28. *A Study on the Propagation of Microseismic Waves. Part IV.*

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1. Introduction.

We are studying microseisms by means of a tripartite network, and treated of the relation between the directions of approach of microseismic waves and the weather patterns at the time of observation, and some results were already published[1]. But we had some doubts about the reliability of the bearings computed from the records obtained by a tripartite network.

Therefore, we examined the accuracy of the arrival direction computed from the records of microseisms by using two pairs of tripartite stations CEF and CEG (See Part III of our paper), and could ascertain that, at the area including these stations at least, the mean bearings computed have considerable accuracy, and so we investigated microseisms by using only the mean bearings which were computed from the records observed at C-, E-, and F-stations shown in Fig. 1 of Part III.[2]

In this paper we will report the results of our observations from September 10 to 16 and September 20, and from October 5 to 7, 1950.

2. Relation between the Directions of Approach of Microseismic Waves and the Weather Patterns at the Time of Observation.

To begin with, we will state the results obtained from September 10 to 16, 1950, when a typhoon (named KEZIA) slowly travelled over the southern sea of Japan to Kyûshû and then passed northwards over the Japan Sea and over Hokkaidô. When the typhoon KEZIA passed through Kyûshû, another tropical storm had appeared over the southern sea. On the other hand, many cold-fronts or warm-

1) R. IKEGAMI and F. KISHINOUYE, *Bull. Earthq. Rest. Inst.*, **27** (1949), 75-80, **28** (1950), 115-119.

2) R. IKEGAMI and F. KISHINOUYE, *ditto*, **29** (1951), 305-312.

fronts passed over the Pacific Ocean off the coast of Tôhoku District, throughout this period.

Microseisms observed during this period were more or less irregular, and microseisms which had periods of more than 4 seconds and moderate amplitude interposed those with periods of less than 3 seconds and small amplitude. (See Figs. 1(a) and (b), and Fig. 10(a).)

The individual microseismic waves were classified according to their periods, and the mean bearings were computed from the mean time differences arriving at *E*-, *F*-, and *C*-stations. These mean bearings are tabulated in the second column of Table I and shown by arrows in weather-maps (Figs. 2 to 8), which indicate the weather patterns at 9 o'clock (Japanese Civil Time) on those days, respectively. We think that these weather patterns did not differ much from those at the time of our observations, because we observed the microseisms from 11 to 15 o'clock

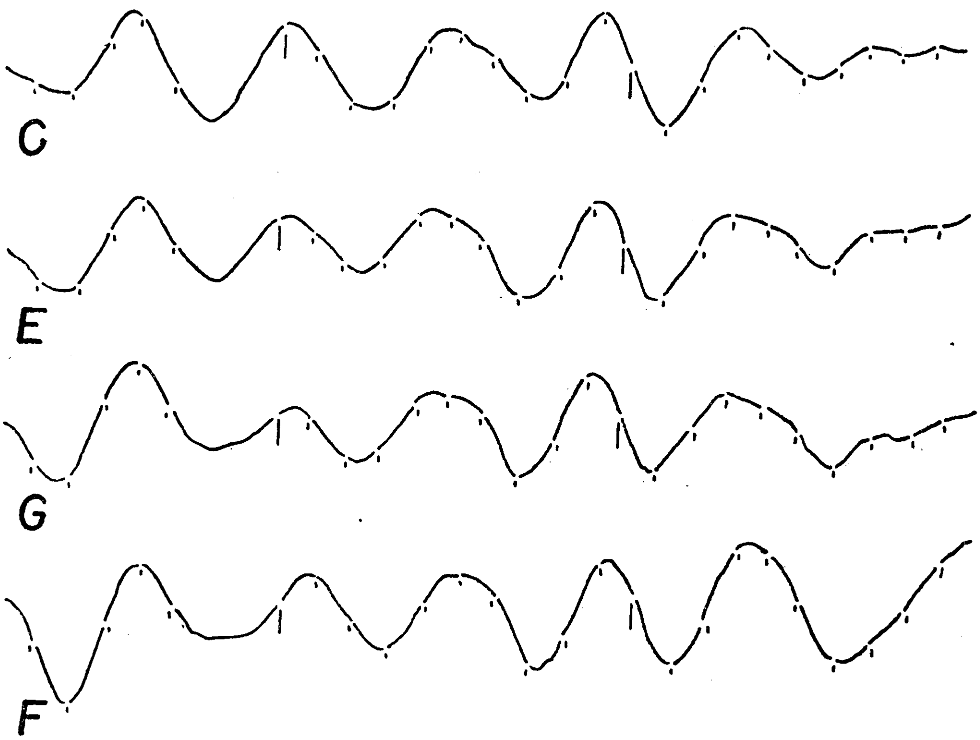

Fig. 1(a). Microseisms, September 11, 1950, 11^h 18^m, observed at *C*-, *E*-, *G*-, and *F*-stations, respectively. Interval between time marks is one second.

