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34. *Local Anomalous Changes in the Geomagnetic Field at Matsushiro.*

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Summary

Geomagnetic observation by a proton precession magnetometer has been resumed at a station in the central area of the 1965-66 Matsushiro earthquake activity towards the end of 1969. The purpose of the present observation is to see whether geomagnetic changes occur or not in association with a water injection experiment into a bore-hole about 2 km distant from the station. Although no marked changes exceeding a few gammas were observed in relation to the experiment, it is ascertained that an anomalous decrease in the total geomagnetic intensity amounting to some ten gammas relative to Kanozan Magnetic Observatory, about 180 km distant from the station, had taken place during the past three years. The observation was made exactly at the same point as that during the violent seismic activity in 1965-66.

1. Introduction

A bore-hole as deep as 2000 m or a little shallower was drilled by the National Research Center for Disaster Prevention at a point north of Mt. Minakamiyama situated in the central area of the 1965-66 Matsushiro earthquake activity. It was aimed at examining the material composing the earth's crust where many earthquakes had actually taken place. A water injection experiment into the bore-hole was also planned in order to see how the seismic activity is influenced by such an experiment.

The geomagnetic group of the Earthquake Research Institute conducted an extensive work over the Matsushiro area when the activity was high as had been reported in a series of papers.[1] Some anomalous geomagnetic changes have been found during a period of high seismic activity. Some of the sites, where the observation by proton precession magnetometers had been conducted, were preserved in such a way that it is possible to reoccupy the observation point. At the station south of Mt. Minakamiyama, the stand on which the detector coil of the mag-

1) T. RIKITAKE et al., *Bull. Earthq. Res. Inst.*, **44** (1966), 363, 409, 1335 and 1735; **45** (1967), 395 and 919.

netometer is mounted was left there, so that we could resume the observation exactly at the same point.

Although the observation is planned for detecting geomagnetic changes, if any, in association with the water injection, it is also aimed at determining the anomalous changes that might occur after the violent seismic activity.

2. Geomagnetic observation

The observation point (which has been called Station B) is shown in Fig. 1 along with the position of the bore-hole. The observation was carried out during a period from the middle of November, 1969 to the end of February, 1970. Five measurements at 00 h 40 m, 00 h 50 m, 01 h 00 m, 01 h 10 m and 01 h 20 m local time are made with the aid of a clock-work on each day. It had been fully discussed in the previous papers[1),2),3)] that geomagnetic noises are relatively small in the mid-night

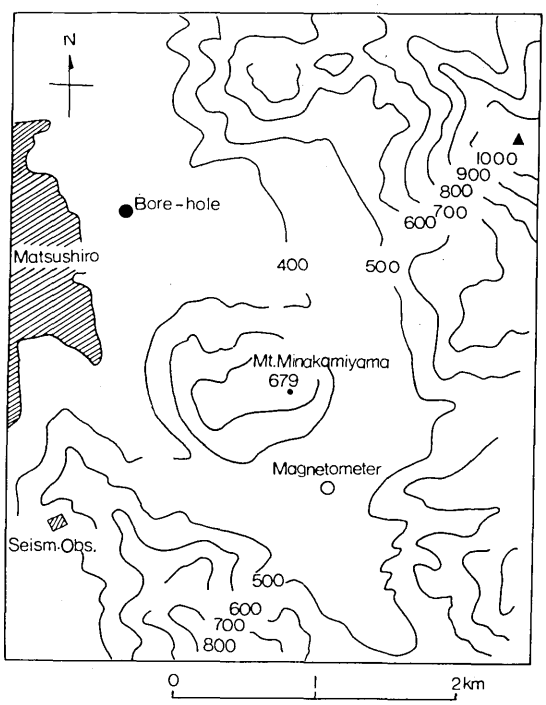

Fig. 1. The locations of the bore-hole and the magnetometer station around Mt. Minakamiyama.

