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26. *Crustal Structure in Central Japan along Longitudinal Line 139°E as Derived from Explosion-Seismic Observations.*

Part 1. Explosions and Seismic Observations.

By The Research Group for Explosion Seismology.

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1. Introduction

Since November 1961, the Research Group for Explosion Seismology has carried out three blasts of about one ton explosives at the sites of Siunzi town, Annaka city and Kawazu town. Seismic waves from the explosions were observed at temporary stations systematically spread along longitudinal line 139°E on which the three shot points were located. Our aim was to obtain precise information about the crustal structure in the boundary region which geologically divides Japan into northeastern and southwestern parts. At the time of the Annaka explosion, seismic waves from a natural earthquake which occurred near Miyake-zima about one minute before the scheduled shot time were observed by the observation network.

An outline of the explosion-seismic observations and the observed data as well as those of the Miyake-zima earthquake will be given in the following. In addition, observed data on the earthquake obtained at routine stations of the Japan Meteorological Agency (J.M.A.) and those of the Siunzi explosion obtained by Dr. H. Kawasumi and others will also be given.

2. Description of explosions

The three shots were carried out only for the purpose of observing seismic waves. The sandy beach of the Japan Sea coast at Siunzi town, Niigata Prefecture, was chosen as the site of the first explosion, where 17 blast holes, each 4 inches in diameter and 40 m deep, were drilled and 1.5 tons of explosives charged in.

In the second explosion, about 0.78 ton of explosives were filled in 7 blast holes, each 4 inches in diameter and 50 m deep, drilled in farmland

in the suburban area of Annaka city, Gumma Prefecture.

The third explosion was planned as the reverse shot of the first one. The shot point was the innermost part of a dead pit of a gold mine at Kawazu town, Sizuoka Prefecture, being located at the southernmost part of Izu Peninsula, where about 1.5 tons of dynamite were concentrated.

Table 1. Location and geology near shot point, shot time, amount of charge and the number of temporary stations for the three explosions.

Shot point	Latitude (N)	Longitude (E)	Height (m)	Shot time
SIUNZI	38°01′40.1″	139°17′31.9″	−15	1961, Nov. 10, $01^h07^m00.691^s$
ANNAKA	36°17′35.3″	138°53′06.5″	206	1962, Sept. 7, $01^h07^m00.217^s$
KAWAZU	34°43′57.0″	138°59′31.8″	159	1963, Mar. 21, $01^h07^m00.313^s$

Shot point	Amount of charge (ton)	Geology near shot point	Number of observation points
SIUNZI	1.503	Sand	Near shot point: 7 Southern profile: 15
ANNAKA	0.78	Mudstone	Near shot point: 5 Northern profile: 4 Southern profile: 10
KAWAZU	1.5	Tuff breccia	Near shot point: 3 Northern profile: 13

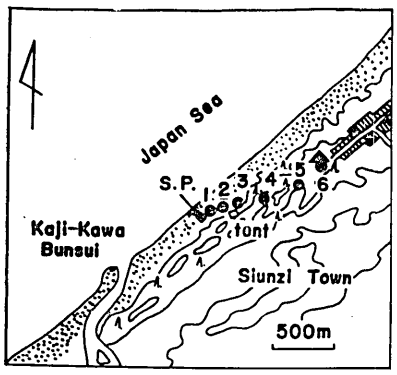

Fig. 1 (a)

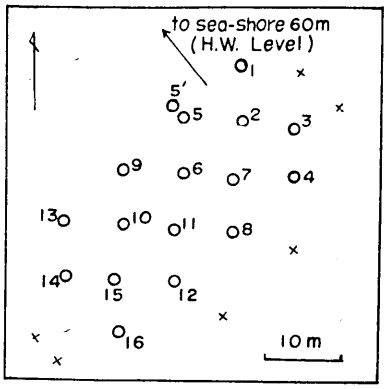

Fig. 1 (b)

Fig. 1 (a). Topographic map near Siunzi shot point. Solid circle: geophone.
Fig. 1 (b). Details of blast hole system for Siunzi explosion. Open circle: blast hole. cross mark: flare bomb.

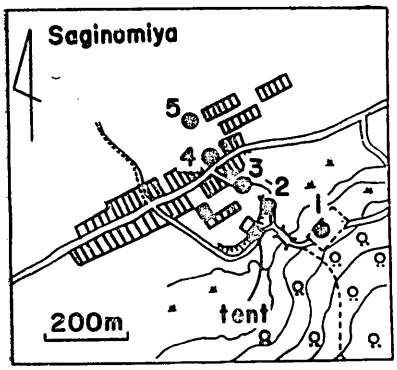

Fig. 2 (a)

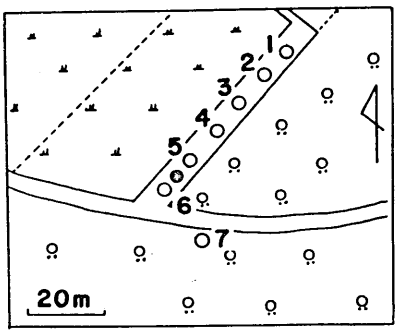

Fig. 2 (b)

