32. *The 1950–1951 Eruption of Oo-sima and Its Seismometrical Investigations. (I).*

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1. Introduction.

Oo-sima, an insular volcano which is the largest of the Seven Izu Islands belonging to the Huzi (Fuji) volcanic zone and easy of access, lying about 110 km SSW of Tokyo city, is well known for its frequent eruptions of the Strombolian type in historical time.

Therefore, since the end of the 19th century, investigations and observations concerning the Oo-sima volcano have been conducted from various standpoints including geology, geophysics and geochemistry. At the occasion of the 1912-1914 eruption of this volcano, F. Omori[1] investigated its developments and its nature together with those of its historical activities. During the fairly long period from 1900 up to date, S. Nakamura[2] frequently visited the place to carry out various observations with his associates.

On the other hand, S. Tsuboi[3] reported in 1920 on the general geology and petrography of the Oo-sima Island, and after that H. Tsuya[4] studied the same problem in connection with other volcanoes belonging to the Huzi volcanic zone.

As concerns the geophysical study of this volcano, investigations were mainly conducted by R. Takahasi, T. Nagata and their associates[5] in the period from 1936 to 1941 including the minor activity of 1940. Their researches include not only the geomagnetic, gravimetric and geodetic surveys but also continuous observa-

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[1] F. OMORI, *Rep. Earthq. Inv. Comm.*, **81** (1951), 1 *etc.*

[2] S. NAKAMURA, and others, *Jour. Geogr. Soc. Tokyo*, **20** (1908), 682 *and* 786, *etc.*.

[3] S. TSUBOI, *Jour. Coll. Sc. Imp. Univ. Tokyo*, **43** (1920), 139.

[4] H. TSUYA, *Bull. Earthq. Res. Inst.*, **15** (1937), 215, *etc.* .

[5] R. TAKAHASI and T. NAGATA, *Bull. Earthq. Res. Inst.*, **15** (1937), 441 and 1047, *etc.*.
R. TAKAHASI, T. NAGATA and K. HIRANO, *Bull. Earthq. Res. Inst.*, **16** (1938), 16
T. NAGATA, *Bull. Earthq. Res. Inst.*, **16** (1938), 288 and 714; **17** (1939), 93; **18** (1940), 102 and 281; **19** (1941), 402, *etc.* .

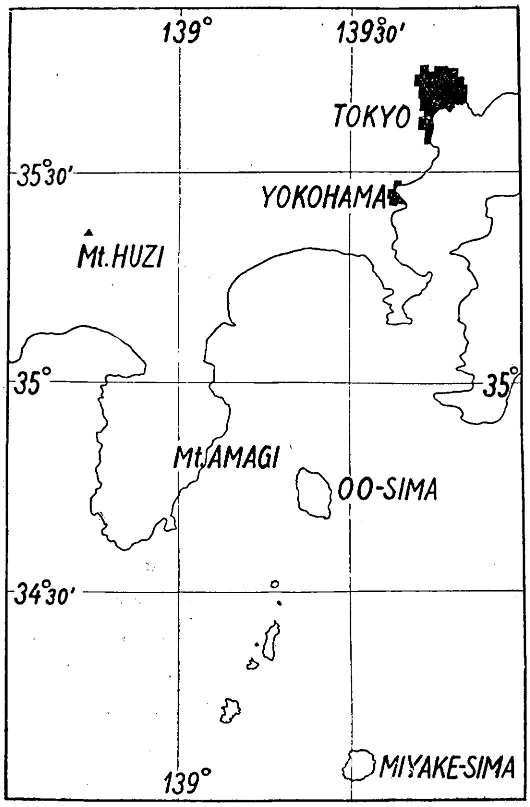

Fig. 1. Geographical position of Volcano Oo-sima.

tions of earthquakes and other volcanic phenomena originating from Oo-sima.

Unfortunately, various difficulties during and after the recent war prevented us from visiting the volcano, which resulted in an interruption of our observations.

However, the present eruption which began on July 16,1950, gave us an opportunity to restart the study of this volcano. In fact, as soon as the Oo-sima resumed its explosive activity, seismometric, geomagnetic and petrological investigations as well as general observations with respect to the developments of effusive phenomena were carried out precisely by a number of geophysicists, geologists and geochemists of the Tokyo University and other Institutes.

In the present eruption of Oo-sima, the writers devoted themselves mainly to the seismometric investigation of earthquakes originating below this volcano and micro-tremors of continuous train accompanying the incessant explosions of the Strombolian type. Although this paper deals with this latter phenomenon, it is necessary to give an outline of the development of the 1950 eruption which is closely related with the occurrence of the micro-tremors.

2. Brief Description of the Development of the 1950 Eruption.

As will be seen to some extent in the topographical map of the Oo-sima volcano in Fig. 3, the summit crater or pit crater which was 250 m deep and about 300 m in its diametre before the present activity, is surrounded by two sommas, the inner somma is of quite circular form with a diametre of 700 m and the outer wanting in its northern part is located at a distance of 1–1.5 km in an elliptic form. Rocks forming this volcano and the recent ejecta are generally characterized by the saturated basalt or andesitic basalt.

After a period of quiescence of just ten years since the minor activity of August 19, 1940, Volcano Oo-sima resumed explosive activity toward 10 h on July 16, 1950, ejecting ash and lava fragments from a lower part of the southern wall of the pit crater. For 70 days from that day to September 23, remarkable eruption of the Strombolian type continued without interruption, belching out molten lava in fountain fashion from several sources on the floor of the pit crater, and on the other hand, ejecting volcanic bombs of incandescent state and scoriae of various sizes every few seconds with detonations which were audible on the flank of the outer somma and sometimes at the sea side, 6 km distant from the active crater. As the result of incessant eruption, a cinder cone (A) grew rapidly around center of paroxysmal eruption through the accumulation of ejecta, and molten lava welling up buried by degree the pit crater. However, it may be said that the general features of eruption suffered little change throughout the present eruption, though afterwards the center of eruption moved about 100 m southeastwards and was newly formed there, and the volume of out-pouring lava as well as the intensity of explosion should undergo some change according as the eruption developed.

After the fluidal lava originating from the jet-like sources filled the pit crater on August 15, it began to overflow its crater wall and invaded the flat area inside the inner somma. On the other hand, the cinder cone (A) grew markedly up to that date, 50 m high as measured from its base.

As soon as the explosive eruption in the craterlet of the cinder cone (A) came to an end on August 23, another craterlet newly opened near the southern base of the former cinder cone and volcanic bombs together with smaller ejecta were thrown up incessantly 100 m high and sometimes 200 m high in the air. Since the paroxysmal eruption at the newly formed craterlet (B) lasted in such state for

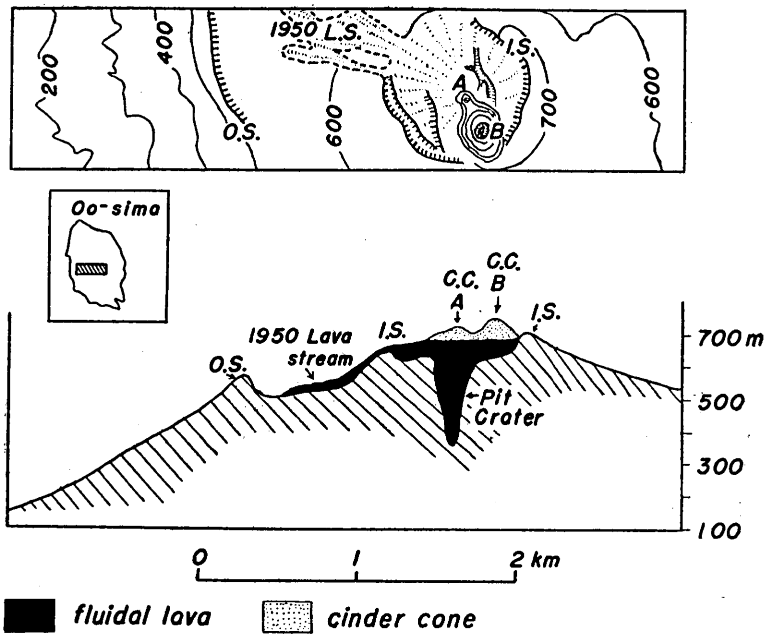

Fig. 2. Topographical sketch in the vicinity of the summit crater.
C.C.A.; cinder cone A, C.C.B.; cinder cone B,
I.S.; inner somma, O.S.; outer somma.

a month without marked change in the intensity of eruption as well as in the position of the center of ejection, a cinder cone (B) was rapidly built there in the same way as in the former case. Therefore, the latter cinder cone (B) on September 20 reached a height of 100 m from its base, or 760 m above the sea-level which is only few metres lower than the highest point of the Oo-sima volcano or the north part of the inner somma. In Figs. 25 and 26, the night views of the eruption at the cinder cone (B) are represented.

At the earlier stage of activity at the cinder cone (B), or in other words, during the period from August 23 to September 5, the craterlet lacking the north-eastern part of its crater-wall, formed a horseshoe shape, as may be seen clearly in Fig. 27, and fresh lava welling up from its vent flowed down through this opening towards the north part of atrio of the inner somma. Since the fluidal lava from various sources was collected within the inner somma, a lava pool was formed there, as may be seen in Fig. 25, usually elevating its surface. It will be, however, needless to say that the inner part of the lava pool was in a fluidal and incandescent state according to observations at fissures, though its surface was cooled and solidified, forming lava blocks of various sizes soon after the outpouring. Towards September 10, the horseshoe craterlet closed its opened part with the accumulation of ejecta and after several days a regular form of cinder cone was completely built.

