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24. *Earthquake Mechanisms Associated with the Conjunction of the Sinking Plates beneath the Kanto District, Central Japan.*

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Abstract

A study of the focal mechanisms was made for 49 subcrustal earthquakes which occurred in the seismically active regions of the Kanto District, by using the dada on P wave first motion. These data were collected from the observational stations of the Earthguake Research Institute (ERI) and from the seismological bulletins of the Japan Meteorological Agenay (JMA) and the International Seismological Centre (ISC).

Shallower earthquakes located at a depth of about 45 km below the western end of Ibaraki Prefecture had the focal mechanism of underthrusting at a low dip angle towards the northwest. The spatial distribution of the hypocenters in this region, showing a linear alignment of the epicenters and a gentle dipping to the northwest, is consistent with the pole on the nodal plane dipping to the northwest. These earthquakes are interpreted as being caused by underthrusting towards the northwest along the upper boundary of the Pacific Plate.

Deeper earthquakes, located in the eastern side of the 140°E line, extending from the western part of Chiba Prefecture to the southwestern part of Ibaraki Prefecture, having a focal d pth around 70 km within the downgoing Pacific Plate, show the focal mechanism of the vertical dip-slip with the western side descend-

ing. These earthquakes take place in the colliding region of the minor seismic zone sinking to the east and the Pacific Plate sinking to the west. The earthquakes in this region are interpreted as being caused by the subcrustal collision of the Philippine Sea Plate with the Pacific Plate.

I. Introduction

The Kanto District, especially the southwestern part of Ibaraki Prefecture and western part of Chiba Prefecture is one of the most seismically active regions in Japan. The Characteristics of the seismic activity in the Kanto District have been disclosed by the recent highly sensitive seismic observations (TSUMURA, 1973 and 1974). In addition to the main inclined seismic zone associated with the underthrusting Pacific Plate from the east, another seismic zone dipping from the west was recognized.

Detailed features of the seismic activity and earthquake mechanisms in the region of the plate conjunction have not yet been investigated mainly because of the paucity of data from nearby stations. The Kanto District is the only place that is located directly above the plate conjunction and is provided with a sufficient number of observing stations to determine the accurate hypocentral locations and focal mechanisms.

Since FUKUTOMI's study (1933), the earthquake mechanisms in the Kanto District have been studied by several investigators. ICHIKAWA (1962) showed that the maximum pressure is normal to the seismic zone dipping from the east, and that its direction varies from the northwest in the offshore region (Kashimanada) and the southwestern part of Ibaraki Prefecture to the west in the middle part of Chiba Prefecture. Regional variations of the fault-types was shown by ICHIKAWA (1970) and KAWASAKI and KATSUMATA (1975). Complexity of the spatial variations of earthquake mechanisms for local earthquekes was reported by MIKUMO (1962), and for larger ones by SUZUKI et al. (1977).

Seismic activity and focal mechanisms in the Kanto District are affected by the complicated feature of the interaction between the northeastern end of the Philippine Sea Plate and the underthrusting Pacific Plate to the west (see Fig. 1). In the present paper, focal mechanisms of the seismically active regions in the Kanto District will be studied by the P wave first motion and spatial distribution of relocated earthquakes and small and micro-earthquakes observed routinely by the highly sensitive seismic network.

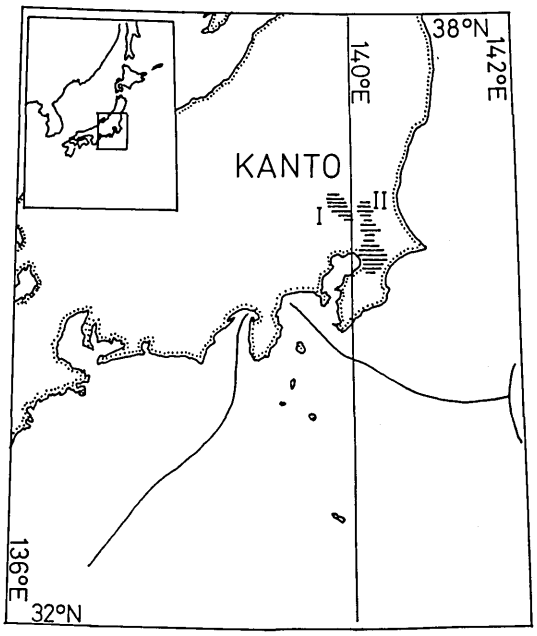


Fig. 1. Locations of the seismically active regions in the Kanto district (shaded areas, Region I: western end of the Ibaraki Prefecture, Region II: east side of the 140°E line). The thick lines show the plate boundaries of the Pacific Plate, the Philippine Sea Plate, and the Asian Plate.

II. Spatial distribution of hypocenters in the Kanto District.

Spatial distribution of earthquakes in the Kanto District has been extensively studied by TSUMURA (1973 and 1974). After TSUMURA's studies, a model of the seismically active zones was constucted by KASAHARA (1974), and 21 "earthquake nests" were derived by USAMI and WATANABE (1977). In this chapter, some of the characteristic features of the spatial distribution of earthquakes in the Kanto District are discussed in connection with the earthquake mechanisms.

From the hypocenter data, determined by the Earthquake Research Institute (ERI) for a period of six and one-half years from June 1, 1971, to December 31, 1977, only the accurately determined epicenters are shown in Fig. 2. Pronounced concentrations of hypocenters were observed in the central part of the Kanto District, especially in the southwestern part of Ibaraki Prefecture and in the western part of Chiba Prefecture (shaded areas I and II in Fig. 1). A linear alignment of the epicenters was observed in the western end of Ibaraki Prefecture. Significant clustering of the epicenters was also seen in the eastern side of

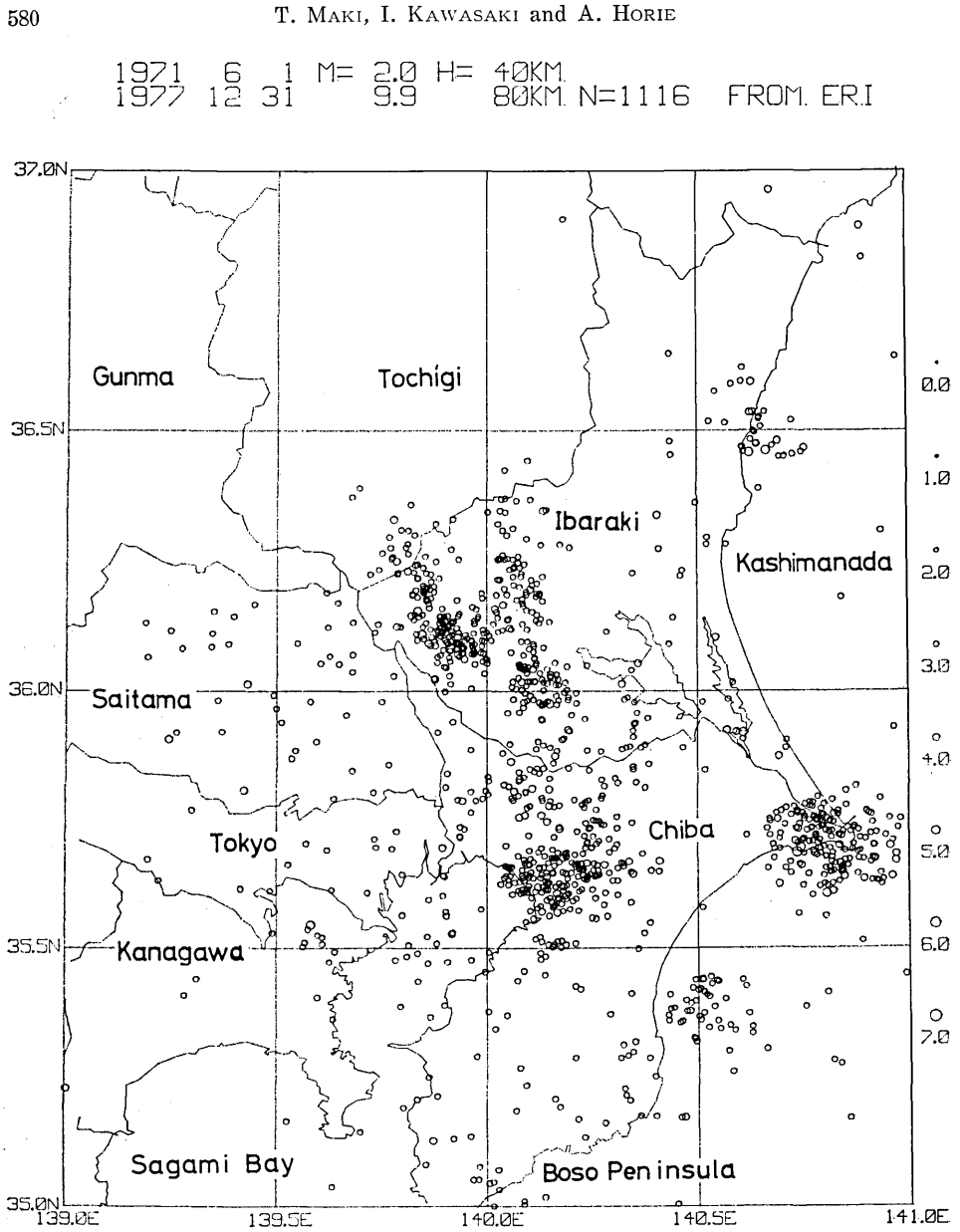


Fig. 2. Distribution of the epicenters in the Kanto District for the range of the earthquake magnitude greater than 2.0 and of focal depths from 40 to 80 km. The earthquakes plotted here have been determined by four or more stations of ERI with standard errors less than 7.5 km.

the 140°E line of the longitude.

