206. Seismic Activity under the Volcanic Area

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1. Foreword. It is well-known that there are close relationships between seismic and volcanic activities, and the superposition of a volcanic zone, in general, upon a seismic zone of about 150 km depth is recognized. In respect of this problem, the present investigation is made into the seismic activity within the areas of active volcanoes and their circumferences in Japan, and a particularly detailed investigation is made for the volcano Asama.

2. Large-scale earthquakes and the distances from a volcano. Regarding the earthquakes with seismic magnitudes (M) of 5 and over in the period from 1926 to 1960, calculation of the total seismic energy has been executed for those earthquakes that occurred within the circles centered at Mt. Asama and with their radii of 50, 75, and 100 km, respectively; the calculated values of total energy show little difference between the circles of 100 and 70 km radius, but the value for the circle of less than 50 km is one-third of what is expected from the value for the 100 km circle. This is due to the fact that earthquakes with larger M’s do not occur in the 50 km circle.

Heretofore it has been recognized by seismologists that earthquakes of large magnitude are difficult to occur at places near to a volcano, and the present authors have studied on the present status of knowledge in this respect, using the

Fig. 1. Distribution of the epicenters of major earthquakes and active volcanoes (1868-1965). Circles show 50 km area from volcanoes.
seismological observational data hitherto. Results obtained are shown in Fig. 1 where the circles indicating the areas less than 50 km distant from principal volcanoes (28 in number) and all the earthquakes of $M \geq 6.5$ which occurred in the period from 1868 to the present time are plotted. Such earthquakes are 70 in number, and out of them, those which occurred in the areas less than 50 km distant from principal volcanoes are only 4, as follows: near the Island of Miyakejima in March 1900 ($M=6.8$), near the Island of Oshima in June 1905 ($M=7.0$), near Mt. Tarumae in July 1910 ($M=6.5$), and near Mt. Unzen in December 1922 ($M=6.5$); and supposing $M \geq 7.0$ only one earthquake is found in such areas. In regard to this fact, an investigation on the old seismic records earlier than the commencement of seismological observations also reveals almost the same tendencies. It can be said namely that major earthquakes are difficult to occur in the area around a principal volcano, less than 50 km apart from the volcano. Relation between the magnitude and the distance is as shown in Fig. 2. Major earthquakes have a tendency to occur at larger distance from an active volcano, but they are difficult to occur at distances larger than 400 km.

Fig. 3 shows the changes in the kinetic energy owing to eruptions of Mt. Asama and in the energy of earthquakes which occurred within the above-mentioned circles, obtained from integrations at intervals of two years, for the period 1934-1951. It is generally
expected that very near to a volcano there will be a tendency of decreasing seismic energy with increasing of eruption energy, but this cannot be distinctly known from the present statistics.

3. Vertical distribution of earthquakes around a volcano. For the earthquakes of M ≥ 5 which occurred in the period from 1926 to 1960 at less than 100 km distances from Mt. Asama, the relation between the distance from this volcano and the depth of the focus is shown in Fig. 4. The following may be said from this figure:

i) In the area of a circle centered at Mt. Asama and being 60 km in diameter, no earthquake of M = 5 and over occurred in the 35 years of the period mentioned above.

ii) As the depth of focus increases, beginning from 30 km, the distance of epicenter from the crater decreases, but this distance increases, having its turning point at the depth value of about 150 km. This may be naturally expected for the earthquakes with their epicenters in the E–W direction of Mt. Asama, but this cannot be changed even by taking account of earthquakes in the N–S direction additionally.

iii) Underneath the volcano, at the depths of 30 km to about 100 km there is a part where no occurrence of earthquake is seen, and this is considered to have some relation with volcanic activity.

Results of quite the same investigation conducted for Mt. Mihara, Mt. Fuji, and Mt. Aso are shown in Fig. 5. For Mt. Mihara, a systematic distribution is not so distinct, but for Mt. Fuji and Mt. Aso, the distributions are similar to that for Mt. Asama. For Mt. Fuji, however, shallow-focus earthquakes are seen also at the distances of about 10 km from the crater, and the distances less than 50 km from the crater have earthquakes with focal depths of 40–60 km, and in these respects the distribution is somewhat different from that for Mt. Asama. As for Mt. Aso, there exists a part where earthquakes are difficult to occur at the distances less than 20 km from the crater and at the depths of 30–100 km, which is similar to the case
Partitions of earthquake distribution are varying with volcanoes, distinct for one volcano, and not so for another; this is considered to be partly due to the difference in the viscosity of magma. As to the nature of lava, it is known that the SiO$_2$ content is decreasing in the order of Mt. Asama, Mt. Aso, Mt. Fuji, Mt. Mihara, and in accordance with this the viscosity decreases.

The above-mentioned are for the earthquakes of M$\geq$5, but in the observational data of the 5 years beginning from 1955 we can hardly find any earthquakes which are presumable to have occurred at the distances less than 30 km from the crater, even among all the felt earthquakes (to be considered as M$>$3). However, during the period from November 1958 to April 1959, when the activity of Mt. Asama was vivid, we have 7 felt earthquakes which are due to eruption itself.

4. Distribution of volcanic earthquakes. According to the data taken by the Karuizawa Weather Station in the period from October 1957 to December 1964, 98%
of all the volcanic earthquakes of Mt. Asama have occurred in the above-mentioned zone where none of felt earthquakes occur. This is more evidently shown by the study of Prof. T. Minakami, which indicates of less than a few kilometers from the crater, as is shown in Fig. 6.

5. Conclusion. In order to summarize the above-mentioned state of earthquake distribution around Mt. Asama, Fig. 4 has been made up. Of course the region where earthquakes are difficult to occur is, in fact, not a circle centered at the crater, but tentatively presuming it to be a circle of a radius of 30 km. On the other hand, based upon the study made by the Explosion Research Group, the depth of Moho-layer in the vicinities of Mt. Asama is assumed to be 30–35 km, and accordingly, the volume of the part which is located around Mt. Asama and shallower than the Moho-layer, and where earthquakes are difficult to occur, is calculated to be about \(8.5 \times 10^{19}\) cm\(^3\). Furthermore, the magnitude of volcanic earthquake is said to be 6.0 or so at the maximum, and in the case of Mt. Asama the largest earthquake caused by its eruption is considered to be that of May 1910 (M=6.0). From this, the energy of strain per cm has been calculated to be about 10 ergs, which is by far smaller than the value obtained by Prof. C. Tsuboi.

Accordingly, it can be said that the ground underneath a volcano is a place where smaller quantities of seismic energy are stored, or a place where earthquakes do not so often occur.

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References