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N° 86

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INFORMATIONS for CONTRIBUTORS

Contributors should follow as closely as possible the rules below :

Manuscripts should be typed (single spaced), 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).

NOTA : *The publisher welcomes the manuscripts which have been prepared using WORD 6 for Macintosh and also accepts ASCII files on diskettes 3"5.*

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.

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. 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 O 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 have 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.

Table. 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.

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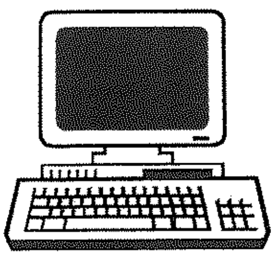

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INTERNAL MATTERS

GENERAL INFORMATION

1. **HOW TO OBTAIN THE BULLETIN**
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3. **USUAL SERVICES B.G.I. CAN PROVIDE**
4. **PROVIDING DATA TO B.G.I.**

1. HOW TO OBTAIN THE BULLETIN

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

The Bulletin contains general information 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, an issue contains the National Reports as presented at the International Gravity Commission meeting. 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 (84 have been issued as of June 30, 1999 but numbers 2,16, 18,19 are out of print).

- or subscribe for regularly receiving the two bulletins per year (the special issues are obtained at additional cost).

Requests should be sent to:

Mrs. Nicole LESTIEU
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18, Avenue Edouard Belin
31401 TOULOUSE CEDEX 4 - FRANCE

Bulletins are sent on an exchange basis (free of charge) to individuals, institutions which currently provide informations, data to the Bureau. For other cases, the price of each issue is 75 FF.

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

2.5.1. CD-Roms

The non confidential data, which have been validated by various procedures are available on two CD-ROMs.

The price of these is :

- *800 (Eight hundred) French francs for individual scientists, universities and research laboratories or groups working in geodesy or geophysics.*
- *3000 (Three thousand) French francs for all other users.*

Most essential quantities are given, in a compressed format. The package includes a user's guide and software to retrieve data according to the area, the source code, the country.

2.5.2. Data stored in the general data base

BGI is now using the ORACLE Data Base Management System. One implication is that data are stored in only one format (though different for land and marine data), and that archive files do not exist anymore.

There are two distinct formats for land or sea gravity data, respectively EOL and EOS.

EOL
LAND DATA FORMAT
RECORD DESCRIPTION
126 characters

Col.	1-8	B.G.I. source number	(8 char.)
	9-16	Latitude (unit : 0.00001 degree)	(8 char.)
	17-25	Longitude (unit : 0.00001 degree)	(9 char.)
	26-27	Accuracy of position	(2 char.)

The site of the gravity measurements is defined in a circle of radius R
0 = no information
1 - R <= 5 Meters
2 = 5 < R <= 20 M (approximately 0'01)
3 = 20 < R <= 100 M
4 = 100 < R <= 200 M (approximately 0'1)
5 = 200 < R <= 500 M
6 = 500 < R <= 1000 M
7 = 1000 < R <= 2000 M (approximately 1')
8 = 2000 < R <= 5000 M
9 = 5000 M < R
10...

28-29 System of positioning (2 char.)
0 = no information
1 = topographical map
2 = trigonometric positioning
3 = satellite

30 Type of observation (1 char.)
1 = current observation of detail or other observations of a 3rd or 4th order network
2 = observation of a 2nd order national network
3 = observation of a 1st order national network
4 = observation being part of a nation calibration line
5 = coastal ordinary observation (Harbour, Bay, Sea-side...)
6 = harbour base station

31-38 Elevation of the station (unit : centimeter) (8 char.)

39-40 Elevation type (2 char.)
1 = Land
2 = Subsurface
3 = Lake surface (above sea level)
4 = Lake bottom (above sea level)
5 = Lake bottom (below sea level)
6 = Lake surface (above sea level with lake bottom below sea level)
7 = Lake surface (below sea level)
8 = Lake bottom (surface below sea level)
9 = Ice cap (bottom below sea level)
10 = Ice cap (bottom above sea level)
11 = Ice cap (no information about ice thickness)

41-42 Accuracy of elevation (2 char.)
0 = no information
1 = E <= 0.02 M
2 = .02 < E <= 0.1 M
3 = .1 < E <= 1
4 = 1 < E <= 2
5 = 2 < E <= 5
6 = 5 < E <= 10
7 = 10 < E <= 20
8 = 20 < E <= 50
9 = 50 < E <= 100
10 = E superior to 100 M

43-44	Determination of the elevation	(2 char.)
	0 = no information	
	1 = geometrical levelling (bench mark)	
	2 = barometrical levelling	
	3 = trigonometric levelling	
	4 = data obtained from topographical map	
	5 = data directly appreciated from the mean sea level	
	6 = data measured by the depression of the horizon	
	7 = satellite	
45-52	Supplemental elevation (unit : centimeter)	(8 char.)
53-61	**Observed gravity** (unit : microgal)	(9 char.)
62-67	**Free air anomaly** (0.01 mgal)	(6 char.)
68-73	**Bouguer anomaly** (0.01 mgal)	(6 char.)
	Simple Bouguer anomaly with a mean density of 2.67. No terrain correction	
74-76	Estimation standard deviation free-air anomaly (0.1 mgal)	(3 char.)
77-79	Estimation standard deviation bouguer anomaly (0.1 mgal)	(3 char.)
80-85	**Terrain correction** (0.01 mgal)	(6 char.)
	computed according to the next mentioned radius & density	
86-87	Information about terrain correction	(2 char.)
	0 = no topographic correction	
	1 = tc computed for a radius of 5 km (zone H)	
	2 = tc computed for a radius of 30 km (zone L)	
	3 = tc computed for a radius of 100 km (zone N)	
	4 = tc computed for a radius of 167 km (zone 02)	
	11 = tc computed from 1 km to 167 km	
	12 = tc computed from 2.3 km to 167 km	
	13 = tc computed from 5.2 km to 167 km	
	14 =tc (unknown radius)	
	15 = tc computed to zone M (58.8 km)	
	16 = tc computed to zone G (3.5 km)	
	17 = tc computed to zone K (18.8 km)	
	25 = tc computed to 48.6 km on a curved Earth	
	26 = tc computed to 64. km on a curved Earth	
88-91	Density used for terrain correction	(4 char.)
92-93	Accuracy of gravity	(2 char.)
	0 = no information	
	1 = E <= 0.01 mgal	
	2 = .01 < E <= 0.05 mgal	
	3 = .05 < E <= 0.1 mgal	
	4 = 0.1 < E <= 0.5 mgal	
	5 = 0.5 < E <= 1. mgal	
	6 = 1. < E <= 3. mgal	
	7 = 3. < E <= 5. mgal	
	8 = 5. < E <= 10 mgal	
	9 = 10. < E <= 15. mgal	
	10 = 15. < E <= 20. mgal	
	11 = 20. < E mgal	
94-99	Correction of observed gravity (unit : microgal)	(6 char.)
100-105	**Reference station**	(6 char.)
	This station is the base station (BGI number) to which the concerned station is referred	

