15. *Anomaly of the Geomagnetic S_q Variation in Japan and Its Relation to the Subterranean Structure.*

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Summary

An anomalous feature of the Z component of the S_q in the central part of Japan is pointed out. From geomagnetic observations at Kakioka and Aburatsubo was ascertained the fact that the maximum decrease of the Z component of the S_q occurs about an *hour* earlier in central Japan than at any other observatory in the Far East. On analysing the S_q during the Second International Polar Year, it is found that the aforementioned anomaly of S_q is most likely caused by the anomalously small internal origin part which would suggest low electrical conductivity under Japan. It is also suggested that the weak conducting region penetrates as deep as 700 *km* or so there.

Introduction

The writers have been investigating the anomalous behaviour of short-period geomagnetic variations in Japan by analysing geomagnetic data obtained at a number of Japanese observatories including a few established by themselves, and also by analysing magnetograms on a particular occasion sent from magnetic observatories distributed all over the earth. As already published in a series of papers in this bulletin[1),2),3),4),5),6)] and elsewhere[7),8)], it became clear that the anomalously large amplitude of geomagnetic vertical component observed at the time of sudden commencements of magnetic storms and bays can only be

1) T. RIKITAKE, I. YOKOYAMA and Y. HISHIYAMA, *Bull. Earthq. Res. Inst.*, **30** (1952), 207.
2) T. RIKITAKE, I. YOKOYAMA and Y. HISHIYAMA, *Bull. Earthq. Res. Inst.*, **30** (1953), 19.
3) T. RIKITAKE, I. YOKOYAMA and Y. HISHIYAMA, *Bull. Earthq. Res. Inst.*, **31** (1953), 89.
4) T. RIKITAKE, I. YOKOYAMA and Y. HISHIYAMA, *Bull. Earthq. Res. Inst.*, **31** (1953), 101.
5) T. RIKITAKE, I. YOKOYAMA and Y. HISHIYAMA, *Bull. Earthq. Res. Inst.*, **31** (1953), 119.
6) T. RIKITAKE and I. YOKOYAMA, *Bull. Earthq. Res. Inst.*, **33** (1955), 297.
7) T. RIKITAKE and I. YOKOYAMA, *Journ. Geomagn. Geoelectr.*, **5** (1953), 59.
8) T. RIKITAKE and I. YOKOYAMA, *Naturwissenschaften*, **41** (1954), 420.

explained by assuming electric currents flowing in a special way underneath the central part of Japan. Since the electric currents are regarded as induced by the geomagnetic variations, a special distribution of the electrical conductivity was presumed in order to account for the anomaly of geomagnetic variations. Although the electric circuit thus presumed seems to be complicated and somewhat artificial, its possibility is supported by an experimental study carried out by T. Nagata, T. Oguti and H. Maekawa[9], while an underground electric circuit of the same sort was also suggested later in Germany[10),11),12]. Unlike the German example, which can be approximated by a line current at a depth of 80 *km* beneath North Germany, the high conducting passage beneath Japan is likely to be a roughly circular one at a depth of 100 *km* or more, the diameter of the circuit being roughly a few hundred *kilometers*. It is also required that both ends of the circuit be connected with the high conducting region of the earth in order to have electric currents strong enough for producing the geomagnetic anomaly concerned. Therefore it is also supposed that a high conducting belt comes up from a depth of several hundred *kilometers* turning around under Japan and then returns again to that depth.

The above distribution of the electrical conductivity is, however, presumed only from the investigations on geomagnetic variations of short period such as bays and sudden commencements of magnetic storms. In order to see how the behaviour of geomagnetic variations changes in the cases of variations of different period, it is highly desirable to examine the S_q and D_{st} field in Japan.

It has been well known that the longer the period of a geomagnetic variation is, the deeper the induced electric currents penetrate into the earth. Although detailed studies in this line have been worked out only for an earth having a conductivity-distribution of spherical symmetry[13),14),15], it is readily supposed that the characteristic distribution of the electrical conductivity obtained from short-period variations would not affect the S_q so much because such a shallow and local irregularity is thought to be nearly transparent for a slow variation such as S_q.

9) T. NAGATA, T. OGUTI and H. MAEKAWA, *Bull. Earthq. Res. Inst.*, **33** (1955), 561.
10) U. FLEISCHER, *Naturwissenschaften*, **41** (1954), 120.
11) U. FLEISCHER, *Zeits. f. Geophys.*, **20** (1954), 120.
12) H. WIESE, *Zeits. f. Meteorologie*, **8** (1954), 77.
13) S. CHAPMAN and A. T. PRICE, *Phil. Trans. Roy. Soc. London A*, **229** (1930), 427.
14) B. N. LAHIRI and A. T. PRICE, *Phil. Trans. Roy. Soc. London A*, **237** (1939), 509.
15) T. RIKITAKE, *Bull. Earthq. Res. Inst.*, **28** (1950), 45, 219, 263; **29** (1951), 61.

The writers, therefore, did not put stress on detailed examinations of the S_q in Japan until recently.

During his stay in England, however, one of the writers (T.R.) had the pleasure of reading Dr. G. A. Wilkins's thesis entitled "A new analysis of the daily variation of the earth's magnetic field"[16] by permission of Professor A. T. Price. In that thesis, world-wide analyses of the S_q during the Second Polar Year had been carried out though only a part of the results has been published[17]. On seeing the curves which show average variations of vertical components of the S_q in the Far East, New Zealand and Australia, one can clearly see that the time of the beginning of the morning decrease as well as that of the maximum decrease occurs one or two *hours* earlier at Kakioka than at any other observatory. One of the examples is reproduced from the thesis in Fig. 1. Although it was not known whether or not the characteristic feature of the S_q at Kakioka has something to do with the underground condition in Japan, a systematic examination of S_q in Japan was put forward by the writers immediately after Rikitake's return to Japan.

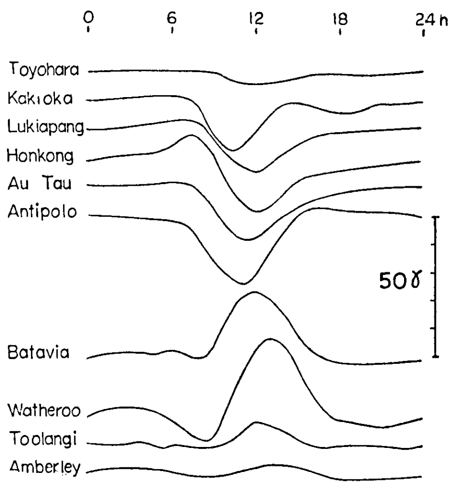

Fig. 1. The vertical component of S_q for equinox seasons during the period 1932–33 at the observatories in the Far East, New Zealand and Australia. (After G. A. Wilkins)

M. Ota[18] has also pointed out the possible effect of different underground conditions on S_q on the basis of the geomagnetic data during the Second Polar Year collected by Professor M. Hasegawa. The geomagnetic data kindly supplied to us by Professor Hasegawa and Dr. Ota will be reproduced in Tables VI, VII, VIII, IX, X and XI.

In Part I of this paper, the S_q observed at Aburatsubo (35°09′N, 139°37′E) will be described on the basis of the observation during a period between 1952 and 1955. At the same time, the S_q at Memanbetsu (43°54′N, 144°12′E), Kakioka (36°14′N, 140°13′E) and Aso (32°55′N,

16) G. A. Wilkins, *Thesis, London University* (1951).
17) A. T. Price and G. A. Wilkins, *Journ. Geophys. Res.*, **50** (1951), 259.
18) M. Ota, *Journ. Geomagn. Geoelectr.*, **6** (1954), 83.

131°04′E) during the same period will be examined in order to find out the anomaly of S_q, especially in the vertical component, in Japan.

With the aid of the data of S_q during the Second Polar Year, separations of the internal origin part of the S_q from the external origin one will be made at all observatories in the Far East in Part II of this paper. This sort of study would be useful for presuming the cause of the anomaly which is found at Kakioka. By comparing the internal origin part thus abstracted with that for an earth having a uniform conductivity, we might be able to discover the special condition of the electrical state underneath Japan.

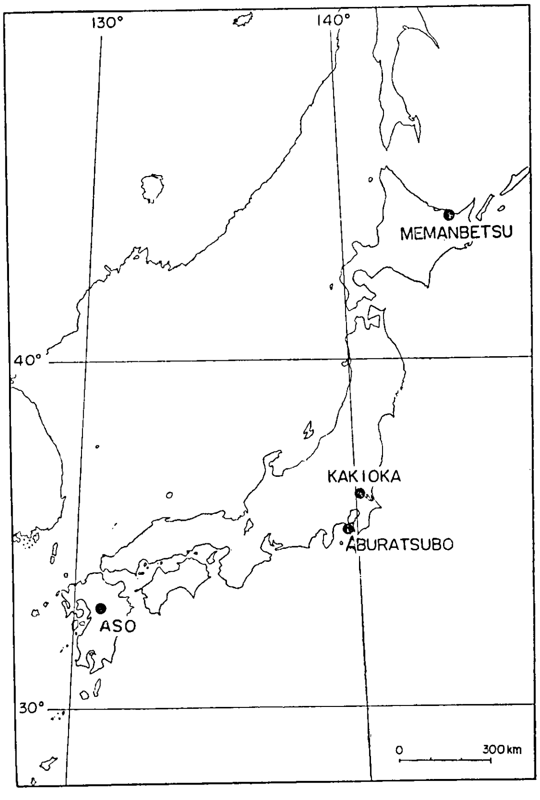

Fig. 2. The four magnetic observatories in Japan.

Part I. The S_q at Aburatsubo and other observatories in Japan

In order to examine the anomaly of the S_q at Kakioka which appeared in G. A. Wilkins's thesis and to study the matter in more detail, the writers are going to investigate the S_q in Japan with the aid of data recently obtained. The material for the study was collected from four existing observatories, Memanbetsu, Kakioka, Aburatsubo and Aso. Their localities are shown in Fig. 2. Of these observatories, Aburatsubo has been set up and managed by the writers themselves as was reported in this bulletin[1].

On the basis of the magnetic character figures C at Kakioka Observatory, we select five of the quietest days in each calendar month during the period from 1952 to 1955. In these four years, annual means of sunspot-numbers which were reported in the Journal of Geophysical Research by the Swiss Federal Observatory were 31.1, 13.3, 4.2 and 37.9 respectively. Thus we see that these years centred at the sunspot minimum period. The writers calculated the monthly means of the S_q from the selected data at each observatory and then made up the mean type of S_q for every season. These curves are shown in Fig. 3 where spring included March and April, summer, May to August, autumn, September and October, and winter, the remaining months. As clearly seen in the figures, vertical components of the S_q at Aburatsubo as well as

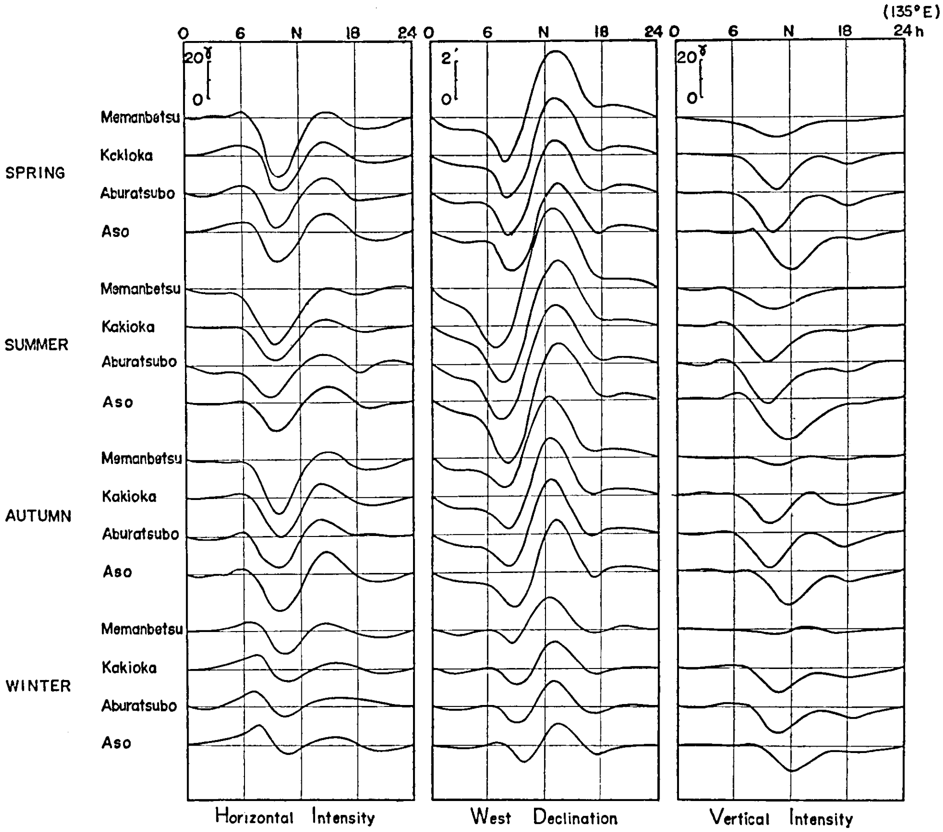

Fig. 3. The S_q variation of horizontal intensity, declination and vertical intensity as obtained for respective seasons at the four Japanese observatories during the period 1952–55.

Kakioka show a particular phase difference in daytime variation, about two *hours* earlier than at other observatories, while no remarkable phase difference is found in the curves for both horizontal intensity and declination through all the observatories. If we correct the differences of the local time or the longitude of each observatory in the figure, the curves for Memanbetsu, Kakioka and Aburatsubo are to be shifted to the right by 37, 21 and 19 *minutes* respectively and for Aso to the left by 16 *minutes*. After these corrections, we still observe a definite phase difference between the curves for the vertical components at Kakioka and Aburatsubo and those at Memanbetsu and Aso.

Now we may say that the anomalous shape of the curve for the vertical component of S_q at Kakioka as can be seen in the data of the Second Polar Year is not due to any mistake or observational error. The tendency should be one of the characteristics of the S_q in the central part of Japan.

In the next place, these S_q curves are analysed in a customary way such as

$$c_1 \sin (t+\delta_1)+c_2 \sin (2t+\delta_2)+\cdots$$

where t is time measured from midnight (135°E local time). The coefficients and phase angles are given in Tables I, II, III and IV for respective seasons.

Table I. Harmonic analysis of the S_q. Mean for spring months during 1952–55.

	Station	Declination		Horizontal Intensity		Vertical Intensity	
		c (min.)	δ (degree)	c (γ)	δ (degree)	c (γ)	δ (degree)
c_1	Memanbetsu	1.60	324.1	7.09	72.1	3.04	70.2
	Kakioka	1.12	355.6	2.91	79.8	5.25	81.9
	Aburatsubo	1.14	332.0	2.65	43.3	4.76	81.4
	Aso	1.79	303.1	1.58	50.9	6.87	104.5
c_2	Memanbetsu	1.13	125.9	8.69	206.8	1.62	215.1
	Kakioka	0.96	146.7	7.23	207.9	3.71	223.6
	Aburatsubo	0.95	132.6	5.85	197.7	4.44	202.4
	Aso	0.88	147.4	7.31	204.0	4.32	270.4
c_3	Memanbetsu	0.78	304.1	6.29	13.6	1.20	24.1
	Kakioka	0.78	321.2	5.03	20.8	3.27	18.0
	Aburatsubo	0.79	312.6	5.42	5.4	4.01	10.9
	Aso	0.72	355.8	4.80	22.9	3.56	88.3
c_4	Memanbetsu	0.23	96.1	3.09	159.8	0.33	197.7
	Kakioka	0.35	40.8	2.28	155.4	1.39	166.8
	Aburatsubo	0.27	116.7	1.97	162.6	1.49	174.9
	Aso	0.31	145.1	1.53	165.6	1.52	256.4

Table II. Harmonic analysis of the S_q. Mean for summer months during 1952–55.

