BULLETIN OF THE EARTHQUAKE
RESEARCH INSTITUTE
Vol. 44 (1966), pp. 1665-1687

78. *High Sensitivity Tripartite Observation of Matsushiro Earthquakes. Part 3.*

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(Read July 19 and September 27, 1966.—Received September 30, 1966.)

The results of the tripartite observation carried out at Hoshina, Nagano Prefecture, within the periods from October 31 to December 18, 1965 and from February 20 to June 20, 1966 in order to investigate the Matsushiro earthquakes have been reported in our previous papers[1),2)]. The present paper is a continuation of these papers and are results obtained within the period from the latter part of June to the middle of September, 1966. The methods of observation and analysis are the same as were described in the first report. From an examination of 1050 felt earthquakes detected by the temporary seismographic network of the Earthquake Research Institute set up in the area around Matsushiro during the period from April to June, we determined the Ōmori coefficient k as 6.12 km/sec with standard deviation of 0.61. After the last part of June, we used this value when determining hypocenters of the Matsushiro earthquakes.

The high sensitivity tripartite observation of the same kind as at Hoshina was also made at Komatsubara, (36°37′N, 138°8′E), about 9 kilometers northwest of the town of Matsushiro, within the period July to August, 1966. The continuous tripartite observation using a magnetic tape recorder of 6-tracks capable of working for 29 hours continuously was started at Osa (36°26′N, 138°18′E), Sanada, Nagano Prefecture, about 6 kilometers northeast of Ueda city on September 5 and is continuing to the end of September, 1966. However, these observational results will be reported at the earliest opportunity.

1. Obtained Seismograms

Examples of seismograms obtained at Hoshina within the period from

1) K. HAMADA and T. HAGIWARA, "High Sensitivity Tripartite Observation of Matsushiro Earthquakes. Part 1," *Bull. Earthq. Res. Inst.*, **44** (1966), 1213.
2) K. HAMADA and T. HAGIWARA, "High Sensitivity Tripartite Observation of Matsushiro Earthquakes. Part 2," *Bull. Earthq. Res. Inst.*, **44** (1966), 1239.

June to September are shown in Fig. 1. Initial motion of P wave was clearly read off on account of its sharpness but we found it difficult in many cases to read S phase on the record of up-down component on account of indistinctness of initial motion of S wave. Therefore we added a seismometer of horizontal N-S component at one of the tripartite stations on July 26 and since then the record of this component was used when identifying initial motion of S wave. By the addition of this horizontal component, the S phase was able to be identified within an accuracy of 0.05 seconds in most cases. As we had used a horizontal component intermittently prior to July 26 in order to check the S phase determined on the seismograms of vertical component, the identification of S phase before that day would not be so much different from that after adding the horizontal component.

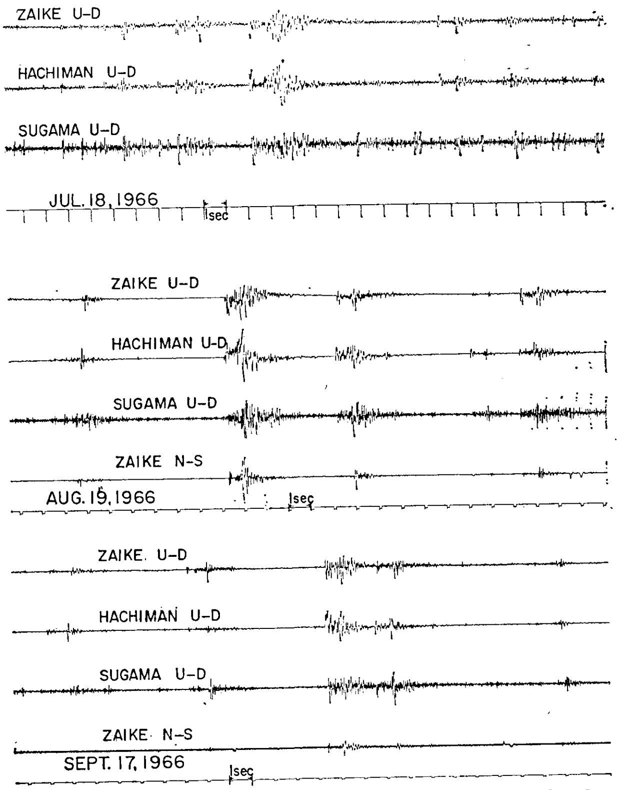


Fig. 1. Examples of the seismograms in each month obtained at Zaike, Hachiman and Sugama in order from top to bottom.

2. The number of earthquakes

The number of earthquakes observed at Hoshina tripartite stations are listed in Table 1. For the sake of comparison, the number of unfelt and felt earthquakes reported from the Matsushiro Seismological Observatory, Japan Meteorological Agency, are listed together. They are also shown in Fig. 2. The scale of the ordinate on the right-hand side in Fig. 2-a indicates daily number of earthquakes obtained by extrapolation, assuming that frequency of occurrence is of the same rate throughout a day.

The number of earthquakes observed at Hoshina tripartite stations in 90 minutes was 1,500 at the end of April, but it decreased gradually later and 800 were counted at the end of July after three months had passed. Then, the number of earthquakes increased again in August, reached 1,000 at the beginning of September and decreased in the middle period of September.

On the other hand, the daily number of unfelt earthquakes announced from JMA was 4,000 on an average in April, decreased gradually later and 800 on an average were counted at the end of July. However in August, the number increased rapidly again, exceeding 5,000 on August 28. After that the number of earthquakes decreased again descending to 500 on September 20. Although the number of unfelt earthquakes registered at the Matsushiro Observatory of JMA showed a large fluctuation as indicated in Fig. 2-b, the number of earthquakes registered at our Hoshina stations did not show such a large fluctuation, as indicated in Fig. 2-a. The difference between the two would seem to be due to the extremely local micro and ultra micro-earthquakes because of the high sensitivity of the used seismographs.

After the large seismic activity in April and May had passed, a strong earthquake with an intensity of IV on the JMA scale took place on June 12. In the period of the last ten days of June and the first ten days of July, large earthquakes with an intensity of IV and V on the JMA scale occurred five times, but there were no large earthquakes with an intensity larger than IV on the JMA scale in the middle and last ten days of July. The number of unfelt earthquakes was also decreasing gradually as a general tendency up to the end of July. At that time the seismic activity in the area of Matsushiro earthquakes seemed to be approaching an end. However in August, large earthquakes with an intensity larger than IV on the JMA scale occurred ten times, including large shocks with an intensity of V on the JMA scale which occurred

Table 1. List of earthquakes. The 2nd column gives the observation intervals, the 3rd the number of detected earthquakes, the 4th the number of analyzed earthquakes, the 5th the number of earthquakes for which Ishimoto-Iida's coefficient were examined, the 6th the daily number of unfelt earthquakes announced from JMA and the 7th column the magnitudes and intensities of larger felt earthquakes.