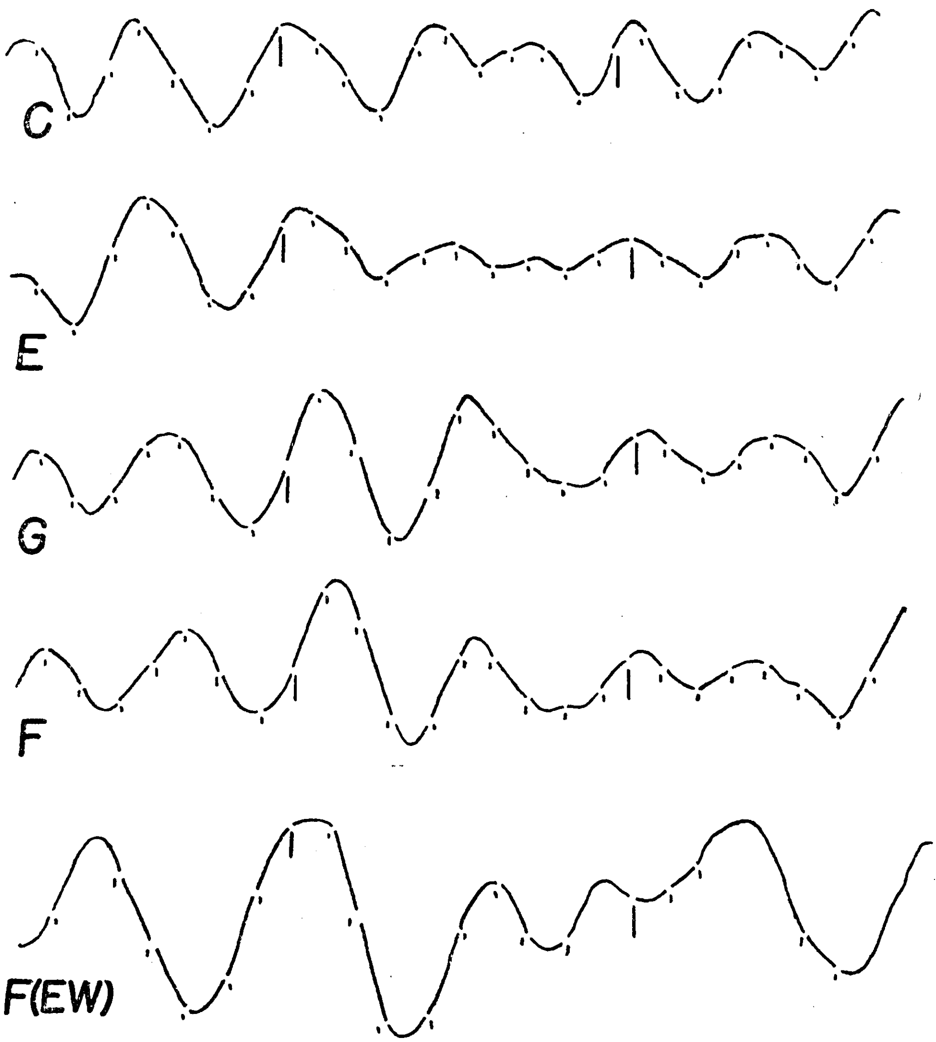

Fig. 1(b). Microseisms, September 13, 1950, 13^h 40^m.

every day.

We see from these figures that the microseisms which came from east or northeast remarkably predominated, nevertheless there was a fairly severe typhoon or tropical storms over the southern sea of Japan. There was no deep depression which generates microseisms over the eastern or the northeastern sea, according to the weather-maps of those days, and swells and sea waves of the northern sea were not higher than those of the southern sea, according to the reports of the observation ships belonging to the Central Meteorological Observatory and of the

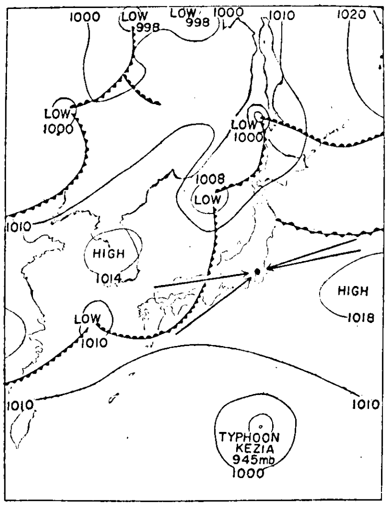

Fig. 2. Weather map for 9:00 a.m., September 10, 1950. Arrows show the directions of approach of microseismic waves.

