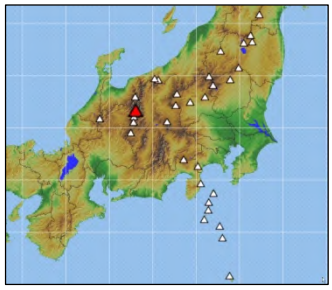
50. Yakedake



Continuously Monitored by JMA

Latitude: 36°13'37" N, Longitude: 137°35'13" E, Elevation: 2,455 m

(Triangulation Point - Yakedake)

Overview of Yakedake taken from the east side on August 4, 2011 by the Japan Meteorological Agency

Summary

The Yakedake volcano group (Harayama, 1990). consists of, from north to south, Warudaniyama, Yakedake,Shirataniyama, and Akandanayama volcanoes among which, only Yakedake is fumarolic at present. Yakedake is anandesite-dacite stratovolcano. A lava dome is located at its summit, and pyroclastic flow deposits on its flanks. In addition tothe summit crater (diameter: approximately 300 m), eruptions have also occurred on its flanks. The most recent magmaticeruption was the discharge of Yakedake Dome Lava and Nakao Pyroclastic Flow Deposits of 2.3ka. At the eastern foot of thevolcano, tephra is confirmed in the black soil on the upper part of these pyroclastic flow deposits (Oikawa, 2002; Oikawa etal., 2002). The SiO_2 content of the andesite and dacite is between 61.0 and 65.0 wt %.

Almost all eruptions within recorded history were phreatic, which are prone to producing lahars. It maintains high fumarolic activity even when the volcano is calm.

Red Relief Image Map

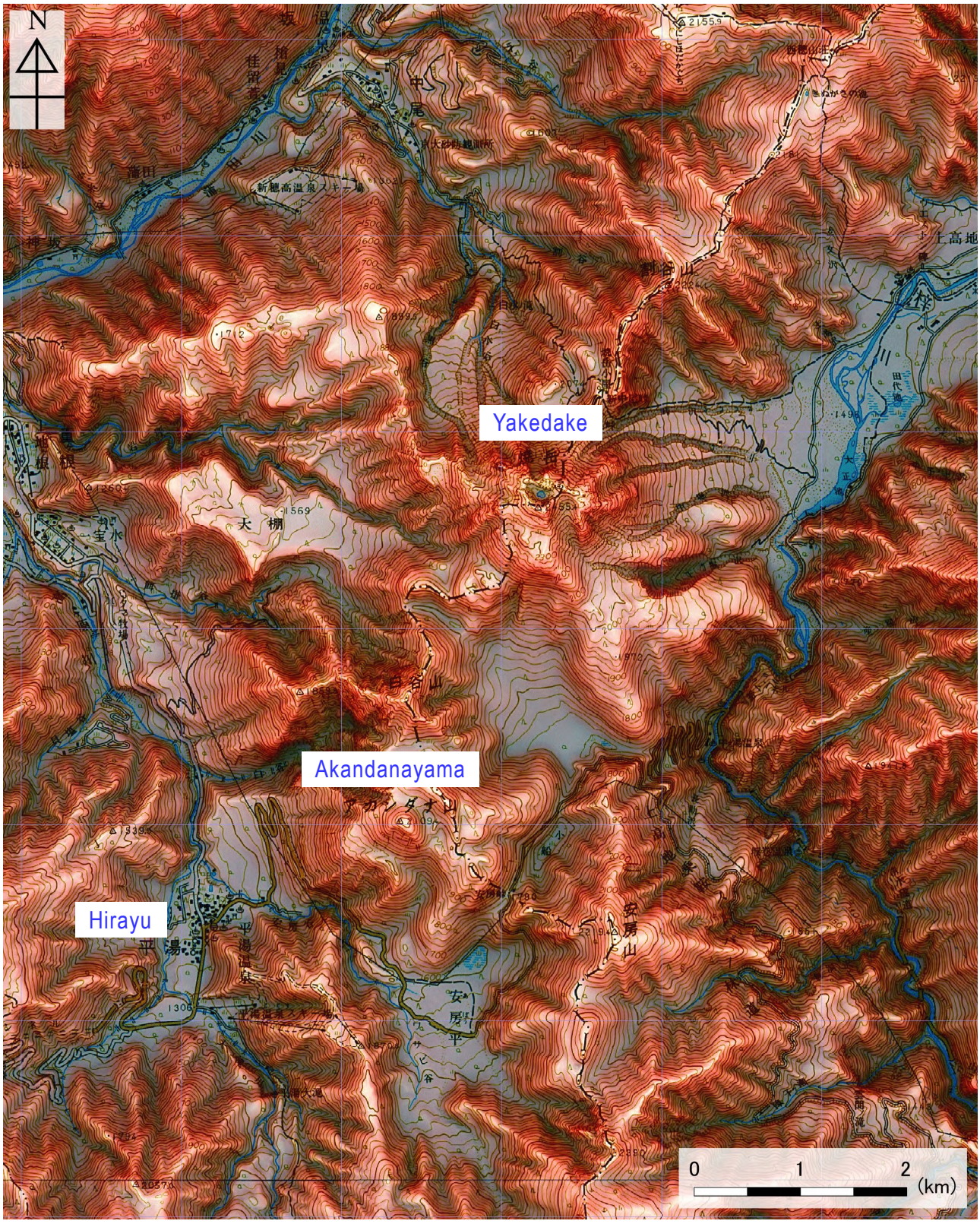


Figure 50-1 Topography of Yakedake and Akandanayama.

1:50,000 scale topographic maps (Norikuradake and Kamikochi) and digital map 50 m grid (elevation) published by the Geospatial Information Authority of Japan were used.

Photo

Figure 50-2 Image of eruption at 15:00 on October 12, 1925 (Taisho 14) (Courtesy of the Hida Takayama Town Museum archives and H.Nakamura). Photo taken from Imami at Okuhida Onsenkyo Spa.

Topography around the Crater

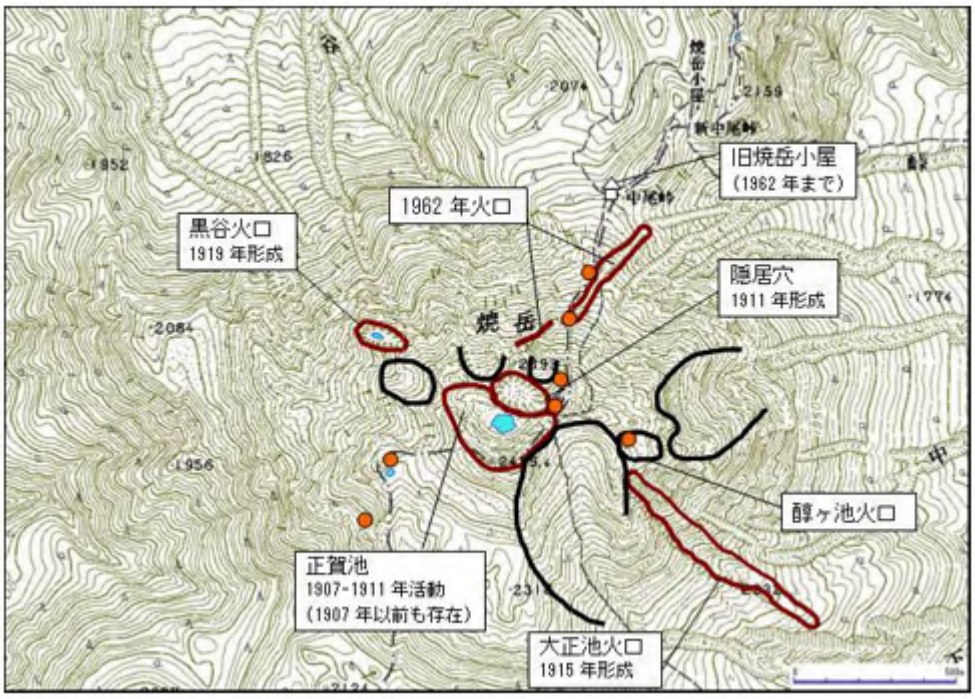


Figure 50-3 Distribution of craters in the summit area (based on Oikawa, 2002).

