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63. *Geomagnetic and Geoelectric Studies of the Matsushiro Earthquake Swarm (3).*

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Summary

Geomagnetic observations have been continued over the Matsushiro area since the middle of October, 1965. The results of observations during the period from February to April are reported. Five-day means of the total intensity observed at the centre of the seismic area revealed small fluctuations amounting to approximately $\pm 2\gamma$. As a result of magnetic dip surveys repeated with an interval of two months, it has turned out that there are localities where magnetic inclination changed more than 1′. Magnetic dip surveys were extended over the Toyono-Nakano-Susaka area in association with an unusual upheaval of land observed. Changes of the same amount as those in the Matsushiro area are indicated there. No clear relation between the geomagnetic changes and the seismic activities has been obtained.

1. Introduction

After a peak in November, 1965, the activity of the Matsushiro Earthquake Swarm has been moderate until the middle of March, 1966 while it became very high again in April. The earthquake area has expanded during the active period when a number of relatively large earthquakes of magnitude 5 or so took place. Geomagnetic observations as reported by Rikitake et al[1),2)] have been continued and intensified during

1) T. RIKITAKE et al., *Bull. Earthq. Res. Inst.*, **44** (1966), 363.
2) T. RIKITAKE et al., *Bull. Earthq. Res. Inst.*, **44** (1966), 409.

the period from February to April.

In Section 2 will be reported the results of a proton precession magnetometer observation at Station B which is situated roughly at the centre of the earthquake area. Another proton precession magnetometer was set at a station (Station C) at Omata Village near Nakano City in the northern part of Nagano Prefecture since March 12 because an unusual upheaval

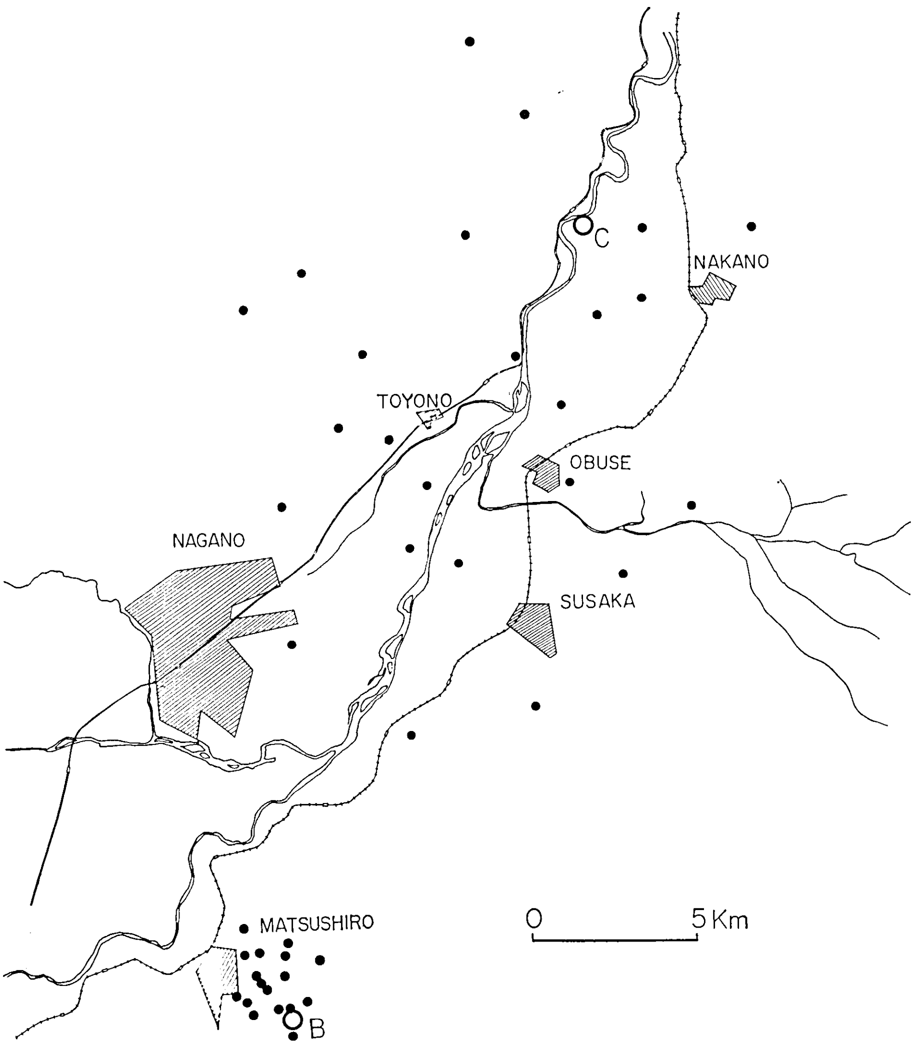

Fig. 1. Magnetic stations in the northern part of Nagano Prefecture.

of land had been found by a precise levelling conducted by the Geographical Survey Institute near Toyono Town about 10 km north of Nagano City. No summary of the comparative observation of the total geomagnetic field intensity between Matsushiro and Nakano will be included in Section 2 this time because the observation period is short.

Magnetic dip surveys were twice conducted over the Matsushiro area and the Toyono-Nakano-Susaka area, the latter covering an area in the northern part of Nagano Prefecture, during February and March. The results of the surveys will be reported in Sections 3 and 4. In Fig. 1 are shown the positions of these stations.

A comparison between the changes in the geomagnetic field observed at Mt. Minakamiyama and the Matsushiro Seismological Observatory was made jointly with Dr. K. Yanagihara of the Kakioka Magnetic Observatory for the October, November and December data last year. The result of comparison will be described in Section 5.

2. Proton precession magnetometer observation

An examination[3] of dispersion of differences in the total geomagnetic intensity value between stations in the central part of Japan made it clear

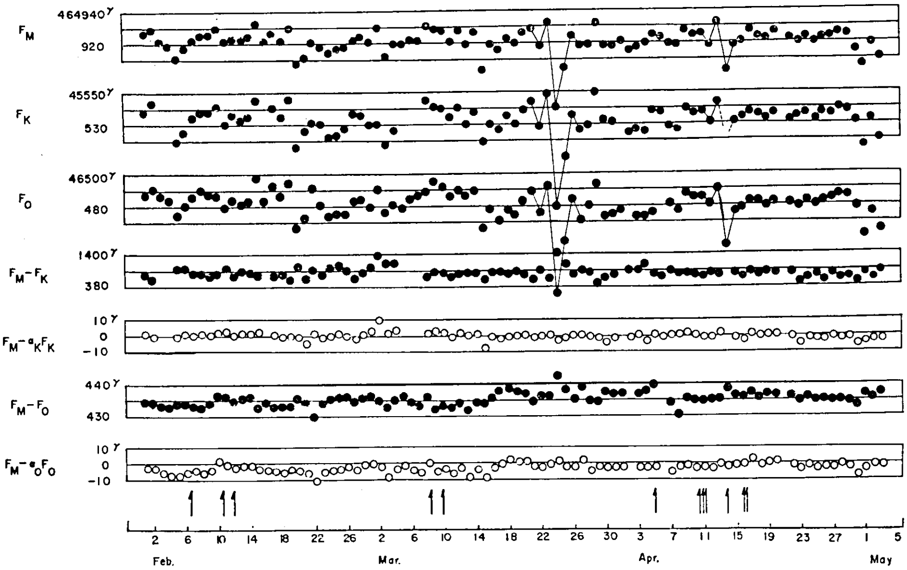

Fig. 2. Changes in F_M, F_K, F_O, F_M-F_K, $F_M-\alpha_K F_K$, F_M-F_O and $F_M-\alpha_O F_O$. Occurrences of large earthquakes are indicated with arrows.

3) T. Rikitake, *Bull. Earthq. Res. Inst.*, **44** (1966), 1041.

Table 1. Total intensity values (F_M) observed at Station B.

Date	Time	F_M	Date	Time	F_M
1965	h m	γ	1966	h m	γ
Feb. 3	20 03	46921.5	Feb. 12	21 36	46922.7
	11	22.0		38	22.0
	17	21.1		42	23.4
Feb. 4	21 22	19.0	Feb. 13	20 02	22.2
	24	18.0		06	21.3
	26	19.0		10	22.2
Feb. 5	20 07	10.7	Feb. 14	20 08	24.4
	09	12.6		12	21.1
	11	10.0		14	23.8
Feb. 6	20 17	13.8		16	24.6
	19	21.8	Feb. 15	20 03	31.6
	23	15.2		05	31.6
Feb. 7	4 09	23.4		07	31.9
	11	22.9		09	30.5
	13	21.8	Feb. 16	20 07	21.8
	21 01	21.3		09	20.4
	05	22.2		11	21.1
	07	21.8	Feb. 17	20 22	26.5
Feb. 8	20 40	25.8		24	25.3
	46	25.8		28	27.4
	50	24.8	Feb. 18	12 20	20.8
	52	26.2		22	19.7
Feb. 9	21 05	22.9		24	19.9
	07	24.8		20 08	23.9
	09	27.9		10	22.2
Feb. 10	20 02	29.5		12	22.0
	04	28.6		14	19.7
	06	29.8	Feb. 19	12 21	26.5
	08	28.4		23	29.1
Feb. 11	20 10	21.1		20 09	27.9
	12	22.0		11	27.2
	14	21.1		13	26.9
	16	22.2		15	30.9

(to be continued)

(continued)

Date	Time	F_M	Date	Time	F_M
1966	h m	γ	1966	h m	γ
Feb. 19	20 17	46929.5	Feb. 26	20 12	46916.8
	19	31.4		14	16.8
	21	31.4	Feb. 27	20 08	20.1
Feb. 20	20 08	05.6		10	21.8
	10	07.4	Feb. 28	20 08	23.4
	12	07.4		10	23.4
	14	09.1		12	24.8
Feb. 21	13 30	04.6		16	23.9
	32	01.6	March 1	20 12	21.1
	34	01.6	March 2	20 06	28.4
	20 16	18.5		10	28.1
	18	17.8		12	28.1
	20	18.0		14	27.9
Feb. 22	20 19	20.1		16	27.4
	21	21.3	March 3	20 08	08.4
	25	19.0		14	11.2
Feb. 23	21 37	17.8		16	11.7
	39	18.0	March 4	20 08	19.4
	41	15.9	March 5	20 08	20.1
Feb. 24	20 19	13.8		10	19.0
	23	11.7		12	18.7
	25	13.6		14	18.5
Feb. 25	14 25	02.6	March 6	20 06	20.1
	29	06.0		08	19.0
	34	08.4		12	21.8
	17 39	21.3		14	21.9
	40	21.5	March 7	20 08	22.0
	41	22.7		16	20.4
	20 08	17.1	March 8	17 03	30.0
	11	16.8		05	32.6
	13	22.2		11	30.5
	17	16.6		13	25.1
Feb. 26	20 06	16.1		15	30.9
	08	16.6			
	10	16.8			

(to be continued)

(continued)

