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MICRO-EARTHQUAKES OCCURRING IN THE VICINITY OF KYOTO [III]

By

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Abstract

The micro-earthquakes occurring in the vicinity of Kyoto were studied by use of the data obtained from Mar. in 1964 to Jul. in 1965. The distributions of the epicenter, focal depth and first motion of P waves do not change their tendency shown in the previous papers. In this paper, the earthquakes are grouped into four classes according to their magnitude for examining the distributions concerning magnitude. However, no tendency concerning the distribution of magnitude is especially found. According to the study of the azimuthal distribution of the initial motion of S waves, it is supposed that the focal mechanism has the force system of the double couple.

1. Introduction

The distributions of the epicenter, focal depth and first motion of P waves as for the micro-earthquakes occurring in the vicinity of Kyoto were investigated in the previous papers (Okano and Hirano [1964, 1965]). The earthquakes studied in these papers were observed from Oct. in 1963 to Feb. in 1965. In this paper, the earthquakes observed from Mar. to Jul. in 1965 are added to study, while the earthquakes observed from Oct. in 1963 to Feb. in 1964 are excluded because of less reliability of hypocentral locations which were determined by use of only four observation stations. Not only the distributions mentioned above but the distribution of the first motion of S waves are studied here.

2. Distribution of epicenter and focal depth

The method of locating hypocenter is the same one adopted in the previous papers except the assumption of $V_p=5.8$ km/sec instead of that of $V_p=5.0$, 5.5 and 6.0 km/sec. The earthquakes classified by magnitude are plotted in the figures of the distributions of the epicenter and focal depth (Figs. 3 and 4). The magnitude is determined by use of the maximum amplitude of seismograms recorded at the five or six stations. The method is as follows. The maximum ground motions at these stations versus hypocentral distances are shown in

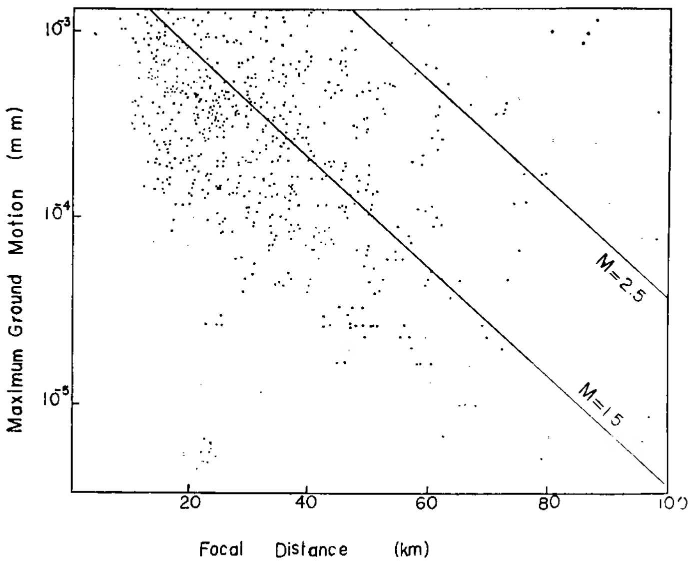


Fig. 1. Relation between maximum ground motions and focal distances with two solid lines indicating attenuation for magnitudes of 1.5 and 2.5.

Fig. 1. The points plotted are separated by the two lines indicating $M=1.5$ and 2.5, which were drawn by the following means. First, the maximum ground motions giving $M=1.5$ and 2.5 are plotted at 100 km of the ordinate after consideration of the constants of Wood-Anderson standard seismograph. The standard seismograph is of horizontal type, while the one used in our observation is of vertical type. We examined the ratio of the horizontal component to the vertical one by use of seismograms recorded by the short period electromagnetic seismographs ($T_1=0.80$ sec and $T_2=1.2$ sec) which are installed at

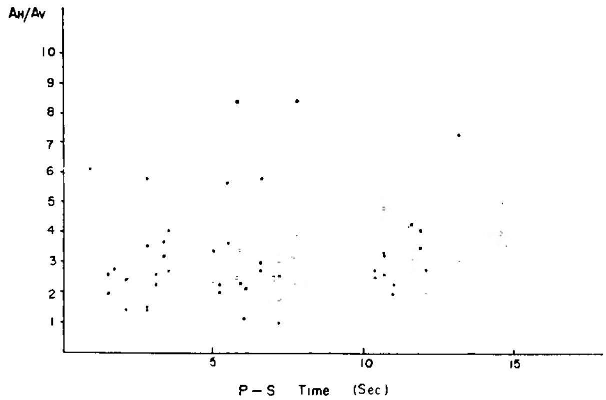


Fig. 2. Variation of ratio of horizontal component (A_H) to vertical one (A_V) with distance for earthquakes observed at Abuyama Seismological Observatory.

