34. *Earth-tilts observed at Mt. Tukuba, Japan.*

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1. Introduction. In his previous note[1] the author reported the earth-tilts that were observed at Mt. Tukuba during the three years and nine months from December 23, 1927, to September 30, 1931, of which this note is a continuation. It deals mostly with observations made between the last-mentioned date and April 9, this year.

The observations were made by a pair of Ishimoto all-silica tiltmeters, installed in a room of uniform temperature built on solid granite foundation. As the period of each horizontal pendulum was adjusted to fifteen seconds, a deflection of 1 cm on a photographic record corresponds to a tilt of 1 second of arc.

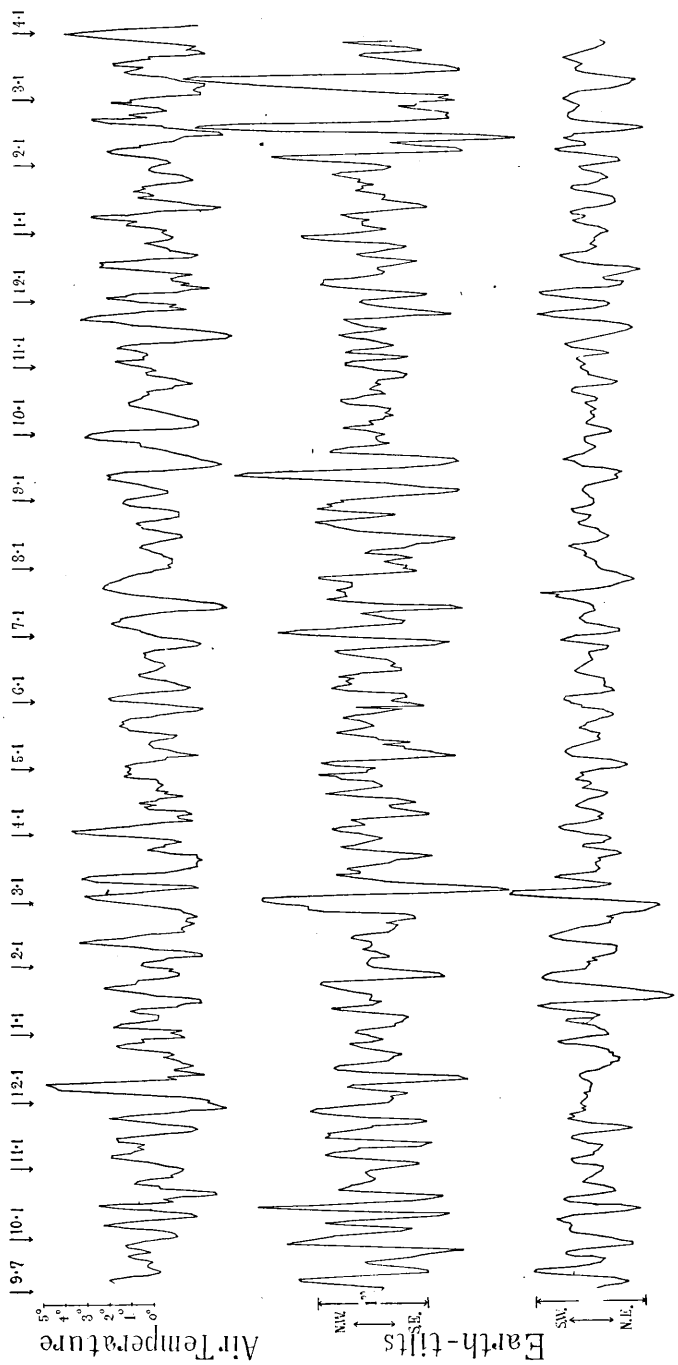
The earth-tilts were separated into two kinds, those that fluctuated in a period of about one or two weeks and those that did so in longer periods, the same as was done in the previous note. The variations in the air temperature at Mt. Tukuba were also divided into two kinds, the short and the long period, in the same way as in the previous note.

2. Short period fluctuations. The two components of the short period fluctuations in the earth-tilts and also the short period fluctuations in the air temperature for the period now under consideration are shown in Fig. 1.

