Effect of the Solar Eclipse, 19 th April, 1958 on the Geomagnetic Field and Earth-current

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概　　要

1958年4月19日の日食に際し，女満別，柿岡，鹿屋の三地磁気観測所に於いて，地磁気，地電流に対する日食の影響を観測した．不幸にして，当日は磁気的には稍あれた状況であつた為に，地磁気，地電流の日変化に対する影響の量を決定的に見出すことはできず，再び次回の観測を待たねばならなくなつた．

§ 1. Introduction

As is well known solar eclipses afford unusual opportunities to study the influences of the sun on the geomagnetic field and earth-current. The same problems are examined by many authors since the last century. The effects of the solar eclipse on the geomagnetic field and earth-current seem to be appear on the solar daily variation, the lunar daily variation and the disturbance field. The lunar daily variation is so small that the deduction of the effect is boyond our ability. The disturbance field varies in an irregular and unpredictable way and it may be impossible to detect the effect. The solar daily variation on quiet days offers practically our only hope of detecting an effect of solar eclipse. Many studies are based on the idea that the solar eclipse diminishes the conductivity in the ionosphere and the current systems of the Sq field are deformed. On the basis of many observation which have been accumulated upto now, it seems certain that we observe a particular change in the geomagnetic field on occasions of solar eclipses, if geomagnetic conditions are favourable.

In the case of the annular eclipse on 19 th, April, 1958 the geomagnetic field was, unfortunately, rather disturbed and therefore no conclusive results can be obtained. But, the center of the eclipsed area goes on along the south-western part of Japan and the maximum magnitude of the eclipse are somewhat different from each other at each our observatories-Memambetsu, Kakioka and Kanoya–where we observed the changes geomagnetism and the earth–current.

And the comparison of the difference curves suggests that the effects of this solar eclipse on the geomagnetic field surely exist. The path of the maximum occultation and locations of three observatories are shown in Fig. 1. The observa-

