25. *Studies of Microseisms by Observations.*

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The period of microseisms is nearly equal everywhere in the world, and many investigations have been made, and many theories published of the origin of microseisms. But the mode of microseisms is found to be different at each place of observation, and the properties of microseisms are not known completely at present. The aim of this paper is to describe the results of various studies as materials for the theory of microseisms.

Microseisms observed at Hongo, Tokyo compared with Variations of Meteorological conditions

Microseisms were recorded every day on the first floor of the Earthquake Research Institute during the period from November 1952 till 1955, to study the annual variation of microseisms.

The observations were carried out once a day for two minutes at $11h-12h$ J. S. T., but when microseisms were large they were recorded two minutes at many times in a day.

The recording instruments used were portable mechano-optical seismographs[1] of horizontal and of vertical component. The magnification of the seismographs was usually 2000, but when microseisms became large it changed to 1000. The free-vibration period of the horizontal seismograph was set at 10 sec., and that of the vertical at 7–8 sec. At most times of recording, only the N–S component was recorded, and when amplitudes became large two horizontal components were observed, or moreover, the vertical component was added to the observation. The time marks were made at every second with an electromagnetic shutter controlled by an electric-contact clock interrupting lamp light in short time. The time marks of seismograms are important for identifying the corresponding times on records of different components or on

1) F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, **20** (1942), 215–219.

records at different places.

How to express microseismic movements by numerical values is a difficulty because of their irregular variations of periods and of amplitudes. Mostly the maximum double amplitude and its period were measured to represent the condition of microseisms at the observation.

The correlations between observed amplitude and period of microseisms and meteorological conditions were studied of data at the Stations Tomisaki, Cyoshi and Onahama during the observation period. A part of the data of the investigation is shown in diagrams (Fig. 1). The variation

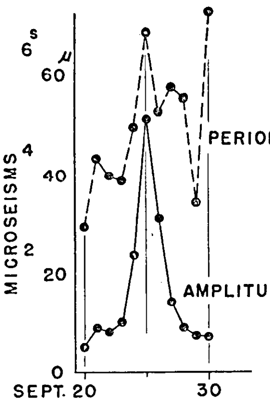

Fig. 1-a.

Fig. 1-c. Positions of the Meteorological Stations.

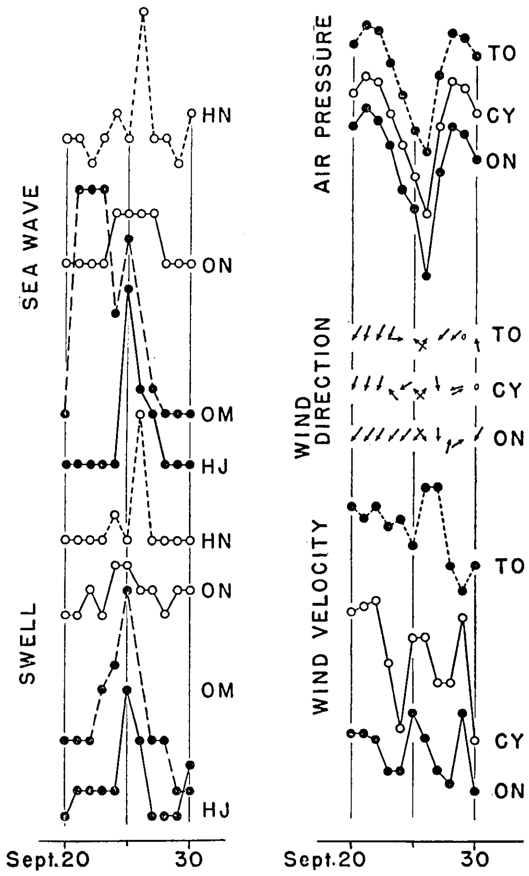

Fig. 1-b.
(The name of stations is shorten)

of microseisms was compared also with conditions of sea waves generated by wind or of swells observed at Hachijōjima, Onahama and Cyoshi.

The correlations between microseisms and the above data were found to be sometimes close and at other times not. And although the number of data was large no definite result could be obtained.

