GRAVITY SURVAY AT SEA

This is a continuation of the report of gravity surveys at sea conducted by the Hydrographic and Oceanographic Department.The results of four surveys made in 1995-2002, Ise Wan, Offing of Fukushima, Minamihiyoshi kaizan and Offing of Miyagi are presented in this report.

Key words: marine gravity survey

1. Surveys

The Hydrographic and Oceanographic Department (JHOD) has carried out gravity surveys at sea by using the sea surface gravity meters, KSS-30 or KSS-31(Bodenseewerk), on board the survey vessels, Meiyo, and Shoyo. The gravity meters are composed of the sensor, stabilized platform and data handling subsystems.

KSS-30 and KSS-31 measures the gravity by means of the zero method using the balance between gravity and electro-magnetic forces. The change of electric current, which balances the gravity change, is filtered in time domain and then converted into frequency variation. A brief explanation of the gravity meter is described in No. 19 of this publication series (Ueda, et al., 1985). ;

2. Reduction

The KSS-30 and KSS-31 gravity meter is calibrated in advance of each cruise using a LaCoste & Romberg gravity meter. A gravity value of 979,778.272 mGal (JGSN75) at the gravity station of the Hydrographic and Oceanographic Department (JHD-G_0) is adopted as the reference value for calibrations. The gravity value at pier for Meiyo is reduced to 979,770.36 mGal and Shoyo reduced to 979,767.66 mGal on the base of the value at JHD-G_0. The corrections of Eotvos and drift effect are applied to measure gravity values.

(a) Free-air gravity anomaly, Δg_0, is calculated by the following equation,

$$\Delta g_0 = g_0 + 0.87 - \gamma \quad \text{(mGal)},$$

where g_0 is the corrected gravity value, 0.87 (mGal) is an atmospheric correction at sea level and γ is the normal gravity value based on the Geodetic Reference System 1980 given by the formula:

$$\gamma = 978.03267715[\ 1 + 0.005279041\sin^2\phi + 0.0000232718\sin^4\phi + 0.0000001262\sin^6\phi + 0.0000000007\sin^8\phi\ ] \quad \text{(Gal)}$$

where ϕ is the latitude of the reference point.

(b) Bouguer gravity anomaly, Δg_1 is calculated by the following equation,

$$\Delta B = 2\pi G (\rho_c - \rho_w) \times d \quad \text{(mGal)} + \rho_c T_c - \rho_w T_w,$$

where d is depth in meter, T_c is terrain correction value for the earth's crust, T_w terrain correction value for the sea water, $G = 6.673 \times 10^{-8}$ (cm^3 /g.sec^2), $\rho_c = 2.67$(g/ cm^3) and $\rho_w = 1.03$ (g/ cm^3) whence the Bouguer anomaly is calculated by

$$\Delta g_1 = \Delta g_0 + \Delta B .$$

Computations in the above procedures are made by using computer EWS-4800 and the resultant gravity data are stored into a file. The drafts of free-air anomaly maps are made by a plotter machine.

The reduction and compilation of four cruises in Table 2 have been completed, and the details of those surveys are shown in this table.

3. Results of gravity survey

Free-air gravity anomaly maps and Bouguer gravity anomaly maps are shown in Figure 1 to 7. The free-air gravity anomaly and associated data have been compiled on digital media with relevant information and are available on request.

The data format and other information concerning the gravity data file of JHDGF should be referred to Ganeko and Koyama(1981).

4. Cruise infomation of gravity survey at sea

Four gravity surveys were carried out from 2002 after the last Data Report. Cruise information for each survey is given in Table 3.

This report was written by T.Kato, Geodesy and Geophysics Office.

References

Ganeko, Y., Koyama, K. 1981: *Report of Hydrographic Researches,* No. 16, p. 103.
Ueda, Y., Harada, Y., Hiraiwa, T. 1985: *Data report of Hydrogr.Obs,Series of astronomy and Geophi.,* No. 19, p. 99.
Ueda, Y., Harada, Y., Hiraiwa, T., Horii, R. 1986: *ibid.,* No. 20, p. 90.

The results of gravity surveys at the sea surface for the preceding years are found in the back numbers of this publication series listed in Table 1.

