33. Zaozan (Zaosan)

Continuously Monitored by JMA

Latitude: 38°08'37" N, Longitude: 140°26'24" E, Elevation: 1,841 m
(Kumanodake) (GSI Measuring Point)

Overview of Zaozan (Zaosan). Taken from Zao Town on November 27, 2011 by the Japan Meteorological Agency.

Summary

Zaozan (Zaosan) is a basalt-andesite stratovolcano group, of which volcanic activity started with subaqueous eruption of the basaltic magma approximately 1 million to 700 thousand years ago. It was dormant for roughly 300,000 years, and then approximately 400,000 to 100,000 years ago many andesitic lava flows were discharged from multiple eruption centers, forming the peaks which make up the upper half of the volcanic edifice, such as Kumanodake (the highest peak) and Kattadake, forming the basic structure of the volcano. Approximately 30,000 years ago a caldera roughly 2 km in diameter was formed at the summit. At the same time, explosive activity involving basaltic andesite magma began, continuing intermittently even until today. Goshikidake is a post-caldera pyroclastic cone (or tuff cone) which formed within the caldera above. It has been active since approximately 2,000 years ago, and is the site of Okama crater lake (360 m in diameter, also known as Goshikinuma). Many records exist of eruptions at Okama within history. The eruptions which caused damage occurred at both inside and outside of Okama. Many of these eruptions were accompanied by lahars. Fumaroles are located in several areas, such as the new fumaroles to the northeast of Okama. The SiO_2 content is between 51.3 and 64.1 wt %.

Photo

Okama. Taken from the north side on June, 1992 by the Japan Meteorological Agency.