Date	Time	F_M
1966	h m	γ
March 9	1 01	46928.4
	03	28.1
	07	28.4
	09	29.3
March 10	1 01	26.0
	03	24.4
	05	26.9
	07	28.1
	09	27.2
	11	26.7
March 11	1 01	22.0
	03	21.1
	05	21.3
	07	20.8
	09	22.2
	11	19.9
March 12	1 03	26.0
	05	25.5
	07	27.4
	09	28.8
	11	27.2
March 13	1 03	16.1
	05	17.8
	07	17.5
	09	19.0
	11	18.7
March 14	1 03	26.7
	05	26.7
	09	24.8
	11	23.9
March 15	1 01	46893.6
	03	95.9
	05	46901.1
	07	06.5
	09	10.5
	11	11.2
1966	h m	γ
March 16	1 01	46919.0
	03	19.7
	05	19.0
	07	18.0
	09	18.0
	11	15.0
March 17	01	15.2
	03	16.6
	05	16.1
	07	15.2
	09	13.8
	11	15.0
March 18	1 01	19.9
	03	21.8
	05	21.8
	07	24.4
	09	23.4
	11	22.2
March 19	1 03	20.4
	05	18.7
	11	17.5
March 20	1 01	27.2
	03	24.8
	05	26.5
	07	24.6
March 21	1 01	26.9
	03	29.5
	05	28.4
March 22	1 01	18.5
	03	16.8
	05	17.1
	07	17.8
	09	17.5
March 23	1 03	28.8
	07	32.1

(to be continued)

(continued)

Date	Time	F_M
1966 March 23	h m 09	γ 46934.2
March 24	1 01	46881.4
	03	79.4
	05	77.9
	07	80.7
	09	80.7
March 25	1 01	46903.7
	03	02.0
	05	03.2
	07	03.7
	09	04.2
March 26	1 01	22.2
	05	22.9
	11	24.4
March 27	1 01	15.9
	03	14.5
	05	18.7
	07	18.5
	09	18.0
March 28	1 01	18.0
	03	18.0
	05	18.7
	09	17.5
	11	16.6
March 29	1 01	33.5
	03	32.2
	05	32.1
	07	30.5
	09	30.7
	11	29.1
March 30	1 01	16.6
	05	18.0
	09	16.8
	11	16.8
1966 March 31	h m 1 01	γ 46915.0
	03	17.3
	05	17.8
	07	17.8
	09	20.1
	11	20.1
April 1	1 01	20.1
	03	20.1
	05	20.1
	07	20.1
	09	20.1
	11	20.1
April 2	1 01	15.4
	03	15.4
	05	15.4
	07	13.1
	09	13.1
April 3	1 01	15.4
	03	15.4
	07	16.8
	09	17.8
April 4	1 01	19.4
	03	18.5
	05	19.0
	07	18.7
	09	18.0
	11	19.0
April 5	1 01	24.4
	03	24.4
	05	23.7
	09	26.0
	11	24.6
April 6	1 01	22.5
	03	24.8
	05	23.7
	07	22.5

(to be continued)

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Date	Time	F_M
1966	h m	γ
April 6	1 09	46923.7
April 7	1 01	17.8
April 8	1 11	17.8
April 9	1 01	27.2
	03	26.0
	05	27.2
	77	27.2
	09	27.2
	11	27.2
April 10	1 01	23.7
	03	23.7
	05	24.8
	07	24.8
	09	23.7
April 11	1 01	23.7
	03	22.5
	07	23.7
	09	24.8
	11	22.5
April 12	1 01	19.0
	03	20.1
	05	17.8
	07	20.1
	09	17.8
April 13	5 42	29.5
	44	28.4
	46	31.9
	50	29.5
	52	31.9
April 14	1 01	01.3
	03	02.5
	05	01.3
	07	01.3
1966	h m	γ
April 15	1 01	46920.1
	03	20.1
	07	16.6
	09	17.8
	11	17.8
April 16	1 01	20.1
	03	22.5
	07	20.1
	09	20.1
	11	20.1
April 17	1 05	24.8
	09	29.5
April 18	1 01	23.7
	03	24.8
	05	23.7
	11	22.5
April 19	1 01	22.5
	05	21.3
	07	23.7
	11	22.5
April 20	1 07	24.8
	09	27.2
	11	26.0
April 21	1 01	22.5
	03	21.3
	05	21.3
	07	22.5
April 23	1 01	14.3
	05	17.8
	07	20.1
	09	22.5
	11	22.5
April 24	1 01	23.7

(to be continued)

(continued)

Date	Time	F_M
1966	h m	γ
April 25	1 01	46920.1
	03	20.1
	05	20.1
	07	20.1
	09	20.1
	11	20.1
April 26	1 01	22.5
	03	22.5
	05	22.5
	07	24.8
	09	23.7
	11	22.5
April 27	1 03	24.8
	05	24.8
	07	23.7
April 28	1 03	26.0
	05	24.8
	07	27.2
	09	27.2
	11	24.8
April 29	1 01	24.8
	03	24.8
	05	24.8
1966	h m	γ
April 29	07	24.8
	09	26.0
	11	24.8
April 30	1 01	17.8
	03	16.6
	07	19.0
	09	20.1
	11	13.1
May 1	1 01	06.0
	03	06.0
	07	06.0
	09	06.0
May 2	1 03	17.8
	07	20.1
	09	20.1
	11	17.8
May 3	1 01	10.7
	03	10.7
	05	06.0
	07	10.7
	09	10.7
	11	10.7

that nighttime data are far better than daytime ones for eliminating non-local geomagnetic changes. In view of this, it has been planned to make observations 6 times at about 1-h in local time by applying a timer to the proton magnetometer at Station B. Such an automatic recording has started there since Feb. 9.

The results of the observation are given in Table 1. Those prior to the present period have already been reported in the previous papers[1),2)].

In a fashion similar to the previous papers, daily mean values of total intensity observed at Station B (F_M), Kanozan (F_K) and Oshima (F_O) are indicated in Table 2 in which simple and weighted differences, *i.e.* F_M-F_K, F_M-F_O, $F_M-\alpha_K F_K$ and $F_M-\alpha_O F_O$ are also given. The proportional

Table 2. Daily mean values of total intensity observed at Station B (F_M), Kanozan (F_K) and Oshima (F_O). Simple and weighted differences are also given, the latter being computed from arbitrary datum lines.

Date	F_M	F_K	F_O	F_M-F_K	F_M-F_O	$F_M-\alpha_K F_K$	$F_M-\alpha_O F_O$
1966							
Feb. 3	46921.5 $^{\gamma}$	—— $^{\gamma}$	46495.3 $^{\gamma}$	—— $^{\gamma}$	426.2 $^{\gamma}$	—— $^{\gamma}$	−5.4 $^{\gamma}$
4	18.7	——	493.0	——	25.7	——	−6.9
5	11.1	45520.0	483.7	1391.1	27.4	−0.7	−7.0
6	16.9	25.7	489.1	91.2	27.8	1.1	−5.3
7	22.3	34.5	495.9	87.8	26.4	0.3	−4.1
8	25.5	37.5	500.1	88.0	25.4	1.4	−5.1
9	25.2	38.7	497.3	86.5	27.9	0.3	−3.2
10	29.1	41.2	496.0	87.9	33.1	2.4	1.7
11	21.6	30.0	489.3	91.6	32.3	2.8	−0.7
12	22.7	35.7	493.5	87.0	29.2	−0.1	−2.8
13	21.9	32.7	491.0	89.2	30.9	1.2	−1.7
14	23.5	35.0	492.0	88.5	31.5	1.2	−0.9
15	31.4	44.8	506.9	86.6	24.5	1.2	−4.3
16	20.8	——	493.1	——	27.7	——	−4.4
17	26.4	40.3	501.5	86.1	24.9	0.3	−5.2
18	21.2	34.4	495.6	86.8	25.6	−0.7	−5.9
19	29.0	45.3	503.8	83.7	25.2	−0.6	−4.4
20	07.4	15.5	476.1	91.9	31.3	−1.3	−4.9
21	10.4	25.9	482.6	84.5	27.8	−5.6	−6.8
22	20.1	30.3	500.8	49.8	19.3	1.3	−11.0
23	17.2	30.3	489.8	86.9	27.4	−1.8	−5.5
24	13.0	22.0	483.1	91.0	29.9	−0.2	−4.6
25	15.5	23.0	484.6	92.5	30.9	1.6	−3.2
26	16.6	27.6	484.7	89.0	31.9	−0.5	−2.2
27	21.0	36.6	492.8	84.4	28.2	−2.5	−4.0
28	23.9	35.6	493.5	88.3	30.4	1.1	−1.6
Mar. 1	21.1	29.2	488.6	91.9	32.5	2.8	−0.7
2	28.0	29.4	499.7	98.6	28.3	9.6	−2.3
3	10.4	16.4	485.2	94.0	25.2	1.1	−8.8
4	19.4	26.2	489.9	93.2	29.5	3.2	−3.4
5	19.1	——	487.8	——	31.2	——	−2.1
6	20.7	——	493.1	——	27.6	——	−4.5

(to be continued)

(continued)

Date	F_M	F_K	F_O	F_M-F_K	F_M-F_O	$F_M-\alpha_K F_K$	$F_M-\alpha_O F_O$
1966	γ	γ	γ	γ	γ	γ	γ
Mar. 7	46921.2	——	46495.4	——	425.8	——	−5.4
8	29.8	45544.2	498.2	1385.6	31.6	1.0	0.7
9	28.5	40.0	504.1	88.5	24.4	2.7	−5.1
10	26.6	39.0	500.8	87.6	25.8	1.5	−4.5
11	19.6	33.8	494.9	85.8	24.7	−1.9	−7.0
12	27.0	39.8	498.8	87.2	28.2	1.3	−2.6
13	17.8	29.0	495.7	88.0	22.1	−0.3	−9.4
14	25.5	37.2	498.1	88.3	27.4	1.6	−3.5
15	03.1	19.8	475.4	83.3	27.7	−8.6	−8.6
16	18.1	29.6	487.1	88.5	31.0	−0.5	−2.6
17	15.3	26.7	480.2	88.6	35.1	−1.2	−0.1
18	22.3	34.9	486.2	87.4	36.1	0.0	2.3
19	18.9	29.9	484.0	89.1	34.9	0.1	0.6
20	25.8	38.6	492.3	87.2	33.5	0.9	1.2
21	27.3	43.3	498.5	84.0	28.8	−0.9	−2.0
22	17.5	28.0	485.5	89.5	32.0	0.1	−1.9
23	31.7	47.6	500.7	84.1	31.0	0.5	0.7
24	46880.1	45479.3	435.9	1400.9	44.2	−3.2	−1.6
25	46903.4	45509.9	467.5	1393.5	35.9	−1.3	−2.3
26	23.2	35.8	493.4	87.4	29.8	0.3	−2.3
27	17.1	26.7	480.0	90.4	37.1	0.6	1.9
28	17.8	29.1	489.3	88.7	28.5	−0.4	−4.5
29	31.4	49.5	503.5	81.9	27.9	−1.1	−1.7
30	17.0	32.2	482.6	84.8	34.4	−3.4	−3.0
31	18.0	30.7	484.4	87.3	33.6	−1.3	−2.6
Apr. 1	20.1	——	486.5	——	33.6	——	−2.1
2	14.5	24.9	——	89.6	——	−0.8	——
3	16.4	26.1	482.5	90.3	33.9	0.3	−3.0
4	18.8	25.4	483.5	93.4	35.3	−3.2	−2.8
5	24.6	37.1	485.7	87.5	38.9	0.8	−2.3
6	23.4	37.4	——	86.0	——	−0.6	——
7	17.8	28.1	484.5	89.7	33.3	0.3	−5.4
8	17.8	27.0	480.5	87.5	29.3	1.1	−2.4
9	27.0	39.0	491.0	88.1	36.0	1.9	−1.2
10	24.1	37.0	489.3	87.1	34.8	0.4	−2.8
11	23.4	37.0	488.7	86.4	34.7	−0.3	−3.0
12	19.0	31.0	484.3	88.4	34.7	−0.5	−4.1
13	30.2	43.0	493.8	87.2	36.4	2.2	−0.1