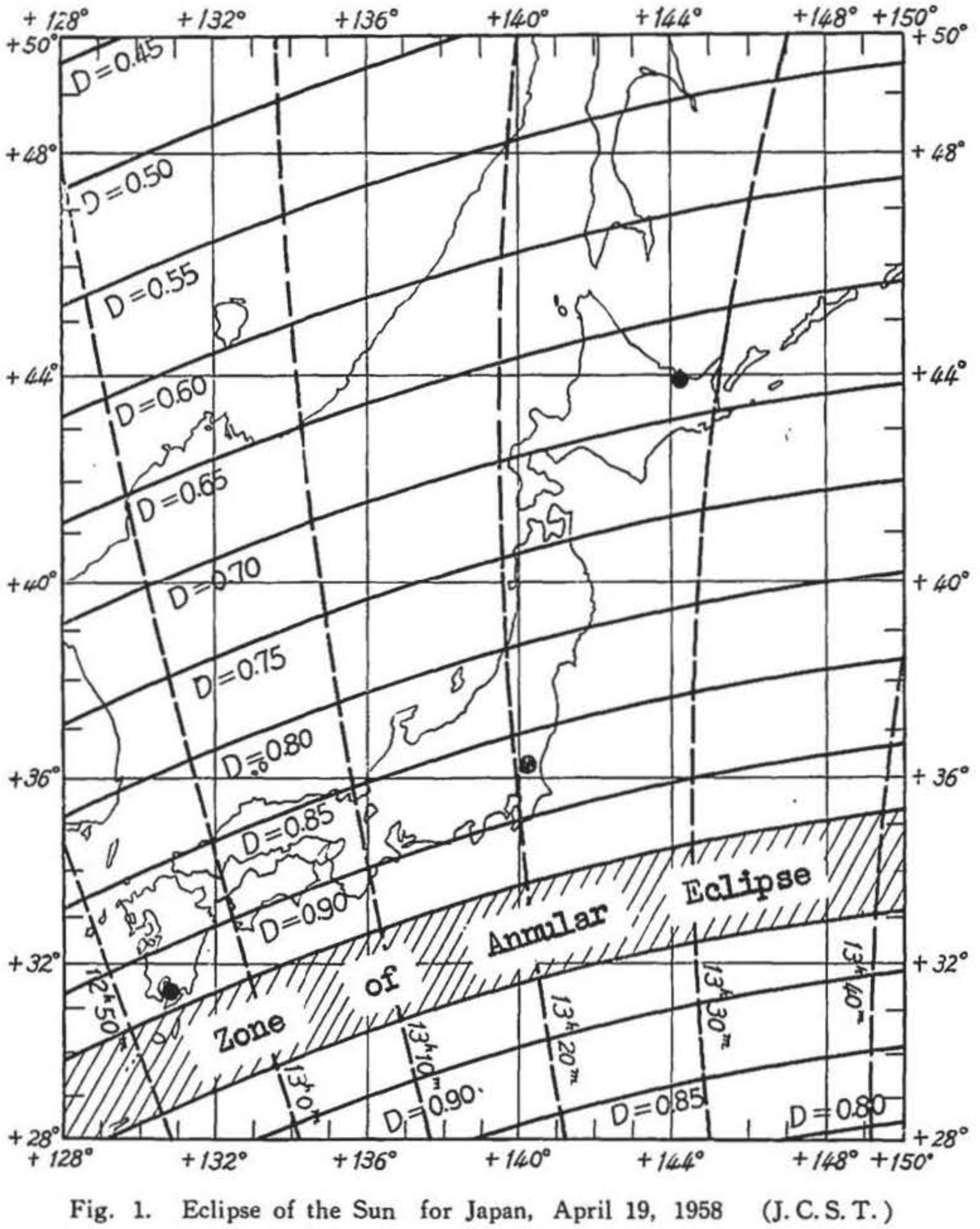

Fig. 1. Eclipse of the Sun for Japan, April 19, 1958 (J. C. S. T.)
——Loci of the points where the maximum magnitude of the eclipse (D) are the same.
······Loci of the points where the maximum magnitude of the eclipse occurs simultaneously.

tional instruments and methods which we employed are the same ones as those for routine works during the IGY, except that we mainly adopted the records of the rapid-run recording systems.

Table 1. Observatories

	Geographic Lat.	Geographic Lon.	Begin. Time	Ending Time	Max. Occultation	Time of Max. Occultation
Memambetsu	43° 55′	144° 12′	$2^h\ 52^m$	$5^h\ 55^m$	68%	$4^h\ 28^m$
Kakioka	36 14	140 11	2 33	5 49	87	4 20
Kanoya	31 25	130 52	2 02	5 43	93	3 54

§ 2. The effect on the geomagnetism

The magnetic field was stormy throughout April and there were few calm days. ΣK (daily sum of K-index) at Kakioka in April, 1958 are shown in Fig. 2. Although ΣK at Memambetsu and Kanoya are not shown, the conditions of the magnetic field are nearly same as that at Kakioka. Furthermore, the day-to-day changes of the Sq field make it very difficult to determine the normal curves on the eclipsed day, unaffected by the solar eclipse, which ought to be subtracted from the actual traces on the day. We took the averages of the traces on days, 8th, 9th, 10 th and 13 th April, 1958, as the normal curves. On the days, ΣK at Kakioka, are 10, 9, 10 and 11 respectively.

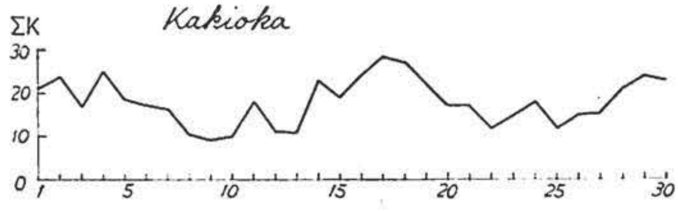

Fig. 2. Daily sum of K-index during April 1958, at Kakioka.