Table 1. The list of back numbers of this publication series

Cruise index	Data Report of Hydrographic Observation, Series of Astronomy and Geodesy
65TEST	Tokuhiro, A., 1966, No.1, p.43. Tokuhiro, A., 1967, No.2, p.29. Sugimoto, K., Yanagi, T., 1968, No.3, p.22.
68TK	Takemura, T., Yanagi, T., Ganeko, Y., 1969, No.4, p.13.
68AK	Takemura, T., Yanagi, T., Ganeko, Y., 1970, No.5, p.33.
68NI	Takemura, T., Yanagi, T., Ganeko, Y., 1971, No.6, p.19.
70IR	Takemura, T., Yanagi, T., Tomioka, Y., 1972, No.7, p.23.
70SN	Takemura, T., Yanagi, T., Nisiya, S., 1974, No.8, p.29.
71SN	Takemura, T., Yanagi, T., Tomioka, Y., 1975, No.9, p.42.
72HU	Yanagi, T., Tomioka, Y., Katsuno, K., 1976, No.10, p.49.
72KU,72HI,72HD, 73HK,73KG,73MI	Yanagi, T., Tomioka, Y., Katsuno, K., 1977, No.11, p.76.
73KO,74NG,74TR 74KG,76IK	Yanagi, T., Kubo, K., 1978, No.12, p.55.
75OK,75YM	Yanagi, T., Matumoto, K., Nisisita, A., 1979, No.13, p.48.
75BO,75SI,76OK,76MK	Ganeko, Y., Yanagi, T., Nisisita, A., 1980, No.14, p.59.
76IK,77JO,78JO	Ganeko, Y., Harada, Y., Komatu, Y., 1981, No.15, p.44.
80KT,80IS-A,80IS-B	Ganeko, Y., Harada, Y., Komatu, Y., 1982, No.16, p.64.
81IO,81YK	Ganeko, Y., Harada, Y., Koyama, K., Futinoue, S., 1983, No.17, p.88.
82SN,82AM	Ganeko, Y., Harada, Y., Koyama, K., Hiraiwa, T., 1984, No.18, p.85.
83SN,83NT,83HN	Ueda, Y., Harada, Y., Hiraiwa, T., 1985, No.19, p.99.
84HN,85TH,85IS	Ueda, Y., Harada, Y., Horii, R., Hiraiwa, T., 1986, No.20, p.90.
84ST,85BM,85TB	Ueda, Y., Asao, T., Hiraiwa, T., 1987, No.21, p.122.
84SM,85SB,85BT,86IZ	Ueda, Y., Nakagawa, H., Onodera, K., Nagaya, Y., 1988, No.22, p.36.
85TR,86TR,86BK	Yanagi, T., Onodera, K., Ito, H., Kato, T., 1989, No.23, p.34.
87HT,87TT,88SN	Yanagi, T., Mihara, S., Yamano, H., 1990, No.24, p.63.
88WP,88ST	Yanagi, T., Mihara, S., Yamano, H., 1991, No.25, p.40.
90ST	Ono, F., Mihara, S., Okumura, M., 1992, No.26, p.44.

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Cruise index	Data Report of Hydrographic Observation, Series of Astronomy and Geodesy
91BEPPU,91UN-T ,91UN-S,91MI	Ono, F., Mihara, S., Kato, T., Usijima, M., 1993, No.27, p.44.
91ZN,91BO,92NI	Ono, F., Kato, T., Usijima, M., 1994, No.28, p.52.
91MF,92EN,92IZ,93KO,93HY,93TO,94EN 94IR	Kato, T., Usijima, M., Tugawa, T., 1995, No29, p.64.
94NI,94AY	Okumura, M., Toyama, S., 1997, No31, p.70.
94ENB,95IS,95AM,96TS	Okumura, M., Toyama, S., 1998, No32.
98KI,98MI,98IZ	Suzuki,A.,Sakamoto,H., 1999, No33.
99FU,99NI	Suzuki,A.,Sakamoto,H., 2000, No34.
98MY,99MY,98IZ,99FU,00MI	Kato, T.,Suzuki,A.,2001, No35.
96SR,96RO,97TM,00BU	Kato, T.,2002, No36.

Table 2. Detailed information on the compiled sea gravity surveys

Cruise index	**95ISE**	**98NI** **99NI** **01NI**	**01HI**	**02NI**
Area	Ise Wan	Offing of Fukusima	Minami-Hiyoshi kaizan	Offing of Miyagi
Period	Aug. - Sep.,1995	Oct. ,1998 Oct. ,1999 Oct. - Nov.,2001	Sep. ,2001	Aug. - Sep,2002
Vessel	Meiyo	Shoyo	Shoyo	Shoyo
Gravimeter	KSS-30	KSS-31	KSS-31	KSS-31
Positioning	Integrated Navigation System	Integrated Navigation System	Integrated Navigation System	Integrated Navigation System
Survey speed	6-8 knot	5-7,12-13 knot	7-9 knot	5-7 knot
Survey line spacing	0.5N.M. SW-NE	5 N.M. NNW-SSE 5 N.M. WNW-ESE	0.5N.M. N-S	2.5 N.M. W-E 5 N.M. NW-SE
Observation interval	5 sec	5 sec	5 sec	5 sec
Drift	+2.0mGal/month	-3.1 mGal/month -3.3 mGal/month -4.0 mGal/month	-2.9 mGal/month	-2.9 mGal/month
Mean of cross difference	±2.2 mGal	±0.5 mGal	±1.0 mGal	±1.6 mGal
Free air Anomaly map	Figure 1	Figure 2	Figure 4	Figure 6
Bouguer Anomaly map	----------	Figure 3	Figure 5	Figure 7
Scale of original chart	1:100,000	1:500,000	1:50,000	1:500,000
Map projection	TM	Lambert Conformal Conic	TM	Lambert Conformal Conic

