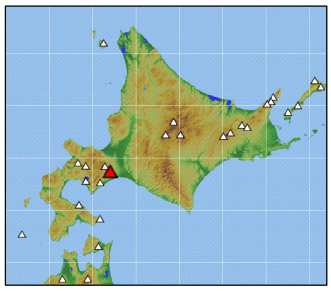
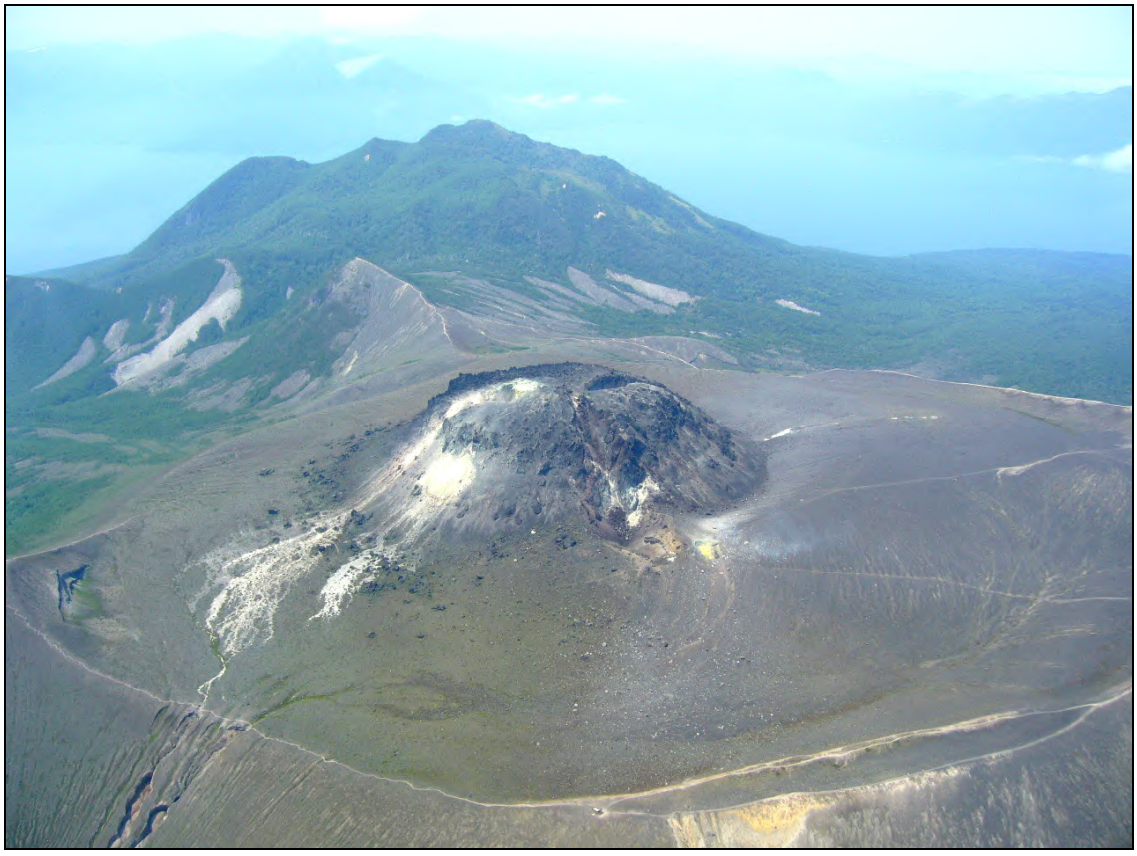
12.Tarumaesan



Continuously Monitored by JMA

Latitude: 42°41'26" N, Longitude: 141°22'36" E, Elevation: 1,041 m (Tarumaesan)
(Elevation Point)
Latitude: 42°43'01" N, Longitude: 141°21'32" E, Elevation: 1,102 m (Fuppushi)
(Triangulation Point)



Overview of Tarumaesan with Fuppushidake (backward), taken from southeast side on June 18, 2008 by the Japan Meteorological Agency

Summary

Tarumaesan is a post-Shikotsu caldera volcano formed to the southeast of Lake Shikotsu approximately 9,000 years ago. The volcanic edifice is composed of a pyroclastic cone and pyroclastic flow deposits on the caldera wall, which is concealed on the summit between 400 and 600 m. The volume of the volcanic edifice is approximately 1 km^3. The summit is a large crater (summit crater foloor), with a north-south diameter of 1.2 km, and an east-west diameter of 1.5 km. A small pyroclastic cone exists inside it, called the central cone. In 1909, a lava dome was formed in the center of the central cone, with a maximum diameter of approximately 450 m and a relative height of approximately 120 m. All eruptions within recorded history occurred at the summit, and fumaroles and ground heating are identified around the lava dome (Furukawa and Nakagawa, 2010). The SiO_2 content is between 52.0 and 64.0 wt %.

Fuppushidake, located about 3 km to the north-to-northwest of Tarumaesan, is a post-Shikotsu caldera volcano formed on the south shore of Lake Shikotsu approximately 26,000 years ago. A phreatomagmatic eruption occurred approximately 8,500 years ago, and a phreatic eruption occurred approximately 4,500 years ago, respectively (Furukawa and Nakagawa, 2009). Currently, no fumarolic activity has been observed.

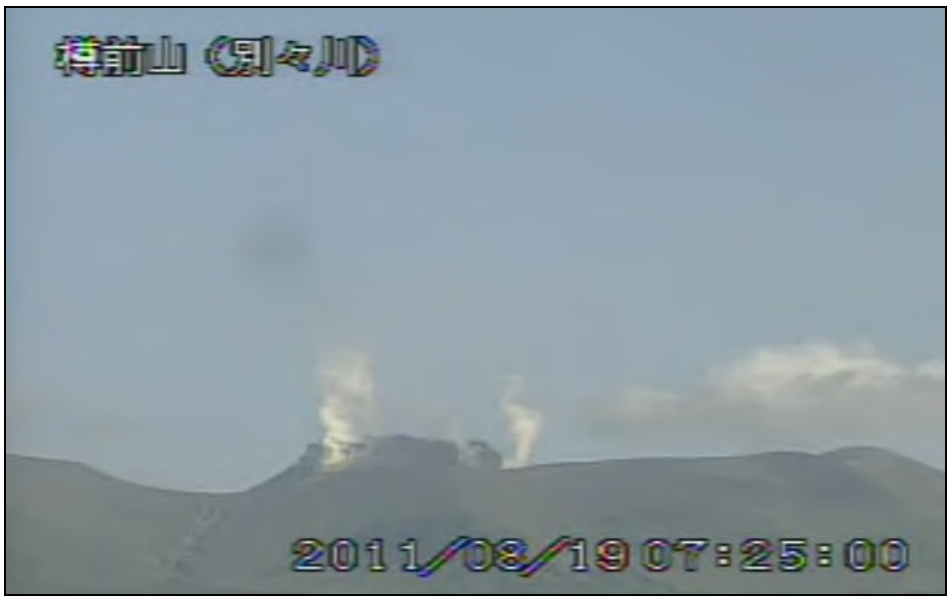
Photos

Lava Dome. taken from southeast side on June 19, 2011 , taken by the Japan Meteorological Agency

B-Fumarole Group - Slide of hot sand lapilli, taken from southeast on May 26, 2011 by the Japan Meteorological Agency

B-Fumarole Group, taken from southwest on October 13, 2011 , taken by the Japan Meteorological Agency

Glow at A-Crater from south on October 19, 2001 Courtesy of Katsui, Y.



Camera image at Betsubetsu river on August 19, 2011 by the Japan Meteorological Agency

Topography around the Crater

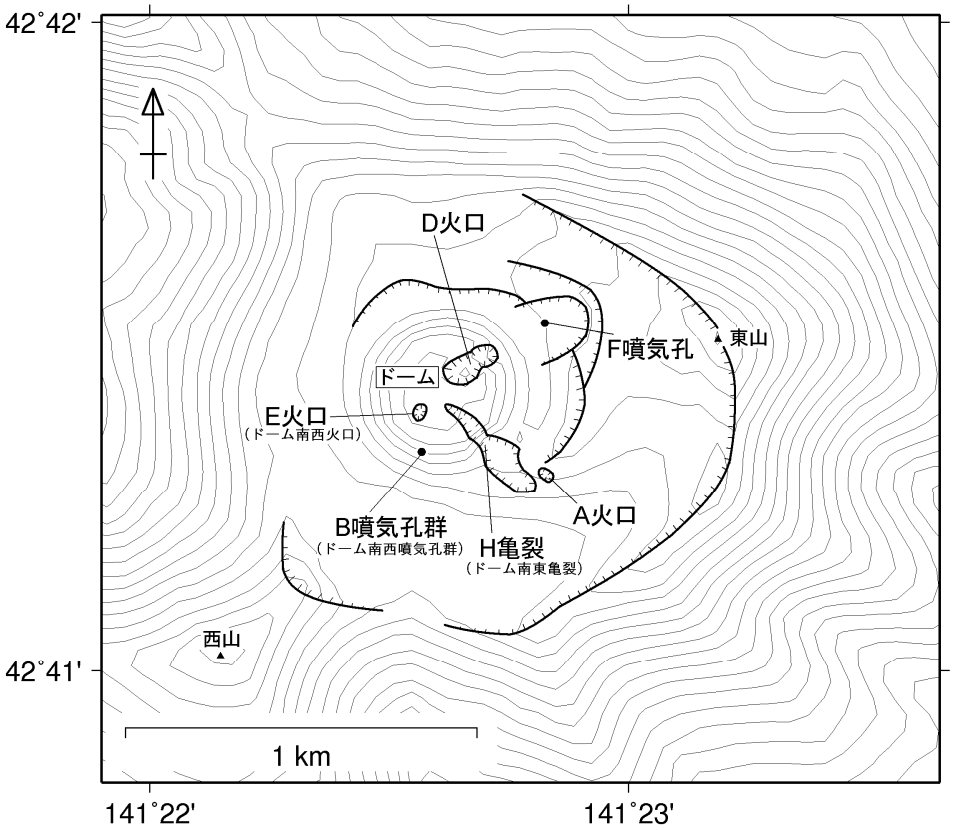


Figure 12-1 Detailed topography of the crater area.

Red Relief Image Map

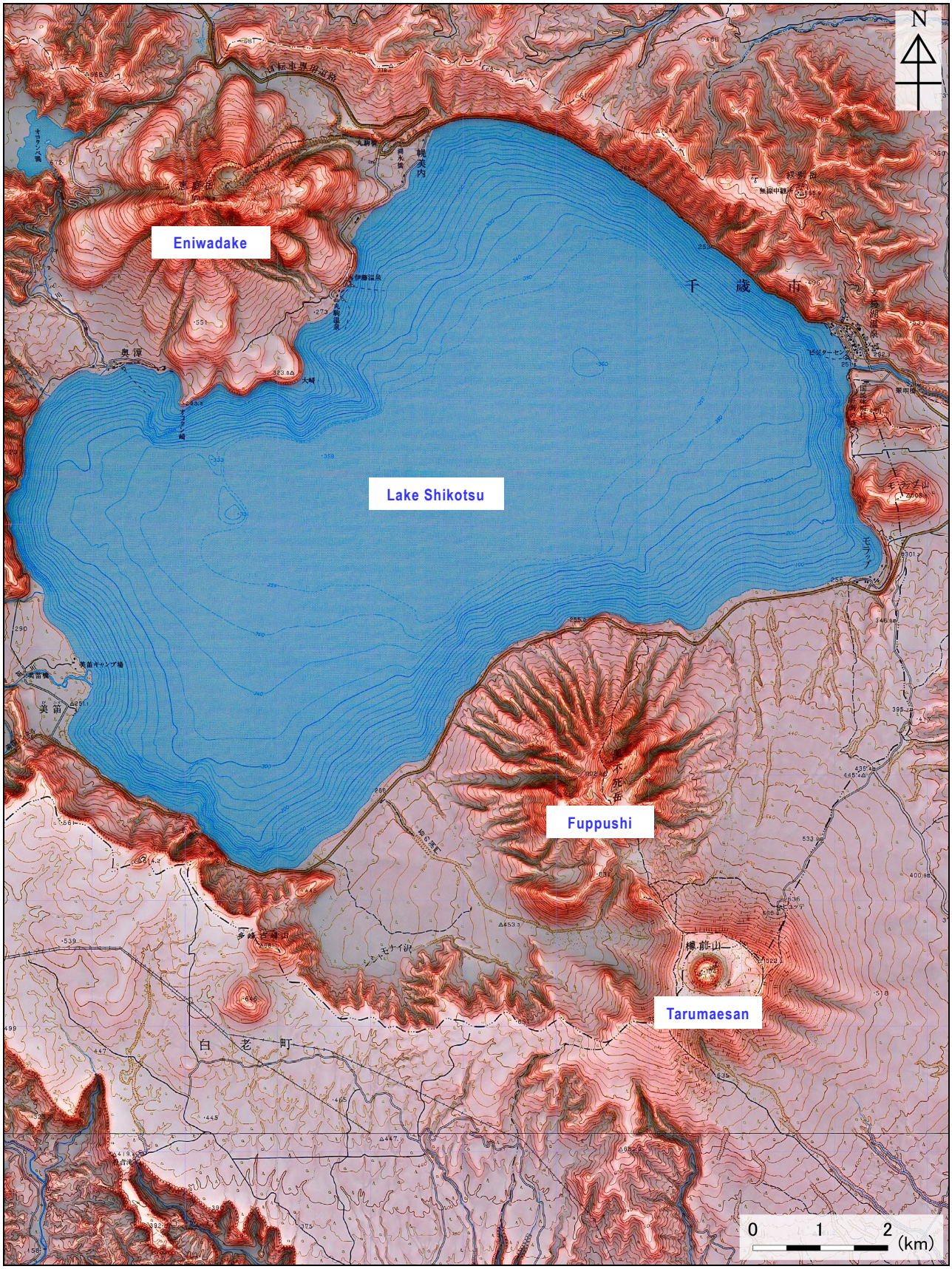


Figure 12-2 Topography of Tarumaesan.
1:50,000 scale topographic maps (Shiraoi and Tarumaesan) and digital map 50 m grid (elevation) published by the Geospatial Information Authority of Japan were used.

