BULLETIN OF THE EARTHQUAKE
RESEARCH INSTITUTE
Vol. 46 (1968), pp. 529-605

25. *Crustal Structure in the Profile across the Northeastern Part of Honshu, Japan, as Derived from Explosion Seismic Observations. Part 1. Observations of Seismic Waves Generated from the Off Kesennuma, the Off Oga Peninsula and the Tutihata Explosions.*

By THE RESEARCH GROUP FOR EXPLOSION SEISMOLOGY,

Earthquake Research Institute.

(Read July 18, 1967.—Received Jan. 31, 1968.)

Abstract

In the middle of March 1965, more than fifty shots were fired at sea off Kesennuma in the northeastern part of Honshu for sixteen temporary observation sites on land and a receiving vessel. The amount of explosives is relatively small, 450 kg in maximum, in comparison with the land shots. In early March 1966, an explosion at Tutihata Mine and twenty one shots were fired off Oga Peninsula for almost the same temporary stations with those in the Off Kesennuma explosions. In these experiments, good records were obtained through the profile. These experiments in the northeastern part of Honshu are described and the observational results are presented.

1. Introduction

Geologically the northeastern part of Honshu is divided into two belts, the inner and the outer by the central mountains. The outer belt is very close to the seismic belt off Sanriku area, one of the most active seismic regions in Japan and farther east there is the Japan Trench. While, the inner belt, adjacent to the Sea of Japan, is a typical green tuff region in the Neogene age.

The explosion seismic observations for the crustal study were carried out for the first time in this district in the case of quarry blast at the Isibuti dam in 1950.[1] Since then, similar experiments had been repeated

1) THE RESEARCH GROUP FOR EXPLOSION SEISMOLOGY, *Bull. Earthq. Res. Inst.*, **29** (1951) 97.

in the same district along the several different profiles until 1957.[2] In the period 1961-63, the profile along the longitude 139°E was studied by the explosion seismic method and the existence of the so-called basaltic layer was first established by using first arrivals.[3] Later, in 1966 from the data of the Kurayosi and the Hanabusa explosions the layer with velocity of about 6.5 km/s was found in the western part of Honshu,[4] so that the existence of the basaltic layer in Japan becomes almost convincing as far as the layered structure is assumed. Furthermore, in this profile, the velocity just below the Mohorovičić discontinuity was determined with higher accuracy than before as equal to or larger than 8.0 km/s. Therefore, it has been required to investigate in more detail the crustal structure of the northeastern part of Honshu by means of the recently developed shooting method and improved observation techniques. Fortunately as one of the items of the Upper Mantle Project the first experiments with shots at sea for observation sites on land were conducted in the northeastern part of Honshu in 1965 and 1966, being expected to give a great detail of information on the variation of crustal structure from the sea to the island arc. In this paper, these experiments are described and the observed data are presented.

Members of the group, who participated in the readings and the reduction of data, shot point determination, were, in alphabetical order S. Asano, T. Asanuma, N. Den, K. Hagiwara, H. Hamaguchi, M. Hashizume, T. Murase, S. Murauchi, M. Nogoshi, K. Noritomi, K. Oike, A. Okada, E. Shima, and T. Yoshii.

2. Explosions and Observations

On March 11 to 12 and March 14 to 15, 1965, more than fifty shots were fired at sea off Kesennuma and sixteen temporary obser-

2) THE RESEARCH GROUP FOR EXPLOSION SEISMOLOGY, *Bull. Earthq. Res. Inst.*, **30** (1952), 279; **31** (1953), 281; **32** (1954), 79; **33** (1955), 699; **37** (1959), 89; 495.
T. MATUZAWA, *Bull. Earthq. Res. Inst.*, **37** (1959), 123.
T. MATUZAWA, T. MATUMOTO and S. ASANO, *Bull. Earthq. Res. Inst.*, **37** (1959), 509.

3) THE RESEARCH GROUP FOR EXPLOSION SEISMOLOGY, *Bull. Earthq. Res. Inst.*, **42** (1964), 515.
H. HOTTA, S, MURAUCHI, T. USAMI, E. SHIMA, Y. MOTOYA, and T. ASANUMA, *Bull. Earthq. Res. Inst.*, **42** (1964), 533.

4) THE RESEARCH GROUP FOR EXPLOSION SEISMOLOGY, *Bull. Earthq. Res. Inst.*, **44** (1966), 89.
M. HASHIZUME, O. KAWAMOTO, S. ASANO, I. MURAMATU, T. ASADA, I. TAMAKI, and S. MURAUCHI, *Bull. Earthq. Res. Inst.*, **44** (1966), 109.

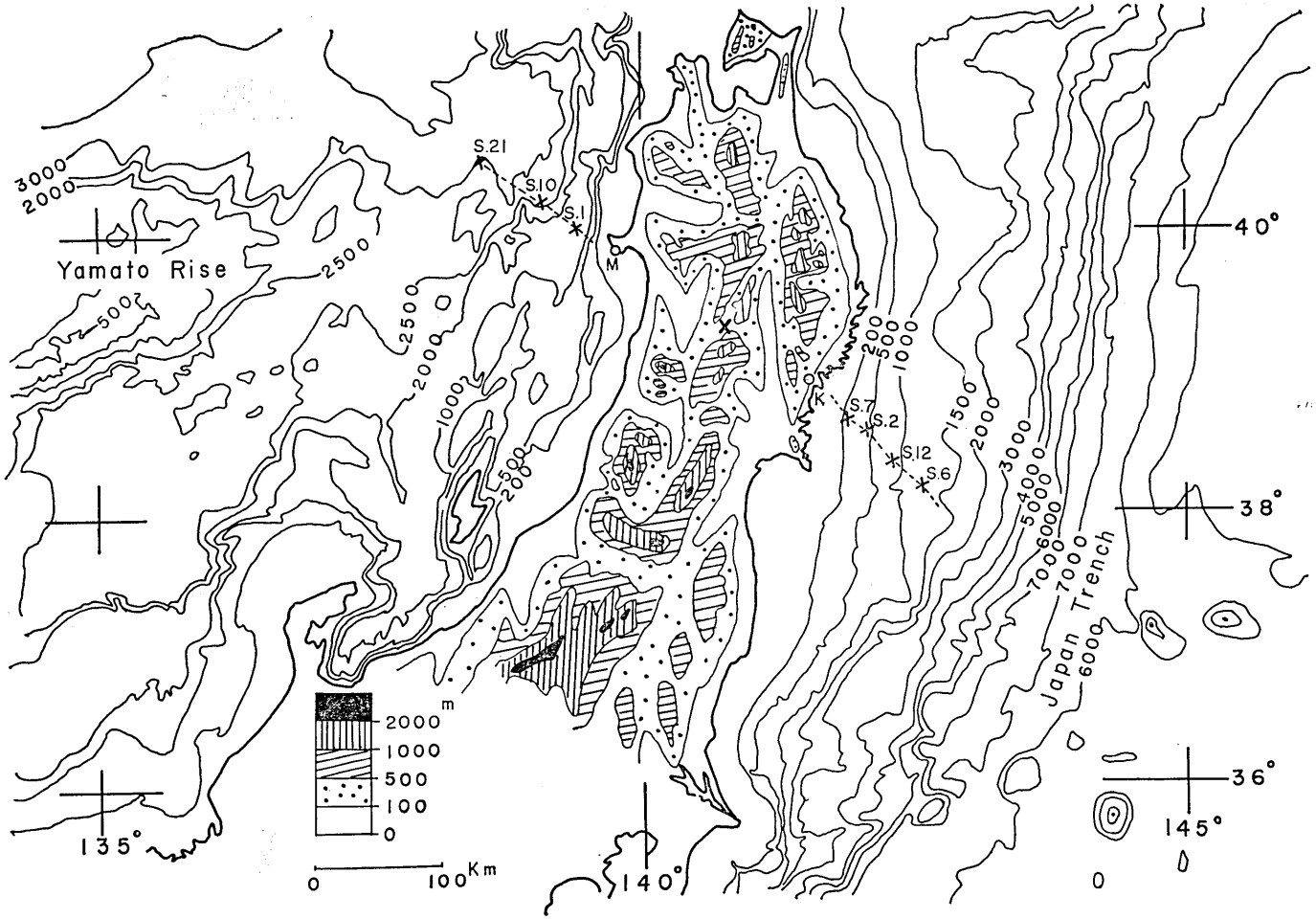

Fig. 1(a). Topography surrounding the surveyed area.
thick cross mark: Tutihata shot point
K: temporary station Kesennuma
M: temporary station Monzen
S.7: Shot No. 7
Number in the figure give water depth of isobath in meters.

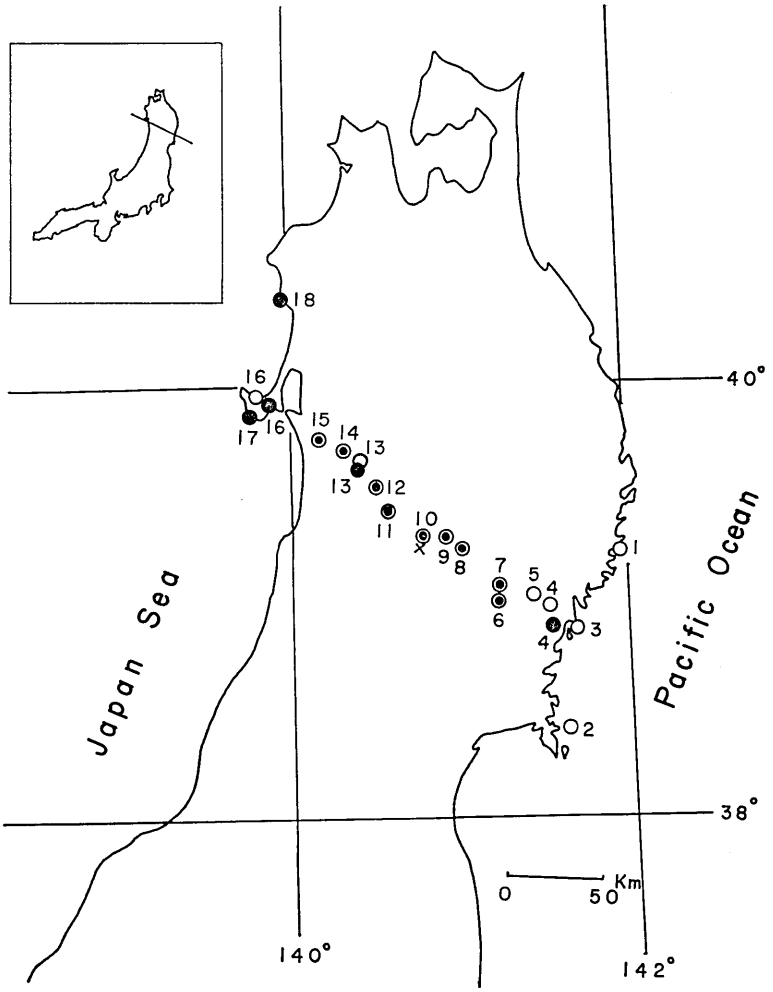

Fig. 1(b). Observation sites.
cross mark: Tutihata shot point
open circle: observation sites for the Off Kesennuma explosions
closed circle: observation sites for the Tutihata and the Off Oga Peninsula explosions
⊙: observation sites for three explosions
Numbers in the figure correspond to those in Tables 2 and 4 except K and O.

vation sites including three hydrophone stations to locate shot points were set up on land as given in Fig. 1 and in Table 2. These stations were equipped with electromagnetic seismometers with natural frequen-

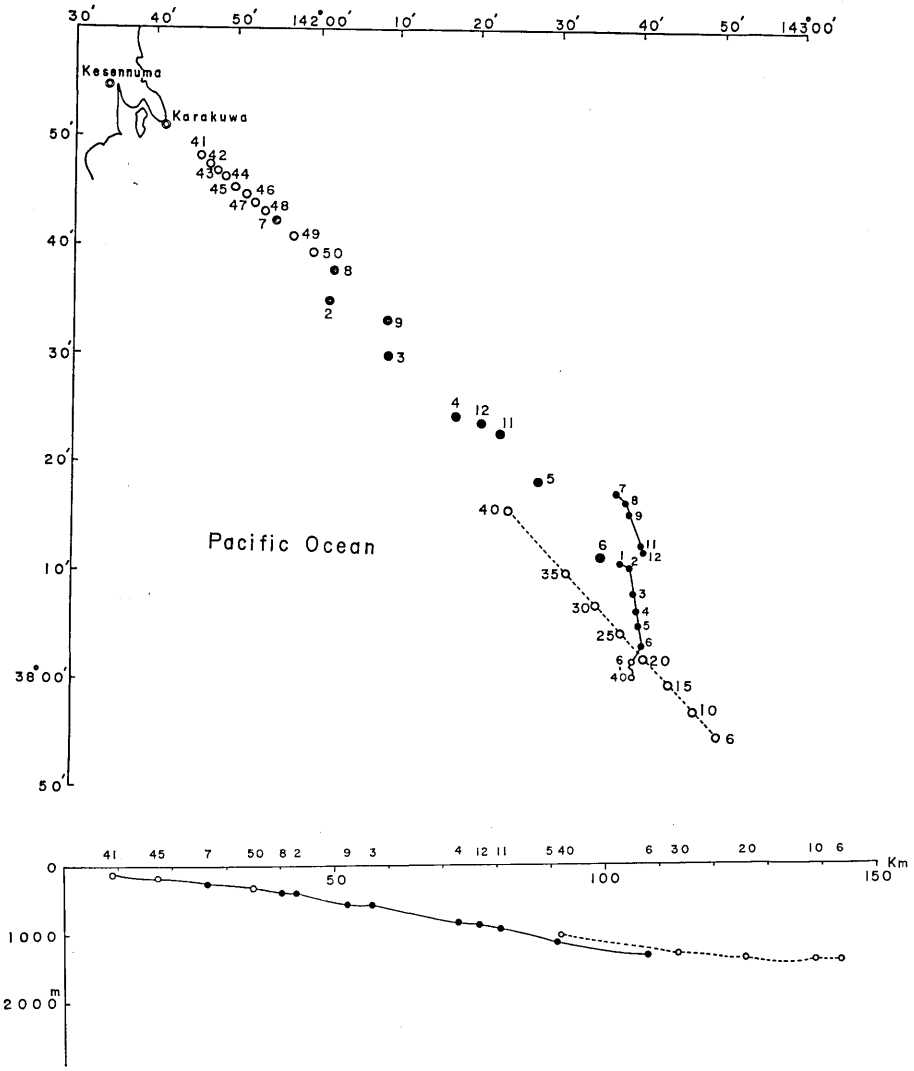

Fig. 1(c). The locations of shot points and the receiving vessel and the topography in the Off Kesennuma explosions.

Large open circle: Test shot
Large closed circle: Shot
Small open circle: the position of receiving vessel for the shot with given number
Small closed circle: the position of receiving vessel for the test shot

The topography of sea bottom under the shot points is given in the lower part and the abscissa is the distance from Karakuwa.

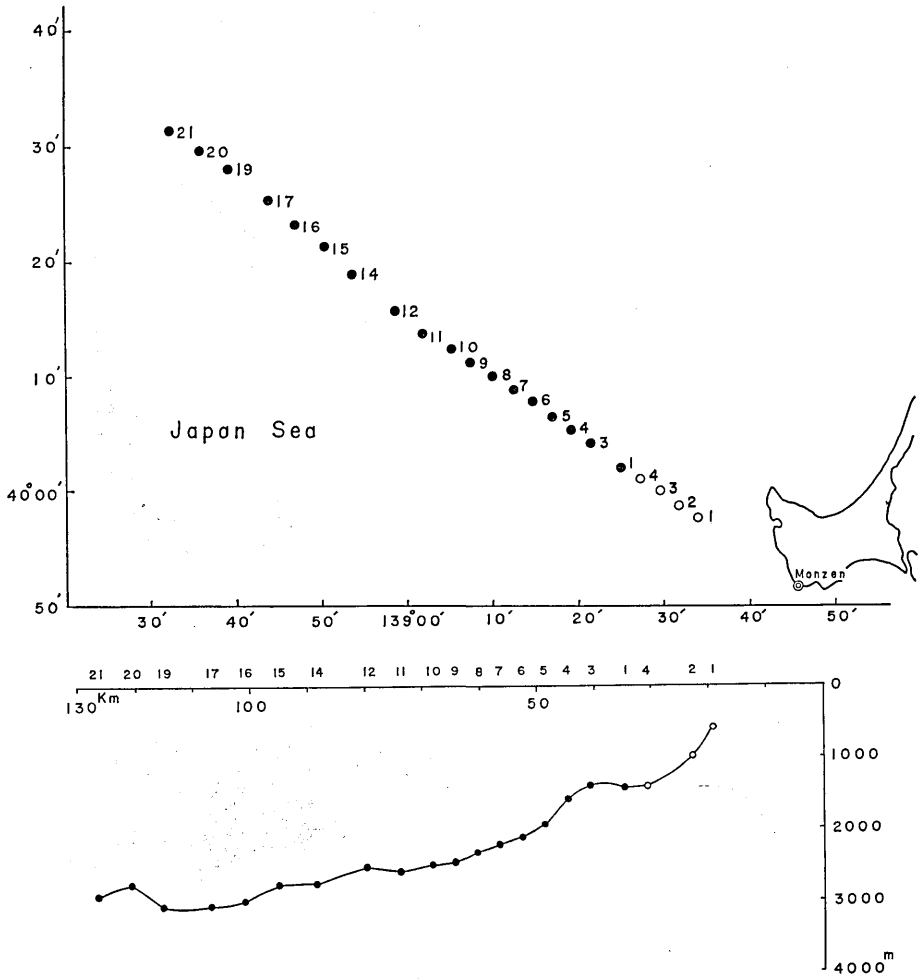

Fig. 1(d). The locations of shot points and the topography in the Off Oga Peninsula explosions.

Open circle: Test shot
Closed circle: Shot

The topography of sea bottom under the shot points is given in the lower part and the abscissa is the distance from Monzen.

cies of 1 to 4 cps and magnetic tape recorders. The ceramic type hydrophones with preamplifier for shot point determination have uniform frequency characteristics in the range 100–10000 cps.

The shooting vessel was the Meiyo-maru of the Hydrographic Office, Maritime Safety Board. The explosives with blasting cap and an ap-

propriate fuse length were dropped from the shooting vessel sailing with constant speed as is usually done in deep sea seismic exploration. The location of shot, the charge size, the shot depth etc. for each explosion are given in Table 1.

In this experiment, there was a receiving vessel at sea, the Seihumaru of the Maizuru Marine Observatory, Japan Meteorological Agency. The receiving vessel was located frequently with LORAN (Table 8). The observation at sea was done with three hydrophones and the technique is the same as that of deep sea seismic exploration.[5]

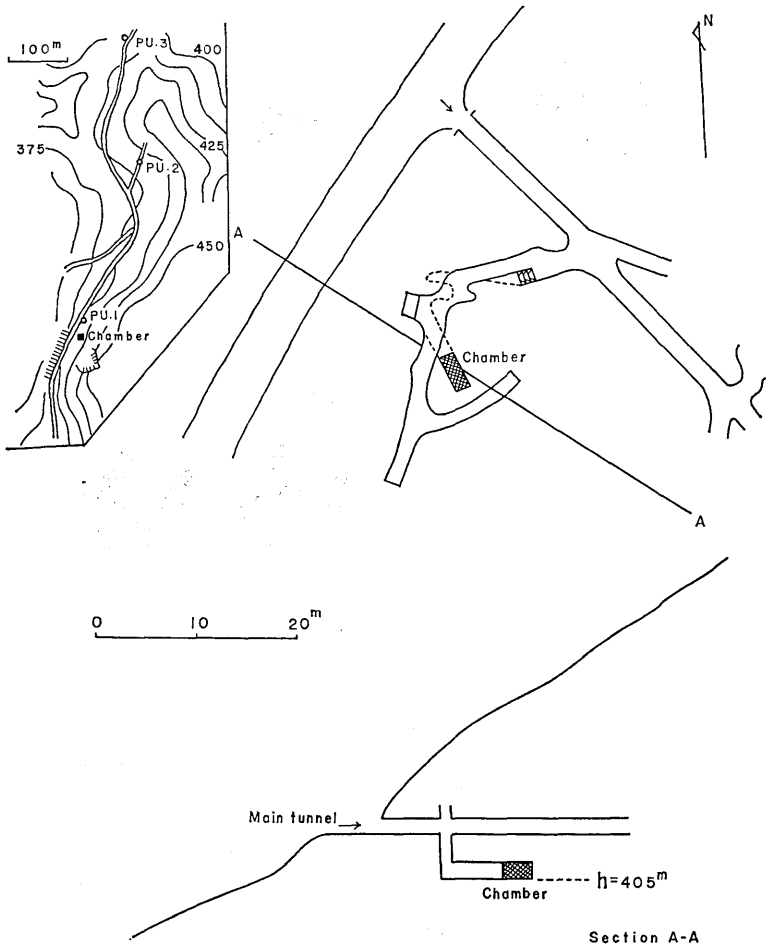

Fig. 2(a). Tutihata shot point.

5) G. G. SHOR, *The Sea*, 3 (Interscience Publishers, 1963), 20.

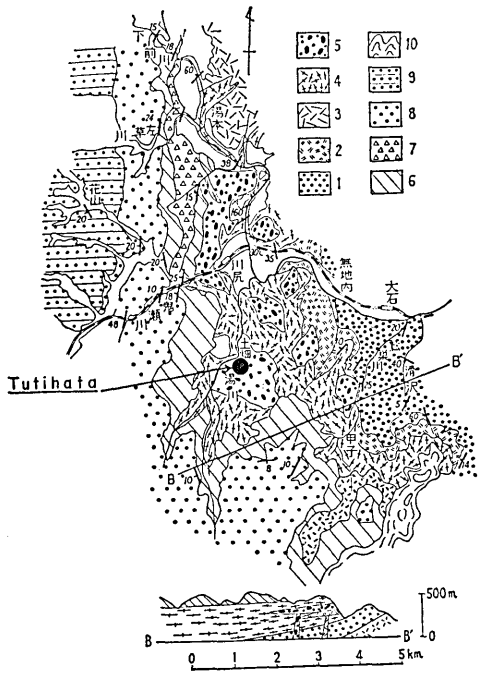

Fig. 2(b). Geology around the Tutihata shot point.[6]

1-4 Ōisi formation
5 rhyolite
6-7 Kotunagisawa formation
8 Kurosawa formation
9 Hanayama formation
10 andesite

On March 5 in 1966 an explosion at the Tutihata Mine, Iwate Prefecture was carried out and on March 9 to 10 in 1966 twenty-one shots were fired at sea off Oga Peninsula (Fig. 1). In these experiments, observation stations were the same as, or very close to, those for the Off Kesennuma explosions except for several sites (Table 4). The topography and the geology around Tutihata shot point are given in Fig. 2. Two tons of dynamite were put into the abandoned level as shown in Fig. 2(a) and this level was closed near the charge chamber. There were two hydrophone stations, Monzen and Iwadate, to locate shot points in the Off Oga Peninsula explosions. The shooting vessel was the Katumaru, a catcher boat of Nihon Kinkai Hogei Company. The amount of explosives, shot depth, location of shot, shot time, etc. are given in Table 3.

The positions of observation points for three explosion experiments were fixed with triangulation and air photos.

3. The location of shot points

As mentioned previously, there were three hydrophone stations for the Off Kesennuma explosions and two, for the Off Oga Peninsula explosions. In each station, hydrophones were suspended in the intermediate depth between sea surface and bottom. Water was usually 10

6) Y. FUJITA *et al.*, *Monograph* **12**, *The Association for the Geological Collaboration in Japan* (1966), 51.

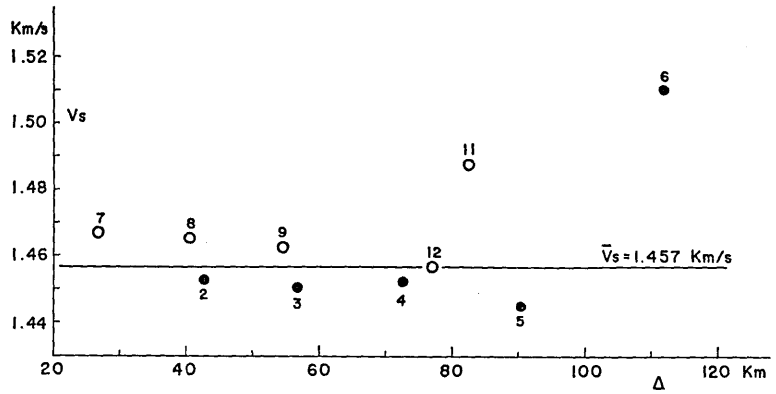

Fig. 3. The sound velocity in water determined from the three hydrophone stations in the Off Kesennuma explosions. The abscissa is the distance from Karakuwa.

to 30 m deep and hydrophones were more than one hundred meters from the coast. Direct sound waves through water from almost all shots were recorded clearly.

Since the unknown quantities are the latitude and longitude of shot point and the sound velocity in water, more than three hydrophone stations are necessary to determine these unknowns. In the Off Kesennuma explosions, at first the unknowns for each shot were determined numerically.

The sound velocity in water for each shot thus obtained is shown in Fig. 3. Except for that for Shot 6 and 11, the sound velocity in water is determined fairly well and its average except Shot 6 and 11 is 1457 m/s. Applying this average sound velocity to all shots, the locations of shot points were adjusted. From surface temperature measurement of water, the sound velocity 1460 m/s was obtained by assuming salinity as normal, $35^0/_{00}$, and using Mathew's Table. This value is quite close to the adopted velocity.

In the Off Oga Peninsula explosions, there were only two hydrophone stations. First, the average observed sound velocity was determined for each station from the locations of shot points determined by LORAN. The average value for station Monzen was 1476 m/s with probable error 5.0 m/s and that for station Iwadate, 1475 m/s with probable error 4.5 m/s. The agreement of these two values is quite good. Assuming 1476 m/s as the sound velocity in water for all shots, the corrections to the locations of shot points were derived.

The locations of shot points thus obtained are estimated to be determined within several hundred meters.

4. Observational results

As given in Table 1, the charge size for each shot was fairly small for the covered epicentral distance. The largest size of explosives was 450 kg in the Off Kesennuma explosions and 475 kg in the Off Oga Peninsula explosions. From 450 kg shot available data were obtained up to 270 km in the Off Kesennuma explosions and up to 315 km in the Off Oga Peninsula explosions. This seems to be due to the large yield of explosion in water in comparison with the yield of shot on land, even shot in a hole. Furthermore unexpectedly large amplitudes of seismic waves were registered at distant stations even from such small charge size as 25 or 50 kg in the Off Kesennuma explosions. The largest epicentral distance for available first arrivals is 195 km for 50 kg shot and 175 km for 25 kg shot. The amplitudes of seismic waves were not so small in comparison with 300 or 450 kg shots. It is not clear how such an amount of energy can be transmitted into the sea bottom and propagate for long range. Seismograms obtained are given in Figs. 4-6.

Since 1964 a tape recording system with almost the same characteristics has been adopted by all crews, this serves to improve the quality of data in addition to good propagation of energy. Also the amount of data is large enough to determine a reasonable crustal structure since seismic waves from more than seventy shots were recorded at about fifteen stations.

In spite of the favourable situations mentioned above, some of the first arrivals are weak or emergent (Figs. 4 and 6). Taking the accuracy of identification, the clearness of phase, etc. into account, each reading was classified into the following four grades:

A: very clear first arrivals
B: clear first and later arrivals
C: fairly clear first and later arrivals
D: inaccurate identification (ambiguity is larger than 0.1 sec) or doubtful phases.

However, if "⌜" mark puts on time, for example, ⌜5.58 sec, it is quite certain that at this instant, 5.58 sec, seismic waves from shots are present already and first arrivals must be earlier than this time even

though the phases were classified as "D". Travel times of the Off Kesennuma, the Off Oga Peninsula and the Tutihata explosions are given in Tables 5, 6 and 7 respectively. The data of the receiving vessel are given in Table 9, which are derived from the original readings by applying such corrections as the shot instant and the shot depth as in the deep sea seismic exploration.[7]

The results of analysis of these data are given in Part 2 under the same title.[8]

5. Acknowledgement

We are much obliged to the following authorities and organizations for their support and cooperation given to us:
Maritime Safety Board, especially Guard and Rescue Division, Hydrographic Office, Regional Maritime Safety Headquarters and Maritime Safety Office concerned; Japan Meteorological Agency, especially Maizuru Marine Observatory; Nihon Hoso Kyokai (Japan Broadcasting Corporation); Nihon Kinkai Hogei Company; Tutihata Mine; prefectural authorities, police headquarters and stations, provincial offices concerned; Kesennuma High School of Fishery; fishermen unions concerned.

Our thanks are also due to Emeritus Professor H. Kawasumi, and Professor T. Hagiwara, the former directors of Earthquake Research Institute for their encouragement in the project. Sincere thanks are extended to Misses K. Fuzii, S. Sugimoto and E. Iwata for their assistance in preparing tables and figures.

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

---

7) C. B. OFFICER, J. I. EWING, J. F. HENNION, D. G. HARKRIDER, and D. E. MILLER, *Physics and Chemistry of the Earth*, **3** (Pergamon Press, London, 1959), 17.

8) M. HASHIZUME, K. OIKE, S. ASANO, H. HAMAGUCHI, A. OKADA, S. MURAUCHI, E. SHIMA, and M. NOGOSHI, *Bull. Earthq. Res. Inst.*, **46** (1968), 607-630.

25. 爆破地震動観測による東北日本を横断する測線上の地殻構造

第1部 気仙沼沖，男鹿半島沖及び土畑爆破地震動の観測

爆破地震動研究グループ

昭和40年3月中旬，宮城県気仙沼沖で50個以上の海中爆破が東北地方を横切る測線上の16個の観測点及び海上観測船のために行われた．薬量は最高450 kgで，小量で遠方まで良好な記録が得られた．又，昭和41年3月上旬，土畑鉱山で1回，秋田県男鹿半島沖で20個以上の海中爆破が気仙沼沖爆破と，ほぼ同じ観測点で観測された．この時も最高薬量475 kgで300 kmを超える距離まで，かなり良好な記録が得られた．海上爆破点の位置は気仙沼沖爆破では3個所，男鹿沖爆破では2個所での水中音波の観測によって推定された．これらの爆破と，得られた観測資料について報告されている．

尚，本研究は国際地球内部開発計画，文部省科学研究費，地震研究所特別事業費によって実施された．記して感謝の意を表する．

Table 1. Charge size, shot time, locations of shot points, shot depth and water depth in the Off Kesennuma explosions.

Shot No.	Charge size	Corrected shot time*	Shot point Latitude (N)	Shot point Longitude (E)	Shot depth	Water depth	
	kg	1965				**m	sec
shot 1	300					255	0.170
		h m s	° ′ ″	° ′ ″	sec		
2	〃	Mar. 11 23 03 13.478	38 35 05.2	142 01 39.7	0.200	400	0.267
3	450	Mar. 12 00 03 26.307	38 30 06.0	142 08 55.0	0.216	588	0.392
4	〃	〃 01 03 28.836	38 24 41.1	142 17 38.8	0.218	848	0.565
5	〃	〃 02 03 25.677	38 18 44.4	142 27 42.6	0.214	1140	0.760
6	〃	〃 03 03 28.827	38 11 52.5	142 35 22.4	0.220	1347	0.897
7	〃	Mar. 14 23 13 29.647	38 42 24.0	141 54 53.3		256	0.167
8	〃	Mar. 15 00 03 27.802	38 37 56.2	142 02 05.2	0.218	403	0.263
9	〃	〃 01 03 27.086	38 33 18.3	142 08 48.9	0.218	567	0.373
10							
11	〃	〃 02 58 28.763	38 23 02.0	142 22 53.4	0.227	946	0.631
12	300	〃 03 22 40.192	38 24 04.2	142 20 28.7	0.240	881	0.590
test 41	25	Mar. 14 22 13 07.983	38 48 19.4	141 45 22.8	0.041	143	0.095
42	〃	〃 22 19 57.134	38 47 38.4	141 46 29.1	0.034	152	0.101
43	50	〃 22 27 08.510	38 46 57.1	141 47 36.2	0.045	160	0.106
44	〃	〃 22 33 09.396	38 46 21.2	141 48 33.5	0.045	166	0.110
45	〃	〃 22 41 15.715	38 45 29.2	141 49 57.2	0.049	178	0.118
46	〃	〃 22 48 23.511	38 44 47.2	141 51 03.8	0.074	190	0.125
47	〃	〃 22 55 22.540	38 44 02.7	141 52 15.4	0.074	205	0.136
48	〃	〃 23 02 23.301	38 43 17.2	141 53 27.8	0.074	224	0.148
49	〃	〃 23 23 24.499	38 40 59.0	141 57 09.7	0.074	284	0.188
50	〃	〃 23 36 26.475	38 39 33.4	141 59 33.7	0.074	328	0.217

(to be continued)

* Shot time is corrected to a shot at sea surface.

