43. *Relation between the Periods of Microseisms and the Situation of Typhoon**.

By Ryôhei IKEGAMI,

Tokyo Gakugei University.

(Read Nov. 3, 1954**.—Received Sept. 30, 1955.)

Introduction

It has been studied by many authors, and by means of various methods, that the patterns of microseismic waves vary according to the situations of severe atmospheric depressions like typhoons or hurricanes. In general, the nearer the depression approaches a station, the larger the amplitudes of microseisms and the longer their periods become, but, on some occasions, the amplitudes or the periods of microseisms are not always related with the distances of the depression.

We have already pointed out that the periods of microseisms are intimately related with the directions of approach of microseisms.

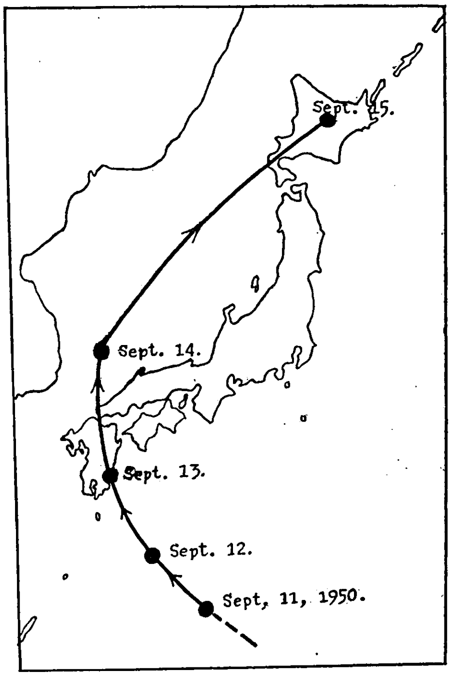
In this paper, in order to study more precisely the relation between the periods of microseisms and the situations of low depression, we constructed the periodograms of the microseismic periods and considered the relations between their patterns and the situations of the typhoon. In addition, we applied Tomoda's simplified correlation method to the same data, and also considered the results obtained.

Materials and Methods Used

The microseismograms used in this paper are those which were observed at the yard of the Tokyo Astronomical Observatory by means of Kishinouye Microseismometers (magnification: 2000, natural period: 10 sec., magnetic damper: critical damping). Periodograms were constructed by ordinary periodogram analysis for five days (from September 11 to 15, 1950), when the Typhoon "Kezia" came up north from the southwest Pacific, passed through Kyushu and Chugoku Districts, and passed over the Japan Sea for Hokkaido. The path of this Typhoon is

* Communicated by F. KISHINOUYE.

** Read at the Meeting of the Seismological Society of Japan.



Fig, 1, The path of the Typhoon "Kezia."

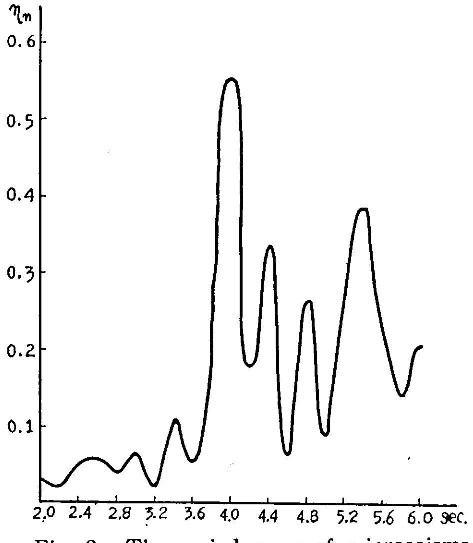


Fig. 2. The periodogram of microseisms observed on Sept. 11, 1950.

shown in Fig. 1.

We restricted the examined periods to the range of 2.0–6.0 sec., for these periods were apparently predominating on the seismograms of those days. The seismograms recording continuously for one minute were used, and the amplitudes of microseismic waves were measured every 0.2 sec. Then we got 300 measured values from the record of each day. Let σ be the standard deviation of the measured values, and let σ_n be the standard deviation to n sec. period in the ordinary periodogram analysis. Then the correlation ratio η_n to n sec. period is given by $\eta_n=\sigma_n/\sigma$, where n stands for 2.0, 2.2, 2.4, 2.6, ... 6.0 sec. The periodograms were constructed by plotting the values of η_n and period n in the ordinate and the abscissa, respectively, and these periodograms are illustrated in Figs. 2–6 for those days of observation.