(to be continued)

(continued)

Date	F_M	F_K	F_O	F_M-F_K	F_M-F_O	$F_M-\alpha_K F_K$	$F_M-\alpha_O F_O$
1966	γ	γ	γ	γ	γ	γ	γ
Apr. 14	46901.6	45530.0	46459.5	1371.6	442.1	——	−2.6
15	18.5	31.0	479.9	87.5	38.6	−1.6	−1.2
16	20.5	34.5	482.3	86.0	38.6	−1.5	−1.1
17	27.2	38.0	492.5	89.2	34.7	2.8	2.4
18	23.7	36.4	492.1	87.3	31.6	0.4	−0.8
19	22.8	34.2	489.0	88.6	33.8	1.1	0.7
20	26.0	37.6	492.5	88.4	33.5	1.8	1.2
21	——	——	——	——	——	——	——
22	21.9	33.2	490.2	88.7	31.7	0.8	−1.1
23	19.4	35.6	489.5	83.8	29.9	−3.3	−3.1
24	23.7	37.0	492.5	86.7	31.2	0.0	−1.1
25	20.1	33.0	490.1	87.1	30.0	−0.8	−2.8
26	23.0	38.6	492.7	84.4	30.3	−1.9	−1.9
27	24.4	36.3	494.6	88.1	29.6	1.1	−2.0
28	26.0	40.6	496.8	85.4	29.2	−0.3	0.2
29	25.0	38.5	496.0	86.5	29.0	0.2	−1.4
30	15.3	32.0	488.4	83.3	26.9	−4.9	−6.3
May 1	06.0	16.5	471.5	89.5	34.5	−3.4	−2.8
2	18.9	32.8	486.0	86.1	32.9	−1.9	−0.9
3	10.7	20.6	475.1	90.1	35.6	−1.5	−0.8

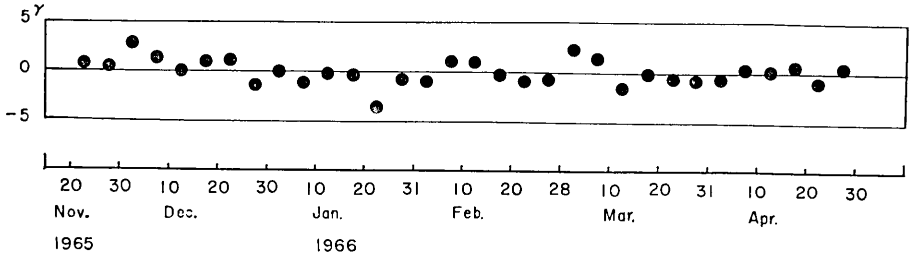

Fig. 3. Changes in the 5-day mean of $F_M-\alpha_K F_K$.

constants α_K and α_O have been determined in the previous paper. Changes with time in the elements involved in Table 2 are shown in Fig. 2. In the hope of seeing the general trend of geomagnetic change at Matsushiro, five-day means of $F_M-\alpha_K F_K$ are made. For December, January and March six-day means are made for the last portion of these months, while a three-day mean is made for that of February. Changes in these

Table 3. Results of magnetic dip surveys over the Matsushiro area. Values within parentheses are the means of measurements at a single locality.

No.	Locality	Date	Time	*I*
		1966	h m	
1	Makiuchi	Feb. 9	16 38	50°07.3′
			43	07.2
			48	07.4
			(16 43)	(50 07.3)
2	Hannyaji	9	12 20	49 48.0
			25	48.1
			(12 22.5)	(49 48.1)
3	Takimoto	9	11 21	49 20.5
			26	20.6
			32	20.6
			(11 26.5)	(49 20.6)
4	Iwasawa	9	10 24	49 55.1
			29	54.9
			(10 26.5)	(49 55.0)
5	Kagai	8	16 55	49 57.9
			17 15	57.5
			23	57.7
			(17 09)	(49 57.7)
6	Nakagawa	9	8 53	49 43.1
			9 00	43.2
			05	43.2
			(8 59)	(49 43.2)
7	Kamiaramachi	9	13 57	50 08.3
			14 00	08.5
			04	08.6
			(14 00.5)	(50 08.5)
8	Miyazaki	9	15 13	49 07.8
			17	07.7
			21	07.8
			(15 17)	(49 07.8)

(to be continued)

(continued)

No.	Locality	Date	Time	*I*
		1966	h m	
9	Kake	Feb. 9	15 55	49°50.4′
			16 00	50.6
			05	50.3
			(16 00)	(49 50.4)
10	Sugama	9	9 46	49 49.8
			51	49.7
			55	49.8
			(9 50.5)	(49 49.8)
11	Miyazaki Jinja	9	14 35	50 04.3
			45	04.1
			54	03.8
			(14 44.5)	(50 04.1)
12	Tanaka	8	17 54	49 55.4
			18 02	55.6
			10	55.4
			(18 02)	(49 55.4)
13	Dainiti Ike	10	8 36	49 50.5
			42	50.4
			(8 39)	(49 50.5)
14	Minakami 1	10	14 46	50 08.7
			54	68.9
			15 01	08.5
			(14 53.5)	(14 53.5)
15	Minakami 2	10	14 06	51 11.3
			11	11.2
			16	11.4
			(14 11)	(51 11.3)
16	Minakami 3	10	10 58	49 24.6
			11 03	24.6
			(11 00.5)	(49 24.6)
17	Minakami 4	10	9 27	49 12.3
			33	12.0
			37	11.9
			(9 32)	(49 12.1)

(to be continued)

(continued)

No.	Locality	Date	Time	*I*
18	Hirabayashi	1966 Feb. 9	h m 17 16 21 25 (17 20.5)	49°33.2′ 32.8 33.0 (49 33.0)
19	Top of Mt. Minakami	10	12 00 04 09 22 (12 11)	54 17.0 16.5 17.1 16.8 (54 16.9)

mean values are shown in Fig. 3. Looking at Figs. 2 and 3, it cannot be said that the geomagnetic field at Station B has markedly changed relative to Kanozan. As the standard deviation of the five-day means would be 2γ or a little smaller, the undulations as seen in Fig. 3 seem to reflect slight fluctuation in the geomagnetic field although no marked correlations between the changes and the seismic activity can be pointed out.

3. Magnetic survey over the Matsushiro area

Geomagnetic dip surveys have been repeatedly conducted over the Matsushiro area since the first one was made during a period from 17 to 19 in November, 1965. The second survey was carried out during a period from 20 to 22 in December, 1965. One of the most seismically active periods was registered around the end of November intervening between the first and the second surveys. The latest survey was made from 8 to 10 in February, 1966, following a relatively quiet period of seismic activity.

Details of the first two surveys were already reported in the previous papers[1),2)]. Only the results of the third survey of February, 1966, are listed in Table 3 and 4. In order to eliminate non-local geomagnetic variations, such as diurnal variations, geomagnetic inclinations computed from variograph records at the Kanozan Geodetic Observatory have been referred to as a standard. Those values are also shown in Table 4. Differences between the successive surveys are shown in Table 4 and in Figs. 4, 5 and 6.

Between the surveys, considerable amounts of changes in inclination

Table 4. Results of magnetic dip surveys and the changes in inclination during a period from November, 1965 to February, 1966.

Survey III

Nos. of Station	Locality		Date	Time (h m)	I_M[1]	I_K[2]	I_{M-K}	δI_{II-I}[3]	δI_{III-II}[4]	δI_{III-I}[5]
1	牧　内	Makiuchi	Feb. 9	16 43.0	50°07.3′	47°53.6′	2°13.7′	−1.1′	+1.1′	0.0′
2	般若寺	Hannyaji	9	12 22.5	49 48.1	54.0	1 54.1	−1.5	+1.6	+0.1
3	滝　本	Takimoto	9	11 26.5	49 20.6	54.0	1 26.6	−1.1	+1.0	−0.1
4	岩　沢	Iwasawa	9	10 26.5	49 55.0	53.8	2 01.2	0.0	+0.2	+0.2
5	加賀井	Kagai	8	17 09.0	49 57.7	53.9	2 03.8	−0.8	+1.1	+0.3
6	中　川	Nakagawa	9	8 59.0	49 43.2	53.7	1 49.4	+0.1	+0.7	+0.8
7	上荒町	Kamiara-machi	9	14 00.5	50 08.5	53.9	2 14.6	−0.4	+0.4	0.0
8	宮　崎	Miyazaki	9	15 17.0	49 07.8	53.7	1 14.1	−0.3	0.0	−0.3
9	欠	Kake	9	16 00.0	49 50.4	53.6	1 56.8	−0.7	+1.5	+0.8
10	菅　間	Sugama	9	9 50.5	49 49.8	53.8	1 56.0	(+2.5)	(−2.5)	0.0
11	宮崎神社	Miyazaki-Jinja	9	14 44.5	50 04.1	53.8	2 10.3	+0.1	+0.9	+1.0
12	田　中	Tanaka	8	18 02.0	49 55.5	54.1	2 01.4	−1.1	+0.3	−0.8
13	大日池	Dainichi Ike	10	8 39.0	49 50.5	53.8	1 56.7	−1.0	+0.3	−0.7
14	皆神 1	Minakami-1	10	14 53.5	50 08.7	53.4	2 15.3	−0.5	−1.1	−1.6
15	皆神 2	Minakami-2	10	14 11.0	51 11.3	53.2	3 18.1	−0.9	+0.7	−0.2
16	皆神 3	Minakami-3	10	11 00.5	49 24.6	53.7	1 30.9	−0.4	+0.3	−0.1
17	皆神 4	Minakami-4	10	9 32.0	49 12.1	53.8	1 18.3	−0.3	+0.4	+0.1
18	平　林	Hirabayashi	9	17 20.5	49 33.0	53.6	1 39.4	−0.5	+0.7	+0.2
19	皆神山頂	Top of Mt. Minakami	10	12 11.0	54 16.9	53.5	6 23.4	−0.9	+0.7	−0.2

1) I_M : Inclination values at respective points.
2) I_K : Inclination values at Kanozan.
3) δI_{II-I} : Differences between the second and the first surveys.
4) δI_{III-II} : Differences between the third and the second surveys.
5) δI_{III-I} : Differences between the third and the first survrys.

have been observed at some parts of this area, amounting to 1.6 minutes of arc at maximum. However, the large variation points are so irregularly distributed that it is hard to correlate them with certain aspects of seismic activity, such as the distribution of the earthquake foci. It is also noticed that the magnetic dip decreased as a rule over this area during the period between the first and the second survey, and then increased again, recovering, at the time of the third survey, almost to the same value as at

