

Compilation of Airborne Magnetic Anomaly Maps in Japan from the Variety of Surveys with Long Epoch Differences

T. Nakatsuka^{1*}, S. Okuma¹, R. Morijiri¹, M. Makino¹

¹ Geological Survey of Japan, AIST, Site-7, Higashi-1, Tsukuba, 305-8567 JAPAN
tad.nktk@ni.aist.go.jp (Tadashi Nakatsuka)

Abstract

Aeromagnetic survey data have been accumulated over the Japanese islands, by the continuous and earnest work in the Geological Survey of Japan (GSJ) and the pertinent project in the New Energy Development Organization (NEDO). The data from two organizations had enough coverage over the Japanese main land and surrounding sea areas. So it was anticipated to build an aeromagnetic database of Japan.

In aeromagnetic survey, mobile magnetic data are subject to correct for the time variation to extract the distribution of magnetic intensity. So it is necessary to acquire continuous magnetic observation data at a base station or a magnetic observatory, and temporal base stations are often settled to monitor the magnetic variation during individual survey periods. Each survey data were thus processed to remove time variation of magnetic field such as diurnals. However, in the compilation of numbers of survey data, there was a problem that the discontinuity exists between IGRF residual maps of adjacent areas surveyed at different epochs. Although this discontinuity could be mitigated, by adopting the DGRF model instead of tentative IGRF model as a reference base, there still remained the discontinuity. This is probably because of the epoch differences from survey to survey, i.e., the problem of the epoch reduction. As it is difficult at this moment to recover absolute value of secular variation term, we applied a statistical method to remove gaps between survey areas. After all, data of aeromagnetic maps were compiled into a magnetic anomaly map of Japan, where no upward continuation filtering or no linear trend removal was applied.

1. Introduction

The aeromagnetic area survey in Japan was first conducted in 1964 at the Geological Survey of Japan (GSJ) as a part of project on natural gas investigation. Since then, the accumulation of aeromagnetic data for the assessment of hydrocarbon resources and the improvement and advancement of survey technology were promoted like the two wheels of a cart, and the offshore areas of Japanese mainland are mostly covered by 1978. The aeromagnetic surveys thereafter in GSJ were aiming at investigating remote sea area or at evaluating detail subsurface structure with higher resolution in smaller areas.

With the background of technical development and abundant data accumulated in GSJ, the New Energy Development Organization (NEDO) soon after its establishment accomplished a big project of aeromagnetic survey for geothermal assessment, named as "Curie Point Survey", in 1981-83. The survey flights were made mainly over land, and the data were combined with GSJ data of mainly offshore, to compile aeromagnetic maps from Hokkaido to Kyushu.

Using those data made available by the two organizations, a wide-view magnetic anomaly map of Japan [1] was also published. However, the data accumulated above can be applied not only for wide-view information but also for finer distribution related to the geologic structure in detail. And it was anticipated to build an aeromagnetic database taking into account the difference of line spacing, flying altitude, etc. in each survey.

2. Building the aeromagnetic survey database of Japan

The data from two organizations, GSJ and NEDO, had enough coverage over the Japanese main land and surrounding sea areas. In order to build the "Aeromagnetic Survey Database of Japan", first we converted the original data from each aeromagnetic survey into a form of unified formats. The data from surveys by GSJ are processed into files of three types formats. Those from NEDO surveys were also recovered from magnetic-tape archives and processed into another types of formats.

The data files in the database consist of GRID files and LINE files. GRID files contain the magnetic anomaly (IGRF residuals) distribution data expressed as a series of values on the square mesh points. There are 3 types of LINE files (TRK, LIN, NLN types) depending on the data processing method used for each survey. In old-style data processing of aeromagnetic survey (until 1977, GSJ), track-line paths and magnetic anomaly contours were drawn by hand on a paper, and only magnetic grid data were digitized manually. As there were no digital data of track-line position in this case, the paths on the published maps were digitized with a tablet digitizer (TRK type). It was in 1974 when the digital aeromagnetic data recording and processing was first adopted successfully at GSJ. The original data along the survey lines were stored in the form that time, latitude, longitude and magnetic anomaly values of each magnetic observation are repeated (LIN type). The original survey data in NEDO surveys is similar to LIN type, but it also included the values of magnetic diurnal variation and altitudes (NLN type).