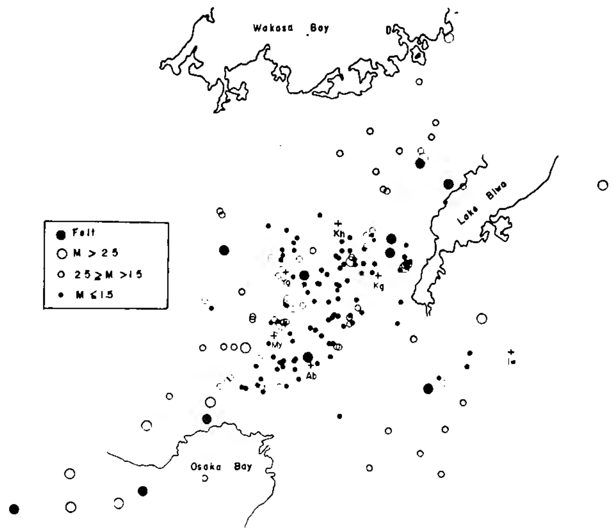
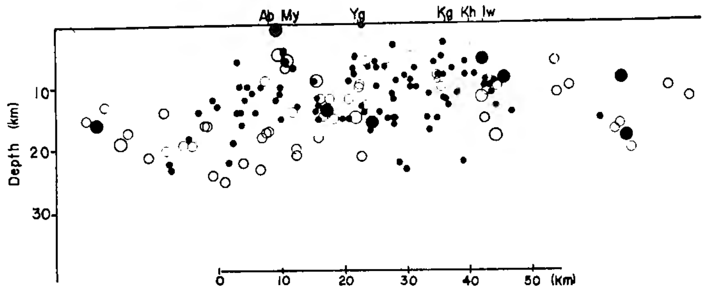


Fig. 3. Distribution of the earthquakes with their magnitude class.



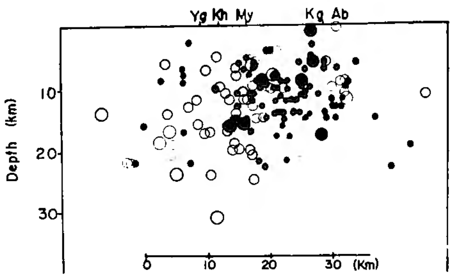


Fig. 4. Distribution of the depths of earthquakes with their magnitude class.

Abuyama Seismological Observatory. The ratio is about 3 as shown in Fig. 2. Therefore the values corresponding to $M=1.5$ and 2.5 are 3.8×10^{-6} and 3.8×10^{-5} mm respectively. Next, an attenuation curve is drawn from the data of about ten earthquakes, for which each point showing their maximum ground motions lie on a comparatively smooth line. The attenuation curve obtained thus is assumed to be approximated by the straight line. All earthquakes are grouped into three classes according to their magnitude, namely, below 1.5, 1.5-2.5 and above 2.5. The felt earthquake is distinguished from the classes. The distributions of the epicenter and focal depth are shown in Figs. 3 and 4. As shown in these figures, no tendency concerning the distribution of magnitude is especially mentioned.

3. Distribution of first motion of *P* waves

In the previous papers, the pattern of the distribution of the first motion of *P* waves was decided by means of superposing the epicenters of all earthquakes. The same means was also adopted for the earthquakes observed from Mar. to Jul. in 1965. Fig. 5 shows the distribution of the first motions. This pattern is almost the same as that of the earthquakes observed before the present period. Namely, it is of quadrant type having two nodal lines; the one runs from NE to SW, and the other from NW to SE. Hashizume *et al.* [1966] showed that the earthquakes occurring in Kinki District have the same focal mechanism as those treated here. The earthquake swarm occurring at Matsushiro

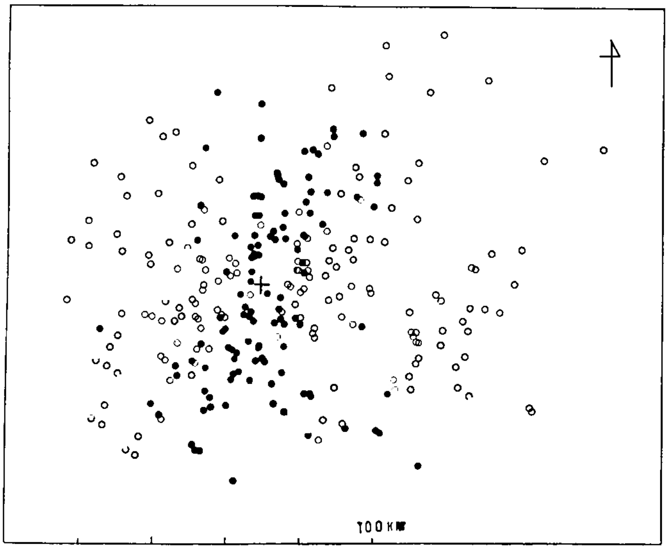


Fig. 5. The first motions of *P* waves of microearthquakes, ● , condensation, ○ ; rarefaction, + ; epicenter.

has also the horizontal component of the maximum pressure lying in the EW direction (BERI [1966)].