: Craters (indicates active craters after 1907), : Fumarole positions

The 1:25,000 Scale Topographic Map (Yakedake) published by the Geospatial Information Authority of Japan was used to create this map.

Figure 50-4 Locations of fumaroles in and around the summit.

The 1:25,000 Scale Topographic Map (Yakedake) published by the Geospatial Information Authority of Japan was used to create this map.

Chronology of Eruptions

・Volcanic Activity in the Past 10,000 Years

Yakedake began forming around 15,000 years ago. In the initial stages, lava and pyroclastic flows were discharged near Kurotani. Lava and pyroclastic material have been emitted within the past 10,000 years as well. The most recent magmatic eruption occurred approximately 2,300 years ago. During this period of activity, both the Yakedake dome lava and Nakao pyroclastic flow were emitted. Around four phreatic eruptions have occurred per thousand years following this eruption (Oikawa et al., 2002).

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
13.5←→4.5 ka	Southwest side of summit	Magmatic eruption	Hosoike dome eruption: Lava dome. Magma eruption volume = 0.1 km^3 DRE.
15.5←→2.3 ka	Nakao Toge area	Magmatic eruption	Nakao Toge lava eruption: Lava flow. Magma eruption volume = 0.05 km^3 DRE.
4.5 ka	Dome with highest point elevation of 2337 m on south side of summit	Magmatic eruption	Shimohorisawa lava eruption: Lava flow. Magma eruption volume = 1.25 km^3 DRE.
2.8 ka	Summit area	Phreatic eruption	Tephra fall.
2.35 ka	Summit area	Phreatic eruption	Tephra fall.
2.3 ka	Summit area	Phreatic eruption → magmatic eruption → phreatic eruption	Yakedake dome lava / Nakao pyroclastic flow deposit eruption: Tephra fall → lava dome, pyroclastic flow, pyroclastic surge, tephra fall → tephra fall. Magma eruption volume = 0.3 km^3 DRE. (VEI 4)

* Volcanic periods, areas of activity, and eruption types taken from the Active Volcano Database of Japan, AIST (Kudo and Hoshizumi, 2006). All years are noted in Western date notation. "ka" within the table indicates "1000 years ago", with the year 2000 set as 0 ka.

A←→B: Eruption events taking place at some point between year A and year B

・Historical Activity

Year	Phenomenon	Activity Sequence, Damages, etc.
630	Small-scale: Phreatic eruption	Tephra fall. The eruptive activity occurred in the summit area. (VEI 1)
685	Moderate: Phreatic eruption	Tephra fall. The eruptive activity occurred in the summit area. (VEI 2)
1270	Phreatic eruption	Tephra fall. The eruptive activity occurred in the summit area.
1440	Phreatic eruption	Tephra fall. The eruptive activity occurred in the summit area.
1460	Moderate: Phreatic eruption	Tephra fall. The eruptive activity occurred in the summit area. (VEI 2)
1570	Phreatic eruption	Tephra fall. The eruptive activity occurred in the summit area.
1746	Moderate: Phreatic eruption	Tephra fall. April 18 to 19. The eruptive activity occurred in the summit area. (VEI 2)
From 1887 (Meiji 20)	Fume	A fumarole appeared on the small hill on the south of Nakao Pass, gradually moving towards the summit, and withering and killing trees.
1907 to 1909 (Meiji 40 to 42)	Phreatic eruption	Tephra fall. Tephra fall and formation of a new crater on the old crater floor. The eruptive activity occurred at the Shogaike crater and to its east. December 8, 11, 21, and 23, 1907. March 8, July 28, and November 23, 1908. January 20 to 21, March 10, 12, 13, 23, 29, April 9, 26, May 7, 13, 15, 28, and June 1, 1909. 1909 eruption: Rumbling and tephra fall in January. Eruption, large amount of volcanic plume emission, and tephra fall on March 4. A new crater was formed near the western edge of the old eruption crater. Eruption, rumbling, and as tephra fall on April 2. Rumbling and tephra fall in May. Rumbling, tephra fall, and new crater formation in June.
1910 to 1912 (Meiji 43 to 45)	Phreatic eruption	2 eruptions. Tephra fall. Rumbling and tephra fall. The eruptive activity occurred at the Shogaike crater and the Inkyoana crater. November 11, 29, and 30, 1910. May 6, 11, June 13, 14, 16, 17, 22, 23, 24, 27, 29, July 7, 8, 10, 12, 13, 17, 19, 20, 22, August 18, 21, 23, 1911. February 11, 13, 16, 18, 19, 22, 23, 26, March 3, 20, April 4, 5, 21, May 6, 8, 1912. 1911 eruption: Explosion, rumbling, and tephra fall in May. Explosion, rumbling, and tephra fall in June. Explosion, crater formation, rumbling, and tephra fall in July. Tephra fall and rumbling in August. February to July and September, 1912, eruption: Tephra fall.