The Annual Variation of Microseisms at Hongo, Tokyo

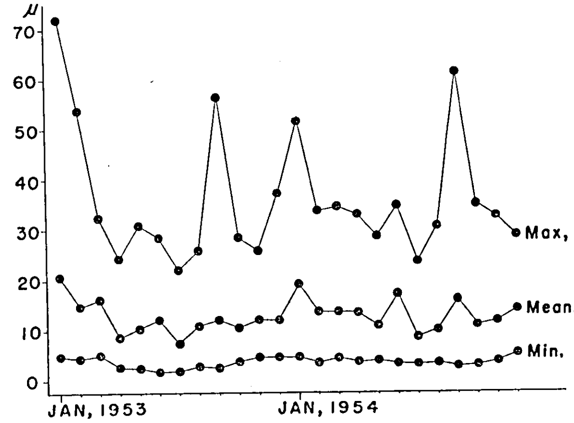

Fig. 2-a. Annual variation of the maximum amplitude in a day, (Maximum, mean and minimum values in a month of the maximum double amplitudes of each day.)

Monthly mean, maximum and minimum of period and those of double amplitude were taken from the data obtained every day in the period 1953 and 1954. The results are shown in Fig. 2 and following characteristics of microseisms were deduced: Microseisms are small in spring and large during later autumn and early winter, except in summer microseisms become very large when a typhoon passes on the sea along the eastern coast of northern Japan.

The frequency distribution of maximum amplitudes and that of periods of microseisms in every month were obtained and shown in Fig. 3.

Frequency distribution of periods at the maximum amplitude was sharp at the period 3–4 sec.

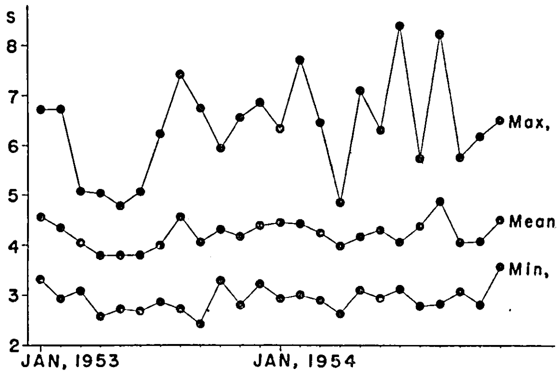

Fig. 2-b. Annual variation of period at the maximum amplitude.

Comparative Observations of Microseisms at Near Places

The results of the tripartite observations in the yard of the Tokyo Astronomical Observatory at Mitaka, Tokyo, have already been reported

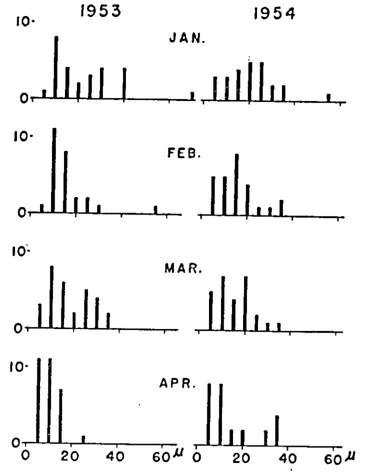

Fig. 3-a-1. Monthly frequency distribution of the maximum amplitude.

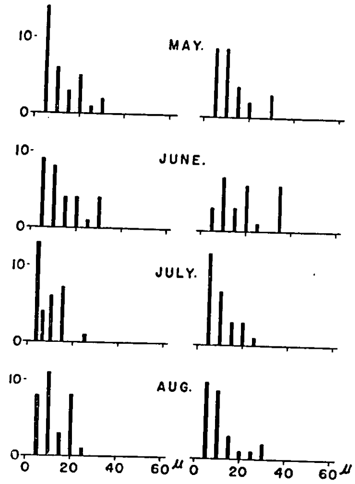

Fig. 3-a-2.

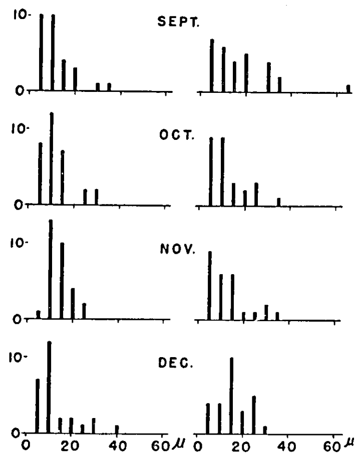

Fig. 3-a-3.