Table 3. Cruise infomation of gravity surveys at sea in 2002

Cruise Index	Area	Period	Vessel	Project name
０２ＨＩ	Minami-Hiyoshi Kaizan	May. - Jun.,2002	Shoyo	Volcanic Eruption Prediction
０２ＫＩ０５	Kita-Fukutoku Tai	May. - Jun.,2002	Shoyo	Volcanic Eruption Prediction
０２ＫＩ０６	Kita-Fukutoku Tai	Jun. - Jul.,2002	Shoyo	Volcanic Eruption Prediction
０２ＮＩ	Offing of Miyagi	Aug.- Sep.,2002	Shoyo	Earthquake Prediction

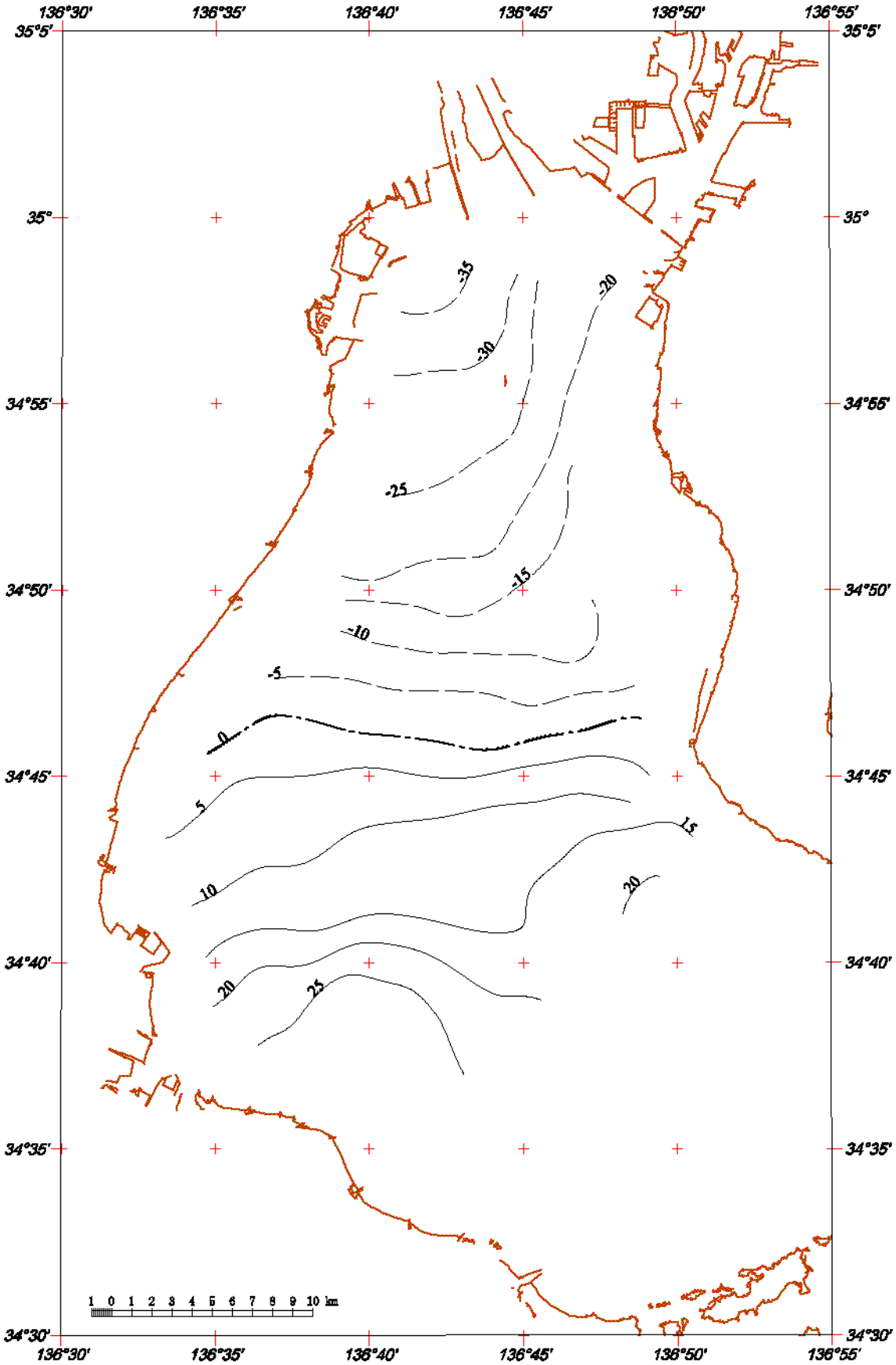

Figure 1. Free Air Gravity Anomaly Map in Ise Wan.
Reduced from the original chart.(unit in mgal)