We applied Tomoda's simplified correlation method[1] which was published recently to the same microseismic data, and got the correlation coefficients for every n sec. period. The results are shown in Figs. 7 and 8.

Discussion of the Results

In Figs. 2 and 3 the periodograms show one pronounced maxi-

1) Y. TOMODA, *Zisin* (*Journ. Seism. Soc. Japan*, [ii]), **7** (1954), 55, (in Japanese).

mum of correlation ratio at the periods 4.0 sec. and 4.4 sec., respectively, ($\eta_n=0.553$ in Fig. 2, $\eta_n=0.759$ in Fig. 3), and the ratios for the other periods all have values less than 0.5. We see from these results that the microseismic waves of these 2 days (Sept. 11 and Sept. 12) were predominated by periods of 4.0 sec. and 4.4 sec., respectively, and that the waves of the other periods were insignificant.

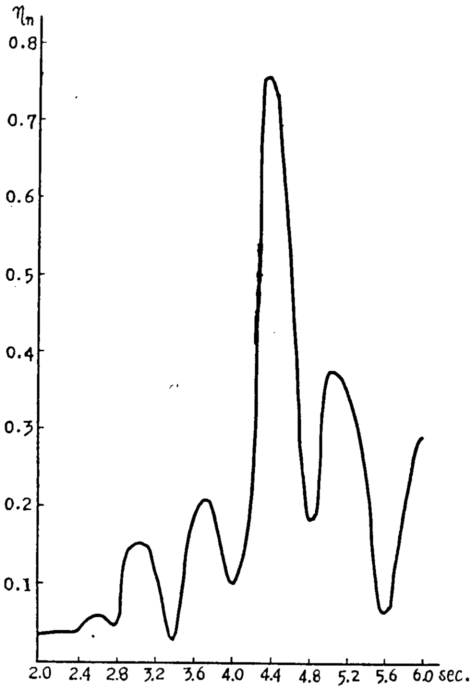


Fig. 3. The periodogram for Sept. 12.

On the other hand, the periodograms of Sept. 13, Sept. 14, and Sept. 15 are markedly different from the above-mentioned ones. In Figs. 4–6, the values of correlation ratio are all less than 0.5, and there is no pronounced maximum. We find on the seismograms that the microseismic waves have various periods in the wide range of about 2.2–5.0 sec. on Sept. 13, 14, and 15. (See Fig. 10.)

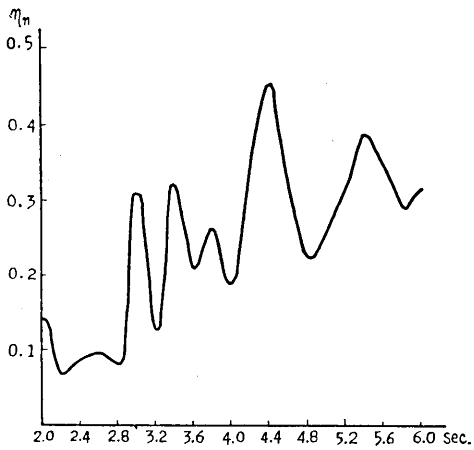


Fig. 4. The periodogram for Sept. 13.

Then we may classify the following two groups of the periodograms in accordance with their characteristics, namely, (a) the periodograms which have a sharp peak, the correlation ratio of which is more than 0.5, (Sept. 11 and 12), (b) the ones which have no striking peak, (Sept. 13, 14 and 15). It is clear that the microseismic waves belonging to the group (a) are markedly predominated by the period of 4.0 sec. (Sept. 11), or 4.4 sec. (Sept. 12), and that the ones belonging to the group (b)

