OBSERVATIONS OF VOLCANIC MICRO-EARTHQUAKES AT MT. ASO

BY

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1. Introduction

It was found during the observation in 1961 that there were good correspondences between the occurrences of the short period volcanic microtremors and the micro-earthquakes originating near the crater. Judging form natures observed, the short period volcanic micro-tremors[1] have been presumed to be the surface waves generated by the micro-earthquakes.

In this paper, the results of the recent observation are shown, and the above-mentioned problems are investigated.

2. On the observation carried out in 1961

Supposing the very shallow origins of earthquakes, six pick-ups were set at the positions shown in Fig. 1. E.T.L. (Electro Technical Lab.) vertical pick-ups with 14 cps natural frequency and E.T.L. amplifier were used. Galvanometers with the proper frequency of 30 cps were connected with the amplifier. Routine observations with SH-III vertical seismograph (T=1.2 sec. T=0.8 sec.) and others are carried out at Hondo observatory shown in Fig. 3. The photoes of Fig. 2 are the micro-earthquakes recorded at the positions near the crater and the corresponding micro-tremors recorded with SH-III vertical seismograph at Hondō observatory.

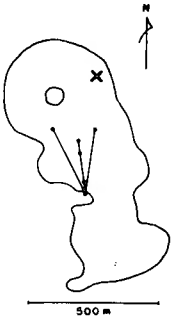


Fig. 1 Map of pick-up location.

It is difficult to make out the initial motion of P-wave in every trace owing to the disturbance of short period micro-tremors. So distinct S-waves were measured and the position of the hypocenter was determined. The location of hypocenter obtained from the finest record is shown in Fig. 1. The depth of the hypocenter is $Z=-3800$ m. The calculated velocity of S-wave is $V_s=1600$ m/sec. $V_p=3500$ m/sec is obtained from the P–S interval, the depth of the hypocenter and the velocity of S-wave (T=1.3 sec, $Z=-3800$ m, $V=1600$ m/sec). Considering that the

location of observation is in the volcanic region, these values are possible. But the position of the hypocenter is deeper than that supposed, and accurate results can not be expected.

P–*S* intervals are read about some micro-earthquakes. Their values are found between 1.3 and 2.0 sec. As Omori constant is 3.0 km/sec, if the epicenters are assumed to be close to the location of observation, the depth of hypocenters become 4-6 km.

At that time, micro-earthquakes occurred one or two times per ten minutes, the corresponding micro-tremors could easily be found. But the time accuracy between two records was the order of ten seconds, it was not clear which phase in a micro-earthquake corresponded to the micro-tremor.

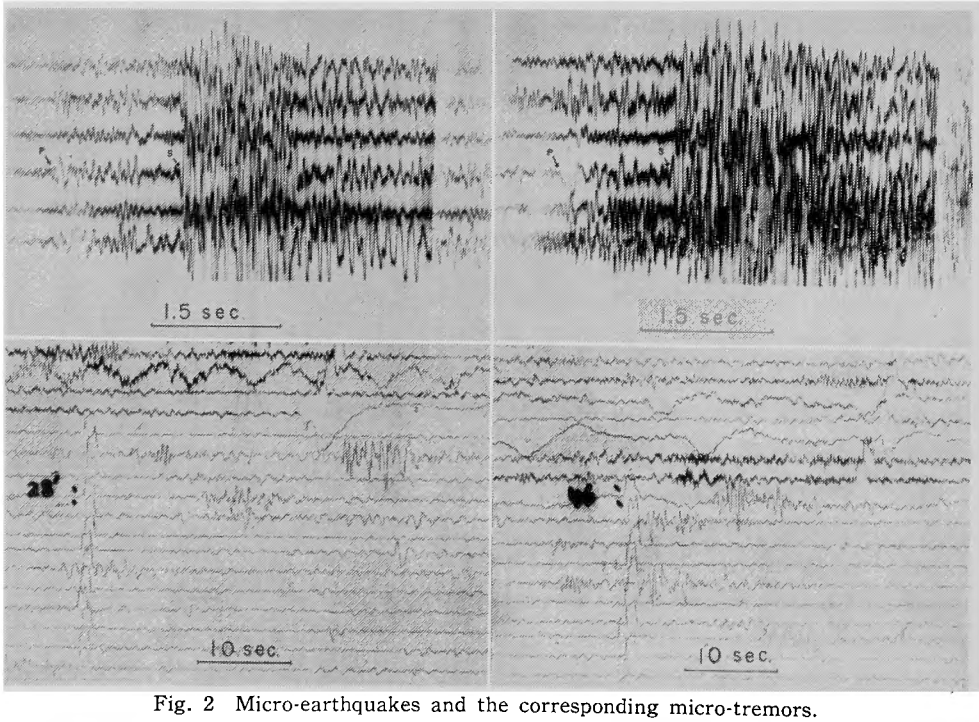


Fig. 2 Micro-earthquakes and the corresponding micro-tremors.

