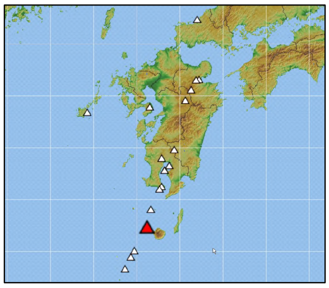
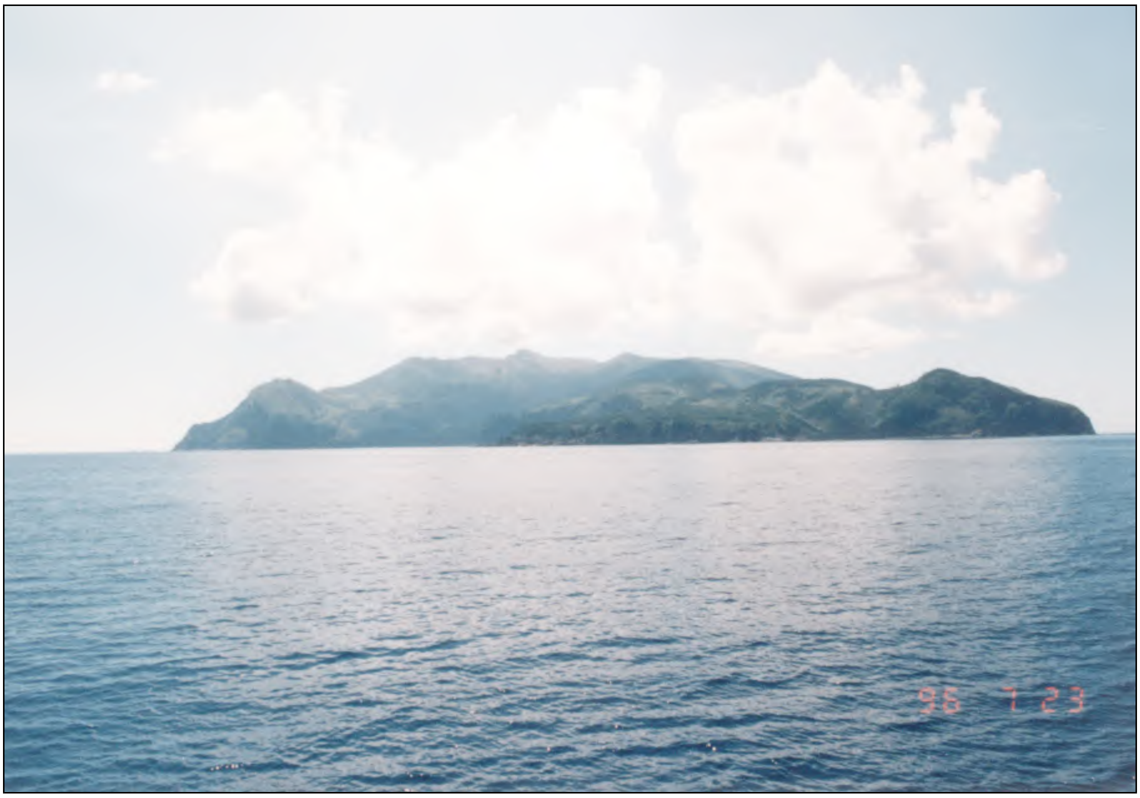


94. Kuchinoerabujima

Continuously Monitored by JMA

Latitude: 30°26'36" N, Longitude: 130°13'02" E, Elevation: 657 m (Furudake) (Elevation Point)



Overview of Kuchinoerabujima taken from the East on July 23, 1996 by the Japan Meteorological Agency

Summary

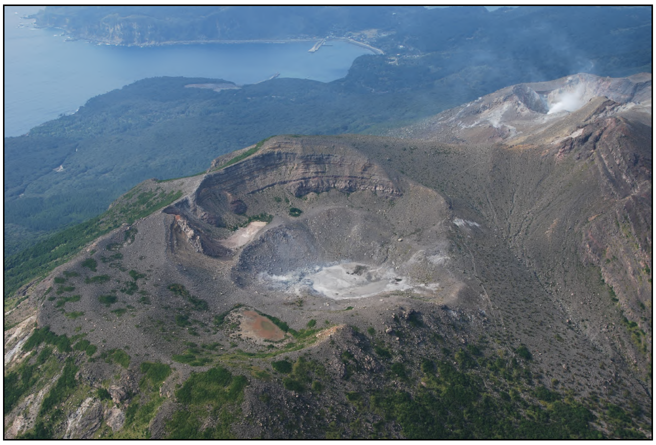
Kuchinoerabujima is a gourd-shaped island that is 12 km long (from west-northwest to east-southeast), and has a maximum width of 5 km. It is composed of the old volcanic edifice of Banyagamine, to the west, and volcanic edifices which have been active up until the present, such as Shindake, Furudake, and Noikeyama, which extend from the center of the island towards the east. In the last 10,000 years, eruptions have occurred at Shindake, Furudake, and Hachikubo volcanoes..