Geological Map

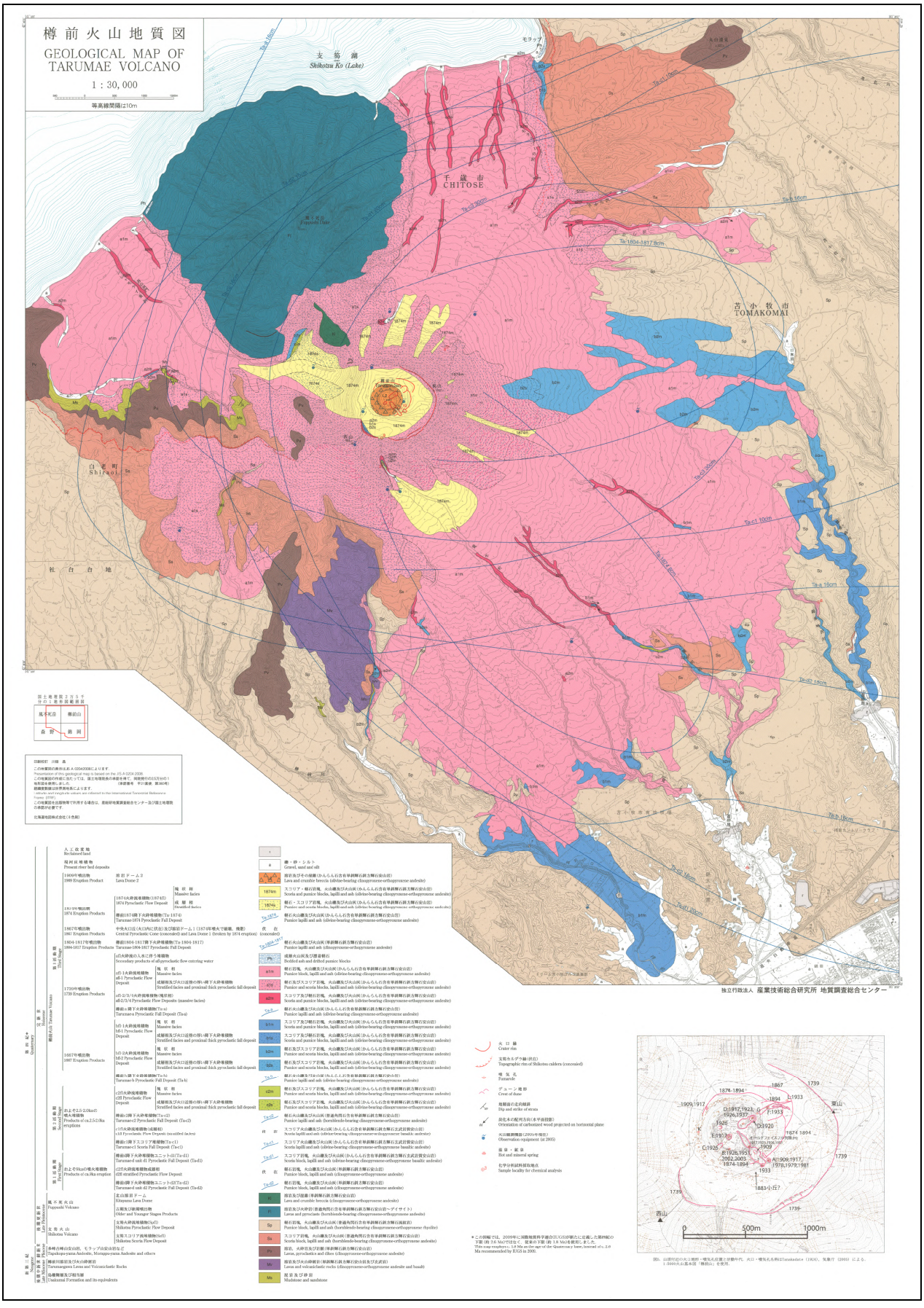


Figure 12-3 Geological map of Tarumaesan (Furukawa and Nakagawa, 2010).

Chronology of Eruptions

・Volcanic Activity in the Past 10,000 Years

Volcanic activity at Tarumaesan began approximately 9,000 years ago. The volcanic activity can be divided into three stages, separated by dormant periods of approximately 1,000 years or more. During the first stage, which began approximately 9,000 years ago, 2 plinian eruptions occurred, ejecting a large amount of pyroclastic material and producing small pyroclastic flows. After a dormant period of approximately 6,500 years, the second stage started approximately 2,500 years ago. During this stage, 3 plinian eruptions occurred with short periods of inactivity between them. These eruptions produced pyroclastic material, pyroclastic flows, and pyroclastic surges. The third stage is the one for which historical records exist, started in the Edo era, and continues on until today. Large plinian eruptions occurred in 1667 and 1739, producing a large amount of pyroclastic material. The eruption in 1909 produced the lava dome that is now visible at the summit. Since the mid-19th century no large eruptions have occurred, but over 70 eruptions is confirmed (Furukawa and Nakagawa, 2010).

At Fuppushidake a phreatomagmatic eruption occurred approximately 8,500 years ago, producing a pyroclastic surge, and a phreatic eruption occurred approximately 4,500 years ago (Furukawa and Nakagawa, 2009).

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
9ka<	Fuppushidake	Phreatomagmatic eruption	Fp3 eruption: An eruption occurred, distributing eruption deposits. This was accompanied by a pyroclastic surge.
9ka	Near summit	Magmatic eruption	Ta-d eruption: 2 plinian eruptions occurred soon after each other. In the interval between the eruptions, a small pyroclastic flow occurred, extending 4 km from the crater. Volcanic projectiles were produced by the Usu River, in Tomakomai, approximately 15 km east-southeast of the crater. Magma eruption volume = 0.75 km^3 DRE. (VEI 5)
4.6←→4.5ka	Fuppushidake	Phreatic eruption	Fp-4 eruption: Distributed eruption deposits.
2.5ka	Near summit	Magmatic eruption	Ta-c1 eruption: A plinian eruption occurred, accompanied by pyroclastic flow. Pyroclastic flow deposits were distributed within an area up to 5 km north of the crater. Magma eruption volume = 0.13 km^3 DRE. (VEI 4)
		Magmatic eruption	Ta-c2 eruption: A plinian eruption occurred within several dozen to 100 years of the previous eruption, accompanied by pyroclastic flow. Pyroclastic flow deposits were distributed within an area up to 6 km from the crater. Magma eruption volume = 1.2 km^3 DRE. (VEI 5)
2ka	Near summit	Magmatic eruption	Ta-c3 eruption: An eruption occurred, distributing eruption deposits, mainly pumice volcanic scoria, within 15 km of the crater. Magma eruption volume = 0.03 km^3 DRE. (VEI 3)

* Reference documents have been appended with reference to the catalog of eruptive events during the last 10,000 years in Japan, database of Japanese active volcanoes, and AIST (Kudo and Hoshizumi, 2006) for eruptive period, area of activity and eruption type. All years are noted in calendar years. "ka" within the table indicates "1000 years ago", with the year 2000 set as 0 ka.
A<: Eruption event before year A.
A←→B: Eruption events taking place at some point between year A and year B

・Historical Activity

Year	Phenomenon	Activity Sequence, Damages, etc.
1667 (Kanbun 7)	Large: Magmatic eruption	On September 23, sometime after 20:00, 4 or 5 rumblings was heard at Tanabu, on the Shimokita Peninsula. From September 24 to 26, volcanic plumes were emitted intermittently (plinian eruption). Air-fall pyroclastic material (Ta-b) was deposited over a wide area to the east, approximately 2 m deep to the north of Tomakomai, and several cm deep as far away as the Tokachi plain. Two major pyroclastic flows may have reached at the foot of the volcano, creating naturally formed lakes, including Kuchinashinuma, upstream from the Nishitappu River, and Moritanuma, downstream from the Tarumae River. Total ejecta: 2.8 km^3. Magma eruption volume: 1.1 km^3 DRE. (VEI 5)

Year	Phenomenon	Activity Sequence, Damages, etc.
1739 (Genbun 4)	Large: Magmatic eruption	An earthquake occurred on August 16, followed by intermittent eruptions on August 18 to 30 (plinian eruptions), in which of 2 or 3 days the tephra fall was so heavy that the area was darkened. At the end of the eruption period, especially strong rumbling occurred. Air-fall pyroclastic material (Ta-a) was deposited over a wide area to the northeast, approximately 1m deep around the present Chitose Airport, and several cm deep in the Taisetsuzan area. Main pyroclastic flows reached the foot of the volcano 4 times, distributed over an area of up to 10km, and flowing into Lake Shikotsu at the north and northwest feet of the volcano. There were 9 pyroclastic deposit layers. The bottom layer consisted of a small amount of air-fall deposits. The topmost layer was the largest, both in terms of distribution and strata thickness, consistent with the strong rumbling at the end of the eruption period. A 1.2x1.5 km diameter somma (small caldera) was formed at the summit. Total ejecta: 4 km^3. Magma eruption volume: 1.6 km^3 DRE. (VEI 5)
1804 to 1817 (Bunka era)	Moderate: Magmatic eruption	An eruption occurred at the summit (an eruption occurred within the Bunka era). A pyroclastic deposits were distributed to the northeast (2-3 cm strata thickness at Uenae). Some documentary evidences indicate there were a high number of casualties. Total ejecta: 0.05 km^3. Magma eruption volume: 0.02 km^3 DRE. (VEI 3)
1867 (Keio 3)	Magmatic eruption	During the fall, earthquakes and rumbling sounds occurred, with a fire column from the summit, and a black volcanic plume (eruption). The central cone and old lava dome were formed, with 5 to 9 cm of ash and gravel fell at Shiraoi.
1874 (Meiji 7)	Moderate: Magmatic eruption	Eruption at the summit from February 8 to 10. Pyroclastic flows occurred to the northwest, northeast, and south. A volcanic plume reached the Pacific Ocean and Hidaka region in Hokkaido. Tephra fall was mainly to the south, with a strata thickness of approximately 45 cm near Nishikioka, Tomakomai. On February 16 an eruption occurred, accompanied by rumbling, and tephra fall in Sapporo. The old lava dome was destroyed, and a crater with a diameter of approximately 180m was formed. Total ejecta: 0.025 km^3. Magma eruption volume: 0.01 km^3 DRE. (VEI 3)
1883 (Meiji 16)	Phreatic eruption	Small eruption at summit on October 7. The area in and around the eruption crater collapsed. Small eruption at summit on October 17 at approximately 19:00. A small amount of tephra fall near Tomakomai Station.
		Small eruption at summit on November 5. Ash and lapilli fall. Small cone, 20 m high and 50 m long, formed at the south foot of central crater. Tephra fall reached Sapporo.
1885 (Meiji 18)	Phreatic eruption	Summit eruption on January 4 at approximately 16:30. A black volcanic plume rose 2 to 10 km in the air, and ash fell in the Tarumae village and Mukawa area. A small eruption also occurred on January 8 at 11:00, and January 10 at 18:00.
		Summit eruption on March 26 at 18:30. The amount of volcanic plume was slightly less than that of the January eruption.
1886 (Meiji 19)	Phreatic eruption	Summit eruption in the early morning of April 13. A volcanic plume rose approximately 360 m, and ash fell 12 km to the northeast (0.6 to 1.0cm deep). Summit eruption on April 15 at 14:00. A volcanic plume rose to the same height as that on April 13: Tephra fall up to approximately 8km southeast. An eruption also occurred on April 16. Summit eruption on April 28 at approximately 04:30. Tephra fall along 20 to 24km of coast, from Tarumae village to Yufutsu village.
1887 (Meiji 20)	Phreatic eruption	Rumbling like distant thunder from approximately 09:30 on September 3, followed by eruption at summit at 09:45. A volcanic plume rose approximately 3,600 m.
		Summit eruption on October 7 at 17:50 (continued for approximately 10 minutes). A volcanic plume rose approximately 2,700 m, carried away to northeast. Small amount of tephra fall at Tomakomai (just enough to leave traces on leaves). Summit eruption on October 8 as well, with tephra fall in Tomakomai.