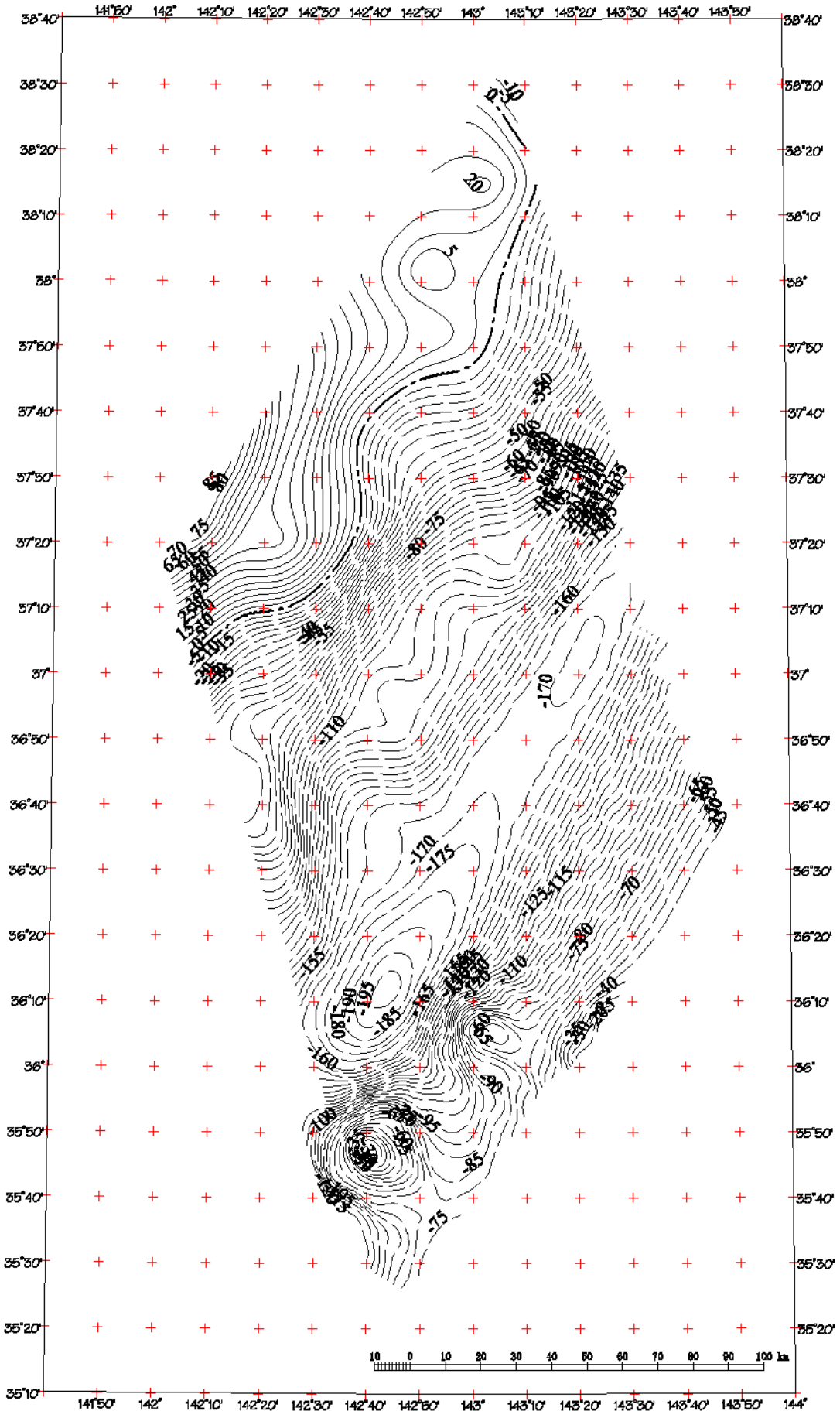

Figure 2. Free Air Gravity Anomaly Map offing of Fukushima.
Reduced from the original chart.(unit in mgal)

