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**BUREAU**

**GRAVIMÉTRIQUE**

**INTERNATIONAL**

**BULLETIN D'INFORMATION**

**N° 82**

**Juin 1998**

**18, Avenue Edouard Belin  
31401 TOULOUSE CEDEX 4  
FRANCE**

## INFORMATION S f o r C O N T R I B U T O R S

*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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INTERNATIONAL**

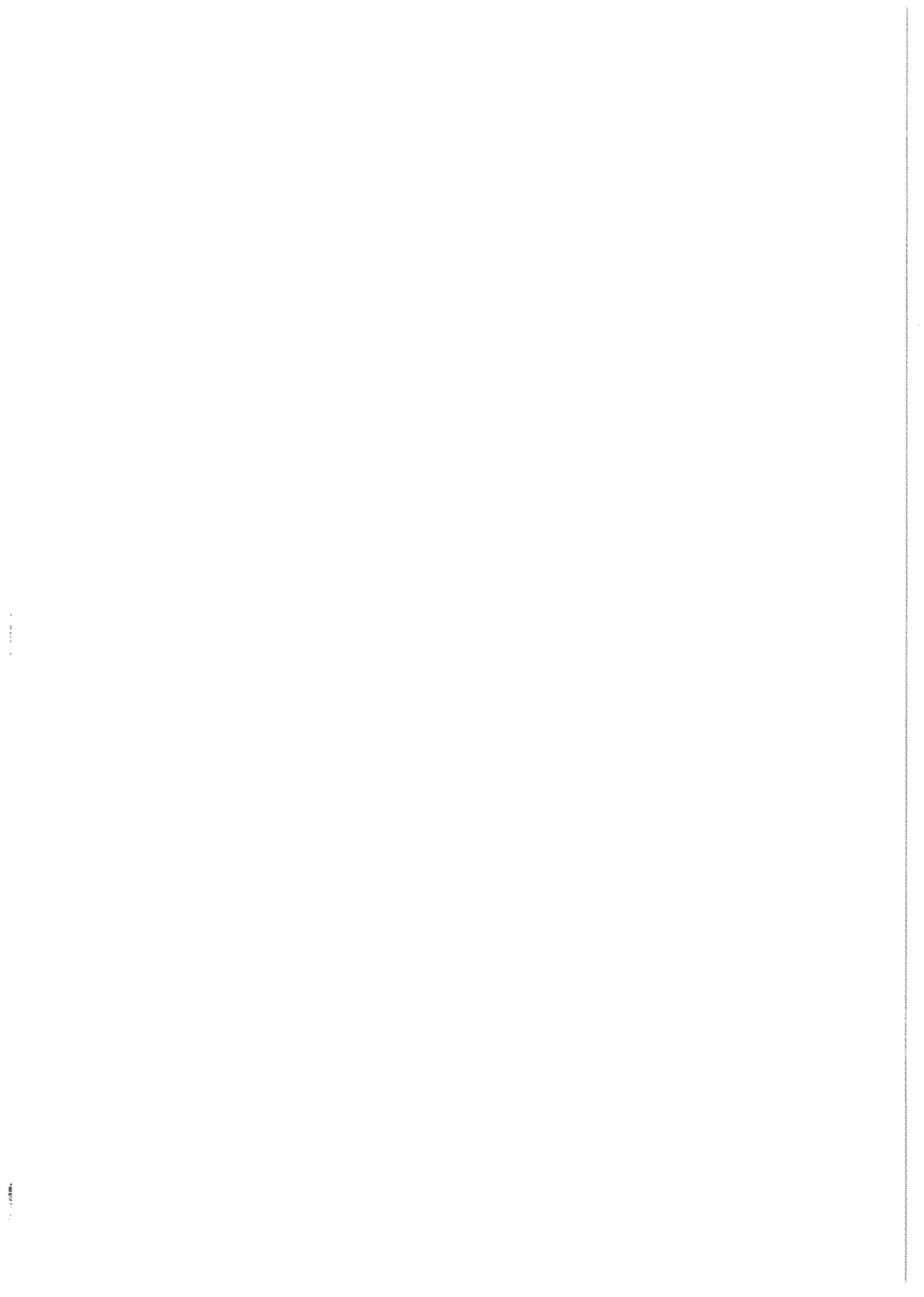
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# Table of Contents

Bulletin d'Information n° 82

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	Pages
<b>PART I : INTERNAL MATTERS.....</b>	<b>2</b>
. How to obtain the Bulletin.....	4
. How to request data.....	5
. Usual services BGI can provide.....	15
. Providing data to BGI.....	20
 <b>PART II : BIBLIOGRAPHY.....</b>	 <b>22</b>



**PART I**  
**INTERNAL MATTERS**



## **GENERAL INFORMATION**

- 1. HOW TO OBTAIN THE BULLETIN**
- 2. HOW TO REQUEST DATA**
- 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 (81 have been issued as of December 31, 1997 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  
CNES/BGI  
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 The site of the gravity measurements is defined in a circle of radius R 0 = no information 1 - $R \leq 5$ Meters 2 = $5 < R \leq 20$ M (approximately 0'01) 3 = $20 < R \leq 100$ M 4 = $100 < R \leq 200$ M (approximately 0'1) 5 = $200 < R \leq 500$ M 6 = $500 < R \leq 1000$ M 7 = $1000 < R \leq 2000$ M (approximately 1') 8 = $2000 < R \leq 5000$ M 9 = $5000 \text{ M} < R$ 10...	(2 char.)
	28-29	System of positioning 0 = no information 1 = topographical map 2 = trigonometric positioning 3 = satellite	(2 char.)
	30	Type of observation 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	(1 char.)
	31-38	Elevation of the station (unit : centimeter)	(8 char.)
	39-40	Elevation type 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)	(2 char.)
	41-42	Accuracy of elevation 0 = no information 1 = $E \leq 0.02$ M 2 = $.02 < E \leq 0.1$ M 3 = $.1 < E \leq 1$ 4 = $1 < E \leq 2$ 5 = $2 < E \leq 5$ 6 = $5 < E \leq 10$ 7 = $10 < E \leq 20$ 8 = $20 < E \leq 50$ 9 = $50 < E \leq 100$ 10 = E superior to 100 M	(2 char.)
	43-44	Determination of the elevation 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	(2 char.)
	45-52	Supplemental elevation (unit : centimeter)	(8 char.)
	53-61	<b>Observed gravity</b> (unit : microgal)	(9 char.)

62-67	<b>Free air anomaly</b> (0.01 mgal)	(6 char.)
68-73	<b>Bouguer anomaly</b> (0.01 mgal) Simple Bouguer anomaly with a mean density of 2.67. No terrain correction	(6 char.)
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	<b>Terrain correction</b> (0.01 mgal) <i>computed according to the next mentioned radius &amp; density</i>	(6 char.)
86-87	Information about terrain correction 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	(2 char.)
88-91	Density used for terrain correction	(4 char.)
92-93	Accuracy of gravity 0 = no information 1 = $E \leq 0.01$ mgal 2 = $.01 < E \leq 0.05$ mgal 3 = $.05 < E \leq 0.1$ mgal 4 = $0.1 < E \leq 0.5$ mgal 5 = $0.5 < E \leq 1.$ mgal 6 = $1. < E \leq 3.$ mgal 7 = $3. < E \leq 5.$ mgal 8 = $5. < E \leq 10$ mgal 9 = $10. < E \leq 15.$ mgal 10 = $15. < E \leq 20.$ mgal 11 = $20. < E$ mgal	(2 char.)
94-99	Correction of observed gravity (unit : microgal)	(6 char.)
100-105	<b>Reference station</b> <i>This station is the base station (BGI number) to which the concerned station is referred</i>	(6 char.)
106-108	Apparatus used for the measurement of G 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)	(3 char.)