106-108 Apparatus used for the measurement of G (3 char.)

0.. no information
1.. pendulum apparatus before 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
34 = Boliden (Sweden)
4.. Metal spring gravimeters for ground measurements
41 = Frost
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
59 = SCINTREX CG2
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

109-111 **Country code** (BGI) (3 char.)

112 **Confidentiality** (1 char.)

0 = without restriction
.....1 = with authorization
2 = classified

113 **Validity** (1 char.)

0 = no validation
1 = good
2 = doubtful
3 = lapsed

114-120 Numbering of the station (original) (7 char.)

121-126 Sequence number (6 char.)

EOS
SEA DATA FORMAT
RECORD DESCRIPTION
146 characters

Col.

1-8 **B.G.I.** source number (8 char.)

9-16 **Latitude** (unit : 0.00001 degree) (8 char.)

17-25 **Longitude** (unit : 0.00001 degree) (9 char.)

26-27 Accuracy of position (2 char.)

The site of the gravity measurements is defined in a circle of radius R
0 = no information
1 - R <= 5 Meters
2 = 5 < R <= 20 M (approximately 0'01)
3 = 20 < R <= 100 M
4 = 100 < R <= 200 M (approximately 0'1)
5 = 200 < R <= 500 M
6 = 500 < R <= 1000 M
7 = 1000 < R <= 2000 M (approximately 1')
8 = 2000 < R <= 5000 M
9 = 5000 M < R
10...

28-29 System of positioning (2 char.)

0 = no information
1 = Decca
2 = visual observation
3 = radar
4 = loran A
5 = loran C
6 = omega or VLF
7 = satellite
8 = solar/stellar (with sextant)

30 Type of observation (1 char.)

1 = individual observation at sea
2 = mean observation at sea obtained from a continuous recording

31-38 **Elevation of the station** (unit : centimeter) (8 char.)

39-40 Elevation type (2 char.)

1 = ocean surface
2 = ocean submerged
3 = ocean bottom

41-42 Accuracy of elevation (2 char.)

0 = no information
1 = E <= 0.02 Meter
2 = .02 < E <= 0.1 M
3 = .1 < E <= 1
4 = 1 < E <= 2
5 = 2 < E <= 5
6 = 5 < E <= 10
7 = 10 < E <= 20
8 = 20 < E <= 50
9 = 50 < E <= 100
10 = E superior to 100 Meters

43-44 Determination of the elevation (2 char.)

0 = no information
1 = depth obtained with a cable (meters)
2 = manometer depth
3 = corrected acoustic depth (corrected from Mathew's tables, 1939)
4 = acoustic depth without correction obtained with sound speed 1500 M/sec. (or 820 fathom/sec)
5 = acoustic depth obtained with sound speed 1463 M/sec (800 fathom/sec)
6 = depth interpolated on a magnetic record
7 = depth interpolated on a chart

45-52 Supplemental elevation (8 char.)

53-61 **Observed gravity** (unit : microgal) (9 char.)

62-67 **Free air anomaly** (0.01 mgal) (6 char.)

68-73	**Bouguer anomaly** (0.01 mgal)	(6 char.)
	Simple Bouguer anomaly with a mean density of 2.67. No terrain correction	
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77-79	Estimation standard deviation bouguer anomaly (0.1 mgal)	(3 char.)
80-85	**Terrain correction** (0.01 mgal)	(6 char.)
	computed according to the next mentioned radius & density	
86-87	Information about terrain correction	(2 char.)
	0 = no topographic correction	
	1 = tc computed for a radius of 5 km (zone H)	
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	16 = tc computed to zone G (3.5 km)	
	17 = tc computed to zone K (18.8 km)	
	25 = tc computed to 48.6 km on a curved Earth	
	26 = tc computed to 64. km on a curved Earth	
88-91	Density used for terrain correction	(4 char.)
92-93	Mathew's zone	(2 char.)
	when the depth is not corrected depth, this information is necessary. For example : zone 50 for the Eastern Mediterranean Sea	
94-95	Accuracy of gravity	(2 char.)
	0 = no information	
	1 = E <= 0.01 mgal	
	2 = .01 < E <= 0.05 mgal	
	3 = .05 < E <= 0.1 mgal	
	4 = 0.1 < E <= 0.5 mgal	
	5 = 0.5 < E <= 1. mgal	
	6 = 1. < E <= 3. mgal	
	7 = 3. < E <= 5. mgal	
	8 = 5. < E <= 10. mgal	
	9 = 10. < E <= 15. mgal	
	10 = 15 < E <= 20. mgal	
	11 = 20. < E mgal	
96-101	Correction of observed gravity (unit : microgal)	(6 char.)
102-110	Date of observation	(9 char.)
	in Julian day - 2 400 000 (unit : 1/10 000 of day)	
111-113	Velocity of the ship (0.1 knot)	(3 char.)
114-118	Eötvös correction (0.1 mgal)	(5 char.)
119-121	**Country code** (BGI)	(3 char.)
122	**Confidentiality**	(1 char.)
	0 = without restriction	
	1 = with authorization	
	2 = classified	
123	**Validity**	(1 char.)
	0 = no validation	
	1 = good	
	2 = doubtful	
	3 = lapsed	
124-130	Numbering of the station (original)	(7 char.)
131-136	**Sequence number**	(6 char.)
137-139	**Leg number**	(3 char.)
140-145	**Reference station**	(6 char.)

