5. Activity of Fuji Volcano

Mt. Fuji is the largest active stratovolcano in Japan. It reaches 3776 m above sea level, making it the highest mountain in Japan. The diameter of its base is about 50 km. It is located about 100 km west of the Tokyo metropolitan area. Geologically, Mt. Fuji is a relatively young volcano, with two volcanic histories: the older Fuji (80,000 B.P. to 11,000 B.P.) and the younger Fuji (11.000 B.P. to the present) (Miyaji *et al*., 1992). Both eruptive materials are basically basaltic in composition (Takahashi *et al*., 1991). Historic records indicate 10 clear eruptions since 782 AD (Koyama, 1998). The most recent eruption is the "Hoei Eruption" occurring in 1707 AD, which was a plinian type eruption with total ejecta of about 1 km^3. No eruptions have been recorded in the approximately 300 years since the Hoei event.

Although surface volcanic activity has been quiet in recent years, swarm-like mid-crustal low-frequency earthquakes were observed in 2000 and 2001. Because they were not accompanied by any phenomena directly warning of eruption or the upward movement of magma, it was reasonably considered that this activity was limited to the mid-crustal depth. The Subdivision of Geodesy of the Council for Science and Technology, partly due to the high degree of public interest in the volcanic activity of Mt. Fuji, presented a report comprising a plan for the improvement of understanding the volcano which proposed the setting up of observational networks. This section briefly describes the low-frequency earthquake activity seen in Mt. Fuji in 2000 and 2001, based chiefly on observations made by the National Research Institute for Earth Science and Disaster Prevention (NIED).

Low-frequency earthquakes have been detected in Mt. Fuji since the early 1980s, when seismic stations were installed in the surrounding area as part of several earthquake prediction research programs (Ukawa and Ohtake, 1984; Kanjo *et al*., 1984; Shimozuru *et al*., 1986). They were located at depths ranging from 10 to 20 km around the summit. Those were the first clear observations of low-frequency earthquake activity in the mid-crust beneath a volcano in the subduction regime. Since then, low-frequency earthquakes in the depth range from mid-crust to the uppermost mantle have been reported in many volcanic areas in Japan and other countries (for example, Ukawa and Ohtake, 1987; Hasegawa *et al*., 1994; Hill, 1996; White, 1996). We call them deep low frequency (DLF) or deep long period (DLP) earthquakes.

The DLF earthquakes at Mt. Fuji have been continuously monitored by NIED, the Earthquake Research Institute of University of Tokyo (ERI) and the Japan Meteorological Agency (JMA) since the 1980s. The observation sites are shown in Fig. 1. Monitoring over the last 20 years has revealed that the ordinary activity of DLF earthquakes was low in both magnitude and occurrence number during the 1980s and 1990s. In the fall of 2000, however, the number of DLF earthquakes increased sharply, with the high activity lasting until May 2001.

A DLF event usually lasts several minutes or more, and consists of a series of small DLF earthquakes. Fig. 2 is an example of a seismogram of a DLF earthquake in comparison with an ordinary tectonic event in the same region. The amplitudes of the DLF earthquakes are in the micro-earthquake range, and since the start of the monitoring, no event larger than *M*3 has been observed. The predominant frequencies of most events range from 1 to 3 Hz, far lower than the expected predominant frequencies of tectonic earthquakes of the same magnitude range.

Since the DLF earthquakes at Mt. Fuji have a tendency to arrive in a series, it is difficult to count their number because the coda waves of successive events often overlap. For this reason, NIED treats one continuous vibration in a seismogram as a single event. We measure the duration time and maximum amplitude of each event and draw diamond diagrams to express the activity (Ukawa and Ohtake, 1984). Fig. 3 is a diamond diagram of activity since 1980 recorded by NIED, showing each event as a diamond (width=maximum amplitude and height=duration time).

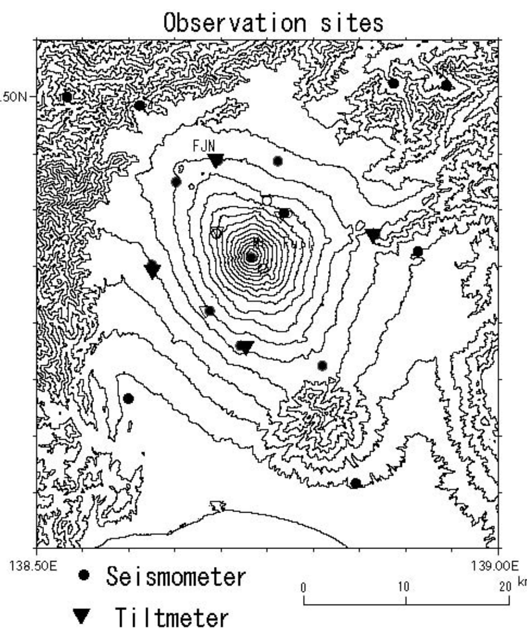

Fig. 1. Map showing permanent observation sites with seismometers and tilt-meters belonging to NIED, ERI and JMA. Solid symbols indicate stations installed before the 2000 high DLF earthquake activity, and open symbols are those installed from 2001 up to now (April 2003).