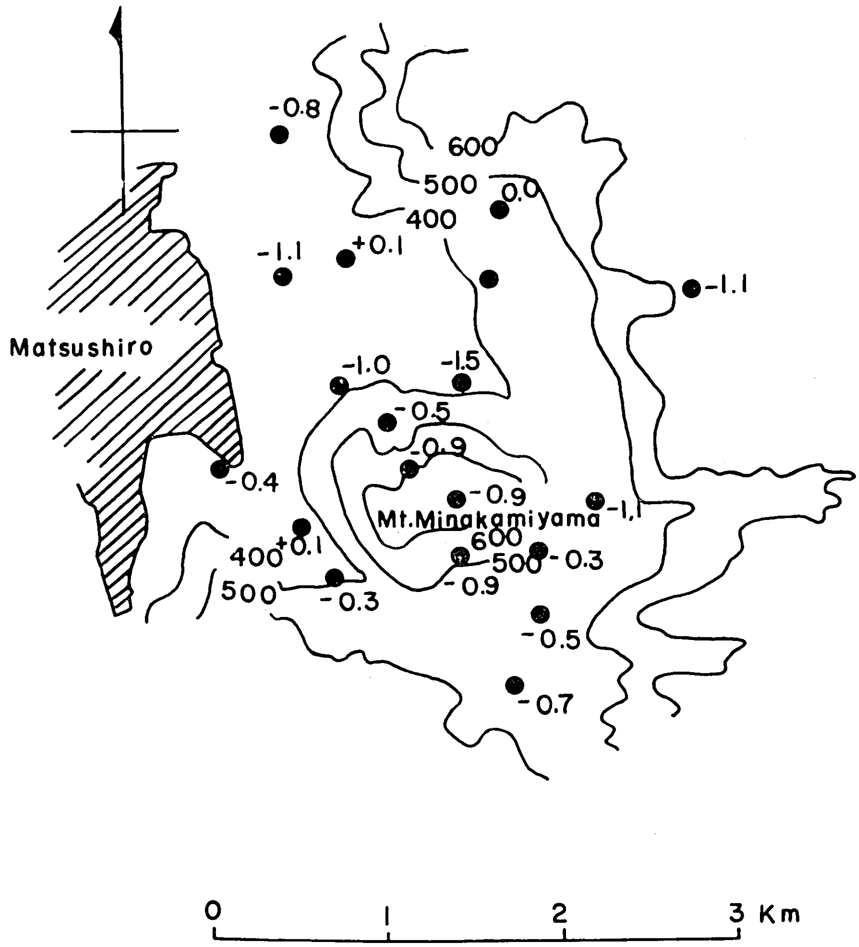

Fig. 4. Changes in the geomagnetic inclination in units of minute of arc between the surveys II and I.

the first survey. At observation point No. 2, for example, the decrease in inclination amounted to $-1.5'$ at the time of the second survey in December. In February, the survey showed an increase of $1.6'$ compared with the previous survey, resulting in a total increase of $0.1'$ during the interval of the first and the third survey.

The undulation of magnetic dip described above seems possibly to coincide with the growth and decay of the seismic activity in this area.

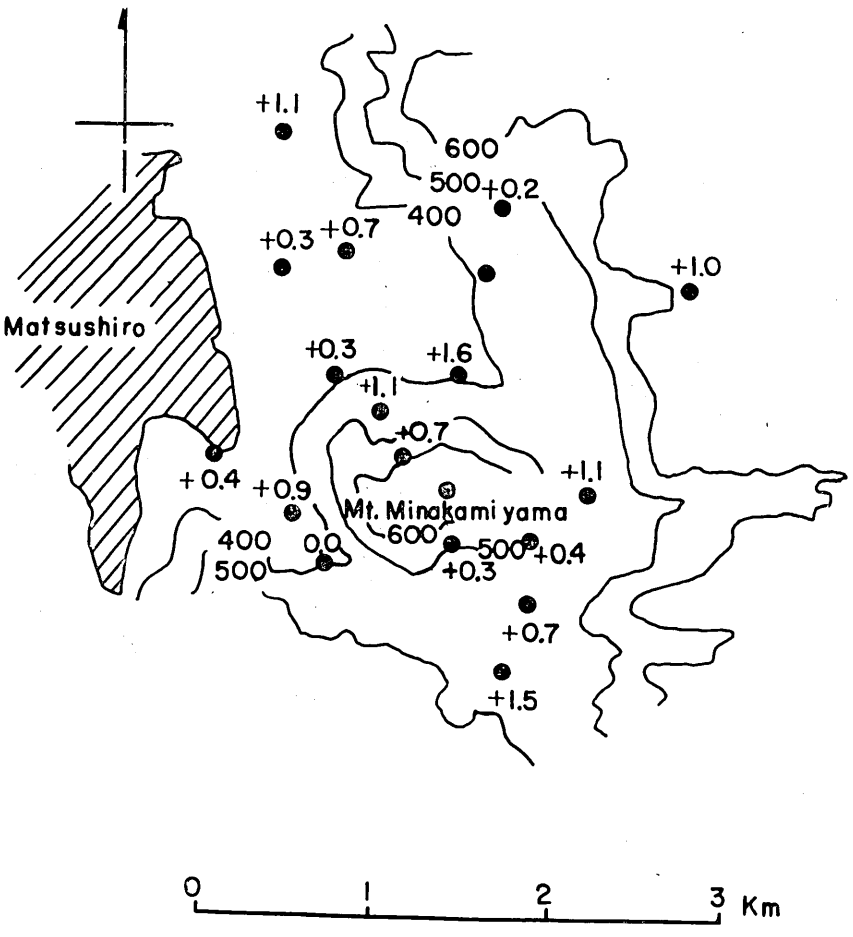

Fig. 5. Changes in the geomagnetic inclination in units of minute of arc between the surveys III and II.

However, when various kinds of noises, which will be discussed in the following section, and especially scarcity of knowledge about non-uniformity of long-term change such as the day to day variation in the geomagnetic field are taken into consideration, further repetition of surveys of this kind should be found necessary for any conclusive remarks being made about this point.

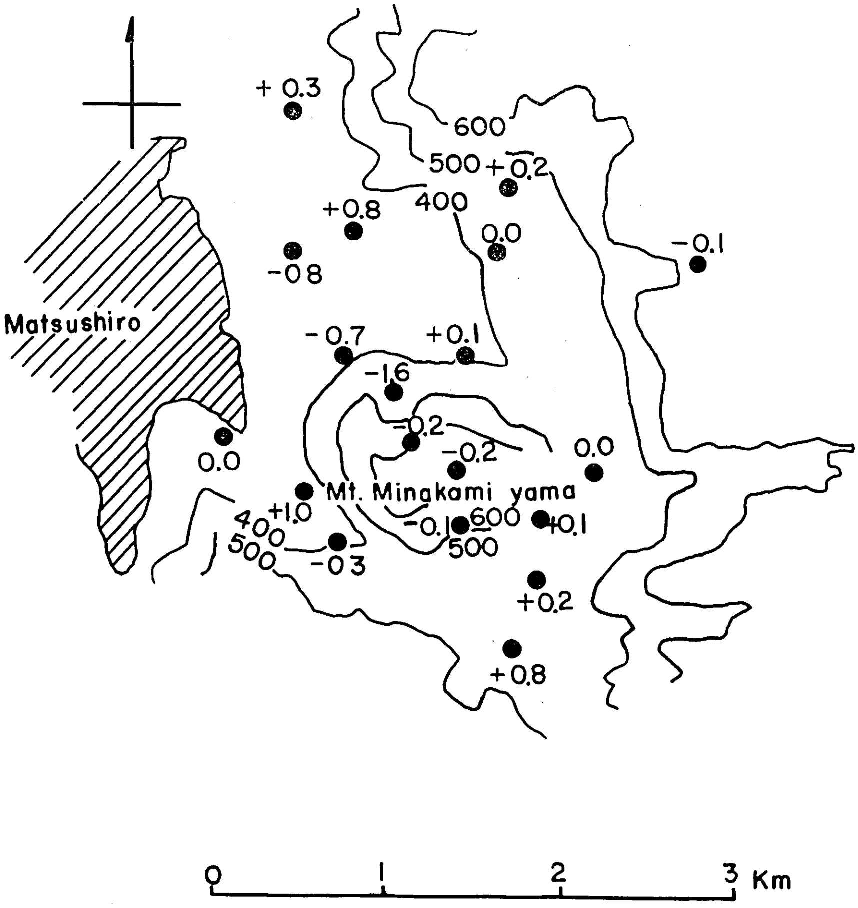

Fig. 6. Changes in the geomagnetic inclination in units of minute of arc between the surveys III and I.

4. Magnetic survey over the northern part of Nagano Prefecture

Magnetic dip surveys were conducted twice over the northern part of Nagano Prefecture in February and March, 1966. During the interval of two successive surveys, i.e. on March 4, a considerably large earthquake took place within the area.

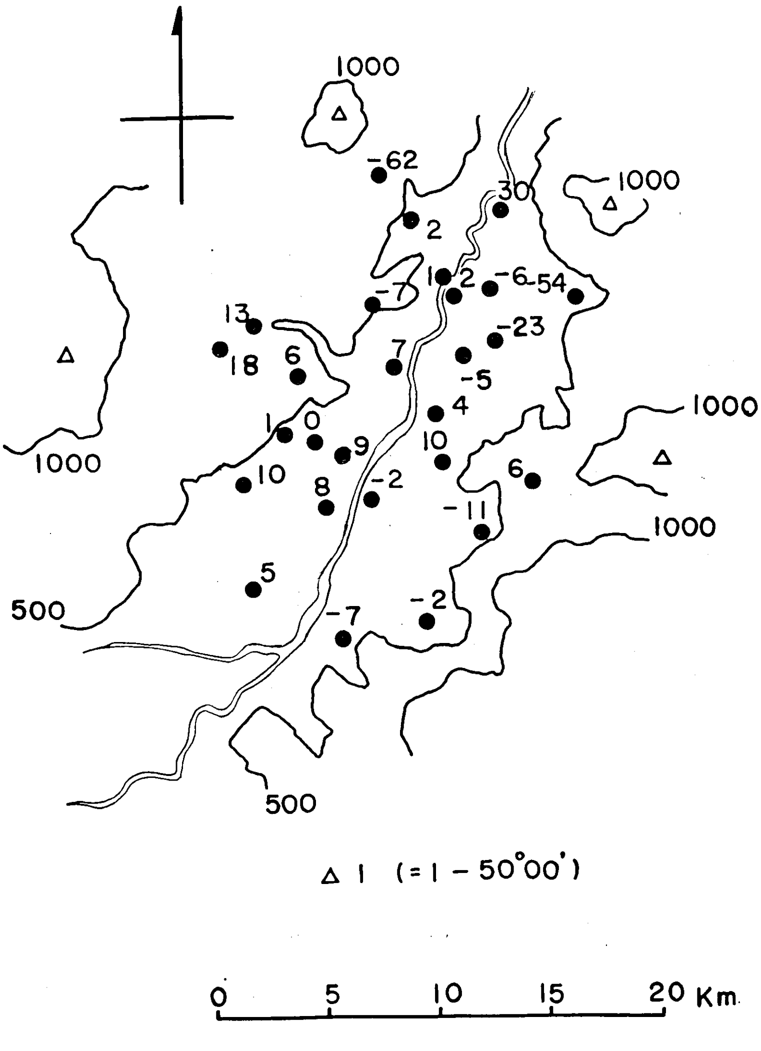

Fig. 7. Distribution of the geomagnetic inclination in terms of the deviation in units of minute of arc from the approximate mean value 50°00′ in the area.