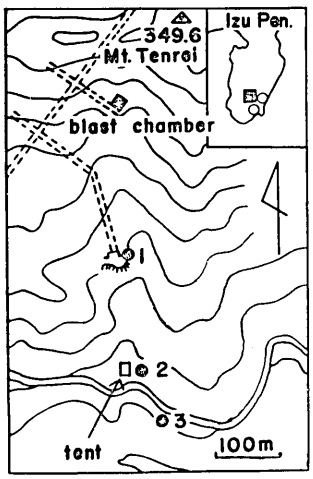

Fig. 3 (a)

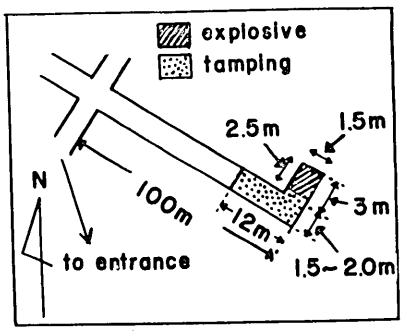

Fig. 3 (b)

Fig. 2 (a). Topographic map near Annaka shot point. Solid circle: geophone. Broken line rectangle: blast hole area.
Fig. 2 (b). Details of blast hole system. Solid circle: geophone (up hole). Open circle: blast hole.
Fig. 3 (a). Topographic map near Kawazu shot point. Solid circle: geophone.
Fig. 3 (b). Details of blast chamber.

In each explosion, the electric blasting caps were attached directly to all dynamite charges in the blast holes and pit in order to fire simultaneously. The shot time was directly registered on the oscillogram. The location of shot point, shot time, amount of charge, geological condition near the shot point and number of temporary stations are tabulated in Table 1. The topography near the shot points and distribution of blast holes and setup of abandoned gold mine are shown in Figs. 1–3.

3. Outline of observations

The temporary observation stations, 52, in total, were spread mainly along longitudinal line 139°E as shown in Fig. 4. The routine observation stations of J. M. A. where seismic waves from the Miyake-zima earthquake were observed are also given in Fig. 4. Name of each temporary station, geographical location, epicentral distance, azimuth relative to the shot point measured from due north as well as instruments employed and name of observers are tabulated in Tables 2–4.

The geographical coordinates of the shot points, observation stations and epicentral distances are determined by the method based on trian-

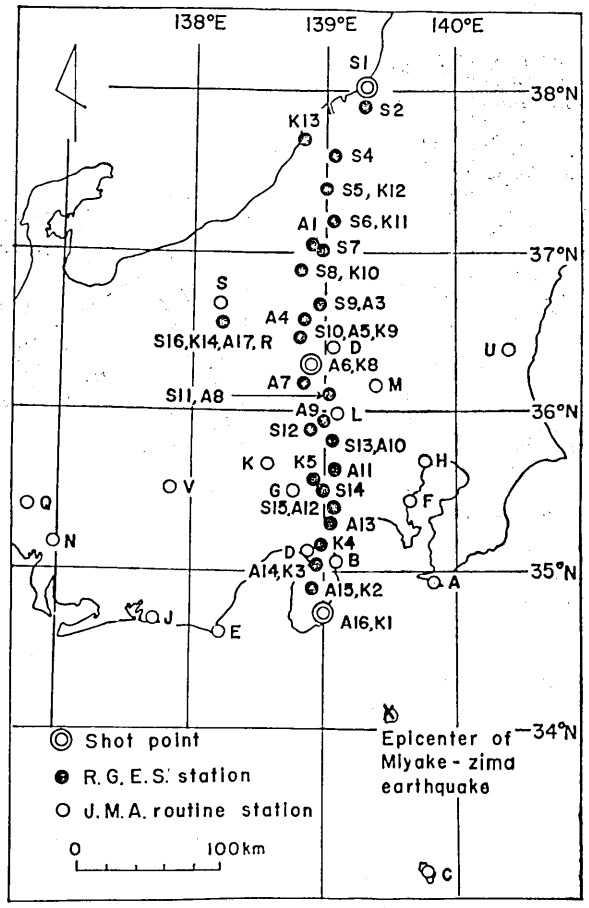

Fig. 4. Distribution of observation stations. Notations correspond to those in Tables 2, 3, 4 and 8.

gulation. As in past experiments of this kind, electromagnetic geophone with proper frequency 3 c/s, amplifier and electromagnetic oscillograph were employed at most of the stations. The JJY radio time signal relayed by the Nihon Hôsô Kyôkai (NHK) was registered directly on the oscillograms. At a few stations magnetic tape recording systems were used.

4. Observed results

In the Siunzi explosion, satisfactory records were obtained at most of the stations, while at the time of the Annaka explosion the initial motion of the artificial seimic wave was disturbed at stations in the southern profile by a natural earthquake which occurred about one minute before the scheduled shot time in the area of the earthquake swarm having followed the great eruption of the Miyake-zima volcano on Aug. 24, 1962. Waves from this earthquake were also recorded at stations in the northern profile. Data of this earthquake obtained at J. M. A. routine stations as well as that at temporary stations was used in determining the epicenter.

In the Kawazu explosion, the blast was not so effective as expected and the background noise were largely excited by snow-melting. These circumstances are the reason why we could not observe the initial motion at northern stations.