As pointed out in the previous note, it will be seen from the figure that the fluctuations of each component of the tilts fairly resemble those of the air temperature. To illustrate this, the relation between the two phenomena during Sept. 11 to Oct. 11, 1931, are shown in Figs. 2 and 3. In these figures the abcissae represent the air temperatures and the corresponding ordinates the components of the earthtilts. As will be seen from these figures, these relations are rather complicated.

The vectors representing the resultants of the short period fluctuations of the tilts are also very complicated. Witness the vector diagrams

1) W. INOUYE, *Bull. Earthq. Res. Inst.*, 10 (1932), 130.


9·7
10·1
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6·1
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8·1
9·1
10·1
11·1
12·1
1·1
2·1
3·1
4·1
0°
1°
2°
3°
4°
5°
Air Temperature
1"
N.W.
S.E.
Earth-tilts
S.W.
N.E.

Fig. 1.

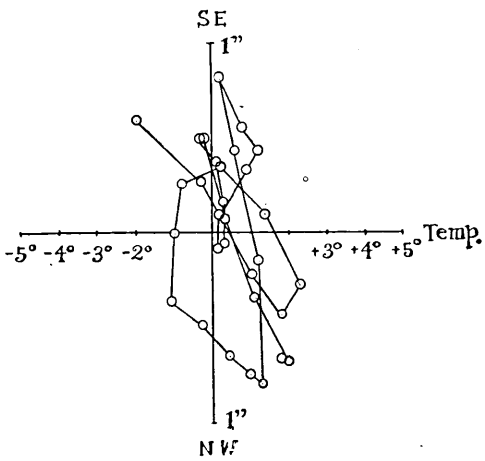


Fig. 2.

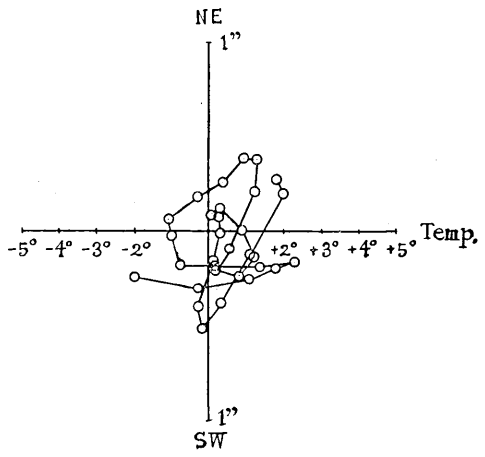


Fig. 3.

representing the earth-tilts during the periods from Sept. 7 to Oct. 13 and from Oct. 13 to Nov. 30, 1931, illustrated in Figs. 4 and 5.

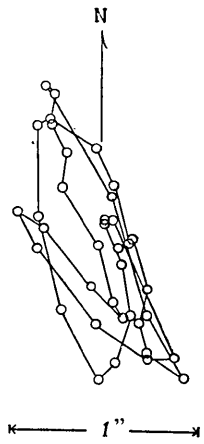


Fig. 4.