2) T. RIKITAKE, *Bull. Earthq. Res. Inst.*, **44** (1966), 1041.
3) T. RIKITAKE, T. YOSHINO and Y. SASAI, *Bull. Earthq. Res. Inst.*, **46** (1968), 137.

period.

The total intensity value for a certain day is represented by the mean value of the five measurements. Such daily mean values are shown in Table 1 along with those for Kanozan Magnetic Observatory, some 180 km distant from the Matsushiro area.

Table 1. Daily mean values of total intensity and their differences observed at Station B (F_M) and Kanozan (F_K).

Date	F_M	F_K	F_M-F_K	Date	F_M	F_K	F_M-F_K
1969 Nov. 12	46841.5γ	45463.7γ	1377.8γ	1969 Dec. 15	46832.8γ	45452.8γ	1380.0γ
13	32.4	54.5	77.9	16	39.6	60.6	79.0
14	32.2	50.6	81.6	17	28.5	47.4	81.1
15	33.3	——	——	18	33.5	55.6	77.9
16	35.6	59.0	76.6	19	38.9	60.4	78.5
17	40.4	64.8	75.6	20	39.6	60.0	79.6
18	37.8	58.0	79.8	21	39.9	63.0	76.9
19	37.7	60.4	77.3	22	38.7	64.4	75.3
20	35.9	58.4	77.5	23	32.3	55.2	77.1
21	35.3	58.6	76.7	24	28.1	48.0	80.1
22	36.8	60.8	76.0	25	32.1	54.0	78.1
23	39.8	62.0	77.8	26	35.3	55.2	80.1
24	37.7	56.6	81.1	27	38.9	63.2	75.7
25	——	56.0	——	28	30.5	54.6	75.9
26	——	62.8	——	29	35.3	56.6	78.7
27	38.2	61.4	76.8	30	34.2	55.0	79.2
28	27.0	51.2	75.8	31	37.6	59.4	78.2
29	33.6	56.0	77.6	1970 Jan. 1	34.1	56.0	78.1
30	32.3	54.0	78.3	2	——	56.6	——
Dec. 1	32.5	57.4	75.1	3	——	34.2	——
2	25.7	48.4	77.3	4	——	52.2	——
3	31.1	54.8	76.3	5	——	56.6	——
4	38.8	61.6	77.2	6	——	58.4	——
5	37.5	57.0	80.5	7	——	53.4	——
6	27.2	53.4	73.8	8	——	58.0	——
7	28.9	50.4	78.5	9	34.8	56.0	78.8
8	31.9	54.2	77.7	10	32.3	53.0	79.3
9	36.1	60.5	75.6	11	33.6	54.6	79.0
10	31.6	51.2	80.4	12	40.1	59.6	80.5
11	40.1	62.0	78.1	13	36.1	57.8	78.3
12	30.9	52.0	78.9	14	33.7	54.4	79.3
13	33.4	53.4	80.0	15	33.2	53.8	79.4
14	37.2	58.8	78.4	16	34.7	56.0	78.7

Date	F_M	F_K	F_M-F_K	Date	F_M	F_K	F_M-F_K
1970 Jan. 17	46815.7γ	45437.4γ	1378.3γ	1970 Feb. 8	46833.4γ	45454.6γ	1378.8γ
18	25.3	45.2	80.1	9	35.6	57.8	77.8
19	36.1	——	——	10	36.8	59.6	77.2
20	34.9	57.4	77.5	11	39.8	61.8	78.0
21	35.9	59.8	76.1	12	33.1	56.4	76.7
22	33.9	55.4	78.5	13	41.1	65.4	75.7
23	33.8	55.6	78.2	14	40.5	67.0	73.5
24	35.7	59.0	76.7	15	23.4	49.0	74.4
25	31.6	51.6	80.0	16	34.2	57.2	77.0
26	34.2	56.6	77.6	17	29.4	53.4	76.0
27	35.9	57.4	78.5	18	29.1	51.2	77.9
28	35.1	57.8	77.3	19	24.1	47.0	77.1
29	47.5	72.4	75.1	20	31.7	——	——
30	35.9	59.8	76.1	21	30.4	53.4	77.0
31	37.6	62.0	75.6	22	31.7	53.6	78.1
Feb. 1	34.3	59.0	75.3	23	33.6	53.4	80.2
2	38.9	63.4	75.5	24	37.8	60.6	77.2
3	28.4	53.4	75.0	25	37.1	61.8	75.3
4	30.3	53.6	76.7	26	32.3	54.2	78.1
5	27.2	50.6	76.6	27	14.9	39.0	75.9
6	29.7	52.0	77.7	28	——	45.8	——
7	32.4	56.6	75.8				