Year	Phenomenon	Activity Sequence, Damages, etc.
1913 to 1914 (Taisho 2 to 3)	Phreatic eruption	Tephra fall. Rumbling and tephra fall. The eruptive activity occurred at the Inkyoana crater. August 1, September 1, 10, and November 11, 1913. January 12 and 13, 1914.
1915 (Taisho 4)	Moderate: Phreatic eruption (lahar)	June 6, July 6, 16. Tephra fall, lahar. The eruptive activity occurred at the Taishoike crater and the Inkyoana crater. Eruption and tephra fall in February. On June 6 an eruption and earthquake swarms occurred immediately preceding the eruption. A large crack 1km long appeared from the plateau at an approximately elevation of 1,900 m to the east wall of the summit, on the east side of the summit. Several dozen craters were formed on its bottom. A blast knocked down trees, lahar blocked the Azusa River, and the rupture of the blockage caused flooding. The Taishoike was formed. A small explosion occurred in July of the same year. (VEI 2)
1916 (Taisho 5)	Phreatic eruption	April 11. Tephra fall. The eruptive activity occurred at the Taishoike crater and the Inkyoana crater.
1919 (Taisho 8)	Phreatic eruption	November 1. Tephra fall? The eruptive activity occurred at the Kurotani crater and the Inkyoana crater.
1922 (Taisho 11)	Phreatic eruption	March 19. Tephra fall. The eruptive activity occurred at the Kurotani crater and the Inkyoana crater.
1923 (Taisho 12)	Phreatic eruption	June 26, July 3, 10, 26, 31, August 2. Tephra fall. The eruptive activity occurred at the Kurotani crater and the Inkyoana crater. Rumbling, large amount of tephra fall, and silk industry damage.
1924 to 1926 (Taisho 13 to 15)	Phreatic eruption (lahar)	Tephra fall, lahar. The eruptive activity occurred at the Inkyoana crater and the Kurotani crater. November 16, 17, December 3, 7, 9, 10, 1924. January 13, 22, 31, February 10, 11, 26, March 3, 4, 28, April 27, May 2, 13, 15, 17 to 19, 21 to 23, June 27 to 28, July 4, August 3, 22, September 22, October 4, 12, 13, 23 to 26, November 1, 12, 13, 17, December 3, 10, 11, 14, 22, 24, 26, 1925 January 27, 1926. January to June and October to December, 1925, eruption activity: Volcanic blocks and fire column. Rumbling and tephra fall over a wide area. Small eruption and tephra fall on January 27, 1926. This eruption event created a lahar flow on May 18, 1925.
1927 (Showa 2)	Phreatic eruption	January, April 23, 29, May 19. Tephra fall. The eruptive activity occurred at the Inkyoana crater and the Kurotani crater. December 15. Tephra fall. The eruptive activity occurred at the Inkyoana crater and the Kurotani crater.
1929 (Showa 4)	Phreatic eruption	April 19. Tephra fall. Rumbling and tephra fall. The eruptive activity occurred at the Inkyoana crater and the Kurotani crater.
1930 (Showa 5)	Phreatic eruption	March 13, 17, 26. Tephra fall. The eruptive activity occurred at the Inkyoana crater.
1931 (Showa 6)	Phreatic eruption	June 18, 23, 24. Tephra fall. The eruptive activity occurred at the Inkyoana crater.
1932 (Showa 7)	Phreatic eruption	February 6. Tephra fall. There are no details regarding the location of the eruptive activity.
1935 (Showa 10)	Phreatic eruption	September 11, November 11 to 12. Tephra fall? Explosion sound, felt-earthquakes. No details exist regarding the location of the eruptive activity.
1939 (Showa 14)	Phreatic eruption	June 4. Tephra fall. No details exist regarding the location of the eruptive activity.
1953 (Showa 28)	Earthquake	Late July.
1958 (Showa 33)	Earthquake	June to September.
1962 to 1963 (Showa 37 to 38)	Moderate: Phreatic eruption (lahar)	Tephra fall, lahar. The eruptive activity occurred at explosion craters of the Nakao Pass and at the Kurotani crater. June 17, 19, July 12, September 16, 24, October 17, November 7, 17, December 13, 17, 1962. A fissure measuring 500 m long was formed on the Nakao Pass side flank, and a large ejection of volcanic blocks and tephra fall injured 2 people at a cabin near the crater. A lahar flow occurred on December 19. Small explosions and lahar flows occurred occasionally from July to December. January 17, 22, February 6, 14, 15, March 1, April 8, June 29, 1963 Tephra fall, earthquake swarms. January to March. Lahars were produced by these eruption events on June 18, 19, 22, 25, July 2, 5, 12, 26, August 9, 14, and 15, 1962. The lahars on June 18 and 19 were directly caused by the eruptions; the others were caused by rainfall. (VEI 2)

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Year	Phenomenon	Activity Sequence, Damages, etc.
1968 (Showa 43)	Earthquake	November 8. Felt-earthquakes occurred frequently near Kamikochi (maximum JMA scale seismic intensity of 3). Details unknown.
1969 (Showa 44)	Earthquake	On August 31 an M4.7 earthquake occurred, followed by an earthquake swarm that continued until late September. On September 2 an M5.0 (JMA scale seismic intensity of 3) earthquake struck. The hypocenter was near Kasumizawatake, to the east of Yakedake.
1990 (Heisei 2)	Earthquake	April 1 to early May. The hypocenters were located approximately 10 km to the east of Yakedake (maximum magnitude of M4.4).
1995 (Heisei 7)	Phreatic Explosion	February 11. A phreatic explosion occurred approximately 3 km southeast of the summit of Yakedake, at the site of construction site to redirect national road 158 in order to build the Abo Tunnel. Steam containing volcanic gas and over 6000 m^3 of sand and gravel were ejected, and the shock caused landslides. 4 construction workers were killed.
1998 to 1999 (Heisei 10 to 11)	Earthquake	August 7 until the following year. Earthquake swarms with hypocenters near Kamikochi (approximately 5 to 10 km east-southeast) began, with the number of earthquakes gradually tailing off.
March to December, 2011 (Heisei 23)	Earthquake	Since the 2011 off the Pacific coast of Tohoku Earthquake (March 11, 2012) many earthquakes have occurred in shallow areas from directly below the summit to the northwest foot of the volcano. High number of felt-earthquakes. March 11, 14:57 - M4.7 (JMA scale seismic intensity of 4), March 21, 13:15 - M4.8 (JMA scale seismic intensity of 3).

* Reference documents have been appended with reference to the Active Volcano Database of Japan, AIST (Kudo and Hoshizumi, 2006) for volcanic periods, areas of activity, eruption types, and eruption events.

