BULLETIN OF THE EARTHQUAKE
RESEARCH INSTITUTE
Vol. 37 (1959), pp. 1-11

1. The Anomalous Behaviour of Geomagnetic Variations of Short Period in Japan and Its Relation to the Subterranean Structure. The 8th report.

By Tsuneji RIKITAKE, Seiya UYEDA, Takesi YUKUTAKE, Iwao TANAOKA and Eiko NAKAGAWA,

Earthquake Research Institute.

(Read Oct. 29, 1958.—Received Oct. 29, 1958.)

Summary

As a result of the magnetic observations that were carried out on two islands in the south sea, roughly 270 and 340 *km* south of Tokyo respectively, it is concluded that the area in which we observe an anomalously large vertical component of short-period geomagnetic variations is not so wide as to cover these islands. The area seems to be very narrow covering only the southern part of Central Japan.

1. Introduction

The writers have thoroughly investigated[1),2),3),4),5)] the anomalous behaviour of geomagnetic variations of short period in Japan. Although it has been established that the anomalously large amplitudes of vertical component are observed only at stations situated in the central part of Japan and that this anomaly is caused by some agency within the earth, some further observations have been required in order to clarify the boundary of the anomalous area.

It has long been hoped, especially, to conduct observations on some of the islands which run towards the south along a line passing Central Japan, because nothing was known about the southern extent of the area in question. During the observation period of a solar eclipse that

1) T. RIKITAKE, I. YOKOYAMA and Y. HISHIYAMA, *Bull. Earthq. Res. Inst.*, **30** (1952), 207, **31** (1953), 19, 89, 101 and 119.

2) T. RIKITAKE and I. YOKOYAMA, *Bull. Earthq. Res. Inst.*, **33** (1955), 297.

3) T. RIKITAKE and I. YOKOYAMA, *Journ. Geomagn. Geoelectr.*, **5** (1953), 59.

4) T. RIKITAKE and I. YOKOYAMA, *Naturwissenschaften*, **41** (1954), 420.

5) T. RIKITAKE, I. YOKOYAMA, S. UYEDA, T. YUKUTAKE and E. NAKAGAWA, *Bull. Earthq. Res. Inst.*, **36** (1958), 1.

occurred on April 19, 1958 along the south coast of Japan Islands, we were able to have temporary stations on Hachijo-shima Island and Aogasima Island, 270 and 340 *km* south of Tokyo, together with a number of permanent and temporary stations widely distributed all over Japan. Accordingly, the observation net-work could provide the necessary magnetic data for investigating the southern limit of the anomalous area.

In the following, the outline of the magnetic observation carried out by the writers on Hachijo-shima Island will be briefly given. The anomalous distribution of the geomagnetic field that is associated with the geomagnetic bay at 12 *h* GMT on Apr. 18 will also be examined in detail with the aid of copies of magnetograms kindly sent from the other observatories. The changes that are likely to be correlated with the solar eclipse are illustrated for each station, too.

2. Magnetic observation on Hachijo-shima Island

At the time of the solar annular eclipse that occurred on Apr. 19, 1958, a net-work of stations for magnetic observation were organized by the National Committee for Solar Eclipse, Science Council of Japan. According to the observation plan proposed, the Earthquake Research Institute set up a magnetic station on Hachijo-shima Island, one of the Seven Izu Islands. Since no magnetic observations have been so far carried out on islands in the south sea, except on Ooshima Island, only 100 *km* south of Tokyo, the observation was expected to be useful not only for the detection of magnetic changes associated with the solar eclipse, but also for investigating the southern limit of the area in which we observe anomalously large amplitudes of geomagnetic variations of shord period.

A RMM magnetograph, of which the details were reported in the previous paper[5], was installed in a cave adjacent to the Hachijo Weather Station (33.°1 *N*, 139.°8 *E*). The environment around the station is shown in Fig. 1.