Fig. 3 shows the depth distributions of earthquakes along the sections passing through the southwestern part of Ibaraki Prefecture in the direction of NW-SE(a) and SW-NE(b). Only the earthquakes within 25

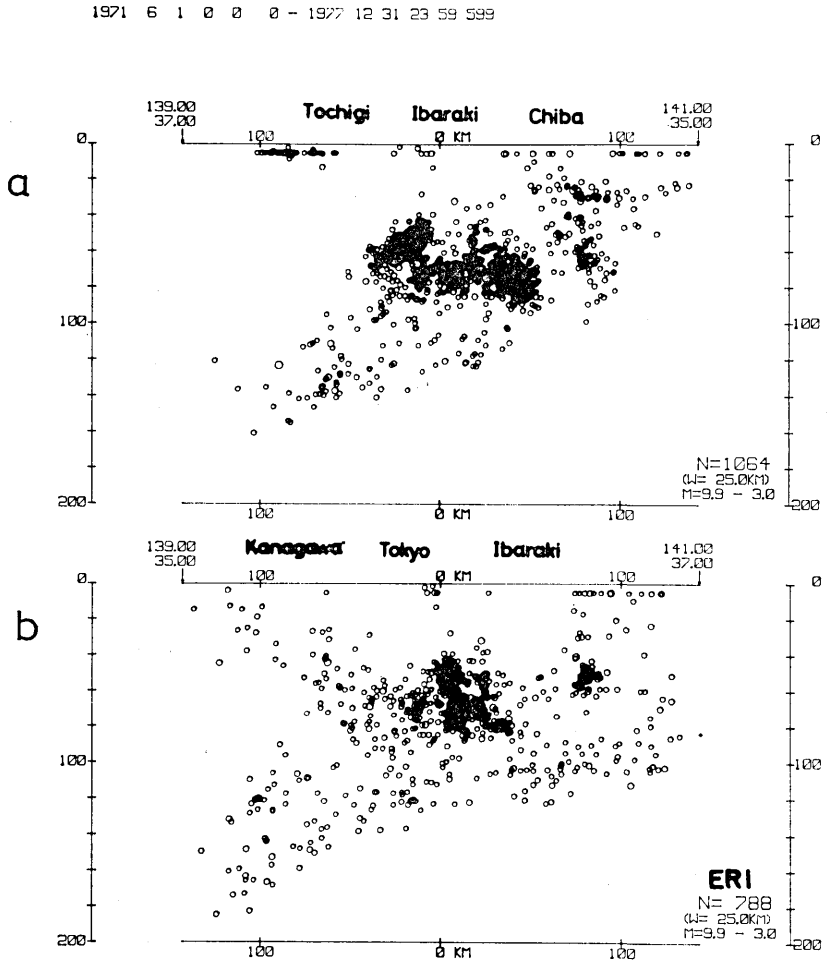


Fig. 3. Depth distributions of the earthquakes along the sections passing through the southwestern part of Ibaraki Prefecture in the direction of northwest-southeast, connecting two points shown by arrows, or A (139.0°E, 37.0°N) and B (141.0°E, 35.0°N) (a), and in the direction of southwest-northeast (b). Only the earthquakes within 25 km on the both sides of the lines are plotted.

km on the both sides of the line connecting the two points shown by arrows are included. The hypocenters in the western end of Ibaraki Prefecture, which show the linear alignment of the epicenters, have a dipping pattern to the northwest at depths of around 45 km. These shallower earthquakes are located along the upper boundary of the Pacific Plate dipping from the east. Deeper earthquakes at depths of around 70 km are located below the eastern side of the 140°E line of the longitude, and are distinguished from the above shallower ones.

Fig. 4 shows the depth distribution of the earthquakes along the sections through the middle part of Chiba Prefecture in the E-W direction along the line 35.5°N of the latitude. Significant concentration of

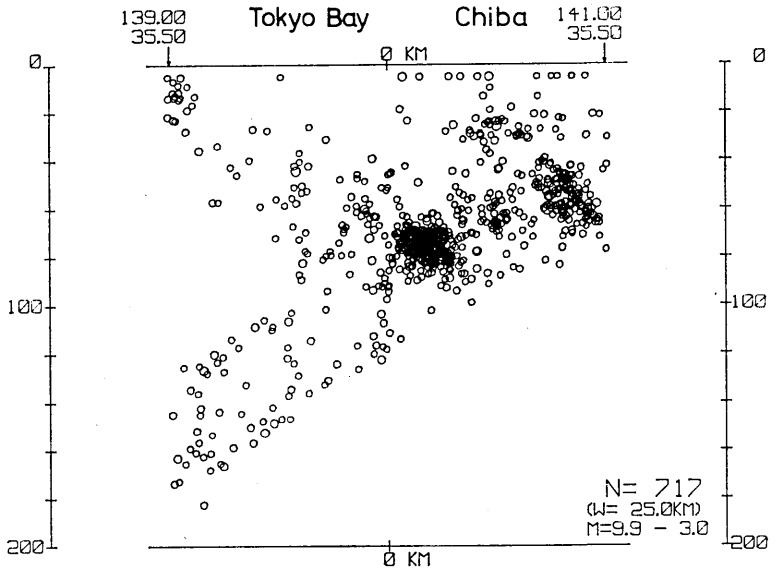


Fig. 4. Depth distribution of the earthquakes along the section passing through the middle part of Chiba Prefecture in the direction of east-west.

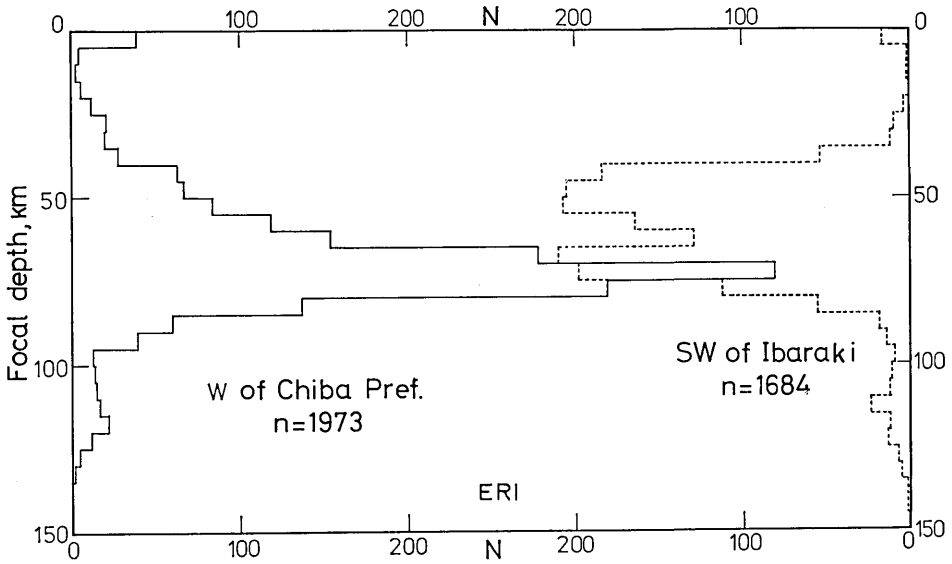


Fig. 5. Comparison of the depth-frequency of the earthquakes in the southwestern part of Ibaraki Prefecture and the western part of Chiba Prefecture. n means the total number of earthquakes.

hypocenters was observed at depths of around 70 km below the eastern side of the 140°E line. These earthquakes take place in the crossing region of the minor seismic zone sinking from the west and the predominent seismic zone associated with the Pacific Plate.