Date		2	3	4	5	6	7
Jun.	21	10:53 - 12:23	909			1704	IV (4.5)
	22	20:50 - 22:20	911	178	307	1224	
	23	10:45 - 12:15	929			1572	
	24	9:59 - 11:29	863	159	303	1202	
	25	10:50 - 12:20	968			1416	
	26	10:30 - 12:00	879	158	316	1897	V (4.6)
	27	10:38 - 12:08	911			1591	
	28	10:45 - 12:15	863	171	323	1542	IV (4.4)
	29	10:24 - 11:54	893			1664	
	30	10:32 - 12:02	856	166	302	1353	
Jul.	1	11:01 - 12:31	978			1257	IV
	2	17:56 - 19:26	851	200	304	1530	
	3	10:28 - 11:58	863			1655	
	4	10:32 - 12:02	985	200	324	1054	
	5	10:16 - 11:46	863			1343	
	6	10:28 - 11:58	942	200	302	1021	
	7	10:33 - 12:03	872			1200	
	8	10:33 - 12:03	974	222	303	1237	
	9	10:29 - 11:59	833			1805	
	10	10:27 - 11:57	854	200	363	1614	IV (4.4)
	11	10:51 - 12:21	892			1140	
	12	10:36 - 12:06	859	200	306	1106	
	13	10:22 - 11:52	867			1272	
	14	10:26 - 11:56	954	182	313	1079	
	15	10:23 - 11:53	939			940	
	16	10:23 - 11:53	989	200	301	1343	
	17	10:03 - 11:34	889			1151	
	18	10:05 - 11:35	941	200	303	946	
	19	10:24 - 11:54	749			997	
	20	10:40 - 12:10	845	191	306	967	
	21	10:53 - 12:23	761			778	
	22	9:50 - 11:20	829	150	307	927	
	23	10:41 - 12:11	891			707	
	24	10:32 - 12:02	838	138	304	969	
	25	10:45 - 12:15	787			947	
	26	10:52 - 12:22	771	187	323	806	
	27	10:50 - 12:20	860			1075	
	28	17:50 - 19:20	672	200	301	716	
	29	16:30 - 18:00	775			1079	
	30	15:21 - 16:51	808	200	347	886	
	31	10:55 - 12:25	856			857	

(to be continued)

Table 1. (continued)

Date		2	3	4	5	6	7
Aug.	1	10:43 - 12:13	720	200	305	840	
	2	11:04 - 12:34	874	175	309	2025	
	3	16:00 - 17:30	800			1321	V (5.0)
	4	10:53 - 12:23	876			916	
	5	10:07 - 11:37	733	200	325	946	
	6	10:54 - 12:24	751			652	
	7	10:31 - 12:01	851	143	314	606	
	8	10:45 - 12:15	1051			1114	
	9	10:55 - 12:25	756	173	300	1403	
	10	10:32 - 12:02	610			903	
	11	10:40 - 12:10	716	147	316	1508	
	12	11:21 - 12:51	773			1615	
	13	11:00 - 12:30	734			1865	
	14	10:25 - 11:55	751	190	300	1794	IV (3.7)
	15	10:20 - 11:50	778	155	307	1355	
	16	10:21 - 11:51	763			1787	IV (3.9)
	17	10:22 - 11:52	894	193	310	2314	
	18	10:27 - 11:57	811			1563	
	19	10:17 - 11:47	914	200	321	1909	
	20	10:51 - 12:21	989			2540	IV (4.6) IV
	21	10:53 - 12:23	897	200	319	2729	
	22	10:56 - 12:26	1006			2853	
	23	10:30 - 12:00	973	200	309	3900	
	24	10:32 - 12:02	1050			2197	
	25	10:32 - 12:02	960	200	313	2166	
	26	10:30 - 12:00	967			3307	
	27	11:24 - 12:54	1025	200	317	2095	
	28	9:19 - 10:49	971			5100	V (5.1)
	29	10:50 - 12:20	1105	187	334	4230	IV (4.8) IV
	30	11:16 - 12:46	830			3090	IV (3.9)
	31	10:18 - 11:48	922	200	341	3667	
Sep.	1	10:15 - 11:45	845	200	332	2861	
	2	10:34 - 12:04	864			3660	
	3	10:12 - 11:42	1075	200	331	2631	
	4	9:58 - 11:28	1021			2462	
	5	10:28 - 11:58	1095	200	361	3718	
	6	10:30 - 12:00	887			2484	IV (4.6)
	7	11:15 - 12:45	870	170	323	3710	IV (4.0)
	8	12:18 - 13:48	917			2212	
	9	10:58 - 12:28	1103	200	348	2400	IV (3.5)
	10	10:42 - 12:12	870			2925	
	11	9:40 - 11:10	973	187	305	3007	
	12	10:59 - 12:29	873			2407	
	13	11:45 - 13:15	832	149	356	2750	
	14	11:15 - 12:45	889			2236	IV (4.9) IV
	15	10:38 - 12:08	712	153	323	2091	
	16	10:45 - 12:15	827			2115	
	17	10:58 - 12:28	803	148	308	1662	
	18	11:10 - 12:40	867			1473	
	19	10:51 - 12:21	706	116	304	1209	
	20	10:40 - 12:10	797			1790	

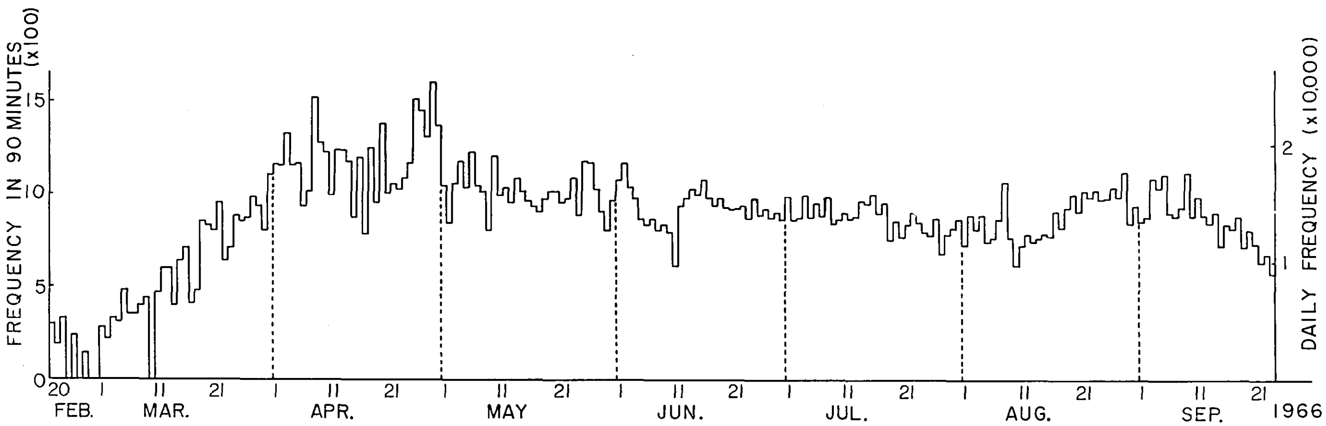


Fig. 2-a. The number of earthquakes observed by the tripartite method at Hoshina in 90 minutes. The scale of the ordinate on right-hand side indicates daily number calculated by extrapolation.

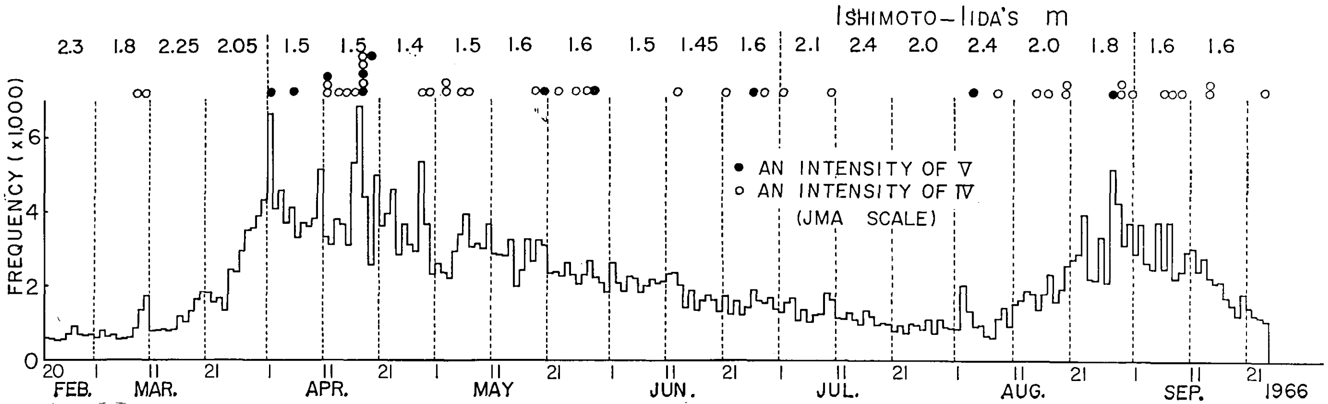


Fig. 2-b. Relation between the values of Ishimoto-Iida's m and the daily number of unfelt earthquakes announced from JMA.

on August 3 and 28. The number of unfelt earthquakes increased also rapidly in this period. After that large earthquakes with an intensity of IV occurred on September 5 and 14 with a decrease in the number of unfelt earthquakes. The end of August and the beginning of September can be called the third climax of the seismic activity within the area of the Matsushiro swarm earthquakes.