** The sound velocity in water is assumed to be 1500 m/s.

Table 1.

(continued)

Shot No.	Charge size	Corrected shot time	Shot depth	Water depth	
	kg	h m s	sec	m	sec
test 1	25	Mar. 11 20 01 10.291	0.040	260	0.173
2	〃	〃 20 11 51.422	0.068	273	0.182
3	〃	〃 20 22 41.905	0.100	287	0.191
4	〃	〃 20 41 10.455	0.042	313	0.209
5	〃	〃 20 51 09.999	0.042	327	0.218
6	10	Mar. 12 05 03 57.492	0.038	1418	0.945
7	〃	〃 05 07 57.515	0.038	1404	0.936
8	〃	〃 05 11 57.925	0.038	1431	0.954
9	〃	〃 05 15 57.718	0.038	1422	0.948
10	〃	〃 05 19 56.664	0.038	1436	0.957
11	〃	〃 05 23 57.239	0.038	1430	0.953
12	〃	〃 05 27 58.304	0.038	1440	0.960
13	5	〃 05 31 52.132	0.020	1455	0.970
14	〃	〃 05 35 53.522	0.021	1458	0.972
15	2	〃 05 40 20.661	0.010	1461	0.974
16	〃	〃 05 44 25.567	0.012	1451	0.967
17	〃	〃 05 48 25.467	0.012	1442	0.961
18	〃	〃 05 52 25.070	0.011	1427	0.951
19	〃	〃 05 56 24.590	0.011	1412	0.941
20	〃	〃 06 00 22.731	0.011	1389	0.926
21	〃	〃 06 04 24.587	0.011	1377	0.918
22	〃	〃 06 08 26.637	0.012	1382	0.921
23	〃	〃 06 12 25.250	0.011	1367	0.911
24	〃	〃 06 16 25.449	0.011	1352	0.901
25	〃	〃 06 20 25.012	0.011	1343	0.895
26	〃	〃 06 24 26.066	0.012	1338	0.892
27	5	〃 06 28 54.073	0.021	1329	0.886
28	〃	〃 06 32 52.493	0.020	1314	0.876
29	〃	〃 06 36 52.422	0.020	1311	0.874
30	10	〃 06 41 58.596	0.038	1304	0.869
31	〃	〃 06 45 58.226	0.038	1292	0.861
32	〃	〃 06 49 56.368	0.038	1275	0.850
33	〃	〃 06 55 00.270	0.038	1254	0.836
34	16	〃 06 58 58.819	0.042	1230	0.820
35	25	〃 07 05 11.855	0.042	1200	0.800
36	〃	〃 07 11 12.360	0.042	1185	0.790
37	50	〃 07 21 08.801	0.043	1158	0.772
38	〃	〃 07 31 08.580	0.043	1124	0.749
39	〃	〃 07 41 09.499	0.084	1074	0.716
40	100	〃 07 51 21.053	0.080	1040	0.693

Table 2. Locations of observation sites and observers in the Off Kesennuma explosions.

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Observers
		° ′ ″	° ′ ″	m	
K- 1	Kamaisi S	39 13 19.7	141 55 34.5	10	M. Hashizume, K. Mino,
	〃 H	39 13 03.9	141 55 51.4	−25	K. Kurokawa, Y. Matuo
K- 2	Enosima S	38 23 52.6	141 36 02.1	15	E. Shima, M. Sibano,
	〃 H	38 24 07.5	141 36 14.8	−20	Y. Ichinose
K- 3	Karakuwa S	38 51 21.4	141 40 35.3	20	T. Asanuma, Y. Hirobe,
	〃 H	38 51 15.5	141 40 41.5	−20	Y. Saizyō
K- 4	Kesennma	38 58 33.1	141 30 49.9	155	N. Nakazima, T. Terashima
K- 5	Daitō	39 01 40.5	141 25 12.4	170	K. Yamamoto, K. Abe, K. Tanaka
K- 6	Higasiyama	39 00 16.5	141 13 05.5	205	I. Karakama, S. Kubota, T. Takahashi, Y. Okuma
K- 7	Mizusawa	39 03 57.1	141 13 45.1	255	T. Asada, H. Shimamura, T. Namie
K- 8	Iwasaki-sinden	39 15 02.9	141 01 25.1	156	H. Watanabe, M. Nakamura
K- 9	Waka-sennin	39 18 26.3	140 54 42.7	165	T. Ōida, T. Tada
K-10	Yuda	39 18 01.6	140 46 56.4	250	Y. Motoya, S. Nakai, T. Moriya
K-11	Rokugō	39 24 18.1	140 34 46.3	62	M. Katsumata, M. Seino, T. Ishizawa, Y. Kawamura
K-12	Nakasen	39 31 58.7	140 31 27.0	80	K. Oike, S. Takemoto, U. Magari
K-13	Miyatamata	39 39 15.3	140 24 56.6	240	I. Muramatu, S. Suzuki, Y. Tooyama
K-14	Kayamori	39 42 54.5	140 18 35.7	90	S. Asano, M. Yanagisawa, M. Imaizumi
K-15	Matubara	39 45 52.3	140 10 12.9	40	O. Kawamoto, Y. Ohba, Y. Nakamori
K-16	Kitaura	39 57 27.9	139 46 49.4	30	K. Noritomi, S. Nabetani, M. Nogoshi
Shooting Vessel, Meiyo-maru					S. Murauchi, K. Ichikawa, K. Hagiwara
Receiving Vessel, Seihu-maru					N. Den, T. Murase, S. Iizuka, T. Yoshii
Surveyer					A. Okada

Table 3. Charge size, shot time, locations of shot points, shot depth and water depth in the Off Oga Peninsula explosions.

Shot No.	Charge size	Corrected shot time*	Shot point Latitude (N)	Shot point Longitude (E)	Shot depth	Water depth	
	kg	1966 h m s	° ′ ″	° ′ ″	sec	**m	sec
test 1	10	Mar. 9 22 20 57.344	39 57 37.8	139 34 07.3	0.050	593	0.395
2	10	〃 22 30 58.043	39 58 40.2	139 31 47.3	0.045	986	0.657
3	22.5	〃 22 41 31.749	40 00 00.2	139 29 40.9	0.058	1359	
4	25	〃 22 51 10.938	40 01 00.3	139 27 19.5	0.054	1420	0.947
Shot 1	300	〃 23 02 25.536	40 01 58.9	139 24 54.8	0.136	1425	0.950
2							
3	〃	〃 23 18 25.261	40 04 02.3	139 21 29.7	0.136	1404	0.936
4	〃	〃 23 28 21.723	40 05 14.2	139 19 15.1	0.156	1593	1.062
5	〃	〃 23 38 29.318	40 06 23.5	139 17 00.1	0.144	1948	1.299
6	〃	〃 23 48 26.233	40 07 44.5	139 14 42.3	0.141	2129	1.419
7	〃	〃 23 58 25.983	40 08 48.9	139 12 22.6	0.143	2214	1.476
8	〃	Mar. 10 00 08 22.088	40 09 59.2	139 10 02.0	0.149	2339	1.559
9	〃	〃 00 18 32.523	40 11 09.0	139 07 43.0	0.136	2470	1.647
10	〃	〃 00 28 26.334	40 12 14.1	139 05 15.9	0.137	2504	1.669
11	〃	〃 00 42 22.388	40 13 42.1	139 01 55.2	0.146	2594	1.729
12	450	〃 00 57 28.991	40 15 46.1	138 58 43.5	0.137	2532	1.688
13							
14	〃	〃 01 20 24.074	40 18 51.6	138 53 52.9	0.162	2756	1.837
15	〃	〃 01 37 22.123	40 21 20.1	138 50 22.9	0.163	2777	1.851
16	〃	〃 01 52 16.280	40 23 12.3	138 47 00.5	0.160	2994	1.996
17	〃	〃 02 07 17.098	40 25 19.6	138 43 51.6	0.157	3062	2.041
18							
19	〃	〃 02 28 20.713	40 28 02.9	138 39 09.2	0.161	3062	2.041
20	〃	〃 02 42 21.221	40 29 43.2	138 35 54.1	0.164	2755	1.837
21	475	〃 02 57 13.733	40 31 20.6	138 32 21.4	0.179	2913	1.942
Tutihata	2000	Mar. 5 01 07 00.033	39 17 00.5	140 48 28.1	405 m (Height)		

* Shot time is corrected to a shot at sea surface.

** The sound velocity in water is assumed to be 1500 m/s.

Table 4. Locations of observation sites and observers in the Tutihata and the Off Oga Peninsula explosions.

Station No.	Observation point	Latitude (N)	Longitude (E)	Height	Observers
		° ′ ″	° ′ ″	m	
O-18	Iwadate S	40 23 52.5	139 58 50.2	20	M. Hashizume, H. Kobayashi, S. Iizuka
T, O-17	Monzen S-1	39 51 44.7	139 45 15.5	40	T. Asanuma, T. Saizyo, Y. Ichinose
	〃 S-2	39 51 49.9	139 45 26.8	75	
	〃 H	39 51 24.6	139 45 10.6		
T, O-16	Kampuzan	39 55 51.9	139 52 41.8	190	K. Noritomi, M. Nogoshi, Y. Ueda
T, O-15	Matubara	39 45 52.3	140 10 12.9	40	Y. Ohba, Y. Nakamori, N. Seto
T, O-14	Kayamori	39 42 58.2	140 18 40.4	90	H. Hamaguchi, Y. Sawada
T, O-13	Arakawa	39 37 24.8	140 23 27.4	95	N. Nakazima, M. Ichinose
T, O-12	Nakasen	39 31 58.7	140 31 27.0	80	K. Oike, T. Onoguchi
T, O-11	Rokugō (a)	39 24 19.4	140 34 45.5	62	T. Ōida, T. Tada, K. Kidono
T-10	Tutihata No. 1	39 17 01.5	140 48 28.2	410	T. Utsu, Y. Motoya, Y. Sasaki
	〃 No. 2	39 17 09.8	140 48 32.7	418	T. Usami
	〃 No. 3	39 17 16.5	140 48 31.9	412	
O-10	Yukawa (A)	39 15 54.6	140 46 35.8	320	
	〃 (B)	39 15 54.7	140 46 36.9	320	〃
T- 9	Waka-sennin	39 18 26.3	140 54 42.7	165	T. Yoshii, S. Suzuki, N. Sakaziri
O- 9	〃	39 18 28.2	140 54 45.5	165	
T, O- 8	Iwasaki-sinden	39 14 35.7	140 59 40.0	250	H. Watanabe, M. Nakamura, A. Kuroiso, T. Minami
T, O- 7	Mizusawa	39 03 57.1	141 13 45.1	255	H. Shimamura, T. Namie
T, O- 6	Higasiyama	39 00 16.5	141 13 05.5	205	M. Yanagisawa, S. Koresawa
T- 4	Kesennuma Pt. 2	38 52 28.7	141 32 21.6	60	S. Asano, A. Mochizuki
O- 4	〃 Pt. 2	38 52 29.4	141 32 20.7	60	
	〃 Pt. 1	38 52 31.0	141 32 17.4	60	
Shooting Vessel, Katu-maru					S. Murauchi, K. Ichikawa, K. Hagiwara
Surveyer					A. Okada

Table 5. Travel time data in the Off Kesennuma explosions.

* θ is the azimuth from the shot points to the stations.

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

*** O is the shot time.

**** $^{h}_{23}\,^{m}_{03}\,^{s}_{26.89}-\mathrm{B}(1.72)$ means that there is a later phase of class B at $^{h}_{23}\,^{m}_{03}\,^{s}_{26.89}$ with downward motion and its reduced travel time $\left(=\mathrm{P}-\mathrm{O}-\frac{\Delta}{6}\right)$ is 1.72.

***** The mark ⌈ means that although the signals can be identified at this time with certainty, the initial might be earlier than the reading.

Shot No.	Δ(km)	θ*	P	Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases
K-1 Kamaisi						*****	
		N° E	h m s **		s	s	****s
shot 2	71.297	7.09	23 03⌈26.60 −	B	13.32	⌈1.43	23 03 26.89− B (1.72)
3	82.268	13.57	00 03⌈40.87 −	B	14.78	⌈1.07	
4	95.492	19.54	01 03 45.33	D	16.71	0.79	01 03⌈45.56 D (1.03)
5	111.196	24.74	02 03⌈44.78 −	B	19.31	⌈0.61	
6	127.484	26.90	03 03⌈50.89 −	C	22.28	⌈1.03	
7	57.227	−0.99	23 13⌈40.32 +	A	10.84	⌈1.30	
8	66.149	8.18	00 03⌈40.98 −	A	13.40	⌈2.37	
9	76.479	14.50	01 03⌈39.72 +	B	12.99	⌈0.10	
11	101.098	23.02	02 58⌈46.32 +	B	17.79	⌈0.95	02 58 47.12+ B (1.75)
12	97.997	21.58	03 22⌈57.09 +	C	17.14	⌈0.81	03 22 58.70 D (2.42)
test 45	52.144	8.95	22 41⌈25.19 +	C	9.52	⌈0.83	
46	53.204	7.03	22 48⌈34.17 +	D	10.73	⌈1.86	
47	54.387	5.05	22 55⌈32.60 +	C	10.13	⌈1.06	
48	55.662	3.14	23 02⌈33.73 +	D	10.50	⌈1.22	
49	59.884	2.19	23 23⌈34.94 +	D	10.51	⌈0.53	
50	62.744	5.27	23 36⌈39.14 −	D	12.73	⌈2.27	
K-2 Enosima							
shot 2	42.640	119.10	23 03 22.26 +	A	8.98	1.88	
3	49.199	103.53	00 03 36.27 +	A	10.18	1.98	
4	60.589	91.41	01 03 40.82 +	A	12.20	2.09	
5	75.868	82.81	02 03 39.84 −	A	14.37	1.73	
6	89.304	75.61	03 03⌈44.61 +	C	16.00	⌈1.12	
7	43.866	141.37	23 13 38.04 −	A	8.56	1.25	
8	45.936	124.49	00 03 37.11 −	A	9.53	1.88	
9	50.758	110.10	01 03 37.31 −	A	10.70	1.97	
11	68.234	88.69	02 58⌈41.99	C	13.46	⌈2.09	
12	64.698	90.32	03 22⌈52.88 +	B	12.93	⌈2.15	
test 48	43.933	35.18	23 02 31.87 +	B	8.64	1.32	
49	44.087	44.13	23 23⌈35.09	D	10.67	⌈3.32	
50	44.835	49.69	23 36 35.63 +	D	9.22	1.75	

(to be continued)

Table 5.

(continued)

Shot No.		Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
K-3 Karakuwa											
			°N °E	h m s	**		s	s			****s
shot	2	42.880	45.42	23 03 22.39	+	A	9.11	1.96	23 03 23.24	C (	2.81)
	3	56.875	46.25	00 03Γ37.46	−	B	11.37	Γ1.89	00 03 40.33	C (	4.76)
	4	72.978	47.46	01 03Γ42.30	+	B		1.52	01 03 42.49	− B (	1.71)
									43.31	D (	2.53)
									45.12	D (	4.34)
	5	91.226	48.59	02 03Γ41.96	−	B	16.49	1.28	02 03 42.37	C (	1.69)
									42.89	C (	2.21)
									44.28	D (	3.60)
	6	108.049	47.47	03 03Γ47.86	+	B	19.25	Γ1.25	03 03 48.13	+ B (	1.52)
									48.58	D (	1.97)
									52.24	C (	5.63)
	7	26.519	51.33	23 13 35.29	−	A	5.81	1.39	23 13 35.60	D (	1.70)
	8	40.230	51.44	00 03 36.16	+	C	8.65	1.94			
	9	54.438	50.78	01 03Γ37.35		C	10.75	Γ1.68			
	11	80.710	49.52	02 58Γ43.37	−	C	14.84	Γ1.39	02 58 45.93	B (	3.95)
	12	76.803	48.91	03 22Γ54.38	+	B	14.43	Γ1.63	03 22 54.81	+ D (	2.06)
test	41	8.920	51.02	22 13 09.94	+	A	2.00	0.51			
	42	10.959	51.14	22 19 59.48	+	A	2.38	0.55			
	43	13.019	51.25	22 27 11.19	+	A	2.73	0.56			
	44	14.790	51.26	22 33 12.43	+	A	3.08	0.61			
	45	17.369	51.30	22 41 19.29	+	A	3.62	0.72			
	46	19.439	51.29	22 48 27.64	+	A	4.20	0.96			
	47	21.641	51.31	22 55 27.19	−	B	4.72	1.11			
	48	23.883	51.31	23 02 28.50	−	B	5.27	1.29			
	49	30.731	51.36	23 23 31.16	+	C	6.73	1.61			
	50	35.098	51.54	23 36 34.00	−	C	7.59	1.74			
K-4 Kesennuma											
shot	7	45.872	49.35	23 13 38.58	−	B	9.10	Γ1.45			
	8	59.174	49.87	00 03Γ39.28	−	C	11.70	Γ1.84	00 03 39.43	+ B (	1.99)
	9	73.771	49.67	01 03Γ40.85	−	B	14.25	Γ1.96			
	11	100.079	48.96	02 58Γ46.30		D	17.77	Γ1.09			
	12	96.180	48.45	03 22 56.96		D	17.01	0.98	03 22 57.44	+ B (	Γ1.46)
test	41	28.293	48.03	22 13 13.35	−	C	5.41	0.69			
	42	30.328	48.27	22 20 02.79	−	B	5.69	0.63			
	46	38.792	48.97	22 48 30.93		B	7.49	1.02			
K-5 Daito											
shot	2	72.140	47.01	23 03Γ27.13	−	C	13.85	Γ1.82	23 03 27.54	− C (	2.23)
	3	86.147	47.30	00 03Γ42.01	−	C	15.92	Γ1.56			

(to be continued)

Table 5.

(continued)

Shot No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
		No E	h m s	**		s	s			****s
4	102.266	48.00	01 03Γ46.64	−	D	18.02	Γ0.98			
5	120.521	48.78	02 03Γ46.70	+	D	21.23	Γ1.14			
6	137.337	47.87	03 03 52.05		D	23.44	0.55	03 03 52.43	+ B (	0.93)
7	55.806	50.29	23 13Γ40.03	+	B	10.55	Γ1.25	23 13 40.34	− B (	1.56)
8	69.113	50.55	00 03Γ40.87		C	13.29	Γ1.77	00 03Γ40.99	+ B (	Γ1.89)
9	83.716	50.26	01 03Γ42.08	−	C	15.48	Γ1.53			
11	110.006	49.47	02 58 47.63	−	D	19.10	0.77			
12	106.099	49.03	03 22 58.46	+	D	18.51	0.83	03 22Γ58.65	+ C (	Γ1.02)
test 41	38.213	49.73	22 13Γ14.74	+	C	6.80	Γ0.43			
42	40.251	49.83	22 20 04.07	−	D	6.97	0.26	22 20 04.38	− B (	Γ0.57)
43	42.309	49.92	22 27Γ15.97	+	B	7.51	Γ0.46			
44	44.080	49.98	22 33Γ17.22	+	C	7.87	Γ0.52			
46	48.722	50.11	22 48 32.42	+	C	8.98	0.86			
47	50.929	50.18	22 55 31.96	+	C	9.49	1.00			
48	53.170	50.22	23 02Γ33.23	+	C	10.00	Γ1.14			
49	60.016	50.37	23 23Γ35.72		D	11.29	Γ1.29			
50	64.380	50.54	23 36Γ38.78		C	12.37	Γ1.64			
K-6 Higasiyama										
shot 2	84.358	56.47	23 03Γ28.98	−	C	15.70	Γ1.64	23 03 29.77	D (	2.43)
3	98.278	55.38	00 03 43.96		D	17.87	1.49	00 03Γ44.04	− D (	1.57)
								44.94	D (	2.47)
4	114.415	54.87	01 03Γ48.86		C	20.24	Γ1.17	01 03 49.62	D (	1.93)
								50.52	D (	2.83)
5	132.740	54.63	02 03Γ48.40	+	C	22.93	Γ0.80	02 03 48.94	D (	1.34)
								49.30	+ D (	1.70)
								51.16	− D (	3.56)
6	149.265	53.15	03 03Γ54.02	−	C	25.41	Γ0.54			
7	68.906	61.32	23 13Γ42.12		B	12.64	Γ1.16			
8	82.067	59.77	00 03Γ42.85	−	C	15.27	Γ1.59	00 03 43.15	C (	1.89)
9	96.578	58.27	01 03Γ44.04	−	D	17.46	Γ1.37			
11	122.399	55.75	02 58Γ50.16	−	C	21.63	Γ1.23	02 58 51.53	C (	2.60)
12	118.440	55.56	03 23 00.67		D	20.72	Γ0.98	03 23Γ01.67	− D (	Γ1.98)
								01.92	C (	2.23)
test 41	51.646	64.65	22 13 17.15	−	A	9.21	0.60			
42	53.636	64.16	22 20 06.64	−	A	9.54	0.60			
43	55.652	63.71	22 27 18.28	−	A	9.82	0.54			
44	57.384	63.33	22 23 19.45	−	A	10.10	0.54			
45	59.913	62.83	22 41 26.25	−	A	10.58	0.59			
46	61.938	62.44	22 48Γ34.60	−	B	11.16	Γ0.84			
47	64.108	62.07	22 55Γ34.08	−	C	11.61	Γ0.92			

(to be centinued)

Table 5.

(continued)

Shot No.		Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
			N° E	h m s	**		s	s			****s
	48	66.313	61.71	23 02 35.34	−	C	12.11	1.06			
	49	73.068	60.76	23 23 37.88	+	D	13.45	1.27	23 23⌈38.03	+ B (	⌈1.42)
	50	77.399	60.32	23 36⌈40.84	+	C	14.43	⌈1.53			
K-7	**Mizusawa**										
shot	2	87.514	52.40	23 03 29.56	−	A	16.28	1.69			
	3	101.511	51.90	00 03⌈44.25	−	C	18.16	⌈1.24			
	4	117.673	51.88	01 03 48.92	+	B	20.30	0.69			
	5	135.994	52.05	02 03 48.53	+	D	23.06	0.39	02 03 48.72	+ C (	⌈0.58)
	6	152.670	50.88	03 03⌈54.30	−	C	25.69	⌈0.25	03 03 54.53	− C (	0.48)
									56.75	D (	2.70)
	7	71.604	56.17	23 13⌈42.61		D	13.13	⌈1.20			
	8	84.884	55.46	00 03⌈43.37	+	C	15.79	⌈1.64	00 03 43.75	D (	2.02)
	9	99.477	54.57	01 03 44.49	+	A	17.41	1.33			
	11	125.564	52.93	02 58 50.13		D	21.60	0.68	02 58⌈50.50	D (	⌈1.05)
	12	121.620	52.65	03 23 01.10		D	21.15	0.88	03 23⌈01.30	D (	⌈1.08)
K-8	**Iwasaki-sinden**										
shot	2	114.220	49.67	23 03⌈34.38	−	B	21.10	⌈2.06	23 03 34.60	D (	2.28)
									35.34	D (	3.02)
	3	128.236	49.57	00 03⌈48.77	−	D	22.68	⌈1.31	00 03 49.50	C (	2.04)
	4	144.385	49.81	01 03⌈53.85	+	C	25.23	⌈1.17			
	5	162.676	50.18	02 03⌈53.36	+	B	27.89	⌈0.77	02 03 53.58	D (	0.99)
									55.46	D (	2.87)
	6	179.439	49.36	03 03⌈58.86	+	B	30.25	⌈0.35	03 03 59.88	C (	1.37)
	7	98.029	51.97	23 13⌈47.40	−	C	17.92	⌈1.58			
	8	111.340	51.93	00 03⌈48.08	+	B	20.50	⌈1.94	00 03 48.60	D (	2.46)
	11	152.190	51.78	02 58⌈54.90	−	B	26.37	⌈1.01	02 58 56.34	D (	2.45)
	12	148.267	50.50	03 23⌈05.98	+	B	26.03	⌈1.32	03 23 06.81	D (	2.15)
test	41	80.430	52.07	22 13⌈22.62	−	C	14.68	⌈1.27			
	42	82.468	52.06	22 20⌈11.92	+	C	14.82	⌈1.07			
	47	93.151	51.99	22 55⌈39.53		D	17.06	⌈1.53			
	48	95.392	51.98	23 02⌈40.78	+	D	17.55	⌈1.65			
K-9	**Waka-sennin**										
shot	2	125.647	50.34	23 03⌈36.01	+	B	22.73	⌈1.79	23 03 36.81	C (	2.59)
	3	139.661	50.18	00 03 51.00		D	24.91	1.63	00 03⌈51.46	D (	⌈2.09)
									54.50	D (	5.13)
	4	155.816	50.34	01 03 54.58		D	25.96	−0.01	01 03 55.53	+ C (	⌈0.94)
									57.24	D (	2.65)

(to be continued)

Table 5.

(continued)

Shot	No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
			N° E	h m s	**		s	s			****s
	5	174.116	50.63	02 03⌈54.73	−	B	29.26	⌈0.23	02 03 56.54	D (	2.04)
									04 00.50	D (	6.00)
	6	190.859	49.82	03 04⌈00.26	+	B	31.65	⌈−0.16	03 04 01.21	D (	0.79)
									03.92	D (	3.50)
	7	109.498	52.49	23 13 49.21	+	B	19.73	1.48	23 13 50.84	D (	3.11)
	8	122.809	52.40	00 03⌈49.76	+	B	22.18	⌈1.71	00 03 50.41	C (	2.36)
									51.03	D (	2.98)
									51.43	D (	3.38)
	9	137.418	52.05	01 03 50.70		D	24.11	1.21	01 03⌈51.20	D (	⌈1.71)
									52.95	D (	3.46)
	11	163.639	51.22	02 58 55.98		D	27.45	0.18	02 58⌈56.36	D (	⌈0.56)
									58.12	D (	2.32)
test	42	93.939	52.66	22 20⌈13.76	+	D	16.66	⌈1.00			
	47	104.621	52.54	22 55⌈42.32		D	19.85	⌈2.41			
	48	106.862	52.52	23 02⌈43.57	+	D	20.34	⌈2.53			
	49	113.710	52.46	23 23⌈44.88		D	20.45	⌈1.50			
K-10	**Yuda**										
shot	5	182.500	53.06	02 03⌈56.48	+	D	31.01	⌈0.59			
	6	199.119	52.08	03 04 01.41		D	32.80	−0.38	03 04⌈02.48	+ C (	⌈0.69)
	7	118.169	56.10	23 13⌈50.81	+	C	21.33	⌈1.63	23 13 50.96	D (	1.78)
	8	131.145	55.65	00 03⌈51.35	+	A	23.77	⌈1.86			
	11	172.094	53.77	02 58⌈57.89	+	C	29.36	⌈0.68			
test	41	100.630	56.90	22 13 25.79	+	D	17.85	1.08			
	42	102.661	56.80	22 20 15.09	+	D	17.99	0.88			
	47	113.308	56.30	22 55 42.71	+	D	20.24	1.35			
	48	115.542	56.20	23 02 44.27	−	D	21.04	1.78			
K-11	**Rokugo**										
shot	2	155.001	54.03	23 03⌈40.87		C	27.59	⌈1.75	23 03 41.56	C (	2.44)
	3	168.976	53.60	00 03 54.74		D	28.65	2.49	00 03⌈55.70	D (	⌈1.46)
									57.16	C (	2.91)
	4	185.134	53.44	01 03 59.10		D	30.48	−0.37	01 03 59.59	C (	⌈0.12)
	5	203.462	53.41	02 03 58.30		D	32.83	−1.09	02 03⌈59.33	D (⌈	−0.06)
	6	220.060	52.50	03 04⌈04.96	−	C	36.35	⌈−0.32			
	7	139.153	56.15	23 13 54.06		B	24.58	1.39			
	8	152.433	55.76	00 03 54.25		D	26.67	1.26	00 03⌈54.48	+ C (	1.49)
									55.06	C (	2.07)
	9	167.024	55.21	01 03⌈54.69		D	28.10	⌈0.27	01 03 59.24	D (	4.82)
	11	193.064	54.06	02 59⌈00.05	+	D	31.52	⌈−0.65	02 59 01.77	D (	1.07)

(to be continued)

Table 5.

(continued)

Shot	No.	Δ(km)	θ*	P	Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		****s
K-12	**Nakasen**		No E	h m s **		s	s			
shot	2	167.358	51.03	23 03Γ42.44	C	29.16	Γ1.27			
	3	181.369	50.86	00 03Γ56.10	D	30.01	Γ−0.22			
	4	197.527	50.93	01 04 00.32	D	31.70	Γ−1.22	01 04Γ00.68	D	(Γ−0.86)
	5	215.834	51.12	02 04Γ00.60	D	35.13	Γ−0.85			
	6	232.557	50.42	03 04 04.79	D	36.18	−2.58	03 04 05.15	D	(−2.22)
								05.40	D	(Γ−1.97)
	7	151.234	52.67	23 13 55.67	D	26.19	Γ0.98	23 13 55.96	C	(−1.27)
	8	164.544	52.59	00 03 55.72	D	28.14	0.71	00 03Γ55.94+	C	(Γ0.93)
								56.90	D	(1.89)
	9	179.154	52.31	01 03Γ56.43	D	29.84	Γ−0.02			
	11	205.366	51.61	02 59Γ01.38	D	32.85	Γ−1.37			
	12	201.435	51.42	03 23Γ12.03	D	32.08	−1.49	03 23Γ12.61	D	(Γ−0.91)
test	41	133.636	52.82	22 13Γ30.82 +	B	22.88	Γ0.61			
	42	135.675	52.80	22 20 20.31 +	B	23.21	0.60			
	47	146.356	52.71	22 55Γ47.64 +	C	25.17	Γ0.78			
	48	148.598	52.69	23 02Γ49.00 −	D	25.77	Γ1.00			
	49	155.445	52.63	23 23Γ51.39 +	C	26.96	Γ1.05			
	50	159.813	52.64	23 36Γ54.29 −	C	27.88	Γ1.24			
K-13	**Miyatamata**									
shot	2	183.086	49.58	23 03Γ43.69 +	D	30.41	Γ−0.11	23 03 44.49	C	(0.69)
	3	197.102	49.53	00 03Γ57.84 +	C	31.75	Γ−1.10			
	4	213.248	49.69	01 04 02.27 +	C	33.65	−1.89			
	5	231.531	49.96	02 04Γ01.86 −	D	36.39	Γ−2.20			
	6	248.306	49.39	03 14Γ07.16 −	C	38.55	Γ−2.83	03 04 08.84	C	(−1.15)
	7	166.843	50.92	23 13Γ57.81 −	B	28.33	Γ0.52			
	8	180.152	50.97	00 03Γ57.72 −	C	30.14	Γ0.13	00 03Γ58.45−	C	(Γ0.84)
	11	221.033	50.36	02 59 03.34 +	B	34.81	−2.02			
	12	217.117	50.16	03 23Γ14.45 −	C	34.50	Γ−1.69			
test	41	149.247	50.85	22 13Γ32.84 −	B	24.90	Γ0.02			
	42	151.285	50.86	22 20Γ22.32 −	B	25.22	Γ0.01			
	43	153.344	50.88	22 27Γ34.06 −	D	25.60	Γ0.04			
	44	155.116	50.88	22 23Γ35.13 −	D	25.78	Γ−0.07			
	45	157.694	50.89	22 41Γ42.07 −	C	26.40	Γ0.12			
	46	159.759	50.90	22 48Γ50.16 −	B	26.72	Γ0.09			
	47	161.966	50.90	22 55Γ49.65 −	D	27.18	Γ0.19			
	48	164.207	50.91	23 02 51.28	D	28.05	0.68			
	49	171.054	50.93	23 23Γ53.35	D	28.92	Γ0.41			
	50	175.419	50.98	23 36Γ56.21	D	29.80	Γ0.56	23 36 56.73	D	(1.14)

(to be continued)

Table 5.