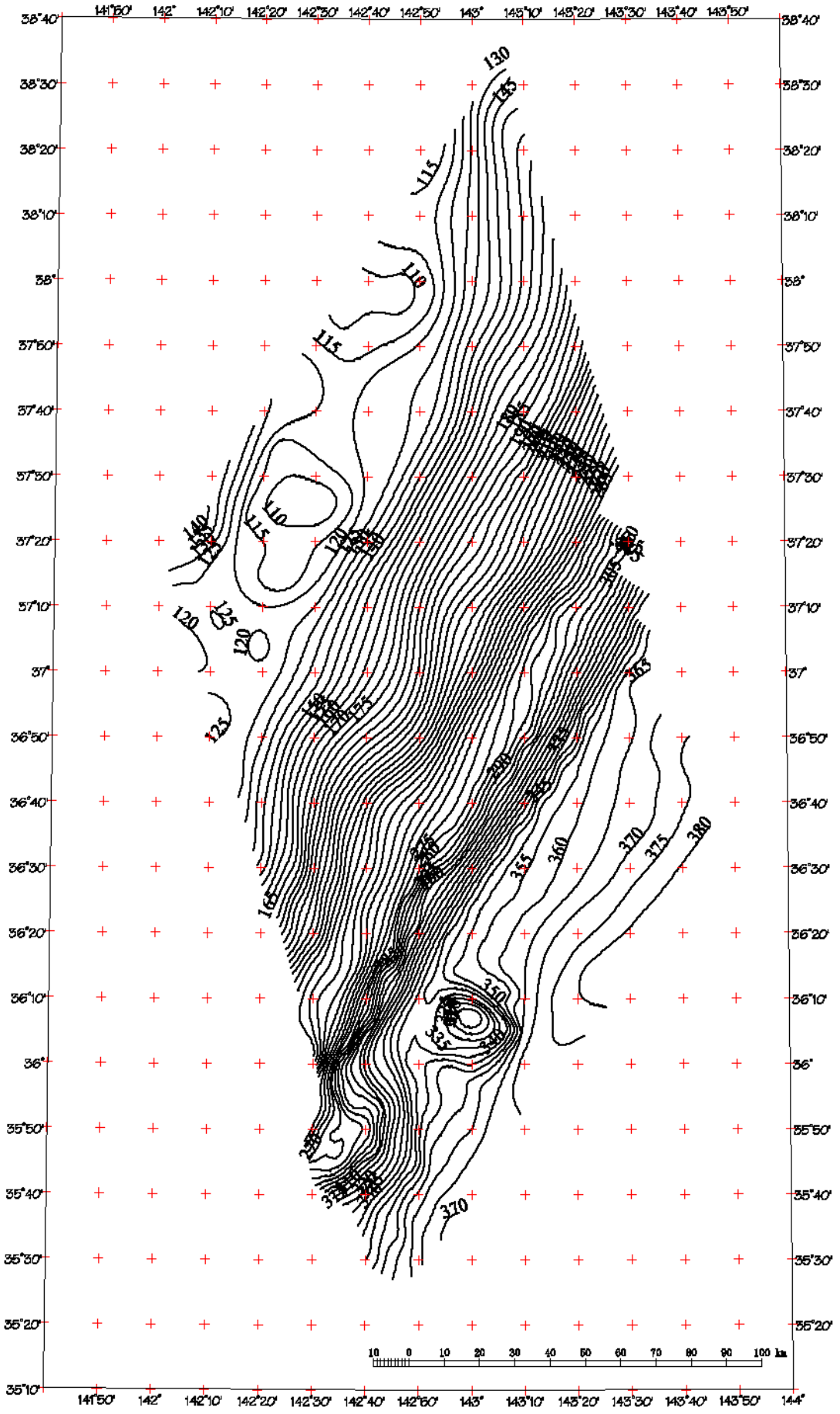

Figure 3. Bouguer Gravity Anomaly Map offing of Fukushima.
Reduced from the original chart.(unit in mgal)