3. Distribution of *P-S* intervals

Distribution of *P-S* intervals observed at Zaike, where one of the tripartite stations was placed, is shown in Fig. 3, and is listed in the 4th column of Table 1, in which the days were divided into the first,

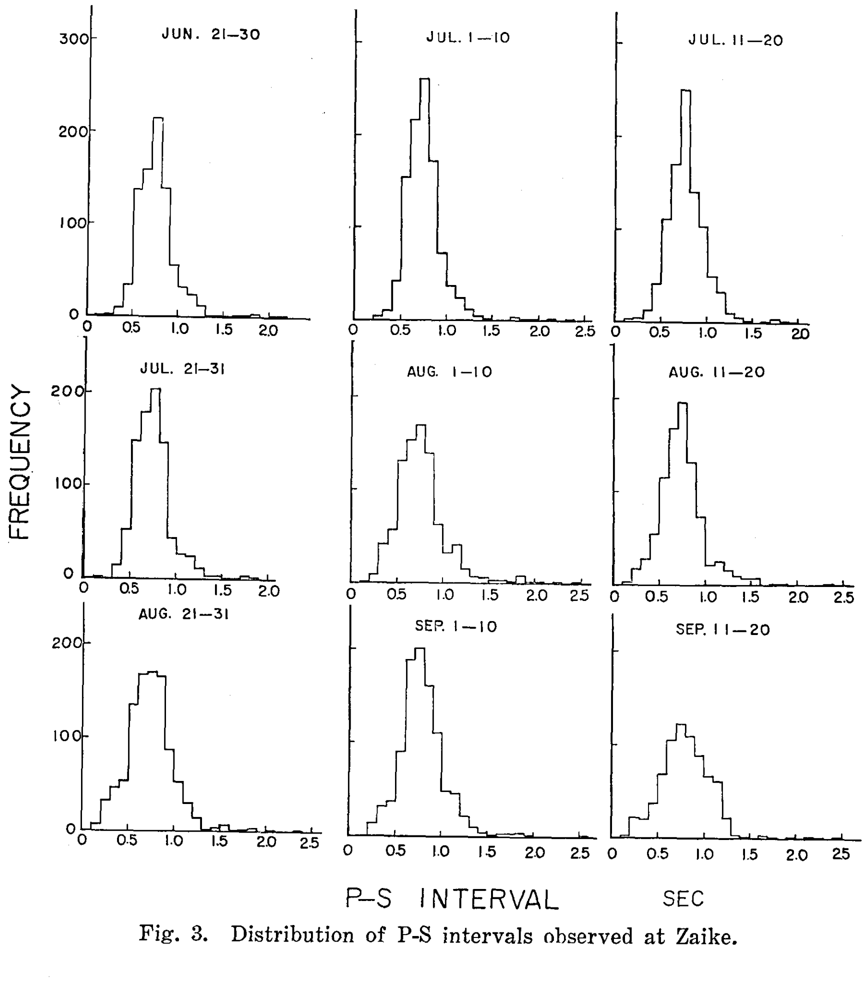


Fig. 3. Distribution of P-S intervals observed at Zaike.

middle and last ten days of each month. The hypocenters were also determined for these shocks. Roughly speaking, the distribution of *P-S* intervals did not change greatly during the period from the last ten days of June to the middle ten days of September 1966, i.e., the large maximum value of *P-S* interval existed always at 0.7~0.8 seconds throughout the whole period of observation, about 80 percent of the *P-S* intervals lay in the range from 0.5 to 1.0 second and the whole *P-S* intervals lay in the range from 0.1 to 2.6 seconds as shown in Fig. 3.

To be more precise, the number of shocks with *P-S* interval larger than 1.5 seconds increased from the beginning of August. Earthquakes with *P-S* interval larger than 2.0 seconds were not observed throughout the whole period from December 1965, when the observation at Hoshina started, to the middle part of June 1966, if we except eight shocks only with *P-S* intervals of 2.0~3.0 seconds which occurred in the first ten days of June. Hence we must affirm the fact that earthquakes with *P-S* intervals larger than 2.0 seconds observed frequently during the period from the last ten days of June to the middle part of September 1966 represented a new event.

4. Ōmori coefficient k

The value of the Ōmori coefficient k was examined again using *P-S* intervals read off from the records of Ishimoto's accelerographs of our seismographic network. Available data were of 1,600 earthquakes in April, May and June, of 100 earthquakes within the period from February 13 to March 4 and of 30 earthquakes within the period from August 28 to 31, 1966. The earthquakes in February, March and August, 1966 were added in order to determine if there is any change due to the elapse of time. As a result we obtained 6.12 ± 0.61 km/sec as a mean value of k. The values of k showed no systematic change during the period from February to August, 1966. For calculating the mean of k, we adopted only 1050 values of k that gave a deviation less than 10 percent when the deviation of 0.1 second was assumed to exist in the reading values of *P-S* interval at each station. The value of k 6.12 obtained here is evidently smaller than the value 7.3 obtained previously. Was this difference caused by an error or does it actually? As we cannot give an immediate answer, we shall postpone the solution to the next opportunity. Anyway 6.12 is used in this report as the value of k for determining the hypocenter of the shocks during the period from the last ten days of June to the middle part of September.

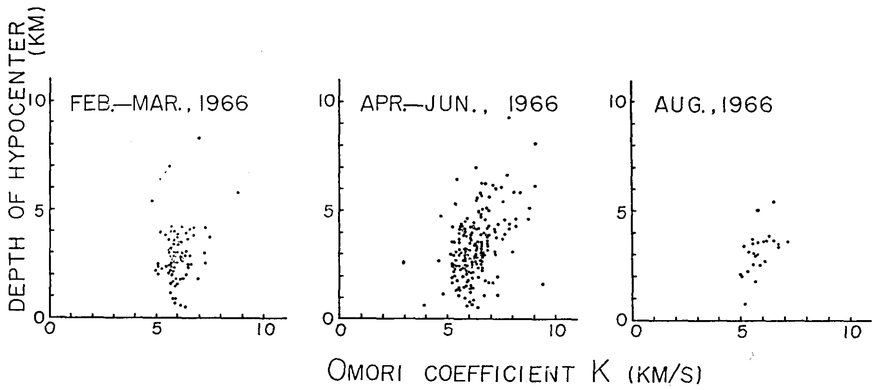


Fig. 4. Relation between the Ōmori coefficient k and the depth of hypocenter.

The relation between k and the depth of the hypocenter is shown in Fig. 4. Generally speaking, the accuracy of k is very rough in the case when k is larger than 7.5 km/sec. k seems to be fairly constant in the range of depth between 0 and 5 km as shown in Fig. 4.