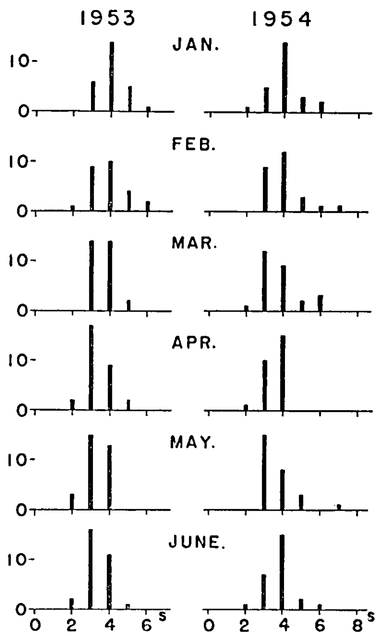

Fig. 3-b-1. Monthly frequency distribution of period at the Maximum amplitude.

in several papers. The observations were mostly at four places simultaneously to make two tripartite observations at the same time taking three stations from the four. The direction and velocity of propagation of microseisms obtained from the two tripartite stations were in accord with each other as mentioned before[2].

The observation net was extended out of the yard. The positions of added stations are shown in Fig. 4 by alphabets. The results of tripartite observations by triangles *CEY* and *CRY* are as shown in Fig. 5, and velocity of propagation calculated were 348 and 267 in m/s for the two triangles respectively.

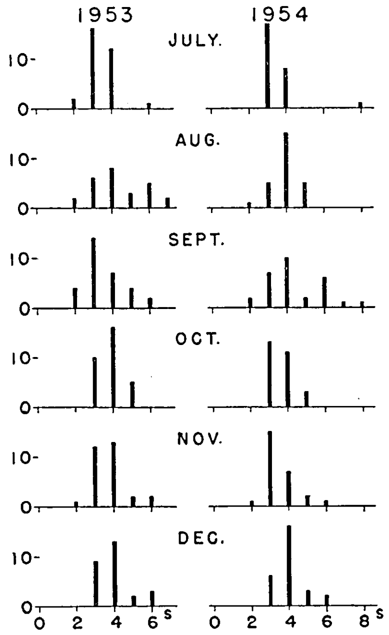

Fig. 3-b-2.

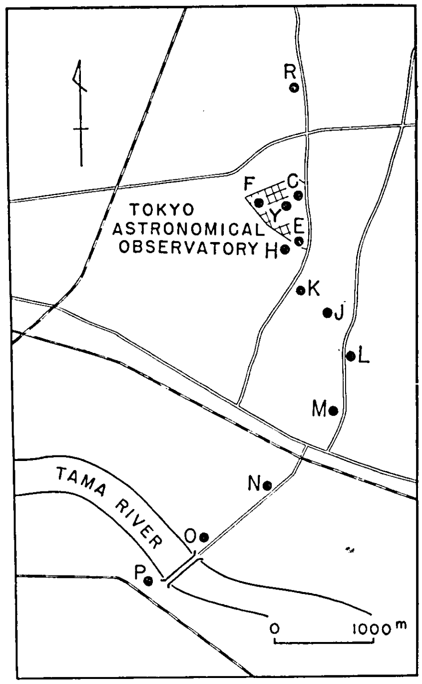

Fig. 4. Positions of the temporary stations.

In 1951 the observation net was further extended south from the observatory. Simultaneous observations at three stations were difficult, so in most cases the observations for comparison were carried out at two stations for each observation. The simultaneous record at various places are shown in Figs. 6-a, 6-b. The earth movements at the cor-

2) R. IKEGAMI and F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, **29** (1951), 305-312.

responding places resemble each other closely, except between stations N and P. Then cross-correlation functions were calculated of the records at N and P. (Fig. 7).

In the investigation of microseisms, methods of harmonic analysis have been applied. Recently correlogram analysis was developed, and it was taken also in this study.