3. On the observation carried out in 1962

Observations were carried out early in May and from the early part of August to the early part of September in 1962. At the observation in May, E.T.L. vertical pick-ups with 14 cps natural frequency were set as shown in Fig. 3 and two components of *S*–*B* type (Sassa *B*-type, $T=0.38$ sec) seismographs were installed at Hondō observatory. Transistor amplifiers were used and the galvanometers with

30 cps natural frequency were connected with those out-put terminals.

Records of micro-earthquakes obtained by the above-mentioned method and those of corresponding micro-tremors recorded with SH-III vertical seismograph installed at Hondō observatory are shown in Fig. 4.

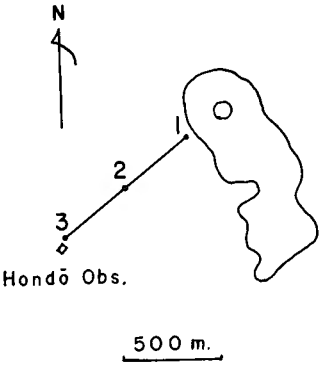


Fig. 3 Map of pick-up location.

P-waves of micro-earthquakes can not be clearly descriminated. On the other hand, comparing traces of *S*–*B* type horizontal seismographs, *S*-waves can be found fairly well. The orbital motions synthesized with two horizontal traces are shown in Fig. 5. In No. 1 figure of Fig. 5, an arrow head indicates the wave which seems to be *P*-wave. But it is not obvious whether this is an initial motion of dircect *P*-wave. No. 2 figure of Fig. 5 is a peculiar case. In Fig. 4 and Fig. 5 marks are put down at each corresponding point. These comparisons were carried out on 12 micro-earthquakes whose *S*-waves could be discriminated. Then it was found that large parts in amplitude of micro-tremors recorded with SH-III vertical seismograph corresponded