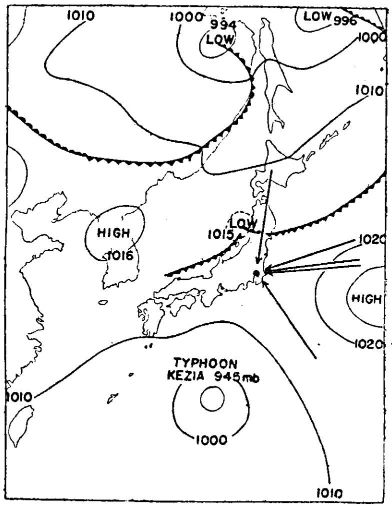

Fig. 3. Weather map for 9:00 a.m., September 11, 1950.

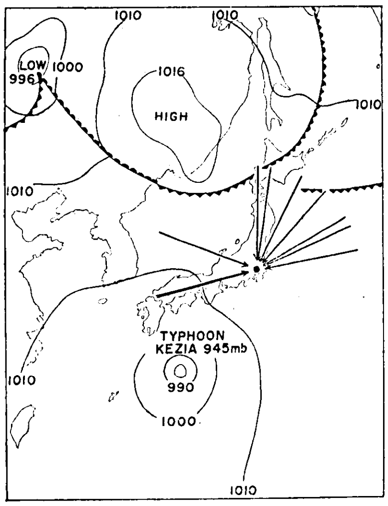

Fig. 4. Weather map for 9:00 a.m., September 12, 1950.

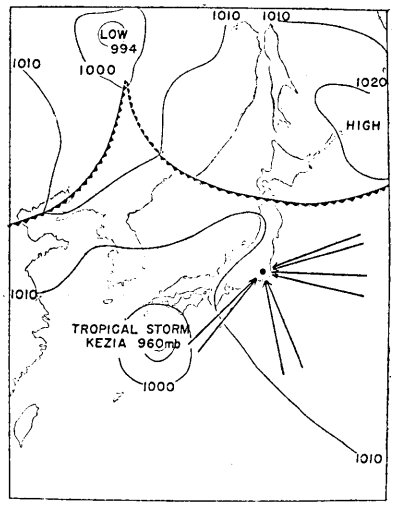

Fig. 5. Weather map for 9:00 a.m., September 13, 1950.

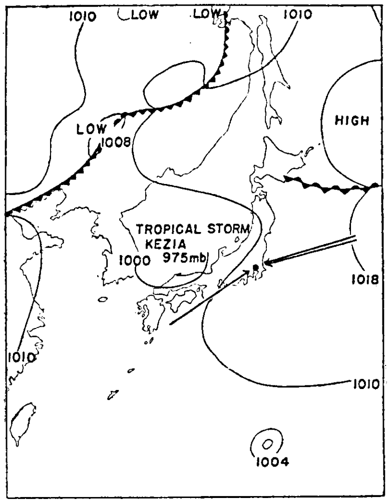

Fig. 6. Weather map for 9:00 a.m., September 14, 1950.

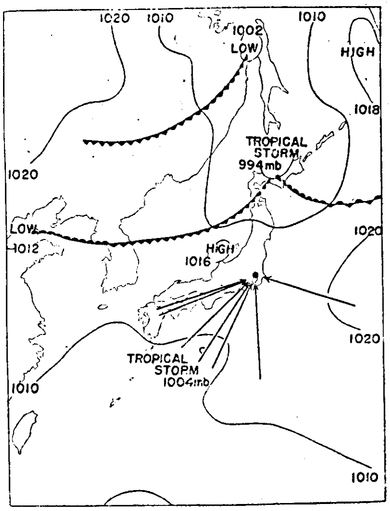

Fig. 7. Weather map for 9:00 a.m., September 15, 1950.

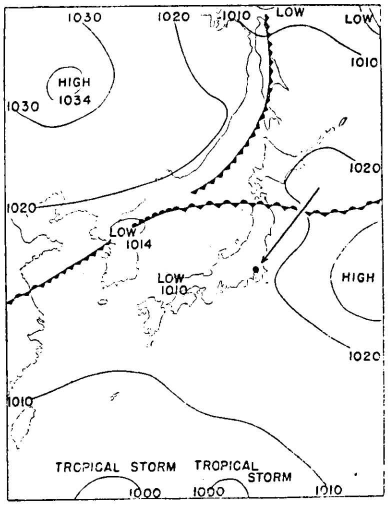

Fig. 8, Weather map for 9:00 a.m., September 16, 1950.

other Meteorological Observatories. Moreover, even when there were cold-fronts or warm-fronts over the northern sea, it may be difficult to suppose that those fronts generated microseisms more powerfully than the southern typhoon. But we have an interpretation of this problem.

