE (GRAND-DUCHY OF LUXEMBURG)

Organized by the European Centre for Geodynamics and Seismology (Council of Europe)
and
the IAG – International Gravity Commission – Working Group V: Monitoring of Non Tidal Gravity Variations

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Luxembourg - 1991

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Friday, September 7th, 1990.

SESSION 3 :Non tidal gravity changes : theoretical aspects

Chairman J. HINDERER

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INTERNATIONAL GRAVITY COMMISSION WORKING GROUP NO. 7 COMPUTATION OF MEAN GRAVITY ANOMALIES

Chairman: Hans-Georg Wenzel, Geodätisches Institut, Universität Karlsruhe
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Report for the Period June 1988 to August 1991

presented to the meeting of the Directing Board of BGI during IUGG General Assembly at Vienna, August 14, 1991.

1 Membership

The current members of the IGC working group 7 are : Dr. Heiner Denker, Institut für Erdmessung, Universität Hannover (FRG); Dr. René Forsberg, Geodetic Institute, Copenhagen (Denmark); Dr. Michel Sarrailh, Bureau Gravimetrique International, Toulouse (France), and Dr. Hans-Georg Wenzel, Geodätisches Institut, Universität Karlsruhe (FRG). The IGC working group 7 is in principle open for new members, but I would like to have the working group as small and efficient as possible.

2 History

The IGC Working group 7 has been created at the meeting of the BGI directing board at June 24th, Paris 1988. The terms of reference defined at that meeting are published in the Bulletin d'Information, Bureau Gravimetrique International, **67**, 61–65, Toulouse 1991. Reports have been presented at the 12th meeting of the International Gravity Commission at August 5th, Edinburgh 1989, and at the 13th meeting of the International Gravity Commission, September 11 to 14, Toulouse 1990. The last report is published in the Bulletin d'Information, Bureau Gravimetrique International, **67**, 61–65, Toulouse 1991.

3 Meetings of the WG

Meetings of the working group took place during the 1st International Geoid Commission Symposium, June 13th, Milano 1990; during the 13th meeting of the International Gravity Commission, September 11 to 14, Toulouse 1990, and during the assembly of the European Geophysical Society, April 22 - 26, Wiesbaden 1991. The main tasks of WG7 are summarized in the following:

- The main task for IGC working group no. 7 is to enable BGI to create a world wide 5' x 5' terrestrial free air gravity anomaly data set. This task has to be as soon as possible.

- The second task is to work out procedures for individuals and institutions to create regional 5' x 5' free air gravity anomaly data sets, which can be released to the international community.

- It is adopted to produce 5' x 5' terrestrial mean free air gravity anomalies (as agreed by the executive committee of the International Geoid Commission and the working group 7 members). BGI has already large 5' x 5' terrestrial mean free air gravity anomaly data sets for Africa and South America by cooperation with the University of Leeds (UK), which unfortunately are not yet freely distributable but can be used for internal comparisons.

- The main procedure should be to use directly digital free air gravity point data bases, as e.g. the BGI data base. For land areas, the BGI data base is already completely screened. For marine areas, the screening of the BGI data base has been started, but not yet finished (the software for track bias adjustment of sea gravity data has been implemented in September 1990 at BGI).

- For the production of 5' x 5' mean free air gravity anomalies on land and sea, the procedure will be to average point free air anomalies, simple Bouguer anomalies and elevations within 1' x 1' cells, and to predict mean free air anomalies using the 1' x 1' averages inside the 5' x 5' block and 2' around the block (see Fig. 1). As a byproduct, mean 5' x 5' Bouguer anomalies and elevations could be computed simultaneously, depending on the software used for the production computation (see section 5). The use of 5' x 5' world wide mean elevations ETOPO5 has been discussed during the first meetings of the working group, but is not considered for the production computation of mean 5' x 5' free air anomalies because of large errors in the ETOPO5 data set (see Table 1). For the production computation of mean 5' x 5' gravity anomalies, least squares collocation will be used, and different programs are available or in the final testing step resp. (see section 5). For the mean anomaly prediction, a numerically integrated point covariance function will be used.

- For the computed 5' x 5' data, the mean free air graity anomaly plus ist standard deviation , the mean Bouguer anomaly and its standard deviation and the mean elevation and it's standard deviation will be stored. Additionally, the number of used point gravity data will be stored.