5. Distribution of hypocenters

The number of the shocks of which the location was determined by the tripartite method are listed in the 4th column of Table 1. The number of earthquakes analyzed is not proportional to the number of the shocks detected at Hoshina. The maximum number of earthquakes analyzed in a day was 200 on account of the limitation of our analytical work. The method of determination of the hypocenters is the same as that reported in the first paper. The value of k used here is 6.12 km/sec. Distribution of the hypocenters thus obtained is shown in Fig. 5. The days were divided into the first, middle and last ten-day period of each month. The distribution of the depth is shown in Fig. 6.

The detail of the distribution of the hypocenters is shown in Fig. 5, the above-mentioned being outlined as follows: Many earthquakes are crowding densely still in Matsushiro and Wakaho on the north-east and north-west sides of Kimyō-zan. However, some earthquakes were located in Kōshoku, Sanada, Azuma and Suzaka beyond the boundaries of Matsushiro and Wakaho. All earthquakes within the period from the last ten days of June to the middle period of September were located in an elliptical area 25 km long in the northeast-southwest direction, 15 km long in the northwest-southeast direction with its center at Kimyō-zan. As regards

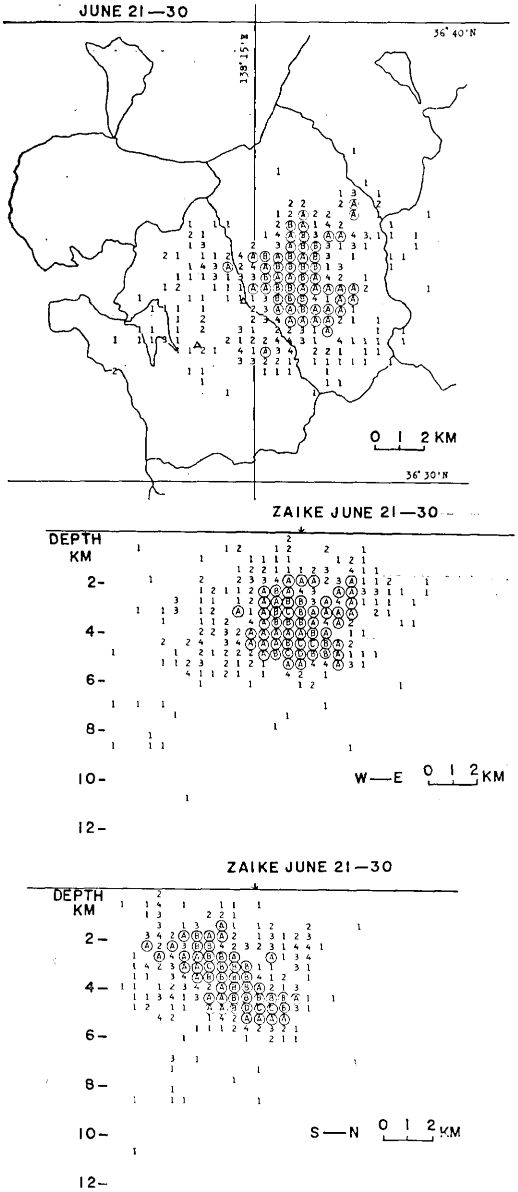


Fig. 5. Distribution of hypocenters determined by the tripartite method at Hoshina. Ⓐ: $5 \leq N < 10$, Ⓑ: $10 \leq N < 20$, Ⓒ: $20 \leq N < 30$, Ⓓ: $30 \leq N < 40$, Ⓔ: $40 \leq N < 50$ and Ⓕ: $50 \leq N < 60$. N is the number of earthquakes.

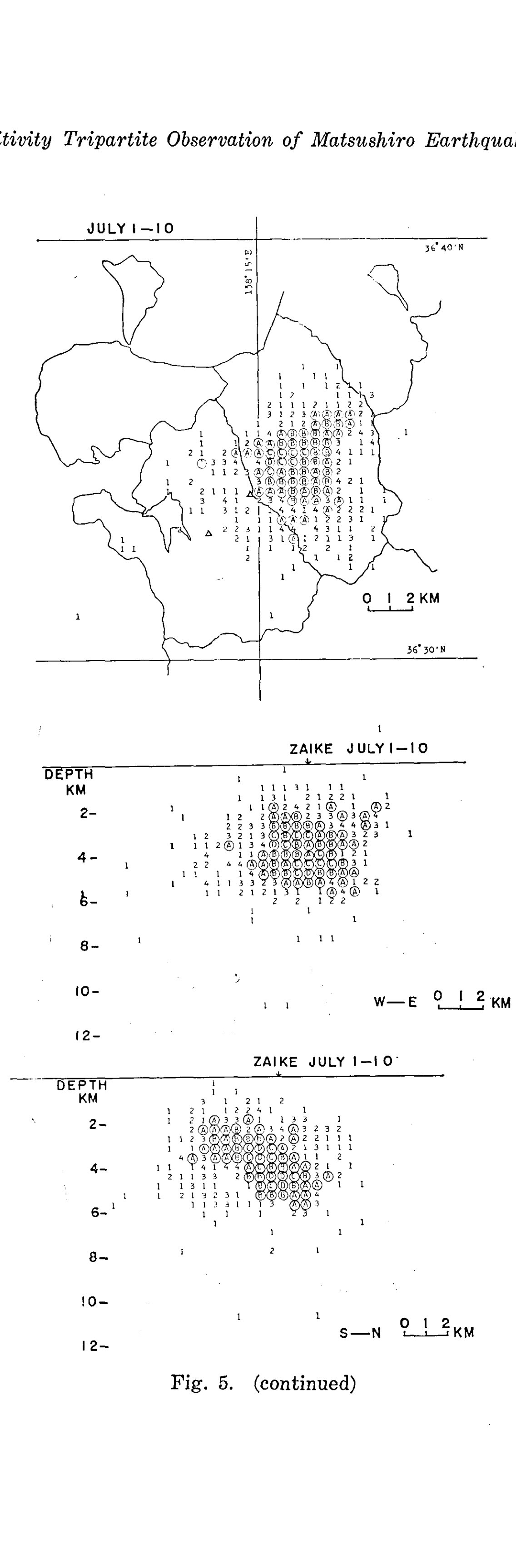
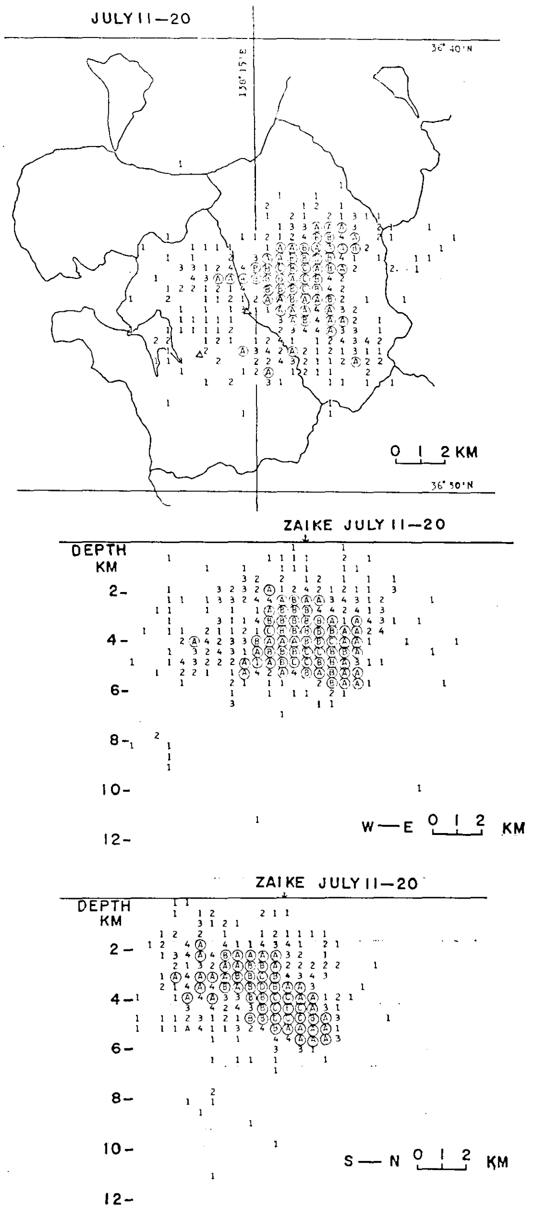