	Station	Declination		Horizontal Intensity		Vertical Intensity	
		c (min.)	δ (degree)	c (γ)	δ (degree)	c (γ)	δ (degree)
c_1	Memanbetsu	2.24	325.2	9.73	55.1	4.39	66.3
	Kakioka	1.81	333.0	4.82	45.9	5.79	70.9
	Aburatsubo	1.63	342.1	5.69	16.3	6.89	73.4
	Aso	1.65	343.4	3.49	22.9	8.86	101.2
c_2	Memanbetsu	1.64	117.3	6.49	191.3	2.53	220.6
	Kakioka	1.43	130.8	5.13	187.2	4.19	207.2
	Aburatsubo	1.31	125.4	4.31	153.8	4.23	199.6
	Aso	1.44	142.7	5.60	187.8	5.32	263.3
c_3	Memanbetsu	0.65	287.3	4.61	352.8	1.27	2.0
	Kakioka	0.68	303.7	3.55	357.8	2.87	346.4
	Aburatsubo	0.50	305.3	4.07	339.5	3.38	343.9
	Aso	0.76	313.4	3.62	13.2	2.71	66.5
c_4	Memanbetsu	0.09	21.3	1.23	114.1	0.17	67.1
	Kakioka	0.73	7.9	0.97	121.3	1.02	113.7
	Aburatsubo	0.16	52.5	0.62	65.8	1.07	87.3
	Aso	0.18	75.4	0.75	132.0	0.89	148.8

Table III. Harmonic analysis of the S_q. Mean for autumn months during 1952–55.

	Station	Declination		Horizontal Intensity		Vertical Intensity	
		c (min.)	δ (degree)	c (γ)	δ (degree)	c (γ)	δ (degree)
c_1	Memanbetsu	1.35	312.9	6.37	53.9	1.28	82.1
	Kakioka	1.13	319.9	3.99	51.7	3.87	85.4
	Aburatsubo	1.02	318.0	4.53	23.5	1.40	87.1
	Aso	0.93	330.3	3.70	26.1	5.58	105.8
c_2	Memanbetsu	0.97	104.3	7.56	187.8	0.63	207.6
	Kakioka	0.96	113.5	6.95	193.3	3.39	184.2
	Aburatsubo	0.93	111.7	5.58	189.0	3.83	187.9
	Aso	0.87	128.0	7.89	192.3	3.32	254.4
c_3	Memanbetsu	0.67	287.2	5.40	0.2	0.83	15.2
	Kakioka	0.71	298.5	4.95	8.5	3.40	351.3
	Aburatsubo	0.72	291.7	4.71	349.4	4.05	348.9
	Aso	0.77	316.9	5.44	13.6	3.10	68.7

(to be continued.)

(Table III. continued.)

	Station	Declination		Horizontal Intensity		Vertical Intensity	
		c (min.)	δ (degree)	c (γ)	δ (degree)	c (γ)	δ (degree)
c_4	Memanbetsu	0.27	79.5	2.42	133.2	0.53	180.0
	Kakioka	0.32	104.5	1.77	154.3	1.51	157.9
	Aburatsubo	0.64	93.9	1.99	139.5	1.93	133.1
	Aso	0.37	132.6	1.54	155.4	1.70	246.9

Table IV. Harmonic analysis of the S_q. Mean for winter months during 1952–55.

	Station	Declination		Horizontal Intensity		Vertical Intensity	
		c (min.)	δ (degree)	c (γ)	δ (degree)	c (γ)	δ (degree)
c_1	Memanbetsu	0.47	291.5	1.62	102.5	0.44	104.8
	Kakioka	0.31	310.7	1.71	165.0	3.81	107.9
	Aburatsubo	0.27	311.9	0.50	344.7	1.36	109.6
	Aso	0.20	304.2	2.44	194.5	4.25	113.9
c_2	Memanbetsu	0.41	105.4	4.28	216.0	0.69	142.6
	Kakioka	0.41	133.1	3.31	241.7	2.51	226.3
	Aburatsubo	0.38	128.9	3.15	245.1	2.76	223.2
	Aso	0.32	142.4	3.25	243.8	2.47	280.1
c_3	Memanbetsu	0.31	310.8	3.56	29.0	0.84	255.7
	Kakioka	0.45	327.0	2.74	49.6	2.42	29.2
	Aburatsubo	0.46	321.1	2.45	33.7	2.95	30.5
	Aso	0.42	346.2	2.82	62.6	2.19	98.8
c_4	Memanbetsu	0.26	105.1	1.74	163.6	0.48	180.0
	Kakioka	0.24	138.2	1.26	164.5	1.03	194.7
	Aburatsubo	0.26	131.3	1.41	155.2	1.10	193.6
	Aso	0.27	189.9	1.20	189.6	1.07	279.9

Part II. The analysis of the S_q during the Second International Polar Year, 1932–1933

1. Data

Professor Hagegawa and Dr. Ota kindly placed the geomagnetic data of S_q during the Second Polar Year at the writers' disposal. As reproduced in Tables VI, VII, VIII, IX, X and XI, the mean daily variations of X-(northward), Y-(eastward), and Z-(downward) components on quiet days, both for summer and winter, are given at some 60 observatories distributed all over the earth, the geographical and geomagnetic latitude and longitude of those observatories being also shown in Table V.

Table V. List of the observatories

Observatory	Abbreviation	Geographic latitude	Geographic longitude	Geomagnetic latitude	Geomagnetic longitude
Calm Bay	CM	80°.3	52°.8	71°.5	153°.3
Sveagruvan	SV	77.9	16.8	73.9	130.7
Björnöya	Bj	74.5	19.2	71.0	124.7
Matotchkin Shar	MS	73.3	56.4	64.8	146.5
Dickson	DI	73.5	80.4	63.0	161.5
Scoresby Sund	SS	70.5	338.0	75.8	81.8
Tromsö	TR	69.7	18.9	67.1	116.7
Petsamo	PE	69.5	31.2	64.9	125.8
Kandalakcha	Kn	67.1	32.4	62.5	124.2
Sodankylä	SO	67.4	26.6	63.8	120.0
Dombas	DO	62.1	9.1	62.3	100.0
Lerwick	LE	60.1	358.8	62.5	88.6
Sloutzk	SL	59.7	30.5	56.0	117.5
Lovö	LO	59.4	17.8	58.1	105.8
Vyssokaya Doubrawa	VD	56.7	61.1	48.5	140.7
Rude Skov	RS	55.8	12.4	55.8	98.5
Kasan	Ka	55.8	49.1	49.2	130.6
Eskdalemuir	ES	55.3	356.8	58.5	82.9
Swider	SW	52.1	21.2	50.6	104.6
De Bilt	DB	52.1	5.2	53.8	89.6
Abinger	AB	51.2	359.6	54.0	83.3
Manhay	Ma	50.3	5.7	52.0	88.8
Val Joyeux	VJ	48.8	2.0	51.3	84.5
Wien	VI	48.2	16.2	47.9	98.1
Ebro	EB	40.8	0.5	43.9	79.7
San Miguel	SM	37.8	334.4	45.6	50.9
San Fernand	SF	36.5	353.8	41.0	71.3
Dehra Dun	DD	30.3	78.0	20.5	149.9
Helwan	HE	29.9	31.3	27.2	106.4
Alibag	AL	18.6	72.9	9.5	143.6
Elizabethville	EL	−11.7	27.5	−12.7	94.0
Tananarivo	TN	−18.9	47.5	−23.7	112.4

(to be continued.)

(Table V. continued.)

Observatory	Abbreviation	Geographic latitude	Geographic longitude	Geomagnetic latitude	Geomagnetic longitude
Mauritius	MU	−20°.1	57°.6	−26°.6	122°.4
Cape Town	CT	−33.9	18.5	−32.7	79.9
Zouy	ZO	52.5	104.0	41.0	174.4
Toyohara	TY	47.0	142.8	36.9	203.5
Kakioka	KA	36.2	140.2	26.0	206.0
Aso	AS	32.9	131.0	22.0	198.0
Lukiapang	LU	31.3	121.0	20.0	189.1
Zô-Sè	ZS	31.1	121.2	19.8	189.2
Honolulu	HO	21.3	201.9	21.1	266.5
Antipolo	AT	14.6	121.2	3.3	189.8
Batavia	Ba	− 6.2	106.8	−17.6	175.6
Apia	AP	−13.8	188.2	−16.0	260.2
Watheroo	WA	−30.3	115.9	−41.8	185.6
Toolangi	TO	−37.5	145.5	−46.7	220.8
Christchurch	CR	−43.5	172.6	−48.0	252.6
Thule	TH	76.5	291.1	88.0	0.0
Godhavn	GO	69.2	306.5	79.8	32.5
Fort Rae	FR	62.8	243.9	69.0	290.9
Juliannehaab	JU	60.7	314.0	70.8	35.6
Sitka	SI	57.0	224.7	60.0	275.4
Meanock	ME	54.6	246.7	61.8	301.0
Agincourt	AG	43.8	280.7	55.0	347.0
Cheltenham	CH	38.7	283.2	50.1	350.5
Tucson	TU	32.2	249.2	40.4	312.2
Teoloyucan	TE	19.8	260.8	29.6	327.0
San Juan	SJ	18.4	293.9	29.9	3.2
Huancayo	HU	−12.0	284.7	− 0.6	353.8
Pilar	PI	−31.7	296.1	−20.2	4.6
Orcadas del Sud	Or	−60.8	315.0	−50.0	18.0

2. The S_q in the Far East

In order to check the anomalous tendency of S_q at Kakioka as has been stated in the Introduction and Part I, the distribution of the Z-component of the S_q is graphically examined with respect to the observatories in the Far East as can be seen in Fig. 4 for the summer. At a glance, we see that the maximum decrease of Z occurs about one *hour* earlier at Kakioka than at any other observatory.

Table VI. *X*-component of the S_q for the summer period.
(Unit: *gammas*)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
CM	−41.6	−65.8	−24.2	− 2.0	11.7	39.6	37.0	29.9	10.2	16.0	3.8	−14.1
SV	− 3.2	−11.6	−14.7	−12.4	−10.4	1.3	16.1	22.6	18.7	3.5	− 5.0	− 3.2
Bj	−42.9	−27.3	3.4	− 0.1	− 8.0	− 7.1	2.7	24.3	42.6	36.3	− 1.7	−22.7
MS	−11.8	0.3	− 5.4	−13.3	−11.2	2.4	15.7	16.4	21.0	16.3	− 6.2	−24.0
DI	−10.2	− 9.1	−17.7	−15.6	− 1.2	17.6	23.9	18.8	17.7	7.6	−12.4	−19.5
SS	−10.7	− 5.4	−17.0	−22.4	−19.9	−23.3	−18.3	1.6	38.8	56.2	24.5	− 4.5
TR	−19.1	2.2	9.5	− 1.0	−14.3	−16.8	− 6.8	6.5	16.4	23.1	13.5	−11.7
PE	− 6.1	2.8	1.9	− 8.4	−22.6	−19.3	− 4.0	8.8	15.5	19.7	12.8	− 1.7
Kn	5.9	13.5	14.8	5.1	−12.8	−23.9	−18.0	− 3.5	4.3	6.3	4.4	4.2
SO	1.6	6.7	6.5	− 5.6	−21.6	−25.0	−11.5	3.5	12.6	16.5	11.5	4.5
DO	6.1	2.5	5.6	4.5	− 6.4	−23.0	−23.9	− 9.0	4.6	13.9	15.4	9.6
LE	6.2	3.6	5.5	1.4	−10.6	−23.5	−22.3	− 6.5	7.5	15.3	14.0	9.3
SL	6.9	7.1	5.0	− 6.1	−20.6	−24.4	−11.1	4.5	9.0	10.8	10.6	8.4
LO	6.3	5.6	5.0	− 5.2	−20.0	−24.8	−12.0	3.3	9.3	12.6	11.5	8.5
VD	5.9	4.3	−10.2	−20.4	−16.2	− 2.9	5.2	6.6	6.9	9.0	7.1	4.3
RS	7.4	5.4	6.7	− 1.8	−17.1	−24.5	−15.3	0.2	8.0	11.1	11.2	9.0
Ka	5.2	4.6	− 2.0	−13.5	−17.9	− 9.6	− 1.1	5.1	5.6	8.2	8.2	6.7
ES	7.0	4.2	5.0	2.6	− 9.0	−21.0	−21.1	− 7.0	5.9	12.7	12.2	8.4
SW	6.1	5.1	6.4	− 4.3	−17.4	−17.7	− 8.9	1.3	5.1	7.5	9.0	7.7
DB	7.5	4.1	5.2	0.9	−12.0	−20.1	−16.4	− 4.9	5.2	9.9	11.0	9.7
AB	7.4	4.8	5.2	2.7	− 8.0	−16.4	−16.3	− 8.2	2.1	8.2	10.0	8.1
Ma	7.0	3.8	4.8	0.3	−11.7	−15.8	−12.0	− 4.5	3.3	7.6	9.4	8.2
VJ	6.1	3.4	3.8	1.1	− 9.2	−14.2	− 9.9	− 5.4	1.2	6.6	8.7	7.3
VI	5.8	4.6	8.9	12.3	− 0.6	−14.8	−17.2	−12.2	− 1.8	3.8	5.5	5.8
EB	4.0	2.2	1.6	− 1.0	− 9.1	− 8.6	1.2	0.1	− 2.1	1.6	5.2	4.8
SM	5.1	2.9	− 0.2	− 0.6	− 0.3	− 1.6	− 5.6	− 8.1	− 6.8	2.7	6.6	5.6
SF	1.7	0.1	− 0.1	1.1	− 0.1	− 1.2	2.9	− 4.2	− 7.6	0.3	3.8	3.2
DD	− 0.1	− 3.1	− 5.3	2.7	8.8	5.4	− 2.2	− 3.3	− 1.8	− 0.1	0.2	− 1.4
HE	− 1.6	− 2.5	− 1.8	− 6.9	− 2.4	12.4	14.4	3.0	− 6.9	− 4.0	− 2.2	− 1.9
AL	− 7.7	− 5.7	8.8	23.3	21.3	8.0	− 4.1	− 8.8	− 9.5	− 8.8	− 8.6	− 8.3
EL	− 5.7	− 5.2	− 0.1	9.1	13.4	14.7	7.4	− 3.7	− 6.9	− 7.5	− 8.0	− 7.6
TN	− 1.6	0.3	5.0	10.9	11.2	8.8	− 1.1	− 8.0	− 7.0	− 7.7	− 6.5	− 4.4
MU	− 1.1	3.4	9.7	7.7	7.4	6.5	− 1.4	− 5.4	− 7.3	− 7.6	− 6.8	− 4.8
CT	− 0.3	1.0	2.8	8.3	8.7	− 1.4	− 8.0	− 5.2	0.5	− 1.2	− 2.8	− 2.5
ZO	− 0.4	−18.5	−22.7	− 8.4	4.5	8.5	5.7	5.6	6.6	6.2	5.0	6.9
TY	−16.8	−17.4	− 5.5	2.6	3.3	3.9	5.5	5.7	5.7	6.0	7.9	− 1.3
KA	− 8.4	− 5.6	2.0	4.7	1.2	− 0.7	1.1	1.8	1.2	1.2	2.4	− 1.3

(to be continued.)