4. Distribution of first motion of *S* waves

Because the means of superposing the epicenters of all earthquakes was very effective for studing of the distribution of the first motion of *P* waves, this means is also adopted for *S* waves. Regretfully, only the vertical component seismograph is installed at each station in our observation, so the horizontal component is not available for the present study. But the routine observation of three components has been carried out at Abuyama Seismological Observatory. Thus the first motion of *S* waves is able to be examined by use of the horizontal components of the short period electro-magnetic sismograph of Abuyama. Generally, it is very difficult to identify the first motion of *S* waves of near earthquakes because this phase appears in the train of *P* waves. Therefore the phase is not able to be identified for all earthquakes. In the present study, the earthquakes with the sharp onset of *S* phase were selected from the horizontal seismograms recorded at Abuyama Observatory. The azimuthal distribution of the horizontal displacement was indicated by the arrows on the relative position of Abuyama with respect to the superposed epicenter in Fig. 6. This shows that the focal mechanism has the force system of the double couple, notwithstanding the arrows of not a few earthquakes indicate random directions. And the direction of the moment of the couple coincides with the one decided from the distribution of the first motion of *P* waves.

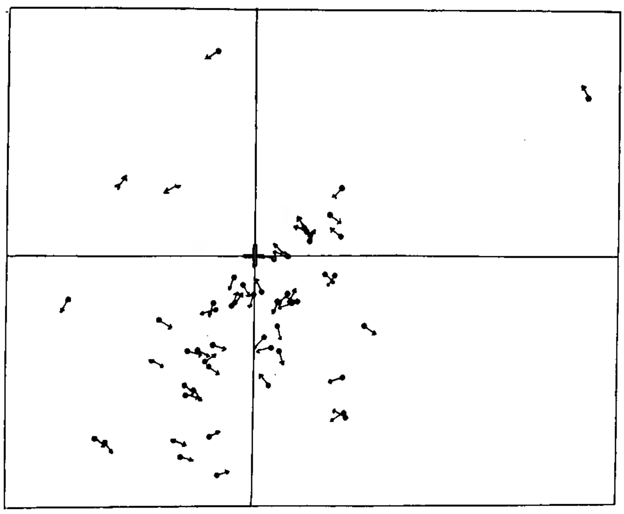


Fig. 6. Directions of the first motions of *S* waves for the earthquakes observed at Abuyama Seismological Observatory.

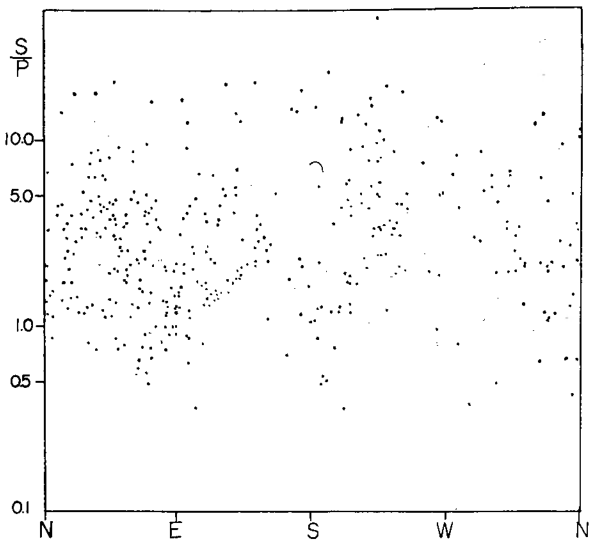


Fig. 7. Azimuthal distribution of the ratios of S_{max} to P_{max} with respect to the superposed epicenter.

Next, the ratios of the maximum amplitude of the P wave part to the maximum of the S wave part obtained by vertical seismograms at the six stations are examined. The azimuthal distribution of the ratios with respect to the superposed epicenter is shown in Fig. 7. This figure does not give the remarkable feature that the ratio is maximum in the direction of nodal lines, and minimum in the direction of 45° from the nodal lines. However, this figure shows the tendency to the force system of the double couple. The lack of clearness of the tendency can be understood by the facts mentioned below. Because the seismographs at the six stations are of vertical type, only SV waves are recorded. When SV waves are incident at the earth surface, the reflected P and SV waves are generated and so the ground motions become very complex. Another reason is that the fault is considered to be generated by not only the strike slip but the dip slip. The quantitative study on this problem will be carried out in future.

5. Conclusion

The distributions of the epicenter and focal depth as for the micro-earthquakes in the vicinity of Kyoto do not changed their tendency according to the analysis of the data obtained after the previous studies. The push-pull distribution of the first motion of S waves shows that the force system acting on the focus is due to the double couple for most earthquakes. Unexpectedly the focal mechanism is very simple.

We suppose that these conclusions do not change the tendency in future.

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