Whenever given, the theoretical gravity (γ_o), 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*

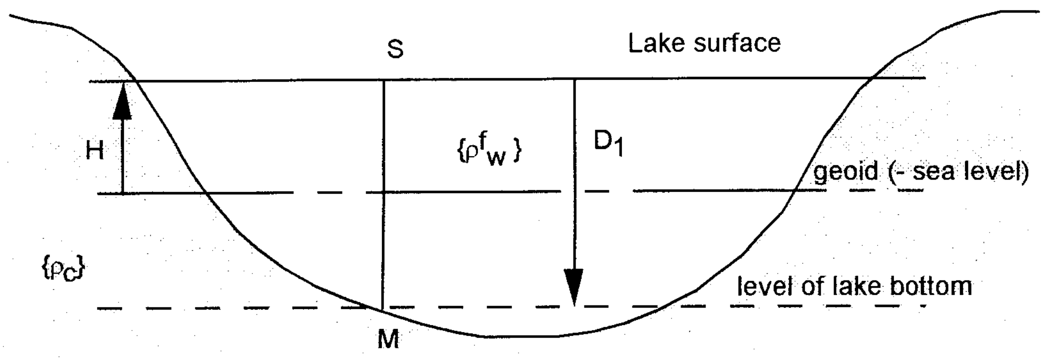
Formulas :

* *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_0 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 :



$$g_S = g_M + 2\,k\,\rho_w^f\,D_1 - \Gamma D_1$$
$$\Rightarrow FA = g_S + \Gamma H - \gamma_0$$

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

$$\begin{aligned}\delta g_s &= g_s - k\,\rho_w^f\,D_1 + k\,\rho_c(D_1 - H)\\ &= g_s - k\,\rho_w^f\,[H + (D_1 - H)] + k\,\rho_c\,(D_1 - H)\\ &= g_s - k\,\rho_w^f\,H + k\,(\rho_c - \rho_w^f)(D_1 - H)\end{aligned}$$

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

The table below covers most frequent cases. It is an update of the list of formulas published before.

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 :

$$\begin{aligned}-k\,\rho_i H + k(\rho_c - \rho_i)(D_1 - H) &\equiv -k\,\rho_i(H - D_1 + D_1) - k(\rho_c - \rho_i)(H - D_1)\\ &\equiv -k\,\rho_i\,D_1 - k\,\rho_c(H - D_1)\end{aligned}$$

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

Elev. Type	Situation	Formulas
1	Land Observation-surface	$FA = g + \Gamma H - \gamma_0$
		$BO = FA - k\,\rho_c\,H$
2	Land Observation-subsurface	$FA = g + 2\,k\,\rho_c\,D_2 + \Gamma(H - D_2) - \gamma_0$
		$BO = FA - k\,\rho_c\,H$
3	Ocean Surface	$FA = g - \gamma_0$
		$BO = FA + k\,(\rho_c - \rho_w^s)\,D_1$
4	Ocean submerged	$FA = g + (2\,k\,\rho_w^s - \Gamma)\,D_2 - \gamma_0$
		$BO = FA + k\,(\rho_c - \rho_w^s)\,D_1$
5	Ocean bottom	$FA = g + (2\,k\,\rho_w^s - \Gamma)\,D_1 - \gamma_0$
		$BO = FA + k\,(\rho_c - \rho_w^s)\,D_1$
6	Lake surface above sea level	$FA = g + \Gamma H - \gamma_0$
	with bottom above sea level	$BO = FA - k\,\rho_w^f\,D_1 - k\,\rho_c\,(H - D_1)$
7	Lake bottom, above sea level	$FA = g + 2\,k\,\rho_w^f\,D_1 + \Gamma(H - D_1) - \gamma_0$
		$BO = FA - k\,\rho_w^f\,D_1 - k\,\rho_c\,(H - D_1)$
8	Lake bottom, below sea level	$FA = g + 2\,k\,\rho_w^f\,D_1 + \Gamma(H - D_1) - \gamma_0$
		$BO = FA - k\,\rho_w^f\,H + k\,(\rho_c - \rho_w^f)\,(D_1 - H)$
9	Lake surface above sea level	$FA = g + \Gamma H - \gamma_0$
	with bottom below sea level	$BO = FA - k\,\rho_w^f\,H + k\,(\rho_c - \rho_w^f)\,(D_1 - H)$
A	Lake surface, below sea level (here $H < o$)	$FA = g + \Gamma H - \gamma_0$
		$BO = FA - k\,\rho_c H + k\,(\rho_c - \rho_w^f)\,D_1$
B	Lake bottom, with surface below sea level ($H < o$)	$FA = g + (2\,k\,\rho_w^f - \Gamma)\,D_1 + \Gamma H - \gamma_0$
		$BO = FA - k\,\rho_c H + k\,(\rho_c - \rho_w^f)\,D_1$
C	Ice cap surface, with bottom below sea level	$FA = g + \Gamma H - \gamma_0$
		$BO = FA - k\,\rho_i\,H + k\,(\rho_c - \rho_i)\,(D_1 - H)$
D	Ice cap surface, with bottom above sea level	$FA = g + \Gamma H - \gamma_0$
		$BO = FA - k\,\rho_i\,D_1 - k\,\rho_c\,(H - D_1)$

All requests for data must be sent to :

Mr. Bernard LANGELLIER
Bureau Gravimétrique International
18, Avenue E. Belin - 31401 Toulouse Cedex 4 - France
E-mail : Bernard.Langellier@cnes.fr

In case of a request made by telephone, it should be followed by a confirmation letter, or fax. 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 as tarfiles on DAT cartridge (4 mm). for large amounts of data, or on diskette in the case of small files. The exact physical format will be indicated in each case. Also a FTP anonymous service is available on our computer center.

