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9. *Crustal Structure in Central Japan as Derived from the Miboro Explosion-Seismic Observations.*

Part 1. Explosions and Seismic Observations.

By The Research Group for Explosion Seismology.

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1. Introduction

Since September 1957, several scores of tons of explosives have been detonated many times by the Dengen Kaihatu Co., for quarrying purposes connected with the construction of a rock-fill dam at the site of Miboro-valley, Sirakawa-village, Gihu Prefecture. The Research Group for Explosion Seismology, making the best use of these opportunities, has carried out six large scale systematic seismic observations. Our aim was to get precise information about the crustal structure in central Japan, over the Kwantô-, Tyûbu-, Kinki- and Tyûgoku-Districts.

An outline of the explosion-seismic observations and the observed results will be given in the following.

2. Description of Explosions

Quarry area where the shots were fired is situated in Hukusima-valley, a gorge of a branch of the Syôgawa, 800–900 m high above sea level, and is adjacent to the south-eastern foot of Mt. Hakusan. From a geological point of view, it consists mainly of granite-porphry. Topographical features near the Miboro dam-site and Hukusima-valley are shown in Fig. 1, and a detail map near the shot points in Fig. 2, and those of six explosion features are outlined in Fig. 3.

As can be seen in the above figures, a coyote-tunnel blast system was adopted in the I–V explosions, and a bench-cut blast system only in the VI detonation, respectively. In the former system, dynamite was detonated in many coyote-tunnels drilled horizontally in the hillsides, and so the exploded area occupied a certain spatial extent, while in the latter system, explosives concentrated in vertically drilled six blast holes, each 10″ in diameter and 25–30 m deep, were fired simultaneously. Only

the last was blasted at midnight. The ignition method was as follows. The initiating fuses extending outside from the dynamite charges in the tunnels or the blast holes, were gathered to an electric blasting cap. This cap was ignited through AC 200 V by operating a knife-switch on a switch-board set up at a spot 200–300 m distant. Shot times were directly registered on the oscillogram. The shot times thus determined and the amount of explosives in the six explosions mentioned above are tabulated in Table 1.

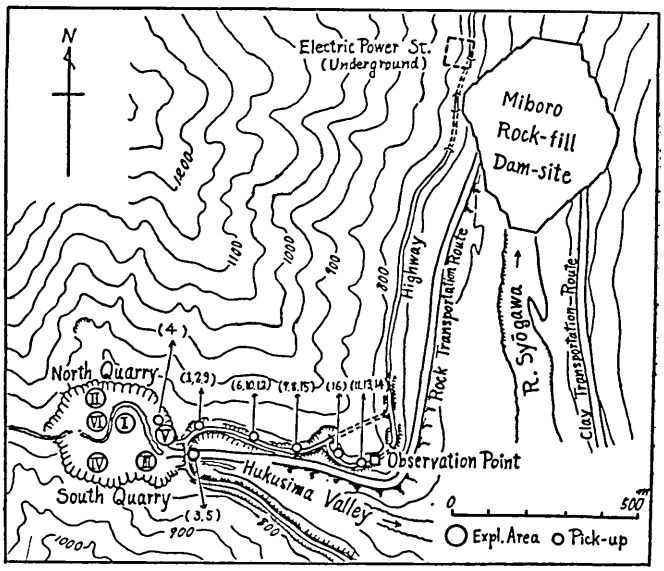


Fig. 1. Topographical map of Miboro dam-site and quarry area in Hukusima-valley.

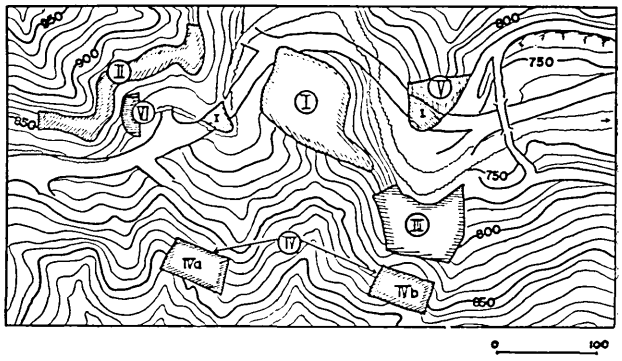


Fig. 2. View of I-VI explosion areas in Hukusima-valley.

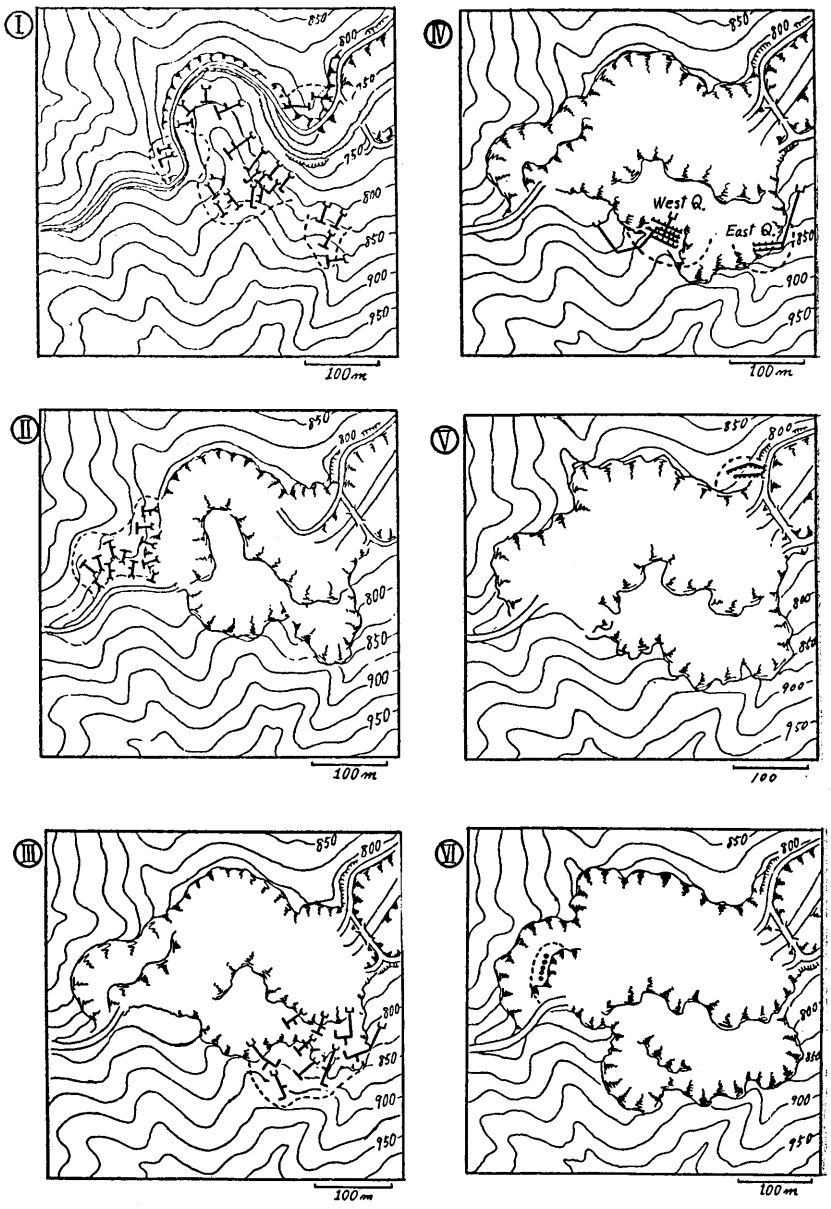


Fig. 3. Details of explosion feature (I–VI).
⊏⊏⊏ Coyote-tunnel blast system.
●●● Bench-cut blast hole system.
--- Quarry area.

Table 1. Observations of the Miboro explosions.

No. of Explosion	Shot time	Amount of charge (tons)	Number of stations
I	1957, Dec. 21, 12h 00m00.831s	86	Shot point, Eastern profile: 8 observation stations, Western profile: 8 observation stations
II	1958, Mar. 5, 12 00	81	Matusiro, Tukuba, Kyoto, Abuyama
III	1958, June 15, 12 00 01.754	155	Shot point, Eastern profile: 15 observation stations, Western profile: 4 observation stations
IV	1959, Apr. 5, 12 00 01.276	77	Shot point, Eastern profile: 3 observation stations, Western profile: 7 observation stations
V	1959, Nov. 20, 12 00 01.173	30	Shot point, Western profile: 14 observation stations
VI	1960, June 10, 01 05 00.906	2.67	Shot point, Western profile: 12 observation stations

3. Outline of Observations

In order to observe the seismic waves from the explosions, temporary observation stations, 75 in total, were spread mainly along a line extending to the Tyûbu—northern Kwantô—southern Tôhoku-Districts (Eastern profile), a line to the Hokuriku—northern Kinki—Tyûgoku-Districts (Western profile A), and a line across the central part of the Kinki-District (Western profile B), as shown in Figs. 4 and 5. The number of stations in each shot is added in Table 1. For reference sake, the shot points in the Nozori and Hokoda explosions[1] are marked in the figures. The geographical coordinates of the shot and observation points were determined by a method based on triangulation.

The place name, latitude, longitude, height, epicentral distance and azimuth from the shot point, of each observation station, and the observational instruments, and observers at the stations, for every experiment are tabulated in Tables 2–7. The epicentral distance means, in the present case, the shortest distance between a station and the nearest point of the explosion area to the station.

Most of the stations were equipped with electromagnetic transducers with a natural frequency of 3 c/s, amplifiers and oscillographs, as in

1) The Research Group for Explosion Seismology, *Bull. Earthq. Res. Inst.*, **36** (1958), 329-348; **37** (1959), 495-508.

past observations of this kind. Time marks were registered on the oscillogram directly from the JJY radio time signal.

In the No. III experiment, the observation of reflected waves was tried at Kamioka station, with apparatus of ETL-M-3 type for seismic prospecting.[2)]

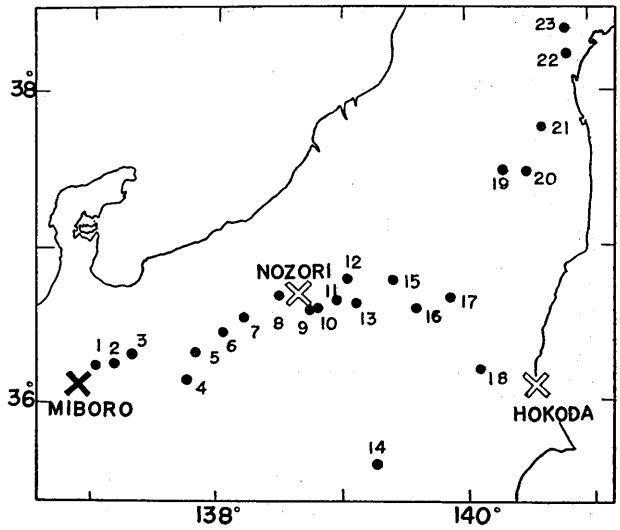


Fig. 4. Observation stations in the Eastern profile.

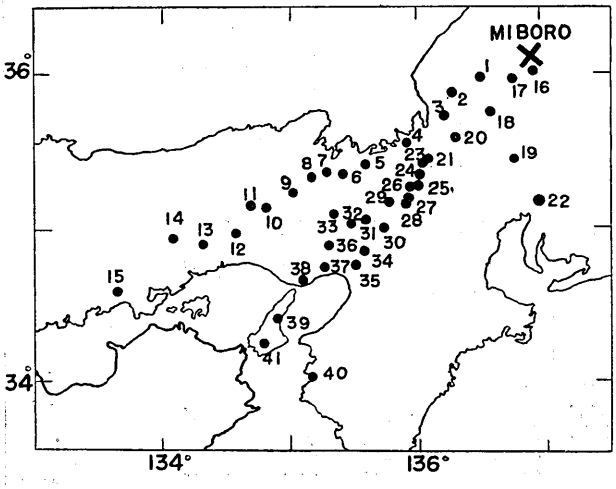


Fig. 5. Observation stations in the Western profile.

2) Report R.G.E.S., No. 17 (1958), 8-10.

Table 2. Observation stations in the 1st Miboro explosion. (Dec. 21, 1957)

Shot point and Station		φ	λ	H(m)	Δ(km)	Θ	Apparatus	Observer
0	(shot point) Miboro (stations) No. 1 No. 2	36° 7′22″6N	136°54′26″5E	790~840	0.000 0.039 0.225	N48° 0′ E 59 8.0	27 c/s E. T. L. ×3	Ninagawa Kamata Kawashima
E 7	Matusiro	36 32 22.4	138 12 23.6	383	125.401	68 22.9	ND 3V, Benioff V	Suyehiro Yamagishi
E 14	Asakawa	35 37 52.7	139 16 45.2	195	220.915	104 17.2	1 H, ND 3 V 2	Utsu, Usami
E 18	Tukuba	36 12 38.6	140 6 39.9	286	288.297	88 3.9	10 V, 1 V, 1 H	T. Matsumoto
E 19	Takatama	37 30 17.5	140 17 54.5	516	339.197	63 7.4	1 V, 3 V 2	Asano, Asanuma
E 20	Siroiwa	37 29 28.3	140 28 53.2	344	353.003	64 32.9	ND 3 V	Santo, Karakama, Goto
E 21	Isida	37 46 5.8	140 38 11.7	163	378.909	62 12.7	ND 3 V 2	E. Shima, Sibano
E 22	Mukaiyama	38 14 32.9	140 17 54.5	128	422.052	56 9.3	ND 3 V, 3 H 2	Mine, Ishigaki
E 23	Miyatoko	38 24 0.6	140 51 0.3	49	431.327	54 9.1	0.8H, 0.7H, ND 3.5V	Z. Suzuki, T. Sato
W 1	Ôno	35 59 30.2	136 30 2.2	171	39.368	N111 40.1W	2 H, Strainmeter	Ôtsuka, T. Tanaka
W19	Gihu	35 27 35.1	136 46 53.3	50	74.358	161 12.5	ND 3 V	Muramatsu, Yabashi
W20	Kinomoto	35 35 30.2	136 18 14.4	340	80.185	137 14.6	14 V 2, 3 V	Okano, Y. Kobayashi, Kawamoto
W22	Nagoya	35 9 9.9	136 58 19.5	53	107.716		3 V 2	Wada
W28	Wani	35 10 52.2	135 54 44.4	128	137.878	139 13.6	2 V, 2 H 2	Mikumo, Funabiki
W30	Kyoto	35 1 30.0	135 46 58.0	54	158.735	140 4.5	2 V	Kamitsuki, Okamoto
W34	Abuyama	34 51 24.4	135 34 22.4	215	185.356	139 14.3	1.3 V, 1 V	Kubodera,
W40	Suhara	34 2 40.4	135 9 47.0	5	279.995	145 23.9	3 V	Ozawa, Fujiwara

Surveyer: A. Okada

Table 3. Observation stations in the 2nd Miboro explosion. (Mar. 5, 1958)

Shot point and Station		φ	λ	H(m)	Δ(km)	Θ	Apparatus	Observer
0	Miboro	36° 7′24″3N	136°54′17″1E	895	0			
E 7	Matusiro	36 32 22.4	138 12 23.6	383	125.691	N 68° 19′ E	ND 3 V 2	Suyehiro
E 18	Tukuba	36 12 38.6	140 6 39.9	286	288.599	88 2	3 V 2, 1 H	T. Matsumoto
W30	Kyoto	35 1 30.0	135 46 58.0	54	158.593	N140 5 W	2 V 2	Mikumo, Ôtsuka
W34	Abuyama	34 51 24.4	135 34 22.4	215	185.208	139 14	3 V, 1 V	Okano

Table 4. Observation stations in the 3rd Miboro explosion. (June 15, 1958)