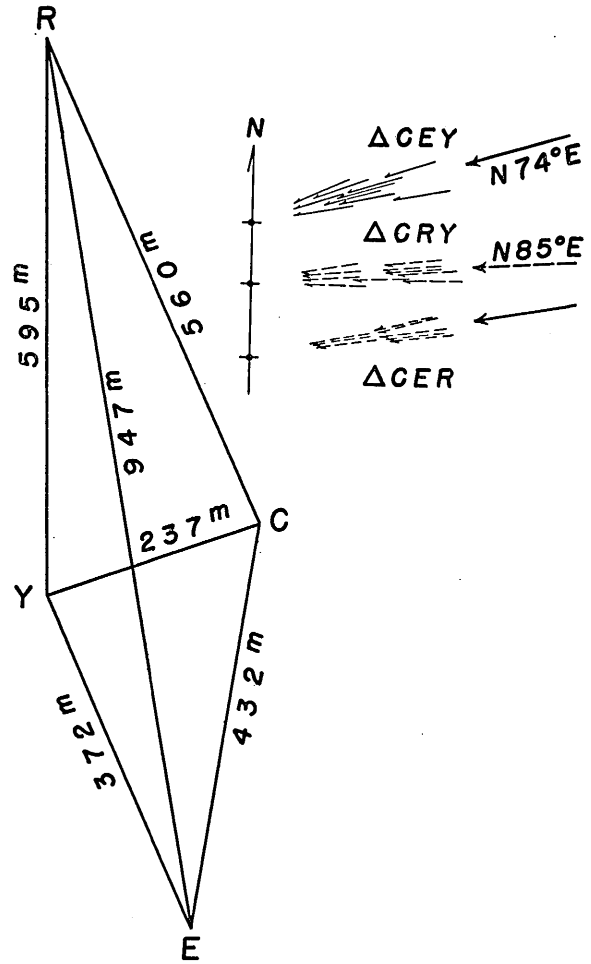

Fig. 5. Comparison of simultaneous tripartite observations.

Readings of amplitudes were made every second on the record, which was 2 minute observation, and then the values of readings were put in the mathematical expressions below. (Sometimes one half-second reading was made to check the results of the one-second readings.)

Functions of cross-correlation or autocorrelation were respectively calculated by the formulae,

$$\varphi' = \frac{1}{N} \sum_{k=1}^{N} \bar{x}_{k+j} \bar{y}_k$$

and

$$\varphi = \frac{1}{N} \sum_{k=1}^{N} \bar{x}_{k+j} \bar{x}_k \, .$$

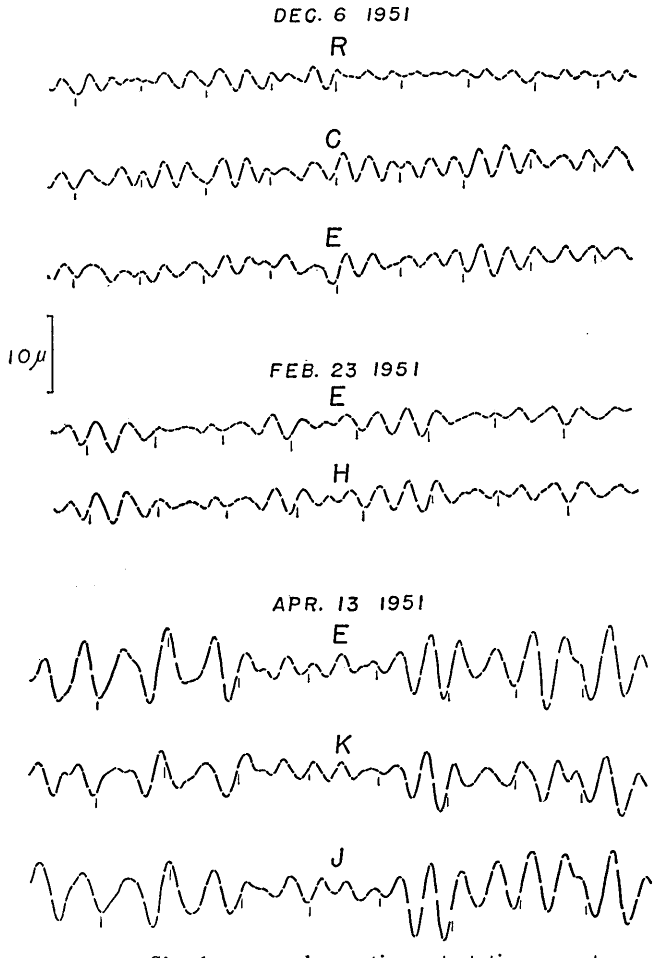

Fig. 6-a. Simultaneous observations at station on sets.

