36. *On the Angle of Incidence of the Initial Motion observed at Hongô and Mitaka.*

By Takeo SUZUKI,

Seismological Institute.

(Read June 21, 1932.—Received June 20, 1932.)

I. Introduction.

It has been already found by Prof. T. Matuzawa[1] and others that the seismograms of certain earthquakes in the Kwantô district observed at Hongô (Tôkyô) show a typical forerunning part of the commencement of motions. In the horizontal component, during about 1·5 seconds in the beginning the motion is quite small and then followed suddenly by somewhat distinct motions. On the other hand, in the vertical component the beginning phase is quite large compared with the second. Moreover, the time difference 1·5 sec. between the first and the second phase is almost independent of the epicentral distance.

To elucidate this observed fact Prof. Matuzawa introduced a surface layer characteristic to the Kwantô district. When the dilatational wave started from the seismic focus, which is situated deeper than this layer, is incident to the boundary where reflexion and refraction occur, the dilatational and the distortional wave are generated in the upper layer. Prof. Matuzawa considered that the first phase which is mainly vertically polarized, corresponds to the refracted dilatational wave and the second phase which is mainly horizontally polarized, corresponds to the refracted distortional wave. By considering such a mechanism of generation of waves the observed facts i.e. the time relation and the polarization of waves are plausibly explained, assuming the most favourable value of the thickness of the upper layer and velocities of the P and the S wave in it. According to the recent investigation of Prof. Matuzawa[2] and T. Fukutomi the velocity of the P and that of the S wave in the upper layer are 1·94 km/sec and 1·14 km/sec respectively

1) T. MATUZAWA, K. HASEGAWA and S. HAENO, *Bull. Earthq. Res. Inst.*, 4 (1928), 85–106.

T. MATUZAWA, K. YAMADA and T. SUZUKI, *Bull. Earthq. Res. Inst.*, 7 (1929), 241–260.

2) T. MATUZAWA and T. FUKUTOMI, *Bull. Earthq. Res. Inst.*, 10 (1932), 499–516.

and the thickness of this layer comes out 4 km from the duration between the first and the second phase.

Such a remarkable polarization of the first phase shows that the angle of incidence of the first motion is considerably small, that is, the trajectory of the wave is almost vertical near the surface. This may be probably due to sudden decrease of velocity near the surface.

T. Isikawa[3] has investigated the relation between the angle of emergence and the epicentral distance in case of some earthquakes. Dr. H. Kawasumi[4] has determined the angle of emergence by using the reported data adopted from "Kisyô Yôran" published by the Central Meteorological Observatory and found statistically that it is comparatively larger than that expected from the superficial structure of the earth crust introduced by Prof. Matuzawa. The present writer has studied the angle of incidence from the seismograms obtained at two seismological stations Hongô (Seismological Institute) and Mitaka (Astronomical Observatory) with special reference to the velocity of seismic wave near the surface.

II. Observation of the angle of incidence.

The angle of incidence is easily determined by taking the resultant of the first motions in the three components of seismogram. In this method it is most important to compare the corresponding phase in each component. For this purpose a tromometer designed by Prof. A. Imamura is quite suitable. With this instrument the three components are recorded on one and the same recording drum and the minute marks are given on the seismogram as breaks of the line in each component. Therefore, the identification of the corresponding motion in each component is quite easy. The instrumental constants of this seismograph are shown in Table I.

Table I.

component	weight of bob	magnification V	period T	
(EW)	7 kg	50	7 sec	At Mitaka the magnification of the vertical component is 18.
(NS)	7	50	7	
(Vert.)	7	28	7	

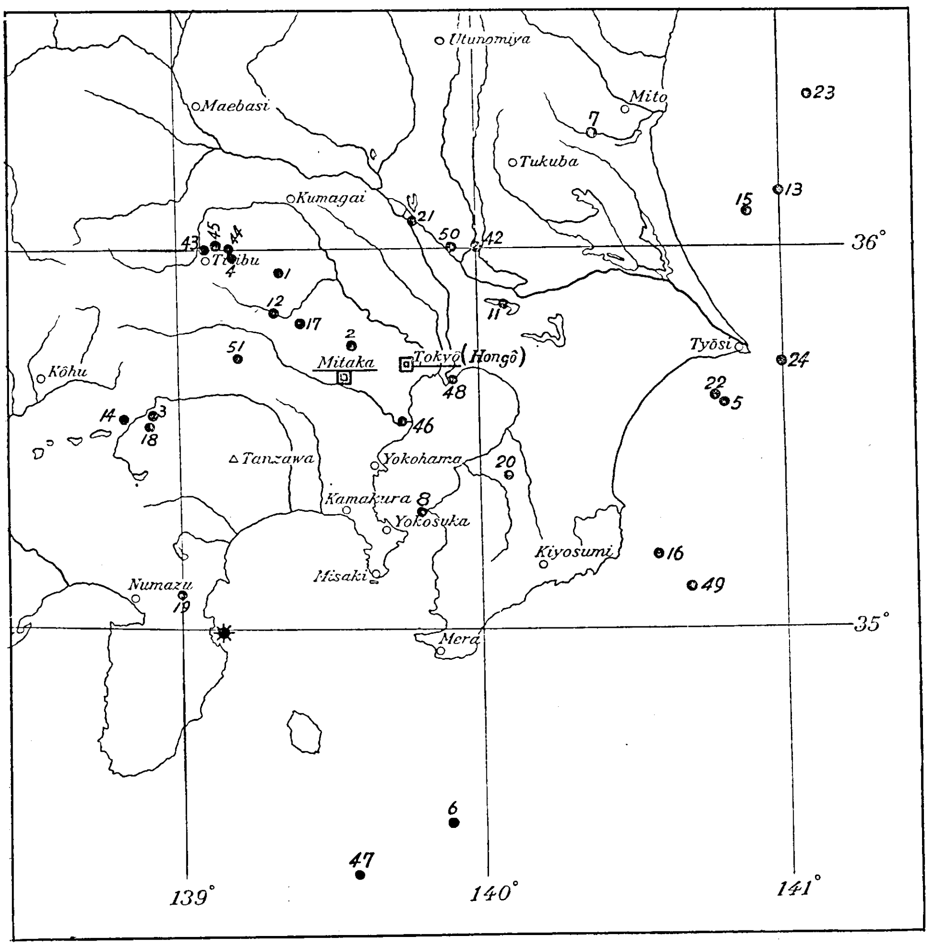
3) T. ISIKAWA, *Journ. Meteor. Soc.*, Japan, [ii] 6 (1928), No. 3.