4 Mean Elevation Problem

It was initially planned, to use the worldwide 5' by 5' mean elevation data set ETOPO5 for the transformation of predicted mean Bouguer gravity anomalies to mean free air gravity anomalies. At the Milano meeting, Forsberg has already mentioned large errors of the ETOPO5 data set in Scandinavia and Canada. After the Milano meeting, Denker has reported on a comparison of the ETOPO5 data set at different areas of the world and reported large errors of the ETOPO5 data set up to 2 km, given in Tab. 1. Thus, we cannot use the ETOPO5 data set for the mean anomaly computation, and there is no other 5' by 5' world wide data set available. The only decision we can make now for the production of a world wide 5' by 5' mean free air gravity anomaly data set from BGI point gravity data base

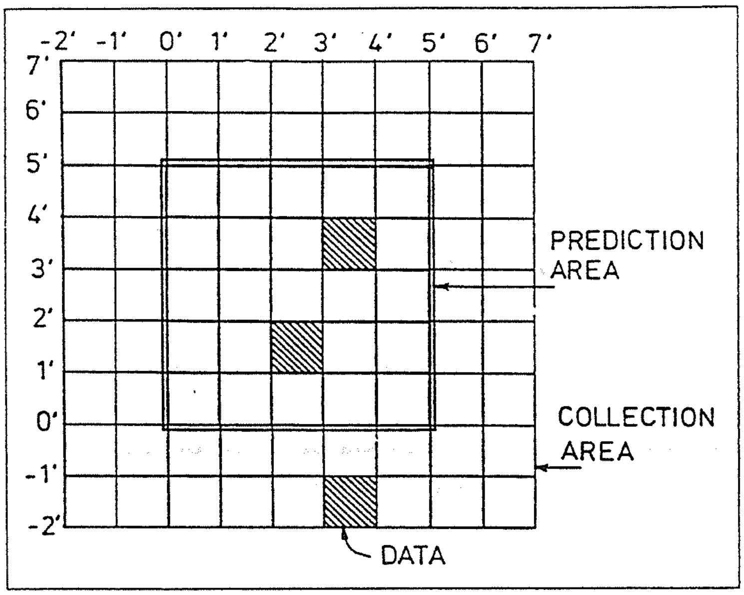


Figure 1: Collection and Prediction Areas

is to directly predict mean free air gravity anomalies from point free air gravity anomalies. Naturally, the predicted mean free air gravity anomalies will have large errors especially in areas with rough topography and in areas with sparse point data distribution. Therefore, it is necessary to work out procedures for anomaly production for individuals and institutions, which can use high quality regional mean elevation data sets, and can release their data sets to BGI to be merged with the global data set.

Table 1: Comparison of 5' by 5' mean elevations with ETOPO5 by H. Denker

data set	number	mean [m]	stdv [m]	min [m]	max [m]
E0505BAK63 Netherland from 3' x 5'	377	2.2	9.3	-50	58
E0505FIN83 Finland	10662	2.0	22.6	-253	314
E0505FRG87 FRG from 1 km x 1km	5332	3.3	60.5	-609	555
E0505IFE87 Northsea, Baltic Sea	7311	-0.4	17.6	-175	110
E0505VEN87 Venezuela	2138	-37.4	310.6	-1900	2050
E0505IFE90 Europe from 6' x 10'*	122210	-16.0	129.1	-1817	1785

*large errors at areas with rough topography (Alps, Norway)

5 Software

There has been made available to the working group a small piece of software for mean anomaly computation by Dr. Peter Vaniček, University of New Brunswick (Canada), which