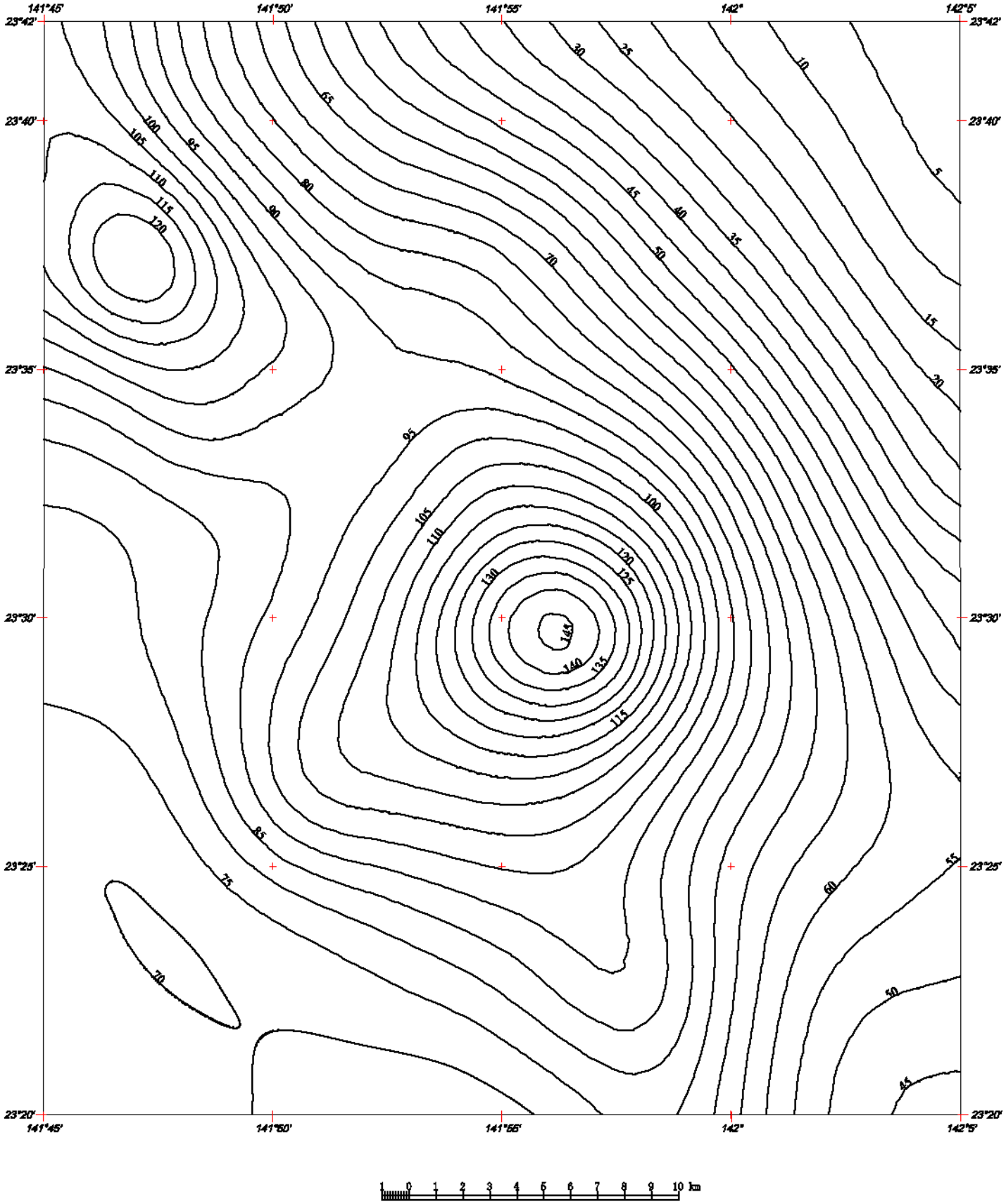

Figure 4. Free Air Gravity Anomaly Map in Minamihiyoshi kaizan
Reduced from the original chart. (unit in mgal)