3. USUAL SERVICES BGI 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 on January 1, 1992 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 CD-Roms : see 2.5.1.
. on one of the following media :
** printout .... 2 F/100 lines*
** diskette........................ 25 F per diskette (minimum charge : 50 F-*
** magnetic tape .... 2 F per 100 records*
+ 100 F per DAT cartridge
(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°x20° 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 scale, 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 ($\Delta\Delta'$) 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 Δ xΔ' area : 10F/ΔΔ' per degree square.

. minimum charge : 150 F

. maximum area : 40°x40°

3.2. Charging Policy for Other Individuals or Private Companies

3.2.1. Digital Data Retrieval

. on CD-Roms : see 2.5.1.

. 1 F per measurement for non commercial use (guaranteed by signed agreement), 5 F per measurement in other cases (direct or indirect commercial use - e.g. in case of use for gridding and/or maps to be sold or distributed by the buyer in any project with commercial application). Minimum charge : 500 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 ihe polygon.

3.2.3. Data Screening

. 1 F per screened point for non commercial use (guaranteed by signed agreement), 5 F per screened point in other cases (cf. 3.2.1.).

. 500 F minimum charge

3.2.4. Gridding

Same as 3.1.4.

3.2.5. Contour Maps of Bouguer or Free-Air Anomalies

Same as 3.1.5.

3.2.6. Computation of Mean Gravity Anomalies

Same as 3.1.6.

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
DAT cartridge (4 mm) 100 F

3.2.2. 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*

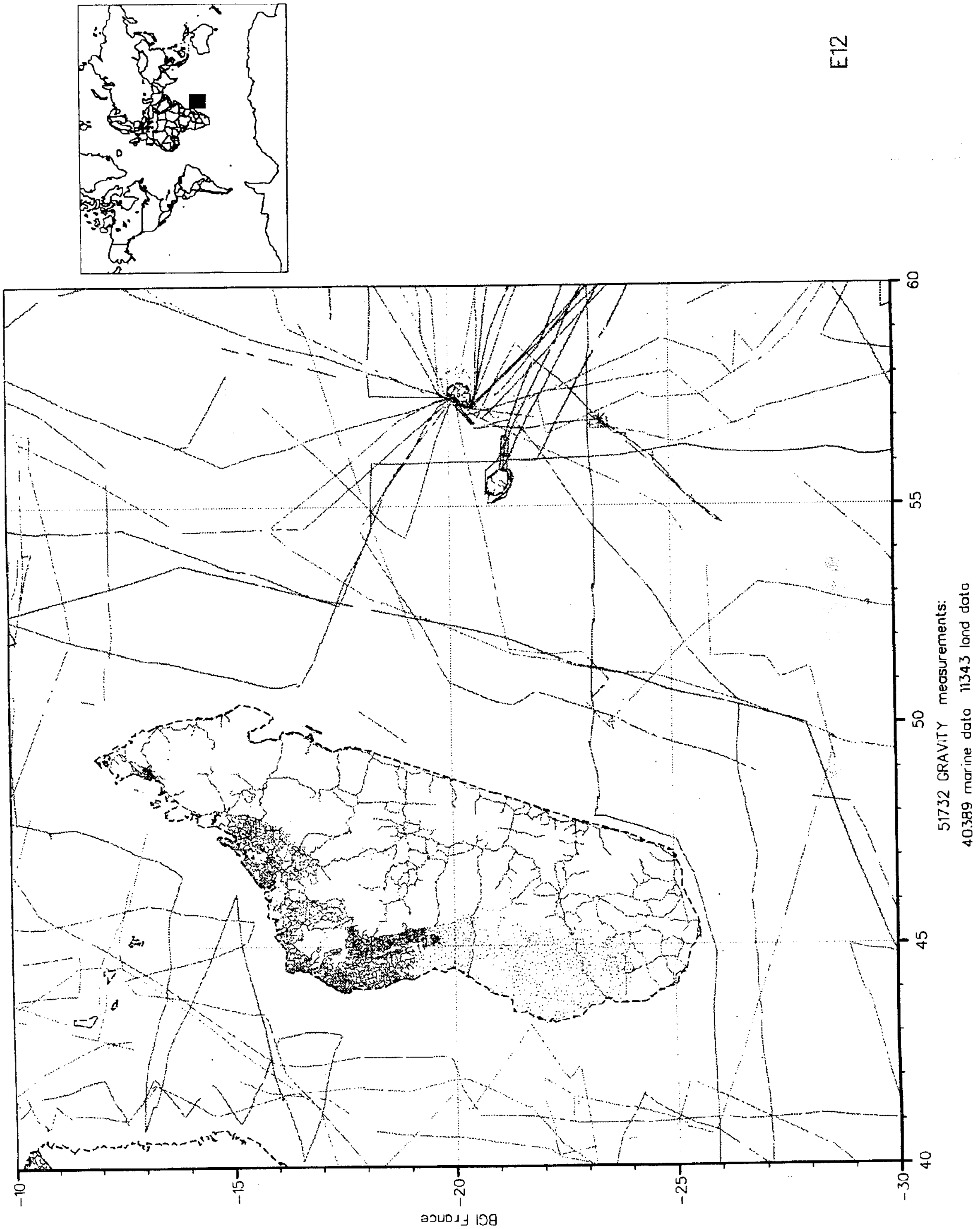
. Black and white copy of maps : 150 F per copy

. Colour copy : price according to specifications of request.