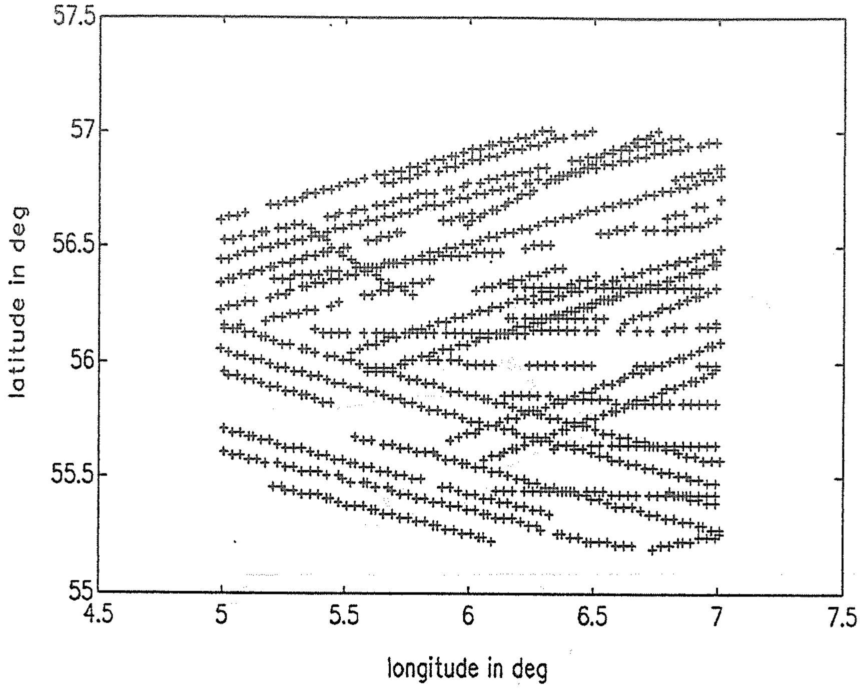


Figure 2: Distribution of 1' by 1' averages for the test area

unfortunately does not meet the requirements of working groups 7 task. Dr. Hans Sünkel, Technische Universität Graz (Austria), has agreed to release an existing complex software package for mean anomaly prediction to the working group, for which a short description is available. Sünkel's program has been investigated, but it seems to be too complex for the production computation of mean 5' x 5' anomalies on a world wide scale. R. Forsberg and H.-G. Wenzel have prepared programs designed especially for the task of working group 7, by modifying existing programs (GEOGRID by Forsberg) or by creating a completely new program (PFAMEAN by Wenzel). Forsberg's program is in the final testing step, and will hopefully be available soon. Wenzel's program PFAMEAN has been distributed to the members of the working group during this meeting, and some features and results from PFAMEAN are discussed in the following. The program PFAMEAN has not been tested extensively, and it has to be adapted to the BGI CDGF data base structure and the BGI mainframe computer, which will be done by BGI.

The program PFAMEAN is written in standard FORTRAN 77 and has been implemented and tested on a PC (IBM-AT compatible) under MS-DOS. It uses as data input a point gravity archive file structure called PG developped at Institut für Erdmessung, Hannover. The point gravity data read from input are selected for a certain storage area and averaged in 1' x 1' cells for free air, Bouguer and elevation and stored in matrices (after reduction for trend). Fig. 2 shows the 1' x 1' cells filled with data for a test data file (sea gravimetry in the North Sea). By option, empirical covariance functions can be computed from the 1' x 1' cells for free air, Bouguer and elevation (see Fig. 3). For this test area, the free air and Bou-