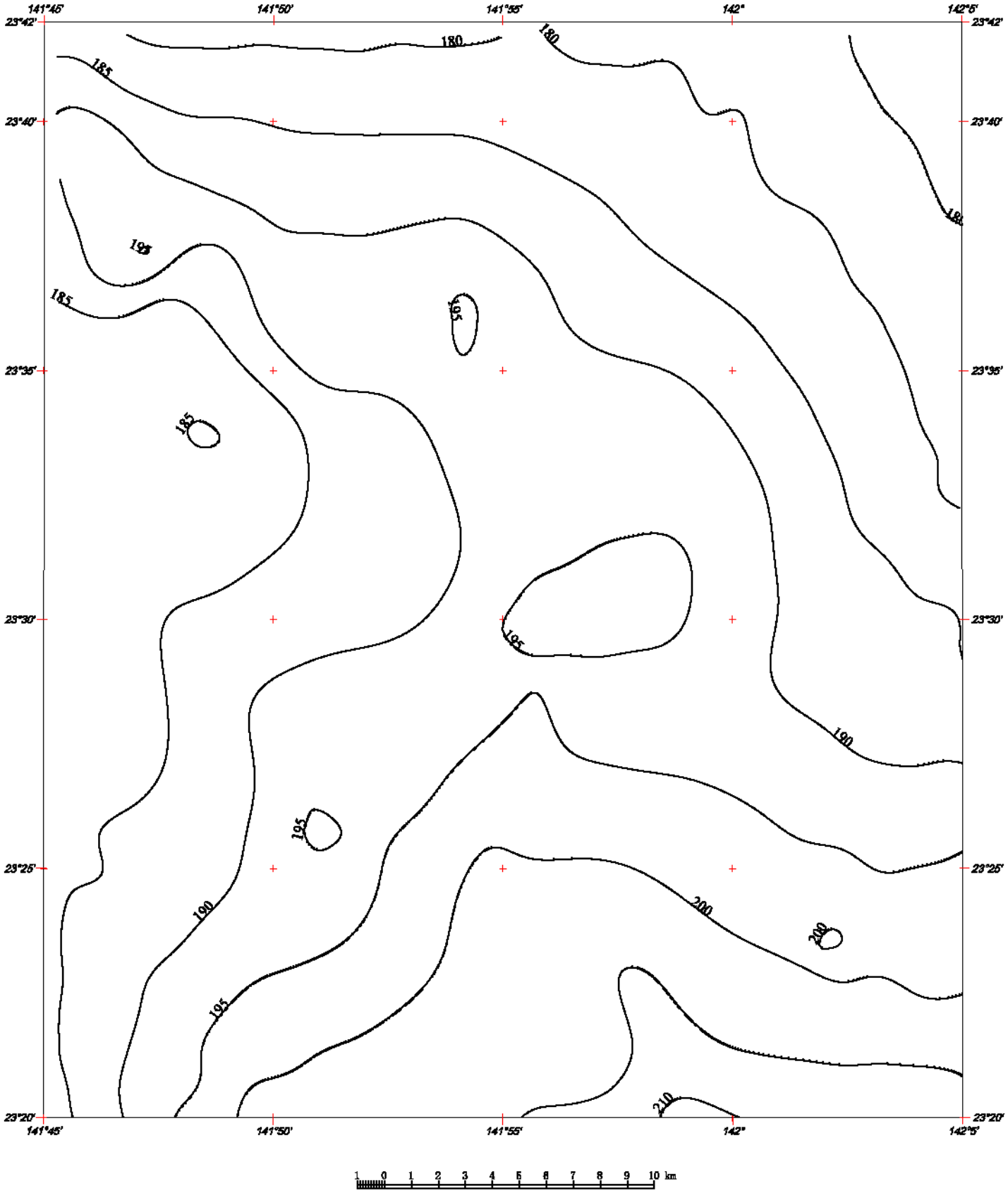

Figure 5. Bouguer Gravity Anomaly Map in Minamihiyoshi kaizan
Reduced from the original chart. (unit in mgal)