3. Geomagnetic effect of water injection

In Fig. 2 are plotted the daily mean values for Matsushiro (F_M) and Kanozan (F_K) along with the differences between them (F_M-F_K). It had been argued[2),3)] that comparison between simultaneously observed values at Matsushiro and Kanozan can be performed with a standard deviation amounting to $2-3\,\gamma$ for night-time observations. The writers do not put much stress, therefore, on scatterings for F_M-F_K which can be seen in Fig. 2.

It had been reported that water injection was carried out for two periods, i. e. from Jan. 15 to 18 and from Jan. 31 to Feb. 12. The amounts of water pushed into the crust were estimated as 32 and 2850 tons respectively for the first and second experiments. Although a sharp drop of the total geomagnetic intensity value was observed at Matsushiro during the first experiment, it seems likely that such a change occurred only by coincidence because a similar drop was also observed at Kanozan resulting in no change in F_M-F_K. However, it might be pointed out that the level of F_M-F_K became low by a few gammas after the injec-

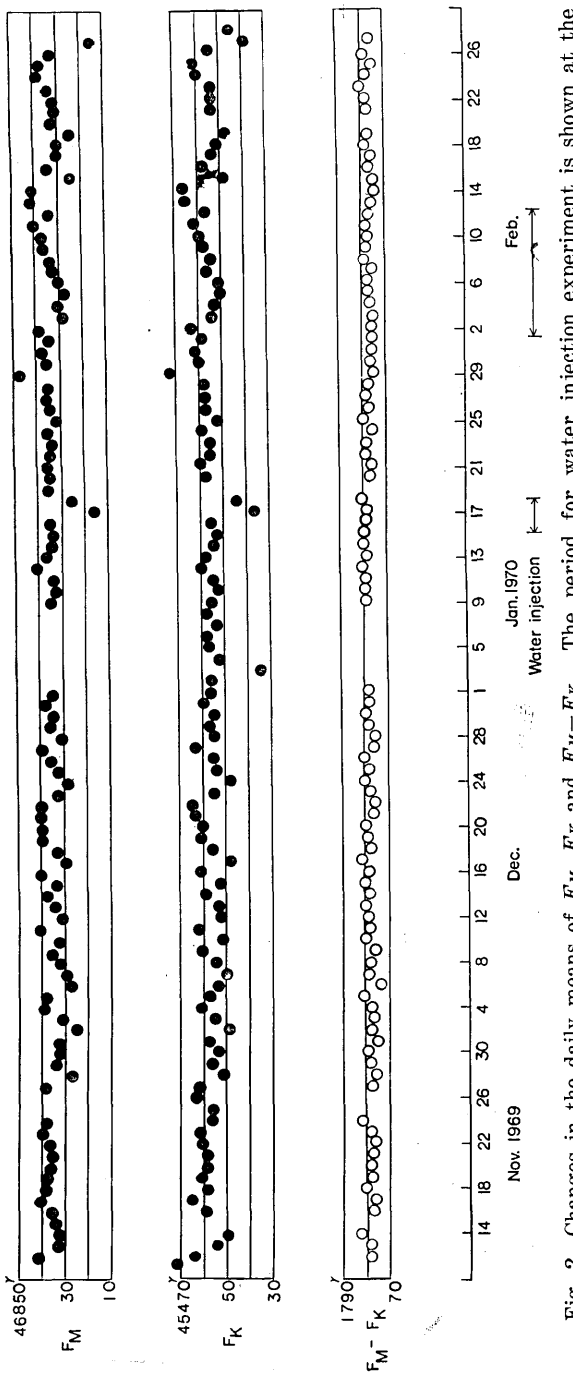

Fig. 2 Changes in the daily means of F_M, F_K and $F_M - F_K$. The period for water injection experiment is shown at the bottom.

tion experiments. But the change is too small for an elaborate analysis.