The seismograms are shown in Fig. 5. The records were read independently by several members of the Group and the arrival times of various phases were adopted as valid when satisfactory agreements were found after discussion. For the sake of convenience, the adopted values were classified into the following four grades according to their accuracy.

a: $\quad \Delta t \leqq 0.02$ sec
b: $\quad 0.02 < \Delta t \leqq 0.05$ sec
c: $\quad 0.05 < \Delta t \leqq 0.10$ sec
d: $\quad 0.10 < \Delta t$

Adopted values of the arrival time of the initial and remarkable later phases, its accuracy and direction of initial motion are tablated in Tables 5–9 for each explosion and the Miyake-zima earthquake. Travel time graphs are shown in Figs. 6–9.

In order to obtain information about the superficial layer near the shot point, several geophones were installed within about 1 km distance from the shot point for each explosion. The observed data is shown in Tables 10–12 and Figs. 10–12.

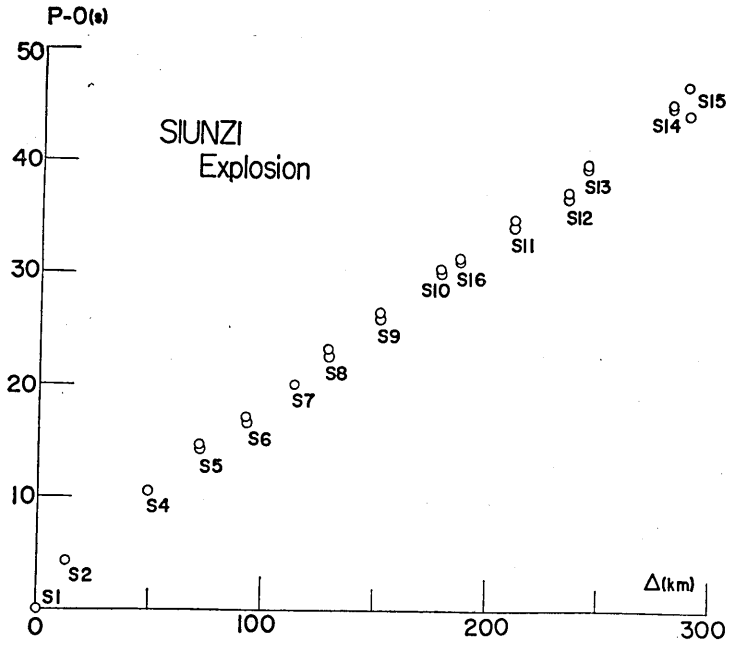

Fig. 6. Travel time graph of Siunzi explosion.

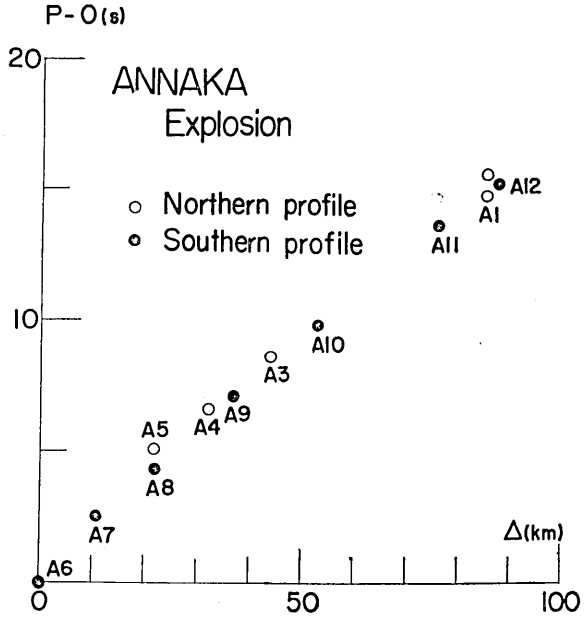

Fig. 7. Travel time graph of Annaka explosion.

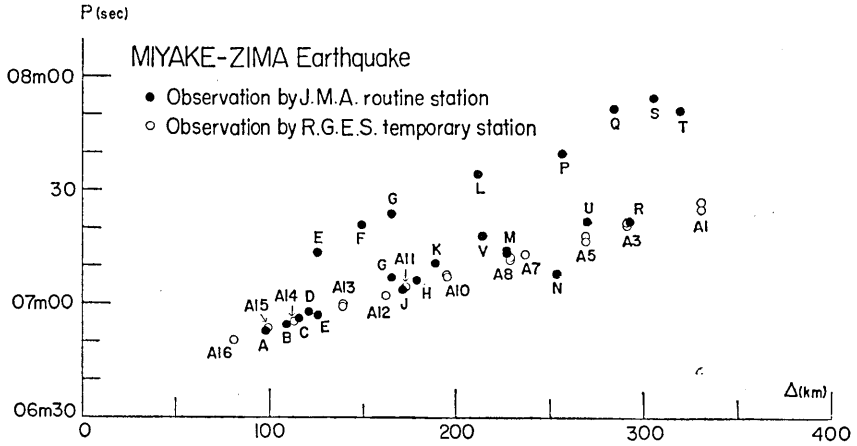

Fig. 8. Travel time graph of Miyake-zima earthquake.

