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31. *Observations of Seismic Waves from the Second Hokoda Explosion.*

By The Research Group for Explosion Seismology.

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1. Introduction

At midnight on August 26, 1957 the Research Group blasted about one ton of explosive at the site of an abandoned aerodrome near Hokoda town, Ibaragi Prefecture, and seismic waves from it were observed at 18 temporary stations.

The essential objects of these observations were as follows: First, this observation forms a profile reverse to Kamaisi Explosions in order to verify the crustal structure of the North-east Japan already obtained by us.[1] Secondly, we aim to find the connection between the crustal structure of the northern part of Kwantô District[2] and that of North-east Japan.

Concretely speaking, because in the northern part of Kwantô District a layer with a P-wave velocity of 5.5 km/sec is found, instead of a layer with a P-wave velocity of 5.75-5.85 km/sec as in North-east Japan, their relation must be found. Moreover, the P_n velocity was taken as 7.7 km/sec in Kwantô District and as 7.5-8.0 km/sec in North-east Japan. For their unified interpretation, more accurate determination of the P_n velocity and of the depth of the Mohorovičić discontinuity were aimed at. For the latter purpose accurate observations are necessary in a region, where the crustal structure in the shallow part is well known. From this view point observation points were spread in a profile nearly reverse to the Kamaisi and Isibuti explosions.

2. Observations

The shot point was shifted by 188 m in the S57°W direction from

1) The Research Group for Explosion Seismology (Japan), *Pub. Bur. Cent. Séism. Intern.*, Sér. A. Trav. Sci., **19** (1954), 229-242.
T. MATUZAWA, *Bull. Earthq. Res. Inst.*, **37** (1959).

2) The Research Group for Explosion Seismology (Japan), *Bull. Earthq. Res. Inst.*, **36** (1958), 329-348; T. USAMI et al., *Bull. Earthq. Res. Inst.*, **36** (1958), 349-357.

Table 1.

Station	λ	φ	H m	Θ	Δ km	Apparatus	Observer
1. Shot Point (Hokoda)	140°33′34.5″E	36°08′16.3″N	41	N 8°30.0′W	0-0.55	S.S.C.	Matuzawa, Kaneko, Tateishi, Ôtaki, Kamata, Kawashima
2. Ôya	30 48.2	14 4.1	29	21 11.1	11.496	15V1, 30H1, 3V1, 3H1	Wada, Kumazawa
3. Mito A	32 29.0	20 2.2	14	4 17.9	21.817	2V1, 2H2	Mikumo, Okamoto
4. Mito B	31 46.8	21 37.4	6	6 12.9	24.836	2V1, 2H2	Otsuka,
5. Sano	30 12.4	26 24.9	34	8 39.2	33.928	E.T.L.M-3	Murauchi, Honda, Asanuma
6. Hitati	35 47.4	38 2.8	357	3 26.5 E	55.161	2V1, 7V1, 4H1	Tanaka, T. Suzuki
7. Daigo	21 6.3	46 27.4	111	14 46.7 W	73.030	3V1, 2H2	Tamaki, Kitamura
8. Tanakura	23 36.6	37 01 9.8	243	8 38.4	98.935	N.D. 3V1, 3V1, 3H1	Muramatu, Takeda
9. Tamagawa	25 2.0	12 30.4	279	6 6.8	119.472	N.D. 3V1, 3V2	Takahashi, Watanabe
10. Tamura	25 11.8	19 12.8	246	5 25.8	131.789	N.D. 3V1	Utsu, Usami
11. Siroiwa	28 53.2	29 28.3	344	2 39.5	150.331	N.D. 3V1, 3V1	T. Matumoto, Karakama
12. Kawamata	36 49.8	41 5.2	176	1 36.8 E	171.720	3V2, N.D. 3V1	Onda, Takeuti, H. Okada
13. Isida	38 11.7	46 5.8	163	2 10.2	181.049	N.D. 3V1	Shima, Sibano
14. Kaneyama	47 52.3	53 45.9	22	6 12.1	196.252	N.D. 3V1, T.A. 4V1	Asano, Yanagisawa
15. Watari	51 19.6	38 01 30.0	10	7 8.6	211.056	N.D. 3V1, 4V1, 1V1	Santo, Terashima
16. Mukaiyama	51 20.7	14 32.9		6 25.4	235.022	N.D. 3V3, 5H1	Mine, Ishigaki
17. Miyatoko	51 0.3	24 0.6	49	5 51.2	252.368	N.D. 3V1, 3V1, 4V1	Z. Suzuki, Emura
18. Matusiro	138 12 23.6	36 32 22.4	383	78 5.1 W	215.870	N.D. 3V1	Suyehiro
Surveyor	A. Okada						

the first shot point. It consisted of six holes as before. Each hole was 5″ in diameter and 60–70 m deep. They were situated at the five angular points of a regular pentagon inscribed in a circle of 7 m redius and at its centre.