Year	Phenomenon	Activity Sequence, Damages, etc.
1894 (Meiji 27)	Phreatic eruption	Eruption at the summit on February 8. Rumbling and tephra fall. [8,23]
		Eruption on west side inside summit crater at approximately 18:00 on August 17. Volcanic plume increased to 10 times normal levels.
1909 (Meiji 42)	Moderate: Magmatic eruption	January to May: Small eruptions and rumbling continued intermittently for approximately 3 months. After 2 explosive eruptions occurred, a lava dome was formed. Volcanic activity was as listed below. On the night of January 11 a fire column was confirmedat the summit. On the night of January 22, ash fell at the foot of the volcano.
		A volcanic plume and rumbling on February 6 at 09:00. Two loud cannon-like booms at 15:00 on February 10, with tephra fall at the eastern foot of the volcano. A volcanic plume rose high above the volcano at 13:00 on February 18 (no ash fall).
		Rumbling on March 3 at 11:00, 15:00, and 16:00. On March 30 cannon-like rumbling occurred for approximately 1 hour, beginning at 06:00. At approximately 07:30 an explosion occurred at the north of the crater interior. A volcanic plume rose approximately 7,600 m, covering the sky from the south to the east for approximately 2 hours. Large volcanic blocks, averaging 15cm, but some with diameters as large as 2 m, were ejected near the crater, as well as ash and gravel fall. Ash fell at the foot of the volcano, in Tomakomai, in Kurumadai, and on fishing vessels on the Pacific Ocean.
		An eruption on April 12 produced lightning and a black volcanic plume. The amount of volcanic plume was emitted was 10 times that of March 30. The first explosion scattered volcanic projectiles to the south. The second explosion scattered them to the northeast and east. Pumice 22 cm in diameter fell at the foot of the volcano. Sand-like ash fell on Lake Shikotsu. From April 13 to 16, a volcanic plume was emitted, strong rumbling occurred, and tephra falls occurred twice at the foot of the volcano. From April 17 to 19, the current lava dome was formed.
		On May 2, lava dome growth had largely stopped, the top flattened, and small projections appeared on the south side. The dome was 134 m high, 450 m wide at its widest point, and had a temperature of 457°C. On May 15, rumbling occurred, accompanied by an eruption, and tephra fall across Lake Shikotsu. The southeast crack and A-crater formed at the southeast foot of the dome. [7, 8,17,23] Total ejecta: 0.02 km^3. Magma eruption volume: 0.02 km^3 DRE. (Dome)
1917 (Taisho 6)	Phreatic eruption	On April 30, at 15:05, rumbling like distant thunder occurred, as well as eruptions from the southeast crack of the dome, A-crater, and E-crater. A volcanic plume rose approximately 780 m. Ash fell at Tomakomai.
		On May 12, at 10:20, rumbling occurred, accompanied by eruptions from the southeast crack of the dome, D-crater, and E-crater. A volcanic plume rose approximately 5,000 m. The rumbling continued for 30 minutes or longer. The rumbling was strong enough to cause paper screen doors in Tomakomai to ripple. The relative height of the lava dome fell to 126 m. Ash fell at the foot of the volcano, Lake Shikotsu, and Hayakita.
1918 (Taisho 7)	Phreatic eruption	Small eruption at approximately 07:30 on June 13. Rumbling occurred for approximately 8 minutes. A small amount of ash fell towards Morappu, on the shore of Lake Shikotsu.
1919 (Taisho 8)	Phreatic eruption	A small eruption occurred on May 4 at approximately 14:40. A volcanic plume rose approximately 1,500 m. A large amount of ash fell at Nishikioka and Shiraoi. A small amount of ash fell at Tomakomai. An earthquake could be felt in some parts of the foot of the volcano at approximately 10:00 the previous day.
1920 (Taisho 9)	Phreatic eruption	Rumbling, a volcanic plume, and eruption on July 17 at 18:20. The D-crater grew to 80 m in diameter and 100 m in depth. Fire smoke was emitted for approximately 1 hour at approximately 00:00 on July 23, followed by rumbling and a small eruption. Tephra fall at the foot of the volcano and in Shiraoi.

Year	Phenomenon	Activity Sequence, Damages, etc.
1921 (Taisho 10)	Phreatic eruption	Small eruption at 03:20 on July 6. Rumbling occurred for approximately 30 minutes. Ash fell at the foot of the volcano and outside Tomakomai.
1923 (Taisho 12)	Phreatic eruption	2 small eruptions occurred at southeast crack of dome on February 21 at 06:00 and 06:45. A large amount of ash fell at Tomakomai. After mid-February, the amount of volcanic plume fell to 1/3 of its previous volume.
		Eruption at approximately 13:40 on June 17. Rumbling occurred for approximately 10 minutes. Tephra fall reached Sapporo from approximately 14:30. Eruption accompanied by loud boom on June 29 at approximately 21:40. Rumbling occurred for approximately 20 minutes, and paper screen doors in Tomakomai shook so hard they almost fell over. Tephra fall in Hayakita and Oiwake.
		Small eruption in the afternoon on July 13, and in the evening on July 14.
		On August 12, two elementary school teachers in Sapporo were injured by volcanic blocks.
1926 (Taisho 15)	Phreatic eruption	From October 19 to 30, 6 explosive eruptions occurred from the new lava dome northwest crater, the southeast dome crack, the B-crater, and the C-crater. The main northeast-southwest crack widened, a new crack appeared on the northwest slope of the dome, the southeast crack of the dome widened, and a small crack appeared on the southwest slope. On October 19, at approximately 04:30, the amount of volcanic plume being emitted increased. At approximately 05:00 an eruption occurred, a felt earthquake which could be felt all around the foot of the volcano, 15 to 20cm of tephra fall near Horobetsu, and tephra fall in the suburbs of Sapporo. This was followed by eruptions at 07:00, 07:10, 08:40, and 09:30. Small eruptions on October 20 at 03:30 and 05:30. A black volcanic plume rose on October 21 at 09:23. On October 24, at approximately 04:30, an explosion occurred sound and an eruption accompanied by volcanic flame. This was followed by eruptions at 05:10, 05:25, and 05:32. On October 26, in the early morning, an explosion occurred accompanied by a boom, a fire column, lightning, and volcanic plume which rose to a height of approximately 1,000 m. On October 30 at 06:30 and 06:35, rumbling and eruptions occurred, with a volcanic plume reaching a height of approximately 2,000 m. The explosion sounds could be heard as far as Sapporo. Lava fragments 1.0 to 2.5 cm in diameter fell at the foot of the volcano, and tephra fall reached as far as Shokotsu, on the coast of the Sea of Okhotsk (240 km to the northeast).
1928 (Showa 3)	Phreatic eruption	On January 4, at approximately 11:00, a black volcanic plume rose. On January 7, at approximately 09:00 and 16:30, three times as much volcanic plume was emitted as usual, and rumbling occurred at Lake Shikotsu.
		On September 6 an explosion occurred.
		On October 25 an explosion occurred.
1929 (Showa 4)	Volcanic plume	On February 10 a large volume of volcanic plume was emitted.
1931 (Showa 6)	Volcanic plume	On October 11 and 24 a large volume of volcanic plume was emitted.
1933 (Showa 8)	Phreatic eruption	Small eruption on December 1 at 06:24. A volcanic plume rose 1,000 m. Small craters (F-crater and crater at south of southeast dome crack) were formed. Tephra fall at Shishamonaisawa and Bifue River.
1936 (Showa 11)	Phreatic eruption	During the early morning of November 15, and on November 25, small eruptions occurred at the D-crater, and a volcanic plume rose 200 m. On November 15, 0.3 cm of ash fell at Morappu, on the shore of Lake Shikotsu, and ash fell at Nishikioka, Ebetsu, and Kuriyama. On November 25 ash fell at Tomakomai.
1944 (Showa 19)	Phreatic eruption	Small eruption at on July 2. Small amount of tephra fall at night.
1947 (Showa 22)	Volcanic plume	A large volume of volcanic plume was emitted in the fall.

Year	Phenomenon	Activity Sequence, Damages, etc.
1951 (Showa 26)	Phreatic eruption	Three small eruptions occurred at the B-fumarole group, accompanied by thudding rumbling, on January 29 at approximately 02:40, 03:30, and 04:30. A small amount of ash fell around the foot of the volcano, with 5g/m^2 of tephra fall at Tomakomai. A small eruption occurred from the B-fumarole group on July 28 at approximately 03:15. Fist-sized lapilli were scattered over an approximately 20m area around the crater, and small lahar over an area of 150 m (10 cm at a distance of 100 m from the crater).
1953 (Showa 28)	Phreatic eruption	Small eruptions from A-crater on September 14. Tephra fall near summit crater.
1954 (Showa 29)	Phreatic eruption	Small eruption and explosion sound from A-crater on May 2 at approximately 14:47. Small amount of lahar and tephra fall near crater.
		Small eruption from A-crater on November 19 at approximately 14:15. JMA scale seismic intensity 2 tremor at Tomakomai, accompanied by explosion sound and air shock. Tephra fall near the summit.
1955 (Showa 30)	Phreatic eruption	Small eruption at approximately 12:19 on February 14. JMA scale seismic intensity 1 tremor and air shock at Tomakomai weather station.
1974 to 1975 (Showa 49 to 50)	Earthquake	Many volcanic earthquakes from December to next February.
1978 (Showa 53)	Earthquake	Many volcanic earthquakes in February.
1978 (Showa 53)	Small-scale: Phreatic eruption	Small eruption from A-crater on May 14. A powder flow of 220 °C or hotter flowed approximately 100m from the crater. Ash fell on the shores of Lake Shikotsu. Total ejecta: 40000m^3. (VEI 1) Tephra fall near the summit on May 17, August 8, December 12, 16, 26, and 29.
1979 (Showa 54)	Phreatic eruption	Very small eruptions from A-crater on January 5, 22, 23, and 27. Tephra fall near summit.
		Very small eruptions from A-crater on February 5, 18, 25, 26, 27, and 28. Tephra fall near summit.
		Very small eruptions from A-crater on March 1, 2, 4, 6, and 8. Tephra fall near summit.
		2 very small eruptions from A-crater on April 13. Tephra fall near summit.
		Very small eruptions from A-crater on May 11 and 12. Tephra fall near summit.
1981 (Showa 56)	Phreatic eruption	Very small eruption from A-crater on February 27. Small amount of tephra fall near summit. Many volcanic earthquakes from November, 1980 to February, 1981.
1983 (Showa 58)	Hot water	The temperature in October increased at the crater floor on the west side of the dome.
1984 (Showa 59)	Earthquake	Many volcanic earthquakes in January.
1988 (Showa 63)	Earthquake	Many volcanic earthquakes in January and February. Felt earthquake on March 21 (JMA scale seismic intensity 2 at the 7th station of Hyutte and Lake Shikotsu).
1992 (Heisei 4)	Earthquake	Felt earthquake on February 25 (JMA scale seismic intensity 2 at the 7th station of Hyutte).
1993 (Heisei 5)	Earthquake	Felt earthquake on April 27 (JMA scale seismic intensity 1 at Lake Shikotsu). Felt earthquake on October 11 (JMA scale seismic intensity 2 at Lake Shikotsu).
1996 (Heisei 8)	Fumarole	Increased fumarolic activity at southeast dome crack in fall.
	Earthquake	Felt earthquake on December 2 (JMA scale seismic intensity 2 at Lake Shikotsu and Marukoma Onsen, etc.).
1997 (Heisei 9)	Earthquake	Many volcanic earthquakes in January and October.
1998 (Heisei 10)	Earthquake	Many volcanic earthquakes from April 30 to May 1.

