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Damage assessment after the eruption of Mount Usu in 2000

by
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Abstract

In the long history of volcanic eruption at mount Usu, there were periodic major eruptions in about 33 years interval. However, major eruption had evidenced there after 23 years in 2000. Due to the preparation of hazard map and development of good seismological network, there were no human casualties. However, the natural disaster due to that eruption had left panic to the people in the area. The eruption was still active after several months of first eruption. The major craters were formed at Nishiyama and Kompirayama. There is the possibility of huge mass movement in various forms after the rainfall. Recalling the triggering of huge mass movement at mount Usu after 1978 eruption, the possible mass movement there in future cannot be neglected, based on the in situ soil condition, existing land deformations and potential topography for slides.

Keywords: Mount Usu, Volcanic eruption, Debris deposition, Disaster preparedness, Land deformation

1. Background and history of Mount Usu

Volcanic crater of mount Usu is located along the southern rim of Toyo Caldera in Hokkaido, Japan (Fig. 1). Usu volcano was formed in the late Pleistocene or early Holocene, on the Rusutsu formation, which is composed of pyroclastic materials and other Pleistocene sediments. The volcanic lava in mount Usu consists of two pyroxene andesites and basalts with or without Olivine. On the top of volcanic area, there are two dacite domes called Ousu (large Usu)and Kousu (smaller Usu), which are separated by less than 2km distance (Fig. 2). Kousu is old and was made less than 1000 years ago. However, Ousu is estimated to have formed 150 years ago. There are periodic eruptions in Mt. Usu since several hundred years ago. Eruption in 1822 and 1853 are some of the examples of it. Meizi Shinzan, a new mountain with an altitude of 211m (amsl) had been formed as a result of severe

