Unzen Volcano : the 1900-1992 eruption

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19. Earthquake Observations at Mt. Mayuyama

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Introduction

Mt. Fugen, one of the Unzen volcanoes, has continued to extrude lava since 20 May 1991. At the time of the last eruption at Mt. Fugen in 1792, Mt. Mayuyama, situated at the east of Mt. Fugen, experienced an extensive landslide caused by two large earthquakes, of which magnitude are estimated at $M=6.4$. Historical documents record that the landslide occured four months after the cessation of the eruption at Mt. Fugen and that the avalanche reached the Ariake Sea and caused a large tsunami. About 15,000 people were killed by the avalanche and the tsunami, which is the worst record of volcanic disasters in Japan. If a landslide would take place again at Mt. Mayuyama, an expected disaster will be far beyond the record, because the population in the area is much greater than that in 1792.

The purpose of this study is to examine the possibility of a landslide at Mt. Mayuyama and to predict it if it will take place. The most important thing is to prevent loss of life due to the collapse of the mountainside. We have been making observations of earthquakes and the strain of mountainside at Mt. Mayuyama, which are useful phenomena forecasting a landslide, although it is very difficult to find the sign of landslide in its early stages. Based on these investigations, we will present a new analytical method of the mechanical strength of Mt. Mayuyama.

Observation methods

We are making earthquake observations at two locations shown in Fig. 19-1. One (Point B) is the Shimabara Earthquake and Volcano Observatory of Kyushu University, and the other (Point A) is located on the northeast mountainside of Mt. Mayuyama, where a landslide is most likely to occur in future. Ovservations at Point A is for investigations of the earthquake behaviour at Mt. Mayuyama, and those at Point B for analyses of seismic waves through the mountain bedrock. One set of seismographic instruments can measure accelerations in three dimensions at the same time and this system can cover wide ranges of acceleration, frequency and strains. We located a landslide meter near Point A, which consists of three steel wires about 40 meters long and measures strains at the surface of the slope. The measurement interval is two hours and a trigger is set for the sudden changes above $\pm 25\,\mu$ due to earthquakes. Data obtained from the seismographs and the landslide meter have been sent to Kyushu University by an extensive digital line and analyzed.

Observation results

One of the epicenter dimension of an earthquake has been determined as follows:

Occurrence 23:17, Nov. 23, 1991

Focus 33°06'N, 130°27.3'E (Southern part of Fukuoka Prefecture)

Depth 9,000 m

Magnitude $M=3.8$

Figure 19-2 shows the time history of the above earthquakes measured at Mt. Mayuyama. The maximum acceleration was 2.5 *gal* in the N-S direction. Figure 19-3 presents the power spectrum, showing the frequency characteristics of seismic motion at Mt. Mayuyama. Data obtained from the landslide meter does not show significant strains of the slope even during the earthquake.

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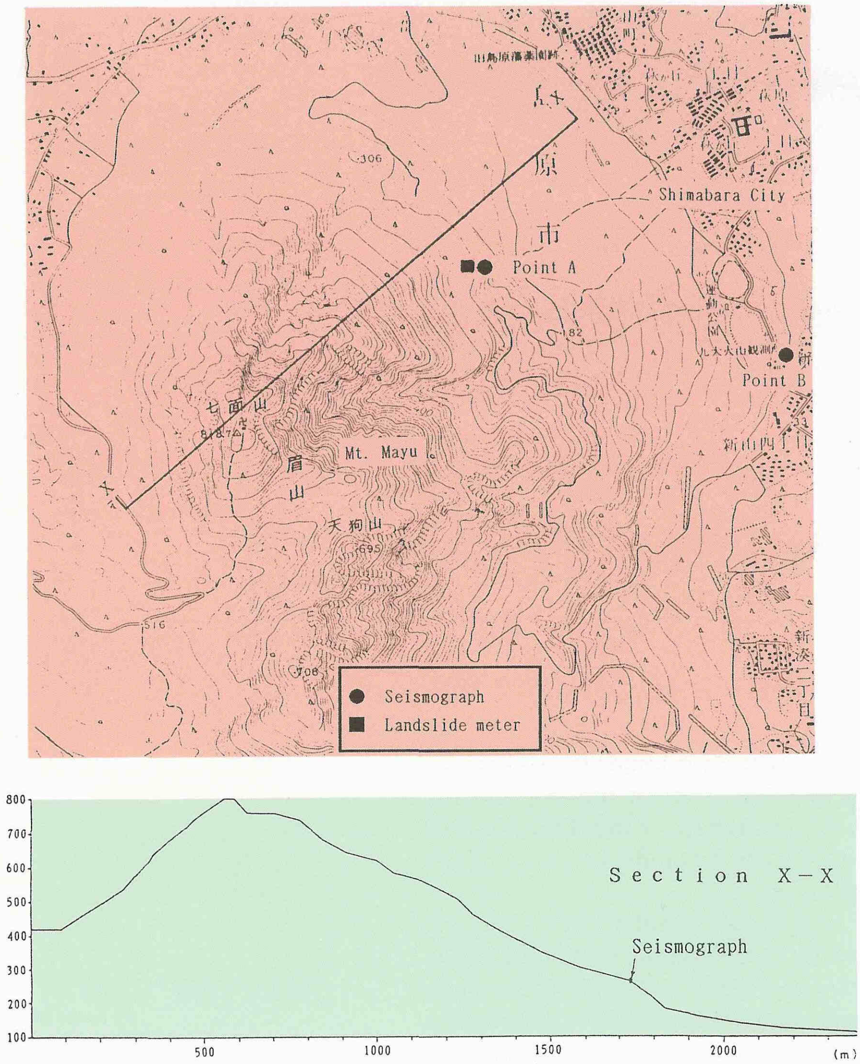

