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5. *Crustal Structure in the Western Part of Japan Derived from the Observation of the First and Second Kurayosi and the Hanabusa Explosions. Part 1. Observation of Seismic Waves Generated by the First and Second Kurayosi and the Hanabusa Explosions.*

By the Research Group for Explosion Seismology.

(Read May 25, 1965.—Received Dec. 28, 1965.)

Abstract

About two tons of explosives were fired twice in Endani, Kurayosi, Tottori Prefecture on November 16, 1963 and on November 21, 1964, and once at Hanabusa Mine, Gifu Prefecture on November 18, 1964. A shaft of an abandoned mine was used as a shot hole for each explosion. There were about twenty temporary stations in each explosion and good seismograms were obtained. These experiments are described and the results of observation are presented in this paper.

§ 1. Introduction

The crustal structure in the western part of Japan was partly derived in 1961 by using data on the Miboro explosions.[1] However, the opportunity to observe reverse profiles of the Miboro explosions has never come until the first Kurayosi explosion on November 16, 1963. Since 1964, the Upper Mantle Project has been under way in Japan and Explosion Seismology has been supported by this project. Our older instruments have been replaced by improved ones almost completely. In 1964, we have one reversed profile as mentioned later and obtained pretty good results recorded by our new instruments. In this paper the result of observation of seismic waves from three explosions by our Group as well as the net of microearthquake observatories of Kyoto University and Gifu University is presented.

1) T. MIKUMO, M. OTSUKA, T. UTSU, T. TERASHIMA and A. OKADA, *Bull. Earthq. Res. Inst.*, **39** (1961), 327-349.

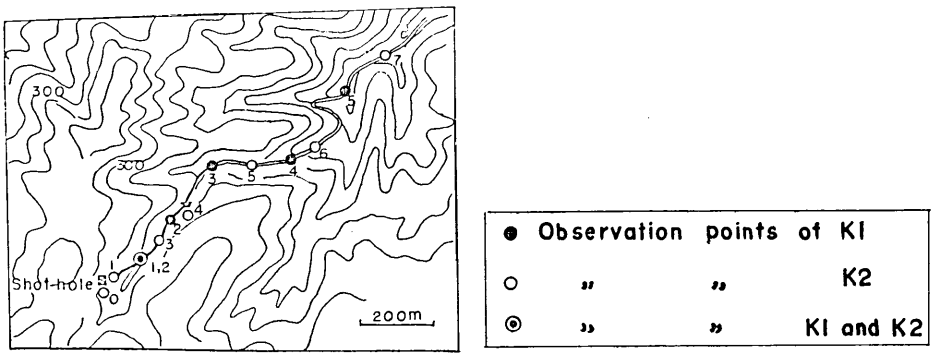

Fig. 1a. Shot point and observation points near the Kurayosi shot point.
$K1$: the first explosion; $K2$: the second explosion.

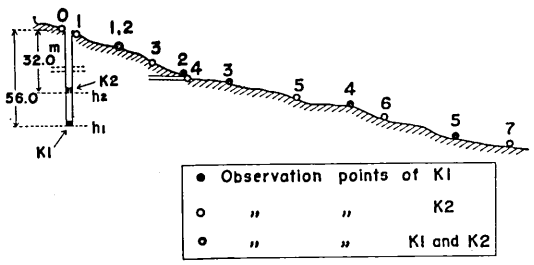

Fig. 1b. Shot point and observation points near the Kurayosi shot point.
h_1, h_2: elevation from mean sea level
h_1=265 m, h_2=289 m.

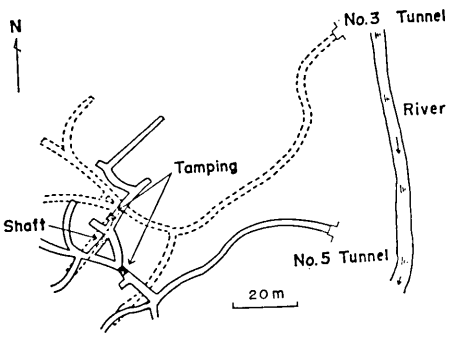

Fig. 2a. Shot point of the Hanabusa explosion.
Broken lines show lower level.

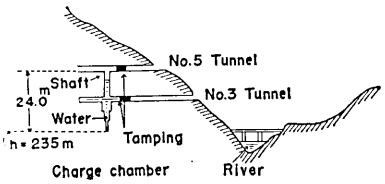

Fig. 2b. Shot hole of the Hanabusa explosion.
h=elevation from mean sea level.

§ 2. Shot points

The same shaft in the abandoned mine of Endani, Kurayosi was used for the first and second Kurayosi explosions. Two tons of explosives were put into the shaft and water was used for tamping (Fig. 1). Fresh granite is most commonly found in this area.

While Hanabusa shot point is about 250 km east from Kurayosi shot point and a shaft of a Hanabusa abandoned mine was used for the explosion. Two tons of explosives were detonated under almost the same conditions as with the Kurayosi explosions. Topography of shot points is given in Figs. 1 and 2. Data of shot points are in Table 1.

Table 1. Data of shot and shot points, charge size and number of observation points

Shot time	Shot point	Latitude (N)	Longitude (E)
Nov. 16, 1963 01 h 07 m 0.499 s	Kurayosi	35°23′26″.4	133°50′20″.0
Nov. 21, 1964 01 h 06 m 58.762 s	Kurayosi	35 23 26. 4	133 50 20. 0
Nov. 18, 1964 01 h 07 m 0.39 s	Hanabusa	35 36 14. 4	136 32 14. 9

Height (m)	Charge size	Number of observation points	
265	1.98 tons	Near shot point: 6	21
290	1.98	Near shot point: 8	29
260	1.98	Near shot point: 4	28

§ 3. Observation

The locations of observation sites are given in Fig. 3. The profile is almost east-west and passes through the area which is situated north to the profile A of Miboro explosion. The name of observation sites, azimuth, epicentral distance, observers, etc. are given in Tables 2 and 3. The positions of shot points and observation sites were determined by triangulation and by using air photos.