Table 5. Results of magnetic dip surveys over the northern part of Nagano Prefecture. Values within parentheses are the means of measurements at a single locality.

A: Measurements at auxiliary points.

d: Distances between measuring points and auxiliary points.

No.	Locality	Survey I Date	Survey I Time	Survey I *I*	Survey II Date	Survey II Time	Survey II *I*
		1966	h m				
1	八幡神社	Feb. 11	10 22	50°04.7′			
			31	05.2			
			40	04.9			
			(10 31)	(50 04.7)			
1-A	(*d*=10 m)		10 54.5	50 04.8			
			59	04.6			
						h m	
2	若槻小学校	11	11 44	50 10.1	Mar. 11	15 45	50°11.7′
			47.5	10.2		49	11.9
			51	10.0		(15 47)	(50 11.8)
			(11 48)	(50 10.1)			
2-A	(*d*=15 m)		12 05.5	50 10.9			
			08.5	10.8			
3	吉	11	13 31.5	50 00.8	11	15 15	50 01.9
			37.5	00.8		17	01.9
			43	00.7		21	01.8
			(13 38)	(50 00.8)		(15 18)	(50 01.9)
3-A	(*d*=20 m)		13 58	49 44.0			
			14 03	43.7			
4	石　村	11	15 11	50 00.3	11	16 16.5	50 01.4
			15	00.4		19.5	01.5
			(15 13)	(50 00.4)		(16 18)	(50 01.5)
4-A	(*d*=10 m)		15 31	50 00.1			
			36.5	00.3			
5	赤　沼	11	16 32	50 09.1	12	15 21	50 10.2
	(三角点)		36.5	09.6		15	10.0
			17 04	08.8		18	10.0
5-A	(*d*=12 m)		09	09.2		(15 15)	(50 10.1)

(to be continued)

(continued)

No.	Locality	Survey I Date	Time	I	Survey II Date	Time	I
		1966	h m				
5	赤沼(三角点)	Feb. 11	(16 32)	(50°09.2′)			
			16 51	50 04.8			
5-A	(d=12 m)		17 00	04.7			
						h m	
6	平出小学校裏	12	10 54.5	50 06.3	11	14 36	50°07.1′
			59.5	06.2		39	07.3
			11 04	06.4		(14 37.5)	(50 07.2)
			(11 00)	(50 06.3)			
6-A	(d=10 m)		11 19	50 05.6			
			23	05.3			
7	中　　宿	12	12 33.5	50 18.1	11	13 24	50 18.0
			39.5	18.2		27	18.2
			42	18.2		31	18.1
			(12 38)	(50 18.2)		(13 27.5)	(50 18.1)
7-A	(d=10 m)		13 01	50 15.1			
				14.7			
8	牟 礼 東 小	12	13 58	50 12.9	11	14 01	50 11.9
			14 01	13.1		05	12.0
			07	12.9		(14 03)	(50 12.0)
			(14 02.5)	(50 13.0)			
8-A	(d=10 m)		14 19.5	50 04.1			
			26	04.3			
9	上　赤　塩	12	15 34	49 52.7	11	12 03	49 52.0
			37	53.3		09	52.0
			41	53.0		13	51.8
			52.5	53.5		(12 08)	(49 51.9)
			(15 43)	(49 53.2)			
9-A	(d=10 m)		16 02.5	49 55.7			
			06.5	55.3			
10	永田小学校	12	16 53	50 02.0	11	9 56	50 01.5
			58	02.0		59	01.3
			17 03	02.0		10 04	01.6
			(16 58)	(50 02.0)		(10 00)	(50 01.5)
10-A	(d=15 m)		17 14	50 02.0			
			18	02.1			

(to be continued)

(continued)

No.	Locality	Survey I Date	Survey I Time	Survey I *I*	Survey II Date	Survey II Time	Survey II *I*
		1966	h m			h m	
11	蟹　　沢	Feb. 13	9 57	50°06.7′	Mar. 11	19 57	50°08.0′
			10 00	06.7		59	07.9
			08	06.5		(16 58)	(50 08.0)
			(10 01)	(50 06.7)			
11-A	(d=10 m)		10 24	50 07.4			
			35.5	07.8			
12	替　　佐	13	11 29	50 01.2	11	9 18	50 01.4
			33	00.9		22	01.5
			42	01.1		26	01.5
			(11 35.5)	(50 01.1)		(9 22)	(50 01.5)
12-A	(d=5 m)		11 54	50 11.8			
			12 08.5	11.9			
13	安 源 寺	13	13 18	49 55.3	10	13 26	49 54.7
			23.5	55.1		34	54.5
			29	55.1		38	54.5
			(13 23.5)	(49 55.2)		(13 32)	(49 54.5)
13-A	(d=10 m)		13 43.5	49 57.1			
			54.5	56.6			
14	中野平中学校	13	15 18.5	49 37.0	10	14 10	49 36.2
			22.5	36.6		17	36.4
			26.5	36.9		25	36.7
			(15 22.5)	(49 36.8)		(14 17.5)	(49 36.4)
14-A	(d=5 m)		15 45	49 37.8			
15	長丘小学校	13	16 21.5	49 54.6	10	15 02	49 54.6
			25	54.5		06	54.7
			28.5	54.5		(15 04)	(49 54.7)
			(16 25)	(49 54.5)			
15-A	(d=20 m)		16 44.5	49 56.4			
			57.5	56.5			
16	竹 原 神 社	14	9 29	49 06.1	10	16 27	49 05.2
			32.5	05.9		31	04.8
			37	05.6		34	05.3
			(9 33)	(49 05.9)		41	05.1
						(16 34)	(49 05.2)
16-A-1	(d=22 m)		9 55.5	49 11.9	A-2	16 54	49 06.3
			10 00.5	11.5		17 00	06.1

(to be continued)

(continued)

No.	Locality	Survey I Date	Survey I Time	Survey I *I*	Survey II Date	Survey II Time	Survey II *I*
		1966	h m		1966	h m	
17	古　　牧	Feb. 14	10 51	50°29.8′	Mar. 10	15 38	50°28.6
			54	29.7		43	28.9
			(10 52.5)	(50 29.7)		47	28.8
						(15 42.5)	(50 28.8)
17-A	(d=15 m)		11 11	30 31.7			
18	北小布施	14	12 04	50 03.6	12	9 14	50 05.3
			08	04.0		17	05.2
			12	04.0		21	05.0
			(12 08)	(50 03.8)		(9 17.5)	(50 05.2)
18-A	(d=12 m)		12 26	50 03.8			
			30	03.9			
19	南小布施	14	13 14	50 09.7	12	9 46	50 10.1
			23	09.4		50	09.8
			33	09.6		54	10.1
			(13 24)	(50 09.6)		(9 50)	(50 10.0)
19-A	(d=10 m)		13 43	50 09.5			
			48	09.6			
20	中　　山	14	14 26	50 05.5	12	10 17	50 04.9
			30	05.9		21	05.2
			35	05.6		26	05.2
			(14 30.5)	(50 05.7)		(10 21.5)	(50 05.1)
20-A	(d=10 m)		14 48	50 06.2			
			52	06.2			
21	千本松三角点	14	15 57.5	49 49.4	12	11 12	49 48.2
			16 01	49.5		19	47.9
			05	49.3		25	48.0
			(16 01)	(49 49.4)		(11 18.5)	(49 48.0)
21-A	(d=17.5 m)		16 24.5	49 50.4			
			28.5	50.1			
22	下　八　町	15	9 41.5	49 58.1	12	11 56	49 57.8
			49	58.4		12 01	58.1
			10 02	58.0		05	58.3
			(9 51.5)	(49 58.2)		(12 00.5)	(49 58.1)
22-A	(d=10 m)		15 12.5	49 53.9			
				54.2			

(to be continued)

(continued)

No.	Lacality	Survey I Date	Time	I	Survey II Date	Time	I
		1966	h m		1966	h m	
23	森一小内神社	Feb. 15	11 01.5	49°52.9′	Mar. 12	12 41	49°50.0
			05.5	52.6		45	50.3
			28	52.8		50	50.0
			(11 14.5)	(49 52.8)		(12 45.5)	(49 50.1)
23-A	(d=10 m)		11 42	49 52.5			
			46	52.0			
24	相 之 島	15	13 12.5	49 58.6	12	14 04	49 58.7
			15.5	58.4		07	58.1
			25.5	58.4		11	58.5
			(13 19)	(49 58.5)		16	58.1
						(14 10)	(49 58.4)
24-A	(d=18 m)		13 56	49 57.9			
			40.5	58.0			
25	大 町	15	14 16	50 07.7	12	14 43	50 08.0
			33	07.8		46	08.0
			45	07.7		55	08.0
			(14 30.5)	(50 07.7)		(14 49)	(50 08.0)
			14 57.5	50 07.3			
25-A	(d=15 m)		15 01	08.0			
			09	07.6			
26	大 俣				Mar. 10	10 11	50 02.2
						36	01.7
						11 20	02.0
						26	02.1
						40	02.0
						(10 55.5)	(50 02.0)
26-A	(d=12 m)					12 05	50 02.1
							02.0
27	親 川				11	10 37	48 57.7
						47	57.8
						(10 42)	(48 57.8)
27-A	(d=10 m)					11 08	48 49.8
						13	49.5

Table 6. Results of dip surveys over the northern part of Nagano Prefecture and the changes in inclination during the period of two surveys.