The frequency distributions of focal depths are compared in Fig. 5. Two peaks of about 45 and 70 km are seen for the southwestern part of Ibaraki Prefecture, but only a single peak of around 70 km is observed for the western part of Chiba Prefecture. Depths around 70 km are commonly observed for two regions, and they are located in the eastern side of the 140°E line of the longitude. The deeper earthquakes are occurring at the intersection between two seismic zones dipping from the west. The minor seismic zone dipping from the west is supposed to be the northeastern tip of the Philippine Sea Plate.

Spatial distribution of the hypocenters in the seismically active regions of the Kanto District is charcterized as following, or

(1) two inclined seismic zones exist below the Kanto region, or one dipping from the east associated with the Pacific Plate, and another dipping from the west corresponding to the northeastern tip of the Philippine Sea Plate,

(2) deeper earthquakes are taking place in the crossing region of the two seismic zones, at a depth of about 70 km below the eastern side of the 140°E line of the longitude, extending from the southwestern part of Ibaraki Prefecture to the middle part of Chiba Prefecture,

(3) underthrusting earthquakes occur along the upper boundary of the Pacific Plate, located at the shallower depths of around 45 km below the western end of Ibaraki Prefecture.

III. Data and method.

Hypocentral locations and origin times of larger earthquakes which occurred during the period from June 1, 1971, to March 31, 1977 have been redetermined by using travel-time data observed at the stations of the ERI and from the bulletins of the JMA. Relocations were made only for the eathquakes observed at more than ten stations, by giving heavier weight to stations within 300 km of the distance from the epicenters. Travel times were calculated for the model of the crustal structure E3A3 by MIKUMO (1966). Epicenter distributions of the 70 relocated earthquakes are shown in Fig. 6. The epicenters are marked by circles whose radii vary according to their magnitude, and focal depths are distingui shed by the number of pairs of sticks attached to their circles, for

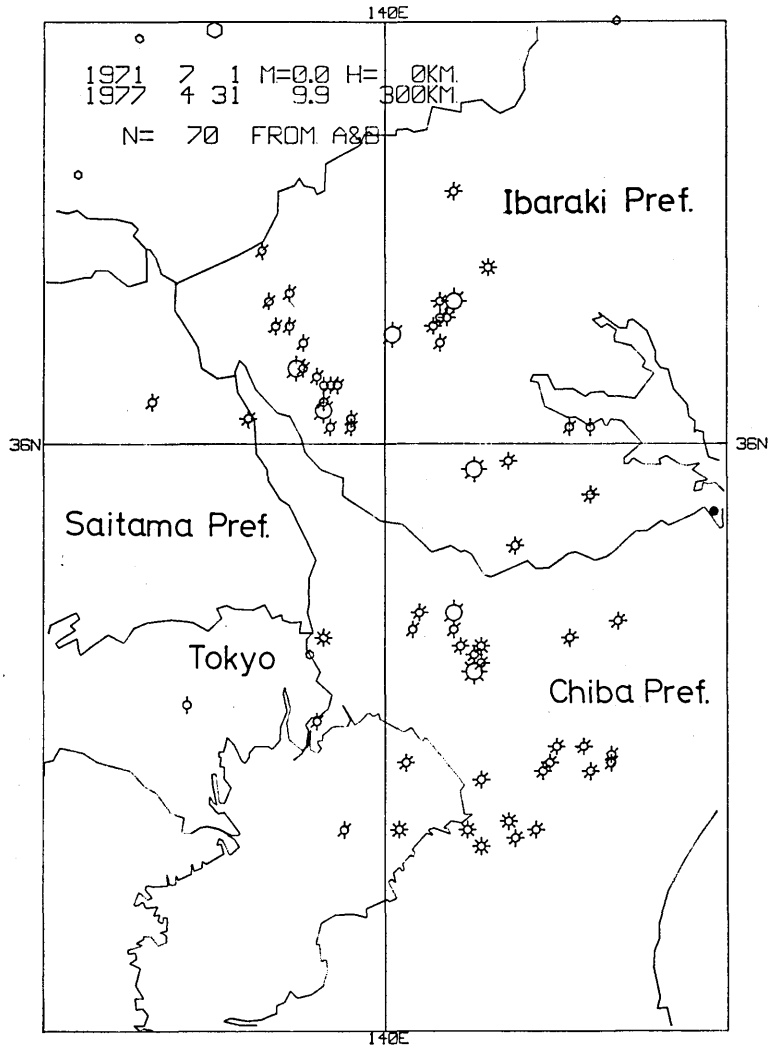


Fig. 6. Epicenter distribution of the relocated earthquakes in the Kanto District. Focal depths are identifled by the number of line segments attached to their circles, whose radii are varied according to their earthquake magnitude.

every 20 km. From this figure the linear alignment is also recognized in the western end of Ibaraki Prefecture.

It has been impossible to obtain the necessary number of P wave first motion data from the long-period seismograms of the WWSSN stations for the earthquakes concerned because of the small magnitude. The data on P wave first motion were collected from the stations of the ERI and from the bulletins of the JMA and the ISC.

It has heen very difficult to obtain the mechanism solution from data at short distances alone, but it was possible to determine the mechanism solution by adding the world-wide data. Take-off angles at foci are calculated for the relocated hypocenters using the model of crustal structure of E3A3 for the stations in Japan, but the ones for the world-wide stations were made for the ISC's hypocenters and for the Jeffreys-Bullen travel-time table (HODGSON and STORELY, 1953).

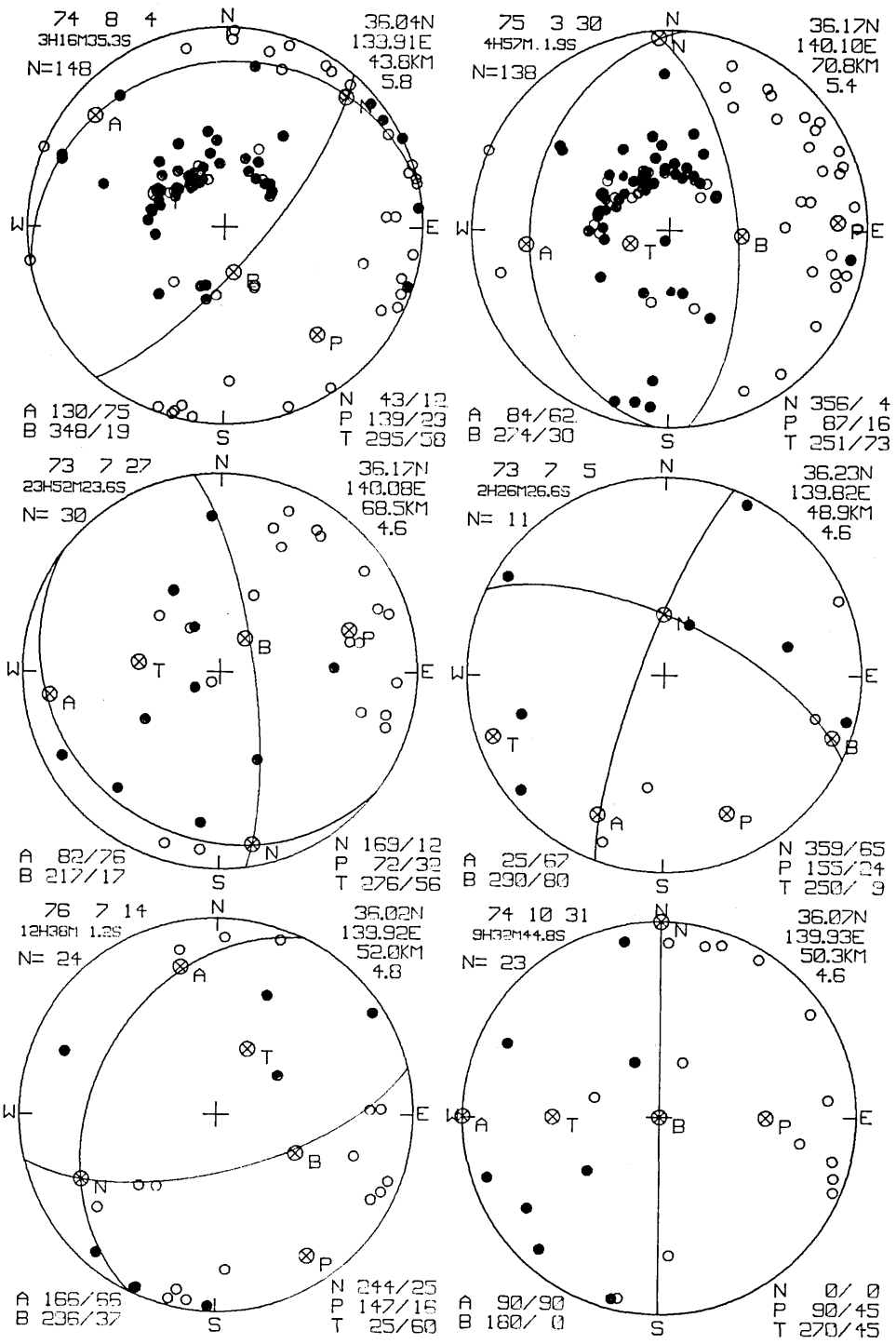
Equal-area projections of the data on the P wave first motion and mechanism solutions are drawn on the lower focal hemisphere by a XY-plotter in a size adequate to compare with each other. Nodal lines are drawn for some trials of the dip directions and dip angles. For each earthquake, several trials of mechanism solutions are repeated by such a graphical method, comparing with the predominent types of the earthquake mechanism in the same regions. Similarities or differences of mechanism solutions are systematically incorporated for earthquakes in the same regions.