The seismic waves were recorded with magnetic tape data recorder at 8 sites in the first Kurayosi explosion and at almost all sites in the second Kurayosi and Hanabusa explosions. At stations other than those

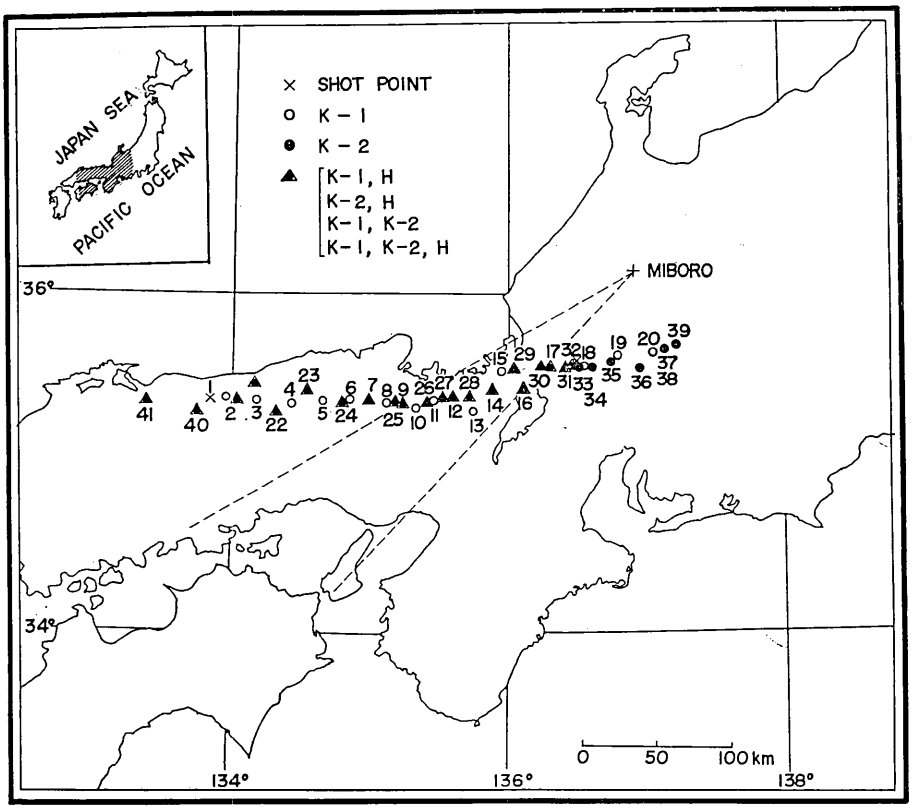

Fig. 3. Observation points for the first and second Kurayosi and the Hanabusa explosions.
K—1: the first Kurayosi explosion, *K*—2: the second Kurayosi explosion, H: Hanabusa explosion. Dashed lines shows A and B profiles of Miboro explosions.

mentioned above, electromagnetic oscillographs were used as previously. *E. T. L. M-3* type seismic prospecting apparatus was used at Misasa in the first Kurayosi explosion to observe reflected waves.

§ 4. Results

Good records were obtained for the three explosions since special data processing has become possible because of improvement and unification of instruments. Especially in the case of both Kurayosi explosions good seismograms were obtained at the farthest stations (the epicentral distance is more than 300 km). Seismograms for each explosion are given

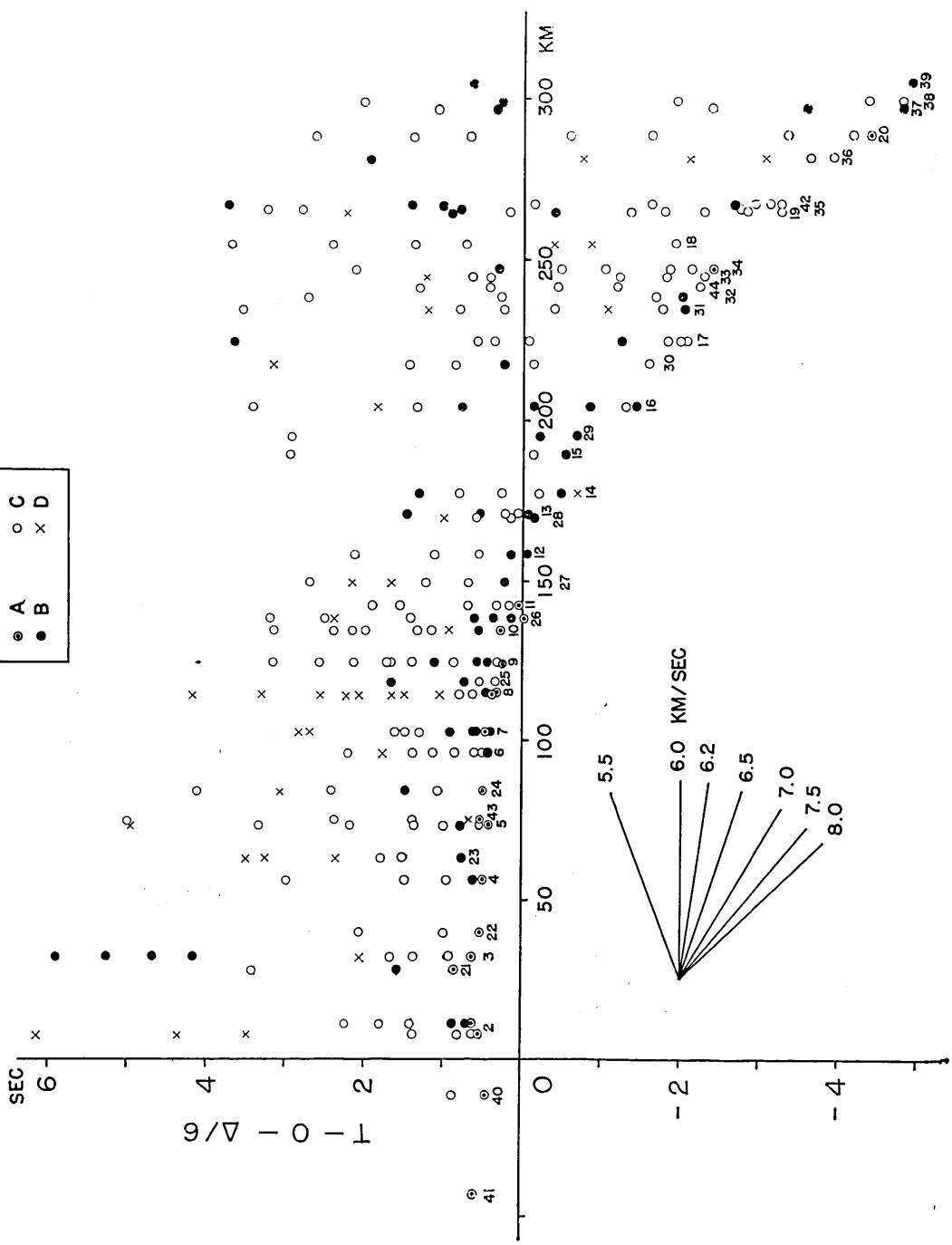

Fig. 5. Travel time graph for the Kurayosi explosions.
A: very clear first arrivals; B: good phases; C: fairly good phases; D: doubtful.