(continued)

Shot	No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		****s
K-14	**Kayamori**		No E	h m s	**		s	s			
shot	2	194.386	49.80	23 03Γ45.59		C	32.31	Γ−0.09	23 03 46.55	C	(0.87)
	3	208.402	49.74	00 03 59.64		D	33.35	−1.19	00 03 59.81	D	(Γ−1.02)
	4	224.550	49.88	01 04Γ04.20		C	35.58	Γ−1.84	01 04 05.46	D	(−0.58)
	5	242.836	50.12	02 04Γ03.11		D	37.64	Γ−2.84	02 04Γ03.58	D	(Γ−2.37)
									05.15	C	(−0.80)
	6	259.605	49.56	03 04 09.26		D	40.65	−2.61	03 04Γ09.50	C	(Γ−2.37)
	7	178.154	51.07	23 13Γ59.65	+	B	30.17	Γ0.48			
	8	191.463	51.11	00 03Γ59.47	−	C	31.89	Γ−0.02	00 04 00.21	D	(0.72)
	9	206.066	50.97			D					
	11	232.340	50.51	02 59Γ05.30	+	C	36.77	Γ−1.95			
	12	228.423	50.32	03 23Γ16.23		D	36.28	Γ−1.79			
test	41	160.556	51.03	22 13Γ34.81	+	C	26.87	Γ0.11			
	42	162.595	51.03	22 20Γ24.26	+	C	27.16	Γ0.06			
	47	173.276	51.06	22 55Γ51.70	+	C	28.23	Γ0.35			
	48	175.518	51.07	23 02Γ53.04	+	B	29.81	Γ0.56			
	49	182.365	51.08	23 23Γ55.38	+	B	30.95	Γ0.56			
	50	186.730	51.12	23 36Γ57.73	+	C	31.32	Γ0.20	23 36 58.37	+ B	(0.84)
K-15	**Matubara**										
shot	2	207.132	50.79	23 03Γ48.18		D	34.90	Γ0.38	23 03 50.24	D	(2.44)
	6	272.338	50.32	03 04Γ11.35		D	42.74	Γ−2.65			
	7	190.967	52.06	23 14Γ01.47		C	31.99	Γ0.16			
	8	204.279	52.03	00 04 01.41		D	33.56	−0.49	00 04Γ01.38	D	(Γ−0.25)
									04.00	D	(2.37)
									05.54	D	(3.91)
	11	245.125	51.31	02 59Γ07.55		D	39.02	Γ−1.83			
test	41	173.368	52.11	22 13Γ36.88	−	C	28.94	Γ0.04			
	42	175.407	52.11	22 20 26.49	+	D	29.39	0.15	22 20Γ26.96	C	(Γ0.62)
	43	177.467	52.11	22 27 38.82		D	30.36	0.78			
	44	179.238	52.10	22 23Γ40.82		D	31.47	Γ1.60			
	45	181.818	52.09	22 41Γ46.05		D	30.38	Γ0.08			
	46	183.882	52.08	22 48Γ54.32	+	B	30.88	Γ0.23			
	47	186.089	52.07	22 55Γ54.28	+	D	31.81	Γ0.79			
	48	188.331	52.06	23 02Γ55.12	−	C	31.89	Γ0.50			
	49	195.179	52.05	23 23Γ57.28	−	C	32.85	Γ0.32			

Table 6. Travel time data in the Off Oga Peninsula explosions.

* θ is the azimuth from the shot points to the stations.

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

*** O is the shot time.

**** $^{h}_{23}\ ^{m}_{03}\ ^{s}_{62.89}$-B(1.72) means that there is a later phase of class B at $^{h}_{23}\ ^{m}_{03}\ ^{s}_{26.89}$ with downward motion and its reduced travel time $\left(=P-O-\frac{\Delta}{6}\right)$ is $^{s}_{1.72}$.

***** The mark ⌈ means that although the signals can be identified at this time with certainty, the initial might be earlier than the reading.

Shot No.	Δ(km)	θ*	P	Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases
O-4 Kesennuma							
		°N °E	h m s **		s	s *****	****s
shot 1	223.367	125.12	23 03 02.18 +	C	36.78	−0.45	
3	229.528	125.20	23 19⌈00.61 +	C	35.49	⌈−2.77	h m s 23 19 02.80 D (−0.58)
4	233.412	125.19	23 29⌈58.28 +	D	36.71	⌈−2.19	
6	241.361	125.21	23 49 04.26 +	D	38.17	−2.06	23 49⌈06.04 D (⌈−0.28)
7	245.212	125.14	23 59 04.75	D	38.91	−1.96	23 59⌈07.04 D (⌈0.33)
8	249.182	125.11	00 09 00.70	D	38.76	−2.77	00 09 01.60 D (−1.87)
							⌈03.14 D (⌈−0.33)
9	253.111	125.08	00 19 11.55	D	39.17	−3.02	00 19⌈14.73 D (⌈0.16)
10	257.117	125.00	00 29⌈05.80	C	39.60	⌈−3.25	00 29 08.55 D (−0.50)
11	262.567	124.89	00 43 02.11	D	39.86	−3.90	00 43 02.69 D (−3.32)
12	268.463	125.01	00 58 09.53	D	40.67	−4.07	00 58⌈09.97 D (⌈−3.63)
14	277.356	125.16	01 21⌈05.90	D	41.89	⌈−4.34	01 21 09.70 C (−0.54)
15	284.033	125.34	01 38⌈04.62	C	42.66	⌈−4.68	
17	295.822	125.48	02 08⌈00.92	C	43.97	⌈−5.33	
19	304.159	125.52	02 29 05.26	D	44.70	−5.99	02 29⌈05.53 D (⌈−5.72)
20	309.698	125.49	02 43⌈06.72	D	45.67	⌈−5.95	
21	315.526	125.41	02 57⌈59.87	D	46.31	⌈−6.28	
O-6 Higasiyama							
test 4	188.679	126.55	22 51 42.88	D	32.01	0.56	22 51⌈43.14 C (⌈0.82)
shot 1	192.518	126.37	23 02 56.38	D	30.99	−1.10	23 02⌈56.79 D (⌈−0.69)
							58.28 B (+0.80)
3	198.687	126.42	23 18 56.23	D	31.10	−2.02	23 18⌈56.50 D (⌈−1.75)
							58.19 C (−0.06)
4	202.570	126.39	23 28 53.46	D	31.89	−1.88	23 28 55.70 C (0.36)
5	206.414	126.34	23 39⌈01.75	B	32.57	⌈−1.83	23 39 03.12 D (−0.46)
							04.15 D (0.57)
6	210.521	126.36	23 48 59.44	D	33.35	−1.74	23 49⌈00.16 C (⌈−1.02)
							01.80 C (0.62)
7	214.366	126.26	23 59 01.94	D	36.10	0.37	
8	218.333	126.21	00 08 56.75	D	34.81	−1.58	00 08⌈58.10 D (⌈−0.23)

(to be continued)

Table 6.

(continued)

Shot	No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases	
			N° E	h m s	**		s	s		****s
	9	222.260	126.15	00 19Γ09.25		D	36.86	Γ−0.18		
	10	226.295	126.04	00 29Γ01.48		D	35.29	Γ−2.42		
	11	231.700	125.89	00 42 58.34	+	C	36.11	−2.51		
	12	237.607	126.00	00 58 05.63	+	C	38.32	−1.28	00 58 07.18	D (+0.27)
	14	246.514	126.14	01 21Γ01.83		C	37.92	Γ−3.17	01 21 05.65	C (0.65)
	15	253.209	126.32	01 38 00.55	−	B	38.59	−3.61	01 38 03.85	D (−0.31)
	17	265.012	126.42	02 07 56.90	+	D	39.96	−4.21	02 07Γ57.07	D (Γ−4.04)
									08 02.32	D (1.21)
	19	273.354	126.44	02 29Γ01.48		B	40.93	Γ−4.63		
	20	278.891	126.39	02 43 02.19		C	41.13	−5.35		
	21	284.712	126.28	02 57 53.00		D	39.44	−8.01		
O-7	**Mizusawa**									
test	1	173.921	124.82	22 21 26.44		C	29.15	0.16		
	4	185.432	124.70	22 51 43.16		C	32.28	1.37		
shot	1	189.286	124.55	23 02 57.70		D	32.30	0.75	23 02Γ57.92	C (Γ0.97)
	3	195.444	124.66	23 18 57.39		D	32.26	−0.31	23 18Γ57.69	C (Γ−0.01)
	4	199.328	124.67	23 28Γ55.15		C	33.58	Γ0.36		
	5	203.174	124.65	23 39Γ01.58		D	32.41	Γ−1.45	23 39 06.19	C (−3.04)
	6	207.276	124.71	23 48 59.75		D	33.67	−0.88	23 49Γ00.01	D (Γ−0.62)
									02.10	D (1.47)
	7	211.128	124.64	23 59 00.70		D	34.86	−0.33		
	9	219.028	124.58	00 19 07.07		D	34.70	−1.81	00 19 09.80	D (−0.55)
	10	223.036	124.50	00 29 01.67		C	35.46	−1.71	00 29 02.90	D (−0.48)
	11	228.489	124.38	00 43Γ58.35		D	36.10	Γ−1.98		
	12	234.381	124.53	00 58 05.49		D	36.65	−2.42		
	14	243.268	124.73	01 21 01.58		D	37.67	−2.88	01 21 05.25	D (0.79)
	15	249.939	124.94	01 38 00.24		C	38.28	−3.38		
	17	261.724	125.11	02 07 56.70		C	39.76	−3.86	02 08 00.94	D (0.38)
	19	270.060	125.17	02.29 01.32		D	40.77	−4.24	02 29 07.05	D (1.49)
	20	275.599	125.15	02.43Γ02.70		C	41.64	Γ−4.29		
	21	281.428	125.06	02.57Γ55.85		C	42.30	Γ−4.61		
O-8	**Iwasaki-sinden**									
shot	1	161.429	122.89	23 02 53.42		D	28.03	1.12	23 02Γ54.11	C (Γ1.81)
	3	167.574	123.09	23 18 53.88	+	C	28.76	0.83	23 18 54.64	D (1.58)
	4	171.455	123.12	23 28 49.70		D	28.14	−0.44	23 28Γ50.39	D (Γ0.25)
	5	175.300	123.14	23 38 59.20		D	29.99	0.77	23 38 59.56	D (1.13)
									39 00.00	C (1.57)
	6	179.395	123.24	23 48 56.97		D	30.88	0.98	23 48Γ57.27	C (Γ1.28)
	7	183.250	123.19	23 58 58.00		D	32.16	1.62		

(to be continued)

Table 6.

(continued)

Shot	No.	Δ(km)	θ*	P	Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases
			No E	h m s **		s	s	****s
	8	187.221	123.19	00 08 53.90	D	31.96	0.76	
	9	191.151	123.19	00 19 05.10	D	32.72	0.86	
	10	195.161	123.12	00 28 56.75	D	30.55	−1.98	00 28Γ57.42 D (Γ−1.31)
	11	200.624	123.03	00 42Γ55.50	D	33.26	−0.18	
	12	206.500	123.23	00 58Γ02.38	D	33.52	Γ−0.90	
	14	215.366	123.51	01 20 58.40	D	34.48	−1.41	
	15	222.017	123.79	01 37 57.13	D	35.16	−1.84	
	17	233.783	124.04	02 07 52.62	D	35.60	−3.36	02 07Γ53.40 D (Γ−2.64)
	20	247.649	124.14	02 42 59.90	D	38.85	−2.43	
	21	253.483	124.06	02 57 52.63	D	39.09	−3.16	
O-9	**Waka-sennin**							
test	1	136.225	122.13	22 21 20.24	D	32.42	0.26	
	4	147.737	122.19	22 51Γ37.25	C	26.36	Γ1.74	
shot	1	151.606	122.07	23 02Γ51.80	D	26.40	Γ1.13	
	3	157.742	122.31	23 18Γ51.68	D	26.56	Γ0.27	
	4	161.620	122.37	23 28 48.66	D	27.10	0.16	
	5	165.464	122.40	23 38 56.30	D	27.13	−0.45	
	6	169.554	122.52	23 48 55.30	D	29.21	0.95	23 48Γ55.71 D (Γ1.36)
	7	173.411	122.49	23 58 55.80	D	29.96	1.06	
	8	177.381	122.50	00 08 51.76	D	29.82	0.26	00 08Γ52.69 D (Γ 1.19)
	10	185.325	122.46	00 28Γ56.85	D	30.65	Γ−0.24	
	11	190.788	122.38	00 42 52.78	D	30.54	−1.26	00 42Γ53.51 D (Γ−0.53)
	12	196.655	122.62	00 58 0.10	D	31.24	−1.54	00 58Γ00.82 D (Γ−0.82)
	15	212.150	123.25	01 37 55.05	D	33.09	−2.27	01 37Γ55.50 D (Γ−1.82)
O-10	**Yukawa**							
	1	144.623	126.11	23 02 51.08 +	C	25.68	1.58	
	3	150.791	126.19	23 18 50.51	D	25.38	0.25	13 18 51.16 C (Γ0.90)
	4	154.675	126.15	23 28 47.59	D	26.02	0.24	23 28Γ48.07 C (Γ0.72)
	5	158.518	126.09	23 38 55.91	D	26.74	0.32	23 38Γ56.75 C (Γ1.16)
	6	162.625	126.13	23 48 53.79	D	27.70	0.60	23 48Γ54.39 C (Γ1.20)
	7	166.470	126.01	23 58Γ54.91	C	29.07	Γ1.32	
	8	170.438	125.94	00 08Γ50.92	D	28.99	Γ0.58	
	9	174.366	125.88	00 19 1.65	D	29.26	0.20	00 19Γ02.65 C (Γ1.20)
	10	178.365	125.74	00 28 56.03	D	29.84	0.11	00 28Γ57.24+C(Γ1.32)
	11	183.808	125.56	00 42Γ52.64	D	30.41	Γ−0.23	00 42 54.20 C (1.33)
	12	189.713	125.71	00 57 59.60	D	30.75	−0.87	00 58Γ00.05 C (Γ−0.42)
	14	198.619	125.89	01 20Γ56.35	D	32.43	Γ−0.67	01 20 57.81 D (0.79)
	15	205.312	126.12	01 37Γ54.40	D	32.44	Γ−1.78	
	17	217.115	126.26	02 07 51.17	D	34.20	−1.99	

(to be continued)

Table 6.

(continued)

Shot	No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
			No E	h m s	**		s	s			****s
	19	225.458	126.29	02 28⌈58.60		D	37.11	⌈−0.47			
	20	230.994	126.23	02 43⌈57.51		D	36.45	⌈−2.05			
O-11	**Rokugo**										
test	1	106.359	125.40	22 21 16.43		C	19.14	1.41	22 21 16.96	C	(1.94)
	2	110.184	125.21	22 31 18.04		C	20.03	1.67	22 31 18.88	C	(2.51)
	4	117.866	125.14	22 51⌈32.72		D	21.83	⌈2.19	22 51 32.94	C	(2.41)
shot	1	121.715	124.91	23 02 47.47		D	22.07	1.78	23 02⌈47.64	D	(⌈1.95)
									47.97	C	(2.28)
	3	127.878	125.06	23 18⌈47.55		C	22.42	⌈1.11	23 18 48.13	C	(1.69)
	4	131.762	125.05	23 28 44.58		C	23.01	1.05	23 28 45.17	C	(1.64)
	5	135.607	125.02	23 38 52.90		B	23.73	1.13	23 38 53.54	C	(1.77)
	6	139.711	125.09	23 48⌈50.44		D	24.36	⌈1.07	23 48 51.38	C	(2.01)
	7	143.561	124.98	23 58⌈50.77		C	24.93	⌈1.00	23 58 51.79	C	(2.02)
	8	147.531	124.93	00 08⌈47.34		C	25.40	⌈0.81	00 08 48.54	D	(2.01)
	9	151.460	124.88	00 18⌈58.24		C	25.85	⌈0.61	00 18 59.52	C	(1.89)
	10	155.465	124.75	00 28 52.73		B	26.54	0.63	00 28 54.09	C	(1.99)
	11	160.915	124.58	00 42⌈49.42		C	27.42	⌈0.60	00 42 50.95	C	(2.13)
	12	166.812	124.78	00 57 56.69		B	27.84	0.04	00 57 58.70	D	(2.05)
	15	182.388	125.33	01 37⌈51.44		C	29.48	⌈−0.92	01 37 53.35	D	(0.99)
	17	194.182	125.53	02 07⌈48.03		C	31.08	⌈−1.28	02 07 50.65	D	(1.34)
	19	202.521	125.60	02 28 52.63		D	32.07	−1.68	02 28⌈52.76	C	(⌈−1.55)
									55.41	C	(1.10)
	20	208.059	125.55	02 42⌈53.44		D	32.39	⌈−2.29	02 42 56.58	C	(−0.65)
	21	213.885	125.42	02 57⌈46.94		D	33.38	⌈−2.27			
O-12	**Nakasen**										
test	1	94.643	120.10	22 21 14.28		D	16.98	1.21	22 21 14.53	C	(1.46)
	2	98.482	120.10	22 31 16.07	+	C	15.59	1.66	22 31 16.52	C	(2.11)
	4	106.142	120.40	22 51 30.56	+	C	19.68	1.99	22 51 31.28	C	(2.71)
shot	1	110.017	120.30	23 02 45.60		C	20.20	1.86	23 02 46.02	D	(2.28)
	3	116.132	120.72	23 18 45.80	−	C	20.68	1.32	23 18 46.14	D	(1.66)
	4	120.004	120.85	23 28 43.02		C	21.45	1.45			
	5	123.844	120.94	23 38 51.24	+	C	22.07	1.43	23 38 52.09	D	(2.28)
	6	127.924	121.15	23 48 48.79	−	C	22.70	1.38			
	7	131.782	121.14	23 58 49.14	−	C	23.30	1.34			
	8	135.749	121.20	00 08 45.78	−	B	23.85	1.22	00 08 46.55	−D	(1.99)
	9	139.676	121.26	00 18 56.70	−	C	24.32	1.04			
	10	143.692	121.22	00 28 51.16	−	B	24.96	1.01	00 28 52.05	D	(1.90)
	11	149.158	121.17	00 42 47.82	−	C	25.58	0.72	00 42 49.25	D	(1.14)
	12	155.009	121.51	00 57 55.05	−	C	26.20	0.36			

(to be continued)

Table 6.

(continued)

Shot	No.	Δ(km)	θ*	P	Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases
			No E	h m s **		s	s	**** s
	14	163.844	121.97	01 20 51.47 +	D	27.56	0.25	01 20 52.82 D (1.60)
	15	170.466	122.39	01 37 49.95 −	B	27.98	−0.43	
	17	182.207	122.08	02 07 46.31	D	29.37	−1.00	02 07Γ46.41−C(Γ−0.90)
								48.60 D (1.30)
	19	190.523	122.99	02 28 51.01	D	30.46	−1.29	02 28Γ51.15+C(Γ−1.15)
								53.62 D (1.32)
	20	196.060	123.02	02 42 52.01 −	C	30.96	−1.72	02 42 54.53 D (0.80)
	21	201.897	122.96	02 57Γ45.25	D	31.70	Γ−1.95	
O-13	**Arakawa**							
test	1	79.738	117.98	22 21 12.77	C	15.47	2.18	
	2	83.573	118.07	22 31 14.55	C	16.56	2.63	
	4	91.211	118.59	22 51 28.30	D	17.42	2.22	
shot	1	95.018	118.56	23 02 44.15	B	18.75	2.90	
	3	101.177	119.14	23 18 44.23	C	19.10	2.24	
	4	105.040	119.35	23 28 41.46	D	19.90	2.39	23 28 42.37 D (3.30)
	5	108.873	119.50	23 38Γ50.01	C	20.84	Γ2.69	
	6	112.941	119.79	23 48Γ47.70	C	21.61	Γ2.79	
	7	116.797	119.83	23 58 47.15	C	21.32	1.85	
	8	120.760	119.94	00 08 44.63	C	22.70	2.57	
	9	124.682	120.04	00 18 55.72	C	23.34	2.56	
	10	128.700	120.04	00 28 49.99	C	23.79	2.34	
	11	134.165	120.03	00 42 46.93	C	24.69	2.33	00 42 47.60 C (3.00)
	12	139.997	120.46	00 57 58.89	C	25.04	1.71	00 57 55.35 D (3.17)
	15	155.411	121.53	01 37Γ48.80	C	26.81	Γ0.91	
O-14	**Kayamori**							
test	1	69.096	113.11	22 21 10.41	D	13.12	1.60	22 21Γ10.72 C (Γ1.91)
	2	72.906	113.48	22 31Γ12.10	D	14.10	Γ1.95	
shot	1	84.330	114.65	23 02 41.67	D	16.27	2.21	
	3	90.340	115.56	23 18 42.02 −	C	16.89	1.83	
	4	94.172	115.94	23 28Γ39.13	D	17.57	Γ1.87	
	5	97.981	116.25	23 38 47.61 −	B	18.43	2.10	23 38 48.92 C (3.41)
	6	102.010	116.70	23 48 45.27 −	C	19.18	2.18	
	7	105.855	116.86	23 58 45.69	C	15.44	2.20	
	8	109.801	117.08	00 08 42.45	C	20.51	2.21	00 08 43.41 D (3.17)
	9	113.707	117.29	00 18Γ53.52	D	21.13	Γ2.18	
	10	117.718	117.39	00 28 47.94	C	21.75	2.13	
	11	123.178	117.49	00 42 44.67 −	C	22.43	1.90	
	12	128.959	118.07	00 57 51.94	C	23.08	1.59	

(to be continued)

Table 6.

(continued)

Shot	No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
			No E	h m s	**		s	s			****s
	14	137.706	118.83	01 20 48.04	−	C	24.13	1.18			
	15	144.252	119.48	01 37 46.65	−	C	24.69	0.65			
	16	150.107	119.73	01 53⌈45.54		D	29.42	⌈4.40			
	17	155.916	120.18	02 07 43.26	−	C	26.32	0.33			
	19	164.194	120.53	02 28⌈47.65		D	27.10	⌈−0.27	02 28 49.87	D (	1.95)
	20	169.720	120.64	02 42⌈48.64		D	27.58	⌈−0.71			
	21	175.558	120.65	02 57⌈41.82		D	28.26	⌈−1.00			
O-15	**Matubara**										
tset	1	55.876	112.92	22 21 8.42	−	C	11.12	1.81			
	2	59.685	113.38	22 31 10.13		C	11.13	1.18			
	4	67.240	114.61	22 51 24.77		C	13.89	2.68			
shot	1	71.111	114.78	23 02 39.72		D	14.29	2.44	23 02 39.85	C (	2.60)
	3	77.127	115.84	23 18⌈39.99	−	C	14.87	⌈2.01			
	4	80.963	116.27	23 28 37.27	−	C	15.70	2.21			
	5	84.775	116.61	23 38 45.75	−	B	16.58	2.45			
	6	88.810	117.11	23 48 43.26		C	17.17	2.37	23 48 46.34	D (	5.45)
	7	92.658	117.27	23 58 43.77		C	17.92	2.48			
	8	96.607	117.51	00 08 40.56		B	18.62	2.52			
	9	100.516	117.73	00 18 51.63		C	19.24	2.49			
	10	104.529	117.82	00 28 46.21		C	21.01	3.59			
	11	109.991	117.92	00 42⌈42.85		D	20.86	⌈2.53			
	12	115.783	118.54	00 57 50.17		C	21.72	2.42	00 57 50.82	C (	3.07)
	14	124.546	119.35	01 20⌈46.30	−	C	22.39	⌈1.63	01 20 46.67	C (	2.00)
	15	131.109	120.03	01 37 44.96		C	23.00	1.15	01 37 46.34	D (	2.53)
	17	142.793	120.75	02 07 41.52	−	C	24.58	0.78			
	19	151.081	121.10	02 28⌈45.76		C	25.20	⌈0.02			
	20	156.611	121.20	02 42⌈46.90	−	C	25.84	⌈−0.26			
	21	162.450	121.19	02 57 39.78		D	26.13	−0.85	02 57⌈40.21	C (⌈−0.42)	
O-16	**Kampuzan**										
test	1	26.655	97.04	22 21 04.10	−	A	6.80	2.36			
	2	30.223	99.89	22 31 05.61		C	7.61	2.57			
	4	37.350	104.75	22 51 20.11	+	B	9.23	3.00			
shot	1	41.135	105.87	23 02 35.29	+	B	9.89	3.03			
	3	46.907	108.81	23 18 35.48	+	B	10.35	2.53			
	4	50.649	110.02	23 28 32.59	+	B	11.02	2.58			
	5	54.390	110.98	23 38 41.09	+	A	11.92	2.85			
	6	58.338	112.13	23 48 38.77	+	A	12.68	2.96			
	7	62.150	112.68	23 58 39.24	+	A	13.40	3.04			

(to be continued)

Table 6.

(continued)

Shot	No.	Δ(km)	θ*	P		Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases		
			No E	h m s	**		s	s			****s
	8	66.057	113.30	00 08 36.01	+	B	14.07	3.06			
	9	69.929	113.86	00 18 47.08	+	C	14.70	3.04	00 18 47.59	D (	3.55)
	10	73.922	114.19	00 28 41.70	+	C	15.50	3.18	00 28 42.24	B (	3.72)
	11	79.362	114.57	00 42 38.60		D	16.36	3.13	00 42⌈38.70	C (	⌈3.23)
									39.05	C (	3.58)
	12	85.080	115.65	00 57 46.15	+	C	17.30	3.12	00 57 46.50	B (	3.47)
	14	93.758	116.99	01 20 42.51	−	B	18.60	2.97	01 20 42.95	C (	3.41)
	15	100.259	118.04	01 37 41.37	+	B	19.41	2.70	01 37 41.70	C (	3.03)
	16	106.098	118.48	01 52 36.38		D	20.26	2.58	01 52⌈37.04−C(		⌈3.24)
	17	111.855	119.16	02 07 37.85	+	C	20.91	2.26	02 07 38.43	C (	2.84)
	19	120.148	119.71	02 28 42.24	+	B	21.69	1.66	02 28 43.07	B (	2.49)
	20	125.669	119.90	02 42 43.17		D	22.12	1.17	02 42⌈43.28−C(		1.28)
									44.57	C (	2.57)
	21	131.506	119.95	02 57 36.48	−	C	22.92	1.00	02 57 38.07	D (	2.59)
O-17	**Monzen**										
test	1	19.245	123.62	22 21 01.91	+	A	4.62	1.41			
	2	23.076	123.03	22 31 03.61	+	A	5.61	1.76			
	4	30.757	123.33	22 51 18.22	+	B	7.34	2.21			
shot	1	34.616	122.71	23 02 33.44	+	B	8.04	2.27			
	3	40.770	123.52	23 18 33.68	+	B	8.56	1.76			
	4	44.653	123.63	23 28 30.89	+	B	9.32	1.88	23 28 32.99	C (	3.98)
	5	48.499	123.64	23 38 39.35	+	C	10.18	2.10	23 38 42.36	D (	5.10)
	6	52.601	123.94	23 48 37.10	+	B	11.53	2.76	23 48 40.59	C (	5.73)
	7	56.453	123.74	23 58 37.62	−	C	11.78	2.37	23 58 41.40	D (	6.15)
	8	60.423	123.69	00 08 34.32		D	12.38	2.31	00 08⌈34.50	B (	⌈2.49)
	9	64.354	123.66	00 18 45.67	+	B	13.29	2.56	00 18 47.08	D (	3.97)
									49.80	D (	6.69)
	10	68.362	123.45	00 28 40.16	−	C	13.95	2.56	00 28 45.03	D (	7.43)
	11	73.818	123.18	00 42 37.01	+	C	14.76	2.46	00 42 41.80	D (	7.25)
	12	79.706	123.69	00 57 44.24		D	15.38	2.10	00 57⌈44.59−B(		⌈2.45)
									49.75	D (	7.62)
	14	88.594	124.31	01 20 40.74		D	16.83	2.06	01 20⌈41.03	C (	⌈2.35)
									41.22	C (	2.54)
	15	95.273	124.91	01 37⌈39.76		D	17.80	⌈1.92	01 37 40.10	D (	2.26)
									45.00	D (	7.16)
	16	101.168	124.97	01 52⌈35.19	−	C	19.06	⌈2.20			
	17	107.068	125.32	02 07⌈36.39		D	19.54	⌈1.69	02 07 36.76	C (	3.06)
									41.27	D (	6.57)
	19	115.409	125.45	02 28⌈41.02		C	20.47	⌈1.23	02 28 41.91	C (	2.12)
	20	120.946	125.38	02 42⌈41.86		D	20.81	⌈0.65	02 42 42.93	C (	1.72)

(to be continued)

Table 6.

(continued)

Shot No.	Δ(km)	θ*	P	Class	P−O***	P−O−$\frac{\Delta}{6}$	Later phases
		No E	h m s **		s	s	**** s
21	126.771	125.18	02 57 35.30	D	21.74	0.61	02 57⌈35.50+C(⌈0.81)
							36.27 C (1.58)
							40.46 D (5.77)
O-18	**Iwadate**						
shot 1	62.905	49.91	23 02⌈38.08	D	12.67	⌈2.19	23 02 39.67 D (3.78)
2	64.436	55.27	23 18 37.50	C	12.38	1.64	
3	65.881	58.43	23 28 34.43 −	C	12.86	1.88	
5	67.563	61.39	23 38 42.32	D	13.14	1.88	23 38⌈42.53 C (2.09)
6	69.318	64.49	23 48 40.02	D	13.92	2.37	23 48⌈40.34 C (2.69)
7	71.506	67.06	23 58 40.18 −	C	14.38	2.46	
8	73.783	69.62	00 08 36.61 −	C	14.67	2.37	
9	76.167	71.99	00 18 47.49	D	15.10	2.40	00 18 48.37 C (3.28)
10	78.897	74.16	00 28⌈41.78	D	15.58	⌈2.43	
11	82.793	76.86	00 42⌈38.42 −	C	16.18	⌈2.38	
12	86.440	80.01	00 57⌈45.68 −	C	16.82	⌈2.41	
14	92.419	84.24	01 20⌈41.87	D	17.95	⌈2.55	01 20 42.03 D (2.71)
							42.30 D (2.98)
15	96.991	87.22	01 37 40.27	D	18.31	2.14	01 37 40.53 C (2.40)
16	101.635	89.30	01 52 35.40	D	19.28	2.34	
17	106.089	91.45	02 07⌈36.38	D	19.44	⌈1.76	
19	112.938	93.92	02 28⌈41.81	D	21.26	⌈2.44	
20	117.746	95.27	02 42⌈41.49	D	20.43	⌈0.81	
21	123.014	96.45	02 57 35.03	D	21.47	0.97	

Table 7. Travel time data in the Tutihata explosions.