4) H. KAWASUMI, Read before the meeting of Earthquake Research Institute on July 7, 1931.

The angle of incidence thus obtained is not a true one but an apparent one owing to the effect of reflexion of incident wave at the surface. Let $\bar{i}$ be the apparent angle of incidence, then the true one i will be given by the formula

$$\sin^2 i = \left(\frac{V_1}{V_2}\right)^2 \cdot \frac{1-\cos \bar{i}}{2},$$

where V_1 and V_2 are the velocity of the dilatational and the distortional wave respectively. Assuming $V_1/V_2 = 1{\cdot}789$—i.e. Poisson's ratio $\sigma = 0{\cdot}273$, all the observed values of $\bar{i}$ are reduced to i by this formula. The amount



✱ Swarm earthquakes in the vicinity of Itô.

Fig. 1.

of this correction is for example such that if $\bar{i}$ is 5°, i becomes 4° 10′.

The distribution of earthquakes studied by the writer is shown in Fig. 1. The results of observation are tabulated in Table II and shown in Fig. 2 and 3.

Table II.

No.	Commencement at Hongô					Epicentre Latitude Longitude	Focal depth	Hongô		Mitaka		Remarks
	Y	M	D	H	M			Δ	i obs.	Δ	i obs.	
							km	km	° ′	km	° ′	
1	1928	10	5	15	58	35·93 N 139·34 E	43	45	4 0	36	2 45	(see Fig. 4)
2	1931	6	17	21	9	35·74 139·57	32	19	0 15	10	2 40	
3	〃	6	11	15	16	35·55 138·91	20	78	7 0			
4	〃	9	28	13	54	35·96 139·18	30	65	4 0			(see Fig. 6)
5	〃	7	10	22	10	35·59 140·83	15	88	2 50	110	3 30	
6	1930	5	24	1	38	34·5 139·9	50	137	3 20			
7	〃	6	1	2	58	36·3 140·4	46	86	11 40	101	4 50	
8	〃	8	17	18	23	35·3 139·8	45	38	4 0			
9	1931	2	20	14	35	44·62 136·38	450	1032	3 18			very deep-seated
10	〃	3	9	12	50	40·75 142·70		608	0° ca.			
11	〃	7	26	10	41	35·85 140·09	60	34	3 0	52	2 15	
12	〃	7	8	5	46	35·84 139·32	43	46	2 40	28	2 45	
13	〃	8	18	14	40	36·15 141·60	19	121	8 20			
14	〃	9	16	21	43	35·55 138·82	20	86	3 20	65	3 30	
15	〃	10	30	3	53	36·1 140·9	17	110	4 50	126	3 0	
16	〃	11	12	15	09	35·2 140·6	20	97	5 20	105	1 36	
17	〃	10	3	2	36	35·8 139·4	18	50	2 30			
18	〃	9	18	15	13	35·54 138·91	18			59	10 0	Fore-shock
19	1930	11	25	16	6	35·1 139·0	shallow	100	4 10	79	5 0	North Idu earthquake (see Fig. 5)
20	〃	11	26	4	3				4 40			

(to be continued.)

Table II. (*continued.*)

No.	Commencement at Hongô Y	M	D	H	M	Epicentre Latitude Longitude	Focal depth	Hongô Δ	Hongô *i* obs.	Mitaka Δ	Mitaka *i* obs.	Remarks
							km	km	° ′	km	° ′	
21	1929	7	17	19	49	36·06 139·80	35	40	4 40	49	3 30	
22	1930	5	1	9	58	35·6 140·8	40	92	6 10			
23	1928	8	27			36·40 141·10	20	140	6 10			
24	1930	8	20	2	41	35·7 141·0		110	0° ca.			
25	〃	3	4	5	11		4	100	5 0	82	3 50	
26	〃	3	9	4	39		3	100	5 30	82	4 0	
27	〃	5	17	5	14		3	100	3 50			(see Fig. 7)
28	〃	5	12	21	27			100	6 10			
29	〃	5	14	8	57			100	7 45			
30	〃	3	14	14	18			100	5 20	82	5 0	
31	〃	3	15	18	34			100	6 50	82	5 5	
32	〃	3	30	0	6			100	3 20	82	5 10	
33	〃	4	1	23	4	34·97 139·14	4	100	4 0	82	4 15	swarm earthquake in the vicinity of Itô
34	〃	5	9	12	52			100	6 10			
35	〃	3	13	4	29					82	4 30	
36	〃	2	23	18	31					82	5 30	
37	〃	3	19	10	16					82	4 30	
38	〃	2	21	8	37					82	1 35	
39	〃	3	21	23	4					82	4 26	
40	〃	3	4	3	50					82	4 0	
41	〃	3	9	19	54					82	4 0	(see Fig. 8)
42	1931	9	24	13	26	36·0 140·0	45	40	0° ca.			
43	〃	9	24	21	11	36·00 139·11		65	0° ca.			
44	〃	9	23	21	46	36·01 139·17				51	4 20	
45	〃	9	24	1	22	36·02 139·13				57	5 40	
46	1928	8	14	7	31	35·53 139·74				24	4 50	
47	〃	8	26	22	30	34·35 139·58				144	6 30	
48	〃	9	18	1	1	35·65 139·91	45			32	11 30	
49	1929	3	28	1	32	35·11 140·67				117	3 30	
50	1929	4	23	23	16	36·0 139·91				48	3 35	
51	1931	3	10	3	41	35·7 139·2				31	1 5	