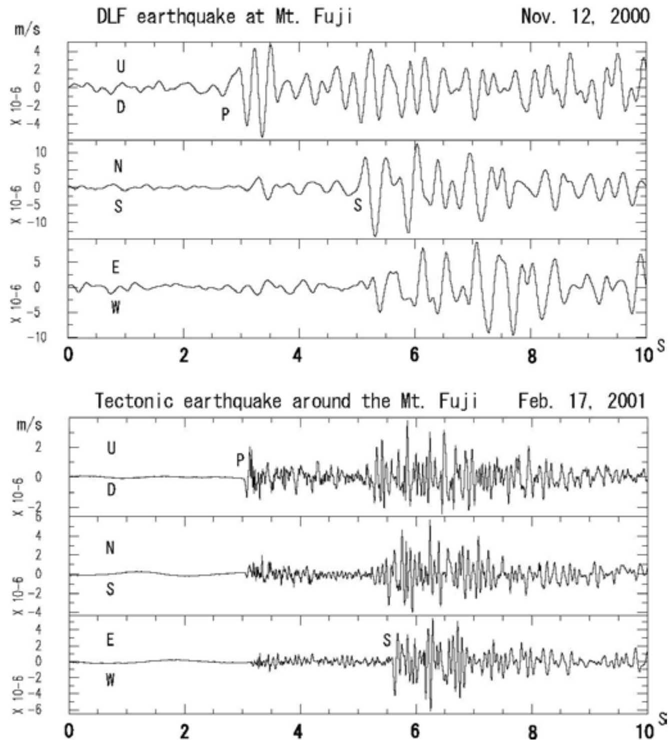

Fig. 2. Examples of three component seismograms of the DLF at Mt. Fuji in comparison with those of a tectonic earthquake around Mt. Fuji. The seismograms were recorded at FJN station of the NIED observation network.

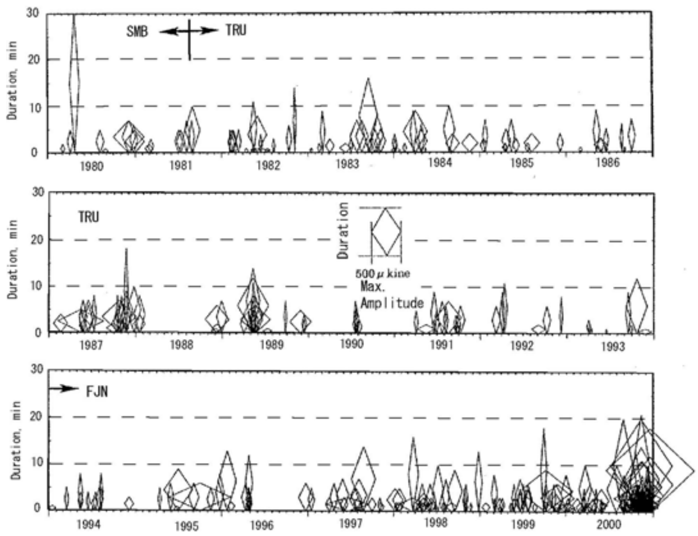

Fig. 3. A diamond-diagram showing the DLF earthquake activity during the period from 1980 to 2000 (NEID, 2002). The height of a diamond indicates the duration time of the successive DLF earthquakes, and the width indicates the maximum amplitude during the event. The duration time and maximum amplitude are measured on the seismograms of mainly TRU and FJN in Fig. 1.

During the period 1980-1999, the total number of DLF events was 274, while in 2000 and 2001 the DLF events numbered 180 and 172, respectively. The duration time of the longest event is 30 minutes and the magnitude of the largest event is in the *M*2 class. Fig. 4 shows the cumulative number of DLF events, indicating that the occurrence rate in the 1980s and in the early 1990s is fairly constant with some small step-like increases, seen for example in 1987 and 1989. The rate slightly increased from the middle of 1990s. This change is due to the improvement of observational networks around Mt. Fuji. The abrupt increase from October 2000 to May 2001 is the most distinctive change since the start of the observation.

The DLF events have been located at 2–4 km northeast of the summit in the depth range 10–20 km. Fig. 5 compares the hypocenter distribution from April 1995 to July 2000, pre-swarm period, with that from August 2000 to July 2001. No significant change is recognized either in the epicenter or focal depth.