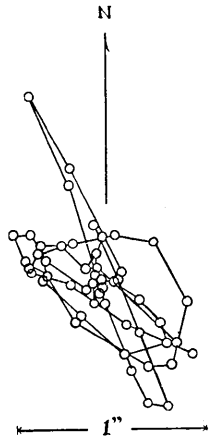
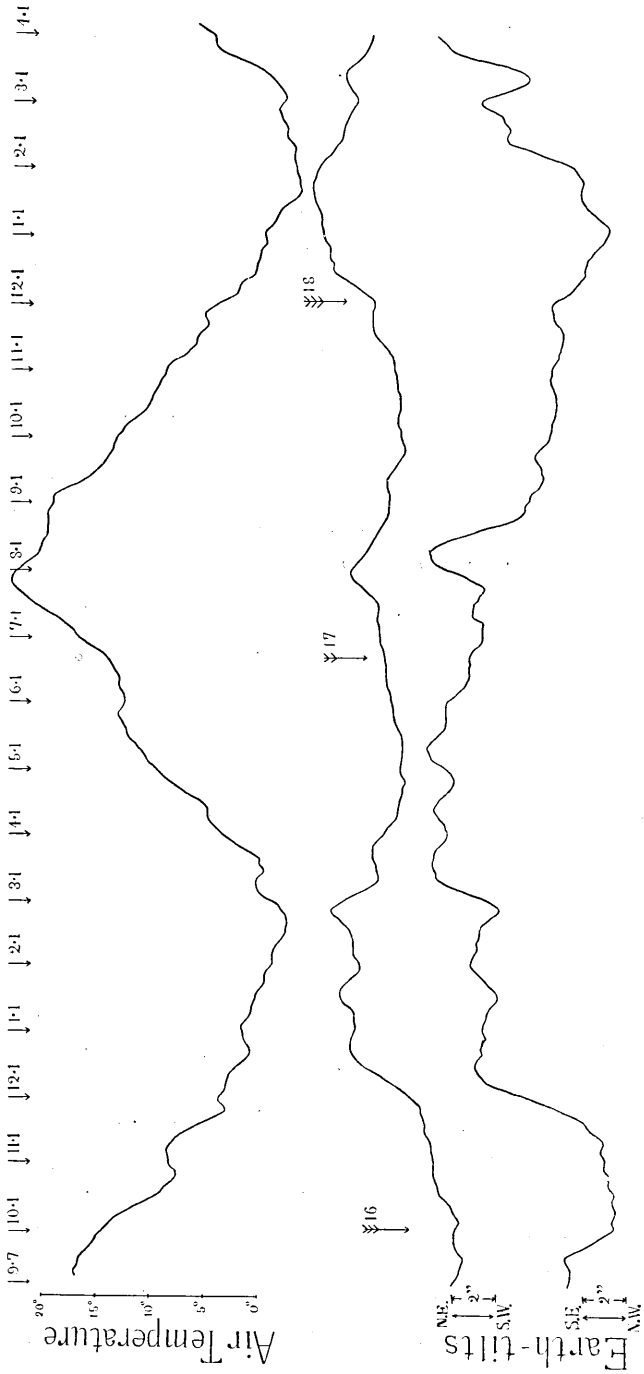


Fig. 5.

3. Secular and seasonal variations. The slow variations in the earth-tilts expressed in two components (as in the previous note) and those in the air temperature are shown in Fig. 6. From the resultant of the two component earth-tilts, a vector diagram was obtained as illustrated in Fig. 7. As stated in the previous note, it will be seen from these figures, that the earth-tilts exhibit secular and seasonal variations, both of which were disturbed several times by tilt-storms.

We notice further that these variations lessen with time since these


9·7
10·1
11·1
12·1
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4·1
5·1
6·1
7·1
8·1
9·1
10·1
11·1
12·1
1·1
2·1
3·1
4·1
16
17
18
Air Temperature
20°
15°
10°
5°
0°
Earth-tilts
N.E.
S.W.
2"
1"
S.E.
N.W.
2"
1"

Fig. 6.

observations were begun. Whether these phenomena are caused by settling of the foundation on which the instruments are set up or whether they are due to secular recovery of the earth's crust since its disturbance by the great Kwantô earthquake of Sept. 1, 1923, is a problem for further investigation.

The secular variation during the period of observation amounted to 21 seconds, N.E.-wards.