(Table VI. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
AS	− 6.5	− 5.4	1.2	5.3	2.8	− 0.9	0.5	0.8	0.6	0.6	1.0	0.1
LU	− 7.5	− 6.0	4.8	10.4	5.6	− 2.6	− 1.2	− 0.3	− 0.6	− 0.8	− 1.3	− 0.7
ZS	− 7.3	− 6.5	4.6	9.4	5.0	− 2.7	− 1.0	− 0.5	− 0.1	− 0.3	− 0.5	− 0.4
HO	10.7	2.9	− 4.0	− 5.6	− 4.9	− 3.4	− 2.2	− 2.3	− 3.4	− 3.0	4.4	10.8
AT	9.2	27.0	31.7	19.0	− 0.7	− 9.6	−12.5	−12.7	−13.3	−14.4	−14.5	− 9.4
Ba	9.4	28.7	34.9	17.6	− 5.7	−15.7	−14.1	−14.6	−14.8	−12.4	− 8.5	− 4.1
AP	13.1	4.0	− 4.9	− 6.9	− 7.5	− 7.7	− 6.8	− 5.7	− 4.1	0.9	9.7	15.7
WA	8.6	10.4	3.9	− 6.9	− 8.4	− 0.9	− 1.6	− 2.7	− 3.2	− 1.9	0.0	3.0
TO	9.4	− 1.9	−11.4	− 8.1	− 0.5	− 0.2	− 0.6	− 0.8	− 0.4	1.4	3.6	9.7
CR	3.0	− 9.8	− 8.4	− 0.9	− 0.5	− 0.3	0.4	− 0.6	− 0.1	1.9	5.1	9.9
TH	− 7.7	9.8	24.7	31.9	33.7	26.9	8.8	−17.5	−28.9	−31.3	−24.9	−25.4
GO	− 6.3	11.5	14.4	13.7	10.4	− 9.1	−23.7	− 5.0	13.0	5.9	− 6.2	−18.4
FR	29.4	35.4	29.8	19.0	− 9.1	−17.0	−33.0	−22.0	−18.3	−17.4	− 6.5	9.8
JU	− 0.5	−29.6	−27.4	−14.2	− 0.8	7.5	− 3.5	− 8.4	0.5	16.2	27.3	32.8
SI	4.3	10.0	5.3	3.9	4.3	7.3	6.7	3.7	− 3.8	−15.0	−18.4	− 9.2
ME	10.4	11.6	6.5	5.8	2.5	6.6	4.9	1.0	−11.4	−21.1	−13.9	− 3.2
AG	6.2	3.5	3.6	2.3	0.7	3.7	3.0	−13.3	−22.4	− 6.9	8.6	10.9
CH	4.5	4.6	4.4	1.3	0.9	3.4	1.5	−15.4	−18.2	− 1.6	8.8	6.4
TU	− 2.2	− 2.8	− 1.0	− 0.7	1.3	2.1	1.5	− 1.7	−10.2	− 0.3	9.0	4.2
TE	− 4.1	− 2.0	− 1.8	− 1.8	− 1.7	− 1.7	− 3.2	− 5.6	3.7	10.7	8.0	0.0
SJ	− 2.6	− 3.0	− 2.4	− 2.9	− 2.6	− 0.8	2.2	9.3	9.3	1.6	− 3.7	− 4.6
HU	−19.6	−21.4	−19.9	−19.8	−17.6	−14.2	− 3.5	24.0	51.5	43.4	10.6	−13.1
PI	− 5.3	− 7.3	− 6.0	− 4.6	− 3.0	0.7	8.0	12.6	9.7	1.7	− 2.5	− 4.2
Or	− 1.6	− 1.6	− 0.5	− 0.2	1.0	3.8	2.5	− 4.3	− 2.6	3.0	1.8	− 1.5

Table VII. *Y*-component of the S_q for the summer period. (Unit: *gammas*)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
CM	47.0	62.8	20.8	− 1.9	−12.8	−25.3	−20.3	−16.4	−21.5	−35.6	−16.6	19.9
SV	12.7	43.6	52.3	35.3	14.9	− 6.5	−25.0	−28.7	−30.2	−31.1	−26.7	−10.6
Bj	25.1	39.4	28.4	20.9	8.7	−10.4	−21.8	−21.4	−20.8	−25.2	−20.8	− 1.5
MS	17.9	19.3	17.8	6.0	−11.8	−22.4	−17.6	− 9.3	− 7.1	− 5.7	0.7	12.3
DI	24.4	21.5	9.7	− 8.8	−23.3	−21.0	− 9.8	− 7.2	− 7.5	− 4.0	6.0	19.4
SS	− 3.9	14.8	40.7	56.5	49.4	25.6	− 1.6	−26.4	−43.6	−47.4	−34.0	−30.1
TR	11.3	17.0	18.4	18.5	9.0	− 7.7	−19.7	−15.9	−10.8	−11.7	−10.6	2.4

(to be continued.)

(Table VII. continued.)

Observatory	0*h*	2*h*	4*h*	6*h*	8*h*	10*h*	12*h*	14*h*	16*h*	18*h*	20*h*	(GMT) 22*h*
PE	8.5	15.2	18.5	16.5	3.4	−12.1	−19.6	−12.1	−6.1	−7.7	−6.7	2.2
Kn	6.8	17.4	23.0	20.5	4.9	−16.3	−23.5	−14.5	−6.7	−7.1	−5.7	1.4
SO	6.2	17.1	22.9	18.4	2.0	−18.5	−25.8	−14.0	−4.1	−3.3	−3.8	2.0
DO	1.0	4.6	12.3	21.1	21.5	10.2	−13.4	−23.4	−14.4	−7.7	−7.7	−4.2
LE	−0.4	5.0	11.3	20.8	22.7	9.7	−12.4	−19.5	−13.8	−10.1	−9.1	−4.0
SL	4.7	11.3	20.8	23.2	11.2	−12.5	−26.3	−18.4	−6.6	−4.1	−3.3	0.1
LO	2.7	9.2	18.5	23.7	16.4	−6.8	−25.9	−19.3	−8.2	−4.9	−5.1	−0.3
VD	12.1	22.2	21.9	7.3	−15.3	−28.2	−19.1	−6.1	−2.6	−0.8	2.0	6.1
RS	1.8	6.9	15.4	22.9	19.8	−2.4	−25.0	−20.7	−8.4	−4.4	−4.8	−1.1
Ka	5.3	13.6	21.2	16.5	−3.0	−21.5	−21.3	−7.5	−3.0	−2.5	−0.2	2.7
ES	0.2	3.8	9.0	20.6	24.8	11.4	−13.5	−22.2	−15.1	−9.3	−6.8	−2.8
SW	3.5	7.7	17.6	24.1	14.8	−12.8	−27.6	−18.3	−5.2	−2.8	−2.4	1.1
DB	2.5	5.6	11.5	22.9	22.8	1.7	−24.1	−22.8	−10.4	−4.8	−4.4	−0.7
AB	0.5	3.5	8.1	20.3	24.9	9.7	−17.2	−23.7	−13.2	−6.2	−4.6	−1.9
Ma	1.4	4.7	10.5	23.5	25.3	4.0	−24.6	−24.0	−11.3	−3.8	−4.5	−1.2
VJ	1.0	3.5	8.4	21.2	25.7	7.1	−19.8	−23.7	−12.4	−4.9	−4.2	−1.6
VI	1.2	3.5	10.0	22.8	22.1	1.1	−22.2	−22.4	−9.4	−2.6	−3.1	−0.8
EB	1.8	4.2	7.5	20.4	25.7	6.9	−20.7	−25.8	−13.0	−3.7	−2.6	−0.9
SM	2.8	3.6	3.4	6.2	14.3	17.7	0.7	−16.7	−19.4	−9.8	−2.5	−0.7
SF	3.4	8.0	10.3	19.0	25.0	8.6	−18.7	−26.1	−17.1	−6.6	−4.0	−1.6
DD	9.6	26.8	21.2	−10.8	−27.4	−19.4	−4.6	−2.4	−2.2	0.4	3.7	4.9
HE	3.6	5.6	20.0	27.2	3.9	−21.0	−23.8	−10.5	−4.2	−3.1	−0.3	1.8
AL	5.7	19.5	21.3	−5.7	−25.4	−16.6	−0.4	−0.6	−3.4	−0.6	2.3	4.3
EL	3.5	4.6	7.3	3.7	−16.5	−13.2	1.3	8.2	−2.2	−1.9	0.9	2.9
TN	1.8	2.8	8.0	−2.0	−13.2	−4.3	9.3	6.9	−4.4	−3.8	−1.6	0.6
MU	0.7	2.4	1.8	−9.9	−7.2	5.3	10.6	−0.5	−3.2	−0.9	0.3	0.7
CT	1.7	2.1	2.3	3.0	−9.8	−12.9	2.7	9.9	0.4	−1.2	0.1	1.4
ZO	27.6	23.5	−3.0	−26.9	−26.1	−10.6	−1.4	−2.6	−1.8	1.7	5.3	14.6
TY	15.8	−10.1	−25.2	−20.5	−4.9	0.2	−1.1	−1.5	1.8	6.1	14.5	24.9
KA	17.5	−10.3	−24.4	−19.2	−3.8	0.3	−0.8	−0.6	2.0	4.7	10.4	24.7
AS	24.4	−2.1	−22.7	−20.3	−5.5	0.3	−1.8	−1.7	0.2	2.9	5.4	20.8
LU	32.5	6.2	−21.8	−24.0	−9.9	−0.2	−2.4	−3.0	−0.9	1.9	2.3	19.6
ZS	31.9	7.7	−19.9	−23.2	−10.5	−1.8	−3.5	−3.5	−1.4	1.8	3.4	18.8
HO	−17.6	−9.2	−3.7	−3.5	−4.0	−3.1	−1.2	2.6	9.7	26.7	14.0	−10.9
AT	21.0	−0.1	−16.8	−15.6	−5.4	−1.7	−3.1	−2.3	−0.2	1.9	5.6	16.7
Ba	2.1	−12.8	−15.2	−0.9	13.3	14.1	4.0	−0.3	−0.7	−1.6	−1.3	−0.8
AP	−10.5	−0.7	5.3	−0.9	−2.8	−3.5	−2.3	−0.1	5.0	9.3	7.5	−5.7
WA	2.1	−8.5	−7.8	2.9	8.7	1.6	−1.4	−2.4	−1.4	1.1	2.1	2.6

(to be continued.)

(Table VII. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
TO	− 5.6	− 7.3	4.9	12.0	2.1	− 1.5	− 3.3	− 3.1	− 1.4	0.9	0.8	1.5
CR	− 7.7	1.7	9.5	3.9	− 0.1	− 3.0	− 3.9	− 0.7	0.7	2.2	1.1	− 2.3
TH	−38.0	−33.9	−18.0	− 7.2	9.5	26.6	38.7	34.4	23.1	0.8	−12.0	−24.6
GO	−34.5	−22.2	− 2.9	5.6	26.8	57.9	55.6	8.3	−20.3	−25.9	−22.3	−26.6
FR	− 3.0	9.1	11.9	0.5	−24.6	−18.7	− 7.6	19.8	26.8	10.1	− 8.9	−15.2
JU	−15.5	10.0	24.9	27.2	31.2	25.9	13.2	− 9.1	−29.7	−31.7	−22.7	−23.8
SI	−26.4	−13.6	− 3.0	− 1.0	− 0.3	1.1	4.0	15.1	27.2	22.1	− 1.9	−24.8
ME	−14.0	− 3.3	− 0.6	− 0.1	− 1.5	1.6	9.9	24.3	25.2	2.6	−19.6	−24.6
AG	− 0.2	− 0.1	0.8	1.6	2.2	11.0	24.9	21.3	− 5.1	−25.0	−22.4	− 9.3
CH	− 1.5	− 1.1	0.1	1.0	1.3	10.8	26.5	22.1	− 6.0	−25.8	−18.9	− 8.8
TU	− 8.0	− 3.3	− 2.2	− 0.5	− 0.2	2.3	7.5	21.8	26.8	− 3.1	−22.2	−18.6
TE	− 4.6	− 2.9	− 1.4	− 0.9	− 0.3	2.1	10.5	25.4	9.6	−11.0	−16.4	9.5
SJ	− 3.8	− 1.5	− 0.5	0.9	3.0	10.9	24.0	11.0	− 6.5	−17.9	−13.7	− 6.3
HU	− 8.0	− 6.0	− 4.9	− 4.2	− 1.9	1.9	9.2	6.3	3.5	6.9	4.0	− 7.0
PI	− 3.1	− 2.1	− 1.8	− 1.9	0.5	3.7	3.6	− 7.7	0.8	10.3	2.6	− 5.0
Or	− 1.4	− 1.4	− 2.0	− 1.0	0.3	0.5	− 1.6	− 0.8	5.5	3.5	− 0.8	− 1.1

Table VIII. *Z*-component of the S_q for the summer period. (Unit: *gammas*)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
CM	30.0	12.8	− 4.6	− 0.1	3.6	0.7	−14.8	−22.4	−26.8	− 9.0	10.9	20.2
SV	30.2	32.5	7.6	− 6.1	− 9.0	− 6.1	− 8.6	−12.7	−20.2	−22.1	− 5.0	18.8
Bj	38.9	5.6	−16.4	−15.2	− 9.7	− 1.2	5.0	9.0	3.3	−22.8	−21.3	21.6
MS	− 3.0	− 1.4	− 4.8	− 3.1	0.4	4.6	9.0	8.3	6.3	− 4.4	− 7.4	− 4.7
DI	− 9.3	− 5.3	3.4	2.4	3.0	7.2	12.0	8.0	4.7	− 4.1	− 8.9	−12.4
SS	33.6	29.1	19.4	− 7.6	−33.3	−22.6	− 3.2	12.6	18.8	−17.0	−28.2	− 3.9
TR	−16.5	− 9.6	0.9	3.1	2.5	0.6	2.0	5.2	8.8	6.5	2.4	− 8.1
PE	−15.8	− 5.4	0.9	2.6	3.8	3.8	6.9	8.3	6.9	5.5	0.9	−16.9
Kn	− 7.5	− 2.1	− 0.6	0.8	− 0.7	− 0.6	2.9	3.9	4.4	4.5	1.3	− 6.0
SO	−10.0	− 3.5	1.3	1.4	0.1	− 0.8	2.2	4.5	5.5	5.3	1.5	− 7.1
DO	—	—	—	—	—	—	—	—	—	—	—	—
LE	− 1.9	− 1.3	2.2	3.7	1.7	− 2.9	− 8.3	− 5.1	1.1	4.7	3.9	2.1
SL	− 0.7	1.6	2.3	1.4	− 2.8	− 7.9	− 4.8	0.6	3.3	3.4	2.9	1.0
LO	− 0.6	1.1	2.9	1.1	− 4.3	− 9.4	− 5.6	1.0	4.6	4.7	3.2	1.1
VD	1.4	1.5	0.3	− 4.0	− 5.8	− 2.2	2.6	2.5	1.3	1.0	0.8	0.9

(to be continued.)