The aeromagnetic survey data included in this database are listed in Table 1, the number or name of which corresponds to that of location map shown in Fig. 1.

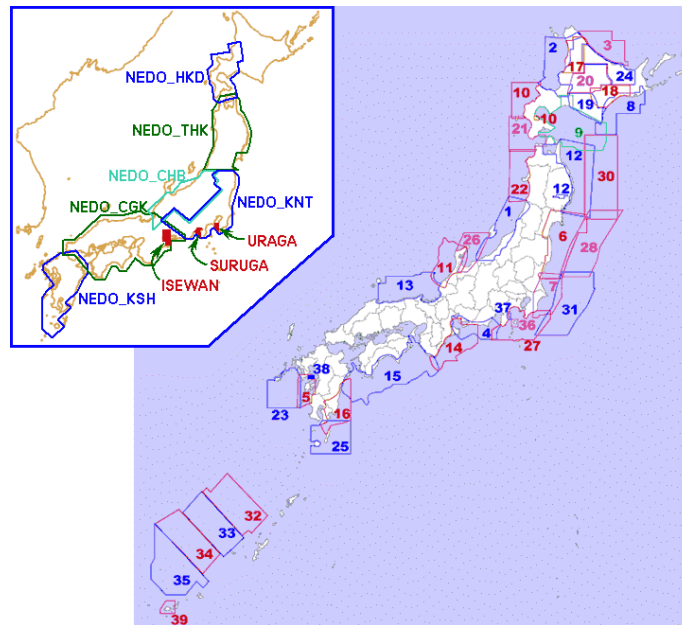


Figure 1. Ranges of aeromagnetic maps published

3. Epoch reduction and level-shift adjustment

In aeromagnetic survey, mobile magnetic measurement of total force magnetic field on board is done together with obtaining position fix. During old years, tremendous effort was devoted to get precise position fixes, although nowadays GPS system provides accurate position data quite easily. Mobile magnetic data are subject to correct for the time variation to extract the distribution of magnetic intensity. So it is necessary to acquire continuous magnetic observation data at a base station or a magnetic observatory, and temporal base stations are often settled to monitor the magnetic variation during individual survey periods.

Each survey data were thus processed to remove time variation of magnetic field such as diurnals. In the compilation of numbers of survey data, there was a problem that the discontinuity exists between IGRF residual maps of adjacent areas surveyed at different epochs. We studied the cause of it, and found that adopting the DGRF model instead of tentative IGRF model as a reference base could mitigate this discontinuity [2]. However, there still remained the discontinuity even after the re-calculation of residual magnetic field based on DGRF. There are some possibilities of the cause. In the old-style data processing, the baseline for the magnetic diurnal correction was selected arbitrarily. The secular variation term in DGRF may not fit well enough to the actual secular variation in Japan. It is difficult today to identify the cause of magnetic gaps between surveys. But, it is impossible that the gap actually exists along the boundary of survey areas, and the gap should be removed.

Table 1. List of surveys included in the aeromagnetic survey database of Japan

No.	Name	Year	Org.	No.	Name	Year	Org.
1	SADO_N	1968	GSJ	25	TANE	1977	GSJ
22	NOSHIRO	1968	GSJ	24	KITAMI_A	1978	GSJ
2	ISHIKARI	1969	GSJ	24	KITAMI_M	1978	GSJ
1	SADO_S	1969	GSJ	26	TOYAMA	1978	GSJ
1	SAKATA	1969	GSJ	27	BOSO	1978	GSJ
2	RISHIRI	1970	GSJ	28	JOBAN1	1980	GSJ
6	ABUKUMA	1970	GSJ	28	JOBAN2	1980	GSJ
3	SOYA	1971	GSJ	30	SANRIKU12	1980	GSJ
5	AMAKUSA	1971	GSJ	30	SANRIKU2	1980	GSJ
7	HITACHI	1971	GSJ	---	ERIMOSMT	1980	GSJ
4	TOKAI	1972	GSJ	31	KANTO1	1981	GSJ
8	DOTO	1972	GSJ	31	KANTO2	1981	GSJ
9	DONAN	1972	GSJ	o	SURUGA	1977-78	JICA ^{*1} ,GSJ
16	MIYAZAKI	1973	GSJ	o	URAGA	1980-81	JICA ^{*1} ,GSJ
10	OKUJIRI	1973	GSJ	o	ISEWAN	1982-85	JICA ^{*1} ,GSJ
11	KOKURIKU	1973	GSJ	o	NEDO_KSH	1981	NEDO
12	SHMOKITA	1973	GSJ	o	NEDO_THK	1981-82	NEDO
13	TOTTORI	1974	GSJ	o	NEDO_HKD	1982	NEDO
14	KUMANO	1974	GSJ	o	NEDO_CHB	1982	NEDO
17	TEMPOKU	1974	GSJ	o	NEDO_KNT	1982	NEDO
---	KAMUIKTN	1974	GSJ	o	NEDO_CGK	1983	NEDO
15	MUROTO	1975	GSJ	32	OKINAWA1	1982-83	GSJ
18	TOKACHI	1975	GSJ	33	OKINAWA2	1983-84	GSJ
15	ASHIZURI	1975	GSJ	34	MIYAKO	1985-87	GSJ
19	HIDAKA	1976	GSJ	35	ISHIGAKI	1986-89	GSJ
21	TSUGARU	1976	GSJ	36	OSHIMA	1978,86	GSJ,NAS ^{*2}
23	GOTO	1977	GSJ	37	ITO	1989	GSJ
20	DAISETSU	1977	GSJ	38	UNZEN	1991	NAS ^{*2} ,GSJ
22	AKITA	1977	GSJ	39	IRIOMOTE	1992	GSJ