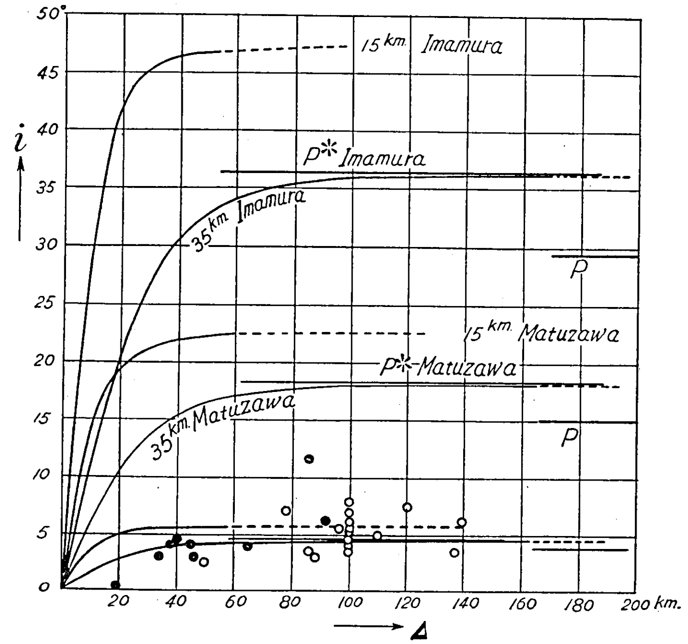


Fig. 2. $\Delta - i$ curve (Hongô).
○ earthquake with its focal depth 0–20 km.
● „ „ „ „ „ 20–50 km.

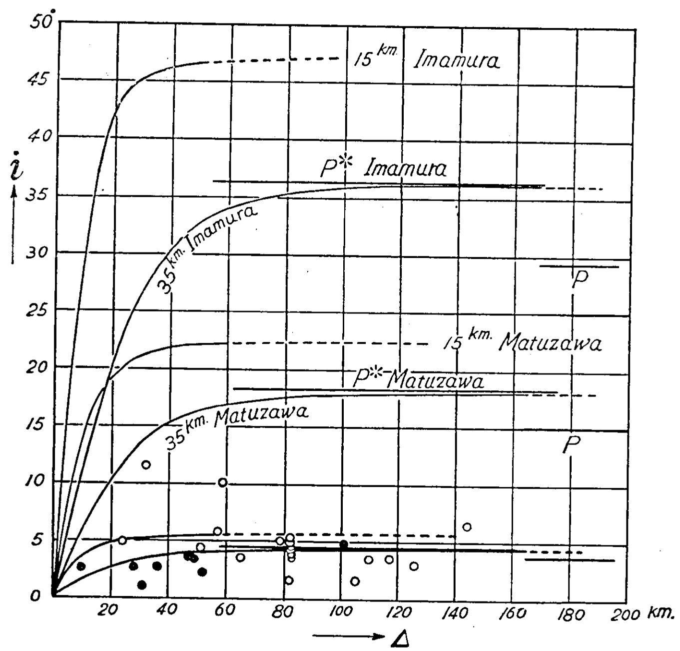


Fig. 3. $\Delta - i$ curve (Mitaka).
○ earthquake with its focal depth 0–20 km.
● „ „ „ „ „ 20–50 km.

In these figures the angle of incidence is plotted against the epicentral distance. Points denoted by ○ and those denoted by ● correspond respectively to the case of focal depth 0–20 km and 20–50 km. As apparent from the figures, the plotted value is nearly independent of the epicentral distance as well as the focal depth, and does not exceed four or five degrees. In illustration, some examples of typical seismogram obtained at Hongô and Mitaka will be shown. (Pl. LXXIX, Fig. 4, Pl. LXXX, Fig. 5, Pl. LXXXI, Fig. 6, Pl. LXXXII, Fig. 7, Pl. LXXXIII, Fig. 8.)

As to be seen from the figures the broad aspect of matter is quite clear. For example, in case of the North Idu earthquake of Nov. 26, 1930 (see Fig. 4), the initial horizontal motion is quite small compared with the vertical one. The time of commencement and the period of the initial motion are quite consistent in both the horizontal and the vertical component as seen from the figure. In horizontal motion a very distinct phase is recognized after 1·5 seconds from the commencement, which is the second phase found by Prof. Matuzawa.

In some ordinary earthquakes which are not so large, the period of the horizontal motion in the beginning phase is often observed different from that of the corresponding vertical one, i.e. the former is shorter than the latter. Even in such a case the horizontal motion with the same period as the vertical can be detected if closely examined. In vertical motion it may be difficult to detect a wave of shorter period on account of its superposition upon waves of longer period. The angle of incidence in such a case is of course determined by taking the resultant of three components with the same period.

The period of the initial motion of earthquakes here studied is nearly the same and ranges between 0·3 sec. and 1·0 sec. If a wave with a period more than 1·5 sec. is incident, then the initial phase is superposed by the transformed wave which is introduced by Prof. Matuzawa, and so that the determination of the angle of incidence may become difficult.

According to T. Isikawa's[5] recent investigation on the North Japan Sea earthquake of Feb. 20, 1931 which is very deep-seated, the angle of emergence of initial motion observed at the stations in Kwantô district is remarkably large compared with that observed at other places. Generally speaking this is quite consistent with the result obtained by the present writer. From T. Isikawa's result the true angle of incidence

5) T. Isikawa, *Journ. Meteor. Soc.*, Japan, [ii] 10 (1932), No. 4.

is calculated with respect to the values at stations in Kwantô district alone and shown in Table III.

Table III.

station	$\bar{e}$	$\bar{i}$	i
Tukubayama	80°0	10°0	8°8
Kakioka	80·0	10·0	8·8
Kumagaya	69·0	21·0	19·0
Tôkyô	73·6	16·4	14·0

The value of i obtained by the writer at Hongô is 3° 18′, as shown in Table II.

III. Discussion.

To explain the observed fact as above stated, the relation between i and Δ must be at first examined in both cases of the mode of superficial stratification of the earth crust introduced by Prof. Matuzawa[6] and by Prof. Imamura[7]. Prof. Imamura has taken into consideration the existence of a superficial sedimentary layer in the upper part of Matuzawa's first layer ($\overline{P}$). Thus, the thickness of the sedimentary layer and its velocity of dilatational wave are determined 10 km and 3·68 km/sec. respectively. The mode of stratification of the earth crust is shown in the following Table (Table IV), referring to the recent investigation of Prof. Matuzawa[8].

Table IV.

	Matuzawa		Imamura	
	depth from the surface	vel. of dil. waves	depth from the surface	vel. of dil. waves
$\overline{P}$	0 km— 4 km 4 --20	1·94 km/sec. 5·0	0 km—10 km (sed. layer)	3·68 km/sec.
P^*	20 —50	6·2		
P	>50	7·5		

6) T. MATUZAWA, *Bull. Earthq. Res. Inst.*, 5 (1928), 1-29; 6 (1929), 177-204.