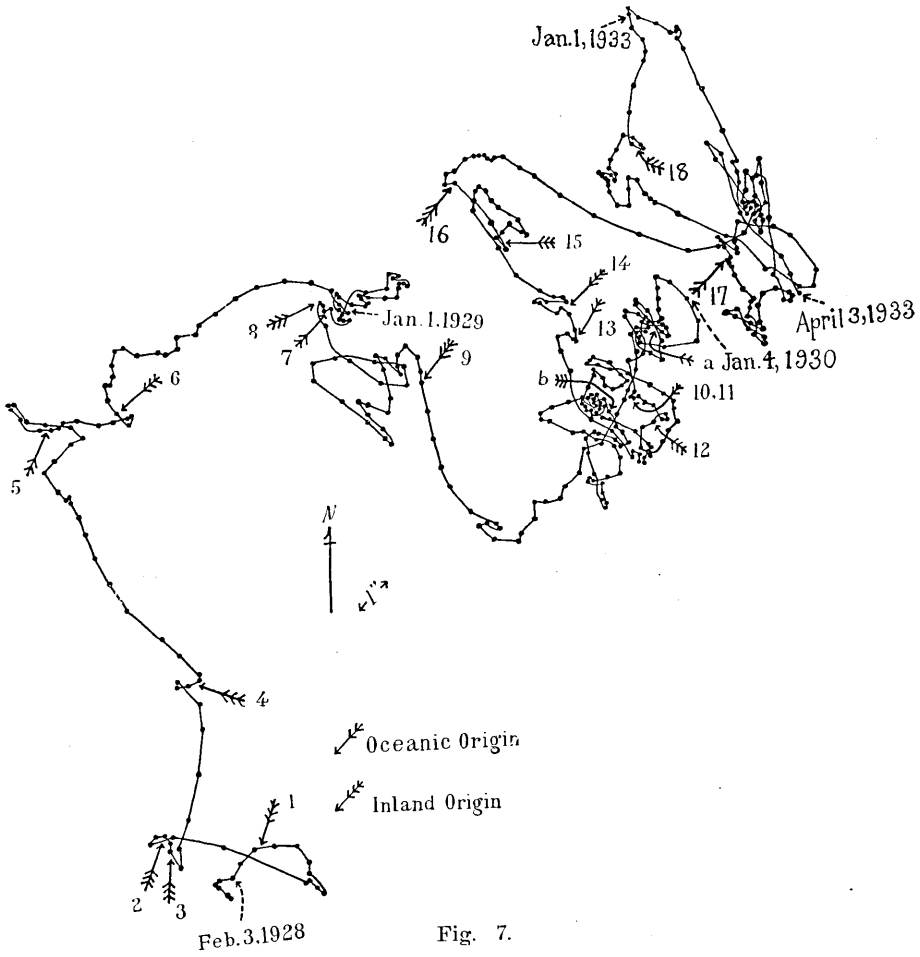

Fig. 7.

4. Earth-tilts and earthquakes. As already stated, the secular changes in the earth-tilts frequently underwent irregular fluctuations of fairly long periods. These fluctuations of earth-tilt may be called " tilt-storms ".

With only one exception, the periods of these tilt-storms usually lasted from one to four months. The exceptional period lasted fifteen months, from Dec. 3, 1929 to Feb. 28, 1931.

Excluding the last-mentioned exceptional period, the author tried to find some possible relation between the earth-tilts and the moderate