About one ton of dynamite was almost equally distributed to these six holes. The depth of the dynamite head in each hole was about 35 m from the ground level in the mean. The rest of the hole was tamped

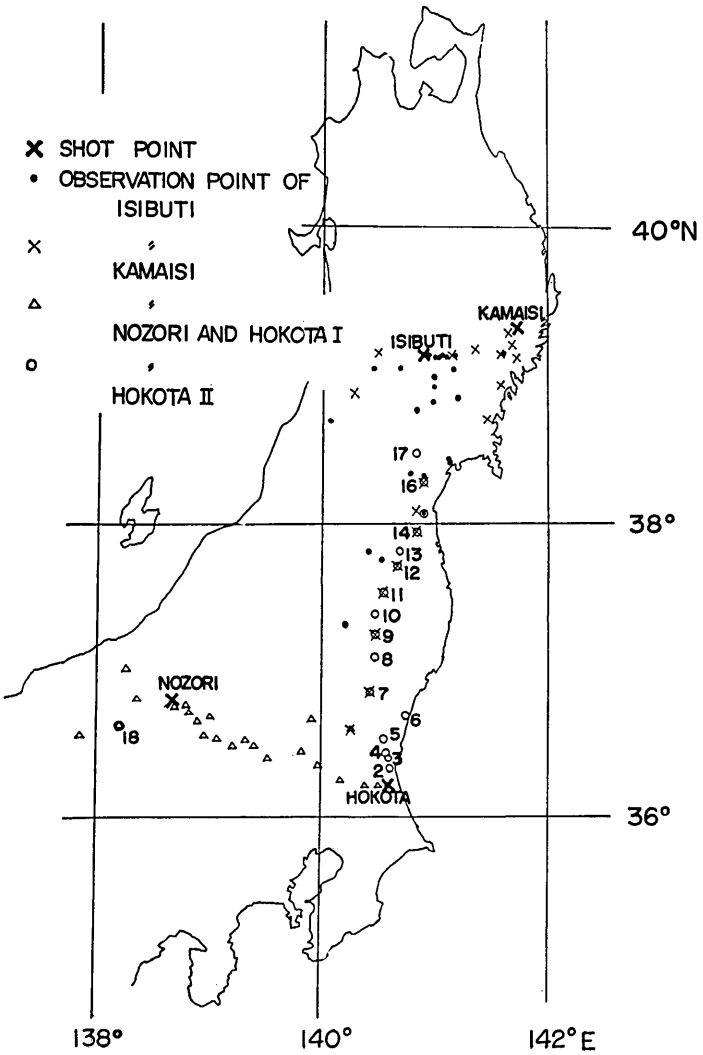

Fig. 1. Shot and observation points

with water. The number of observation points was 7 in the northern part of the Kwantô District, 10 in North-east Japan and one at Matusiro, i.e., 18 points in total. Among these points 7 are common (Siroiwa, Kaneyama, and Mukaiyama) or near (Hitati, Tamagawa, Kawamata and

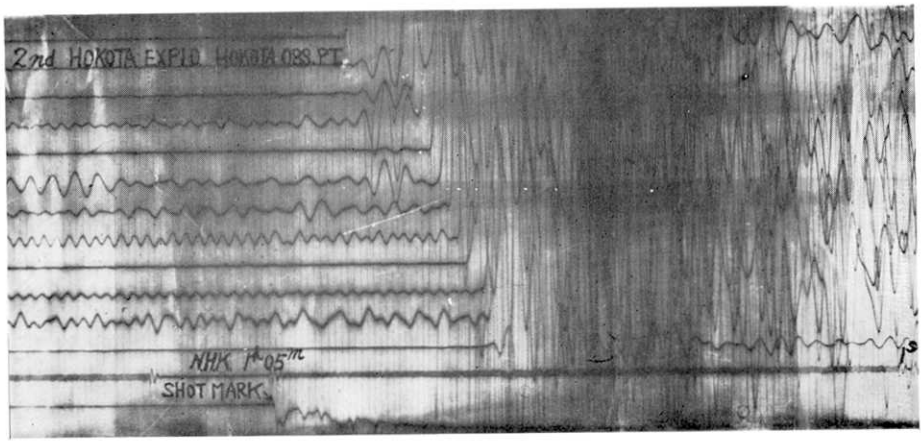

Fig. 2. Seismogram obtained at Hokoda.