^{*1}JICA : Japan International Cooperation Agency, ^{*2}NAS : Nakanihon Air Service Co. Ltd.

For such data standardization, it is desirable to acquire control data surveying the whole region roughly within a short period, but it has not been realized yet. In the regional aeromagnetic anomalies compilation so far, the upward continuation filtering and the trend surface removal were applied to elucidate wide-view distribution of magnetic anomalies. However, we selected the policy to reserve original data accuracy and resolution in editing the aeromagnetic anomalies database, and we only made the magnetic level adjustment based on the statistical examination of level shifts between survey areas.

The magnetic level shifts thus estimated were adjusted as in the Table 2.

4. Compilation of magnetic anomaly map of Japan

After the correction for magnetic level shift between surveys, it is ready to merge magnetic anomalies of different surveys. The only point to be decided is the method of merging within the overlapping zones. The method we adopted is as follows.

- < In case that one side is better in resolution > If the line spacing or flying altitudes on both sides are different considerably, the priority was given to the data of narrower line spacing or lower flying altitude, and the transition zone was selected at the margin of the data of priority.
- < In case of comparable resolution > If the line spacing and flying altitudes on both sides are similar, the arithmetic mean was used within the overlapping area, with the transition zones at the margin of both side data.

This procedure of merging data was performed for all surveys data to produce the magnetic anomaly

grid data files of the whole Japan, which were used to generate the map image as in Fig. 2.

The aeromagnetic database of Japan was thus constructed and is going to be published in 2005 [3] by the Geological Survey of Japan, AIST.

Table 2. Level-shift adjustment applied to each survey data

Name	Adjusted by (nT)	Name	Adjusted by (nT)	Name	Adjusted by (nT)
SADO N	46.4	KAMUIKTN	-1.7	KANTO1	-26.2
NOSHIRO	-3.1	MUROTO	-45.1	KANTO2	-15.6
ISHIKARI	58.9	TOKACHI	51.8	SURUGA	-23.2
SADO S	19.2	ASHIZURI	-74.0	URAGA	-5.6
SAKATA	26.6	HIDAKA	29.6	ISEWAN	4.5
RISHIRI	19.0	TSUGARU	-2.9	NEDO KSH	18.2
ABUKUMA	-6.9	GOTO	-11.2	NEDO THK	27.9
SOYA	30.5	DAISETSU	39.0	NEDO HKD	20.7
AMAKUSA	15.7	AKITA	4.2	NEDO CHB	15.1
HITACHI	-25.2	TANE	-13.3	NEDO KNT	18.0
TOKAI	-15.0	KITAMI A	16.5	NEDO CGK	4.3
DOTO	-6.5	KITAMI M	18.0	OKINAWA1	0.0
DONAN	9.7	TOYAMA	4.0	OKINAWA2	0.0
MIYAZAKI	16.6	BOSO	-29.6	MIYAKO	-77.5
OKUJIRI	-49.9	JOBAN1	1.3	ISHIGAKI	-77.5
KOKURIKU	-5.3	JOBAN2	1.4	OSHIMA	-19.4
SHMOKITA	-51.9	SANRIKU12	10.5	ITO	-27.1
TOTTORI	-9.9	SANRIKU2	16.1	UNZEN	79.5
KUMANO	-39.1	ERIMOSMT	16.1	IRIOMOTE	0.0
TEMPOKU	10.0				