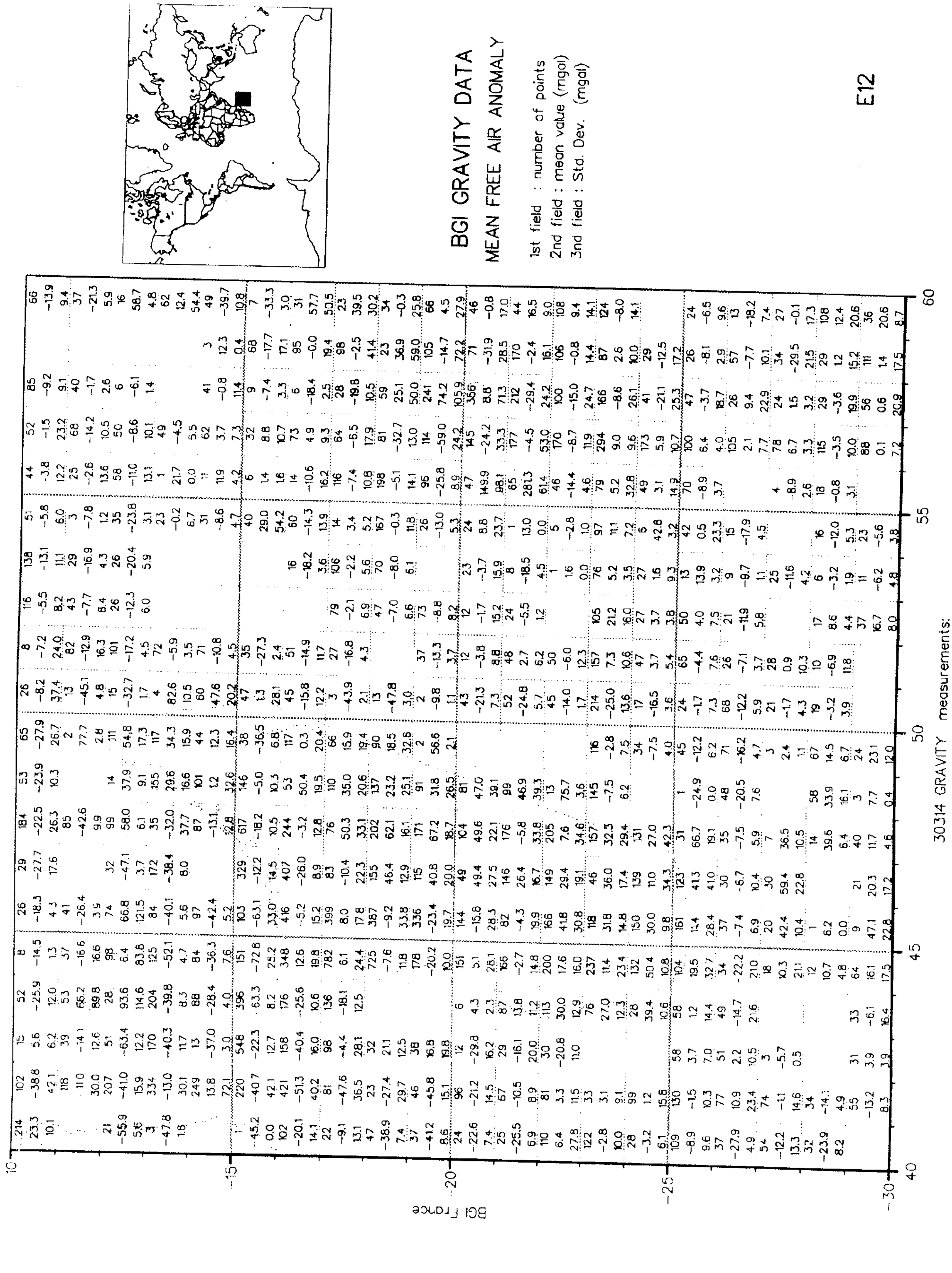
Mailing charges will be added for air-mail parcels when "Air-Mail" is requested)

Map 1. Example of data coverage plot

E12



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 instrument 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.

---

* 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 whether 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.

. 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.

The contributor may use the EOL and/or EOS formats as described above, or 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, ana recalled in Bulletin n° 50 (pages 112-113).

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

PART II

CONTRIBUTING PAPER

An International Reference Station for Inter-comparison of Absolute Gravimeters (ISIAG) in Walferdange, Luxembourg: the GRAVILUX Project

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Abstract.

The Grand Duchy of Luxembourg is establishing a new International Reference Station for Intercomparisons of Absolute Gravimeters (ISIAG). The station is located in the Walferdange Underground Laboratory for Geodynamics 100 meters below the surface. Since 1967, the laboratory has been used for Earth tides research and from that work has gained an international reputation as a seimogenically quiet location where sensitive instruments can be tested and evaluated. A permanent staff of scientists and a technical engineer from the European Centre for Geodynamics and Seismology (ECGS) maintain the laboratory under the authority of the National Museum of Natural History of Luxembourg (NMNH) and the Royal Observatory of Belgium (ROB).

Four Luxembourg institutes including the NMNH, ECGS, Institut Supérieur de Technologie (IST) and the Administration du Cadastre et de la Topographie (ACT), have recently joined together to manage the station under the framework of the new GRAVILUX project. GRAVILUX is a program established to enhance geodynamics research within Luxembourg. The project has added two geophysicists in 2000 and is expected to add two additional technical engineers in 2001. The instrumentation to support the project includes a superconducting gravimeter, which is currently being built, an absolute gravimeter, which will be purchased in 2001, and other ancillary equipment necessary to support research.

Introduction.

The Walferdange Underground Laboratory for Geodynamics (WULG) is located at the far end of a long labyrinth of galleries which originally have been established for the commercial extraction of very pure gypsum (Figure 1). Exceptional temperature and humidity stability, the absence of water and human perturbations, distance from the ocean and easy access, were some of the motivations for initially choosing this site for instrumentation and Earth tide research. Instruments to measure the micro-deformations produced by the tidal forces have been developed and tested in the Laboratory for more than 30 years. Ground deformations and earthquakes are recorded continuously by means of spring gravimeters, vertical and horizontal pendulums, long base water-tube tiltmeters, vertical and horizontal strain meters, short period and broad band seismometers. Meteorological parameters (temperature, humidity and atmospheric pressure), as well as radon gas emissions, are also continuously monitored in various locations within the mine.