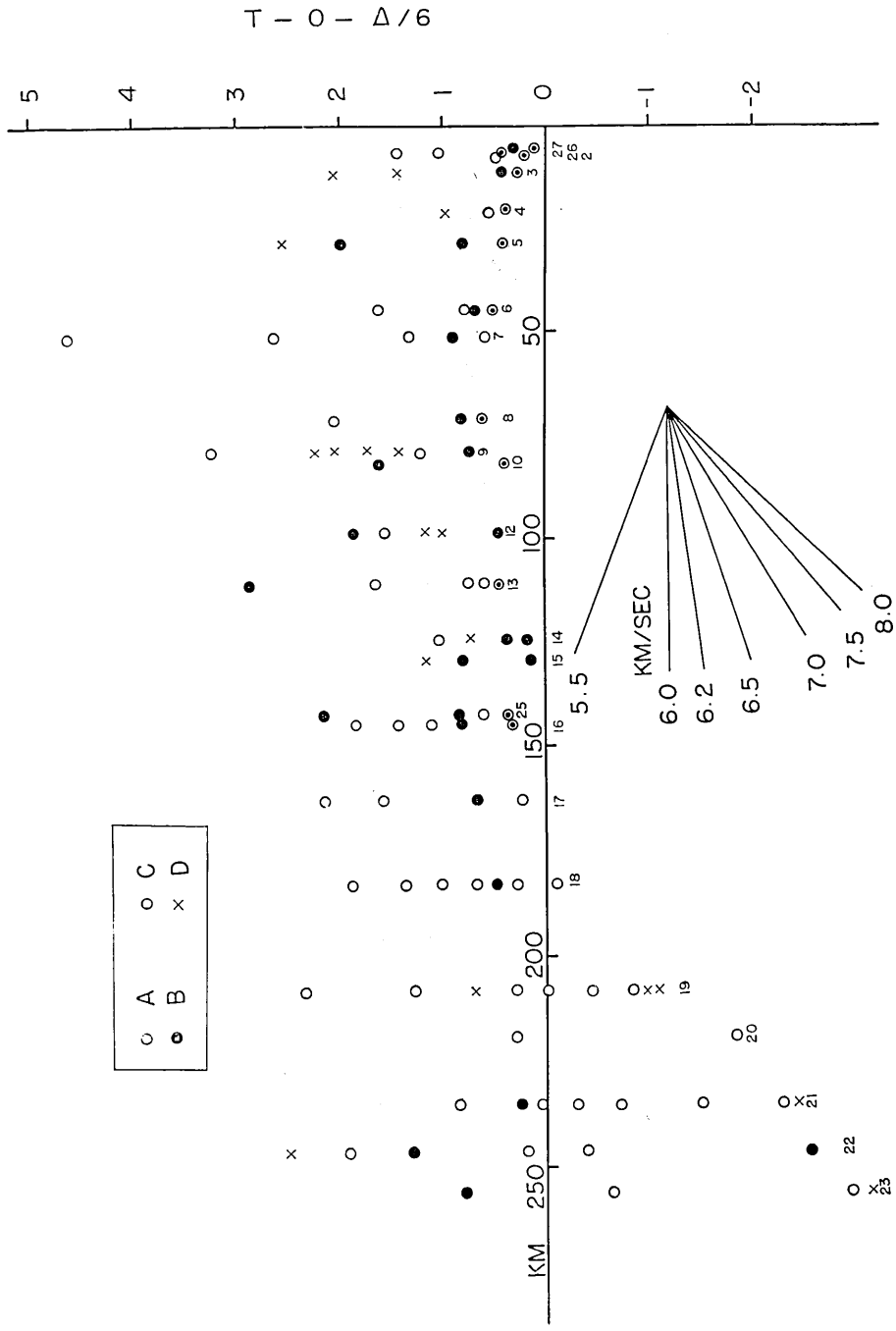

Fig. 6. Travel time graph for the Hanabusa explosion.
A: very clear first arrivals; B: good phases; C: fairly good phases; D: doubtful.

in Fig. 4.

Each phase including first arrivals on seismograms was classified into the following four grades by taking clearness of phases, accuracy of identification, etc. into account:

A: very clear first arrivals
B: good first arrivals and later phases
C: fairly good first arrivals and later phases
D: accuracy of identification worse than 0.1 sec., or doubtful phases.

In Tables 4 and 5, time of the first arrivals and later phases, class of these phases, etc. are given. In Figs. 5 and 6, travel time graphs are given. The results of analysis of these data are given in Part 2 under the same title.[2)]

§ 5. Acknowledgement

We are much obliged to Atomic Fuel Corporation; Japan Broadcasting Company (NHK); Kansai, Tyubu and Tyugoku Electric Power Co.; Nagoya Branch, Geological Survey of Japan; prefectural authorities, police headquarters and stations, provincial offices concerned; Microearthquake Observatories of Kyoto University and Gifu University for their inestimable help and cooperation given to us.

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Financial aid was granted by the fund for special works of the institute, the Upper Mantle Project and Science Research Fund, Ministry of Education.

2) M. HASHIZUME, O. KAWAMOTO, S. ASANO, I. MURAMATU, T. ASADA, I. TAMAKI and S. MURAUCHI, *Bull. Earthq. Res. Inst.*, **44** (1966), 109.

Table 2. Data of observation points for the first Kurayosi explosion.

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Θ*	Δ (km)	Recorders	Observers
K 1	Kurayosi	35°23′26.4″	133°50′20.0″	265 m			Oscillograph	H. Kawasumi, M. Yanagisawa A. Okada, K. Ichikawa
	No. 1			325		0.061		J. Takahashi, Y. Ichinose
	No. 2			306	N27°.00E	0.102		
	No. 3			292	12.30	0.179		
	No. 4			288	8.00	0.250		
	No. 5			277	9.00	0.470		
	No. 6			254	12.00	0.662		
K 2	Misasa N-1	35 24 32.7	133 55 19.3	110	74°52′	7.823	E.T.L. M 3	S. Murauchi, S. Nagumo M. Katsumata, M. Seino
	〃 E-1	35 24 31.4	133 55 33.8	113	75 48	8.167		Ch. Dix
K 3	Kawahara	35 23 10.1	134 11 41.3	31	90 54	32.333	Oscillograph	M. Sibano, T. Kumagaya
K 4	Wakasa	35 20 38.1	134 27 35.6	440	96 04	56.430	〃	Y. Motoya, Y. Sasaki T. Kakuta
K 5	Sekimiya	35 22 20.2	134 38 50.6	188	96 31	73.455	〃	N. Nakajima, S. Ogata
K 6	Wadayama	35 23 11.9	134 53 54.6	220	90 16	96.258	Data recorder	H. Aoki, M. Kumazawa
K 7	Yakuno	35 22 19.9	134 58 12.8	360	91 09	102.804	〃	T. Asanuma, T. Kimura
K 8	Hukutiyama	35 21 32.8	135 06 15.7	50	91 45	115.033	〃	A. Takagi, K. Kamamoto M. Abe, H. Ishii
K 9	Kajiya	35 20 16.4	135 12 29.8	60	92 45	124.576	〃	S. Suyehiro, K. Takahashi
K10	Ankokuzi	35 20 33.3	135 19 04.4	95	92 17	134.501	〃	T. Asada, M. Ohtake

(to be continued)

Table 2. Data of observation points for the first Kurayosi explosion. (continued)

