

9. *Spatial Dependence of Short-period Geomagnetic Fluctuations on Oshima Island (1).*

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Summary

Simultaneous observations with three portable magnetometers are made at a number of stations on Oshima Island, a volcanic island about 100 km south of Tokyo. The observations bring to light remarkable differences in short-period Z variation between various stations on such a small island, approximately 10 km in diameter. Z variations having a period of 30 min. or so show a complete reversal of sign between the north and south sides of the island, while no marked differences are found for slower variations such as S_q . Such an anomaly seems to be caused by electric currents induced in the surrounding sea-water by changes in the geomagnetic field of external origin. Statistical as well as spectral analyses are made on the available data obtained along the N—S profile. Even if the anomalous part due to the sea-water effect is removed on a simple assumption, it seems likely that there still remains a substantial enhancement of the Z variations of short period. It is therefore concluded that Oshima Island belongs to the anomalous area of the "Central Japan Anomaly" which has been well-established by nation-wide observations in the past.

1. Introduction

Three sets of portable flux-gate magnetometers were purchased by the Earthquake Research Institute in 1966 with the object of making simultaneous observations of geomagnetic variation anomaly with a dense network of temporary observatories. In order to test these instruments the writer has operated them on Oshima Island since April. It so happened that short-period fluctuations (say 10-30 minutes' period) of the vertical component were found to show a complete reversal of sign between the north and south sides of the island.

It was discovered only recently that short-period geomagnetic fluctuations differ substantially in amplitudes and phases of the vertical component at various points on an island. Mason¹⁾ reported on phase reversals of the short-period vertical variations and even the phase differences of up to 70° in the Z component of Sq (Solar daily variation on quiet days) between the opposite sides of Christmas Island. He conducted simultaneous observations at various points on the island using two portable three-component variometers, and concluded that such anomalies are caused by the electric currents induced in the surrounding ocean. Since then similar phenomena have been found on Oahu²⁾, Canton³⁾ and Puerto Rico Islands⁴⁾. Such a geomagnetic variation anomaly on an island has now become to be called the "island-effect", although we still have not arrived at a full understanding of its cause.

The spatial dependence of short-period vertical fluctuations discovered on Oshima Island has a strong resemblance to the "island-effect". As has been reported in a series of papers in this bulletin and summarized by Rikitake⁵⁾, we observe anomalous Z variations of short period in the central part of Japan. We could determine the extent of anomalous area on Japan Islands rather well, while its south-eastern border is still ambiguous because of the technical difficulties of measuring geomagnetic variations on and beneath the sea. All the existing data have been obtained on the tiny island observatories such as Oshima, Hachijojima and so on. It would be of importance to investigate how the "Central Japan Anomaly" is affected or modified on Oshima by the "island-effect", together with a study of the "island-effect" itself.

It is intended in this paper to report on the results of observations and analyses of the records obtained at various points on Oshima Island. In section 2 will be given a brief description of the magnetometers; and in section 3 the field program. The writer still continues observations on Oshima. Sufficient data have been obtained only for the N—S profile, to which the following report will be limited. The results of analyses on the N—S profile will be described in section 4 and some discussion will be made in section 5. Results of further analyses now

1) R. G. MASON, *Geophysics Department, Imperial College of Sci. and Tech.*, REF. 63-3 (1963).

2) R. G. MASON, *Trans. Amer. Geophys. Un.*, 44 (1963), 40.

3) R. G. MASON, *Geophysics Department, Imperial College of Sci. and Tech.*, REF. 64-1 (1964).

4) D. ELVERS and D. PERKINS, *Trans. Amer. Geophys. Un.*, 45 (1964), 46.

5) T. RIKITAKE, *Geophys. Jour.*, 2 (1959), 276.

in progress and, if possible, a more advanced study on theoretical interpretation of this phenomenon will be given in the future.

2. Instrument

The instruments used are flux-gate type magnetometers, compactly designed for the convenience of transportation. The detector and the amplifier are shown in Fig. 1 (a) and (b) respectively. The working principle of flux-gate magnetometer can be found elsewhere (e.g. Whitham,⁶ 1960).

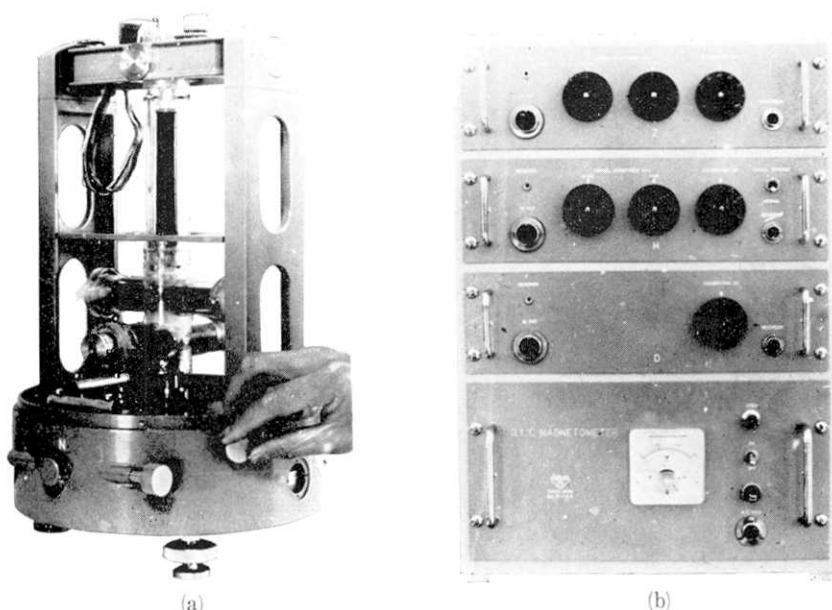


Fig. 1. Flux-gate magnetometer (a) the detector, (b) the amplifier.

The writer first operated these instruments on the premises of the Oshima Magnetic Observatory, which is a permanent station of the Earthquake Research Institute established at Nomashi in 1959. It was ascertained that the records of the instruments show a fair parallelism with each other and with the magnetogram obtained by a photo-recording variograph operated there. As the test period was not so long, we could not check the possible instrumental drift over a few weeks' period.

6) K. WHITHAM, *Measurement of the geomagnetic elements*. In: S. K. RUNCORN (Editor), *Methods and Techniques in Geophysics*. Interscience, New York, N. Y., 1: 104-167.