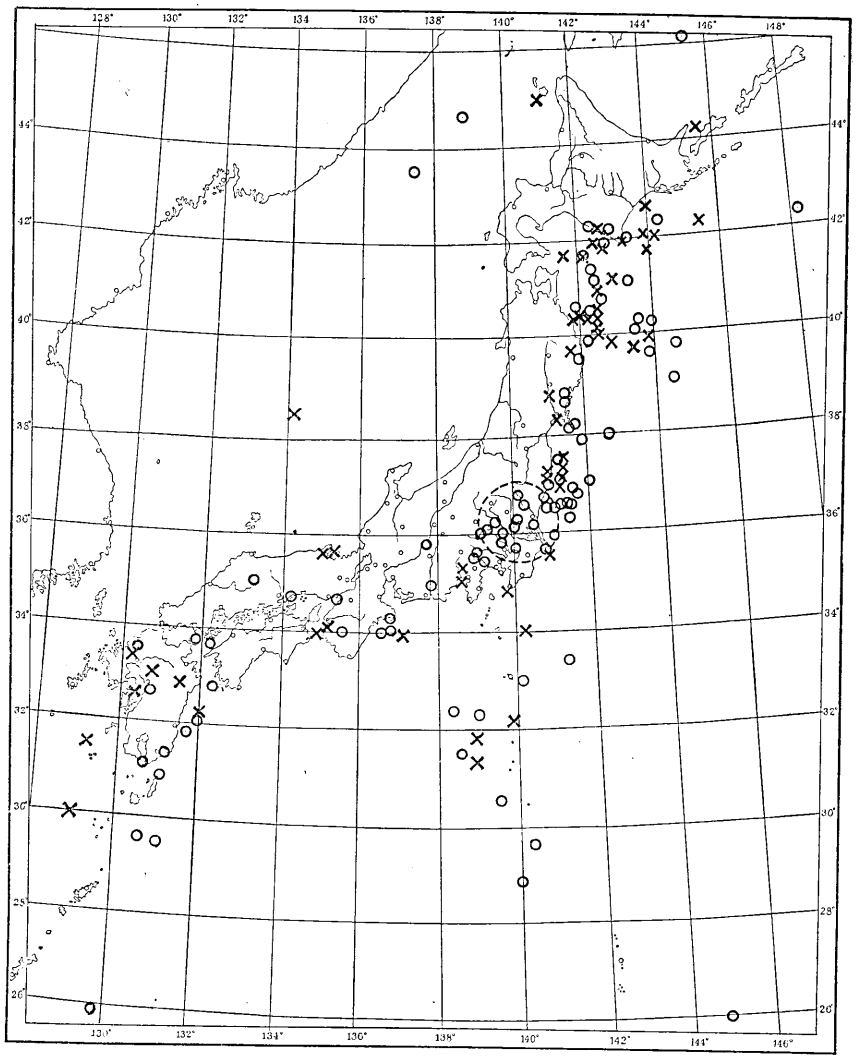

Fig. 8. The epicenters of earthquakes.

○....Those that occurred during the periods of tilt-storms, and

×.... those that occurred during the periods without them.

The larger circle has its center at Mt. Tukuba, the radius being 90 km.

earthquakes that originated in and about the main island of Japan. These earthquakes were divided into two groups according to whether they occurred during the periods of tilt-storms or not. The epicenters of these earthquokes, with marks distingushing the two groups, are plotted in Fig. 8.

Now, since the total period of the tilt-storms amounted to about 770 days, while that of the period without them was about 670 days, it follows that if there were no relation connecting the tilt-storms at Mt. Tukuba and the earthquakes that originated in a certain region, these earthquakes might occur with equal probability in the period of tilt-storms as in the other period.

As will be seen in the figure, in the region about Mt. Tukuba earthquakes occurred mostly in the periods of tilt-storms, while in the regions beyond they occurred regardless almost of the tilt-storms at Mt. Tukuba.

To illustrate this, the author has selected the moderate earthquakes that were reported by the Central Meteorological Observatory as having originated within a distance of about 90 km from Mt. Tukuba. The data concerning these earthquakes are given in Table I, and the dates of their occurrences plotted in Fig. 7.

The earthquakes that originated about Mt. Tukuba, at all events, seem to have some definite connection with the tilt-storms at Mt. Tukuba.

Table I.

No.	Date	Time of occurrence		Epicentre	
				λ	φ
		h	m	°	°
1	1928 II 12	6	10	140·0	36·1
2	„ III 23	10	21	139·8	36·0
3	„ IV 13	1	36	140·1	36·2
4	„ V 21	1	29	140·1	35·6
5	„ VIII 27	3	11	141·1	36·4
6	„ X 5	15	58	139·6	36·1
7	1929 IV 18	3	33	140·9	36·3
8	„ IV 23	23	16	140·0	36·1
9	„ VIII 16	22	21	140·2	36·5
10	1930 V 1	9	58	140·8	35·7
11	„ V 1	13	20	140·8	35·7
12	„ VI 1	2	58	140·4	36·4
13	1931 VI 9	14	07	140·9	36·5
14	„ VI 17	21	09	139·4	35·6
15	„ IX 21	11	20	139·3	36·0
16	„ X 3	2	36	139·3	36·0
17	1932 VI 22	9	36	141·1	35·9
18	„ XII 2	2	41	140·5	36·4

Table II_1. The Values of the Earth-tilts.

N.E.—S.W. (N.E.—ward is taken positive.) The unit is 0·1 second of arc.

Day \ Month	1931 IX	X	XI	XII	Day \ Month	1931 IX	X	XI	XII
1	4	0	10	16	16	− 8	6	10	37
2	1	0	10	17	17	− 6	4	11	39
3	1	− 2	10	18	18	− 4	3	12	42
4	1	− 3	10	20	19	− 5	2	13	44
5	1	− 5	9	21	20	− 4	5	16	45
6	0	− 5	6	22	21	− 3	6	18	47
7	0	− 4	8	24	22	− 2	8	17	48
8	1	− 4	10	25	23	− 5	9	14	49
9	1	− 5	10	27	24	− 5	10	10	49
10	2	− 4	10	28	25	− 3	9	15	49
11	2	− 4	10	30	26	− 3	8	12	49
12	− 1	− 1	12	31	27	2	8	13	48
13	− 3	0	11	33	28	4	8	14	49
14	− 9	7	12	34	29	2	10	15	45
15	−10	7	11	35	30	2	9	16	44
					31		9		43

Table II_2. N. E.—S. W.