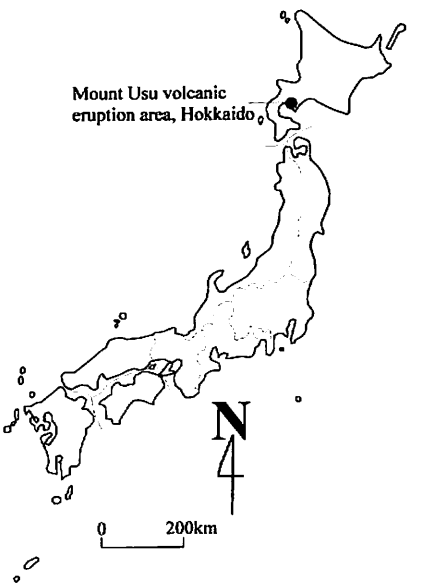

Figure 1 : Location map of study area

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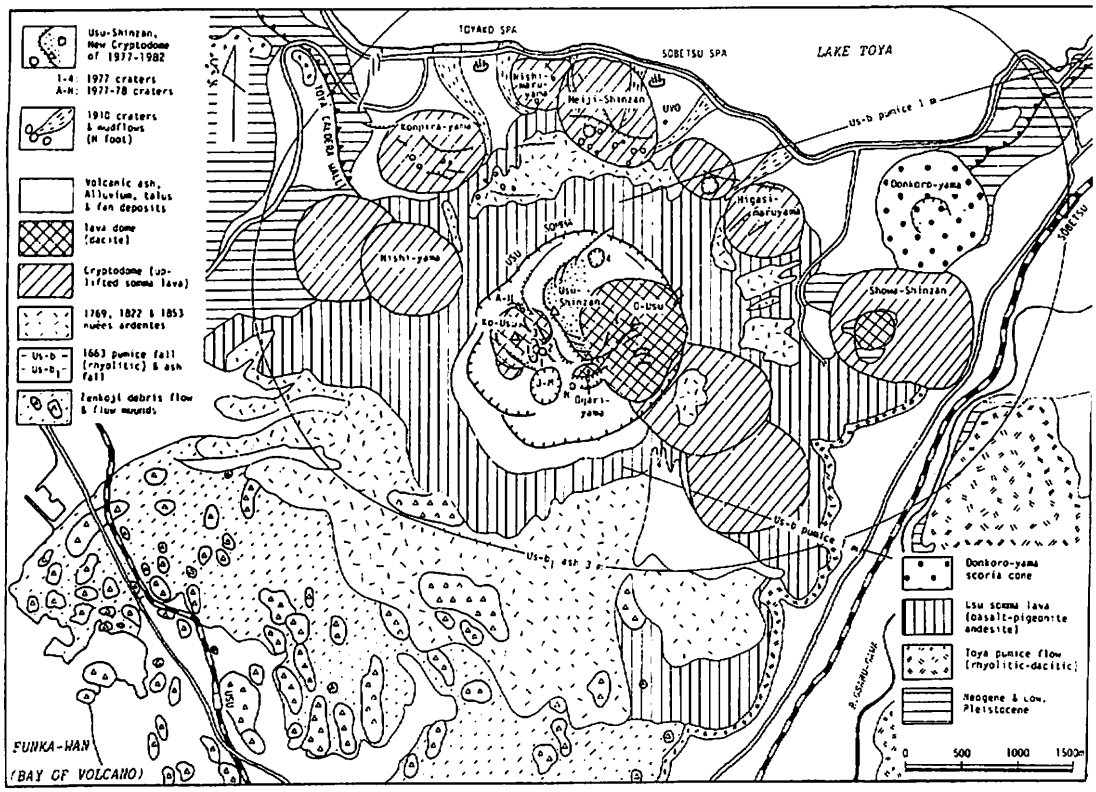

(Figure copied from Showa Shinzan Volcanic Museum)

Figure 2 : Locations of various craters within mount Usu

eruption in 1910. Toya hot spring was also formed during that time. The instrumental observation of volcanic activity had been carried out in Japan for the first time after the 1910 eruption. That eruption had resulted the formation of Toya hot spring. As 3800 shocks were recorded just before the expulsion on July 24, 1910, the outburst forecasting to warn and evacuate the inhabitants from the area was possible. This resulted in no loss of human life due to eruption.

According to the guide book of Showa Shinzan (Mimatsu Memorial hall, 1992), severe earthquakes localized at northern foot had been instrumented on December 28, 1943, after about 34 years of dormancy since 1910 eruption. Pre-eruption stages with many earthquakes and upheaval of the ground continued for 6 months followed by the paroxysmal eruption stage from June 23 to Oct 31, 1944. Many explosions were evidenced on the top of the uplifted area on June 23, which exploded out water vapor with small amount of mud and ash that were probably caused by the super heated underground water. The great eruption on July 2, which ejected more than 2×10^6 tons of ash covering the Subetsu village, was caused by vapor pressure generated due to rising magma. Different types of shallow and deep centered earthquakes were recorded during that time. However, no more explosions were noticed from October 31, 1944. The rising lava at the center of the area surrounded by the crater started from mid-November and continued until September 1945, forming a pyramid shaped lava dome, that has been risen up to 400masml. This eruption is known as formation of Showa Shinzan. No more activities have been observed for several years after it.