It is a well-known fact that when a typhoon is passing over the sea of north off the coast of the Bôsô Peninsula or when the sea of the same area is rough, microseisms with large amplitude and long period always predominate remarkably in Tôkyô.
The reason for this fact is not found yet, but we cannot neglect the fact that the northern sea is apt to generate microseisms more easily than the southern sea.

In this case it is true that the southern sea was much more rough than the northern sea throughout the period, but we can not refrain from thinking that "a force generating microseisms" of the northern sea acted more strongly than that of the southern sea. In most cases the bearings computed from the records of microseisms, whose periods were longer than 4 seconds, pointed to the eastern and the northeastern sea, and the bearings computed from those of periods shorter than 3 seconds pointed to the southern sea where the typhoon or the tropical storms raged. However, microseisms with periods longer than 4 seconds were more predominant than those with periods shorter than 3 seconds, and the latter appeared on the records only here and there when the former took a pause. It now becomes necessary to reconsider the bearings in case of the typhoon PATRICIA on October 26 and 27, 1949[3]. On October 26 the typhoon was situated far off in the southern sea of Japan, and many conspicuous cold-fronts passed over the northeastern sea. All microseismic waves that day came from the northeast, and we considered them to be caused by the northeastern cold-fronts.

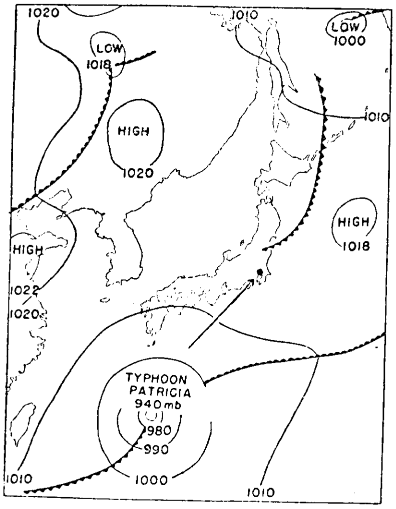

Fig. 9. Weather map for 9:00 a.m., October 27, 1949. Arrow shows the direction of approach of microseismic waves.

On October 27, 1949, the typhoon proceeded farther northwards than on the previous day, and its situation was near that of the typhoon KEZIA on September 12, 1950. All the microseismic waves on October 27 came from southwest. The weather-map and the direction of approach of microseismic waves on that day are shown in Fig. 9.

Microseisms of October 27 were quite different in wave form from those of September 12, 1950 and their periods were all shorter than 3 seconds as shown in Figs. 10(a) and (b), respectively.

We will refer to the relation between the periods and the directions of approach of microseismic waves later.

Next, we will state the results obtained on September 20 and from October 5 to 7, 1950. The weather patterns and the mean bearings computed from microseismic waves on those days are shown in Figs. 11—14.

3) R. IKEGAMI and F. KISHINOUYE, *loc. cit.*, **28** (1950), 115-119.