Whole Rock Chemical Composition

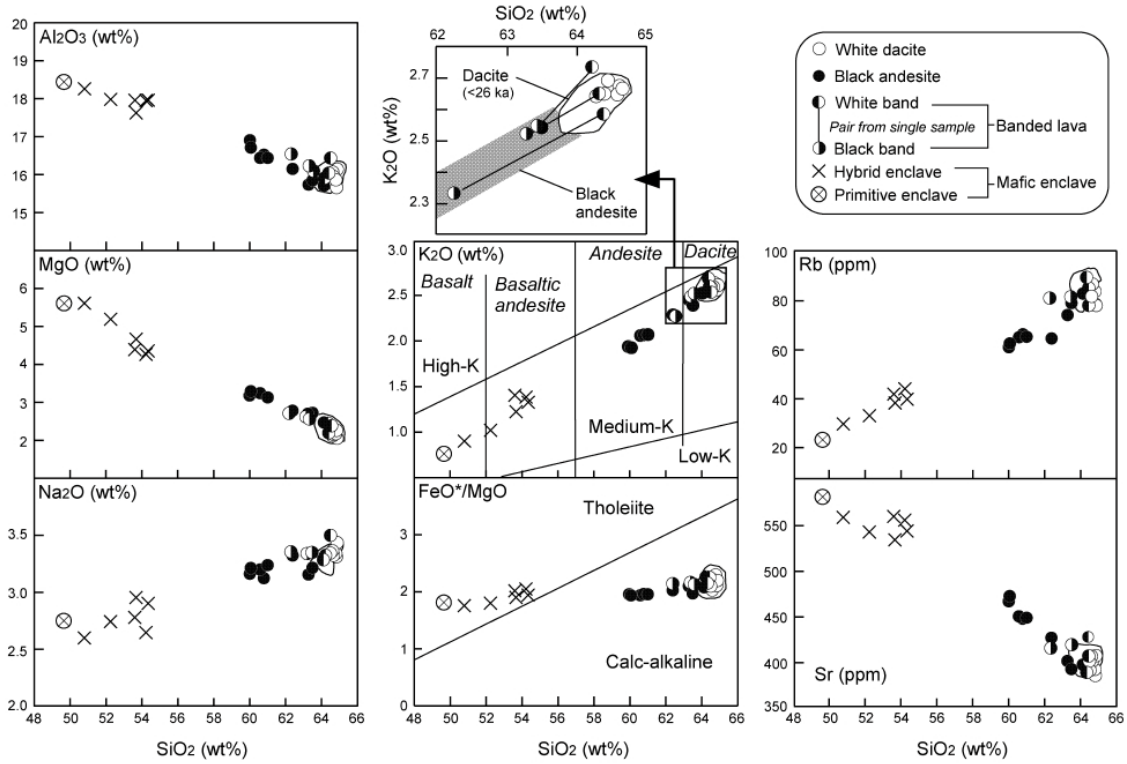


Figure 50-5 Whole rock chemical composition (Ishizaki, 2007).

Period - Cumulative Magma Volume

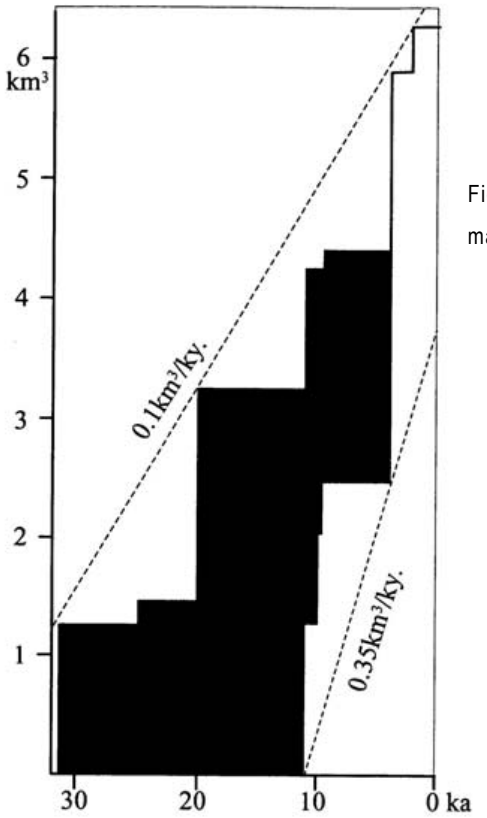
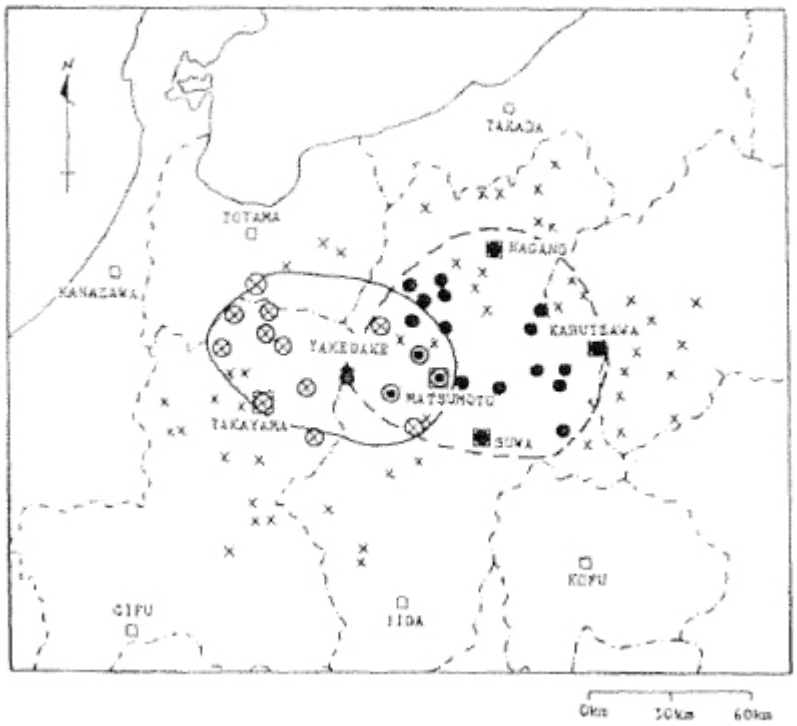


Figure 50-6 Period - cumulative magma volume (Oikawa, 2002).

Major Volcanic Activity

・1962 Volcanic Activity



○: Locations where explosion sounds or infrasonic waves were confirmed

●: Locations where ash fall was observed

x: Locations where ash fall was not observed

□: Meteorological office

Dotted line: Ash fall area

Solid line: Area where explosion sounds or infrasonic waves were confirmed

Figure 50-7 Distribution of explosion sounds and ash fall from explosive eruption (Japan Meteorological Agency (1962)).
The explosion sounds correspond to the explosion on June 19, 14:00.
The ash fall corresponds to the explosion on June 17, 21:57.

Recent Volcanic Activity

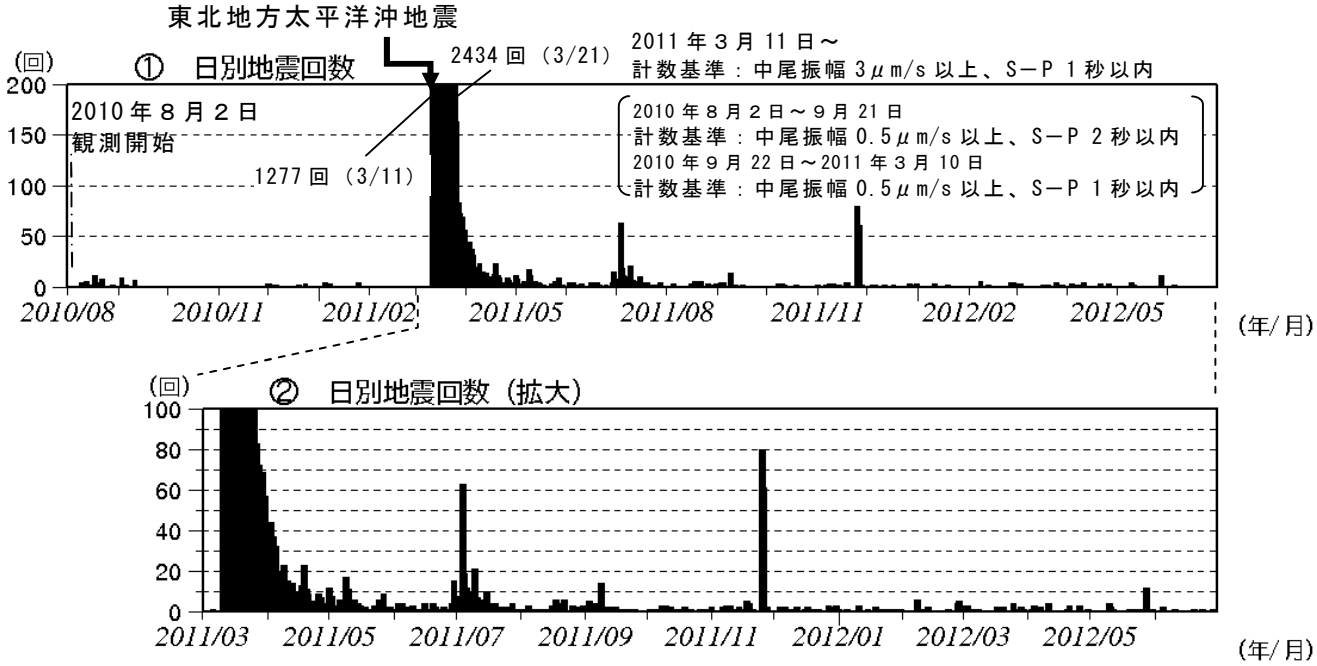


Figure 50-8 Number of earthquakes in and around the Yakedake area (July 1, 2010, to June 30, 2012).