Close collaborations have been pursued for the last 30 years with many different organizations including (but not limited to): the Royal Observatory of Belgium, GeoForschungZentrum (Potsdam) and Bonn Univeristy (Gemany), Institute of Astronomy and Geodesy of the University of Madrid (Spain), Nordic Volcanological Institute of Reykjavik (Iceland), Osservatorio Vesuviano and University Federico II, Napoli (Italy), Instituto Superior Tecnico (Lisboa, Portugal), State Seismological Bureau of Wuhan (China), Russian Academy of Science, University of Savoie and Insitut de Physique du Globe (France), Finnish Geodetic Institute (Finland), and Kyoto University (Japan).

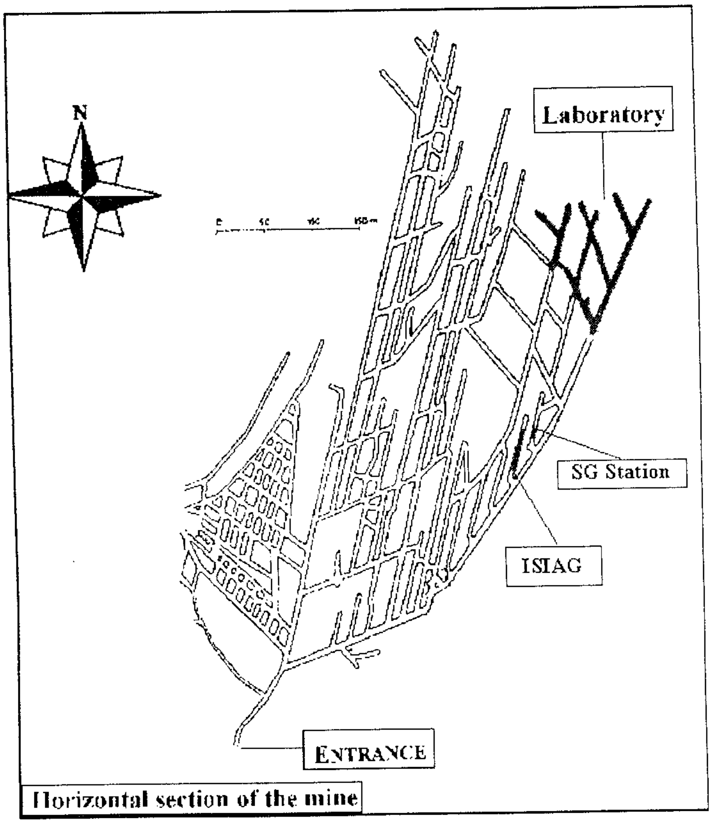

Figure 1: Horizontal cross-section of the Walferdange Mine.

The GRAVILUX project.

Although not very common, absolute gravimeters are used worldwide to measure the instantaneous-absolute value of the gravitational acceleration. The precision and accuracy of these instruments currently reaches one microgal (1 microgal = 10^{-8} m/s^2), i.e. one billionth of the mean gravity on the surface of the Earth. The acceleration of gravity at the surface of the Earth varies in time and space due to mass changes above and below the Earth's surface and changes in the height of that surface. Hence, absolute gravity observations can be used to constrain the geoid, to calibrate local gravity networks, and to measure small crustal deformations such as those associated with post-glacial rebound, sea level, tectonics and environmental loading. In addition, they may also be used to monitor magmatic intrusions on volcanoes, changes in local hydrology, or changes in the ice mass of glaciers and ice sheets.

Being absolute instruments, these gravimeters cannot really be calibrated. Only some of their components (such as the atomic clock or the laser) can be calibrated by comparison with known standards. The only way one currently has to verify their good working order is via a simultaneous intercomparison with other absolute gravimeters of the same or even of a different model. Intercomparisons of this type are difficult to arrange which is why they have only officially been organized every 4 years by the BIPM. This time scale is not sufficient for most users as most also regularly deploy their instruments for field observations.

In the case of regular field deployments, the users must be sure that there isn't an offset in their measured values of gravity caused by instrument malfunction. To be sure that an instrument is indeed in good working condition, the instrument needs to be regularly checked by measuring gravity in a place where gravity is well known. But as mentioned above, gravity at any given location will change with time due to Earth tides, ocean or atmospheric loading effects, or water table variations. So, gravity changes of the reference station must be carefully monitored in time. The best way to achieve this with enough precision is to continuously measure the gravity variations by means of a superconducting gravimeter. Those relative gravimeters operate by measuring the voltage required to maintain the position of a levitating sphere in a magnetic field. The field is produced by an electric current caught in a coil at the temperature of the liquid helium. At that temperature (about 4 °K, i.e. -269 °C), the current circulates without any resistance and produces a very stable magnetic field. Superconducting gravimeters reach a precision of a few nanogal (10^{-12} m/s^2), i.e. one thousandth of a billionth of the mean gravity on the surface of the Earth) on diurnal and semi-diurnal periods by integrating over 2 or 3 years.

The establishment of a quiet gravity reference station in the WULG was one of the motivations behind the establishment of the GRAVILUX project. The current infrastructure, scientific knowledge, technical support, and the scientific instruments to be obtained will allow for 1) international comparisons of all absolute gravimeters at a seismically quiescent site in Europe and 2) a gravity reference site where temporal changes in gravity are continuously monitored.

The gravity stations

Many structural renovations and other practical matters needed to be addressed to convert our old gypsum mine into an underground laboratory appropriate for absolute gravity intercomparisons. For the sake of safety, the first 300 meters of the entrance of the mine were recently shored up by using large steel I-beams and concrete. To transport the 500 kilograms of equipment (the typical weight of an FG5 absolute gravimeter and its peripherals) over the 400 meters to the gravimetric stations, an electric golf cart was purchased. The cart travels on a smooth newly installed concrete surface.