(Table VIII. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
RS	0.6	2.2	4.8	2.2	− 4.6	−13.4	−10.0	1.2	5.9	5.6	3.3	2.3
Ka	—	—	—	—	—	—	—	—	—	—	—	—
ES	0.9	0.6	2.9	3.5	1.1	− 5.6	−11.9	− 5.4	2.6	5.5	3.5	2.2
SW	1.8	2.3	4.1	1.1	− 6.9	−14.7	− 8.9	2.8	6.5	5.0	4.0	3.4
DB	0.0	− 0.1	1.5	2.9	2.0	− 5.1	−10.5	− 3.7	3.3	5.1	3.2	1.4
AB	1.5	1.2	3.5	3.3	0.6	− 7.8	−14.4	− 5.1	4.9	6.9	3.6	1.9
Ma	0.9	1.1	2.5	2.3	− 0.8	− 8.0	−11.2	− 2.5	4.9	5.3	3.0	2.5
VJ	2.0	1.9	3.7	4.1	1.4	− 6.6	−13.3	− 6.7	1.7	4.1	2.9	2.2
VI	1.9	1.8	3.7	4.5	1.2	− 7.7	−11.0	− 4.6	2.6	3.6	2.4	1.9
EB	4.0	4.3	5.1	4.8	− 0.8	− 9.2	−14.4	−10.2	1.6	6.3	4.9	3.6
SM	4.7	6.2	6.4	5.0	3.6	0.9	− 8.4	−11.5	− 8.7	− 1.7	0.9	2.9
SF	—	—	—	—	—	—	—	—	—	—	—	—
DD	5.5	5.6	− 3.9	−12.4	−10.0	− 2.8	1.2	2.2	3.0	4.0	4.2	3.9
HE	4.3	5.0	6.5	− 0.9	−14.9	−15.2	− 3.6	5.2	3.9	2.4	3.5	3.9
AL	5.2	10.7	− 5.5	−21.8	−14.4	1.4	7.7	1.9	2.1	4.4	4.6	4.1
EL	2.1	2.3	1.8	5.1	0.4	− 8.6	− 9.7	− 2.7	2.4	2.2	2.2	2.2
TN	2.7	4.5	6.2	6.0	0.0	− 4.2	− 5.2	− 3.8	− 3.2	− 2.5	− 1.3	0.9
MU	0.4	0.3	2.0	3.9	− 1.1	− 7.3	− 6.2	1.4	2.7	2.1	1.4	0.6
CT	− 3.6	− 1.7	− 4.4	− 5.8	2.6	1.0	− 4.0	− 2.0	5.3	6.2	4.8	1.5
ZO	—	—	—	—	—	—	—	—	—	—	—	—
TY	− 3.6	− 7.6	− 4.9	0.1	2.0	1.7	1.1	1.3	1.9	2.5	3.7	1.6
KA	−13.0	− 9.9	− 2.6	0.9	0.4	1.9	4.1	3.8	3.8	5.0	6.6	− 1.4
AS	− 6.2	−14.8	−10.3	− 2.7	2.0	2.1	3.4	4.0	4.5	4.9	6.5	5.9
LU	1.0	− 9.0	−11.6	− 6.4	0.0	2.5	3.2	3.5	3.6	3.5	3.8	5.6
ZS	− 0.2	−10.7	−12.7	− 6.3	0.6	3.0	3.5	4.1	4.1	4.0	4.4	6.2
HO	− 7.7	− 1.1	0.2	− 0.6	0.4	1.3	2.4	3.6	7.2	11.0	− 3.7	−12.9
AT	− 6.6	−16.4	−13.8	− 3.7	4.8	7.0	6.7	5.7	5.0	4.4	3.6	2.9
Ba	− 2.0	− 5.3	−10.9	− 7.9	− 0.4	6.7	6.8	5.3	3.4	1.7	1.2	1.2
AP	—	—	—	—	—	—	—	—	—	—	—	—
WA	− 0.1	4.1	− 1.5	− 8.6	− 3.4	3.4	4.1	3.7	1.6	− 0.6	− 1.1	− 1.1
TO	− 3.3	− 3.8	− 2.0	2.4	3.1	1.8	1.5	1.6	1.3	0.7	− 0.2	− 3.1
CR	− 1.6	− 0.7	0.9	1.5	1.8	1.7	1.2	0.3	− 0.5	− 0.8	− 1.3	− 2.4
TH	− 7.6	− 1.5	2.1	3.6	5.2	4.0	6.9	6.9	3.1	− 6.1	−13.4	− 5.3
GO	3.6	20.7	27.0	34.0	50.9	53.4	3.7	−25.2	−55.6	−59.6	−36.5	−18.9
FR	14.0	12.6	0.1	−27.2	− 2.0	25.5	20.0	− 4.1	−15.3	−16.1	− 9.4	2.0
JU	−30.0	8.8	15.0	3.2	−11.0	− 8.3	− 8.7	− 1.8	9.7	18.0	13.3	−10.8
SI	4.6	9.2	7·4	4.9	3.2	− 0.4	− 1.5	− 0.8	− 2.1	− 9.4	−11.1	− 4.0
ME	8.0	8.7	4.6	1.0	−10.3	− 7.9	− 1.8	2.8	0.2	− 4.1	− 4.0	2.6

(to be continued.)

(Table VIII. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
AG	1.2	1.0	0.5	0.0	-0.1	0.4	0.3	-0.5	-1.7	-2.1	-0.2	1.0
CH	3.6	2.4	1.1	0.9	0.6	2.7	2.9	-2.6	-10.3	-7.8	1.0	5.7
TU	2.7	2.9	2.4	2.5	2.2	2.0	2.7	5.6	-1.7	-10.3	-7.8	-3.2
TE	-2.1	0.5	1.7	2.4	2.7	3.0	4.6	3.4	-3.8	-5.7	-3.9	-2.1
SJ	2.0	1.8	1.5	1.1	1.5	2.0	-3.8	-8.3	-4.4	-0.2	4.2	3.2
HU	0.5	1.7	2.3	2.3	2.8	3.6	4.7	-0.5	-5.1	-4.4	-5.3	-4.0
PI	2.2	2.3	2.5	2.2	1.8	1.2	0.8	-2.2	-9.8	-5.4	1.7	2.4
Or	—	—	—	—	—	—	—	—	—	—	—	—

Table IX. *X*-component of the S_q for the winter period. (Unit: *gammas*)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
CM	-22.2	-18.9	-0.5	16.6	17.7	15.1	10.5	-2.0	2.6	-5.5	-2.1	-10.8
SV	-4.6	-7.0	-8.1	-0.7	5.0	6.9	9.5	8.1	2.4	-5.2	-5.6	-4.8
Bj	-27.5	-3.8	12.3	14.4	11.1	10.2	12·7	15.1	11.9	9.1	-30.4	-35.1
MS	-7.3	7.2	7.8	4.4	2.7	4.4	5.4	7.3	6.1	3.3	-19.4	-22.3
DI	-1.0	3.9	1.3	-0.3	4.2	6.7	8.2	9.5	3.7	-8.9	-14.7	-12.5
SS	-20.0	-5.0	-8.2	-1.5	5.1	1.1	5.7	8.5	12.9	12.7	3.0	-14.1
TR	-13.5	1.3	6.4	6.7	1.5	-2.3	-0.8	0.7	2.4	4.9	0.0	-7.9
PE	-5.0	0.7	4.3	3.6	-0.7	-3.0	0.5	1.0	1.8	2.5	-1.6	-3.4
Kn	-1.4	-0.2	1.7	1.6	-1.7	-4.8	-2.5	-0.5	0.7	1.9	2.8	2.6
SO	-3.1	-0.5	3.2	3.8	-1.2	-4.8	-1.6	-0.3	1.8	0.8	0.7	0.3
DO	0.4	-1.8	-0.2	4.1	4.6	-4.5	-7.5	-2.2	0.6	2.9	2.4	1.1
LE	0.3	-1.0	1.2	4.9	2.5	-4.9	-7.9	-2.9	1.2	2.6	2.2	1.8
SL	0.1	-0.4	2.2	3.4	-1.4	-5.6	-3.3	-0.2	0.7	1.4	1.1	1.7
LO	-0.4	-0.4	2.5	4.5	-0.9	-6.8	-3.7	-0.3	1.3	1.4	1.5	0.9
VD	0.4	1.7	3.6	-1.3	-3.2	-1.4	-1.5	-1.3	0.4	1.3	0.6	0.3
RS	-0.2	-0.1	2.6	5.4	0.4	-7.8	-5.8	-0.9	1.2	1.6	1.8	1.3
Ka	-0.5	-0.4	1.8	1.8	-1.8	-1.9	-0.3	0.3	0.5	0.6	0.5	-0.5
ES	0.7	0.4	2.0	5.8	3.2	-6.0	-9.7	-4.0	0.7	2.3	2.5	2.1
SW	-0.6	-0.1	2.6	5.6	-0.4	-6.4	-4.1	-0.5	1.0	0.9	1.4	0.8
DB	0.9	-1.2	1.6	5.4	2.6	-7.2	-8.8	-2.6	0.9	2.7	3.1	2.7
AB	1.2	0.8	2.5	6.8	4.6	-5.1	-10.3	-5.7	-0.4	1.9	2.1	2.0
Ma	-0.5	-0.8	1.5	4.4	3.9	-3.1	-5.2	-2.7	0.2	1.6	0.9	0.1
VJ	0.3	-0.4	2.1	6.1	4.8	-5.2	-8.1	-4.4	-0.3	1.9	1.9	1.3

(to be continued.)

(Table IX. continued.)

Observatory	0*h*	2*h*	4*h*	6*h*	8*h*	10*h*	12*h*	14*h*	16*h*	18*h*	20*h*	(GMT) 22*h*
VI	0.6	− 2.2	0.2	6.3	6.5	− 3.7	− 8.2	− 4.7	− 0.7	1.9	1.7	2.7
EB	− 0.7	− 1.3	1.4	5.4	6.8	− 0.9	− 5.4	− 5.7	− 1.2	0.8	1.0	0.4
SM	1.6	− 0.2	− 1.7	0.6	2.7	5.9	− 2.5	− 8.9	− 6.3	1.5	4.2	3.3
SF	− 1.3	− 0.4	1.3	6.8	13.7	7.2	− 5.6	−12.9	− 6.5	− 1.5	− 0.6	− 0.3
DD	− 1.8	2.2	5.0	6.1	6.0	2.0	− 1.2	− 4.2	− 5.1	− 3.2	− 4.0	− 2.4
HE	− 4.3	− 4.0	− 0.3	8.0	11.0	8.2	2.0	− 4.2	− 4.0	− 4.4	− 4.5	− 3.8
AL	− 5.1	− 1.5	8.4	17.5	16.0	5.0	− 2.6	− 6.3	− 8.0	− 8.4	− 7.9	− 6.0
EL	− 5.4	− 5.5	− 4.3	1.5	12.6	16.0	8.4	0.0	− 4.5	− 7.0	− 6.3	− 5.6
TN	− 0.4	− 1.8	− 0.8	3.2	9.2	8.0	1.2	− 5.2	− 4.6	− 4.9	− 2.8	− 1.1
MU	− 1.2	− 2.3	− 1.2	4.7	8.4	6.4	− 0.8	− 3.1	− 3.7	− 4.1	− 2.3	− 1.1
CT	1.9	1.1	1.5	0.5	− 4.3	− 4.4	− 0.5	− 0.4	0.8	0.5	1.1	2.3
ZO	3.3	0.1	− 5.4	− 1.8	3.0	1.1	− 0.4	− 0.7	− 0.8	− 0.2	0.0	2.0
TY	− 2.3	− 7.0	0.0	4.8	2.7	− 0.3	− 0.9	− 1.1	− 1.0	0.1	1.5	3.4
KA	3.5	− 2.6	− 1.8	1.9	1.2	− 1.9	− 2.4	− 2.4	− 0.8	− 1.1	1.2	5.2
AS	4.4	0.5	0.0	1.7	1.4	− 1.5	− 2.3	− 2.6	− 2.1	− 1.3	− 0.4	2.3
LU	7.3	4.2	1.9	2.2	1.2	− 2.5	− 3.2	− 3.7	− 3.4	− 3.2	− 2.4	1.3
ZS	—	—	—	—	—	—	—	—	—	—	—	—
HO	8.6	3.6	− 1.9	− 4.9	− 5.6	− 5.2	− 3.8	− 3.5	− 1.9	1.5	3.7	9.3
AT	6.0	27.5	31.0	16.1	0.6	− 7.5	−11.1	−14.0	−14.6	−14.2	−12.6	− 7.4
Ba	5.4	24.2	31.9	18.6	− 1.4	−12.0	−12.8	−14.7	−14.6	−11.8	− 8.9	− 4.6
AP	26.2	10.5	− 5.4	− 8.9	− 9.1	−10.4	−10.1	−10.6	− 9.5	− 7.8	7.2	28.1
WA	2.9	0.3	− 0.1	− 2.1	− 3.9	− 0.9	0.3	0.0	− 0.3	0.3	0.3	3.6
TO	−14.6	−15.3	− 2.4	5.5	3.3	3.7	4.9	4.3	2.8	2.9	4.9	− 0.1
CR	−21.1	− 7.7	7.2	8.6	7.1	6.0	5.3	3.1	2.0	3.6	0.2	−14.7
TH	− 2.5	4.9	10.0	12.1	12.1	8.5	2.4	− 8.0	−11.0	−11.8	−10.4	− 6.2
GO	− 7.0	3.3	8.9	7.0	3.4	− 2.3	− 4.2	− 5.2	0.0	2.0	− 1.2	− 4.7
FR	12.5	14.1	15.2	13.0	−11.9	−28.9	−21.1	−13.0	− 1.0	1.8	7.8	11.9
JU	7.8	−21.6	−22.7	− 3.0	3.1	6.6	3.0	− 4.8	− 1.6	6.7	12.2	15.1
SI	0.3	2.6	1.1	0.1	− 1.7	− 0.4	1.3	1.7	0.5	− 2.0	− 2.9	− 1.5
ME	3.8	3.6	0.7	0.4	− 0.5	− 0.7	2.0	2.2	− 1.9	− 7.4	− 4.3	1.9
AG	5.0	2.2	1.2	1.2	2.4	4.1	5.4	− 2.0	−14.2	−11.8	0.0	6.5
CH	3.7	2.1	− 0.1	1.3	3.4	5.9	6.1	− 0.3	−14.0	−12.8	− 1.2	5.6
TU	3.6	0.5	− 2.2	− 2.3	0.2	2.1	4.1	4.2	0.3	− 5.9	− 5.5	0.9
TE	− 1.4	− 3.3	− 3.9	− 3.4	− 1.8	− 1.2	1.2	3.5	2.1	2.8	3.3	1.8
SJ	− 1.6	− 2.6	− 3.3	− 2.6	− 0.4	2.3	9.7	11.1	3.1	− 7.9	− 6.4	− 1.4
HU	−17.4	−18.0	−18.7	−18.3	−16.8	−13.9	− 2.4	30.6	49.7	32.0	4.6	−11.5
PI	− 8.2	− 7.3	− 7.2	− 7.5	− 6.1	− 3.7	0.7	10.6	18.7	12.7	3.1	− 5.4
Or	6.3	7.7	6.3	6.6	4.6	− 1.2	−13.2	−18.3	− 7.1	2.3	1.7	4.2

Table X. Y-component of the S_q for the winter period.
(Unit: *gammas*)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
CM	15.3	13.6	-0.1	-10.1	-6.3	-1.8	-1.4	-2.2	-8.6	-9.6	1.5	10.0
SV	8.7	13.1	16.2	4.4	-3.2	-5.2	-8.7	-8.2	-6.1	-6.7	-8.7	0.9
Bj	9.5	7.2	1.1	-2.4	-2.4	-3.7	-5.1	-3.6	-4.0	-2.7	-1.1	8.2
MS	-2.0	-0.9	0.4	-0.9	-2.5	-2.4	-0.7	-1.0	-0.4	1.7	6.4	2.1
DI	1.9	1.6	-0.1	-2.0	-2.3	-0.9	0.6	0.4	-2.6	-0.8	2.1	2.0
SS	8.3	15.1	18.8	16.7	0.9	-3.5	-8.2	-12.2	-12.8	-11.1	-8.1	-4.2
TR	5.0	0.0	0.1	-0.5	-0.8	-2.7	-4.1	-3.3	-2.1	-1.0	2.3	7.1
PE	1.5	-0.1	0.9	0.4	-0.2	-3.2	-3.7	-2.4	-2.0	1.1	3.4	4.3
Kn	-1.4	-1.5	-2.3	-2.6	-1.1	-2.3	-1.4	1.2	1.3	2.9	4.2	3.2
SO	0.4	0.1	1.6	1.9	0.1	-4.1	-4.4	-2.4	-1.3	0.6	3.4	4.2
DO	5.0	-0.1	-1.2	-0.7	0.1	3.3	-3.2	-6.2	-2.6	-1.0	-0.4	7.0
LE	3.3	-0.6	-0.2	1.1	2.1	1.1	-5.5	-6.4	-2.1	-0.7	2.3	5.6
SL	1.3	-0.6	0.0	1.9	2.2	-3.1	-6.3	-2.6	-1.0	0.8	2.8	4.1
LO	1.2	-0.9	0.0	1.8	3.3	-2.2	-7.3	-3.4	-1.3	0.6	3.5	4.9
VD	-1.5	-1.5	0.3	1.3	-4.7	-4.3	-1.6	-0.1	1.5	4.7	4.5	1.6
RS	2.0	-1.1	-0.5	1.8	4.0	-1.4	-8.3	-4.6	-0.9	0.8	3.3	5.0
Ka	-0.5	-0.5	0.2	3.4	1.1	-3.6	-2.2	-0.3	-0.2	0.9	1.7	1.5
ES	3.2	-0.5	-0.8	0.8	3.3	3.0	-5.9	-7.6	-2.3	-0.5	2.2	5.0
SW	1.2	-1.0	-0.3	3.3	4.7	-4.1	-9.4	-3.1	-0.8	1.7	3.7	3.9
DB	2.5	-0.9	-0.5	1.3	4.7	0.2	-9.1	-6.3	-0.9	1.0	3.8	5.1
AB	3.3	-0.8	-1.4	0.5	4.1	3.4	-7.7	-8.4	-2.0	1.0	2.9	4.9
Ma	2.9	0.7	0.0	0.9	3.6	0.6	-8.5	-7.0	-0.9	0.6	2.1	4.7
VJ	3.0	-0.6	-0.9	1.0	4.5	3.0	-9.1	-8.7	-1.5	1.2	3.3	4.8
VI	2.8	-1.0	-2.6	2.3	5.4	0.7	-8.0	-6.5	-1.7	1.2	3.0	4.3
EB	3.5	0.5	-0.3	1.5	5.3	4.0	-9.4	-11.1	-2.8	1.0	3.1	4.4
SM	5.1	2.7	0.7	0.6	2.2	8.9	4.3	-12.1	-13.1	-3.8	1.4	3.2
SF	5.9	6.3	5.4	3.9	3.7	3.9	-9.1	-13.3	-7.9	-3.6	1.4	3.7
DD	-3.7	-2.4	4.9	1.5	-4.8	-1.5	1.0	0.5	1.5	2.5	1.9	-1.0
HE	0.4	-2.5	-2.3	4.1	5.8	-6.5	-6.1	-2.6	0.2	2.9	3.4	2.8
AL	-4.3	-6.1	-0.6	2.4	-1.0	1.6	2.9	2.0	2.1	1.4	1.1	-1.1
EL	0.1	-2.8	-9.8	-18.9	-6.4	7.4	11.1	6.1	2.0	4.1	4.6	2.4
TN	-4.3	-6.1	-12.8	-11.7	2.3	16.6	14.8	5.4	0.2	-0.4	-1.0	-2.9
MU	-5.6	-11.1	-16.8	-6.6	7.9	14.4	9.7	5.5	2.7	2.5	0.1	-3.1
CT	-0.6	-3.4	-9.2	-22.1	-20.0	2.5	16.7	14.6	6.6	5.7	5.4	3.4
ZO	-1.4	4.9	2.4	-5.1	-3.2	0.8	0.6	0.3	1.1	1.6	0.4	-2.0
TY	5.6	-0.7	-7.5	-2.3	1.9	0.5	-0.1	0.4	0.2	0.3	0.0	1.2
KA	9.0	0.4	-10.5	-4.7	2.2	1.3	0.0	0.3	0.3	0.5	-0.3	1.2

(to be continued.)