Shot point and Station		φ	λ	H(m)	Δ(km)	Θ	Apparatus	Observer
0	Miboro	36° 7′18″7 N	136°54′29″3 E	815	0	N E	S. S. C ×3	Ninagawa, Hirasawa, Kawashima, Furuya
	No. 1				0.124	19°		
	No. 2				0.277	28		
	No. 3				0.526	59		
E 1	Myôgase	36 13 30.7	137 1 16.2	650	15.239	41° 34′0	15V (E.T.L.), 3V, 3H	Wada, Shichi
E 2	Kotakari	36 14 22.2	137 9 30.0	530	25.930	59 53.2	2V, 2H, Strainmeter	Ôtsuka, T. Tanaka
E 3	Kamioka	36 17 53.1	137 19 3.3	568	41.585	62 3.9	E. T. L. ×12	Murauchi, Asanuma
E 4	Inekoki	36 9 29.5	137 45 57.6	831	77.222	87 0.6	4 V, 2 V	Muramatsu, Yabashi
E 5	Hotako	36 19 39.2	137 49 21.1	988	85.224	74 29.0	3 V 3	Nakajima, Yamazaki
E 6	Omi	36 27 47.0	138 2 34.6	756	108.614	69 40.1	3 V	H. Okada, Takeuchi
E 7	Matusiro	36 32 22.4	138 12 23.6	383	125.354	68 19.1	Benioff	
E 8	Hoppo	36 43 39.1	138 30 39.8	1670	158.578	64 56.6	3 V	Suyehiro, Takeyama
E 10	Sawatari	36 37 1.6	138 46 39.8	515	176.440	71 51.9	3 V 2	E. Shima, Yanagisawa
E 11	Takayama	36 37 40.6	138 58 7.0	604	193.124	73 6.4	3 V 2	Asada, Terashima, Kurimoto
E 12	Hujiwara	36 48 5.8	139 2 56.7	604	206.080	68 32.7	3 H, 1.3 V, 2.8 V	Santo, Karakama
E 13	Kawaba	36 40 11.2	139 6 30.0	497	206.418	72 52.9	3 V 3	Asano, Oguchi
E 15	Yumoto	36 18 6.9	139 25 19.5	1498	237.510	71 29.5	3.4 V, 2 H 2	Z. Suzuki, H. Shima, Emura
E 16	Nisioasi	36 37 48.0	139 36 32.2	405	248.702	76 54.3	3 V, 6 V, 6 H	Utsu, Usami
E 18	Tukuba	36 12 38.6	140 6 39.9	286	288.218	88 2.4	3 V, 1 V	T. Matsumoto, Saito
						N W		
W24	Sin'asahi	35 21 8.2	136 0 59.4	148	117.353	136 37.8	1.5 V	Ozawa, Fujiwara
W34	Abuyama	34 51 24.4	135 34 22.4	215	185.303	139 11.8	1 V	Kubodera, H. Watanabe
W37	Rokkô	34 45 52.7	135 14 56.6	868	212.866	134 59.3	3 V	Okano, Nishi
W39	Sizuki	34 25 52.9	134 53 50.6	20	261.860	135 42.6	3 V, 2 V	Mikumo Kamitsuki

Surveyer: A. Okada

Table 5. Observation stations in the 4th Miboro explosion. (Apr. 5, 1959)

Shot point and Station		φ	λ	H(m)	Δ(km)	Θ	Apparatus	Observer
0	Miboro (a)(*)	36° 7′18″8N	136°54′20″2E	850	0 (*)	N E		Furuya, Hirasawa, Kamata
	(b)(*)	36 7 18.0	136 54 31.3	815	0 (*)			
	No. 1			770	0.192	17°	(made in NEC) 28 c/s	
	No. 2			775	0.385	41	〃	
	No. 3			775	0.575	55	〃	
W10	Ikuno	35 9 42.5	134 48 18.1	355	218.008	240°45′5	3 V	Okano
W12	Yamazaki	34 58 41.4	134 33 24.4	86	247.874	249 13.0	3 V 2	Usami, Utsu, Asanuma
W26	Takasima	35 17 4.9	135 56 40.6	282	127.233	223 6.9	Den 1V2, Den 3.5 H 2	Terashima, Oguchi, Den
W32	Kameoka	35 2 0.7	135 28 22.3	355	177.306	226 59.0	3 V 1	Muramatu, Kajita
W33	Taki	35 6 58.6	135 20 30.3	298	180.312	231 46.8	3 V, 3 H 2	Tamaki, Kawamoto
W38	Tainohata	34 39 31.6	135 5 54.4	110	230.849	225 19.7	3 V 2	Mikumo, Ôtsuka, Nakajo
W41	Kitaama	34 16 9.9	134 46 53.2	125	282.195	223 16.3	3 V 3, 1 V	Santo, Tsujiura, Maruyama
E 7	Matusiro	36 32 22.4	138 12 23.6	383	125.418	68 19.0	Benioff	
E 9	Ôiwa	36 36 19.4	138 43 37.5	696	171.774	71 47.7	3 V 3	Nakajima, Yamazaki
E17	Sinoi	36 41 15.8	139 50 4.6	355	274.064	73 14.1	3 V 2	Asano, Yanagisawa

(*) (a) is a standard point for western stations.
(b) is a standard point for eastern and near-by stations.

Surveyer: A. Okada

Table 6. Observation stations in the 5th Miboro explosion. (Nov. 20, 1959)

Shot point and Station		φ	λ	H(m)	Δ(km)	Θ	Apparatus	Observer
						N E		
0	Miboro	36°7′26″28 N	136°54′29.76 E	770				Ninagawa, Ichikawa, Tamura
	No. 1				0.114	56°		
	No. 2				0.334	71		
	No. 3				0.483	73		
						N ° ′ W		
W 2	Nakai	35 52 56.5	136 16 38.1	104	62.886	115 13.8	3 V 2	Asanuma, Iino
W 3	Utuo	35 43 37.0	136 13 47.4	201	75.421	125 44.1	3 V	Nakajima, Yamazaki
W 5	Ôi	35 26 45.4	135 36 14.4	45	139.853	122 32.2	3 V 3	Muramatu, Komatu
W 6	Yatuai	35 21 6.5	135 24 58.2	197	159.851	122 24.2	3 V 2	T. Matsumoto, Karakama
W 7	Yasiro	35 22 52.3	135 18 4.9	125	167.055	119 33.3	1 H, 1 V	Terashima, Noguti
W 8	Hukutiyama	35 20 19.5	135 10 15.8	155	179.672	118 59.9	ND 3, DK 1 V	Onda, Seino, Hotta
W 9	Aogaki	35 14 11.4	135 1 34.1	179	196.761	120 1.6	3 V 2	Sakai, Hamamatsu
W11	Kawakami	35 9 4.5	134 42 45.0	466	226.243	118 29.1	3 H 2, 3 V	Kawamoto and two others
W13	Kamigori	34 53 51.2	134 21 12.0	189	268.723	120 24.8	3 V, 1 H 2	Hori, Tsujiura, Ando
W14	Yanahara	34 57 5.8	134 4 32.5	122	287.882	116 51.1	3 V, 1 H 2	Santo, H. Matsumoto, Saito
W15	Yakage	34 35 12.6	133 38 17.4	105	342.602	119 50.4	4 V 2	E. Shima, Asano, Oguchi
W21	Kaizu	35 26 45.3	136 5 22.1	86	105.533	135 27.8		Takagi, Ito
W29	Bessyo	35 10 2.6	135 46 56.2	640	147.168	136 8.6	3 V	Okano, Wada
W31	Sikibigahara	35 3 47.5	135 36 49.5	498	166.155	135 5.5	3 V	Mikumo, Ôtsuka

Surveyer: A. Okada

Table 7. Observation stations in the 6th Miboro explosion. (June 10, 1960)

Shot point and Station		φ	λ	H(m)	Δ(km)	Θ	Apparatus	Observer
						N E		
0	Miboro	36° 7′23″4N	136°54′18″8E	794～812				Chujo, Mori, Kawashima
	No. 1			780	0.170	51.9	S.S.G 26 c/s	
	No. 2			775	0.373	77.8	〃	
	No. 3			770	0.487	77.1	〃	
	No. 4			770	0.646	79.6	〃	
	No. 5			770	0.755	79.0	〃	
W 2	Nakai	35 52 58.1	136 16 37.3	107	62.596	115°12.9′	3 V 2	Asanuma, Terashima
W 4	Mikata	35 32 52.0	135 55 7.6	90	109.619	125 36.9	3 V 2	Onda, Hotta
W 9	Aogaki	35 14 11.4	135 1 34.1	179	196.480	120 2.4	3 V 2, 2/3 H	Utsu, Hamamatsu
W16	Arabuti	36 1 43.9	136 57 33.8	789	11.545	165 0.9		Kumazawa, Aoki
W17	Itosiro	35 58 10.5	136 46 28.4	685	20.711	145 21.5	3 V 2, 1 V	Oguchi, Asano
W18	Ôgawara	35 44 53.7	136 34 53.0	452	50.832	144 54.9	3 V 2, 3 H	Muramatus, Kajita
W23	Kitoge	35 25 7.3	136 2 3.4	87	110.945	134 47.1	3 V 3	Nakajima, Yamazaki
W25	Sirahige	35 16 19.2	136 0 48.4	98	124.215	139 28.9	3 V 2	Saito, Karakama
W27	Kido	35 11 54.9	135 55 2.0	72	137.040	138 54.5	3 V	Ôtsuka, Mikumo
W34	Abuyama	34 51 24.4	135 34 22.4	215	185.333	139 17.3	3 V 2	Okano, H. Watanabe
W35	Senriyama	34 46 8	135 30 46	70	196.330	139 55.1	3 V	Kamitsuki
W36	Ôharano	34 54 26.4	135 18 24.2	210	198.020	132 55.8	3 V, 3 H 2	Tamaki, Kawamoto

Surveyer: A. Okada

4. Observed Results

Observations were carried out successfully, obtaining satisfactory seismograms at most of the stations. The seismograms are shown in Fig. 9. These records were read independently by several members of our group, and then the arrival times of various phases were determined only when satisfactory agreement was found. For the sake of convenience, the accuracy of the adopted values was classified into four grade, taking the clarity of the initial motion and time marks into consideration :

a : $\Delta t \leqq 0.02$ sec
b : $0.02 < \Delta t \leqq 0.05$ 〃
c : $0.05 < \Delta t \leqq 0.1$ 〃
d : $0.1 < \Delta t$ 〃

where Δt is the expected errors in the time determination.

Tables 8–13 indicate the arrival times of the first P wave and prominent later phases observed at all stations in the six observations. They are reduced to the travel times and rearranged in Tables 14, 15

Table 8. Observational data of the 1st Miboro explosion. (Dec. 21, 1957)

Station		P	Direction	Accuracy	Later phases			
0	Miboro	12h 00m 00.s831						
	No. 1	00.855	U	a				
	No. 2	00.933	U	a				
E 7	Matusiro	22. 70	U	b	28.37	41.5		
E14	Asakawa	37. 16	D	a	43.18	44.98	01 m 04.00	
E18	Tukuba	45. 04	D	b	48.31			
W 1	Ôno	07. 93	D	b	13.39			
W19	Gihu	13. 95	U	a	15.22	16.30	18.11	23.65
W20	Kinomoto	14. 91	U	b	17.10	24.67		
W28	Wani	24. 7	U	d	42.5			
W30	Kyoto	28. 3	D	d	48.3			
W34	Abuyama	32. 18	U	a	32.43	54.98		
W40	Suhara	44. 6	D	d	01m 19.2	20.7		

Table 9. Observational data of the 2nd Miboro explosion. (Mar. 5, 1958)

Station		P	Direction	Accuracy	Later phases		
E 7	Matusiro	12h 00m 20s.42	D	b	20.80	21.70	37.88
W34	Abuyama	30.06	U	b	31.15	33.42	

Table 10. Observational data of the 3rd Miboro explosion. (June 15, 1958)

Station		P	Direction	Accuracy	Later phases
0	Miboro	12h 00m 01s.754			
	No. 1	01.874	U	a	
	No. 2	01.864	U	a	
	No. 3	01.903	U	a	
E 1	Myôgase	04. 66	U	a	09.66 10.33 12.41 14.35 19.78
E 2	Kotakari	06. 57	U	a	06.88 10.90
E 3	Kamioka	09. 12	U	a	09.89 10.29 11.13 12.60 12.99 14.47 15.15
E 4	Inekoki	15. 41	D	a	16.53 21.27 25.37
E 5	Hotaka	16. 60	D	b	17.56
E 6	Omi	20. 7	D	d	20.9 23.0 34.1 39.2
E 7	Matusiro	22. 9	D	d	
E 8	Hoppo	28. 97	D	b	29.45 32.68 36.08 49.25 49.80
E10	Sawatari	32. 3	D	d	
E11	Takayama	34. 33	D	a	
E12	Hujiwara	35. 73	U	b	35.95
E13	Kawaba	35. 84	U	b	36.24 38.40 42.03 01m 00.43 01.43
E15	Yumoto	40. 13	D	a	42.04 49.68 01m 08.81
E16	Nisioasi	41. 36	D	b	41.55 45.74
E18	Tukuba	45. 92	D	b	47.66 48.73 55.90 01m 07.26 20.65 27.75
W24	Sin'asahi	22. 0	U	d	23.1 30.5 39.3 42.2
W34	Abuyama	32. 6	U	d	
W37	Rokkô	37. 80	U	a	01m 03.90 04.07
W39	Sizuki	46. 35	U	b	01m 17.23 18.68

Table 11. Observational data of the 4th Miboro explosion. (Apr. 5, 1959)

Station		P	Direction	Accuracy	Later phases				
0	Miboro	$12^h\ 00^m\ 01^s.276$							
	No. 1	01.382		a					
	No. 2	01.385		a					
	No. 3	01.422		a					
W10	Ikuno	36. 36	U	d	36.65				
W12	Yamazaki	40. 35	U	a	42.58	43.52	72.02		
W26	Takasima	22. 28	D	c	23.78	40.27	40.58	40.82	41.10
W32	Kameoka	30. 94	U	c	31.05	31.57	53.15		
W33	Taki	31. 54	U	c	32.32				
W38	Tainohata	38. 38	U	c	38.42	40.78			
W41	Kitaama	44. 48	D	a	53.37				
E 7	Matusiro	23. 4	U	d					
E 9	Ôiwa	30, 29	D	d	31.35				
E17	Sinoi	44. 5	D	d					

Table 12. Observational data of the 5th Miboro explosion. (Nov. 20, 1959)

Station		P	Direction	Accuracy	Later phases				
0	Miboro	$12^h\ 00^m\ 1^s.73$(*)							
	No. 1	1.762	U	a					
	No. 2	1.814	U	a					
	No. 3	1.846	U	a					
W 2	Nakai	12. 48	U	a	13.13				
W 3	Utuo	14. 77	D	a	14.95	15.28	24.09		
W 5	Ôi	25. 26	D	c	25.44	25.53	25.73	42.62	
W 6	Yatuai	28. 99	U	b					
W 7	Yasiro	29. 79	Pull	b	29.79	30.03	49.7		
W 8	Hukutiyama	31. 38		b	32.06	32.14	52.88		
W11	Kawakami	37. 64	D	a	37.97	39.34	65.66		
W13	Kamigori	43. 44	U	b	77.69				
W14	Yanahara	45. 99	D	b	46.45	46.54	49.98		
W15	Yakage	51. 34	U	d					
W21	Kaizu	19. 64	U	b	19.89	20.00	20.42	20.71	21.33
W29	Bessyo	26. 98	D	c	27.35	27.66	27.72	46.35	
W31	Sikibigahara	30. 13	D	a	30.45	50.3			

* The shot time is checked using the data of Nakai station in the 6th Miboro explosion.