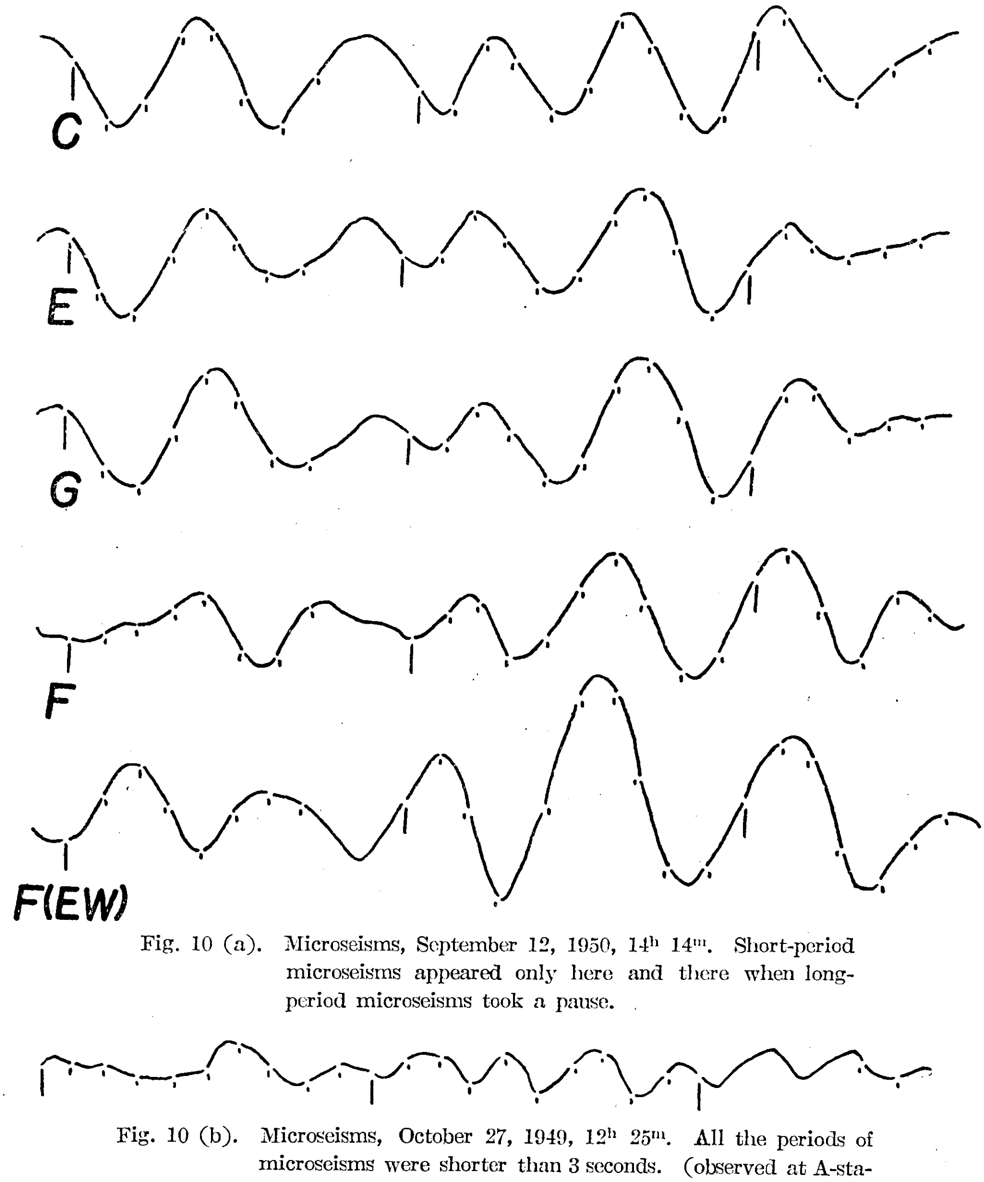

Fig. 10 (a). Microseisms, September 12, 1950, $14^h\ 14^m$. Short-period microseisms appeared only here and there when long-period microseisms took a pause.

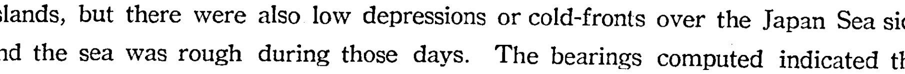

Fig. 10 (b). Microseisms, October 27, 1949, $12^h\ 25^m$. All the periods of microseisms were shorter than 3 seconds. (observed at A-station.)

According to the weather-maps, on September 20 and October 5 and 6, there were fairly deep depressions and cold-fronts over the Pacific Ocean near the Japan Islands, but there were also low depressions or cold-fronts over the Japan Sea side, and the sea was rough during those days. The bearings computed indicated that

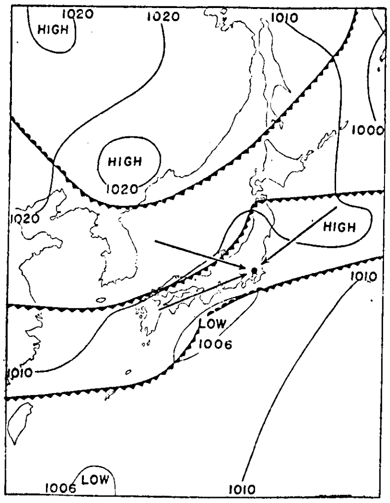

Fig. 11. Weather map for 9:00 a.m., September 20, 1950.

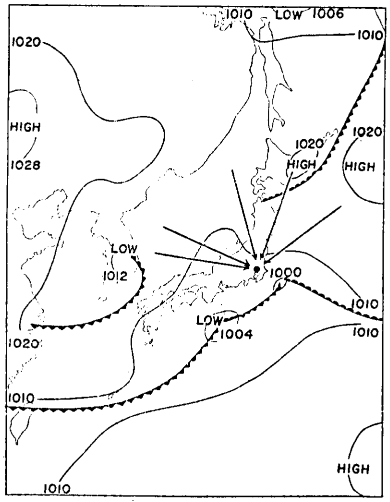

Fig. 12. Weather map for 9:00 a.m., October 5, 1950.