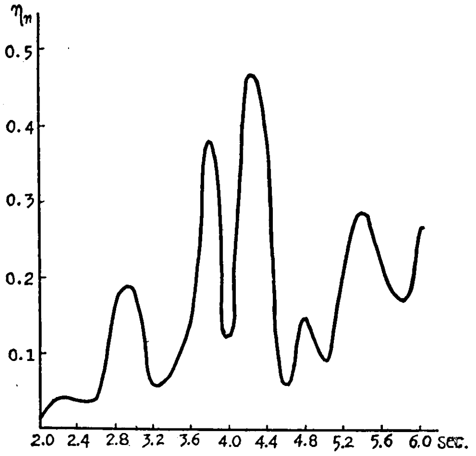


Fig. 5. The periodogram for Sept. 14.

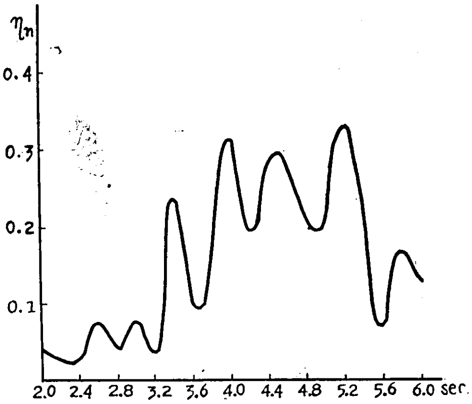


Fig. 6. The periodogram for Sept. 15.

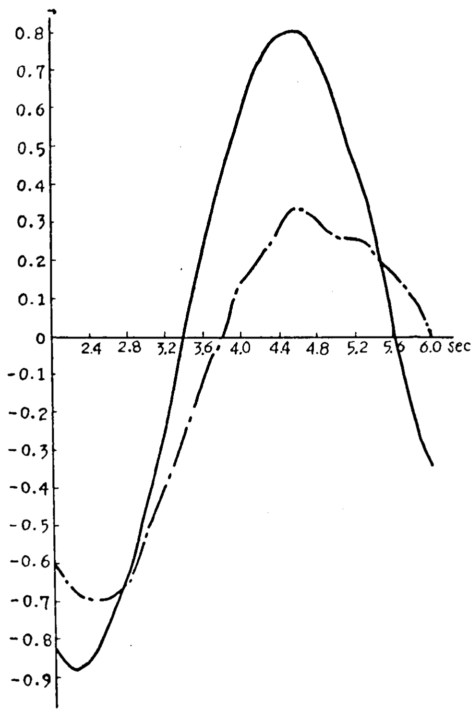


Fig. 7. Microseismic period spectra for Sept. 11 and Sept. 12.

- - - - Sept. 11,
——— Sept. 12.

are mixed with waves of various periods.

According to the weather charts of those days, the Typhoon "Kezia" was situated in the Pacific Ocean to the south of Japan on Sept. 11 and 12, 1950, and struck the shore of Kyushu on the morning of Sept. 13, passed over the land and the Japan Sea rapidly, and reached Hokkaido on Sept. 15.

It has been frequently pointed out that there may be a conspicuous relation between the microseisms at Tokyo and the severe atmospheric depressions over the Pacific Ocean. We may consider that the predominant microseisms with 4.0–4.4 sec. period, which appeared on Sept. 11 and 12, were directly related with the Typhoon "Kezia" over the Pacific Ocean. When she was moving over the land and the Japan Sea on and after Sept. 13, the regular microseisms predominated by the period of 4.0 sec. or 4.4 sec. disappeared, and gave place to irregular ones of various periods.

The results obtained by Tomoda's method are shown in Figs. 7 and 8. They can be classified into two groups, (a) and (b), like the above-mentioned periodograms, but they have a maximum value at the period of 4.6 sec. on Sept. 11 and 12, respectively. This is different from the above-mentioned results of periodograms, and the difference may be due to the simplified method.