Autocorrelations between simultaneous microseisms at the Earthquake Research Institute (E.R.I.) and the Tokyo Astronomical Observatory (T.A.O.), or the Mitaka Branch of the Transportation Technical Research Insti-

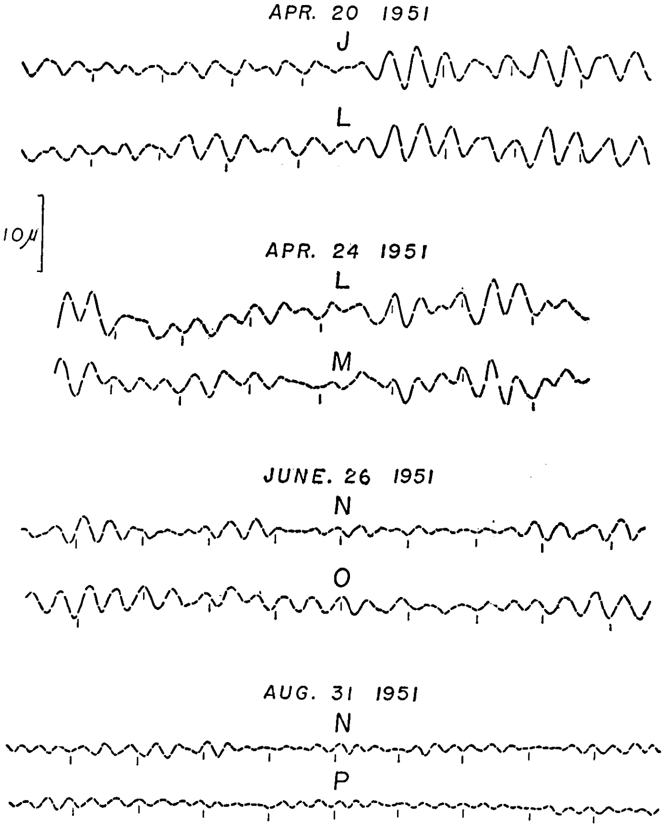

Fig. 6-b.

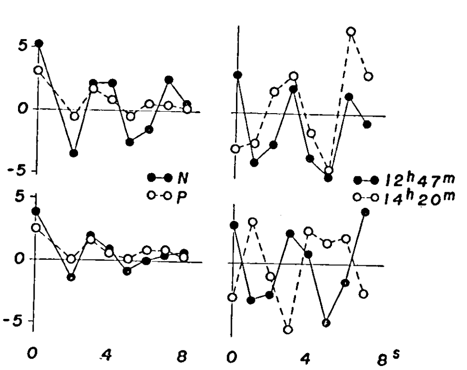

Fig. 7. Autocorrelation and cross correlation of microseisms at stations *N* and *P*.

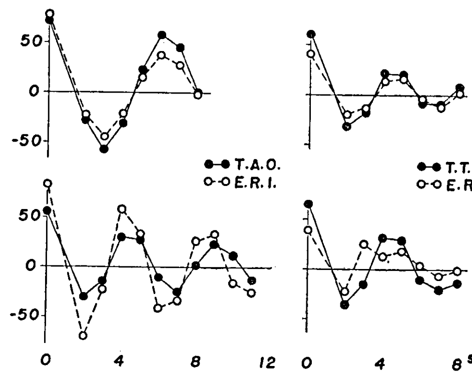

Fig. 8. Autocorrelation of microseisms simultaneous at different places.

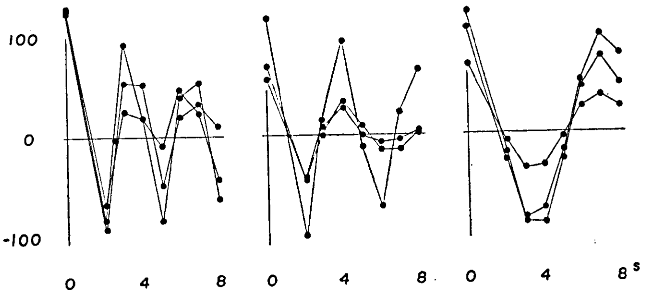

Fig. 9. Autocorrelation of microseisms at E. R. I.