	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	<b>Country code (BGI)</b>	(3 char.)
112	<b>Confidentiality</b>	(1 char.)
	0 = without restriction	
	.....1 = with authorization	
	2 = classified	
113	<b>Validity</b>	(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>B.G.I.</b> source number	(8 char.)
	9-16	<b>Latitude</b> (unit : 0.00001 degree)	(8 char.)
	17-25	<b>Longitude</b> (unit : 0.00001 degree)	(9 char.)
	26-27	Accuracy of position 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...	(2 char.)
	28-29	System of positioning 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)	(2 char.)
	30	Type of observation 1 = individual observation at sea 2 = mean observation at sea obtained from a continuous recording	(1 char.)
	31-38	<b>Elevation of the station</b> (unit : centimeter)	(8 char.)
	39-40	Elevation type 1 = ocean surface 2 = ocean submerged 3 = ocean bottom	(2 char.)
	41-42	Accuracy of elevation 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	(2 char.)
	43-44	Determination of the elevation 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	(2 char.)
	45-52	Supplemental elevation	(8 char.)
	53-61	<b>Observed gravity</b> (unit : microgal)	(9 char.)
	62-67	<b>Free air anomaly</b> (0.01 mgal)	(6 char.)
	68-73	<b>Bouguer anomaly</b> (0.01 mgal) Simple Bouguer anomaly with a mean density of 2.67. No terrain correction	(6 char.)
	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	<b>Terrain correction</b> (0.01 mgal) <i>computed according to the next mentioned radius &amp; density</i>	(6 char.)
86-87	Information about terrain correction 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 O2) 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	(2 char.)
88-91	Density used for terrain correction	(4 char.)
92-93	Mathew's zone <i>when the depth is not corrected depth, this information is necessary. For example : zone 50</i> <i>for the Eastern Mediterranean Sea</i>	(2 char.)
94-95	Accuracy of gravity 0 = no information 1 = $E \leq 0.01$ mgal 2 = $.01 < E \leq 0.05$ mgal 3 = $.05 < E \leq 0.1$ mgal 4 = $0.1 < E \leq 0.5$ mgal 5 = $0.5 < E \leq 1.$ mgal 6 = $1. < E \leq 3.$ mgal 7 = $3. < E \leq 5.$ mgal 8 = $5. < E \leq 10.$ mgal 9 = $10. < E \leq 15.$ mgal 10 = $15 < E \leq 20.$ mgal 11 = $20. < E$ mgal	(2 char.)
96-101	Correction of observed gravity (unit : microgal)	(6 char.)
102-110	Date of observation <i>in Julian day - 2 400 000 (unit : 1/10 000 of day)</i>	(9 char.)
111-113	Velocity of the ship (0.1 knot)	(3 char.)
114-118	Eötvös correction (0.1 mgal)	(5 char.)
119-121	<b>Country code</b> (BGI)	(3 char.)
122	<b>Confidentiality</b> 0 = without restriction 1 = with authorization 2 = classified	(1 char.)
123	<b>Validity</b> 0 = no validation 1 = good 2 = doubtful 3 = lapsed	(1 char.)
124-130	Numbering of the station (original)	(7 char.)
131-136	<b>Sequence number</b>	(6 char.)
137-139	<b>Leg number</b>	(3 char.)
140-145	<b>Reference station</b>	(6 char.)

Whenever given, the theoretical gravity ( $\gamma_0$ ), 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 :

$$\gamma_0 = 978031.85 * [ 1 + 0.005278895 * \sin^2 (\phi) + 0.000023462 * \sin^4 (\phi) ] , \text{ mgals}$$

where  $\phi$  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
- $\gamma$  : theoretical value of gravity (on the ellipsoid)
- $\Gamma$  : vertical gradient of gravity (approximated by 0.3086 mgal/meter)
- $H$  : elevation of the physical surface of the land, lake or glacier ( $H = 0$  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 ( $667.2 \cdot 10^{-13} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ )  $\Rightarrow k = 2 \pi G$
- $\rho_c$  : mean density of the Earth's crust (taken as  $2670 \text{ kg m}^{-3}$ )
- $\rho_w^f$  : density of fresh water ( $1000 \text{ kg m}^{-3}$ )
- $\rho_w^s$  : density of salted water ( $1027 \text{ kg m}^{-3}$ )
- $\rho_i$  : density of ice ( $917 \text{ kg m}^{-3}$ )
- FA : free-air anomaly
- BO : Bouguer anomaly

Formulas :

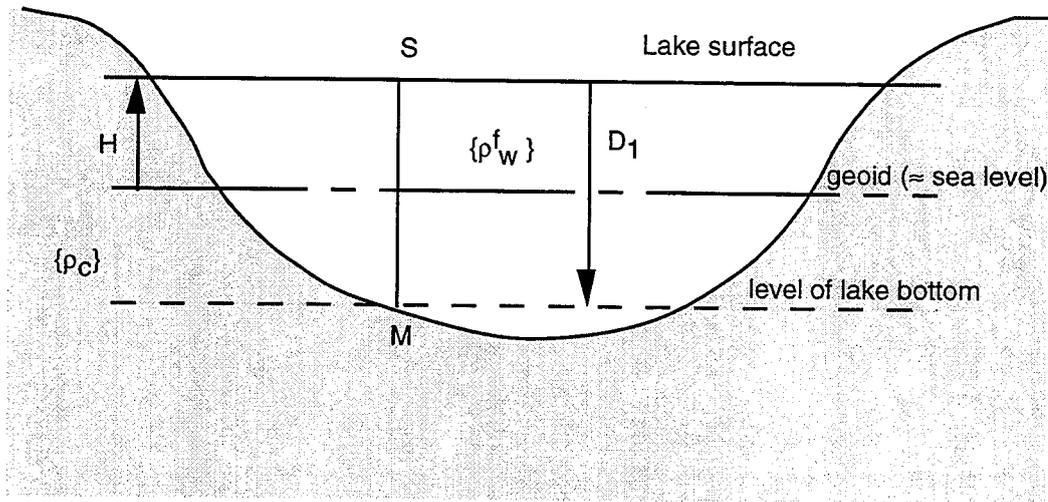
\* FA : The principle is to compare the gravity of the Earth at its surface with the normal gravity, which first requires in some cases to derive the surface value from the measured value. Then, and until now, FA is the difference between this Earth's gravity value reduced to the geoid and the normal gravity  $\gamma_0$  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  $\rho_c$  and that the parts above the geoid have the density of the existing material (which is removed).