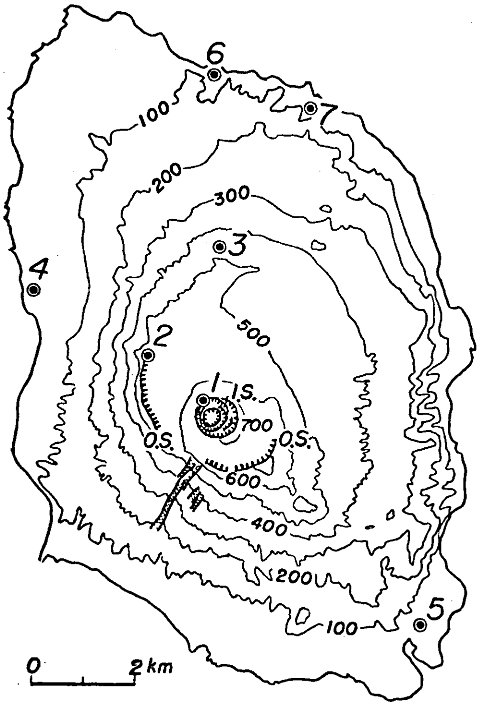

Fig. 3. Topographical map of Oo-sima.
I.S.; inner somma,
O.S.; outer somma.
1~7, temporary seismometric stations.

On September 12, the incandescent lava collected in the lava pool began to flow out from two places of the inner somma and went down along its steep flank. This overflowing of lava from the lava-pool lasted for 11 days, forming ten several narrow streams, each being 2-5 m wide and 0.5-1.5 m thick at its upper part, and enlarging at the base of the inner somma both in width and thickness. Judging from the nature of these lava streams, it may be said that they are of block type or aa type, though they formed in spots ropy structure.

According to the temperature measurements of fresh lava made by S. Murauchi[6] and others[7], maximum temperatures in the lava pool and at the upper part of the lava streams ranged from 1000°C to 1100°C.

After the 1950 eruption of Oo-sima developed in the manner as just mentioned, it ceased suddenly on September 23.

However, the volcano recovered its activity towards the beginning of February 1951 and the eruption of the same type as described above still continues up to date at the craterlets which were newly opened on the flank of the 1950 cinder cone (B). With respect to the 1951 eruption, the writers will report in detail in the forthcoming Bulletin.

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6) S. MURAUCHI, *Natural Science and Museum*, **17** (1950), 1.

7) R. MORIMOTO, I. MURAI, N. NASU and A. SUGIMURA, Read at the monthly meeting of E.R.I. on October 17, 1950.

At any case, the present seismometric investigation of tremors with which the present paper deals, was carried out in the course of the explosive eruption at the cinder cone (B), or in other words, in the period from September 5 to September 22, 1950.

3. The Seismometric Observation of Tremors and the Seismographs used for the Purpose.

From the seismometric studies made at the occasions of the volcanic activities in Japan as well as in the other part of the world, it is well known that[8] besides the earthquakes of the ordinary type, tremors or volcanic pulsations occur accompanying the eruption of the Strombolian type. From the nature of the phenomena, it is supposed that these tremors originate from the active crater or directly below it, and not from the deep place. Since the eruption of this type consists of minor explosive eruption of every few seconds or every ten and several seconds, earthquakes caused by those numerous explosions are recorded in form of continuous train on the seismograms and last as long as the eruption continues, though the amplitude of the tremors depends largely on the intensity of eruption.

In the present activity of Oo-sima, the writers planned researches into the nature of this type of tremors, as well as of the ordinary type of earthquakes which occurred under this volcano. However, it will be needless to say that, so long as the eruption lasted as mentioned above, tremors of continuous train disturbed seriously the recording of the earthquakes of the other type. Since the explosive eruption stopped on September 23, 1950, the writers planned out the observation of the earthquakes of the other type, with which the forthcoming paper will deal.

The seismographs used for these purposes were of the inverted pendulum type for recording the horizontal motion of vibration, of which the instrumental constants were 1.0 second for the period of proper vibration and were variable with respect to the geometrical magnification according to our purposes. In other words, the magnification is 200 in recording on the smoked paper, and 4000, 2000' or 1200 in the case of the optical record, which is easily adjustable with the aid

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8) F. OMORI, *Bull. Earthq. Inv. Comm.*, **5**, **6**, **7**, **8** and **9** (1911–1921), *etc.*.
K. SASSA, *Mem. Coll. Sc. Kyoto Imp. Univ., Ser.* A, **18** (1935), 255: **19** (1936) 11, 171.
T. MINAKAMI, *Bull. vol.*, **10** (1950), 59; *Bull. Earthq. Res. Inst.*, **19** (1941), 171.
R. H. FINCH, *Bull. Seism. Soc. Am.*, **39** (1949), 39 *etc.*.
G. C. OMER, *Bull. Seism. Soc. Am.*, **40** (1950), 175.

of the length of optical lever.

Seeing that the amplitudes of tremors differed greatly according to the distances from the origin of vibration or from the active crater, it was necessary to put in order the magnification of seismographs without changing their instrumental characteristics. In addition, for the observation at the distant stations in which the amplitudes of tremors were remarkably attenuated, the optical recorder was applied in order to reduce the solid frictions of the instruments.

To determine the acceleration of tremors, the plate springs of the pendulum were replaced by other springs by which the proper period of vibration was adjusted to 0.1 second. As the result of the procedure, the seismographs were used as acceleration-seismographs, with a sensibility of 2.0 gal per 1 mm on the smoked paper and 0.025, 0.05 or 0.083 gal per 1mm on the optical recorder.

It must be added that the speed of the recording paper was adjusted to the range from 2 mm/sec to 5 mm/sec according as the purposes of observation.

It is believed that the volcanic tremors would show several times of ebb and flow in accordance with variations in the intensity of the eruptive phenomena which lasted for 70 days from July 16. However, our seismometric observation covered the period from September 3 to 23, when the Strombolian eruption in the crater B, as already described, was in a quite constant state. According to the observations of the eruptive phenomena made near the active crater, the explosive eruption after 16 h on September 23 lost by degree its intensity and tending towards a dormant state came to a standstill at the noon of the following day. On the other hand, the phenomena were confirmed also by continuous seismometric observations at Station No. 4 located at Moto-mura, where the volcanic tremors of a constant state lasting up to nearly 14h of September 23, began to decrease in amplitude and completely disappeared on the seismogram after 16h of the following day. Fig. 4 shows the developments of the tremors observed at Motomura, by taking the mean value of the largest five amplitudes for every four hours.

At Station No. 1 on the inner somma lying only 600 m distant from the active craterlet B, tremors or shocks were so intense as to be felt every several seconds, and at the nearer place on the northeastern part on the same somma, 400m apart, tremors were always felt but not so sharply as at the base of the cinder cone B, only 200 m apart from the active craterlet. On the basis of these facts, it may be reasonable to infer that the tremors originated inside the active craterlet B or directly under its floor not exceeding 200-300 m in depth. This assumption con-

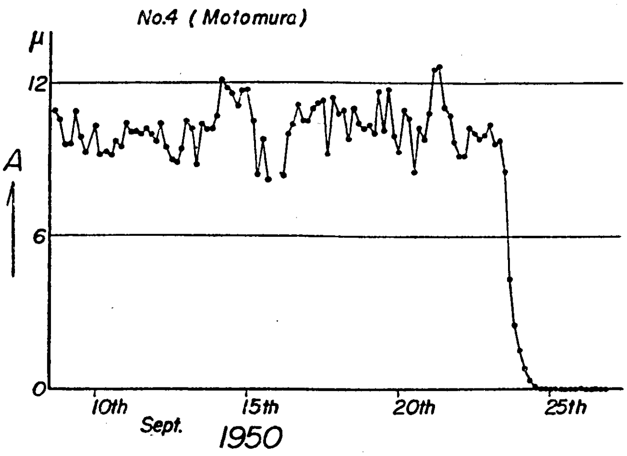

Fig. 4. Development of volcanic tremors at the standard station.
A: Mean amplitude of the five largest tremors for every four hours.

cerning the origin of the vibration is supported from the features of propagation of the tremors, especially from the relation between their amplitude at each seismometric station and the distance from the craterlet B, with which we will deal in the following paragraphs.

A seismometric station was established as the standard station at Moto-mura (No. 4) and observations have been continued without interruption during the period from September 3 to the present (March 1951). Seismographs of the same type as those of the standard station were removed from one temporary station to another in the period from September 3 to 23, in order to record the tremors at various places including the base, flank and summit of the Oo-sima volcano. The positions of these stations are indicated on the map of Fig. 3, and in Table I the distance between each station and the craterlet B or the origin of tremors, together with the height above the sea-level at each station are given.

The present seismometric observations were made mainly with respect to the two components of horizontal motion with the aid of the same type of seismographs, one being set in the direction towards the active crater and the other in the rectangular direction to the former.

However, observation at Station No. 7 which commenced on September 23, was excluded from the present research, for the reason that the eruption stopped in the course of the seismometric observation at this station.

Table I. The locality of the temporary seismometric station.

Station No.	Locality	Epic. dist.
1	Inner somma (Kako-Tyaya)	0.6 Km
2	Outer somma (Gozinka-Tyaya)	2.0 〃
3	Yuba	3.6 〃
4	Moto-mura	4.6 〃
5	Habuko-mura	5.8 〃
6	Okata-mura	6.7 〃
7	Senzu-mura	

4. The Nature of Volcanic Tremors Recorded by the Displacement Seismographs.

1) Analyses of Seismograms.