Table 13. Observational data of the 6th Miboro explosion. (June 10, 1960)

	Station	P	Direction	Accuracy	Later phases				
0	Miboro	$01^h\ 05^m\ 0^s.906$							
	No. 1	0.955	U	a					
	No. 2	0.999	U	a					
	No. 3	1.020	U	a					
	No. 4	1.052	U	a					
	No. 5	1.075	U	a					
W 2	Nakai	11. 61	U	a	12.27				
W 4	Mikata	19. 94	U	a	19.97	20.38	20.40	20.44	21.00
W 9	Aogaki	33. 25	U	a	34.32	34.36	57.35		
W16	Arabuti	3. 00	U	a	4.65	4.89			
W17	Itosiro	4. 64	U	a	7.46	7.69			
W18	Ôgawara	9. 65	U	a	10.20	13.11			
W23	Kitoge	20. 38	D	b	21.13	21.16			
W25	Sirahige	22. 48	U	c	23.09				
W27	Kido	25. 86	D	c					
W34	Abuyama	31. 60	U	b	32.53	55.84	56.55		
W36	Ôharano	33. 64	U	c	33.79	34.37	58.09	58.13	

and 16 for the said three profiles, respectively. Travel-time graphs are shown in Figs. 6 and 7.

In order to obtain knowledge about the superficial structure, pickups were set up within a distance of 800 m from the shot points. The results are shown in Table 17 and Fig. 8. But the here-mentioned distance must be corrected in the travel-time calculation, taking the topographical effects into account.

It is to be added here that fairly distinct phases were observed at Kamioka station[3]. The observed data are listed in Table 18.

Crustal structure in central Japan, derived from the above observed data will be discussed in Part 2 of this paper under the same title[4].

3) S. MURAUCHI, *Report R.G.E.S.*, No. 17 (1958), 9.
4) T. MIKUMO *et al.*, *Bull. Earthq. Res., Inst.*, **39** (1961) 321-343.

Table 14. Travel times for the Eastern profile.

No. of Station	No. of observation	Station	Δ(km)	$P-O$(see)	$(P-O)-\Delta/6$(sec)
E 1	III	Myogase	15.24	2.91	+0.37
〃 2	〃	Kotakari	25.93	4.82	+0.50
〃 3	〃	Kamioka	41.59	7.37	+0.44
〃 4	〃	Inekoki	77.22	13.66	+0.79
〃 5	〃	Hotoka	85.22	14.85	+0.65
〃 6	〃	Omi	108.61	18.8	+0.7
〃 7	I	Matusiro	125.40	21.87	+0.98
〃 8	III	Hoppo	158.58	27.22	+0.70
〃 9	IV	Ôiwa	171.77	29.01	+0.38
〃 10	III	Sawatari	176.44	30.4	+1.0
〃 11	〃	Takayama	193.12	32.58	+0.40
〃 12	〃	Huziwara	206.08	33.98	−0.36
〃 13	〃	Kawaba	206.42	34.09	−0.31
〃 14	I	Asakawa	220.92	36.33	−0.48
〃 15	III	Yumoto	237.51	38.38	−1.20
〃 16	〃	Nisioasi	248.70	39.61	−1.84
〃 17	IV	Sinoi	274.06	43.2	−2.5
〃 18	III	Tukuba	288.22	44.17	−3.87

Table 15. Travel times for the Western profile (A).

No. of Station	No. of observation	Station	Δ(km)	$P-O$(sec)	$(P-O)-\Delta/6$(sec)
W 1	IV	Ôno	39.37	7.10	+0.54
〃 2	I	Nakai	62.89(V) 62.60(VI)	10.75(V) 10.70(VI)	+0.27
〃 3	VI	Utuo	75.42	13.04	+0.47
〃 4	V VI	Mikata	109.62	19.03	+0.76
〃 5	V	Ôi	139.85	23.53	+0.22
〃 6	VI	Yatuai	159.85	27.26	+0.62
〃 7	V	Yasiro	167.06	28.06	+0.22
〃 8	V	Hukutiyama	179.67	29.65	−0.29
〃 9	VI	Aogaki	196.48	32.34	−0.41
〃 10	IV	Ikuno	218.01	35.07	−1.26
〃 11	V	Kawakami	226.24	35.91	−1.80
〃 12	IV	Yamazaki	247.87	39.07	−2.24
〃 13	V	Kamigōri	268.72	41.71	−3.07
〃 14	V	Yanahara	287.88	44.26	−3.72
〃 15	V	Yakage	342.60	49.61	−7.49

Table 16. Travel times for the Western profile (B).

No. of Station	No. of observation	Station	Δ(km)	$P-O$(sec)	$(P-O)-\Delta/6$(sec)
W 16	VI	Arabuti	11.55	2.09	+0.17
〃 17	VI	Itosiro	20.71	3.73	+0.28
〃 18	VI	Ôgawara	50.83	8.74	+0.27
〃 19	I	Gihu	74.36	13.12	+0.71
〃 20	I	Kinomoto	80.19	14.08	+0.72
〃 21	V	Kaizu	105.53	17.91	+0.32
〃 23	VI	Kitoge	110.95	19.47	+0.98
〃 24	III	Imazu	117.35	20.2	+0.6
〃 25	VI	Sirahige	124.21	21.57	+0.87
〃 26	IV	Takasima	127.23	22.00	+0.79
〃 27	VI	Kido	137.04	23.95	+1.11
〃 28	I	Wani	137.88	23.9	+0.9
〃 29	V	Bessyo	147.17	25.25	+0.72
〃 30		Kyôto	158.74	27.20*	+0.74
〃 31	V	Sikibigahara	166.16	28.40	+0.71
〃 32	IV	Kameoka	177.31	29.66	+0.11
〃 33	IV	Taki	180.31	30.26	+0.21
〃 34	I VI	Abuyama	185.36(I) 185.33(VI)	31.35 (30.69)	+0.46 (−0.20)
〃 36	VI	Ôharano	198.02	32.73	−0.27
〃 37	III	Rokkô	212.87	36.05	+0.57
〃 38	IV	Tainohata	230.85	37.10	−0.37
〃 39	III	Sizuki	261.86	44.60	+0.96
〃 40	I	Suhara	280.00	43.9	−3.83
〃 41	IV	Kitaama	282.20	43.20	−2.8

* This was obtained in the explosion of Nov. 2, 1958.

Table 17. Travel times near the shot point.

No. of Explosion	P. U. Number	Δ (m)	$P-O$ (msec)
I	1	39	24
V	1	114	32
III	1	124	93
VI	1	170	49
IV	1	192	106
I	2	225	102
III	2	277	110
V	2	334	84
VI	2	373	93
IV	2	385	109
V	3	483	116
VI	3	487	114
III	3	526	149
IV	3	575	146
VI	4	646	146
VI	5	755	169

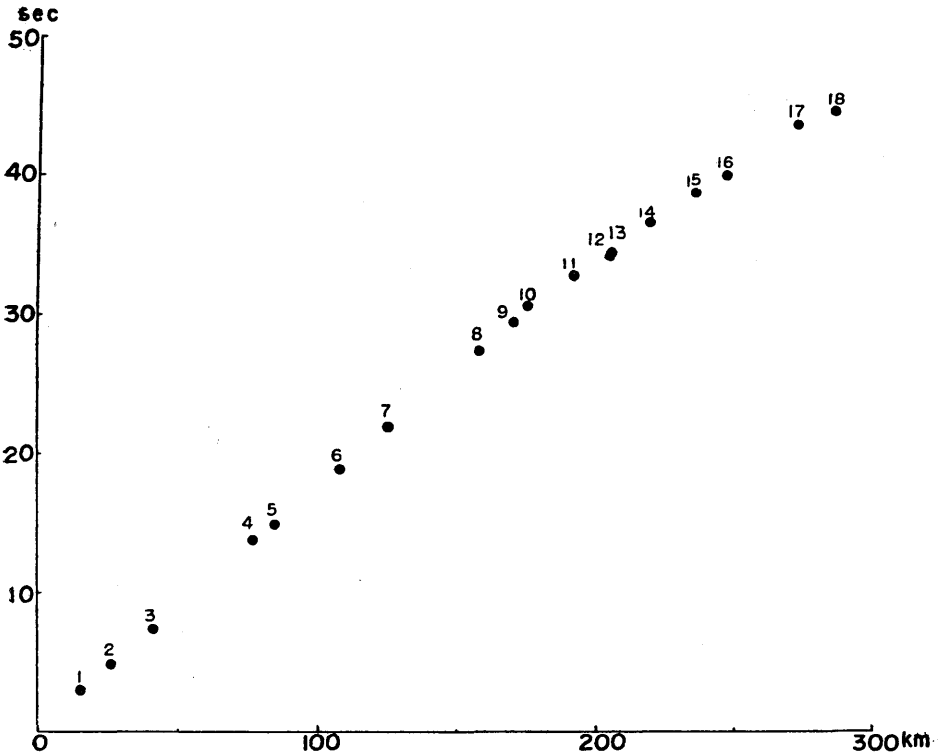


Fig. 6. Travel-time graph in the Eastern profile.

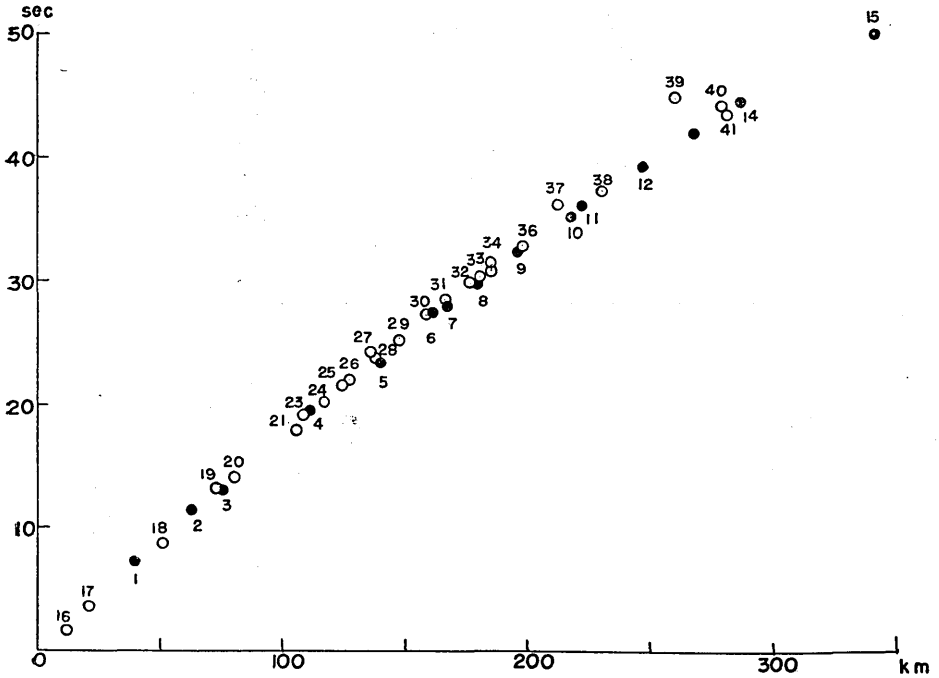


Fig. 7. Travel-time graph in the Western profile.

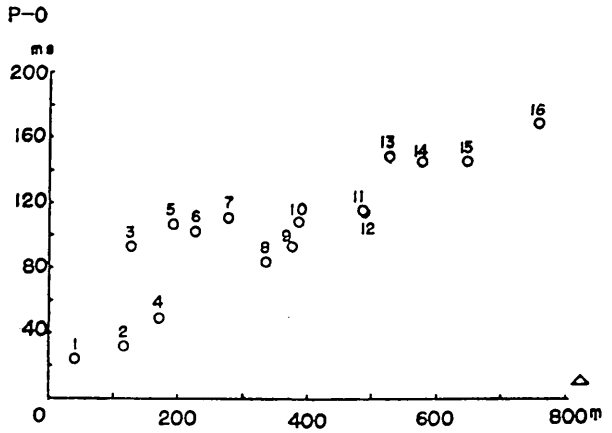


Fig. 8. Travel-time graph near the shot point.

Table 18. Distinct phases observed at Kamioka station.

Arrival time	Travel time	Apparent velocity
$12^h\ 00_m\ 09.^s12$	$7.^s37$	5.98 km/sec
09.91	8.16	5.30
10.29	8.54	6.01
10.48	8.73	5.11
11.07	9.32	8.63
11.13	9.38	6.44
11.39	9.64	4.95
11.64	9.89	7.98
12.60	10.85	11.25
12.99	11.24	8.41
13.29	11.54	10.38
13.96	12.21	6.86
14.47	12.72	11.38

1)

2)

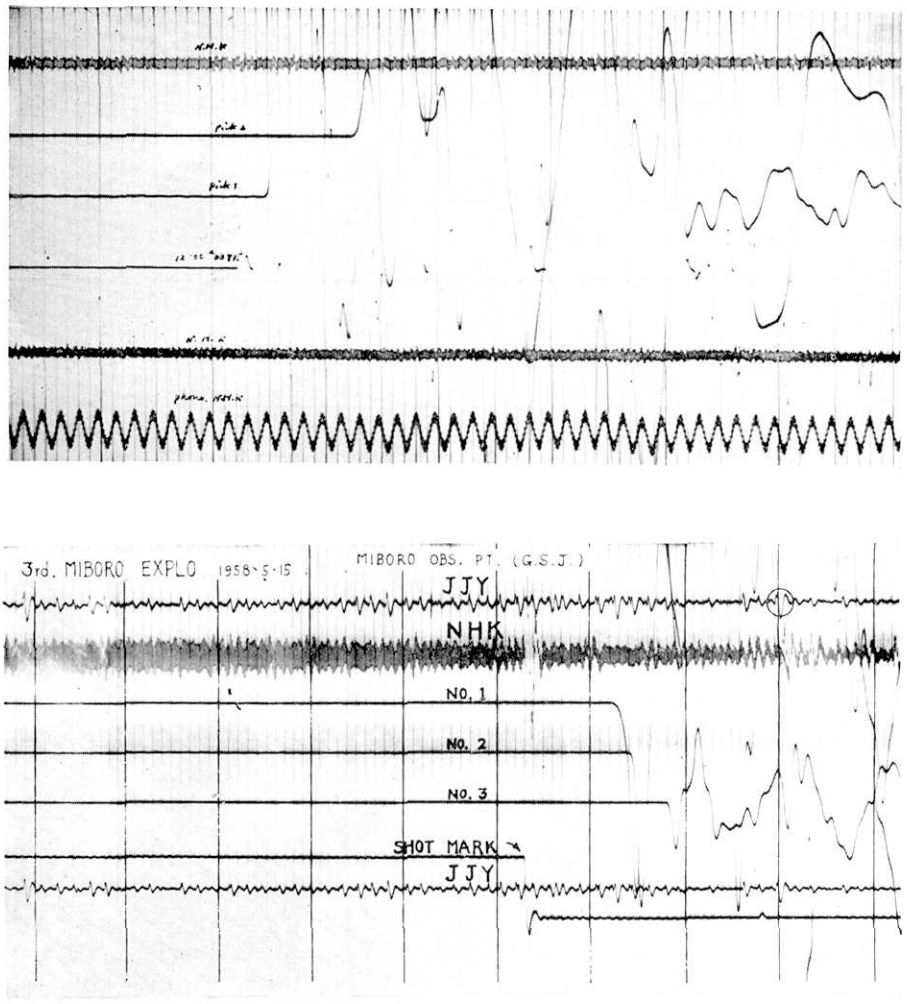


Fig. 9. Seismograms at:

1) Miboro shot point in the 1st explosion.
2) Miboro shot point in the 3rd explosion.