Year	Phenomenon	Activity Sequence, Damages, etc.
1999 (Heisei 11)	Fumarole	Fumarole observed at southwest dome crater on January 13, for first time in approximately 4 years (since March, 1995). This was observed occasionally thereafter.
	Earthquake	Many volcanic earthquakes from May 1 to 3 and July 1 to 10.
	Heat	From May 17 to 18, A-crater temperature 482 °C (measured via infrared radiation thermometer at a distance of 5 m). The temperature then rose to 500 to 600 °C through October. On November 22, the A-crater temperature was 619 °C (measured via infrared radiation thermometer at a distance of 5 m). Observed very weak red-hot glowing inside crater.
2000 (Heisei 12)	Heat	On May 15, the A-crater temperature was 582 °C (measured via infrared radiation thermometer at a distance of 5 m). The crater floor west side geothermal area temperature rose, and its size increased. High temperatures persisted from June to November. A-crater temperatures of 453 to 556 °C.
	Earthquake	On June 23, 8 felt earthquakes occurred, with shaking equivalent to a seismic intensity of 1 on JMA scale at Morino, Shiraoi. M2.5 earthquake with hypocenter approximately 8 to 10km to southwest of Tarumaesan. 7 more earthquakes occurred leading up to June 24 with hypocenters in the same area. Felt earthquake on June 29 (seismic intensity of 1 on JMA scale at Tomakomai Shirakaba and Shiraoi Omachi). Hypocenter approximately 8 to 10km to southwest of Tarumaesan. M2.6.
	Earthquake, heat, crustal deformation	Earthquake swarm from November 14 to 22. Localized inflation and thermal demagnetization were observed below the lava dome (observed via repeated GPS measurement and geomagnetic total intensity observation).
2001 (Heisei 13)	Earthquake	Many volcanic earthquakes in January. Many volcanic earthquakes from July to August.
	Heat	A-crater temperatures of 641 °C in May, and 679 °C in June. (measured via infrared radiation thermometer at a distance of 5 m).
2002 (Heisei 14)	Heat	High-sensitivity cameras observed brightness at night at the dome's southwest fumaroles from April 27 to 30. May study found high fumarole temperatures between 270 and 293 °C. Sand-like ejecta were also observed in the area.
2003 (Heisei 15)	Heat	High-sensitivity cameras observed brightness at night at the dome's southwest fumaroles in July. Slightly increased volcanic plume production at summit from approximately October 4. High-sensitivity cameras observed brightness at night at the dome's southwest fumaroles from October 5. Site survey on October 7 and 8 found high temperatures of fumaroles to southwest of dome to be approximately 500 °C, and confirmed molten sulfur, burning sulfur, and sand-like ejecta in the area. A-crater temperature approximately 650 °C (measured via infrared radiation thermometer at a distance of 5 m).
	Earthquake	Increase in earthquakes from December 4 to 5.
2005 (Heisei 17)	Crustal deformation	Localized inflation observed below the lava dome (observed via repeated GPS measurement). Continued until 2009.
2006 (Heisei 18)	Topographic change	Collapse within A-crater
2009 (Heisei 21)	Volcanic tremors	Volcanic tremors occurred on July 2 and September 25. Volcanic tremors accompanied by tilt-changes occurred on October 16 and 23.
	Heat	New fumarole observed on eastern edge of southeast crack of the dome on September 2. Geothermal area expansion near A-crater area and southeast crack of the dome.
2010 (Heisei 22)	Volcanic tremors	Volcanic tremor occurred on February 23.
	Heat, crustal deformation	Temperatures rose in June in dome's southwest fumarole group and fumarole at southeast crack of the dome. Localized inflation observed below the lava dome (observed via repeated GPS measurement).

Year	Phenomenon	Activity Sequence, Damages, etc.
2011 (Heisei 23)	Bright crater appearance, heat, fumarole	High-sensitivity cameras observed brightness at night at the dome's southwest fumarole group in January. This was observed intermittently until November. A new fumarole was observed in the dome's southwest fumarole group on the morning of May 26. Site survey found high temperature gas emissions accompanied by intermittent emissions of dry sand gravel, repeated several times, from dome's southwest fumarole group. Temperature increase in dome's southwest fumarole group. Fumarole volume increased at A-crater and dome's southwest fumarole group.
2012 (Heisei 24)	Bright crater appearance	High-sensitivity cameras observed brightness at night at the dome's southwest fumaroles in April. This was observed intermittently thereafter.

* Reference documents have been appended with reference to the catalog of eruptive events during the last 10,000 years in Japan, database of Japanese active volcanoes, and AIST (Kudo and Hoshizumi, 2006) for eruptive period, area of activity and eruption type.

Whole Rock Chemical Composition

▪ Tarumaesan

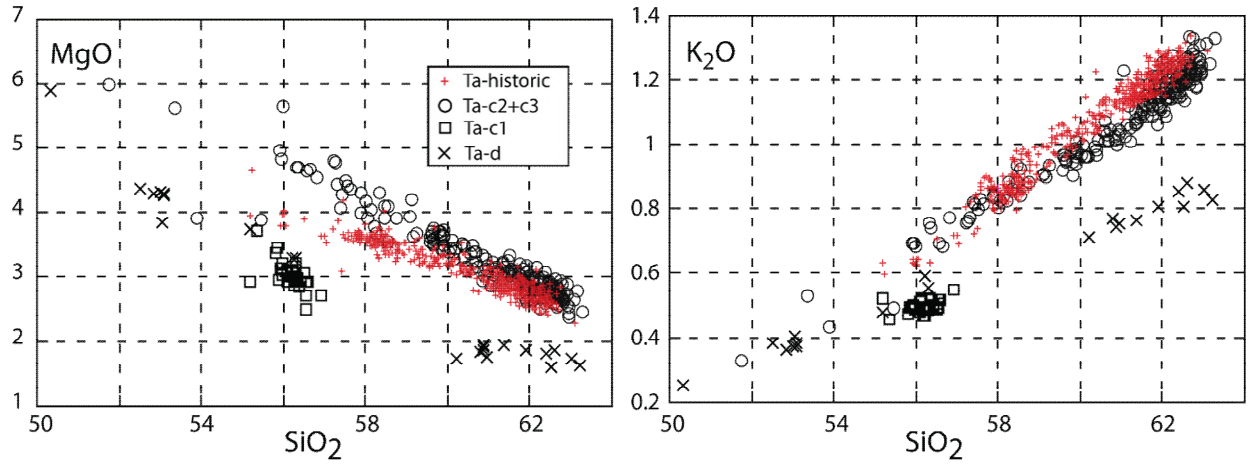


Figure 12-4 Whole rock chemical composition by Harker diagram (Furukawa and Nakagawa, 2010).

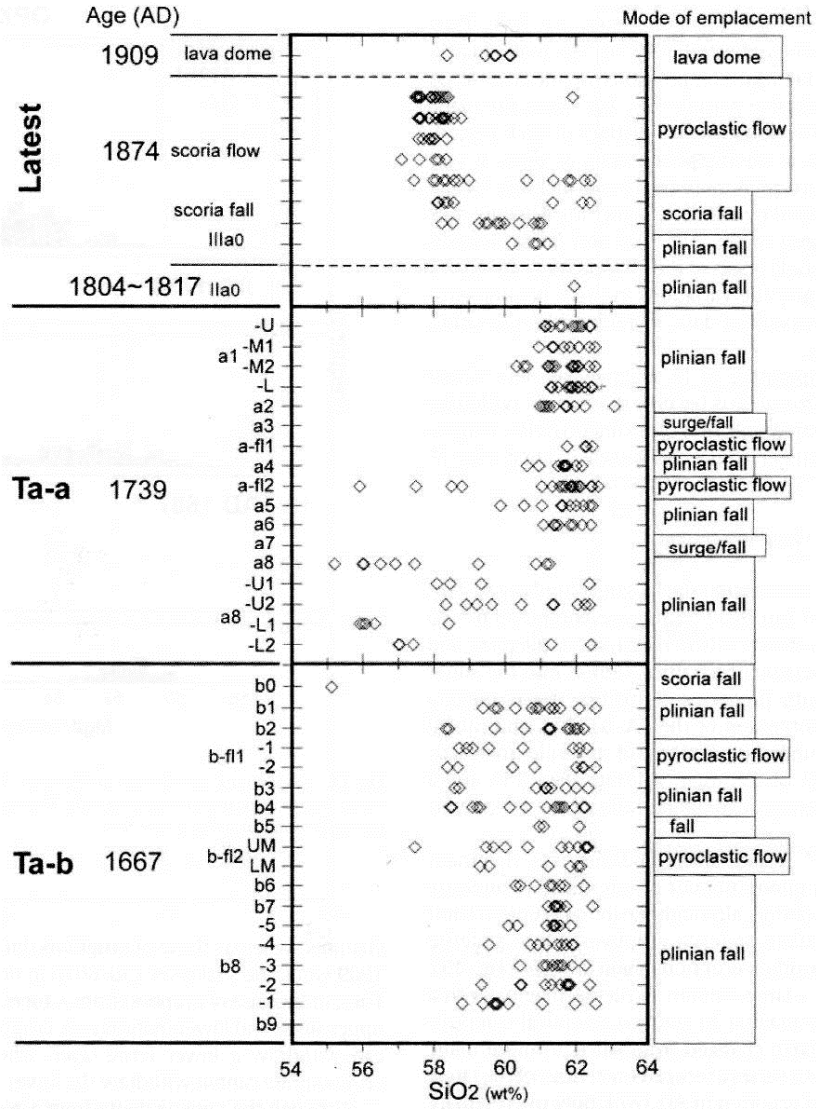


Figure 12-5 Change in SiO_2 wt % within historical period (Nakagawa et al., 2011)

.

・**Fuppushidake**

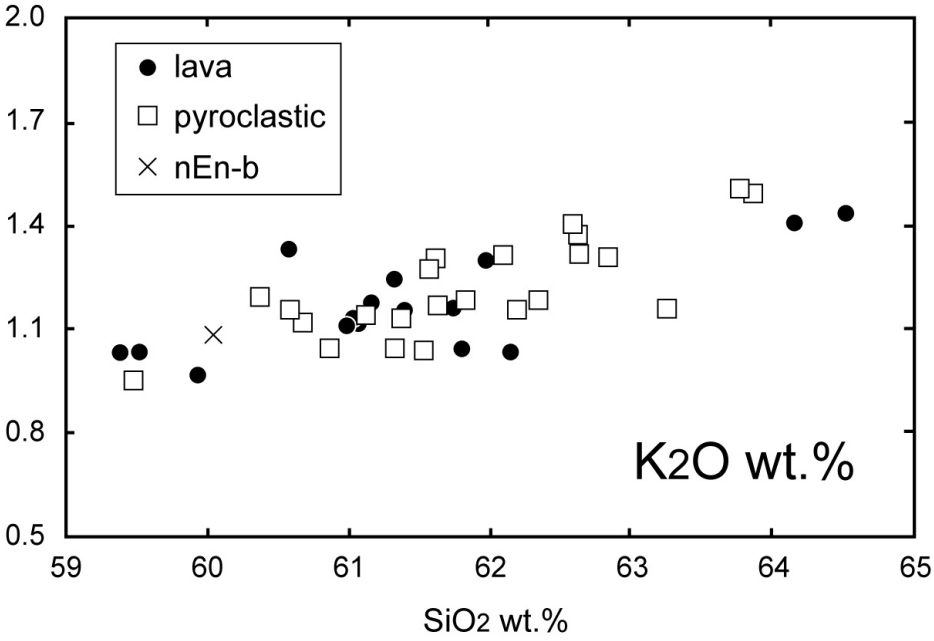


Figure 12-6 Whole rock chemical composition by Harker diagram at Fuppushi volcano (Nakagawa, 1993).