Nos. of Station	Locality	Survey I					Survey II					
		Date	Time	I_T 2)	I_K 2)	I_T-I_K	Date	Time	I_T 2)	I_K 2)	I_T-I_K	δI_{II-I}
			h m					h m				
No. 1	八幡神社	Feb. 11	10 31	50°04.7′	47°53.3′	2°11.4′	Mar. 11	15 47	50°11.8′	47°54.9′	2°16.9′	+0.1′
2	若槻小学校	11	11 48	50 10.1	53.3	2 16.8	11	15 18	50 01.8	54.7	2 07.2	0.0
3	吉	11	13 38	50 00.8	53.6	2 07.2	11	16 18	50 01.5	55.0	2 06.5	+0.2
4	石村	11	15 12	50 00.4	54.1	2 06.3	12	15 15	50 10.1	54.3	2 15.8	+0.6
5	赤沼(三角点)	11	16 49	50 09.2	54.0	2 15.2	11	14 37.5	50 07.2	54.6	2 12.6	0.0
6	平出小学校裏	12	11 00	50 06.3	53.7	2 12.6	11	13 27.5	50 18.1	54.6	2 23.5	−0.7
7	中宿	12	12 38	50 18.2	54.0	2 24.2	11	14 03	50 12.0	54.5	2 17.5	−0.9
8	牟礼東小	12	14 02.5	50 13.0	54.6	2 18.4	11	12 08	49 51.9	54.1	1 57.8	−0.6
9	上赤塩	12	15 43	49 53.2	54.8	1 58.4	11	10 00	50 01.5	54.2	2 07.3	+0.3
10	永田小学校	12	16 58	50 02.0	55.0	2 07.0	11	16 58	50 08.0	54.9	2 13.1	+0.2
11	熊沢	13	10 01	50 06.7	53.9	2 12.9	11	9 22	50 01.5	54.2	2 07.3	0.0
12	替佐	13	11 35.5	50 01.1	53.8	2 07.3	10	13 32	49 54.5	54.7	1 59.8	−0.7
13	安源寺	13	13 23.5	49 55.2	54.7	2 00.5	10	14 17.5	49 36.4	54.7	1 41.7	−0.3
14	中野平中学校	13	15 22.5	49 36.8	54.8	1 42.0	10	15 04	49 54.7	54.7	2 00.0	+0.2
15	長丘小学校	13	16 25	49 54.5	54.7	1 59.8	10	16 34	49 05.2	54.7	1 10.5	−1.8
16	竹原神社	14	9 33	49 05.9	53.6	1 12.3	10	15 42.5	50 28.8	54.7	2 34.1	−1.7
17	古牧	14	10 52.5	50 29.6	53.8	2 35.8	12	9 17.5	50 05.2	54.4	2 10.8	+1.0
18	北小布施	14	12 08	50 03.8	54.0	2 09.8	12	9 50	50 10.0	54.1	2 15.9	+0.6
19	南小布施	14	13 24	50 09.6	54.3	2 15.3	12	10 21.5	50 05.1	53.7	2 11.4	+0.1
20	中山	14	14 30.5	50 05.7	54.4	2 11.3	12	11 18.5	49 48.0	53.5	1 54.5	−0.3
21	千本松三角点	14	16 01	49 49.4	54.6	1 54.8	12	12 00.5	49 58.1	53.7	2 04.4	0.0
22	下八町	15	9 51.5	49 58.2	53.8	2 04.4	12	12 45.5	49 50.1	54.0	1 56.1	−0.5
23	森一小内神社	15	11 14.5	49 52.8	54.2	1 58.6	12	14 10	49 58.4	54.2	2 04.2	+0.1
24	相之島	15	13 19	49 58.5	54.4	2 04.1	12	14 49	50 08.0	54.3	2 13.7	+0.2
25	大町	15	14 30.5	50 07.7	54.2	2 13.5	10	10 55.5	50 02.0	54.4	2 07.6	—
26	大俣	—	—	—	—	—	11	10 42	48 57.8	53.9	1 03.9	—
27	親川	—	—	—	—	—						

I_T : Inclination values at respective stations.
I_K : Inclination values at Kanozan.
δI_{II-I}: Differences between the first and the second surveys.

The distribution of measuring points is already shown in Fig. 1. The results of the surveys are listed in Table 5. The mean value of magnetic dip over the area is approximately 50°. As can be seen in Fig. 7, the magnetic dip is distributed so uniformly that deviations from the mean are within 20′ at most of the measuring sites.

When surveys of this kind are repeated with a long interval of time,

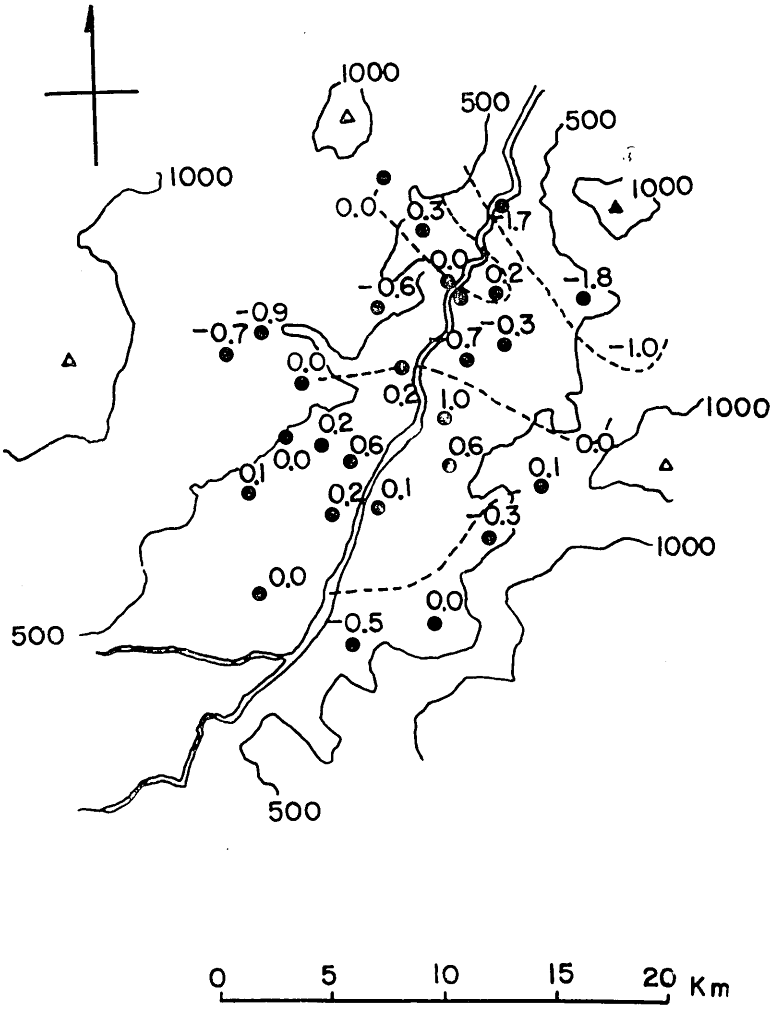

Fig. 8. Changes in the geomagnetic inclination in units of minute of arc between the surveys II and I.

it is not always easy to set a magnetometer exactly at the same place as before. Errors caused by inaccurate location of a magnetometer are considerably large where the magnetic field is not uniform as in volcanic areas. Measuring sites were carefully selected so as to minimize the above type errors. At auxiliary points, approximately 10 m apart from the measuring points, measurements were also made, so that even if it should happen that owing to an unavoidable circumstance the previous point could not be relocated, the magnitude of the uncertainty could be estimated. The field gradients near the measuring points were approximately 0.2′/m over the surveyed area except for a few localities. The magnetic dips at the auxiliary points are together shown in Table 5.

External variations included in the individual measurements are corrected by making use of continuous observation at the Kanozan Geodetic Observatory. The differences between the two surveys are listed in Table 6 and shown in Fig. 8. These differences suggest a general tendency that the magnetic dip during a month decreased in the northern half of the surveyed area, while the increase in the magnetic dip was a prevailing feature in the southern half. The maximum change reached −1.8′ at a northeastern site.

In order to extract magnetic variation that is likely to be accompanied by seismic activity, several kinds of noises should be eliminated from the measurements. The maximum error of a single observation is approximately 0.2′. The observed variation stated above manifestly exceeds this limit. As has already been discussed, it is often the case that inaccurate relocations of an instrument produces significant errors. In our case, however, the observation points were reoccupied within a range of 5 cm, by reference to the maps in Fig. 9. This could produce an error of 0.01′ on an average over the area.

When diurnal variations at magnetic stations are corrected by making use of a distant station, non-uniformity of the variation is one of the sources which produce noises. For the estimation of non-uniformity of the magnetic variation, hourly values of the magnetic inclination at the Kakioka and Kanozan observatories during the surveyed period are computed and shown in Fig. 10. During the period, the mean value of simple differences is 67.9′ and the standard deviation for the single measurement is estimated as 0.12′. Since the distance between the surveyed area and Kanozan is approximately 230 km, whereas the distance between Kakioka and Kanozan is 120 km, the standard deviation of simple difference between Kanozan and the area concerned might be extrapolated as

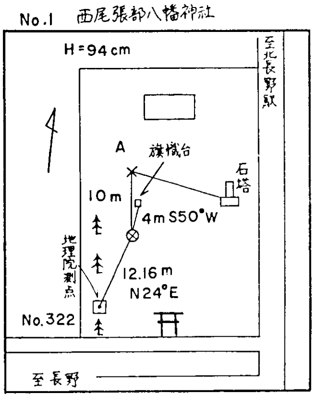

Fig. 9-1. Sketch map around Station No. 1.

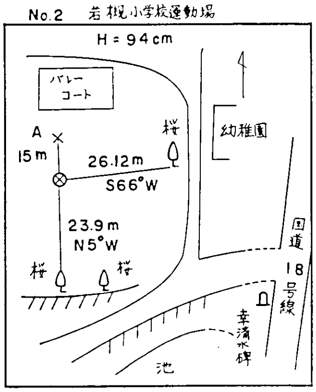

Fig. 9-2. Station No. 2.

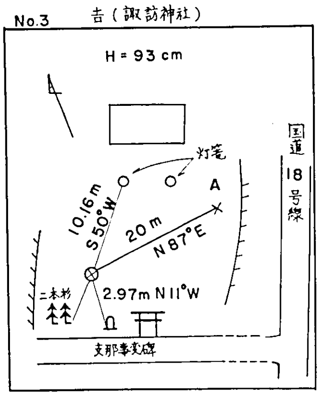

Fig. 9-3. Station No. 3.

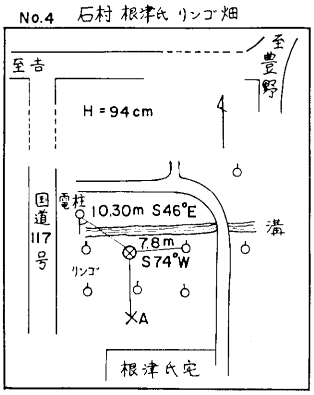

Fig. 9-4. Station No. 4.

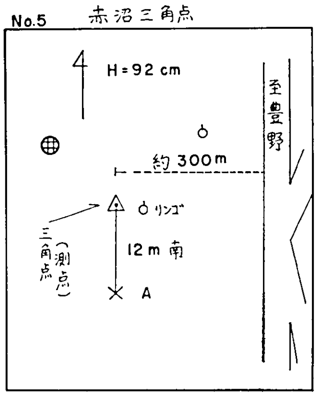

Fig. 9-5. Station No. 5.

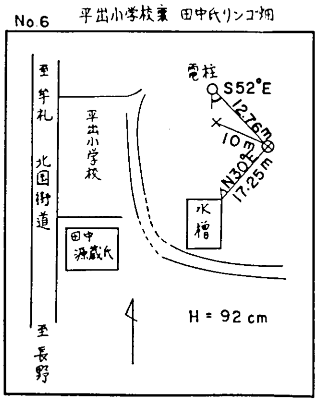

Fig. 9-6. Station No. 6.

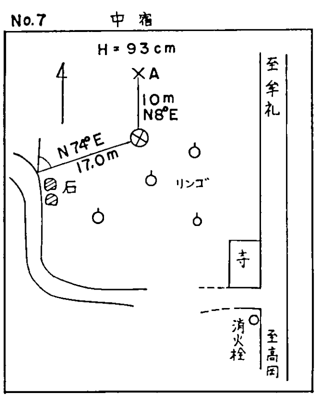

Fig. 9-7. Station No. 7.

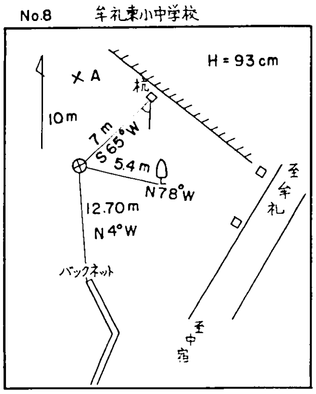

Fig. 9-8. Station No. 8.