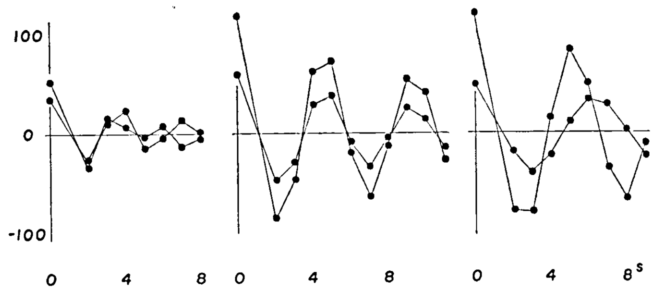

Fig. 10. Autocorrelation of microseisms at T.A.O.

tute (T.T.R.I.) were obtained. The results are shown in Fig. 8. Microseisms at the same time at these places may be equal in period.

Autocorrelation functions of microseisms at E. R. I. and T. A. O. were calculated more to know the period of microseisms there precisely (Figs. 9 and 10).

From the results, all stations from R southward to O (distance about 6 km.) may be on a block of the ground, because microseisms at those stations closely resemble. But the station beyond the River Tama moved differently from the northern side of the river. The writer was reminded of his old paper on microseisms[3] in which he supposed as land block vibrations. This consideration may have weak points in that the observations were small in number and did not include all types of microseisms there, moreover the analysed amplitudes were comparatively small, in other words "signal to noise ratio" was small, so it may be not sufficient to conclude different movement of the opposite side of the river.

3) F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, **13** (1935), 146-154.

Seismic Prospecting of the Ground at the Tripartite Stations at the Tokyo Astronomical Observatory

Seismic prospecting was carried out to discover subsoil conditions of the net of the tripartite observations. The spread was set 70 m in North from the station Y in Fig, 4. Shots were made with less than 90 grams of dynamite, and waves were recorded with a five element electromagnetic oscillograph and three transducers. The velocity of P wave was obtained as 210 m/s at the ground surface, and 1700 m/s in the under layer. The profile of the ground deduced is shown in Fig. 11. Mr. E. Shima[4] studied the subsoil of the yard of the Mitaka Branch of T. T. R. I. about 2.5 km east from the net, and found the wave velocities 200, 300, 400 and 1700 m/s. Then the subsoil conditions at two places may be considered similar.

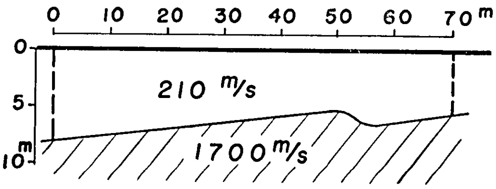

Fig. 11–Profile.

Microseims at T. A. O. had been studied as surface waves[5]. The result in this paper could not be used to promote the surface wave theory. Above studies concerning microseisms were aimed at making clear the properties of microseisms, however many questions still remain to be investigated. The writer will continue further the observational studies of microseisms.

Lastly the writer expresses his thanks to many persons who helped his studies at their desks or in field observations. Especially he thanks Mr. R. Ikegami and Miss M. Kotaka for their assistance in this investigation.

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25. 観測による土地の脈動の研究

地震研究所 岸 上 冬 彦

土地の脈動の原因についての理論は，現在数種あつて決定的のものはない．そこで脈動についてまだ多くの知られてない性質をもとめるために筆者の得た結果を研究材料として提出する．

本郷において観測した脈動と各地の気象海象と比べたが，相関のあう時とあわない時とがあつて簡単な関係は見られなかつた．

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4) E. SHIMA, Private communication. The prospecting described in this paper was made by the kind help of Mr. Shima, to whom the writer wishes to express his thanks.

5) R. IKEGAMI and F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, **28** (1950), 118.

脈動の振幅について，その年変化を見ると，春小さく秋の終りから冬の初めに大きい．但し夏には台風のある時に大きくなることがある．周期は余り変らない．

異なる場所における脈動の比較をした．結果，天文台附近では各観測点が，どれもよく似た振動をしているが，多摩川の対岸とは似てない．しかし，対岸の測定の時は都合悪く振幅が小さかつたので，はつきりしたことは後日にゆずる．

天文台附近の弾性波地下探査を行い，脈動波の研究の参考にした．

これらの研究の結果，更に測定し観測すべき点が多いので，なおも研究を進めている．