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# INSTALLATION OF GEOMAGNETIC ABSOLUTE OBSERVATION POINT AT SEAL ROCK, EAST ANTARCTICA, AND THE ABSOLUTE OBSERVATIONS IN 1987

Ryoki SAKAI, Kazuo SHIBUYA and Masaru AYUKAWA

*National Institute of Polar Research, 9-10, Kaga 1-chome, Itabashi-ku, Tokyo 173*

***Abstract:*** A non-magnetic pillar for observation of geomagnetic field was installed at Seal Rock, East Antarctica in January 1987 by the 28th Japanese Antarctic Research Expedition. A G.S.I. (second-order) precise magnetometer was set on the pillar, and absolute measurements of the geomagnetic field were made 7 times during 19 September–18 December, 1987. The averaged values of the observed declination angle, inclination angle and the total magnetic intensity are −36°19.2′ (westward), −63°53.3′ (upward) and 43073 nT, respectively. These observed values are consistent with the theoretical values calculated by the IGRF (1985) model.

## 1. Introduction

Geomagnetic secular variations in the Antarctic region are rather large compared with those at mid-latitudes of the northern hemisphere (NAGATA, 1982), and long-term monitoring of geomagnetic field at an absolute observation point is important for studies on geomagnetism, geodesy and solid earth geophysics. Figure 1 illustrates geomagnetic repeat stations operating in 1987, among which, for example, geomagnetic field has been observed for more than 20 years at Syowa Station. The observed data at Syowa Station are included in the IGRF (International Geomagnetic Reference Field) modeling or used for baseline determination of epoch reduction in the aeromagnetic survey over the Mizuho Plateau and Lützow-Holm Bay.

As one of the basic research items, geophysical surveys have been included in the programs of the Japanese Antarctic Research Expedition (JARE) to the Sør Rondane Mountains region of the East Queen Maud Land. However, there were no geomagnetic repeat stations between Syowa and Novolazarevskaya Stations after Roi Baudouin Station had been closed in 1966, and installation of an absolute observation point in the Sør Rondane Mountains region was an urgently requested program.

As an item of the geophysical observation programs of the 28th Japanese Antarctic Research Expedition (JARE-28) (SHIBUYA and SAKAI, 1989), we had a chance to construct a permanent pillar at Seal Rock, 2 km west of Asuka Station, for the absolute measurements of the geomagnetic field. This report summarizes the installation procedure and the measurements during our 1987 wintering.