Deduced from observation every ten minutes during the eclipsed period, the difference between the obtained normal curves and the actual traces are calculated. These differences show considerable irregularities, due to the magnetic disturbances and it seems impossible to denote the effect. So, we calculated the running averages and obtained the smoothed curves. Each component at three observatories bear a striking resemblance to each other and scarecely dependent on the time of maximum occultation. The fact may suggest to us that the difference curves are more affected by the magnetic conditions, and we may not be able to conclude the magnitude of the effect.

Assuming the linear relation between the effect and the eclipsed area, the effect of the solar eclipse may be maximum at Kanoya and minimum at Memambetsu.

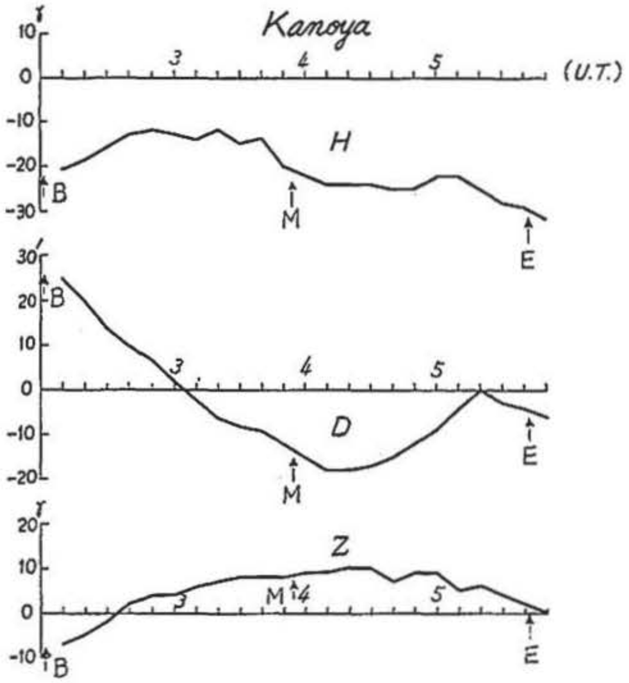

Fig. 3 a.

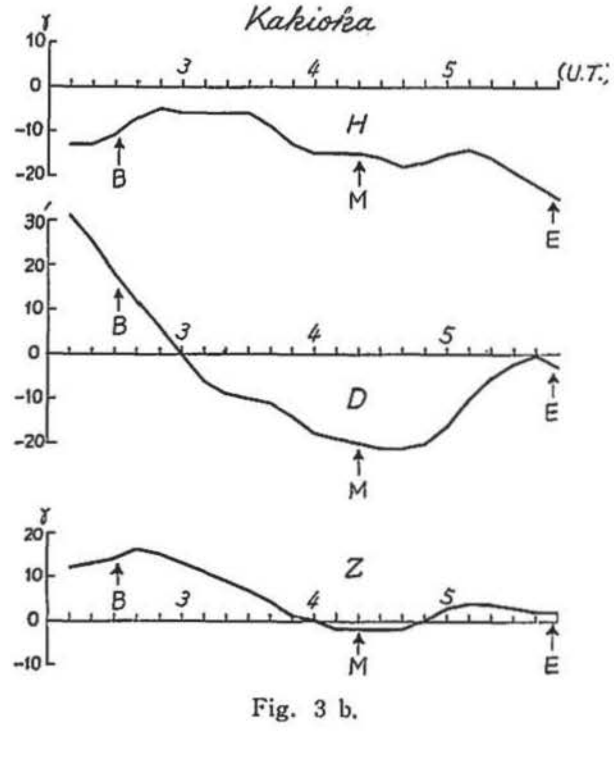

Fig. 3 b.