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Θ	Δ (km)	Recorders	Observers
K11	Yatuai	35°21′38.9″	135°24′24.9″	160 m	91°06′	142.487	Oscillograph	I. Tamaki, O. Kawamoto T. Fujita
K12	Nadasho	35 23 26.3	135 34 59.1	161	90 00	158.447	Data recorder	M. Hashizume, Y. Kishimoto
K13	Asiu	35 18 25.9	135 43 08.4	375	93 06	171.125	〃	H. Watanabe
K14	Simonegori	35 26 20.6	135 47 35.2	85	88 16	177.558	Oscillograph	F. Kishinoue, Y. Yamazaki H. Kobayashi, S. Koresawa
K15	Mikata	35 32 52.0	135 55 07.6	90	84 43	189.566	〃	H. Hotta, K. Hamada T. Koyanagi, T. Yoshii
K16	Kaizu	35 26 45.3	136 05 22.1	86	88 16	204.471	〃	H. Hamaguchi, M. Suzuki K. Suzuki
K17	Tutikura	35 35 30.3	136 18 16.1	340	84 18	224.815	〃	K. Oike, M. Nakamura
K18	Tanikumi	35 32 44.2	136 33 22.1	215	86 00	247.205	〃	I. Muramatu, S. Suzuki M. Sakō
K19	Miyama	35 34 59.5	136 45 00.5	140	85 23	265.017	Data recorder	I. Karakama, S. Saito S. Kubota
K20	Mugi	35 33 53.3	137 00 42.1	145	86 10	288.562	Oscillograph	S. Asano, T. Terashima H. Tsuruta
K42	Shinpukuzi	35 27 35.0	136 46 53		88 30	267.540	Drum recorder	Observatory of Microearthquakes, Gifu University
	Surveyer							A. Okada

* Θ is the azimuth of observation points from the shot point.

Table 3. Data of observation points for the second Kurayosi and Hanabusa explosions.

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Θ_H^*	Θ_K^*	Δ_H(km)**	Δ_K(km)**	Recorders	Observers
K39	Sirakawa	35°35′36.2″	137°11′22.7″	405 m		N85°77E		304.821	Data recorder	M. Hashizume, S. Takemoto T. Miyauchi
K38	Hongō	35 32 24.1	137 07 12.3	175		86.82		298.240	Oscillo-graph	I. Muramatu, T. Murase
K37	Kamibuti	35 34 56.9	137 06 13.4	275		85.89		296.980	Data recorder	S. Suzuki, Y. Tōyama
K36	Kutinono	35 32 54.3	136 56 08.2	150		86.44		281.569	〃	S. Kubota, S. Saitō Y. Ōkuma
K35	Itibora	35 33 02.0	136 45 48.9	105		86.18		266.003	〃	T. Asada, M. Ōtake H. Simamura
K34	Nagase	35 31 53.6	136 38 41.0	85		86.49		255.134	〃	S. Suyehiro, T. Shibata A. Seki
H 1	Hanabusa	35 36 14.4	136 32 14.9	260					E.T.L.	K. Ichikawa, M. Hayakawa S. Kamata, K. Itō
	No. 2			225			0.135			A. Okada
	No. 3			220			0.205			
	No. 4			217			2.297			
K33	Ozu	35 34 24.8	136 31 38.6	305		85.25		244.785	Data recorder	M. Hayakawa, K. Itō S. Kamata
K32, H2	Yokoyama	35 35 14.1	136 27 31.9	210	N104.62W	84.76	7.361	238.704	〃	S. Asano, T. Terashima
K31, H3	Sakauti	35 34 20.6	136 25 03.0	350	107.88	85.08	11.423	234.841	〃	
	〃	35 34 19.7	136 25 01.8	365	107.96	85.08	11.461	234.809		E. Shima, M. Sibano
H 4	Tutikura	35 35 30.3	136 18 16.1	340	93.68		21.155		〃	M. Hashizume, S. Takemoto T. Miyauchi
K30, H5	Kaminiu	53 34 02.0	136 13 37.9	202	98.26	84.84	28.413	217.598	〃	I. Karakama, T. Takahasi
H 6	Kaizu	35 26 45.3	136 05 22.1	86	113.35		44.253		〃	T. Asada, M. Ōtake H. Simamura
K29, H7	Matuya	35 31 39.3	135 59 03.3	160	99.60	85.54	50.858	195.310	〃	M. Katumata, M. Homae M. Seino

(to be continued)

Table 3. Data of observation points for the second Kurayosi and Hanabusa explosions. (continued)

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Θ_H	Θ_K	Δ_H(km)	Δ_K(km)	Recorders	Observers
H 8	Simonegori	35°26′06.3″	135°47′09.3″	105 m	105°37		70.692		Data recorder	I. Muramatu, S. Suzuki Y. Tōyama
K28, H9	Musikano	35 24 02.2	135 42 41.4	130	106.76	89°63	78.252	170.101	〃	O. Kawamoto, Y. Ohba
H10	Asiu	35 18 24.3	135 43 05.0	360	113.91		81.359		〃	S. Kubota, S. Saitō Y. Ōkuma
H11	Nadasho	35 23 26.3	135 34 59.1	161	105.29		89.760		〃	S. Suyehiro, T. Shibata A. Seki
K27, H12	Kowaki	35 23 44.6	135 29 13.3	245	103.63	89.79	98.056	149.714	〃	T. Ōida, T. Tada
K26, H13	Ine	35 20 59.7	135 21 44.1	220	104.80	91.87	110.306	138.491	〃	K. Noritomi, S. Nabetani M. Nogoshi
K9, H14	Kaziya	35 20 16.4	135 12 29.8	60	103.75	92.69	124.185	124.574	〃	S. Nagumo, H. Kobayashi S. Koresawa
K25, H15	Ōe	35 22 11.4	135 08 35.8	50	101.60	91.12	129.138	118.529	〃	H. Hamaguchi, K. Tanaka T. Inoue
	〃	35 22 18.6	135 09 26.1	55	101.62	91.00	127.850	119.793		
K7, H16	Yakuno	35 22 19.9	134 58 12.8	360	100.25	91.14	144.505	102.803	〃	T. Asanuma, T. Kimura
K24, H17	Hirotani	35 22 37.7	134 46 02.3	80	98.91	91.02	162.563	84.359	〃	S. Murauchi, K. Hagiwara
K23, H18	Ōtani	35 27 05.1	134 31 59.1	285	95.32	83.90	182.556	63.397	〃	H. Watanabe, M. Nakamura
K22, H19	Hunaoka	35 19 59.3	134 16 18.4	140	98.31	99.21	207.800	39.852	〃	K. Oike, T. Mikumo K. Mino
K21, H20	Yosioka	35 28 48.0	134 07 44.5	25	93.60	69.38	218.804	28.145	〃	N. Nakajima, M. Ichinose
K2, H21	Misasa	35 23 40.7	133 57 42.2	460	95.68	87.74	234.815	11.167	〃	N. Den, H. Hotta T. Yoshii
	〃	35 23 47.5	133 57 37.4	320	95.62	86.63	234.912	11.056		
	〃	35 23 50.1	133 57 29.1	282	95.60	86.14	235.111	10.852		
H22	Kurayosi	35 23 31.9	133 50 23.9	275	95.48		245.837		Oscillo-graph	M. Yanagisawa, I. Ichinose T. Daikubara

(to be continued)

Table 3. Data of observation points for the second Kurayosi and Hanabusa explosions. (continued)