Fig. 5. (continued)



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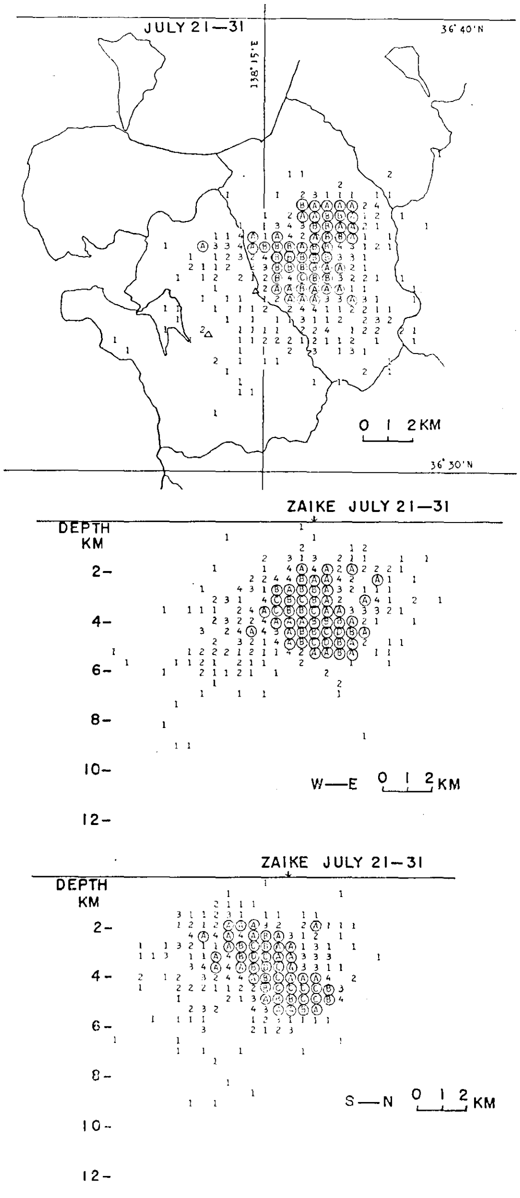

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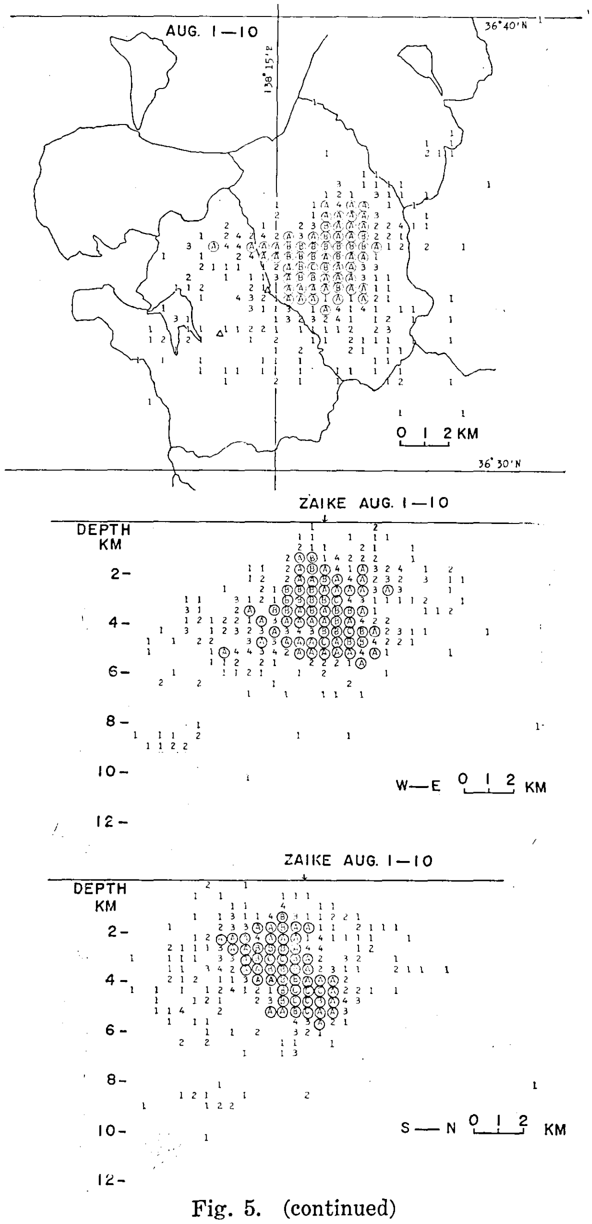

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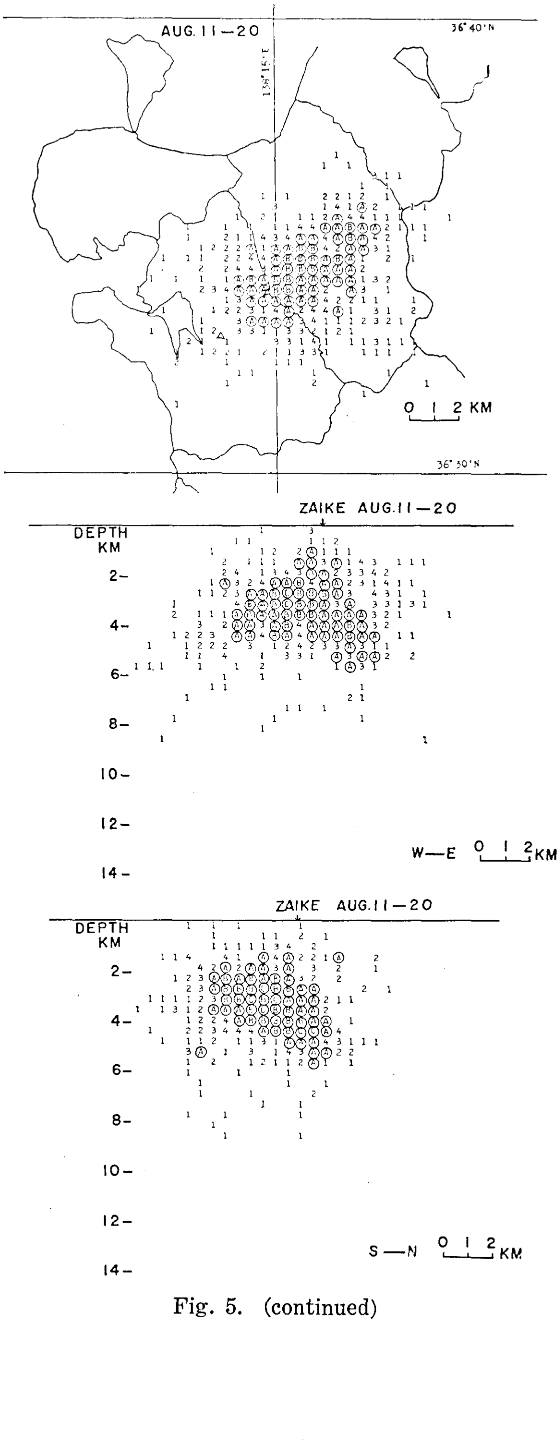