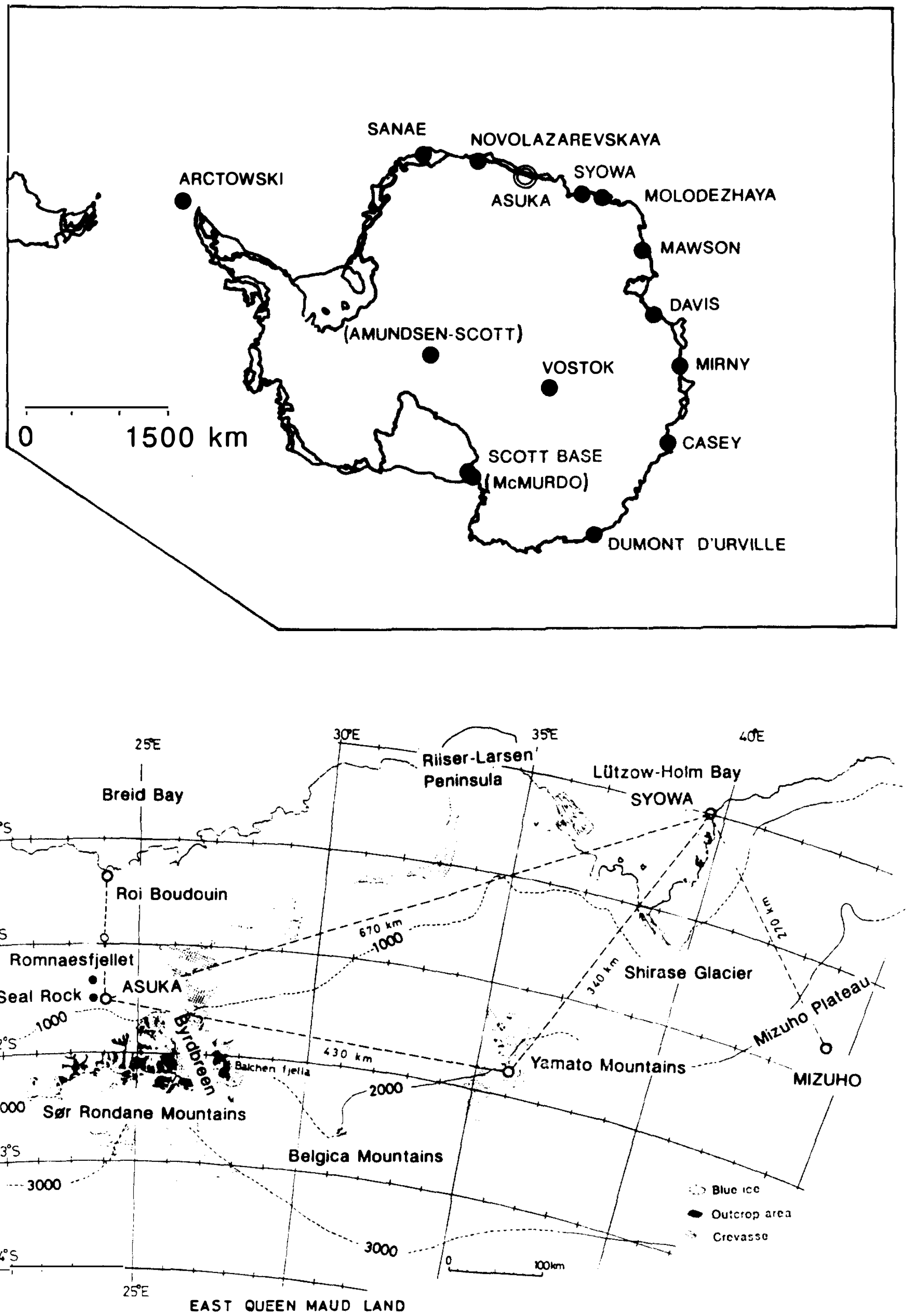


*Fig. 1. Distribution of geomagnetic repeat stations (solid circles) in Antarctica operating in 1987 (upper part), and overview of the JARE research area (lower part).*

## 2. Construction of the Pillar

Figure 2 schematically illustrates the installed pillar. As an immovable place near Asuka Station, the Seal Rock area was selected and a large moraine rock was chosen as the basement of the pillar in the western slope of the area to avoid strong katabatic

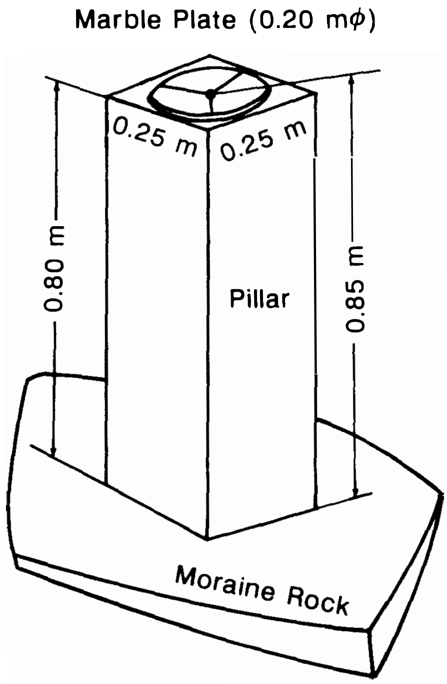


*Fig. 2. Sketch of the non-magnetic pillar for absolute observation point at Seal Rock.*