After 32 years of second eruption, Mt. Usu erupted again on August 7, 1977 for the third time. The eruption at that time consisted of pumice and ash ejections with intense crustal movement. This eruption has given birth to 180m high Usu Shinzan. The local earthquakes were observed on August 6, influencing up to 8㎞, followed by traverse fault at eastern foot of Kousu. The volcanic eruption had been witnessed only after about 30 hours from the beginning of earthquake. Height of erupted material had been estimated to be 12㎞. A large volume of pumice and ash were ejected and transported to the southwest of volcano by the westerly wind. The repeated eruptions on the explosion day had created 100m-diameter crater. Second and third pumice eruptions had been noted on August 8, forming two more craters at the eastern foot of Kousu. Crater 3 lasted longer, ejecting pumice and ash intermittently even in the rainy day. However, almost all inhabitants and tourists had been evacuated from Toyako spa, which was located on the northwestern foot of the volcano. The 'cement mortar like drops' had devastated the forest and cultivated land. Forth crater had been formed on August 9, ejecting pumice continuously for three hours. The volcanic activities had not been noticed then after until November 1977. However, the crustal deformations along with NW-SE direction faults had been noticed in Kousu, Ogariyama and Ousu in November 1977. That had been evidenced on November 16, 1977. That time, the character of activities varied from phreatic to phreatomagmatic and magmatic eruptions, ranging into various sub-stages. The phreatomagmatic and magmatic eruption as well as phreatic ones had continued until October 1978. Fourteen craters, some ranging up to 130m diameters, had been formed along the northwestern foot of newly growing Usu-Shinzan. The growth of Usu-shinzan continued with accompanying earthquakes and reached a maximum upheaval of about 180m in March 1982 when earthquakes and crustal movement ceased. The pumice and ash showered caused collapse of 8 houses and partial destruction in 374 houses, besides the damage to cultivation lands and forests. The volume of pumice and ash that has been cleared had been estimated to be about 1.8×105㎥. The accumulated ash and pumice took the form of lahar flow and surface erosion even with small amount of rainfall. The local downpour with an intensity of 15 to 20㎜ per hour on October 24, 1978 caused large-scale mudflow, with the speed of 10m/sec, which destroyed the settlement on the foot by accumulating 1.5×10^3㎥ of debris. Three persons were killed and two were injured. The crustal movement caused damage to more than 266 houses, stone walls, stairs, paved roads, water supply lines, hot spring orifices and so on Various mitigation measures had been applied such as more than 200 dams along 11 streams around the volcanic area, 5 drainage channels into lake Toya as so on.

2. Volcanic eruptions in 2000 and its impacts

Due to the interval of 33 years in the first, second and third eruptions in Mount Usu in the past, volcanic eruptions had not been estimated so early. The eruption of Mount Usu in 2000 was occurred after 23 years interval. According to Hirose and Tajika (2000), frequent earthquakes had been recorded in the instruments from the early morning of March 24, with the increased frequency and intensity (up to 120 numbers/hr) until the afternoon of March 30, 2000. Many faults had been evidenced along the mountain, roads and hot spa locations from March 30. The widest fault was observed on March 31 at national highway 230 near northwest side of Mount Usu. Following the increment of deformation, the magma had started to erupt out at 13:07 on March 31, 2001, in the form of steam like gas. That had estimated to be risen up to 3500m, producing more than 94000 tons of

volcanic ash. Similar eruption had been evidenced in Kompirayama on April 1, 2001. Many new craters had been observed around Nishiyama and Kompirayama (Fig. 2), which erupted large amount of volcanic ash in the form of cauliflower shaped cloud. However, due to the prediction of possible eruption after the analysis of abnormal earthquakes, inhabitants had been well evacuated to the safer place. The hazard map that had been prepared beforehand had become very useful.

According to the nature of eruption and eruption material, the magma had seemed to be cooled down underneath before eruption, which had erupted the stream like gas, incorporating the soil near the surface.

3. Damage Assessment by field observation after the eruption

Although all habitants had been successfully evacuated to the evacuation center before the volcanic eruption, the volcanic eruption left a lot of panic to the vicinity. Main highway i. e. national highway 230, passing through Nishiyama volcanic area, had been fully damaged by the formation of staircase like faults along various sections and accumulation of cider stone and volcanic ash (Photo 1). All the side drains and road pavements for more than 400m stretches had fully been damaged. It could not be repaired until the field observation. Due to the formation of fault across the tunnel, the main sewerage line passing through it had been destroyed, emitting bad odor (Photo 2). The surface deformation had been evidenced by the cracks at the abutment and displacement of slab from the abutments, near the edit of the tunnel. The culvert was eccentric due to unequal settlement of the abutments. Movement of the lahar after eruption had destroyed the surrounding area, forest and cultivation land. More than 2m deposition of eruption material had been observed near the crater (Photo 3). Some of the erupted materials were of large size, which could be seen along the damaged road.