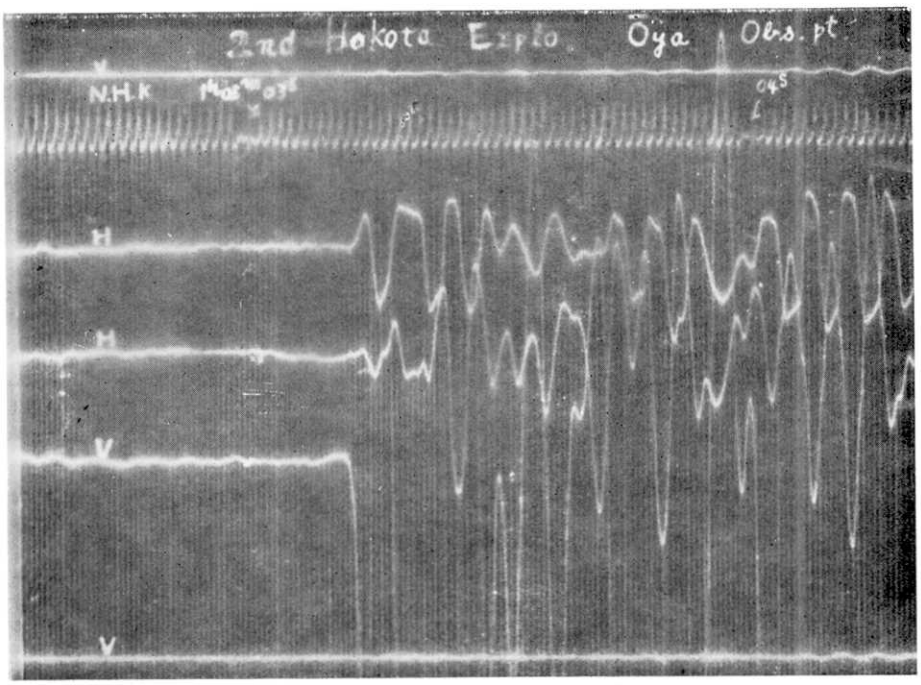

Fig. 3. Seismogram obtained at Ôya.

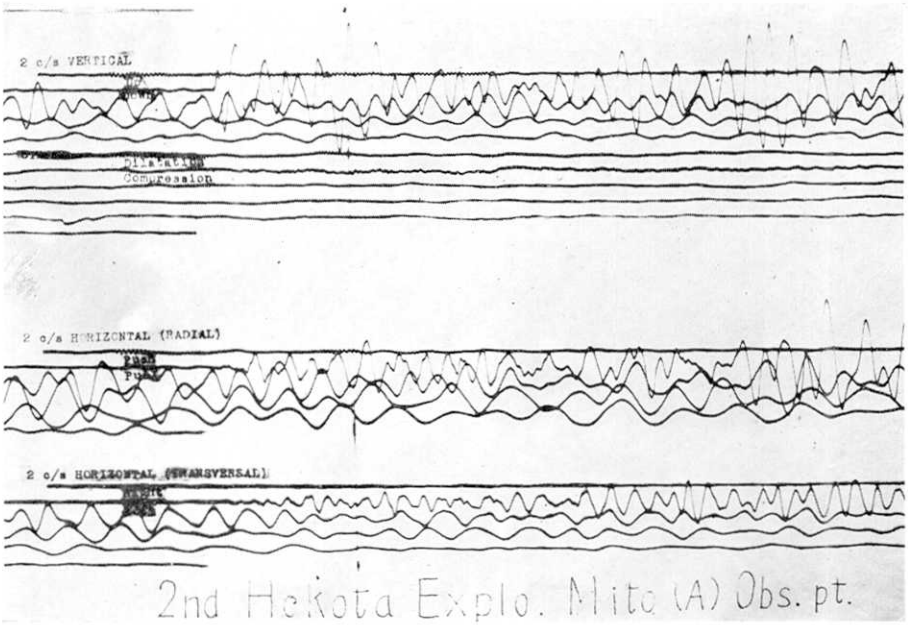

Fig. 4. Seismogram obtained at Mito A.

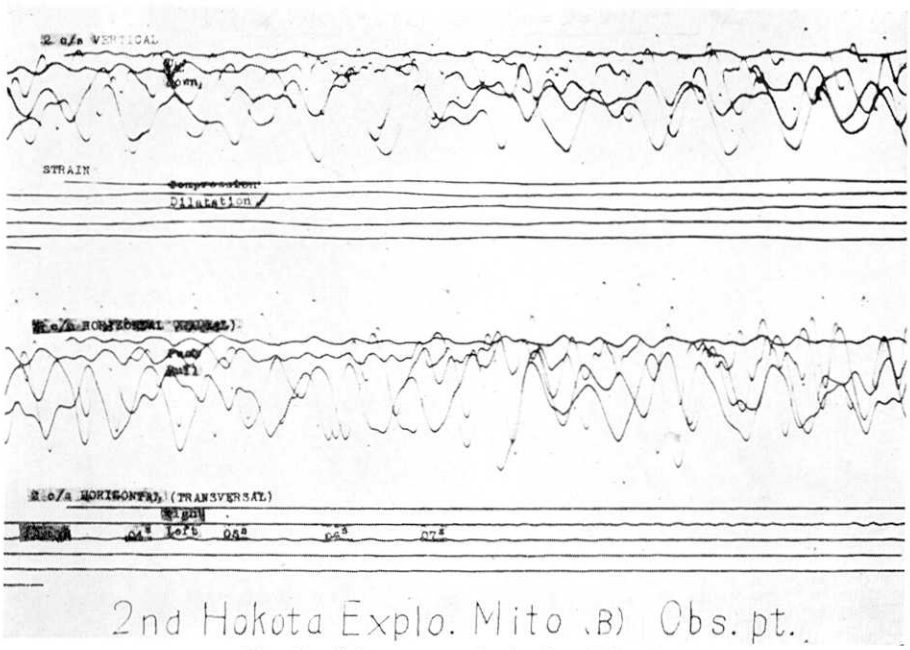

Fig. 5. Seismogram obtained at Mito B.