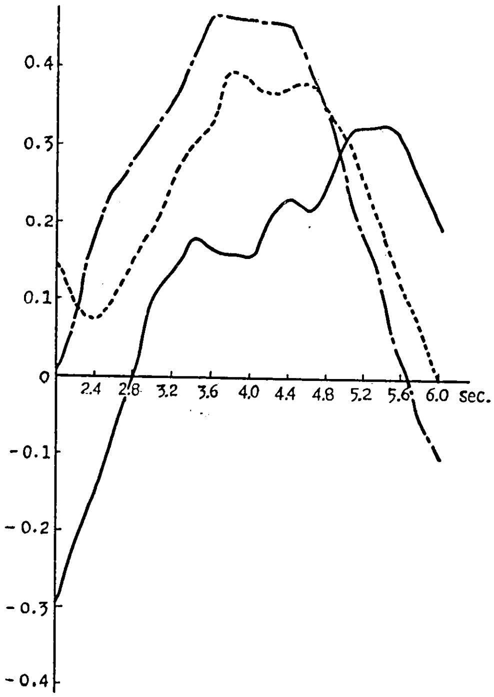


Fig. 8. The period spectra for Sept. 13, 14, and 15.

——— Sept. 13,
— — — Sept. 14,
- - - - - Sept. 15.

F. Kishinouye[2] has constructed the frequency distribution diagram of the periods, using the same record of Sept. 11, 1950, and it shows a predominant maximum at the period of 4.0 sec. in both the NS- and EW-components.

Therefore we suppose that the results obtained in this paper is certainly a corroborative evidence of the close relation between the predominant microseisms observed at Tokyo and the severe depression over the Pacific Ocean. Those microseisms may be caused actually by the depression, but there are still many doubtful points about the origin of microseisms, and on the occasion of our preceding tripartite observations[3], the directions of approach of microseisms were not always in accord with the situation of atmosphere depression over the ocean. Accordingly, we admit that the predominant microseisms of Sept. 11 and 12 had some relations with the Typhoon "Kezia" over the Pacific Ocean, but we can not hastily con-

2) F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, **29** (1951), 577.
3) R. IKEGAMI, *Bull. Earthq. Res. Inst.*, **29** (1951), 313.

clude that the center of the Typhoon was the real origin of the microseisms.

For the purpose of studying the nature of microseismic waves, we made an attempt to lay on the microseismic record of Sept. 11, sinusoidal waves with the amplitudes adequately adjusted and the period of 4.0 sec., and on the microseismic record of Sept. 12 those with the period of 4.4 sec. Then we found that both the sinusoidal waves and the microseismic records are almost in concord with each other. This fact indicates that the predominant microseisms with the period of 4.0 and 4.4 sec., respectively, were almost continuous.

Fig. 9. ———: microseisms of Sept. 14. The waves of 3.5 sec. period intervene between the waves of 4.2 sec. period, and there is a phase difference (about $\frac{1}{4}$ wave-length) between the preceding waves of 4.2 sec. and the following ones of 4.2 sec.

- - - - -: the sinusoidal waves with the period of 4.2 sec.

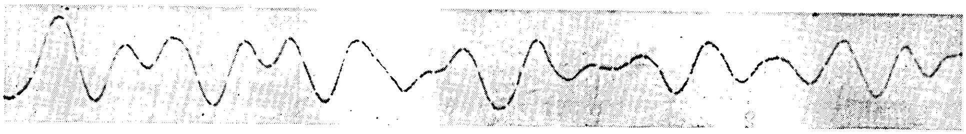
— — — -: the sinusoidal waves with the period of 3.5 sec.

After Sept. 13, microseismic waves of a certain period intervened between the other periods, and microseisms of the same period which appeared intermittently are generally different from each other in their phases. We will take the seismograms of Sept. 14 as an example. As shown in Fig. 9, microseisms of 3.5 sec. period intervene between microseisms of 4.2 sec. period, and there is the phase difference (about quarter wave-length) between the preceding microseisms of 4.2 sec. period and the following ones of 4.2 sec. period. From this instance, we may say that the irregular microseisms consist of many isolated waves with various periods (possibly, with different origins).