Red Relief Image Map

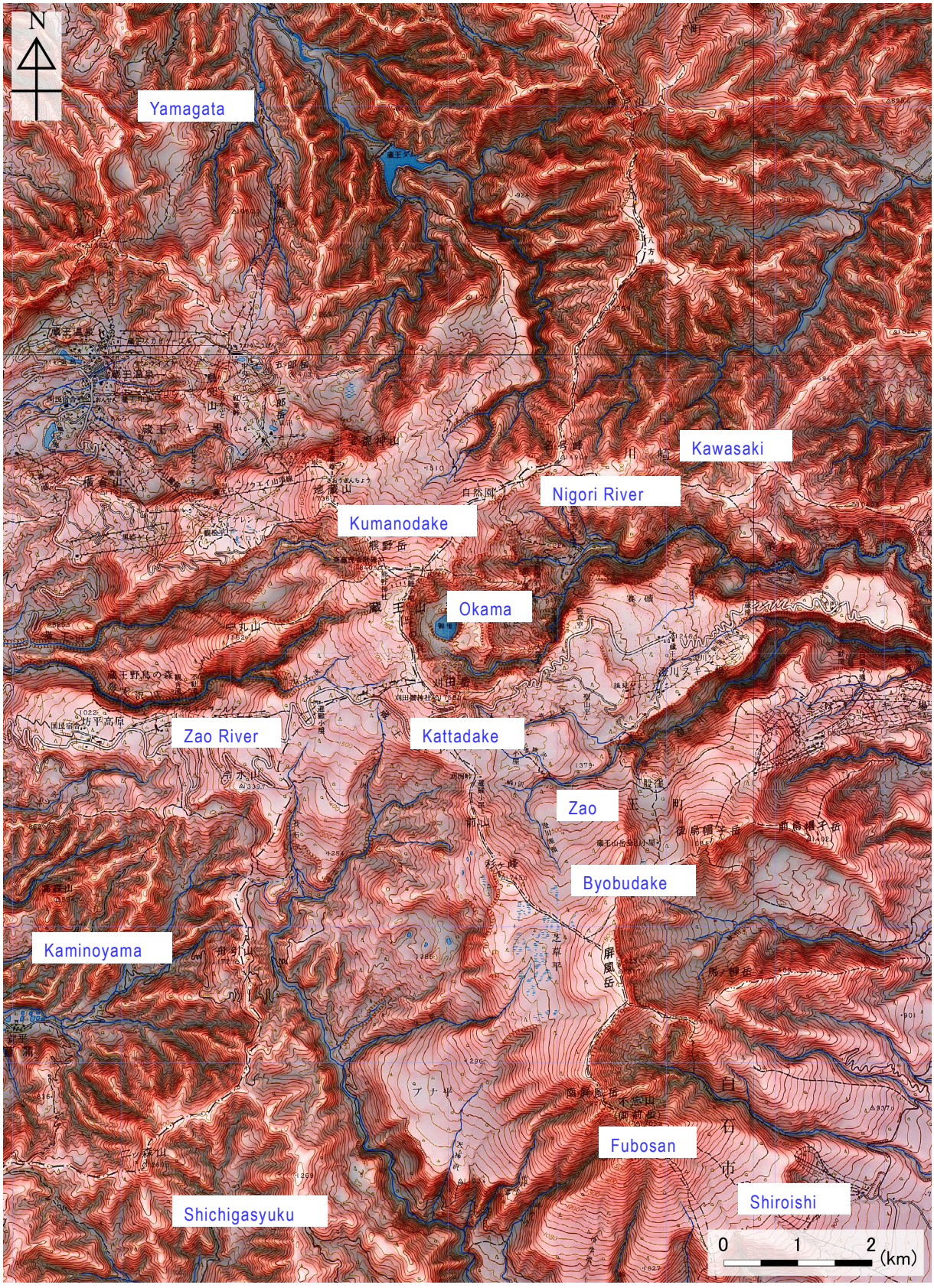


Figure 33-1 Topography of Zaozan (Zaosan).

1:50,000 scale topographic map (Kaminoyama, Shiroishi, Yamagata and Kawasaki) and digital map 50 m grid (elevation) published by the Geospatial Information Authority of Japan were used.

Chronology of Eruptions

・Volcanic Activity in the Past 10,000 Years

The latest period of eruptive activity began approximately 30,000 years ago. This period can be further divided into three sub-periods, approximately 30,000 to 20,000 years ago, approximately 8,000 to 3,000 years ago, and since approximately 2,000 years ago. During the period approximately from 8,000 to 3,000 years ago large scale magmatic eruptions of up to $10^7 m^3$ occurred intermittently, separated by periods of dormancy. The eruptions within the last approximately 2,000 years have been relatively smaller than those of the past, with discharges of 10^6 to 10^7 m^3, but were more frequent than in earlier periods. The eruptions during this period frequently began with phreatic explosions, and then transformed into magmatic eruptions (Ban et al., 2008).

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
9.5ka	Near Goshikidake	Phreatic eruption	Tephra fall.
7.5ka	Goshikidake	Magmatic eruption	Tephra fall.
7.5ka	Near Goshikidake	Phreatic eruption	Tephra fall.
6.1ka	Near Goshikidake	Magmatic eruption	Tephra fall.
6.1←→5.8ka	Near Goshikidake	Phreatic eruption	Tephra fall.
5.8ka	Near Goshikidake	Magmatic eruption	Pyroclastic surge → tephra fall.
5.3ka	Near Goshikidake	Magmatic eruption	Tephra fall.
4.5ka	Near Goshikidake	Magmatic eruption	Tephra fall.
4.1ka	Near Goshikidake	Magmatic eruption	Tephra fall.
3.5ka	Near Goshikidake	Phreatic eruption	Tephra fall.
2←→1.2ka	Goshikidake	Phreatic eruption? →Magmatic eruption	Tephra fall. Multiple eruptions.

* 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←→B: Eruptive events taking place at some point between year A and year B.

・Historical Activity

Year	Phenomenon	Activity Sequence, Damages, etc.
773 (Hoki 4)	Eruption	The site of the eruptive activity may have been Kattadake.
Sometime between the 8th and 13th century	Moderate: Phreatic eruption? →Magmatic eruption	Tephra fall. The eruptive activity occurred at Goshikidake. Multiple eruptions. Magma eruption volume = 0.026 km^3 DRE. (VEI 3)
1183 (Juei 2)	Eruption	The eruptive activity occurred at Goshikidake (Okama).
1227 (Antei 1)	Eruption	October or November. Tephra fall.
1230 (Kangi 2)	Eruption	November 22. Tephra fall. Volcanic blocks caused a large number of human and animal casualties.
12th to 13th century	Moderate: Phreatic eruption? →Magmatic eruption	Z-To11 eruption: Tephra fall. The eruptive activity occurred at Goshikidake. Magma eruption volume = 0.0053 km^3 DRE. (VEI 3)
1331 to 1333 (Genko 1 to Genko 3)	Volcanic plume?	Details unknown.
Approximately 1350 (Kanno era)	Volcanic plume?	Details unknown.

