

## Report of Emergency Survey Group of Usu Eruptive Activity on March 31, 2000

### Detail of volcanic activity, damage caused, emergency communications, And evacuation operations

#### Ikuo TOHNO

Member of JSCE, Dr. of Eng.,  
National Institute for Environmental Studies

#### Hiroshi IMAI

Member of JSCE,  
Dr. of Science, Taisei Corporation

#### Hideaki INAGAKI

Member of JSCE,  
Kankyo Chishitsu Corporation

#### Toshitaka KATADA

Member of JSCE, Dr. of Eng.,  
Associate Professor, Gunma University

#### Summary of the survey group

Usu Volcano restarted its activity with an eruption occurred at the western foot of Mt. Nishiyama at 1:07 p.m. on March 31, 2000, after the repose time of 23 years since the activity during 1977-1978. The following day, April 1, four representatives Times of Volcanic Engineering Subcommittee arrived at Muroran City as an emergency survey group to carry out a three-day survey of conditions associated with the eruptive activity in the early stage. The same group members performed the further survey during May 13-15, to investigate about the change in the observation circumstances, in the evacuation operations, and in the eruptive activity.

#### Past eruptive activity on Usu Volcano

Usu Volcano is a double volcano lying at the southern rim of Toya caldera located at the southern part of Hokkaido in Japan. Usu Volcano is a small stratovolcano with a somma of 6 km in diameter and has nine lava domes and cryptodomes. The volcano is active and dangerous and has erupted seven times in the last 300 years. It is thought that the formation of the volcano was in the alluvial epoch (approximately 15,000-20,000 years ago). The volcano repeated the production of basaltic and andesitic lava flows and scoria eruptions, and formed a cone-shaped konide-type volcano as similar to Mt. Fuji in Honshu and Mt. Yotei in Hokkaido. The major summit collapse occurred approximately 5,000-8,000 years ago, turning the somma into a horse-shoe-shaped crater open to the south. Zenkoji mudflow

distributed around Usu Station (southern foot), a myriad of mudflow mounds around Zenkoji (temple located at southeast), and isles in the nearby bay are all remains of large blocks from the collapse peak.

The volcano lay dormant for a long period after the big collapse. During the period, there was a significant petrological change in magma and the styles of eruptions occurred during 1661 to 1663 became explosive due to the rhyolitic magma with viscosity high 1,000 times more than andesitic magma. In this activity, approximately two billion cubic meters of rhyolite pumice was blown out to a great height, and the part of it traveled far to the east and finally was deposited on Tokachi Plain. At that time, a small caldera whose size is 1.2 km in diameter was formed instead of cone-shaped summit, and thereafter, Ko-Usu lava dome was made in the caldera.

Further eruptions were observed in 1769, 1822, 1853, 1910, 1943-1945 and 1977-1978, indicating that the volcano erupted at the interval of 30 or 60 years. The magma relative to these eruptive activity was of dacite and the volcano spewed out an enormous quantity of ash at each eruption, then forming lava domes and cryptodomes: O-Usu in 1853, Yosomiyama (Meiji Shinzan) in 1910, and Showa Shinzan in 1943-1945. The activity in 1977 to 1978 was started at the first eruption on August 7 and volcanic ash fell down in Sapporo about 80 km directly far from the volcano. On the following day, large quantities of pumice were ejected toward Lake Toya. Ground level in the atrio rose remarkably and Usu Shinzan was created rear Ogariyama. As the record of damage by the volcano, the 1822 eruption resulted in approximately nine million cubic meters of a high-temperature pyroclastic flow and

the victims were 150.

### **Time sequence of 2000 eruptive activity**

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Muroran Meteorological Observatory said that volcanic earthquakes were recorded from March 27 in the morning and became more active on March 28. This is because Japan Meteorological Agency (JMA) issued the first temporal information on Usu Volcano. On March 29, the magnitude of earthquakes increased gradually and the activity involved with earthquake swarms and some strong enough to be felt. Under these conditions, JMA announced the first emergency advisory on the volcano, suggesting that the volcano could erupt within a few days with high probability. A phreatomagmatic explosion took place at the western foot of Mt. Nishiyama at about 1:07 p.m. on March 31. And the plume of volcanic ash cloud reached a height of 3,000 m. This was the first successful prediction of volcanic eruption in Japan, where the past activity were carefully studied and an observation system was already in place.

