Abstract

The Meteorological Research Institute has conducted volcanological research for the purpose of prediction and disaster prevention of volcanic eruptions. It is effective for the prevention and mitigation of such disasters to detect phenomena preceding eruptive activities and to cope beforehand with their occurrence.

It has been known that extraordinary variations of ground & crustal deformations, seismological events, volcanic cloud ejections, geothermal activities, etc., occur as precursory phenomena of volcanic eruptions. It will be possible to predict the occurrence time, location, magnitude, etc., of volcanic eruptions by precise measurements and analysis of these phenomena.

We have conducted the investigations in the 1 st and 2 nd National Projects for Prediction of Volcanic Eruptions (1974—1978 and 1980—1983), assuming that the various accompanying phenomena and their occurrence sequences from the beginning of underground activities of magma till the occurrence of eruptions will take place on the following simple model.

Volcanic Activities from the Underground Magma Activity till the Occurrence of Volcanic Eruptions, and Their Observations and Research

(1 st Stage)

The subground magma reservoir begins to vibrate by activation of volcanic activity.

Research item: Observation of long-period seismic waves.

* Observation of vibrations of magma reservoir by volcanological long-period seismograph (1982—1983)
* Others.

(2 nd Stage)

Then, the magma reservoir expands and/or ascends.

Research item: Crustal and ground movements observation.

* Ground surface strain measurements by geodimeter (1974—1978)
* Tilt observation of volcano edifice by tilt meter (1974—1978)
* Underground strain observation by volcanological volume strain meter (developed in 1983)
* Others.

(3 rd Stage)

By successive ascent of magma, underground materials are destroyed and volcanic earthquakes occur.

Research item: Seismological observation.

* Observation of volcanic earthquakes and tremors by short-period seismograph (routinely conducted by the Japan Meteorological Agency at designated volcanoes. The materials were used in our investigations).
* Others.

(4 th Stage)

Magma and volcanic gases approach the ground surface, the geothermal temperature increases, and an active ejection of volcanic clouds occurs.

Research item:Visual observation of volcanic clouds and field inspections.

* Observation of volcanic clouds by means of remote sensing techniques (using wavelengths of visible, infrared and ultraviolet, 1980—1983).
* Thermal inspections in and around active craters by aerial and ground measurements (1974—1979).
* Others.

(5 th Stage)

Occurrence of volcanic eruptions.

Research item:Observation of long-period seismic waves.
Observation of crustal / ground deformation.
Seismological Observation.
Visual observation.
Field inspection.

As volcanic activities are complicated, eruption does not always take place after the occurrence of the phenomena listed in the l st to the 4 th Stages in the table above. It is likely that some of the forerunning phenomena fail to occur or the order of occurrence may change. Though there are some complicated problems, the measurement items of long-period seismic wave observation, crustal/ ground deformation measurement, seismological observation, visual observation and field inspection shown in the above table are important and fundamental techniques for volcanological surveillance.

In this special research, Investigation on the Techniques for Volcanic Activity

Surveillance (1980—1983) conducted under the 2 nd National Project for Prediction of Volcanic Eruptions, developments of the techniques for quantitative and dynamic measurements of volcanic clouds, for observations of long-period vibrations generated by magma reservoir activities and for observation of underground strain have been conducted on the following three research items:

a. Investigation on Quantitative Measurements of the Surface State of Volcanoes by Means of Remote-sensing (1980—1983)
b. Investigation on Detection of Activity of the Magma Reservoir by Volcanological Long-Period Seismograph (1982—1983)
c. Development of the Volcanological Volume Strain Meter (1983)

The results of these investigations, as reported in the respective sections in Chapter 1, are in brief as follows:

a. It was confirmed that the system developed can observe the state of volcanic clouds more precisely than the conventional visual observations. In the case of the conventional observation method, the height of volcanic clouds has been observed in the order of 100 m, and the expanded volcanic clouds (quantity) have been observed in seven. However, the newly developed system can measure the height of volcanic clouds in 10 m order, and can measure the expansion of clouds in the order of 100 m^2. Furthermore, the techniques for measuring the surface temperature of rising volcanic clouds and concentrations of SO_2 gases in clouds, which have not been carried out by the conventional method, were developed.