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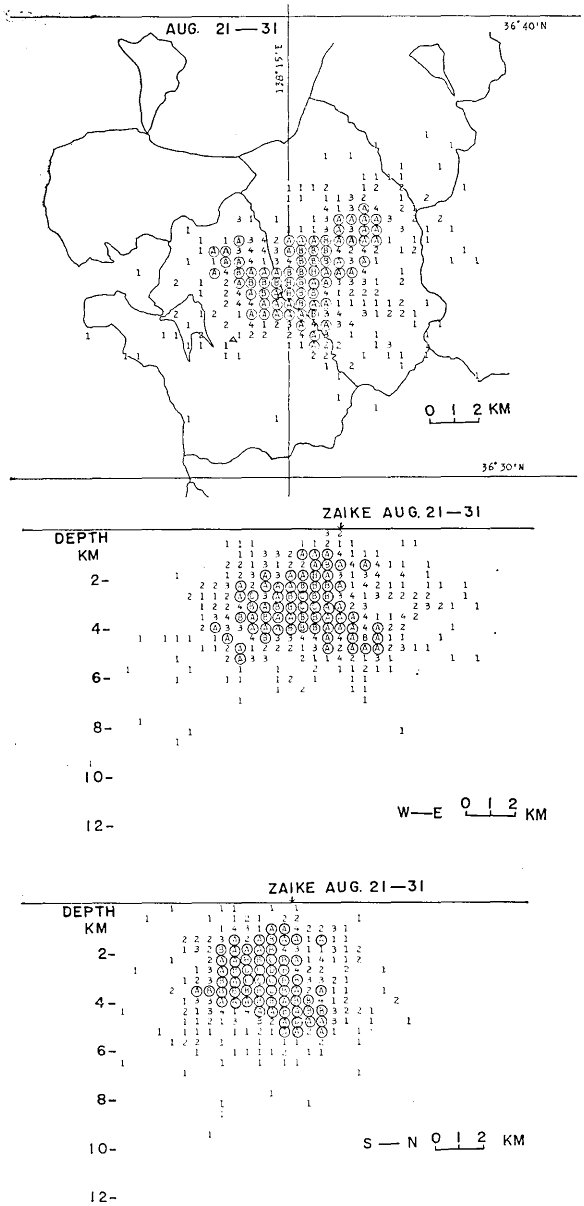

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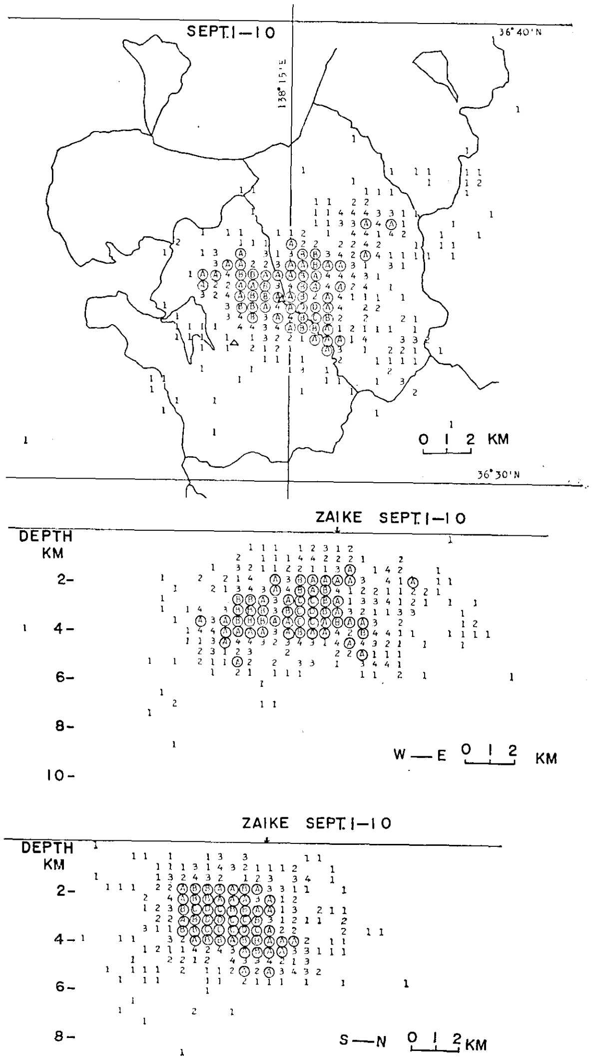

Fig. 5. (continued)

the change in the activity with respect to time, the distribution of hypocenters did not change remarkably till the end of July, but the number of earthquakes occurring in Kōshoku, Sanada, Azuma and Suzaka increased in August and September. The cluster of earthquakes crowding on the northeast side of Kimyō-zan moved gradually westwards to Matsushiro in August and September 1966. The range of depth of the hypocenters was from 0 to 11 km, but an earthquake with a depth of 14 km occurred

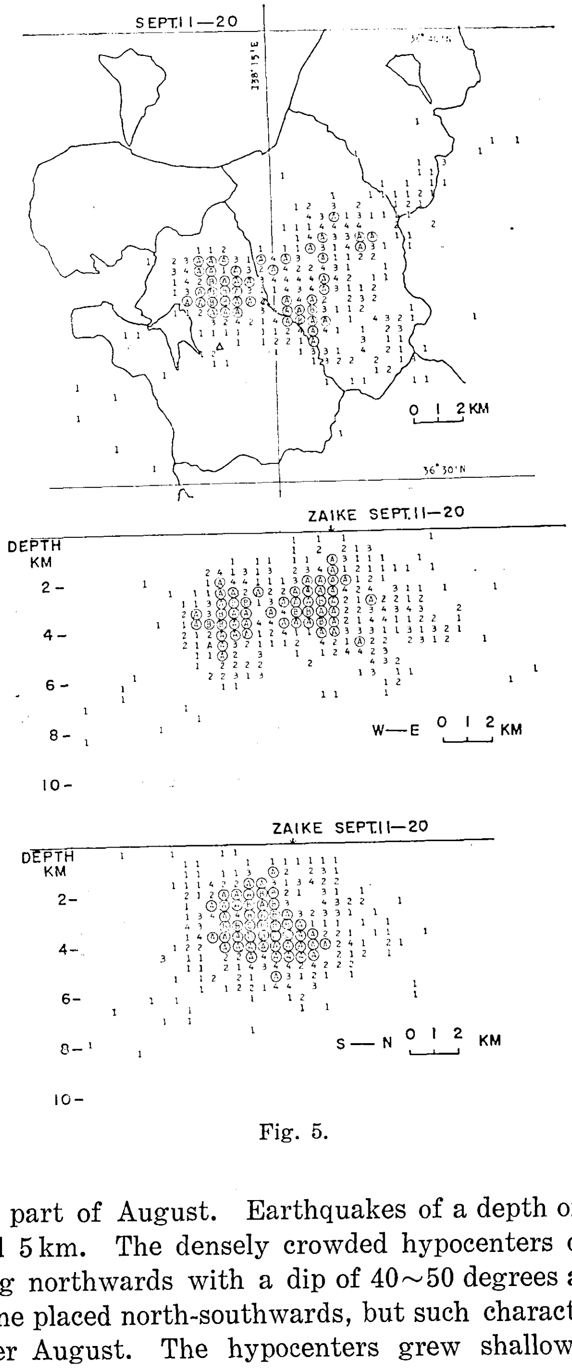

Fig. 5.

in the middle part of August. Earthquakes of a depth of 80 percent lay between 2 and 5 km. The densely crowded hypocenters distributed in a shape inclining northwards with a dip of 40～50 degrees as shown on the projection plane placed north-southwards, but such characteristics became indistinct after August. The hypocenters grew shallower as a whole