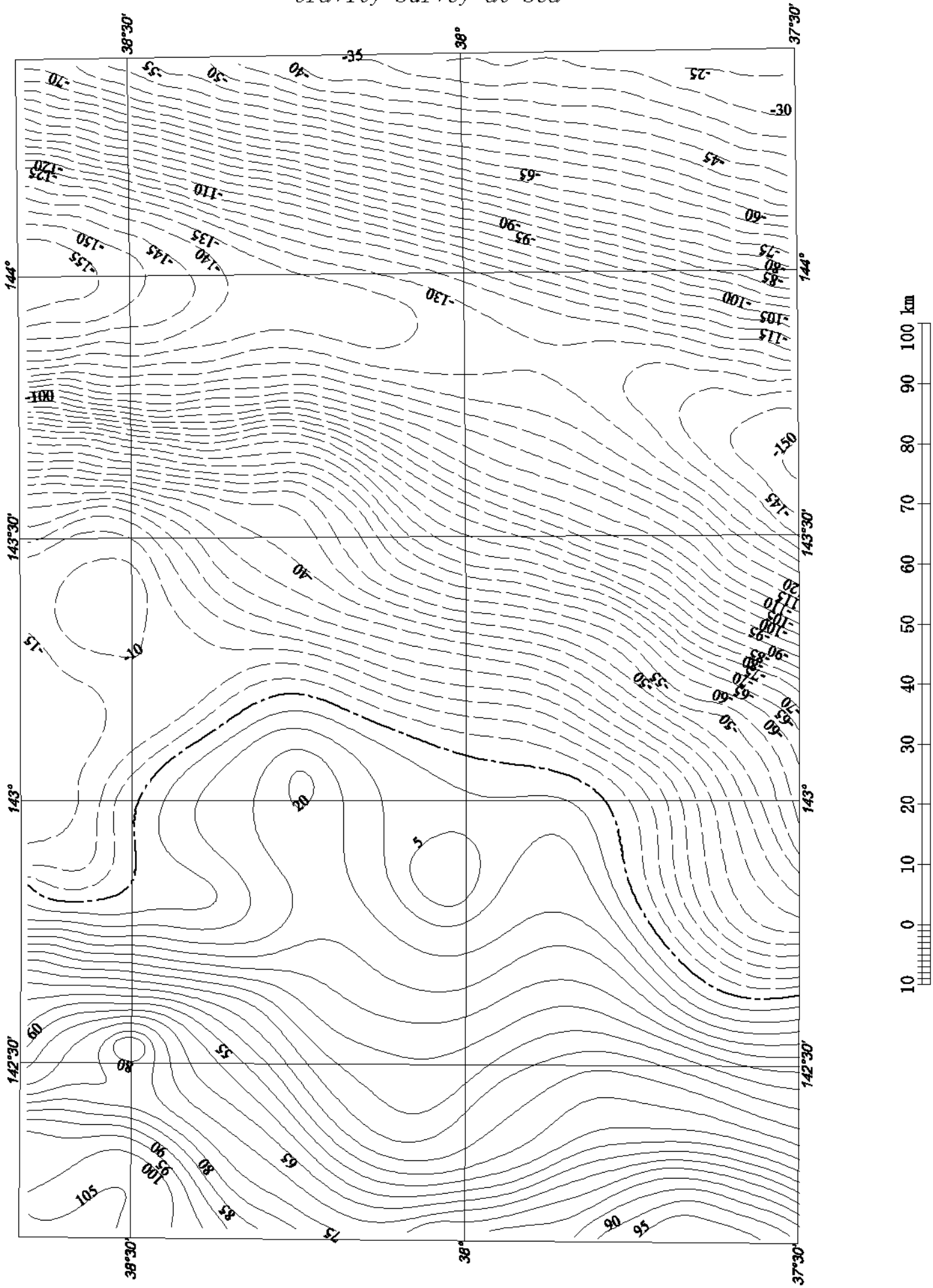

Figure 6. Free Air Gravity Anomaly Map offing of Miyagi.
Reduced from the original chart.(unit in mgal)
Compiled with a part of offing of Fukushima shown in Fig. 2.

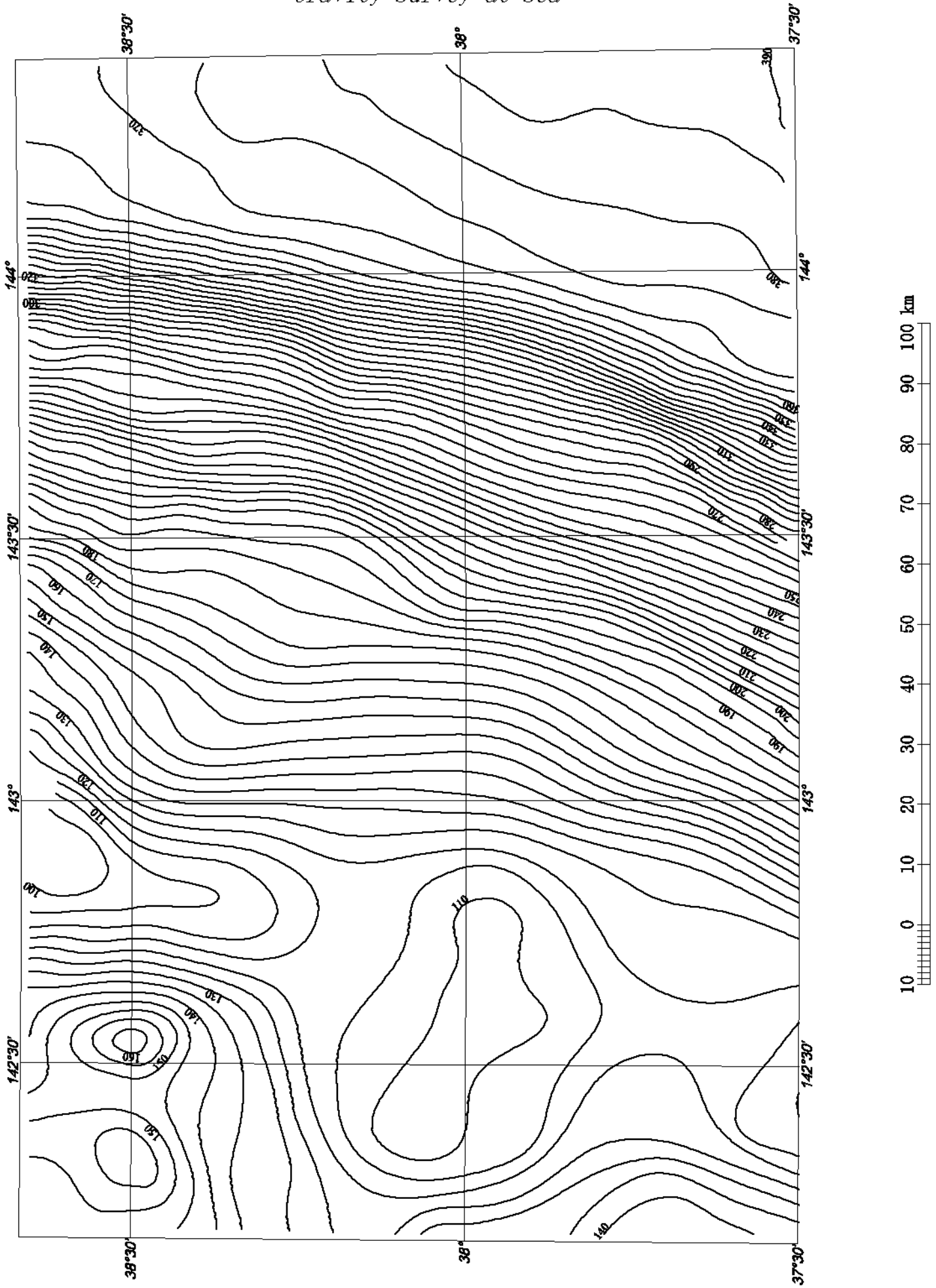

Figure 7. Bouguer Gravity Anomaly Map offing of Miyagi.
Reduced from the original chart.(unit in mgal)
Compiled with a part of offing of Fukushima shown in Fig. 3.