Year	Phenomenon	Activity Sequence, Damages, etc.
Sometime between the 12th and 15th century	Moderate: Phreatic eruption? →Magmatic eruption	Z-To12 eruption: Tephra fall. The eruptive activity occurred at Goshikidake. Magma eruption volume = 0.014 km^3 DRE. (VEI 3)
Sometime between the 12th and 15th century	Moderate: Phreatic eruption? →Magmatic eruption	Z-To13 eruption: Tephra fall. The eruptive activity occurred at Goshikidake. Magma eruption volume = 0.006 km^3 DRE. (VEI 3)
1620 (Genna 6)	Eruption	It is possible that the site of the eruptive activity was Goshikidake (Okama).
1622 (Genna 8)	Eruption	Details unknown.
1623 to 1624 (Genna 9 to Kan'ei 1)	Eruption	Tephra fall. Rumbling, volcanic blocks.
16th to 17th century	Phreatic eruption? →Magmatic eruption	Tephra fall. The eruptive activity occurred at Goshikidake. Magma eruption volume = 0.011 km^3 DRE. (VEI 3)
1625 (Kan'ei 2)	Rumbling?	Details unknown.
1626 (Kan'ei 3)	Rumbling?	Details unknown.
1630 (Kan'ei 7)	Eruption	Details unknown.
1641 (Kan'ei 18)	Eruption	Details unknown.
1668 (Kanbun 8)	Eruption	August.
1669 (Kanbun 9)	Eruption	Tephra fall..
1670 (Kanbun 10)	Eruption	Tephra fall. Volcanic plume from April 26, tephra fall in distant areas on September 26.
1694 (Genroku 7)	Moderate: Phreatic eruption?	May 29. It is possible that the site of the eruptive activity was Goshikidake (Okama). [2]A shrine was burned down. On August 30 an earthquake turned river water toxic and killing fish. (VEI 3)
1794 (Kansei 6)	Phreatic eruption?	From September 22. Tephra fall. The eruptive activity occurred at Goshikidake (9 craters formed in southeast Okama).
1796 (Kansei 8)	Eruption	March 24.
1804 (Bunka 1)	Eruption	Eruption started around May from 5 craters near Okama.
1806 (Bunka 3)	Eruption	July 12, from 2 craters.
1809 (Bunka 6)	Phreatic eruption?	December 29. The eruptive activity occurred at Goshikidake (Okama). Activity began in June, with an explosion on December 29. A sulfur inflow killed river fish.
1821 (Bunsei 3)	Eruption	January 27 to May. Rumbling, clouding and boiling in Okama, raised water levels in the Nigori River, sulfur deposits.
1830 (Tenpo 1)	Eruption	Details unknown.
1831 (Tenpo 2)	Eruption	November 22 etc.
1833 (Tenpo 4)	Eruption	Tephra fall. The eruptive activity occurred at Goshikidake (Okama).[2,8] Frequent eruptions, tephra fall, boiling water in Okama.
1867 (Keio 3)	Phreatic eruption? [2,3,8]	October 21. Rumbling, boiling water in Okama, rising level of muddy water mixed with sulfur, and flooding which killed 3 people.
1873 (Meiji 6)	Eruption	August to September. It is possible that the site of the eruptive activity was Goshikidake (Okama). [3]
1894 (Meiji 27)	Eruption	Volcanic plume from roughly March. On July 3, tephra fall in July.
1895	Unrest	White volcanic plume and tephra fall. Boiling water with sulfer in Okama, causing floods in Shiroishi River and gamage to fish.
1896-1897	Unrest	Tephra fall, rumbling.
1906	Small-scale phreatic eruption?	Deposit possibly caused by a small-scale phreatic eruption.

Year	Phenomenon	Activity Sequence, Damages, etc.
1940 (Showa 15)	Small-scale: Phreatic eruption	April 16. Tephra fall. The eruptive activity occurred at the Torijigoku, northeast of Okama. New fumaroles were formed. (VEI 1)
1949 (Showa 24)	Fume	Fumarolic activity increased at the Maruyamazawa fumarole.
1962 (Showa 37)	Earthquake and fume	August 19 to 20. Over 20 incidents of rumbling, earthquake swarm, high level of fumarolic activity.
1966 (Showa 41)	Fumarole, hot spring anomaly	A new fumarolic area appeared near Furikozawa, as well as several new hot springs.
1971 (Showa 46)	Rumbling	October 4.
1972 (Showa 47)	Rumbling	May 14, 28, 29.
1984 (Showa 59)	Earthquake	July 8 to approximately September. Earthquake swarms approximately 5km southeast of Kumanodake.
1990 (Heisei 2)	Earthquake	July 14 to July 15: Earthquake swarm from Okama to Kattadake area.
1992 (Heisei 4)	Earthquake	February 22. High number of felt-earthquakes to the west of Fubosan.
	Earthquake	September 1. Earthquake swarm in summit area.
1995 (Heisei 7)	Earthquake	April. Fubosan area. Earthquake swarm approximately 10 km northwest of Kumanodake in December.