In order to throw a light on the nature of the volcanic tremors and the mode of their propagation, the writers made the analyses with respect to their amplitudes and vibration periods, on the basis of the seismograms recorded by means of the displacement-seismographs at each station. Figs. 21 and 22 show the seismograms recorded on the smoked papers and Fig. 23 those obtained optically.

Firstly, the amplitudes and vibration periods of the tremors were read carefully on these seismograms and then the amplitude-period diagrams were made, by taking the double amplitude in ordinate and its vibration period in abcissa, as shown in Figs. 5～11. Of these figures, Figs. 5 and 6 are those at Station No. 1 and both stand for the radial component of the active crater, of which Fig. 5 is based on the seismogram recorded in an interval from 16h 55m on September 16 to 16h 57m of the same day, and Fig. 6 from 17h 35m to 36m. As these two figures indicate clearly, the character concerning the amplitude and the vibration-period of the tremors, especially the maximum amplitude of each vibration-period is in a fixed relation, or in other words is independent of the time of observation. Seeing that the phenomena just mentioned are in the same manner at the other five stations including the standard station No. 4, it may be said that the nature and magnitudes of the tremors did not change with respect to the time throughout the present survey, excepting the observation at Station No. 7.

Figs. 5～11 show the diagrams for six stations of various epicentral distances, in which the components I and II represent those for the two horizontal components of the tremors as already mentioned. By comparing these diagrams, it is

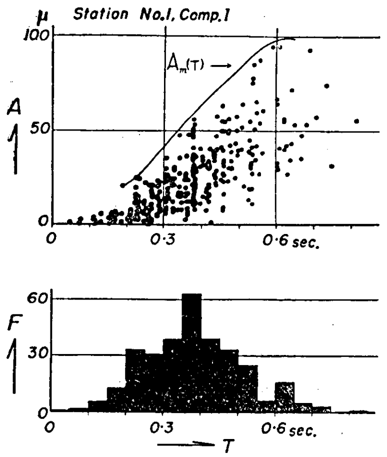

Fig. 5. Amplitudes and vibration-periods of the tremors during 2 minutes from 16h 55m on September 16, at the station No. 1.

(Comp. I. Component towards the origin.)

(Comp. II. Component rectangular to the former.)

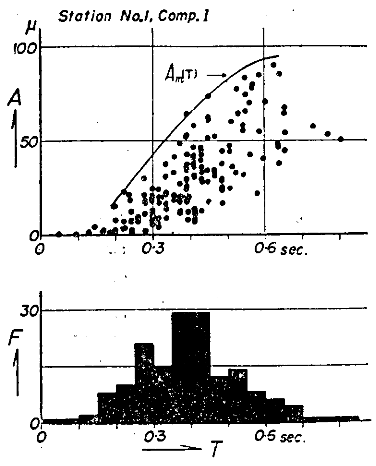

Fig. 6. Amplitudes and vibration-periods of the tremors during 1 minute from 17h 35m on September 16.

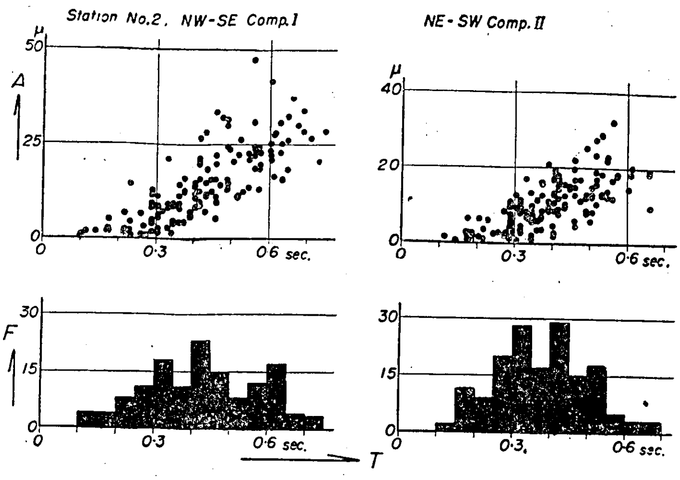

Fig. 7. Amplitudes and vibration-periods of the tremors at the Station No. 2.

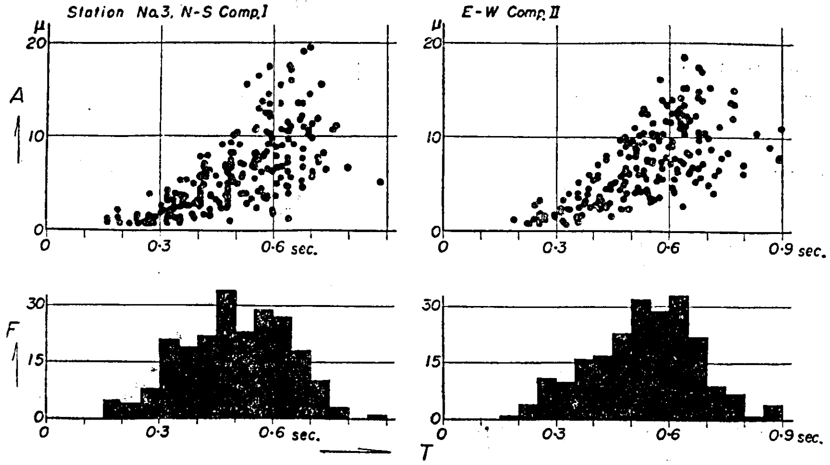

Fig. 8. Amplitudes and vibration-periods of the tremors at the Station No. 3.
F; frequency

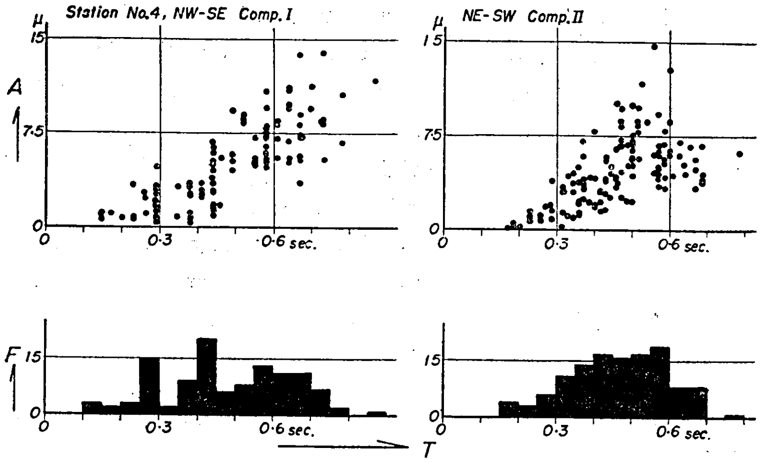

Fig. 9. Amplitudes and vibration-periods of the tremors at the Station No. 4.
F; frequency of tremors for respective vibration-periods.
T; vibration-period.

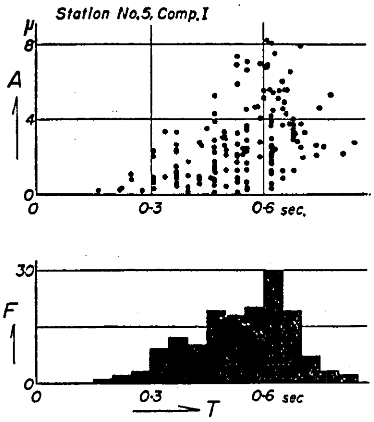

Fig. 10. Amplitudes and vibration-periods of the tremors at the Station No. 5.

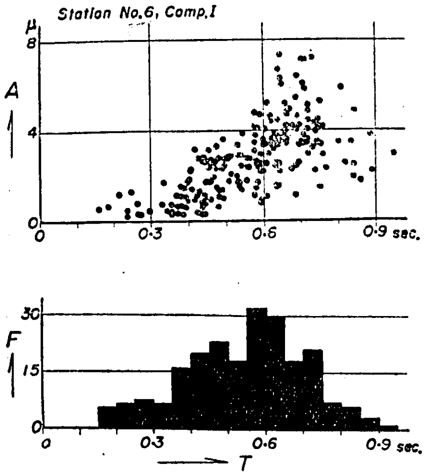

Fig. 11. Amplitudes and vibration-periods at the Station No. 6.

evident that the forms of the diagrams, or to be more exact, the maximum amplitude and the vibration period resemble each other in their general feature, notwithstanding the fact that the magnitude of amplitude varies greatly according to the epicentral distance. However, if these diagrams are precisely examined, the above relations concerning the maximum amplitudes and their vibration-periods are found to depend more or less on the epicentral distance. For instance, the vibration period of the largest amplitude at each station becomes longer by degree according to the distance from the origin, namely 0.6 second at the stations No. 1 and No. 2, and 0.7 second for the stations more distant than the formers. The phenomena are evident also from the frequency diagrams with respect to the vibration periods shown on the lower part of these figures, in which the nearer the station is situated from the origin, the shorter vibration-period is predominant.

2) The Relation between the Amplitude of Tremors and the Distance from their Origin.

The maximum amplitudes for various vibration-periods at the six stations are given in Table II, in which the double amplitudes are taken in micron unit. In addition, the relation between the maximum amplitudes of the tremors with respect to the five vibration periods, namely 0.2, 0.3, 0.4, 0.5 and 0.6 second, and the epicentral distances of these six stations is illustrated in Fig. 12, in taking the logarithmic amplitude in ordinate.