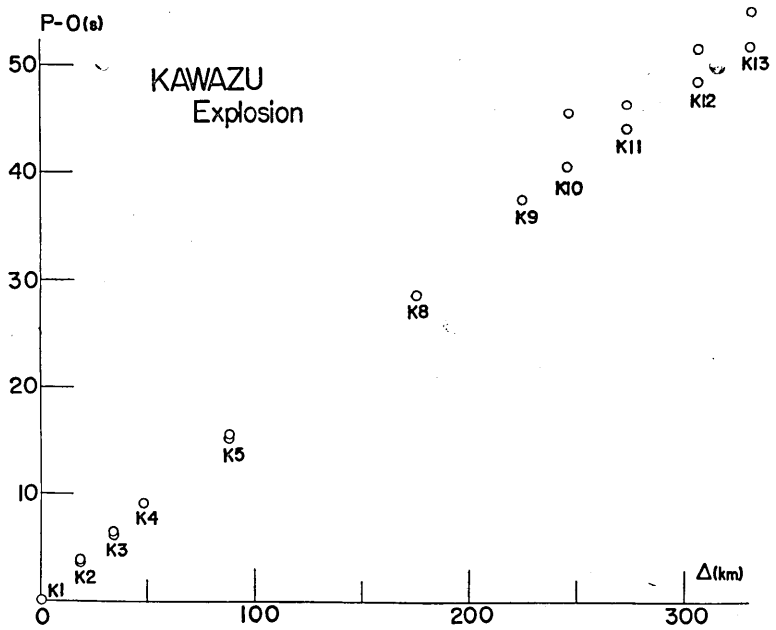

Fig. 9. Travel time graph of Kawazu explosion.

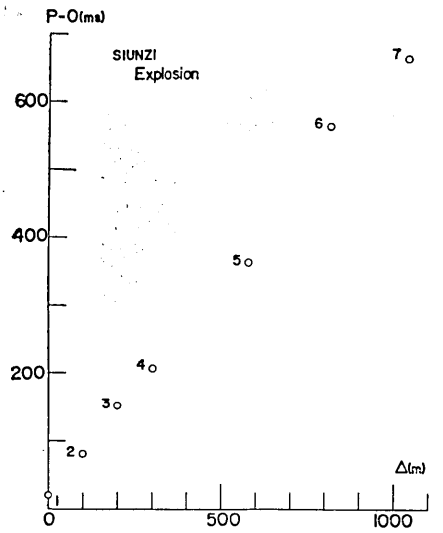

Fig. 10.

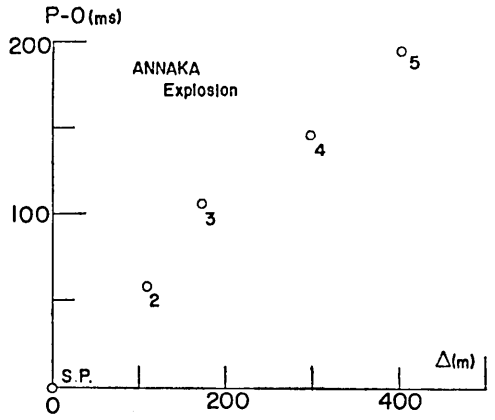

Fig. 11.

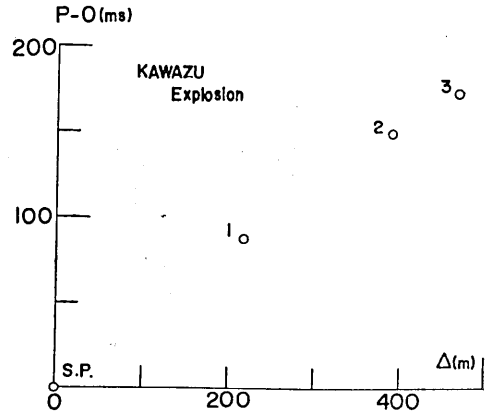

Fig. 12.

Fig. 10. Travel time graph near the shot point of Siunzi explosion.
Fig. 11. Travel time graph near the shot point of Annaka explosion.
Fig. 12. Travel time graph near the shot point of Kawazu explosion.

Crustal structure in the profile along longitudinal line 139°E, derived from the above-mentioned data will be discussed in Part 2 of this paper under the same title.[1)]

As to the romanization of station name, the Japanese system was adopted except J.M.A. routine stations which were expressed by Hepburn system as J.M.A. usually does. Confusion in romanizing station name in Fig. 5 were left unchanged, since they are direct photographic copies from the original records.

1) H. HOTTA et al., *Bull. Earthq. Res. Inst.*, **42** (1964), 533-541.

Table 2. Table of temporary stations, apparatus and observers for Siunzi explosion. In tables 2–4, Θ is the azimuth of stations relative to shot point and the notation mVn in the column "geophone" means that n vertical (H means horizontal) geophones with proper frequency m c/s were used.