Day \ Month	1932 I	II	III	IV	V	VI	VII	VIII	XI	X	XI	XII
1	43	41	60	36	23	29	32	50	30	24	28	38
2	47	43	58	34	24	27	30	49	30	24	27	38
3	47	43	57	34	23	27	34	47	30	25	27	39
4	47	42	54	32	26	27	36	47	30	26	27	40
5	46	45	48	29	27	27	38	46	30	28	28	39
6	46	45	39	27	28	26	38	45	30	27	28	38
7	46	46	35	26	28	28	36	44	30	26	27	38
8	46	46	33	26	26	32	35	42	30	26	27	38
9	42	49	34	27	23	33	35	41	30	25	30	41
10	42	49	36	28	22	32	34	41	31	26	32	45
11	46	47	38	27	22	32	35	40	31	27	33	49
12	48	49	36	27	21	32	34	39	32	26	31	54
13	47	49	36	26	21	33	34	36	34	25	30	54
14	46	45	31	27	22	33	35	37	32	26	31	54
15	45	43	31	26	22	32	35	38	32	26	33	54
16	44	43	32	24	24	31	35	38	32	26	35	57
17	46	43	34	23	25	30	35	38	31	25	36	60
18	52	44	36	24	24	30	35	38	28	25	38	60
19	58	46	37	24	26	30	35	37	26	25	40	61
20	60	47	36	24	26	31	35	36	25	27	40	60
21	60	48	36	24	26	31	34	35	24	26	42	57
22	58	51	38	25	25	32	34	34	22	25	42	56
23	55	56	38	25	26	33	37	32	21	25	42	56
24	53	55	38	25	26	32	40	31	23	24	40	56
25	51	55	38	22	28	32	43	31	22	25	39	54
26	48	57	41	21	27	33	45	32	23	27	37	55
27	44	58	41	23	29	35	47	31	24	29	32	58
28	40	60	37	23	30	35	49	30	23	30	32	60
29	41	60	34	21	30	34	50	28	24	29	34	59
30	39		36	23	30	32	51	28	24	27	36	59
31	39		36		29		51	30		27		60

Table II_3. N. E.—S. W.

Month / Day	1933 I	II	III	IV	Month / Day	1933 I	II	III	IV
1	61	64	44	40	16	64	49	54	
2	61	62	44	40	17	65	49	54	
3	61	61	44	40	18	67	50	50	
4	62	60	44	38	19	67	51	47	
5	63	60	45	37	20	68	50	47	
6	63	61	43	36	21	67	55	45	
7	62	61	44	35	22	67	57	44	
8	61	60	45	35	23	66	54	44	
9	59	57	47	36	24	64	51	43	
10	60	54	47	37	25	63	48	40	
11	61	51	50		26	64	46	39	
12	62	50	53		27	64	46	39	
13	61	51	53		28	65	45	40	
14	60	53	54		29	66		40	
15	62	52	56		30	64		40	
					31	65		40	

Table II_4. S. E.—N. W.

(S. E.—ward is taken positive.)

Month / Day	1931 IX	X	XI	XII	Month / Day	1931 XI	X	XI	XII
1	4	−26	−21	8	16	2	−30	−21	37
2	5	−26	−20	13	17	− 1	−24	−19	38
3	4	−25	−15	18	18	1	−21	−17	35
4	2	−20	−17	17	19	− 3	−16	−17	35
5	− 7	−20	−16	22	20	− 5	−20	−14	39
6	− 1	−21	−19	27	21	0	−18	−11	40
7	− 1	−26	−24	31	22	− 1	−26	− 9	40
8	− 5	−32	−23	29	23	− 3	−25	1	38
9	− 2	−27	−22	30	24	− 3	−25	− 3	39
10	−10	−21	−22	30	25	− 3	−23	− 6	39
11	−12	−19	−18	39	26	− 1	−24	− 6	37
12	−10	−18	−14	41	27	−20	−22	− 5	36
13	−10	−18	−13	48	28	−25	−21	− 4	34
14	− 2	−40	−15	47	29	−25	−22	− 2	34
15	3	−33	−22	41	30	−23	−22	3	33
					31		−20		35

Table II_5. S. E.—N. W.