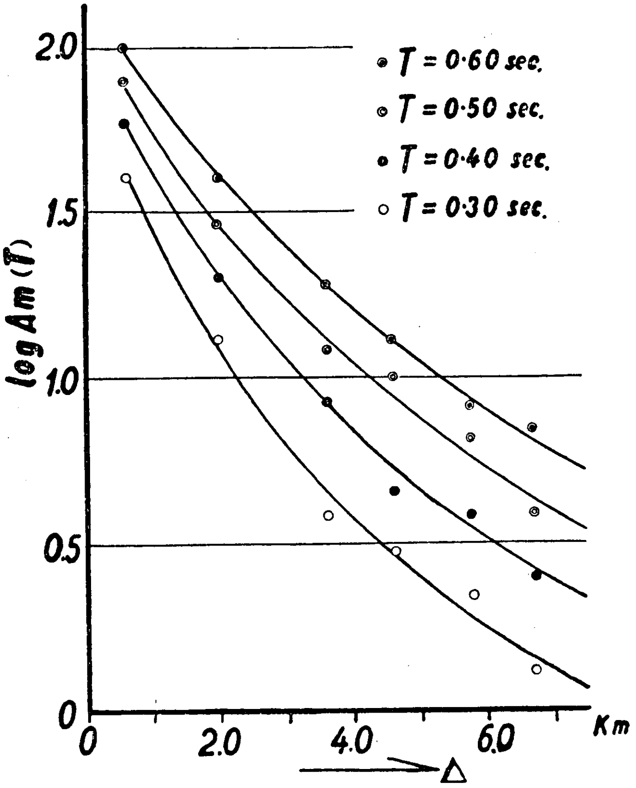

Fig. 12. Relation between the maximum amplitude at each station and its distance from the origin.

Table II. Maximum amplitudes of various vibration periods.

Station No.	Maximum amplitudes of various vibration periods				
	0.6 sec.	0.5 sec.	0.4 sec.	0.3 sec.	0.2 sec.
1	100.0μ	80.0μ	58.0μ	40.0μ	18.0μ
2	40.0	29.0	20.0	13.0	8.0
3	19.0	12.0	8.5	5.0	3.5
4	13.0	10.0	4.5	3.0	2.3
5	8.2	6.5	3.8	2.2	1.5
6	7.0	3.9	2.5	1.5	1.2

As will be seen clearly in this figure, the attenuation of amplitude with respect to the epicentral distance is remarkable and is evidently related with the vibration period, or in other words, the shorter the vibration period is, the more seriously the amplitude is attenuated.

It will be interesting to investigate whether the present volcanic tremors accompanying the Strombolian eruption have the character of the body wave or the surface wave, on the basis of the attenuation of their amplitude. For this examination, it is necessary to take in consideration the attenuation due to the damping in the course of the propagation from the origin to each station.

Concerning the elastic wave of spherical form, the relation between its amplitude and the distance from the centre of disturbance is given by the following formula, and in the present case, the distance from the origin of the tremors is similar to that of the epicentral distance, or the distance from the active craterlet (B).

$$A(T,\ \Delta)=A_0(T)\cdot e^{-k(T)\Delta}\cdot\Delta^{-n}\cdot e^{ip(t-\frac{\Delta}{V})},$$

where $A(T,\ \Delta)$, amplitude of vibration period T at the distance Δ,
$A_0(T)$, amplitude of vibration period T at the origin,
$k(T)$, attenuation coefficient for the amplitude of vibration period T,
Δ, distance from the origin,
p, frequency of vibration, equal to $2\pi/T$,
n, 1/2 or 1 according to surface or body wave,
V, propagating velocity of tremors,

Since, the above relation in the present case, is applied to the maximum amplitudes of the respective vibration periods, the quantities relating to the time are constant as described already and therefore, the above formula may be written in the following form;

$$\frac{A_m(T,\ \Delta_m)}{A_1(T,\ \Delta_1)}=\frac{e^{-k(T)\cdot\Delta m}\cdot\Delta_m^{-n}}{e^{-k(T)\cdot\Delta 1}\cdot\Delta_1^{-n}},\quad(m=2,\ 3,\ 4,\ 5,\ 6).$$

With the aid of the relation obtained from the observation (Fig. 12) and the above relation, the attenuation coefficient (k) and the value of n are determined by the method of the least square, the result of which is given in the following table;

Table III. Values of n and k for the respective vibration periods.

Vibration period	n	k
0.6 sec.	0.47	2.7×10^{-6} C.G.S.
0.5 〃	0.45	3.2 〃
0.4 〃	0.55	3.1 〃
0.3 〃	0.62	3.3 〃

Although the values of n vary to some extent according to the vibration periods, almost all of them come near to 1/2. Consequently, it is reasonable to conclude that the volcanic tremors, at least those of the present Oo-sima, propagate in the two-dimensional manner or in the mode of the surface wave.

On the other hand, the attenuation due to the internal friction in the course of propagation and other causes is shown in the same table by its coefficients for various vibration periods, which range from 2.7×10^{-6} C.G.S. to 3.3×10^{-6} C.G.S.. However, since the tremors propagate two-dimensionally, the attenuation coefficient k may be reasonably redetermined from the the calculation in which the value of n is taken as 1/2. From the calculation made by the above assumption, the values of k are given in a range from 2.5×10^{-6} C.G.S. to 3.9×10^{-6} C.G.S., as will be seen in Table IV.

Judging from the relation of the attenuation coefficients with the vibration periods, the phenomena concerning the attenuation are consistently interpreted if the attenuation of amplitude are caused by the viscous damping proportional to the inverse square of its vibration period, though another alternative interpretation is possible, for instance, an interpretation from the complex structures of the volcano formation.

From the assumption⁹⁾ that the attenuation of amplitude is caused entirely by the viscosity of the surface formation of this volcano, its coefficients for the respective vibration periods are given in a range from 2.7×10^{9} C.G.S. to 1.0×10^{9} C.G.S..

As is shown in Table IV, the viscosity coefficient based on the attenuation of longer periods is larger than those given from the shorter vibration periods. However the phenomena are consistently explained if the vibrations of longer period affect the deeper parts of the volcano formation than in the case of the rapid

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9) K. SEZAWA and K. KANAI, *Bull. Earthq. Res. Inst.*, **18** (1940), 169, *etc.*
A. KUBOTERA, *Zisin, Ser.* 2, **3** (1950), 16.

Table IV. Attenuation coefficients and viscosity coefficients for various vibration periods.

Vib. period	Atten. Coef.	Vis. Coef.
0.60 sec.	2.5±0.1 × 10⁻⁶/cm	2.7×10⁹ C.G.S.
0.50 〃	3.0±0.2	2.2 〃
0.40 〃	3.4±0.3	1.6 〃
0.30 〃	3.9±0.5	1.0 〃

vibrations, and, in addition, the extremely upper parts of the volcano formation have smaller viscosity than the deeper parts.

The mean vibration period of the tremors at each station is represented in Fig. 13 and Table V in relation to the epicentral distance, which show the period near the origin to be shorter than that at the distant stations. The phenomena

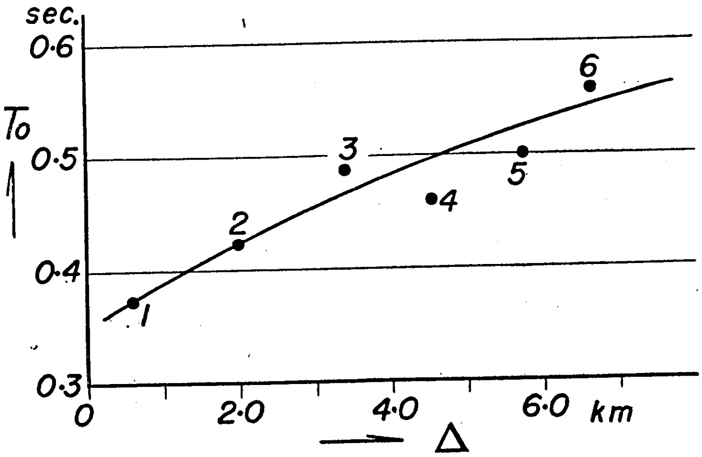

Fig. 13. Mean vibration-period of tremors and distance from their origin.

Table V.

Station No.	Epic. Dis.	Mean vib. period
1	0.6 km	0.37 sec.
2	2.0	0.42
3	3.6	0.49
4	4.6	0.46
5	5.8	0.50
6	6.7	0.56

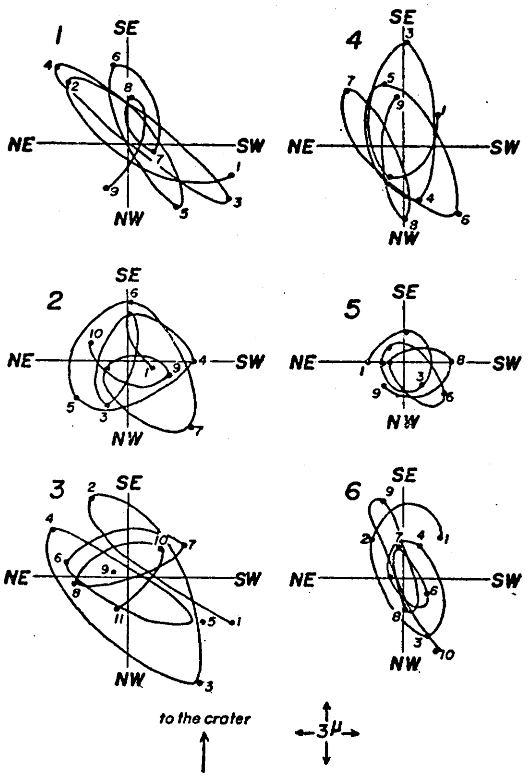

Fig. 16. Horizontal motions of the tremors at Station No. 4.

directly the type of the surface wave from the present investigations. However, the problem must be reexamined with the aid of the complete observations of the three components of the tremors including their vertical motions.