Since the 2011 off the Pacific coast of Tohoku Earthquake a large number of earthquakes occurred in the Yakedake area, but it has been gradually decreasing.

① Number of earthquakes per day

② Number of earthquakes per day (detail view)

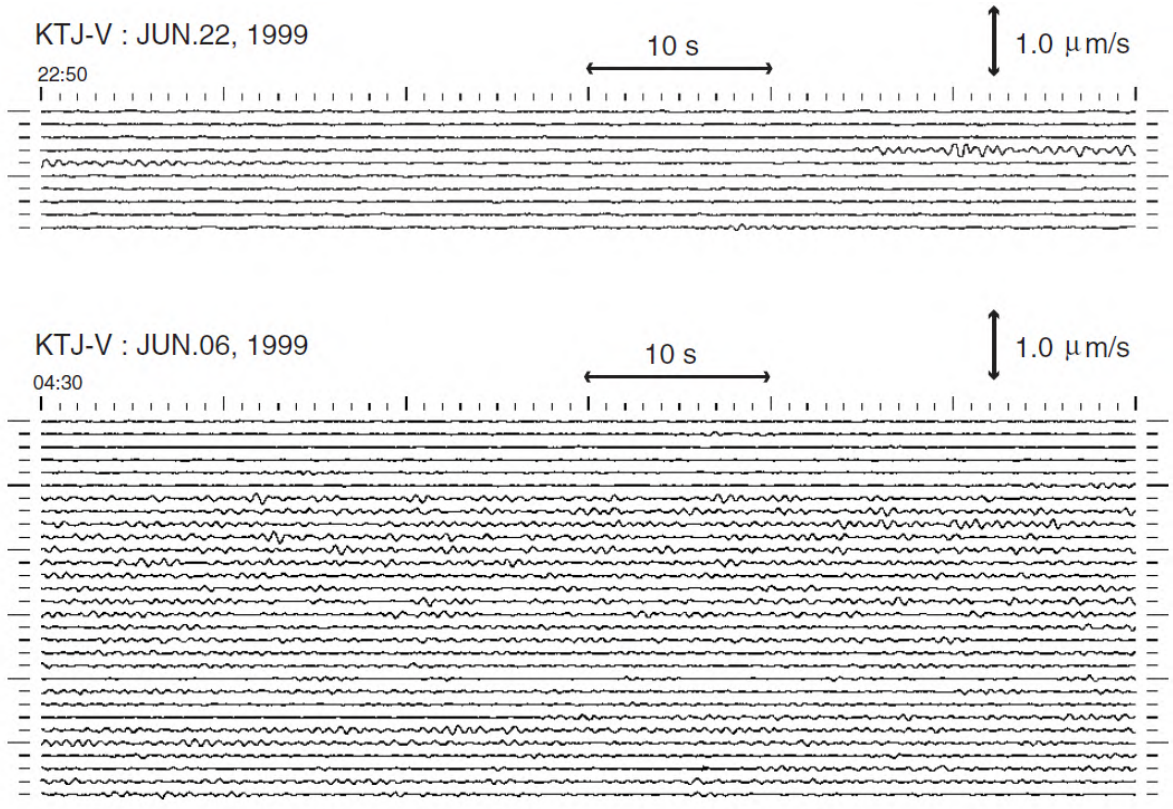


Figure 50-9 Deep low-frequency earthquakes observed at station KTJ (vertical component) (Ohmi et al., 2003).

(Top) Isolated earthquakes (June 22, 1999)

(Bottom) Continuous earthquake with a duration of over 30 minutes (June 6, 1999)

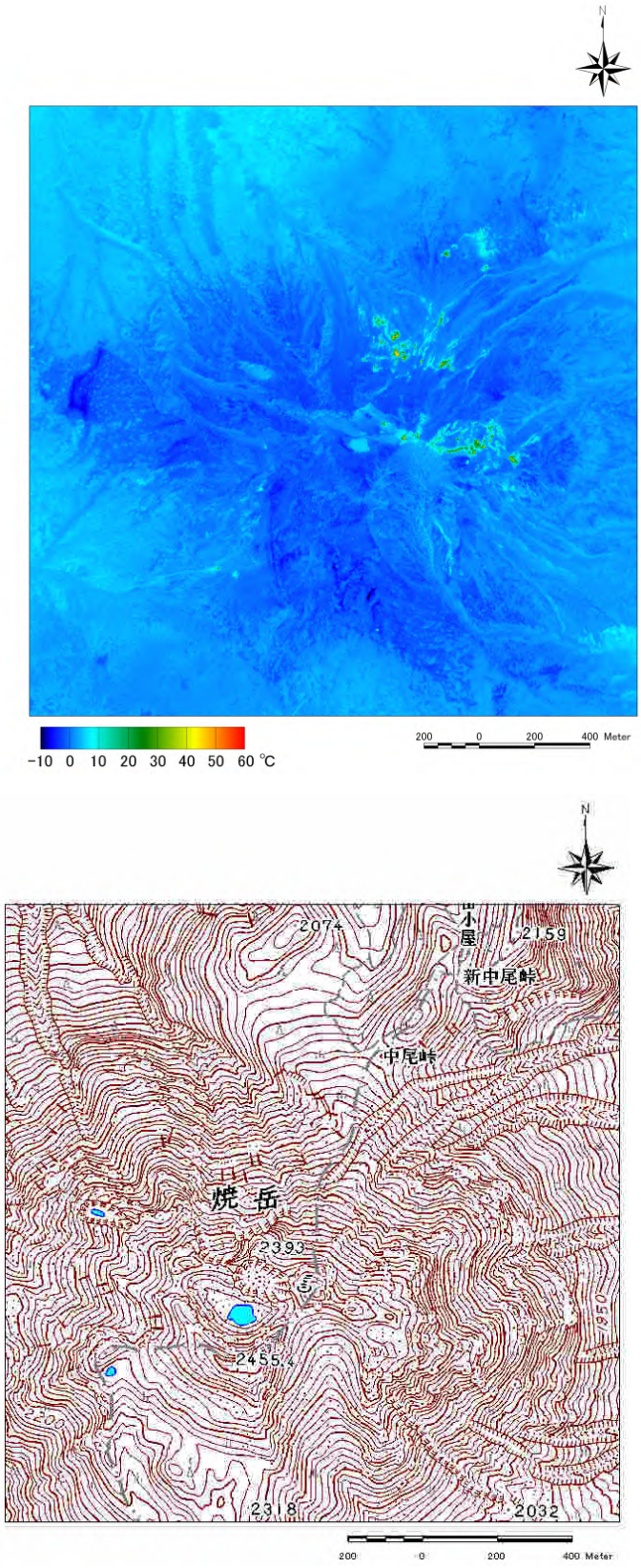


Figure 50-10 Thermal image of Yakedake area by airplane (performed on the night of October 2, 2008) (Japan Meteorological Agency, 2008).