* 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

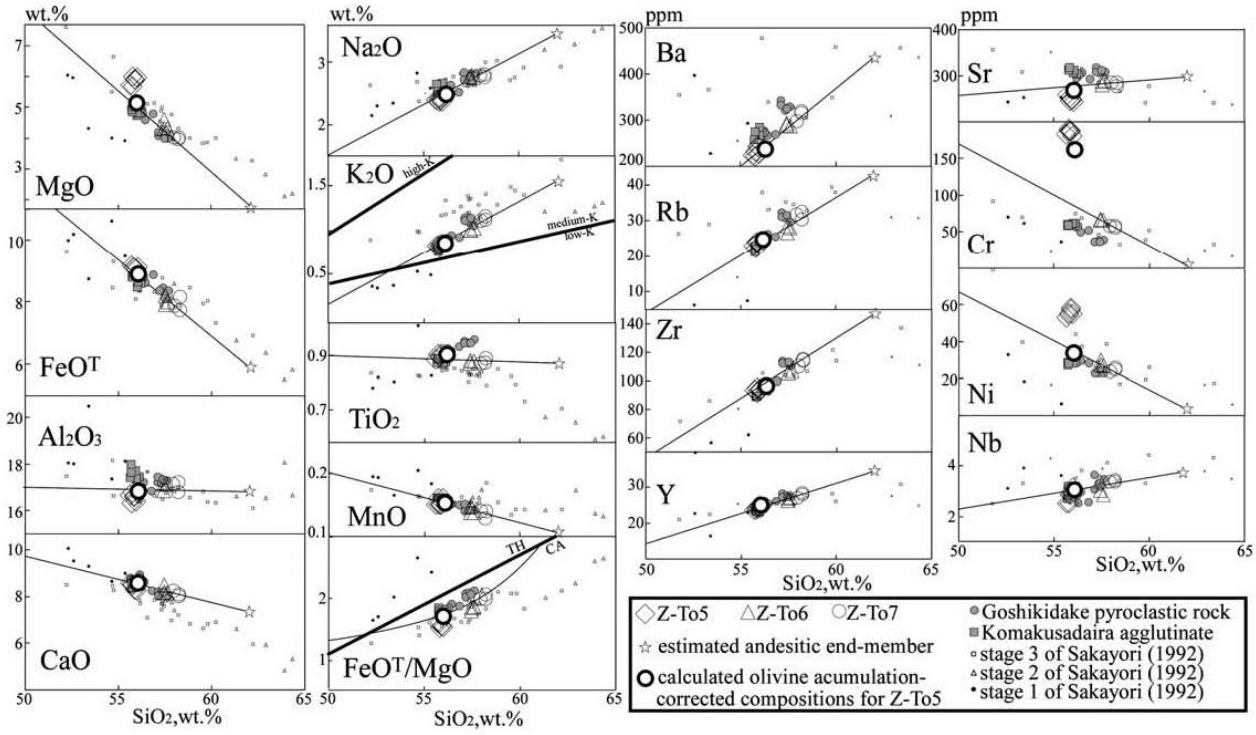


Figure 33-2 Whole rock chemical composition (Ban et al., 2008).