### **Observations before eruption**

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Various kinds of observations had been performed before the first eruption on March 31. Earthquake activity had been closely monitoring, mainly by Faculty of Science of Hokkaido University and JMA. According to Muroran Meteorological Observatory, the occurrence of volcanic earthquakes began in the morning on March 27 and activities were more active on March 28. On March 29, a total of 127 earthquakes including 57 events strong enough to be felt were recorded in an hour between 5 to 6 p.m. Earthquakes at 5:22 p.m. and 8:01 p.m. on the same day measured intensity of five-week on the Japanese seismic scale of seven at the emergency observation station temporarily installed near Sobetsu hot spring resort between O-Usu and Showa Shinzan. Furthermore, volcanic earthquake swarm occurred continuously more than 32 hours at the northeast of the volcano. Considered that their hypocenters were stationary and their magnitudes were increasing, JMA issued the first emergency advisory on the volcanic eruption. On the other hand, the observation of the ground deformation by using Global Positioning System (GPS) operated by Geographical Survey Institute. This system indicated that Toyako-Onsen Junior High School, located at the lower northwestern flank of the volcano (near the lake),



Photo.1 Pumice floating on Lake Toya



Photo 2. Volcanic ash cloud of eruption at 2:00 p.m. on April 2

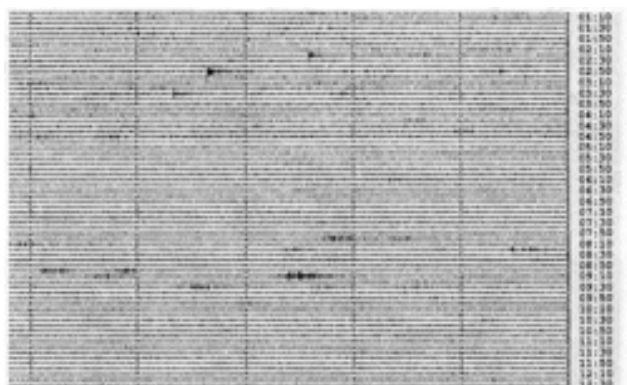


Photo.3 Seismogram recorded on May 12 (by Japan Meteorological Agency)

had moved approximately 15 cm to the west relative to western and southeastern the lake shore.

Hokkaido Geological Institute and Geological

Survey Station measured ground water levels in the area. At Nagawa district in Date City, the ground water level became higher more than 4 m after March 27 and there was a well overflowing a day before the first eruption.

### **Observations after eruption**

The observation system was bolstered by setting up the Usu Observation Team which was consisted of members from the associated universities and JMA. After the eruption occurred at the western foot of Mt. Nishiyama at 1:07 p.m. on March 31. At about 1:00 p.m. on April 1, a following eruption occurred at the northwestern foot of Mt. Konpira located at the south of the hot spring resort by the lake. Pumice blasted away at the eruptions during March 31 to April 2 fell on the lake, and drifted on the westerly wind, and washed up near Takinoue Campsite on the eastern shore of the lake early in the afternoon on April 2 (Photo 1). When the survey group was examining ash fall at Showa Shinzan district, an eruption took place about at 2:00 p.m. on April 2 (Photo 2). Its volcanic cloud rose up to about 2,000 m. Then the survey group was able to find out coarse volcanic ash fall deposit on their vehicles. Although the eruptions continued involving ash with juvenile material in volcanic cloud, the activity gradually decreased after April 2.

On the meeting of Usu Group of Coordinating Committee for Volcanic Eruption Prediction held on April 16, it was announced that they confirmed 32 craters on the western flank of Mt. Nishiyama and 19 ones on the northwestern flank of Mt. Konpira.

The headquarters of Usu Eruption Emergency Disaster Prevention, originally set up in Date City Office, moved to Matsugae district of the city as of May 12. Usu Volcano Observatory (UVO) of Hokkaido University had been carrying out emergency observation at Tateyama-cho. By this time, JMA's observation at fixed points indicated that the number of earthquakes had decreased after April 9 and thereafter remained unchanged. The amplitudes of pulsating vibrations increased momentarily and thereafter decreased gradually, and there was little change in period of the vibrations. The magnitudes of earthquakes were generally measured not more than three on JMA scale, and most were two or smaller. As to the distribution of hypocenters, most earthquakes were taking place under the west-southwestern part at the flank of south rim of Usu Volcano and

very few took place near the lake. The hypocenters were mostly 3 to 5 km in depth and there is the characteristics that the shallower their depths, the nearer to Mt. Nishiyama. Photo 3 shows a seismogram recorded on May 12 by JMA, indicated that seismic activity was at a low level.