The observation covered a period from March to June though it was sometimes interrupted by unexpected troubles. It turns out that, on occasions of geomagnetic bays and polar magnetic storms, the changes in the vertical component (ΔZ) are not as large as those observed at the stations, *e.g.* Simosato, Aburatsubo and Kakioka, situated at the central part of the anomalous area. In contrast to those anomalous stations, we also found that shapes of ΔZ curves are different from those of ΔH (changes in the horizontal intensity). The maxima of both ΔH and ΔZ

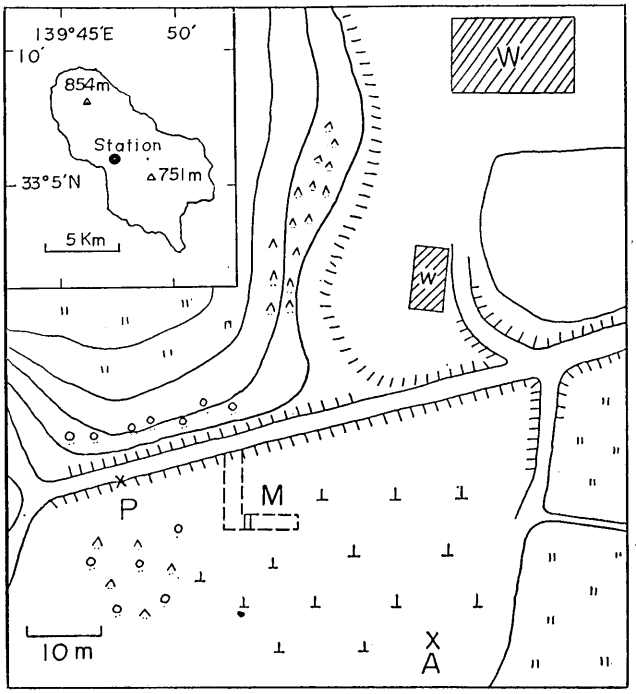

Fig. 1. Location and environment of the magnetic station on Hachijo-shima Island, W: Buildings of the Hachijo Weather Station, A: Absolute measurement point, M: Underground variometer room, P: Proton magnetometer.

do not occur at the same time at Hachijo station, while it has been confirmed that ΔH curves are parallel to ΔZ ones at Simosato, Aburatsubo and Kakioka. It seems likely that the maximum of ΔZ is delayed considerably compared to that of ΔH as can be seen, for example, in Fig. 5.

The relationship between $\Delta Z_{\max.}$ and $\Delta H_{\max.}$ are examined in regard to many bays and polar magnetic storms during the observation period. It is found that $\Delta Z_{\max.}$ is approximately proportional to $\Delta H_{\max.}$ as shown in Fig. 2, the mean value of $\Delta Z_{\max.}/\Delta H_{\max.}$ being estimated at 0.46. Since there is phase difference between ΔZ and ΔH, the ratio $\Delta Z/\Delta H$ at the maximum epoch of ΔH is substantially smaller than $\Delta Z_{\max.}/\Delta H_{\max.}$.

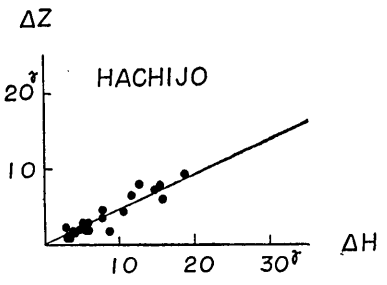

Fig. 2. The relationship between $\Delta Z_{\max.}$ and $\Delta H_{\max.}$ at Hachijo.

Similar relations between ΔZ and ΔH

have been examined for Aburatsubo, Kakioka and Ooshima Island, where we observe no phase difference between them, as already reported in the previous reports. The mean values of $\Delta Z/\Delta H$ at these stations are much larger than that for the maximum epoch of ΔH at Hachijo Station. It has been known that $\Delta Z/\Delta H$ takes a very small value at stations situated near the coast of Japan Sea. Even at Komoro, only 170 *km* north of Aburatsubo, it is generally small though $\Delta Z_{\max.}/\Delta H_{\max.}$ amounts to 0.30 there. For illustration the relation between $\Delta Z_{\max.}$ and $\Delta H_{\max.}$ for Komoro is shown in Fig. 3. If we consider the distribution of $\Delta Z/\Delta H$ along