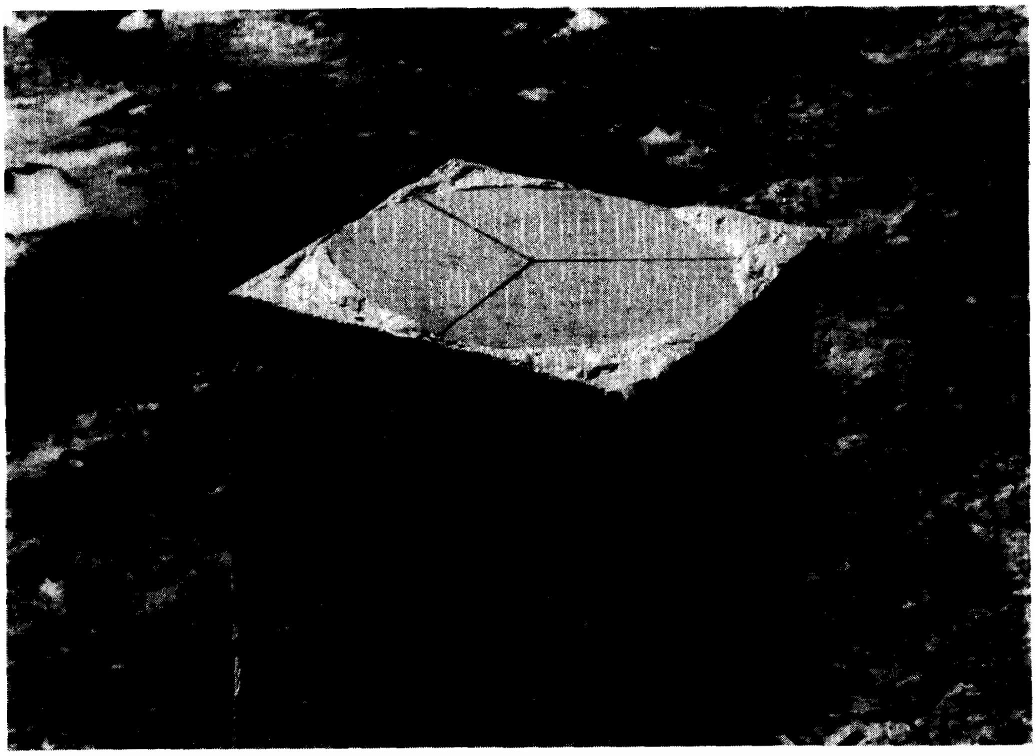

*Fig. 3. Top view of the constructed non-magnetic pillar at Seal Rock for setting the G.S.I. (second-order) precise magnetometer.*

winds. Practically the chosen place is the only one suitable place for construction. Non-magnetic rods which are made of copper and plaster are used to build a pillar of 0.25 m by 0.25 m in widths and 0.80 m in height. At the top of the pillar, a marble plate with Y-shaped cut was placed for easy setting of the tripod of the precise magnetometer-theodolite and for easy adjustment of the rotating coil. The construction was made during 31 January–2 February, 1987 by R. SAKAI and Y. MIYASHITA.

Figure 3 shows the top of the accomplished pillar. During the winter season, "futon cushion" was tied round the pillar against the wind at intervals of measurements. This worked good, because no cracks or peel-off of the pillar occurred under the severe meteorological condition with 12.8 m/s yearly-average wind speed (45.2 m/s instantaneous maximum), and −48.7°C yearly minimum air temperature (YAMANOUCHI *et al.*, 1988). We call the constructed pillar the "absolute observation point" hereafter.

## 3. Installation of the Telescope Mark

In order to fix the baseline azimuth, two geodetic control points are required. Figures 4 and 5 illustrate the geographical relationship of the Seal 25–01 geodetic control point (P), the absolute observation point (G), and the Romnaesfjellet (fjellet = mountain) azimuth control pole (T). Though we tried to use the pole at T set by JARE-27 as a telescope mark (T mark), it was rather difficult to recognize the pole