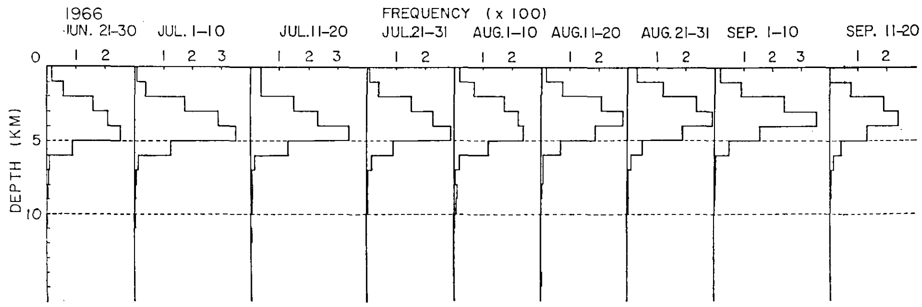

Fig. 6. Vertical distribution of the hypocenters determined by the tripartite method at Hoshina.

after August, i.e. they distributed around a depth of $4\sim5$ km up to the end of July and distributed around a depth of $3\sim4$ km from the beginning of August.

6. Frequency of occurrence of earthquakes and the maximum trace amplitude

The number of earthquakes used here is listed in the 5th column of Table 1. Earthquakes with a maximum trace amplitude larger than 3 mm were picked up and the relation between the number of occurrences and the maximum trace amplitude was examined. The results are shown in Fig. 7. The inclination of the straight line drawn in the figure gives the value of m classified as Ishimoto-Iida's coefficient. In order to make a comparison with the seismic activity, the values of m determined from the data obtained at Hoshina are shown in Fig. 2-b in parallel with the number of unfelt earthquakes announced from JMA for the period from the last ten days of February to the middle ten days of September 1966.

The m takes a larger value $1.8\sim2.4$ during the period from the end of February to the end of March and from the beginning of July to the middle of August, while it takes a smaller value $1.4\sim1.6$ during the period from the beginning of April to the end of June and after the end of August, as shown in Fig. 2-b. As seen in the figure, we discovered a very interesting fact that the larger value $m=1.8\sim2.4$ appeared before two climaxes of seismic activity at the beginning of April and the end of August, and the smaller value $m=1.4\sim1.6$ appeared just after the climaxes. We think that the difference of the values of m with respect to time are significant. The value of m might grow larger again before the climax if the 4th climax of seismic activity should take place in the

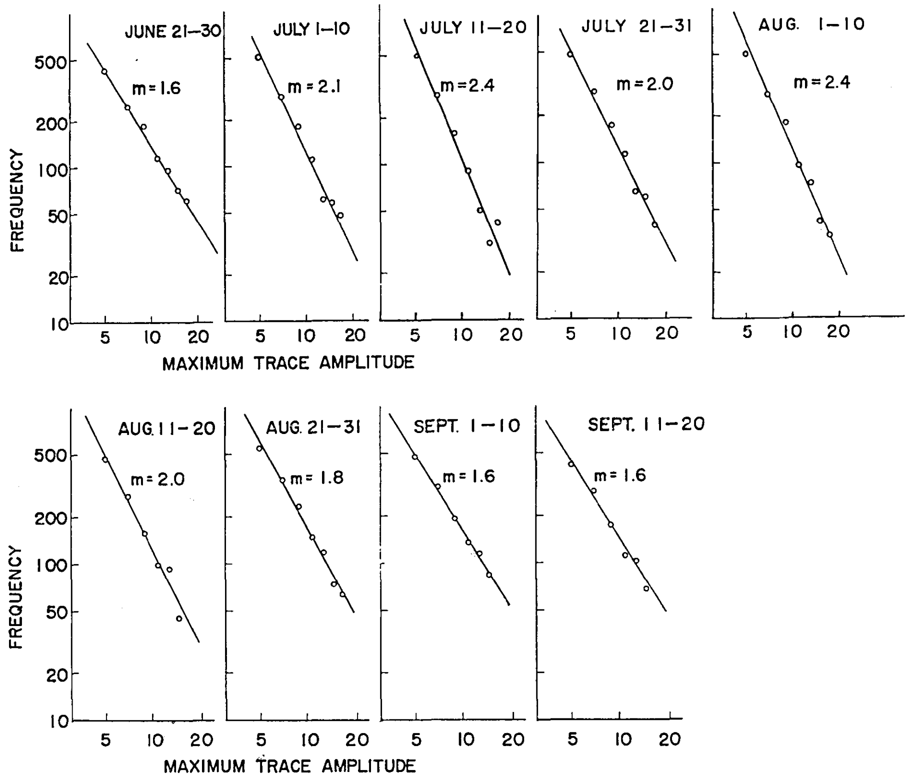

Fig. 7. Relation between the frequency of occurrence of earthquakes and the maximum trace amplitudes.

area of Matsushiro at some future date.

In conclusion the authors would like to extend thanks to the authorities of Hoshina town office, Nagano Prefecture, and to the principal of Hoshina primary school for their co-operation in our seismological observation. The members of the Institute who participated in the field seismological observation were Sadao Saito, Ikuo Karakama, Mutsuro Shibano, Masao Watanabe, Tadao Watanabe, Heihachiro Chiba, Yoshihiro Maeda to whom the authors' thanks are also due.

78. 高感度3点方式による松代地震の観測(3)

地震研究所 { 浜 田 和 郎
萩 原 尊 礼

松代群発地震を調査するために長野県若穂町保科で行なつた高感度 3 点方式による極微小地震観測の結果は，すでに第1報および第2報で報告した．ここではその後の1966年6月下旬から同年9月中旬までの観測結果について報告する．観測方式および解析方法は第1報で述べた通りである．1966年4, 5, 6月の1050個の有感地震を用いて松代臨時地震観測網のデータから大森定数 k の値として新たに6.12 km/sec, 標準偏差0.61を得た．本報告では震源決定にこの値を採用することとした．

1966年7, 8月には松代の北西約 9 km の小松原 (36°37′N, 138°8′E) においても保科と同じ方式の3点方式による極微小地震観測が行なわれた，さらに9月には上田市の北東6 km の真田町，長 (36°26′N, 138°18′E) において同じく3点方式による極微小地震の連続観測が開始され9月末現在継続中である．しかし小松原および真田における観測結果については次の機会に報告をする．

1. 地震記録

6月下旬から9月中旬にかけて得られた地震記録の例は第1図に示してある．依然として初動は非常に立上がりが鋭く明瞭に読取れる．しかし上下動記録の S 相は不明瞭なものがかなり多くなつてきた．従来保科では上下動成分のみを記録させていたが S 相の読取りにさいして読取りが困難な場合が多くあった．そのために7月26日以後からN-S方向の水平成分1つを付加し S 相の読取りはこの成分を用いることにした．実際に水平成分の付加によつて S 相の読取りは容易になり，精度もほとんどが 0.05 秒以内になつた．今までも時々水平成分の記録を取つて上下成分から S 相を決める場合の参考にして来たので7月26日以後とそれ以前とで S 相の読取り結果に大きな違いはないと思う．しかし水平動の記録を見ないで上下動のみから S 相をきめるならば上下動から決めた S 相の方がいくらか早くなるようである．