Day \ Month	1932 I	II	III	VI	V	VI	VII	VIII	IX	X	XI	XII
1	37	42	23	53	44	62	45	53	18	7	8	6
2	35	40	23	54	58	54	39	54	11	6	8	6
3	33	42	23	51	53	54	28	55	15	6	2	3
4	34	42	25	50	51	54	29	56	16	12	6	2
5	37	39	29	49	51	52	28	60	17	2	0	3
6	39	41	38	51	53	54	33	55	21	3	1	4
7	38	41	53	53	61	50	34	61	25	5	7	5
8	36	43	62	56	69	43	39	67	21	5	9	1
9	39	38	60	53	67	41	41	63	18	7	3	− 7
10	37	38	59	53	70	42	39	58	11	4	− 1	− 8
11	37	39	59	62	65	42	44	61	13	8	− 2	− 8
12	33	39	60	66	67	43	41	65	11	6	4	−14
13	28	38	51	61	64	39	39	66	0	5	4	−10
14	29	39	61	61	64	43	41	60	− 5	5	2	−11
15	29	37	56	63	59	37	46	61	− 4	7	1	− 8
16	32	33	57	57	59	44	51	66	3	5	0	− 7
17	32	39	59	58	62	46	51	59	8	0	− 1	− 8
18	29	39	56	65	55	47	41	54	15	0	− 3	− 8
19	27	39	56	59	51	44	34	48	16	3	− 2	− 9
20	32	40	62	51	53	43	35	41	18	0	4	− 9
21	30	38	61	50	53	46	36	36	19	4	2	− 4
22	27	36	61	48	53	43	38	36	22	6	3	− 6
23	30	34	62	52	56	43	33	28	19	5	1	− 7
24	29	38	66	52	52	42	33	25	11	4	2	−14
25	28	38	65	49	51	38	34	20	11	6	3	−14
26	31	30	58	52	53	38	36	26	5	7	2	−12
27	33	22	53	50	49	39	37	24	10	7	12	−13
28	43	23	55	48	55	43	39	22	12	6	14	−15
29	45	24	55	43	58	47	37	14	9	8	12	−12
30	45		54	50	53	42	36	12	10	10	7	−15
31	44		55		59		44	12		9		−23

Table II_6. S. E.—N. W.

Day \ Month	1933 I	II	III	VI	Day \ Month	1933 I	II	III	IV
1	−27	− 5	43	55	16	− 3	39	3	
2	−25	− 2	45	55	17	− 2	39	7	
3	−25	0	42	55	18	− 7	39	19	
4	−18	2	40	62	19	− 6	25	27	
5	−19	1	39	56	20	− 7	12	37	
6	−19	0	43	59	21	− 5	11	37	
7	−21	− 2	35	65	22	− 6	8	48	
8	−20	3	40	66	23	− 9	15	47	
9	−16	17	29	64	24	−11	24	47	
10	−16	21	28	64	25	− 6	30	51	
11	−15	31	16		26	−10	37	51	
12	−17	35	8		27	− 8	38	49	
13	−12	27	10		28	− 8	42	51	
14	−11	25	0		29	− 9		57	
15	− 7	32	− 3		30	−10		61	
					31	− 9		60	

34. 筑波山に於ける傾斜變化觀測報告

地震研究所　井　上　宇　胤

筑波山に於ては，昭和三年一月から地表面の傾斜變化觀測が行はれて居るが，昭和六年十一月迄の觀測結果の報告は前の論文に掲載して置きましたから，此處では主にそれ以後昭和八年四月上旬迄の結果を取扱つてあります．觀測結果の取扱方及び其れから得られた結果は殆ど前報告と同樣であります．

日本各地に發生した地震を筑波山に於ける傾斜嵐の時期に發生したものと，然らざるものとに分けて見ると，少くとも筑波山附近の地震は明かに傾斜嵐に關係ある事を知りました．