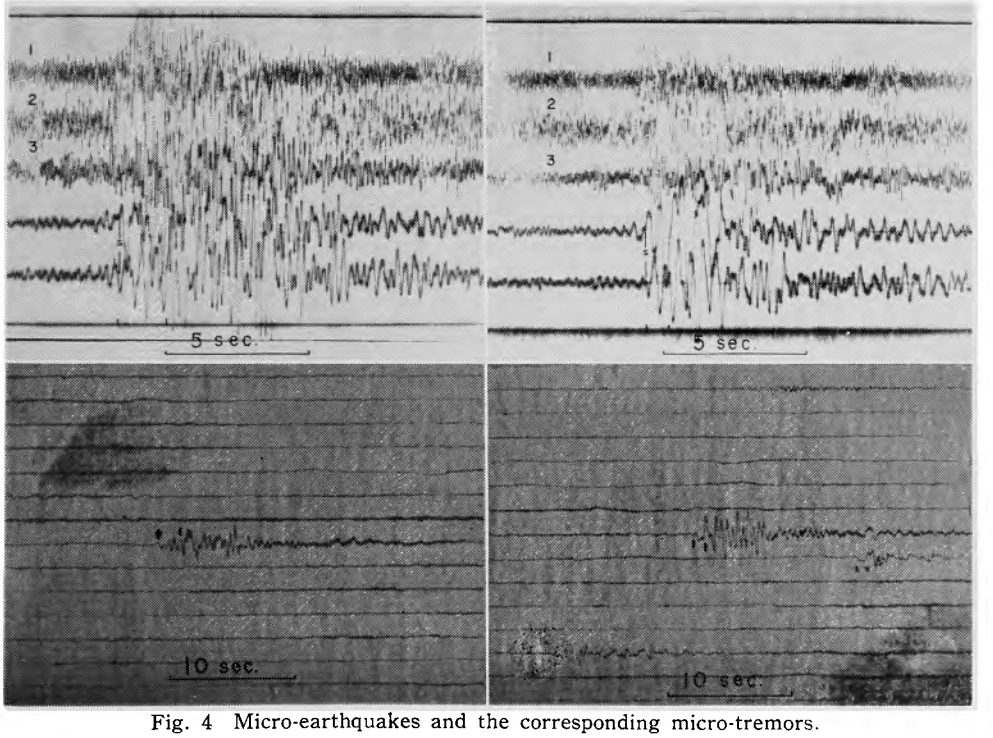
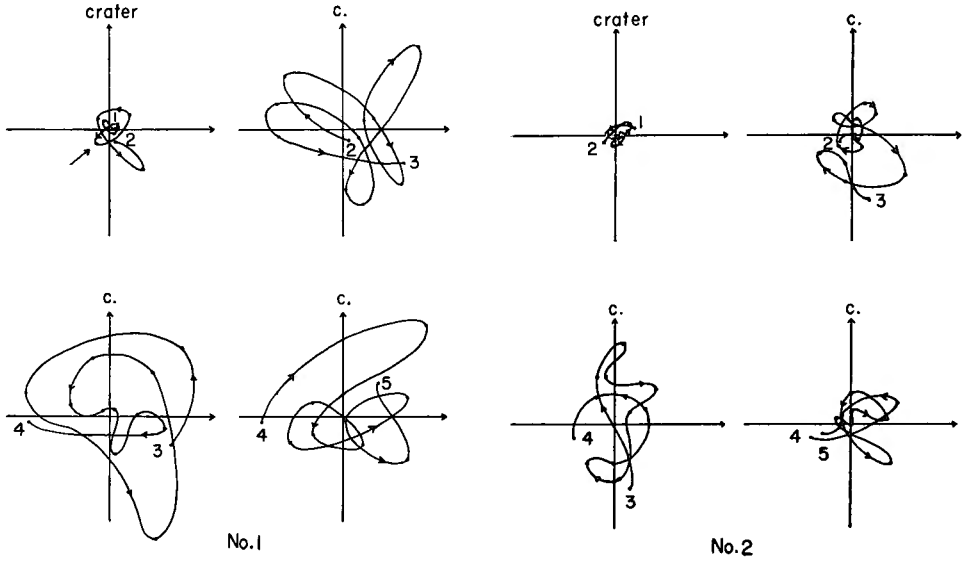


Fig. 4 Micro-earthquakes and the corresponding micro-tremors.