Magma Discharge Rate

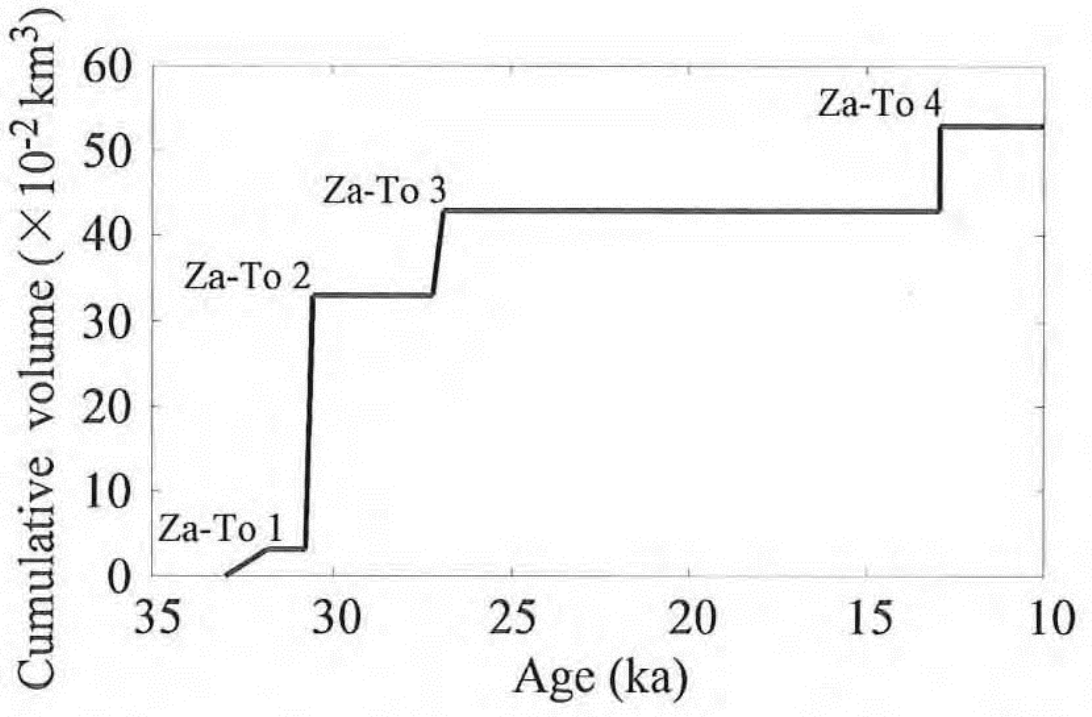


Figure 33-3 Cumulative volume of discharged magma (Miura et al., 2008).

Recent Volcanic Activity

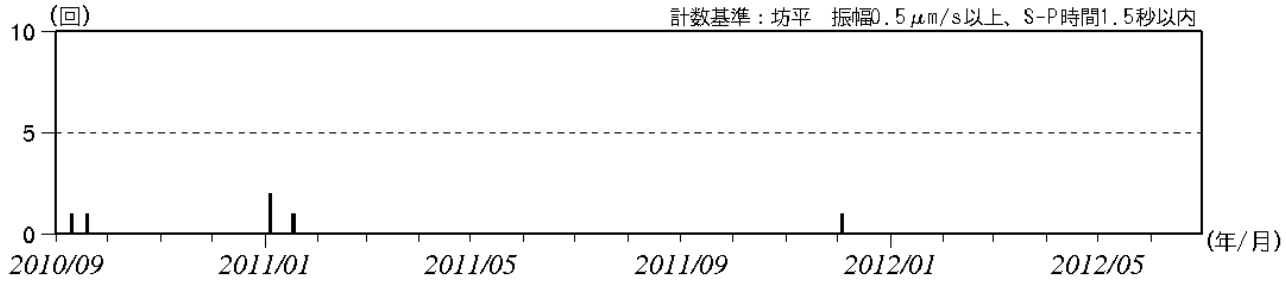


Figure 33-4 Number of volcanic earthquakes per day (September 1, 2010, to June 30, 2012).