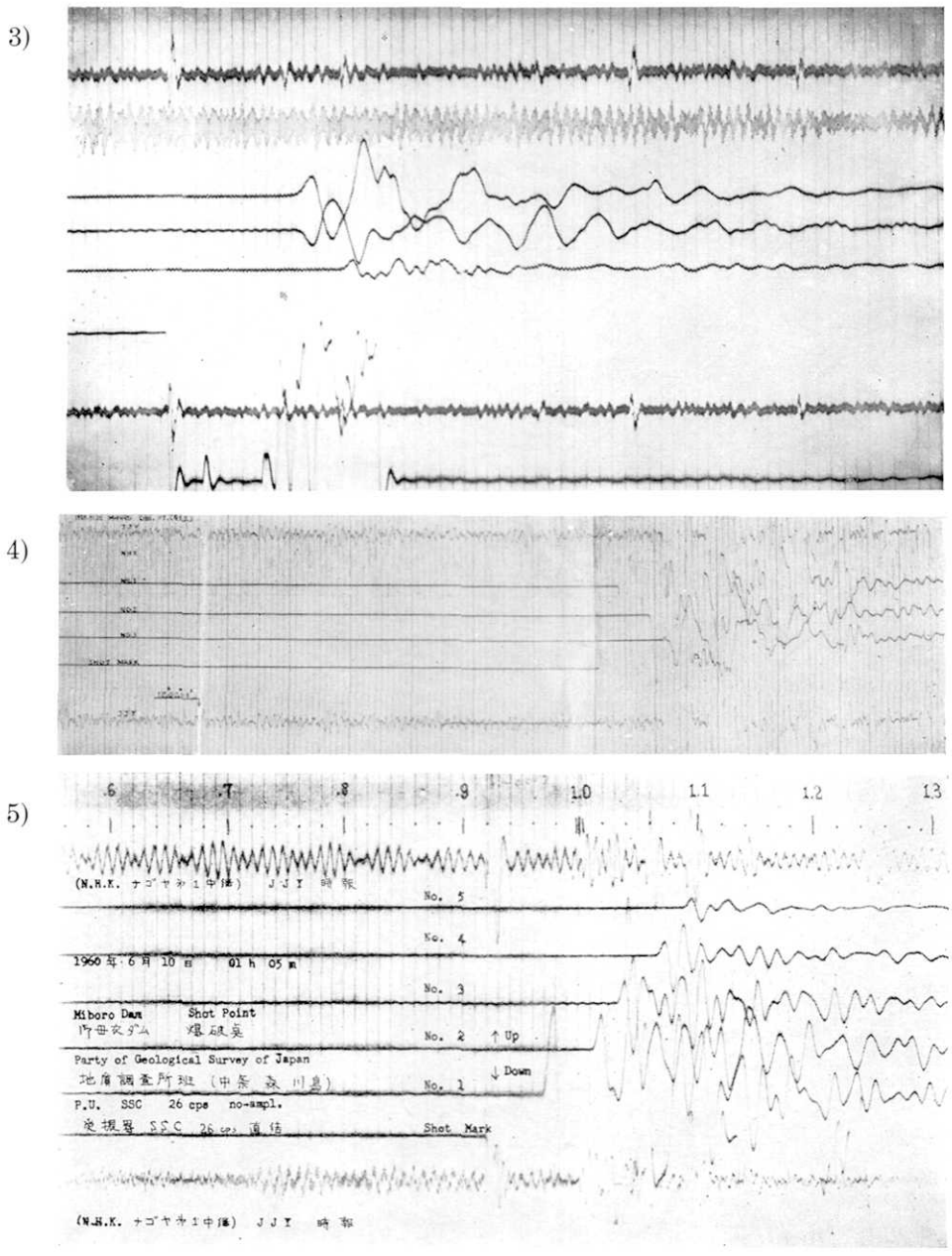
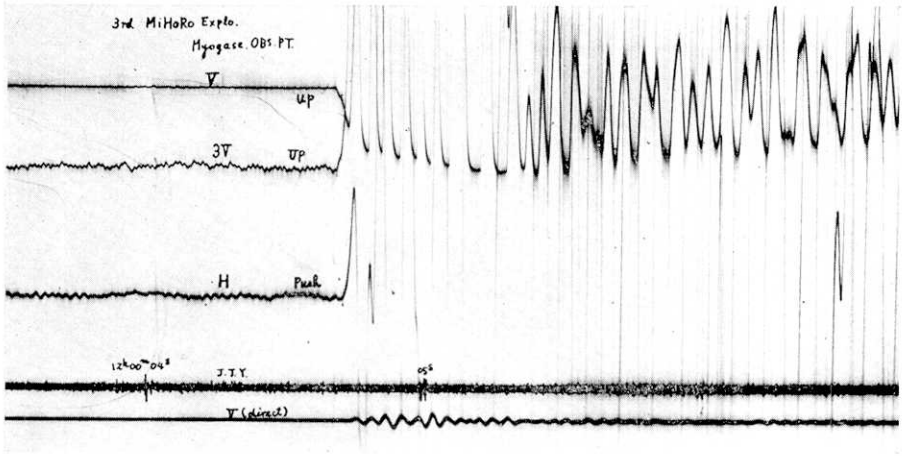


Fig. 9. Seismograms at:

3) Miboro shot point in the 4th explosion.
4) Miboro shot point in the 5th explosion.
5) Miboro shot point in the 6th explosion.

6)



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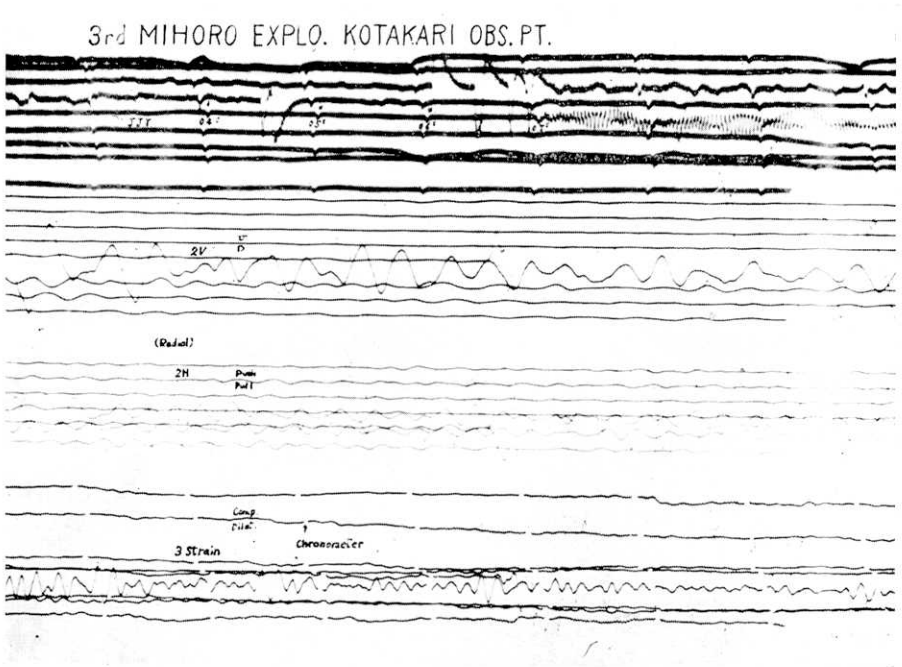


Fig. 9. Seismograms at:

6) E-1 Myôgase in the 3rd explosion.

7) E-2 Kotakari in the 3rd explosion.

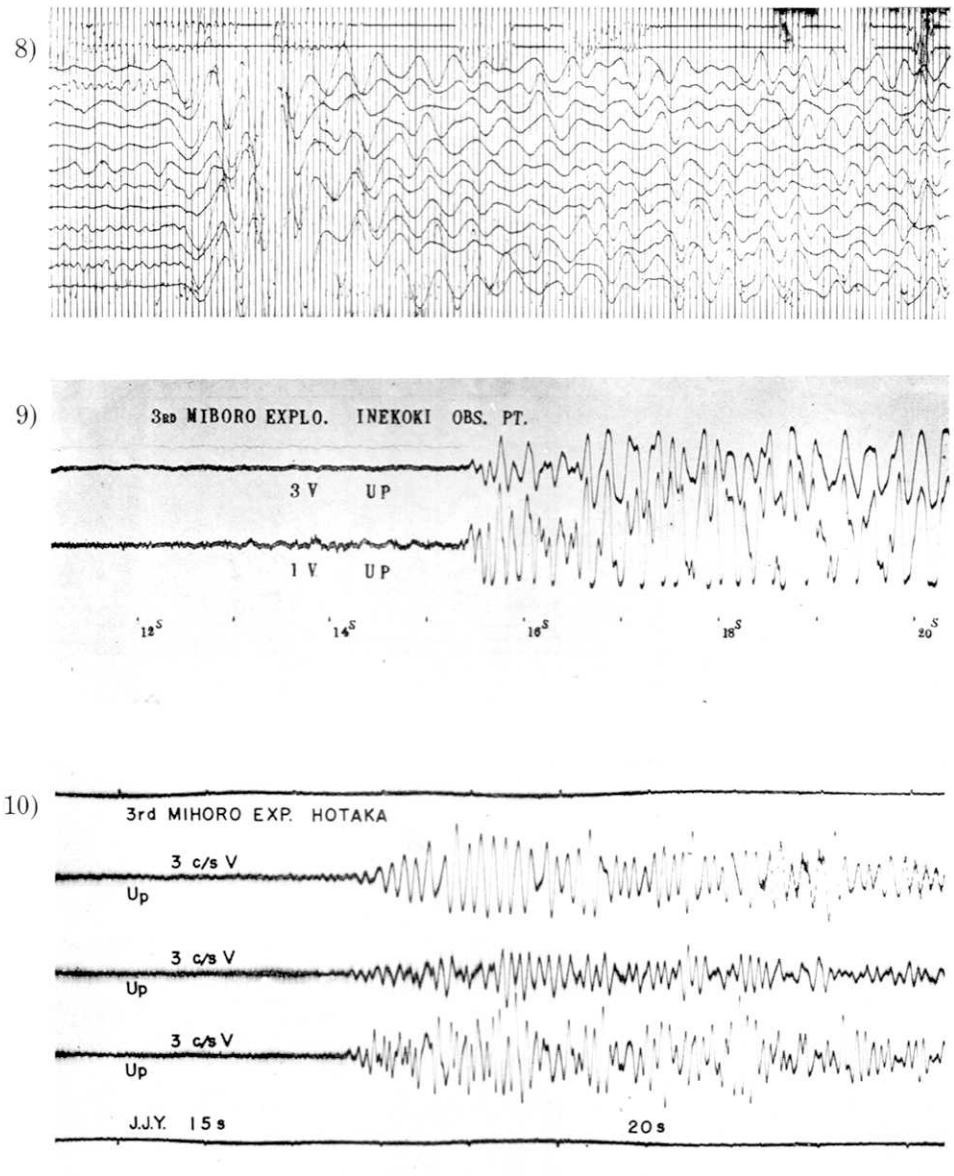


Fig. 9. Seismograms at:

8) E-3 Kamioka in the 3rd explosion.
9) E-4 Inekoki in the 3rd explosion.
10) E-5 Hotaka in the 3rd explosion.

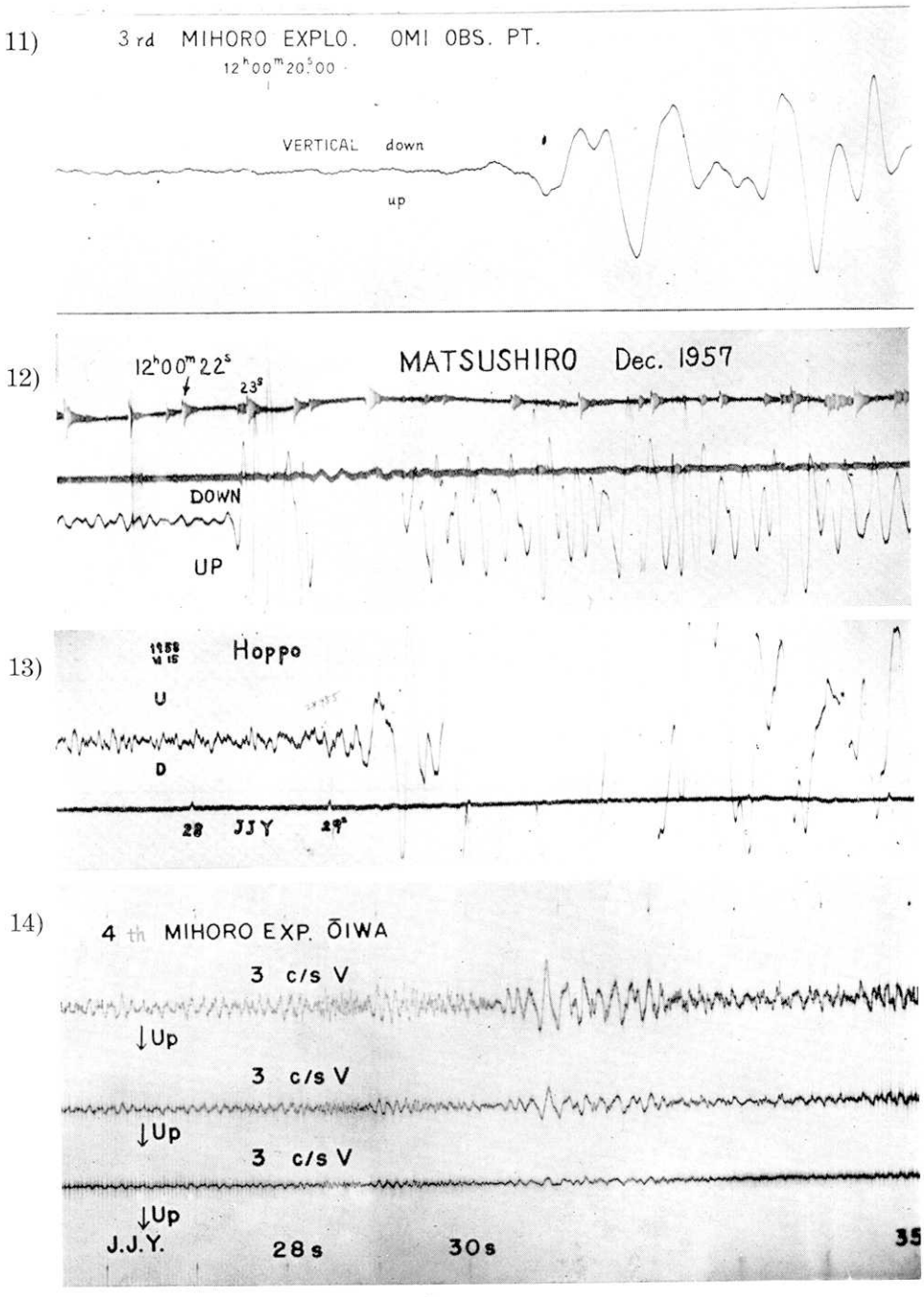
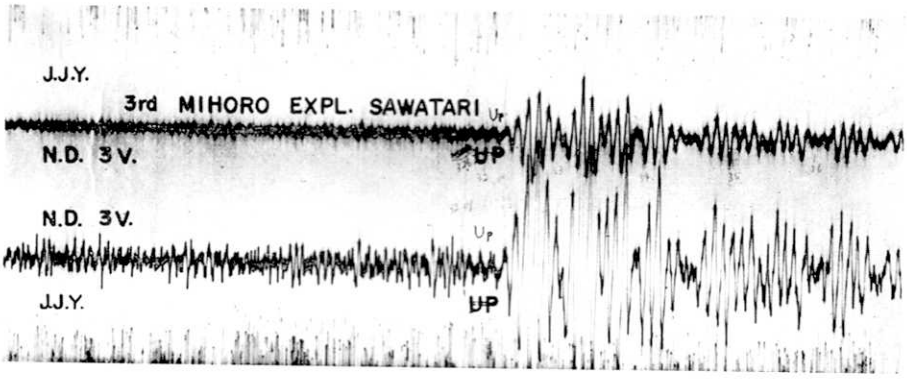


Fig. 9. Seismograms at:
11) E-6 Omi in the 3rd explosion.
12) E-7 Matushiro (Matsusiro) in the 1st explosion.
13) E-8 Hoppo in the 3rd explosion.
14) E-9 Ôiwa in the 4th explosion.