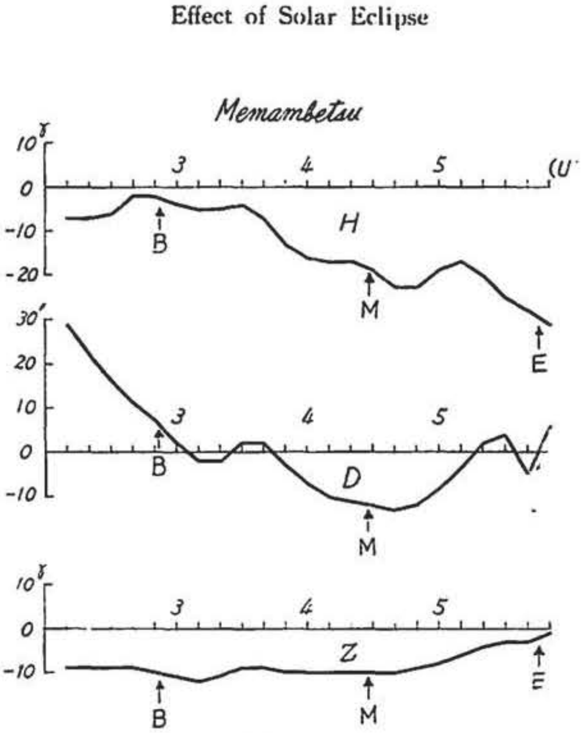

Fig. 3 c

Fig. 3. The difference curves for the three geomagnetic components at respective station as obtained from the actual observation.

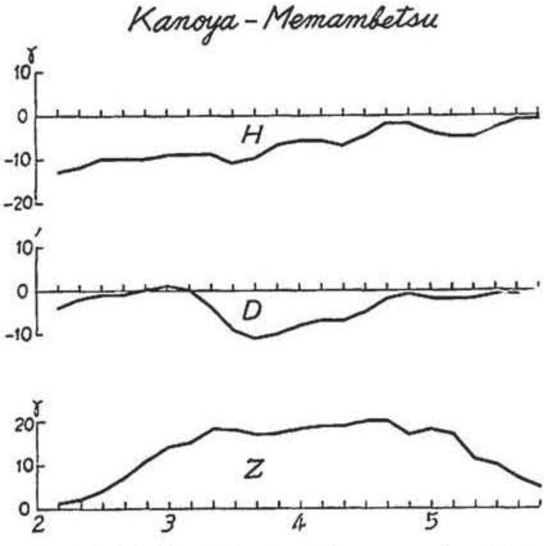

Fig. 4 (a). The differences between the effect at Kanoya and that at Memambetsu.

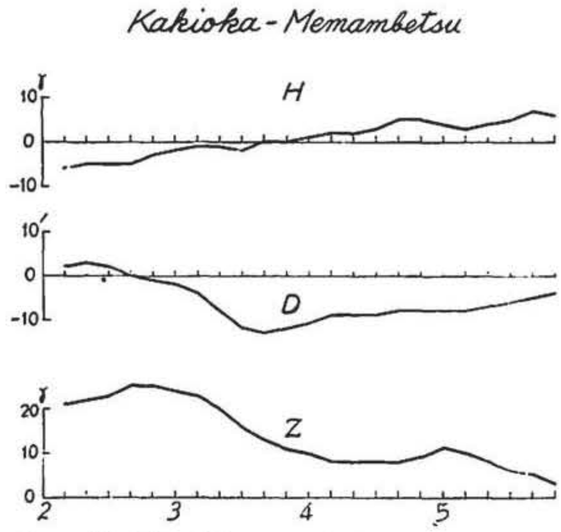

Fig. 4 (b). The differences between the effect at Kakioka and that at Memambetsu.

Therefore, when the difference curves at Memambetsu are subtracted from curves at Kanoya and Kakioka, the differences of the effects are remained, eliminating a part of world disturbance field. The deduced curves are shown in Fig. 4.

The figures may show it is difficult to say conscientiously magnitude of the effects, even when we take into consideration the difference of the maximum occultation at each observatory.