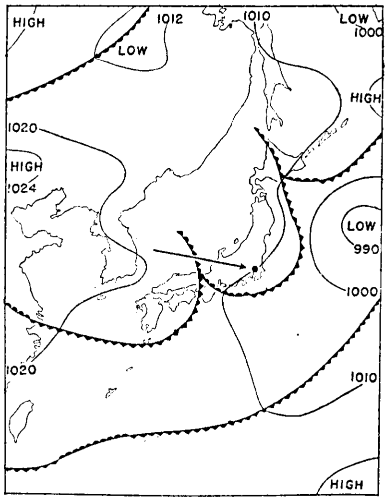

Fig. 13. Weather map for 9:00 a.m., October 6, 1950.

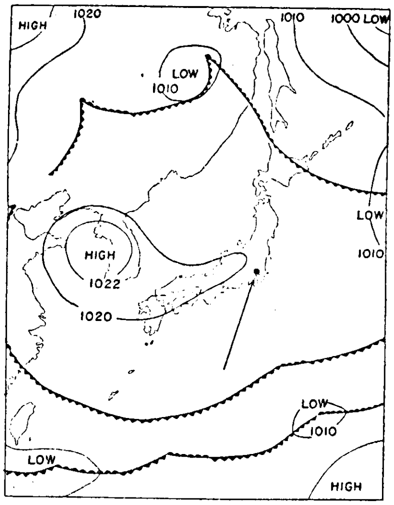

Fig. 14. Weather map for 9:00 a.m., October 7, 1950.

on September 20 and October 5 and 6 the microseismic waves came from the direction of the Japan Sea. We insist that these conditions of the Japan Sea may cause microseisms, but we cannot explain satisfactorily the reason why we could entirely

Table I.

Date	Starting time	Record-No.	Bearings computed	Period	Velocity	Wave-length
	h m		degree	sec.	m/sec.	km.
Sep. 10, 1950.	11 20	2	81	4.2	655	2.75
	13 15	4	265	4.5	590	2.65
	13 15	4	75	4.4	565	2.48
	14 40	7	236	3.0	780	2.34
Sep. 11.	10 55	1	85	4.3	605	2.60
	11 05	2	74	3.9	780	3.04
	11 18	3	88	4.0	780	3.12
	14 12	7	12	5.7	495	2.82
	14 12	7	149	2.7	1200	3.24
Sep. 12.	11 00	1	68	4.4	500	2.20
	14 04	3	258	4.0	490	1.96
	14 04	3	12	4.5	670	3.01
	14 14	4	257	3.3	740	2.44
	14 14	4	294	3.8	815	3.09
	14 14	4	2	4.1	645	2.64
	14 14	4	43	5.2	343	1.78
	14 24	5	27	4.1	500	2.05
	14 24	5	58	4.8	408	1.95
	14 24	5	81	3.8	540	2.05
Sep. 13.	11 33	3	222	3.1	846	2.62
	11 33	3	160	3.0	885	2.65
	11 33	3	105	3.6	670	2.41
	11 33	3	71	5.0	473	2.36
	13 27	4	170	4.0	635	2.54
	13 27	4	77	3.9	625	2.43
	13 40	5	230	3.5	736	2.57
	13 40	5	93	4.2	553	2.32
Sep. 14.	11 38	2	241	3.1	755	2.34
	11 38	2	77	4.0	430	1.72
	13 43	5	79	3.6	730	2.62
Sep. 15.	11 25	1	231	3.5	752	2.63
	11 25	1	111	3.5	850	2.97
	13 50	4	251	4.0	600	2.40
	13 50	4	208	3.4	788	2.67
	14 15	6	255	3.1	672	2.08
	14 15	6	218	3.4	707	2.40
	14 15	6	180	3.4	880	2.99
Sep. 16.	10 57 and 11 08	3 and 4	42	4.0	460	1.84
Sep. 20.	13 47	2	55	4.5	490	2.20
	15 40	5	290	4.1	916	3.75
	15 40	5	252	5.2	504	2.62
Oct. 5.	12 10	1	348	4.7	729	3.42
	12 10	1	298	3.9	892	3.47
	12 22	2	282	4.0	693	2.77
	12 22	2	22	4.0	600	2.40
Oct. 6.	12 04	1	285	4.7	679	3.19
Oct. 7.	11 48	2	201	5.0	481	2.40

Mean, 2.57 ±0.30

observe no microseismic waves coming from the Pacific Ocean side in the present situation of our study.