References

- [1] M. Makino, Y. Okubo, and T. Nakatsuka (1992) Magnetic map of the Japanese Islands (1:2,000,000), *1:2,000,000 Map Series*, no.23, Explanatory text, 24p., Geol. Surv. Japan.
- [2] T. Nakatsuka (2001) Building a database system for the aeromagnetic anomalies over Japan, *Bull. Geol. Surv. Japan*, Vol.52, pp.125-132 [in Japanese with English abstract].
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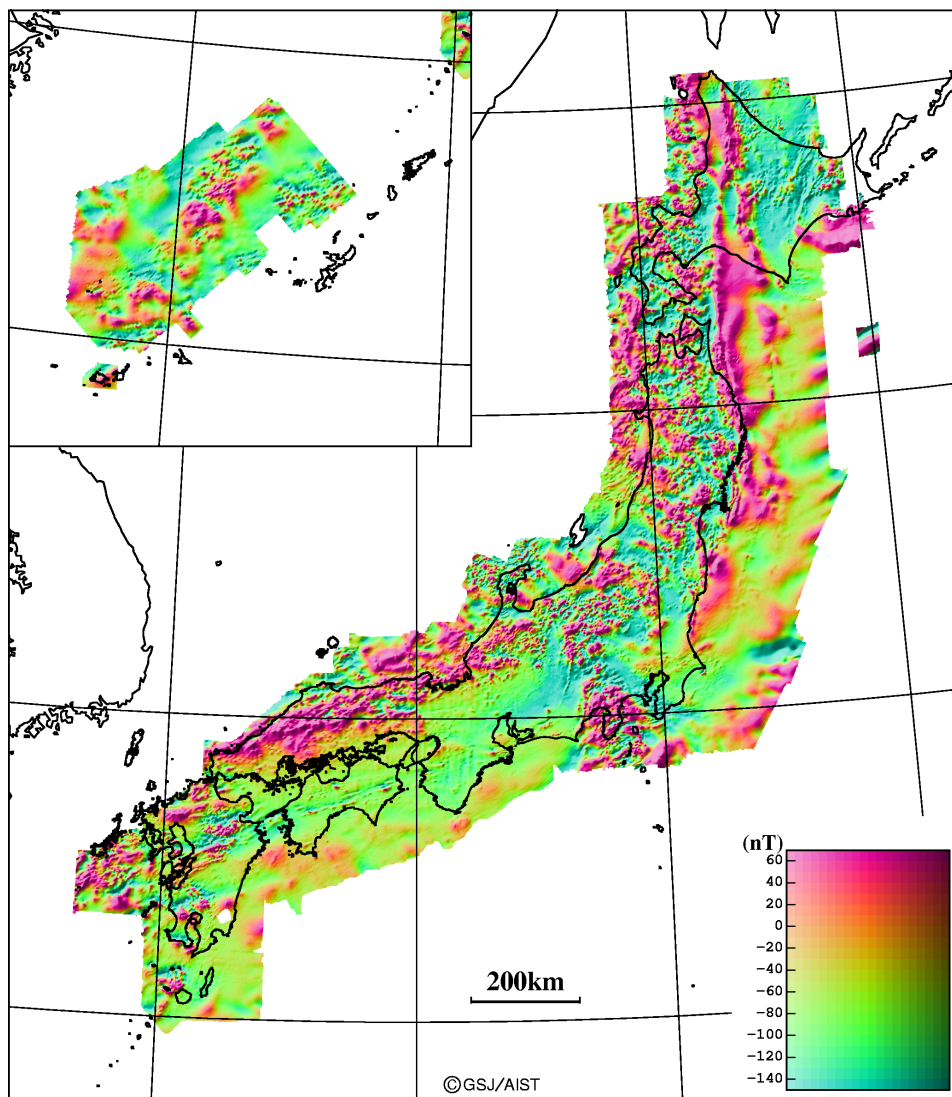


Figure 2. Aeromagnetic map of whole Japan (level-shift adjusted DGRF residuals)