4. Anomalous secular variation in the geomagnetic field at Matsushiro

In order to see long-range geomagnetic changes at Matsushiro, five-day means of $F_M - F_K$ are plotted in Fig. 3. We see very clearly the

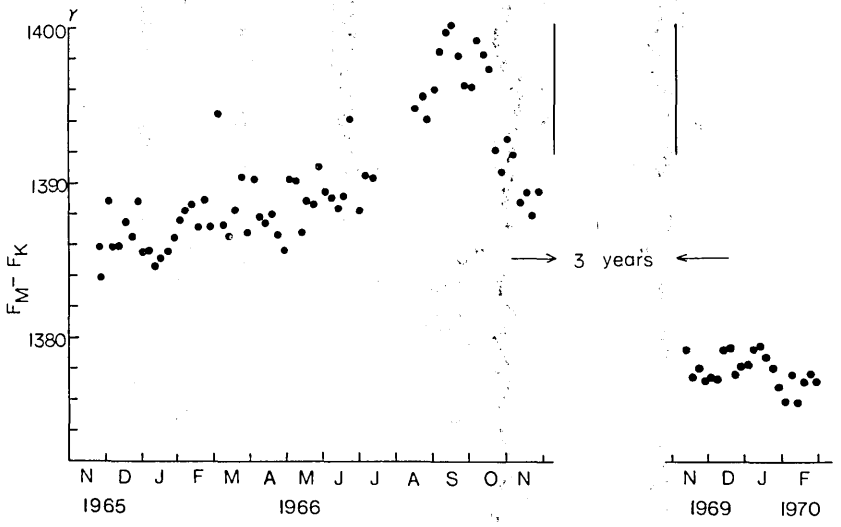

Fig. 3 Five-day means of $F_M - F_K$ during the seismically active period and the present observation.

anomalous increase in F_M relative to F_K amounting several gammas at one of the most violent periods in August and September, 1966. After that period $F_M - F_K$ decreased fairly rapidly.

It is interesting to note that a marked decrease in $F_M - F_K$ amounting to some 10 γ had been found after the three-year interval. The change is so large that it exceeds the range of probable geomagnetic noises. As the geomagnetic field at Kanozan may not be subjected to an anomalous change, $F_M - F_K$ as shown in Fig. 3 reflects the anomalous change in the geomagnetic field at Matsushiro.

As had been discussed in the previous papers, the increase in F_M during the active period may be caused by a piezo-magnetic effect arising from a compressional force in the earth's crust in an east-west direction. If such a force becomes weak, the observed decrease in F_M might be expected though no detailed discussion can be presented from the observation at one station only. The seismic activity there having been

decreasing in these three years, the observed geomagnetic change may be compatible with the decay of seismicity at least qualitatively.

In conclusion the writers are grateful to Mr. K. Ogawa who helped them in the geomagnetic observation. The writers are also indebted to the members of the Kanozan Magnetic Observatory who provided geomagnetic data at the writers' request.

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34. 松代における地磁気異常変化

地震研究所 山崎良雄 力武常次

松代における深いボーリング孔への水圧入実験に伴なう変化を調べる目的で，皆神山南方のプロトン磁力計観測が再開された．1965—66 年の地震活動が活発だった時期の観測点に設置された検出コイル支持台は，そのままに放置されていたので，正確に同じ場所で観測を再開したことになる．

観測の結果，水圧入実験に伴なう変化は検出されなかったが，最近 3 年間にこの観測点の地磁気全磁力が，鹿野山を規準とした場合，約 10 ガンマの減少を示したことがわかった．