It seems likely that the nature of the geomagnetic change on occasions of solar eclipses can be explained by Chapman's theory. From such a view point, T. Nagata et al and H. Volland studied, theoretically the effect of the solar eclipse on the geomagnetic field [2], [3]. In this discussion, we adopted the same method as Volland's. But, we have not still in hand knowledges about the geographical distribution of the electric conductivity in the ionosphere during this eclipse. Therefore it is assumed as the same as that of the eclipse on 30 th, June 1954 [4] and define $\mathcal{E}=(\sigma_q-\sigma_{min})/\sigma_q$, where σ_q is the electric conductivity which produces Sq and σ_{min} the minimum value of the conductivity of the eclipsed area in the ionosphere. We take a spherical coordinates $(\gamma, \theta, \lambda)$ with the center of the eclipsed area as its pole.

Assuming that the currents for Sq are uniform, the affected fields are obtained as follows,

$$H_\theta=\mathcal{E}H_qX(\theta)\ \sin\lambda$$
$$H_\lambda=\mathcal{E}H_qY(\theta)\ \cos\lambda$$
$$H_\gamma=-\tfrac{1}{2}\mathcal{E}H_qZ(\theta)\ \sin\lambda$$

where Hq is the horizontal component of Sq at the center of the eclipsed area on the earth and $X(\theta)$, $Y(\theta)$ and $Z(\theta)$ are some functions of θ. And then, we transform the coordinates, adjust the changes of the direction of Sq current as the center of the eclipsed area goes on and calculate the components along the direction of the local magnetic north and east.

The curves in Fig. 5 are obtained by substituting $\mathcal{E}=0.5$, $H_q=30\gamma$ and assu-

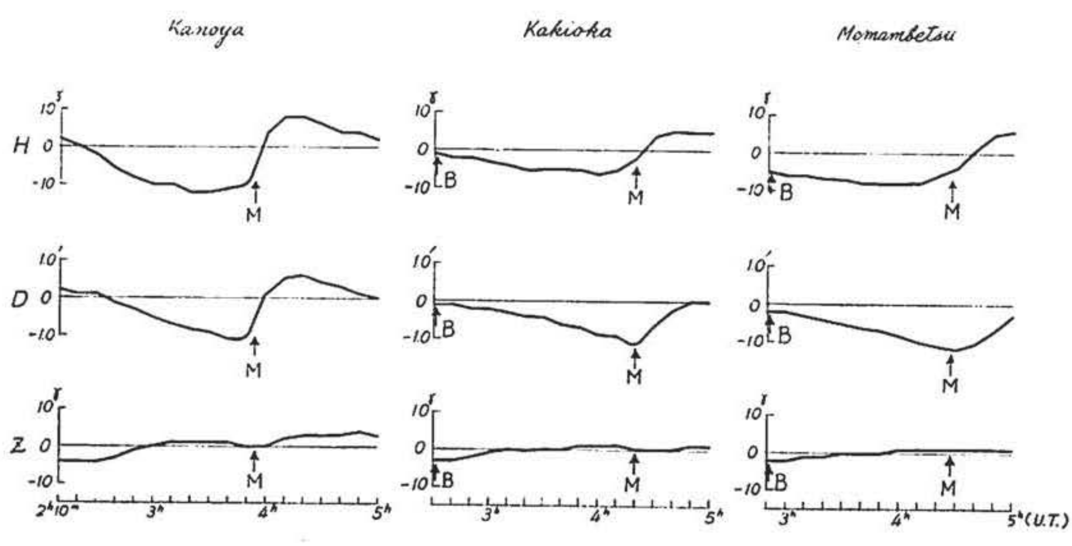

Fig. 5. The calculated differences in the three geomagnetic components at respective station.

ming that the height of the current sheet is 150 km. The calculated and the observed values are nearly same order in its magnitude and its courses are approximately coincident. Especially, the coincidence of the declination is distinguishable. The discrepancy between the observed and the calculated curves may be attributed to the magnetic conditions which influence on the observed curves, and the assumption in calculation that the Sq field is uniform. The latter is the rough assumption, especially in such cases as the center of the current system of Sq goes on near by the belt of the maximum occultation.