2. 地震の数

保科の3点方式観測によつて得られた地震の数は第1表に示してある．比較のために松代町西条の気象庁松代観測所から報告された無感地震と有感地震の回数も一しよに示してある．これらはまた，グラフにして第2図に示してある．保科3点方式で得た90分間の地震の数は4月末に1,500個でその後徐々に減少し100日後の7月末には平均800個になつた．しかし8月以後はまた再び増加に転じ9月上旬には平均1,000個に達した．しかし9月中旬にはすぐ減少し21日には700個になつた．一方松代観測所報告の1日の無感地震の数は4月には平均4,000個あつたがその後徐々に減少し7月末には平均800個になつた．しかし8月に入るとまた増加に転じ8月28日は5,000個を越えている．そして28日以後また再び減少の傾向にあり，9月20日には約500個になつた．保科において数えられた地震の数が極端に変化していないにもかかわらず，気象庁松代観測所から報告された無感地震の数は非常に大きく変動している．両者の間のこの違いは地震計が高感度のために観測点に非常に近い所の地震活動の影響が強く現われるためであろう．

主な有感地震の数が4, 5月にクライマックスに達した後，6月12日に震度 IV の地震が1度あつた．6月下旬，7月上旬には震度 IV, V 合わせて5度あり，7月中，下旬にはまた鳴りをひそめて震度 IV 以上の地震は1度も起つていない．無感地震の数も7月下旬までは減少の一途をたどつていた．あたかもこのまま地震活動はおとろえていくかに見えた．しかし8月に入るや8月3日の震度 V を皮切りに8月中に震度 IV, V 合わせて10回発生している．8月は今回の松代群発地震の第3回目のクライマックスである．その後9月5日と14日に震度 IV が起つた．

3. *P-S* 頻度分布

P-S 頻度分布は第3図に示してある．ここで用いた地震は，震源を求めたものと同じで，3点で P 相が明瞭で，かつ3点のうちの1つ在家の水平動または上下動で S 相も明瞭なものである．これらの地震の数は第1表第4列に載せてある．

6月下旬から9月中旬にかけては *P-S* 頻度分布の形は，粗くいうとほとんど時間的に変化していな

い．すなわち常に0.7～0.8秒を中心に鋭い山を持つており約80%は0.5～1.0秒の間にある．*P-S*時間の範囲は0.1～2.6秒である．しかし詳しく見ると，1.5秒以上のものが8月に入つてからは，それ以前に比べて多くなつている．保科における観測が開始された1965年11月から1966年6月中旬までの*P-S*頻度分布を見ると，6月上旬に起つた2.0～3.0秒の8個の地震を除けば，全期間を通して2.0秒をこえるものはなかつた．6月下旬～9月中旬に*P-S*時間が2.0秒以上のものが観測されたのは新しい事実であつて，震源域の拡大を意味するものであろう．

4. 大森係数 *k*

松代臨時地震観測網のうちの4ヶ所の石本式加速度計記録の計測から得られる大森係数 k の値を再び調べなおした．データは1966年4月，5月，6月の1600個，2月13～3月4日の100個および8月29～31日の30個の有感地震である．2月，3月および8月のデータは時期による変化があるかどうか，4月，5月および6月のデータと比較するためにつけ加えたものである．結果は2～8月の期間中特に k の値の変化は認められず平均値 6.12 km/sec 標準偏差 0.61 となつた．ここでは *P-S* 時間の読取り精度 0.1 秒の変化に対して k の値が 10% 以下の変化しか示さない 1050 個の k のみを平均している．

今回求めた k の値 6.12 は従来用いて来た k の値 7.3 と比較するとかなり小さい．7.3 を求めた時のデータは1965年10月と11月の地震であり，そのとき用いた記録は保科，赤柴，象山が加速度地震計，森が HES 地震計のものである．k の値が時期によつて実際に変化したか，または森の地震計の種類が異なつているなど k の決定方法の違いが見かけ上そうさせているのか，これは大きな問題である．次の機会にこの問題を解決したい．今回はとりあえず6月下旬以後の震源決定に当つて k の値 6.12 ± 0.61 を用いた．2月下旬～6月中旬の地震についても k の値 6.12 を用いて震源を決めなおすべきかも知れないが，さらに吟味をした後，次の機会にあらためて報告をしようと思う．

今回の計算で求めた k の値とその時に求まつた震源の深さとの関係の例を第4図に示してある．k が 7.5 よりも大きなものは例外なく精度の非常に悪いものである．この図からは震源の深さが0から少なくとも 5 km までのものについては k はほぼ一定値と見なせよう．

5. 震源分布

ここで震源を求めた地震の数は第1表第4列に載せてある．これらの地震はすべて記録紙上 3 mm 以上の振幅を持つている．しかし観測された地震の数と震源を求めた地震の数とは比例しておらず処理能力の都合で解析された地震数は1日最大200個である．震源決定の方法は第1報で述べたとおりであるが，ここで用いた k の値は 6.12 km/sec である．震源分布は各月の旬別に第5図に示してある．また震央位置は無視して深さの分布のみを第6図に示してある．

震源分布の詳細は第5図の通りであるが，その概略は次のごとくである．震央分布は，あいかわらず圧倒的に多数の地震が松代町と若穂町の中にある．特に奇妙山の北東側と北西側には震源の密集した場所がある．松代，若穂の周辺では更植市，真田町，東村，須坂市方面に拡がつている．6月下旬～9月中旬の期間でわれわれの保科3点方式によつて定めた震央はすべて奇妙山を中心として，長径が北東一南西方向に 25 km，短径が北西一南東方向に 15 km のだ円形の中にある．時期による違いを見ると7月下旬まではあまり変化はないが8月に入つてから更植市，真田町，東村，須坂市方面の地震が増加している．また奇妙山の北東側で密集していた震源の群れは8月から9月にかけて徐々に松代町の方に移動している．

震源の深さ分布の範囲は 0～11 km である．ただし8月中旬の1つだけは深さ 14 km である．その中でも 2～5 km の深さに約80%の震源が集中している．南北に平行な鉛直面上に投影した震源分布図に見られるように，特に密集している震源の群れは北に向つて深くなつている．しかし8月に入るとこのことはあまりはつきりしなくなる．単に深さだけの分布では第6図に見られるように8月から9月にかけて全体として震源は浅くなつて来た．すなわち7月末までは 4～5 km の深さのものが多いがそれ以後は 3～4 km の深さのものが分布の中心である．

6. 記録紙上の最大振幅と地震の発生頻度

各月の旬別に，いわゆる石本一飯田の係数 m の値を調べ第7図にその結果を示してある．ここで調べた地震の数は第1表第5列に載せてある．ここでもう一度2月下旬からの石本一飯田の係数の値

を見なおし地震活動との関係を調べその結果を第2-b図に示してある．第2-b図では気象庁松代観測所報告の無感地震の数と保科において得た極微小地震のデータから求めた m の値を一緒に示している．ここで m の値によつて期間を分けると $m=1.8 \sim 2.3$ の期間は2月下旬～3月下旬と7月上旬～8月中旬であり，$m=1.4 \sim 1.6$ の期間は4月上旬～6月下旬と8月下旬以後である．ここで非常に興味のある事実は，4月上旬と8月下旬の地震活動のクライマックスの直前まで $m=1.8 \sim 2.4$ という比較的大きい値を示し，クライマックスの直後から $m=1.4 \sim 1.6$ という比較的小さい値を示していることである．われわれは m の値が地震活動のクライマックスの前後で変化していることを知つたが，これは有意な変化であると考えている．今後また第4回目の地震活動のクライマックスが来るならばその少し前から m の値は 1.8～2.4 に変化するかも知れない．

謝　辞

現地における長期間の地震観測に，多くの協力をいただいた長野県若穂町および保科小学校当局に心から感謝の意を表する．なお毎日の観測は地震研究所の斎藤貞夫，唐鎌郁夫，渡辺政雄，渡辺唯夫，千葉平八郎，前田良弘の各氏が交代で行なつた．以上の方々に心からお礼を申し上げる．