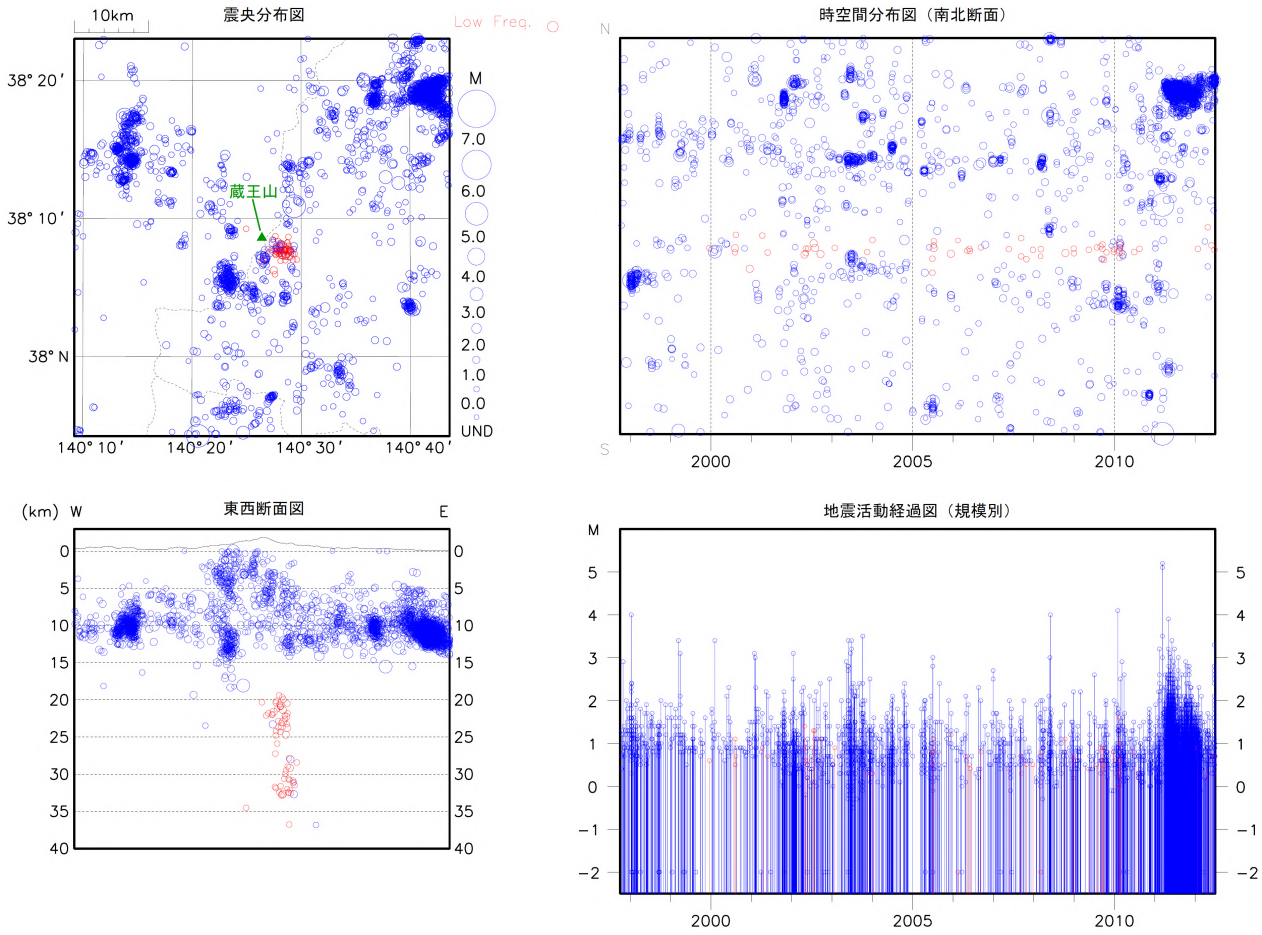


Figure 33-5 Activity of shallow VT earthquakes (blue circles) and deep low-frequenc y earthquakes (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter di stribution (upper left), space-time plot (N-S cross-sec tion) (upper right), E-W cross -section (lower left) and magnitude-time diagram (lower right).

Information on Disaster Prevention

①Hazard Map

Zaozan Volcano Disaster Prevention Map (Wide Area Version) March, 2002 - Published by Miyagi Prefecture, Kawasaki Town, Zao Town, Shiroishi City, Shichikashuku Town, Yamagata Prefecture, Yamagata City, and Kaminoyama City, Editorial supervision by the Zaozan Volcano Disaster Prevention Map Deliberating Committee

Source: Zaozan Volcano Disaster Prevention Map

Date of Publication: March, 2002

Created by: Miyagi Prefecture, Kawasaki Town, Zao Town, Shiroishi City, Shichikashuku Town, Yamagata Prefecture, Yamagata City, and Kaminoyama City

Editorial supervision: Zaozan Volcano Disaster Prevention Map Deliberating Committee

(Participating organizations: Iwate University, Tohoku University, Yamagata University, National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure, Transport and Tourism, Public Works Research Institute, Sendai Meteorological Observatory, Tohoku Regional Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, Miyagi Prefecture, Yamagata Prefecture, Shiroishi City, Yamagata City, Kaminoyama City, Zao Town, Shichikashuku Town, Kawasaki Town, Regional Sightseeing Related Organizations)