Due to the movement of magma underneath, searching the weak place for eruption, the highway passing through Toyako day care center had been highly undulated and faulted (Photo 4). The side drains and road pavements had been depressed whereas culverts have been uplifted. Many faults had been formed across the road. The day care center had been totally damaged by the dropped eruption materials that could be observed around the whole school compound (Photo 5). The structures had been tilted and thick volcanic ash accumulation could be observed on the roof of the school. Due to uplifting of the ground, two factories had been totally collapsed (Photo 6) and remaining buildings around the area had been fully damaged. One building had been fully covered up with erupted materials. As mentioned by Tiwari et al. (2001), many landslide topographies could be observed that had been created due to faults and undulations. The earthquake before volcanic activity had damaged Sankei Hospital. The movement of magma beneath had shank down three storied hospital and only two meters part can be seen now from the ground. Besides, the magma movement underneath had shifted the sidewall of Toyo Lake by 30m towards the lake.

Besides those collapses adjacent to the Nishiyama crater, some of the wells were discharging water naturally, breaking the locked door. Sand boiling in the springs had been observed few kilometers away from the crater. The discharge of the spring was measured to be 67 lps during the field visit. According to the office of Toyo hot spa, about four out of thirteen deep wells (depth ranging 150-1200m) had been malfunctioning during the eruption period, showing sudden drop down of ground water level in all the wells.

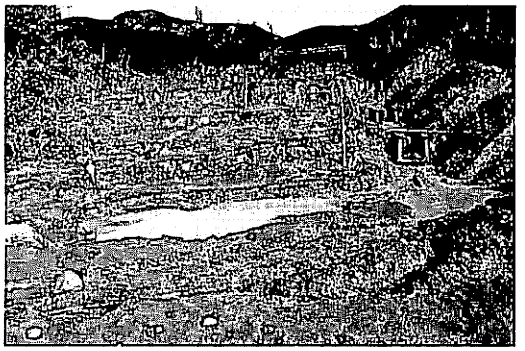

Photo 1 : Deformation of the main highway 230 and accumulation of debris after the volcanic eruption

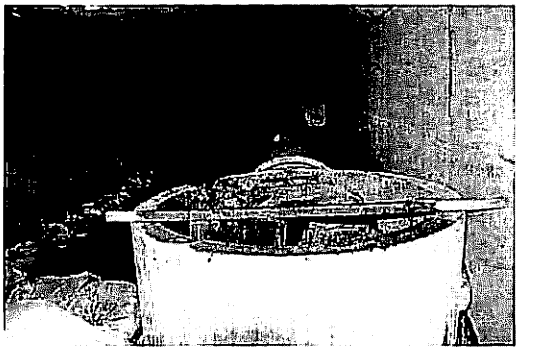

Photo 2 : Damage to the main sewerage line due to the movement of magma underneath

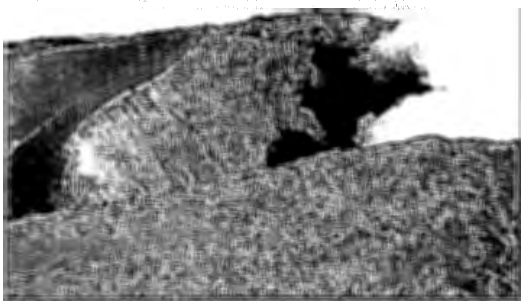

Photo 3 : Deposition of loose silty volcanic material around the crater of Nishiyama volcanic eruption

Photo 4 : Landslide topography and heavy deformation along the road near Toyako day care center