But so far as short-period variations and daily variations are concerned, the magnetometers work very well and no systematic differences are found between them within an accuracy range of 1 gamma or so. The chart speed is kept at 50 mm/h and hourly time marks are recorded on the chart by a signal supplied from a crystal clock. Since the recorder is of a multi-channel type and geomagnetic variations are plotted at 15 seconds' interval, very rapid variations such as micropulsations cannot be observed. It may be said, therefore, that the magnetometers cover a period range of a few minutes to several days. Such a frequency response of our instruments would be sufficient for investigating local conductivity anomalies of the crust and the upper mantle.

3. Field program

Fig. 2 shows the location of Oshima Island. It is very close to Honshu Island, the main land of Japan, and surrounded by a rather shallow sea. The writer has operated the magnetometers at seven points on the island, the localities of which are illustrated in Fig. 3.

Oshima Island is a volcanic one and Mt. Mihara at its center is still active. As lava on Oshima Island is abundant in magnetic minerals, the

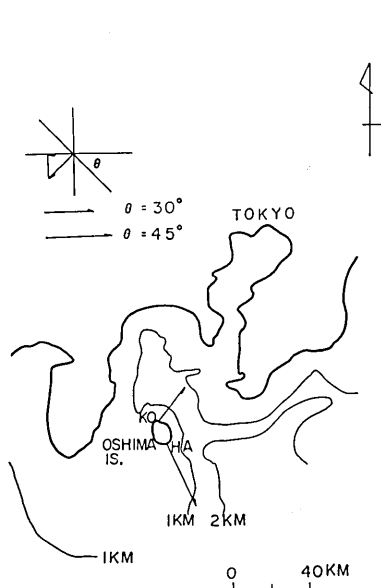


Fig. 2. Location of Oshima Island. The arrows indicate the Parkinson vectors.

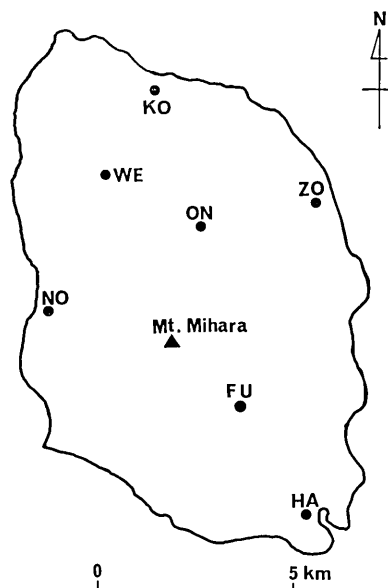


Fig. 3. Localities of the observational points.

declination of the geomagnetic field differs much from place to place. We measured the exact direction of the H axis (magnetic north) relative to the geographic north at each point using a 2nd-order G.S.I. travelling magnetometer. Positions and abbreviations of the observational points are tabulated in Table 1, together with their declinations.

Table 1. Locations of observational points

No. Station	Abbr.	Long.	Lat.	Dec.
1 Nomashi	NO	139° 11.5' E	34° 43.8 N	4° 50' W
2 Onsen Hotel	ON	24.2	45.3	9 30
3 Oshima Zoo	ZO	26.4	45.0	8 50
4 Weather Station	WE	22.5	45.7	5 10
5 Kowakien Hotel	KO	23.5	46.9	6 40
6 Habu	HA	25.9	41.0	7 50
7 Futagoyama	FU	24.9	42.5	—

The writer has conducted the observations under the following field program.

I. North-South profile

- a) KO—ON—NO—HA May—August, 1966.
- b) ON—NO—FU Sept.— 1966.

II. East-West profile

- a) ZO—ON—WE—NO April, 1966.
- b) ZO—ON—NO Sept.— 1966.

During the earlier period of the E—W profile observation (April), we could not obtain sufficient records of geomagnetic disturbances. The following N—S profile observation having manifested remarkable discrepancies of Z variations, one of the instruments was again set at ZO in September for making further observations of the E—W profile. Another set was also moved to FU, in order to obtain further information about the N—S profile. During the whole period, one instrument was operated at ON to serve as a standard, which is situated near the center of the island and is thought to suffer the sea-water effect less than at any other point.

4. Results of observations and analyses on the N—S profile

4-1. The N—S profile of typical isolated events

Fig. 4 shows a typical feature of some short-period variations along

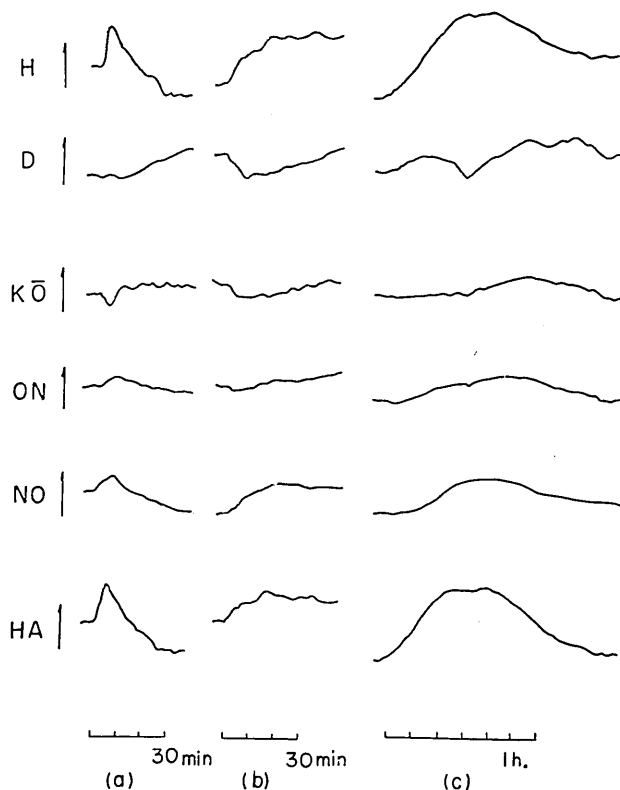


Fig. 4. N-S profile of typical isolated events; (a) an s.s.c. occurred at 03:40 U. T. on May 31, (b) an s.s.c. occurred at 23:25 U. T. on May 25, (c) a bay-like event occurred at 19:00 U. T. on May 31. Arrows indicate 30 gammas.

the N—S profile. In the case of an s.s.c. in Fig. 4 (a), we can clearly see that the phase delay of the Z variation relative to the H one increases as we go from the south to the north, amounting to almost 180° out of phase at KO. When a rapid fluctuation is accompanied with an E—W component variation as shown in another case of an s.s.c. in Fig. 4 (b), the Z variation is affected by the D component at KO and ON, while the Z variation at HA and NO has nothing to do with the D. For a bay-like variation (Fig. 4 (c)) having a longer duration and showing a more gradual increase than s.s.c.'s, the modification of the Z component seems to be weakened.