(Top) Temperature distribution around Yakedake summit area (Bottom) Topography of Yakedake summit area

The 1:25,000 Scale Digital Map (Map Image) (Yakedake) published by the Geospatial Information Authority of Japan was used to create this map.

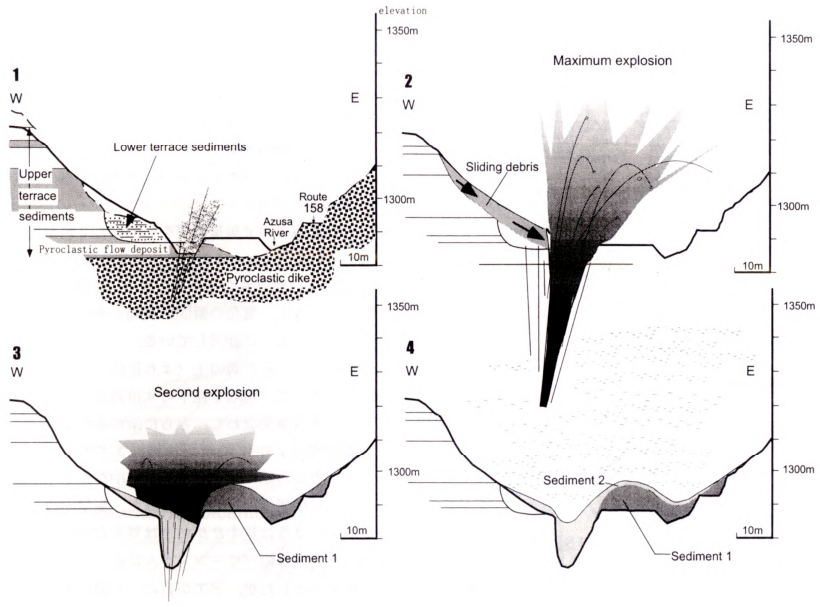


Figure 50-11 Cross-sections and schematic of ejection routes (Miyake and Osaka, 1998).

1. First small explosion. The dashed line indicates the original topography. The thick solid line indicates the altered topography immediately before the event.
2. Largest explosion. The west cliff collapsed into the ejection vent.
3. Secondary explosion after the ejection vent was filled with collapse material.
4. Steam vented after the explosion, turning into water vapor.

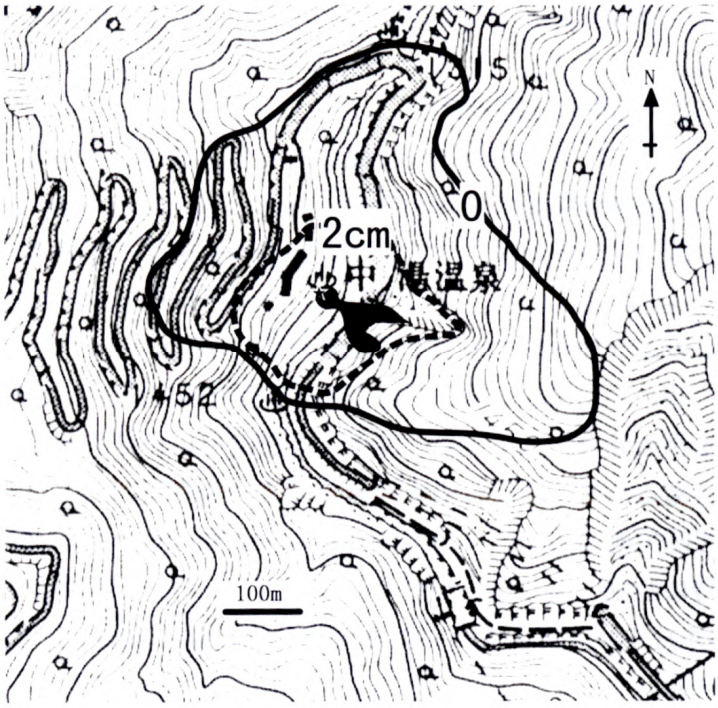


Figure 50-12
Distribution of ejecta (Miyake and Osaka, 1998).

The solid line indicates the area over which ejecta was distributed. The dashed line indicates an isopach of approximately 2cm thick. The black area is the one with 50cm or more of deposits.

The 1:25,000 Scale Topographic Map (Yakedake) published by the Geospatial Information Authority of Japan was used.