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Θ_H	Θ_K	Δ_H(km)	Δ_K(km)	Recorders	Observers
K 1	Kurayosi	35°23′26.4″	133°50′20.0″	290 m					Oscillo-graph	K. Ichikawa, A. Okada M. Yanagisawa Y. Ichinose T. Daikubara
	No. 1			322				0.033		
	No. 2			322				0.033		
	No. 3			306				0.097		
	No. 4			295				0.132		
	No. 5			292				0.188		
	No. 6			281				0.373		
	No. 7			265				0.556		
	No. 8			250				0.773		
K40, H23	Sekigane	35 19 27.2	133 44 26.1	315	96°.97	N129°.52W	255.724	11.582	Data recorder	Y. Motoya, T. Murase S. Nakai
K41, H24	Aimi	35 21 43.9	133 22 04.3	85	95.33	94.22	288.833	42.913	Oscillo-graph	Y. Kishimoto, A. Hattori
H25	Hikami	35 13 36.8	135 02 44.8	250			142.01		Drum recorder	Observatory of Microearthquake, Kyoto University
K43	Ōya	35 20 02.0	134 39 52.2	260			172.60	75.28	〃	
H26	Kami-kanbara	35 32 44.2	136 33 22.1				5.65	247.20	〃	Observatory of Microearthquake, Gifu University
K44, H27	Turumi	35 38 05.0	136 29 12.4				5.72	241.69	〃	
	Surveyer									A. Okada

* Θ_H means the azimuth of observation points from Hanabusa shot point and Θ_K, from Kurayosi shot point.

** Δ_H stands for the epicentral distance from Hanabusa shot point and Δ_K, from Kurayosi shot point.

Table 4a. The travel time of the first Kurayosi explosion.

Shot time: 1963 Nov. 16, 1 h 07 m 0.496 s

Station No.	Observation point	Δ (km)	P	Class	$P-O$**	$P-O-\frac{\Delta}{6}$	P (Later phases)***
			1 h 07 m		s *	s	
K 1	Kurayosi	0.061	0.523	A	0.027+	0.017	
		0.102	0.539		0.043+	0.026	
		0.179	0.555		0.059+	0.029	
		0.250	0.570		0.074+	0.032	
		0.470	0.614		0.118+	0.040	
		0.662	0.622		0.126+	0.016	
K 2	Misasa	7.823	2.330	A	1.834+	0.53	1 h 07 m s 2.62C, 3.18C, 5.30C, 6.18C, 7.96C, 10.45C, 11.24C, 12.53C
K 3	Kawahara	32.333	6.52	A	6.02 +	0.63	6.58D, 6.63D, 6.80C, 7.25C, 7.55C
K 4	Wakasa I	56.430	10.40	A	9.90 +	0.49	7.94C, 10.04B, 10.56B, 11.13B, 11.78B
	〃 III	56.631	10.42	A	9.92 +	0.51	10.52B, 10.86C, 11.37C, 12.89C
K 5	Sekigane	73.455	13.16	A	12.66 +	0.42	13.20C, 13.28C, 13.52B, 13.73C, 14.10C, 14.90C, 16.05C, 17.67C
K 6	Wadayama	96.258	16.97	B	16.47 +	0.43	17.05C, 17,16B, 17.41C, 17.67C, 17.92C, 18.30D, 18.73C
K 7	Yakuno	102.804	18.04	B	17.54 +	0.41	18.11C, 18.22B, 18.52B, 18.92D, 19.12C, 20.46D
K 8	Hukutiyama b	114.443	19.95	A	19.45 −	0.39	20.20C, 20.37C, 20.62D, 21.06D, 21.22D, 21.62D, 21.80D, 22.12D, 22.85D, 23.73D
	〃 a	115.033	20.00	A	19.50 −	0.32	20.15B
K 9	Kajiya	124,576	21.53	B	21.03 +	0.27	21.56B, 21.59C, 21.71B, 22.14C, 22.38B, 22.93C, 22.98C, 23.41C, 23.83C, 24.41C

(to be continued)

Table 4a. The travel time of the first Kurayosi explosion. (continued)

Station No.	Observation point	Δ (km)	P	Class	$P-O$**	$P-O-\frac{\Delta}{6}$	P (Later phases)***
			1 h 07 m s		s	s	1 h 07 m s
K10	Ankokuji	134.501	23.19	A	22.69	0.28	23.48B, 23.86D, 24.07C, 24.24C, 24.90C, 25.06C, 25.30C, 26.05C
K11	Yatuai	142.487	24.30	A	23.80+*	0.06	24.42C, 24.58C, 24.96C, 25.80C, 26.14C
K12	Nadasho	158.447	26.80	D	26.30+	−0.10	26.86B, 27.07B, 27.47C, 28.03C, 29.02C
K13	Asiu	171.125	28.97	B	28.47+	−0.05	29.09C, 29.26C, 29.58B, 30.49B
K14	Simonegori	177.558	29.43	D	28.93−	−0.66	29.63B, 29.90C, 30.37C, 30.91C, 31.41B
K15	Mikata	189.566	31.58	B	31.08	−0.51	31.98C, 33.24D, 35.04C
K16	Kaizu	204.471	33.15	B	32.65+	−1.43	33.29C, 33.75B, 34.45B, 35.36B, 35.91C, 36.42C, 37.98C
K17	Tutikura	224.815	35.93	C	35.43+	−2.04	36.00C, 36.16C, 36.74B, 37.90C, 38.34C, 38.55C, 41.60B
K18	Tanikumi	247.205	39.33	A	38.83+	−2.37	39.61C, 39.88C, 40.69C, 41.24C, 42.02B, 43.81C
K19	Miyama	265.017	41.45	C	40.95+	−3.22	41.88C, 42.42C, 42.91C, 43.33C, 44.30B, 44.86C, 45.59B, 46.90C
K20	Mugi	288.562	44.24	A	43.74+	−4.35	44.48C, 45.29C, 46.99C, 48.02C, 49.28C, 49.99C, 51.21C
K42	Sinpukuzi	267.540	41.86	C	41.36+	−3.23	42.00C, 42.19C, 42.45B, 43.48C, 45.22C, 46.12B, 46.51B, 48.80B

* + sign means that the direction of ground motion is upwards and − sign, downwards.

** O means the shot time.

*** A, B, C and D after numbers stand for the class of phases. For example, 2.62C means that the class of phase at 2.62^{s} is C.