15)



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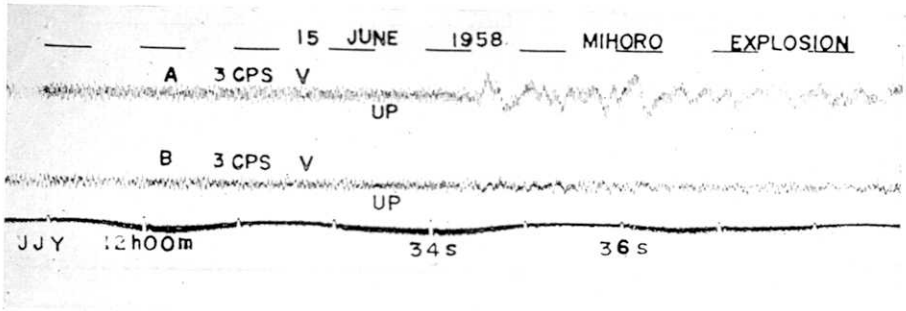

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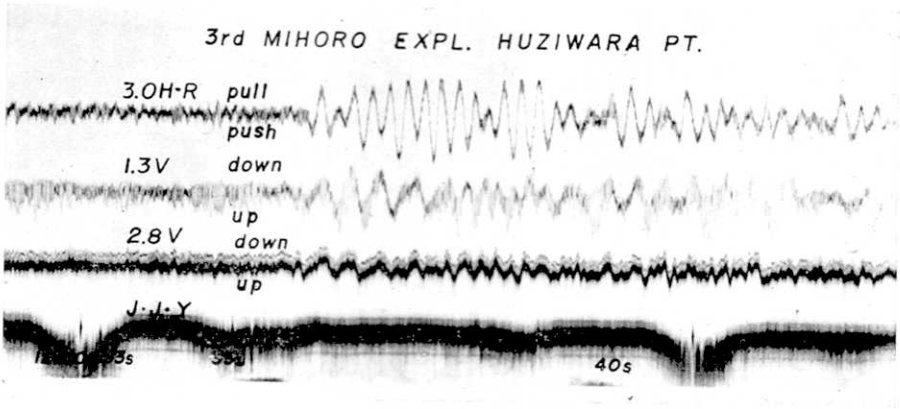


Fig. 9. Seismograms at:
15) E-10 Sawatari in the 3rd explosion.
16) E-11 Takayama in the 3rd explosion.
17) E-12 Huziwara in the 3rd explosion.

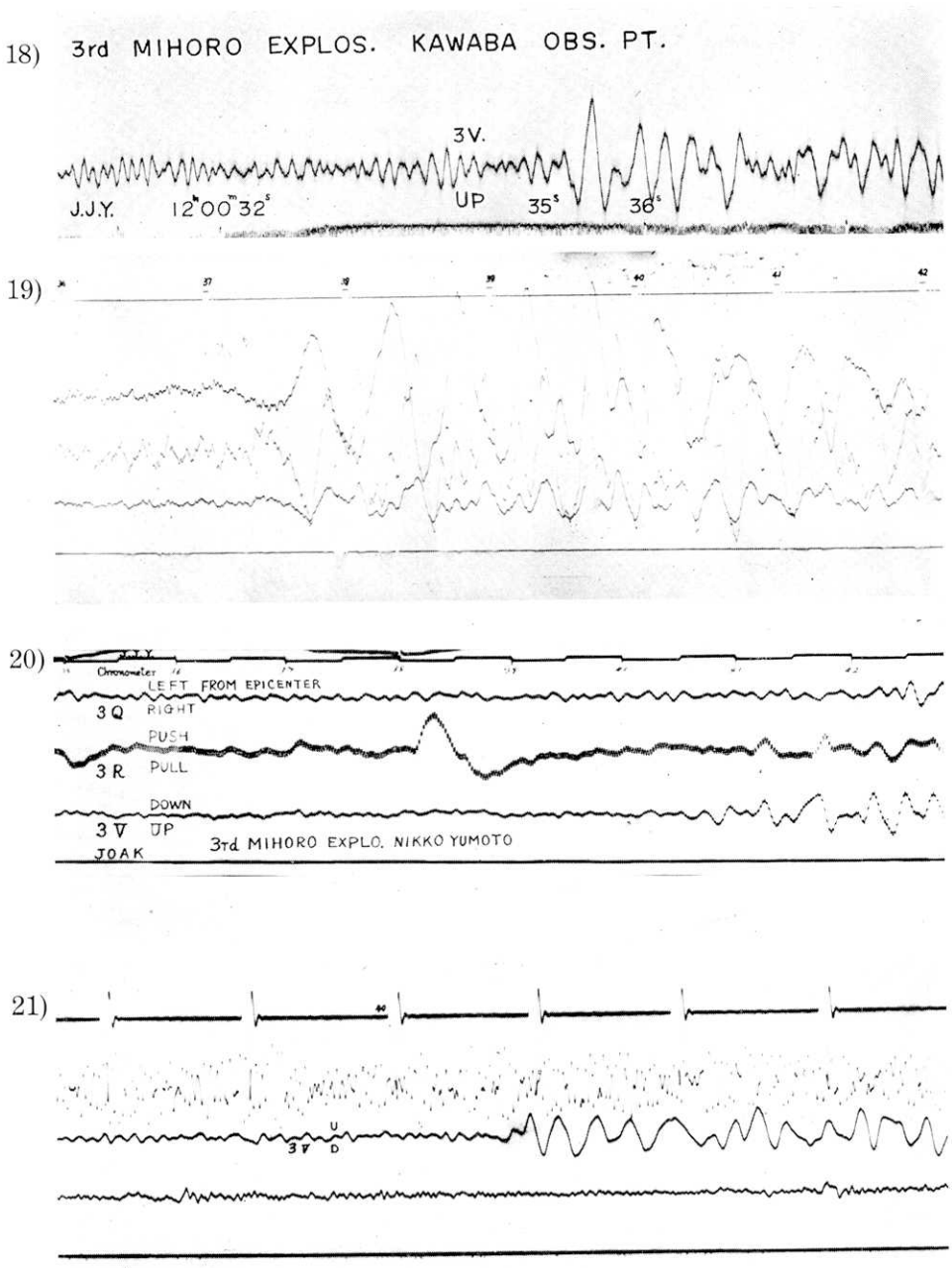
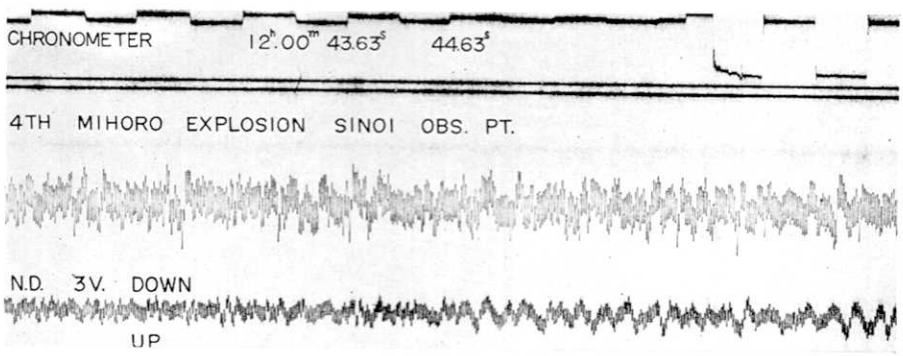


Fig. 9. Seismograms at:

18) E-13 Kawaba in the 3rd explosion.
19) E-14 Asakawa in the 1st explosion.
20) E-15 Yumoto in the 3rd explosion.
21) E-16 Nisiôasi (Nishiōashi) in the 3rd explosion

22)



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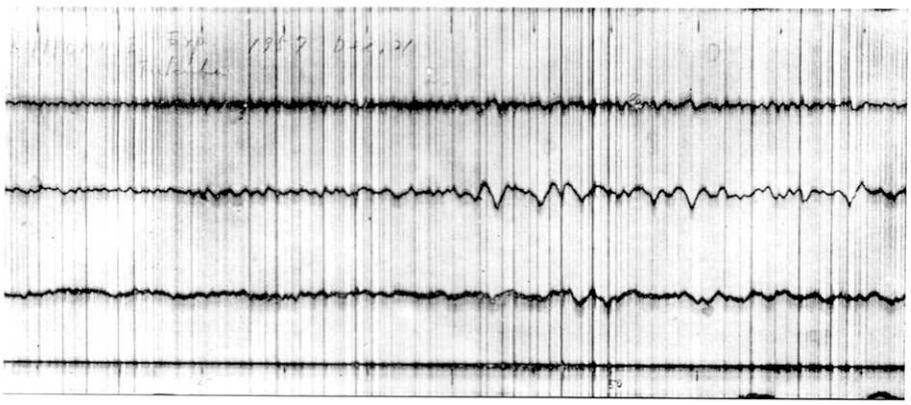

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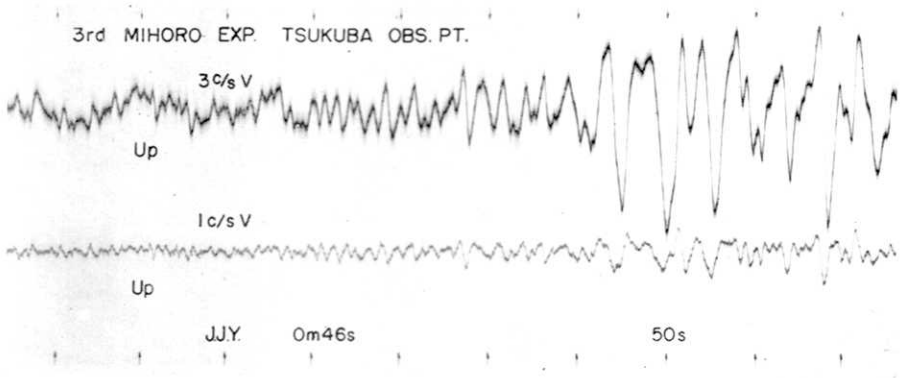


Fig. 9. Seismograms at:

22) E-17 Sinoi in the 4th explosion.
23) E-18 Tukuba in the 1st explosion.
24) E-18 Tukuba (Tsukuba) in the 3rd explosion.

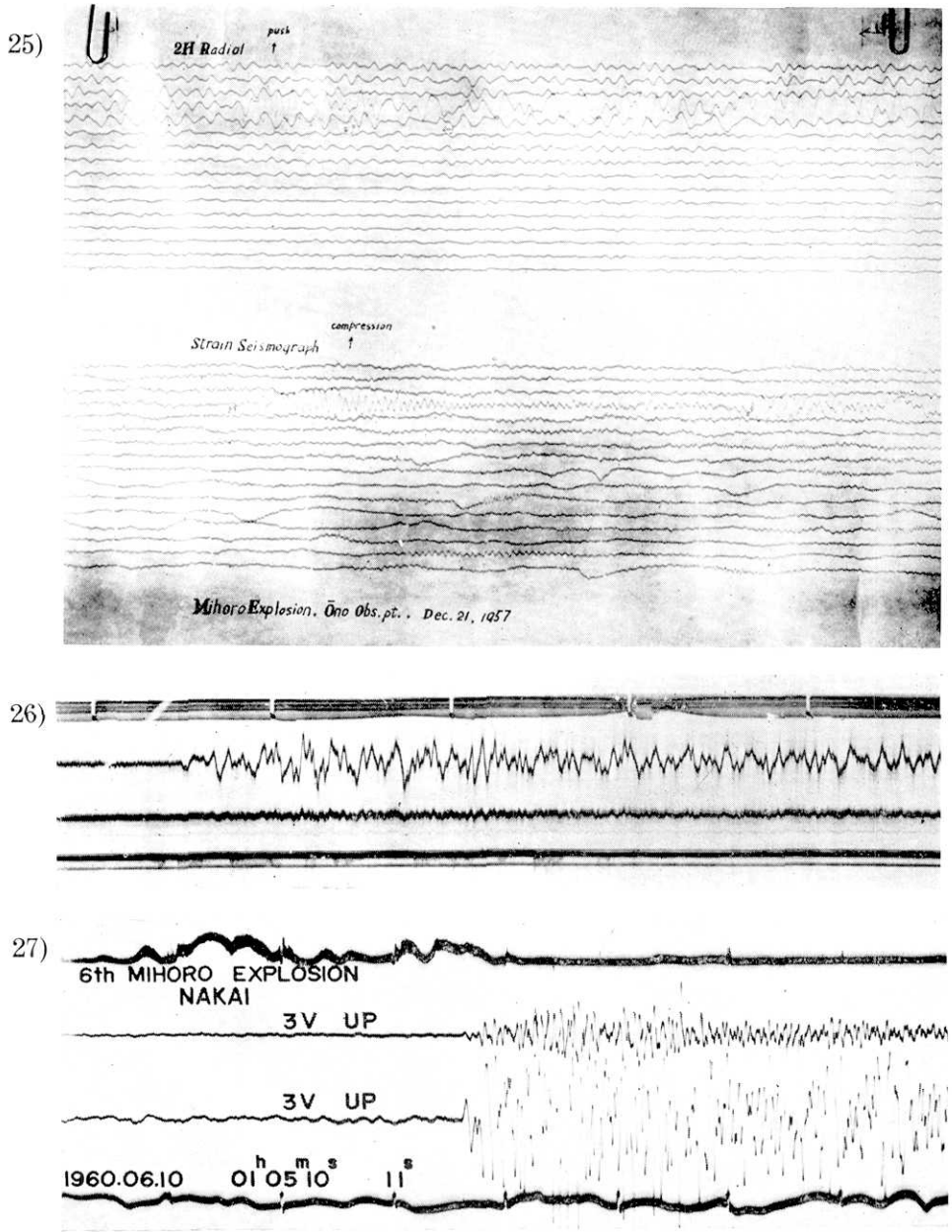
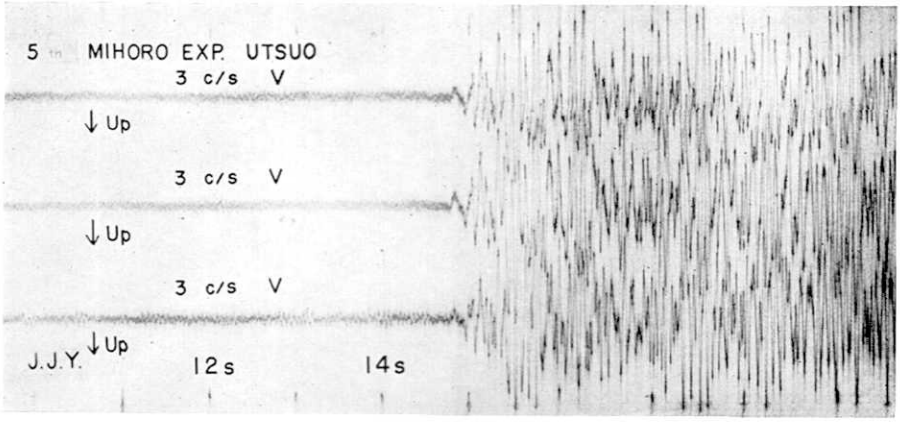


Fig. 9. Seismograms at:
25) W(A)-1 Ôno in the 1st explosion.
26) W(A)-2 Nakai in the 5th explosion.
27) W(A)-2 Nakai in the 6th explosion.