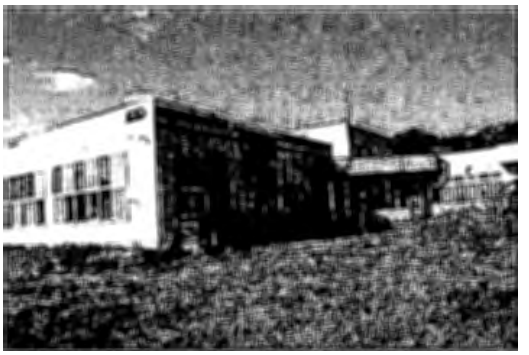

Photo 5 : Damage to Toyako day care center due to the volcanic eruption material

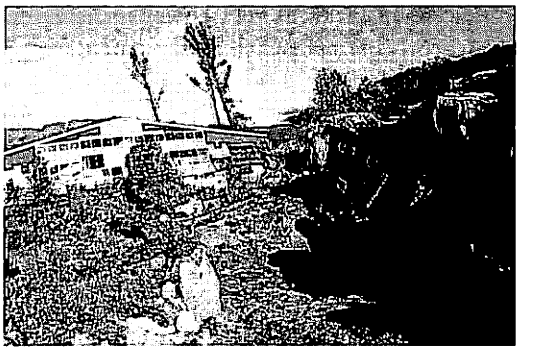

Photo 6 : Damage to the factories due to uplifting of ground by magma movement underneath

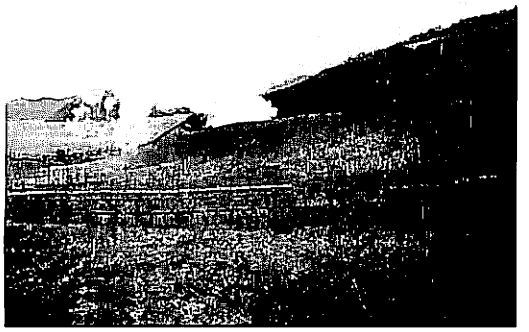

Photo 7 : Volcanic eruption of Kompirayama crater that was still active during the field visit after several months of eruption

Photo 8 : Accumulated huge amount of debris after the eruption of Kompirayama

Photo 9 : Damage to the buildings in the housing project due to the deposited debris after eruption

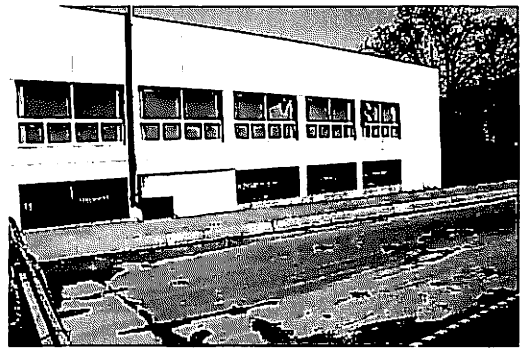

Photo 10 : Damage to the gymnasium by the deposited debris triggered after the eruption

Photo 11 : Deflection in the road after the movement of the ground (can be noticed from the deflected road marking)

Similar to the Nishiyama volcanic eruption, Kompirayama eruption was also active during the field observation (October 16, 2000) (Photo 7). It was continuously erupting with black cloud consisting of volcanic ash and cider with large blasting sound. The whole community near Kompirayama has been either destroyed or threatened by the active volcanic eruption. The debris flow was very huge and continuous (Photo 8). About 1.2m deposits had been measured inside the community. Due to huge lahar flow after eruption, one bridge had fully been swung parallel to the riverbank and swept down 400m downstream. Although huge amount of debris had been cleared off, there was still huge debris mass in the community and at the streamsides that had still being cleared off by the remote controlled dozers. The buildings in the housing project had been either damaged or filled up with the debris (Photo 9). The debris had broken the windows of the gymnasium (Photo 10). Likewise, the floor had fully been covered up with deposited debris. Due to the earthquake and formation of fault, clear shifting of road between the gymnasium and housing blocks could be observed from the deflected road markings (Photo 11). The destruction by Kompirayama eruption was seen to be more violent to the community than the Nisiyama eruption.

4. Recommendation for the disaster preparedness

The volume of deposited mass near Kompirayama and Nishiyama has been found to be very large. Even after several months of disaster, huge loss has been evidenced. The looseness and continuous accumulation of the deposited debris are potential to slide down after the downpour. The calculation of accumulated debris along the slope and near the crater should be done as far as possible. Moreover, the possible flow route of the deposited mass should be estimated before countermeasure planning. It is utmost to prepare the primary disaster preparedness strategy before the heavy rain.

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