Period - Cumulative Magma Volume

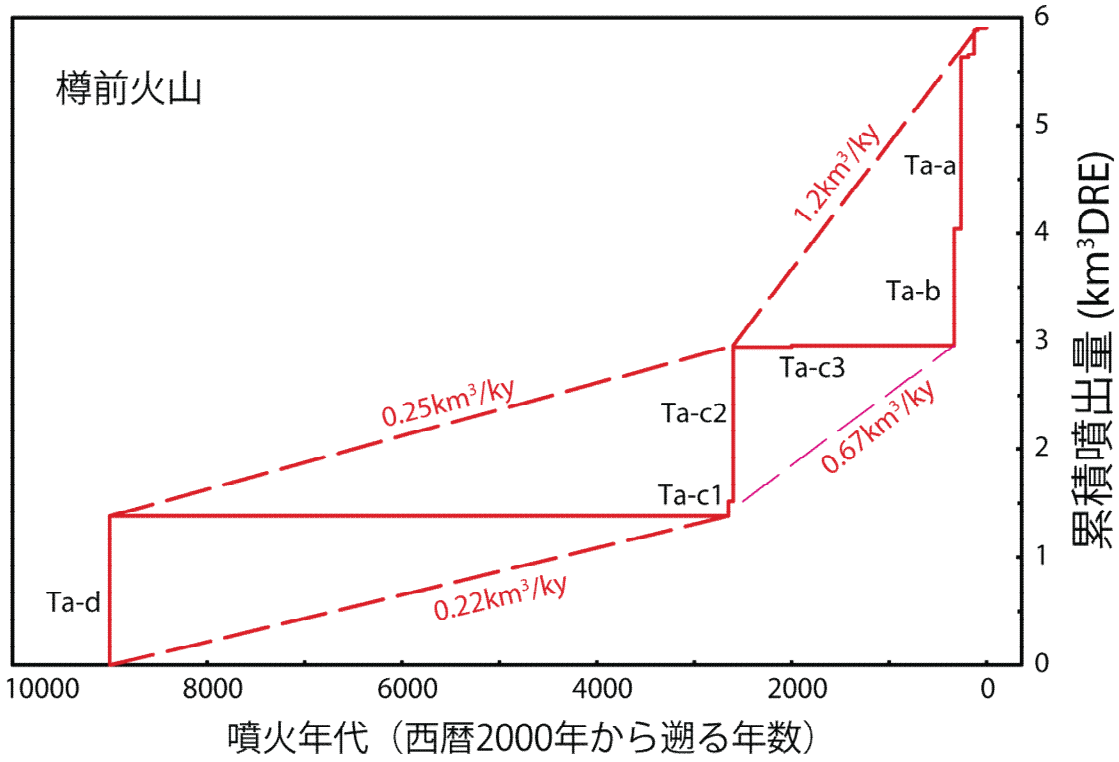


Figure 12-7 Eruption period cumulative magma volume (Furukawa and Nakagawa, 2010).

Major Volcanic Activities

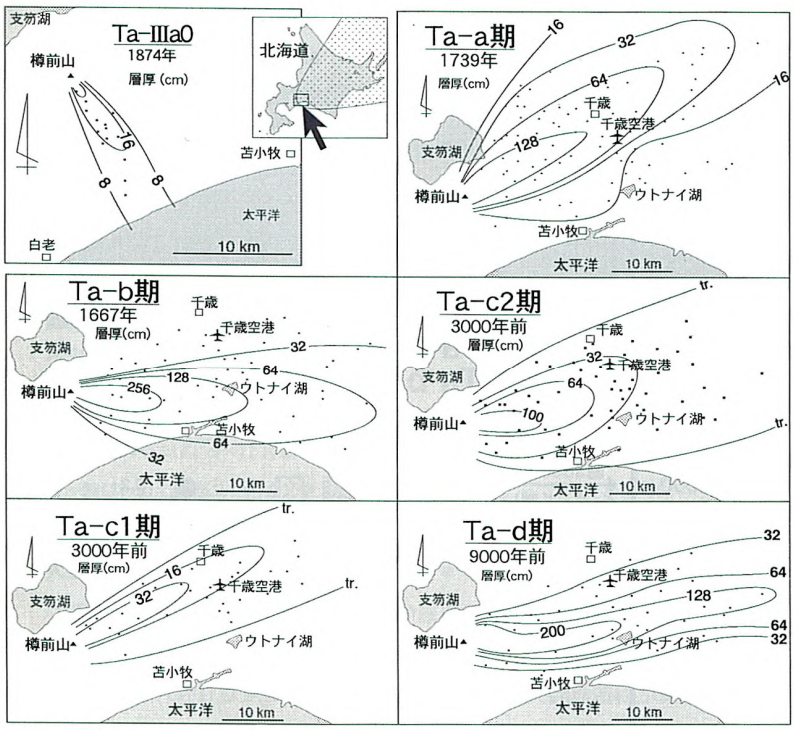


Figure 12-8 Distribution of air-fall pyroclastic deposit for eruptions over past 100 years. (isopach, black dots indicate strata thickness measurement points) (Furukawa, 1998)

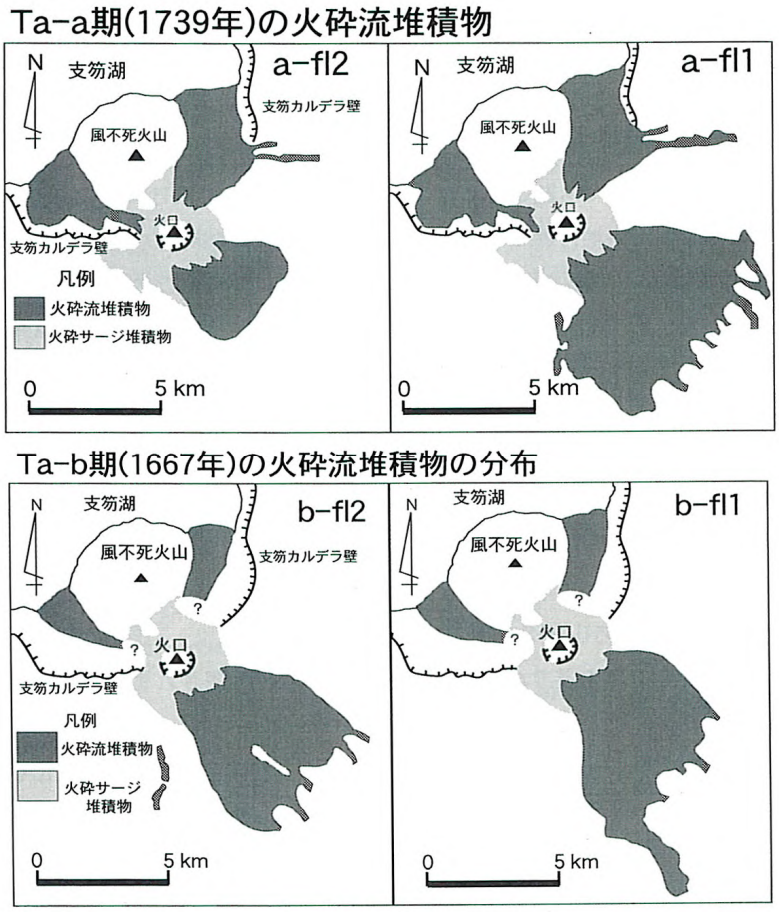


Figure 12-9 Distribution of pyroclastic flow deposits from 1667 and 1739 eruptions (Furukawa, 1998).

・1909 Eruption

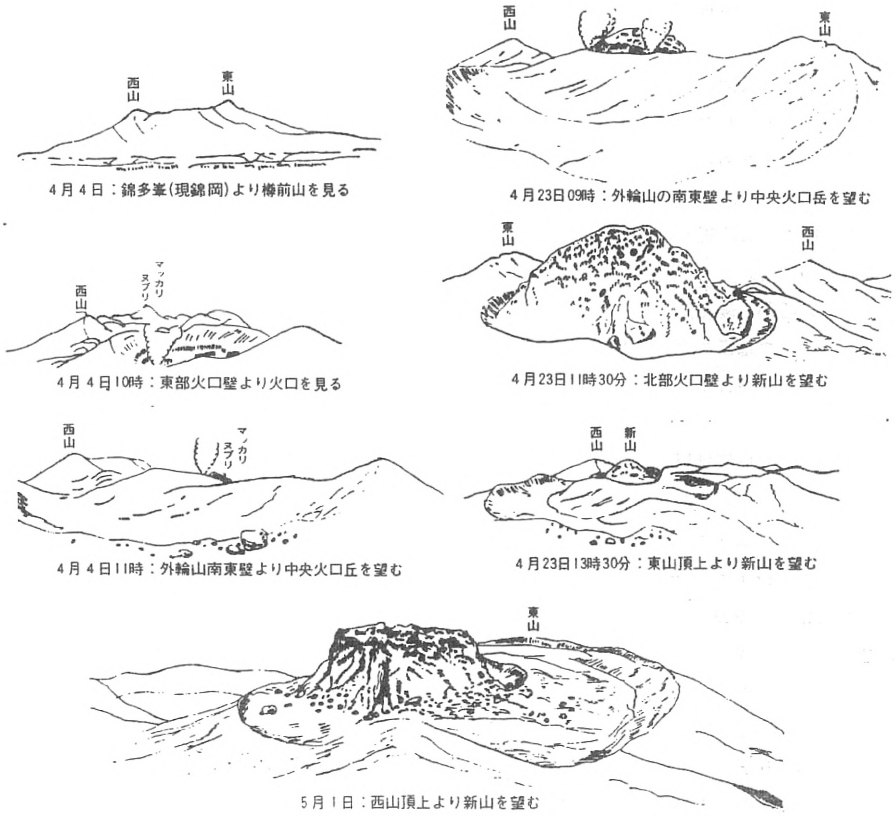


Figure 12-10 Growth of summit lava dome formed by eruption (Ishikawa et al., 1972).

・1978 Eruption

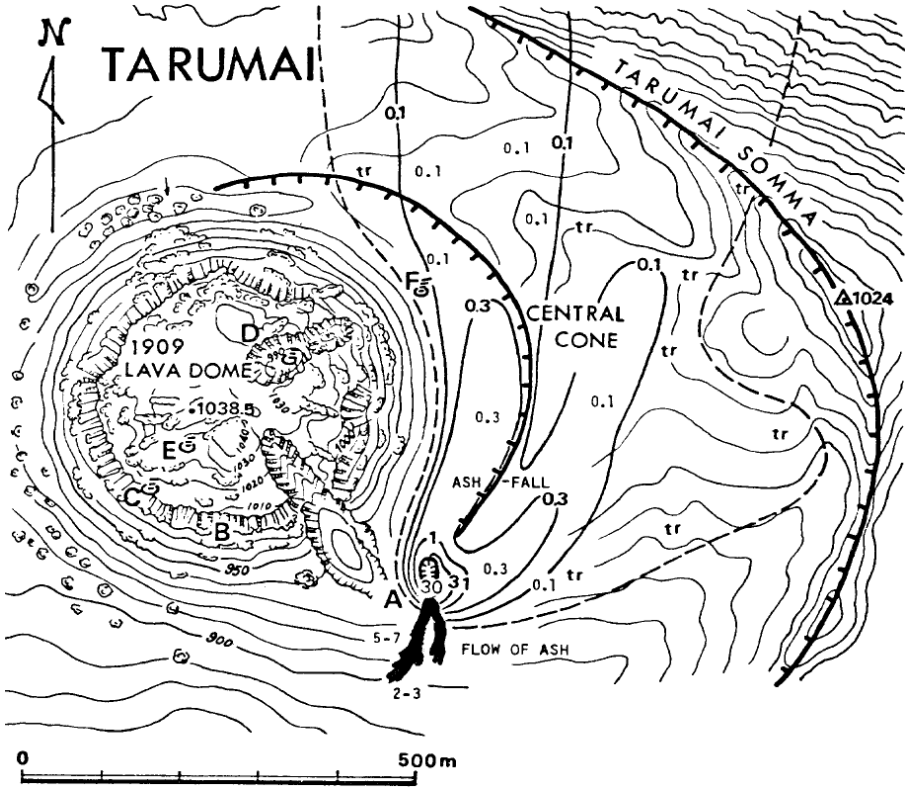


Figure 12-11 Distribution of ejecta by eruption at A-crater from May 14 to 15 (Katsui et al., 1979).

・Black area to south of A-crater indicates powder flow. Lines on north and northeast sides indicate volcanic ash depths (m)

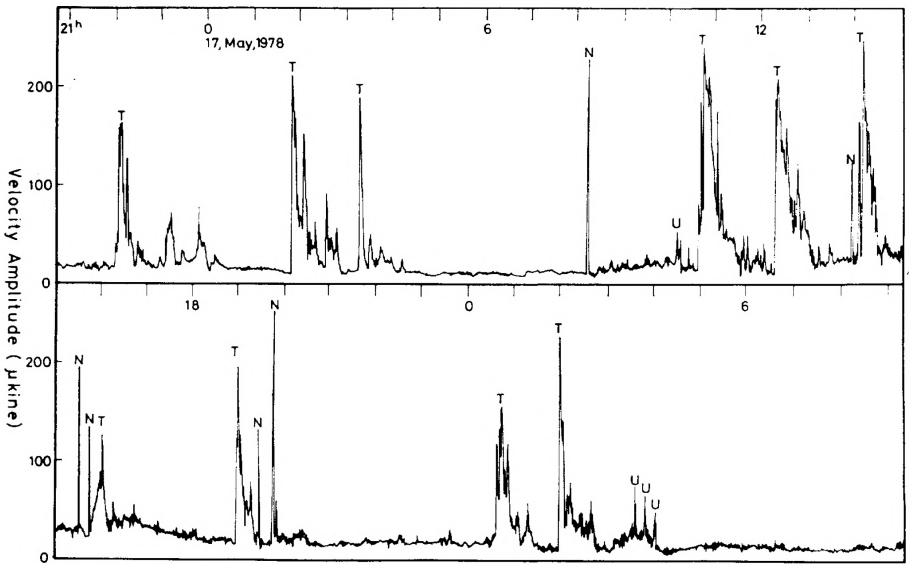


Figure 12-12 Minor eruption tremors observed by a short-period seismometer at the summit crater floor (May 16 to May 17, 1978) (Moriya, 1981).