The volcanic activity of Aso Volcano where this research was carried out was in a calm state throughout the investigation period. However, remarkable annual variations of the quantity of rising volcanic clouds, which is very great in the winter season, i.e., about 10 times the quantity of the summer season, were observed. The surface temperature of volcanic clouds (at around the crater-rim or at a height of about several tens of meters above the crater-rim) also indicated a clear annual variation showing higher temperatures in summer and lower in winter. These phenomena are due to meteorological effects. There was a tendency of some increase in SO_2 concentrations in winter. The SO_2 measurements were carried out in rising volcanic clouds at positions slightly above the crater-rim.

The results of measurements of volcanic clouds by the new system during this research-work period are shown below. Values in parentheses are mean ones.

Height: 50—200m (120m)

Width: 50—220m(140m)

Vertical profile: 5×10^3—4×10^4m^2 (2×10^4m^2)

Estimated volume: 1×10^5—5×10^6m^3 (2×10^6m^3)

Velocity of rising cloud: 1—8m/sec (2.7m/sec)

Temperature: 3—23°C (13°C)

SO_2 concentration: 100—650 ppm-m (310ppm-m)

The quantity of water vapour ($\dot{W}$), thermal energy release ($\dot{Q}$) and quantity of SO_2 gases ($\dot{G}$) ejected by volcanic clouds were estimated as $\dot{W}=7\times10^3$ton/day, $\dot{Q}=5\times10^7$ cal/sec and $\dot{G}=11$ ton/day, respectively.

b. At volcanoes, it is very difficult to operate stable and continuous seismological observations for long-period seismic waves by existing long-perid seismograhps using heavy pendulums, which are apt to lose their balance owing to disturbances of large variations of airtemperature and ground tilts on the slope at great altitudes. For the present research, a new type of long-period seismograph, called Volcanological Long-Period Seismograph, has been developed. This seismograph, combining the exising 2-second period electromagnetic transducer and the electrical feedback system, is a stable 10-second period displacement type seismograph.

By continuous observations with this seismograph at Aso Weather Station, long-period (6—10 seconds) volcanic seismic wave-trains (the second kind of volcanic microtremor), which have not been well detected by the conventional short-period seismographs, could be registered very well. This type of volcanic tremor has been considered to be generated by the vibrations of the magma reservoir. During the research work period, the volcanic activity of Aso Volcano has been calm, and the occurrence frequency of the second kind of volcanic microtremor was several—150 times / month.

c. Usually, a large horizontal distance strain of 10^{-5} / year takes place in active volcanic regions, and possibly there are high underground temperatures with their time variations. The newly developed volume strain meter is operable under a large strain of 10^{-5} and a time variation of ground temperature of 0.3°C. The strain meter sensor, designed so as to be installed in a drill hole, is composed of three units: the volume strain meter, the very high resolution thermometer using the same princple as the

volume strain meter and the diode thermometer, all three encased inside a pressure-proof cylinder. The amplification and control system is operated on the ground and has almost the same characteristics as the bore-hole type volume strain meter in operation for the purpose of earthquake prediction. The newly developed strain meter is called the Volcanological Volume Strain Meter. The resolution of ground temperature by the diode thermometer is 2/1000°C.

The performance of the strain-meter subjected to experiments in various temperatures and water-pressures conducted in the 100 m deep observation well of the Meteorological Research Institute showed satisfactory results for operation in volcanic regions.

In 1979, during the period of this research, there were two remarkable eruptions of Aso and of Ontake Volcanoes. The 1979 Aso Eruption was the one of the greatest of recent activities. The eruption caused victims near the crater and big damage to constructions around the crater. A large quantity of ashes was distributed over a wide area. The 1979 Ontake Eruption was the first event in the history of this volcano, an utterly unexpected one for this volcano where there had been no routine observation facilities.

The researches for both volcanic eruptions were conducted by the fund of the National Science and Technology Agency and the variations of thermal state in and near the active craters after the eruptions by air-borne infrared thermoscanners were investigated. The results of those investigations, which are reported in Chapter 2, are in brief as follows;

In the research on Aso Volcano, the relations between the state of volcanic activity and thermal activity were inspected by analyzing the observation results and the existing materials on thermal activities of this volcano. Through this analysis, it became clear that the thermal activity in 1980 was at a high level.

In the research on Ontake Volcano, the first thermal inspections of this volcano were done. Existence and locations of high-thermal anomalies were detected at eruption sites and on the upper slope of this volcano. The time variations of shape, state and intensity of the high-temperature areas from December, 1979 through March, 1980 were analyzed. Through this investigation, a technique of image analysis to process geographical corrections of infrared images by using visible MSS images was newly developed. Then, the distributions of ashfall areas etc. were also investigated and the results were used in assessing the state of volcanic activity of this volcano.