7) A. IMAMURA, F. KISHINOUYE and T. KODAIRA, *Bull. Earthq. Res. Inst.*, 7 (1929), 471-487.

8) T. MATUZAWA and T. FUKUTOMI, *loc. cit.*, 517.

The relation between the angle of incidence at the earth surface and the epicentral distance can be easily determined, if the focal depth is given, as the problem is quite the same as that of geometrical optics. Numerical calculations were carried out for two cases and shown in Fig. 2 and 3. At first the depth of focus is taken 15 km, i.e. the source of seismic disturbance is in the first layer ($\overline{P}$). In Fig. 2 and 3 the relation is shown by the curves denoted by "15 km Imamura" and "15 km Matuzawa". The former curve shows the $\Delta - i$ relation for Prof. Imamura's assumption and the latter one for Prof. Matuzawa's assumption.

On account of stratification of the earth crust, beyond a certain epicentral distance the first incidence is the wave which is transmitted through the second layer parallel to the surface. For instance, in case of Matuzawa's assumption at a place 62 km from the epicentre the wave denoted by $\overline{P}\,P^*\,\overline{P}$ will first appear, which starts from the first layer and is refracted into the second layer and again into the first layer. Up to this epicentral distance the angle of incidence varies continuously with the distance, but beyond this distance it remains constant and 18° 30′ in the above mentioned case.

In the next place, the depth of focus is taken 35 km i.e. the origin of seismic disturbance is in the second layer (P^*). At small distance the angle of incidence approaches asymtotically to that of $\overline{P}\,P^*\,\overline{P}$ in the preceding case. According to Matuzawa's assumption, beyond the epicentral distance 165 km the first incidence is a wave denoted by $P^*\ P\ P^*\ \overline{P}$ (a wave which starts in the second layer and is refracted into the lower medium and again into the upper layers). In other words, to obtain these curves the travel time of different waves is taken into consideration. The same notice as above holds with respect to other set of curves.

As to be seen from Fig. 2 and 3 the curves thus obtained are not consistent with the observed values which are far smaller than that calculated as above. This may be rather natural. In order to obtain a curve which is well consistent with the observed values, it may be plausible to assume that there exists a quite superficial surface layer in which the velocity of transmission of waves is very small. Although such a factor may have already been taken into account by others, the present writer has examined it only numerically. The velocity of dilatational wave in this layer is easily determined from the observed value of i of the wave $\overline{P}\ P^*\ \overline{P}$. At the epicentral distance 80 km or so, the mean observed value of i is approximately $4° 30'$. Let v be the velocity to be determined, then the following relation is obtained, unless there is any oblique boundary separating two media,

$$\sin i = \frac{v}{6 \cdot 2},$$

where 6·2 km/sec. is the velocity of dilatational wave in the second layer (P^*).

As the observed values of i are nearly the same both at Hongô and Mitaka, the value of v becomes also the same at both places. From above formula v comes out approximately 0·5 km/sec.

Now the velocity is determined 0·5 km/sec. as above, but the thickness of such a layer can not be obtained at all. At any rate there is no doubt that such a layer is only confined to the very surface.

To obtain the $i-\Delta$ relation, the thickness of the layer with velocity 0·5 km/sec. is tentatively assumed 0·5 km, because the thickness of this layer does not much affect the $i-\Delta$ curves. The $i-\Delta$ relation is calculated for two cases of focal depth as before under the mode of stratification of earth crust tabulated as follows. (Table V)

Table V.

Thickness of layers	0·5 km.	4	16	30	>50.5
Vel. of dil. waves	0·5 km/sec.	1·94	5·0	6·2	7·5

The results of calculations are shown in Fig. 2 and 3. In this case also, the curves have been drawn, the travel time of different waves being taken into consideration. From the figures, the observed values seem to be generally well explained in this manner.

Recently it has been suggested by some seismologists[9] that the earth crust has no stratified structure and the velocity of propagation of waves increases with depth continuously. As far as the angle of incidence at the surface alone is concerned, there is no remarkable difference whether the earth crust is stratified or not.

In the earthquakes shown in Table II, the period of the initial motion is nearly from 0·3 sec. to 1·0 sec. When the period is so large as a few tens of seconds, the matter becomes somewhat different. In case of the great Tango earthquake of March 7, 1927 the seismograms

9) K. SAGISAKA, *Geophys. Mag.*, 4 (1931), 147–155.
H. HONDA, *Geophys. Mag.*, 4 (1931), 201.

obtained at Hongô ($\Delta=427$ km) revealed motions with very long period from the beginning. Therefore, the record of the seismograph must undergo certain reductions.

Using the customary notations, the equation of motion of a seismograph is given by

$$\frac{d^2a}{dt^2}+2\varepsilon\frac{da}{dt}+n^2a=-V\frac{d^2x}{dt^2}.$$

If this equation is integrated twice from $t=0$ to $t=t$, then

$$a+2\varepsilon\int_0^t a\,dt+n^2\int_0^t dt\int_0^t a\,dt=-Vx.$$

The displacement of the earth-movement at any time t is obtained by the reduction shown in the left-side of this equation. In case of great Tango earthquake the period of initial motion is approximately 35 sec. and the angle of incidence comes out 58°.

Another example is the strong earthquake of Nov. 2, 1931 which took place in Miyazaki Prefecture in Kyûsyû. The seismogram of the vertical seismograph obtained at Hongô has been already reduced by Dr. H. Kawasumi[10]. From Dr. Kawasumi's result and the record of Imamura's long period horizontal pendulum seismograph, the angle of incidence is determined approximately 50°, the period of the motion being 25 sec. Although these are only two cases, it will be seen that the angle of incidence varies with the period of motion. This fact may suggest that the most superficial structure, varying from place to place, is not effective to the refraction of seismic waves with long period.

It follows from the theory of elasticity, that the law of refraction of elastic waves at the boundary separating two media is independent of the wave length of incident wave. It holds indeed, if the boundary is large enough compared with the wave length or infinitely extended.

On the other hand, suppose that the upper medium is separated by vertical boundaries into blocks, loosely connected with each other, dimensions of which are of the order of magnitude of wave length. In such a case if the elastic wave whose wave length is much larger than the dimension of each block, is incident from the lower medium to the upper one, then the strain distribution in the upper medium may be nearly uniform. Therefore such a surface block behaves as if this is only a part of the lower medium, and does not contribute to the refraction of elastic wave.