Precursory Phenomena

Recent phreatic eruptions have been preceded by frequent earthquakes for several years before the eruptions, and by increased low-frequency earthquakes in shallow summit areas several months before the eruptions.

In recent years, inflation and increased thermal activity have been observed occasionally below the dome, though they have not resulted in eruptions.

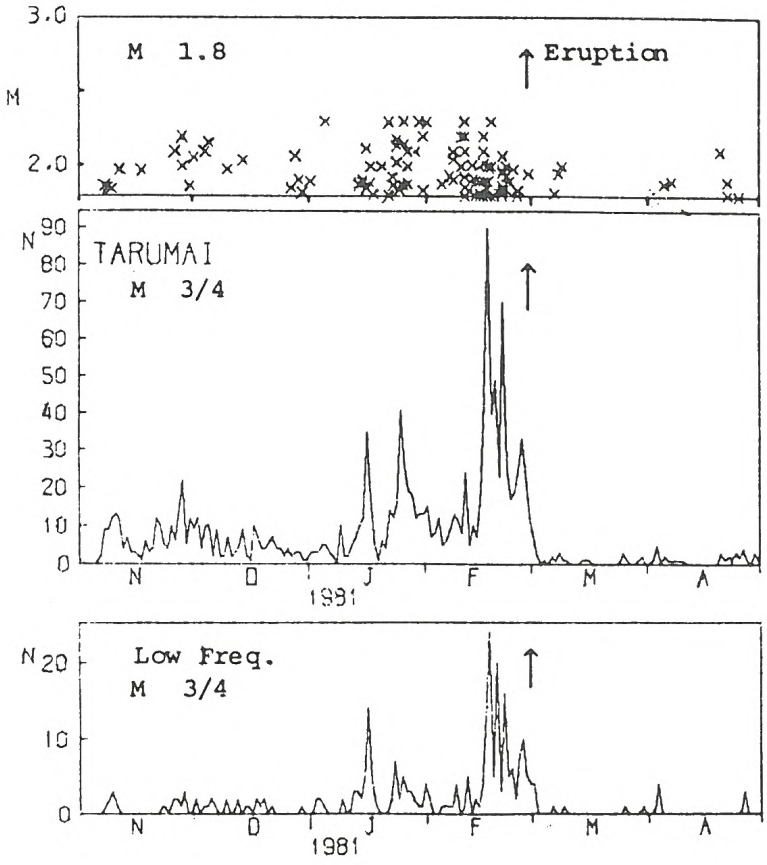


Figure 12-13 Increased earthquake activity seen before the 1981 eruption (Okada et al., 1985).

Recent Volcanic Activity

・Activity Chronograms

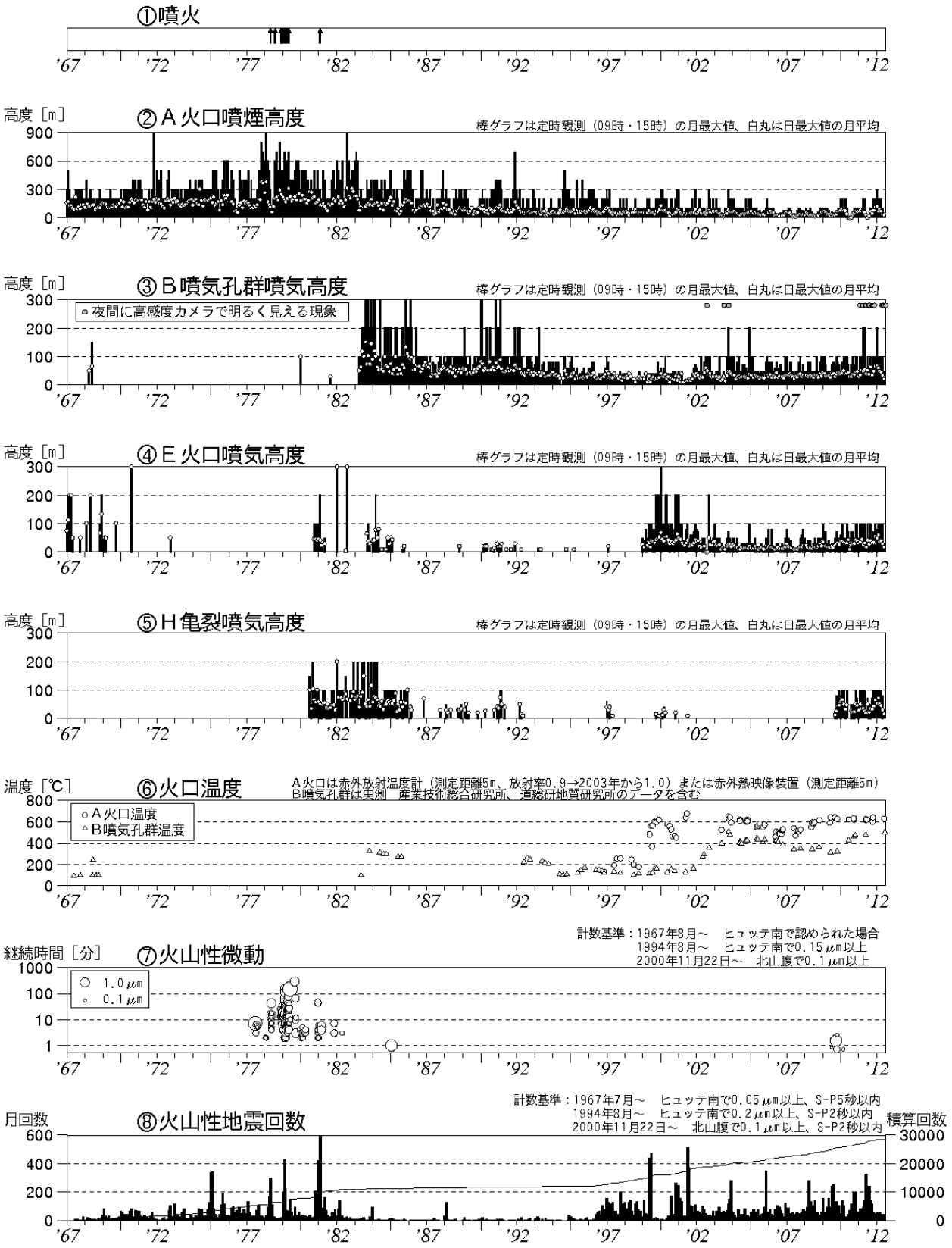


Figure 12-14 Volcano activity (1967 to June, 2012).

①Eruptions, ②Plume heights at A-crater, ③Plume heights at B-fumarole group, ④ Plume heights at E-crater

⑤Plume heights at H-crack, ⑥Temperatures at Craters, ⑦Volcanic tremors, ⑧Number of volcanic earthquakes

・Volcanic Earthquake Epicenter Distribution

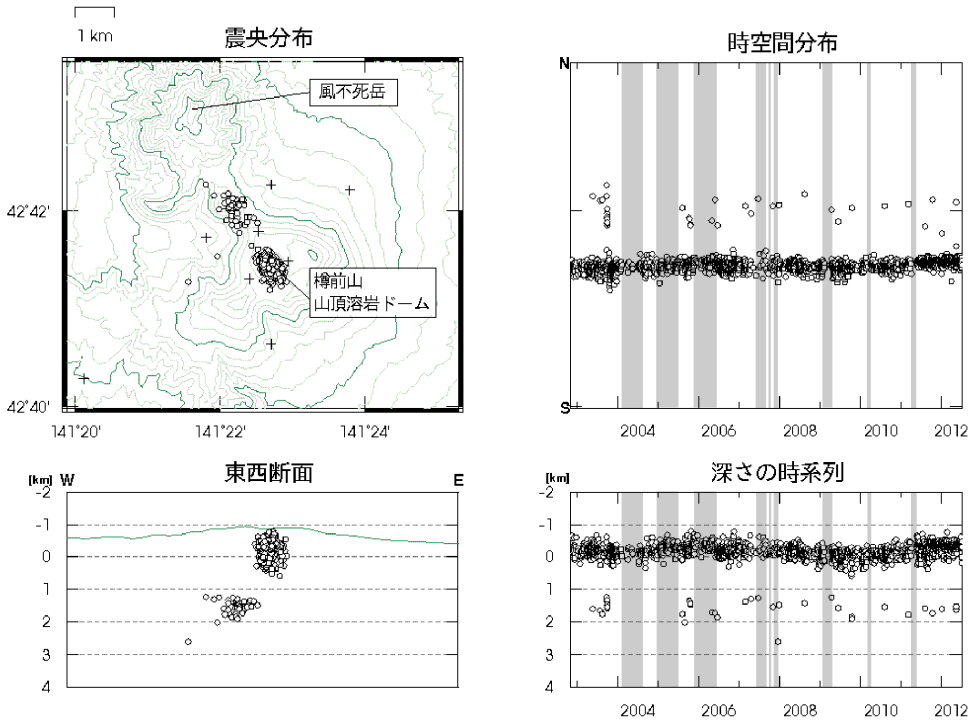


Figure 12-15 Distribution of volcanic earthquakes (November, 2002, to June 30, 2012).
+ symbols indicate observation points
①Epicenter distribution
②Space-time plot
③E-W cross-section
④Depth time series

・Seismic Activity

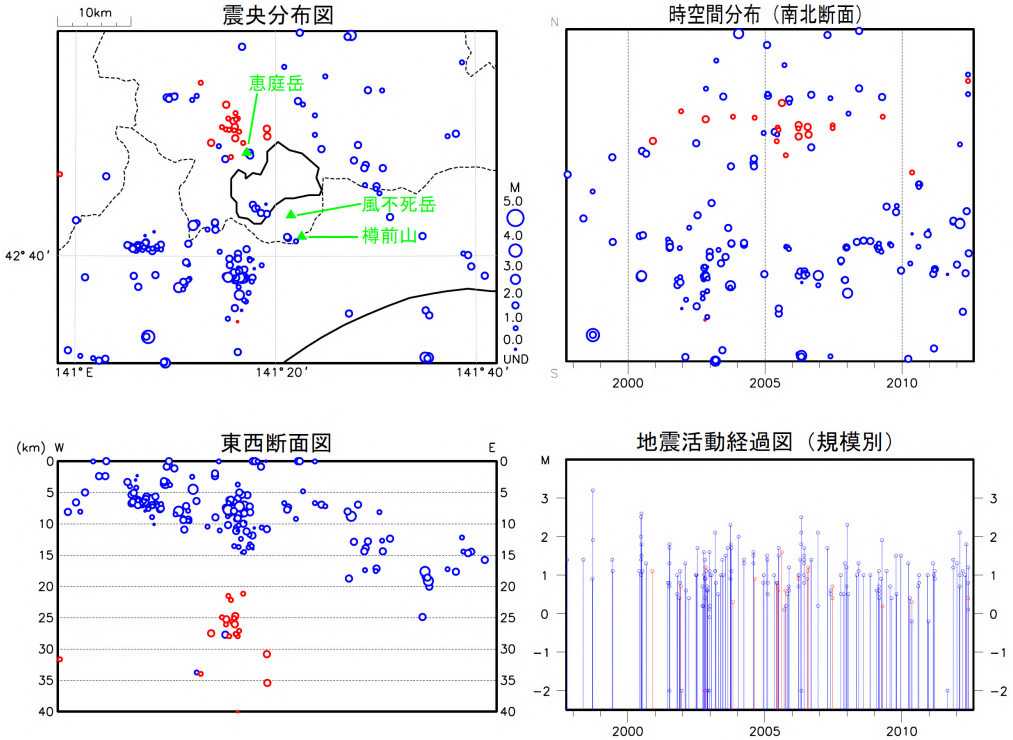


Figure 12-16 Activity of shallow VT earthquakes (blue circles) and deep low-frequency earthquakes (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter distribution (upper left), space-time plot (N-S cross-section) (upper right), E-W cross-section (lower left) and magnitude-time diagram (lower right).