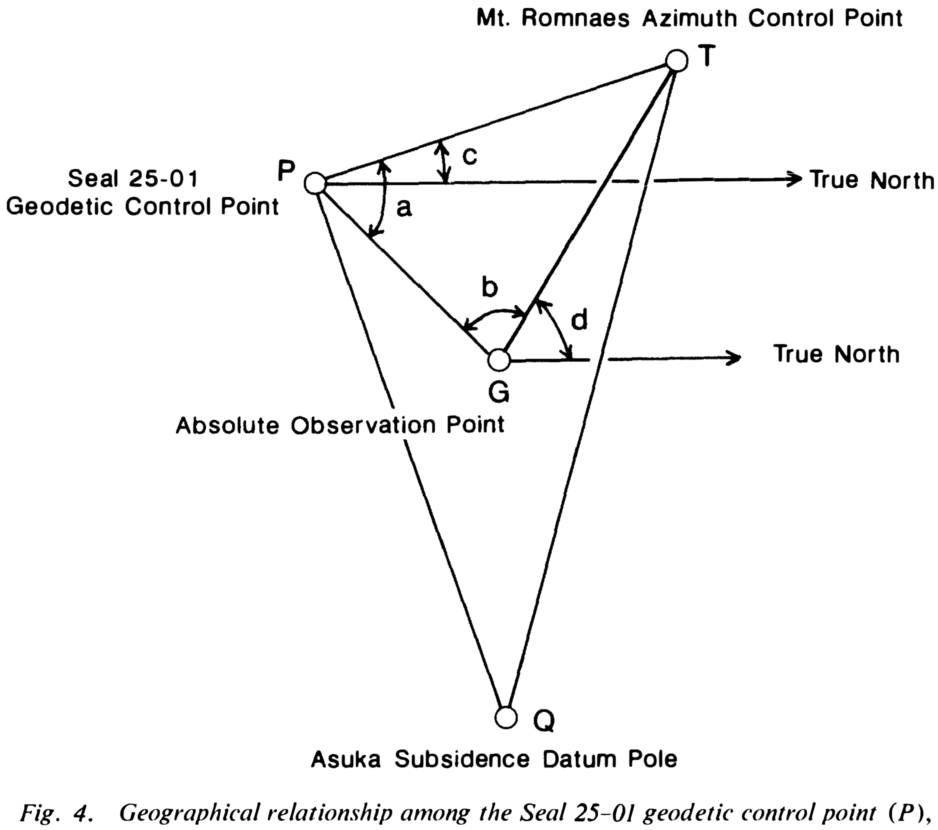


*Fig. 4. Geographical relationship among the Seal 25–01 geodetic control point (P), the absolute observation point (G), Mt. Romnaes azimuth control point as the telescope mark (T), and the Asuka subsidence datum pole (Q).*

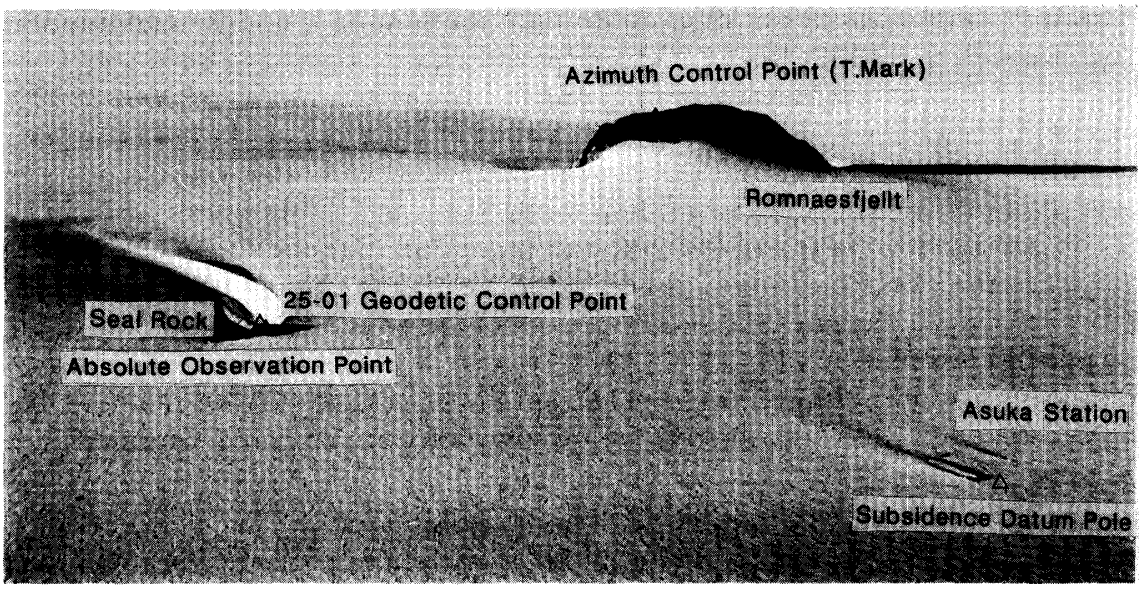


*Fig. 5. Seal Rock with the absolute observation point and Mt. Romnaes with the telescope mark.*

in strong wind or dim condition. Therefore, we made a new marker pole and set it up in place of the old thinner pole on 28 August 1987.