Multiple andesite lava flows have been confirmed from the southwest to the southeast foot of Furudake, and are considered to be less than 7,300 years old (Geshi and Kobayashi, 2006). The pyroclastic flow deposit which covers these lava flow is connected to the pyroclastic cones which surround theFurudake summit crater. Based on the radiometric age of approximately 200 years ago, obtained from wood charcoals in these deposits, it is thought that the eruptions from theFurudake crater generated pyroclastic flows until several hundred years ago (Kobayashi et al., 2002).

Shindake was formed within the collapse area on the northwest side of Furudake. The pyroclastic cone which forms the summit of Shindake is mainly composed of volcano breccia, and has many volcanic bombs and blocks having cooling joints. Multiple volcanic ash strata have been confirmed, so multiple explosive magmatic eruptions are considered to have occurred within the past 1,000 years at either Furudake orShindake. Rocks of this volcano are all andesite whose SiO_2 content has a limited range from 54.5 to 60.5 wt %.

Photos

Shindake Crater and Fissure Crater taken from East Side on April 24, 2000 by the Japan Meteorological Agency



Furudake Crater and Shindake Crater (Top Right) taken from Southeast Side on March 2, 2009 by the Japan Meteorological Agency

September 28, 1980, Shindake Fissure Eruption taken from east on October 10, 1980
Courtesy of Kyoto University Volcano Research Center

Topography around the Crater

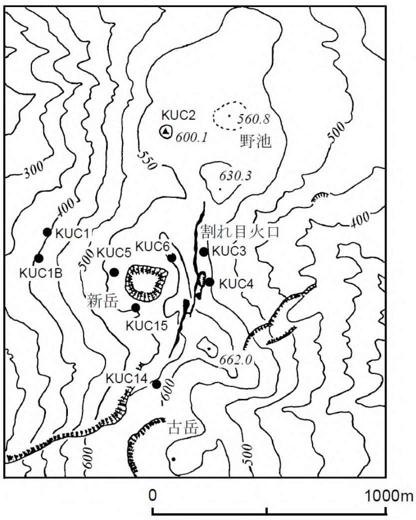


Figure 94-1
Topography around the Kuchinoerabujima Shindake crater (Iguchi et al., 2007)