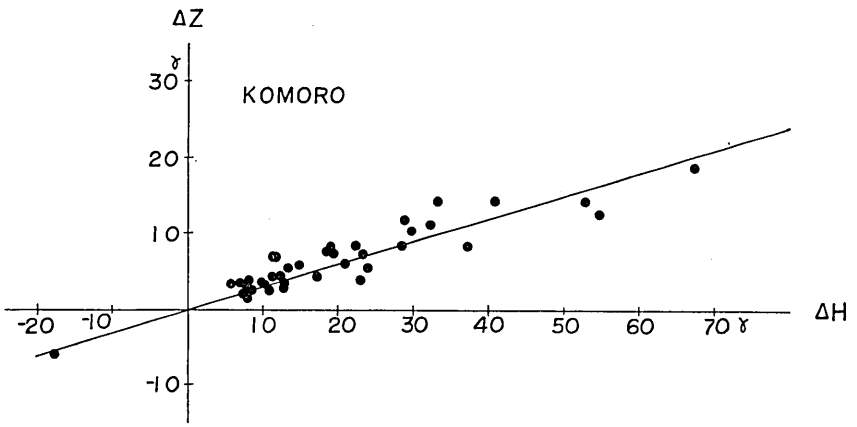

Fig. 3. The relationship between $\Delta Z_{\max.}$ and $\Delta H_{\max.}$ at Komoro.

a roughly north-west line passing Tokyo, we thus see that, for usual bays and polar magnetic storms, $\Delta Z/\Delta H$ at the maximum epoch of ΔH takes high values, 0.6 or so say, around the Tokyo area, though it falls off very steeply to small values on both sides of this area. The width in which $\Delta Z/\Delta H$ exceeds 0.5 would be approximately less than 200 *km*.

3. Geomagnetic bay that occurred at 12 *h* GMT on April 18, 1958

On April 18, a geomagnetic bay of moderate amplitude occurred at about 12 *h* GMT. On that occasion, 12 magnetic stations, permanent and temporary, were at work in Japan. They are Memambetsu, Kakioka and Kanoya (Central Meteorological Agency), Onagawa (Tohoku University), Kanosan (Geographical Survey Institute), Komoro, Aburatsubo and Hachijo (Earthquake Research Institute, Tokyo University), Aogasima

and Simosato (Hydrographic Office, Maritime Safety Agency), and Aso and Kikaigashima (Kyoto University). The geographic latitude and longitude of the stations are summarized in Table 1 and their localities are shown on the map in Fig. 4. The following study is made on the basis of copies of magnetogram kindly sent from these observatories.

Table 1. Magnetic station

Station	Geographic latitude	Geographic longitude
Memambetsu	43.°9*N*	144.°2*E*
Onagawa	38.4	141.5
Komoro	36.3	138.4
Kakioka	36.2	140.2
Kanosan	35.3	140.0
Aburatsubo	35.2	139.6
Simosato	33.6	135.9
Hachijo	33.1	139.8
Aso	32.9	131.0
Aogasima	32.5	139.8
Kanoya	31.4	130.9
Kikaigasima	28.6	129.9

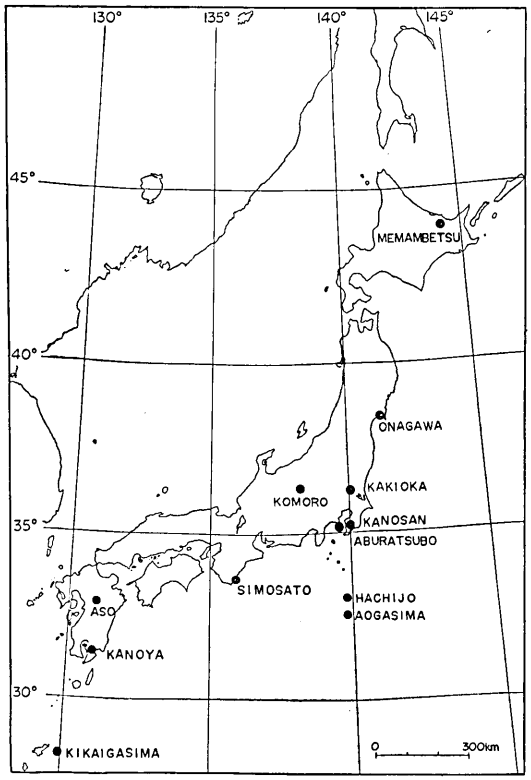

Fig. 4. The locations of magnetic stations.