(Table X. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
AS	7.4	5.3	− 8.2	− 6.1	2.8	2.0	0.1	− 0.3	− 0.1	− 0.1	− 1.1	− 1.5
LU	2.7	9.5	− 2.7	− 7.3	0.0	1.8	0.1	− 0.2	0.1	− 0.1	− 1.0	− 3.3
ZS	—	—	—	—	—	—	—	—	—	—	—	—
HO	− 7.6	− 4.1	2.6	2.3	− 0.7	− 2.3	− 2.9	− 1.5	− 0.3	3.2	10.6	1.2
AT	− 4.1	4.1	0.6	− 0.8	2.7	3.1	0.7	0.0	0.2	− 0.1	− 1.3	− 5.0
Ba	−35.6	−29.2	− 2.9	24.1	32.9	25.7	15.3	6.6	0.0	− 5.1	−11.6	−20.3
AP	22.6	19.8	6.3	3.6	2.2	− 1.7	− 3.4	− 3.9	− 3.5	−15.8	−24.6	− 1.1
WA	−26.6	−23.8	2.9	21.1	19.6	10.0	5.9	3.9	1.6	0.2	− 2.2	−12.2
TO	−27.4	9.1	34.5	27.0	10.0	2.3	− 0.6	− 2.2	− 3.3	− 3.8	−13.5	−32.0
CR	− 7.0	22.7	28.0	16.5	6.7	2.8	− 0.7	− 2.7	− 4.0	− 8.5	−23.4	−30.9
TH	−11.9	− 9.0	− 3.8	0.4	7.1	11.4	13.2	10.5	3.6	− 2.7	− 8.5	−10.5
GO	−10.3	− 5.9	1.9	5.1	11.2	18.6	14.4	3.1	− 9.8	−11.8	− 9.1	− 7.3
FR	3.5	8.5	11.7	7.3	−14.7	−18.0	− 5.7	1.6	7.7	3.3	− 3.2	− 2.4
JU	− 2.1	11.2	14.9	8.0	6.8	1.5	0.2	− 7.0	−12.0	− 8.9	− 7.2	− 5.9
SI	− 5.2	− 0.7	1.5	0.7	1.4	− 0.9	− 1.0	1.9	4.5	4.6	− 1.0	− 5.8
ME	− 1.8	1.5	2.6	0.8	− 0.6	− 2.0	0.9	4.0	7.4	1.0	− 7.3	− 5.9
AG	1.1	3.2	2.2	− 1.1	− 2.5	0.5	4.3	10.4	2.5	−10.2	− 8.4	− 2.1
CH	0.8	2.7	1.4	− 1.7	− 3.3	− 0.5	4.2	12.3	6.1	−10.0	− 9.2	− 2.3
TU	− 0.6	3.7	2.8	0.3	− 2.2	− 2.7	− 1.2	2.2	11.6	5.4	−10.3	− 9.0
TE	0.8	3.1	1.5	− 1.6	− 3.3	− 2.8	− 1.2	2.3	9.5	4.0	− 6.9	− 5.2
SJ	0.9	1.3	− 1.0	− 3.1	− 3.5	− 2.3	2.3	17.6	8.4	− 9.1	− 9.9	− 1.7
HU	− 2.3	− 2.1	− 4.4	− 7.8	− 9.6	−10.0	−14.4	5.4	22.6	18.7	6.7	− 2.5
PI	− 0.4	− 1.6	− 4.2	− 7.6	− 8.7	−13.8	−15.9	2.1	21.6	21.8	6.4	− 0.2
Or	5.2	2.5	− 2.8	− 9.9	−16.5	−19.9	−13.6	2.2	19.1	18.0	9.0	6.5

Table XI. *Z*-component of the S_q for the winter period. (Unit: *gammas*)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
CM	14.4	− 2.0	−11.2	− 5.6	− 3.3	− 3.9	−12.1	−13.4	− 7.2	9.1	16.6	19.2
SV	19.2	4.5	− 5.2	−13.4	− 8.1	− 3.8	− 3.8	− 8.1	− 7.8	− 3.3	7.7	24.9
Bj	11.2	− 1.8	− 9.8	− 8.8	− 3.6	1.4	3.8	4.4	1.3	−11.5	− 5.5	15.9
MS	− 3.9	− 1.5	− 3.8	0.7	5.7	6.8	8.2	9.6	1.5	− 5.7	− 8.9	− 8.8
DI	—	—	—	—	—	—	—	—	—	—	—	—
SS	16.3	13.3	9.0	− 6.0	−17.5	− 2.4	0.6	5.4	4.1	− 5.4	−12.2	− 3.6
TR	−13.8	− 1.2	1.7	1.5	3.4	4.8	5.1	4.7	3.0	5.1	− 1.5	−14.2

(to be continued.)

(Table XI. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
PE	−10.2	0.9	2.1	2.1	3.1	4.8	4.1	4.3	3.2	5.5	− 3.0	−15.5
Kn	− 5.3	− 2.6	− 3.7	− 5.0	− 2.8	− 0.8	0.8	5.7	7.7	6.5	3.1	− 4.4
SO	− 8.3	0.4	1.2	0.4	1.0	2.6	3.4	2.9	2.0	3.5	− 0.8	− 8.3
DO	—	—	—	—	—	—	—	—	—	—	—	—
LE	− 1.2	− 2.2	− 2.1	− 2.5	− 0.8	1.1	1.5	1.8	1.2	0.8	1.2	1.2
SL	− 0.9	− 1.2	− 1.3	− 1.2	− 1.3	− 1.4	0.8	2.0	1.7	1.7	1.4	− 0.4
LO	− 1.9	− 1.2	− 0.8	− 0.6	− 1.1	− 1.3	1.0	2.3	1.7	1.5	0.7	− 0.7
VD	− 0.8	0.1	0.0	− 1.6	− 1.4	− 0.2	1.0	0.9	1.5	1.2	0.7	− 1.2
RS	− 1.6	− 0.9	− 0.1	0.3	− 1.6	− 3.8	− 0.7	3.1	2.0	1.6	1.4	0.0
Ka	—	—	—	—	—	—	—	—	—	—	—	—
ES	− 0.2	− 1.2	− 1.2	− 1.2	− 0.7	− 0.6	− 1.0	0.8	1.6	1.1	1.3	1.2
SW	− 0.9	− 0.4	0.2	0.8	− 2.0	− 3.9	− 0.9	2.1	1.9	1.4	1.4	0.4
DB	− 0.4	− 1.5	− 2.1	− 1.9	− 0.5	− 1.2	− 0.3	2.5	2.2	1.3	1.4	1.1
AB	0.1	− 1.0	− 1.2	− 0.3	− 0.2	− 2.3	− 3.0	1.4	2.1	2.1	1.6	1.3
Ma	1.1	0.6	0.7	− 0.3	− 1.8	− 4.5	− 2.0	1.7	1.5	1.8	1.3	1.3
VJ	0.2	− 0.2	0.4	0.0	− 0.7	− 2.6	− 2.7	0.7	1.6	1.2	1.0	1.0
VI	1.1	0.3	0.3	1.2	0.0	− 3.8	− 3.3	1.1	0.9	0.7	0.6	0.6
EB	4.1	4.0	3.1	1.4	− 1.1	− 9.9	−11.1	− 3.5	2.0	3.6	3.5	3.7
SM	—	—	—	—	—	—	—	—	—	—	—	—
SF	—	—	—	—	—	—	—	—	—	—	—	—
DD	0.0	0.3	0.5	− 2.5	− 1.4	− 0.2	1.8	0.5	− 0.2	0.8	− 0.2	0.2
HE	1.6	1.7	1.3	0.0	− 6.5	− 7.4	− 0.9	1.7	1.8	1.8	2.2	2.0
AL	− 0.6	− 1.6	2.2	− 3.4	− 2.6	− 1.0	1.4	1.2	1.5	1.4	1.0	0.1
EL	4.2	4.7	4.9	0.4	− 6.8	−10.1	− 7.0	− 1.7	1.9	2.3	3.3	4.1
TN	3.9	6.5	9.1	7.4	3.0	− 2.3	− 6.4	− 8.6	− 8.0	− 5.0	− 1.6	2.0
MU	1.7	3.1	3.6	− 0.4	− 4.1	− 4.8	− 1.9	− 0.4	0.2	0.4	1.0	1.3
CT	1.1	2.3	0.6	5.9	− 7.2	−17.4	−12.7	− 1.1	7.8	8.3	7.4	4.7
ZO	—	—	—	—	—	—	—	—	—	—	—	—
TY	− 0.3	− 0.9	0.4	1.1	− 0.3	− 0.9	− 0.2	0.3	0.4	0.0	0.0	0.5
KA	− 4.6	− 9.1	− 1.7	1.9	− 0.9	− 0.8	0.7	1.7	2.3	2.9	3.5	3.4
AS	1.2	− 7.7	− 8.7	− 2.3	0.8	0.5	1.5	2.3	2.7	2.8	3.0	3.4
LU	2.3	− 2.9	− 7.8	− 4.9	0.1	0.7	0.8	1.4	2.0	2.6	2.7	2.5
ZS	1.7	− 4.4	− 9.1	− 5.1	0.8	1.7	1.9	2.3	2.4	2.6	2.7	2.5
HO	− 9.3	− 4.0	1.9	1.9	1.9	2.1	1.9	2.2	2.1	3.4	3.6	− 7.7
AT	1.4	− 4.0	− 9.5	− 5.2	1.9	3.7	3.1	2.3	1.8	1.5	1.4	1.3
Ba	5.9	− 3.8	−16.9	−15.1	− 5.3	4.7	5.7	5.7	5.3	4.7	4.3	4.3
AP	—	—	—	—	—	—	—	—	—	—	—	—
WA	12.8	− 5.6	−25.0	−12.3	− 4.2	5.1	5.8	6.1	5.4	4.4	5.1	11.0

(to be continued.)

(Table XI. continued.)

Observatory	0h	2h	4h	6h	8h	10h	12h	14h	16h	18h	20h	(GMT) 22h
TO	− 2.1	− 6.8	− 6.1	− 1.0	2.3	1.1	0.4	1.4	2.1	2.6	3.5	2.8
CR	− 2.8	− 4.8	− 2.4	0.9	1.6	0.9	0.9	0.9	0.7	0.7	1.9	1.2
TH	− 0.1	3.0	4.0	5.2	5.2	3.7	− 1.6	− 2.6	− 2.9	− 6.3	− 5.7	− 3.4
GO	5.0	11.0	13.8	13.2	16.6	16.1	0.7	−16.1	−24.8	−18.7	−10.3	− 5.4
FR	6.8	7.6	3.9	−10.0	−10.2	7.3	7.4	− 7.1	− 6.3	− 3.2	− 0.1	4.1
JU	−12.9	− 3.1	− 4.2	− 2.4	− 8.0	− 6.3	− 2.7	1.3	10.9	11.9	8.5	3.9
SI	3.1	2.2	2.2	1.4	0.6	− 3.3	− 2.7	− 2.7	− 1.0	− 1.0	0.1	1.3
ME	3.3	4.3	2.4	0.9	− 5.3	− 7.2	− 4.2	− 1.8	0.4	0.9	2.2	4.0
AG	0.1	0.0	0.0	0.0	0.0	0.0	0.2	− 0.3	− 1.1	− 0.2	0.8	0.5
CH	1.2	0.8	0.0	0.6	0.5	0.5	0.5	− 2.0	− 6.0	− 1.6	2.8	2.5
TU	2.0	2.5	1.9	1.2	1.1	1.1	1.4	1.6	0.6	− 4.5	− 7.0	− 2.2
TE	0.3	0.6	0.4	0.5	1.2	2.0	2.7	3.8	1.8	− 4.6	− 6.3	− 2.4
SJ	2.0	2.4	2.6	2.5	2.6	1.7	0.2	− 2.7	− 7.8	− 5.6	0.5	1.8
HU	− 3.2	− 2.4	− 2.6	− 2.5	− 1.2	− 0.8	0.6	5.9	8.2	3.5	− 0.5	− 4.2
PI	3.1	3.9	4.3	4.4	4.1	3.8	− 1.4	−10.1	−10.4	− 5.5	1.2	2.4
Or	—	—	—	—	—	—	—	—	—	—	—	—

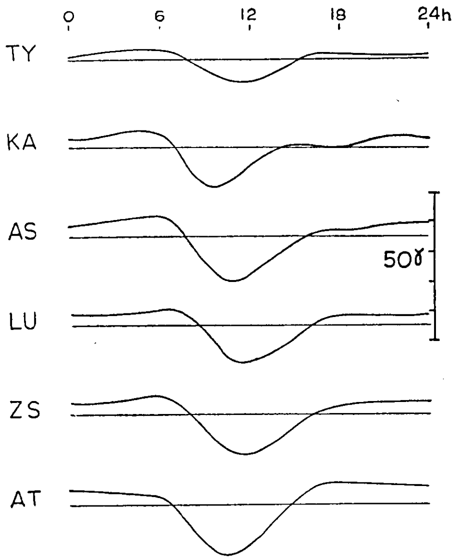

Fig. 4. The S_q variation in the vertical component for the summer season as observed at the observatories in the Far East during the period 1932–33.

3. Magnetic potential for S_q

For the purpose of making a separation of the internal origin part of geomagnetic variations from the external origin one, it is necessary to know the distribution of the magnetic potential over the earth provided we adopt Vestine's method of surface integral[19]. As for the estimate of the potential over the earth, two methods have been hitherto proposed, one is the method of graphical integration by Hasegawa and Ota[20] and the other the method of residuals by Wilkins[16]. It seems difficult to decide which method is better, but the writers are going to adopt the former method in this paper because they are familiar with it. No detailed description will be given here, the detailed practice of the method having been given in the writers' previous paper[2].

From Tables VI, VII and VIII, the deviations from the midnight value at every two *hours* are calculated for each component. As has been attempted by Wilkins[16], Ota[17] and others, it would be sometimes natural to define S_q as above under the assumption of no magnetic field during midnight period. From X and Y thus calculated, the magnetic potential between 60°N and 60°S is obtained by means of the method of graphical integration at 20, 22, 0, 2, 4 and $6h$ GMT. Only the S_q for the summer period is dealt with here, because the amplitude of S_q becomes small in winter.