May 12, observations of crustal movement near the craters of Mt. Nishiyama indicated that the ground was rising 10 cm per day. At the time, it was impossible to form a judgement as to whether the volcanic activity would terminate with a crater formation by volcanic explosion similar to the activity in 1910. Or it would terminate with effusions of enormous amount of volcanic ash and pumice, as with the plinian eruption of 1977, or as the worst case it would terminate with making pyroclastic flows or with the collapse of the body of volcano. Neither could it be predicted whether the rate of ground deformation would decrease and terminate the activity.

### **Damage caused by eruption**

The eruption caused damage as a result of upward crustal deformation and collapse of the ground due to volcanic earthquakes. Neither pyroclastic flows nor large-scale mud or debris flows occurred as of May 15. The outline of damage conditions around Usu Volcano is as shows in Fig. 1. No lava dome appeared to the ground surface and a latent dome affected the remarkable crustal deformations around the active four craters as of May 15 and those caused the damage to the buildings and the ground. The damage in the area can be characterized as follows:

- (1) Structures damaged by lifting up and deforming the ground resulted by the latent lava dome.



Photo 4. Damaged revetment and volcanic ash deposit at the hot spring resort on Lake Toya

- (2) Structures damaged by fallen rocks erupted from the volcano.
- (3) Bridges washed away by mud flows and other flood damage.
- (4) Deforming and crushing the structures by volcanic earthquakes.
- (5) Slope collapses and fallen rocks by volcanic earthquakes.
- (6) Damage to agriculture and forestry environments by volcanic ash fall.

Figure 2 and Photo. 4 show the conditions of the revetments by the lake near the hot spring resort on May 15. The quay wall was pushed toward the lake by earthquakes and lateral movement of the ground was confirmed in some place around there. The volcanic ash fall was 1 to 3 cm thick there and trees in the garden of a near hotel were damaged by the ash fall.

On the contrary, no significant damage was found in the area far from 1 km or more from the craters, associated with forming the lava dome, and the characteristics of the damages are as follows:

- (1) Damage to structures by volcanic earthquakes
  - Cracks and fissures, and movements of the ground ( with no land slides ) were observed at the

embankments along roads.

- Cracks and fissures at the roads on the boundary of the ground cut and heaped up.
- (2) Slope collapses and fallen rocks by volcanic earthquakes
    - The sizes of collapses and fallen rocks were small at the steep slopes only.
  - (3) Damage caused by volcanic ash fall

- The thickness of volcanic ash fall was not more than several millimeters, causing that no significant damages were reported.
- No mud and debris flows occurred in the rivers around the volcano, though the rivers got muddy as a result of the fall.

It should be noticed the reports that some cracks opening at the ground heaped up and slopes just after the eruptions led to the ground collapses during rains with a maximum hourly rainfall to be 14 mm on April 29. Thus, as for the disasters lasting for long periods such as volcanic eruptive activity, it is very important to perform the countermeasures for the ground having got loose. Restorations of the cracks and fissures, which were discovered at the heap-up ground at the first survey, were completed mostly before the second survey. Here we

would like to appreciate people in related field for their efforts of repairing.

It is important to survey of the damage caused by crustal deformation at the area kept out because of the vicinity to the craters, however, the investigation will have to be postponed until the volcanic activity becomes tranquil. And we hope that the activity abates immediately without any large-scale pyroclastic flows.