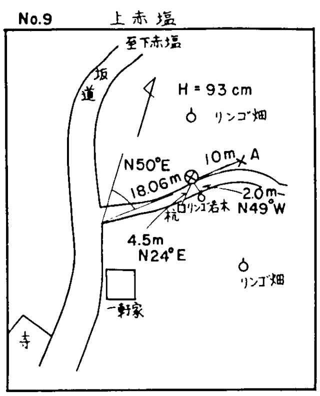

Fig. 9-9. Station No. 9.

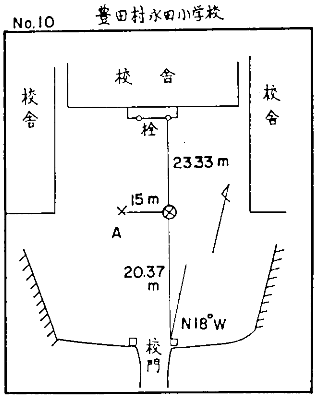

Fig. 9-10. Station No. 10.

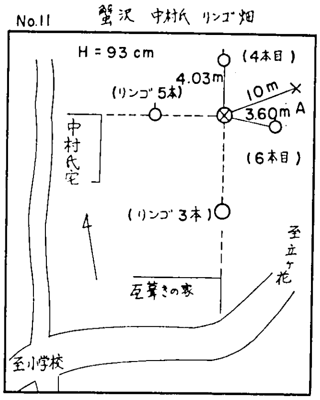

Fig. 9-11. Station No. 11.

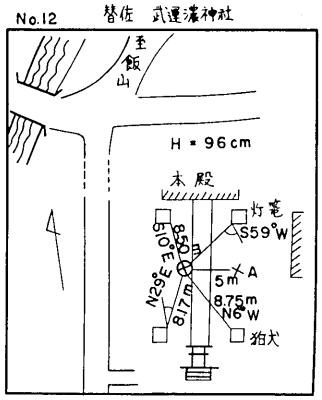

Fig. 9-12. Station No. 12.

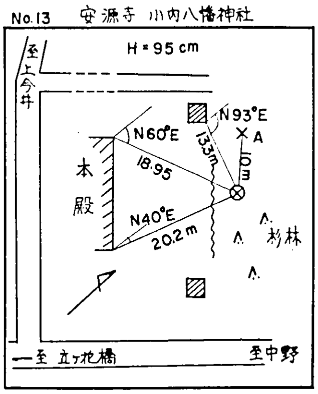

Fig. 9-13. Station No. 13.

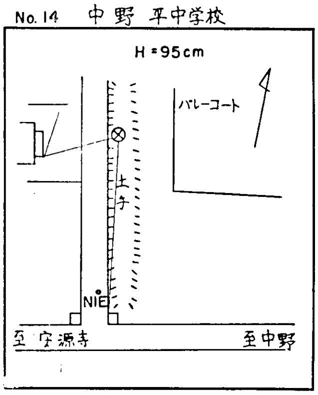

Fig. 9-14. Station No. 14.

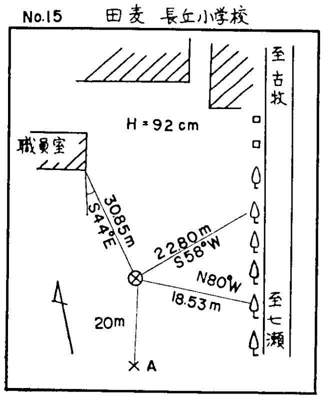

Fig. 9-15. Station No. 15.

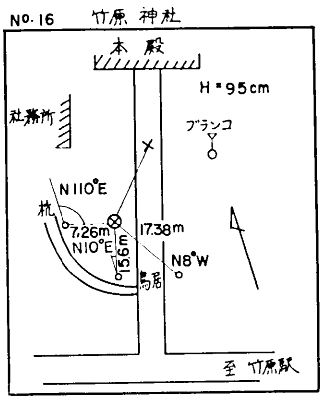

Fig. 9-16. Station No. 16.

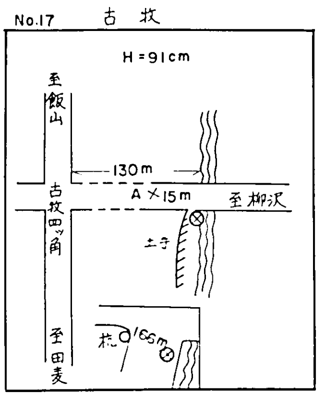

Fig. 9-17. Station No. 17.

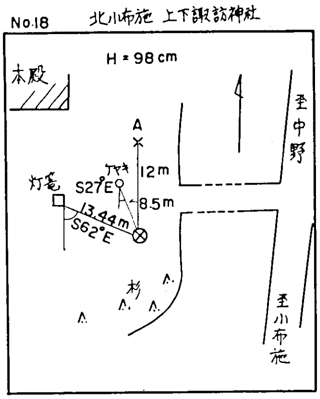

Fig. 9-18. Station No. 18.

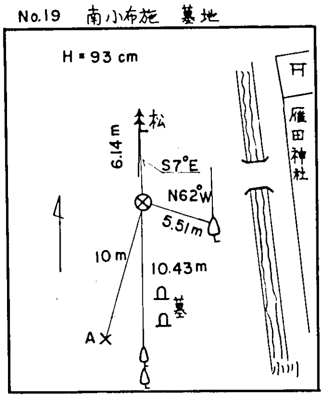

Fig. 9-19. Station No. 19.

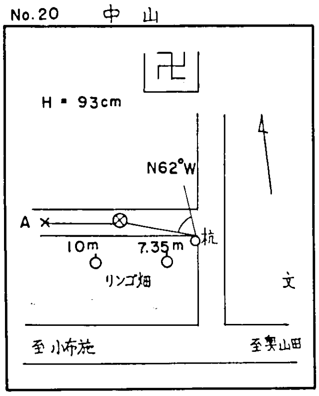

Fig. 9-20. Station No. 20.

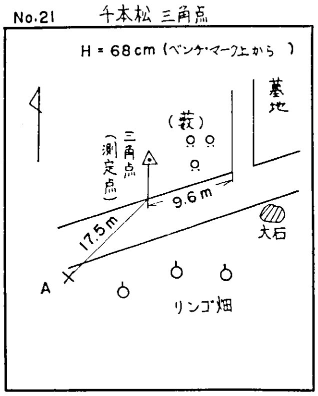

Fig. 9-21. Station No. 21.

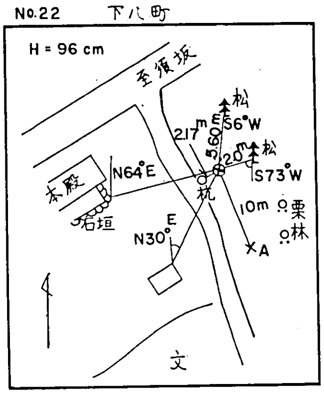

Fig. 9-22. Station No. 22.

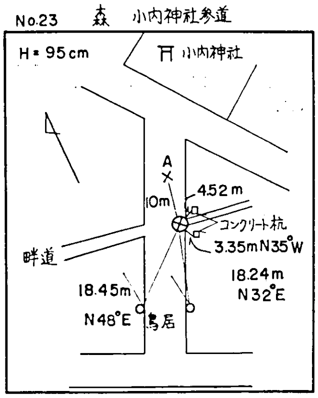

Fig. 9-23. Station No. 23.

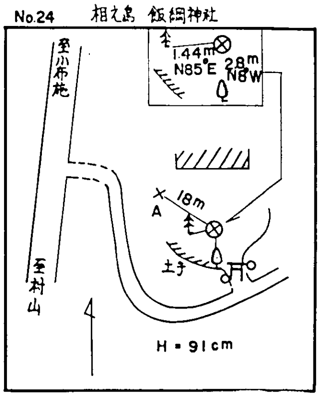

Fig. 9-24. Station No. 24.

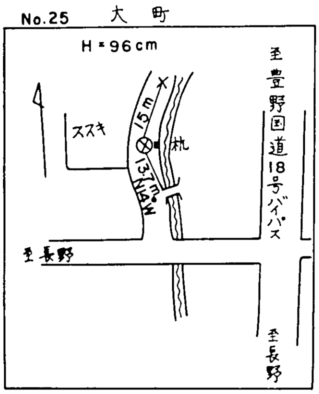

Fig. 9-25. Station No. 25.

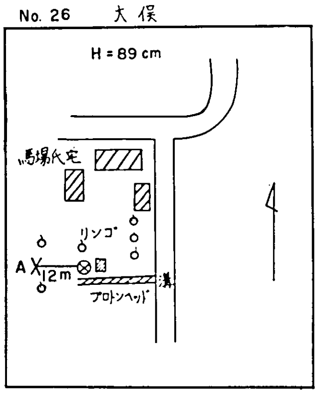

Fig. 9-26. Station No. 26.

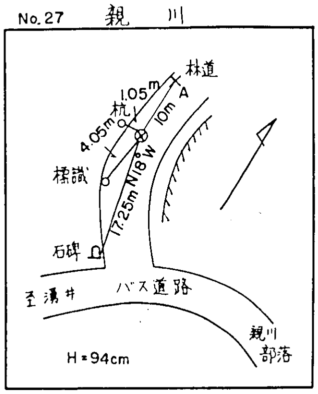

Fig. 9-27. Station No. 27.

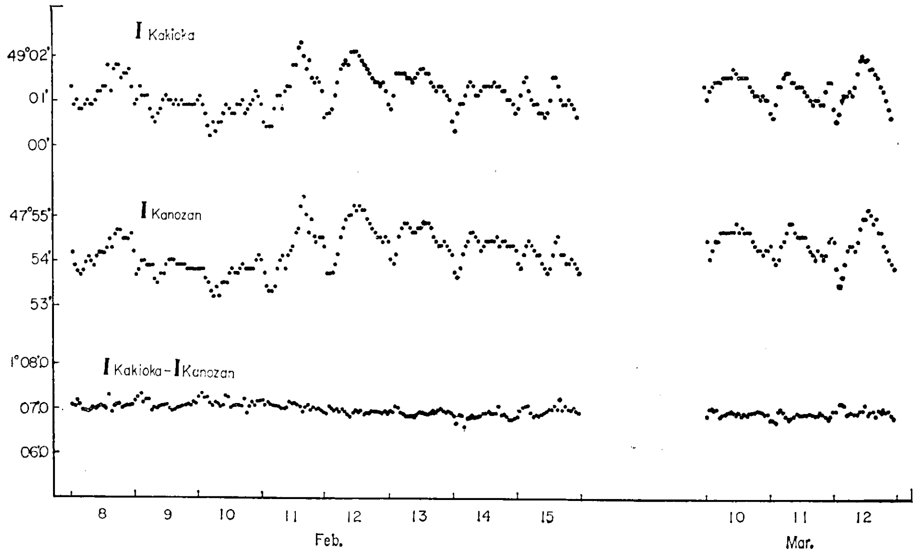

Fig. 10. Changes in the hourly values at the Kakioka Magnetic Observatory and the Kanozan Geodetic Observatory. Differences between the observatories are shown at the bottom.

approximately 0.3′, on condition that the diurnal variation develops with the same pattern over the areas.