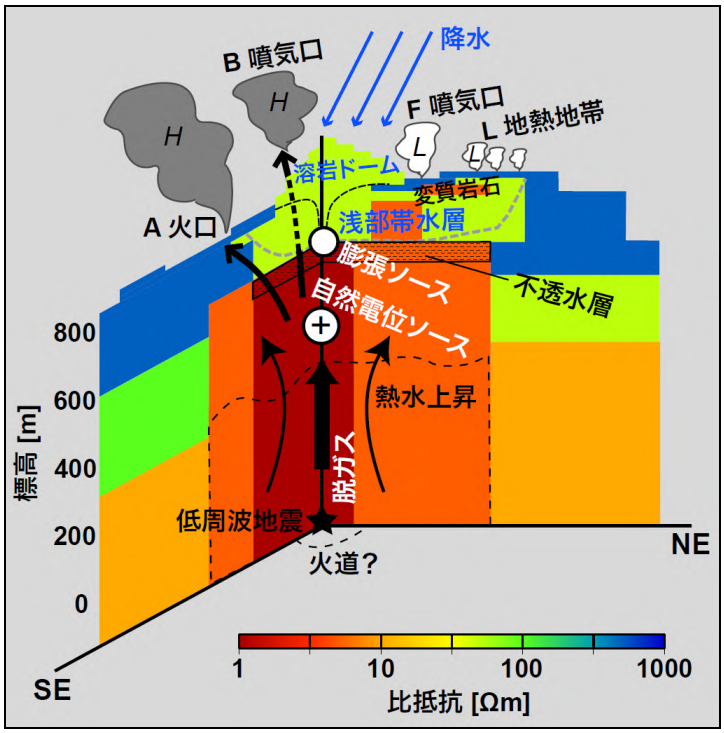


Figure 12-17 Model of resistivity at shallow part in Tarumaesan (Yamaya et al., 2009).

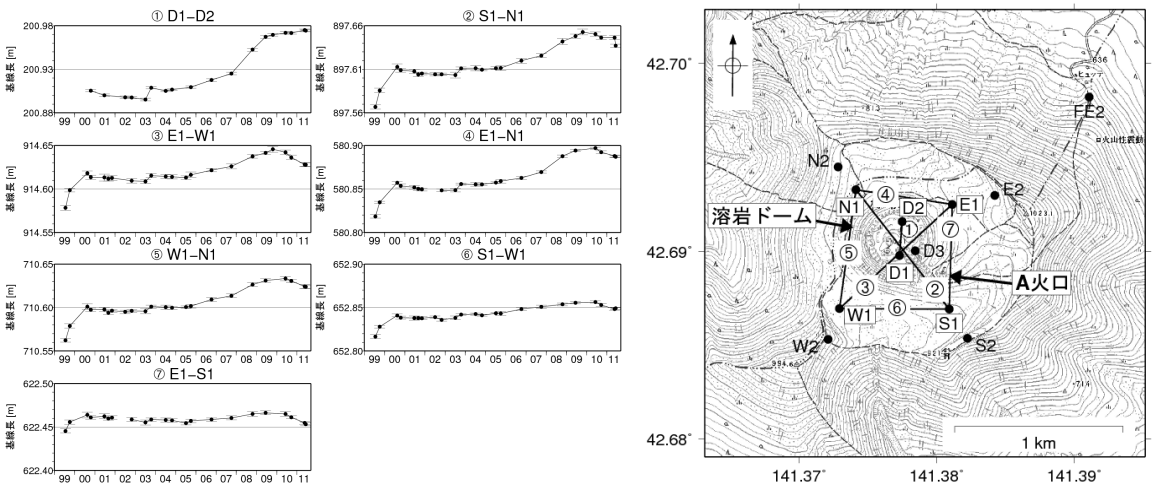


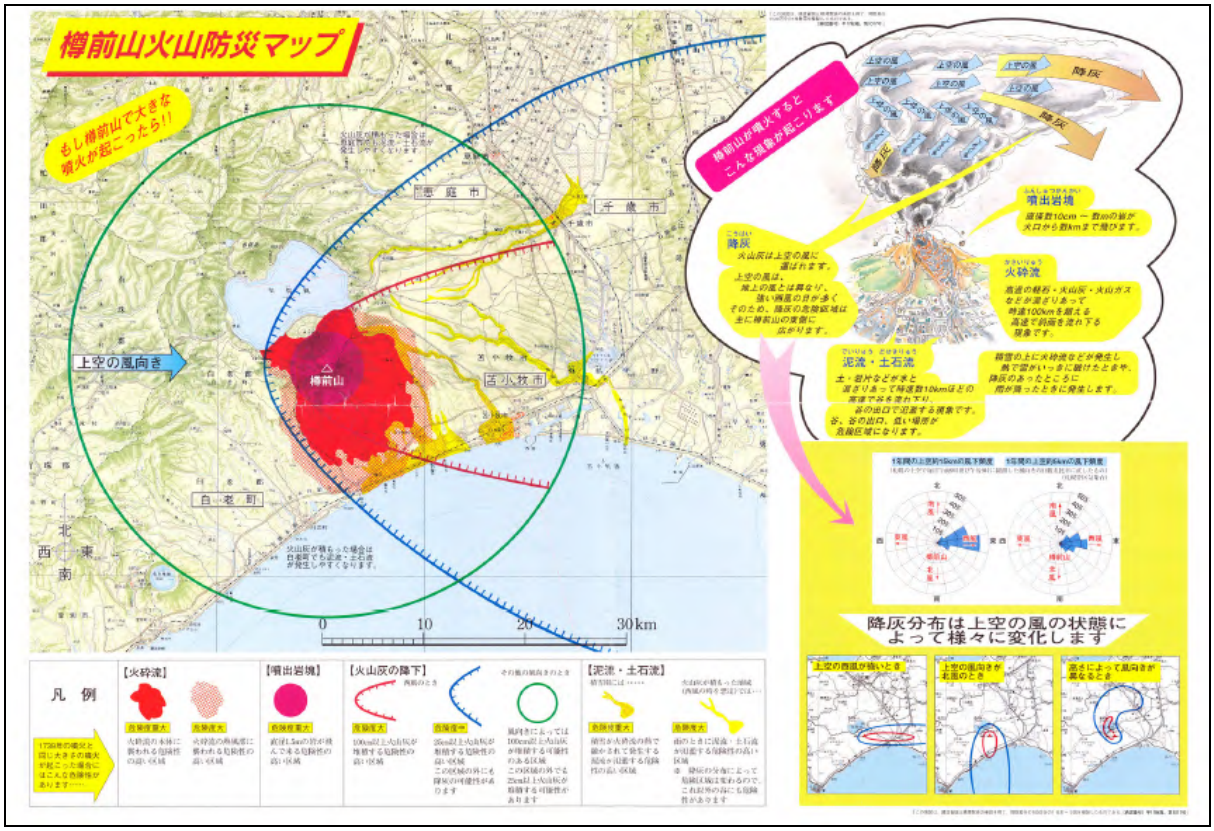
Figure 12-18 Crustal deformation in shallow area below summit lava dome (1999 to 2011) (Japan Meteorological Agency, 2011). Left: Change in baseline length, Right: Observation points

Information on Disaster Prevention

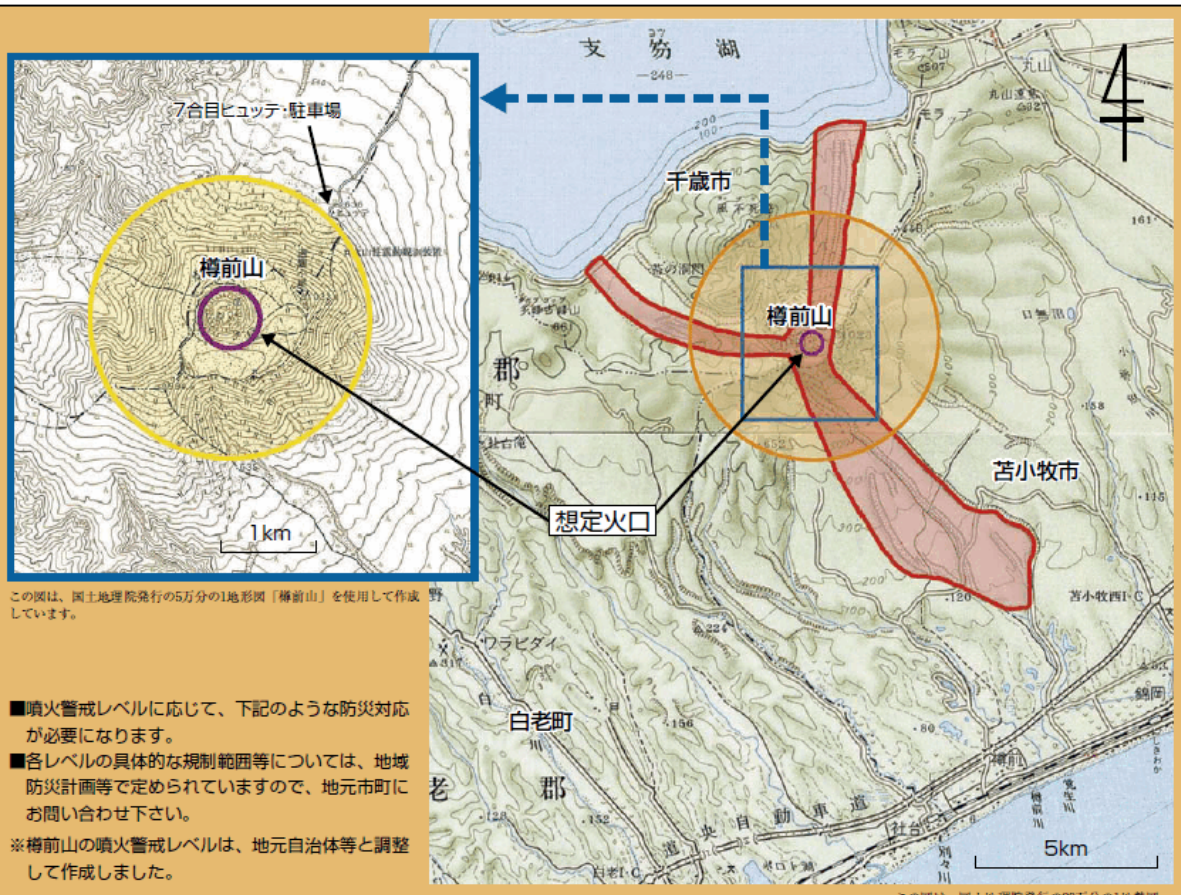
①Hazard Map

Tarumaesan Volcano Disaster Prevention Map (Wide Area Version) March, 1994 - Published by the Hokkaido Department of General Affairs Disaster and Fire Prevention Division / Tomakomai Civic Affairs Department Disaster Prevention Manager / Chitose Department of General Affairs, General Affairs Division / Eniwa Department of General Affairs, General Affairs Division / Shiraoi General Affairs Public Affairs Department, General Affairs Division

http://www.city.tomakomai.hokkaido.jp/kikikanri/kazan1new.htm



②Volcanic Alert Levels (Used since December 1, 2007)



この図は、国土地理院発行の5万分の1地形図「樽前山」を使用して作成しています。

この図は、国土地理院発行の20万分の1地勢図「札幌」「苫小牧」を使用して作成しています。

■噴火警戒レベルに応じて、下記のような防災対応が必要になります。
■各レベルの具体的な規制範囲等については、地域防災計画等で定められていますので、地元市町にお問い合わせ下さい。
※樽前山の噴火警戒レベルは、地元自治体等と調整して作成しました。

警報・予報	噴火警戒レベル(キーワード)	必要な防災対応
噴火警報	5（避難）	居住地域で避難
	4（避難準備）	居住地域で避難準備
火口周辺警報	3（入山規制）	状況に応じ、●内や◯内の立入規制
	2（火口周辺規制）	状況に応じ、◯内の立入規制
噴火予報	1（平常）	状況に応じ、火口内や火口近傍への立入規制

Volcanic Alert Levels for the Tarumaesan Volcano (Valid as of December 1, 2007)