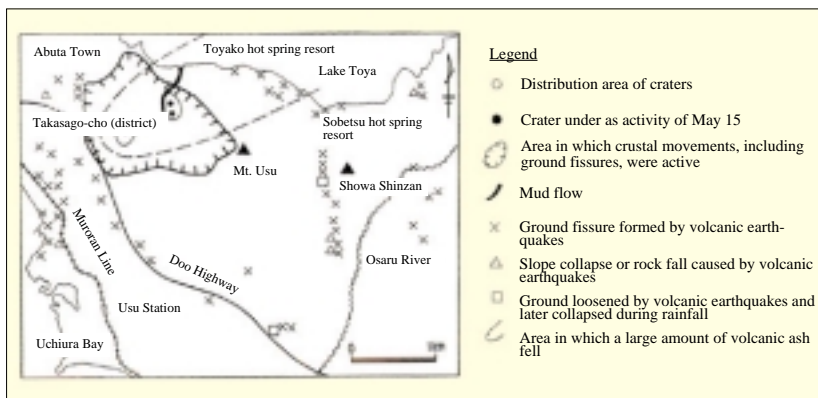


Fig.1 Map of damage caused by the volcanic eruption

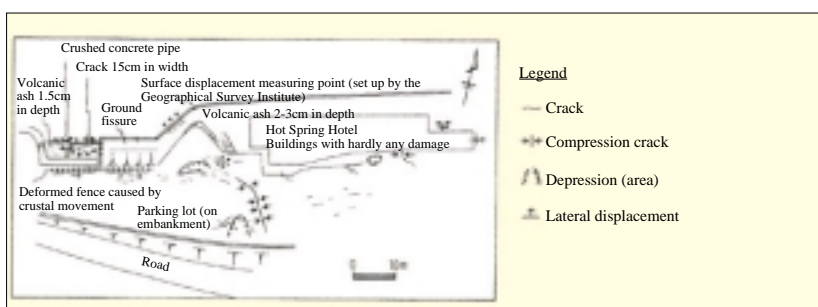


Fig.2 Outline of damage at Sobetsu hot spring resort in Sobetsu Town on Lake Toya

## Disaster reports and resident evacuation

We have some things remarkable in view of the disaster reports and resident evacuations. First, an emergency advisory was announced before the occurrence of the first volcanic eruption and that really became the successful prediction of an eruption about this time. Such an advisory was newly



introduced at the opportunity of the eruptions at Fugendake of Unzen Volcano and the advisory are to announce under the danger condition involving the threat to the residents. In this case, the first warning was made possible by the latest observation equipment with high-accuracy and by the relatively regular activity inferred from the history of the volcano. Among other factors, however, the most crucial determinant in the ability to make an accurate prediction could be said that the UVO had been observing and researching for long period since the last volcanic activity, much like a family physician in charge of Usu Volcano.

Also worthy of special mention is the process by which the initial warnings before the eruptive activity were put to appropriate use for the evacuation of residents. The most important point in predicting earthquakes and volcanic eruptions, and also the most difficult point is to forecast precisely the time to occur. As for this eruptive activity, Professor Hiromu Okada of Hokkaido University stated definitively that an eruption would occur within a day or two. His words based on the observation and research for long years were enough for convincing the mayors of municipality to overcome the hesitation which they are apt to feel in giving the residents the order to evacuate. In spite of the uncertainty in a natural phenomenon, a wise decision was done by the judgment of the mayors to have made a decisive call to the residents to evacuate.

On the other hand, the action of residents in response to the evacuation call was mostly appropriate. The result of hearing surveys carried out at Sobetsu Town shows that the action of residents for the evacuation call was quick and orderly. As there was a thought that the evacuation might last for long time, a good many of the residents carried their household effects and some took summer clothes.

The background to this orderly response by local officials and residents was a relationship of mutual trust among researchers, local government and inhabitants. The government had an ongoing awareness of risk management, while the residents awareness of disaster prevention had been developed in an atmosphere of trust. The researchers from Hokkaido University who had been



Fig. 3 Hazard map of Usu Volcano  
(Source: Disaster Prevention Map of Usu Volcano)

studying on Usu Volcano for many years kept local residents up to date about the condition of the volcano on the basis of the characteristics of activity, while administrative officials enthusiastically worked to improve disaster prevention education.

The representative was a hazard map made in 1995 as shown in Fig. 3, by using the records observed at the last activity 23 years ago as a lesson. This played a significant role in sharing information about damage prevention among researchers, municipality and residents. Considered the hypothetical volcanic activity as inferred from the map, the municipality made an elaborate plan of evacuation and implemented the evacuation drills regularly to develop the awareness of residents, while they had been studying a detailed actions that might need to be taken in case of an emergency. Thus, the residents had deeply understood about the characteristics of eruptive activity of the volcano and were braced for an emergency. Through theses preparatory works, a firm relationship of trust was established between officials and researchers. These ongoing as well as the timely provision of evacuation information led to the problem-free evacuation of residents. This important point should be kept in mind as disaster-prevention efforts continue in the future.