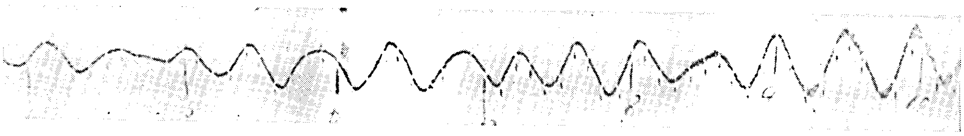
Summary

Periodograms of periods of microseismic waves have been constructed for the five days from September 11 to 15, 1950, when the Typhoon "Kezia" passed over Japan. The following results have been obtained:

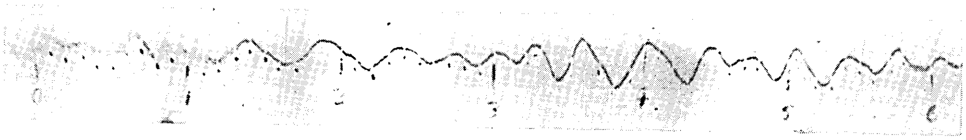
1. The periodograms may be classified into two groups; (a) the periodograms of one group show a sharp peak, the correlation ratio of which is more than 0.5 (Sept. 11 and 12) (Figs. 2 and 3): (b) those of



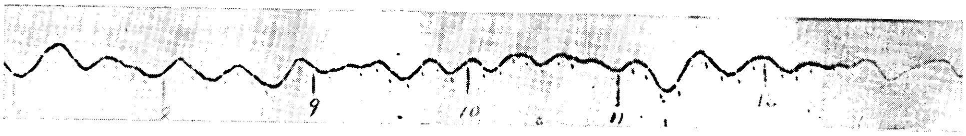
Sept. 11, 1950.



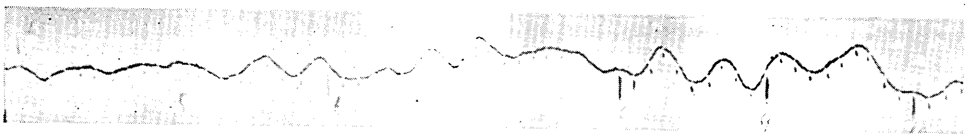
Sept. 12, 1950.



Sept. 13, 1950.



Sept. 14, 1950.



Sept. 15, 1950.

Fig. 10. Microseisms at Tokyo (×0.418).

the other group show no striking peak, (Sept. 13 to 15), (Figs. 4-6).

2. It may be considered that the predominant microseisms of Sept. 11 and 12 were directly related with the Typhoon "Kezia" over the Pacific Ocean. But microseismic waves did not always approach the station from the center of the Typhoon.

3. The individual waves of very irregular microseisms from Sept. 13 to 15 had different phases, and may possibly have been of different origin.

4. Microseismic period spectra have also been constructed by means of Tomoda's simplified correlation method (Figs. 7 and 8). The results obtained were also similar to the above-mentioned results.

---

43. 土地の脈動の周期と台風位置との関係

東京学芸大学 池 上 良 平

1950 年 9 月 11 日～15 日の 5 日間に東京に於て観測された脈動記録 (第 10 図) を用いて，周期のペリオドグラムを作つた．このペリオドグラムと台風位置 (第 1 図) とを比較して次の結果を得た．

1. ペリオドグラムは 2 群に分類できる．

(a) 相関比の値が 0.5 以上の著しい極大を有するもの．(11 日及び 12 日の脈動で，第 2 図及び第 3 図に示す)．

(b) 相関比の値に著しい極大のないもの．(13 日以後の脈動で，第 4 図～第 6 図に示す)．

2. 11 日及び 12 日の優勢な脈動は，太平洋上の台風 "Kezia" と密接な関係を持つている．然しこれらの脈動波が台風の中心地域から，東京まで伝播して来たものであると速断することはできない．

3. 13 日以後の非常に不規則な脈動の個々の波は，夫々異つた位相を持つていた．(一例を第 9 図に示す)．この事実は，これらの脈動波は，種々な周期と振幅を持つたいくつかの弧立波の集合である事を示すものであると考えられる．脈動波が一連の同一方向から連続して伝播して来る波であると考えることに，なお疑いを残している．

4. 友田氏の簡単化された相関係数計算法を用いて，同一脈動記録から周期解析を行つた．その結果は第 7，8 図に示してある．上述の結果と大体同じ結果を示している．