Changes in the three geomagnetic components during the three *hours* including the bay are illustrated in Fig. 5 for each station with the same scale throughout. In spite of the fairly regular distribution of changes in horizontal intensity and declination, we observe anomalously large ΔZ at stations in the central part of Japan. It is striking that ΔZ slightly exceeds ΔH at Simosato.

The observations on the two islands in the south sea clarify that the anomalous area does not extend that far south. The tendency of ΔZ observed there seems to be nearly the same as that observed at Komoro. The maximum of ΔZ takes place about half an *hour* later than that of ΔH, while in the anomalous area both the maxima of ΔH and ΔZ are observed at the same time.

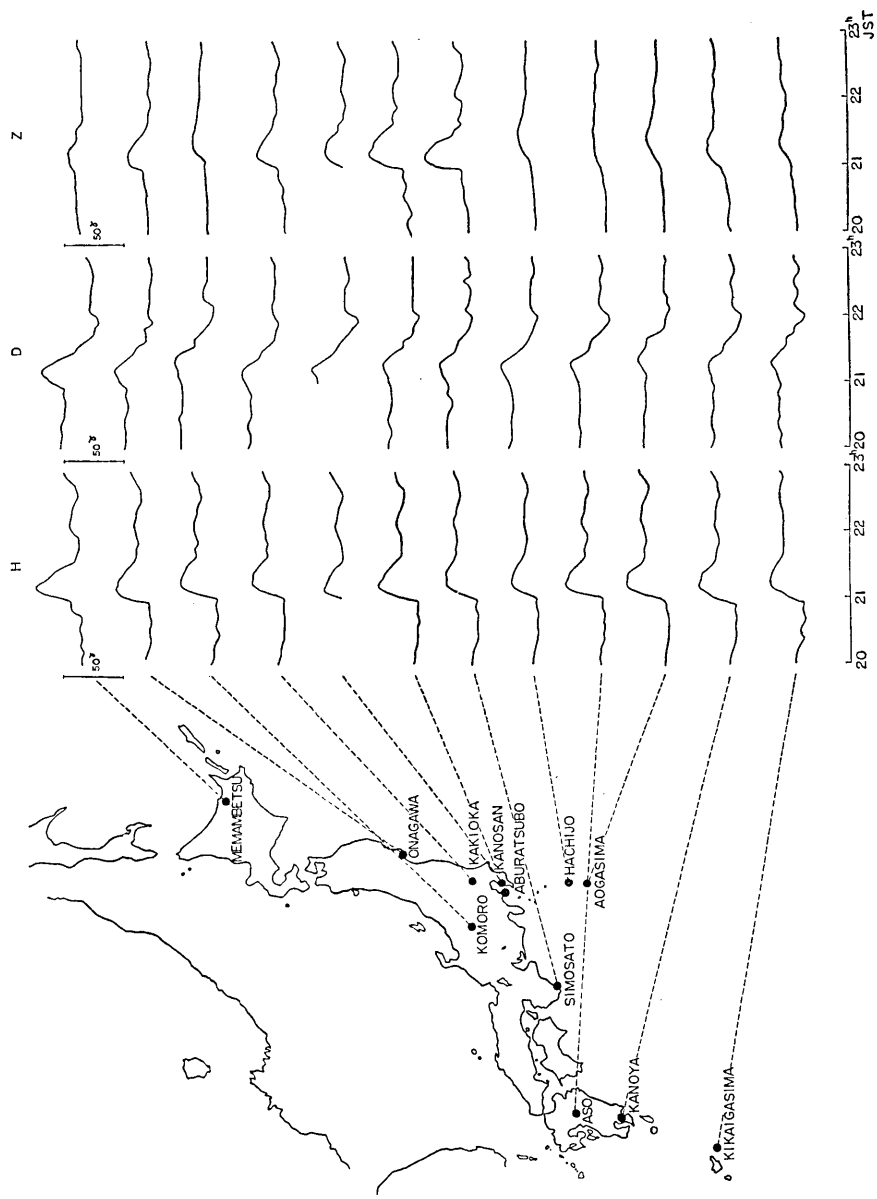

Fig. 5. The changes in the three geomagnetic components at the time of the bay on April 18, 1958 the locations of the magnetic stations being also shown.