Red Relief Image Map

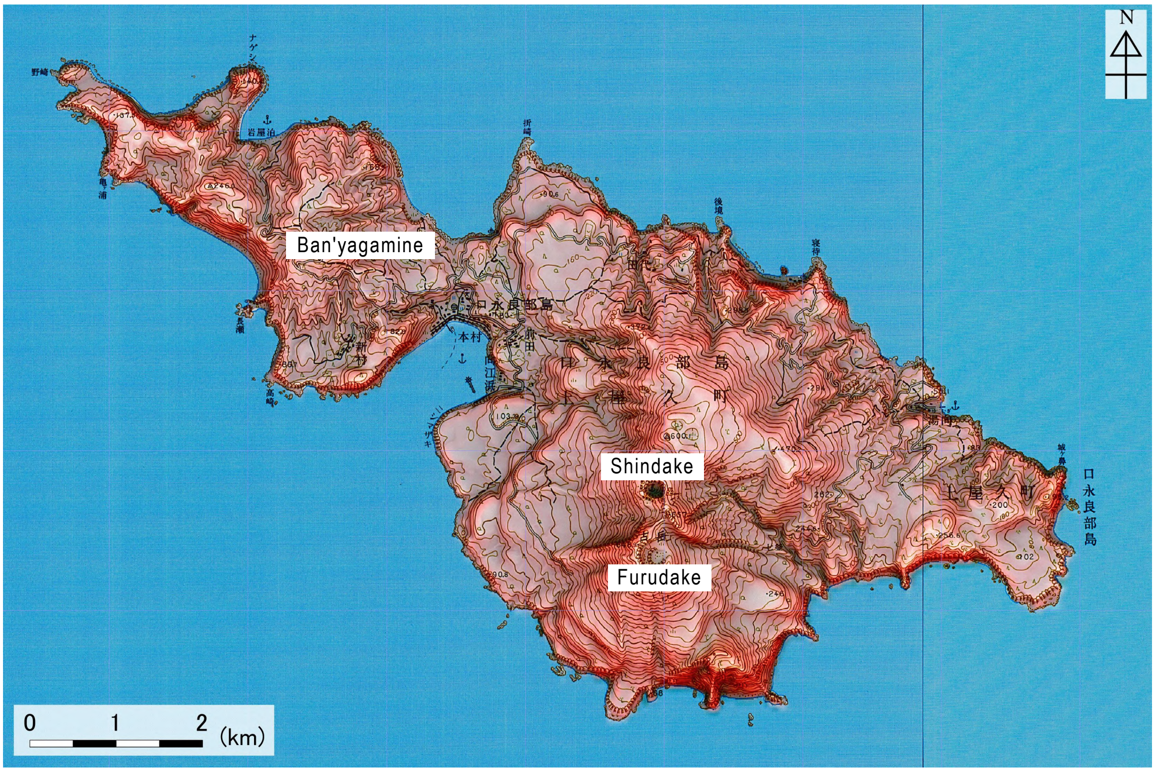


Figure 94-2 Topography of Kuchinoerabujima.

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

Submarine Topographic Map

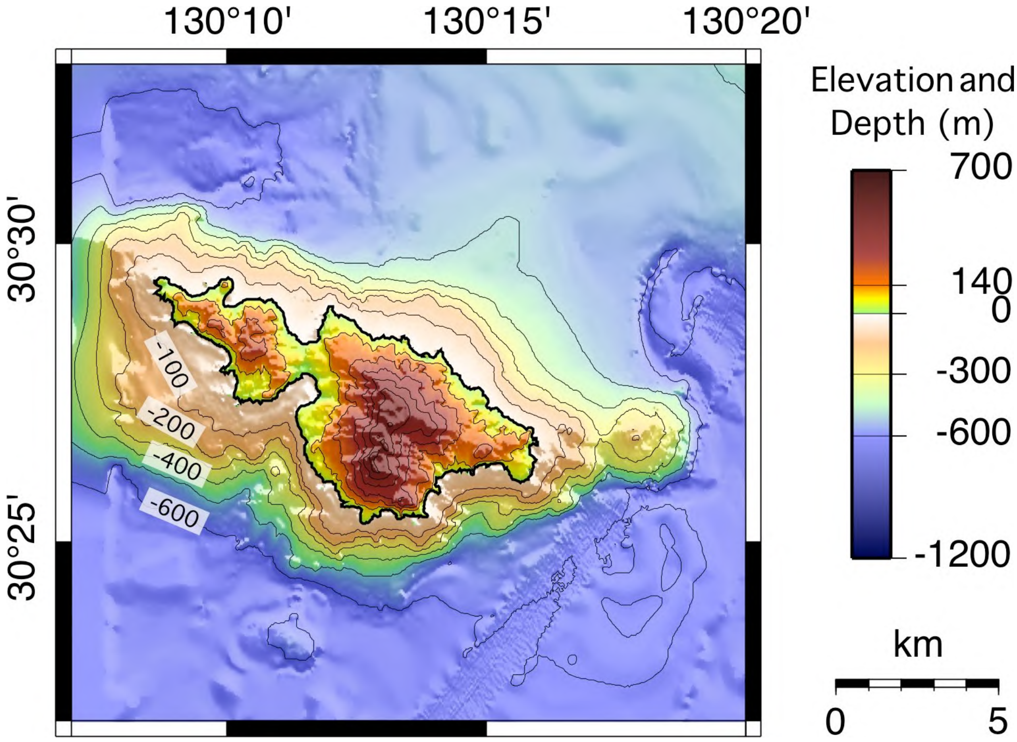


Figure 94-3 Submarine topographic map of the Kuchinoerabujima area (Japan Coast Guard).