The azimuth surveying by JARE-27 (T. KOMETANI) indicates the angle $c=32°46'27''$ and the angle measurements made on 3 April 1987 for the old pole at T using T-2 theodolite gave us values $a=75°41'47''$ and $b=104°04'22''$. Thus the azimuth of the baseline GT from the geomagnetic control point to the T. mark is calculated as

$$\begin{aligned} d &= 180° - a - b + c \\ &= 33°00'18''. \end{aligned} \tag{1}$$

We had no chance for classical geodetic surveying during our wintering, but GPS relative carrier phase measurement to the determination of position was made between P and Q (Asuka subsidence datum pole), and Q and G (SHIBUYA and SAKAI, 1989). Though the analysis is not completed yet, a tentative geographical location of G is given by

$$\varphi=71°31'36''\text{S}, \quad \lambda=24°04'31''\text{E}, \quad H=925\ \text{m}. \tag{2}$$

## 4. Absolute Observation

A G.S.I. (second-order) precise magnetometer was used for the measurement of declination and inclination angles. Since there are no clamps for the Helmholtz-Gaussian coil and rotating coil, carrying by hand on the helicopter from the icebreaker SHIRASE to Asuka Station was required in order to prevent malfunctioning by shock and vibration.

In the early stage of our wintering from February to April, we had to be trained in handling the magnetometer-theodolite and making circuit check of the amplifier under severe wind ($\sim 10$ m/s) and low-temperature ($-15°$C) conditions. As for the measurement of total intensity, we used the EG&G-866 base-station type proton magnetometer with a resolution of 0.1 nT at a sampling interval of 1 s. After 19 September 1987, we became skillful in the measuring procedures and were able to make observations constantly once or twice a month.