In Figs. 5-1, 5-2, 5-3 and 5-4, short-period fluctuations superposing on a storm are illustrated for points KO, ON NO and HA respectively.

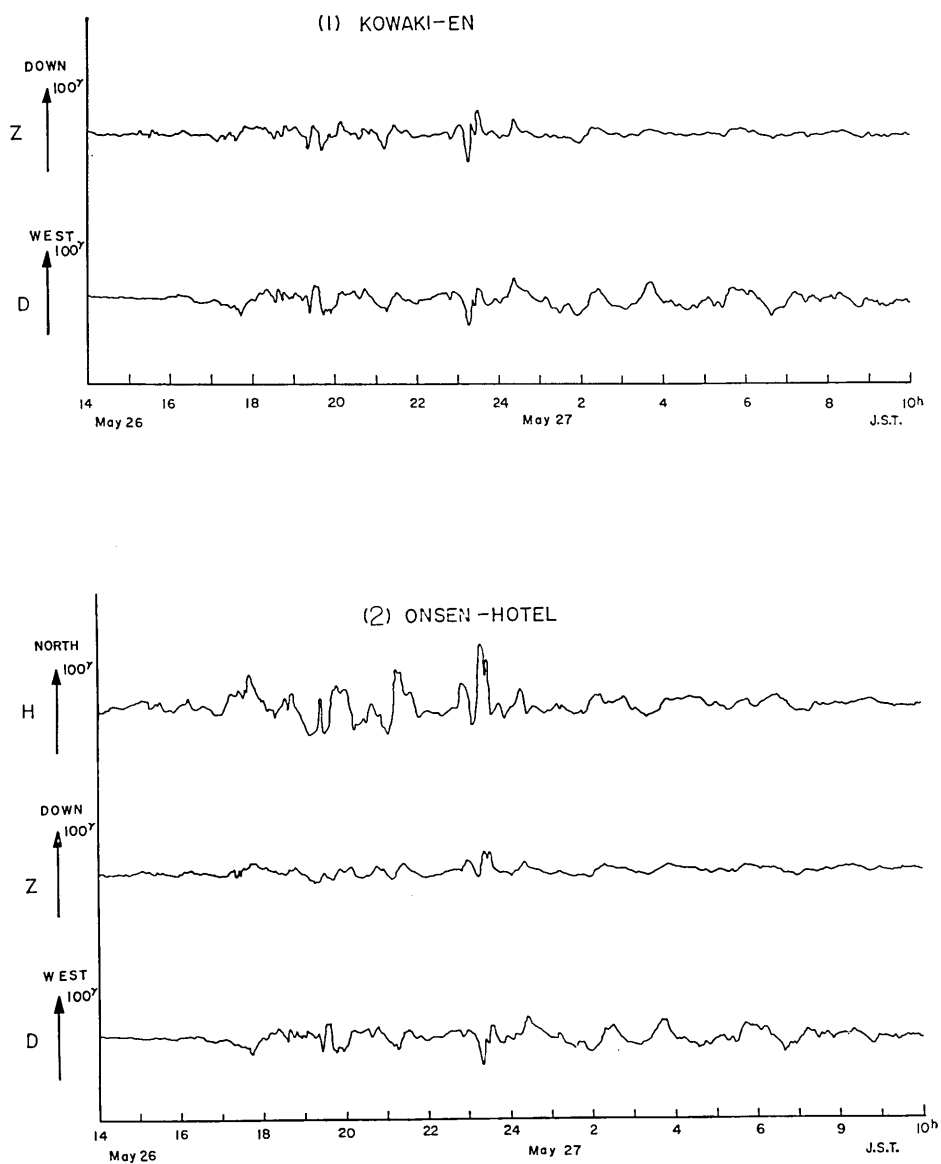


Fig. 5

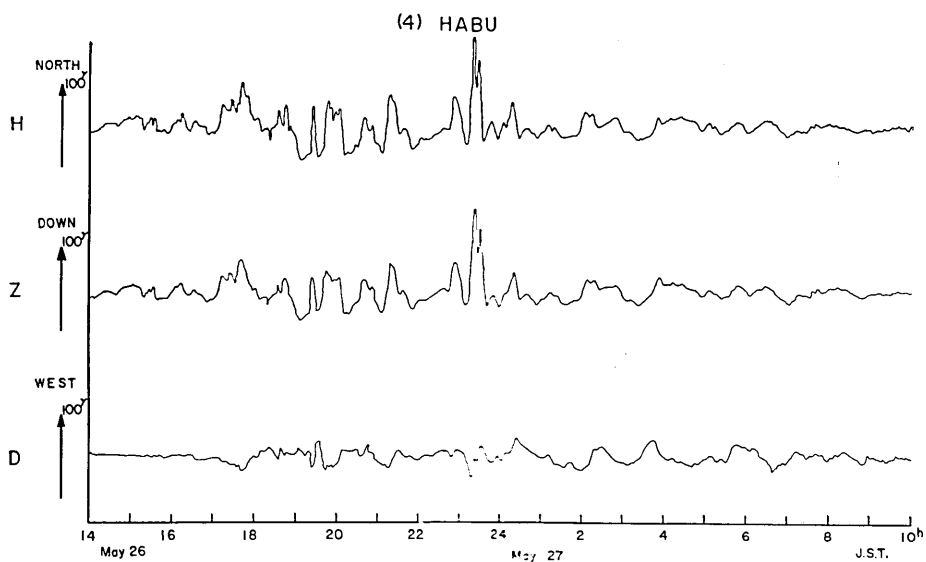
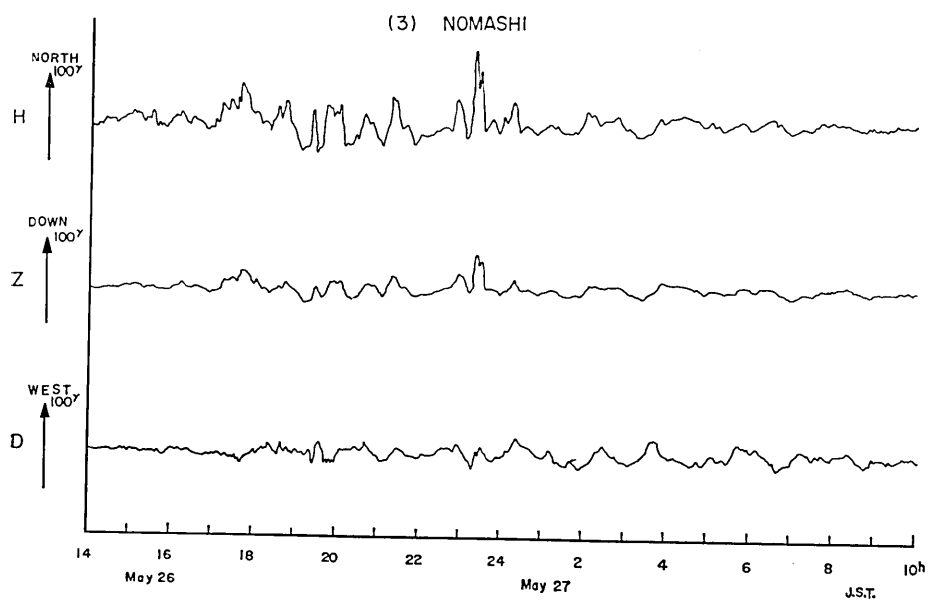