Table 4b. The travel time of the second Kurayosi explosion

Shot time: 1964 Nov. 21, 1 h 06 m 58.746 s

Station No.	Observation point	Δ (km)	P	Class	$P-O$**	$P-O-\frac{\Delta}{6}$	P (Later phases)***
			1 h 06 m s		*		
K 1	Kurayosi	0.132	58.788	A	0.042+		
		0.188	58.805		0.059+		
		0.373	58.832		0.086+		
		0.556					
		0.773					
			1 h 07 m				
K 2	Misasa	11.056	1.18	A	2.43 +	0.59	
		11.167					1 h 07 m s 1.30A, 1.48A, 2.01C, 2.40C 2.84C
K21	Yosioka	28.145	4.28	A	5.54 +	0.85	5.00B, 6.84C
K22	Hunaoka	39.852	5.91	A	7.16 +	0.52	6.37C, 7.44C
K23	Ōtani	63.397	10.08	B	11.33 +	0.76	10.83C, 11.10C, 11.86D, 12.57D 12.81D
K24	Hirotani	84.359	13.29	A	14.55 +	0.49	13.87C, 14.27B, 15.21C, 15.87C 16.91C, 20.88C
K 7	Yakuno	102.803	16.33	A	17.59 +	0.46	16.50B, 16.79B, 17.18C, 17.48C 18.55D, 21.37D
K25	Ōe	118.529	18.84	C	20.09 +	0.34	19.04C, 19.24B, 20.15B
K 9	Kajiya	124.574	19.75	A	21.00 +	0.24	20.08B, 20.63C, 20.89C, 21.62D
K26	Ine	138.491	21.81	A	23.06 +	−0.02	21.96B, 22.18B, 22.43B, 23.24C 24.20D, 24.31C, 25.00C
K27	Kowaki	149.714	23.93	B	25.18	0.23	24.39C, 24.91C, 25.35D, 25.84D 26.38C
K28	Musikano	170.101	26.96	B	28.21 −	−0.14	27.26C, 27.69C, 28.11D, 30.48D
K29	Matuya	195.310	30.63	B	31.88 −	−0.67	31.09B, 34.20C, 37.08C

(to be continued)

Table 4b. The travel time of the second Kurayosi explosion. (continued)

Station No.	Observation point	Δ (km)	P	Class	$P-O$**	$P-O-\frac{\Delta}{6}$	P (Later phases)***
			1 h 07 m s				1 h 07 m s
K30	Kaminiu	217.598	33.44	C	34.69+*	−1.58	34.90C, 35.26B, 35.88C, 36.46C 38.17D
K31	Sakauti	234.841	35.86	B	37.11+	−2.03	36.14C, 36.84D, 37.50C, 38.13C 38.69C, 39.10D, 41.40C
K32	Yokoyama	238.704	36.53	B	37.78+	−2.00	36.87C, 38.81C, 41.23C, 46.06D
K33	Ozu	244.785	37.28	C	38.53+	−2.27	37.76C, 38.34C, 39.96C, 40.20C 40.77D
K34	Nagase	255.134	39.36	C	40.61	−1.91	40.42D, 40.90D, 41.40D, 42.00C 42.64C, 43.68C, 44.94C, 45.94C 47.52D
K35	Itibora	266.003	39.41	D	40.66+	−3.67	39.84C, 40.36C, 42.86D, 43.68B 45.86C, 46.30C
K36	Kutinono	281.569	41.78	C	43.03−	−3.90	42.08C, 42.65D, 43.61D, 44.94D 47.61B, 49.83C, 52.50C, 56.03C
K37	Kamibuti	296.980	43.49	B	44.74+	−4.76	44.69B, 45.89C, 48.59B, 49.33C 50.84B
K38	Hongō	298.240	43.69	C	44.94−	−4.76	44.12C, 45.30D, 46.23D, 47.54D 48.72B, 50.45C
K39	Shirakawa	304.82	44.67	B	45.92+	−4.88	50.19A
K40	Sekigane	11.582	1.12	A	2.37	0.44	1.54C
K41	Aimi	42.913	6.48	A	7.73+	0.58	
K43	Ōya	75.28	11.82	A	13.07+	0.53	11.96D, 12.67C, 13.65C, 16.27C 21.46C
K44	Turumi	241.69	36.82	C	38.07+	−2.21	37.85C, 38.50C, 39.45C, 40.34C

* + sign means that the direction of the ground motion is upwards and − sign, downwards.

** O means the shot time.

*** A, B, C and D after numbers stand for the class of phases. For example, 1.30 A means that the class of phase at $1^{s}.30$ is A.

Table 5. The travel time of the Hanabusa explosion.

Shot time: 1964 Nov. 18, 1 h 07 m 0.39 s

Station No.	Observation point	Δ (km)	P	Class	$P-O$**	$P-O-\frac{\Delta}{6}$	P (Later phases)***
			1 h 07 m s		s		
H 1	Hanabusa	0.135	0.43	A	0.040		
		0.205	0.44		0.050		
		0.297	0.46		0.070		
					*	s	1 h 07 m s
H 2	Yokoyama	7.361	1.82	A	1.43+	0.20	1.96D, 2.08C
H 3	Sakauti	11.461	2.56	A	2.17+	0.26	2.72B, 3.72D, 4.34D
H 4	Tutikura	21.155	4.31	A	3.92+	0.39	4.46C, 4.87D
H 5	Kaminiu	28.413	5.55	A	5.16+	0.42	5.93B, 7.11B, 7.67D
H 6	Kaizu	44.253	8.28	A	7.89+	0.51	8.44B, 8.54C, 9.38C
H 7	Matuya	50.858	9.45	B	9.06−	0.58	9.76B, 10.18C, 11.50C, 13.47C
H 8	Simonegori	70.692	12.78	A	12.39+	0.61	12.98B, 14.22C
H 9	Musikano	78.252	14.10	D	13.71+	0.67	14.15B, 14.64C, 14.86D, 15.14D, 15.47D, 15.65D, 16.67C
H10	Asiu	81.359	14.33	A	13.94+	0.38	15.56B
H12	Kowaki	98.056	17.18	B	16.79+	0.45	17.73D, 17.88D, 18.28C, 18.59B
H13	Ine	110.306	19.21	A	18.82+	0.44	19.35C, 19.50C, 20.41C, 21.65B
H14	Kajiya	124.185	21.25	B	20.86−	0.16	21.45B, 22.11C
H15	Ōe	129.138	22.04	B	21.65+	0.13	22.70B, 23,06D

(to be continued)

Table 5. The travel time of the Hanabusa explosion. (continued)

Station No.	Observation point	Δ (km)	P	Class	$P-O$**	$P-O-\frac{\Delta}{6}$	P (Later phases)***
			1 h 07 m s		*	s	1 h 07 m s
H16	Yakuno	144.505	24.78	A	24.39+	0.31	25.27B, 25.56C, 25.88C, 26.31C
H17	Hirotani	162.563	27.69	C	27.30+	0.21	28.15B, 29.04C, 29.61C
H18	Ōtani	182.556	30.72	C	30.33−	−0.10	31.09C, 31.29B, 31.48C, 31.82C, 32.17C, 32.68C
H19	Hunaoka	207.800	33.95	D	33.56+	−1.07	34.07D, 34.19C, 34.59C, 35.01C, 35.30C, 35.71D, 36.28C, 37.33C
H20	Yosioka	218.804	35.04	C	34.65	−1.82	37.14C
H21	Misasa	234.815	37.14	D	36.75+	−2.39	37.28C, 38.04C, 38.82C, 39.22C, 39.57C, 39.77B, 40.36C
H22	Kurayosi	245.837	38.83	B	38.44+	−2.53	40.97C, 41.55C, 42.63B, 43.26C, 43.82D
H23	Sekigane	255.724	39.91	D	39.52+	−3.10	40.10C, 42.38C, 43.79B
H25	Hikami	143.01	24.41	A	24.02+	0.35	24.66C, 24.90B, 26.21B
H26	Kamikanbara	6.697	1.93	A	1.54	0.42	2.53C, 2.93C
H27	Turumi	5.72	1.44	A	1.05	0.10	1.64C, 2.34C

* + sign means that the direction of ground motion is upwards and − sign, downwards.