The continuous observation records by the three component flux-gate magnetome-

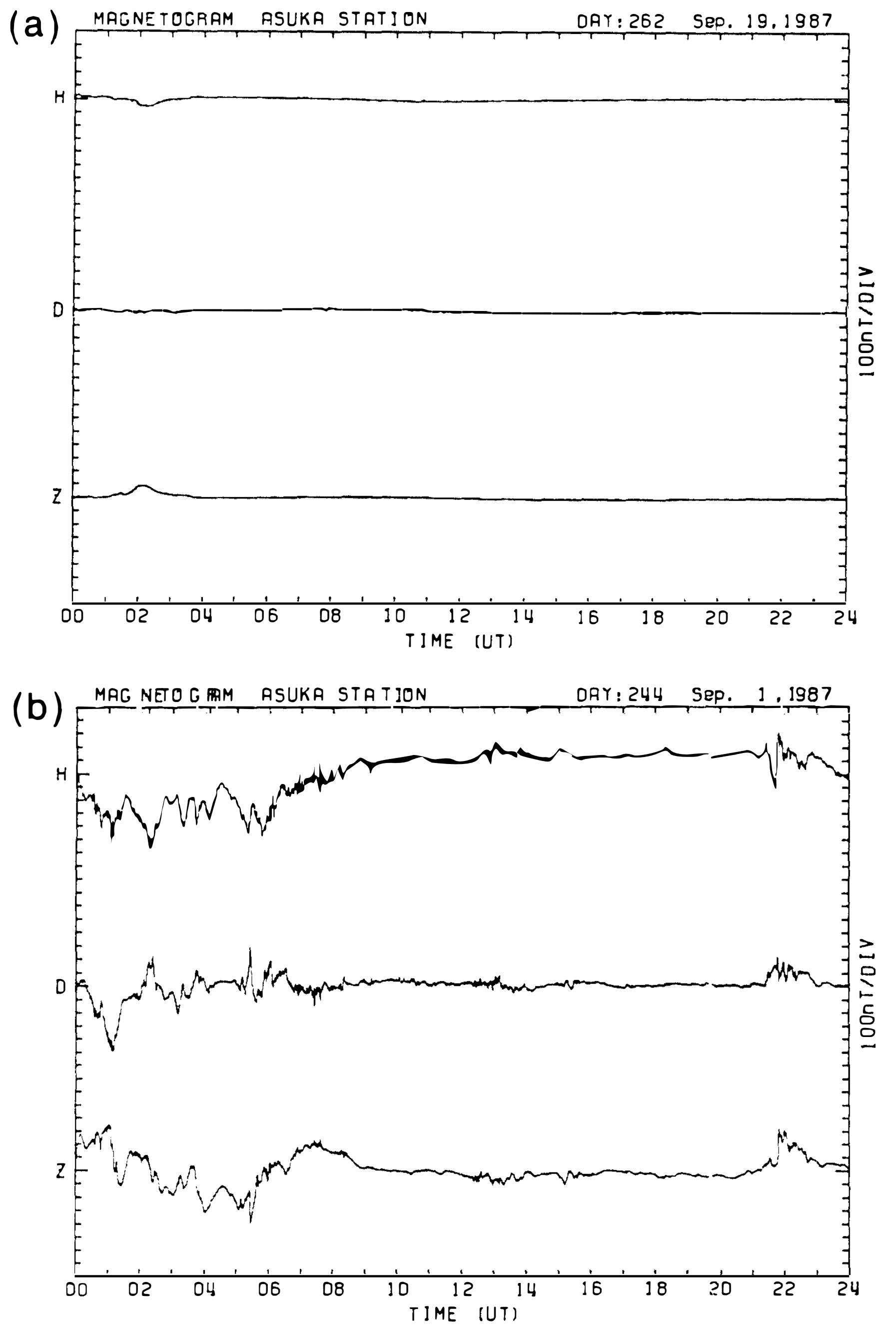


*Fig. 6. (a) Observation records by the three-component fluxgate magnetometer at Asuka Station on a geomagnetically quiet day (19 September) when the absolute measurement was carried out at Seal Rock. (b) Similar records on a geomagnetically disturbed day (1 September).*

*Table 1. An example of field log (19 September 1987) according to the observation procedure by the Geomagnetic Observatory of the Japan Meteorological Agency.*

Date 9 ·19· Instrument No. Observer R. Sakai

Log K. Shibuya

## T. Mark

| Obs. | Tele. | Time | A | B |
|---|---|---|---|---|
| I | L | 1320 | 98·26.0 | 278·26.0 |
| | R | 1325 | 278·26.2 | 98·26.1 |
| | R | 1327 | 278·26.1 | 98·26.0 |
| | L | 1328 | 98·25.9 | 278·25.9 |
| | mean | | · · | 98·52·1 |
| II | L | 1407 | 98·25.5 | 278·25.5 |
| | R | 1409 | 278·26.0 | 98·26.0 |
| | ~~L~~ R | 1411 | 278·25.6 | 98·25.5 |
| | R ~~L~~ | 1412 | 278·26.0 | 98·25.9 |
| | mean | | · · | 98·51·5 |
| | | | ① Mean | 98·51·8 |
| | | + | ② α | ~~[illegible]~~ 33°00.3′ |
| | | | T.Mark(①+②) | 131·52·1 |

| | |
|---|---|
| ΔT1 | s |
| ΔT2 | s |
| mean | s |
| ΔT | m |

## Level

| Obs. | Level | E | W | Level | N | S |
|---|---|---|---|---|---|---|
| I | S | 20.0 | 15.0 | E | 65.0 | -30.0 |
| | N | 10.0 | 25.0 | W | 15.0 | 15.0 |
| | S+N | 30.0 | 40.0 | E+W | 80.0 | -15.0 |
| | E−W | -10.0 | | N−S | 95.0 | |
| II | S | +50 | -10 | E | +80.0 | -50 |
| | N | +10 | +30 | W | +10 | +15 |
| | S+N | 60 | 20 | E+W | 90 | -35 |
| | E−W | 40 | | N−S | 125 | |
| mean | | 15 | | mean | 110 | |
| (D)= −0.083(E−W)tan I | | | | (I)=0.083(N−S) | | |
| Corr(D) | | -3.4″ (−0.1′) | | Corr(I) | 9.13″ (0.2′) | |