28)



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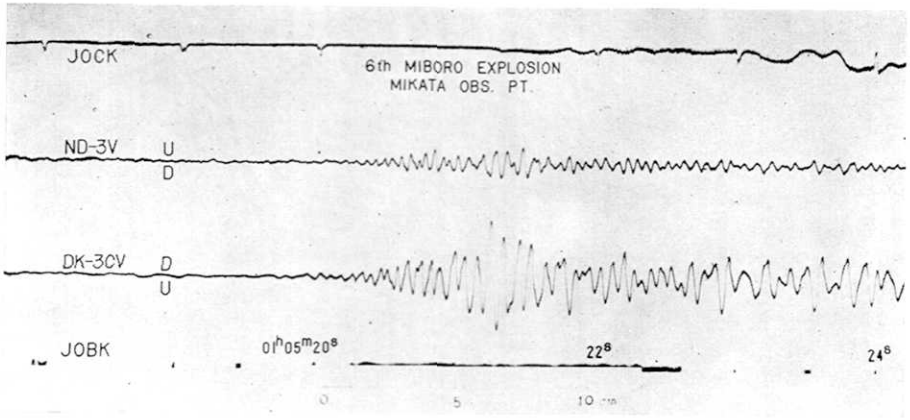

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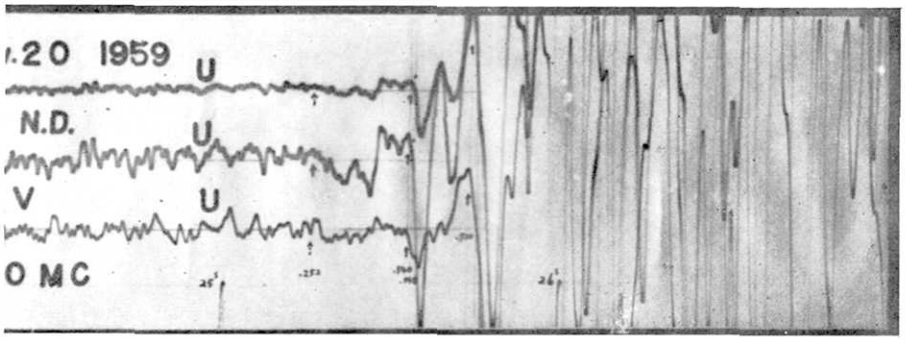


Fig. 9. Seismograms at:
28) W(A)-3 Utuo (Utsuo) in the 5th explosion.
29) W(A)-4 Mikata in the 5th explosion.
30) W(A)-5 Ôi in the 5th explosion.

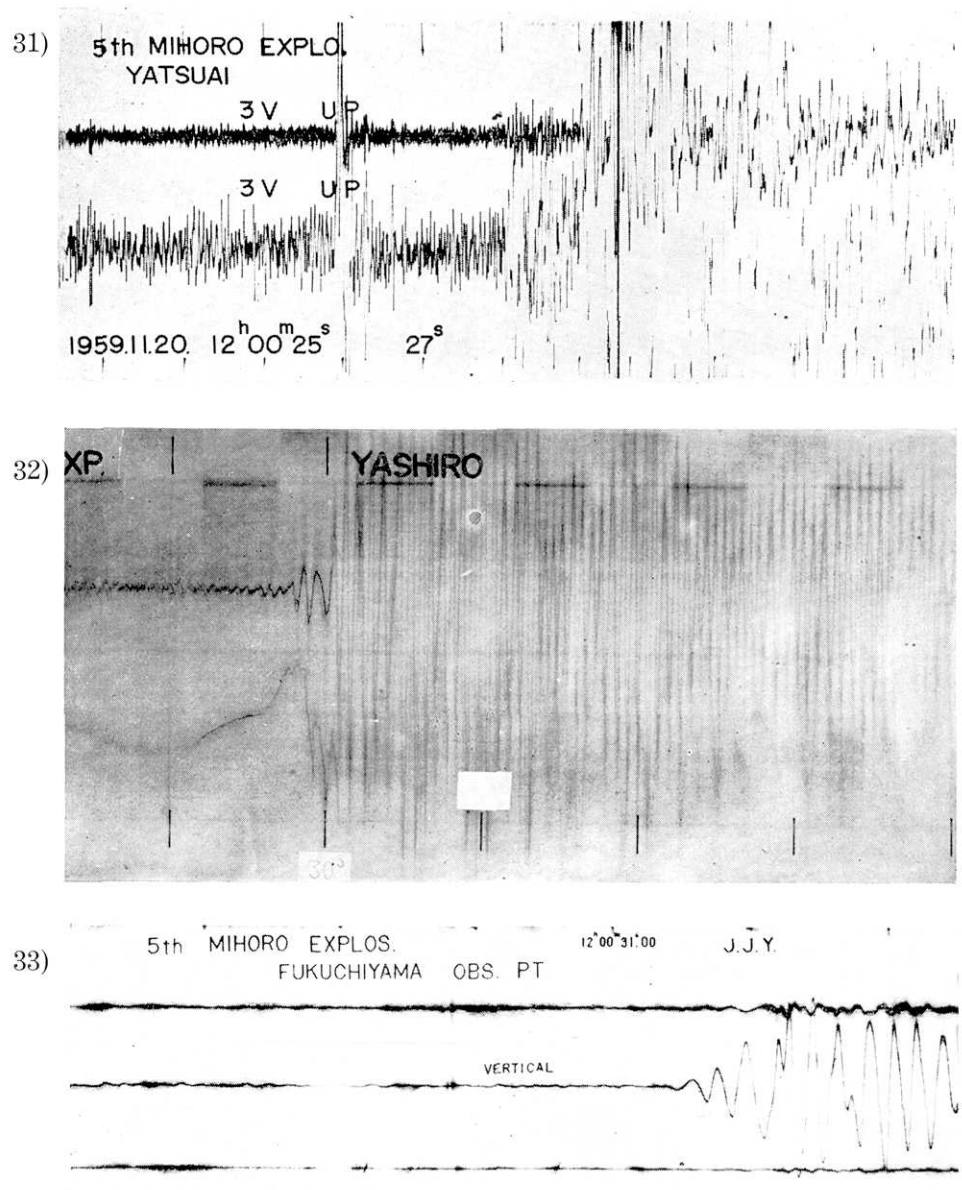
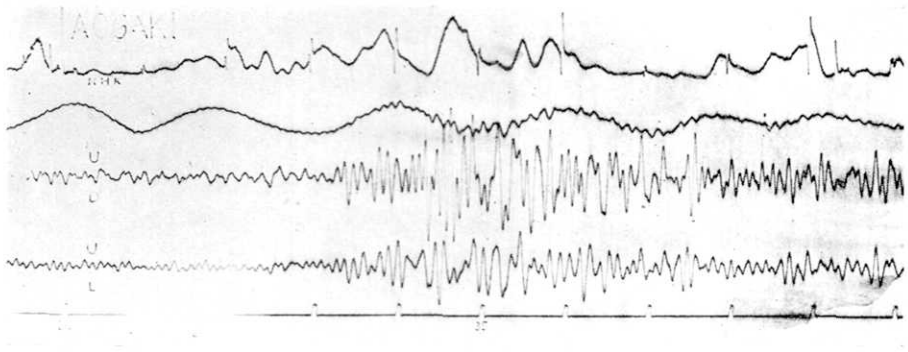


Fig. 9. Seismograms at:
31) W(A)-6 Yatuai (Yatsuai) in the 5th explosion.
32) W(A)-7 Yasiro (Yashiro) in the 5th explosion.
33) W(A)-8 Hukutiyama (Fukuchiyama) in the 5th explosion.

34)



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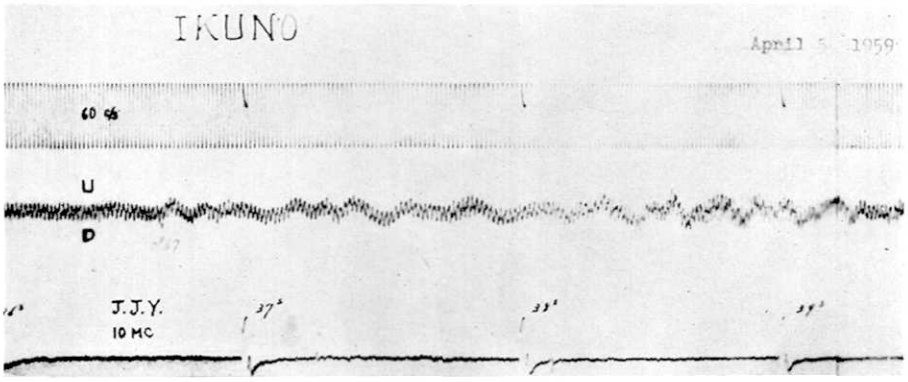

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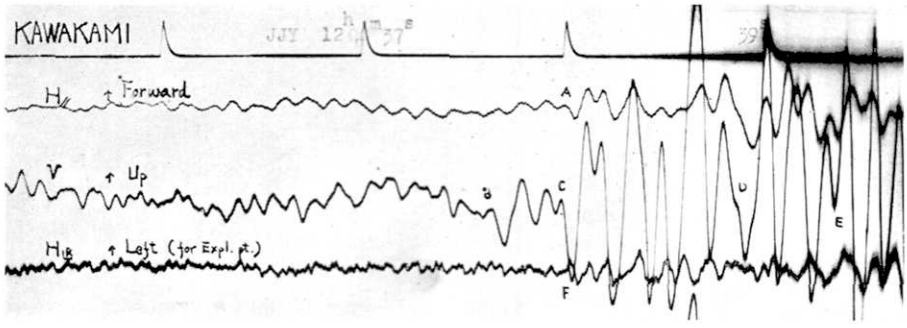
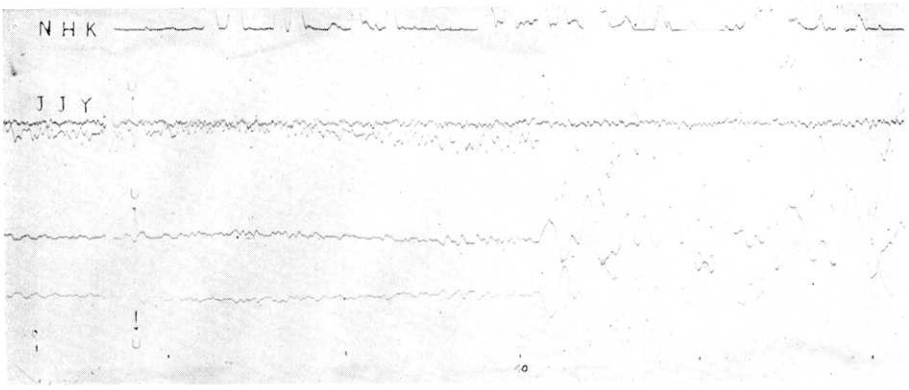


Fig. 9. Seismograms at:
34) W(A)-9 Aogaki in the 6th explosion.
35) W(A)-10 Ikuno in the 4th explosion.
36) W(A)-11 Kawakami in the 5th explosion.

37)



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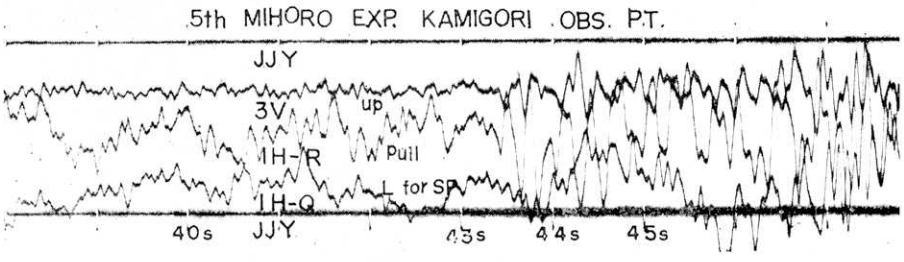

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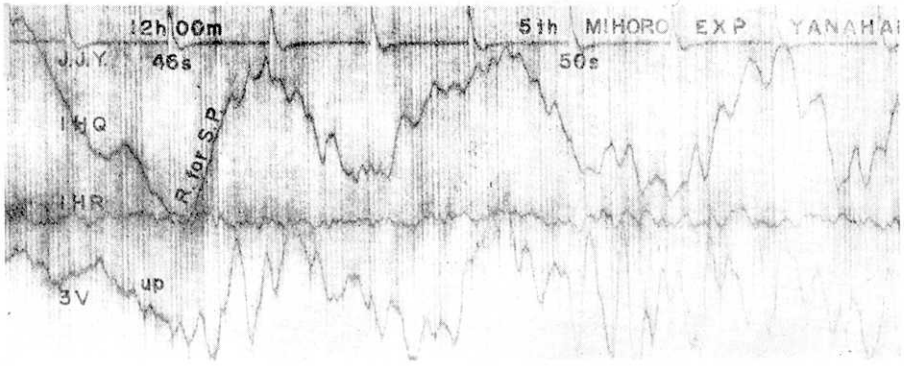
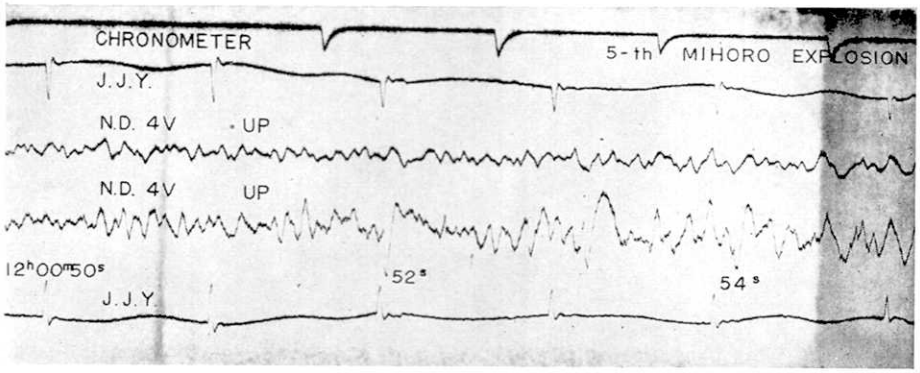


Fig. 9. Seismograms at:

37) W(A)-11 Yamazaki in the 4th explosion.
38) W(A)-13 Kamigôri in the 5th explosion.
39) W(A)-14 Yanahara in the 5th explosion.

40)



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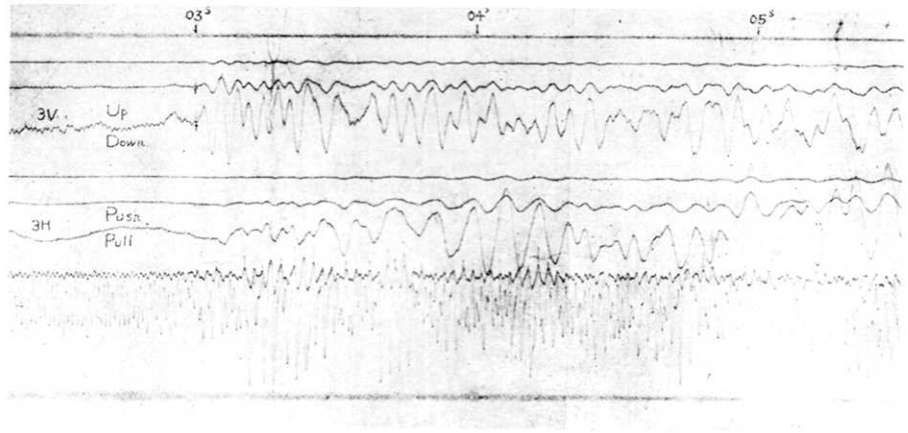

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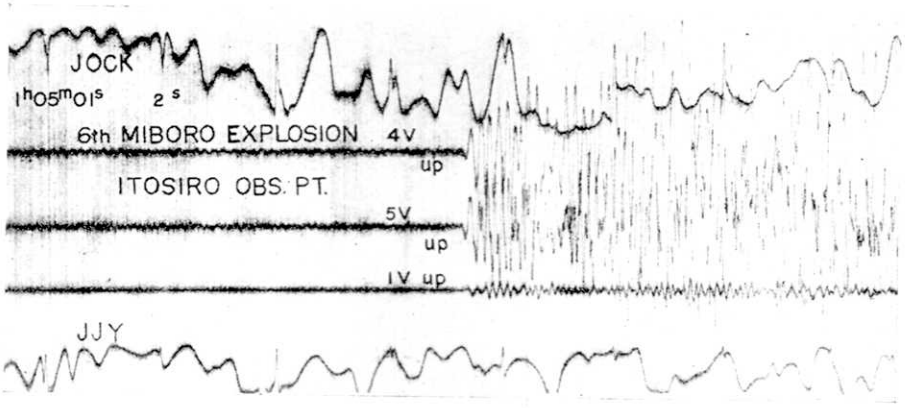


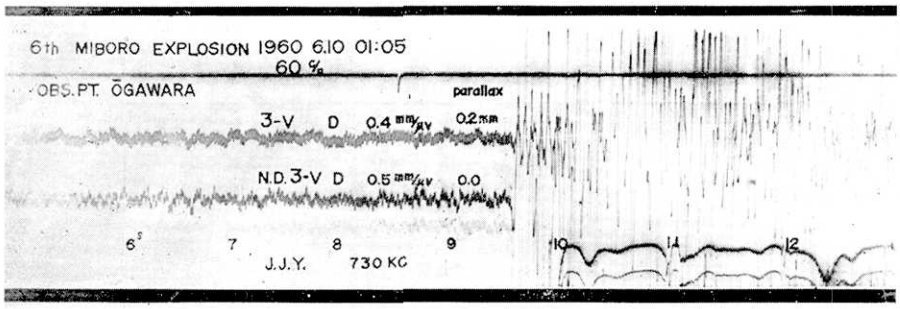
Fig. 9. Seismograms at:

40) W(A)-15 Yakage in the 5th explosion.