On asssuming that the normal variation, that should have been observed if the bay did not occur, is given by the straight line connecting the beginning of the bay with its end, we define ΔH and ΔZ as the departures from the normal curves. ΔH and ΔZ at 12 *h* 10 *m* GMT, when ΔH seems likely to reach its maximum, are given in Table 2. With these values, the distribution of ΔZ may be illustrated as shown in Fig. 6. In order to make up the equal-variation lines of ΔZ, results of many previous observations at various places are also taken into consideration though we have no observation this time. The previous observations made at the southern part of Izu Peninsula and Ooshima Island are of special importance.

Table 2. ΔH and ΔZ at 12 *h* 10 *m* on April 18.

Station	ΔH	ΔZ
Memambetsu	30.5$^{\gamma}$	7.2$^{\gamma}$
Onagawa	22.8	12.8
Komoro	24.2	3.2
Kakioka	23.2	17.5
Aburatsubo	25.5	25.4
Simosato	20.9	29.8
Hachijo	19.7	4.0
Aso	26.5	3.5
Aogasima	25.6	4.8
Kanoya	22.8	8.8
Kikaigasima	21.8	4.2

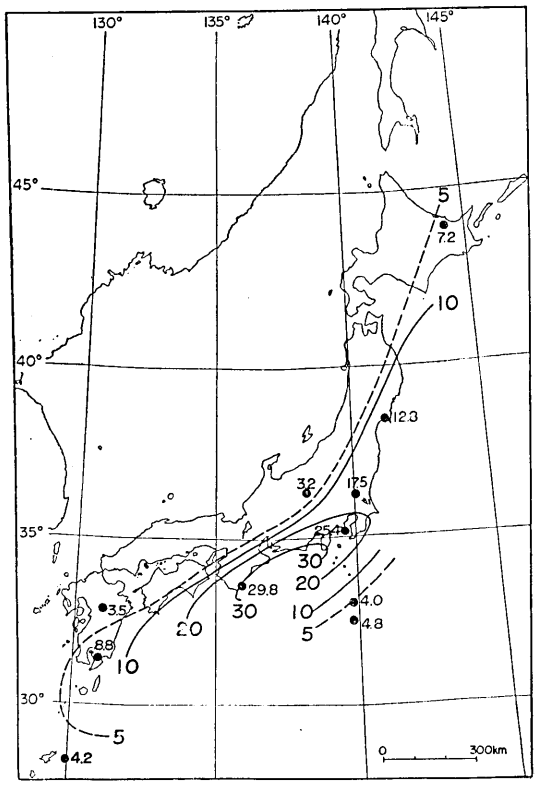

Fig. 6. The distribution of ΔZ for the maximum stage of the bay. (Unit: *gamma*)

At a glance, the general tendency of the distribution of ΔZ as demonstrated in Fig. 6 seems to be the same as that reported frequently in the writers' previous papers. It is important, however, that the southern extent of the anomaly can be brought out. Although practically nothing is known about the cause of such an anomaly, the present observation enables us to confirm that the anomalous area is a very con-

centrated one. From a close examination of ΔH, we see that its distribution is not utterly regular, for example, ΔH at Hachijo seems to be a little smaller than that expected from the general distribution. However, nothing definite can be said on this point until some more observations can be utilized from much denser net-work of observatories.