Fig. 5. Short-period fluctuations superposing on a storm (May 26 5 h U. T.—27 1 h U. T., 1966) observed at (1) KO, (2) ON, (3) NO, (4) HA.

Similar tendencies mentioned above are confirmed again in these figures. Slower variations including Dst and daily variations are eliminated by a numerical high-pass filter described below. (After R.G. Mason⁷⁾).

Let $x_1, x_2, \dots, x_i \dots x_N$ denote the original record digitized with a sampling interval Δt . The weighted running mean at each instant is calculated as follows :

$$x'_i = x_{i+m} - \sum_{j=-m}^m W_j \cdot x_{i+m+j}, \quad (1)$$

where W_j is a weighting factor and given by :

$$W_j = (1 + \cos \pi j/m)/2m. \quad (2)$$

The response of this filter is

$$A = [1 - Q(f)]^2, \quad (3)$$

where

$$Q(f) = Q_0(f) + \frac{1}{2} Q_0(f+f') + \frac{1}{2} Q_0(f-f'), \quad (4)$$

$$Q_0(f) = \sin 2\pi f m \Delta t / 2\pi f m \Delta t, \quad f' = 1/2m \Delta t,$$

and thus the cut-off period T_c is given by :

$$T_c = m \cdot \Delta t. \quad (5)$$

In the present case, $\Delta t = 2.4$ min. and $m = 50$ are taken, and therefore variations shorter than 2 hours are taken out in Figs. 5. These filtered data were used for the spectral analysis, the results of which will be described later.

4-2. Statistical analysis

As shown in Figs. 5, the Z variations at HA resemble the H and seem to have nothing to do with the D, while at other points the Z variations show more or less similarity to the D. In order to discuss this tendency more quantitatively, we investigated the statistical relation between the vertical and the horizontal components for short-period fluctuations. Selecting about 70 samples of isolated geomagnetic events having durations shorter than 30 min., we read their maximum ampli-

7) R. G. MASON, *Scripps Institution of Oceanography Reference* 63-13 (1963).

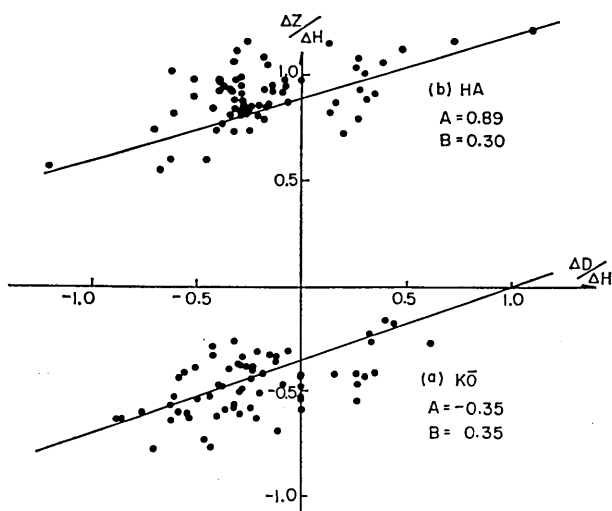


Fig. 6. $\Delta Z/\Delta H$ values plotted against $\Delta D/\Delta H$ at (a) KO, (b) HA.

tudes ΔZ , ΔH and ΔD in gammas. For longer variations such as bays the Z variations are not always in phase with the horizontal variations, and hence the following analysis is impossible. The phase delay of Z variations relative to the H and D occurs even in the case of shorter period fluctuations as can be clearly seen in Fig. 4 (a) and (b), but we neglected it and read the ΔZ 's referring to the maximum epoch of the H variations. $\Delta Z/\Delta H$ values against $\Delta D/\Delta H$ at KO and HA are plotted in Fig. 6. They scatter substantially, partly because of errors in the original reading process and partly because the period range adopted may be rather too wide, but the ratio $\Delta Z/\Delta H$ seems to be linearly correlated with $\Delta D/\Delta H$. If we assume a linear correlation between $\Delta Z/\Delta H$ and $\Delta D/\Delta H$, the following relation holds good:

$$\Delta Z = A \cdot \Delta H + B \cdot \Delta D. \quad (6)$$

This means that short-period disturbance vectors are confined on a plane characterized by the coefficients A and B , and this plane is nothing but the "preferred plane" originally studied by Rikitake and Yokoyama⁸⁾ and Parkinson⁹⁾. The horizontal projection of a unit vector normal to the "preferred plane" is called the "Parkinson vector" or the "induction arrow" and represents the inclination and the azimuth

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

9) W. D. PARKINSON, *Gcophys. Jour.*, 2 (1959), 1.

of the plane. It has been reported that at magnetic observatories near the sea shore this plane can be defined with a good accuracy and the arrow points to the deep sea. A qualitative explanation of this phenomenon is given in such a way that the sea-water behaves as a perfect conductor for short-period variations and reflects lines of force, and hence disturbance vectors tend to lie on a plane along the conductor.

The orientation and the magnitude of the Parkinson vector is given as follows:

$$\phi = \tan^{-1} \frac{B}{A}, \quad \theta = \tan^{-1} \sqrt{A^2 + B^2}, \quad l = \sin \theta \quad (7)$$

where ϕ is the azimuth of the vector measured counterclockwise from the magnetic south and l the magnitude, while θ is the inclination of the preferred plane.