On October 27, 1950, according to the weather-map, the predominant high pressure area made a considerable advance from the Continent of Asia to east, and most part of the Japan Islands was covered with this high pressure. The low depressions and the cold-fronts over the Japan Sea moved away and the Japan Sea became calm, but there were as always low depressions and cold-fronts over the sea south of the Japan Islands. On this day the bearings computed indicated that all the microseismic waves came from south.

Judging from the results mentioned above, we consider that the cause of the microseisms generated is more complicated than many seismologists think. Recently, forecasting of typhoon or hurricane by utilizing the directions of approach of microseismic waves was advocated by American Seismologists and many valuable treatises on this problem were published. But, judging from our results, we doubt whether this problem can be similarly solved in Japan.

3. Velocity, Period, and Bearings of Microseismic Waves.

We have stated that, according to our results, the velocities of microseismic waves are connected with their periods, and that the products of both values, (viz. wave-length), maintained almost a constant value[4]. This relation between velocity and period was always maintained, though new data were added to the previous ones, but the mean wave-length varied from 2.2 km. to 2.57 ± 0.30 km. as shown in Fig. 15.

It has been already stated that this relation can not yet be explained theoretically, if the velocities observed are phase-velocities.

On the other hand, we re-examined the relation between periods and bearings, and we obtained the relation shown in Fig. 16. The values of period, velocity, and wave-length are tabulated in the third, the fourth, and the fifth columns of Table I, respectively. In Fig. 16. except the two values on October 28, 1949 and October 7, 1950, (shown by white triangle and circle, respectively), we see that the periods of microseismic waves arriving at the stations from azimuths ranging between 0° and 150° (clockwise from north=0°), and between 240° and 360°, were from 3.5 to 5 seconds, and that the periods between 150° and 240° were

4) R. IKEGAMI and F. KISHINOUYE, *loc. cit.*, **28** (1950), 118.

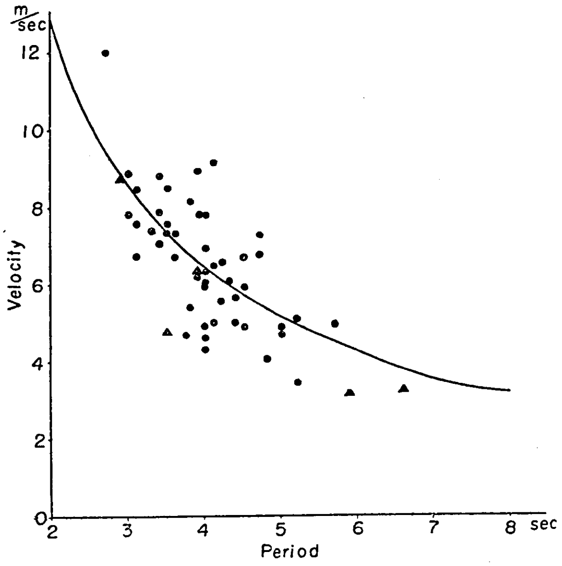

Fig. 15. Relation between mean velocity and period. Circles show the values observed this time, and triangles show the values observed last time, (viz. in case of typhoon PATRICIA).

from 2.5 to 3.5 seconds. The fact that the area between 150° and 240° coincided with the area of sea shallower than 6000 meters as shown in Fig. 17 aroused much interest in us. Judging from these results, the depth of sea in a certain place may be related with the periods of microseismic waves caused in that place, and it seems that microseismic waves caused in the area between 150° and 240° have shorter periods than those caused in other areas. This deduction will be consistent with the fact that microseisms caused in the sea of north of the Bôsô Peninsula have longer periods and larger amplitudes than those caused in the southern sea.

If the velocity of the short-period microseisms is larger than that of the long-period microseisms for some reasons, and if the former is different in kind from the latter, we need not hold fast to the view that the products of velocity and period have always a constant value. That is to say, we may take the view that the periods plotted in Fig. 15 may be all divided into two groups in accordance with their periods. But we can not determine which of the two views is to be adopted in the present situation. Microseisms having especially long-periods, as those on October 28, 1949 and October 7, 1950, are possibly exceptional, and they