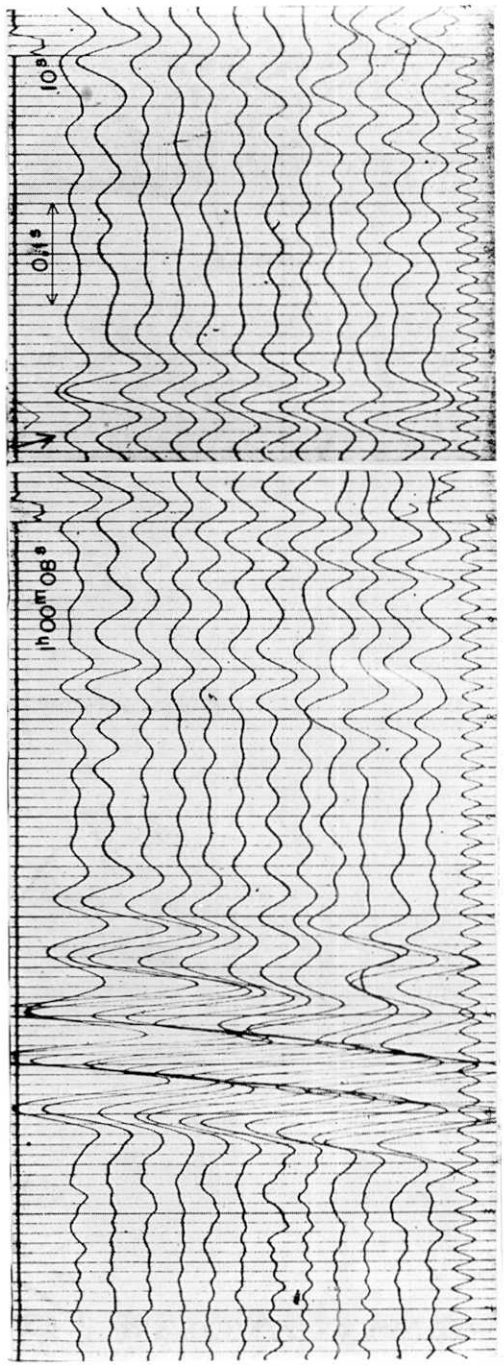

Fig. 6-a. Seismogram obtained at Sano.

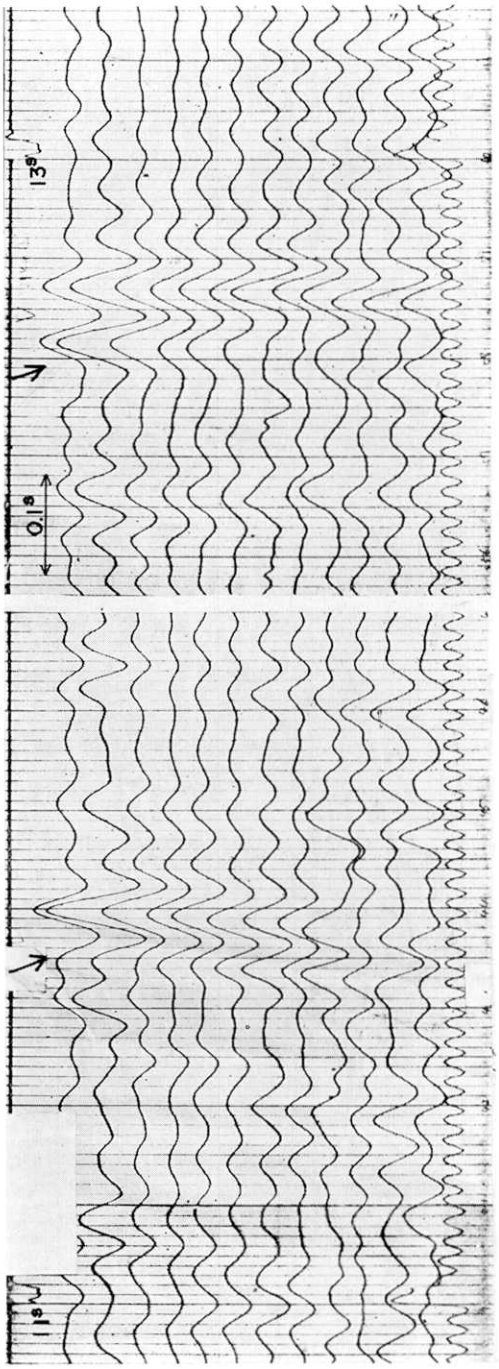

Fig. 6-b. Seismogram obtained at Sano.

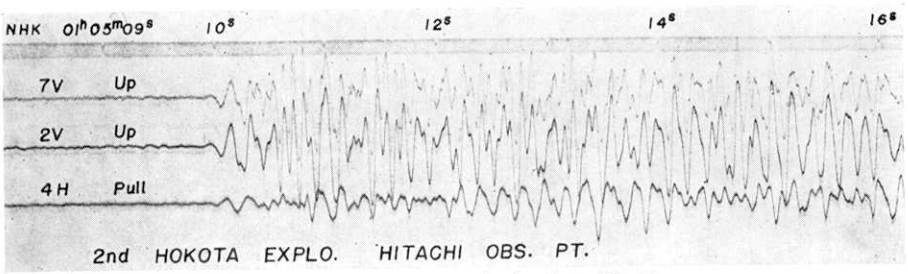

Fig. 7. Seismogram obtained at Hitati.