Quantities determining the preferred plane at KO and HA are summarized in Table 2 and the Parkinson vectors are illustrated in Fig. 2.

Table 2. Parkinson vector at KO and HA

St.	A	B	ϕ	θ	l
KO	-0.35 ± 0.02	0.35 ± 0.02	N45°E	26°	0.44
HA	0.89 ± 0.01	0.30 ± 0.03	S19°E	43°	0.68

Arrows turn to the deep sea side, which is consistent with the general characteristics reported by many researchers. This result strongly suggests that the sea-water behaves as a perfect conductor for rapid geomagnetic fluctuations and reflects the varying external fields.

4-3. Spectral analysis

If the frequency dependent behavior of the Oshima geomagnetic variation anomaly becomes clear, it would certainly provide a clue to a more realistic understanding. The spectral analysis technique seems to be the best means for such a purpose. Following the method developed by Munk and others¹⁰⁾, the writer made a spectral analysis of magnetograms of a storm which occurred on May 26, 1966. The 24-hour records of the storm main phase (May 26, 3 h. U. T. to 27, 3 h. U. T.) were hand-digitized with a sampling interval 2.4 min. In order to eliminate the contamination of longer period variations, the original data were high-

10) W. MUNK, *et al.*, *Bull. Scripps Institution of Oceanography*, 7 (1959), 223.

pass filtered as described in section 4-1. This operation reduces the length of the analysed record to 20 hours. The frequency range was chosen from 0 to 50 cycles per 240 min., and the first two harmonics ($F=0$ and $F=1$) should be omitted.

Figs. 7, 8 and 9 show the power spectra of Z, H and D components respectively. Since the number of the degree of freedom is 19.5, the 80% confidence limits are calculated as 1.62 to 0.70 multiplied by each estimated power. Errors due to the original reading process are at most $0.03 \gamma^2/\text{c.p. 240 min.}$ The Z powers at HA are significantly large for the whole periods and they decrease gradually from the south to the north. Taking the confidence limits into account, we see that no remarkable discrepancies in the H and D components are found between the four stations. The record of the H component at KO is missing because of an instrumental error, but another analysis of a storm on May 31 tells us that the H powers at KO are almost the same as those

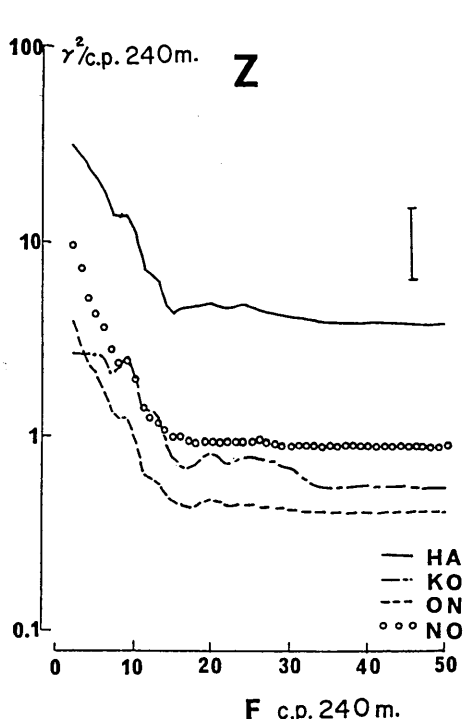


Fig. 7. Power spectra of the Z component. The error flag indicates the 80% confidence limits of the estimated values.

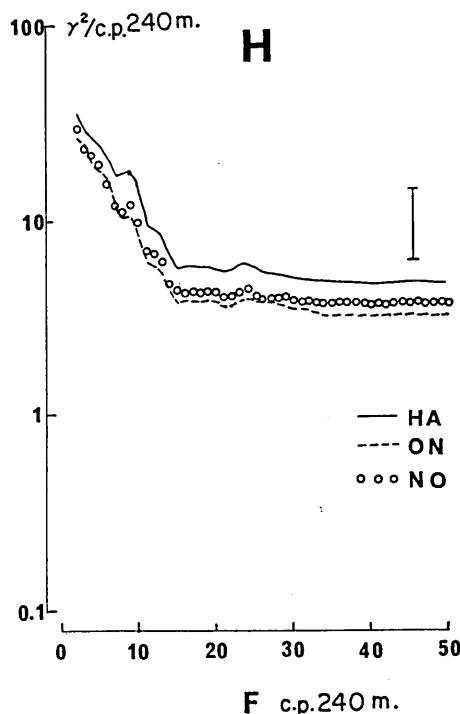


Fig. 8. Power spectra of the H component.

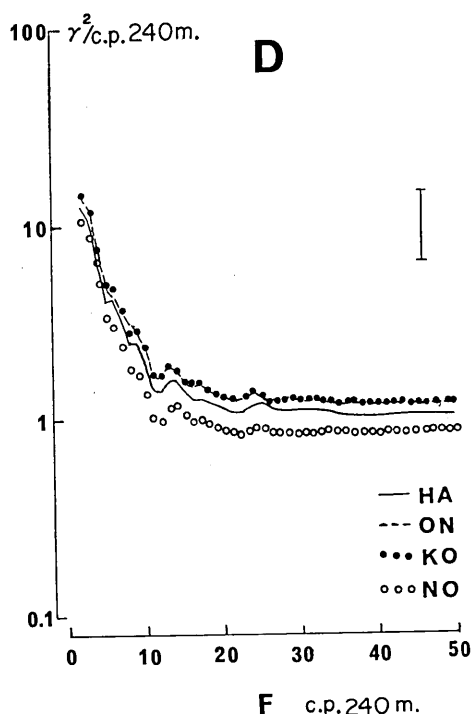


Fig. 9. Power spectra of the *D* component.

obtained at other points. In the case of the latter storm, however, the records were not so disturbed and the analysed period was short, which made the results less reliable; hence, the writer does not here report on them.

Coherences and phase differences between *Z* and *H*, and *Z* and *D* at each point are calculated and illustrated in Figs. 10. Fig. 10 (a) indicates that the *Z* component at HA varies very coherently with *H* and is independent of the *D*. The coherence between *Z* and *H* becomes poorer while on the contrary the similarity of *Z* to *D* increases from south to north. But as a whole the *Z* component has a better coherence with *H* than with *D*. When the coherence is poor, the estimated values of phase difference are unreliable. For the period range

of 30 minutes to 2 hours (2–8 c.p. 240 min.) where the coherences between *Z* and *H* are good, a development of phase delay of *Z* relative to *H* is clearly observed from south to north, this tendency seeming to be strengthened as the frequency increases.