5. The Nature of Volcanic Tremors Recorded by the Accerelation Seismographs.

Besides the observations by use of the displacement seismographs with which the previous paragraph deals, the writers made the measurements of acceleration of the tremors with the aid of the acceleration seismographs.

Examples of these seismograms are shown in Fig. 24. The analyses based on the acceleration seismograms were made with respect to the vibration period and amplitude, as in the former seismograms, and the results of the analyses are indicated in the form of amplitude-period diagrams together with the frequency of vibration periods. As these diagrams of Figs. 17∼19 show clearly, the vibration are explained, as is usually the case, by the fact that rapid vibrations are damped more seriously than slow vibrations.

3) The Orbits of the Tremors.

It was made clear by the above researches that the tremors have the character of the surface wave in the mode of their energy expansion. To determine whether the tremors have the nature of the Rayleigh type or the Love type, the following investigation concerning the orbit of vibration was carried out on the basis of the seismograms.

For this purpose, the seismometric observations at each station were made simultaneously with respect to the two components of the horizontal motion, and the time was marked every second on the seismograms, in order to make exact the correspondence of the respective wave which was separately recorded by its two components. By means of the seismograms thus obtained the orbits of the tremors on the horizontal plane were drawn carefully, as illustrated in Figs. 14—16.

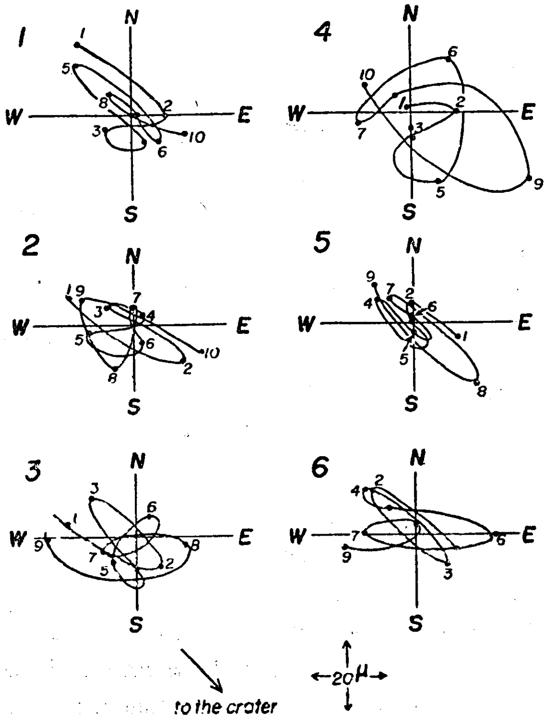

Fig. 14. Horizontal motions of the tremors at Station No. 2.

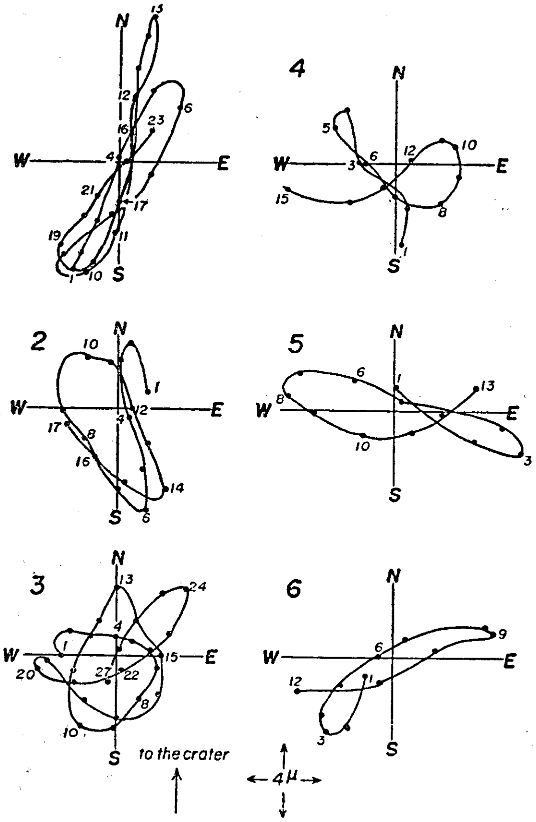

Fig. 15. Horizontal motions of the tremors at Station No. 3.

As will be seen in these figures, the orbits are mostly of elliptic form, but the prevailing direction of vibration, or in other words, the direction of the longer radius of these elliptic orbits does not keep one direction and changes every few seconds. Therefore, the volcanic tremors show by no means a simple mode of vibration, in which vibrations predominate in the direction connecting the station to the origin of the tremors or in the rectangular direction to the former.

On the other hand, K. Sassa[10] studied the same problem concerning volcanic tremors accompanying the 1932 eruption of Mt. Aso, on the basis of comparison of three components of the tremors. As the result, he determined the type of the tremors and classified them into four kinds.

Since the phenomena are unexpectedly complex, it is impossible to determine

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[10] K. SASSA, *loc. cit.*

periods at each station range from 0.05 sec. to 0.35 sec. and the maximum amplitudes at the stations No. 1, No. 2 and No. 4 are 2.1 gal, 0.8 gal and 0.11 gal respectively. It is only natural that in the observation of acceleration, the tremors of the short periods are remarkably predominant in comparison with the displacement observation.

In order to compare the acceleration of the tremors which was observed in the above-described way, with that calculated from their displacment amplitude, the following relation concerning the displacement amplitude and its acceleration was used;

$$\ddot{A}(T)=\frac{4\pi^2}{T^2}\,A(T).$$

Since the vibrations recorded clearly by the displacement seismograph do not always harmonize in their vibration periods with those recorded by the accelera-

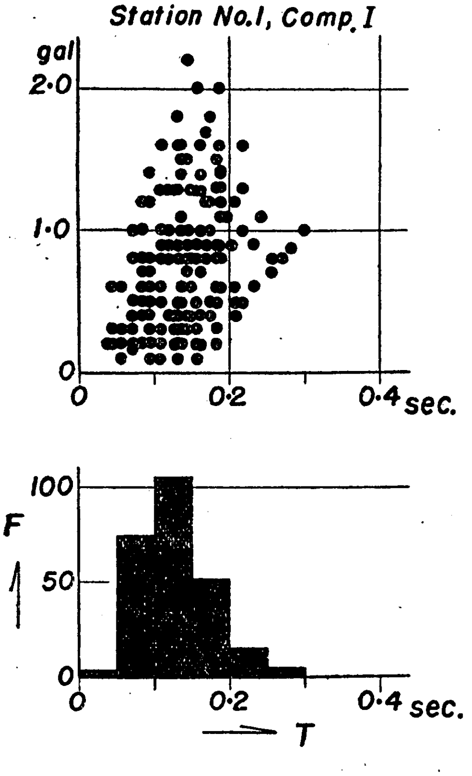

Fig. 17. Acceleration of tremors and their vibration-periods observed at the Station No. 1.

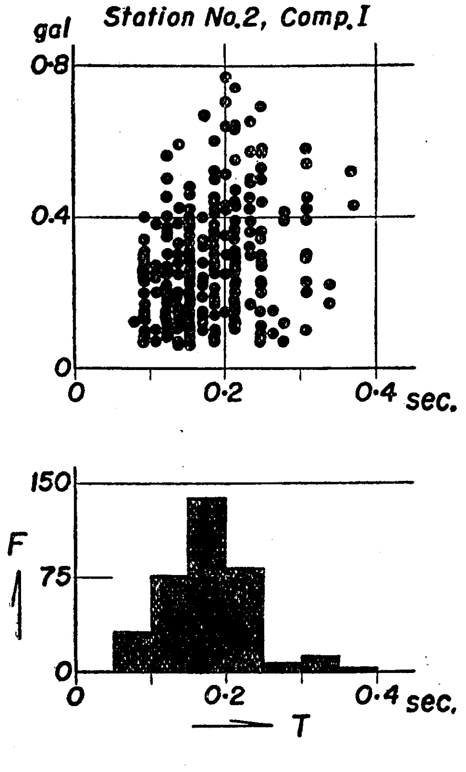

Fig. 18. Acceleration of the tremors and their vibration-periods observed at the Station No. 2.

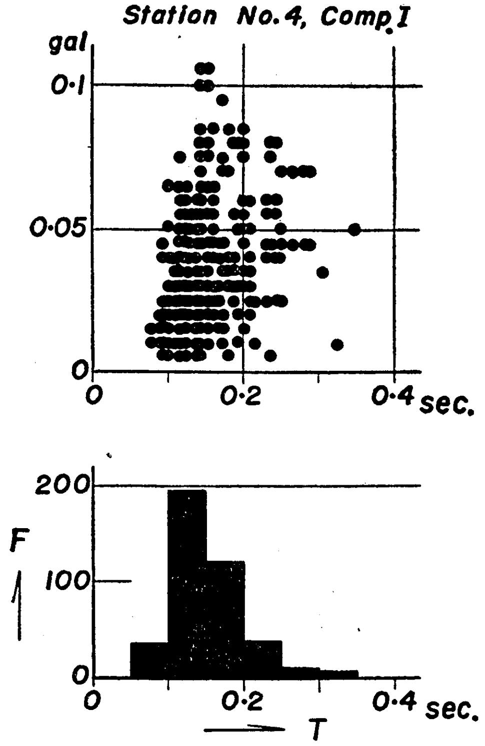

Fig. 19. Acceleration of the tremors and their vibration-periods observed at the Station No. 4.