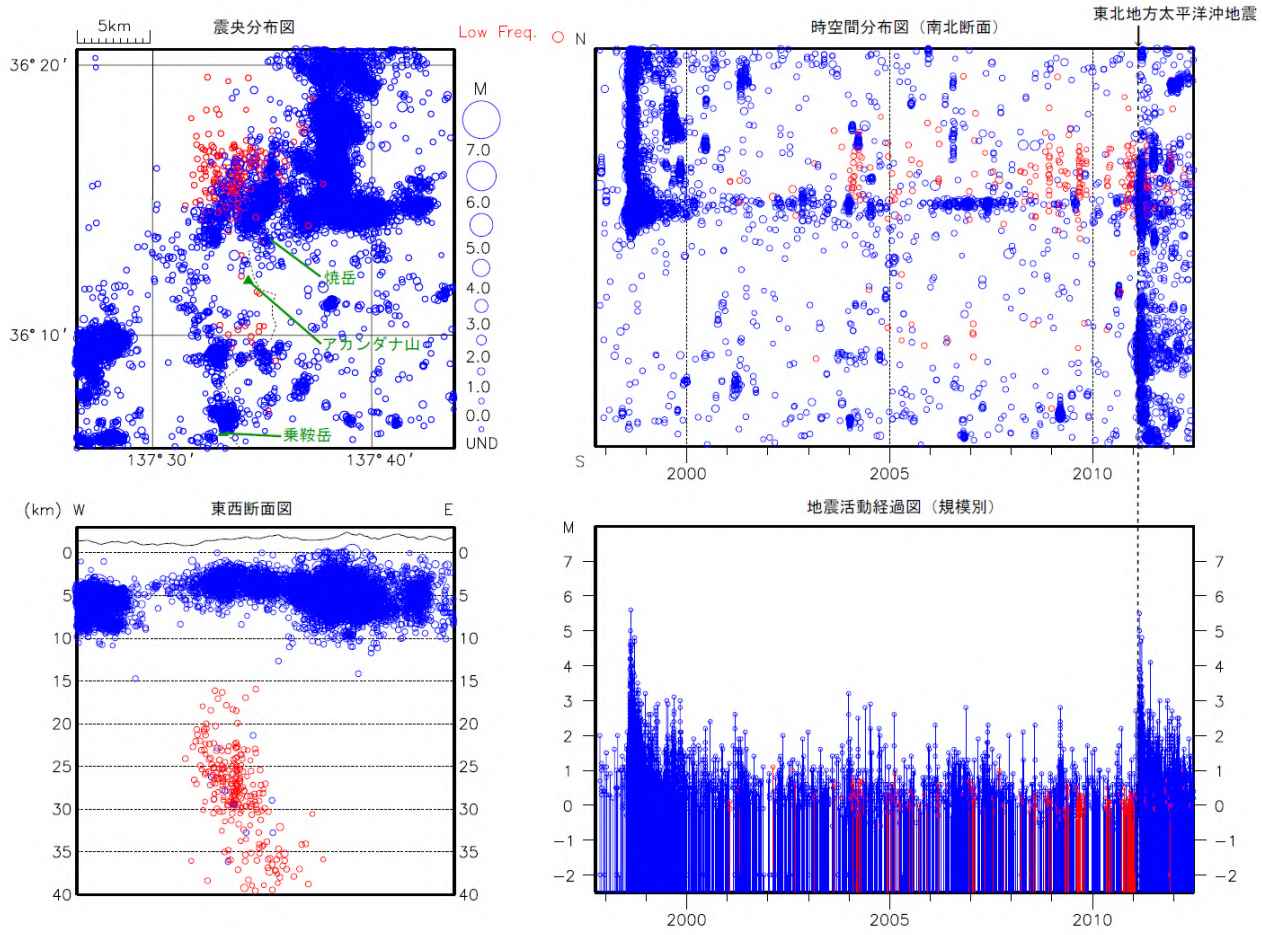


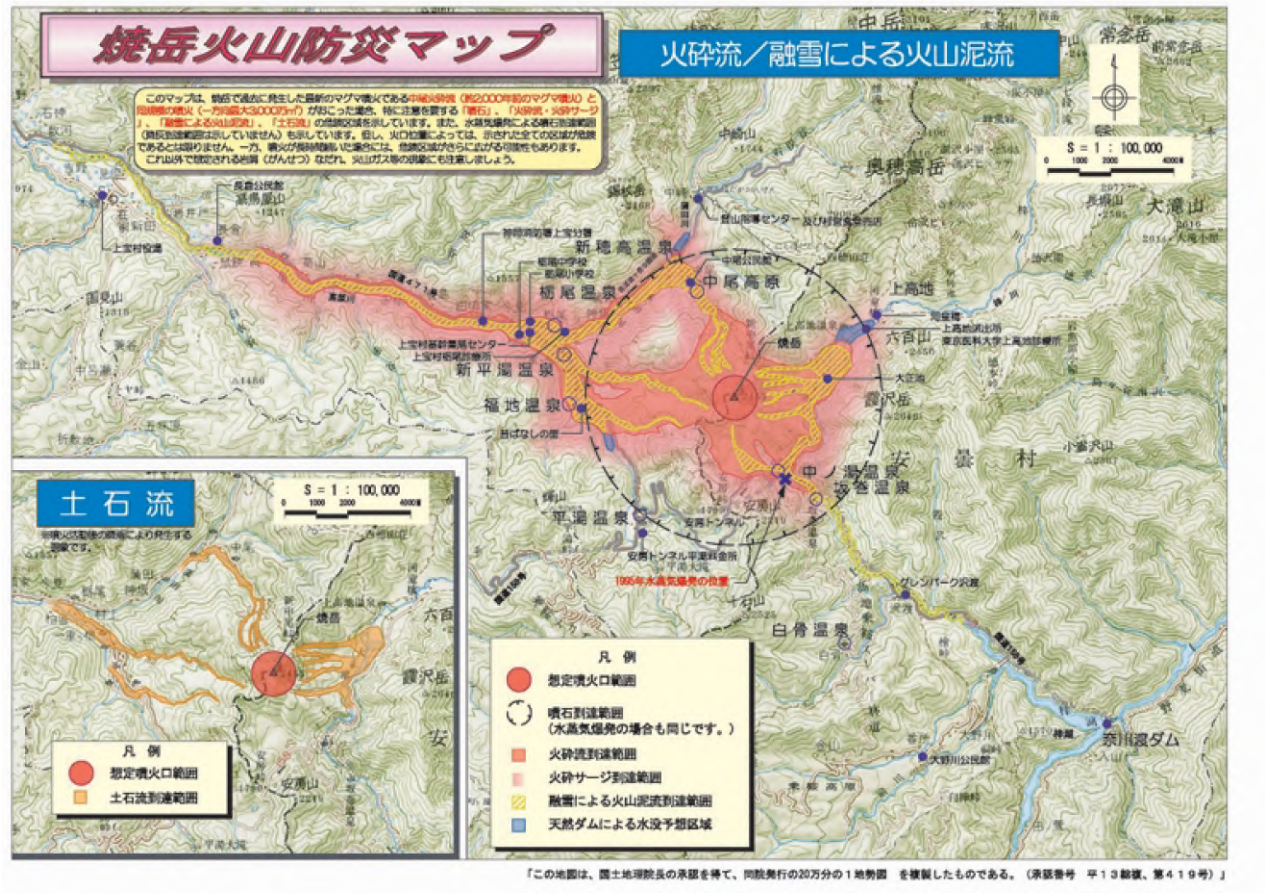
Figure 50-13 Activity of shallow VT earthquakes (blue circles) and deep low-frequency earthquakes (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter distribution (upper left), space-time plot (N-S cross-section) (upper right), E-W cross-section (lower left) and magnitude-time diagram (by scale) (lower right).

Information on Disaster Prevention

①Hazard Map

Yakedake Volcano Disaster Prevention Map (Wide Area Version) March, 2002 (Heisei 14) - Published by the Kamitakara town hall, Azumi town hall, and Yakedake Volcano Eruption Alert Evacuation Measure Expert Committee

http://www.city.matsumoto.nagano.jp/kurasi/bosai/bosai/yakedak_kazanbousaimap.html



②Volcanic Alert Levels (Used since March 31, 2011)

焼岳の噴火警戒レベル1～3に対応した規制範囲

この地図は、国土地理院「数値地図50000(地図画像)」を使用しています。

【焼岳の特徴】 (標高2455m)

- 安山岩・デイサイトの成層火山で、約4,000年前の噴火で下堀沢溶岩流、約2,300年前の最新のマグマ噴火で、焼岳円頂丘溶岩、中尾火砕流が発生した。
- 山頂の溶岩ドームにはいくつもの火口地形があり、明治以降の噴火は水蒸気爆発で、泥流を生じやすい。
- 1915年(大正4年)の噴火では泥流により大正池が形成された。
- 最近では、1962年(昭和37年)に水蒸気噴火が発生し、噴石により2名の負傷者がでている。

【地図の説明】

- 想定される噴火口の範囲 [北西－南東方向 2.4km、北東－南西方向 1.4km の小判型円内]
- 周辺の居住地域
- 登山口や登山道の分岐点
- レベル2(火口周辺規制)の規制範囲 (想定火口から約1kmまで)
- レベル2で規制の対象となる登山道
- レベル3(入山規制)の規制範囲 (想定火口から約2kmまで)
- レベル3で規制の対象となる登山道や道路など
- レベル3の道路規制箇所