If we make up the distribution curve of ΔZ along a line connecting Komoro with Hachijo, which runs nearly perpendicular to the contours of ΔZ in the central part of Japan, we find that it is approximately symmetrical about the maximum point as can be seen in Fig. 7 in which values of ΔZ at stations in Central Japan are also shown by projecting their positions on the line concerned. The ΔZ curve thus obtained seems likely to be approximated with the magnetic field of a magnetic dipole, directed downwards, which is put in the earth right below the point for maximum ΔZ. It is found that the depth of the hypothetical dipole would be some 150 *km* in order to let its field on the earth's surface agree with the distribution shown in Fig. 7. Although the consideration of such a dipole is a matter of mathematical convenience, we may

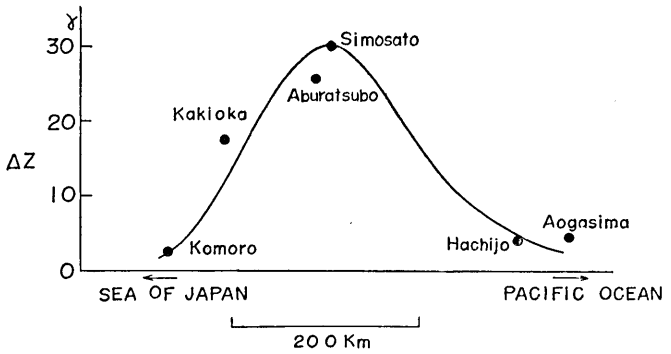

Fig. 7. The distribution of ΔZ along the line connecting Komoro with Hachijo. ΔZ's observed at stations around the anomalous area are also projected on the line.

take it that the origin of the anomalous distribution of ΔZ would lie somewhere at a depth not greatly different from that of the hypothetical dipole.