IV. Earthquake mechanisms in the southwestern part of Ibaraki Prefecture.

Twenty-three solutions of the earthquake mechanisms were obtained for earthquakes in the southwestern part of Ibaraki Prefecture. One of the predominent types of the earthquake mechanisms is the underthrusting with a low dip-angle towards the northwest and another is the east-west compression. By comparing with these predominent types of the earthquake mechanisms, the fault-plane solutions were determined for the individual earthquakes.

Examples of equal-area projections on the lower focal hemisphere of the P wave first motion data and mechanism solutions are shown in Fig. 7. Focal coordinates are the relocated ones, and the earthquake magnitudes are those determined by the JMA. The top and middle examples show the mechanism solutions determined uniquely due to the sufficient number of initial motion data. The two bottom examples denote the mechanism solutions that are different from the others.

The earthquake of August 4, 1974 has the greatest magnitude observed in this region, or M=5.8 (JMA). The mechanism solution of this earthquake can be uniquely determined due to the sufficient number of the first motion data observed at the distant stations. The earthquake mechanism of this earthquake is characterized by a pole on the nodal plane dipping at a low angle towards the northwest or gently


74 8 4
3H16M35.3S
N=148
36.04N
133.91E
43.6KM
5.8
A 130/75
B 348/19
N 43/12
P 139/23
T 295/58
75 3 30
4H57M. 1.9S
N=138
36.17N
140.10E
70.8KM
5.4
A 84/62
B 274/30
N 356/ 4
P 87/16
T 251/73
73 7 27
23H52M23.6S
N= 30
36.17N
140.08E
68.5KM
4.6
A 82/76
B 217/17
N 169/12
P 72/32
T 276/56
73 7 5
2H26M26.6S
N= 11
36.23N
139.82E
48.9KM
4.6
A 25/67
B 230/80
N 359/65
P 155/24
T 250/ 9
76 7 14
12H36M 1.2S
N= 24
36.02N
139.92E
52.0KM
4.8
A 166/66
B 236/37
N 244/25
P 147/16
T 25/60
74 10 31
9H32M44.8S
N= 23
36.07N
139.93E
50.3KM
4.6
A 90/90
B 180/ 0
N 0/ 0
P 90/45
T 270/45

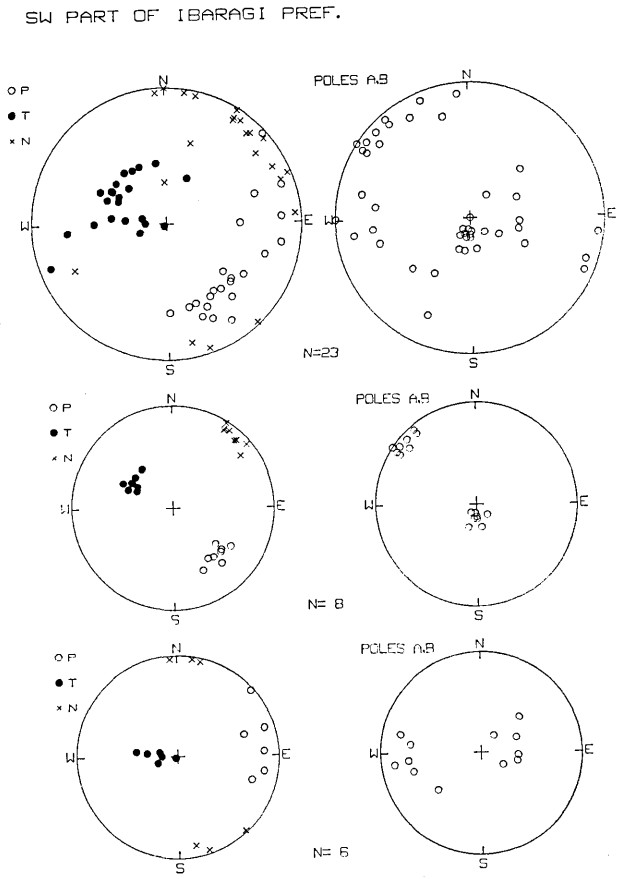


Fig. 8. Summary of the fault-plane solutions on the common focal hemisphere for the earthquakes in the southwestern part of Ibaraki Prefecture. The axes of the maximum pressure (P), maximum tension (T), and null vector (N) are shown on the left-hand side by the open and solid circles, and crosses, respectively. The poles of the nodal planes (A, B) are shown on the right-hand side. (Upper) All 23 earthquakes, (middle) Northwest underthrusting earthquakes, and (lower) East-west compression earthquakes.

Fig. 7. Examples of equal-area projections on the lower focal hemisphere of the P wave initial motion data and focal mechanisms for the earthquakes in the southwestern part of Ibaraki Prefecture. Solid and open circles denote the compression and dilatation of the initial motion, respectively. Poles of the nodal planes (A and B), and pressure axes (P, T and N) are shown by the encircled crosses, and their dip direction and dip angles are also shown in the lower part.

Table 1. Fault-plane solutions of the earthquakes in the southwestern part of Ibaraki Prefecture.

NO	DATE Y	M	D	O.T. H	M	S	LAT °N	LONG °E	DEP km	MAG	Q	A DD	D	B DD	D	N DD	D	P DD	D	T DD	D	NUMBER NT	NI	FT
A1	74	8	4	3	16	35.3	36.04	139.91	43.8	5.8	A	130	75	348	19	43	12	139	29	295	58	148	13	RD
A2	75	4	12	7	15	49.1	36.12	140.01	47.9	5.0	A	123	83	359	12	34	10	131	38	292	51	56	4	RD
A3	72	11	6	20	39	50.8	36.09	139.87	45.0	5.1	A	0	10	127	84	37	7	133	37	309	51	51	4	RD
A4	73	1	21	17	16	20.4	36.09	139.88	43.9	4.8	A	11	12	133	83	44	10	141	38	301	51	37	3	RD
A5	74	10	9	4	42	9.9	36.05	139.91	46.9	4.8	A	10	7	140	85	50	5	146	40	321	50	37	4	RD
A6	74	10	9	4	9	17.7	36.03	139.95	43.1	4.6	A	34	8	124	90	34	8	131	8	296	45	25	4	D
A7	76	1	17	0	50	22.5	36.12	139.88	47.8	4.3	A	123	79	315	12	33	2	124	33	300	57	14	0	RD
A8	74	5	27	20	57	45.3	36.07	139.92	44.1	4.0	A	20	20	140	80	53	17	155	33	301	52	12	1	RD
B1	75	4	18	3	41	9.2	36.14	139.84	47.3	4.2	A	30	12	158	83	70	10	166	37	328	52	60	5	RD
B2	75	5	15	1	23	5.5	36.18	139.86	46.0	4.1	A	20	10	175	81	86	5	179	35	351	53	14	0	RD
B3	75	5	5	20	58	41.7	36.14	139.86	42.4	4.1	A	10	20	150	75	63	12	160	28	314	59	11	0	RD
B4	72	12	4	1	32	27.6	36.17	140.08	42.6	4.0	A	158	83	356	8	68	3	161	38	335	52	13	1	D
C1	75	3	30	4	57	1.9	36.17	140.10	70.8	5.4	A	84	62	274	30	356	4	87	16	251	73	138	9	RD
C2	73	7	27	23	52	23.6	36.17	140.08	68.5	4.6	A	82	76	217	17	169	12	72	32	276	56	30	2	RD
C3	77	3	30	8	45	38.8	36.15	140.09	64.9	4.4	A	97	60	283	30	9	3	100	15	282	75	26	2	RD
C4	73	6	8	19	24	49.9	36.12	140.08	57.9	4.7	A	103	71	300	20	14	4	108	25	275	65	44	7	RD
C5	76	7	18	17	7	33.5	36.03	139.80	76.2	4.4	A	75	59	247	31	162	4	72	11	270	77	23	0	RD
C6	73	5	5	14	12	25.1	36.14	140.07	64.0	4.5	A	50	47	227	43	138	2	48	3	230	88	20	1	RD
D1	74	10	31	9	32	44.8	36.07	139.93	50.3	4.6	A	90	90	180	0	0	0	90	45	270	45	23	2	D
D2	71	8	4	0	32	44.8	36.30	140.10	67.4	4.4	A	277	85									11	0	NS
D3	76	12	31	18	20	43.1	36.21	140.15	83.6	4.1	A	34	40	295	82	18	38	150	38	265	27	8	0	D
D4	73	7	5	2	26	26.6	36.23	139.82	48.9	4.6	A	25	67	290	80	359	65	155	24	250	9	11	3	NS
D5	76	7	14	12	38	1.2	36.02	139.92	52.0	4.8	A	166	66	296	37	244	25	147	16	25	60	24	3	RD