** O means the shot time.

*** A, B, C and D after numbers stand for the class of phases. For example, 1.96 D means that the class of phase at 1.96^{s} is D.

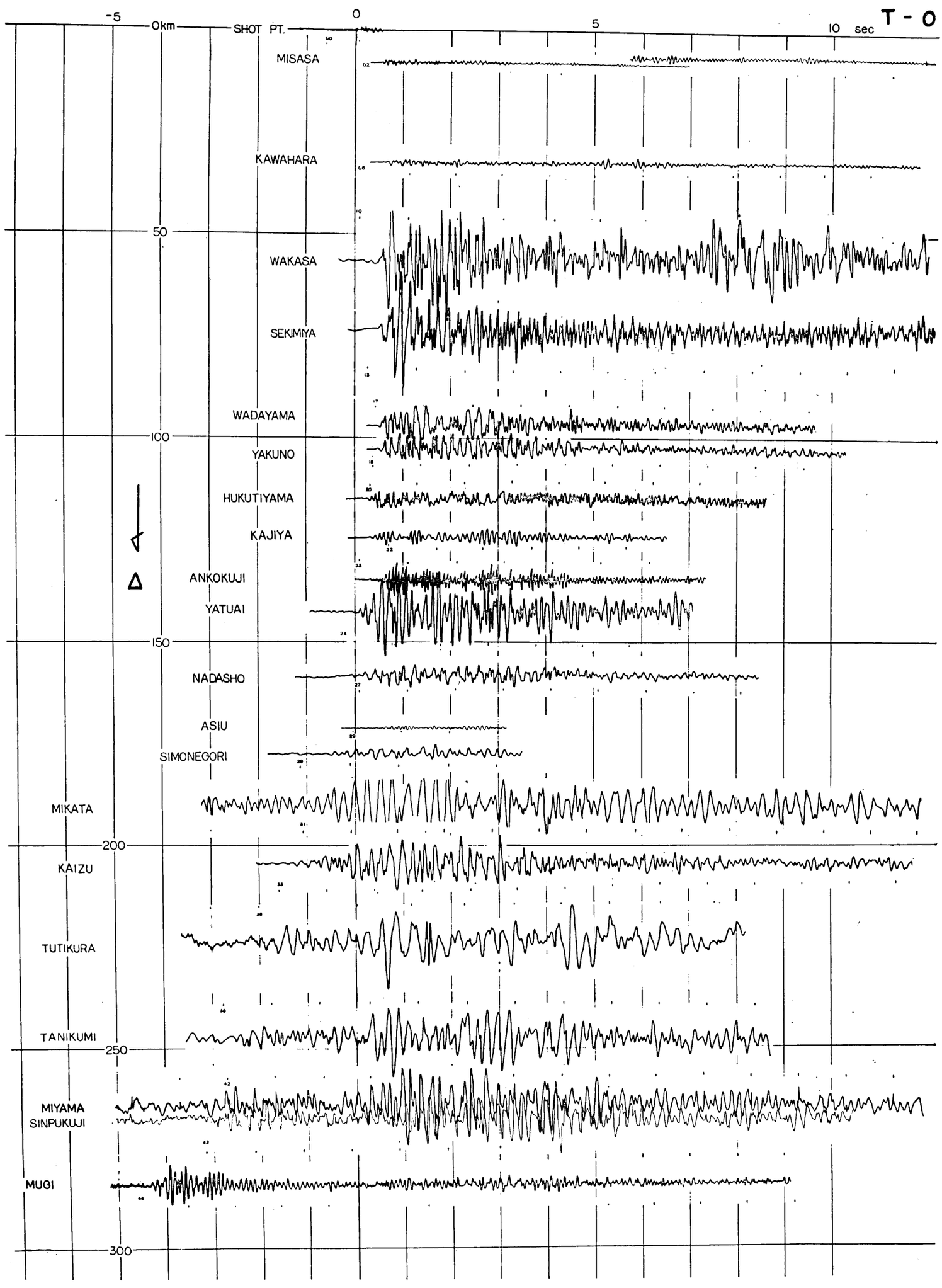

Fig. 4(a). Seismograms obtained in the first Kurayosi explosion. Small number near each seismogram is time in sec for respective seismogram. Seismogram at Mugi should be shifted to right by about 0.3 sec.