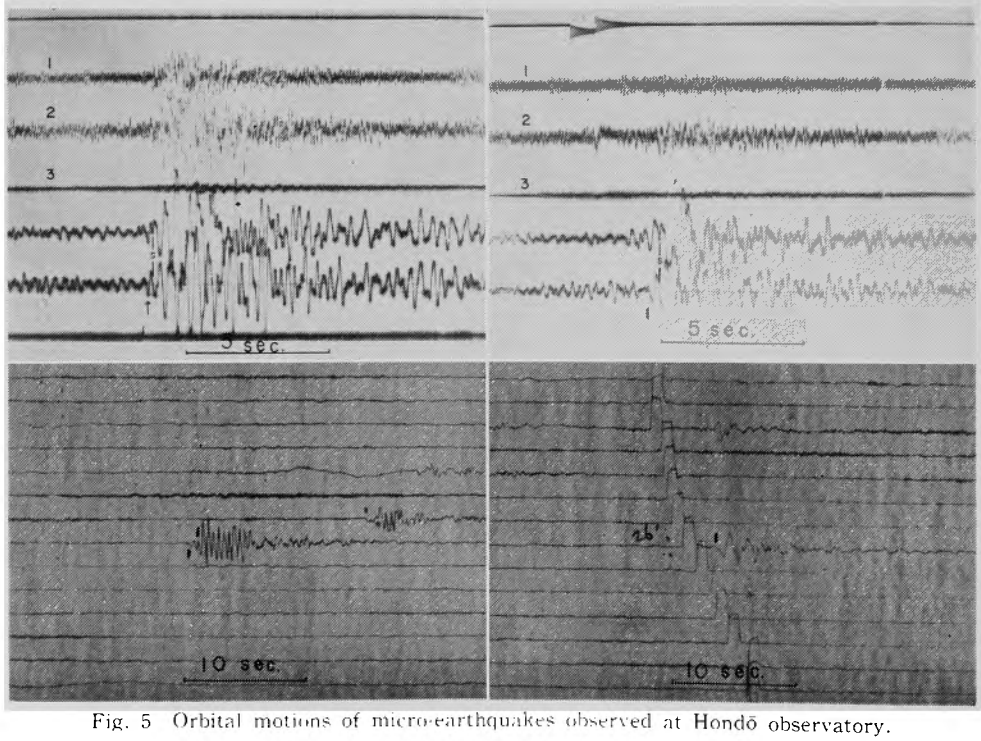


Fig. 5 Orbital motions of micro-earthquakes observed at Hondō observatory.

to the parts after S-waves of micro-earthquakes.

As the initial motions of body waves in micro-earthquakes were not distinct, the direction of propagation was not obvious. On the microtremors with the shorter period, they were propagating from the crater and were rapidly decreasing in amplitude as they became more distant from the crater.

To seek for the more accurate position of hypocenter, the observation was carried out in summer, 1962. The positions of seismographs are shown in Fig. 6. E.T.L. vertical pick-ups with the natural frequency of 14 cps, transistor amplifiers and the galvanometers with the proper frequency of 100 cps were used. To keep off the disturbances near the earth's surface, each pick-up was buried at the bottom of a hole in two meters' depth. Records of micro-earthquakes obtained by such network and the corresponding records of micro-tremors are shown in Fig. 7.

In many cases, initial motions of micro-earthquakes are not distinct and the discrimination of S-waves is difficult, because many different phases appear in each trace. So it is hard to determine the position of hypocenter. About fifty micro-earthquakes were recorded and their corresponding micro-tremors were ascertained, but S-waves of micro-earthquakes could be read only twice and that with difficulty.

At first, six equations were solved directly and the roots were regarded as approximate values. Then these were corrected with the least square analysis. But this method was not successful. So, assuming the position of hypocenter, the velocity of S-wave and the origin time of micro-earthquake, tables of arrival time at each station were calculated. These values were compared with reading values and the most appropriate suit was regarded as approximate values. The approximate values were corrected with the least square analysis.

The roots are as follows.

Aug. 24 th 05 : 45

$x=12\pm3.1$ m, $y=201\pm3.0$ m, $z=-1015\pm4.2$ m,

$t_s-t_0=1.96\sim2.20\pm0.008$ sec, $V_s=488\pm1.9$ m/sec,

Sep. 01st 07 : 40

$x=82\pm0.4$ m, $y=162\pm0.5$ m, $z=-784\pm1.9$ m,

$t_s-t_0=1.64\sim1.84\pm0.004$ sec, $V_s=500\pm1.0$ m/sec,

The positions of hypocenters are shown in Fig. 6. Comparing the velocity of S-wave shown above with that of P-wave obtained by the seismic exploration,[2] these values are thought to be rather small. As the position of hypocenter is not determined by the reading of the times of initial motions and the reading of the time of S-wave is not unique, too much trust can not be set in these values. Let two micro-earthquakes be compared in Fig. 7. These two recording systems did

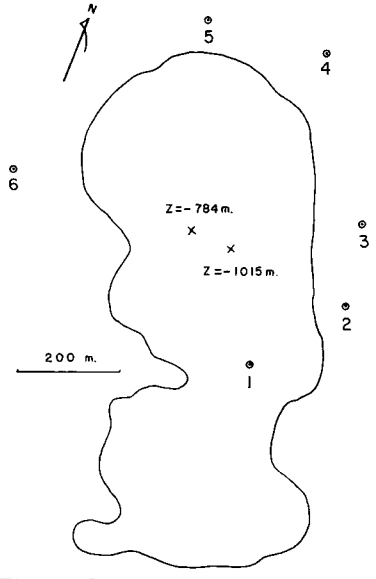


Fig. 6 Observation net for micro-earthquakes and locations of hypocenters.

not be handled during the period, so their characteristics and magnifications are thought to have been unchanged. At the crater, the amplitude of the micro-earthquake on 24 th of Aug. is larger than that of the earthquake on Olst of Sep. On the contrary, the amplitude of the micro-tremor on Olst of Sep. is larger (at Hondō observatory). If the phenomenon is investigated merely with a view to the calculated roots, only the depth is concerned, because the positions of epicenters are near each other. But the positions of hypocenters are not decisive and the problem is open to investigation.