Warning and Forecast	Target Area	Levels & Keywords	Expected Volcanic Activity	Actions to be Taken by Residents and Climbers	Expected Phenomena and Previous Cases
Eruption Warning	**Residential areas and areas closer to the crater**	**5 Evacuate**	**Eruption or imminent eruption causing significant damage to residential areas**	**Evacuate from the danger zone**	●Large eruption or imminent large eruption, with pyroclastic flow reaching residential areas. Past Examples 1667 and 1739: Large eruption, with volcanic blocks scattered approximately 4km from the crater, pyroclastic flow extending over a wide area, reaching the coast, over 10km from the crater, and depositing a large amount of pumice and volcanic ash over a wide area. ●Medium to large eruption or imminent medium to large eruption, with melted snow lahar reaching residential areas. Past Examples No observed examples
		4 Prepare to evacuate	**Forecast of eruption causing significant damage to residential areas (increased probability).**	**Those within the alert area should prepare for evacuation. Those requiring protection in the event of an disaster must be evacuated.**	●Frequent moderate eruptions result in forecast of large eruption with pyroclastic flow reaching residential areas. Past Examples No observed examples ●Forecast of small eruption during period snow has accumulated, resulting in melted snow volcanic lahar. Past Examples No observed examples
Crater Area Warning	**Non-residential areas near the volcano**	**3 Do not approach the volcano**	**Eruption or prediction of eruption causing significant damage to areas near residential areas (entering area is life threatening).**	**Residents can go about daily activities as normal. When necessary, evacuation preparations should be performed for those requiring protection in the event of a disaster. Access restrictions for dangerous areas, including mountain climbing and mountain access prohibitions, etc.**	●Moderate eruption with volcanic blocks scattered 3km or less, or pyroclastic flow within valley. Past Examples 1874 and 1909: Moderate eruption, with volcanic block scattered 2 to 3km from the crater, and pyroclastic flow within the valley, extending up to 9km from the crater (1874), and several cm of volcanic ash deposits at the foot of the volcano. ●Increase in earthquake activity and crustal deformation, etc. results in forecast of moderate eruption. Past Examples No observed examples
	Crater area	**2 Do not approach the crater**	**Eruption or prediction of eruption affecting area around crater (entering area is life threatening).**	**Residents can go about daily activities as normal. Access to crater area restricted, etc.**	●Very small eruption scattering volcanic blocks in and around the summit crater floor. Past Examples Repeated small eruptions which have occurred since the 1909 eruption, scattering volcanic blocks around the summit. ●Increase in earthquake activity and crustal deformation, etc. results in forecast of moderate eruption. Past Examples 2002 to 2003: Rapid increase in heat activity in summit B-fumarole group. 1999: Rapid increase in summit A-crater heat activity. 1997 to 2001: Increased earthquake activity.
Eruption Forecast	**Inside the crater**	**1 Normal**	**Little or no volcanic activity. Volcanic ash may be emitted within the crater as a result of volcanic activity (entering area is life threatening).**	**Access to interior of and area around crater restricted as necessary, etc.**	●Little or no volcanic activity. Possibility of emissions which may affect summit crater interior and nearby area.

Note 1) The volcanic blocks mentioned in this table refer mainly to blocks large enough that their trajectories are not affected by wind.

Note 2) Large eruptions refer to eruptions with volcanic plumes extending 10,000m or more, with pyroclastic flows over a wide area, accompanied by melted snow lahars in periods when snow has accumulated.

Note 3) Moderate eruptions refer to eruptions with volcanic plumes extending several thousand meters, scattering volcanic blocks over an area of 2 to 3km, with small pyroclastic flows accompanied by melted snow lahars.

Note 4) Small eruptions refer to eruptions with volcanic plumes extending 1,000 meters or less, scattering volcanic blocks inside and outside the summit crater floor.

Social Circumstances

①Populations

- Tomakomai City:174,023 (83,620 households) (as of October 31, 2011)
- Chitose City:94,292 (45,003 households) (as of November 1, 2011)
- Shiraoi Town:19,357 (9,717 households) (as of October 31, 2011)

②National Parks, Quasi-National Parks, Number of Climbers

Shikotsu-Toya National Park (Shikotsu, Jozankei, Noboribetsu areas)

- Tarumaesan - - Number of mountain-climbers per year: 20,574 in 2010
- Lake Shikotsu - Estimated number of sightseers per year: 901,200 in 2010

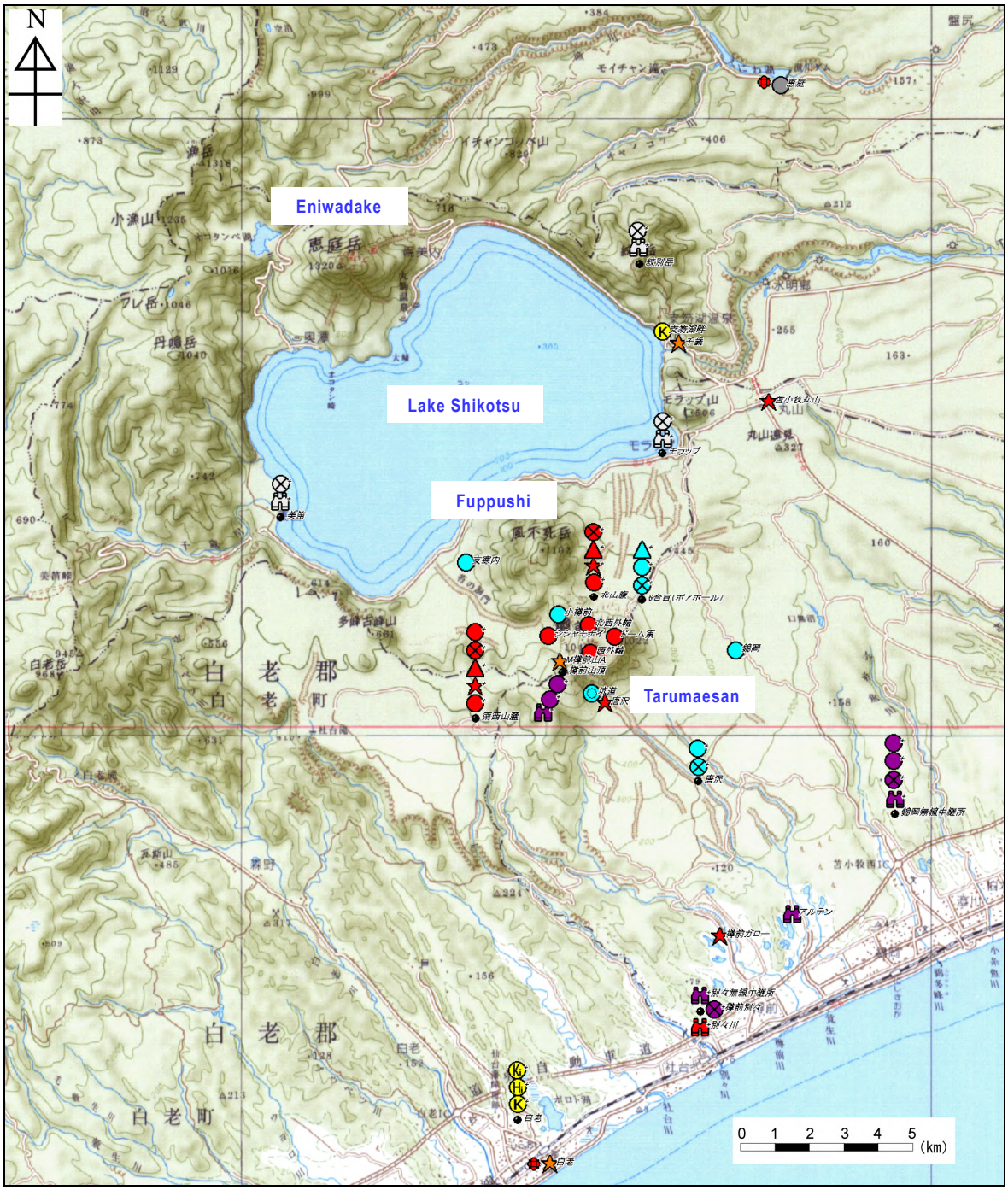
③Facilities

- Tomakomai City, Tomakomai City Museum
- Chitose City
  Chitose City Learning and Communication Center for Disaster Prevention, Lake Shikotsu Visitor's Center
- Shiraoi Town
  Tarumae Volcano Disaster Prevention Station at Shiraoi

Monitoring Network

Wide Area

* Monitoring sites with multiple observation instruments are indicated by small black dots, and other symbols indicate types of monitoring.



1:200,000 scale regional maps (Tomakomai and Sapporo) published by the Geospatial Information Authority of Japan were used.

Legend

(JMA)
seismometer(SP)
GPS
tiltmeter
infrasonic microphone
visual camera
seismic intensity mete
seismometer(SP)
(For earthquakes and tsunamis)

(GSI)
GPS

(NIED)
Hi-net
K-NET
KiK-net

(Hokkaido Univ.)
seismometer(SP)
seismometer (broadband)
tiltmeter
infrasonic microphone

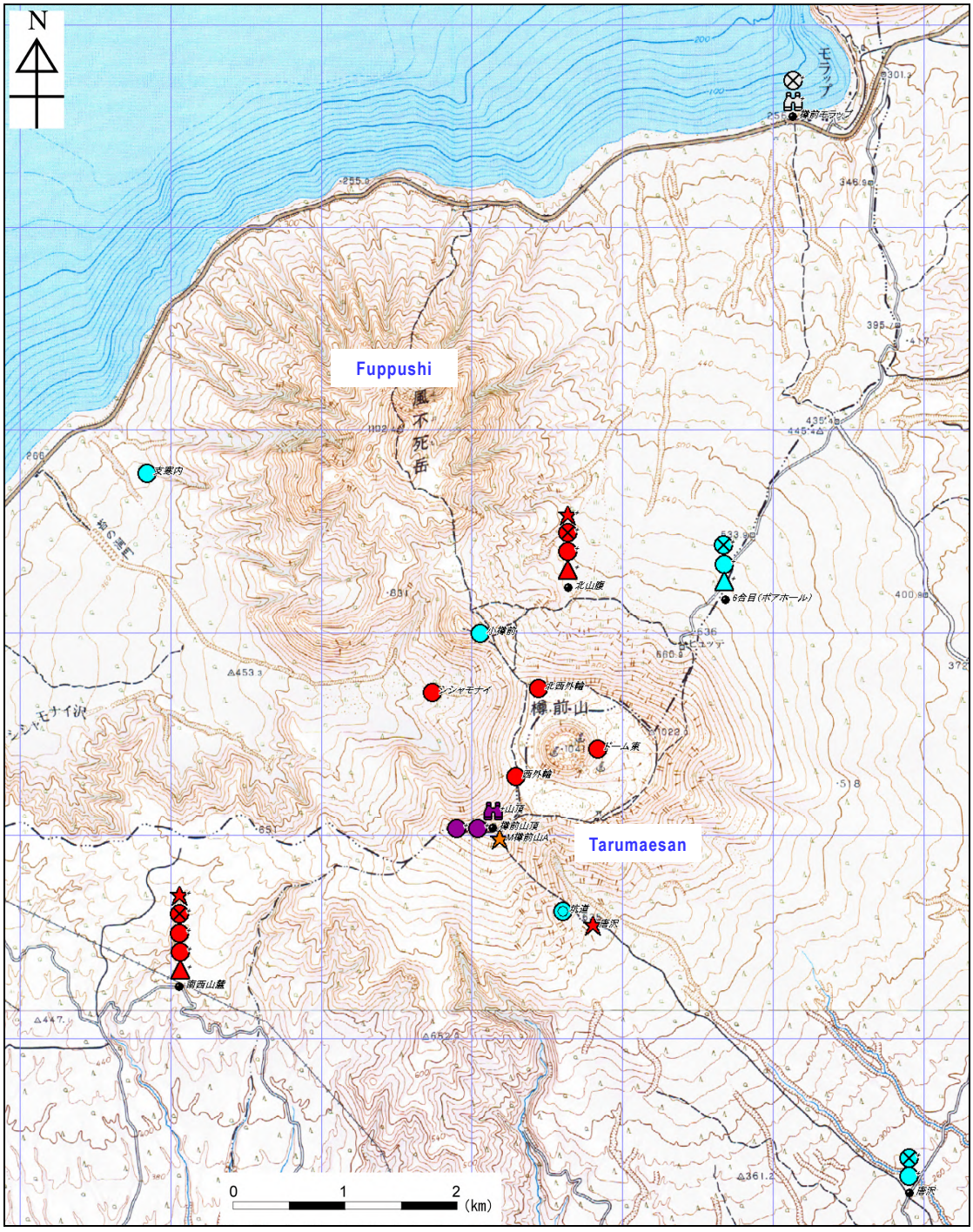
(MILT)
seismometer(SP)
infrasonic microphone
visual camera

(Hokkaido Govt.)
infrasonic microphone
visual camera

Figure 12-19 Regional monitoring network.

In and Around the Summit

* Monitoring sites with multiple observation instruments are indicated by small black dots, and other symbols indicate types of monitoring..



1:50,000 scale topographic maps (Shiraoi and Tarumaesan) published by the Geospatial Information Authority of Japan were used.

Legend

(JMA)
seismometer(SP)
GPS
tiltmeter
infrasonic microphone
visual camera
seismic intensity meter
seismometer(SP)
(For earthquakes and tsunamis)

(GSI)
GPS

(NIED)
Hi-net
K-NET
KiK-net

(Hokkaido Univ.)
seismometer(SP)
seismometer (broadband)
tiltmeter
infrasonic microphone

(MILT)
seismometer(SP)
infrasonic microphone
visual camera

(Hokkaido Govt.)
infrasonic microphone
visual camera

Figure 12-20 Local monitoring network.

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