## Declination

| e. | V.C. | Hand | Time | A | B | mean |
|---|---|---|---|---|---|---|
| ① ② Up | E | R | 13h34m | 95·13.5 | 275·13.5 | · · |
| | | L | 1337 | 95·13.0 | 275·12.9 | ·26·5 |
| | W | R | 1345 | 275·15.7 | 95·15.5 | · · |
| | | L | 1347 | 275·16.0 | 95·16.0 | ·31·6 |
| | | | | | T.Mark | 131·52·1 |
| | | | | + | Corr(D) | ·−0·1 |
| | | | | − | Mean | 95·29·0 |
| ③ | | | | | D | 36·23·0 |
| ④ ⑤ Down | W | R | 13 53 | 275·15.2 | 95·15.1 | · · |
| | | L | 13 54 | 275·15.5 | 95·~~18~~15.2 | ·30·5 |
| | E | R | 1401 | 95·15.2 | 275·15.2 | · · |
| | | L | 1403 | 95·15.5 | 275·15.4 | ·30·7 |
| ⑥ | | | | | T.Mark | 131·52·1 |
| | | | | + | Corr(D) | ·−0·1 |
| | | | | − | Mean | 95·30·6 |
| | | | | | D | 36·21·4 |

36° 22.2′

## Dip

| I | II | mean |
|---|---|---|
| 334·26.2 | 154·26.3 | · · |
| 334·26.5 | 154·26.5 | ·52·8 |
| 27·03.2 | 207 03.4 | · · |
| 27·03.3 | 207·03.5 | ·06·7 |
| | 1/2(Em−Wm) | 153·53·1 |
| + | Corr(I) | · ·2 |
| | φ | 153·53·3 |
| | I=90°−φ | 63·53·3 |
| 207·03.4 | 27·03.7 | · · |
| 207·03.4 | 27·03.1 | ·06·5 |
| 154·27.2 | 334·27.1 | · · |
| 154·27.0 | 334·27.0 | ·54·2 |
| | 1/2(Em−Wm) | 26·06·2 |
| + | Corr(I) | · ·2 |
| | φ | 26·06·4 |
| | I=90°−φ | 63·53·6 |

平均 63° 53.5′

## Total Intensity

| | ① | ② | ③ |
|---|---|---|---|
| Time | 13h28m40s | 13h38m40 | h49m10 |
| | 43077.3 γ | 77.6 γ | 78.3 γ |
| | 77.7 | 77.9 | 78.6 |
| | 78.3 | 77.7 | 78.5 |
| | 77.5 | 77.7 | 79.2 |
| | 77.2 | 77.4 | 79.5 |
| | 78.0 | 77.6 | 79.1 |
| | 78.3 | 77.5 | 79.6 |
| Time | 13h29m20 | 13h29m20 | h m |
| mean | 43077.8 | 43077.6 | 43079.0 |

| | ④ | ⑤ | ⑥ |
|---|---|---|---|
| Time | h m | 13h55m20 | h04m20 |
| | γ | 79.4 γ | 80.0 γ |
| | | 78.6 | 80.4 |
| | | 78.7 | 80.2 |
| | | 78.6 | 80.1 |
| | | 78.7 | 80.3 |
| | | 78.8 | 80.5 |
| | | 78.6 | 79.9 |
| Time | h m | h m | h m |
| mean | | 43078.8 | 43080.2 |

| Time | 13h41m |
|---|---|
| F | 43078 γ |
| I | −63°·53·3′ |
| D | −36°·23·0′ |
| H | 18960 γ |
| Z | 38682 γ |

| Time | 13h58m |
|---|---|
| F | 43079 γ |
| I | −63°·53·5′ |
| D | −36°·21·4′ |
| H | 18958 γ |
| Z | 38683 γ |

*Fig. 7. Snapshot of the observation; the surveyor is R. SAKAI and the data logger is K. SHIBUYA. Clothings, boots, gloves, etc. of the observer are all made from non-magnetic material.*

ter at Asuka Station were monitored to determine geomagnetically quiet day (Fig. 6a; MIYAOKA *et al.*, 1990). For comparison, geomagnetically disturbed records are also shown in Fig. 6b. Figure 7 shows a snap-shot of the measurement. Table 1 shows an example of the field log, where the measurement was done with the procedure by the Geomagnetic Observatory of the Japan Meteorological Agency.