4. Geomagnetic changes that are likely to be associated with the solar eclipse on April 19, 1958

The influence of the solar eclipse on the earth's magnetic field ob-

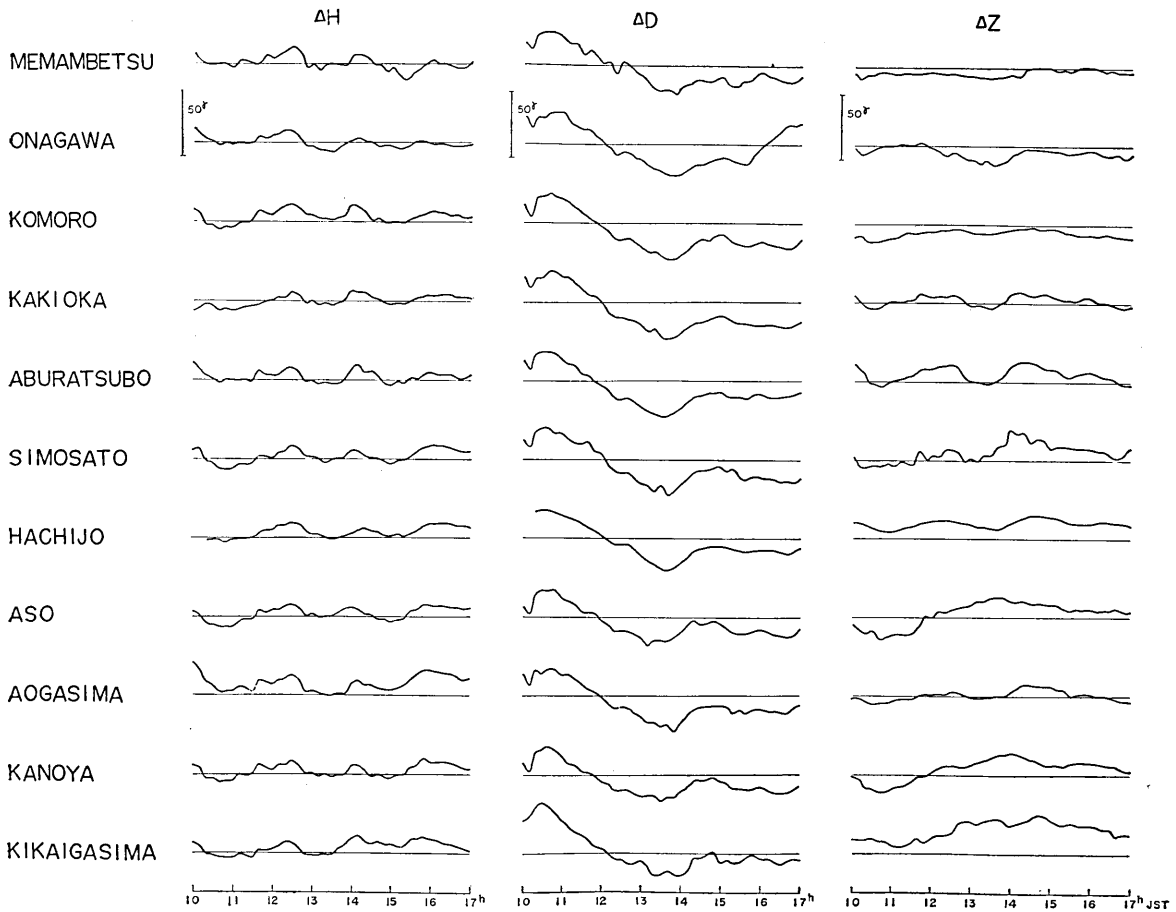

Fig. 8. Geomagnetic changes that are likely to be associated with the solar eclipse on April 19, 1958.

served during the present observation period will be reported in detail elsewhere[6]. However, it is of some interest to see how ΔZ will behave in the case of changes associated with a solar eclipse, because the overhead electric current system for such a change would be quite different from the one of a geomagnetic bay.

Fig. 8 shows the differences for the three geomagnetic components between the curves on the eclipse day and the ones obtained as the mean of a few calm days before and after the eclipse day. The marked decrease in the westerly declination at about 13 h JST may be regarded as the effect of solar eclipse. In ΔH, we observe a corresponding decrease during the interval from 12 h to 14 h. Meanwhile, ΔZ curves at Aburatsubo, Simosato and Kakioka are similar to ΔH curves, the amplitudes of the former being almost the same as those of the latter. At other stations, ΔZ is not so large as the values observed at the above three stations. We may thus say that the tendency that an anomalously large amplitude of ΔZ is observed in the central part of Japan can be also seen even in the case of the effect of a solar eclipse. The detailed characteristics of the geomagnetic changes relevant to the solar eclipse, however, will be published elsewhere.

5. Concluding remarks

From the results of magnetic observation during the observation period relevant to the solar eclipse on April 19, 1958, the extent of the area, in which we observe an anomalously large amplitude of ΔZ at the time of short-period geomagnetic variations, can be well located. Especially, it is found that the southern boundary of the area would lie somewhere around Hachijo-shima and Aogasima Islands. Consequently, the width of the area is found to be very limited, only 200 km being suggested for remarkable large amplitude of ΔZ as far as the distribution along a line connecting Komoro with Hachijo is concerned.

It is also pointed out that, even in the case of geomagnetic changes related to a solar eclipse, the anomalous tendency can be observed.

As for the cause of the anomaly, no definite idea can be obtained yet, though a rough estimate in regard to the depth of the origin has been tried. The model for the origin that has been discussed in the previous papers would still be the best explanation of the anomalous

6) T. RIKITAKE, S. UYEDA, T. YUKUTAKE, I. TANAOKA and E. NAKAGAWA, *Rep. Ionos. Res. Japan*, **12** (1958), 174.

phenomenon.

In conclusion, the writers thank the members of the Hachijo Weather Station with whose aid large parts of the observation on Hachijo-shima Island were carried out. The writers are also grateful to all the members of the magnetic stations, Memambetsu, Onagawa, Kakioka, Kanosan, Aogasima, Simosato, Aso, Kanoya and Kikaigasima, for copies of magnetogram by which the present work could be performed.

---

1. 日本に於ける地磁気短周期変化の異常と地下構造 (第8報)

地震研究所 { 力武常次 / 上田誠也 / 行武毅 / 棚岡巌 / 中川英子 }

1958 年 4 月 19 日の日本南方洋上に於ける日食の際に，日本全国に 12 カ所の地磁気観測所が設置された．この期間の観測結果を利用して，日本中部の地磁気変化異常地域の範囲を調べたところ，その南端は八丈島，青ガ島附近であろうことが推定された．