---

10) H. KAWASUMI, *Disin* or *Journ. Seism. Soc.*, Japan, 4 (1932), No. 2, (in Japanese).

In case of earthquakes shown in Table II, their period of initial motion being from 0·3 sec. to 1·0 sec., the most superficial surface whose velocity is 0·5 km/sec. may play an important part. On the other hand it may not be brought into question for the wave of long period as that of great Tango earthquake or of the strong earthquake in Miyazaki Prefecture.

Dr. S. Haeno[11] has obtained 0·25 km/sec. as the velocity of dilatational wave of the ground by the Radio-Seismograph which he has constructed, in his experimental study made in the compound of our university. This value is one half of that obtained by the writer, but the superficial ground may not afford to contribute to the refraction of ordinary seismic waves by the reason as above mentioned.

Dr. N. Nasu[12] has investigated the propagation of artificial disturbance produced by falling a stone on the ground and obtained 0·78 km/sec. as the velocity of the dilatational wave in the experiment made at neighbourhood of our university. This is somewhat greater than that obtained by the writer, but nearly the same in the first approximation.

Now the writer will remark on some observational facts with regards to the seismogram.

At first it is often observed that at the commencement the vertical movement apparently occurs one or two seconds earlier than the horizontal one. This point was found by Visser and Berlage[13] from their observation of distant earthquakes in Batavia. The way of explanation of this phenomenon is similar to that proposed by Prof. Matuzawa.

The apparent earlier commencement of the vertical motion is also often observed in the earthquakes shown in Table II. For instance, in case of the earthquake of March 9, 1931 608 km distant from Tôkyô, the amplitude of the vertical initial motion is 0·1 mm (magnification: 28) and the horizontal one (magnification: 50) is observed with difficulty two seconds after the commencement of the vertical one. The amplitude of the first phase may diminish so much partly due to several refractions and reflexions[14] at boundaries of discontinuity, partly due to the mechanism of occurrence at origin. At any rate, the horizontal motion becomes so small compared with the vertical one, because the

---

11) S. Haeno, *Journ. Astr. Geophys.*, Japan, 8 (1931), 39-50.

12) N. Nasu, *Disin* or *Journ. Seism. Soc.*, Japan, 1 (1929), No. 5, (in Japanese).

13) S. W. Visser und H. P. Berlage, *Gerl. Beitr. z. Geophys.*, 19 (1928), 147-152.

14) H. Kawasumi and T. Suzuki, *Disin* or *Journ. Seism. Soc.*, Japan, 4 (1932), No. 5, (in Japanese).

tangent of the angle of incidence is one-tenth or so at Hongô and Mitaka. Therefore, the apparent earlier commencement of the vertical motion than the horizontal one is naturally understood in case of small earthquakes as well as somewhat distant earthquakes.

In the next place, the seismogram of the vertical component does not often reveal any distinction between the preliminary tremor and the principal portion, especially in case of near earthquakes. Fig. 5 [Pl. LXXX] shows the most typical example. On the other hand, the horizontal motion is literally small in the preliminary tremor and becomes suddenly large when the distortional wave is incident. This fact may also be due to nearly vertical trajectory of the wave near the surface. Although it will depend upon the mechanism of occurrence at the origin, whether the *SH*-wave (distortional wave with its plane of vibration parallel to the surface) or the *SV*-wave (the same with its plane of vibration in the incident plane) will be mainly produced, the vibration of the particle will become gradually parallel to the surface from deep place toward the earth-surface even in case of predominance of *SV*-wave. If such a consideration is taken for granted, the observed fact may be plausibly understood.

One more remark will be added to this phenomenon. In case of great Tango earthquake, the three components of the seismogram obtained at Hongô revealed clearly the distinction between the preliminary and the principal portion. It must be remembered that the angle of incidence in this case is 58°.

Summary.

(1) A remarkable forerunner of earthquake motion obtained at Hongô and Mitaka has been fully discussed and plausibly elucidated by Prof. Matuzawa and others. The present writer has studied the angle of incidence of the first motion and it becomes approximately 4° as the mean value at both stations, its fluctuation being small.

(2) From this value of angle of incidence, 0·5 km/sec. is determined as the velocity of dilatational wave in the most superficial layer.

(3) The angle of incidence of the first motion seems to vary with its period such that 4° when the period is 0·4 sec. or so and 50° when the period is about 30 sec.

(4) A few remarks are added to explain some characteristic features of seismogram.

In conclusion the writer wishes to express his heartfelt thanks to

Prof. Matuzawa for his kindness in revising of the original n nuscript and valuable advices. Further the writer wishes to record his ndebtedness to Dr. H. Kawasumi.

---

36. 本郷、三鷹に於ける初動入射角に就て

地震學教室　鈴　木　武　夫

(1) 本郷、三鷹に於ける近地地震の記象に於て初動が著しく鉛直方向に近く偏つて居ることは既に松澤先生の指摘説明せられた所であるが、筆者は地震記象より初動部分の三成分を合成して初動入射角を求めたるに本郷、三鷹に於てそれは震央距離や震原の深さにはあまり依らず約四度乃至五度である。

(2) 入射角が小即ち震波線が鉛直に近づくことは地表近くの地震波の速度が深處に較べて小なることに因ると考へられ上述の入射角の値より地表近くの疎密波の速度として 0·5 km/sec. を得た。

(3) 入射角は初動部分の週期が 0·3–1·0 秒位では 4–5 度であるが、週期が 25–30 秒になると 50 度位となる。これは地震波の波長が大となるとその波長より小なる廣がりを持つ地表近くの局部的地層は波の屈折には問題とならない爲であらう。