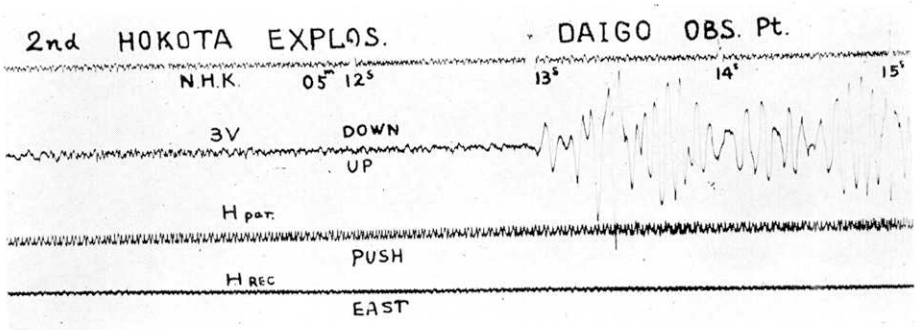

Fig. 8. Seismogram obtained at Daigo.

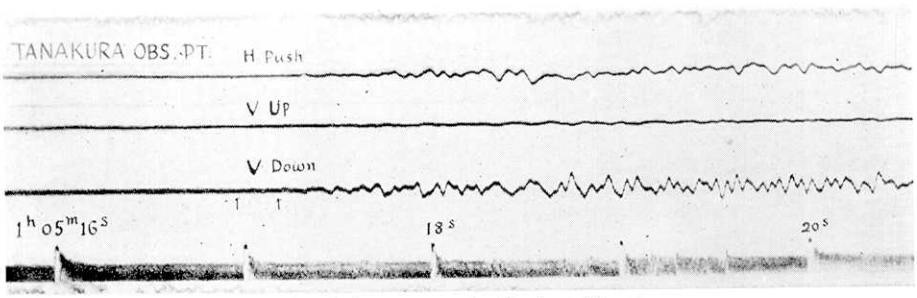

Fig. 9. Seismogram obtained at Tanakura.

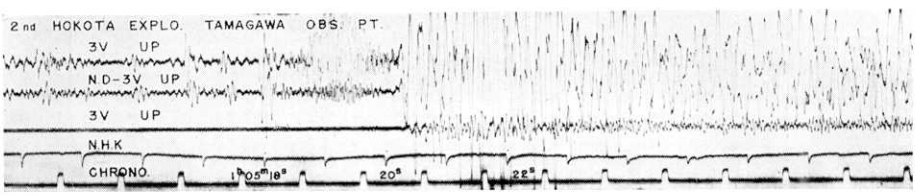

Fig. 10. Seismogram obtained at Tamagawa.

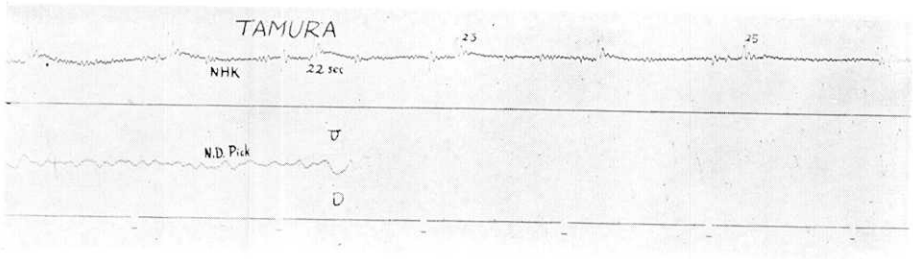

Fig. 11. Seismogram obtained at Tamura.

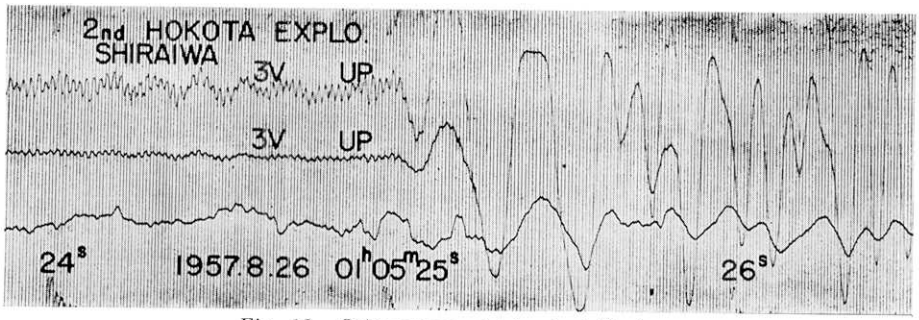

Fig. 12. Seismogram obtained at Siroiwa.

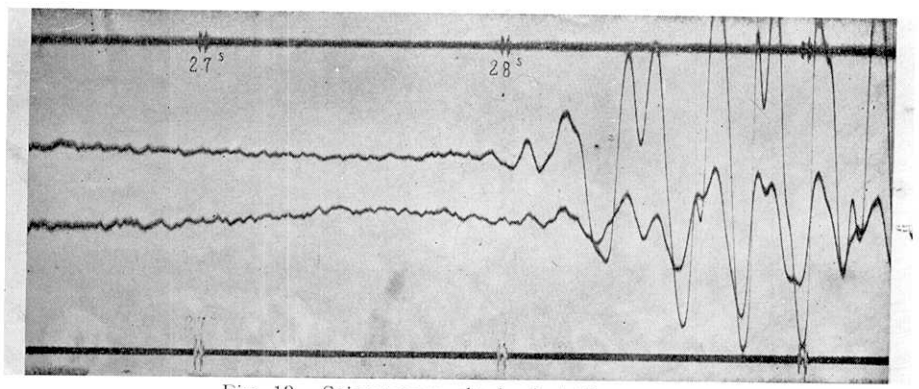

Fig. 13. Seismogram obtained at Kawamata.