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\* 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 :



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

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

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

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

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 with bottom above sea level	$FA = g + \Gamma H - \gamma_0$ $BO = FA - k \rho_w^f D_1 - k \rho_c (H - D_1)$
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 with bottom below sea level	$FA = g + \Gamma H - \gamma_0$ $BO = FA - k \rho_w^f H + k(\rho_c - \rho_w^f)(D_1 - H)$
A	Lake surface, below sea level (here $H < 0$ )	$FA = g + \Gamma H - \gamma_0$ $BO = FA - k \rho_c H + k(\rho_c - \rho_w^f) D_1$
B	Lake bottom, with surface below sea level ( $H < 0$ )	$FA = g + (2 k \rho_w^f - \Gamma) D_1 + \Gamma H - \gamma_0$ $BO = FA - k \rho_c H + k(\rho_c - \rho_w^f) D_1$
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. Gilles BALMA  
Bureau Gravimétrique International  
18, Avenue E. Belin - 31401 Toulouse Cedex 4 - France  
E-mail : Gilles.Balma@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  $\Delta$  in longitude and  $\Delta'$  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  $\Delta$  (1, 2, 5,... mgal), on a given projection :  
10 F/ $\Delta$  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  $\Delta$  x  $\Delta'$  area : 10F/ $\Delta\Delta'$  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 the 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

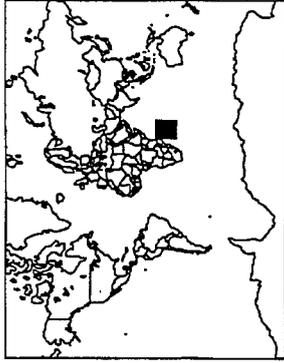
(Vol. 1 and 2)	1979	150 FF
----------------	------	--------

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

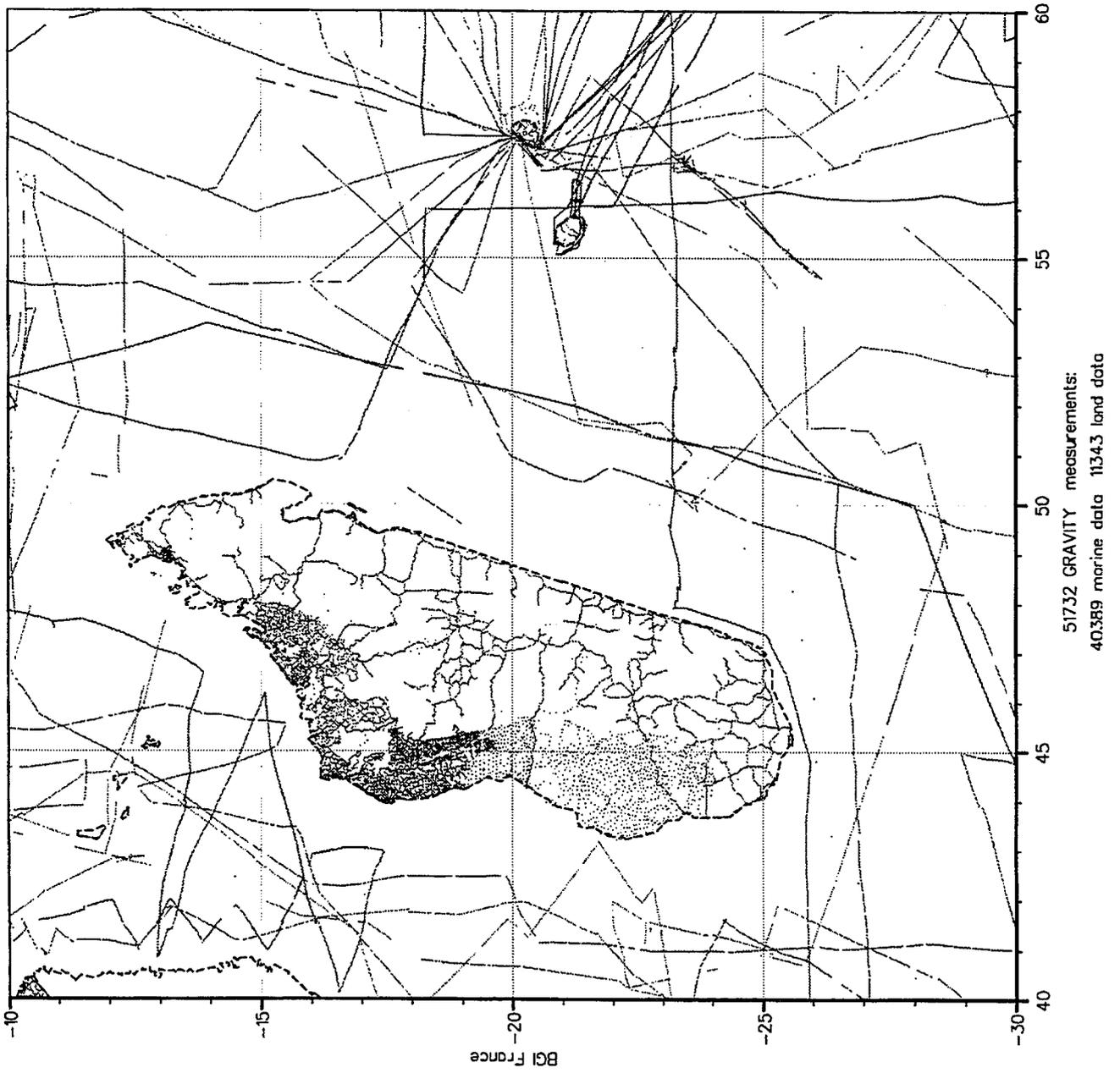
. Colour copy : price according to specifications of request.

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

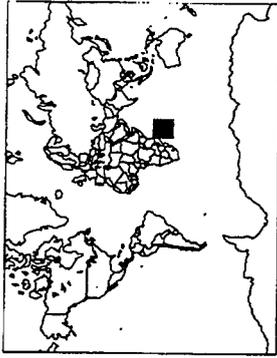
Map 1. Example of data coverage plot



E12



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



**BGI GRAVITY DATA  
MEAN FREE AIR ANOMALY**

1st field : number of points  
2nd field : mean value (mgal)  
3rd field : Std. Dev. (mgal)