(4) 初動に於て上下動は水平動より少し早く初まると云ふ觀測事實と、上下動に於ては一般に初期微動と主要動との區別が明瞭でないと云ふ事柄に就て少しく考へて見た。

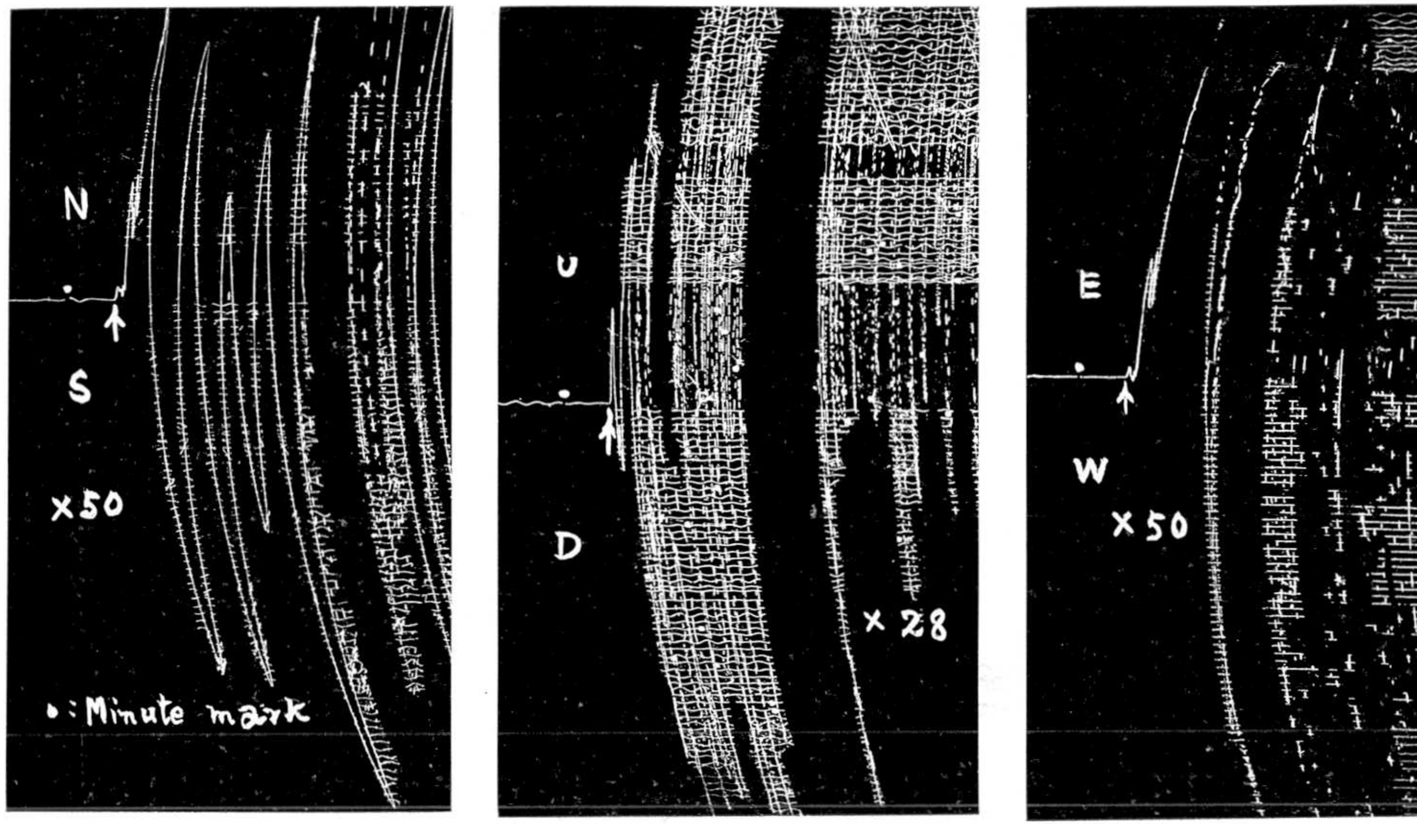


Fig. 4. Earthquake of November 26, 1930. (No. 20)
Recorded at Hongô.