The results of the spectral analysis reported so far produce the following conclusions:

(1) Along the N–S profile, the observed anomaly of *Z* variations are associated mainly with *H* variations.

(2) Judging from the power spectra, the secondary part of *Z* component intensifies the primary part at HA, is in opposition to it at KO, and is minimized at the intermediate points ON and NO. The term “secondary part” is regarded as the locally induced field which causes the Oshima anomaly, while the “primary part” means the regional external and internal field including the “Central Japan Anomaly” and is considered as being uniform over the island.

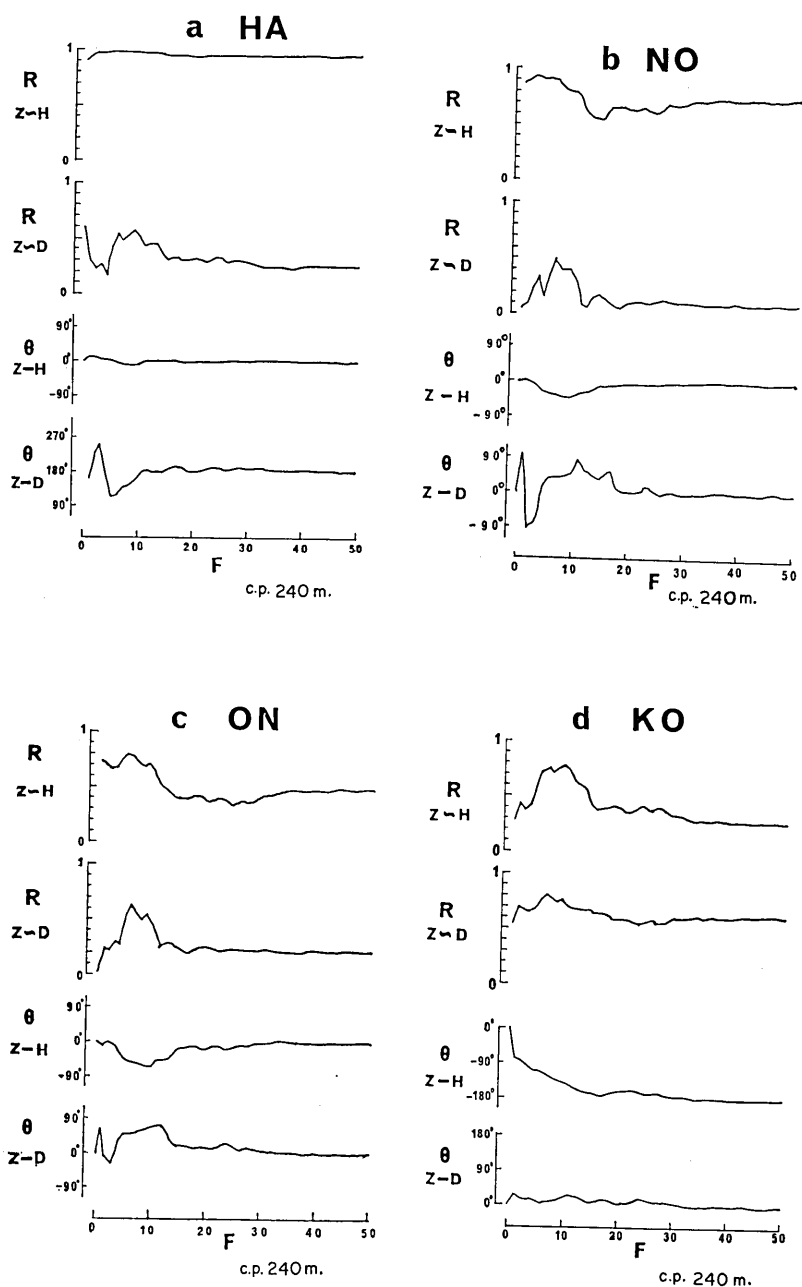


Fig. 10. Coherence (R) and phase difference (θ) spectra between Z and H, and Z and D at (a) HA, (b) NO, (c) ON and (d) KO.

(3) The phase difference in spectral analyses suggests that the secondary part becomes larger compared with the primary part as the frequency increases.

4-4. The N—S profile of an Sq

We have so far been concerned with short-period variations only. It would also be of importance to investigate whether such an anomaly appears in slower variations. Fig. 11 shows an Sq variation on May 22

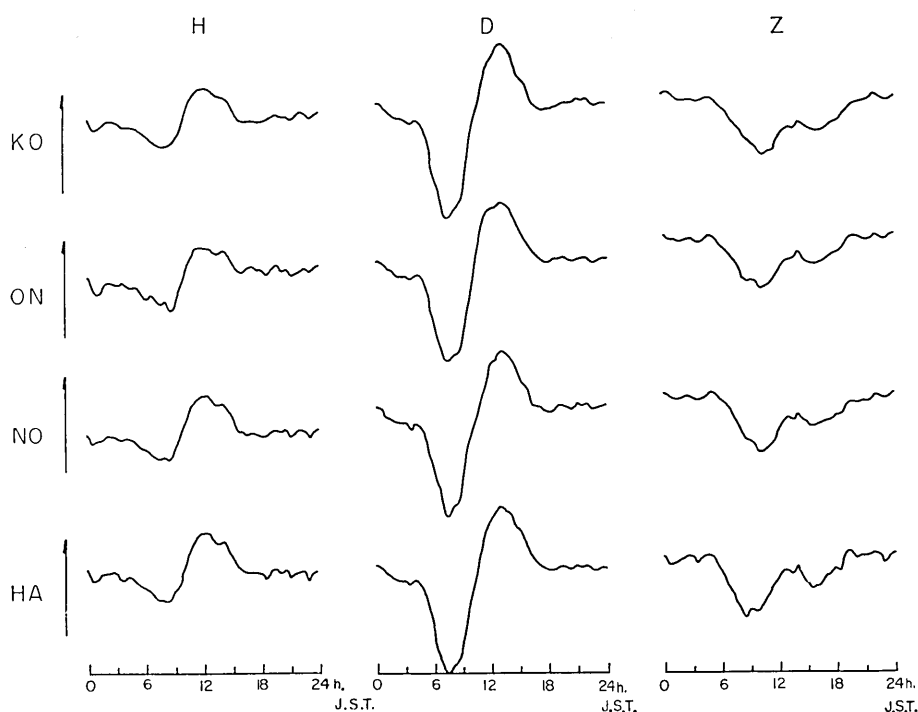


Fig. 11. N—S profile of an Sq variation on May 22. Arrows indicate 50 gammas and north-for H, west-for D and downward increase for Z respectively.

along the N—S profile. At a glance, no significant discrepancies are found between the four points. Some fluctuations appearing in Z component would be ascribable to the influence of short-period variations. We gave up making a Fourier analysis of these records, but it can be said that the anomaly observed for the short-period range vanishes at a period ranging from 8 to 24 hours.