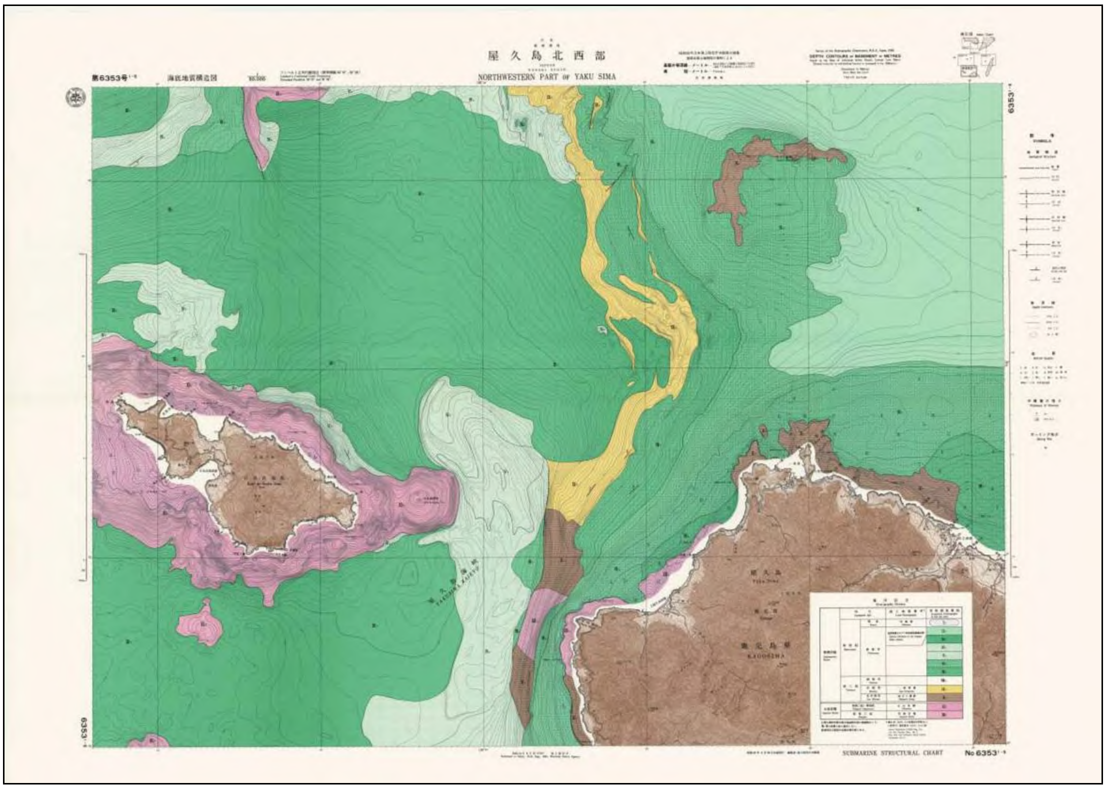


Figure 94-4 Submarine topographical map of the Kuchinoerabujima area (Maritime Safety Agency, 1981).