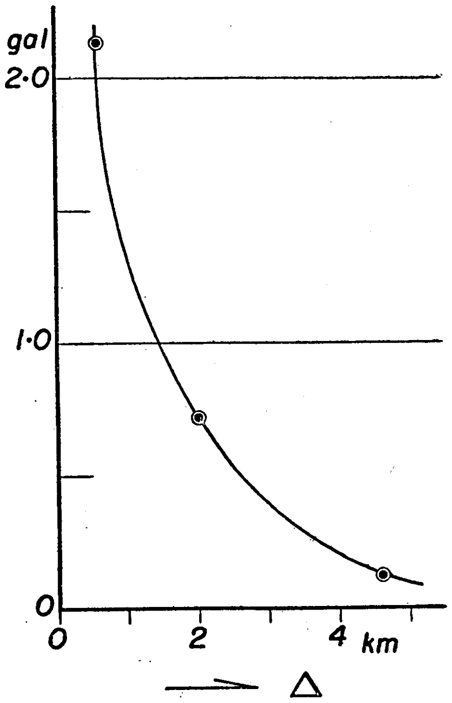

Fig. 20. The maximum acceleration of the tremors(vibration-period, 0.15 sec.) and the distance from their origin.

tion seismograph, the comparison of these two kinds of acceleration, the observed and the calculated, are made only for the tremors of 0.2 sec. and 0.3 sec. in their vibration periods and for their maximum amplitude.

As will be seen in Table VI, the accelerations calculated at the Station No. 2 are only 50 per cent of those directly observed. It seems that this discrepancy comes from the difficulty in reading the rapid and small vibrations in question on the displacement seismograms which are seriously masked by large vibrations of 0.5 and 0.6 second in their periods.

Fig. 20 shows the attenuation of the acceleration amplitude with respect to the epicentral distance.

Table VI.

Locality	Epic. Dis.	Acc. obs. 0.2 sec.,	0.3 sec.	Acc. cal. 0.2 sec.,	0.3 sec.
St. No. 1	0.6 km	1.7 gal,	1.0 gal	0.89 gal,	0.88 gal
St. No. 2	2.0 〃	0.8 〃 ,	0.6 〃	0.40 〃 ,	0.31 〃
St. No. 4	4.6 〃	0.09 〃 ,	0.06 〃	0.11 〃 ,	0.07 〃

6. Résumé.

1. This report deals with the nature of the volcanic tremors accompanying the 1950 eruption of Oo-sima, with a brief description of its development included. The present research of the tremor is based on observations made by means of the displacement and acceleration seismographs.

2. On the basis of the relation between the amplitude of the tremor and the distance from its origin, it was made clear that these tremors propagated two-dimensionally along the earth's surface from the active crater to each station.

3. From the assumption that the attenuation of amplitude is entirely caused by the viscosity of the mountain-formation, its coefficients are estimated to the range from 1.0×10^9 to 1.6×10^9 C.G.S. for the upper part of the formation and from 2.2 to 2.7×10^9 C.G.S. for the deeper part.

4. In order to make clear whether the tremors have the character of the Rayleigh type or the Love type, the problem was investigated with respect to the orbit of vibration. But the research failed to arrive at a final conclusion for the reason that the mode of vibrations was remarkably complex.

5. The acceleration of tremor observed directly by the acceleration-seismograph was compared with that calculated from the seismograms recorded by the displacement-seismograph.

6. The seismometric investigations of Oo-sima are still under way and this report deals only with vibrations of continuous train accompanying the Strombolian eruption. The research concerning the earthquakes of the ordinary type which occurred in the course of the present activity, will be reported in the forthcoming Bulletin.

In conclusion, the writers wish to express their sincere thanks to Mr. S. Hiraga for the valuable assistance be afforded them in the seismometric observations at Oo-sima.

[T. MINAKAMI, T. MIYAZAKI and T. TAKAHASHI.]

[Bull. Earthq. Res. Inst., Vol. XXIX, Pl. XIV.]

（震研彙報 第二十九號 圖版 水上・宮崎・高橋）

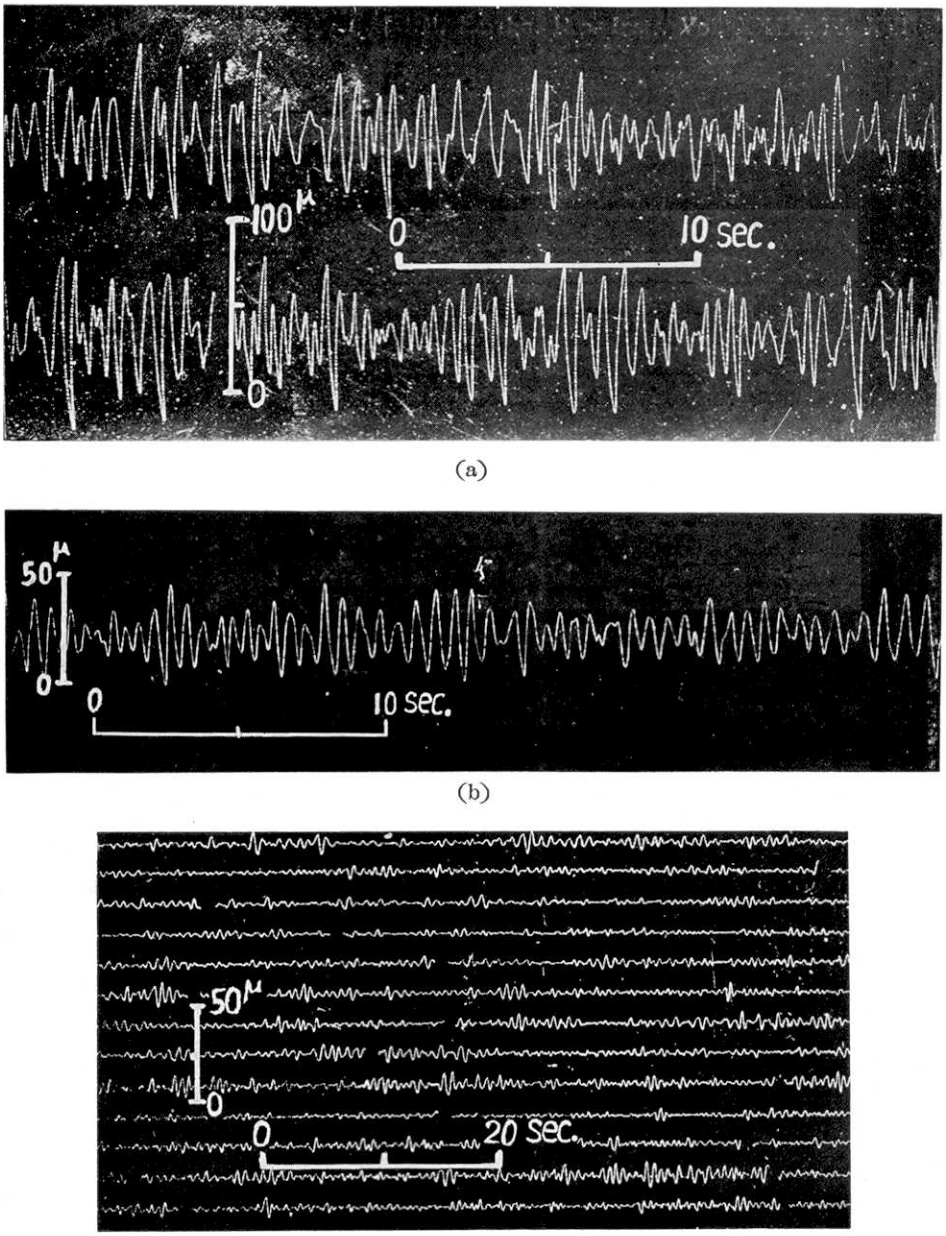

Fig. 21. Seismograms recorded at Stations Nos. 1, 2, and 3.

[T. MINAKAMI, T. MIYAZAKI and T. TAKAHASHI.]

[Bull. Earthq. Res. Inst., Vol. XXIX, Pl. XV.]