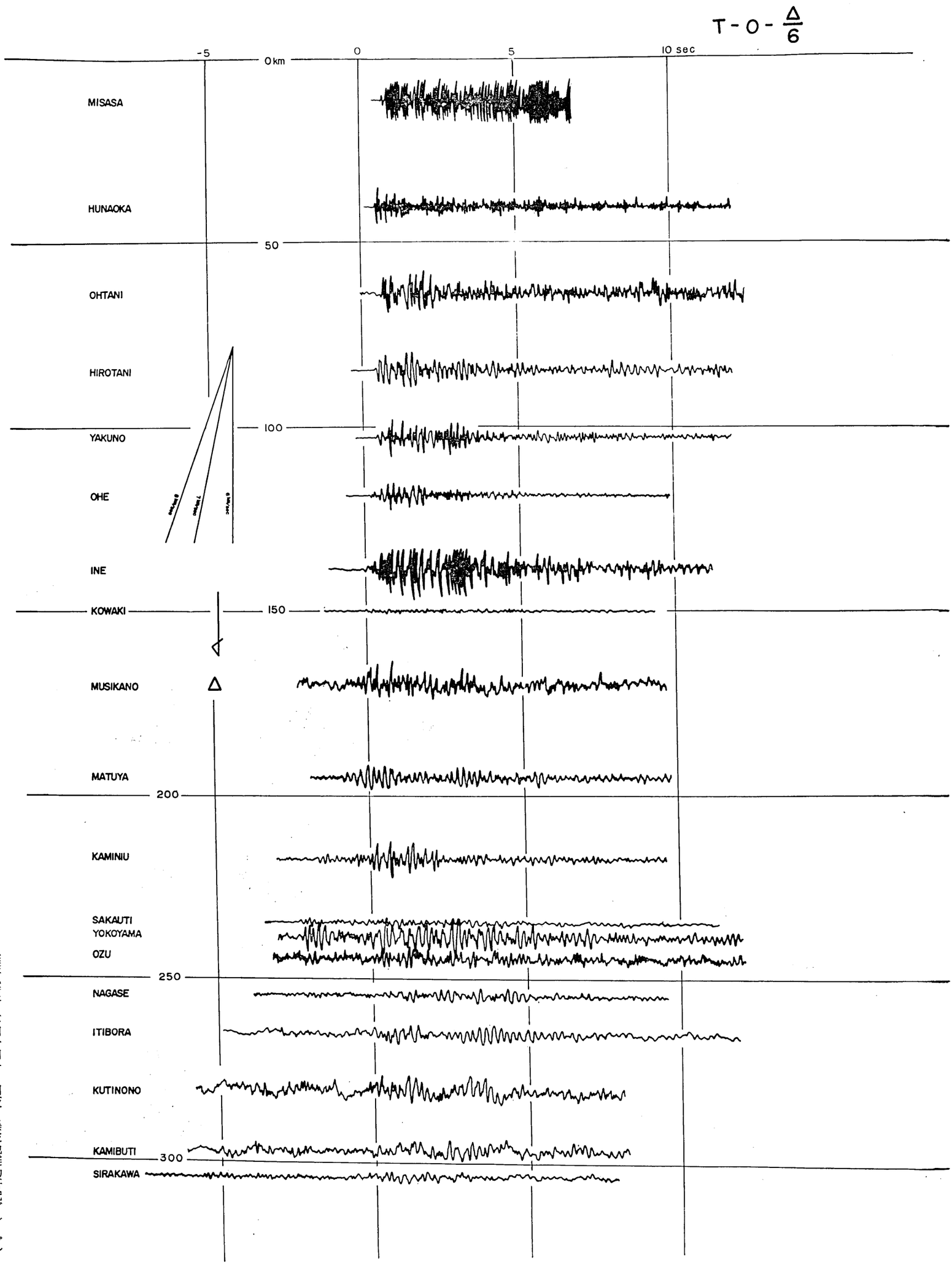

Fig. 4(b). Seismograms obtained in the second Kurayosi explosion. Seismogram at Sirakawa should be shifted to right by about 0.5 sec.

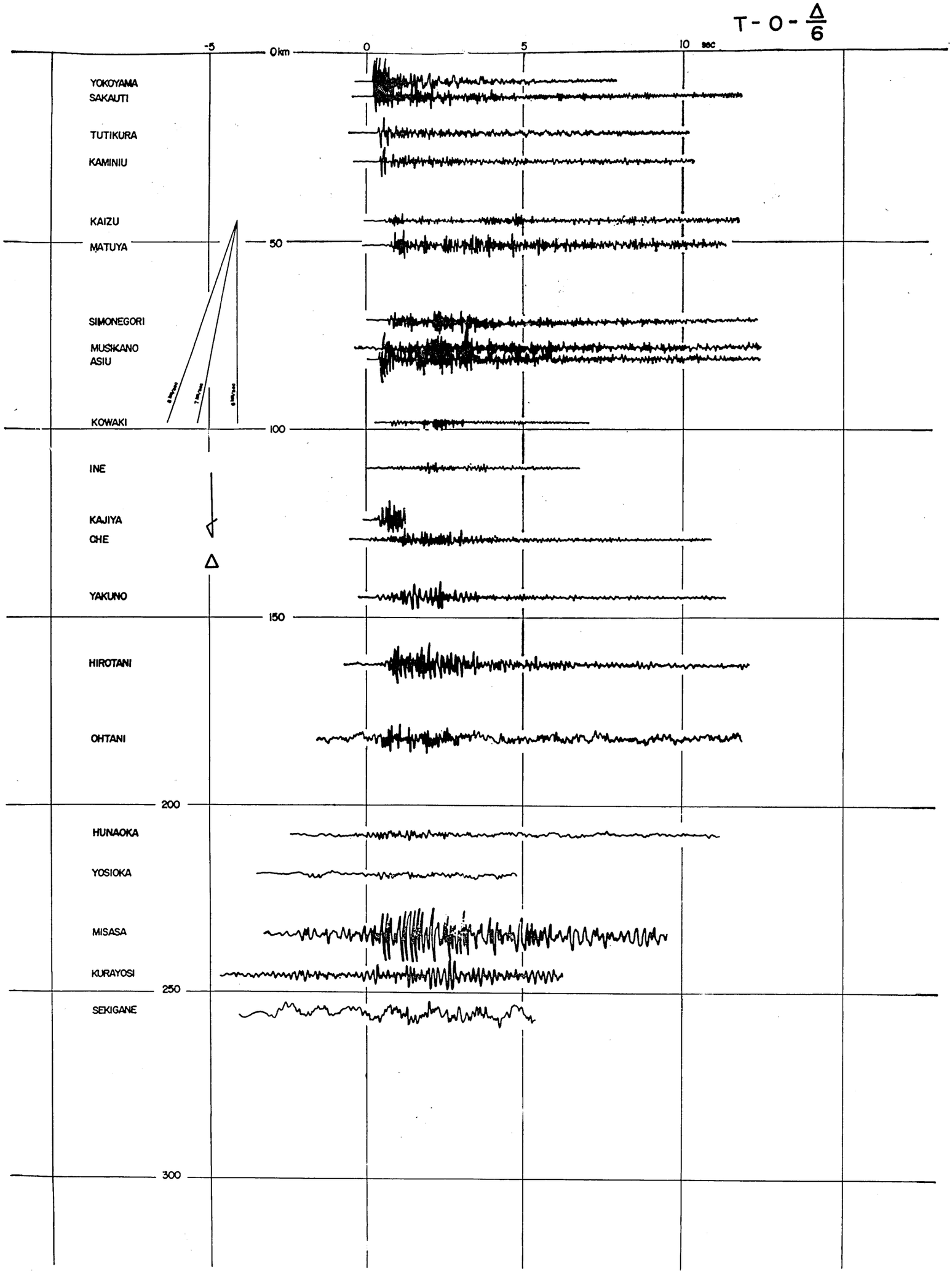

Fig. 4(c). Seismograms obtained in the Hanabusa explosion.

5. 第 1 回，第 2 回倉吉爆破及び花房爆破観測より得られた西部日本の地殻構造

第 1 部　第 1 回，第 2 回倉吉爆破及び花房爆破地震動の観測

爆破地震動研究グループ

昭和 38 年 11 月 16 日，昭和 39 年 11 月 21 日の 2 回にわたつて鳥取県倉吉市円谷にある廃坑において，約 2 屯の火薬を爆発させ，それによる地震動の観測を，主に東方の約 20 ヶ所ずつの観測点で実施した．また，第 2 回倉吉爆破の 3 日前，昭和 39 年 11 月 18 日に岐阜県の花房鉱山の廃坑を利用して，約2屯の火薬の爆発を，倉吉爆破の逆測線のために行なつた．どの爆破も従来と異なり竪坑に全部の火薬をつめ，水を入れて実施し，特に倉吉爆破では，震央距離 300 km 附近でも良好な記録が得られた．第 1 回倉吉爆破では約 8 ヶ所で，第 2 回倉吉および花房爆破では大部分の観測点で磁気録音方式によつて観測を実施し，極めて良好な記録を得た．本報告においては，爆破の記述，得られた資料が与えられている．なお，この観測は地震研究所特別事業費，文部省科学研究費，国際地球内部開発計画人工地震部門経費によつて実施された．記して謝意を表する．