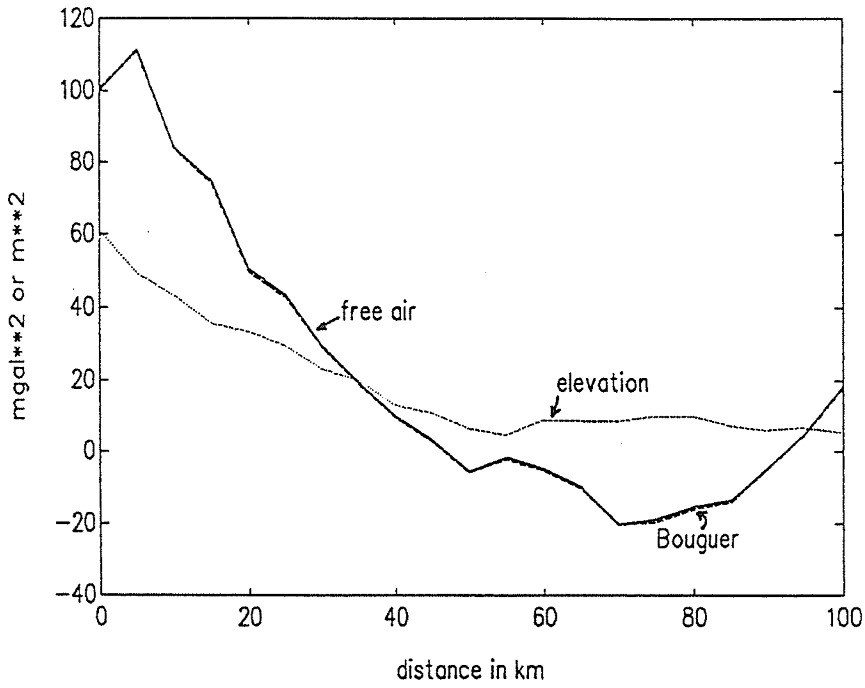


Figure 3: Empirical covariance functions for the test area

guer anomaly covariance function can hardly be distinguished, and the elevation covariance function looks similar to the anomaly covariance function after scaling. From the emipirical covariance functions, covariance parameters are estimated (variances and correlation length's). Because the computation of empirical covariances takes considerable computer time, default values for the covariance parameters may be used by option. Using these parameters, a model covariance function of the form

$$cov_{(s)} = var \cdot e^{\frac{-s}{a}} \tag{1}$$

is used for the prediction. The mean 5' by 5' free air and Bouguer anomalies and elevations are predicted from the data inside the data selection area (Fig. 1) simultaneously using the numerically integrated model free air covariance function in order to save computation time. But the prediction errors for Bouguer anomalies and elevations are proper scaled to their regional variances. All prediction errors are scaled to the local variance of the data inside data selection area, if more than five 1' x 1' cells are filled with data inside the data selection area. Finally, the program prints histograms of the prediction errors for mean free air and Bouguer anomalies and mean elevations. The predicted mean free air anomalies, their prediction standard deviations and the number of 1' x 1' cells used for the prediction are shown for the test area in Figs. 4, 5 and 6. The computation takes about 0.4 sec per 5' x 5' block on an IBM Ps/2 8580 (20 Mhz speed). It is assumed that the computation on a mainframe vector processor is about 1000 times faster. The application of Bouguer and elavation covariance functions is in principle possible, but would increase the computation time by a factor of three. Until now, the program has not been extensively tested, and the program has to be adapted to the BGI mainframe and BGI CDGF data base.

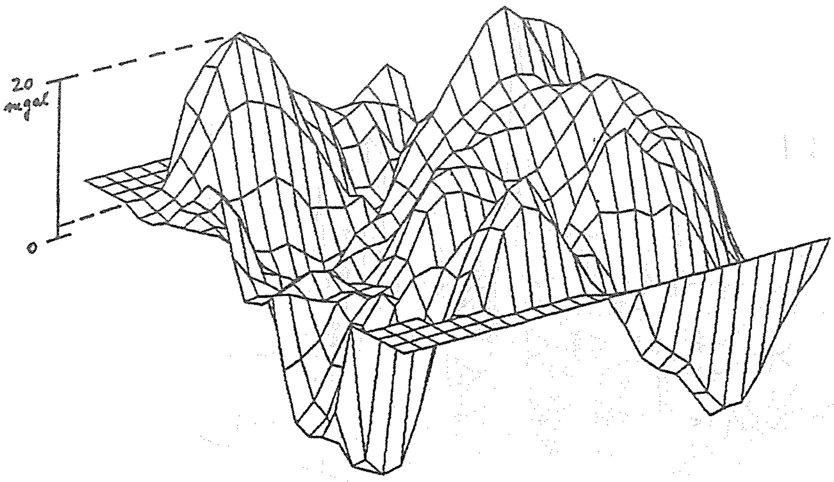


Figure 4: Predicted mean 5' x 5' free air anomalies for the test area, unpredictable blocks set to mean value inside storage area

Hans-Georg Wenzel

Karlsruhe, August 8th 1991.