E12

102	102	102	15	52	8	26	29	184	53	65	26	8	116	138	51	44	52	85	66	
25.3	-38.8	5.6	-25.9	-14.5	-18.3	-27.7	-22.5	-23.9	-27.9	-8.2	-7.2	-5.5	-13.1	-5.8	-3.8	-1.5	-9.2	-13.9		
10.1	42.1	6.2	12.0	1.3	4.3	17.6	26.3	10.3	26.7	37.4	24.0	8.2	11.1	6.0	12.2	23.2	9.1	9.4		
	118	59	53	37	41	26.4	85	2	13	82	43	29	3	25	68	40	40	37		
	-110	-14.1	66.2	-16.6	-26.4	-42.6	-42.6		77.7	-45.1	-12.9	-7.7	-16.9	-7.8	-2.6	-14.2	-1.7	-21.3		
21	207	51	28	88	74	32	99	14	2.8	4.8	16.3	8.4	4.3	1.2	13.6	10.5	2.6	5.9		
-55.9	-41.0	-63.4	93.6	6.4	68.8	-47.1	-58.0	37.8	54.8	15	101	26	26	35	58	50	6	16		
5.6	15.9	12.2	14.6	83.8	121.5	3.7	6.1	91	17.3	-32.7	-17.2	-12.3	-20.4	-23.8	-10.0	-8.6	-6.1	58.7		
3	334	170	204	125	84	172	35	155	117	4	72	6.0	5.9	3.1	13.1	10.1	1.4	4.8		
-47.8	-13.0	-40.3	-39.8	-52.1	-40.1	-38.4	-32.0	28.5	34.3	82.6	-5.9	-0.2	-0.2	-0.2	21.7	-4.5		62		
18	30.1	11.7	8.3	4.7	5.6	8.0	37.7	6.9	15.9	10.5	3.5	3.5	3.1	11	62	41	3	49		
	249	13	88	84	97	71	87	101	44	60	71	11	8.6	11.9	3.7	-0.8	12.3	54.4		
	13.8	-37.0	-28.4	-36.3	-42.4		-13.1	1.2	12.3	47.6	-0.8	-8.6	4.2	4.2	7.3	11.4	0.4	12.4		
	72.1	3.0	4.0	7.6	5.2	12.8	32.6	16.4	20.2	4.5	2.2	4.5	4.7	4.7	3.3	11.4	0.4	12.4		
	220	54.8	35.6	15.1	10.3	32.9	61.7	146	38	47	35	40	6	32	9	68	7	49		
-45.2	-40.7	-22.3	-63.3	-72.8	-63.1	-12.2	-18.2	-5.0	-36.5	1.3	-27.3	29.0	14	8.8	-7.4	-17.7	-33.3			
0.0	42.1	12.7	8.2	25.2	33.0	14.5	10.5	10.3	6.8	28.1	2.4	54.2	16	10.7	3.3	17.1	30			
102	42.1	158	176	348	416	407	244	53	117	45	51	16	60	14	7.3	6	95	31		
-20.1	-51.3	-40.4	-25.6	12.6	-5.2	-26.0	-3.2	50.4	0.3	-15.8	-14.9	-18.2	-14.3	-10.6	4.9	-18.4	-0.0	57.7		
14.1	40.2	16.0	10.6	19.8	15.2	8.9	12.8	19.5	20.4	12.2	11.7	3.6	13.9	16.2	9.3	2.5	18.4	50.5		
22	81	98	136	78.2	389	83	76	10	66	3	27	79	106	14	16	64	28	86	23	
-9.1	-47.6	-4.4	-18.1	6.1	8.0	-10.4	50.3	35.0	15.9	-43.9	-6.8	-2.1	-2.2	3.4	-7.4	-6.5	-19.8	2.5		
13.1	36.5	28.1	12.5	24.4	17.8	22.3	33.1	20.6	19.4	2.1	4.3	6.9	5.6	5.2	10.8	17.9	10.6	41.4		
47	23	32	72.5	387	155	202	137	90	13	13	4.3	47	70	67	198	81	59	23		
-38.9	-27.4	21.1	-7.6	-4.2	46.4	62.1	23.2	18.5	-47.8	-7.0	-8.0	-0.3	-6.1	-32.7	25.1	36.9	-0.3			
37	46	38	178	11.8	33.8	12.9	16.1	25.1	32.6	3.0	2	37	75	26	96	114	241	105		
-41.2	-45.8	16.8	-20.2	-23.4	40.8	67.2	318	566	2.1	11	37	8.2	-8.8	-13.0	-25.8	-59.0	74.2	-14.7		
8.6	15.1	19.8	6	151	144	49	104	81	43	2	12	12	23	24	47	145	386	71		
24	96	12	6	151	144	49	104	81	43	2	12	12	23	24	47	145	386	71		
-22.6	-21.2	-29.8	4.3	5.1	-15.8	49.4	48.6	47.0	-21.3	-3.8	-1.7	-3.7	8.8	149.9	-24.2	8.6	-31.9	-0.8		
7.4	14.5	6.2	2.3	28.1	28.3	27.5	22.1	38.1	7.3	8.8	15.2	15.9	23.7	88.1	33.3	71.3	28.5	17.0		
25	67	29	87	166	82	146	176	99	52	48	24	8	1	65	177	212	170	44		
-25.5	-10.5	-16.1	13.8	-2.7	-4.3	26.4	-5.8	46.9	-24.8	2.7	-5.5	-18.5	-18.5	13.0	281.3	-4.5	-29.4	-2.4		
6.9	8.9	20.0	11.2	14.8	18.9	16.7	33.8	39.3	5.7	6.2	1.2	4.5	0.0	61.4	53.0	24.2	16.1	16.5		
10	81	30	115	200	86	149	205	15	16	214	157	105	76	97	79	294	166	87		
6.4	3.3	-20.8	30.0	17.6	41.8	29.4	7.6	75.7	-25.0	7.3	21.2	5.2	11.1	5.2	9.0	-8.6	2.6	-8.0		
27.8	11.5	11.0	76	237	118	46	157	145	6.2	34	17	47	27	27	6	49	173	41		
-2.8	3.1	27.0	114	31.8	31.8	36.0	32.3	-7.5	-2.8	-16.5	3.7	3.7	16	42.8	3.1	5.9	-2.1	-12.5		
10.0	9.1	12.3	23.4	14.8	17.4	29.4	6.2	34	17	47	27	6	49	173	41	5.9	-2.1	-12.5		
26	99	26	132	150	30.0	110	27.0	-7.5	-2.8	-16.5	3.7	3.7	16	42.8	3.1	5.9	-2.1	-12.5		
-3.2	1.2	39.4	50.4	9.8	9.8	34.3	42.3	4.0	3.6	5.4	3.8	9.3	3.2	14.9	10.7	23.3	17.2	24		
6.1	15.8	10.6	10.8	8.8	16.1	123	31	1	45	24	65	50	13	42	70	100	47	26		
103	130	58	104	161	144	413	66.7	-24.9	-12.2	-17	-4.4	4.0	13.9	0.5	-8.9	6.4	-3.7	-8.1		
-8.9	-1.5	3.7	1.2	19.5	11.4	41.3	66.7	-24.9	-12.2	-17	-4.4	4.0	13.9	0.5	-8.9	6.4	-3.7	-8.1		
9.6	10.3	7.0	14.4	32.7	28.4	41.0	19.1	0.0	6.2	7.3	7.6	7.5	3.2	23.3	3.7	4.0	18.7	2.9		
37	77	51	49	34	37	30	35	48	71	68	26	21	9	15	105	26	57	13		
-27.9	10.9	2.2	-14.7	-22.2	-7.4	-6.7	-7.5	-20.5	-16.2	-12.2	-12.2	-11.9	-8.7	-17.9	2.1	9.4	-7.7	-18.2		
4.9	23.4	10.5	21.6	21.0	6.9	10.4	5.9	7.6	4.7	5.9	3.7	5.8	11	4.5	7.7	22.9	10.1	7.4		
54	74	3	18	20	30	7	3	21	28	-1.7	0.9	-1.6	-1.6	-1.6	7.7	22.9	10.1	7.4		
-12.2	-11	-5.7	10.3	42.4	59.4	36.5	2.4	2.4	2.4	-1.7	0.9	-1.6	-1.6	-1.6	7.7	22.9	10.1	7.4		
13.3	14.6	0.5	21.1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
32	34		12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-23.9	-14.1		12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
8.2	4.9		4.8	0.0	6.2	6.2	39.6	33.9	14.5	-3.2	-6.9	8.6	-3.2	-12.0	-0.8	-3.5	-3.6	12		
55	31	33	64	9	21	40	3	24	3.9	11.8	11.8	37	11	23	31	10.0	19.9	15.2		
-13.2	3.9	-6.1	16.1	47.1	20.3	11.7	7.7	23.1	0.4	0.4	17.0	8.0	4.8	3.8	7.2	20.9	17.5	8.7		
8.3	3.9	16.4	17.5	22.8	17.2	4.6	0.4	17.0	0.4	0.4	17.0	8.0	4.8	3.8	7.2	20.9	17.5	8.7		