4. Conclusion

As the volcano becomes active, the frequency of occurrence of the above-mentioned

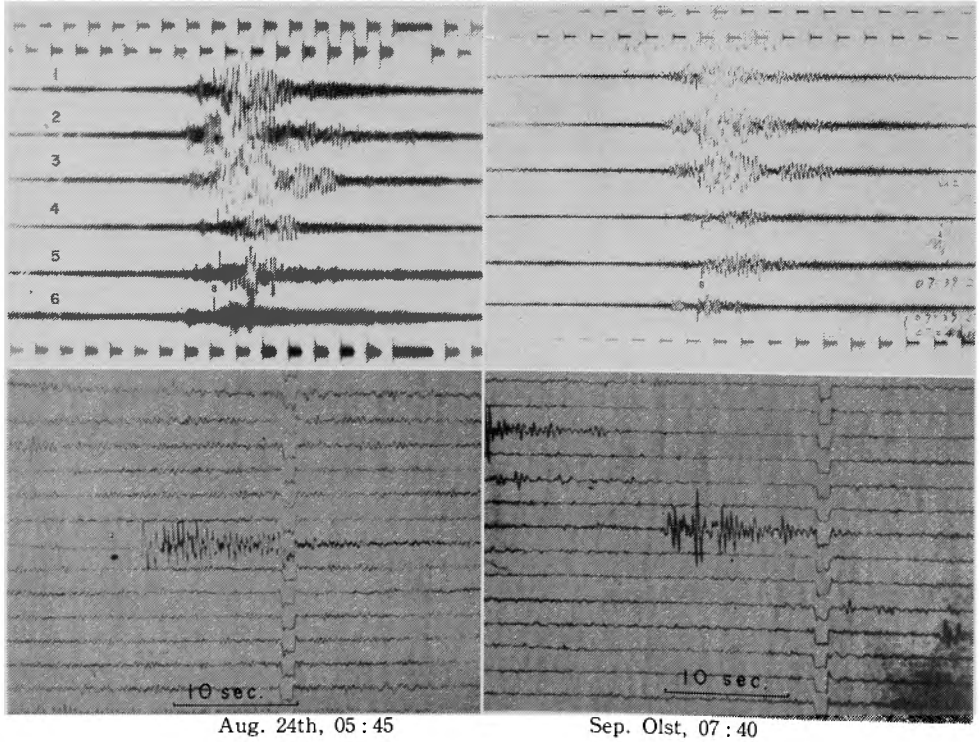


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Fig. 7 Micro-earthquakes and the corresponding micro-tremors.

micro-tremor increases. When the phenomena which are presumed to be the increase in volcanic activity near the crater bottom, begin to appear, micro-tremors become rather continuous ones with the shorter period. This process are imagined to represent the phenomena that the location of destruction moves from the deep position to the shallow one near the crater. But the determination of the hypocenter has not been made to confirm such phenomena. Especially as for the continuous micro-tremor, it has not been made sure whether the micro-earthquakes occur continuously corresponding to the micro-tremors.

It was found that the large parts in amplitude of micro-tremors recorded with SH-III vertical seismograph at Hondō observatory, corresponded to the parts after *S*-wave of micro-earthquakes. And the depth of the hypocenter probably had some relation to the amplitude of the micro-tremor. When the micro-earthquake occurs at the slightly deep position, it appears in the shape of the micro-tremor on the record of SH-III seismograph at Hondō observatory. But when it is recorded with the shorter period seismograph, body wave can be observed fairly well. When the continuous micro-tremors were investigated in the previous observations, they showed the nature of surface waves. These phenomena are presumed to indicate that the shallower the hypocenter becomes, the more the predominance of surface wave is emphasized in the period from 0.1 to 0.5 sec.

The writer wants to determine the accurate positions of hypocenters and to investigate the relation between them and the micro-tremors. If the relation between the position of the hypocenter and the shape or the period of the micro-tremor becomes clear, the routine observation at Hondō observatory will make the better contribution to the prediction of the volcanic activity.

5. Acknowledgement

In conclusion, the writer wishes to express his hearty thanks to Prof. K. Sassa for his constant guidance and encouragement. Financial support for these observations was partly granted from the Research Fund for Science of the Ministry of Education.

References

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