■この図は焼岳火山防災計画(平成23年2月23日焼岳火山噴火対策協議会)に基づき、作成しています。
■焼岳の噴火警戒レベルは、岐阜・長野両県の地元自治体と調整して作成しました。
各レベルにおける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、詳細については高山市、松本市へお問い合わせください。

Volcanic Alert Levels for the Yakedake Volcano (Valid as of March 31, 2011)

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**	●Eruption or imminent eruption, with pyroclastic flow, lava flow, and/or lahar by melted snow (during periods when snow has accumulated) reaching residential areas. Past Examples Eruption approximately 4,000 years ago (Shimohorisawa lava flow eruption) Eruption approximately 2,300 years ago (dome lava and Nakao pyroclastic flow eruption)
		4 Prepare to evacuate	**Possibility 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.**	●Lava flow and/or lava dome formation. ●Possibility of eruption producing pyroclastic flow, lava flow, and/or lahar by melted snow (during periods when snow has accumulated) which reach residential areas. ●Pyroclastic flow and/or lava flow which are expected to reach residential areas if the eruption grow larger. Past Examples Eruption approximately 4,000 years ago (Shimohorisawa lava flow eruption) Eruption approximately 2,300 years ago (dome lava and Nakao pyroclastic flow eruption)
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 activity 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.**	●Large eruption, with scattering of volcanic blocks within a distance of approximately 2 km from the crater. Past Examples 1915: A phreatic eruption occurred, and the blast knocked over trees as far as 1 km from the crater
	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 activity as normal. Access to crater area restricted, etc.**	●Small phreatic eruption, with scattering of volcanic blocks within a distance of approximately 1 km from the crater. Past Examples 1962: A phreatic eruption occurred, scattering volcanic blocks as far as the old Yakedake cabin
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 discharge which may affect summit crater interior and nearby area. Current status as of March, 2011

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

Social Circumstances

①Populations

・Matsumoto City: 243,472 (1,846 in Azumi area)

(as of October 1, 2011 (Heisei 23) - according to the results of the Nagano Prefecture monthly population movement survey)

・Takayama City: 93,666 (1,489 in Okuhida Onsen Spa area)

According to "Overall Population by Administrative Area (by Neighborhood)" Takayama government data

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

・Chubu-Sangaku National Park - Hotaka Mountain Range

Number of sightseers per year: Matsumoto City (1,423,500: Kamikochi)

(according to the results of the 2010 sightseeing land usage statistical survey: Nagano Prefecture - Sightseeing Planning Division)

Takayama City: Approximately 661,000 (in Okuhida Onsen Spa area)

According to Gifu Prefecture "Number of Visitors by Sightseeing Location in 2010"

Number of mountain-climbers per year: Unknown

③Facilities

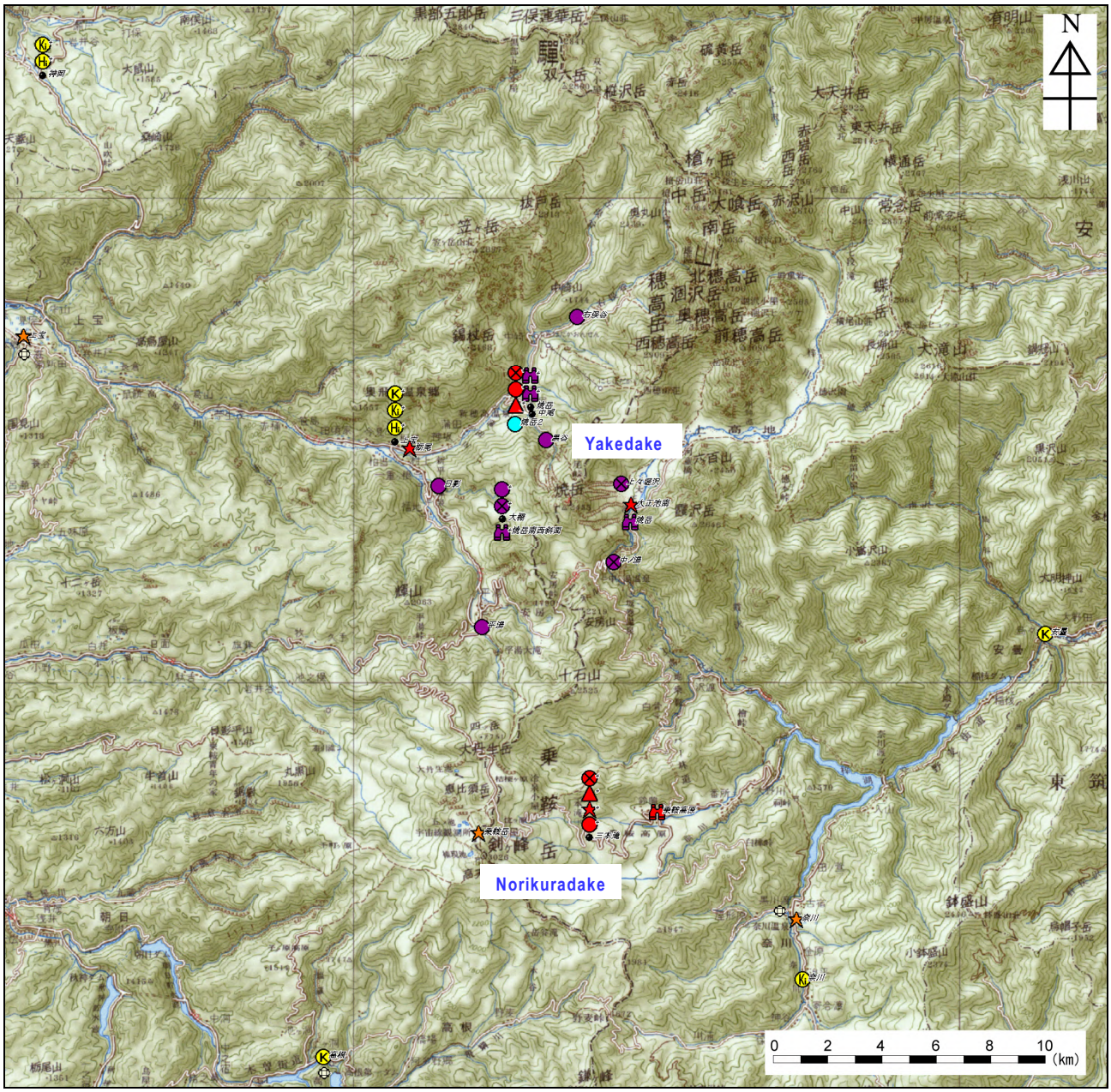
・Kamikochi Visitor Center

Monitoring Maps

Wide Area

* Including Akandana and Norikurayama monitoring network.

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



1:200,000 scale regional map (Takayama) published by the Geospatial Information Authority of Japan was used.

Legend

(JMA)
seismometer(SP)
GPS
tiltmeter
infrasonic microphone
visual camera

(GSI)
GPS

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

(DPRI)
seismometer(SP)

(Municipalities)
seismic intensity meter

(MILT)
seismometer(SP)
visual camera
infrasonic microphone

(MILT)
visual camera

Figure 50-14 Regional monitoring network.

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(Miyake, Y., and Ohmi, S.)