30314 GRAVITY measurements:  
19050 marine data 11264 land data

## 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, and recalled in Bulletin n° 50 (pages 112-113).*

*If magnetic 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**

# **BIBLIOGRAPHY**

*We give hereafter the complete list of all papers, meeting and workshop reports, which have been published in the Bulletin d'Information since its beginning (May 1960).*

*We thought that some of this material would be of interest : most facts get diluted in our memories as time flies and one has a tendency to re-invent the wheel from time to time !*

*The file printed here is part of the general bibliographic file which is maintained at BGI. It can be obtained on request.*

*G. Balmino*































- Bulletin n° 34**                      **01-FEB-74**                      **ref.: 8331**  
 THE INTERNATIONAL GRAVITY STANDARDIZATION NETWORK 1971 - PUBLICATION SPECIALE DE  
 L'ASSOCIATION INTERNATIONALE DE GEODESIE (AIG) - ABSTRACT  
 MORELLI C., GANTAR C., HONKASALO T., MCCONNELL R. K., TANNER J. G., SZABO B., UOTILA U.,  
 WHALEN C. T.
- Bulletin n° 34**                      **01-FEB-74**                      **ref.: 8329**  
 PROJECTS OF GRAVITY SURVEYS AT SEA  
 Anonymous
- Bulletin n° 34**                      **01-FEB-74**                      **ref.: 8328**  
 DETERMINATION OF GRAVITATIONAL ACCELERATION AT MOSCOW (LEDOVO), MURMANSK,  
 ODESSA & NAKHODKA  
 BOULANGER YU. D., GUSEV N. A., LOKHOV V. V., SLIVIN YU. A., HEIFETZ M. E., SHCHEGLOV S.  
 N.
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8304**  
 LISTE DES PUBLICATIONS RECUES AU BGI DE OCTOBRE A DECEMBRE 1973  
 Anonymous
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8305**  
 PROPOSAL FOR THE RE-ORGANIZATION OF THE INTERNATIONAL GRAVITY COMMISSION  
 (APPENDIX)  
 MORELLI C.
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8307**  
 GRAVITY MEASUREMENTS AT SEA, SPECIAL STUDY GROUP NR. 3.20, LIST OF ALL MEMBERS  
 Anonymous
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8306**  
 THE INTERNATIONAL GRAVITY BUREAU  
 CORON S.
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8310**  
 THE GRAVITY FIELD OF ISLAND ARC - TRENCH SYSTEMS: SOME NEW RESULTS AND THEIR  
 IMPLICATIONS  
 FLEISCHER U.
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8312**  
 GRAVITY MEASUREMENTS AT SEA, SPECIAL STUDY GROUP NR. 3.20  
 Anonymous
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8314**  
 REPORT ON ABSOLUTE MEASUREMENTS OF GRAVITY  
 SAKUMA A.
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8316**  
 PAPERS PRESENTED OR DISTRIBUTED AT THE MEETING  
 Anonymous
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8318**  
 TERMS OF REFERENCE OF THE INTERNATIONAL GRAVIMETRIC BUREAU  
 Anonymous
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8317**  
 RESOLUTIONS - TEXTE ANGLAIS ET FRANCAIS  
 Anonymous
- Bulletin n° 35**                      **01-NOV-74**                      **ref.: 8323**  
 SEVENTH MEETING OF THE INTERNATIONAL COMMISSION, PARIS, SEPTEMBER 2-6, 1974  
 Anonymous



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 THE EOTVOS TENSOR & ITS IMPORTANCE FOR THE DETAILED MAPPING OF THE GRAVITY FIELD  
 NEAR THE EARTH'S SURFACE, & FOR DEFINING A SUITABLE LEVEL SURFACE FOR SOLVING  
 THE EXTERNAL BV-PROBLEM OF GEODESY AS A UNIQUE NEUMANN PROBLEM  
 VERMAAT E., TENGSTROM E.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8291**  
 GRAVITY MEASUREMENTS ON THE MOON  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8293**  
 SECULAR VARIATION OF GRAVITY  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8295**  
 NEW GRAVIMETRIC INSTRUMENTATION - GRAVITY GRADIOMETRY  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8294**  
 GRADIOMETRY - AN ASSESSMENT OF THE STATE-OF-THE-ART  
 WILLIAMS O. W.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8303**  
 VARIOUS TOPICS - INTERNATIONAL GRAVITY NET - GRAVITY SURVEYS AT SEA  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8302**  
 INTERNATIONAL GRAVITY STANDARDIZATION NETWORK - SPECIAL STUDY GROUP NR. 3.05 - (C-  
 R VIITH MEETING OF IGC, PARIS, SEPTEMBER 2-6, 1974 (CONTINUED))  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8301**  
 CALIBRATIONAL PROBLEMS - INVESTIGATION OF CALIBRATION FUNCTIONS  
 GERSTENECKER G.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8300**  
 COMPARISON OF WESTERN & AUSTRALIAN CALIBRATION LINE GRAVITY SCALES &  
 EVALUATION OF SECULAR VARIATION  
 WELLMAN P., BARLOW B. C., COUTTS D. A.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8299**  
 AIRBORNE GRAVITY MEASUREMENTS  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8298**  
 HIGH PRECISION GRAVIMETRY - SPECIAL STUDY GROUP NR. 3.37  
 Anonymous
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8297**  
 SPECIAL TECHNIQUES OF GRAVITY MEASUREMENTS (REPORT OF IAG SPECIAL STUDY GROUP  
 NR. 3.37)  
 HONKASALO T.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8296**  
 AN EVALUATION OF THE LACOSTE-ROMBERG MODEL G GRAVIMETER  
 MCCONNELL R. K., HEARTY D. B., WINTER P. J.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8292**  
 SECULAR VARIATIONS OF GRAVITY  
 BOULANGER YU. D.
- Bulletin n° 36**                      **01-MAR-75**                      **ref.: 8290**  
 INTERPOLATION OF GRAVITY VALUES & THE BOUNDARY VALUE PROBLEM OF GEODESY







BARTA M.

- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8241**  
HIGH PRECISION GRAVITY MEASUREMENTS FOR STUDYING THE SECULAR VARIATIONS OF GRAVITY IN FENNOSCANDIA  
PETTERSSON L.
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8240**  
THE RESULTS OF REPEATED GRAVITY MEASUREMENTS IN NORWAY & SWEDEN ON THE LAND UPLIFT GRAVITY LINE ALONG THE LATITUDE 63 DEGREES NORTH  
PETTERSSON L.
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8248**  
WORLD GRAVITY STANDARDS  
UOTILA U. A. (CONVENOR)
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8247**  
INTERNATIONAL GRAVITY STANDARDIZATION NETWORK  
MORELLI C. (CHAIRMAN)
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8246**  
ABSOLUTE GRAVITY MEASUREMENTS  
SAKUMA A. (CHAIRMAN)
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8245**  
PROGRESS ON THE DEVELOPMENT OF A PORTABLE ABSOLUTE GRAVIMETER  
FALLER J. E., RINKER R. L., ZUMBERGE M. A.
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8244**  
GRAVITY MEASUREMENTS AT SEA  
WOODSIDE J. M.
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8243**  
BRIEF REVIEW OF RESEARCH OF NON-TIDAL GRAVITY VARIATIONS 1974-1978 - REPORT OF THE PRESIDENT - SPECIAL STUDY GROUP 3.40, IAG  
BOULANGER YU. D.
- Bulletin n° 44**                      **01-MAY-79**                      **ref.: 8242**  
GRAVITY CHANGES OBSERVED IN THE KINKI DISTRICT, JAPAN  
NAKAGAWA I., SATOMURA M.
- Bulletin n° 45**                      **01-DEC-79**                      **ref.: 8226**  
LISTE DES PUBLICATIONS RECUES AU BGI DE JANVIER A JUIN 1979  
Anonymous
- Bulletin n° 45**                      **01-DEC-79**                      **ref.: 8227**  
COMPARISON & COMBINATION OF SATELLITES - RESULTS WITH SURFACE DATA  
RAPP R. H. (CHAIRMAN)
- Bulletin n° 45**                      **01-DEC-79**                      **ref.: 8228**  
PREDICTION OF GRAVITY VALUES  
UOTILA U. A. (CHAIRMAN)
- Bulletin n° 45**                      **01-DEC-79**                      **ref.: 8229**  
NEW GRAVIMETRIC INSTRUMENTATION  
WILLIAMS O. W. (CHAIRMAN)
- Bulletin n° 45**                      **01-DEC-79**                      **ref.: 8231**  
GEOPHYSICAL INTERPRETATION OF GRAVITY DATA  
SAXOV S. (CHAIRMAN)
- Bulletin n° 45**                      **01-DEC-79**                      **ref.: 8230**  
REPORT TO WORLD GRAVITY STANDARDS WORKING GROUP ON THE ADJUSTMENT OF THE LATIN AMERICAN GRAVITY STANDARDIZATION NET 1977 (LAGSN 77)



- Bulletin n° 48**                      **01-JUL-81**                      **ref.: 8213**  
 INSTRUMENTAL CAPABILITIES OF LACOSTE-ROMBERG GRAVITY METERS FOR THE DETECTION  
 OF SMALL GRAVITY VARIATIONS WITH TIME  
 BOEDECKER G.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8188**  
 LIST OF PUBLICATIONS DEALING WITH GRAVITY MATTERS RECEIVED AT BGI (BULLETIN NR. 48,  
 CONTINUED)  
 Anonymous
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8189**  
 RESOLUTIONS  
 Anonymous
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8190**  
 PRACTICAL FORMULAE FOR FREE FALL ABSOLUTE GRAVITY GRADIENT MEASUREMENT  
 JEUDY L. M. A.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8193**  
 CURRENT OBSERVATIONS OF GRAVITY VARIATIONS & VERTICAL CRUSTAL MOVEMENTS  
 DURING THE RECENT RIFTING PROCESS IN NORTHERN ICELAND  
 TORGE W., KANNGIESER E.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8192**  
 STUDY OF SHORT TERM GRAVITY VARIATIONS ALONG A BASELINE IN THE RHEINGRABEN  
 BECKER M.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8191**  
 ESTABLISHMENT OF A LACOSTE & ROMBERG GRAVITY NETWORK IN GREENLAND  
 FORSBERG R.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8194**  
 PRECISION OF THE SUPERCONDUCTING GRAVIMETERS DETERMINED BY SIMULTANEOUS  
 MEASUREMENTS WITH TWO INSTRUMENTS  
 GOODKIND J. M.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8196**  
 LOCAL GRAVITY CHANGES AT THE ASHKHABAD GEODYNAMIC TEST-AREA (ABSTRACT)  
 BOULANGER YU. D., GAIPOV B. N., DEMIANOVA, KUZMIN YU. O., KURBANOV M. K.,  
 MARAKHOVSKAYA L. A., CHELPANOV S. S.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8198**  
 NONLINEARITIES IN LACOSTE & ROMBERG MODEL D GRAVIMETERS DETERMINED BY THE  
 "CLOUDCROFT JUNIOR" METHOD  
 LAMBERT A., LIARD J. O.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8197**  
 SPACE-TIME REPRESENTATION OF THE GRAVITY FIELD (ABSTRACT)  
 GRAFAREND E. W.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8207**  
 INTRODUCTION TO THE PROBLEMS OF HIGH-PRECISION GRAVIMETRY  
 GROTEN E.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8206**  
 THE JILA ABSOLUTE GRAVIMETER (PAPER NOT SENT ON TIME)  
 FALLER J. E., RINKER L., ZUMBERGE M. A.
- Bulletin n° 49**                      **01-DEC-81**                      **ref.: 8204**  
 ON NON-TIDAL GRAVITY VARIATIONS  
 BOULANGER YU. D.







BEETZ H., RICHTER B., WOLF P.