	Observation point	Latitude (N)	Longitude (E)	Height (m)	Θ	Δ (km)	Geophone	Gain of Amplifier (μV/mm)	Observers
S1	SIUNZI	38°01′40.1″	139°17′31.9″	−15		00.000			S. Murauchi, T. Asanuma
	No. 1					0.000	3V1		K. Ichikawa, T. Kawashima
	No. 2			6	N 81° E	0.100	3V1		Y. Tamura, A. Okada
	No. 3			7	N 81° E	0.200	3V1		
	No. 4			9	N 81° E	0.300	3V1		
	No. 5			15	82	0.582	3V3 (Accelero-meter)		H. Kawasumi, Y. Ichinose J. Takahasi
	No. 6			17	78	0.828			
	No. 7			21	73	1.049	3H3 (Accelero-meter)		
S2	NAKAURA	37°54′30.1″	139°18′27.6″	17	174°08.7′	13.326	4.5V3 3V1 3H1	4~11	H. Aoki, M. Kumazawa
S4	SIMO-TAKAYANAGI	37 36 07.3	139 06 47.9	78	198 26.0	49.809	11V2 20V8 20H1	4~23	K. Noritomi, Y. Ueda T. Kikuchi
S5	MATUO	37 24 52.2	139 00 11.2	240	200 31.6	72.678	2.8V1 3.5V1	10 38	E. Shima, M. Yanagisawa

(to be continued)

(continued)

	Observation point	Latitude (N)	Longitude (E)	Height (m)	θ	Δ (km)	Geophone	Gain of Amplifier (μV/mm)	Observers
S6	YUNOTANI	37 12 23.5	139 03 36.4	208	192 40.1	93.417	(3.4~7.2)V5 5H2	3 (5 c/s) 6, 9	Z. Suzuki, M. Abe Y. Sayama, M. Yamakawa
S7	IKAZAWA	37 02 20.8	138 57 07.5	225	195 19.2	113.763	3V2	3, 8	M. Ōtsuka, M. Hashizume T. Mikumo
S8	YUZAWA	36 55 55.4	138 47 33.9	895	199 57.8	129.374	3V3	1.5, 1.7, 2.2	N. Nakajima, Y. Yamazaki
S9	NIIHARU	36 41 25.3	138 55 18.8	470	192 27.8	152.001	3H1 3V2	1 0.8, 10	I. Muramatsu, S. Kajita
S10	ZINDA	36 28 09.1	138 46 41.1	695	194 46.3	178.871	2.3V1 1V1	2.8 50	M. Sibano, T. Terashima T. Miura
S11	SIMOKUBO	36 07 50.7	139 01 32.7	210	186 25.3	211.839	3H2 3V1	0.3~0.5 0.2	O. Kawamoto, I. Tamaki T. Mitsuhashi
S12	OTAKI	35 56 11.1	138 51 17.7	721	189 31.4	235.313	3V2	4.3, 5.6	I. Karakama, T. Daikubara
S13	NIPPARA	35 49 57.1	139 03 57.5	620	184 43.8	244.430	1.1V1 4.3V1	2 1.3	H. Okada, H. Hotta S. Kubota, T. Takahashi
S14	DOSI	35 30 26.3	138 58 29.2	1050	195 47.1	281.101	4V2	1.4	Y. Motoya, M. Nogosi M. Seino
S15	YAMAKITA	35 26 10.0	139 06 11.7	580	193 21.5	288.064	3V1	1	A. Takagi, H. Hamaguti T. Sugiyama
S16	MATSUSHIRO	36 32 20.0	138 12 30.0	440	210 45.0	187.870	1V2 (Benioff Seismograph)		K. Aihara

Table 3. Table of temporary stations, apparatus and observers for Annaka explosion.

	Observation point	Latitude (N)	Longitude (E)	Height (m)	Θ	Δ (km)	Geophone	Gain of Amplifier (μV/mm)	Observers
A1	MUIKAMATI	37°03′46.1″	138°55′12.4″	194	N2°05.7′E	85.468	3V1	62×10⁵*	M. Hashizume, K. Oike
							3H1	1.4	
A3	NIIHARU	36 41 25.3	138 55 18.8	470	4 16.3	44.196	3.3V2	2.5~8.3	I. Muramatsu, Y. Endo
							20V9		
A4	NAKANOJO	36 34 55.8	138 51 09.3	305	N5 12.0 W	32.201	20H1	9~42	K. Noritomi, M. Nogoshi Y. Ueda
							11V1		
A5	ZINDA	36 28 09.1	138 46 41.1	695	26 11.0	21.767	3V2	5.6, 9.1	M. Sibano, Y. Yamazaki
							2.8V1	6.7	
A6	ANNAKA	36 17 35.3	138 53 06.5	206		0.000			T. Asanuma, T. Kimura
	No. 2			208	60 48.0	0.109	7V1		K. Ichikawa, A. Tanaka
	No. 3			217	56 06.0	0.174	6V1		A. Okada
	No. 4			220	56 06.0	0.299	7V1		
	No. 5			220	50 00.0	0.401	7V1		
							3H1	12.5	
A7	AKIHATA	36 11 40.5	138 53 04.5	350	179 44.3	10.935	3V1	3.1	H. Aoki, M. Kumazawa
							4.5V2	25.0	
							12V1	9.5	
A8	SIMOKUBO	36 07 50.7	139 01 32.7	210	N144 56.4 E	22.010	3.6H1	11.0	M. Abe, H. Ishii
							3.4H1	40.0	
A9	ARAKAWA	35 57 15.9	138 59 06.5	340	168 08.7	36.511	E. T. L. M-3		S. Murauchi, S. Iino K. Sakakibara
A10	NIPPARA	35 49 57.1	139 03 57.5	620	162 19.2	53.637	3V1	1.3	H. Hotta, Y. Koyanagi
							1V1	1.8	H. Ueda, M. Yoshimura
A11	UENOHARA	35 37 44.4	139 03 43.9	390	168 49.2	75.696	3V2	4.7, 13.0	M. Yanagisawa, Y. Ichinose
							5V1	0.2	Y. Motoya, Y. Sasaki,
A12	DOSI	35 30 26.3	138 58 29.2	1050	174 51.7	87.536	3V1	1.8	H. Mishina
							4.7H2	1.1, 1.4	
A13	ASIGARA	35 18 51.6	139 02 04.1	450	172 54.9	109.428	3.6V1	5.4	H. Hamaguti, M. Suzuki
							2V1		
A14	IZU-NAGAOKA	35 02 07.9	138 55 19.8	40	178 37.4	139.575	4V2	0.3~0.74	I. Karakama, S. Kubota
							1V1	1.0	
A15	YUGASIMA	34 52 50.6	138 54 42.5	251	179 06.9	156.712	3V1	1.0	T. Utsu, T. Kumagai
A16	KAWAZU	34 43 54.3	138 12 32.0	159	N176 48.9 W	173.516	3V3		T. Asada, K. Takano H. Kurimoto