Shot time: 1966 March 5, $1^{h}\ 07^{m}\ 0.033^{s}$

Station No.	Observation Point	Δ(km)	θ*	P(1h 07m)	Class	$P-O-\frac{\Delta}{6}$***
			N °E	s **		
T- 4	Kesennuma	77.757	125.6	13.33 +	B	0.32
T- 6	Higasiyama	47.083	131.1	8.32 +	A	0.44
T- 7	Mizusawa	43.694	123.6	7.89	A	0.57
T- 8	Iwasaki-sinden	16.713	105.5	3.72 +	B	0.90
T- 9	Waka-sennin	9.357	73.6	2.10 +	A	0.51
T-10	Tutihata No. 1	0.031	8.8	0.062		0.024
	No. 2	0.307	21.0	0.210		0.126
	No. 3	0.502	10.5	0.273		0.156
T-11	Rokugo (a)	23.892	−55.5	5.10	A	1.08
T-12	Nakasen	36.929	−41.4	7.07 +	C	0.88
T-13	Arakawa	52.080	−43.6	9.45	C	0.74
T-14	Kayamori	64.275	−41.6	11.63 +	C	0.88
T-15	Matubara	76.527	−45.7	****「13.81 +	C	1.02
T-17	Mozen (2)	110.879	−54.5	19.12 −	D	0.61

* θ is the azimuth from the shot points to the stations.

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

*** O is the shot time.

**** The mark 「 means that although the signals can be identified at this time with certainty, the initial might be earlier than the reading.

Table 8. Travel time data of the receiving vessel.

D: travel time of direct sound wave in water
Gi: travel time of refracted ground waves
R: travel time of sound wave reflected at sea bottom
SBi: travel time of waves reflected at subbottom discontinuities
Ds/Vv: water depth in second under the shot point
Dr/Vv: water depth in second under the receiving vessel
Dsts/Vv: water depth in second of baseline under the shot point

The last two lines give the locations of the receiving vessel.

Shot No.	T-49	T-50	S-8	S-3	S-9	S-4	S-12	T-40	S-11
D	50.589	48.030	45.219	40.927	37.989	31.687	25.589	23.538	22.128
G_1	15.735	15.180	14.408	13.772	12.703	11.845	10.041	9.998	9.030
G_2				14.548	15.157	12.599		14.078	
G_3				15.640		13.241		15.777	
G_4						15.468			
G_5									
R				40.956		31.712		23.590	
SB_1									
SB_2									
Ds/Vv	0.187	0.215	0.257	0.392	0.368	0.564	0.592	0.693	0.632
Dsts/Vv	0.294	0.325	0.364	0.415	0.452	0.527	0.601	0.620	0.643
Dr/Vv	0.853	0.862	0.877	0.933	0.884	0.943	0.900	0.885	0.906
Lat. (N)			38° 17.0′	38° 08.6′	38° 15.9′	38° 07.0′	38° 12.5′	38° 01.2′	38° 13.0′
Long. (E)			142° 38.5′	142° 39.4′	142° 39.0′	142° 40.0′	142° 40.7′	142° 39.3′	142° 40.6′

(to be continued)

Table 8.

(continued)

Shot No.	S-5	T-38	T-37	T-36	T-35	T-34	S-6	T-33	T-32
D	20.833 s	19.054 s	16.914 s	14.791 s	13.520 s	12.269 s	11.617 s	11.427 s	10.365 s
G_1	9.430	8.622	8.042	7.590	7.377	7.029	6.915	6.838	6.546
G_2	9.700	11.219	8.909	13.546	9.676	11.014		9.508	
G_3			9.853		12.111	11.515			
G_4			15.627						
G_5									
R	20.888	19.123	17.004	14.903	13.635	12.388	11.686	11.570	
SB_1									
SB_2									
Ds/Vv	0.760	0.749	0.772	0.790	0.880	0.820	0.896	0.836	0.850
Dsts/Vv	0.657	0.673	0.699	0.725	0.740	0.754	0.768	0.765	0.777
Dr/Vv	0.933	0.889	0.890	0.892	0.894	0.896	0.927	0.897	0.896
Lat. (N)	38° 05.8′	38° 01.1′				38° 01.4′	38° 04.0′		
Long. (E)	142° 40.6′	142° 39.4′				142° 39.4′	142° 40.6′		

Shot No.	T-31	T-30	T-29	T-28	T-27	T-26	T-25	T-24	T-23
D	9.536 s	8.694 s	7.646 s	6.885 s	6.045 s	5.213 s	4.361 s	3.515 s	2.694 s
G_1	6.358	6.001	5.818	5.710	5.358	5.149			
G_2	8.188	6.148	5.938						
G_3	9.084	7.188	7.604						
G_4		7.678							
G_5		8.424							
R	9.693		7.886	7.025	6.254	5.506	4.706	3.938	3.231
SB_1						5.543	4.999	3.985	3.292
SB_2							5.199		4.322
Ds/Vv	0.861	0.869	0.874	0.876	0.886	0.892	0.895	0.901	
Dsts/Vv	0.787	0.797	0.810	0.820	0.829	0.838	0.848	0.859	0.868
Dr/Vv	0.894	0.895	0.896	0.897	0.898	0.900	0.900	0.900	0.900
Lat. (N)				38° 01.5′					
Long. (E)				142° 39.0′					

(to be continued)

Table 8.

(continued)

Shot No.	T-22	T-21	T-20	T-19	T-18	T-16	T-15	T-14	T-13
D	1.864 s	1.124 s		1.141 s	1.892 s	3.553 s	4.421 s	5.489 s	6.342 s
G_1								5.351	5.553
G_2									5.641
G_3									
G_4									
G_5									
R	2.592	2.135	1.963	2.152	2.635	4.001	4.795	5.797	6.616
SB_1	2.672	2.235	2.059	2.247	2.714	4.065	4.843		
SB_2	4.284	3.923		3.963	4.262				
Ds/Vv	0.921	0.918	0.926	0.941			0.974		0.970
Dsts/Vv	0.878	0.888	0.892	0.887	0.878	0.858	0.847	0.836	0.826
Dr/Vv	0.900	0.900	0.900	0.900	0.901	0.903	0.904	0.906	0.903
Lat. (N)			38° 01.7′						38° 02.0′
Long. (E)			142° 39.5′						142° 38.9′

Shot No.	T-12	T-11	T-10	T-9	T 8	T-7	T-6		
D	7.212 s	8.045 s	8.985 s	9.748 s	10.610 s	11.458 s	12.215 s		
G_1	6.205	6.066	6.328	6.654	6.892	7.333	7.526		
G_2	6.547	6.502	7.424			7.551	8.301		
G_3	6.957		8.490				11.947		
G_4									
G_5									
R									
SB_1									
SB_2									
Ds/Vv	0.960	0.953	0.957	0.948	0.954	0.936	0.945		
Dsts/Vv	0.815	0.801	0.795	0.785	0.774	0.764	0.755		
Dr/Vv	0.904	0.905	0.906	0.905	0.903	0.905	0.906		
Lat. (N)							38° 02.4′		
Long. (E)							142° 39.3′		

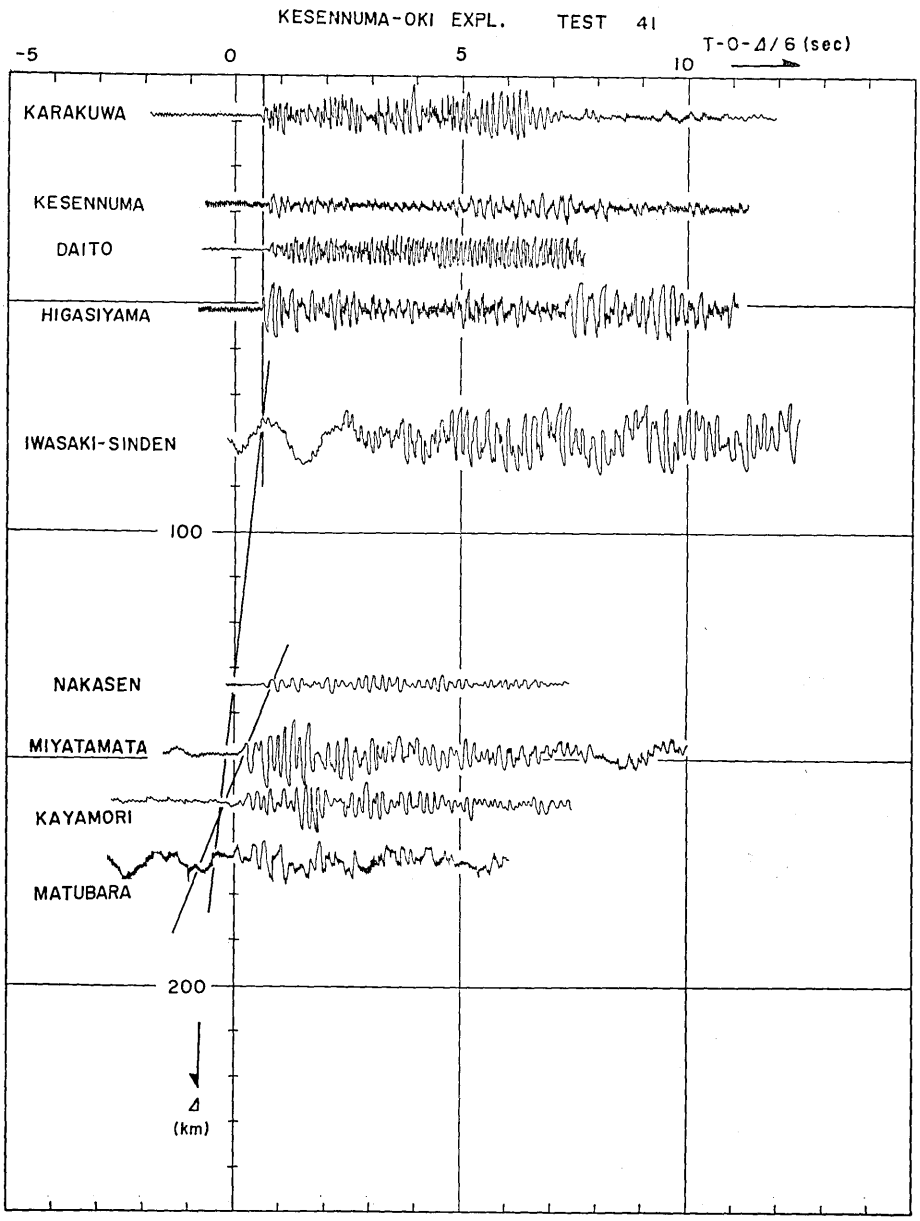

Fig. 4(1). Seismograms obtained in the case of the Off Kesennuma explosions. The travel time curves derived from the model in Fig. 10 of Part 2 are inserted.

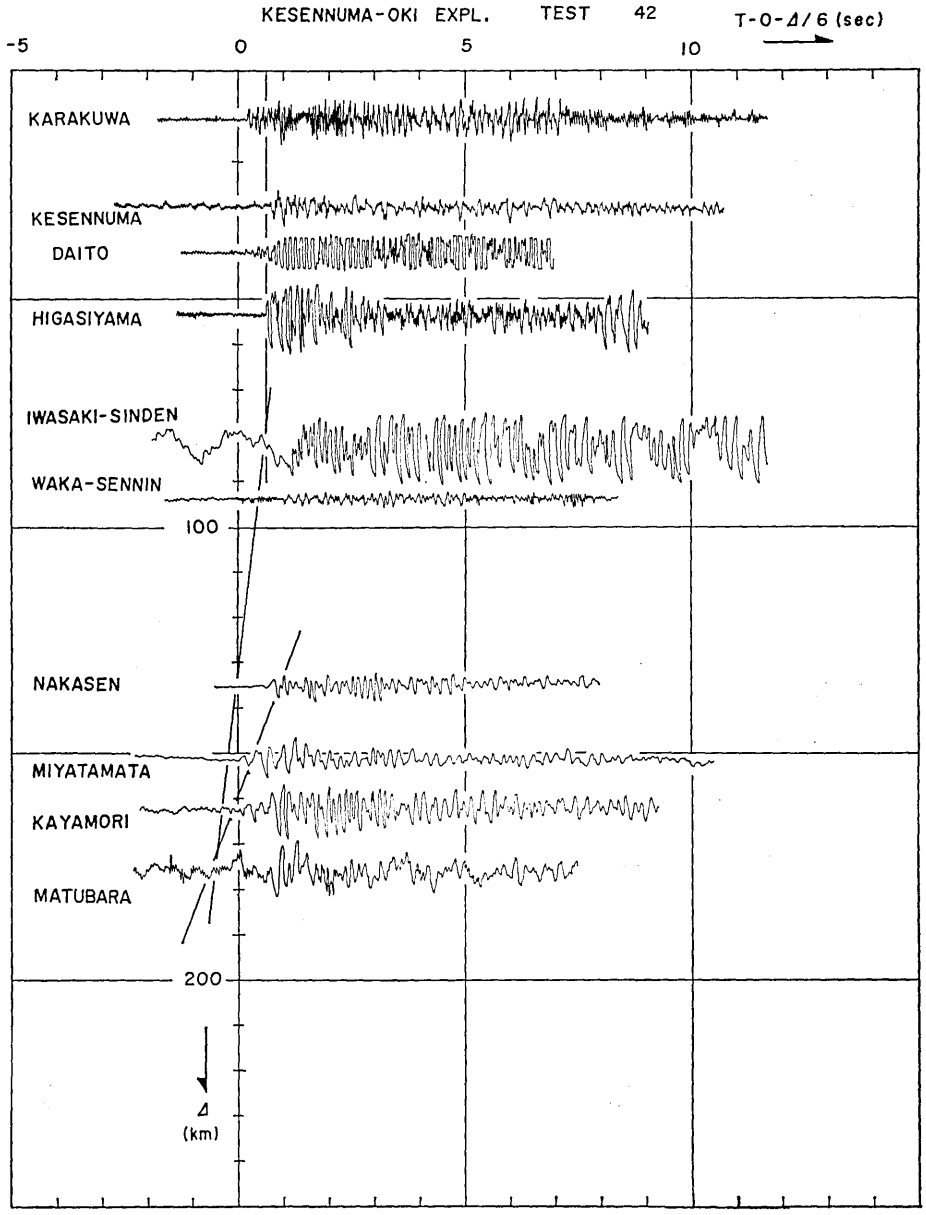
KESENNUMA-OKI EXPL. TEST 42
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
KESENNUMA
DAITO
HIGASIYAMA
IWASAKI-SINDEN
WAKA-SENNIN
100
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
200
Δ
(km)

Fig. 4(2).

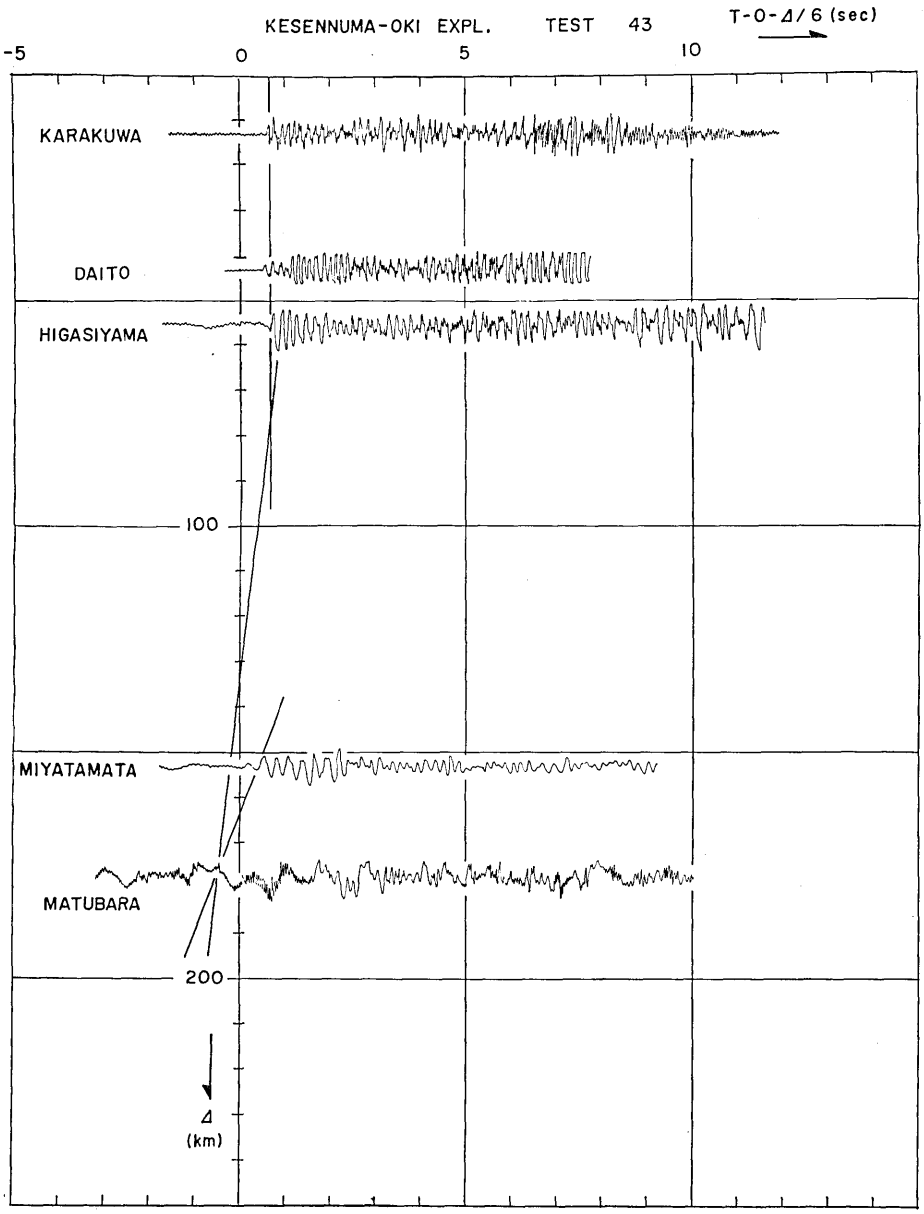
KESENNUMA-OKI EXPL. TEST 43
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
100
MIYATAMATA
MATUBARA
200
Δ
(km)

Fig. 4(3).

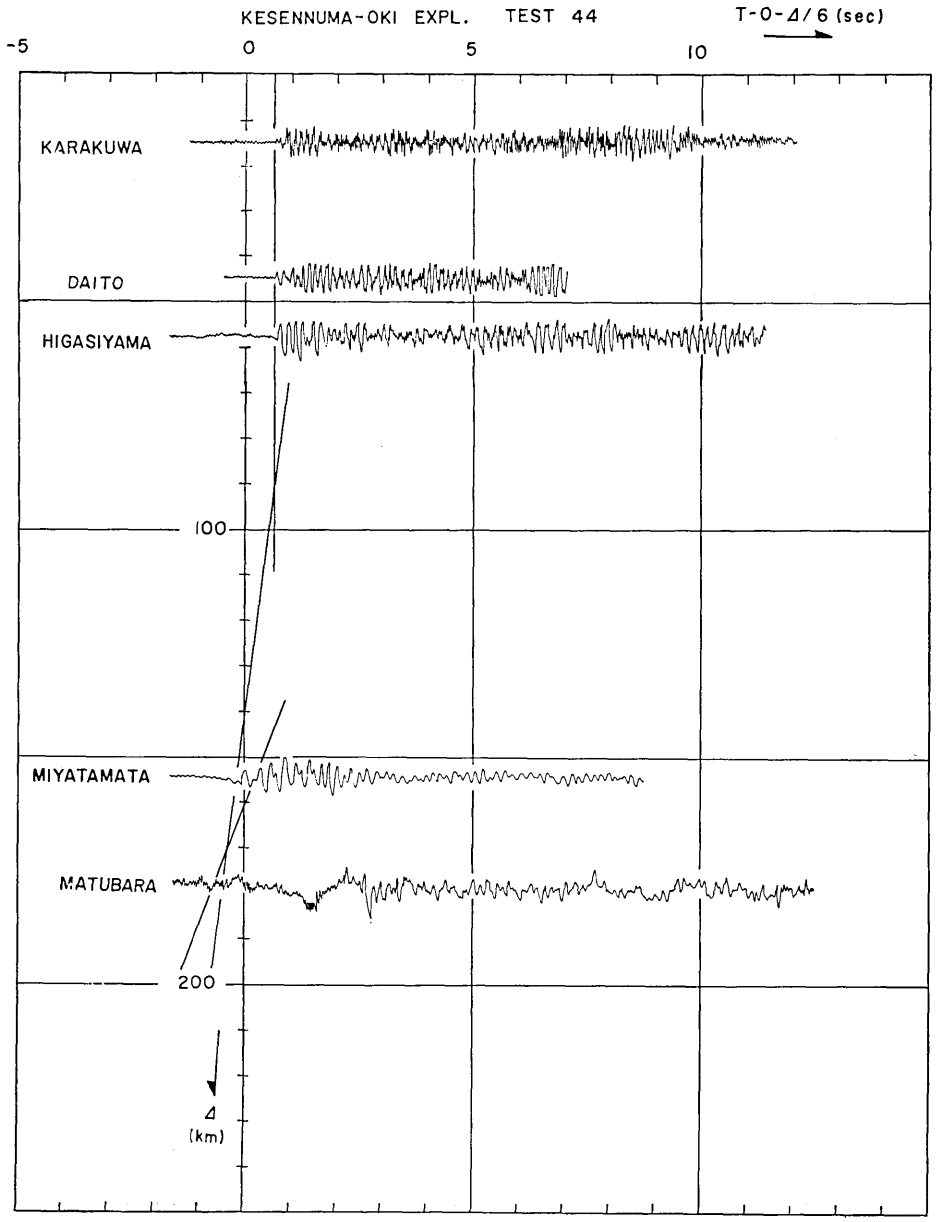
KESENNUMA-OKI EXPL. TEST 44
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
100
MIYATAMATA
MATUBARA
200
Δ
(km)

Fig. 4(4).

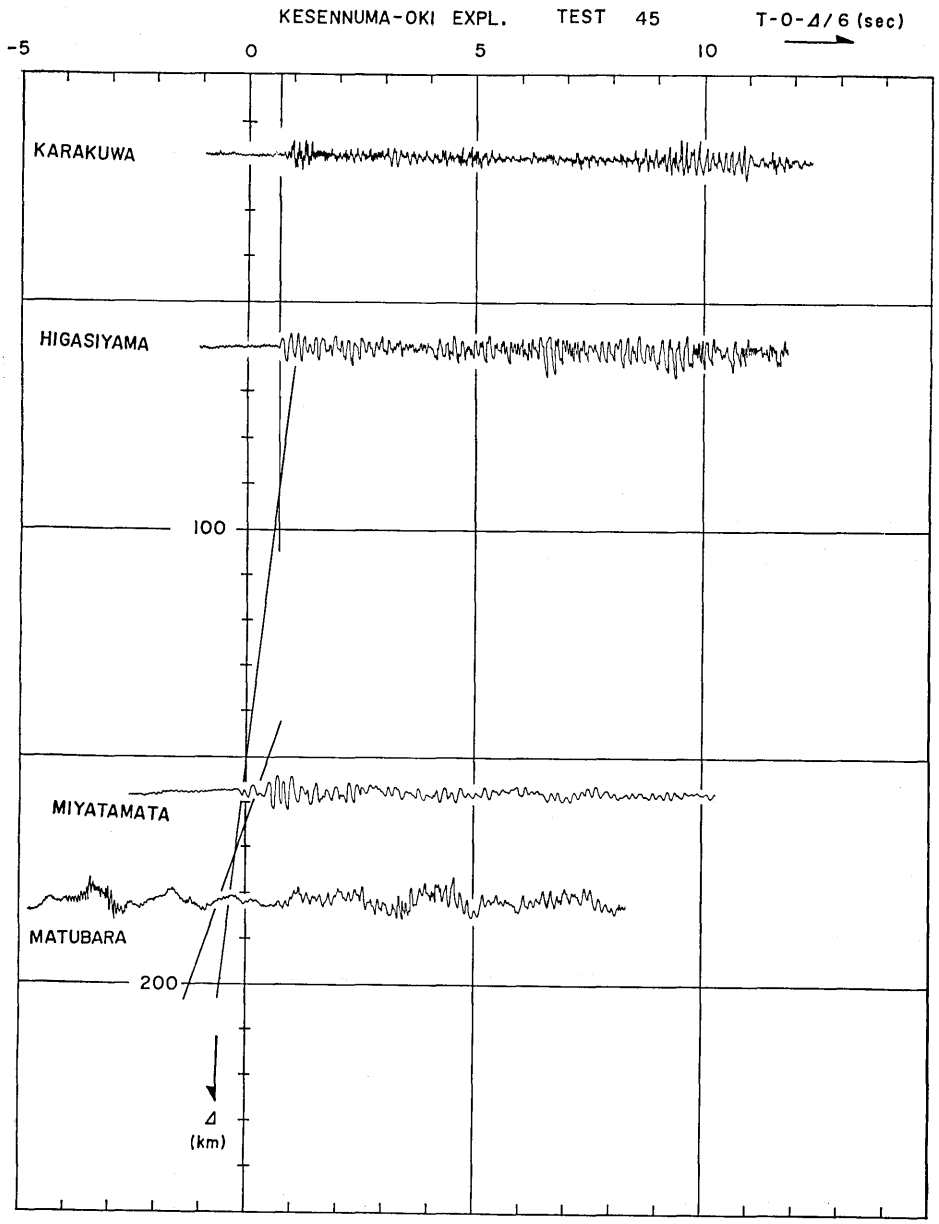
KESENNUMA-OKI EXPL. TEST 45
T-0-Δ/6 (sec)
-5
0
5
10
KARAKUWA
HIGASIYAMA
100
MIYATAMATA
MATUBARA
200
Δ
(km)

Fig. 4(5).

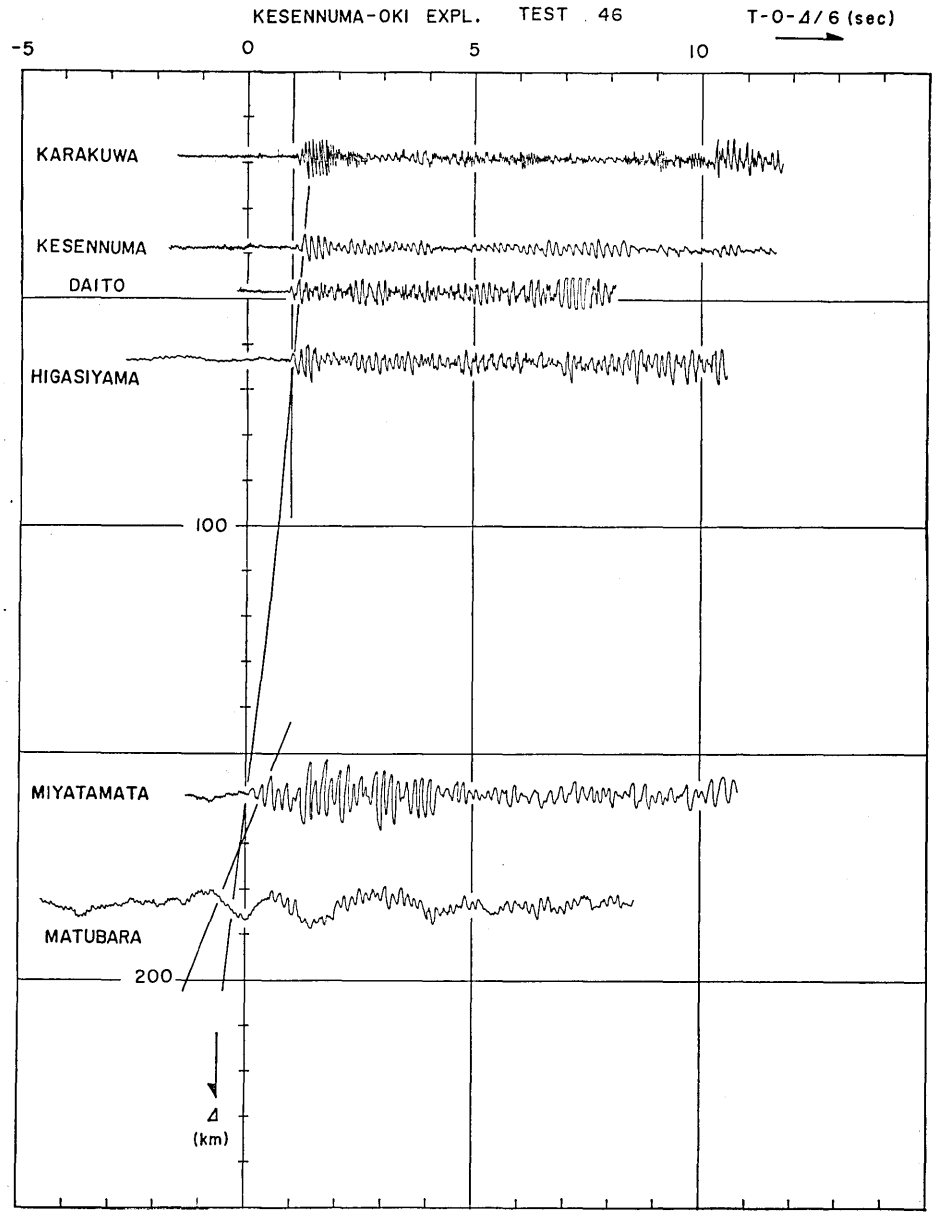
KESENNUMA-OKI EXPL. TEST 46
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
KESENNUMA
DAITO
HIGASIYAMA
100
MIYATAMATA
MATUBARA
200
Δ
(km)

Fig. 4(6).

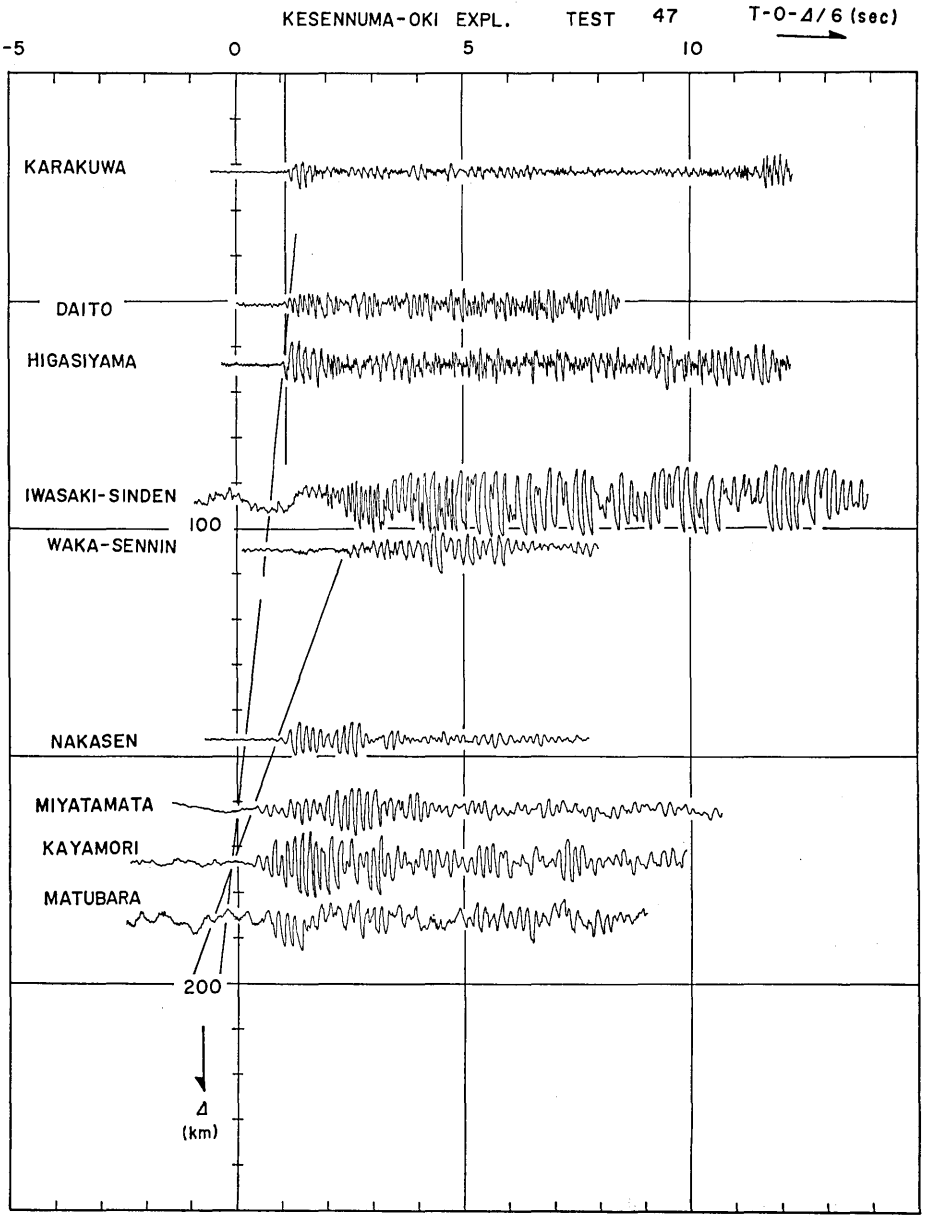
KESENNUMA-OKI EXPL. TEST 47
T-0-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
IWASAKI-SINDEN
100
WAKA-SENNIN
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
200
Δ
(km)

Fig. 4(7).