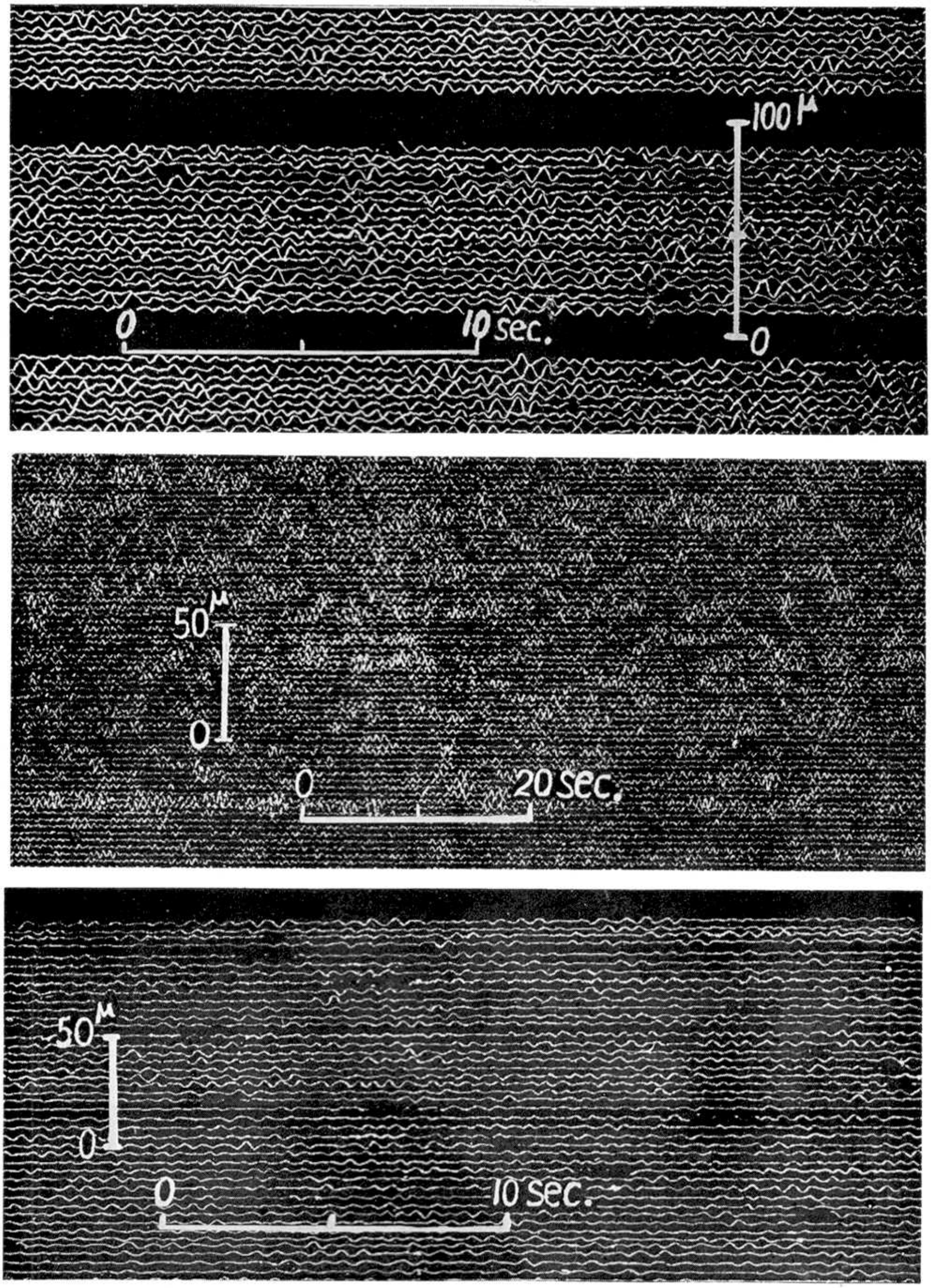

Fig. 22. Seismograms recorded at Stations Nos. 4, 5 and 6.

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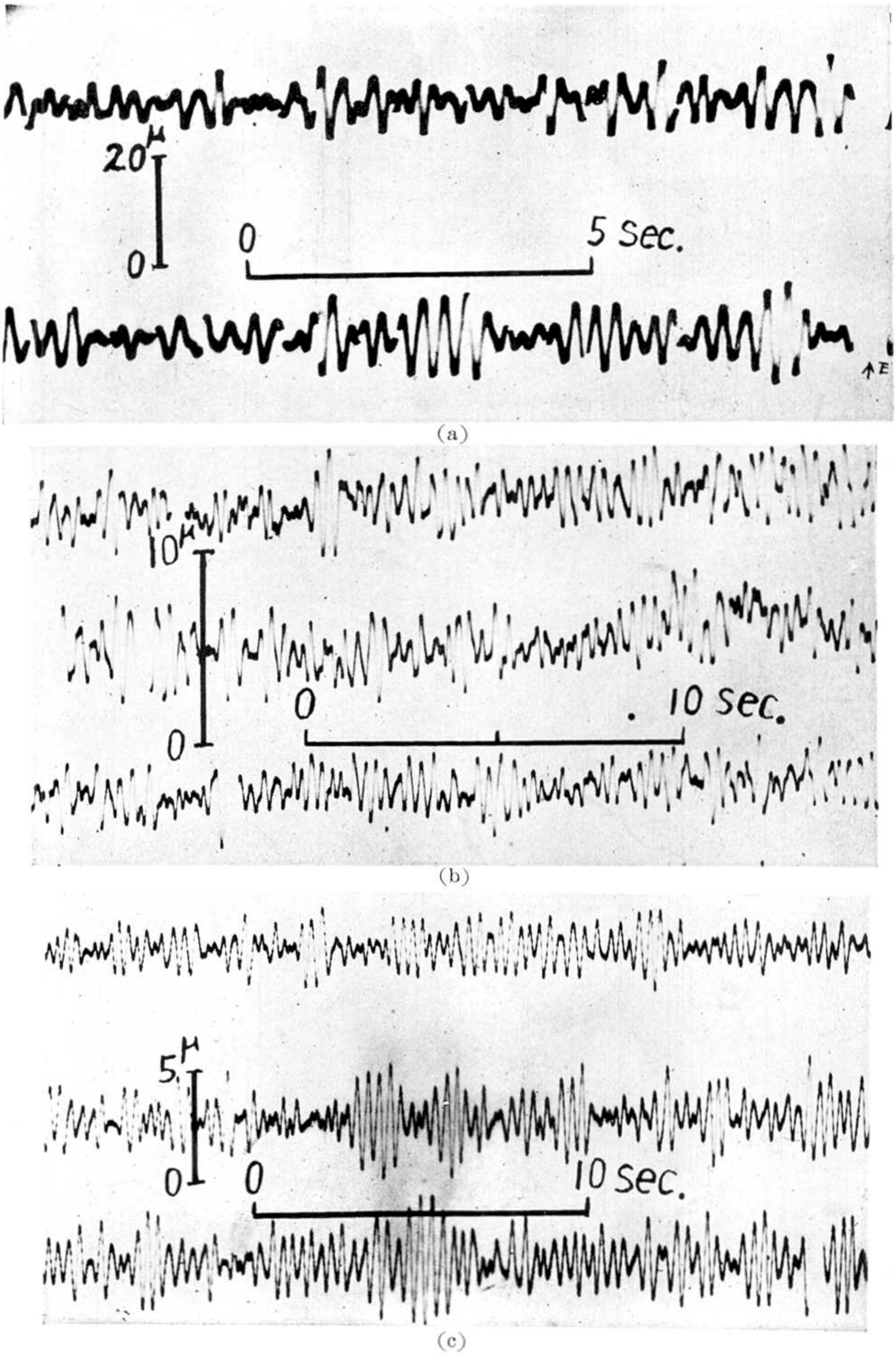
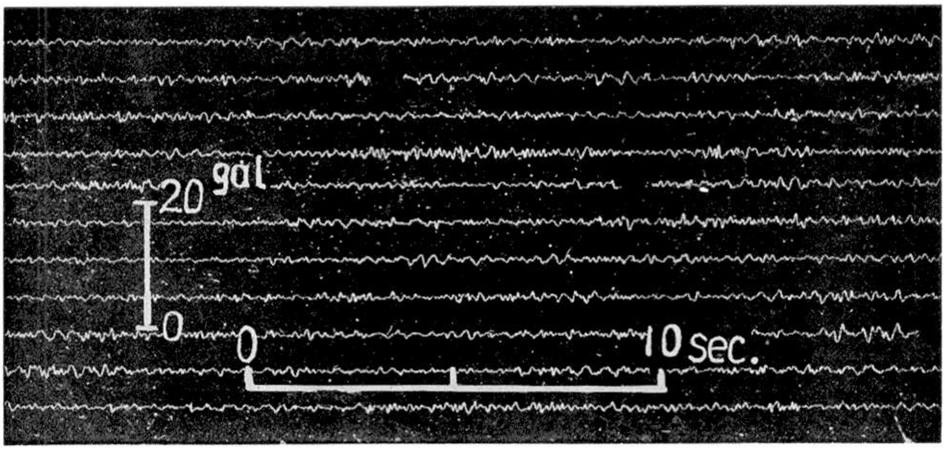
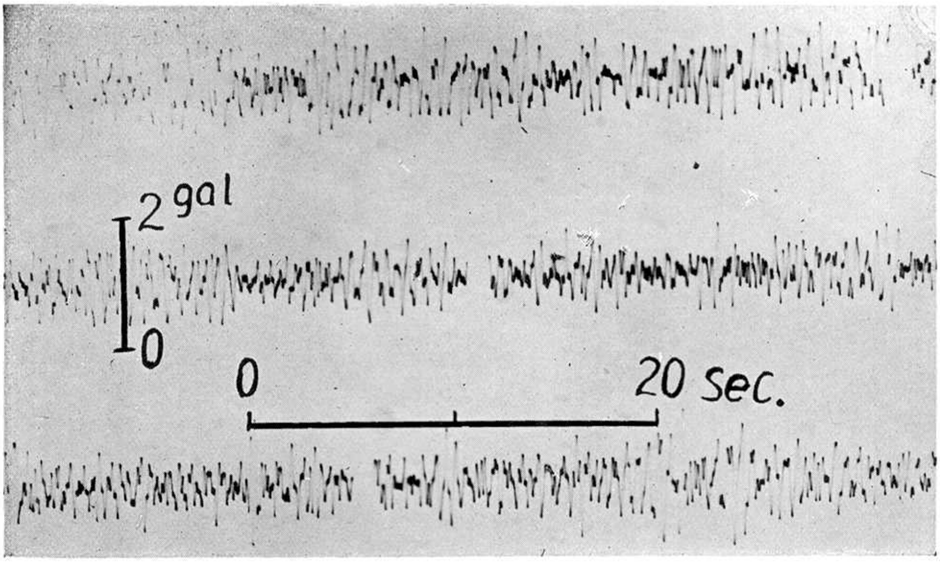


Fig. 23. Seismograms recorded optically at Stations Nos. 3, 4 and 5.