* Magnification.

Table 4. Table of temporary stations, apparatus and observers for Kawazu explosion.

	Observation point	Latitude (N)	Longitude (E)	Height (m)	Θ	Δ (km)	Geophone	Gain of Amplifier (μV/mm)	Observers
K1	KAWAZU	34°43′57.0″	138°59′31.8″	159					T. Utsu, M. Katumata
	No. 1			158	N180°50′E	0.216	4V1		K. Ichikawa, S. Honsho
	No. 2			95	177 10	0.387	4V1		H. Kawasumi, H. Kuno
	No. 3			76	174 40	0.463	4V1		A. Okada
K2	YUGASIMA	34 52 42.8	138 54 32.1	280	334 49.2	17.902	1V3	1.25	T. Santo, M. Tsujiura
K3	IZU-NAGAOKA	35 02 07.9	138 55 19.8	40	349 13.4	34.218	4.5V1 6V1 2H1	0.3~1.25 3	H. Aoki, M. Kumazawa
K4	SUSONO	35 10 09.1	138 57 07.6	193	355 40.9	48.580	E. T. L. M-3		S. Murauchi, K. Sakakibara S. Iino
K5	YAMURA	35 31 33.5	138 55 29.8	605	356 01.1	88.234	4.3V1 4.5V5	10 7.1, 5.9	S. Kubota, S. Saito
K8	ANNAKA	36 18 34.0	138 50 38.8	252	355 36.4	175.456	1V2	1.1, 1.4	M. Sibano, T. Kumagai S. Saito
K9	NIIHARU	36 45 20.9	138 53 24.1	655	357 38.6	224.663	3V2, 3.5V1 3H1, 2.2H1	0.67~2	A. Takagi, H. Hamaguchi M. Suzuki
K10	YUZAWA	36 55 55.4	138 47 33.9	895	355 46.7	244.694	2.8V2	70~80 db	N. Nakajima, S. Ueno
K11	YUNOTANI	37 10 59.5	139 05 21.0	305	1 50.6	272.038	2.8V1 3.3V1	1.25 0.33	M. Yanagisawa, Y. Ichinose
K12	TOTIO	37 29 21.9	139 01 05.0	82	0 26.2	305.871	3V1 2.2V1	5 1.7	N. Den, H. Hotta
K13	YAHIKO	37 41 49.0	138 49 49.5	40	357 29.0	329.231	3V2	0.96, 3	I. Karakama, T. Daikubara
K14	MATSUSHIRO	36 32 30.0	138 12 32.0	440	340 32.1	212.876	1V1 (Benioff Seismograph)		K. Aihara

Table 5. Epicentral distance, arrival and travel times of P waves for Siunzi explosion.

	Observation point	Δ (km)	P_1 (sec)	Direction	Accuracy	P_1-O (sec)	$P_1-O-\Delta/6$ (sec)	P_2 (sec)	P_2-O (sec)	$P_2-O-\Delta/6$ (sec)	Remarks
S1	SIUNZI	0.000	0.691	—	—	0.000	0.00				Shot point
S2	NAKAURA	13.326	5.12	U	a	4.43	+2.21				
S4	SIMOTAKA-YANAGI	49.809	11.38	U	b	10.69	+2.39				
S5	MATUO	72.678	15.16	U	a	14.47	+2.36	15.31	14.62	+2.51	
S6	YUNOTANI	93.417	17.67	U	b	16.98	+1.41	17.72	17.03	+1.46	
S7	IKAZAWA	113.763	20.95	D	a	20.26	+1.30				
S8	YUZAWA	129.374	23.61	U	a	22.92	+1.36	24.00	23.31	+1.75	
S9	NIIHARU	152.001	26.88	U	a	26.19	+0.86	27.28	26.59	+1.26	
S10	ZINDA	178.871	30.88	D	a	30.19	+0.38	31.33	30.64	+0.83	
S11	SIMOKUBO	211.839	35.26	U	c	34.57	−0.74	35.74	35.05	−0.23	
S12	OTAKI	235.313	37.98	?	d	37.29	−1.93	39.24	38.55	−0.67	large ground noise
S13	NIPPARA	244.430	40.67	U	b	39.98	−0.76	40.73	40.04	−0.70	
S14	DOSI	281.101	46.15	D	b	45.46	−1.39	46.35	45.66	−1.19	
S15	YAMAKITA	288.064	48.11	?	d	47.42	−0.59	45.59	44.90	−3.11	large ground noise
S16	MATSUSHIRO	187.870	32.0	D	—	31.30	0.00	32.3	31.6	+0.3	