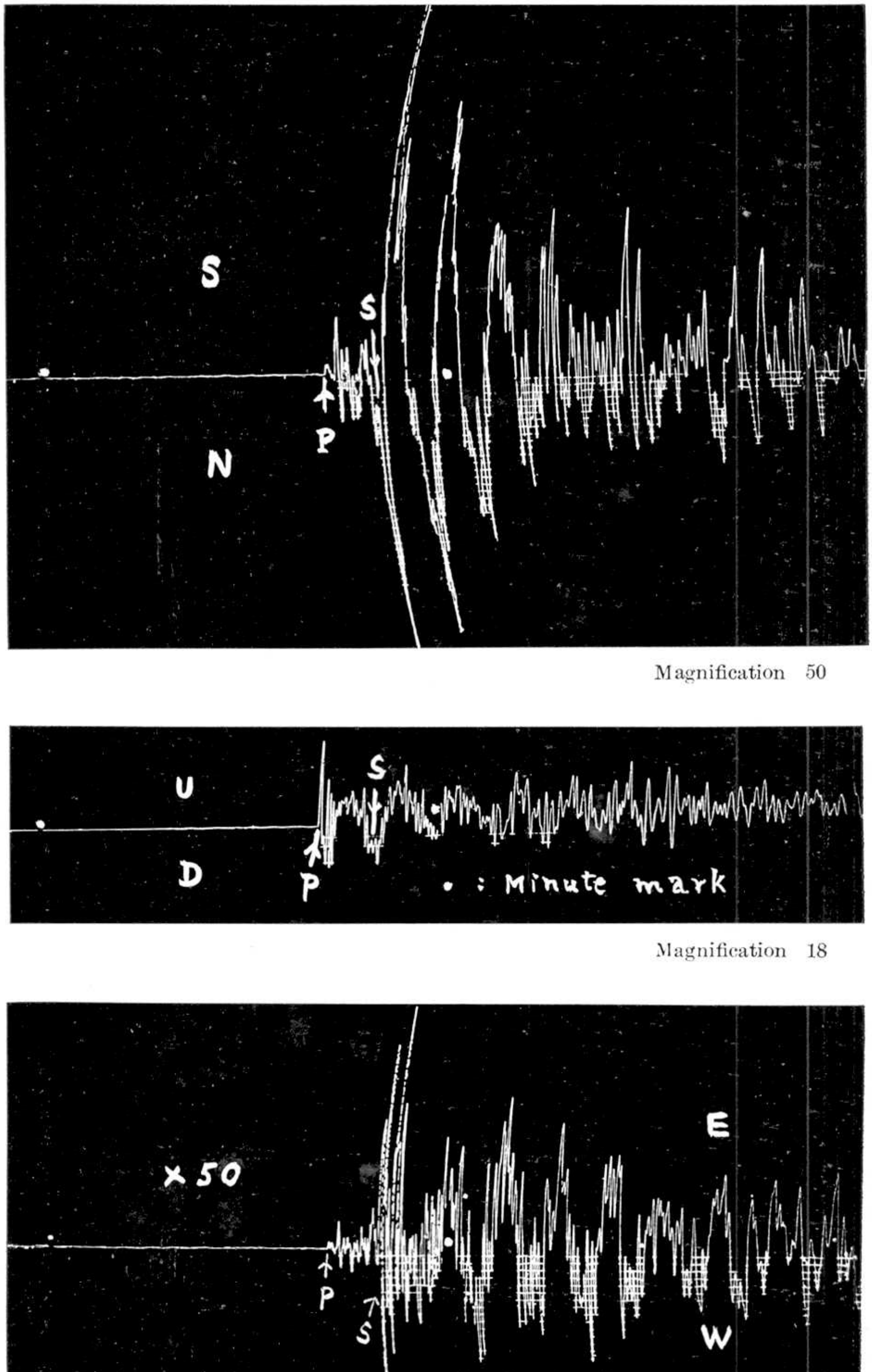
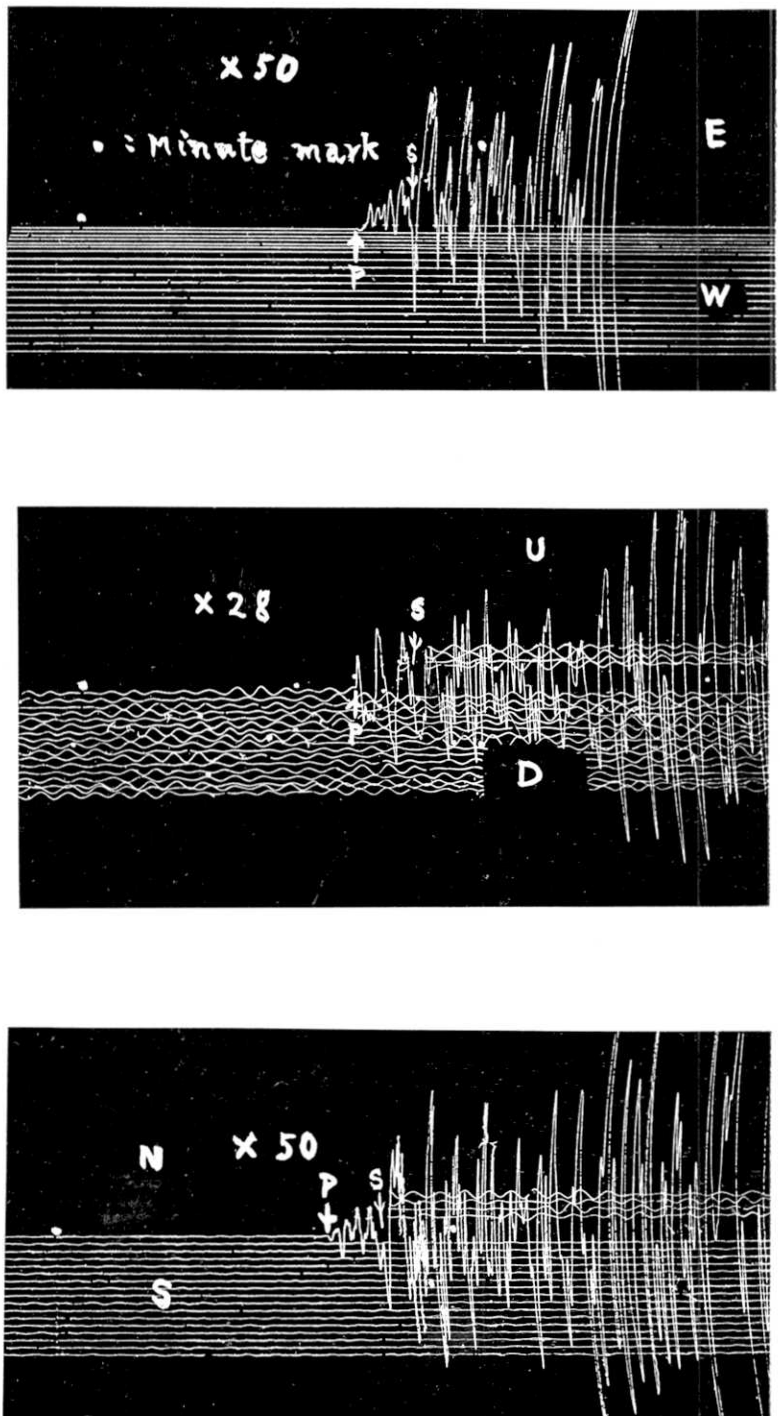


Fig. 5. Earthquake of October 5, 1928. (No. 1)
Recorded at Mitaka.

(震研彙報、第十號、圖版、鈴木)



（震研彙報、第十號、圖版、鈴木）

Fig. 6. Earthquake of September 28, 1931. (No. 4)
Recorded at Hongô.