## 5. Results and Discussion

Table 2 summarizes the results of the observation. In column 2, the negative sign indicates that the magnetic north is declined to west as compared with the true north, while the negative sign in column 3 indicates that the geomagnetic field line is inclined upward by definition, respectively. As an average of the observations from September to December, we obtain the following mean values;

$$\begin{aligned} \bar{D} &= -36^\circ 19.2', \\ \bar{I} &= -63^\circ 53.3', \\ \bar{H} &= 18960\ \mathrm{nT}, \\ \bar{Z} &= 38676\ \mathrm{nT}, \\ \bar{F} &= 43073\ \mathrm{nT}. \end{aligned} \tag{3}$$

In order to compare the above measured values with those of model fields, synthetic values of declination, inclination, etc. are calculated using IGRF(1985) Gauss'

*Table 2. Summary of observation results.*

| Date | $D$ | $I$ | $H$ | $Z$ | $F$ |
|---|---|---|---|---|---|
| September 19 | −36°22.2′ | −63°53.4′ | 18959nT | 38683nT | 43079nT |
| October 12 | −36°17.6′ | −63°53.8′ | 18960 | 38695 | 43090 |
| October 22 | −36°19.2′ | −63°53.7′ | 18952 | 38678 | 43071 |
| November 07 | −36°25.3′ | −63°52.5′ | 18970 | 38678 | 43079 |
| November 29 | −36°17.1′ | −63°53.3′ | 18953 | 38668 | 43063 |
| December 08 | −36°15.9′ | −63°53.3′ | 18955 | 38669 | 43065 |
| December 18 | −36°23.0′ | −63°52.0′ | 18968 | 38661 | 43062 |
| Average | −36°19.2′ | −63°53.3′ | 18960 | 38676 | 43073 |

*Table 3. Difference between the observed values and the calculated values by the IGRF(1985) model.*

| Date | $D$ (O−C) | $I$ (O−C) | $H$ (O−C) | $Z$ (O−C) | $F$ (O−C) |
|---|---|---|---|---|---|
| September 19 | −0.50′ | 0.16′ | 87nT | 88nT | −41nT |
| October 12 | −0.43 | 0.15 | 89 | 69 | −23 |
| October 22 | −0.45 | 0.15 | 81 | 83 | −39 |
| November 07 | −0.56 | 0.16 | 100 | 78 | −26 |
| November 29 | −0.42 | 0.15 | 88 | 71 | −24 |
| December 08 | −0.40 | 0.15 | 86 | 77 | −31 |
| December 18 | −0.52 | 0.16 | 99 | 82 | −31 |
| Average | −0.47 | 0.15 | 90 | 78 | −31 |

coefficients (IAGA DIVISION I, WORKING GROUP 1, 1985). Table 3 summarizes the difference between the observed and the calculated values (O−C residuals) of declination, inclination, etc. The negative sign in column 2 indicates that the magnitude of the observed westward declination is smaller than that of the IGRF(1985)-model westward declination, while the positive sign in column 3 indicates that the magnitude of observed upward inclination is smaller than that of the IGRF(1985)-model inclination, respectively. As shown in Table 3, the average discrepancy between the observed value and the calculated value for each component is small;

$$\begin{aligned}
&\bar{D}(\mathrm{O-C}) = -0.47',\\
&\bar{I}(\mathrm{O-C}) = 0.15',\\
&\bar{H}(\mathrm{O-C}) = 90\ \mathrm{nT},\\
&\bar{Z}(\mathrm{O-C}) = 78\ \mathrm{nT},\\
&\bar{F}(\mathrm{O-C}) = -31\ \mathrm{nT}.
\end{aligned} \tag{4}$$

Though it is difficult to give standard deviation error to each component of the observation in Table 2 except total intensity (±0.5 nT accuracy), small discrepancies in eq. (4) suggest the reliability of our measurement.

The measurement will be continued by JARE-31 (1989-1991) to monitor secular change of the geomagnetic field in the region concerned.

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