5. Discussion

It is obvious that the anomaly investigated so far is caused by a local conductivity contrast. A possible explanation of this phenomenon might be that of an electromagnetic induction in a conducting sphere underneath Oshima Island on which Mt. Mihara is still active, and that there might exist a lump of magma of high temperature. But this idea is excluded at once, because the observed anomaly is quite opposite to the one expected from such a model. The well-established theory of electromagnetic induction in a uniform conducting sphere tells us that the induced field by a uniform inducing field is a dipole-like one centered at the sphere having the opposite direction to the external field; if we assume a conducting spherical body embedded beneath the center of the island, the internal field of the Z component should be upward at the south, and downward at the northern point for the northward inducing field. This feature is exactly contrary to the observational results.

Rikitake¹¹⁾ studied size and depth of a local high-conducting mass possibly detected by geomagnetic variation anomaly. According to his calculation, a 100 gamma inducing field gives rise to an induced field as small as 3 gammas or so provided a perfectly conducting sphere 2 km in radius is placed at a depth of 5 km as also estimated by Rikitake¹²⁾ as the magma reservoir beneath Mt. Mihara on the basis of the results of repeated magnetic surveys. It is therefore clear that a magma mass of a conceivable size has nothing to do with the present anomaly even if it exists underneath the island.

A statistical analysis reported in 4-2 enables us to imagine that the observed anomaly is due to an effect of the sea-water. A northward increase of the geomagnetic field (for example; bays, s.s.c.'s and such like) has an equivalent current system flowing from the west to the east direction, and then the currents having an opposite direction, namely east to west, should flow in the conducting sea. The induced currents will be deflected by an island which can be regarded as an insulator. Such a modified flow produces a magnetic field which is downward at the south and upward at the northern edge of the island. A qualitative explanation would thus be possible. But a more rigorous discussion seems to be very difficult. Mason¹⁾ conducted a model experi-

11) T. RIKITAKE, *Bull. Earthq. Res. Inst.*, **40** (1962), 495.

12) T. RIKITAKE, *Bull. Earthq. Res. Inst.*, **29** (1951), 161.

ment for the case of the anomaly on Christmas Island. Using electrically conducting paper, he observed the modification of uniform stationary flow of electric currents around the island, which is consistent with the proceeding discussion. Rikitake¹³⁾ studied the so-called "hole-in-a-plate" problem; that is an electromagnetic induction around a hole in a infinitely extending thin sheet of conductor. He assumed a uniaxial inducing field and the infinite conductivity of the sheet which corresponds to the rapid variations, and confirmed a reversal of the magnetic field around the edge of the hole using the relaxation method. He¹⁴⁾ also tried to solve the same problem more rigorously, but the resolving process was found to require a tremendous amount of numerical integrations, which are impossible to be achieved even by an electronic computer.

It is desirable, however, to estimate the anomalous part in some way or other. Following the idea developed by Mason¹⁾ in his study of the anomaly on Christmas Island, the writer would here like to separate, to a rough degree of approximation, the secondary part due to the induced currents in the sea.

If everything is symmetric around the island, the induced current pattern will also be symmetric. For the north-south inducing field, such a flow of current will produce the secondary part of equal amplitude with a 180° phase difference at the northern and southern edges of the island. It would be rather reckless, however, to infer such a simple feature of the secondary part, considering the complicated situation around Oshima Island. But the coherence and phase difference spectra between Z and H tell us that the observed anomaly of the Z component along the N—S profile is mainly caused by the northward inducing field. This fact seems to support the above-mentioned symmetry of the induced field as a first approximation. If we assume that the secondary part at KO and HA are equal in amplitude and opposite in phase, the observed Z variation of a particular frequency ω can be written as follows:

$$\begin{aligned} \text{at HA ; } P \cos (\omega t + \alpha) + S \cos (\omega t + \beta) &= A \cos \omega t \\ \text{at KO ; } P \cos (\omega t + \alpha) - S \cos (\omega t + \beta) &= B \cos (\omega t + \phi) \end{aligned} \quad (8)$$

where A , B , P and S are the mean amplitude (e.g. the square root of the power) of the Z component at HA, KO, and that of the primary and secondary part respectively. A , B and ϕ are obtained by the

13) T. RIKITAKE, *Jour. Geomag. Geoelec.*, **16** (1964), 31.

14) T. RIKITAKE, *Personal Communication* (1965).

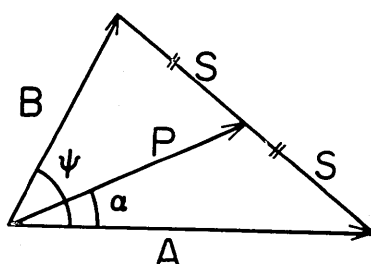
spectral analysis. Equations (8) should always hold good without regard to t . This condition leads to the following relations:

$$P = \frac{1}{2} [A^2 + B^2 + 2AB \cos \phi]^{1/2}$$

$$S = \frac{1}{2} [A^2 + B^2 - 2AB \cos \phi]^{1/2} \quad (9)$$

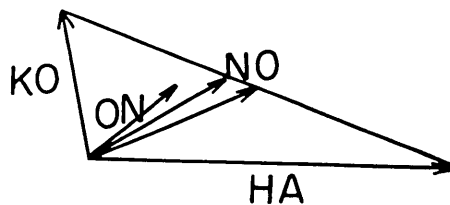
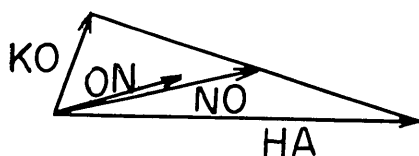
$$\tan \alpha = \frac{B \sin \phi}{A + B \cos \phi}, \quad \tan \beta = \frac{B \sin \phi}{A - B \cos \phi}$$

(a)



(b) $T = 120$ min.

(d) $T = 30$ min.



(c) $T = 60$ min.

(e) $T = 10$ min.