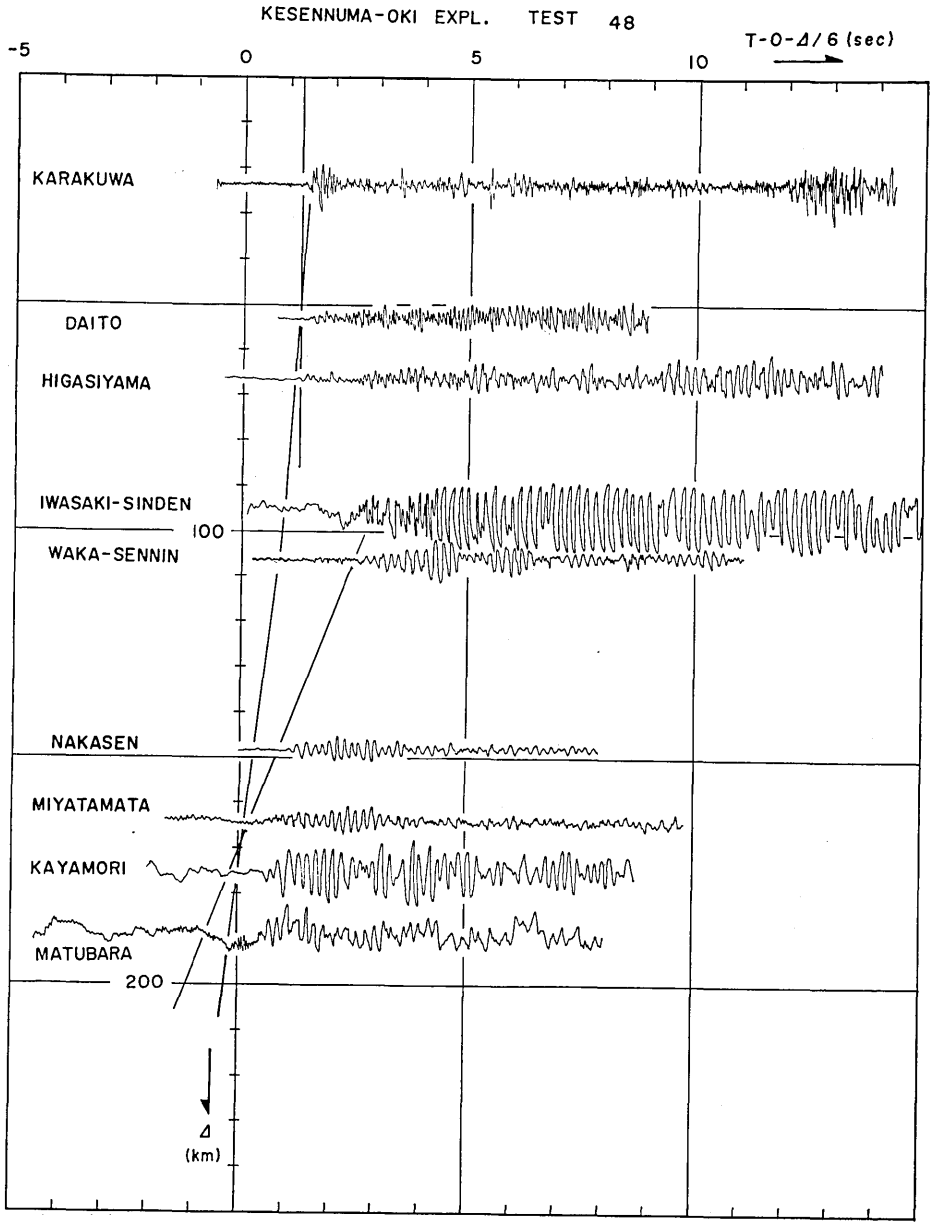
KESENNUMA-OKI EXPL. TEST 48
-5
0
5
10
T-O-Δ/6 (sec)
KARAKUWA
DAITO
HIGASIYAMA
IWASAKI-SINDEN
100
WAKA-SENNIN
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
200
Δ
(km)

Fig. 4(8).

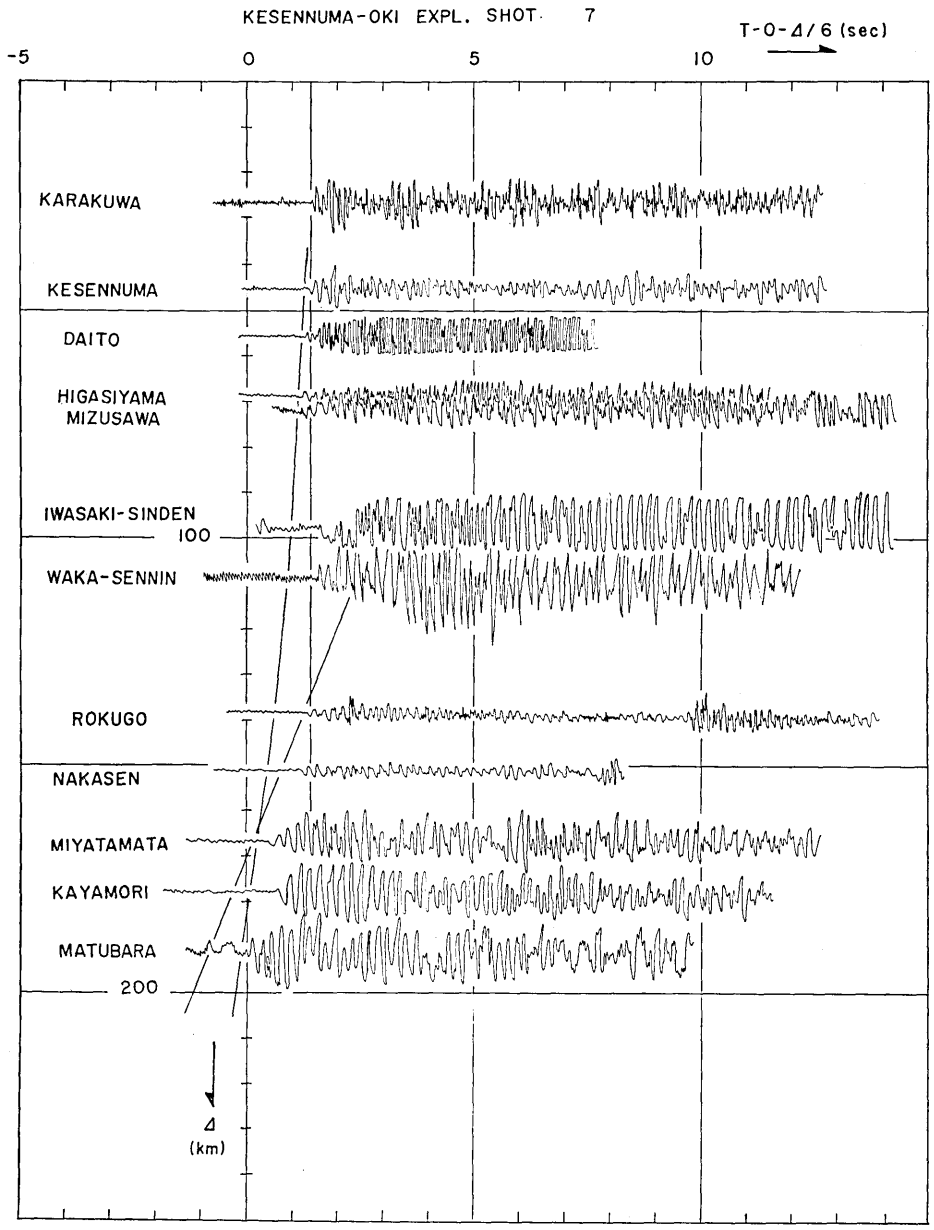
KESENNUMA-OKI EXPL. SHOT 7
T-0-Δ/6 (sec)
-5
0
5
10
KARAKUWA
KESENNUMA
DAITO
HIGASIYAMA
MIZUSAWA
IWASAKI-SINDEN
100
WAKA-SENNIN
ROKUGO
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
200
Δ
(km)

Fig. 4(9).

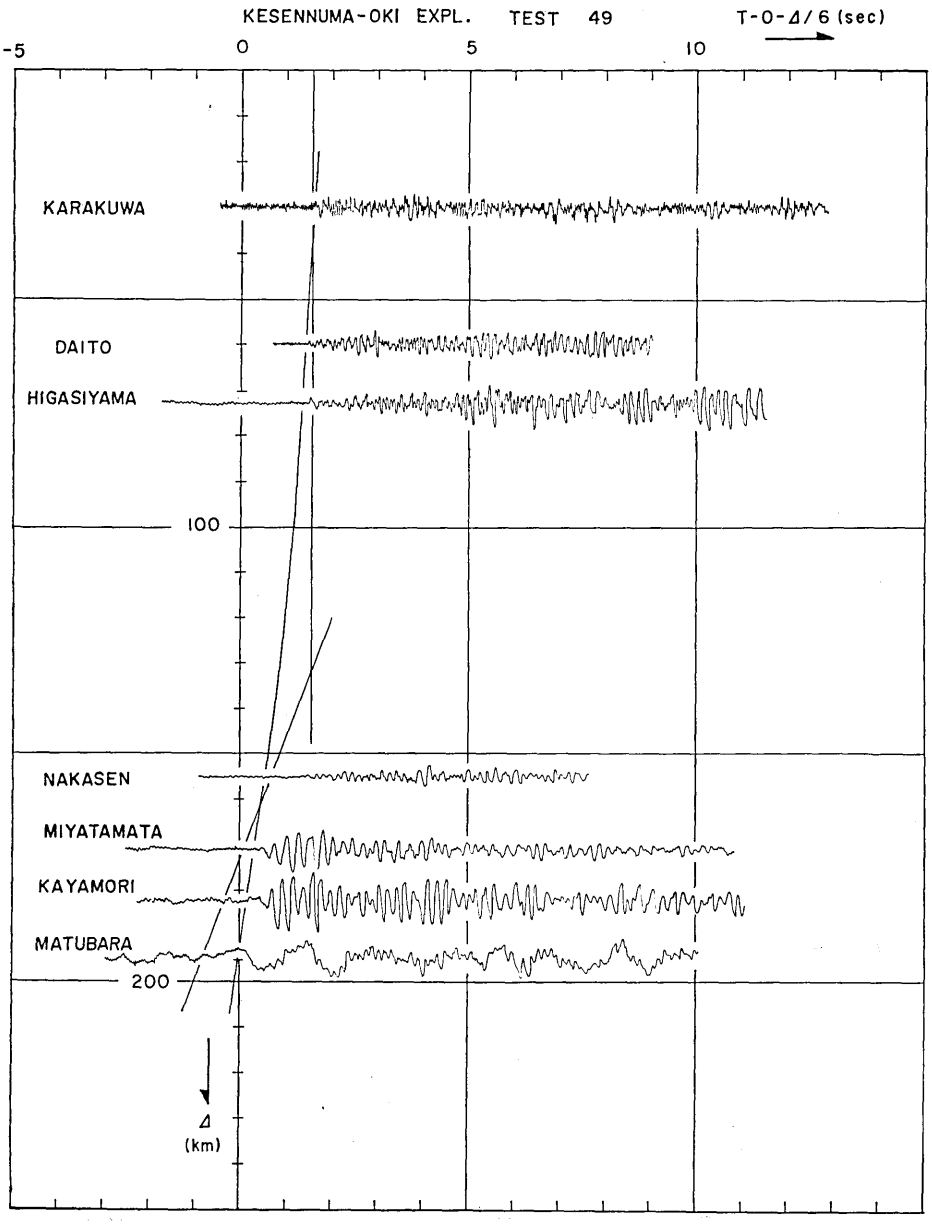
KESENNUMA-OKI EXPL. TEST 49
T-0-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
100
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
200
Δ
(km)

Fig. 4(10).

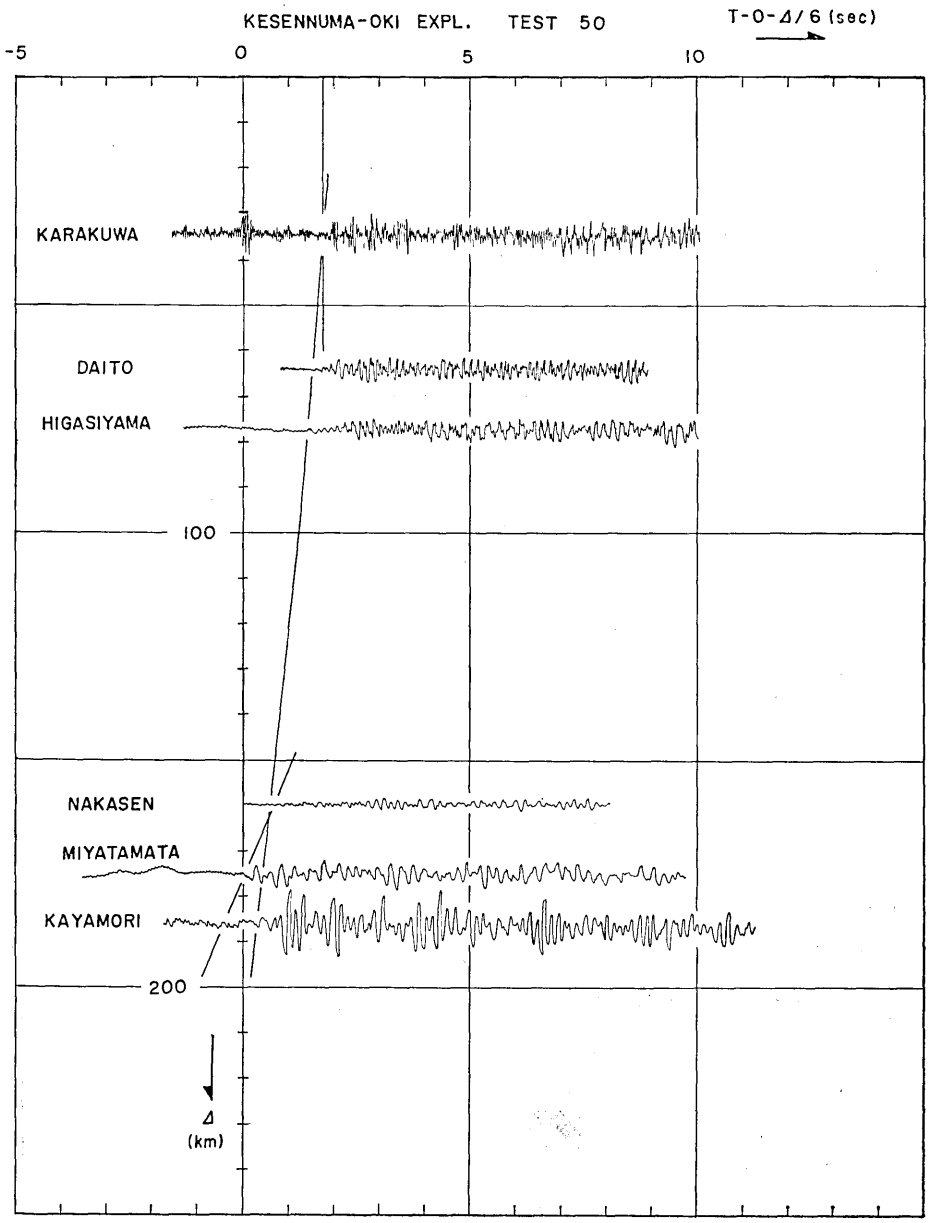
KESENNUMA-OKI EXPL. TEST 50
T-0-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
100
NAKASEN
MIYATAMATA
KAYAMORI
200
Δ
(km)

Fig. 4(11).

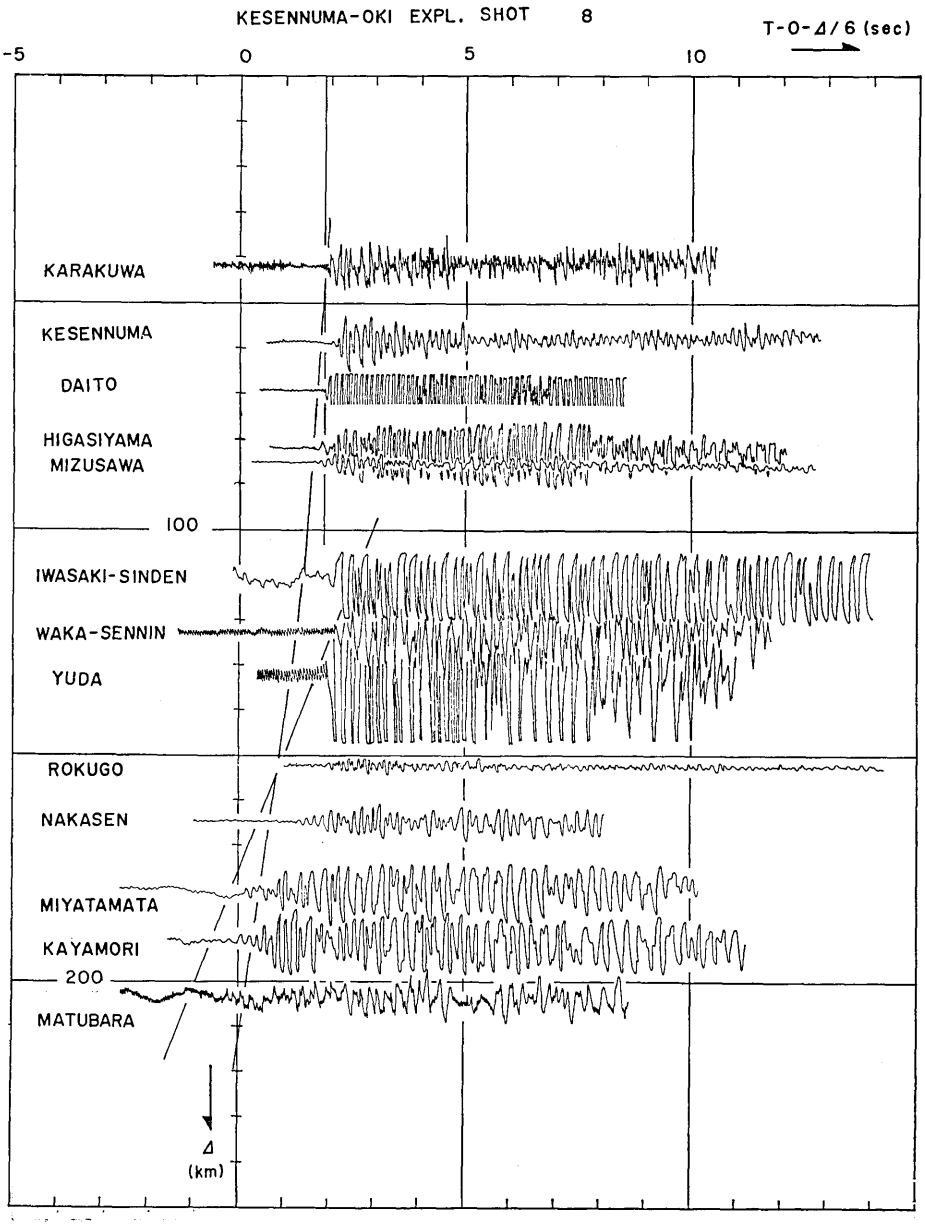
KESENNUMA-OKI EXPL. SHOT 8
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
KESENNUMA
DAITO
HIGASIYAMA
MIZUSAWA
100
IWASAKI-SINDEN
WAKA-SENNIN
YUDA
ROKUGO
NAKASEN
MIYATAMATA
KAYAMORI
200
MATUBARA
Δ
(km)

Fig. 4(12).

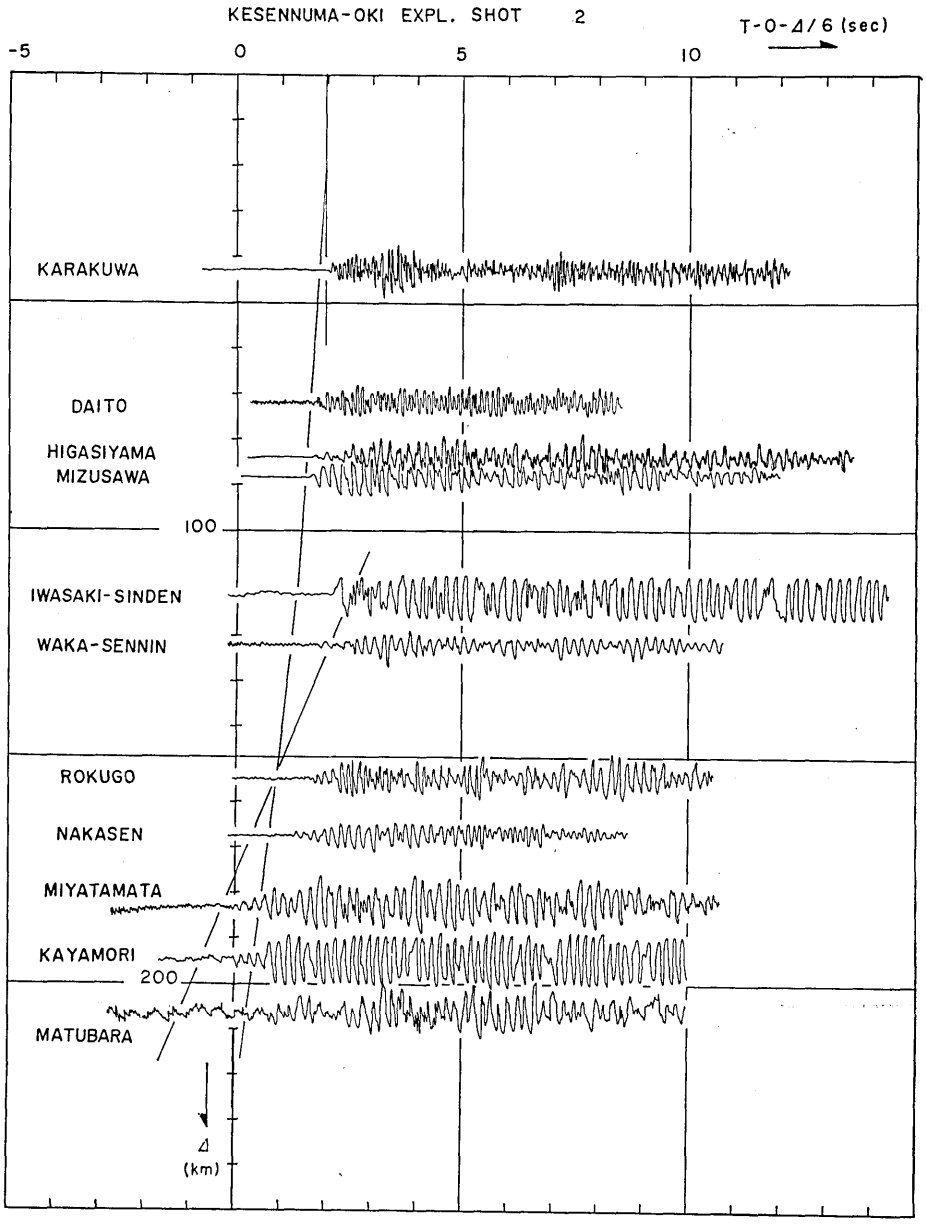
KESENNUMA-OKI EXPL. SHOT 2
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
MIZUSAWA
100
IWASAKI-SINDEN
WAKA-SENNIN
ROKUGO
NAKASEN
MIYATAMATA
KAYAMORI
200
MATUBARA
Δ
(km)

Fig. 4(13).

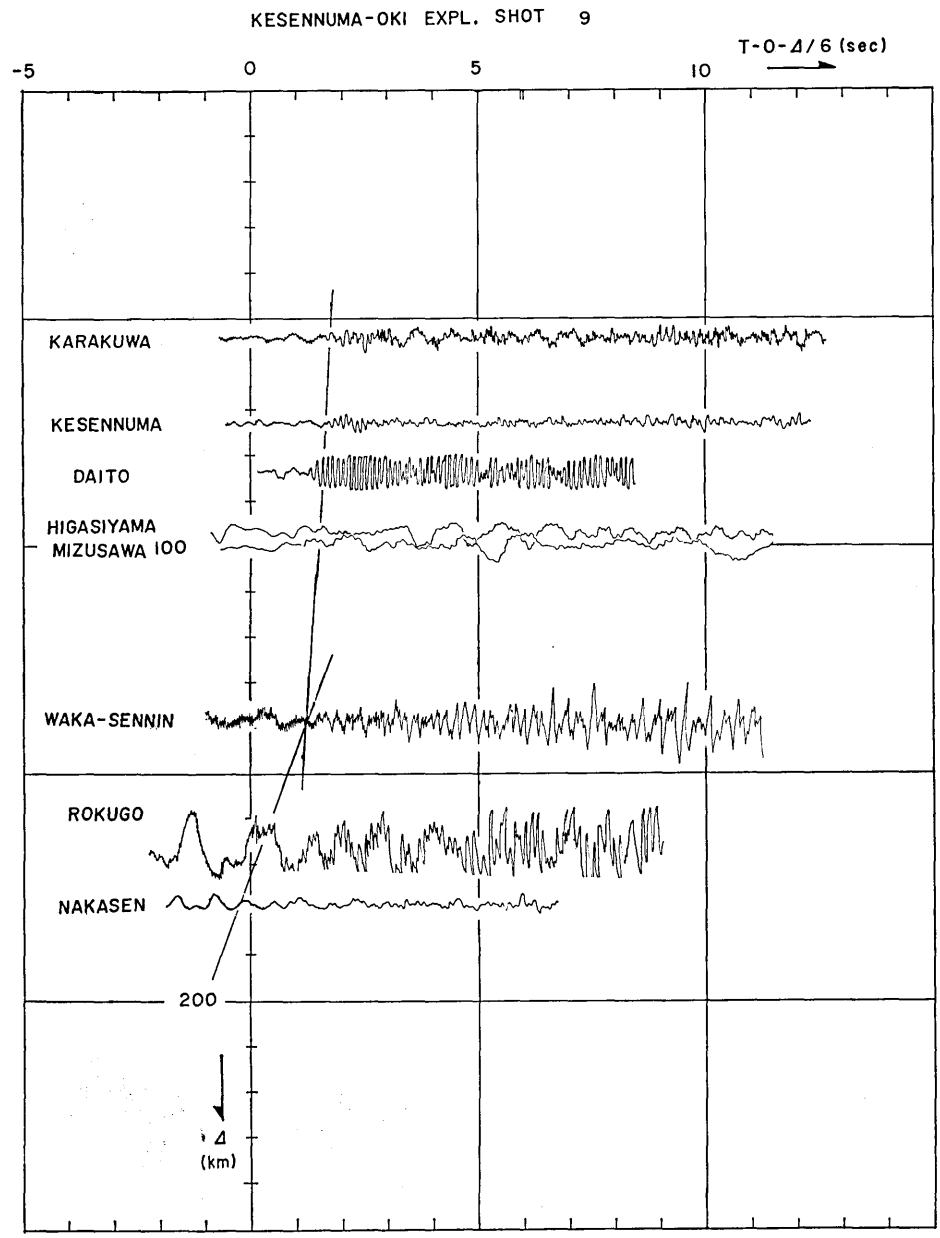
KESENNUMA-OKI EXPL. SHOT 9
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
KESENNUMA
DAITO
HIGASIYAMA
MIZUSAWA 100
WAKA-SENNIN
ROKUGO
NAKASEN
200
Δ
(km)

Fig. 4(14).

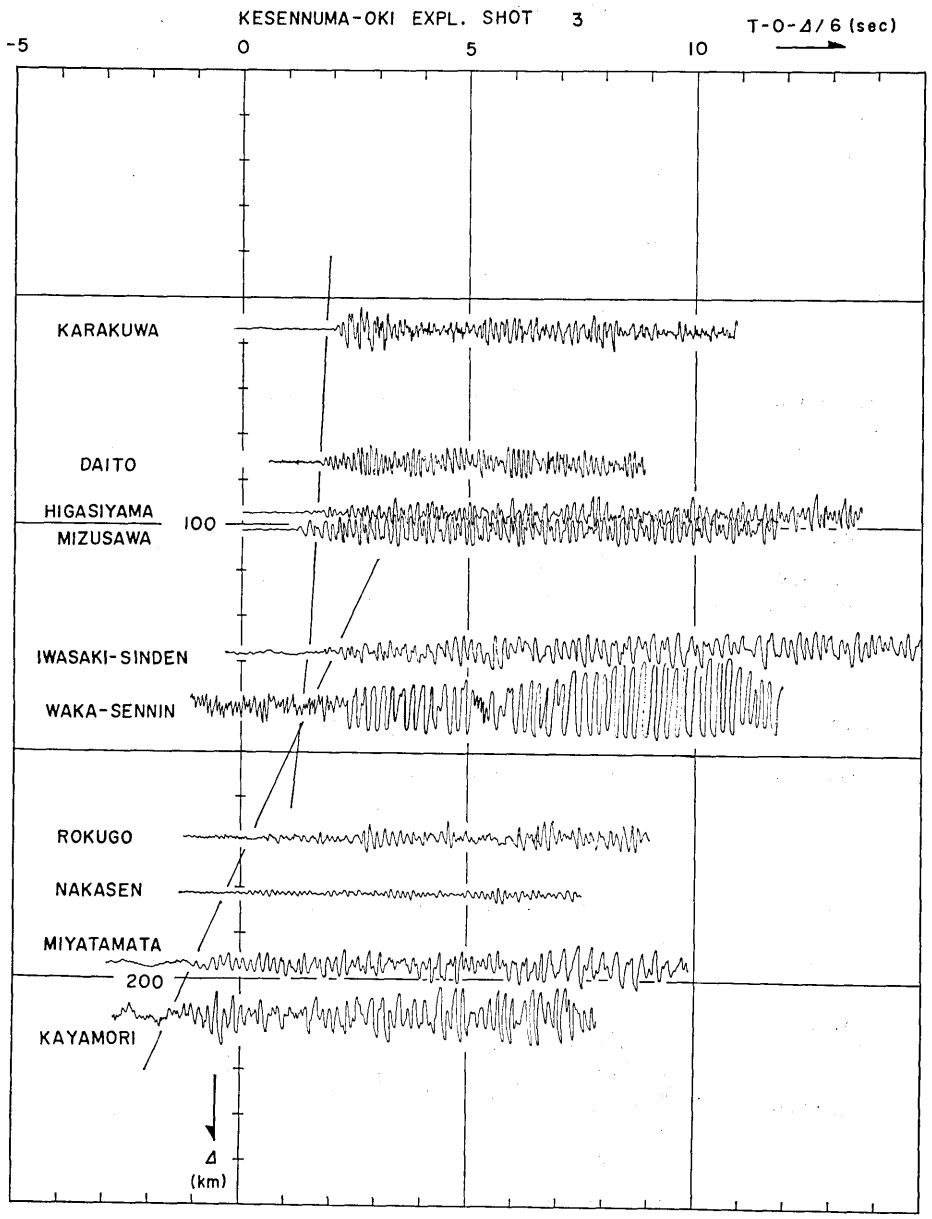
KESENNUMA-OKI EXPL. SHOT 3
T-O-Δ/6 (sec)
-5
0
5
10
KARAKUWA
DAITO
HIGASIYAMA
MIZUSAWA
100
IWASAKI-SINDEN
WAKA-SENNIN
ROKUGO
NAKASEN
MIYATAMATA
200
KAYAMORI
Δ
(km)

Fig. 4(15).