- Bulletin n° 53**                      **01-DEC-83**                      **ref.: 8152**  
PARTIAL ANALYSIS OF GRAVITY MEASUREMENTS ON THE FENNOSCANDIAN GRAVITY LINES  
BECKER M., GROTEN E.
- Bulletin n° 54**                      **01-JUN-84**                      **ref.: 8175**  
LIST OF PUBLICATION DEALING WITH GRAVITY MATTERS RECEIVED AT B.G.I.  
SARRAILH M.
- Bulletin n° 54**                      **01-JUN-84**                      **ref.: 8176**  
BGI DATA MANAGEMENT SYSTEM - TECHNICAL DESCRIPTION  
ISAAC J. F.
- Bulletin n° 55**                      **01-DEC-84**                      **ref.: 8145**  
6' X 10' BOUGUER ANOMALIES AND ELEVATION OF EUROPE INCLUDING MARINE AREAS  
TORGE W., WEBER G., WENZEL H.-G.
- Bulletin n° 55**                      **01-DEC-84**                      **ref.: 8146**  
AN IMPROVED ELECTRONIC FEEDBACK FOR LACOSTE-ROMBERG GRAVITY METERS  
SCHNULL M., RODER R. H., WENZEL H.-G.
- Bulletin n° 55**                      **01-DEC-84**                      **ref.: 8147**  
RECENT DEFINITION OF ABSOLUTE GRAVITY AT SINGAPORE-2 SITE  
BOULANGER YU. D., ARNAUTOV G. P., KALISH E. N., STUS YU. F., SCHLEGLOV S. N.
- Bulletin n° 56**                      **01-JUN-85**                      **ref.: 8144**  
ONCE MORE ABOUT COMPARISON OF ABSOLUTE GRAVIMETERS IN SEVRES IN 1981 (FRANCE)  
BOULANGER YU. D.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8134**  
DETECTION OF REGIONAL BIAS IN 1 DEGREE BY 1 DEGREE MEAN TERRESTRIAL GRAVITY  
ANOMALIES  
MAINVILLE A., RAPP R. H.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8135**  
GEODETIC ASPECTS OF GRAVITY MEASUREMENTS IN AFRICA  
BOEDECKER G.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8137**  
RESULTS OF ABSOLUTE GRAVITY SURVEYS IN TOHOKU DISTRICT, JAPAN  
HANADA H., TSUBOKAWA T., OOE M.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8138**  
AN ESTIMATION ON THE NEEDED NUMBER OF STATIONS IN THE INTERNATIONAL ABSOLUTE  
GRAVITY BASE NET  
BIRO P., THONG N. C., WEISZ E.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8136**  
ON THE DESIGN OF THE INTERNATIONAL ABSOLUTE GRAVITY BASESTATION NETWORK (IAGBN)  
BOEDECKER G.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8139**  
GRAVIMETRY WITH AN ELECTROSTATIC FEEDBACK SYSTEM  
RODER R. H., SCHNULL M., WENZEL H.-G.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8141**  
HIGH PRECISION GRAVITY MEASUREMENTS ACROSS THE NORTH ANATOLIAN FAULT ZONE  
BECKER M., AKSOY A., DEMIREL H., GROTEN E.
- Bulletin n° 57**                      **01-DEC-85**                      **ref.: 8143**  
FREE AIR GRAVITY ANOMALIES OVER THE OCEANS FROM SEASAT AND GEOS 3 ALTIMETER  
DATA  
BALMINO G., MOYNOT B., SARRAILH M., VALES N.



- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8096**  
 THE PRESENT STATE OF THE EUROPEAN GEOID  
 BIRARDI G.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8106**  
 DETERMINATION STATISTIQUE DU GRADIENT VERTICAL DE LA PESANTEUR SUR LE PILIER A3  
 DE SEVRES (HAUTS DE SEINE-FRANCE)  
 OGIER M., MILLON R.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8105**  
 RELATIVE GRAVITY OBSERVATIONS AT BIPM, SEVRES IN 1985 AND 1986  
 RODER R. H., TORGE W.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8104**  
 OBSERVATIONS WITH A FULLY-DAMPED LCR G-GRAVIMETER  
 KIVINIEMI A.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8103**  
 SCREW ERROR & ELECTROSTATIC EFFECTS ON THREE LCR GRAVIMETERS WITH FEEDBACK  
 SYSTEM VRL 8350  
 KUNGEN Z., DUCARME B., POITEVIN C.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8102**  
 HIGH PRECISION GRAVITY MEASUREMENTS FOR THE DETECTION OF CRUSTAL DEFORMATION  
 BY SURFACE LOADS  
 BAKKELID S., BECKER M., GROTEN E., HARRSON B. G., MIDTSUNDSTAD
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8101**  
 COMPARISON BETWEEN THE THEORETICAL & OBSERVED TIDAL GRAVIMETRIC FACTORS  
 DEHANT V., DUCARME B.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8100**  
 GRAVITY NETWORK & REFLECTION OF THE GEOLOGICAL STRUCTURE OF CZECHOSLOVAKIA IN  
 GRAVITY MAPS  
 BLIZKOVSKY M., IBRMAJER J., OLEJNIK S., SEFARA J.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8099**  
 GRAVITY FIELD OF XIANG PLATEAU & ITS RECENT UPLIFT  
 FUZEN J., HOUTZE H.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8122**  
 SATELLITE ALTIMETRY DERIVED GRAVITY ANOMALIES OVER THE OCEANS  
 BALMINO G., MOYNOT B., SARRAILH M., VALES N.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8121**  
 STATUS OF THE GRAVITY GRADIOMETER SURVEY SYSTEM  
 ECKHARDT D. H.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8120**  
 STATUS OF THE SATELLITE GRAVITY GRADIOMETER PROJECT GRADIO  
 BALMINO G., BERNARD A.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8119**  
 RESULTS OF THE SECOND INTERNATIONAL COMPARISON OF ABSOLUTE GRAVIMETERS IN  
 SEVRES 1985  
 BOULANGER YU. D.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8118**  
 FIRST RESULTS WITH THE ABSOLUTE GRAVITY METER JILAG-3  
 TORGE W., RODER R. H., WENZEL H.-G., FALLER J. E.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8117**  
 PAST & FUTURE COMPARISONS: SOME THOUGHTS



- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8109**  
STATUS OF THE INTERNATIONAL ABSOLUTE GRAVITY BASESTATION NETWORK  
BOEDECKER G.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8108**  
A REVIEW OF THE DETERMINATION OF THE GEOGRAVITATIONAL CONSTANT, THE NEWTONIAN  
GRAVITATIONAL CONSTANT & THE MASS OF THE EARTH  
BOUCHER C.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8107**  
LARGE SCALE MEASUREMENTS OF THE NEWTONIAN GRAVITATIONAL CONSTANT: A SUMMARY  
TUCK G. J., STACEY F. D., HOLDING S. C., MOORE G. I.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8098**  
ISOSTASY IN NORTHERN BRITAIN  
HIPKIN R. G.
- Bulletin n° 59**                      **01-DEC-86**                      **ref.: 8094**  
FIRST COMPUTATION OF A GRAVIMETRIC GEOID OVER MADAGASCAR  
RAKOTOARY J., BALMINO G.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8080**  
THE AFGL ABSOLUTE GRAVITY SYSTEM'S ERROR BUDGET REVISITED  
ILIFF R. L., SANDS R. W.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8081**  
ON THE DETERMINATION OF THE HEIGHT CORRECTION IN THE MEASURED ABSOLUTE GRAVITY  
VALUE  
SHTEYMAN M. B., KOPAYEV A. V., LEONTYEV I. A.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8082**  
THE ESTABLISHMENT OF THE IRANIAN GRAVITY DATUM (IGD)  
ZOMORRODIAN H.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8085**  
RAPPORT SUR LES ACTIVITES DE RECHERCHE DU B.R.G.M. EN GRAVIMETRIE POUR L'ANNEE  
1986  
MILLON R.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8086**  
GRAVIMETRIC RESEARCH CARRIED OUT WITHIN THE FRAME OF INTERNATIONAL  
COOPERATION OF COUNTRIES MEMBERS OF SUB-COMMISSION 7 "EAST EUROPE & SOVIET  
UNION IN 1983-1986  
BOULANGER YU. D.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8084**  
FOUR YEARS EXPERIENCE WITH KSS30 SEAGRAVIMETER  
LONCAREVIC B. D.
- Bulletin n° 60**                      **01-JUN-87**                      **ref.: 8083**  
THE SWISS GRAVIMETRIC CALIBRATION LINE FROM INTERLAKEN TO JUNGFRAUJOCH  
(SWITZERLAND)  
KLINGELE E., KAHLE H.-G.
- Bulletin n° 61**                      **01-DEC-87**                      **ref.: 8074**  
ON CHINA GRAVIMETRIC STANDARD  
JIANG Z.
- Bulletin n° 61**                      **01-DEC-87**                      **ref.: 8076**  
EVALUATION OF GRAVITY DATA WITHIN THE DEPARTMENT OF DEFENSE GRAVITY LIBRARY  
HILLE K. L.











- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8000**  
 THE USE OF OPTIMAL ESTIMATION FOR GROSS-ERROR DETECTION IN DATABASE OF  
 SPATIALLY CORRELATED DATA  
 TSCHERNING C. C.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8002**  
 ON THE CALIBRATION TABLE OF LACOSTE-ROMBERG GRAVIMETERS  
 STRANG VAN HEES G. L.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8001**  
 ABSOLUTE GRAVITY OBSERVATIONS DOCUMENTATION STANDARDS  
 BOEDECKER G.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8005**  
 ABSOLUTE AND RELATIVE GRAVITY MEASUREMENTS AT HANNOVER AND POTSDAM IN THE  
 PERIOD 1988 - 1990  
 TORGE W., RODER R. H., TIMMEN L., KAUTZLEBEN H., ELSTNER CL.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8007**  
 RESULTS OF THIRD INTERNATIONAL COMPARISON OF ABSOLUTE GRAVIMETERS IN SEVRES,  
 1989  
 BOULANGER YU., FALLER J., GROTEN E., ARNAUTOV G., BECKER M., BERNARD B., CANNIZZO  
 L., CERUTTI G., COURTIER N. & AL.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8006**  
 CANADA'S CONTRIBUTION TO THE 1989 INTERNATIONAL COMPARISON OF ABSOLUTE  
 GRAVIMETERS AT THE BIPM : INSTRUMENTAL IMPROVEMENTS AND ANALYTICAL APPROACH  
 LIARD J., COURTIER N.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8004**  
 GRAVIMETRIC WORKS ON THE SOVIET LOMONOV SITE  
 VITUSHKIN L.
- Bulletin n° 68**                      **01-JUN-91**                      **ref.: 8003**  
 DISSIMILARITY OF THE GRAVITY FIELD ON AND OVER POSTAMENTS  
 BARANOVA S. M., PUSHCHINA L. V., RUKAVISHNIKOV R. B.
- Bulletin n° 69**                      **01-DEC-91**                      **ref.: 8179**  
 DIRECTING BOARD OF BGI, AUGUST 14, 1991, IUGG VIENNA, 20TH GENERAL ASSEMBLY  
 Anonymous
- Bulletin n° 70**                      **01-JUN-92**                      **ref.:7978**  
 GRAVITY: EARTH SYSTEM DATA  
 NATIONAL GEOPHYSICAL DATA CENTER
- Bulletin n° 70**                      **01-JUN-92**                      **ref.:7979**  
 NATIONAL REPORT OF UNITED KINGDOM - UNITED KINGDOM RESEARCH ON GEODESY 1987 -  
 1990  
 THE DEPARTMENT OF SURVEYING - THE UNIVERSITY NEWCASTLE UPON TYNE
- Bulletin n° 70**                      **01-JUN-92**                      **ref.:7981**  
 NATIONAL REPORT OF THAILAND - REPORT ON THE GEODETIC ACTIVITIES OF THE THAI  
 NATIONAL COMMITTEE ON GEODESY & GEOPHYSICS - PERIOD 1987 - 1990  
 THAI NATIONAL COMMITTEE ON GEODESY & GEOPHYSICS
- Bulletin n° 70**                      **01-JUN-92**                      **ref.:7980**  
 NATIONAL REPORT OF TURKEY - NATIONAL REPORT OF GEODETIC COMMISSION OF TURKEY  
 GENERAL COMMAND OF MAPPING
- Bulletin n° 70**                      **01-JUN-92**                      **ref.:7984**  
 NATIONAL REPORT OF PORTUGAL - NATIONAL REPORT ON GEODETIC WORKS EXECUTED FROM  
 1987 TO 1990  
 Anonymous











- Bulletin n° 78**                      **01-JUN-96**                      **ref.:7918**  
GRAVITY DATA IN OMAN  
RAVAUT P. M. U., WARSI W. E. K.
- Bulletin n° 78**                      **01-JUN-96**                      **ref.:7920**  
ABSOLUTE GRAVITY MEASUREMENTS IN SOUTH AFRICA  
KLEYWEGT R. J., MAKINEN J., MERRY C. L., WONNACOT R. T.
- Bulletin n° 78**                      **01-JUN-96**                      **ref.:7921**  
DIGITAL GRAVITY DATA SETS FOR THE MEDITERRANEAN SEA DERIVED FROM AVAILABLE  
MAPS  
BEHREND D., DENKER H., SCHMIDT K.
- Bulletin n° 78**                      **01-JUN-96**                      **ref.:7919**  
THE VERTICAL GRAVIMETER CALIBRATION LINE AT KARLSRUHE  
WENZEL H. G.
- Bulletin n° 78**                      **01-JUN-96**                      **ref.:7922**  
TURKISH NATIONAL GRAVITY FILE (TNGF) AND DETECTION OF GROSS ERRORS  
ALP O., EMIN AYHAN M.
- Bulletin n° 79**                      **01-DEC-96**                      **ref.:7917**  
MEAN 1 DEGREE BY 1 DEGREE VALUES OF POTENTIAL FUNCTIONALS OVER CHINA  
BALMINO G., CHEN J.Y., VALES N.
- Bulletin n° 80**                      **01-JUN-97**                      **ref.:7914**  
THE NATIONAL GRAVIMETRIC NETWORK OF URUGUAY  
TIMMEN L., TORGE W.
- Bulletin n° 80**                      **01-JUN-97**                      **ref.:7915**  
ABSOLUTE GRAVITY VALUE MEASURED AT SYOWA STATION, ANTARCTICA  
KAMINUMA K., TSUKAHARA K., TAKEMOTO S.
- Bulletin n° 80**                      **01-JUN-97**                      **ref.:7916**  
RESULTS OF ABSOLUTE GRAVITY MEASUREMENTS AT THE GEODETIC OBSERVATORY PECNY  
SIMON Z.
- Bulletin n° 81**                      **01-DEC-97**                      **ref.: 8561**  
RELATIVE GRAVITY MEASUREMENTS WITH A SCINTREX CG3-M IN THE GRAVIMETER  
CALIBRATION SYSTEMS HANNOVER AND HORNISGRINDE  
REHREN F.
- Bulletin n° 81**                      **01-DEC-97**                      **ref.: 8562**  
A NEW GRAVITY BASE NET IN THE EMIRATE OF DUBAI  
AL ZAFFIN M., PADMANABHAN R., PASSINI R., TORGE W., REHREN F., SCHNULL M.

624 articles references