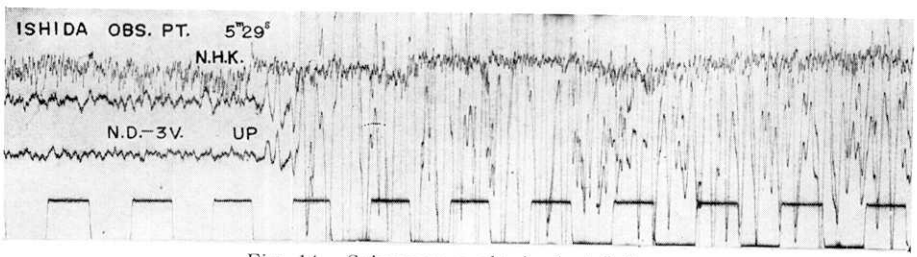

Fig. 14. Seismogram obtained at Isida.

Fig. 15. Seismogram obtained at Kaneyama.

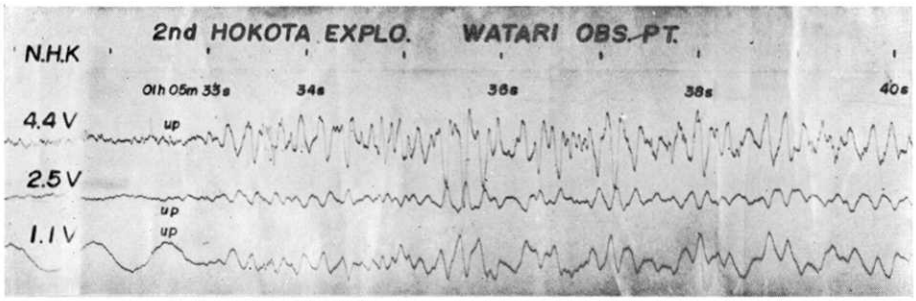

Fig. 16. Seismogram obtained at Watari.

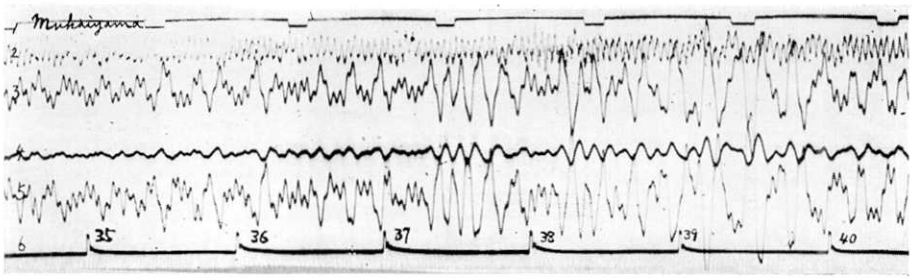

Fig. 17. Seismogram obtained at Mukaiyama.

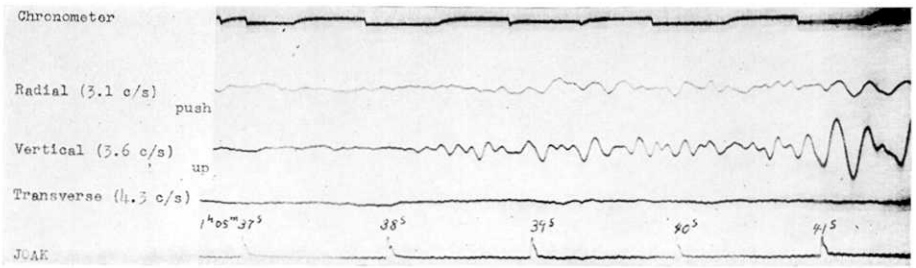

Fig. 18. Seismogram obtained at Miyatoko.

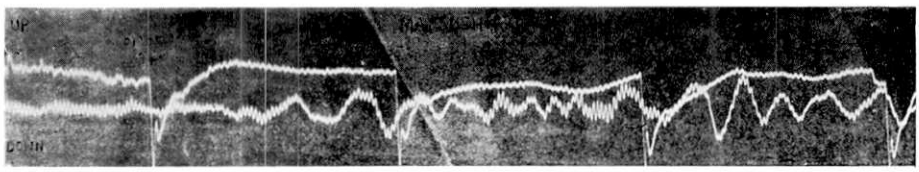

Fig. 19. Seismogram obtained at Matusiro.

Watari) to those of the Isibuti or Kamaisi explosions. At most stations pick-ups with a proper frequency of 3 c/s were connected to amplifiers. At Sano observation of reflected waves was especially tried by an apparatus of E.T.L.M-3 type, the proper frequency of the vertical pick-up being 7 c/s. Twelve vertical component pick-ups were set at every 20 m in the direction of the profile. Observations were carried out with a filter of high-cut above 20 c/s and without suppressor.

The shot point, observation points, observers and instruments are shown in Table 1 and in Fig. 1. In Fig. 1 are added also the shot and observation points for Isibuti, Kamaisi, Nozori and the first Hokoda explosions. Seismograms are shown in Figs. 2～19.