(a)



(b)

Fig. 24. Acceleration seismograms recorded at Stations Nos. 1 and 2.

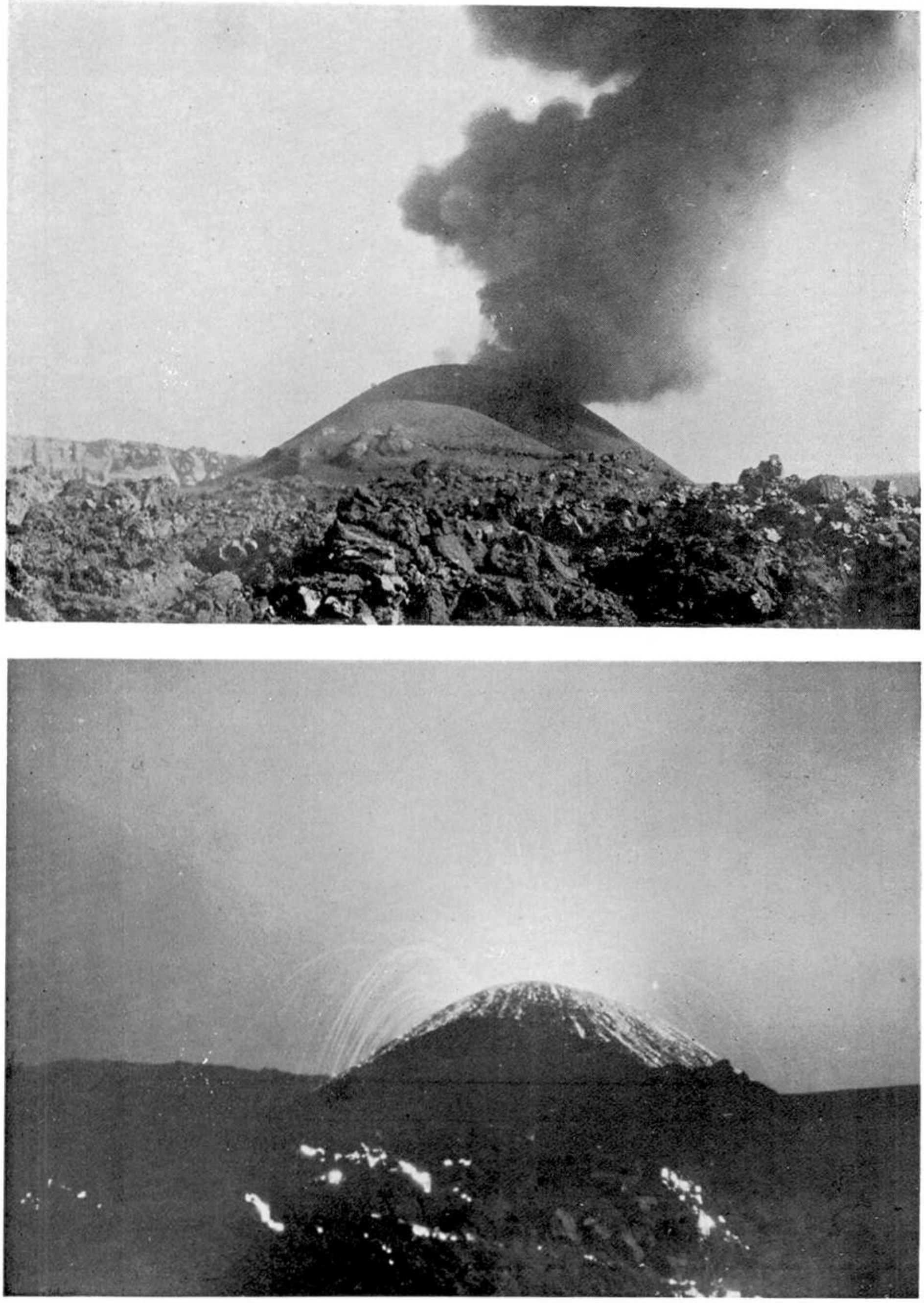


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Fig. 25. The cinder cone (B) viewed from Station No. 1 on the inner somma.
(September 16, 1950)

Fig. 26. Lava streams flowing down on the flank of the inner somma. (September 16, 1950)

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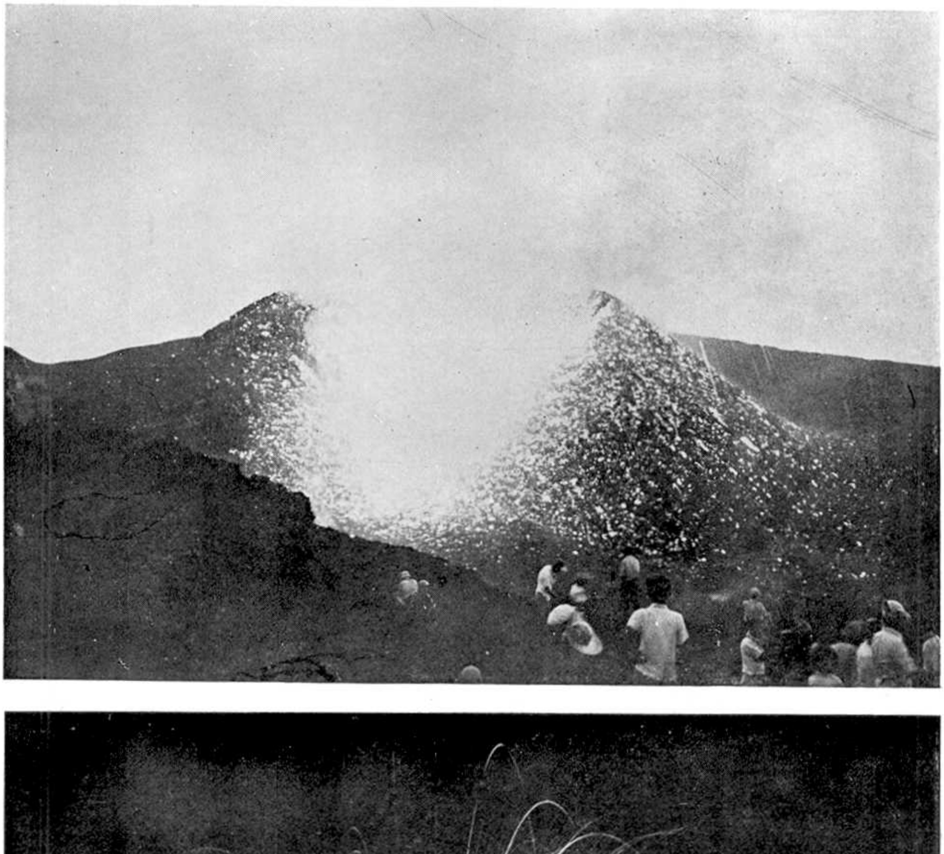

Fig. 27. The newly formed cinder cone (B) and its craterlet of a horseshoe shape.
(September. 1, 1950) (After S. Murauchi)

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32. 最近の大島の噴火とその地震計測學的研究（I）

地震研究所 水上 武
宮崎 務
高橋智子

大島火山は1940年の小噴火以來約10年ぶりで，1950年7月16日より約70日に亙つて著しい活動を示した．その後約4ヶ月間は平穩な狀態を續けたが1951年2月以來再び噴火を開始し熔岩を流出し，現在（1951年3月31日）尙活動中である．本文は1950年の第1期活動のストロンボリ式噴火に伴つた火山脈動の計測學的研究についての報告である．

火山脈動はストロンボリ式噴火と密接な關係があるので7月16日より9月23日に至る今回の大島の噴火現象についても，簡單に記述してある．

今回の調査に使用した地震計は周期1.0秒，幾何倍率は200倍，及び光學的記錄を用いて，脈動の振幅に應じて，4,000, 2,000並に1,200倍にして使用した．更に脈動の加速度を觀測するために，振子の板ばねを取りかえて周期を0.1秒の加速度地震計として使用した．

活動中の火口から種々の距離に於いて觀測した結果並にその火口附近に於ける有感脈動の强度分布等から判斷して脈動の震動源は火口の下200〜300米より淺い所にあるらしい．

脈動の振幅と震動源との距離の關係から脈動は地表に沿うて二次元的な擴りを以つて傳播している事を確めた．

振幅の減衰が傳播中に於いて火山體を構成する物質内部の粘性に由るものとしてその係數を求めた．その結果，周期0.5〜0.6秒の脈動の減衰よりは粘性係數の値として $2.2\sim2.7\times10^9$ C.G.S.，0.3〜0.4秒の脈動からは $1.0\sim1.6\times10^9$ C.G.S. を得た．長周期脈動の方が地表下深部まで影響を持つ事を考えれば，大島火山は地表面よりやや深い部分を構成する火山堆積物の方が極めて地表近くを構成するものに較べてやや粘性が大きい事を示すものである．

水平二成分の觀測より地表面に於ける脈動の orbit の模樣を調べたが，振動の方位は極めて複雜に變化して特定の方向に卓越する事實は認められなかつた．從つてこれから直ちに表面波の type を定めることは困難であつた．しかしこの問題は上下動を加えた完全なる觀測によつて再び檢討する必要がある．

加速度地震計による觀測結果について上記と略同樣に脈動の傳播についてその性質を考究した．また變位地震計による觀測から算出された加速度と加速度地震計によつて直接觀測された結果とを比較し，略滿足する結果を得た．

本研究は目下尙進行中であるが，1951年3月中の同火山の活動の際にも同樣の測定を行い，第一期噴火中の脈動の性質と相異するか否かについて目下檢討を行つている．