The distribution of the magnetic potential thus obtained is shown in Figs. 5, 6, 7, 8, 9 and 10 respectively for 20, 22, 0, 2, 4 and $6h$ GMT. An investigation of the same sort has been already made by Hasegawa and Ota[20], but they obtained the potential for the mean state of summer and winter.

It is most interesting that the pattern of the potential distribution changes from time to time as it goes around the earth. The characteristic movements of the foci of the pattern have also been pointed out by Nagata[21] and Ota[22].

4. Separation of the geomagnetic potential into internal and external origin parts

If we combine the world-wide distribution of the magnetic potential (W) with that of Z, it is well known that the internal origin part of S_q can be separated from the external origin one by making use of

19) E. H. VESTINE, *Terr. Mag.*, **46** (1941), 27.

20) M. HASEGAWA and M. OTA, *Trans. Oslo Meeting, I.A.T.M.E.I.U.G.G.*, (1950), 431.

21) T. NAGATA, *Trans. Oslo Meeting, I.A.T.M.E.I.U.G.G.*, (1950), 362.

22) M. OTA, *Trans. Oslo Meeting, I.A.T.M.E.I.U.G.G.*, (1950), 438.

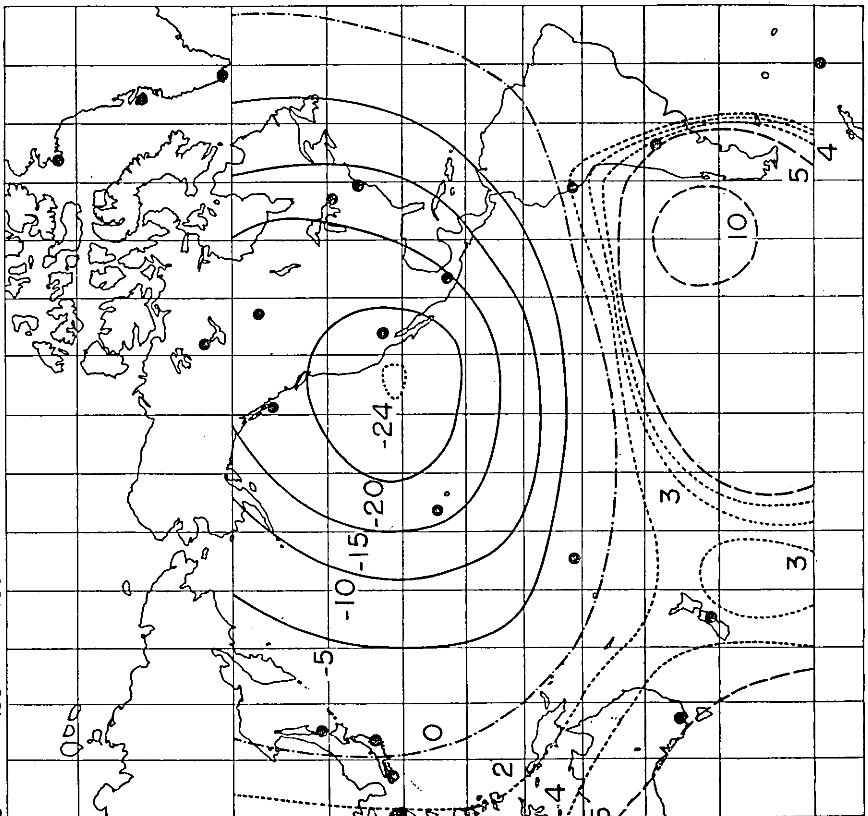

Fig. 5. Geomagnetic potential of the S_q at 20*h* GMT for the summer period. The unit of the potential should be read in *gammas* multiplied by the earth's radius.

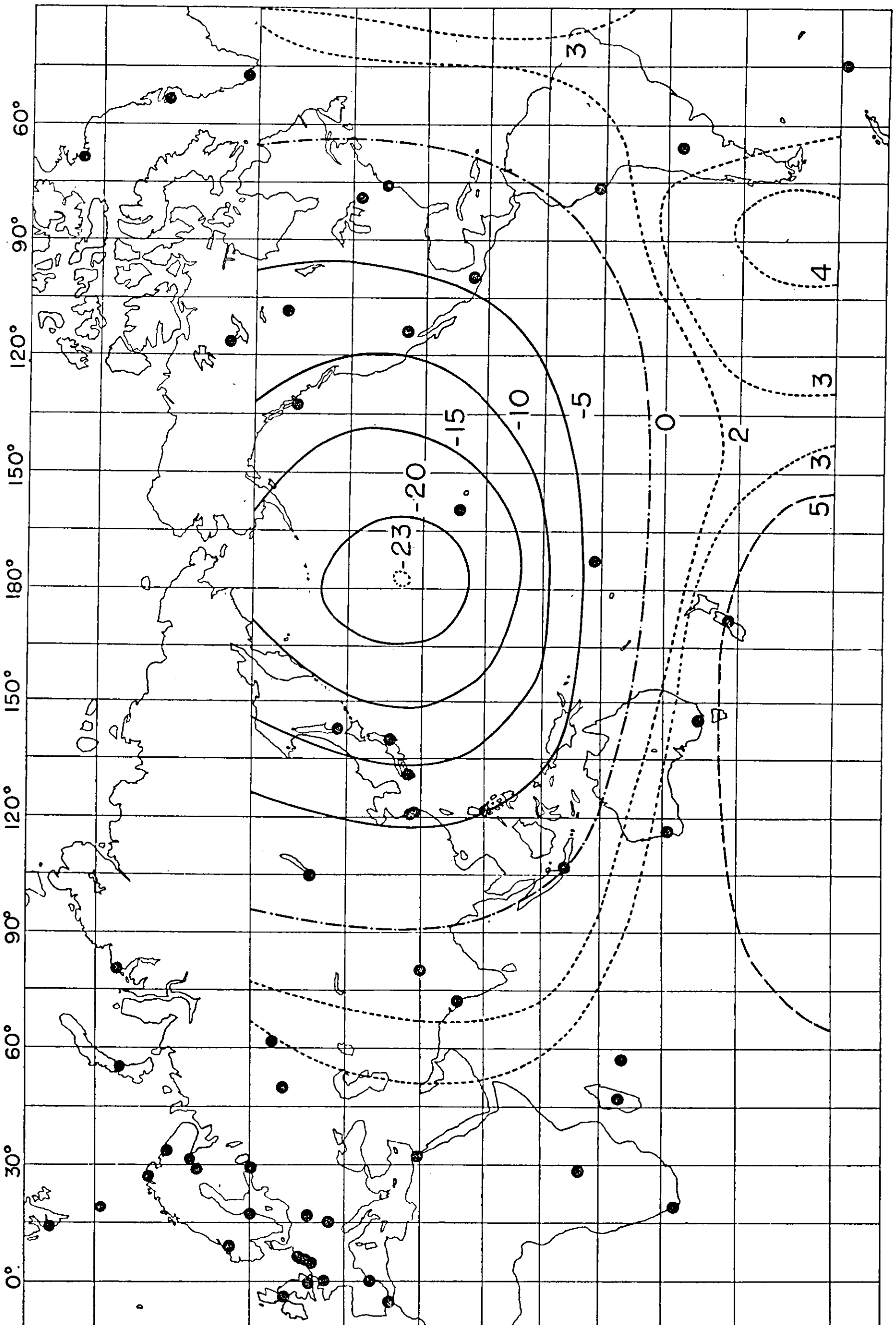

Fig 6. Geomagnetic potential of the S_q at $22h$ GMT for the summer period. The unit of the potential should be read in *gammas* multiplied by the earth's radius.

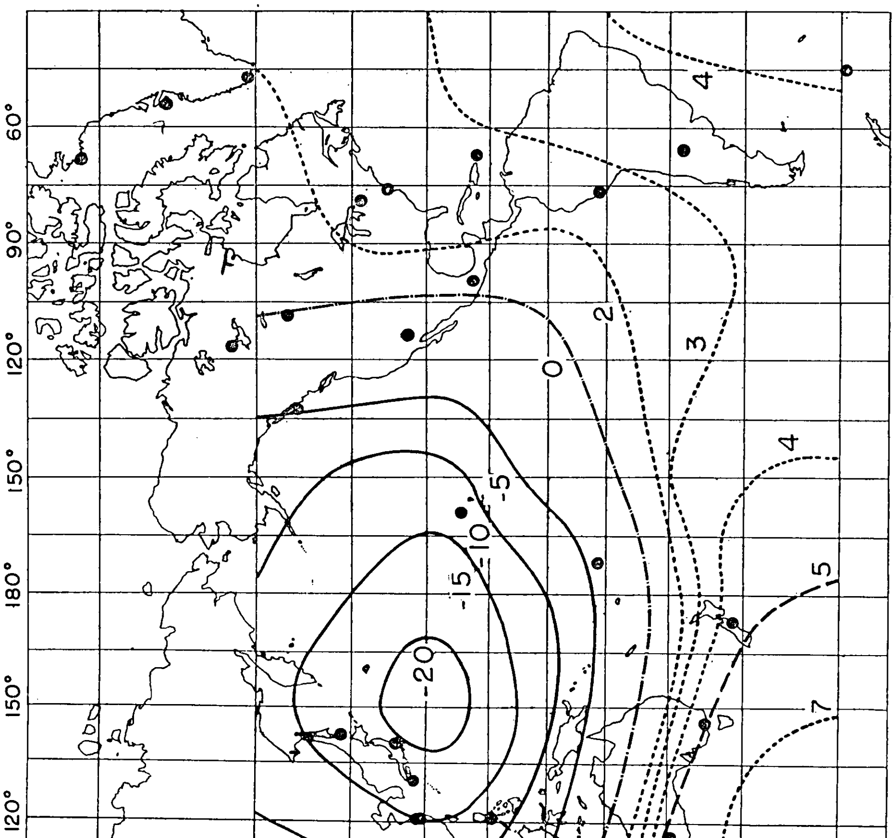

Fig. 7. Geomagnetic potential of the S_q at $0h$ GMT for the summer period. The unit of the potential should be read in *gammas* multiplied by the earth's radius.

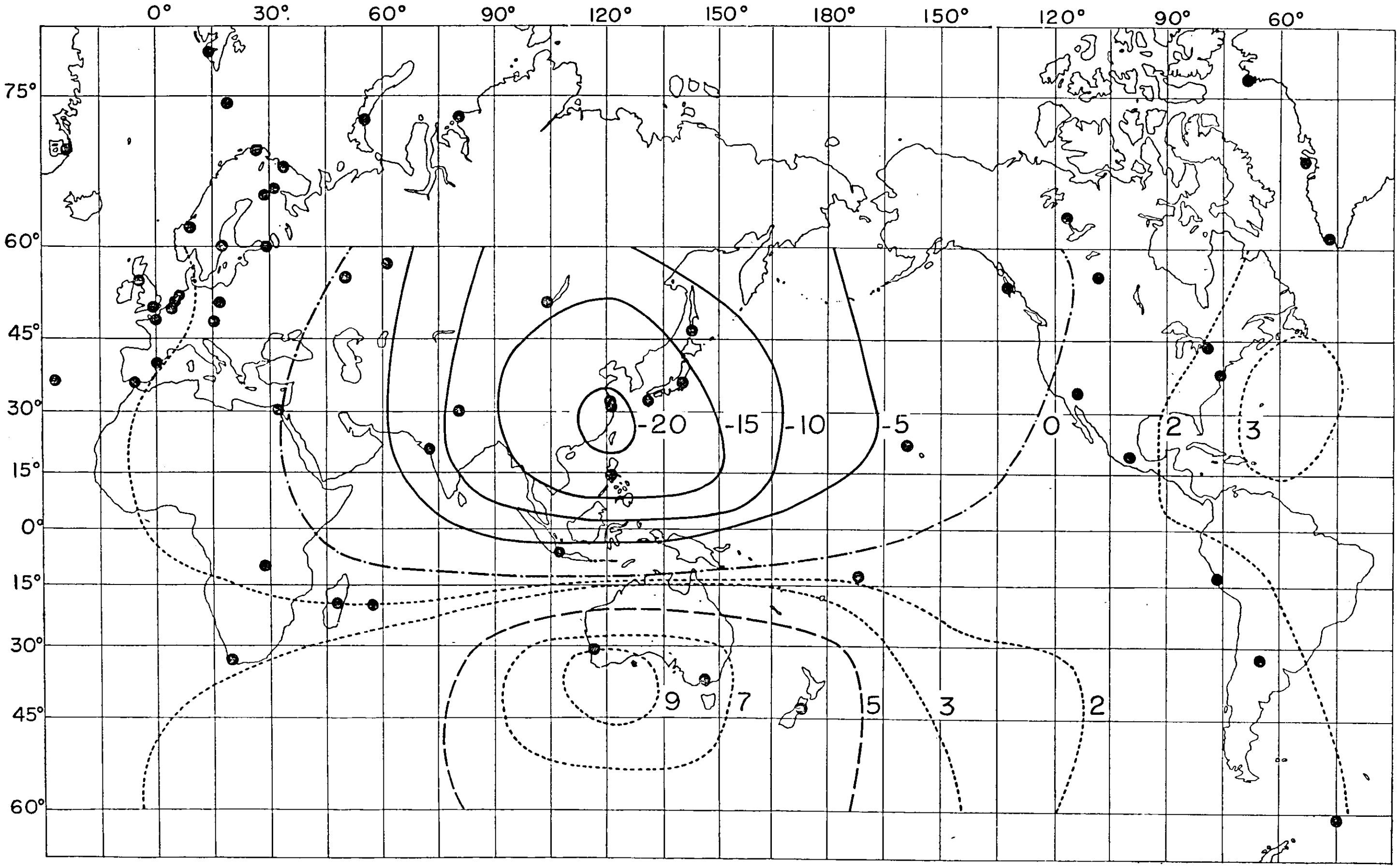

Fig. 8. Geomagnetic potential of the S_q at $2h$ GMT for the summer period. The unit of the potential should be read in *gammas* multiplied by the earth's radius.

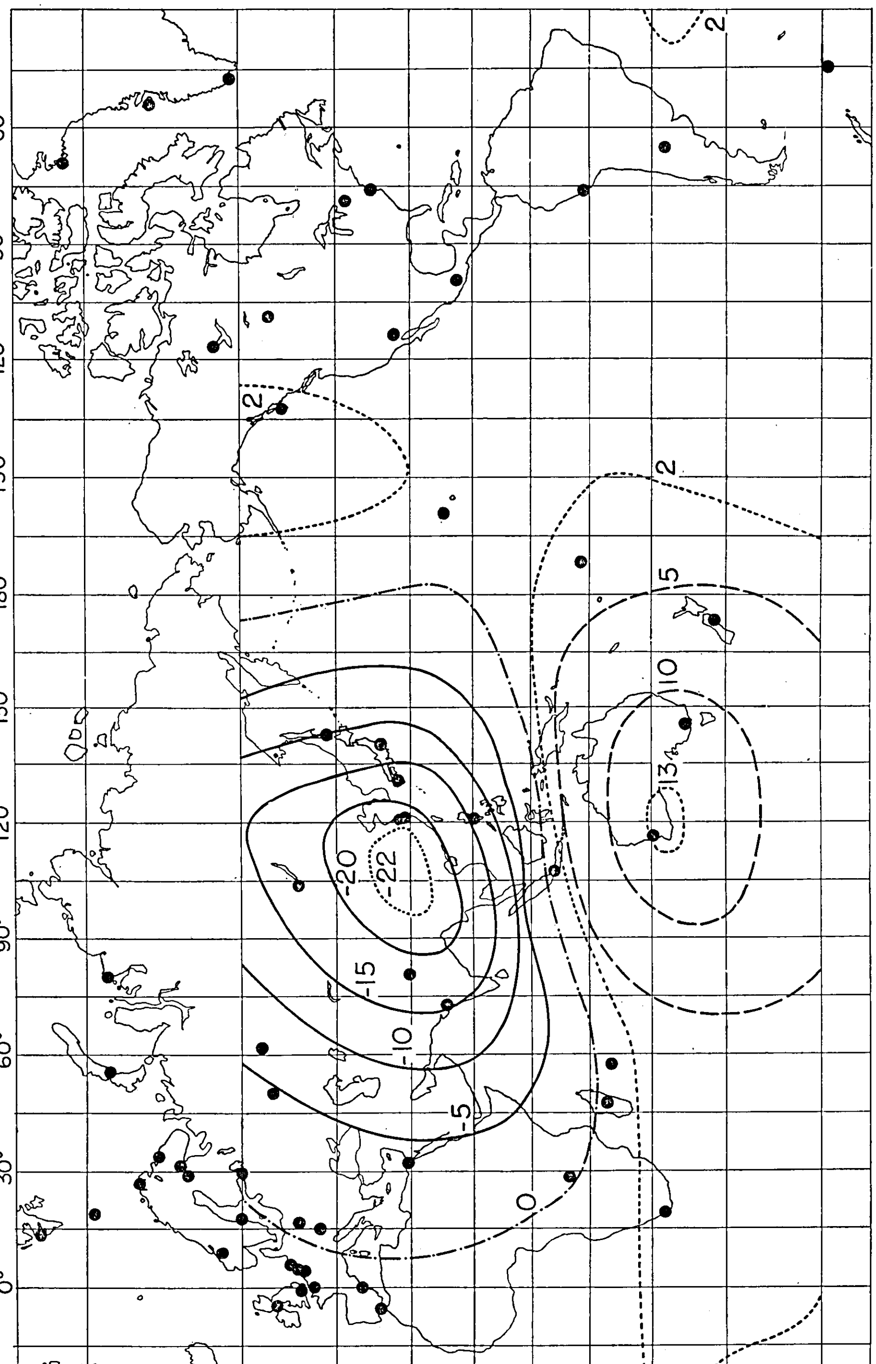

Fig. 9. Geomagnetic potential of the S_q at $4h$ GMT for the summer period. The unit of the potential should be read in *gammas* multiplied by the earth's radius.