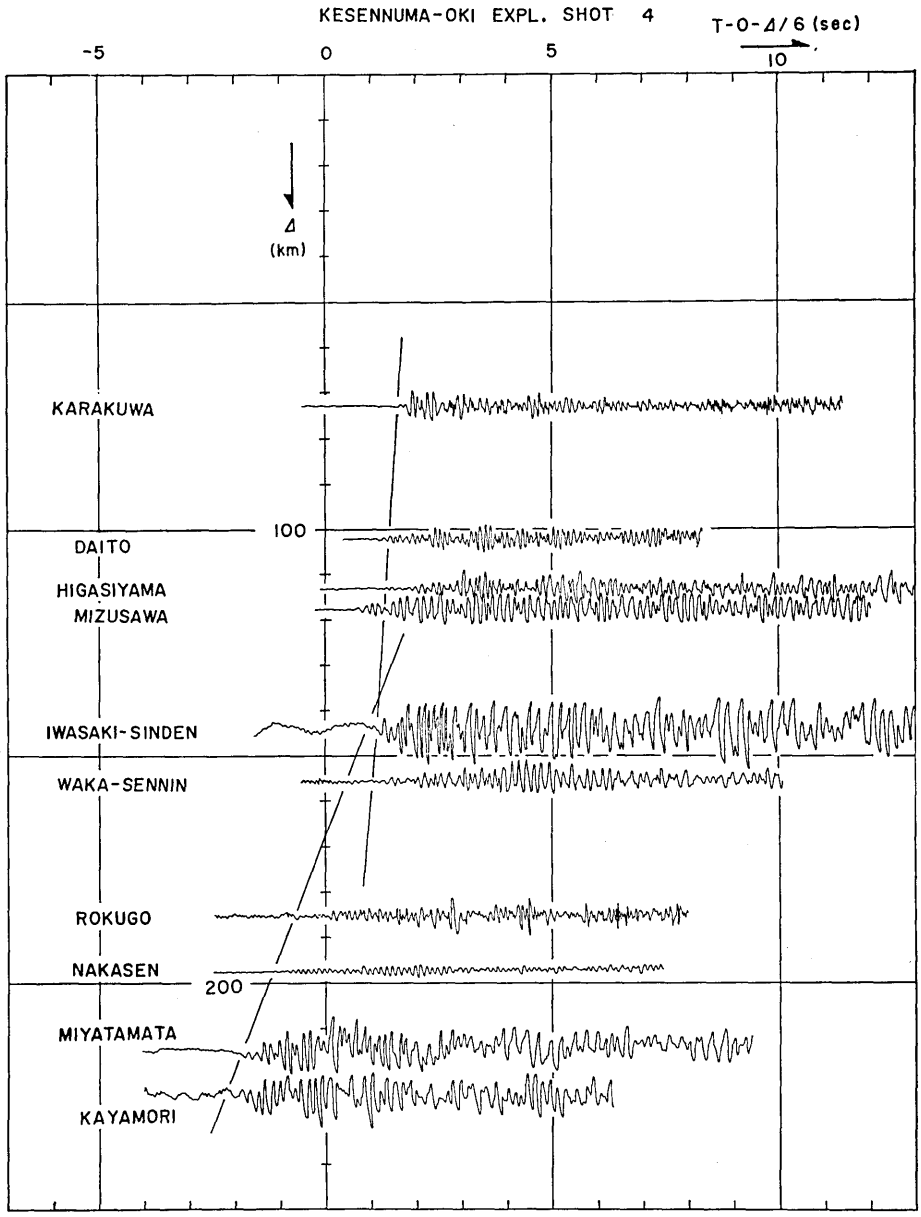
KESENNUMA-OKI EXPL. SHOT 4
T-O-Δ/6 (sec)
-5
0
5
10
Δ
(km)
KARAKUWA
100
DAITO
HIGASIYAMA
MIZUSAWA
IWASAKI-SINDEN
WAKA-SENNIN
ROKUGO
NAKASEN
200
MIYATAMATA
KAYAMORI

Fig. 4(16).

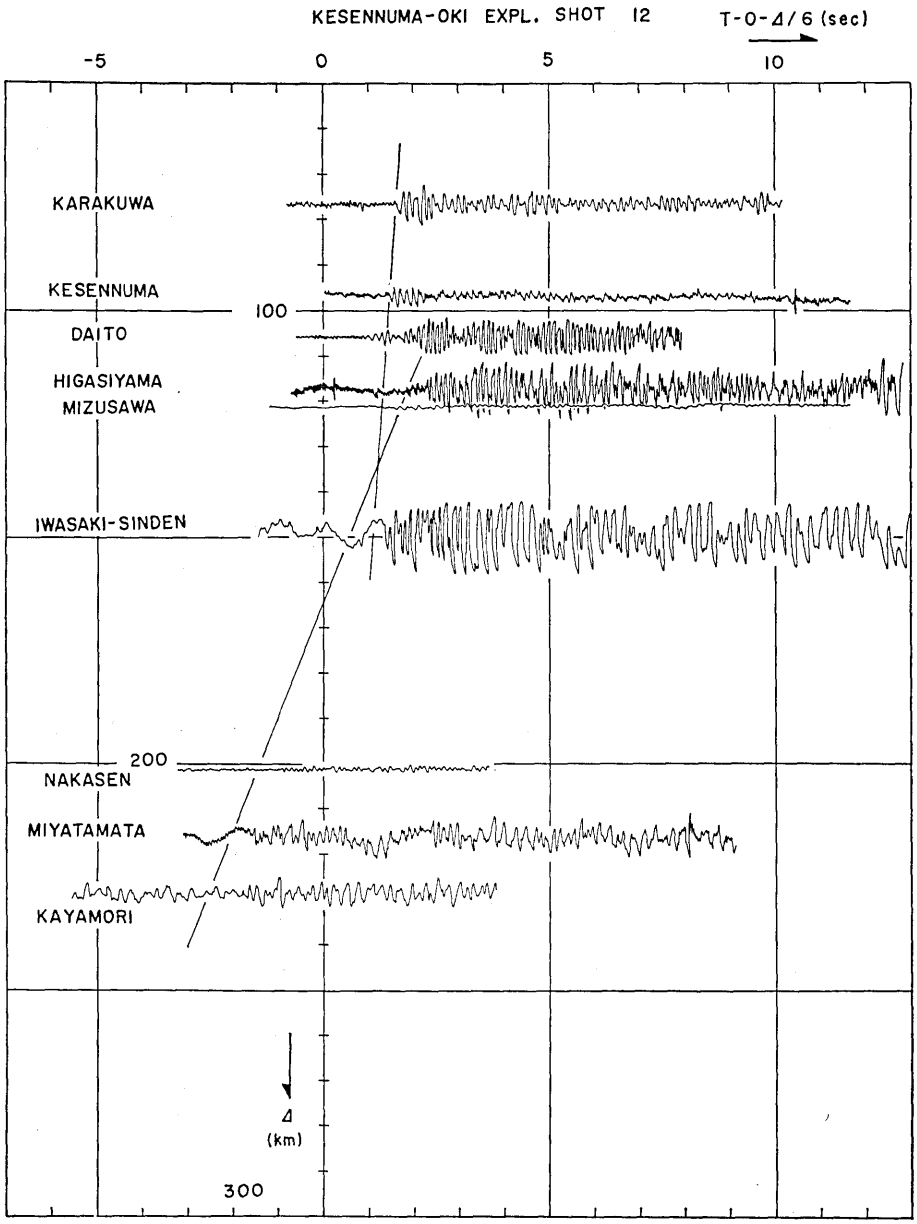
KESENNUMA-OKI EXPL. SHOT 12
T-0-Δ/6 (sec)
-5
0
5
10
KARAKUWA
KESENNUMA
100
DAITO
HIGASIYAMA
MIZUSAWA
IWASAKI-SINDEN
200
NAKASEN
MIYATAMATA
KAYAMORI
Δ
(km)
300

Fig. 4(17).

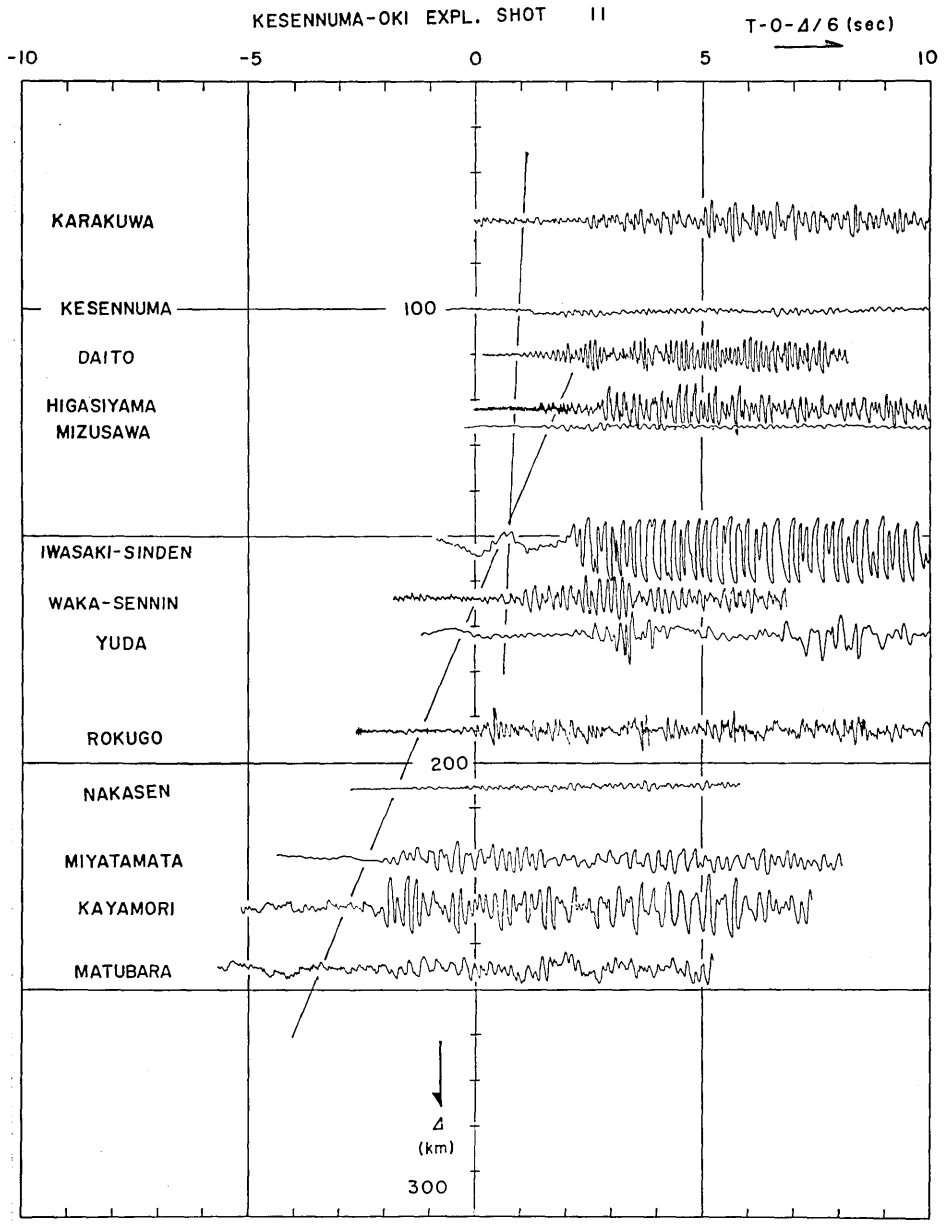
KESENNUMA-OKI EXPL. SHOT II
T-0-Δ/6 (sec)
-10
-5
0
5
10
KARAKUWA
KESENNUMA
100
DAITO
HIGASIYAMA
MIZUSAWA
IWASAKI-SINDEN
WAKA-SENNIN
YUDA
ROKUGO
200
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
Δ
(km)
300

Fig. 4(18).

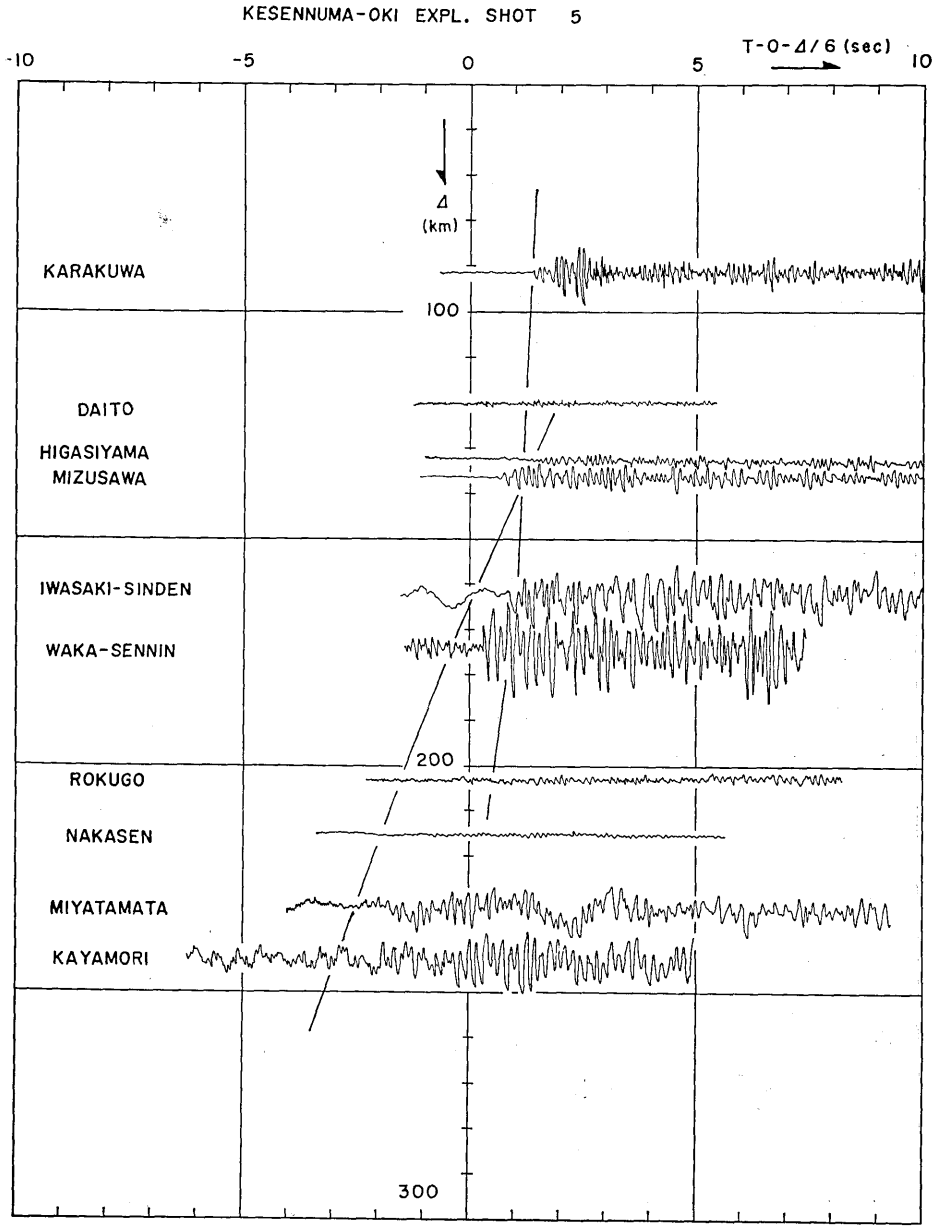
KESENNUMA-OKI EXPL. SHOT 5
T-O-Δ/6 (sec)
-10
-5
0
5
10
Δ
(km)
KARAKUWA
100
DAITO
HIGASIYAMA
MIZUSAWA
IWASAKI-SINDEN
WAKA-SENNIN
200
ROKUGO
NAKASEN
MIYATAMATA
KAYAMORI
300

Fig. 4(19).

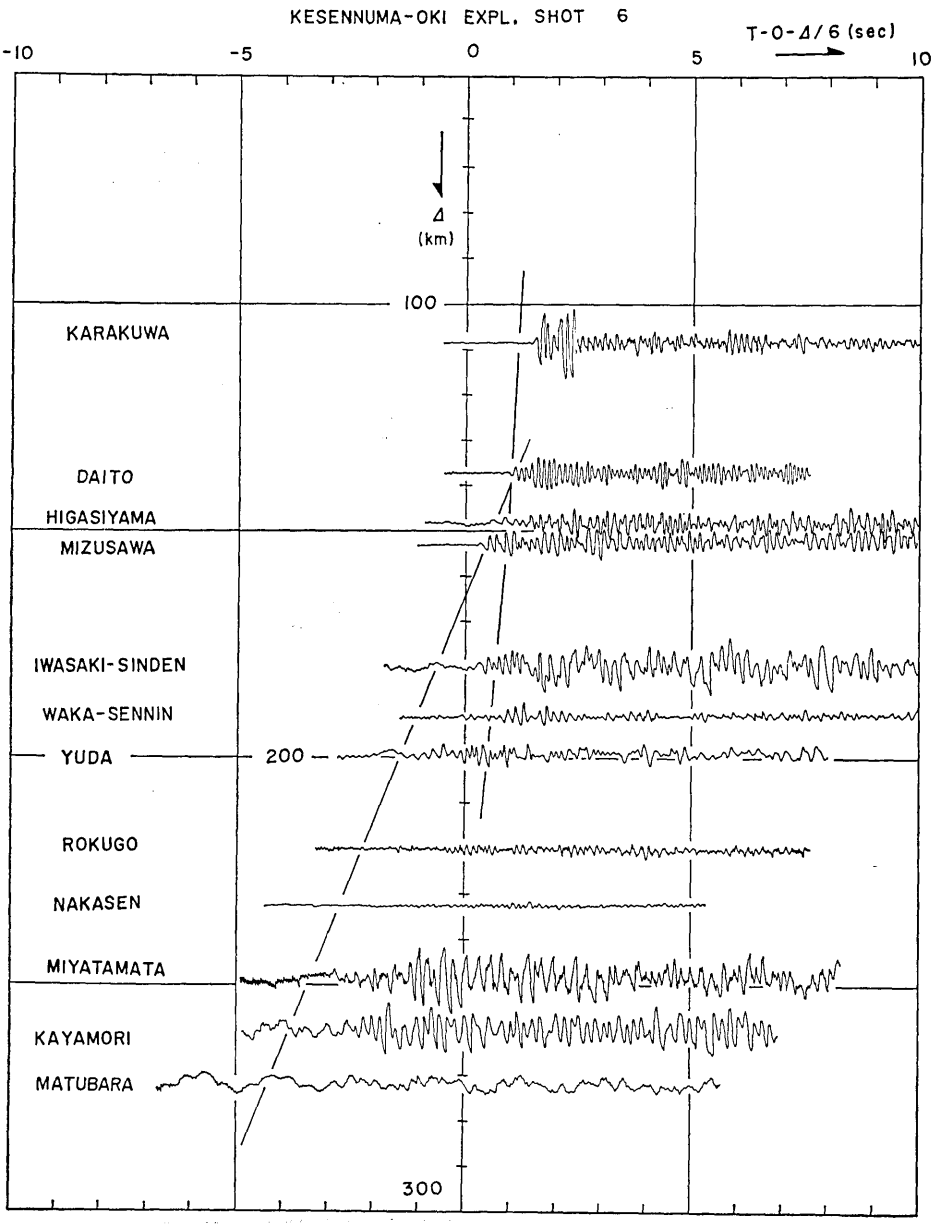
KESENNUMA-OKI EXPL. SHOT 6
T-0-Δ/6 (sec)
-10
-5
0
5
10
Δ
(km)
100
KARAKUWA
DAITO
HIGASIYAMA
MIZUSAWA
IWASAKI-SINDEN
WAKA-SENNIN
YUDA
200
ROKUGO
NAKASEN
MIYATAMATA
KAYAMORI
MATUBARA
300

Fig. 4(20).

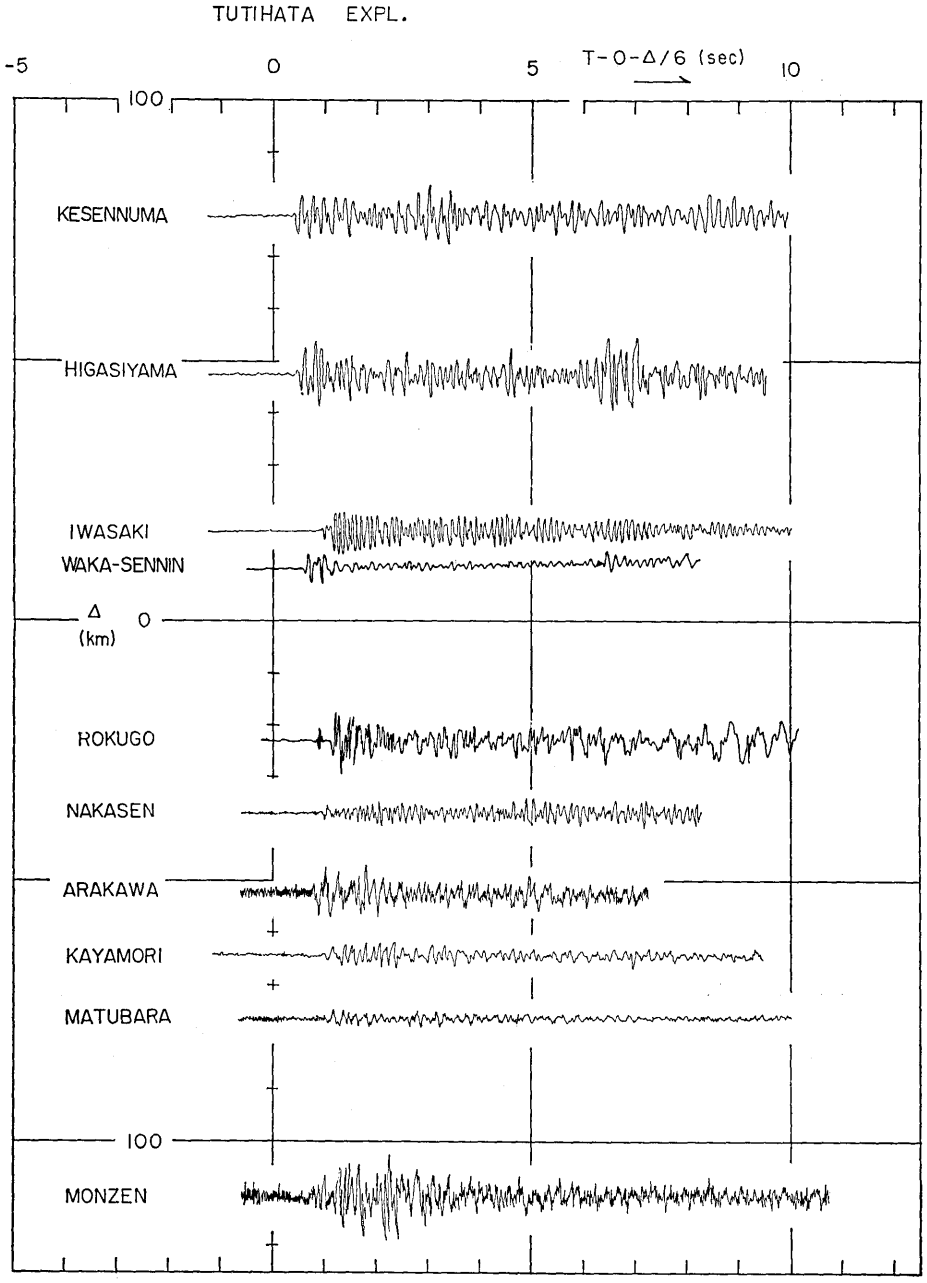

Fig. 5. Seismograms obtained in the case of the Tutihata explosion.

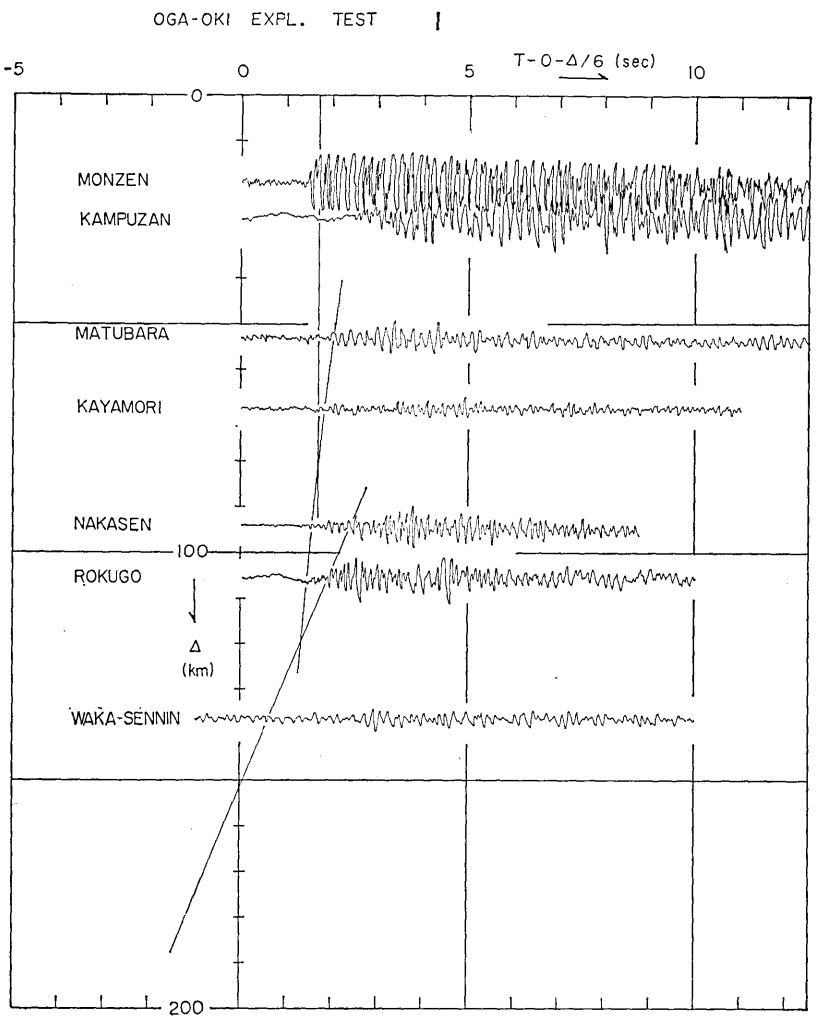

Fig. 6(1). Seismograms obtained in the case of the Off Oga Peninsula explosions. The travel time curves derived from the model in Fig. 10 of Part 2 are inserted.

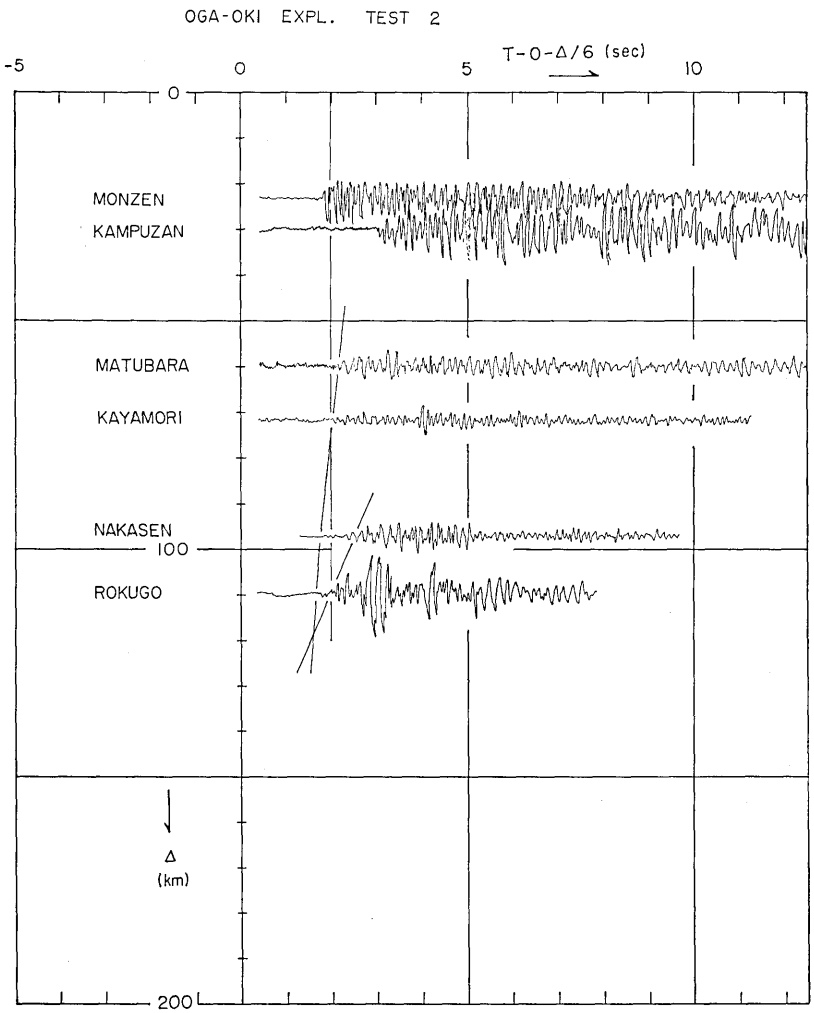
OGA-OKI EXPL. TEST 2
T-O-Δ/6 (sec)
-5
0
5
10
0
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
NAKASEN
100
ROKUGO
Δ
(km)
200

Fig. 6(2).

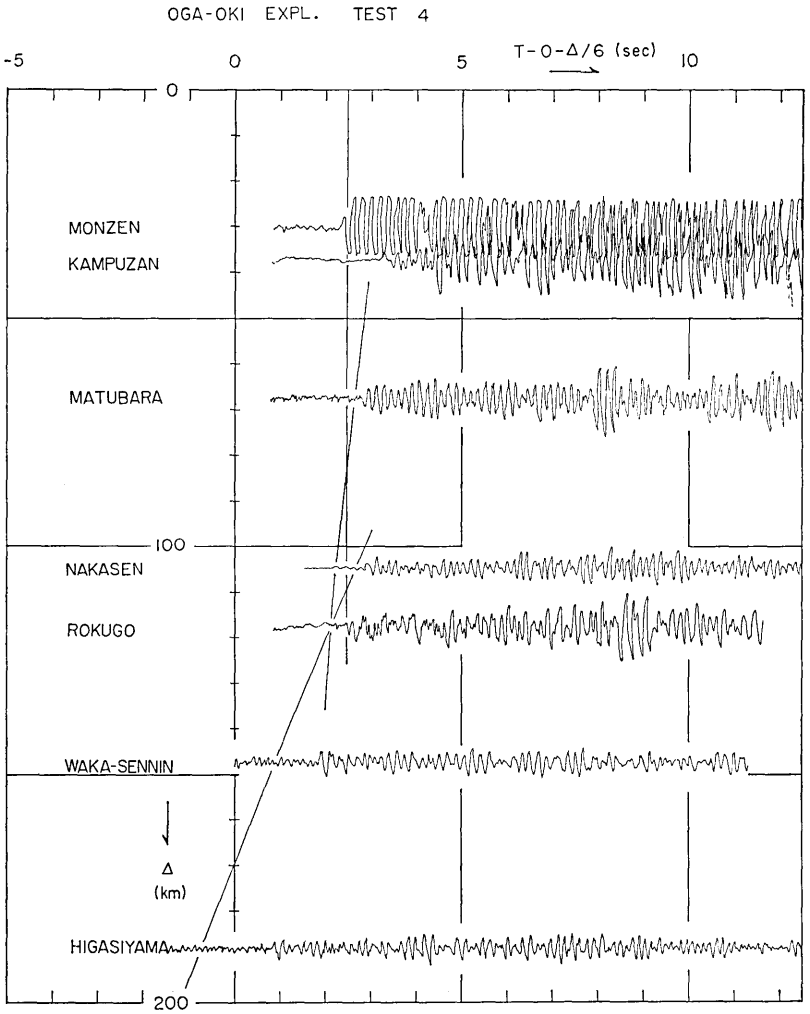
OGA-OKI EXPL. TEST 4
-5
0
5
T-0-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
100
NAKASEN
ROKUGO
WAKA-SENNIN
Δ
(km)
HIGASIYAMA
200

Fig. 6(3).