3. Measurement of seismograms

First, seismograms were read independently by 3 persons (T. Matuzawa, T. Matumoto and S. Asano) and then comparing them together with the original seismograms, final values were determined. According to the distinction of the onset of the first motion, that of the time marks, regularity of paper speed etc., the accuracy of the observed values was classified in the following four groups;

class a : $\Delta t \leqq 1/100$ sec
class b : $1/100 < \Delta t \leqq 3/100$ 〃
class c : $3/100 < \Delta t \leqq 1/10$ 〃
class d : $1/10 < \Delta t$

where Δt is the expected error of the travel time determination. From various reasons the accuracy was fairly good on the whole, and most observations were included in class a and b, and only 4 stations belong to class c or d.

Onset times of the initial motion and remarkable late phases are tabulated in Table 2 and their travel time diagram is shown in Fig. 20.

Table 2. Travel time for the second Hokoda Explosion Shot time : 1 h 05 m 0.006 s

Station	Δ km	P_1 class	L (late phase) in sec	$\Delta/6$ in sec	$P_1-O-\frac{\Delta}{6}$	$L-O-\Delta/6$ in sec	Remark
		sec			sec		
Hokoda	0.00	0.006		0	0		
Ôya	11.50	3.18 a	3.37, 3.66, 28.82	1.92	1.25	1.44, 1.73, 26.89	
Mito A	21.82	5.05 c		3.64	1.40		
Mito B	24.84	5.52 b	6.76	4.14	1.37	2.61	
Sano	33.93	7.35 b		5.66	1.68		
Hitati	55.16	9.89 a	10.54, 10.80, 11.33 12.08	9.19	0.69	1.34, 1.60, 2.13, 2.88	
Daigo	73.03	13.02 b	13.20	12.17	0.84	1.02	
Tanakura	98.94	17.17 c	17.80, 18.27	16.49	0.67	1.30, 1.77	May be earlier, owing to the small initial motion.
Tamagawa	119.47	20.23 b	20.84, 35.22	19.91	0.31	0.92, 15.30	
Tamura	131.79	22.28 a	22.55, 40.20, 41.55	21.97	0.30	0.57, 18.22, 19.57	
Siroiwa	150.33	25.01 a	44.30	25.06	−0.06	19.23	
Kawamata	171.72	27.92 b	28.24	28.62	−0.71	−0.39	
Isida	181.05	29.16 a	29.59, 52.80, 71.6, 111.5	30.18	−1.03	−0.60, 22.61	
Kaneyama	196.25	30.77 b	31.90, 32.47, 37.21	32.71	−1.95	−0.82, −0.25, 4.49	
Watari	211.06	32.92 b	33.14, 35.32	35.18	−2.27	−2.05, 0.13	
Mukaiyama	235.02		37.30(d), 38.16 39.00, 40.50, 42.25	39.17		−1.88, −1.02, −0.18 1.32, 3.07	
Miyatoko	252.37	38.15 c	38.90, 40.77	42.06	−3.92	−3.17, −1.30	The initial motion is small.
Matusiro	215.87	34.28 d	36.25	35.98	−1.71	0.26	

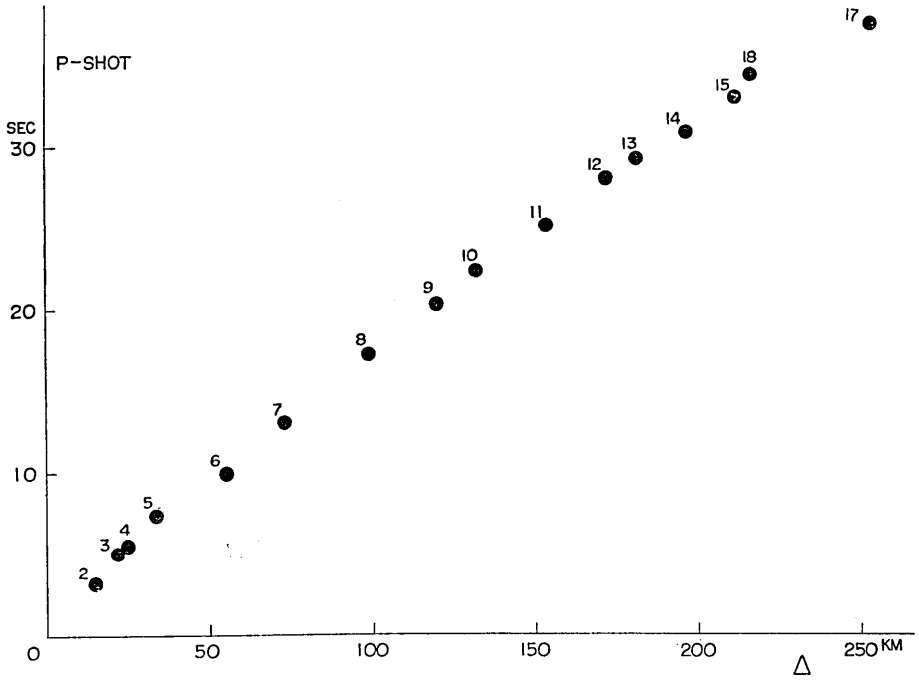

Fig. 20. Travel time diagram of the waves from the Second Hokoda Explosion.