DD: dip direction, D: dip, NT: total number of stations, NI: inconsistent stations,
FT, fault type, R: reverse fault, N: normal fault, D: dip slip, S: strike slip

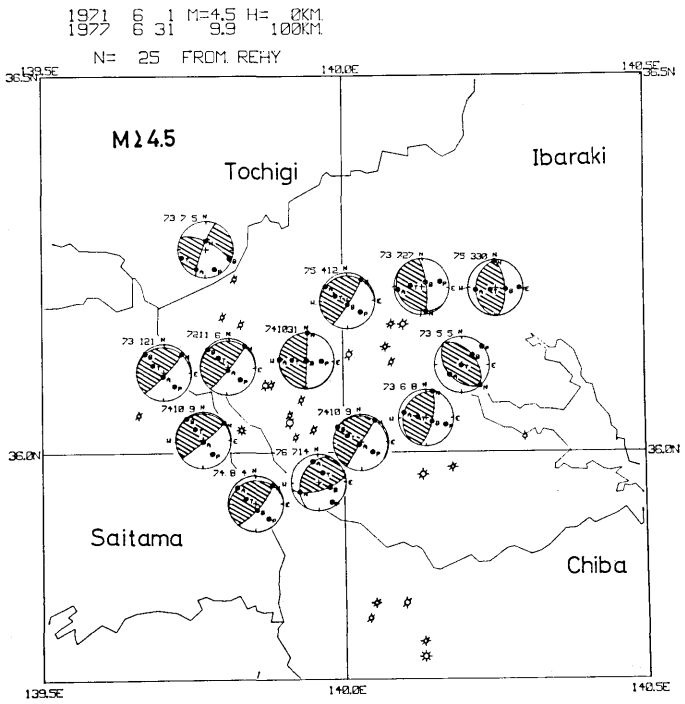


Fig. 9a.

underthrusting to the northwest. This type of earthquake mechanism is clearly different from that of an earthquake of March 30, 1975 (M_{JMA} =5.4), indicating the east-west compression. The former occurred at the depth of 44 km, while the latter is located at the depth of 70 km below the eastern side of the 140°E line of the longitude. Other types of focal mechanisms were also observed in this region such as the northward underthrusting of shallower earthquakes in the western end of Ibaraki Prefecture, and the vertical dip slip with the western side descending in the eastern side of the 140°E line of the longitude.

In Table 1 four types of the fault-plane solutions of 23 earthquakes occurring in the southwestern part of Ibaraki Prefecture are listed with the redetermined focal coordinates. Figure 8 summarizes the fault-plane solutions on the common focal hemisphere for all 23 earthquakes (upper). The middle and lower parts show the two predominent types of the focal mechanisms, (middle) underthrusting towards the northwest and (lower) the east-west compression. A quite small variation of the mechanism solutions is seen in these figures.

Geographical distributions of the mechanism diagrams are represented

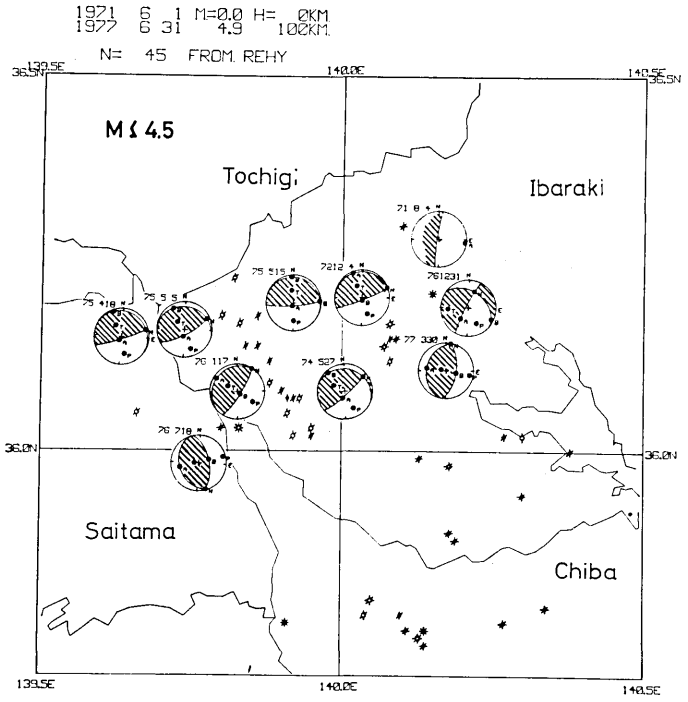


Fig. 9b.

Fig. 9. Geographical distributions of the mechanism diagrams in the southwestern part of Ibaraki Prefecture for the earthquakes of magnitude greater than 4.5(a), and for the ones less than 4.5(b). Hatched areas denote the tensional areas and open ones denote the compressional ones. Numerals attached to the mechanism diagrams denote the date.

in Fig. 9 for the earthquakes with magnitudes greater than (a) and less than 4.5 (b). The earthquakes with the mechanism of underthrusting at a low dlip angle towards the northwest are located in the western end of Ibaraki Prefecture, and the poles on the nodal plane gently dipping to the northwest are consistent with the linear alignment of the epicenters.

On the other hand, the earthquakes located at a depth of around 70 km below the eastern side of the 140°E line show the focal mechanism of the east-west compression or the vertical dip slip with the western side sinking. These deeper earthquakes take place within the Pacific Plate sinking towards the west, and they can be distinguished from the shallower ones in the western side of the 140°E line. Some variations of the mechanism solutions were observed for earthquakes with smaller magnitude and for these located near the northern end of the active region.

V. Earthquake mechanisms in the western part of Chiba Prefecture.

Twenty-six mechanism solutions were obtained for earthquakes occurring in the western part of Chiba Prefecture. A majority of the earthquakes have a focal mechanism of dip slip along the north-south striking plane with the western side descending. Examples of equal-area projection of the first motion data and nodal plane solutions are shown in Fig. 10.

Only three earthquakes have magnitude greater than 5.0. The earthquake of July 27, 1971 ($M_{JMA}=5.1$, $h=66$ km) shows the horizontal east-west compression, and the earthquake of October 18, 1972 ($M_{JMA}=5.1$, $h=83$ km) had a mechanism of the vertical dip slip with the western side sinking. The difference between these types of focal mechanisms is indicated by a change of dip angles of the maximum pressure and of the nodal planes striking nearly north-south. The earthquake of February 8, 1975, having the greatest magnitude observed in this region during the six and one-half years, or $M_{JMA}=5.4$, indicates a mechanism of strike slip. This earthquake is located at a shallower depth of 54 km in contrast with the above two earthquakes. The middle two examples show the focal mechanisms determined uniquely, even with fewer data of initial motion. The bottom ones show the types of focal mechanism that are different from the others.