Table 6. Epicentral distance, arrival and travel times of P waves for Annaka explosion.

	Observation point	Δ (km)	P_1 (sec)	Direction	Accuracy	P_1-O (sec)	$P_1-O-\Delta/6$ (sec)	P_2	P_2-O	$P_2-O-\Delta/6$	Remarks
A1	MUIKAMATI	85.468	15.11	U	d	14.89	+0.64	16.00	15.78	+1.53	
A3	NIIHARU	44.196	8.82	U	b	8.60	+1.23				
A4	NAKANOJO	32.201	6.82	D	b	6.60	+1.23				
A5	ZINDA	21.767	5.33	D	a	5.11	+1.48				
A6	ANNAKA	0.000	0.217			0.00	0.00				Shot point
A7	AKIHATA	10.935	2.76	U	a	2.54	+0.72				
A8	SIMOKUBO	22.010	4.55	U	a	4.33	+0.66				
A9	ARAKAWA	36.511	7.38	U	c	7.16	+1.07				
A10	NIPPARA	53.637	9.88	D	c	9.66	+0.72				
A11	UENOHARA	75.696	13.76	D	b	13.54	+0.92				
A12	DOSI	87.536	15.45	?	d	15.23	+0.64				

Table 7. Epicentral distance, arrival time of P waves for the earthquake which occurred near Miyake-zima. Epicentre was assumed to be at 34°06′N, 139°26′E.

	Observation point	Δ (km)	P_1 (sec)	Direction	Accuracy	$P_1-\Delta/6$ (sec)	P_2 (sec)	$P_2-\Delta/6$ (sec)
			01^h06^m					
A 16	KAWAZU	80.98	50.50	?	a	37.00		
A 15	YUGASIMA	98.90	53.32	D	a	36.84		
A 14	IZUNAGAOKA	113.86	55.87	U	a	36.89		
							06^m	
A 13	ASIGARA	139.63	59.55	U	a	36.28	59.70	36.43
			07^m					
A 12	DOSI	169.59	2.64	U	b	35.71		
A 11	UENOHARA	172.91	4.38	D	a	35.56		
							07^m	
A 10	NIPPARA	195.38	7.35	U	b	34.79	7.45	34.89
A 8	SIMOKUBO	228.27	11.68	?	d	33.64	12.44	34.40
A 7	AKIHATA	237.75	12.89	U	c	33.37		
A 5	ZINDA	269.56	17.00	?	d	32.07	17.71	32.78
A 3	NIIHARU	291.09	21.08	U	a	32.57	21.54	33.03
A 1	MUIKAMATI	330.97	25.00	U	c	29.84	27.29	32.13

Table 8. Data obtained at J. M. A. routine stations where seismic waves from the Miyake-zima earthquake were observed.

	Station	Latitude (N)	Longitude (E)	Height (m)	Δ (km)	P_1 (sec)	$P_1-\Delta/6$ (sec)	P_2 (sec)	$P_2-\Delta/6$ (sec)
						06^m			
A	TOMISAKI	34°55′2	139°49′7	12	97.92	53	37		
B	AJIRO	35 02.6	139 05.8	66	109.10	54.7	36.5		
C	HACHIJO	33 06.1	139 47.9	80	115.52	56.7	37.4		
D	MISHIMA	35 06.7	138 55.8	20	121.36	58	38		
								07^m	
E	OMAEZAKI	34 36.2	138 12.8	45	125.37	57.2	36.3	13.6	52.7
						07^m			
F	YOKOHAMA	35 26.2	139 39.3	38	149.66	21.1	56.2		
G	FUNATSU	35 29.9	138 45.8	860	165.42	07.4	39.8	24.1	56.5
H	TOKYO	35 41.2	139 45.7	21	178.56	06.5	36.7		
J	HAMAMATSU	34 42.5	137 43.4	32	171.09	04.0	35.5		
K	KOFU	35 39.9	138 33.5	272	189.81	11	39	31.6	60.0
L	CHICHIBU	35 59.5	139 04.9	218	212.30	34.6	59.2		
M	KUMAGAYA	36 08.8	139 23.1	30	227.10	13.5	35.6	14.0	36.1
N	NAGOYA	35 09.9	136 58.1	52	254.32	08	26		
P	MAEBASHI	36 24.1	139 03.9	112	257.55	40.1	57.2		
Q	GIFU	35 23.9	136 45.9	13	284.18	52	65		
R	MATSUSHIRO	36 32.3	138 12.5	440	292.55	22	33	57.0	68.2
S	NAGANO	36 39.6	138 11.8	418	305.44	54.8	63.9		
T	HIKONE	35 16.4	136 14.8	87	319.71	51.5	58.2		
U	MITO	36 22.7	140 28.3	30	270.22	22.2	37.2		
Y	IIDA	35 30.6	137 50.1	482	214.79	18.0	42.2		

Table 9. Epicentral distance, arrival and travel times of P waves for Kawazu explosion.