Two stations, in neighbouring galleries, were especially constructed and outfitted with power, UPS, and internet access for the GRAVILUX gravity instrumentation intercomparison goal: the smallest room ('SG station', 20 m^2) will house the superconducting gravimeter (figure 2). The larger room ('ISIAG station', 150 m^2), built in a dead end gallery, is large enough to accommodate as many as 15 absolute gravimeters operating simultaneously (figure 3). (At the Table Mountain Gravity Observatory in Boulder, Colorado and at the BIPM, where previous intercomparisons have been held, only 5 and 6 absolute instruments respectively, can operate simultaneously.)

Figure 2: the SG station.

Figure 3: the ISIAG station.

In 1997 and 1998, absolute gravity observations were undertaken in the Underground Laboratory by the team from the ROB (Tables 1 and 2) using the FG5-202 absolute gravimeter. The precision (set standard deviation) of the measurements is about 1 microgal. The drop-to-drop scatter (mean standard deviation) is between 7.8 and 10.0 microgal. (For comparison, the drop-to-drop scatter is 21.4 microgals and 7.8 microgals at the BIPM and TMGO respectively for the same instrument.) This was the lowest value observed by the ROB team with that instrument in all of 1997, confirming the quality of the WLUG as a quiet "gravimetric" site. (It is interesting to note that at the time of the 1997 observations, the electronics of the FG5-202 had been not yet upgraded with the fast data rate card. And, in 1998, the superspring was not perfectly tuned due to electronic problems. We would thus expect even better performance with the new FG5.)

In addition to the absolute gravity measurements, vertical gravity gradients have been measured at the absolute gravity point as well as at 4 different places within the gallery where the absolute gravimeter intercomparisons are expected to take place. To determine the vertical gravity gradient, gravity differences have been measured between 3 different height levels (floor, 0.9 m and 1.3 m) using a Scintrex spring gravimeter. The values of the vertical gradient in the gallery are very close, with values in the range -2.77 and -2.79 +- 0.01 microgal/cm. Moreover, no strong non-linearities in the vertical values were observed.

A small gravity network has also been established connecting the entrance of the gallery to the different points where the vertical gravity gradients have been measured. We obtained a 1.697 milligal difference in gravity between the site at the entrance to the mine and the Laboratory at the end of the gallery where the absolute gravity measurements were carried out. We also determined a difference of 1.110 milligal between the Laboratory and the gallery where the new absolute gravity stations will be established. So in addition to providing a location for absolute gravity intercomparisons, the laboratory also maintains a relative gravity calibration line in a seismogenically quiet site with no temperature variations. In the future, regular absolute gravity observations will be performed at the two extremities of the calibration line further enhancing its usefulness.

In tables 3-5, we display the results of the absolute gravity measurements carried out at the Centre Universitaire de Luxembourg. The site is located on the University Campus in Luxembourg city. The first measurements were taken there by Jaakko Maakinen with the Jilag-5 in 1991. We can see the remarkably low noise level for a gravity station located within an urban environment.

Acknowledgements

We are especially grateful to Ms E. Hennicot-Schoepges, Minister of Cultural Affairs and Research, who always faithfully supported and promoted the WULG and the GRAVILUX project in particular. We are also extremely grateful to N. Stomp, Director of the NMHN, without whose enthusiasm, support and diligent advocacy, GRAVILUX would not exist. And to J. Flick, President of the ECGS, P. Schroeder, President of IST, and R. Terrens, President of ACT who came together as partners to make the project happen. We would also like to thank Jean-Marc Delinte who performed the spring gravimeter measurements for the ROB. We are finally very grateful to the Ministry of Public Buildings, which made the improvements needed to convert the mine into a scientific laboratory.

Table 1.

STATION: WALFERDANGE			
City:	Walferdange	Country:	Grand-Duché de Luxembourg
Location:	Laboratoire souterrain	Particularity:	
Situation:	Laboratoire	Remarks:	
Date:	July 10-11, 1997		

Code number:	
Latitude:	49.6647 degrees
Longitude:	6.1528 degrees
Elevation:	295 m
Gradient:	-2.522 μgal/cm
Reference height:	502.5 mm
Meter:	FG5
S/N:	202

Ocean loading correction (μgal, -local phase- degree)

Waves	M_2	S_2	K_1	O_1	N_2	P_1	K_2	Q_1	M_f	M_m	S_{sa}
Ampl.	0.184	0.060	0.021	0.015	0.037	0.007	0.015	0.042	0.0	0.0	0.0
Phase:	299.1	328.1	297.1	190.3	283.2	284.5	329.5	126.2	0.0	0.0	0.0

Polar motion correction			Air pressure correction	
X-coordinate:	0.0550	arc seconds	Nominal air pressure:	978.31 mbar
Y-coordinate:	0.5342	arc seconds	Barometric admittance factor:	0.3 μgal/mbar

Gravity

Set gravity mean:	**9 80 963 955.4**	microgal
Set std. dev.:	1.186	microgal
Mean std. dev.:	7.79	microgal
Number of sets:	25	
Number of drops per set:	100	
Drop interval:	10 seconds	
Set interval:	60 minutes	
Nominal/datum height:	0.0 cm	

Local Contact: Nicolas d'Oreye

Author: O. Francis — Observatoire Royal de Belgique

Date: October 12, 1999

Table 2.