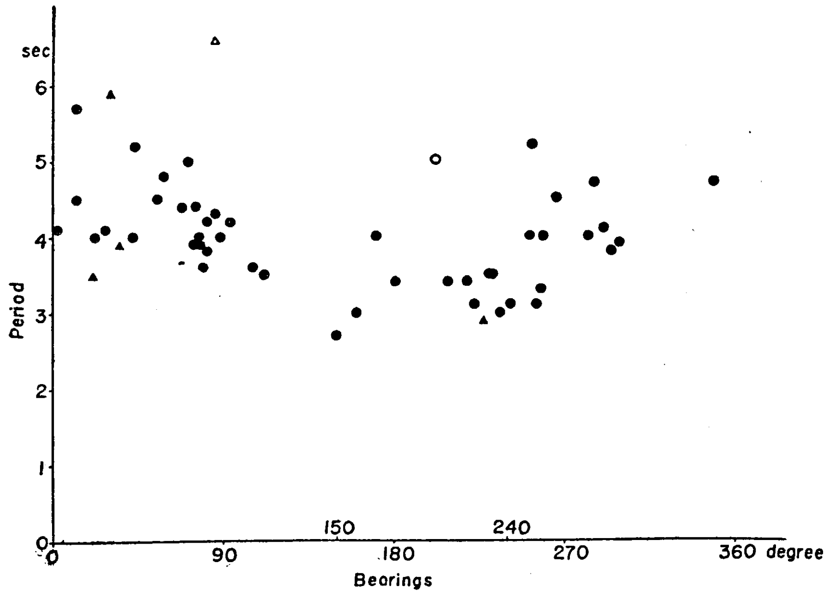

Fig. 16. Relation between period and direction (bearings) of approach of microseismic wave.
Circles show the values observed this time, and triangles the values observed last time, (viz. in case of typhoon PATRICIA). White triangle and circle show microseisms having especially long-periods, which seem to be different in kind from the other.

are different in kind from the others. F. Omori[5] formerly classified microseisms in Tôkyô into three types, i.e. the q-, Q_1-, and Q_2-types according to their period and amplitude, and the range of the period of q-type was from 2 to 3 seconds, that of Q_1-type about 4 seconds, and that of Q_2-type, from 6 to 9 seconds. We consider that this classification of microseisms has a new signification in the light of the results mentioned above.

4. Acknowledgement.

I wish to express my appreciation to Dr. F. Kishinouye for his guidance and advice, and to the other members of his seminary-room for their aids in the observations, and to the staffs of the Tokyo Astronomical Observatory for all the kindness they have shown us in our observations.

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5) F. OMORI, *Bull. Imp. Earthq. Invest. Commit.*, **3** (1909), 1-35.

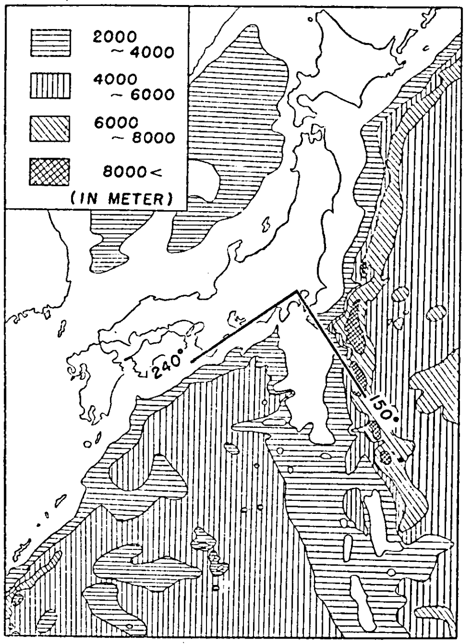

Fig. 17. Relation between depth of the Pacific Ocean and period of microseisms. Microseismic waves caused in the area between 150° and 240°, (depth of this area is shallower than 6000 meters), have shorter periods than those caused in the other area of Pacific Ocean.

The cost of this investigation was defrayed from the Scientific Research Expenditure of the Department of Education.

28. 土地の脈動の傳播性の研究
(第 4 報)

地震研究所　池 上 良 平

昭和 25 年 9 月 11 日乃至 16 日, 及び 20 日, 10 月 5 日乃至 7 日の脈動の傳播方向とその際の天氣圖の示す氣象狀態とを比較した. その結果東京の脈動發生に對しては房總半島以北の海が特に脈動を發生させ易い性質をもつてゐて, ここでは他の場所に於けるより一層弱い低氣壓とか寒冷前線等の通過によつても容易に大きな脈動を發生させる事が確められた. 又脈動の傳播速度週期, 傳播方向の關係を調べた結果傳播速度と週期の積が常に略々一定の値を保つような性質のある事は既に報告した所であるが, 更に傳播方向と週期の間にも顯著な關係がある事が判つた. 卽ち太平洋岸で房總半島沖より以北の深い海 (6000 米以上) に原因があると考へられる場合は週期 4 秒以上の脈動が多く發生し以南の淺い海では 3 秒以下の短週期脈動が多い. 云ひかへれば海の深さと脈動の週期との間には密接な關係があるようである。