Other than these predominant types, other types of focal mechanisms were observed suchas the strike slip with the the opposite motions and the dip slip with the southern part sinking. Table 2 lists six types of the fault-plane solutions of twenty-six earthquakes, with the relocated hypocenters in the western part of Chiba Prefecture. Fig. 11 summarizes the fault-planess olutions on the common focal hemisphere for all earthquakes (top). Large variation of the mechanism solutions are seen for the earthquakes which occurred in the western part of Chiba Prefecture. Fault-plane solutions of the east-west compression and the vertical dip slip are represented in the middle and lower part of the figure, respectively. It is to be noted that the focal mechanism of underthrusting, predominent in the western end of Ibaraki Prefecture, is not seen in the western part of Chiba Prefecture.

Geographical distributions of the mechanism diagrams are represented in Figs. 12a and b for the earthquakes with magnitudes greater than and less than 4.5, respectively. Focal mechanisms in the most active region, or the middle part of Chiba Prefecture, could not be determined

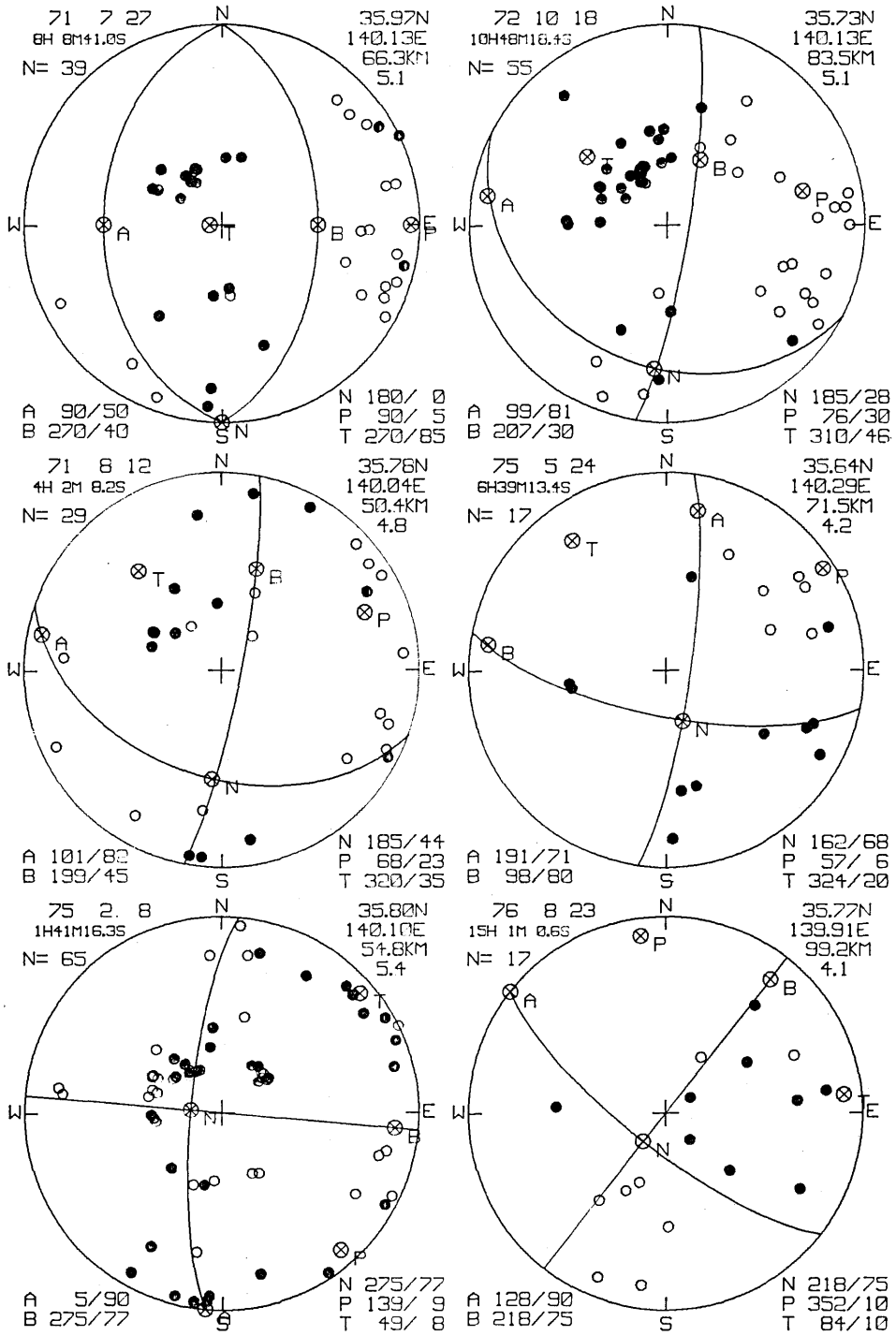


Fig. 10. Examples of the equal-area projections of the P wave initial motion data and focal mechanisms for the earthquakes in the western part of Chiba Prefecture.

Table 2. Fault-plane solutions of the earthquakes in the western part of Chiba Prefecture.

NO	DATE			O.T.			LAT	LONG	DEP	MAG	Q	A		B		N		P		T		NUMBER		FT
	Y	M	D	H	M	S	°N	°E	km			DD	D	DD	D	DD	D	DD	D	DD	D	NT	NI	
A1	71	7	27	8	8	41.0	35.97	140.13	66.3	5.1	A	90	50	270	40	180	0	90	5	270	85	39	4	RD
A2	72	12	8	8	37	56.7	35.62	140.03	75.0	4.8	A	106	55	268	37	190	9	98	9	323	77	46	0	
B1	72	10	18	10	48	18.4	35.73	140.13	83.5	5.1	B	99	81	207	30	185	28	76	30	310	46	55	0	RD
B2	73	5	17	5	27	22.1	35.98	140.18	66.4	4.6	A	82	72	214	17	169	12	72	33	277	54	34	0	RD
B3	71	8	12	4	2	8.2	35.78	140.04	50.4	4.8	A	101	82	199	45	185	44	68	23	320	35	29	0	RD
B4	77	2	14	18	8	26.3	35.75	140.13	79.9	4.7	A	82	79	193	29	166	27	60	29	291	48	26	0	RD
B5	76	3	30	20	23	22.2	35.60	140.14	79.7	4.0	B	115	79									21	0	RD
C1	73	3	27	11	8	32.5	35.54	139.94	57.3	4.9	A	185	30	283	85	196	30	80	45	302	37	56	0	ND
C2	74	6	2	22	12	20.0	35.67	139.90	52.5	4.1	A	172	15	275	87	185	15	79	46	287	39	18	0	D
C3	75	6	4	17	56	55.0	35.64	140.25	77.6	4.1	A	90	90	270	0	0	0	90	45	270	45	23	0	ND
C4	75	6	4	14	52	31.6	35.61	140.23	76.5	4.2	A	206	50	105	76	179	47	71	16	328	39	16	0	RD
D1	72	7	7	12	29	12.3	35.88	140.19	72.3	4.4	A	78	80	335	38	354	38	106	25	221	42	15	0	D
D2	75	5	2	4	8	45.5	35.76	140.11	73.4	4.2	A	84	90	354	38	354	38	115	34	232	34	14	0	
D3	72	11	16	14	23	48.7	35.76	140.14	80.5	4.2	B	90	75	340	39	11	34	116	21	232	48	10	0	RD
D4	76	11	9	12	46	41.6	35.79	140.34	71.4	4.2	B	112	80									15	0	D
D5	77	3	20	9	7	45.9	35.55	140.18	82.3	4.4	A	283	76									23	0	ND
D6	75	12	15	9	54	0.0	35.52	140.14	85.3	4.6	B	250	74									23	0	ND
E1	74	11	21	20	59	29.9	35.62	140.33	57.7	4.7	A	109	47	358	69	69	40	224	47	322	13	20	0	ND
E2	75	5	24	6	39	13.4	35.64	140.29	71.5	4.2	A	191	71	98	80	162	68	57	6	324	20	17	0	RD
E3	74	10	29	20	0	1.6	35.63	140.33	56.2	4.9	A	180	82	292	21	267	20	22	48	162	35	21	0	ND
E4	73	6	9	17	37	20.1	35.80	140.05	60.0	4.5	A	166	51	273	70	203	44	46	44	305	11	14	0	D
E5	72	8	11	14	12	12.2	35.94	140.30	60.1	4.3	A	83	68	345	70	37	60	213	30	305	2	12	1	ND
F1	75	2	8	1	41	16.3	35.80	140.10	54.8	5.4	A	5	90	275	77	275	77	139	9	49	8	65	0	S
F2	75	4	12	5	48	31.1	35.78	140.10	53.6	4.2	A	170	68	263	84	189	68	303	10	37	20	13	0	RD
F3	76	8	23	15	1	0.6	35.77	139.91	99.2	4.1	A	128	90	218	75	218	75	352	10	84	10	17	0	S
F4	72	3	14	16	15	36.4	35.54	140.02	89.6	4.4	A	42	90	312	55	312	55	82	23	189	23	13	0	S