Another problem is caused by the induced electric currents within the earth. It is well known[4] that geomagnetic disturbances having a period of about one hour show quite an anomalous feature at the Pacific side of the central part of Japan probably due to an anomalous distribution of electrical conductivity in the upper mantle. Instanteneous values at Kanozan may possibly be subjected to the above effect on magnetically disturbed days. Although no accurate estimate has been made in this paper, such an effect on the simple difference of single measurements at daytime seems considerable.

From the above consideration, the observed change during a period between the two surveys seems fairly to exceed the noise level. However, it is not ascertained clearly yet whether the observed variation is really due to the seismic effect or not.

4) T. RIKITAKE, *Geophys. Journ. Roy. Astr. Soc.*, **2** (1959), 276.

5. Comparison between the changes in the geomagnetic field observed at Mt. Minakamiyama and the Matsushiro Seismological Observatory

Since the end of October, 1965, a continuous observation of three geomagnetic components has been continued at the Matsushiro Seismological Observatory by K. Yanagihara[5] and other members of the Kakioka Magnetic Observatory with a fluxgate type magnetometer. Nighttime means of inclination were computed from hourly values. Then the differences between those corresponding means at the Seismological Observatory (Kansokusho) and at the Kakioka Geomagnetic Observatory were taken. ΔI_2 in Fig. 11 shows these differences.

As has been reported in the previous papers[1),2)], measurements of

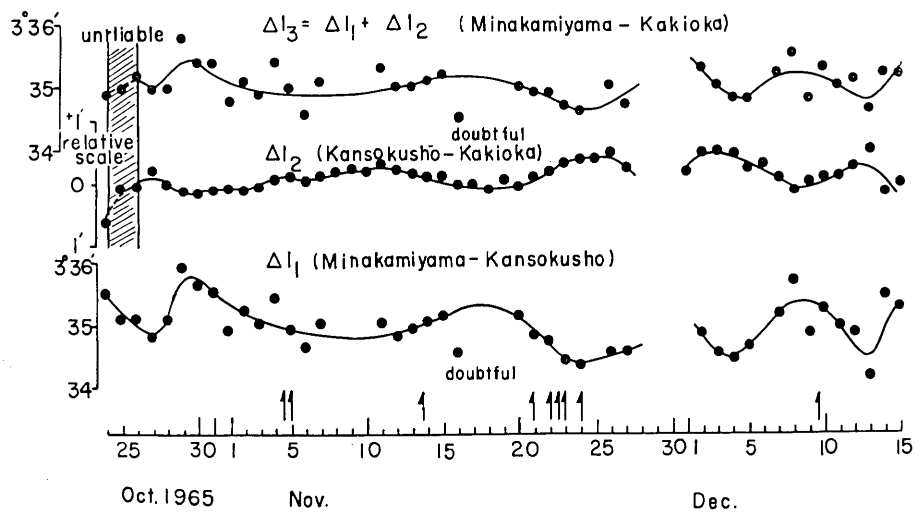

Fig. 11. Changes in the inclination values at Mt. Minakamiyama and the Seismological Observatory (Kansokusho). (after K. Yanagihara)

ΔI_1: Differences between the mean values of the measurements conducted at the top of Mt. Minakamiyama and the means of nighttime values at the Seismological Observatory (Kansokusho).

ΔI_2: Differences between the means of nighttime values at the Seismological Observatory and the Kakioka Magnetic Observatory.

$\Delta I_3 = \Delta I_1 + \Delta I_2$.

5) K. YANAGIHARA and T. RIKITAKE, Read at the Annual Meeting of the Society of Terrestrial Magnetism and Electricity, Japan. May, 1966.

geomagnetic inclination and declination were repeated manually more than several times a day with a second-order G.S.I. magnetometer, covering the period from October to December. Simple arithmetic means were computed for each day. Differences between these means and the nighttime means at the Seismological Observatory are shown in Fig. 11 with ΔI_1. At the top of the diagram, differences between the mean values at Mt. Minakamiyama and Kakioka are shown by ΔI_3.

It is noteworthy that the changes in the geomagnetic inclination at Minakamiyama (ΔI_3) are in an opposite direction to those at the Seismological Observatory (ΔI_2). Thus ΔI_1 in Fig. 11 seems to suggest a very local change in the magnetic field which took place only within a 2 km's distance.

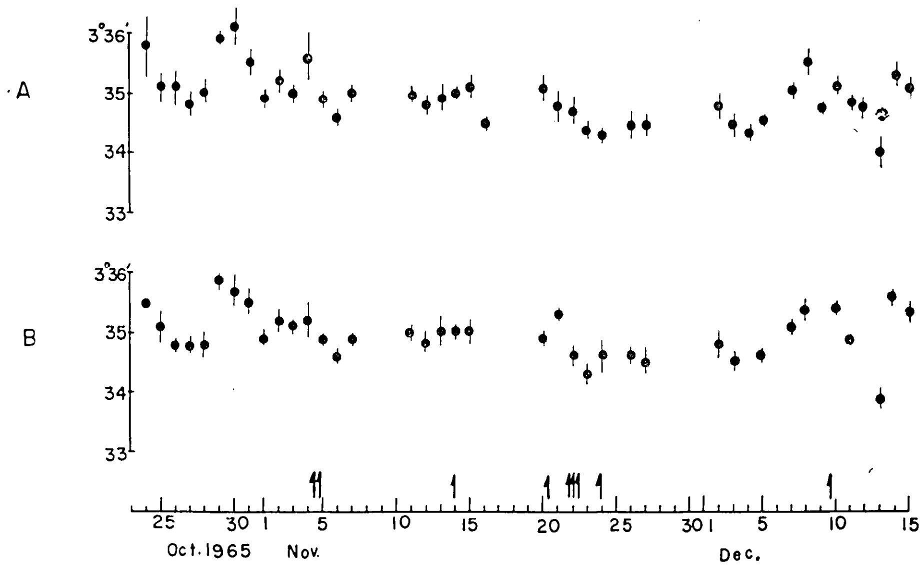

Fig. 12. Mean values with standard deviations of the differences in instantaneous inclinations at Mt. Minakamiyama and the Seismological Observatory.

A: Mean values for all the measurements in a day.

B: Mean values for the data obtained later than 16h 00m in local time.

Instead of making use of nighttime means at the Seismological Observatory, instantaneous values at Mt. Minakamiyama are corrected by those of corresponding instant at the Observatory, and then mean values were computed. The results are shown in Fig. 12, fluctuating within a range of approximately 1.5′. Probable errors for the individual values scattered from 0.1′ to 0.5′ are as shown by vertical lines in the figure. It indicates, however, little difference from Fig. 11, where nighttime averages are taken as standards. Since nighttime data indicate smaller dispersions than daytime ones when differences of a geomagnetic component at two stations are taken[3], mean values were computed for the data later than 16 h and shown in the lower diagram of Fig. 12. In this case, probable errors are less scattered, *i.e.* from 0.1′ to 0.3′, although the above procedure does not seem to alter the general feature of the previous results.

Although observations shown in Fig. 11 and Fig. 12 do not exclude the possibility of correlating the above local changes with the seismic activity, anything conclusive cannot be stated from the present data.

6. Concluding remarks

Measurement of total force intensity has been continued by renewing the recording system so as to pick up nighttime values. Five-day means were made following subtraction of corresponding values at Kanozan from those at Station B. The results suggest small fluctuations of the magnetic field, amounting to approximately $\pm 2\gamma$, at the station. However, it has not been clarified yet whether the observed undulations have a direct connection with the seismic activity in the area or not.

Magnetic dip surveys were repeated over the Matsushiro area. In connection with the upheaval of land around the Toyono area as observed by the Geographical Survey Institute, the survey has been extended to the wider area covering the northern part of Nagano Prefecture. Both the surveys indicated that at some localities the geomagnetic inclination had changed more than 1 minute of arc within a month. One minute of arc in inclination may correspond to 15γ or so in magnetic intensity in this area. Then the above variation is considerably large compared with the time variation of five-day means of total intensity at station B. Conceivable sources of noises were considered and errors produced by them were roughly estimated. The above obtained changes seem to barely exceed the estimated noise level. However, there still remains ambiguity about the local nature of short-period disturbances of geomagnetic field which may have a great effect on a single measurement at daytime.

Inclination values at Mt. Minakamiyama were compared with those at the Seismological Observatory, situated at a distance of 2 km. The comparison showed that there are local fluctuations in inclination, amounting approximately to 1′, even within a 2 km's distance. It is also brought to light that the directions of changes are opposite to one another at the two stations. As has been discussed in the previous paper[1], such a fact suggests a very shallow origin for the changes whatever the cause of the changes is.

The observation at Station B has been conducted by Mr. Ogawa. The writers are thankful to him for his work.

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63. 松代地震群の地球電磁気学的調査 (3)

地震研究所
力 武 常 次
行 武 毅
山 崎 良 雄
沢 田 宗 久
笹 井 洋 一
萩 原 幸 男
川 田 薫
吉 野 登 志 男
下 村 高 史

松代における全磁力の測定はその後も続けられ，2月9日以来B測点では午前1時より2分間隔で6回自働的に測定するような装置に切りかえた．これは夜間の測定が昼間の測定よりよいデータを供するからである．この測定値と鹿野山の同時刻の値との差の 5 日平均の変動は ±2γ 程度のものであるが，これと地震活動との直接的な関係は明らかでない．

松代地方の磁気測量はこれ迄都合3回行われた。この論文では第3回測量（2月8日～10日）の結果を報告するが，伏角の変化はいちじるしく，最大 1.6′ を示す．だが分布は不規則であり，地震活動と結びつけて考えられない．一般的傾向として第2回の測量では第1回に比べて伏角が減少したのに，第3回では再び第1回のレベルに復帰している．この事実は地震活動の成長・減衰と地磁気変化との関係を示すものかもしれない．

長野県北部の磁気測量は1箇月間隔をおいて 2回行われ，その結果測量地域の北半分では伏角が減少し，反対に南半分では増大していることがわかった．最大変化は北東部の −1.8′ である．このように長期間をおいて測量をくり返えすときには，前回と全く同じ位置に測定器を設置することが困難なので，測点から 10 m 程離れた場所に補助測点を設けて測定し，測点附近の磁気勾配を知っていれば，設定位置のズレによる磁気測定の誤差を判定することができる．今回の測量では設定位置の誤差は 5 cm, 0.01′ であった．設定位置の問題の他に誤差の原因を作るものには，日変化の不均一性がある．120 km 離れた柿岡と鹿野山との伏角の差の標準偏差は 0.12′ であり，また今回の測量地域と鹿野山との距離が 230 km であることから，標準偏差 0.3′ 位の変動を見込まなければならない．もう一つは Central Japan anomaly に見られるような，地球内の誘導電流に起因する短周期変化が誤差の原因となるが，これについては詳論しない．これらの誤差を考慮しても，この2回の測定では，観測された伏角の差が誤差の範囲をはるかにこえてはいるものの，磁気変動を地震活動に結びつけて解釈することはむづかしい．

皆神山で測定した伏角と同時刻の柿岡の伏角との差と，松代地震観測所の伏角と柿岡との差とは，変動が逆センスに表われる．このことは皆神山と地震観測所との距離 2 km 以内に局地的な磁気変化が存在することを示すものであり，極めて浅い所に原因があると考えられる．この局地的変化を地震と結びつけて考えることはできるが，現在のところ結論的なことは云えない．

終りに B 測点での観測に協力されている小川氏に感謝する．