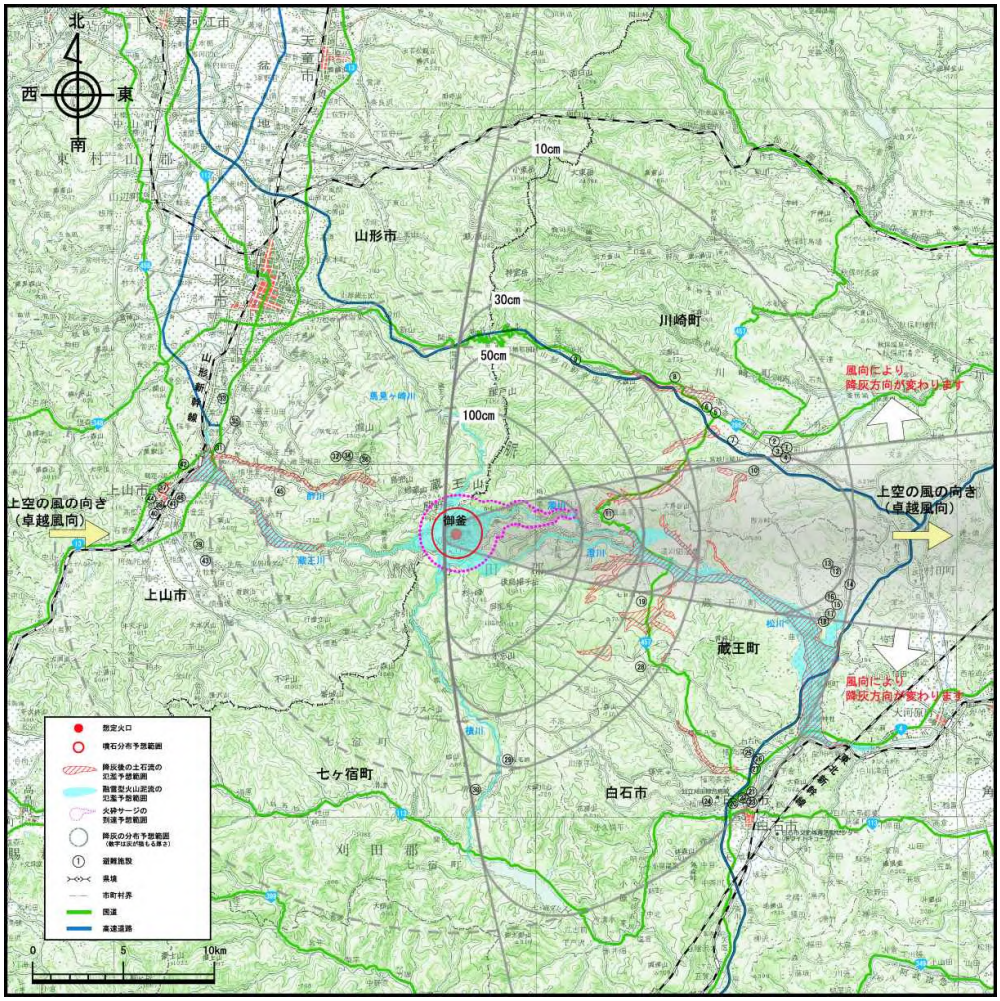
URL:

Disaster Prevention Erosion Control Bureau , Civil Engineering Office, Miyagi Prefecture

http://www.pref.miyagi.jp/sabomizusi/zao_kazan/zao_hazadomap.htm

Erosion and Disaster Prevention Measure Bureau, Department of Prefecture Land Development , Yamagata Prefecture

http://www.pref.yamagata.jp/ou/kendoseibi/180010/sabo/zaoukazanhazard.html



Social Circumstances

①Populations

・Miyagi Prefecture

Kawasaki Town: 9,925 (as of October 31, 2011)

Zao Town: 13,086 (as of October 31, 2011)

Shichikashuku Town: 1,706 (as of October 31, 2011)

・Yamagata Prefecture

Yamagata City: 253,583 (as of April 1, 2011)

Kaminoyama City: 33,602 (as of April 1, 2011)

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

・Zao Quasi-National Park – Zaozan

Number of sightseers per year: 584,676 (according to the summary and number of visitors to Zao (summit of Kattadake), 2010 Miyagi Prefecture sightseeing statistics)

ditto: Approximately 258,600 (according to the 2010 Yamagata Prefecture sightseeing number survey)