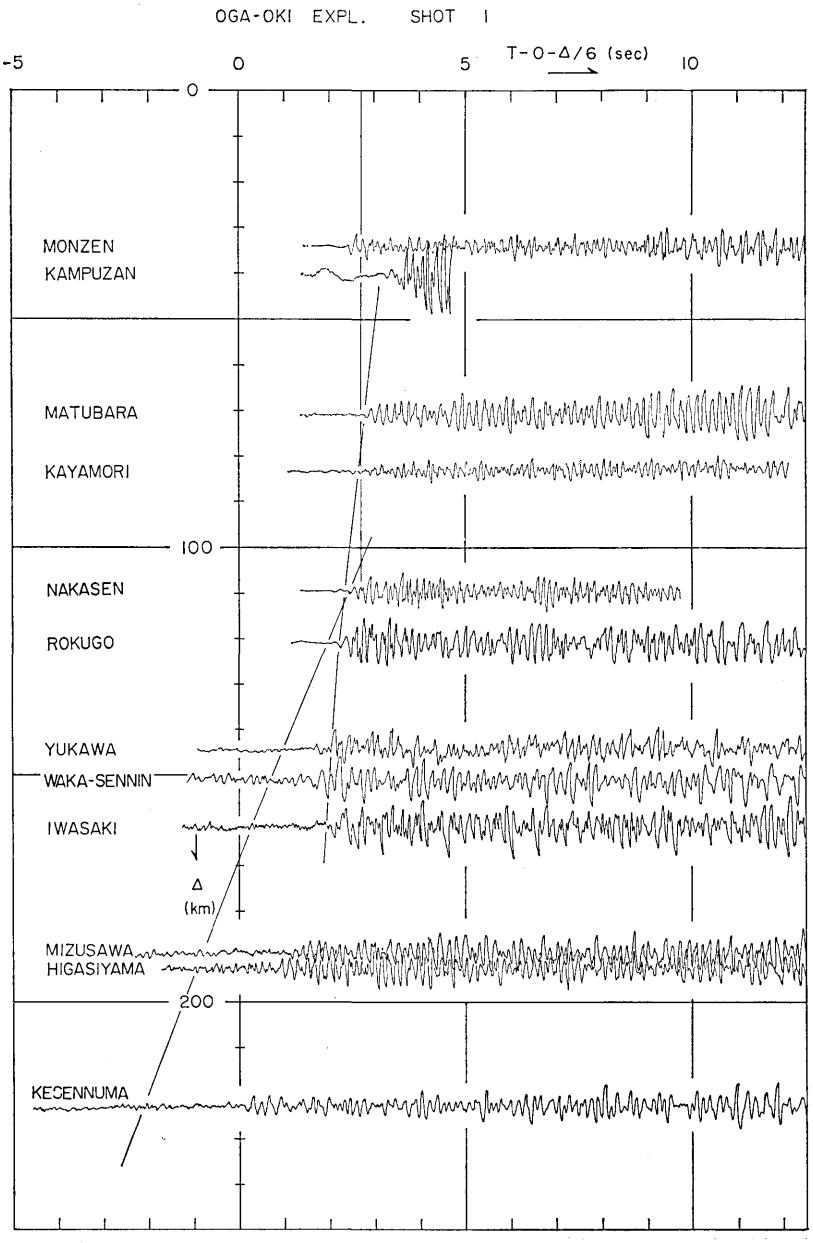
OGA-OKI EXPL. SHOT I
-5
0
5
T-O-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
100
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
Δ
(km)
MIZUSAWA
HIGASIYAMA
200
KESENNUMA

Fig. 6(4).

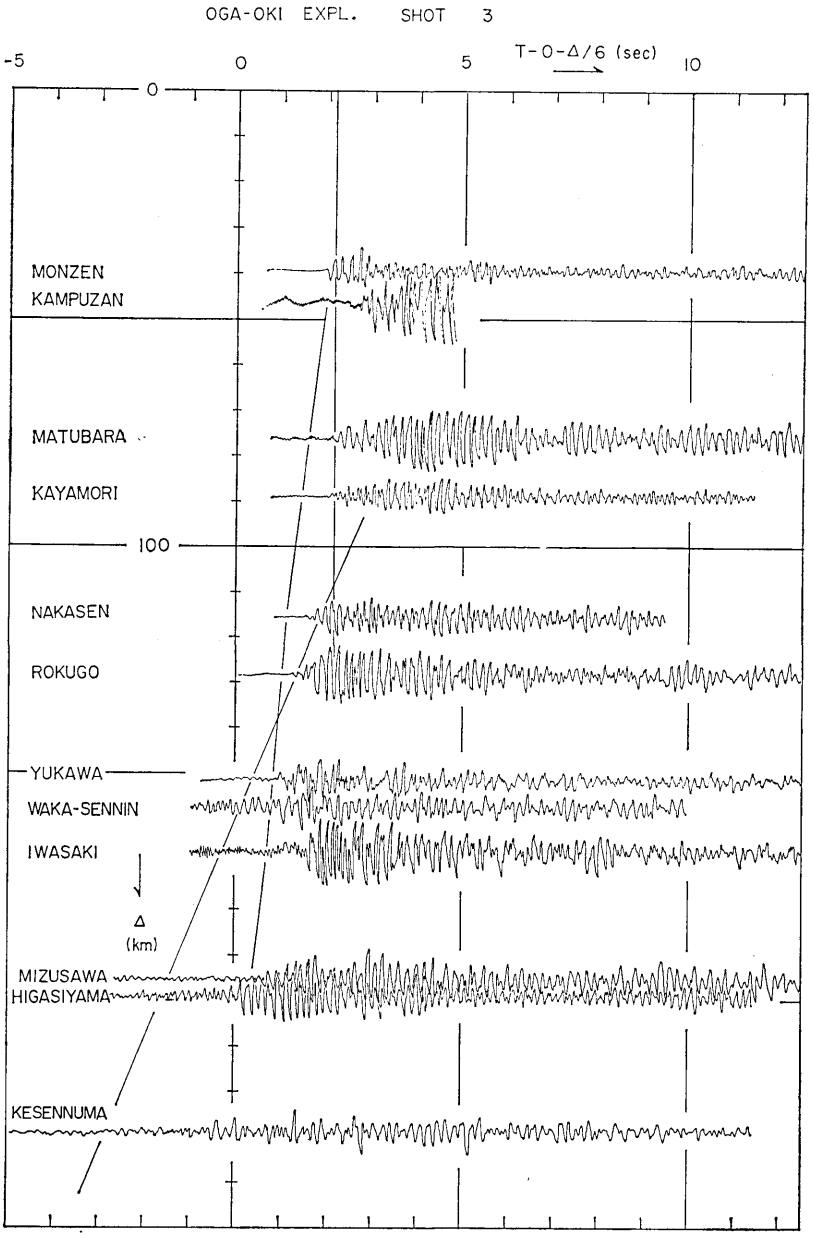
OGA-OKI EXPL. SHOT 3
-5
0
5
T-O-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
100
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
Δ
(km)
MIZUSAWA
HIGASIYAMA
KESENNUMA

Fig. 6(5).

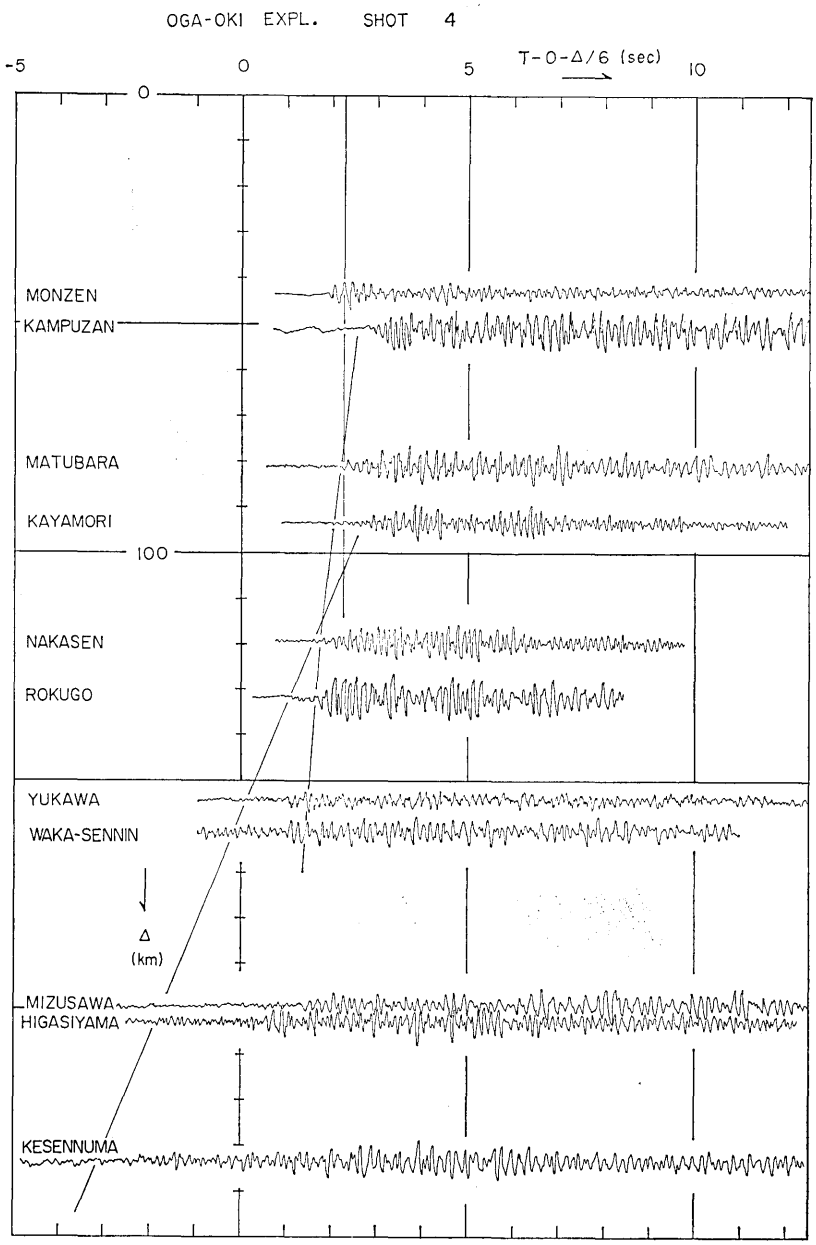
OGA-OKI EXPL. SHOT 4
-5
0
5
T-0-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
100
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
Δ
(km)
MIZUSAWA
HIGASIYAMA
KESENNUMA

Fig. 6(6).

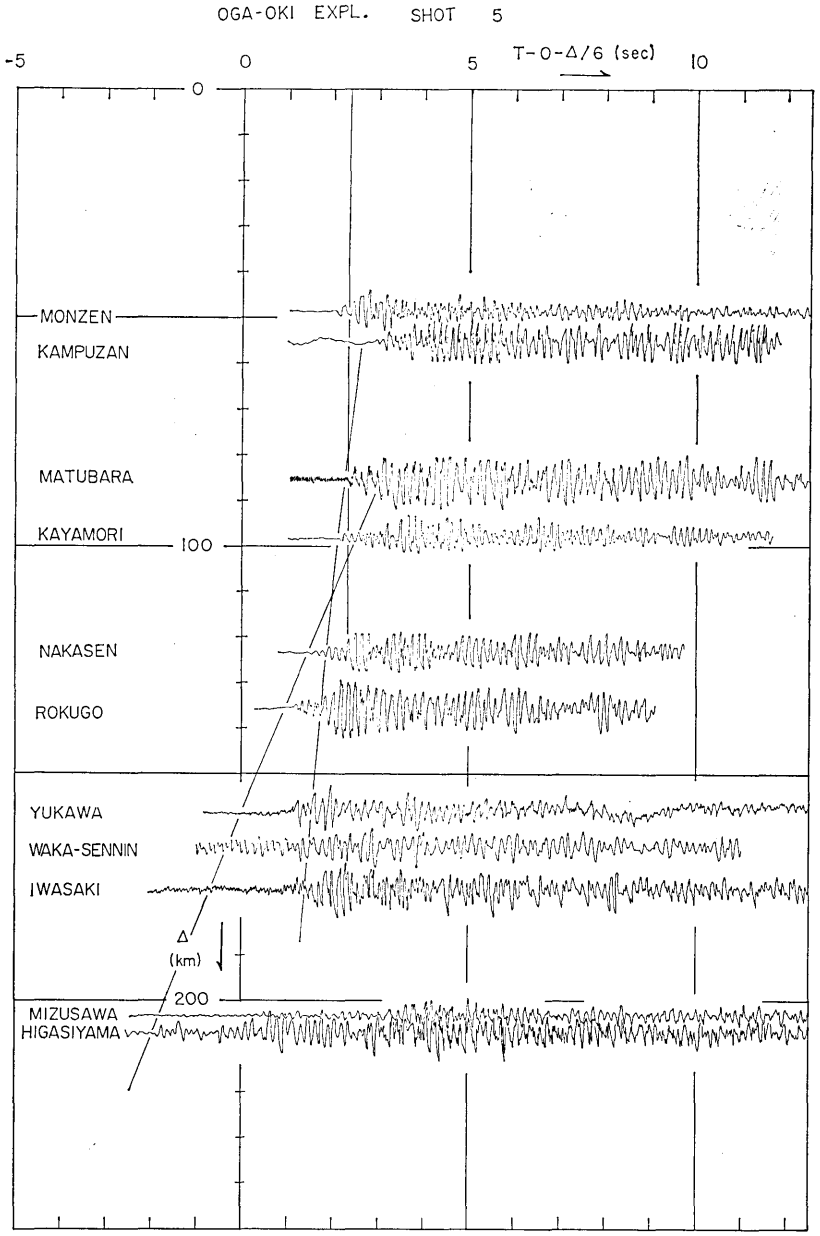
OGA-OKI EXPL. SHOT 5
-5
0
5
T-O-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
100
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
Δ
(km)
200
MIZUSAWA
HIGASIYAMA

Fig. 6(7).

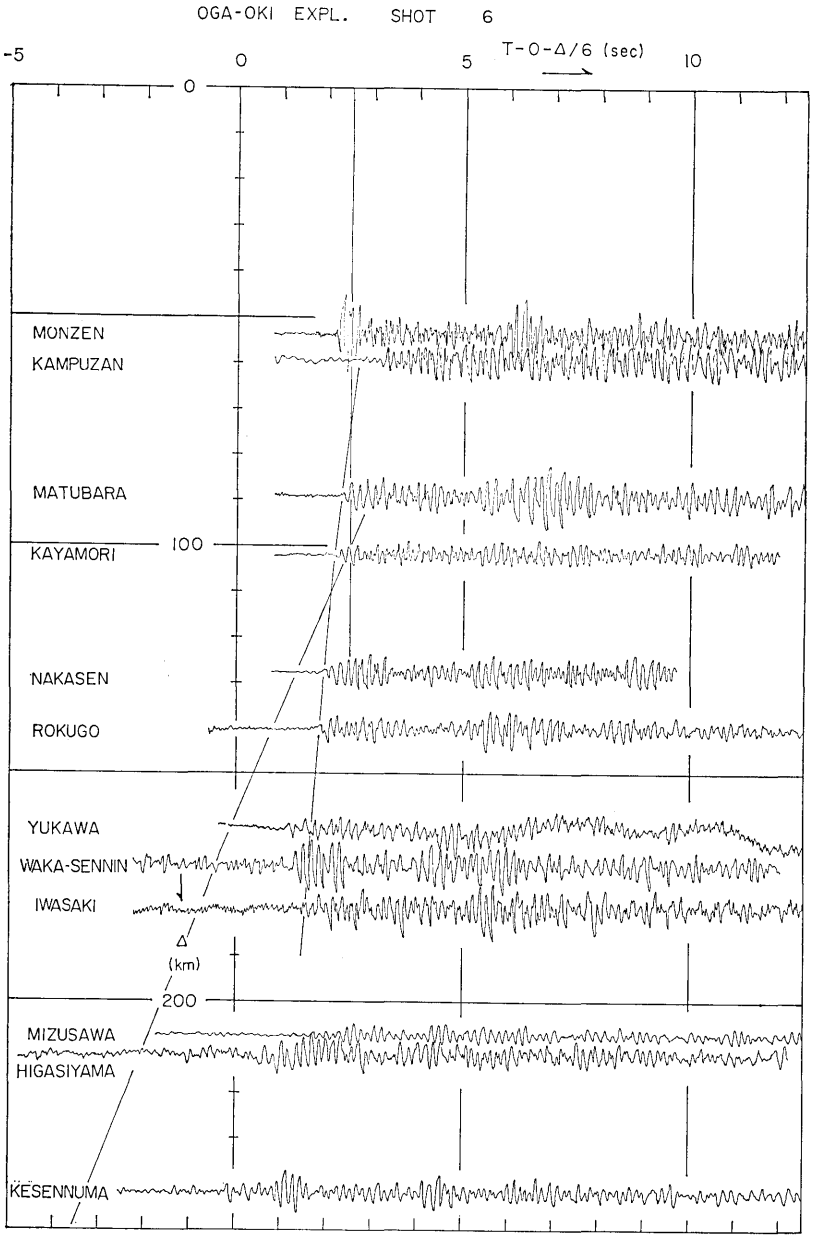
OGA-OKI EXPL. SHOT 6
-5
0
5
T-O-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
100
KAYAMORI
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
Δ
(km)
200
MIZUSAWA
HIGASIYAMA
KESENNUMA

Fig. 6(8).

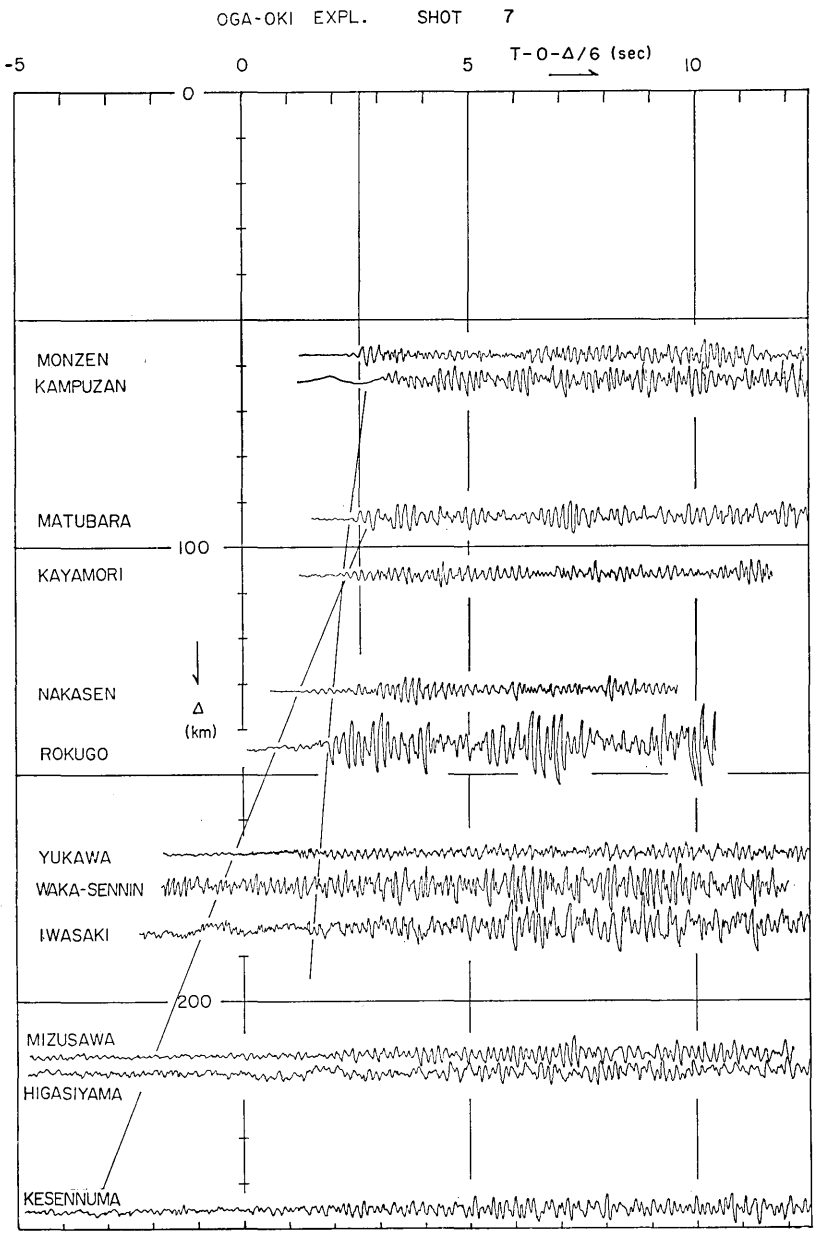
OGA-OKI EXPL. SHOT 7
-5
0
5
T-0-Δ/6 (sec)
10
0
MONZEN
KAMPUZAN
MATUBARA
100
KAYAMORI
NAKASEN
Δ
(km)
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
200
MIZUSAWA
HIGASIYAMA
KESENNUMA

Fig. 6(9).

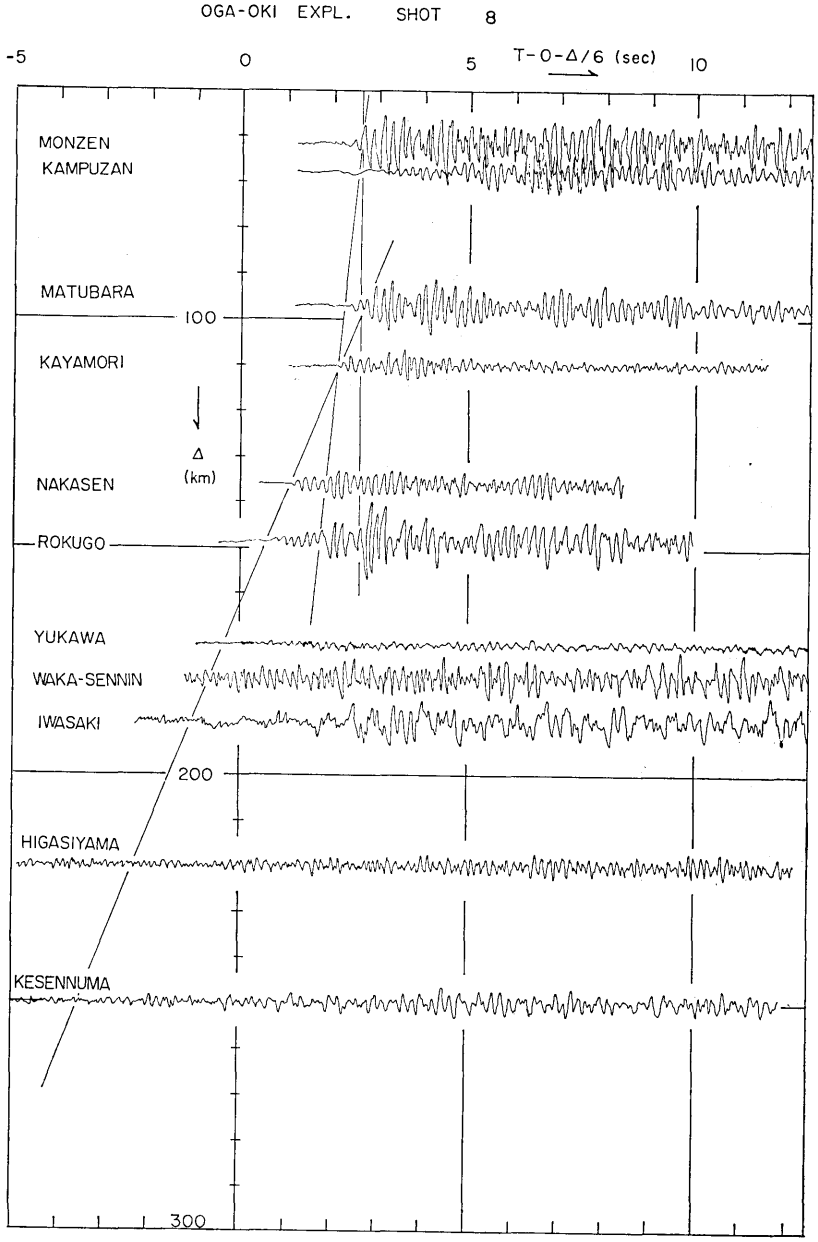
OGA-OKI EXPL. SHOT 8
-5
0
5
T-O-Δ/6 (sec)
10
MONZEN
KAMPUZAN
MATUBARA
100
KAYAMORI
Δ
(km)
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
200
HIGASIYAMA
KESENNUMA
300

Fig. 6(10).

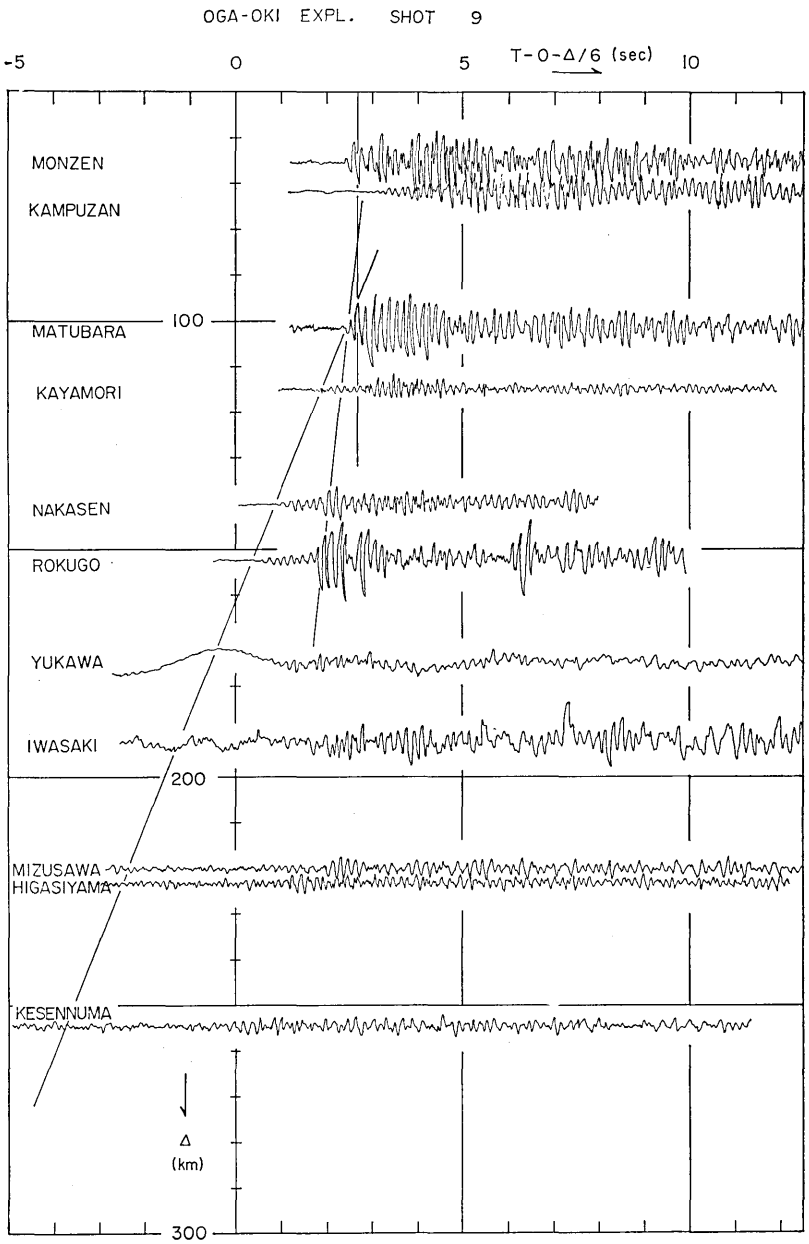
OGA-OKI EXPL. SHOT 9
-5
0
5
T-0-Δ/6 (sec)
10
MONZEN
KAMPUZAN
100
MATUBARA
KAYAMORI
NAKASEN
ROKUGO
YUKAWA
IWASAKI
200
MIZUSAWA
HIGASIYAMA
KESENNUMA
Δ
(km)
300

Fig. 6(11).

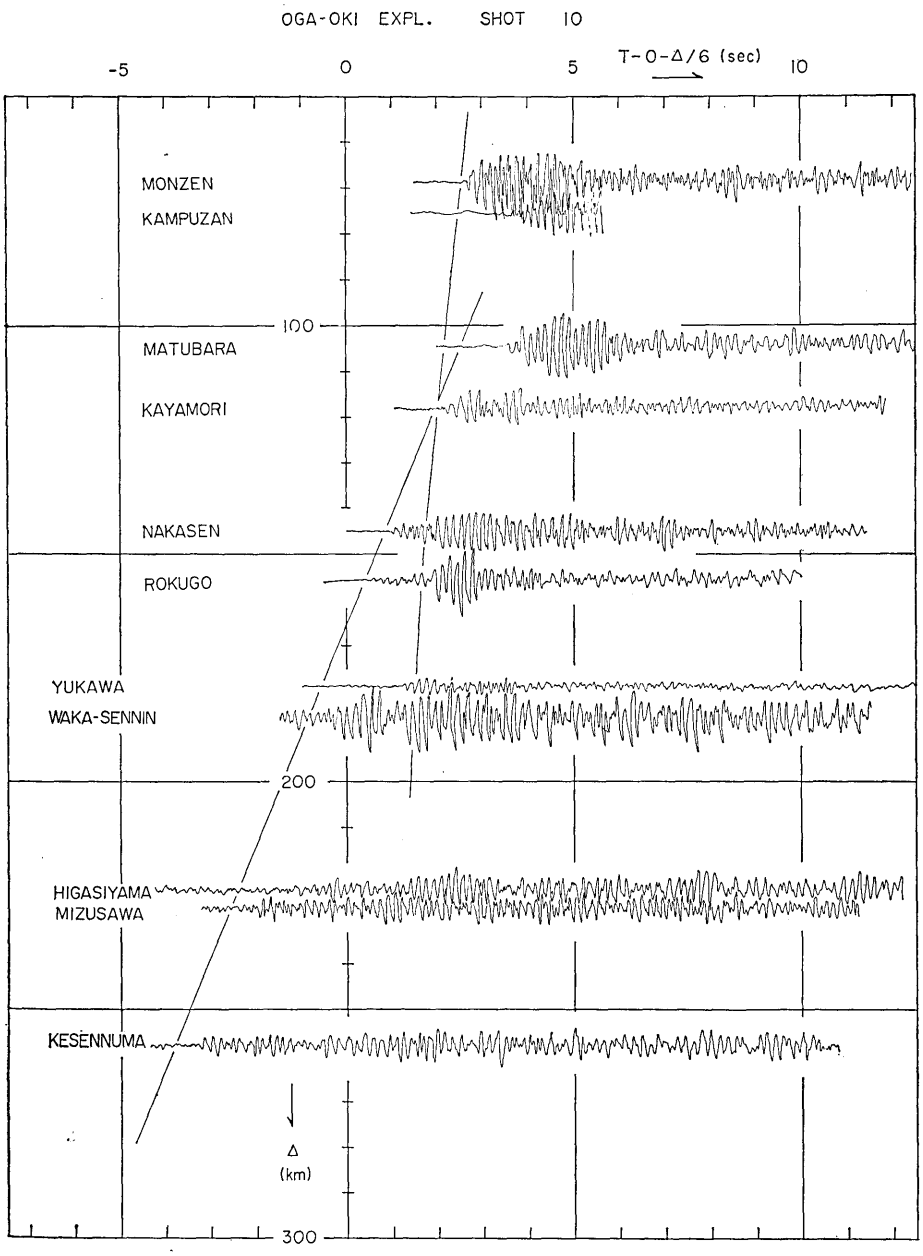
OGA-OKI EXPL. SHOT 10
-5
0
5
T-0-Δ/6 (sec)
10
MONZEN
KAMPUZAN
100
MATUBARA
KAYAMORI
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
200
HIGASIYAMA
MIZUSAWA
KESENNUMA
Δ
(km)
300

Fig. 6(12).