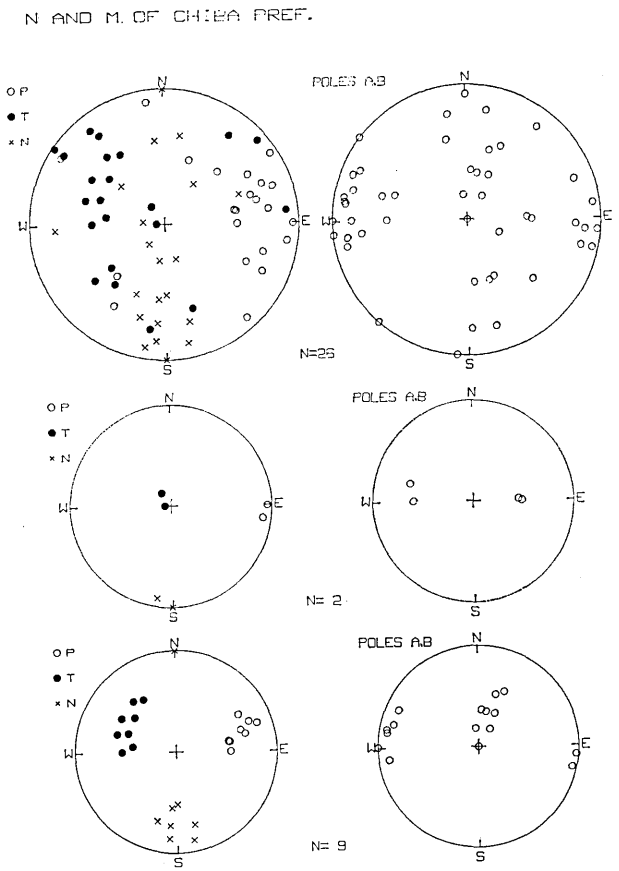


Fig. 11. Distributions of the fault-plane solutions on the common focal hemisphere for all 26 earthquakes in the western part of Chiba Prefecture (Upper), the east-west compression earthquakes (Middle), and the vertical dip slip with the western side downgoing (Lower).

in the present study because of the small magnitudes. Two earthquakes occurring on October 29 and Nobvember 21, 1974, at nearly the same place near Inbanuma Lake, show the opposite first motions along the nearly vertical plane striking east-west.

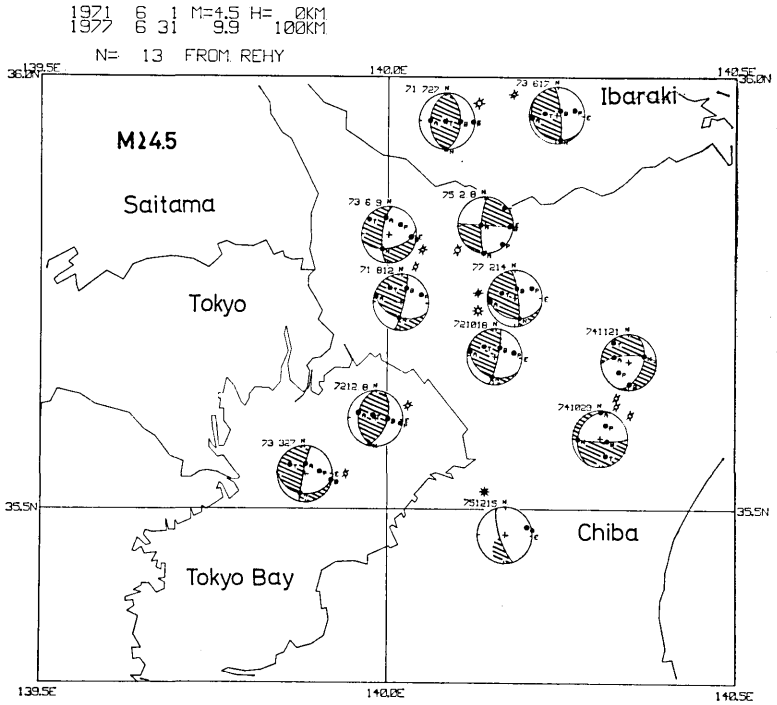


Fig. 12a.

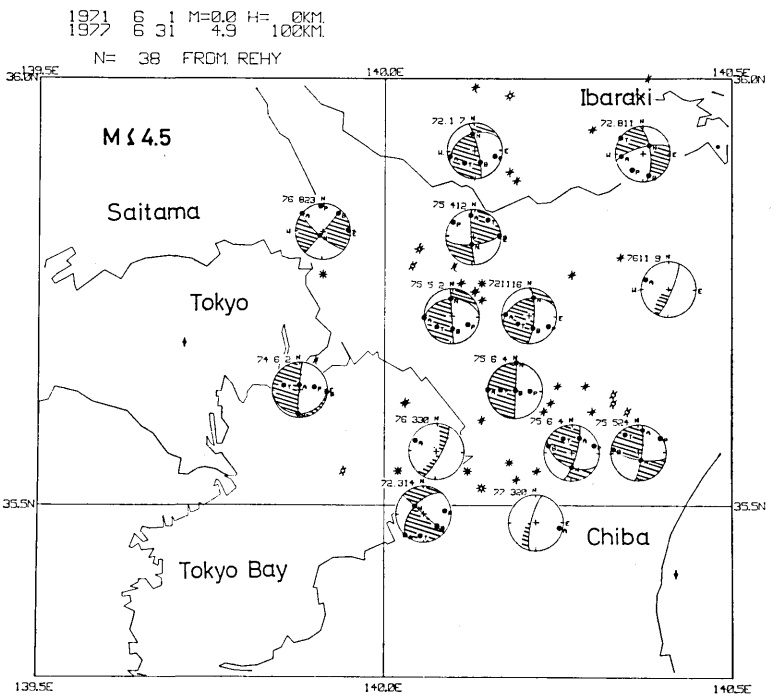


Fig. 12b.

Fig. 12. Geographical distribution of the mechanism diagrams in the western part of Chiba Prefecture for the earthquakes of the magnitudes greater than 4.5(a), and for the those of less than 4.5(b).

VI. Conclusion and discussion.

Focal mechanisms have been analyzed for 49 earthquakes in the most seismically active regions of the Kanto District during the period of six and half-years from June 1, 1971, to March 31, 1977, by using the P wave first motion data. Focal mechanism of the vertical dip-slip with the western side downgoing was obtained for earthquakes located at larger depths in the region just east of the 140°E line extending from the southwestern part of Ibaraki Prefecture to the middle part of Chiba Prefecture. On the other hand, the earthquakes occurring at shallower depths near the western end of Ibaraki Prefecture have the focal mechanism of underthrusting with a low-dip angle towards the northwest, which is familiar to earthquakes in the offshore region of Ibaraki Prefecture (Kashimanada) (MAKI, 1975; HORIE, MAKI and KAWASAKI, in preparation).

Fig. 13 showes the depth distributions of the relocated hypocenters along two sections, passing through the southwestern part of Ibaraki Prefecture from the southeast to the northwest (a) and through the middle part of Chiba Prefecture from the east to the west (b). A dipping seismic zone along the upper boundary of the sinking Pacific Plate is clearly shown at depths of around 45 km below the western end of Ibaraki Prefecture. And a minor seismic zone dipping from the west is observed and an earthquake clustering is seen at larger depths within the Pacific Plate, which is located at the colliding region of the Philippine Sea Plate and the Pacific Plate.

A linear alignment is observed in the western end of Ibaraki Prefecture from the epicenter distribution of the smaller earthquakes located by the ERI, and also of the relocated hypocenters of the present study. These earthquakes are located at a shallower depth of about 45 km and show a dipping pattern with a low dip angle towards the northwest. The shallower earthquakes below the western end of Ibaraki Prefecture are considered to be caused by underthrusting of the Pacific Plate beneath the Asian Plate.