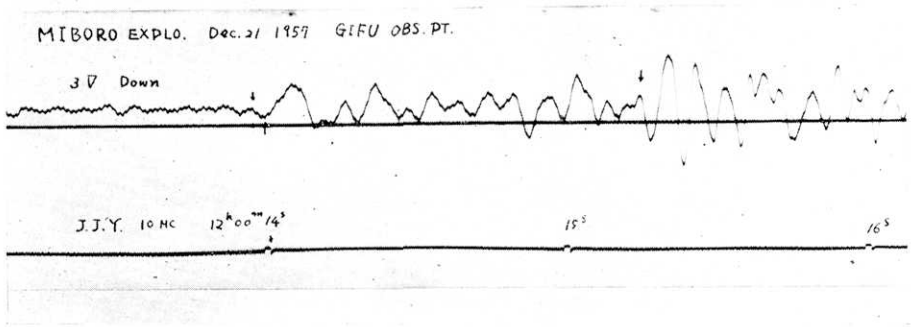
41) W(B)-16 Arabuti in the 6th explosion.

42) W(B)-17 Itosiro in the 6th explosion.

43)



44)



45)

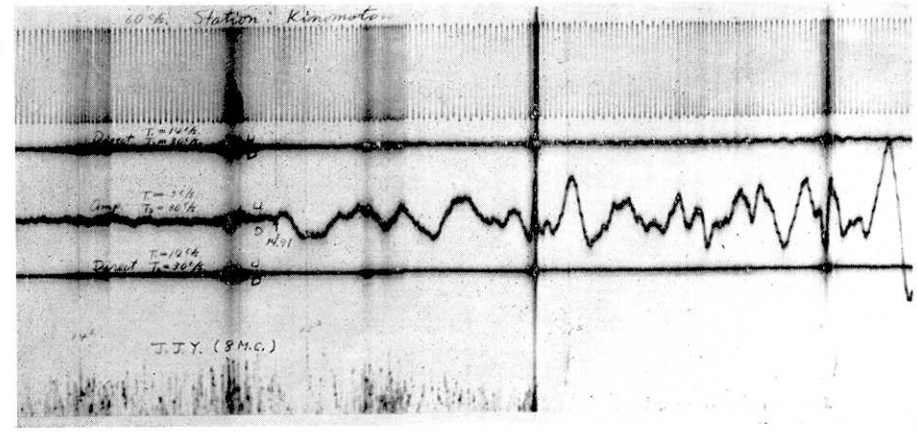


Fig. 9. Seismograms at:
43) W(B)-18 Ôgawara in the 6th explosion.
44) W(B)-19 Gihu (Gifu) in the 1st explosion.
45) W(B)-20 Kinomoto in the 1st explosion.

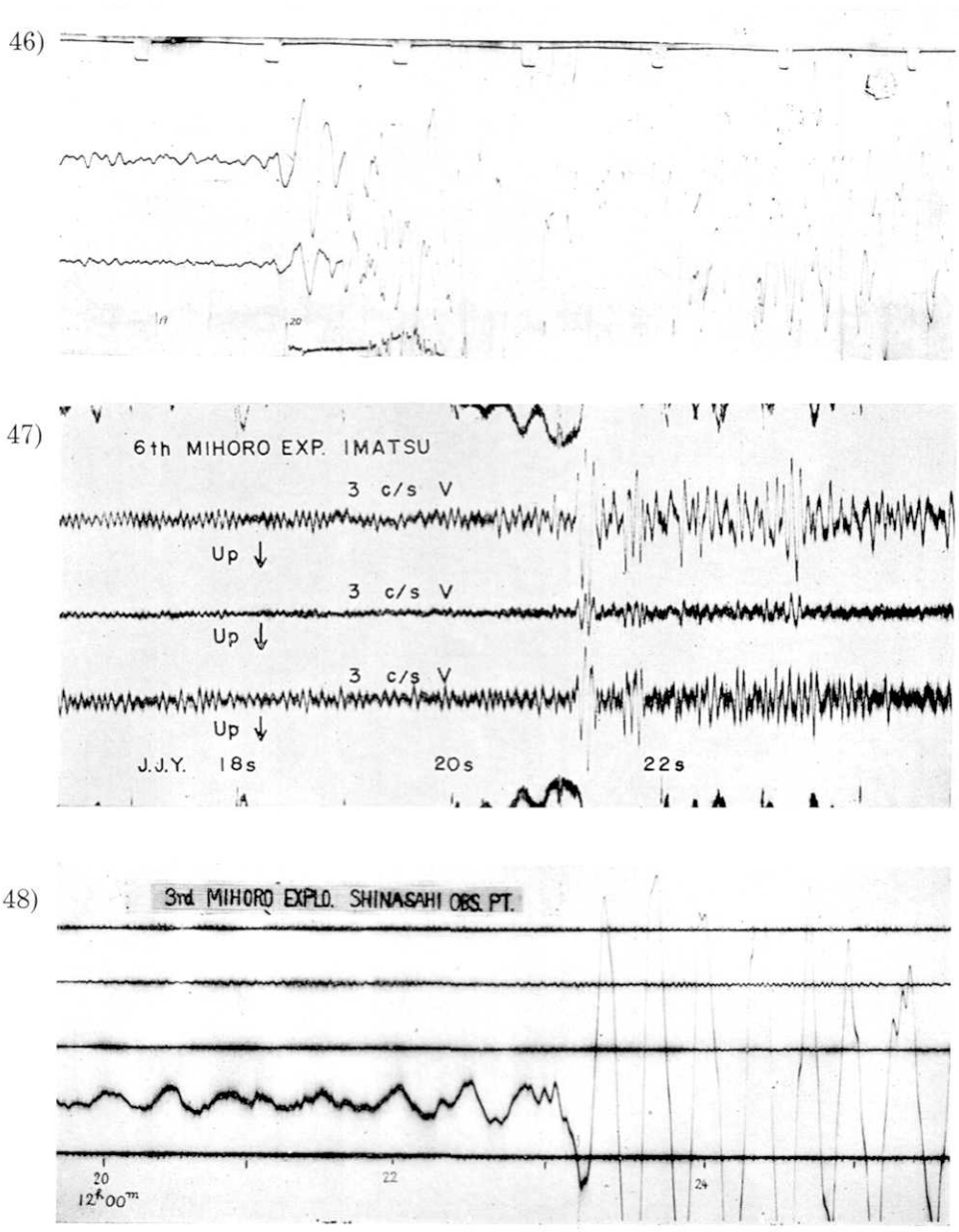


Fig. 9. Seismograms at:
46) W(B)-21 Kaizu in the 5th explosion.
47) W(B)-22 Kitoge (Imatsu) in the 6th explosion.
48) W(B)-24 Imazu (Shin'ashi) in the 3rd explosion.

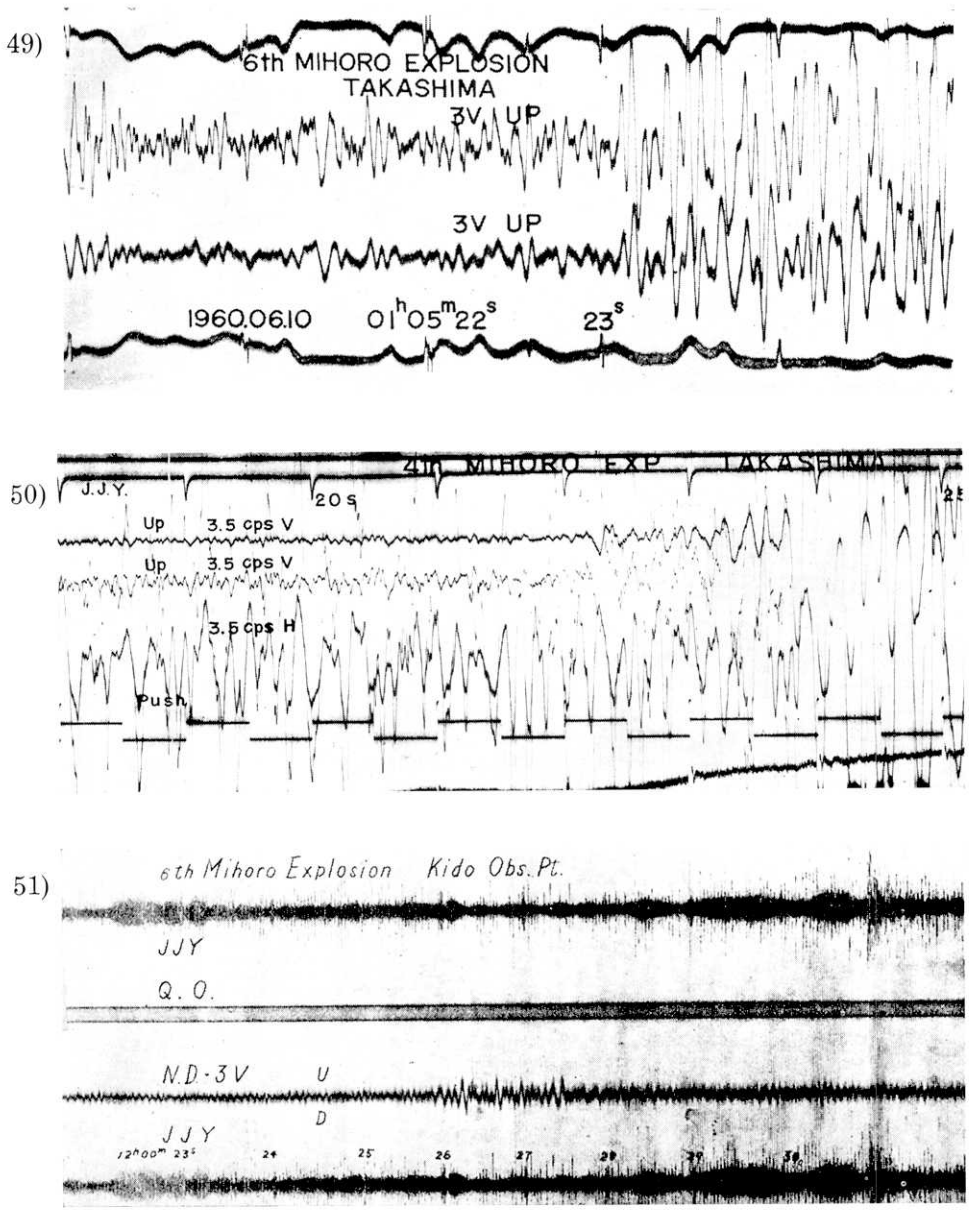
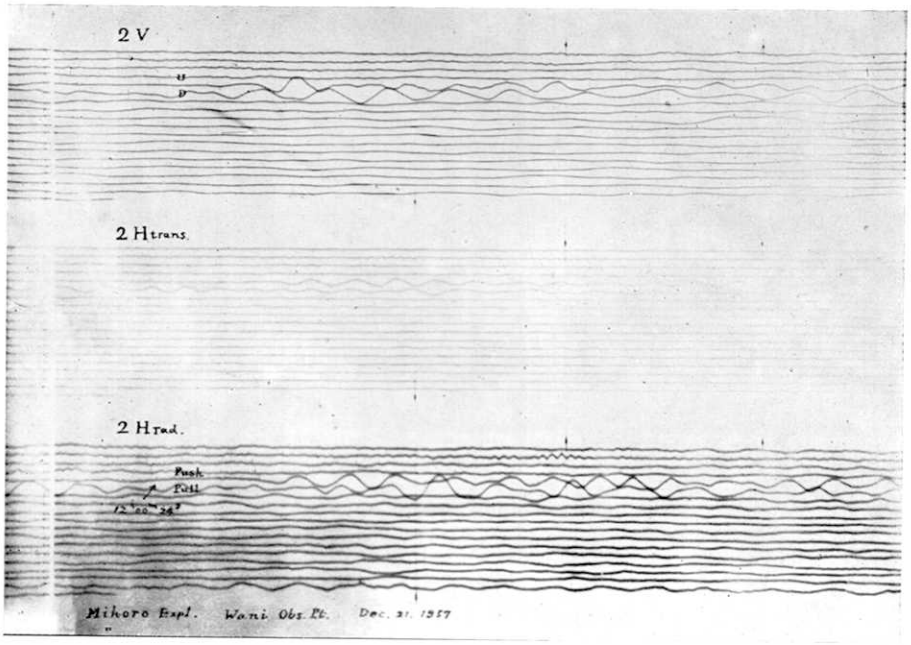


Fig. 9. Seismograms at:

49) W(B)-25 Sirahige (Takashima) in the 6th explosion
50) W(B)-26 Takasima (Takashima) in the 4th explosion.
51) W(B)-27 Kido in the 6th explosion.

52)



53)

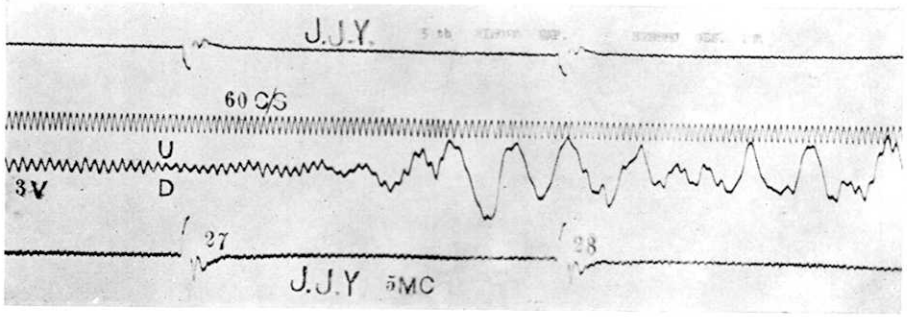


Fig. 9. Seismograms at:
52) W(B)-28 Wani in the 1st explosion.
53) W(B)-29 Bessyo in the 5th explosion.