Fig. 19-1. Planimetric map and observation points.

Failure analysis

To examine the possibility of the slope failure at Mt. Mayuyama, it is important not only to continue the observations of earthquakes and landslides, but also to study the dynamic characteristics of Mt. Mayuyama. There is little information concerning the geological data and material properties of this slope. However, dynamic failure analysis can be improved and reinforced, if combined with observed seismic data. We will present here one possible process for failure analysis, which is schematically outlined in Fig. 19-4.

We will model the slope of Mt. Mayuyama as an assemblage of many "elements" for computation by means of finite element method. Definition of such elements depends on an elastic material behaviour, a damping factor, and so on. The mechanical responses of these elements to the earthquake can be computed based on data of the seismic waves through the bedrock obtained at Point B. Comparing the acceleration recorded at Point A with the computed accelerations, we can get useful information to improve computational parameters describing mechanical properties of the elements. Repeating this procedure

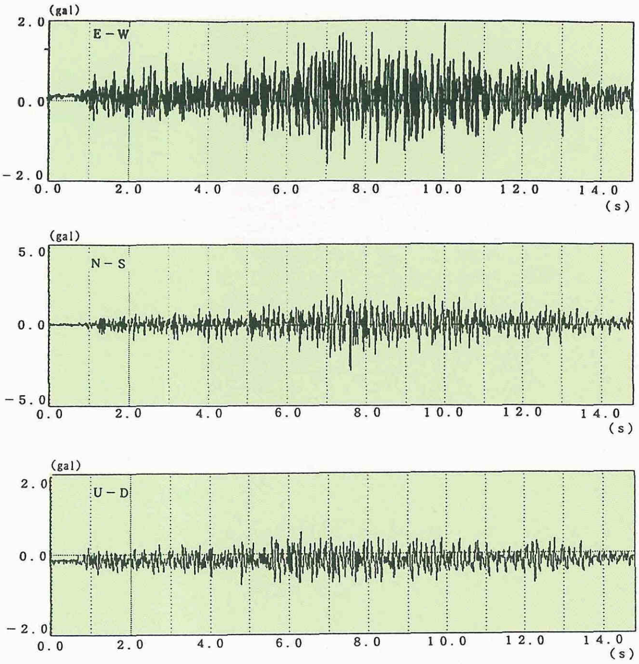

Fig. 19-2. Time history of observed earthquake.