Geological Map

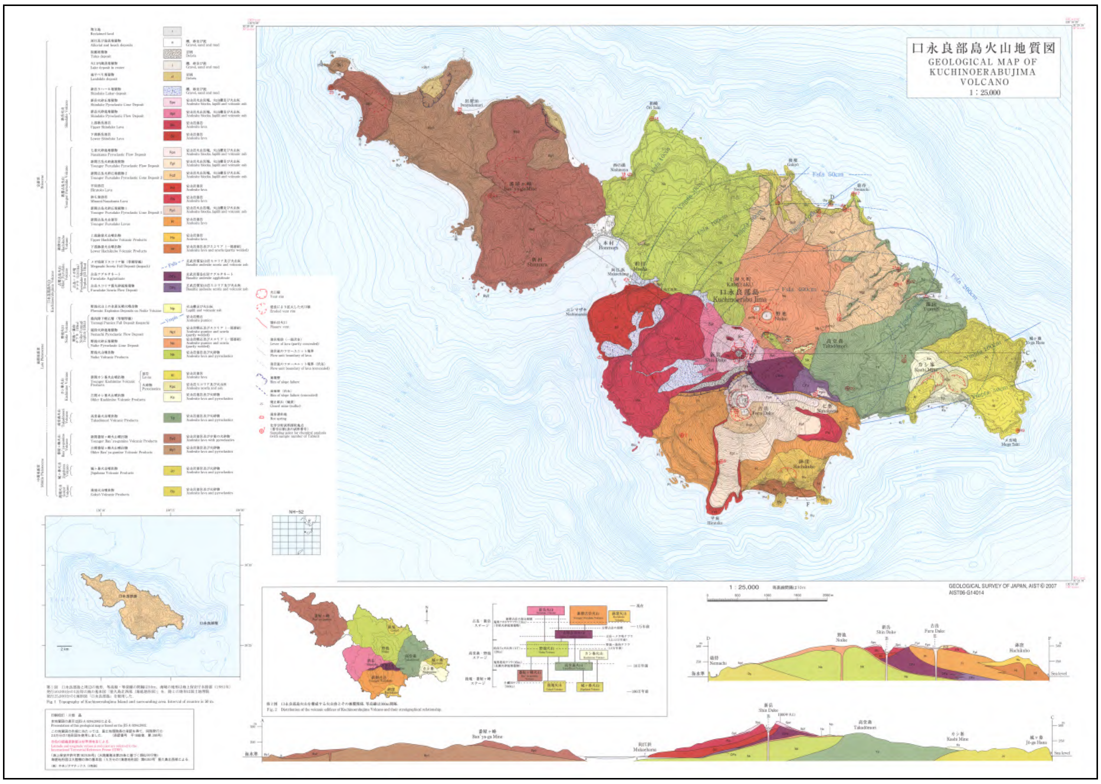


Figure 94-5 Geological map of Kuchinoerabujima (Geshi and Kobayashi, 2007).

Chronology of Eruptions
・Volcanic Activity in the Past 10,000 Years

Activity in the past 10,000 years has occurred at the Furudake, Shindake, and Hachikubo earthquakes (Geshi and Kobayashi, 2006; 2007). Multiple andesite lava flows have been confirmed from the southwest to the southeast foot of Furudake. The top surface of the lava flow distributed across the top strata has not been found to contain Kikai-Akahoya ash, so the lava flow distributed in the top strata is considered to be younger than 7,300 years old (Geshi and Kobayashi, 2006).

Based on the paleomagnetic analysis, the Shindake lava is considered to have been erupted either in the 9th century or in the 11th century (Miki et al., 2002).

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
11→3ka	Furudake crater	Magmatic eruption	Lava flow and tephra fall. Magma eruption volume = 0.01 km^3 DRE. (VEI 3)
11→0.2ka	Furudake crater	Magmatic eruption, phreatomagmatic eruption, phreatic eruption	Tephra fall and pyroclastic flow. Magma eruption volume = 0.05 km^3 DRE. (VEI 4)
7.3→3ka	Hachikubo crater	Magmatic eruption	Lava flow and tephra fall. Magma eruption volume = 0.05 km^3 DRE.
3.5←→3.4ka	Furudake crater	Magmatic eruption	Tephra fall.
3←→1ka	Furudake crater	Magmatic eruption	Lava flow. Magma eruption volume = 0.05 km^3 DRE.
1.5←→1.3ka	Furudake crater	Phreatomagmatic eruption	Tephra fall.
1.3←→1ka	Shindake crater	Magmatic eruption	Lava flow. Magma eruption volume = 0.24 km^3 DRE.
1ka	Furudake crater	Magmatic eruption	Lava flow. Magma eruption volume = 0.05 km^3 DRE.
1→0.02ka	Shindake crater	Magmatic eruption, phreatomagmatic eruption, phreatic eruption	Tephra fall and pyroclastic flow. Magma eruption volume = 0.005 km^3 DRE. (VEI 3)
1←→0.8ka	Shindake or Furudake crater	Phreatomagmatic eruption or phreatic eruption	Tephra fall.
1←→0.5ka	Shindake or Furudake crater	Phreatic eruption	Tephra fall.
0.8←→0.034ka	Shindake or Furudake crater	Magmatic eruption or phreatomagmatic eruption	Tephra fall.
0.8←→0.034ka	Shindake or Furudake crater	Magmatic eruption or phreatomagmatic eruption	Tephra fall.
0.8←→0.034ka	Shindake crater	Phreatic eruption	Tephra fall.
0.8←→0.034ka	Shindake or Furudake crater	Magmatic eruption or phreatomagmatic eruption	Tephra fall.
0.6←→0.5ka	Shindake or Furudake crater	Phreatic eruption	Tephra fall.
0.5←→0.34ka	Shindake or Furudake crater	Phreatic eruption	Tephra fall.
0.3←→0.2ka	Shindake or Furudake crater	Magmatic eruption	Pyroclastic flow. Magma eruption volume = 0.001 km^3 DRE. (VEI 2)

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

A→B: Indicates a continuous chain of eruption events beginning in year A and ending in year B.

A<B: Eruption event before year A.