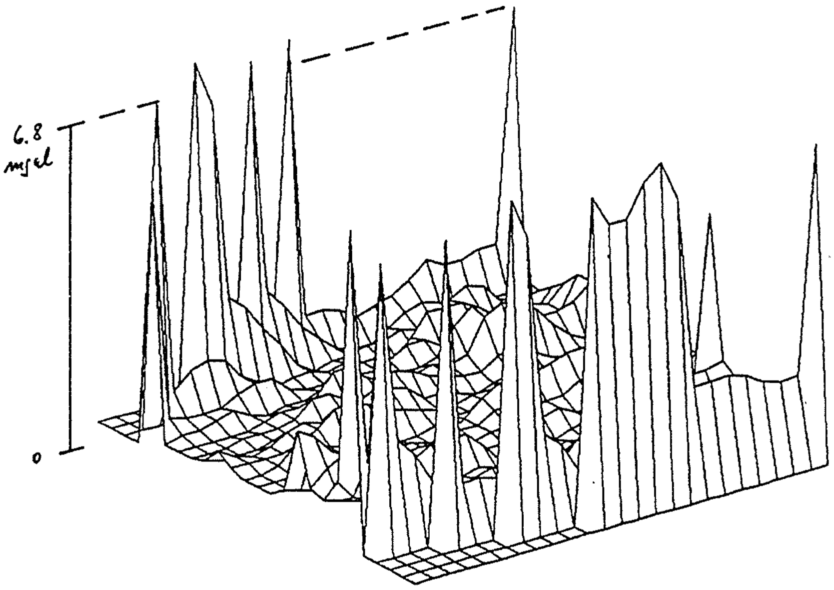


Figure 5: Standard deviations of predicted mean 5' x 5' free air anomalies in the test area, unpredictable blocks set to zero

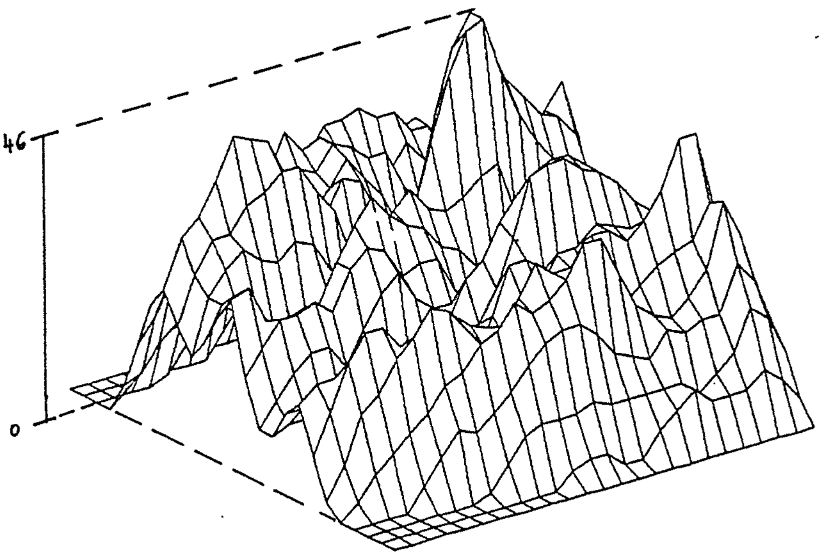


Figure 6: Number of 1' x 1' cells used for the prediction in the test area

Geologic Hazards Slide Sets

SE-0801 06/91

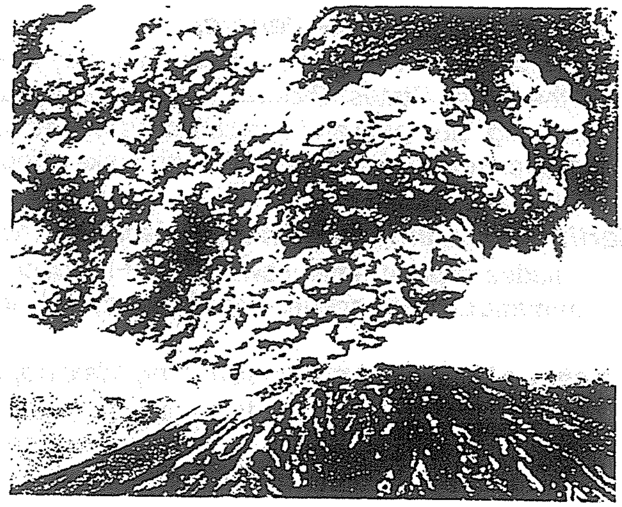
Twenty unique sets of 35-mm slides depicting geologic hazards throughout the world are available from the National Geophysical Data Center (NGDC). These special slide sets provide an affordable tool for presentation to both technical and nontechnical audiences.

Each slide set consists of 20 slides in color and/or black and white. Included with the slides is documentation that provides background material, dates, locations, and descriptions of effects for the depicted hazards.