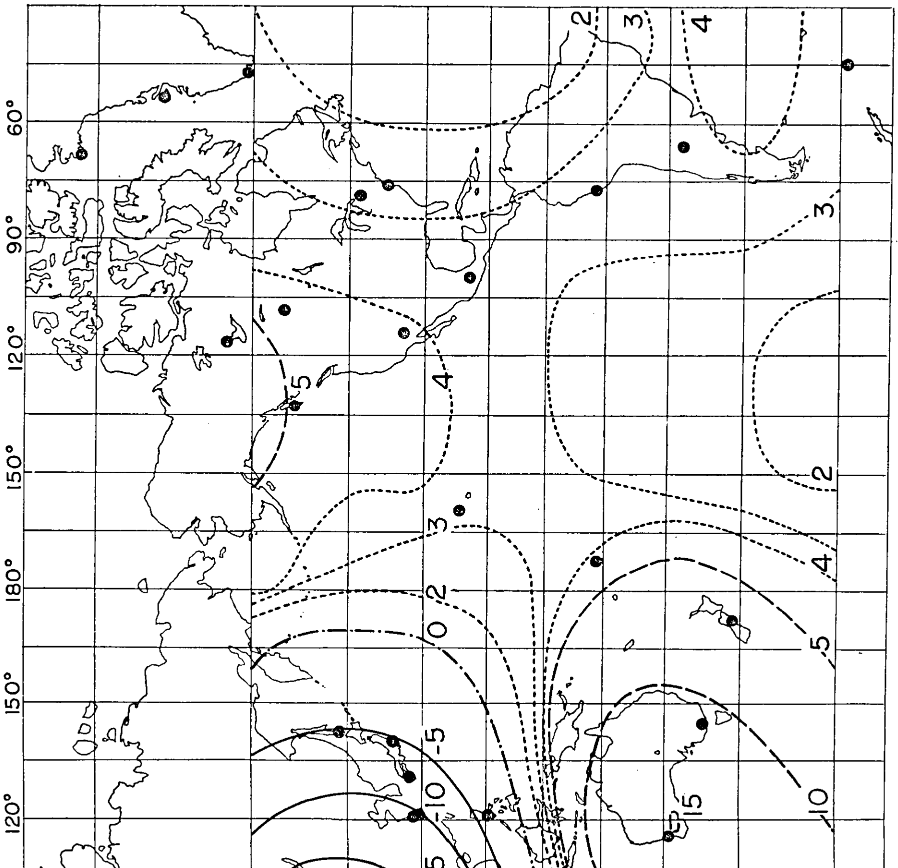

Fig. 10. Geomagnetic potential of the S_q at $6h$ GMT for the summer period. The unit of the potential should be read in *gammas* multiplied by the earth's radius.

Vestine's method of surface integral. Since the writers[2),4)] have often applied the method to actual geomagnetic variations, no detailed description of the process of separation will be given here.

The separation is made for 20, 22, 0, 2, 4 and 6*h* GMT at all observatories in Far East, both the internal (W_i) and external (W_e) parts thus deduced being given in Table XII and also shown in Fig. 11 together with W. The internal (Z_i) and external (Z_e) parts of Z are also calculated as are given in Table XIII and shown in Fig. 12. The separa-

Table XII. Total, external and internal origin parts of the magnetic potential.

W (total)

Observatory	20*h*	22*h*	0*h*	2*h*	4*h*	6*h* (GMT)
TY	−1	−12	−17	−13	−11	− 5
KA	−1	−12	−19	−16	−13	− 6
AS	1	− 9	−18	−18	−18	− 8
LU	2	− 6	−15	−20	−22	−10
ZS	2	− 6	−15	−20	−22	−10
AT	2	− 5	−12	−18	−14	− 4

W_e (external)

Observatory	20*h*	22*h*	0*h*	2*h*	4*h*	6*h* (GMT)
TY	−2.2	−10.5	−13.6	−12.1	−10.9	−6.2
KA	−2.1	−10.6	−15.4	−14.2	−12.5	−6.8
AS	−0.6	− 8.0	−14.1	−15.1	−15.4	−8.1
LU	0.1	− 5.8	−11.7	−15.8	−17.9	−9.7
ZS	0.1	− 5.8	−11.7	−15.8	−17.9	−9.7
AT	0.2	− 5.6	−10.1	−15.2	−13.9	−5.9

W_i (internal)

Observatory	20*h*	22*h*	0*h*	2*h*	4*h*	6*h* (GMT)
TY	1.2	−1.5	−3.4	−0.9	0.4	1.2
KA	1.1	−1.4	−3.6	−1.8	−0.5	0.8
AS	1.6	−1.0	−3.9	−2.9	−2.6	0.1
LU	1.9	−0.2	−3.3	−4.2	−4.2	−0.3
ZS	1.9	−0.2	−3.3	−4.2	−4.1	−0.3
AT	1.8	0.6	−1.9	−2.9	−0.1	1.9

(Unit: *gammas* multiplied by a)

Table XIII. Total, external and internal origin parts of the Z-component.

Z (total)

Observatory	20*h*	22*h*	0*h*	2*h*	4*h*	6*h* (GMT)
TY	2.4	0.3	−4.9	−8.9	−6.2	−1.2
KA	3.4	−4.6	−16.2	−13.1	−5.8	−2.3
AS	2.5	1.9	−10.2	−18.8	−14.3	−6.7
LU	0.3	2.1	−2.5	−12.5	−15.1	−9.9
ZS	0.4	2.2	−4.2	−14.7	−16.7	−10.3
AT	−1.7	−2.4	−11.9	−21.7	−19.1	−9.0

Z_e (external)

Observatory	20*h*	22*h*	0*h*	2*h*	4*h*	6*h* (GMT)
TY	3.2	−5.2	−13.2	−10.9	−4.3	−0.9
KA	1.4	−7.5	−20.2	−16.5	−12.6	−7.2
AS	4.2	3.4	−19.7	−30.9	−27.3	−13.4
LU	2.9	0.4	−13.8	−29.4	−35.6	−15.6
ZS	2.9	0.4	−13.8	−30.4	−36.5	−15.6
AT	−8.3	−0.5	−14.1	−31.0	−21.8	−10.6

Z_i (internal)

Observatory	20*h*	22*h*	0*h*	2*h*	4*h*	6*h* (GMT)
TY	−1.2	5.5	8.3	2.0	−2.1	−0.3
KA	2.0	2.9	4.0	3.4	6.8	4.9
AS	−1.7	−1.5	9.5	12.1	13.0	6.7
LU	−3.2	1.7	11.3	16.9	20.5	5.7
ZS	−3.3	1.8	9.6	15.7	19.8	5.3
AT	6.6	−1.9	4.2	9.3	2.7	1.6

(Unit: *gammas*)

tion is also made for all observatories between 60°N and 60°S only at 0*h* GMT because it is very laborious to make analyses of this sort. Equipotentials for both the external and internal parts of the potential are shown in Figs. 13 and 14. We see that the relation between both the parts is more or less the same as that obtained from the spherical harmonic analyses[23),24),25)].

23) S. CHAPMAN, *Phil. Trans. Roy. Soc. London A*, **218** (1919), 1.
24) N. P. BENKOVA, *Terr. Mag.*, **45** (1940), 425.
25) M. HASEGAWA and M. OTA, *Trans. Oslo Meeting I.A.T.M.E.I.U.G.G.*, (1950), 426.

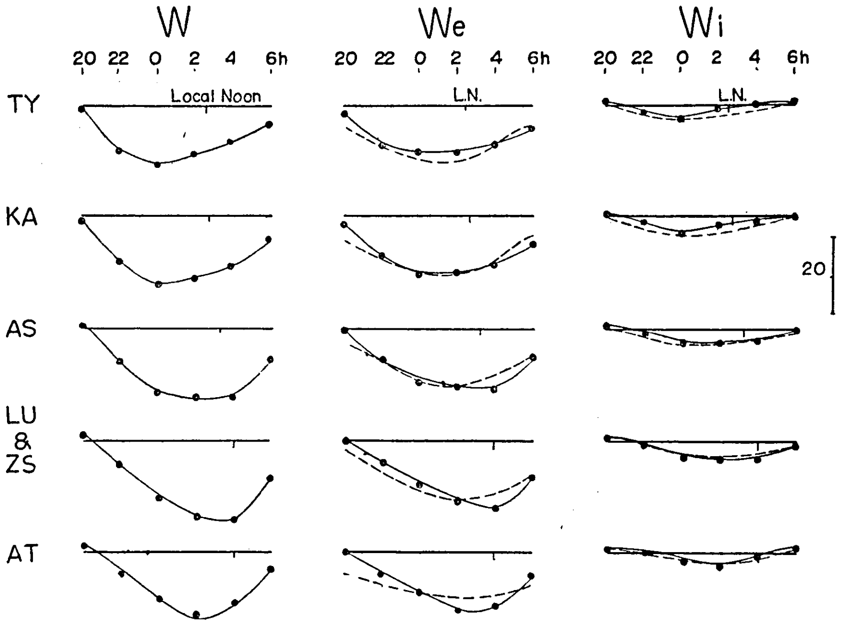

Fig. 11. The total, external and internal origin parts of the magnetic potential (full line) at the observatories in the Far East. The unit should be read in *gammas* multiplied by the earth's radius. The broken line for W_e denotes the approximation by the several terms of spherical surface harmonics, while that for W_i corresponds to the internal origin part which is expected for the mean state of the earth from the theory of electromagnetic induction.

5. The relation between the external and internal origin parts of the S_q in the Far East

On examining the curves in Figs. 11 and 12, we find that the total potential (W) and its external origin part (W_e) change fairly regularly at all observatories, while the amplitude of the internal origin part of the potential (W_i) seems a little smaller than that which has been obtained for the mean state of the earth by means of spherical harmonic analyses. The curves for the vertical component, which are essentialy of lower accuracy than those for potentials because of the errors in the numerical integration, seem to be distributed fairly regularly according to the latitude in the case of Z_e, while those for Z_i are not so regular. We observe that Z_i takes a very small amplitude at Kakioka. Since the accuracy is not so high, it will not be possible to discuss the matter definitely. But the smallness of Z_i at Kakioka should be noticed.

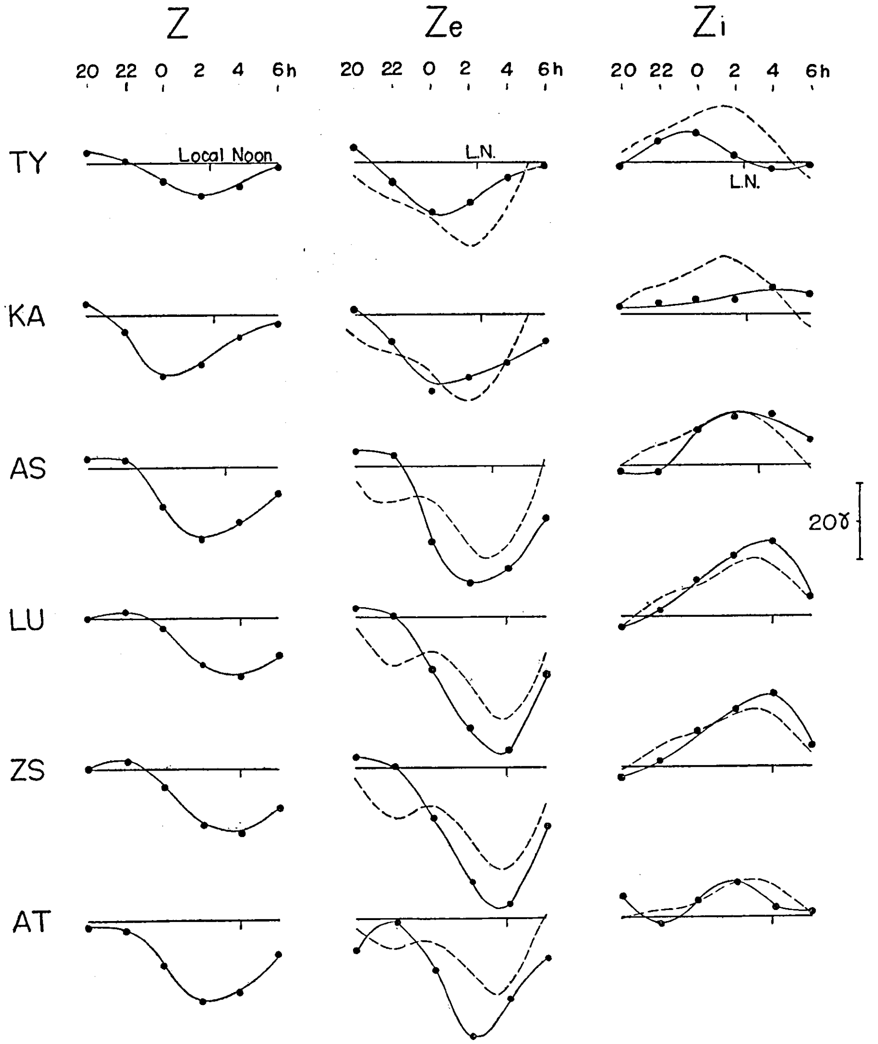

Fig. 12. The total, external and internal origin parts of the Z component (full line) at the observatories in the Far East. The broken lines for Z_e are deduced from the approximation of W_e obtained before, while those for Z_i denote the internal origin part which is expected for the mean state of the earth from the theory of electromagnetic induction.