Table 3. Travel times near the shot point

Hokoda I			Hokoda II			
Station	Δ m	$P-O$	Station	Δ m	P	$P-O$
		ms			ms	ms
1	0	0	1	150	120	114
2	188	160	2	300	212	206
3	471	318	3	325	226	220
4	676	432	4	350	238	232
5	840	519	5	375	252	246
6	1090	634	6	400	269	263
7	1240	767	7	425	282	276
			8	450	295	289
			9	475	308	302
			10	500	333	327
			11	525	340	334
			12	550	?	?

4. Observations near the shot point

Seismic waves at 12 points in a profile 550 m long from the shot point were observed. Their travel times are tabulated in Table 3 together with those of the first Hokoda explosion and plotted in Fig. 21.

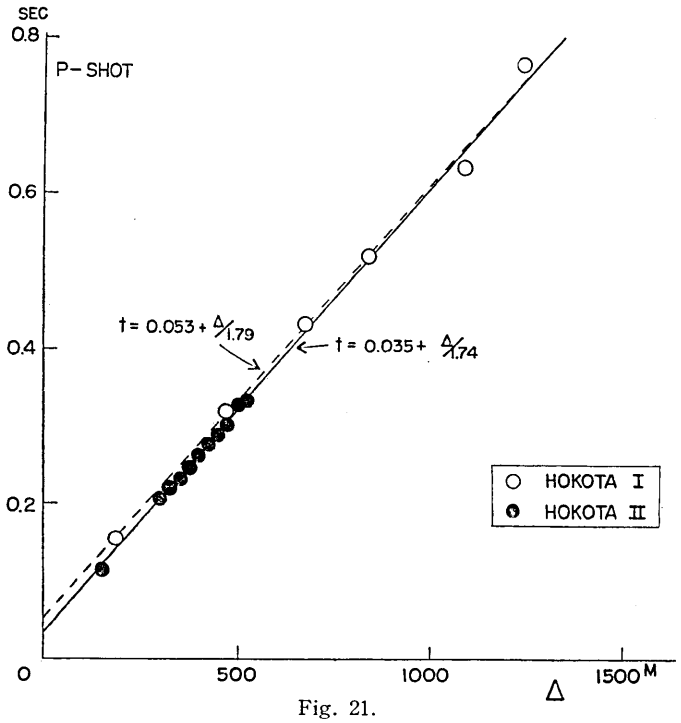

Fig. 21.

From observations exclusively of the second explosion the P velocity turns out as 1.71 km/sec with the intercept time of 0.028 sec. This value is somewhat different from 1.79 km/sec for the first explosion, but this difference can be explained by the difference of the shot points about 200 m apart.

Adding both observations, the following equation is obtained,

$$t=0.035+\Delta/1.74$$

with t in sec and Δ in km.

5. Observation of reflected waves at Sano

Seismograms obtained were excellent (refer to Fig. 6), and predom-

inant phases were read as follows:

1 h 05 m 9.61 sec; 11.35 sec; 12.85 sec.

These three phases are especially distinct among other phases.

Discussions of the observed travel times from the standpoint of the crustal structure are given in a separate paper.[3)]

6. Acknowledgement

We are much obliged to personnel of NHK., Tôkyô Electric Power Co., Tôhoku Electric Power Co., the Broadcast Station of Standard Frequency, the Radio Time Signal Committee, Tôhoku-Tihô-Kensetu-Kyoku, Japan National Railway, Nippon-Yusi Co., police stations, provincial bureaus etc., for their inestimable help and cooperation given to us.

Financial aid was granted by the fund for special works of the Earthquake Research Institute.

Our thanks are due to Prof. N. Nasu, director of the institute, Professors F. Kishinouye, H. Kawasumi and T. Hagiwara for their kind advices in the project.

Postscript

After the completion of this paper, it was found that the name of the town near the shot point should be written "Hokoda" instead of "Hokota". But owing to the lack of sufficient time for correction, inscriptions in seismograms and text figures are left as hitherto used.

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31. 第2回鉾田爆破地震動の観測

爆破地震動研究グループ

1957年8月26日午前1時5分，茨城県鹿島郡大洋村の旧飛行場跡で約1屯の火薬の大爆破が行われ，その地震動を Fig. 1, Table 1 に与えられている 18 ヶ所で観測した．爆破点は第1回の場所から S 57° W の方向に 188 m移つた点で前回同様の方法で行つた．

今回の観測の目的は，第1には，既に得られている東北地方の地殻構造を検討する逆測線であり，第2には，関東地方北部と東北地方の地震構造の関係を求めることである．得られた観測値は Table 2 及び Table 3 に与えられている．

なお，今回の実験についても，日本放送協会，東京電力株式会社，東北電力株式会社，電波研究所，学術会議報時委員会，東北地方建設局，日本国有鉄道，日本油脂株式会社，観測点所在の各県警察本部，市町村役場などの非常な御協力を得たので心から感謝の意を表します．

また本観測は地震研究所特別事業費により実施し，那須所長，岸上，河角，萩原各教授には大変お骨折りいただいたので，記して感謝致します．

3) T. MATUZAWA, T. MATUMOTO and S. ASANO, *Bull. Earthq. Res. Inst.*, **37** (1959).