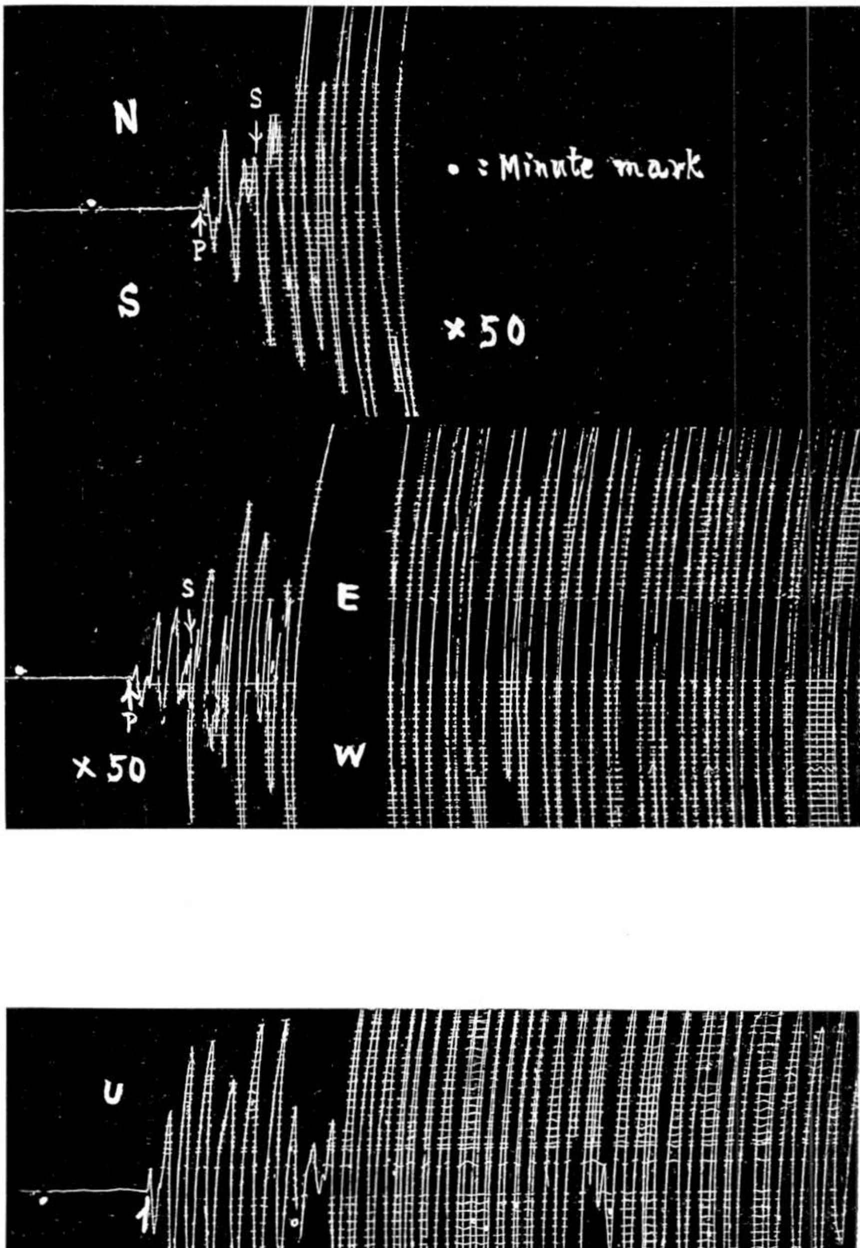


Fig. 7. Earthquake of May 17, 1930. (No. 27)
Recorded at Hongô.

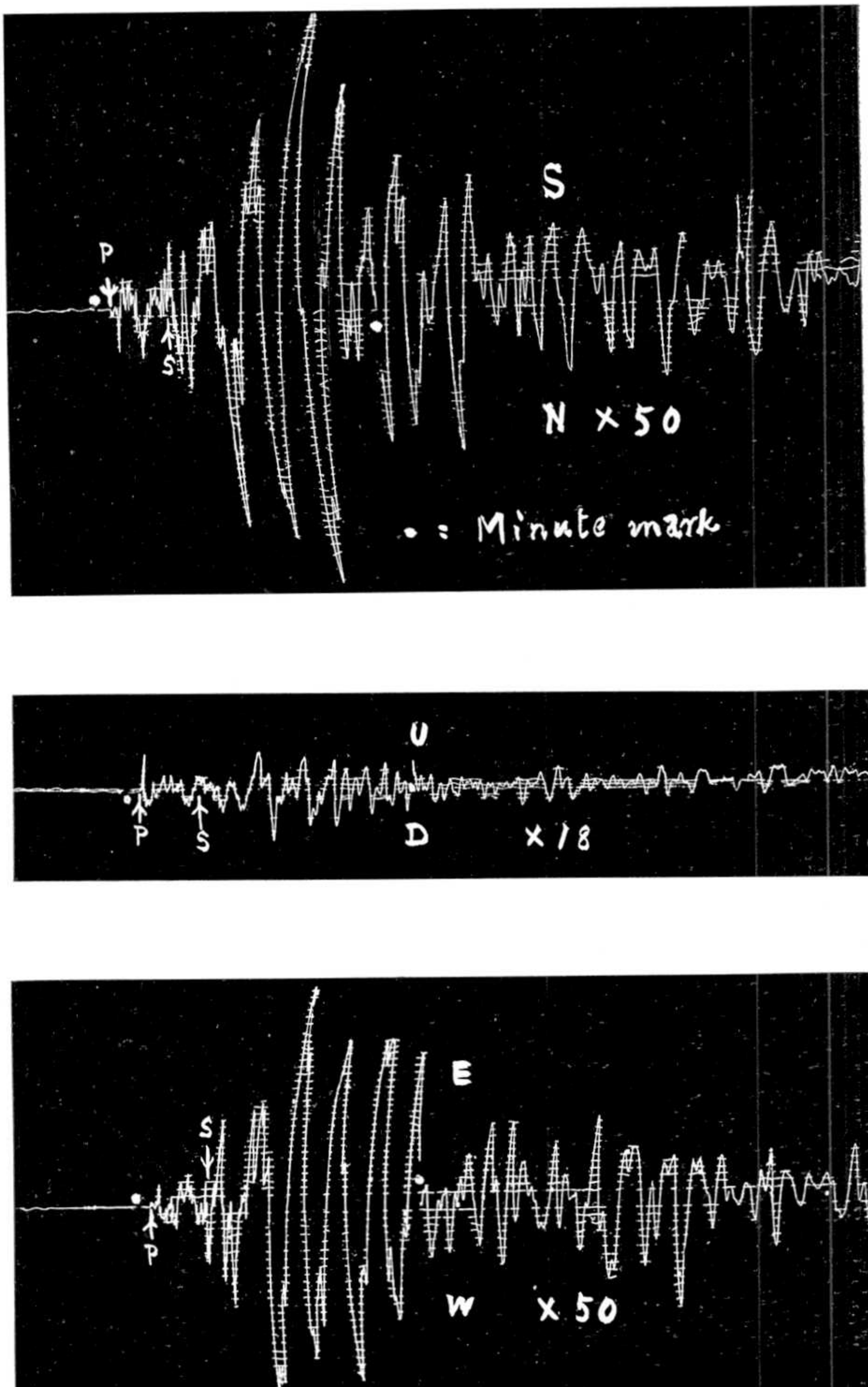


Fig. 8. Earthquake of March 9, 1930. (No. 41)
Recorded at Mitaka.

(震研彙報、第十號、圖版、鈴木)