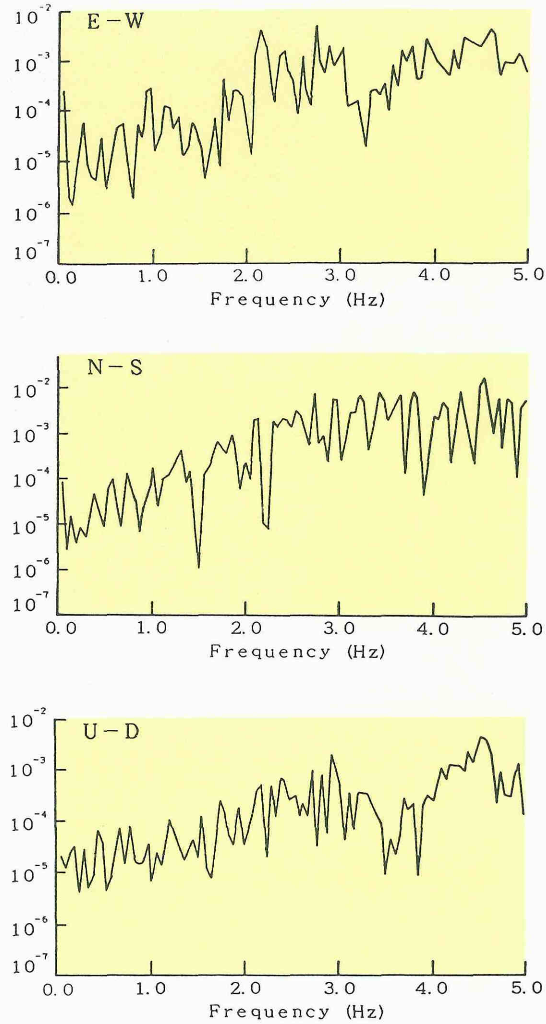

Fig. 19-3. Power spectrum of observed earthquake.

will enable us to precisely estimate the soil profile and dynamic characteristics of the slope in the linear range. If the strength of the slope material can be known by some methods, we can compute failure acceleration.

Here we have to consider an additional important factor controlling the slope failure: the underground water level. It will significantly affect the mechanical strength of Mt. Mayuyama and make it difficult to evaluate the possibility of the slope failure exactly.

Conclusion

To estimate the conditions required for the slope failure of Mt. Mayuyama, local earthquakes and landslides have been observed. No sign of a failure has been found by now. However, no one can deny the possibility of slope failure by earthquakes, even after the volcanic eruption will have ceased. So we have to keep the careful observations to get any signs of slope failure. It seems impossible to make a long-range forecast for the slope failure, however, we believe that the careful observations make a short-range forecast possible.

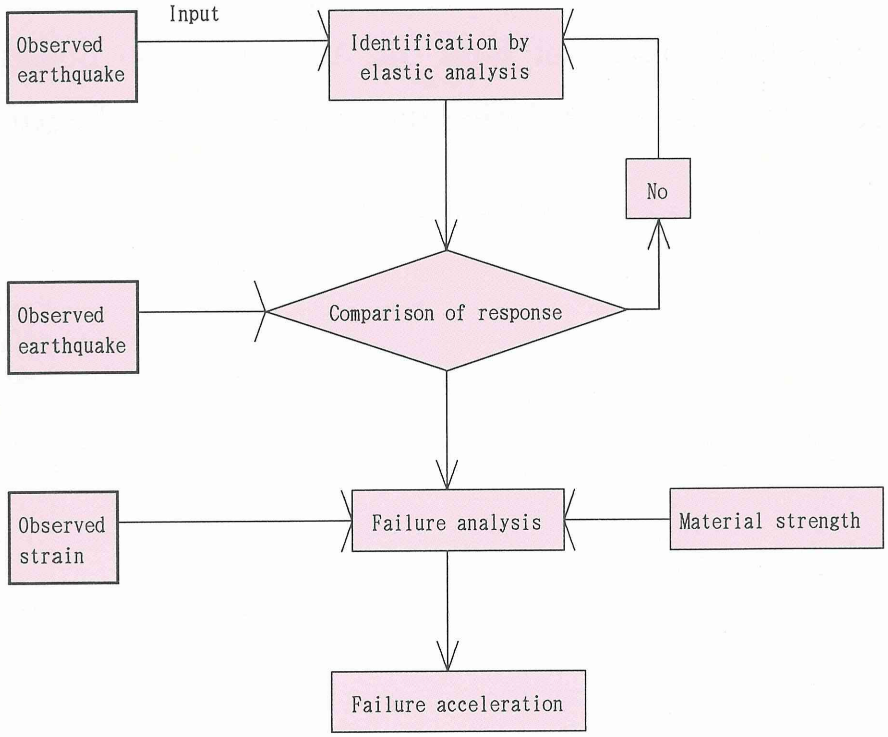

Fig. 19-4. Analysis procedure.