In order to examine the relation between the internal and external parts, the writers would here like to calculate the internal part which is caused by the induced electric currents in the earth, the mean electrical conductivity of which has been obtained from the theory of

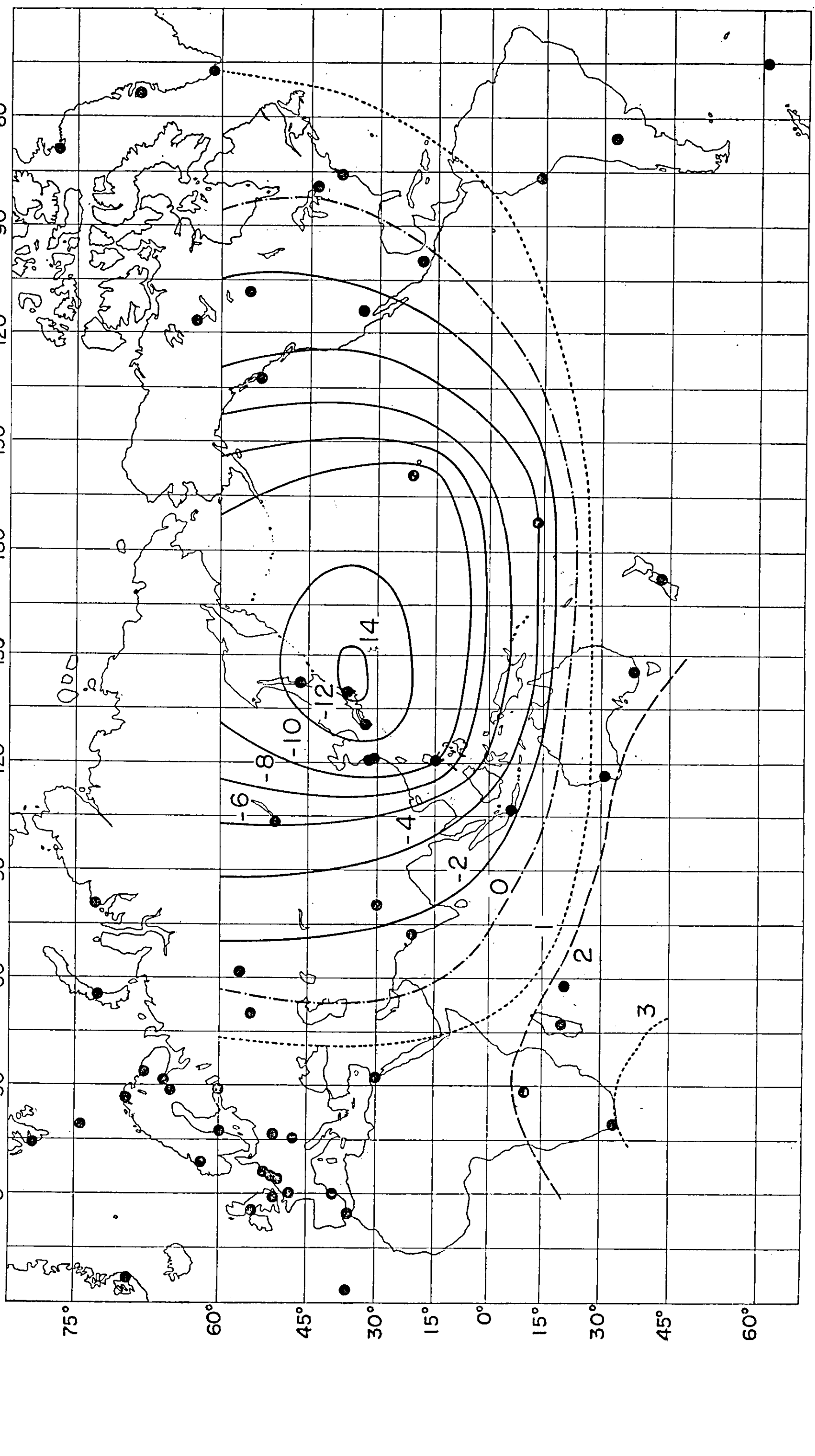

Fig. 13. The external origin part of the magnetic potential of the S_q at $0h$ GMT. The figures should be read in *gammas* multiplied by the earth's radius.

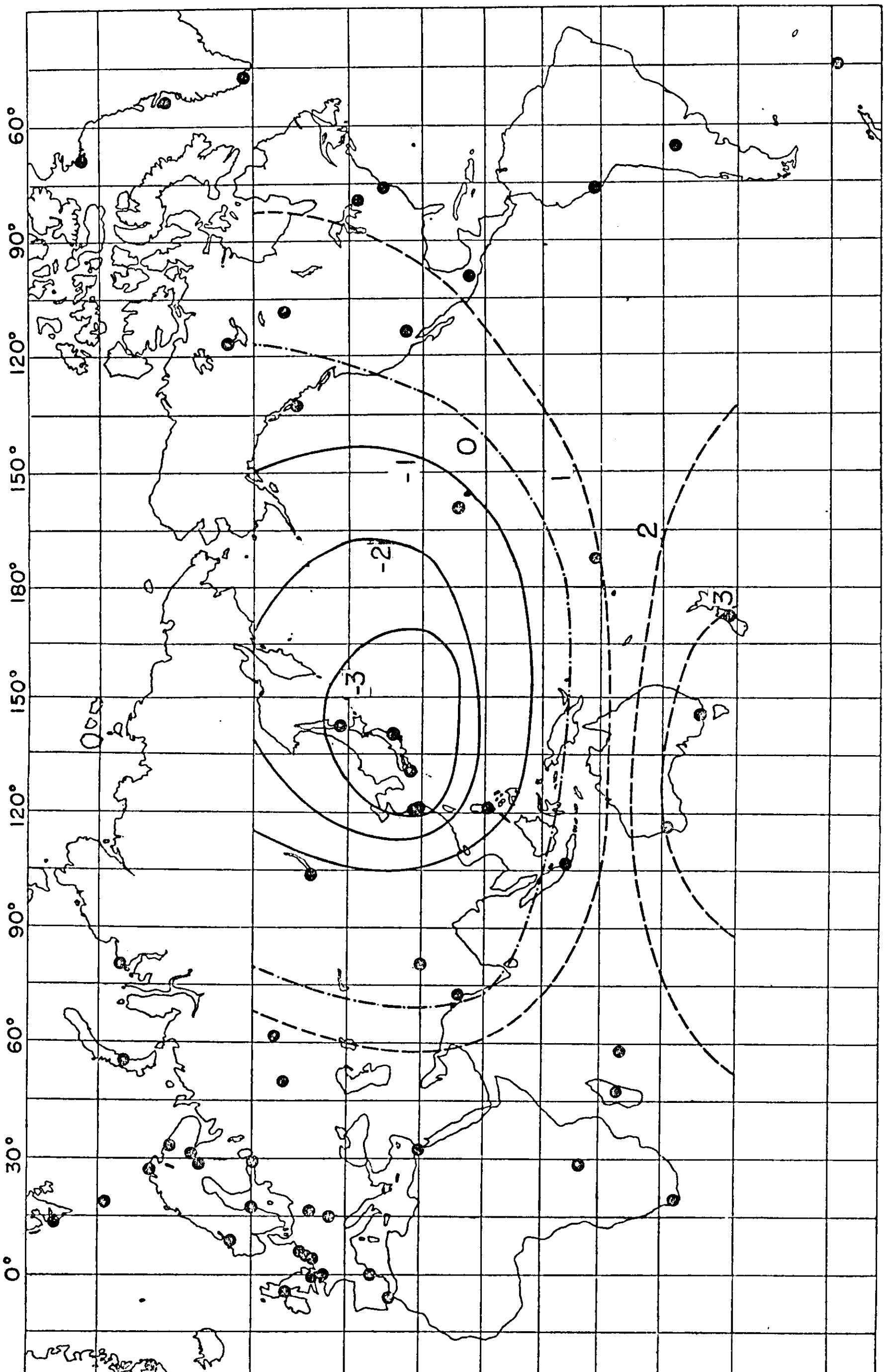

Fig. 14. The internal origin part of the magnetic potential of the S_q at $0h$ GMT. The figures should be read in *gammas* multiplied by the earth's radius.

electromagnetic induction within the earth and spherical harmonic analyses. First of all, W_e at Kakioka is subjected to a Fourier analysis assuming that W_e takes zero value from $10h$ to $18h$ GMT, whence W_e can be expressed as

$$W_{e,KA}=a(-5.3+7.4\cos t-2.2\sin t-1.9\cos 2t-1.9\sin 2t \\ -0.7\cos 3t-1.5\sin 3t+0.4\cos 4t-0.4\sin 4t)\ , \qquad (1)$$

where a and t denote respectively the earth's radius and the local time in angular measure. In general, W_e is expressed as

$$W_e=a\sum_n\sum_m(r/a)^n\{e_{n,a}^m\cos mt+e_{n,b}^m\sin mt\}P_n^m(\cos\theta)\ , \qquad (2)$$

when we assume that the S_q changes according to the local time. Since the terms like P_{n+1}^n predominate in S_q, we may take only the harmonics such as P_2^1, P_3^2, P_4^3, and P_5^4. Putting $\theta=53.8°$ for Kakioka, we can determine the coefficients $e_{n,a}^m$ and $e_{n,b}^m$ by comparing (2) to (1). Finally, we obtain the inducing field in a form such as

$$W_e=a\{9.4(r/a)^2P_2^1\cos(t+16°)+3.6(r/a)^3P_3^2\cos(2t+135°) \\ +3.2(r/a)^4P_4^3\cos(3t+115°)+1.0(r/a)^5P_5^4\cos(4t+45°)\}\ , \qquad (3)$$

from which we also obtain the vertical component at $r=a$ as follows;

$$(Z_e)_{r=a}=-\left(\frac{\partial W_e}{\partial r}\right)_{r=a}=19P_2^1\cos(t+16°)+11P_3^2\cos(2t+135°) \\ +13P_4^3\cos(3t+115°)+5P_5^4\cos(4t+45°)\ . \qquad (4)$$

In (1), (3) and (4), the numerals are to be read in *gammas*.

If we assume the uniform core model of the earth, the conductivity in which amounts to 5×10^{-12} *emu* below the depth of 400 *km* with an upper layer of zero conductivity, we can easily calculate the amplitude ratio and phase difference of the potential and magnetic field which are produced by the induced electric currents. The surface values thus calculated become

$$(W_i)_{r=a}=a\{4.1P_2^1\cos(t+22°)+1.6P_3^2\cos(2t+140°) \\ +1.4P_4^3\cos(3t+120°)+0.4P_5^4\cos(4t+50°)\}\ , \qquad (5)$$

$$(Z_i)_{r=a}=-\left(\frac{\partial W_i}{\partial r}\right)_{r=a}=12P_2^1\cos(t+22°)+6.2P_3^2\cos(2t+140°) \\ +6.9P_4^3\cos(3t+120°)+2.6P_5^4\cos(4t+50°)\ . \qquad (6)$$

With the aid of the expressions (4), (5) and (6), Z_e, W_i and Z_i are calculated for respective observatories as are also shown in Figs. 11 and 12, while W_e expected from (3) is also shown in the figure. We see, then, the analytical expression (3) for the inducing field of which coefficients are determined at Kakioka fits fairly well for the other observatories.

Now we are in a position to compare W_i obtained from the actual observation with that expected for the uniform core model. Although the former agrees very well with the latter at Lukiapang, Zô-Sè and Antipolo, we find differences between them at the other three observatories, especially W_i at Kakioka for the uniform core model is definitely larger than that obtained from the analysis in the last section. At Toyohara and Aso, however, the differences between them are not so large as that observed at Kakioka though the same tendency is likely to exist there. As for the relation between Z_e and Z_i, nothing definite can be said because the inducing field given by the analytical expression (4) does not agree well with the ones obtained by Vestine's method. However, the difference between them is very large at Kakioka, this fact being in harmony with the tendency found in the case of W_i.

The fact stated above would suggest that the electrical state beneath the observatories in the Far East does not differ much from that of the uniform core model assumed here with the exception of Kakioka. At Kakioka, the small amplitude of W_i and Z_i seems likely to be caused by the fact that either the conductivity is smaller than that of the model or the non-conducting layer penetrates deep into the earth. Unfortunately, however, it seems difficult to discuss the phase difference between both the parts, so we can not decide which reason is likely to exist under Kakioka.

If we assume that either the thickness of the non-conducting layer or the conductivity are different from that of the uniform core model which represents the mean electrical state of the earth, W_i and Z_i for any other models can be easily calculated assuming the same inducing field as (3). Owing to the low accuracy, however, it is assumed here that the conductivity is kept constant. W_i and Z_i for different depths of the non-conducting upper layer are calculated at Kakioka as are shown in Fig. 15 together with those obtained by the analysis. Suppose q (the ratio of the radius of the conducting core to the earth's radius) takes a value 0.90 or a little less, the small amplitude of W_i and Z_i is likely to be explained though much more accurate analyses will be needed to discuss the apparent phase difference which is seen in the case of Z_i. We may suppose, therefore, that the non-conducting layer underneath Kakioka area would be thicker than that of the mean state of the earth, the depth of the layer being estimated at roughly 700 *km*. An alternative interpretation will also be possible by assuming the same depth as that of the mean state, whence we shall have a low conductivity there. In so far as the phase difference between the inducing and induced fields is ignored, no further discussion is possible. The large depth of the non-conducting layer or the low conductivity thus suggested would be the cause of the anomaly of S_q in Japan.

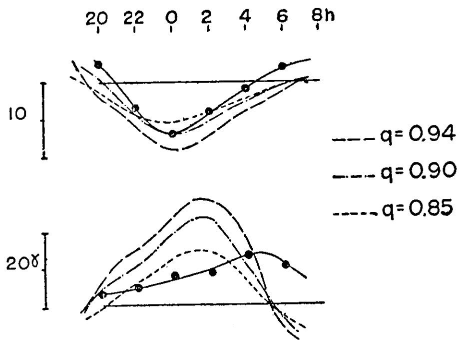

Fig. 15. The internal origin part of the magnetic potential (upper) and the vertical component (lower) at Kakioka, curves for three different depths of the non-conducting layer being shown together with that obtained from the analysis (full line). The unit of the potential should be read in *gammas* multiplied by the earth's radius.

6. Discussion and conclusion

On the basis of the results of the magnetic observation at Aburatsubo, the writers clarified that the characteristic feature in the vertical component of the S_q which has been observed at Kakioka is by no means due to observational error. Since exactly the same tendency can be observed at Aburatsubo, the anomaly that the maximum decrease of Z of the S_q occurs about one *hour* earlier should be a common characteristics in the central part of Japan.

After analysing the data of S_q during the Second International Polar Year, it is concluded that the internal origin part of the S_q is rather smaller than that expected for an earth model which has been established through investigations of various geomagnetic variations by applying the theory of electromagnetic induction. This fact would suggest that the electrical conductivity under Japan is smaller than that obtained for the mean state of the earth. Although no exact estimate is possible owing to lack of appropriate observations, it seems possible to imagine that the weak conducting layer in the upper part of the earth's mantle is extended as deep as about 700 *km* under central Japan.

This figure will be subject to alteration if a more detailed study can be completed.

No knowledge about the length and width of the weak conducting region has been obtained by the present study. However, it might be said that the region is not so wide. It is likely that the region does not reach China and southern Japan because the S_q at observatories situated in those territories shows no anomaly.

Although no definite relation exists between the conductivity distribution thus obtained and seismic or volcanic activities in Japan, the writers are of the opinion that the special conditions which are closely related to the occurrence of deep focus earthquakes have something to do with the electrical state under Japan. It would be of interest to construct a hypothetical model which roughly accounts for almost all the geophysical and geological phenomena which have been hitherto established. Investigation along this line is now under way.

The writers found no relation between the hypothetical circuit of which existence has been suggested from the studies of short-period geomagnetic variations and the weak conducting region inferred from the present investigation, because the circuit would be almost transparent for slow variations such as S_q. Hence it is still not known why such an abnormal passage of electric currents exists beneath Japan.

The writers are grateful to Professor T. Nagata and Professor A. T. Price for their helpful discussion. The writers are also indebted to Professor M. Hasegawa and Dr. M. Ota who gave them the geomagnetic data during the Second International Polar Year. Geomagnetic data were also supplied from Memanbetsu, Kakioka and Aso Observatories to the writers. The writers would like to express their thanks to all the members of these observatories. The writers would also like to extend their thanks to the Ministry of Education who provided financial aid for this study through a Research Grant.

15. 日本に於ける地磁気日変化の異常と地下構造

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地磁気日変化の鉛直分力は柿岡に於いて，いちじるしい異常を呈することを指摘し，油壺，女満別および阿蘇の日変化を整理して，この異常が日本中部に特有なものであることを明らかにした．すなわち柿岡および油壺においては，日変化鉛直分力の最小が他の極東地方の観測所にくらべて1〜2時間早く起るのである．この異常の原因を調べるために，第二回極年の資料を整理したところ，日本中部に於ては日変化のうち地球内に原因をもつ部分が地球の平均状態に対して期待されるものより小さいことがわかつた．このことは日本の地下数百粁の深さの部分の電気伝導度が小さいことを示唆する．