Volcanoes

NEW ***The Eruption of Mount Saint Helens May 1980***

Includes views of pre-May 18th (1980) eruption activity, views of the major May 18th eruption, and views of the devastation caused by the major eruption. Shows effects of the eruption including the blast area, mud flows, ash fall, and altered terrain. (Color; product number 739-A11-004)



NEW ***Hawaii Volcanism: Impact on the Environment***

Illustrates impact on communities, vegetation, marine life, roads, and coastlines. Also illustrates benefits of volcanism such as geothermal power, increase in land area of the islands, and opportunities for viewing and studying volcanism in relative safety. Includes views of eruptions that took place in the 1980s at Kilauea and Mauna Loa. (Color; 739-A11-005)

NEW ***Hawaii Volcanism: Lava Forms***

Includes spectacular views of lava fountains, lakes, cascades, flows, spatter, and lava entry into the sea, from eruptions occurring in the last 30 years. (Color; 739-A11-006)

Volcanic Rocks and Features

Illustrates eruption products and features resulting from volcanism in Australia, the Canary Islands, New Zealand, Scotland, and the United States. Pictures are examples of lava types, ash, cinders, bombs, necks, dikes, and sills. Aerial views of Devils Tower, Wyoming, and Ship Rock, New Mexico, landmark volcanic neck remnants, and Diamond Head, famous tuff cone on the Island of Oahu, are of special interest. (Color; 739-A11-002)

National Geophysical Data Center

Volcanoes in Eruption, Set I

Depicts explosive eruptions, lava fountains and flows, steam eruptions, and fissure eruptions from 19 volcanoes in 13 countries throughout the world. Volcano types include strato, cinder cone, complex, fissure vent, lava dome, shield, and island-forming. Spectacular views of Kilauea's fire fountains, a night eruption of Paricutin, and the 1980 eruption cloud of St. Helens are included. (B&W/Color; **739-A11-001**)

Volcanoes in Eruption, Set II

Depicts ash clouds, fire fountains, lava flows, spatter cones, glowing avalanches, and steam eruptions from 18 volcanoes in 13 countries. Volcano types included are strato, cinder cone, basaltic shield, complex, and island-forming. Highlights include a spectacular night exposure of electrical discharge accompanying an eruption, and an eye-witness drawing of the famous eruption of Krakatau in 1883. (None of the slides in this set duplicate those in **Set I** although several of the same volcanoes are represented in both sets.) (B&W/Color; **739-A11-003**)

Earthquakes

Earthquake Damage - General

Illustrates several kinds of effects caused by 11 earthquakes in seven countries and four states in the United States. Pictures show strike-slip and thrust faulting, surface ruptures, landslides, fissuring, slumping and sand boils, as well as structural damage. This set is designed to give an overview and summary of earthquake effects. (Color; **647-A11-001**)

Earthquake Damage, San Francisco, California, April 18, 1906

Includes a panoramic view of San Francisco in flames a few hours after the earthquake, dramatic damage scenes from the area, and other unique photographs. (B&W; **647-A11-002**)

Earthquake Damage, Mexico City, Mexico, September 1985

Shows different types of damaged buildings and major kinds of structural failure including collapse of the top, middle, and bottom floors and total building failure. The effect of the subsoils on the earth shaking and building damage is emphasized. (Color; **647-A11-003**)

Earthquake Damage to Transportation Systems

Depicts earthquake damage to streets, highways, bridges, overpasses, and railroads caused by 12 earthquakes in Guatemala, Japan, Mexico, Armenia, and five states in the United States. Views of structural damage to the San Francisco-Oakland Bay Bridge and the Nimitz Freeway (I-880) resulting from the October 1989 earthquake are included. (B&W/Color; **647-A11-004**)

Earthquake Damage to Schools

Nine destructive earthquakes that occurred in the United States and eight earthquakes that occurred in foreign countries from 1886 to 1988 are depicted. The set graphically illustrates the potential danger that major earthquakes pose to school structures. The photograph taken in 1886 of the damage at Charleston College, Charleston, South Carolina, is of special interest since it is an illustration of earthquake damage possible on the east coast of the United States. (B&W/Color; **647-A11-005**)