Number of mountain-climbers per year: Unknown

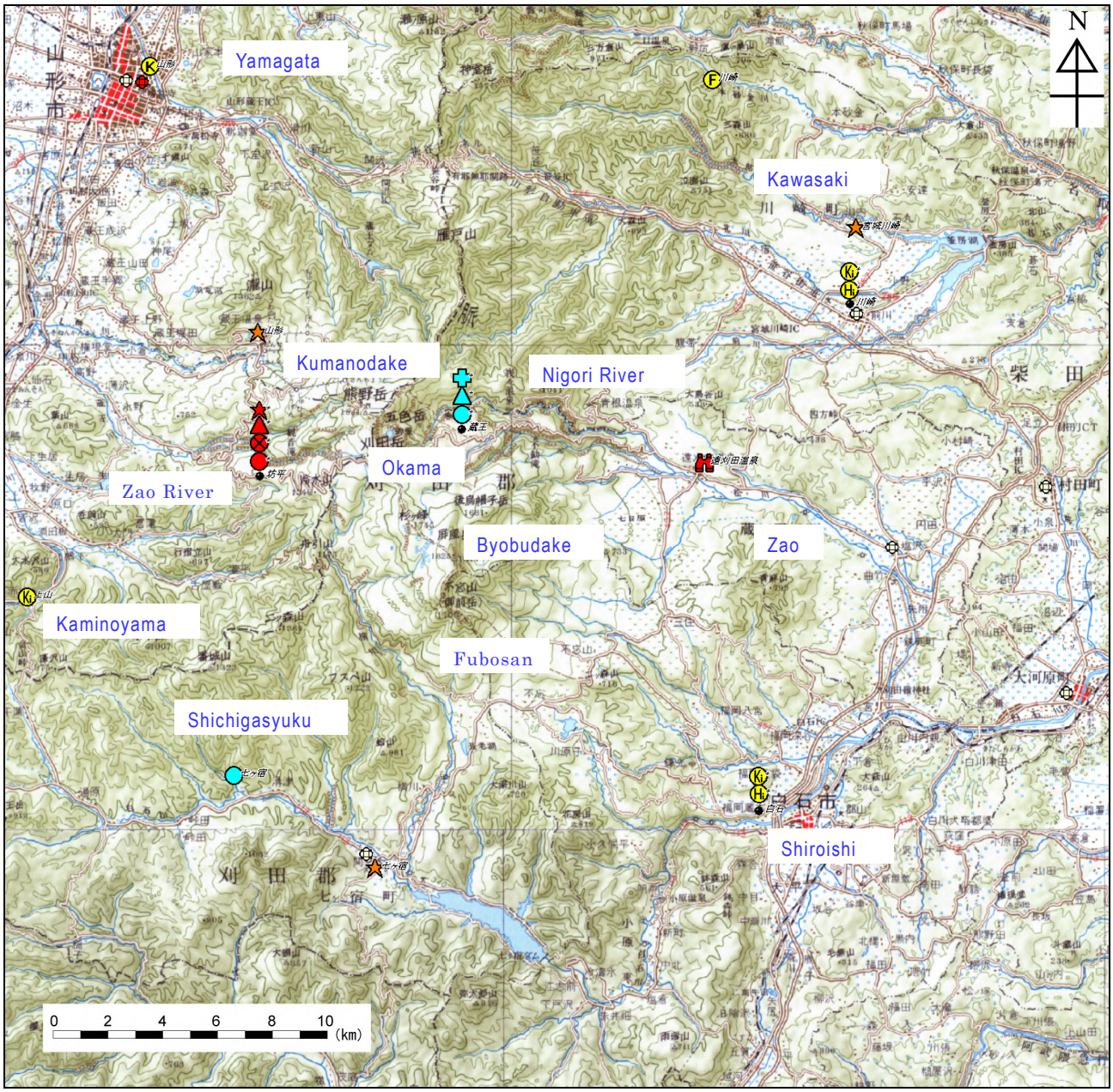
③Facilities

None

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 (Murakami, Sendai, Niigata and Fukushima) published by the Geospatial Information Authority of Japan were used.

Legend

(JMA)
- seismometer(SP)
- GPS
- tiltmeter
- infrasonic microphone
- visual camera
- seismic intensity meter

(GSI)
- GPS

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

(Tohoku Univ.)
- seismometer(SP)
- tiltmeter
- thermometer

(Municipalit... Shiroishi)
- seismic intensity meter

Figure 33-6 Regional monitoring network.

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(Ban, M., and Ueki, S.)