Combining the studies of the focal mechanisms and spatial distributions of the hypocenters in the western part of Chiba Prefecture, the following conclusion can be derived. Deeper earthuakes are located at depths of around 70 km in a limited region below the eastern side of the 140°E line of the longitude, striking nearly north to south and extending from the southwestern part of Ibaraki Prefecture to the middle part of Chiba Prefecture. These deeper earthquakes have a focal me-

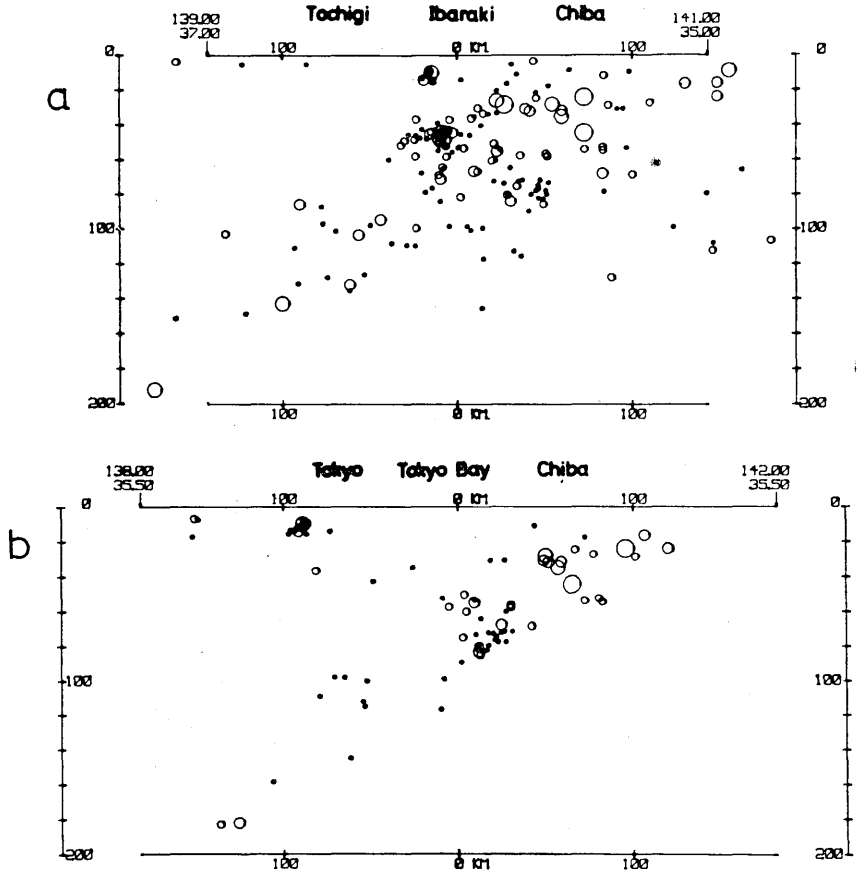


Fig. 13. Comparison of the depth distributions of the relocated earthquakes along the sections passing through the southwestern part of Ibaraki Prefecture in the direction of west-east (b).

chanism suggesting the collision of two plates, or the vertical dip slip with the western side sinking and the maximum pressure dipping from the west. The significantly high seismic activity in this region is caused by the stress concentration due to the collision of the Philippine Sea Plate (minor seismic zone dipping towards east) with the Pacific Plate (predominent seismic zone dipping toward west) at a depth of about 70 km.

Fig. 14 is a schematic representation of two types of the earthquake mechanisms and their relative locations in the southwestern part of Ibaraki Prefecture. Circles denote the relocated hypocenters and the solid line denotes the upper boundary of the seismic zone associated with the underthrusting Pacific Plate. Shallower earthquakes show a dipping

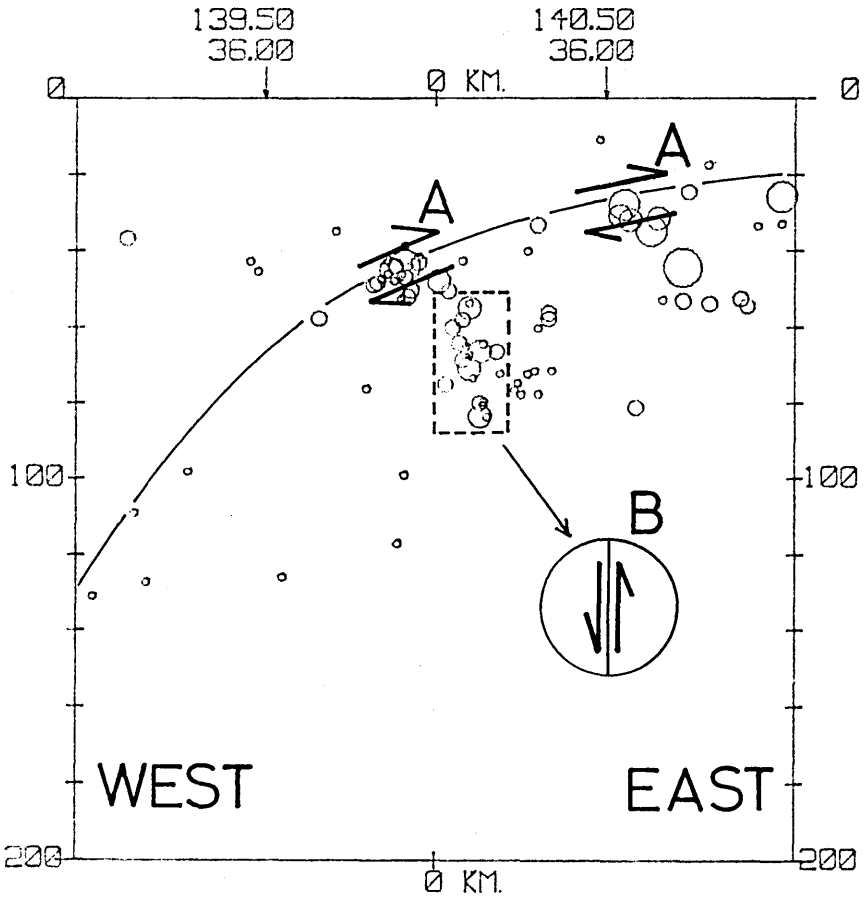


Fig. 14. Schematic representation of the focal mechanisms of the subcrustal earthquakes in the Kanto District. Type A shows underthrusting along the upper boundary of the Pacific Plate, and type B shows the vertical dip-slip with the western side downgoing, located within the Pacific Plate.

towards northeast along the upper boundary of the Pacific Plate, or underthrusting with a low angle (type A). On the other hand, deeper earthquakes within the Pacific Plate show the vertical alignment, or the vertical dip-slip with the western side downgoing (type B).

The northward extension of the inclined seismic zone dipping from the west has been assumed (KASAHARA, 1973). Enhanced seismicity map, derived from the ERI's hypocenters during the six and one-half years reveals that such inclined seismic zone dipping from the west extends from the northern end of Saitama Prefecture to the coastal region south of the Boso Peninsula (MAKI and TSUMURA, 1978). And it might be also related to the northward and deeper extent of the fault surface of the

1923 Great Kanto Earthquake. The Great Kanto Earthquake is interpreted by the right-lateral reverse fault towards the northwest between the Philippine Sea Plate and the Asian Plate (KANAMORI and ANDO, 1973; ANDO, 1974). Understunding of the Philippine Sea Plate in Southwest Japan has been well studied (FITCH and SCHOLZ, 1971; FITCH, 1972; KANAMORI, 1972; SHIONO, 1977), but more detailed studies are required for the region of the northeastern margin of the Philippine Sea Plate.

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24. 関東地方の地震メカニズム

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関東地方の地震活動域におこる地殻下地震の発震機構がしらべられた．地震研究所観測網の他，気象庁・ISC の地震報告からも初動方向の資料が収集された．

茨城県南西部には2つの著しい地震活動域があるが，西端部の地震は北西 — 南東の線状配列を示し，東側から傾むき下がる大規模な地震帯の上面に沿って起っている（震源の深さは 45 km）．地震メカニズムは北西への低角逆断層型を示し，震源の配列と良く一致している．従って茨城県西端部の地震は，太平洋プレートの北西方向への沈みこみに伴なう反撥運動によるものである．

もう一つの顕著な活動域は，茨城県南西部から千葉県中部にかけた，東経 140° 線の東側に位置し震源の深さは約 70 km である．この位置は東側から沈みこむ大規模な地震帯に，西側から傾むき下がる小規模な地震帯が交叉しているところにあたる．又地震メカニズムは東西圧縮型あるいは西側が落ちこむ鉛直縦づれ型が優勢であり，その主圧力軸は西側から傾むき下がっている．このような西側から傾斜している地震帯がフィリピン海プレートの北東端であるならば，この地域の地震はフィリピン海プレートの北東端が太平洋プレートに衝突していることによって起っていると考えられる．