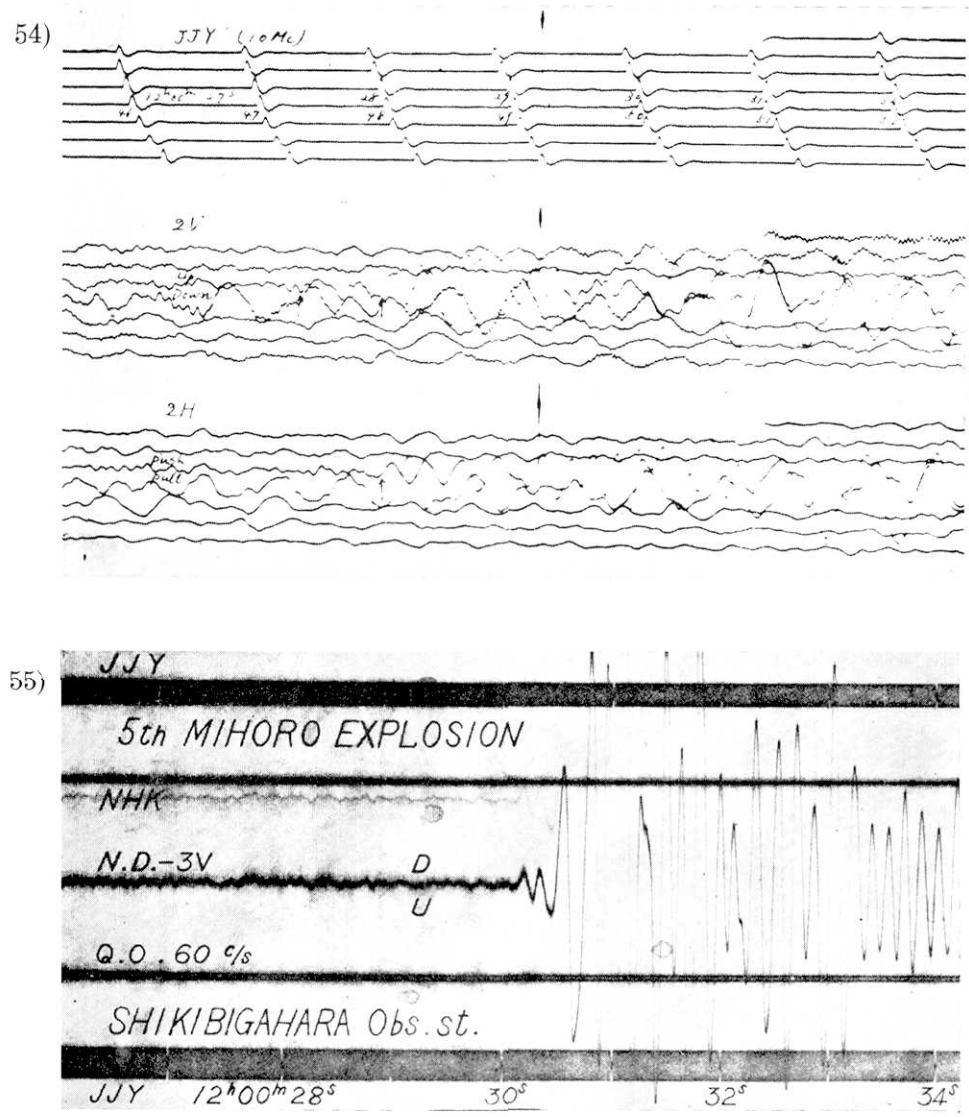
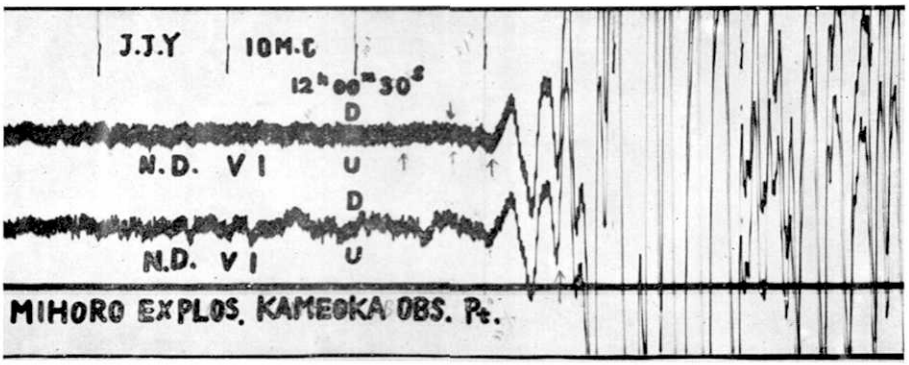
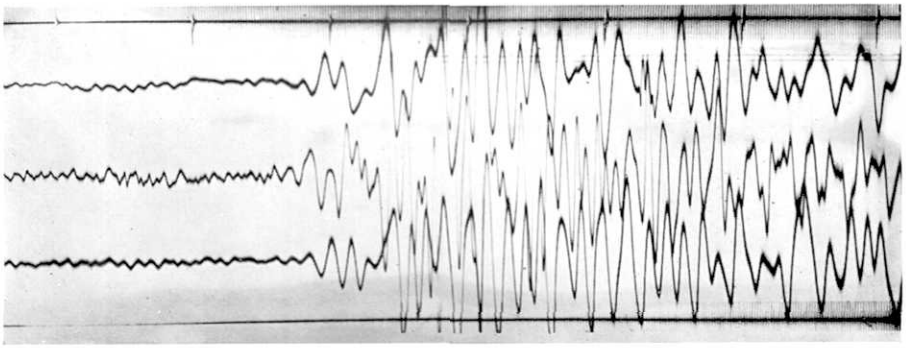


Fig. 9. Seismograms at:
54) W(B)-30 Kyôto in the explosion of Nov. 2, 1958.
55) W(B)-31 Sikibigahara (Shikibigahara) in the 5th explosion.

56)



57)



58)

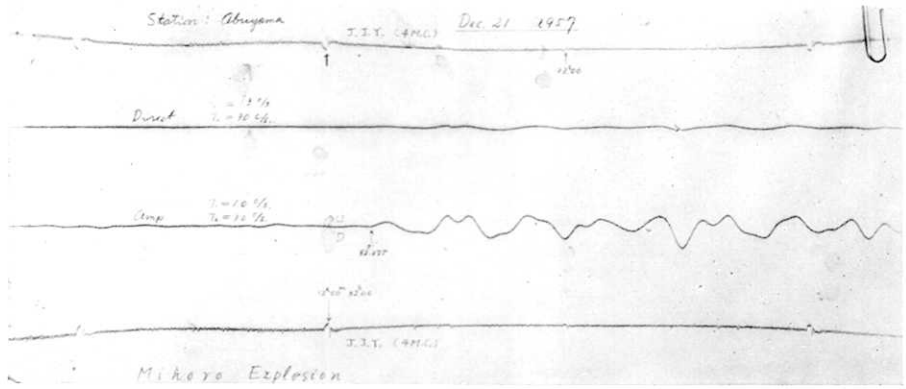


Fig. 9. Seismograms at:

56) W(B)-32 Kameoka in the 4th explosion.
57) W(B)-33 Taki in the 4th explosion.
58) W(B)-34 Abuyama in the 1st explosion.

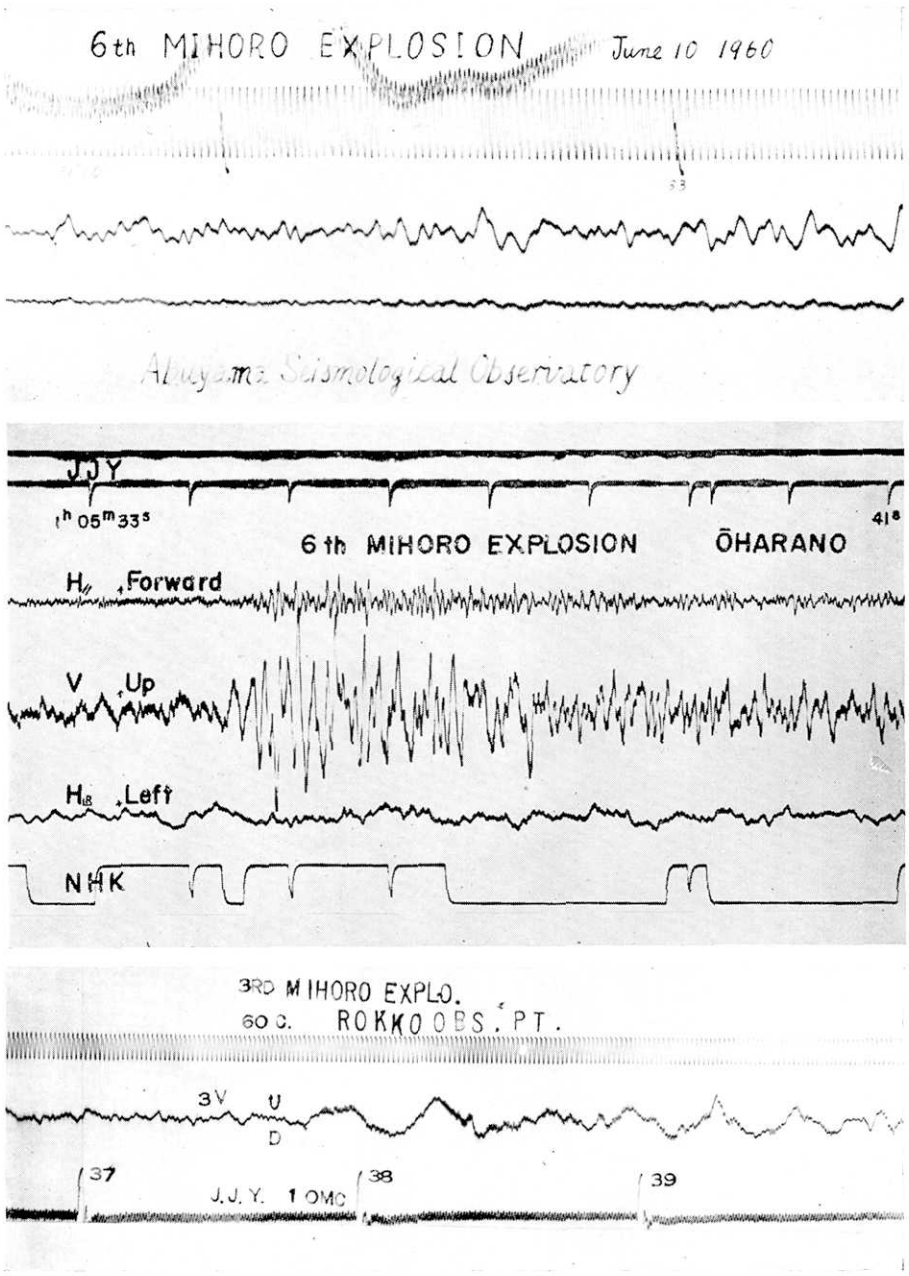
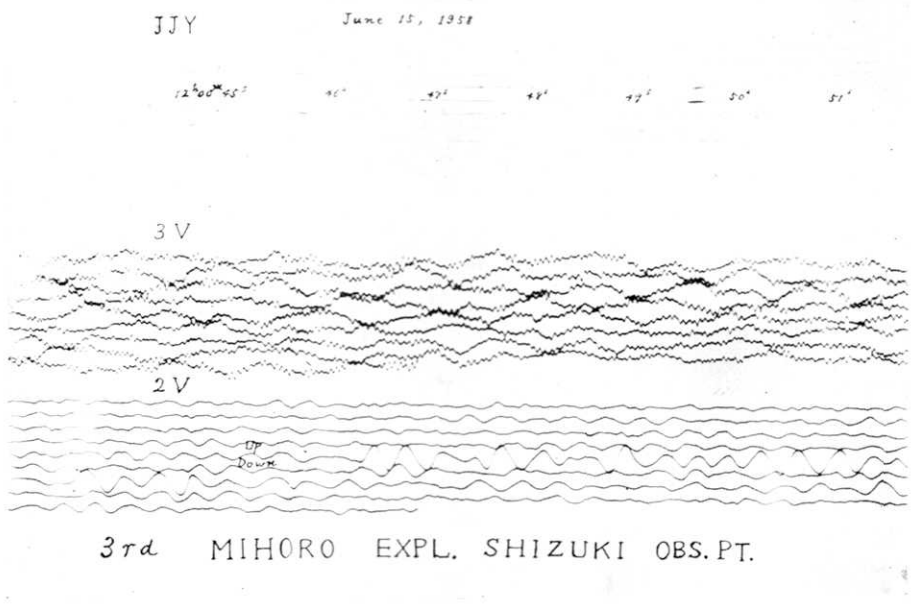


Fig. 9. Seismograms at:
59) W(B)-35 Abuyama in the 6th explosion.
60) W(B)-36 Ôharano in the 6th explosion.
61) W(B)-37 Rokkô in the 3rd explosion.

62)

63)



64)

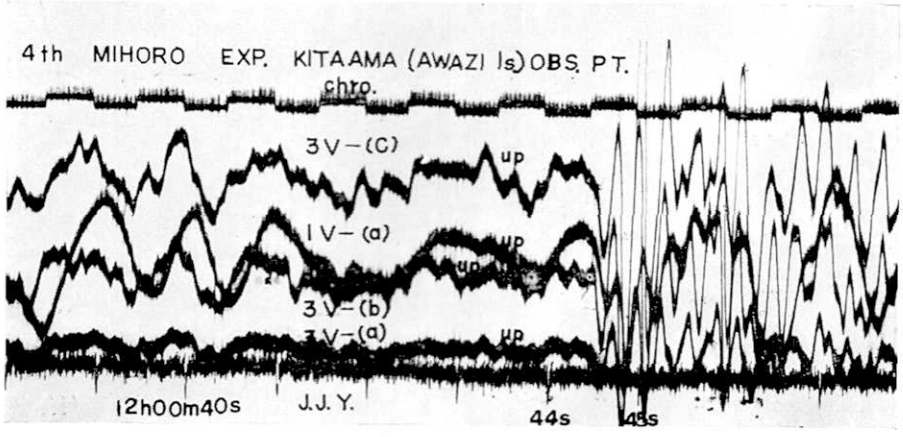


Fig. 9. Seismograms at:
62) W(B)-38 Tainohata in the 4th explosion
63) W(B)-39 Sizuki (Shizuki) in the 3rd explosion
64) W(B)-41 Kitaama in the 4th explosion.

5. Acknowledgement

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Postscript

Inscriptions on seismograms, "Mihoro" should be corrected to "Miboro", but they are left as hitherto used.

Romanization for place names follows the modern Japanese system instead of the Hepburn style.

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9. 御母衣爆破地震動観測による日本中部の地殻構造

第1部 御母衣爆破地震動の観測

爆破地震動研究グループ

1957 年9月以来，岐阜県大野郡白川村御母衣においては，電源開発株式会社によつて，ロックフィルダム建設工事に伴なう大爆破が度々実施されてきた．爆破地震動研究グループは，これらの爆破を利用して，関東，中部，近畿，中国の各地域にわたる地殻構造を研究するために，6 回にわたる組織的な地震動観測を行なつた．

各回の爆破点の位置，爆破時刻，火薬量，および観測点の詳細な位置は Table 1～7 に示された通りである．

観測点は総計 75 に上るが，Fig. 4 および 5 に示されるように，主として中部—関東北部—東北南部地方に到る測線（東方測線），北陸—近畿北部—中国地方に伸びる測線（西方A測線）および近畿地方中部を横切る測線（西方B測線）上に配置された．

観測の結果は，数点を除いて良好な記録を得ることができた．観測値は Table 8～18 に与えられ，これにもとづく走時図は Fig. 6, 7 および 8 に示されている．

本観測は御母衣ダム建設工事担当の電源開発株式会社および間組の御協力により実施されたものである．また日本放送協会，東北，東京，中部，北陸，関西各電力会社および関係府県庁当局，警察本部ならびに観測点所在の市町村役場，警察署からも多くの御便宜をはかつて頂いた．これらの各位に対して厚く感謝の意を表する次第である．

なお，この観測は東京大学地震研究所特別事業の一部として行なわれたもので，高橋所長 および岸上，河角，萩原各教授の御助力をいただいた．記して感謝する次第である．