§ 3. The effect on the earth-current

Concerning the earth-current, the circumstances are more complicated. We must take into consideration the locality when we discuss the observations of the earth-current. Although the relation between the geomagnetism and the earth-current potential are not very plain, we may think the induced current within the earth by the electric current flowing in the ionosphere as the earth-current. Then, the effect of the solar eclipse on the earth-current may, if any, be detectable through the same procedure as the geomagnetism. The smoothed curves are shown in Fig. 6. The normal curves are deduced from the records on 8 th, 9 th, 10 th and 13th, April.

Here, under magnetically disturbed conditions, we have scruple about answering

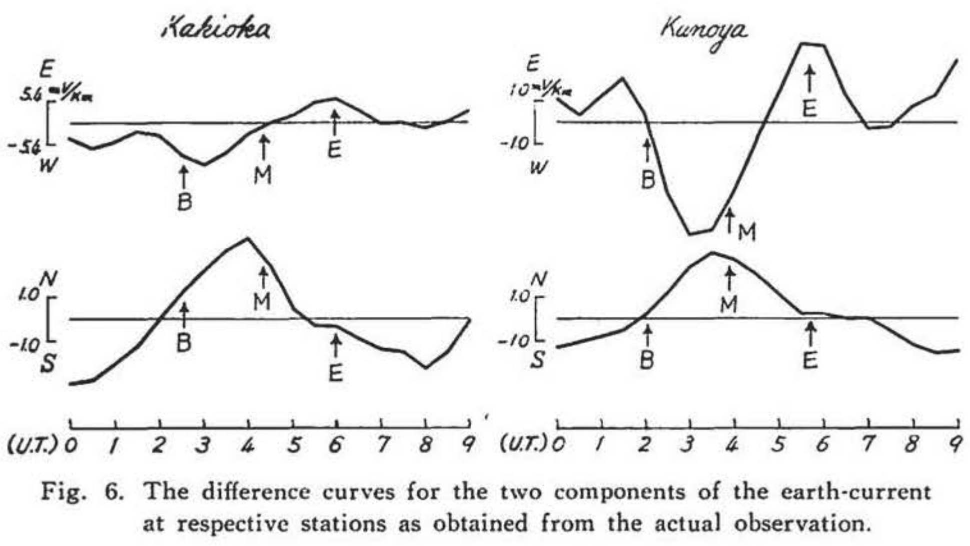

Fig. 6. The difference curves for the two components of the earth-current at respective stations as obtained from the actual observation.

to the question " How much parts of the differences are the true effects of the solar eclipse ? ". However, the good resemblance between the curves in Fig. 5 and those in Fig. 6——EW component to horizontal component and NS component to declination——may not be fortuitous.

§ 4. Conclusion

On the basis of the observations of the geomagnetism and earth-current potential at Kakioka, Memambetsu and Kanoya, the effect of the solar eclipse on 19 th, April 1958 on them (mainly on solar diurnal variation on calm days) are examined.

Owing to the magnetical conditions, conclusive results cannot be obtained but the observed effects fairly coincide with the calculated values.

In the case of the solar eclipse, a temporary night appears. Otherwise, it is said that the occurence of the variation of the terrestrial magnetic field, such as pulsations, bays etc. depends on the local time. Also, the magnitude of them depends on the local time. It may be possible, therefore, they are affected by temporary night in case of the solar eclipse.

We examined the circumstances and the results will be published in near future.

In concluding the present report, the writers express their sincere thanks to Dr. T. Yoshimatsu Director of the Kakioka Magnetic Observatory and the staff who encouraged the present study. We are much indebted to the members of the Memambetsu and Kanoya Magnetic Observatory for reducing the observational data.

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