	Observation point	Δ (km)	P_1 (sec)	Direction	Accuracy	P_1-O (sec)	$P_1-O-\Delta/6$ (sec)	P_2 (sec)	P_2-O (sec)	$P_2-O-\Delta/6$ (sec)	Remarks
K1	KAWAZU	0.000	0.313	—	—	0.000	0.00				Shot point
K2	YUGASIMA	17.902	4.03	U	a	3.72	+0.74	4.07	3.76	+0.78	
K3	IZU-NAGAOKA	34.218	6.78	U	a	6.47	+0.77	6.85	6.54	+0.84	
K4	SUSONO	48.580	9.50	U	b	9.19	+1.09				
K5	YAMURA	88.234	15.63	U	c	15.32	+0.61	15.82	15.5	+0.80	P_2: clear
K8	ANNAKA	175.456	29.00	?	d	28.69	−0.55				
K9	NIIHARU	224.663	37.78	U	c	37.47	+0.03				
K10	YUZAWA	244.694	46.00	?	d	45.69	+4.91	40.64	40.33	−0.45	
K11	YUNOTANI	272.038	44.50	?	d	44.19	−1.15	46.56	46.25	+0.91	
K12	TOTIO	305.871	48.89	?	d	48.58	−2.40	51.70	51.39	+0.41	
K13	YAHIKO	329.231	52.21	?	d	51.90	−2.97	55.06	54.75	−0.12	
K14	MATSUSHIRO	212.876	35	?	—	35	−1.00				

Table 10. Travel time near the shot point for Siunzi explosion.

Observation point	Δ (m)	P (sec)	$P-O$ (sec)
Shot point	0	01^h07^m 00.691	0.000
No. 1 (Up hole)	0	0.713	0.022
No. 2	100	0.773	0.082
No. 3	200	0.842	0.151
No. 4	300	0.900	0.209
No. 5	582	1.055	0.364
No. 6	823	1.255	0.564
No. 7	1049	1.353	0.662

Table 11. Travel time near the shot point for Annaka explosion.

Observation point	Δ (m)	P (sec)	$P-O$ (sec)
Shot point	0	01^h07^m 00.217	0.000
No. 2	109	0.276	0.059
No. 3	174	0.324	0.107
No. 4	299	0.363	0.146
No. 5	401	0.410	0.193

Table 12. Travel time near the shot point for Kawazu explosion.

Observation point	Δ (m)	P (sec)	$P-O$ (sec)
Shot point	0	01^h07^m 00.313	0.000
No. 1	216	0.401	0.088
No. 2	387	0.462	0.149
No. 3	463	0.488	0.175

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26. 爆破地震動観測による本州中央部を南北に横断する測線上の地殻構造

第1部　紫雲寺，安中，河津爆破地震動の観測

爆破地震動研究グループ

爆破地震動研究グループは，本州を南北に 2 大別する構造境界線附近の地殻構造を調査するために 1961 年 11 月以来，新潟県紫雲寺町，群馬県安中市，静岡県河津町の 3 カ所で計 3 回の大規模な火薬爆破を行い，それによる地震動を観測した．これらはいわゆる自力爆破で，紫雲寺，安中では径 4 インチ，深さ 40～50 m の発破孔を掘り，河津では，廃坑の奥を利用した．安中では約 0.8 トン，紫雲寺，河津では，1.5 トンの火薬を使つた．観測点はこれらの爆破点を南北に結ぶほぼ 139°E 線上に配置された．最遠点の震央距離は約 300 km である．安中爆破に際しては，予定爆破時刻の約 1 分前に，三宅島附近にかなりの地震が生じ，これによる地震波のために，南方観測点では，爆破による地震動を観測できなかつた．しかし，この地震は，北方観測点でも観測されたので，この地震についても解析を行つた．種々の理由により，紫雲寺爆破を除いては，初動をとりえなかつた観測点があつた．これらの観測値および走時図は本文中に示してある．

本観測に当つて次の方々から多大の御便宜を計つていただいた．これらの方々に厚く感謝します．

日本放送協会；東北，関東，東京，中部各電力会社；関係日本国有鉄道管理局；関係府県庁当局，警察本部；日本鉱業株式会社；石油資源株式会社；爆破点，観測点所在の市町村役場，警察署．

また，三宅島地震の観測資料を提供下さつた気象庁，紫雲寺爆破の観測資料を供与下さつた河角教授に感謝します．なお，この観測は東京大学地震研究所特別事業費の一部として行われたもので，高橋前所長，河角所長，萩原，岸上各教授の御援助をいただいた．記して感謝します．