Earthquake Damage, Great Alaska Earthquake, March 1964

Shows geologic changes; damage to structures, transportation systems, and utilities; and tsunami damage. Features the effects of four major landslides in Anchorage including the dramatic Fourth Avenue and Turnagain Heights landslides. (Color; 647-A11-007)

Earthquake Damage, Southern California, 1979-1989

Shows earthquake damage from the following events: Imperial Valley, 1979; Westmorland, 1981; Palm Springs, 1986; and Whittier, 1987. Partially and totally collapsed buildings caused by the Whittier Narrows earthquake are shown. (Color; 647-A11-008)

Earthquake Damage, Central California, 1980-1984

Shows earthquake damage from the following events: Livermore, 1980; Coalinga, 1983; and Morgan Hill, 1984. Several totally and partially collapsed buildings in the downtown area of Coalinga are shown. (Color; 647-A11-009)

Faults

Includes a schematic and illustrations showing normal, reverse, and strike-slip faults and related features. The faults are located in Alabama, California, Idaho, Montana, Nevada, Oregon, and Wyoming in the United States, and in Algeria, Guatemala, and Iceland. The set includes an aerial view and other views of the famous San Andreas fault in California. (Color; 647-A11-010)

Earthquake Damage, the Armenian Soviet Socialist Republic, December 1988

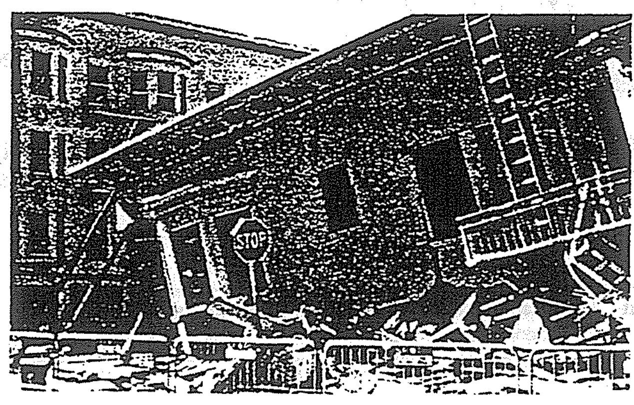
Includes spectacular damage photographs taken in and around the devastated cities of Spitak and Leninakan where 25,000 deaths occurred. Illustrates the structural types that were vulnerable to failure. This set graphically shows that inadequate building construction combined with shaking from a moderate earthquake can result in high death tolls and tremendous economic loss. (Color; 647-A11-011)

Earthquake Damage, Loma Prieta, October 1989, Set I - Loma Prieta vicinity

Includes damage in Boulder Creek, Aptos, Los Gatos, San Jose, Santa Cruz, Scott's Valley, and Watsonville. The slides depicting earth cracks and structural damage to homes in the Santa Cruz mountains are especially dramatic. (Color; 647-A11-012)

Earthquake Damage, Loma Prieta, October 1989, Set II - San Francisco and Oakland

Highlights the spectacular damage in the Marina area of San Francisco. The set also includes photographs of the damaged building in the area south of Market Street where five deaths occurred, the now famous damage to the San Francisco-Oakland Bay Bridge, and the Cypress Section of the Nimitz Freeway (I-880) where 41 deaths occurred. (Color; 647-A11-013)



A collapsed building in the Marina District of San Francisco. Damage from the Loma Prieta earthquake.

Tsunamis

Tsunamis - General

Depicts advancing waves, harbor damage, and structural damage from seven tsunami events which have occurred since 1946 in the Pacific region. The set includes dramatic before-and-after views of Scotch Cap Lighthouse in the Aleutian Islands that was completely washed away by a wave of more than 30 meters! A somewhat out-of-focus, but nevertheless unique photograph of a man about to be inundated by a huge wave that destroyed the Hilo, Hawaii, waterfront is also included. (B&W/Color; **648-A11-001**)

Landslides

Landslides

Depicts diverse types of landslides and mass wasting. Photos were taken at various locations in the United States, Canada, Australia, Peru, and Switzerland. Of particular interest are views of the famous 1903 rock slide at Frank, Alberta, Canada, that covered the town of Frank in less than two minutes, and the 1970 earthquake-induced rock- and snowslide that buried the towns of Yungay and Ramrahirca in Peru. (Color; **647-A11-006**)

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