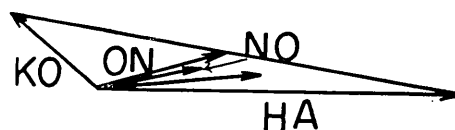
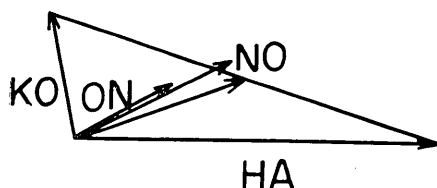


Fig. 12. Vector representations of the observed Z variations (a) a schematic representation (after R. G. Mason) (b) $T=120$ min. (c) $T=60$ min. (d) $T=30$ min. (e) $T=10$ min.

We can thus separate the observed Z variation into the primary and secondary parts. The quantities appearing in (9) can be represented vectorially as shown schematically in Fig. 12 (a). (after Mason¹⁾) The vectorial illustrations of the primary and secondary parts for periods $T=120, 60, 30$ and 10 min. are given in Figs. 12 (b), (c), (d) and (e) respectively, together with the vectorially represented spectral values of the Z variations at ON and NO. Although the assumption adopted in estimating the primary and secondary parts is rather tentative, the estimated P 's and α 's would give the approximate spectral values of the Z variations peculiar to Oshima Island after removing the sea-water effect. In Table 3 are summarized the ratios S/H , P/H , Z_{ON}/P , Z_{NO}/P and the phase differences α , θ_{ON} , θ_{NO} . The attenuation of the secondary part relative to H with increasing period T could be explained provided the sea around Oshima Island becomes more transparent for the slower

Table 3. Spectral values of the primary and secondary parts. H is the average of the mean amplitude of the H component at HA, ON and NO.

F c. p. 240 m.	T. m.	S/H	P/H	ZON/P	ZNO/P	α	θ_{ON}	θ_{NO}
1	240	0.45	0.54	0.64	1.00	-14°	-18°	-7°
2	120	0.48	0.57	0.63	0.97	-14	-17	-14
3	80	0.54	0.53	0.63	0.98	-17	-20	-16
4	60	0.58	0.51	0.63	0.94	-20	-29	-28
5	48	0.57	0.50	0.64	0.90	-21	-35	-26
6	40	0.57	0.49	0.66	0.94	-23	-39	-27
8	30	0.62	0.48	0.65	0.91	-24	-41	-31
12	20	0.65	0.37	0.79	1.12	-25	-31	-28
24	10	0.67	0.37	0.82	1.20	-21	-14	-5
48	5	0.68	0.31	1.03	1.52	-1	0	0

variations. It was reported by the writer¹⁵⁾ that the Z variation having a period of one hour or so is much enhanced compared with the H near the central area of the "Central Japan Anomaly". A similar tendency is also confirmed in the increase of the P/H values for the longer periods as shown in Table 3.

Amplitudes and phases of the primary part are roughly coincident

15) Y. SASAI, *Bull. Earthq. Res. Inst.*, **44** (1966), 167.

with those of the Z variations at NO. A question why the Z variations at NO, which is very close to the western coast-line, seem to suffer the sea-water effect to a less extent than those at ON is then to be raised. The poorer coherence between Z and D at NO than that at ON makes us imagine that the induced currents flowing in the western area of the sea near the island might be weakened because of the shallowness and narrowness of the sea between Oshima Island and Izu Peninsula. As shown in Fig. 2, the Parkinson vector at KO points not to the nearest shore but to the deeper sea. There might exist a certain "effective depth" of the sea to cause such an anomaly. A model experiment could give some clue to the foregoing speculations, but it is beyond the scope of this paper.

Judging from the results in Fig. 12 and Table 3, it might be said that the Oshima Magnetic Observatory at NO has been built, fortunately, at a very suitable place, so that the geomagnetic variations observed there represent the "normal" ones on Oshima Island. It is therefore justified that Oshima Island belongs to the anomalous area of the "Central Japan Anomaly" as has been reported by Rikitake and Yokoyama⁸⁾.

It seems likely that some sort of "island-effect" could be found on other islands such as Miyakejima, Hachijojima and so on. Utashiro¹⁶⁾ has already suggested an anomaly similar to the present one on the basis of his observations on Miyakejima Island although his observations were not simultaneous. Furthermore, at an observatory near the edge of a peninsula, we might observe some anomalous variation, a "peninsula effect" so to speak, because induced currents in the sea would be substantially modified around a peninsula. We observe a remarkable enhancement of the Z component of short period at Aburatsubo and Simosato along the Pacific Ocean side of Honshu Island. (See Rikitake⁵⁾) These observatories are sited near the extremities of peninsula stretching southerly to the Pacific Ocean. The situations around them are similar to those around the station HA. Some portion of the observed ΔZ enhancement at these observatories might be ascribed to the influence of induced currents in the sea, although the "Central Japan Anomaly" seems to be hardly explained as the accumulation of such an effect of the sea-water. (See Rikitake⁵⁾) But the remarkable spatial dependence of the short-period vertical variations discovered on Oshima Island makes us

16) S. UTASHIRO, *Comment on the annual meeting of the Society of Terrestrial Magnetism and Electricity, Japan*, (1966).

imagine that the sea-water plays a very important role on the "Central Japan Anomaly", and a drastic alteration of the distribution contours of the anomalous Z variations might be needed after removing the effects of the sea-water. Further observations in a fashion similar to the one as conducted on Oshima Island with a dense network of temporary observatories in Japan are certainly necessary in the near future in order to clarify the extent of the effect of the sea on the "Central Japan Anomaly".

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9. 伊豆大島に於ける地磁気短周期変化の異常 (1)

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1966 年春以来携帯用フラックスゲイト型磁力計を用い、伊豆大島の各所で地磁気変化の同時観測を行なった結果、短周期の z 成分が島内各地で著しく異なることを見出した。即ち数分から数十分の継続時間を持つ短周期擾乱において島の南と北で z 成分が全く逆転し、島の中央部では位相の遅れが起る。この現象は外部磁場の変動によって海水中に誘起された電流が不良導体である島の周囲を流れ、それによって作られた 2 次的な磁場によるものらしい。十分な観測資料が得られた南北のプロファイルについて、スペクトル解析を行なって、この現象の周期特性を調べた。簡単な仮定の下に、海の影響による二次的磁場と大島全体ではほぼ一様と考えられる一次的な部分とを分離すると、一次成分においても大きな振幅が得られ、大島は日本列島中央部の地磁気変化異常領域に属することを示している。又二次的成分は周期が長くなると共に減少し、日変化になると消失している。