STATION: WALFERDANGE			
City:	Walferdange	Country:	Grand-Duché de Luxembourg
Location:	Laboratoire souterrain	Particularity:	
Situation:	Laboratoire	Remarks:	
Date:	December 16-18, 1998		

Code number:	
Latitude:	49.6647 degrees
Longitude:	6.1528 degrees
Elevation:	295 m
Gradient:	-2.522 µgal/cm
Reference height:	500.5 mm
Meter:	FG5
S/N:	202

Ocean loading correction (µgal, -local phase- degree)

Waves	M_2	S_2	K_1	O_1	N_2	P_1	K_2	Q_1	M_f	M_m	S_{sa}
Ampl.	0.184	0.060	0.021	0.015	0.037	0.007	0.015	0.042	0.0	0.0	0.0
Phase:	299.1	328.1	297.1	190.3	283.2	284.5	329.5	126.2	0.0	0.0	0.0

Polar motion correction

X-coordinate:	0.1379	arc seconds
Y-coordinate:	0.3157	arc seconds

Air pressure correction

Nominal air pressure:	978.31 mbar
Barometric admittance factor:	0.3 µgal/mbar

Gravity

Set gravity mean:	**9 80 963 952.6**	microgal
Set std. dev.:	1.098	microgal
Mean std. dev.:	10.00	microgal
Number of sets:	37	
Number of drops per set:	100	
Drop interval:	10 seconds	
Set interval:	60 minutes	
Nominal/datum height:	0.0 cm	

Local Contact: Nicolas d'Oreye

Author: O. Francis — Observatoire Royal de Belgique

Date: October 12, 1999

Table 3.

STATION: LUXEMBOURG			
City:	Luxembourg	Country:	Grand-Duché de Luxembourg
Location:	Centre Universitaire	Particularity:	
Situation:	Cave	Remarks:	Site occupied by Jaakko Mäkinen
Date:	20/21 August 1996		with a Jilag-5 in March 1991

Code number:	
Latitude:	49.6278 degrees
Longitude:	6.1153 degrees
Elevation:	328 m
Gradient:	-2.782 µgal/cm
Reference height:	503.5 mm
Meter:	FG5
S/N:	202

Ocean loading correction (µgal, -local phase- degree)

Waves	M_2	S_2	K_1	O_1	N_2	P_1	K_2	Q_1	M_f	M_m	S_{sa}
Ampl.	0.184	0.060	0.021	0.015	0.037	0.007	0.015	0.042	0.0	0.0	0.0
Phase:	299.1	328.1	297.1	190.3	283.2	284.5	329.5	126.2	0.0	0.0	0.0

Polar motion correction			**Air pressure correction**	
X-coordinate:	0.29248	arc seconds	Nominal air pressure:	974.4 mbar
Y-coordinate:	0.38644	arc seconds	Barometric admittance factor:	0.3 µgal/mbar

Gravity

Set gravity mean:	**9 80 960 407.5**	microgal
Set std. dev.:	1.534	microgal
Mean std. dev.:	13.54	microgal
Number of sets:	12	
Number of drops per set:	181	
Drop interval:	10 seconds	
Set interval:	60 minutes	
Nominal/datum height:	0.0 cm	

Local Contact: Antoine Kies (352) 46 66 44 328

Author: O. Francis — Observatoire Royal de Belgique

Date: August 30th. 1996

Table 4.

STATION: LUXEMBOURG			
City:	Luxembourg	Country:	Grand-Duché de Luxembourg
Location:	Centre Universitaire	Particularity:	
Situation:	Cave	Remarks:	Site occupied by Jaakko Mäkinen with a Jilag-5 in March 1991
Date:	11/12 July 1997		

Code number:	
Latitude:	49.6278 degrees
Longitude:	6.1153 degrees
Elevation:	328 m
Gradient:	-2.782 µgal/cm
Reference height:	503.0 mm
Meter:	FG5
S/N:	202

Ocean loading correction (µgal, -local phase degree)

Waves	M_2	S_2	K_1	O_1	N_2	P_1	K_2	Q_1	M_f	M_m	S_{sa}
Ampl.	0.184	0.060	0.021	0.015	0.037	0.007	0.015	0.042	0.0	0.0	0.0
Phase:	299.1	328.1	297.1	190.3	283.2	284.5	329.5	126.2	0.0	0.0	0.0

Polar motion correction

X-coordinate:	0.0610	arc seconds
Y-coordinate:	0.5355	arc seconds

Air pressure correction

Nominal air pressure:	974.4 mbar
Barometric admittance factor:	0.3 µgal/mbar

Gravity

Set gravity mean:	**9 80 960 410.3**	microgal
Set std. dev.:	1.524	microgal
Mean std. dev.:	8.48	microgal
Number of sets:	15	
Number of drops per set:	100	
Drop interval:	10 seconds	
Set interval:	60 minutes	
Nominal/datum height:	0.0 cm	

Local Contact: Antoine Kies (352) 46 66 44 328

Author: O. Francis — Observatoire Royal de Belgique

Date: July 13th, 1997

Table 5.

STATION: LUXEMBOURG			
City:	Luxembourg	Country:	Grand-Duché de Luxembourg
Location:	Centre Universitaire	Particularity:	
Situation:	Cave	Remarks:	Site occupied by Jaakko Mäkinen
Date:	22 December 1998		with a Jilag-5 in March 1991

Code number:	
Latitude:	49.6278 degrees
Longitude:	6.1153 degrees
Elevation:	328 m
Gradient:	-2.782 μgal/cm
Reference height:	502.0 mm
Meter:	FG5
S/N:	202

Ocean loading correction (μgal, -local phase degree)

Waves	M_2	S_2	K_1	O_1	N_2	P_1	K_2	Q_1	M_f	M_m	S_{sa}
Ampl.	0.184	0.060	0.021	0.015	0.037	0.007	0.015	0.042	0.0	0.0	0.0
Phase:	299.1	328.1	297.1	190.3	283.2	284.5	329.5	126.2	0.0	0.0	0.0

Polar motion correction			**Air pressure correction**	
X-coordinate:	0.1430	arc seconds	Nominal air pressure:	974.4 mbar
Y-coordinate:	0.3082	arc seconds	Barometric admittance factor:	0.3 μgal/mbar

Gravity

Set gravity mean:	**9 80 960 410.9**	microgal
Set std. dev.:	0.850	microgal
Mean std. dev.:	10.16	microgal
Number of sets:	14	
Number of drops per set:	100	
Drop interval:	10 seconds	
Set interval:	60 minutes	
Nominal/datum height:	0.0 cm	

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