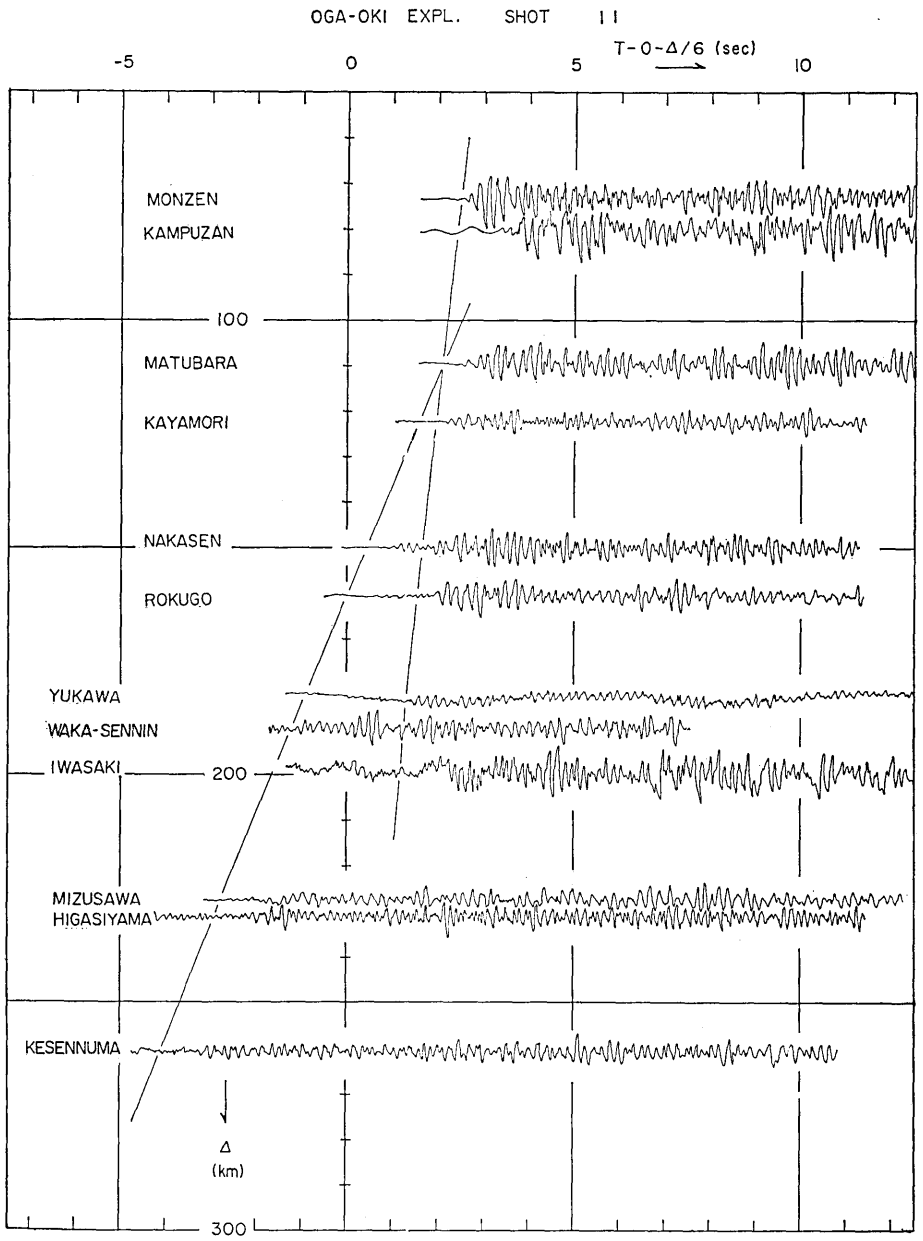
OGA-OKI EXPL. SHOT 11
T-0-Δ/6 (sec)
-5
0
5
10
MONZEN
KAMPUZAN
100
MATUBARA
KAYAMORI
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
IWASAKI
200
MIZUSAWA
HIGASIYAMA
KESENNUMA
Δ
(km)
300

Fig. 6(13).

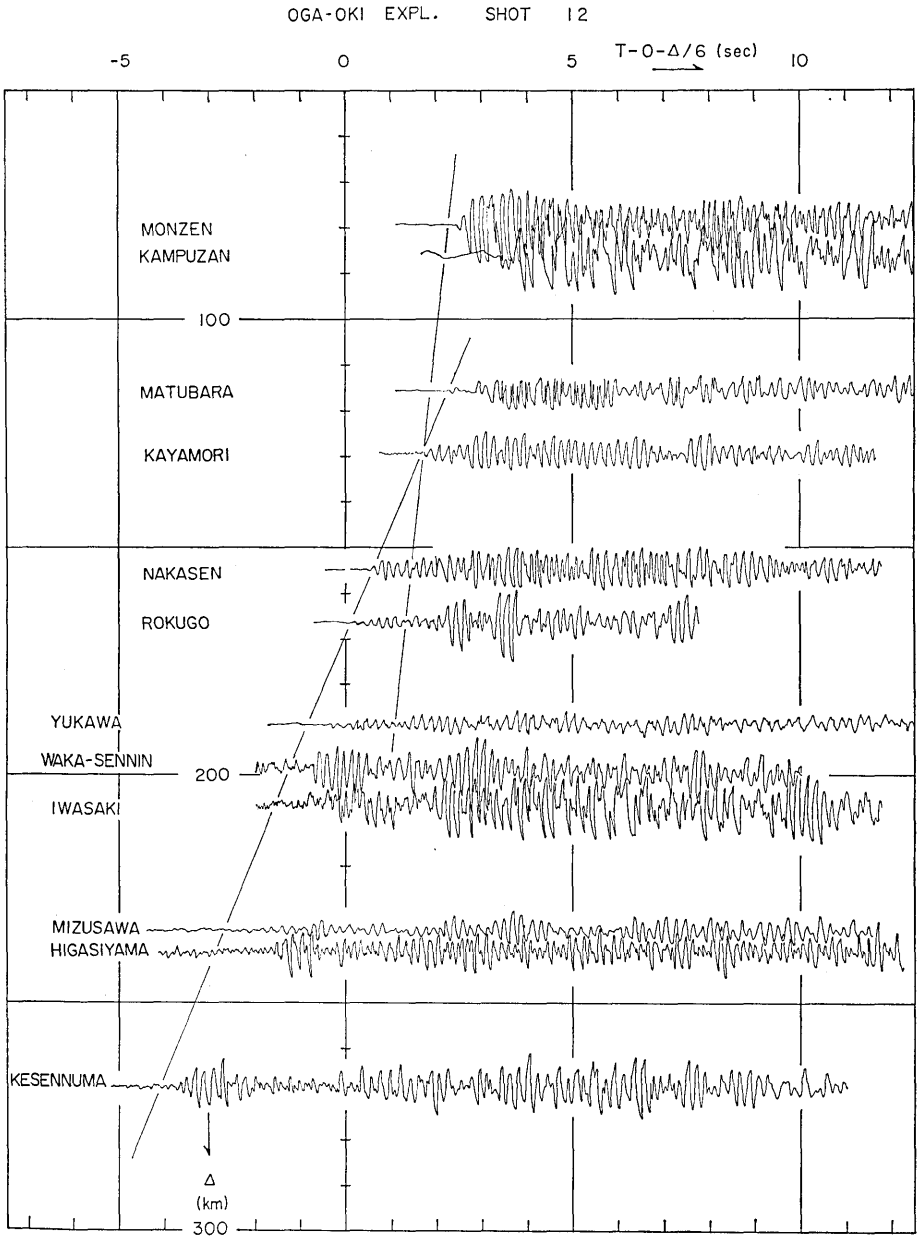
OGA-OKI EXPL. SHOT 12
-5
0
5
T-O-Δ/6 (sec)
10
MONZEN
KAMPUZAN
100
MATUBARA
KAYAMORI
NAKASEN
ROKUGO
YUKAWA
WAKA-SENNIN
200
IWASAKI
MIZUSAWA
HIGASIYAMA
KESENNUMA
Δ
(km)
300

Fig. 6(14).

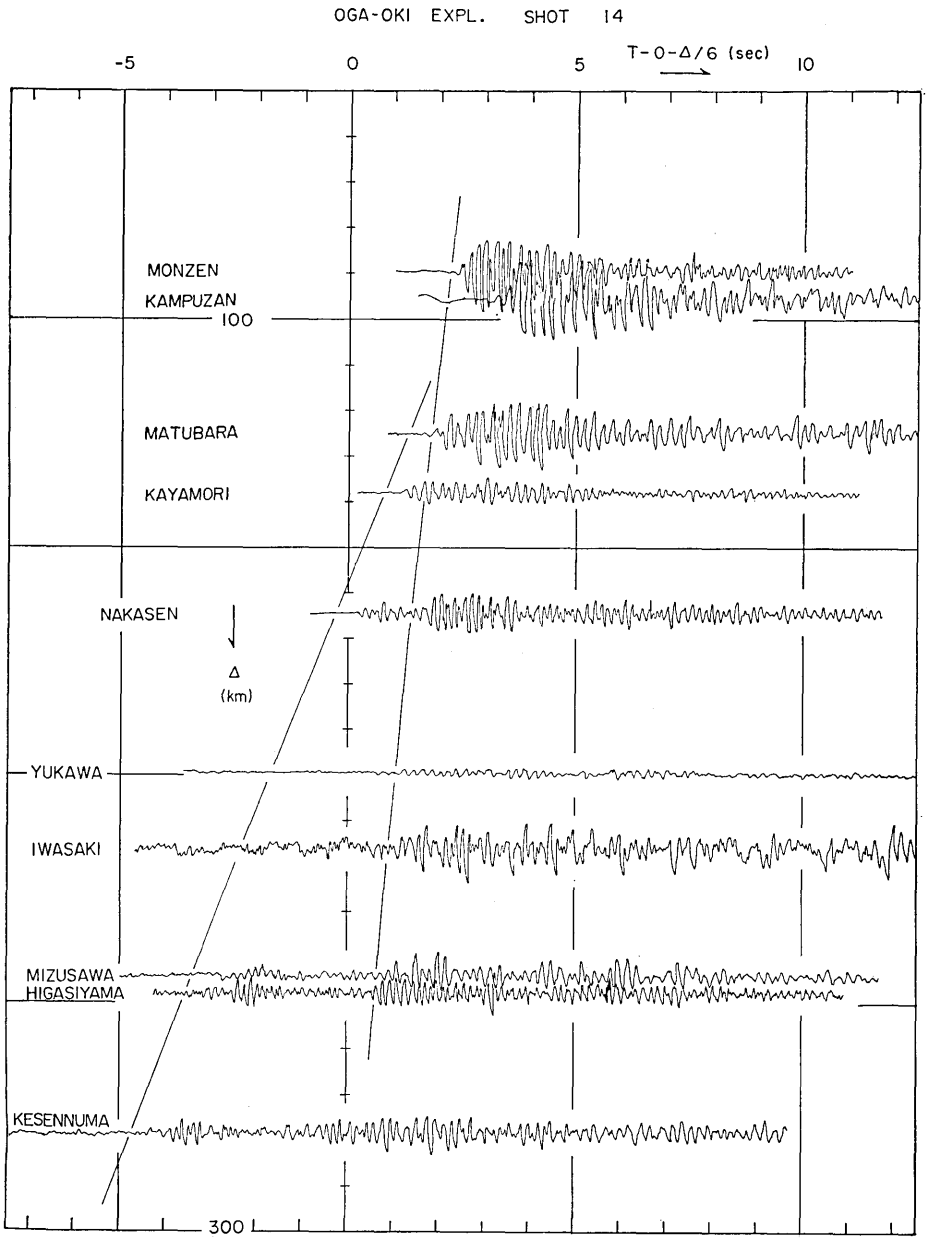
OGA-OKI EXPL. SHOT 14
-5
0
5
T-0-Δ/6 (sec)
10
MONZEN
KAMPUZAN
100
MATUBARA
KAYAMORI
NAKASEN
Δ
(km)
YUKAWA
IWASAKI
MIZUSAWA
HIGASIYAMA
KESENNUMA
300

Fig. 6(15).

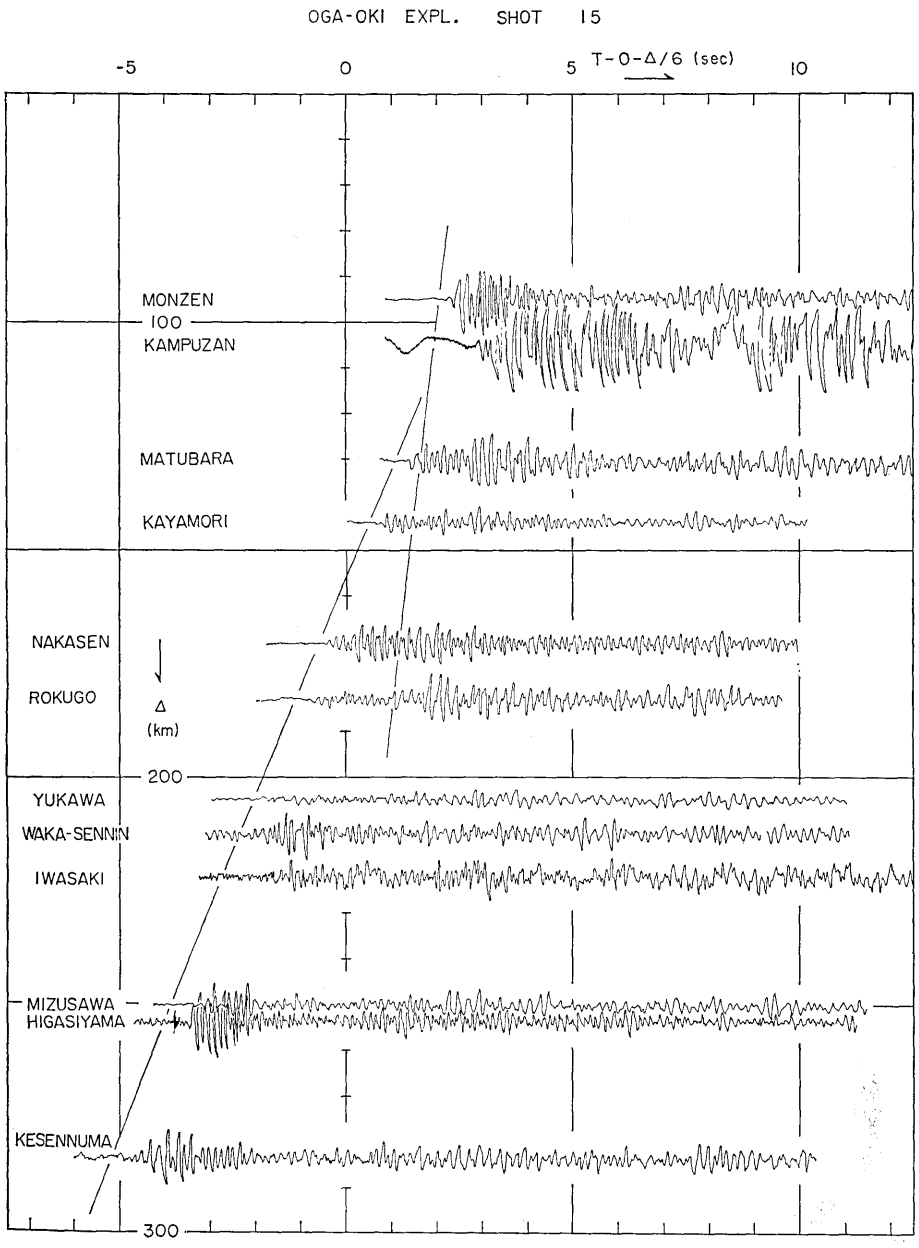
OGA-OKI EXPL. SHOT 15
-5
0
5
T-O-Δ/6 (sec)
10
MONZEN
100
KAMPUZAN
MATUBARA
KAYAMORI
NAKASEN
ROKUGO
Δ
(km)
200
YUKAWA
WAKA-SENNIN
IWASAKI
MIZUSAWA
HIGASIYAMA
KESENNUMA
300

Fig. 6(16).

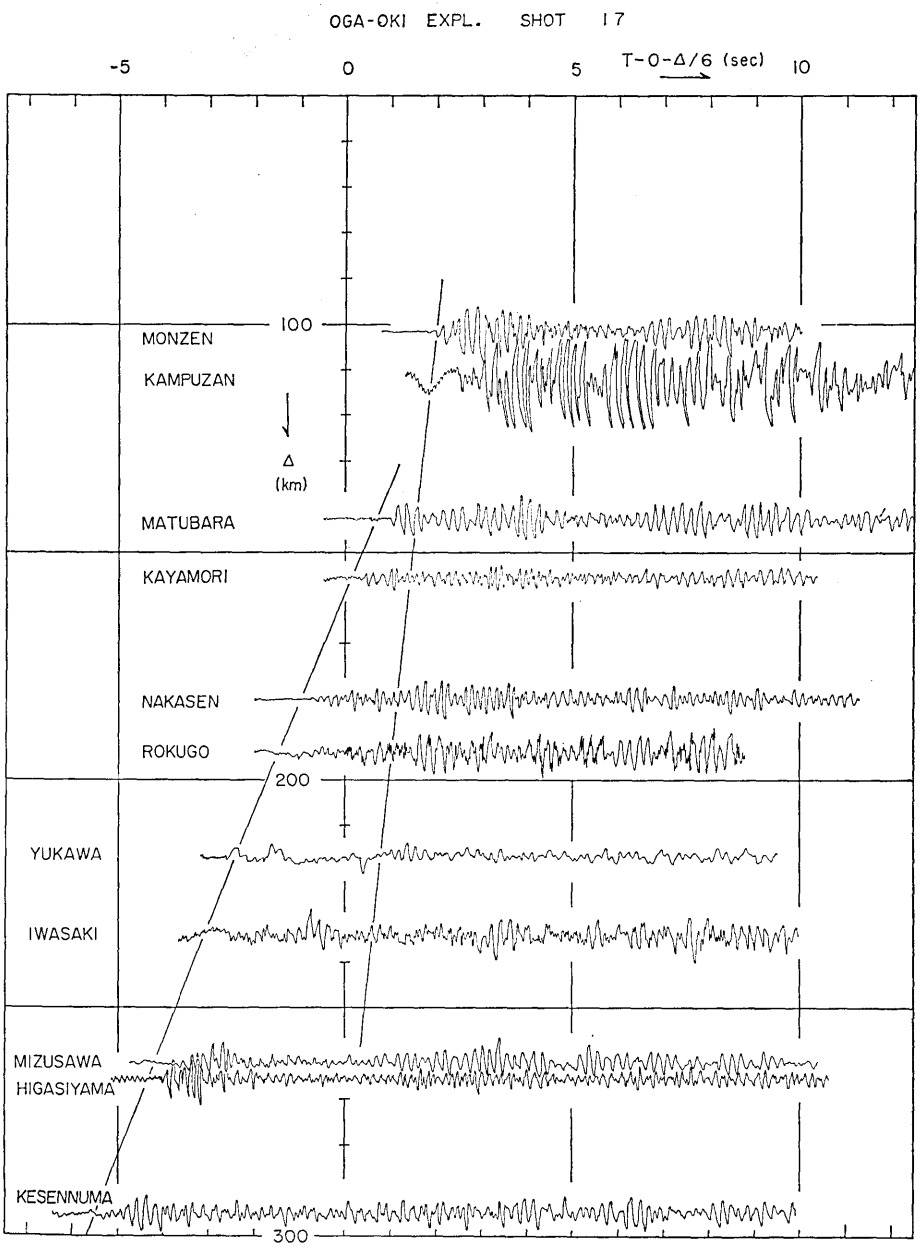
OGA-OKI EXPL. SHOT 17
-5
0
5
T-0-Δ/6 (sec)
10
100
MONZEN
KAMPUZAN
Δ
(km)
MATUBARA
KAYAMORI
NAKASEN
ROKUGO
200
YUKAWA
IWASAKI
MIZUSAWA
HIGASIYAMA
KESENNUMA
300

Fig. 6(17).

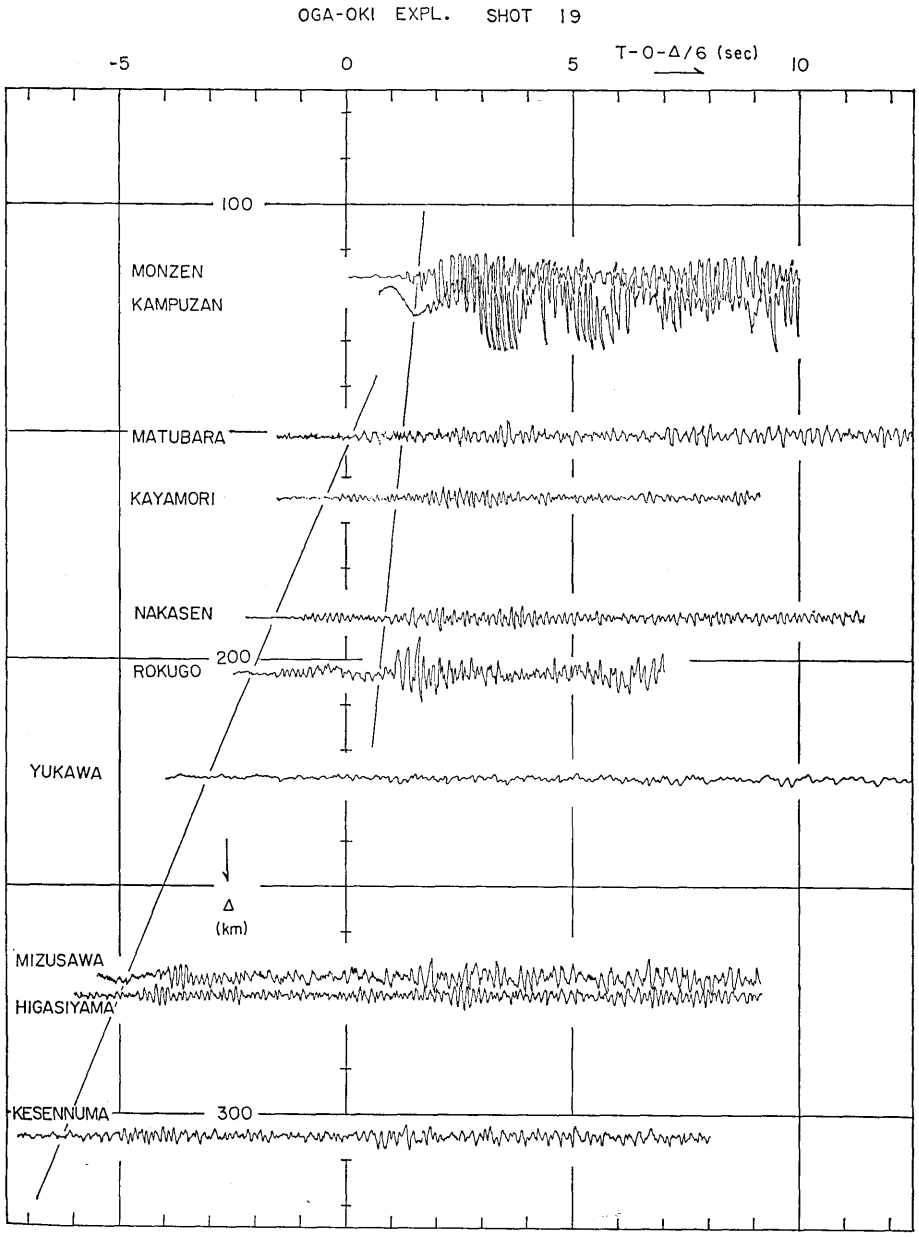
OGA-OKI EXPL. SHOT 19
-5
0
5
T-O-Δ/6 (sec)
10
100
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
NAKASEN
200
ROKUGO
YUKAWA
Δ
(km)
MIZUSAWA
HIGASIYAMA
KESENNUMA
300

Fig. 6(18).

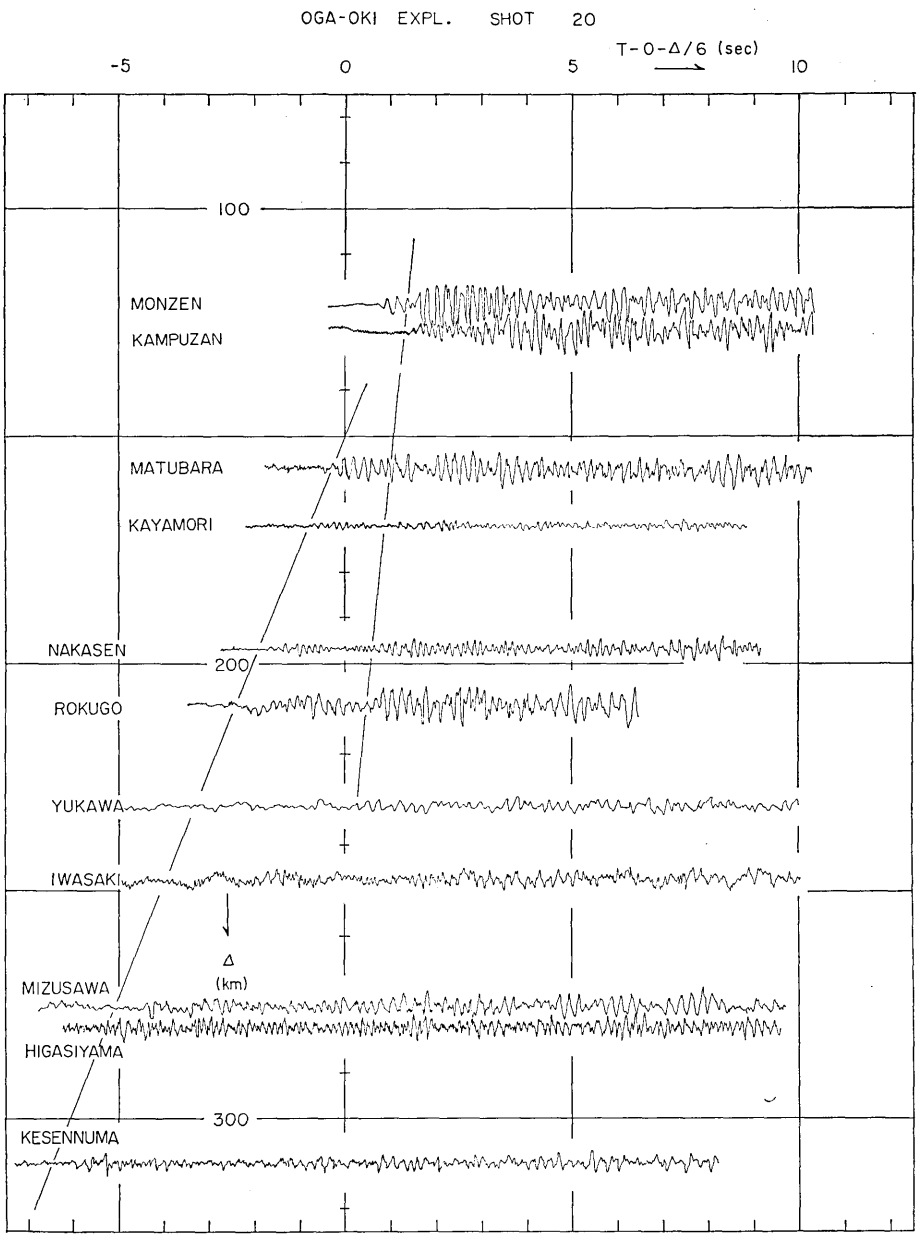
OGA-OKI EXPL. SHOT 20
T-0-Δ/6 (sec)
-5
0
5
10
100
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
NAKASEN
200
ROKUGO
YUKAWA
IWASAKI
Δ
(km)
MIZUSAWA
HIGASIYAMA
300
KESENNUMA

Fig. 6(19).

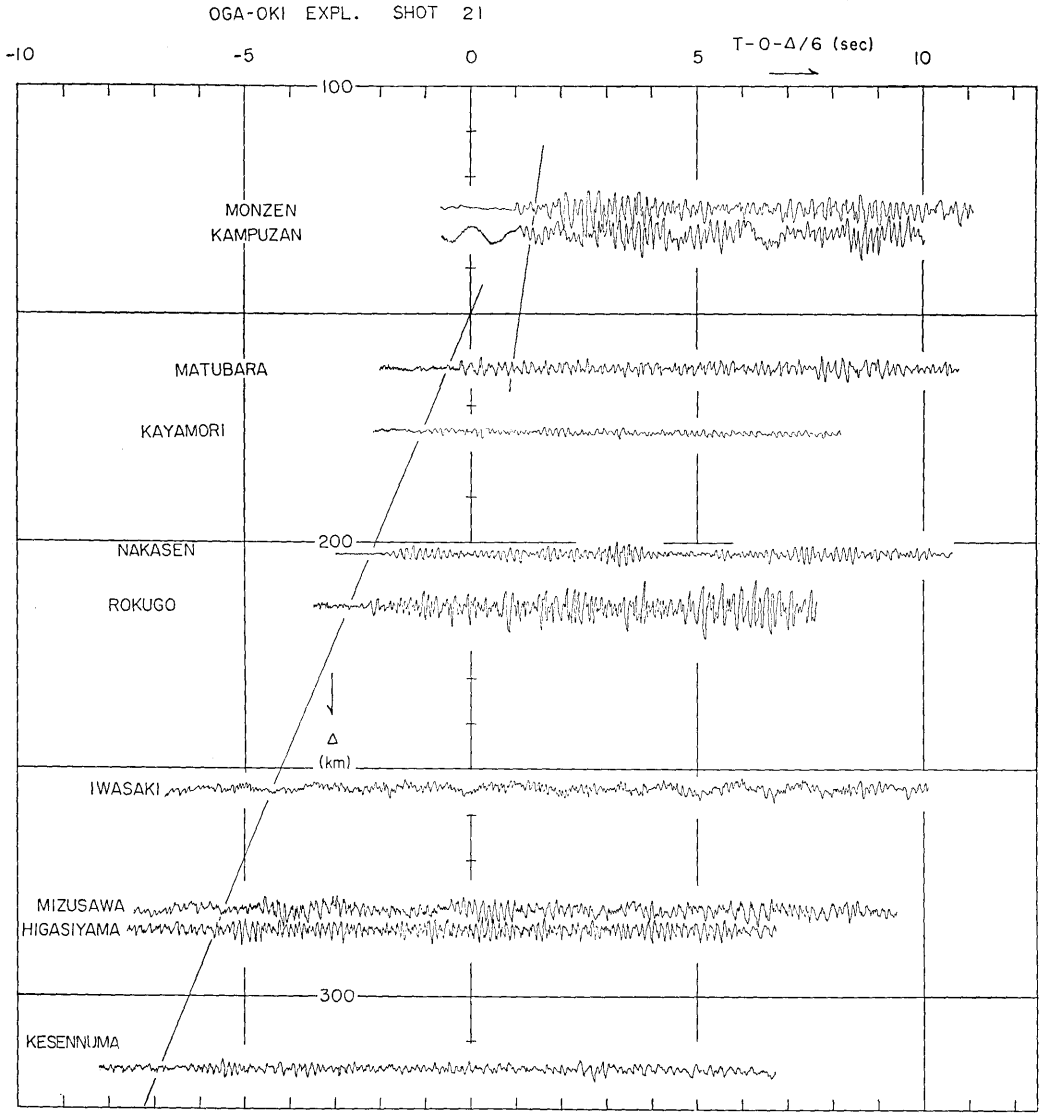
OGA-OKI EXPL. SHOT 21
-10
-5
0
5
T-O-Δ/6 (sec)
10
100
MONZEN
KAMPUZAN
MATUBARA
KAYAMORI
200
NAKASEN
ROKUGO
Δ
(km)
IWASAKI
MIZUSAWA
HIGASIYAMA
300
KESENNUMA

Fig. 6(20).