In the active period of the DLF earthquakes, tectonic earthquake activity in the Mt. Fuji area increased slightly. In Fig. 5, clusters of

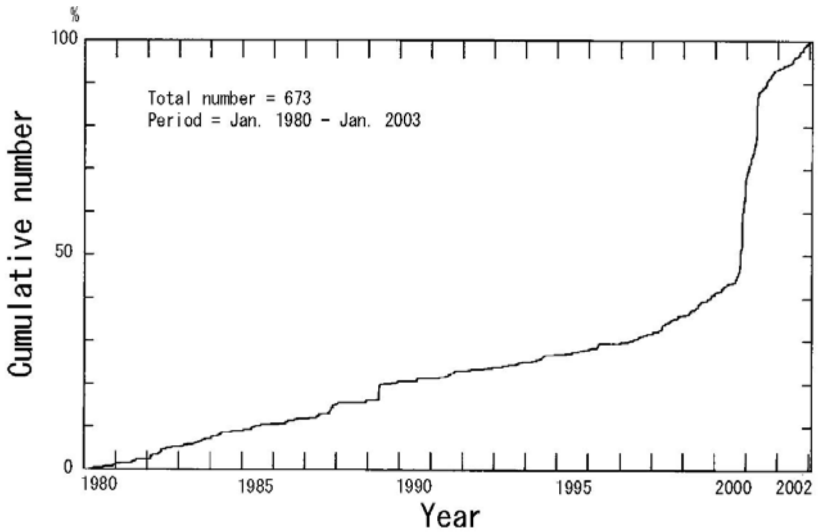

Fig. 4. Cumulative number of the DLF events from Jan. 1980 to Jan. 2003. The dataset is the same as those in Fig. 3.

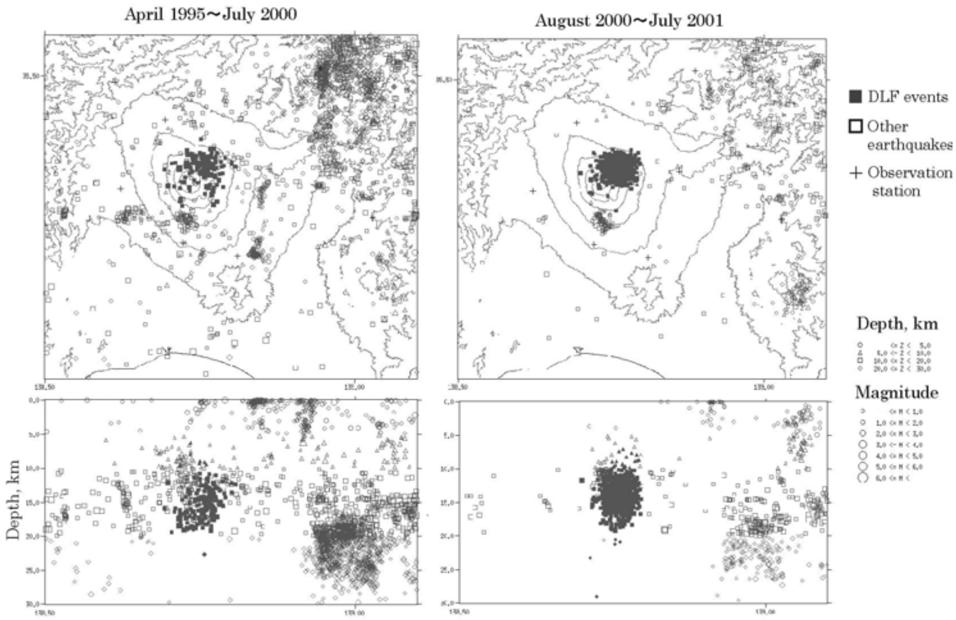

Fig. 5. Hypocenter distribution maps around Mt. Fuji determined by the NIED. The left is the hypocenters from April 1995 to July 2000, and the right is those from August 2000 to July 2001, which includes the period of the high DLF earthquake activity. The solid symbols indicate the DLF earthquakes.

tectonic earthquakes can be seen at the southwestern flank of Mt. Fuji. The focal depths range from 8 to 12 km. The low-level activity of these tectonic events probably indicates minor stress change beneath the volcano. No volcanic tremors, large earthquake swarm activity or abnormal crustal deformations were detected in or around Mt. Fuji in this or any other period. Since the abnormal activity was limited to the mid-crustal depth beneath the volcano, we concluded that magma did not migrate upwards.

In response to the report on the observation plan of Mt. Fuji presented by the Council for Science and Technology in 2001, the JMA has installed new seismic stations in high altitude areas, and the ERI is constructing three borehole stations with seismometers and/or a tilt-meter on the northeastern middle flank. The GSI has installed several GPS stations around Mt. Fuji, including the summit, and the NIED is constructing two borehole observational sites with tilt-meters and seismometers on the mid-flank of the volcano. This development of observational networks is undoubtedly contributing to the improvement of monitoring volcanic activity and of research into the volcano. The Coordinating Committee for Prediction of Volcanic Eruption has formed a working group to address topics related to expected phenomena if future eruptions occur, especially focusing on the potential for Hoei-type eruptions, and on the recommendation of a suitable observation network.

Concerning the hazard mitigation aspects of Mt. Fuji, the Committee for the Hazard Map of Mt. Fuji has carried out a two-year project, starting in 2001, to study past volcanic hazards around Mt. Fuji and to establish methods for hazard mitigation in the Mt. Fuji area. A variety of volcanic hazards is expected during future eruptions of Mt. Fuji, including lava flows, ash falls, pyroclastic flows and debris flows. To evaluate these volcanic hazards, the committee has summarized previous studies and carried out onsite geological research to improve the database.

Hazard mitigation plans for affected local governments will be designed based on the Committee's final report.

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