・Historical Activity

Year	Phenomenon	Activity Sequence, Damages, etc.
1841 (Tenpo 12)	Eruption	May 23. Eruption at Shindake. August 1. A village was burned down, resulting in a large number of deaths. Eruption at Shindake.
1914 (Taisho 3)	Rumbling, topographic changes, molten sulfur discharge	January. Subsidence in the crater bottom.
1931 (Showa 6)	Eruption	Eruption at west rim of Shindake crater. Rumbling from March. Explosion on April 2 (western flank of Shindake). A landslide killed 2 and caused damage to horses and mountain fields and forests. On May 15 an explosion occurred and ash fell. Sulfur was emitted, and a ground deformation was observed.
1932 (Showa 7)	Volcanic plume, rumbling	From approximately July 23.
1933 to 1934 (Showa 8 to 9)	Eruption	Eruptions at Shindake crater. Multiple eruptions from December 24, 1933 to January 11, 1934. Nanakama village was completely burned down, killing 8 people, injuring 26 people, burning down 15 houses, and causing serious damage to cattle and horse livestock and mountain forests and agricultural land.
1945 (Showa 20)	Eruption	November 3. Eruption at Shindake crater eastern outer rim. Fissure eruption, volcanic blocks, tephra fall.
1966 (Showa 41)	Eruption	November 22. Eruption at Shindake. 3 people were injured, as was 1 cow. The infrasonic wave could be felt as far away as Kagoshima and Tanegashima.[2] A small pyroclastic flow occurred.
1968 to 1969 (Showa 43 to 44)	Eruption	December to March of following year. Eruption at Shindake.
1972 (Showa 47)	Eruption	September 2. Eruption at Shindake.
1973 (Showa 48)	Eruption	November 5 to 19. Eruption at Shindake.
1974 (Showa 49)	Eruption	June 3. Eruption at Shindake.
1976 (Showa 51)	Eruption	April 2. Eruption at Shindake. The explosion sound could be heard from the foot of the volcano. Approximately 1 cm of ash fell in Mukaehama and Maeda, approximately 2 km to the northwest.
1980 (Showa 55)	Small-scale: Phreatic eruption	September 28. Eruption on eastern flank of Shindake.[1] Multiple explosion craters were formed along a straight fissure running 800 m north-south on the eastern flank of Shindake (same location as Showa 20 fissure). Magma eruption volume = 0.0001 km^3 DRE. (VEI 1)
1982 (Showa 57)	Fumarole	October. 4 fumaroles were formed to northeast of Shindake crater.
1996 (Heisei 8)	Earthquake	January to June. Increase in volcanic earthquakes.
1999 to 2000 (Heisei 11 to 12)	Earthquake	July, 1999 to February, 2000. Increase in volcanic earthquakes. Earthquake swarm in sea to northeast.
2003 (Heisei 15)	Earthquakes, volcanic tremors	January to February. Increase in volcanic earthquakes. Volcanic tremors observed from February.
2004 (Heisei 16)	Earthquakes, volcanic tremors	February. Increase in volcanic earthquakes. Volcanic tremors continued to occur occasionally.
2005 (Heisei 17)	Earthquakes, volcanic tremors, crustal deformation, fume	Slightly high number of volcanic earthquakes. Volcanic tremors continued to occur occasionally. Slightly high level of fumarolic activity from February to April. Changes indicating inflation were observed near the Shindake crater from January to May.
2006 (Heisei 18)	Earthquakes, volcanic tremors, crustal deformation	Slightly high number of volcanic earthquakes and volcanic tremors. Changes indicating inflation were observed near the Shindake crater from September to December.
2007 (Heisei 19)	Earthquakes, volcanic tremors	Number of volcanic earthquakes and volcanic tremors repeatedly increased and decreased, for an overall slightly high level of activity.

Year	Phenomenon	Activity Sequence, Damages, etc.
2008 (Heisei 20)	Earthquakes, volcanic tremors, crustal deformation	Temporary increase in volcanic earthquakes with relatively large amplitudes occurred on September 4. Changes indicating inflation were observed near the Shindake crater from September to February of next year, and number of volcanic tremors was slightly high. White volcanic plume activity began from south wall of Shindake in October.
2009 (Heisei 21)	Earthquakes, volcanic tremors	Number of volcanic tremors increased in April. Number of volcanic earthquakes increased in September.
2010 (Heisei 22)	Earthquakes, volcanic tremors, crustal deformation	Number of volcanic earthquakes increased from January to April. Number of volcanic tremors increased in March and December. Changes indicating inflation were observed near the Shindake crater from September.
2011 (Heisei 23)	Earthquake	Number of volcanic earthquakes increased 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

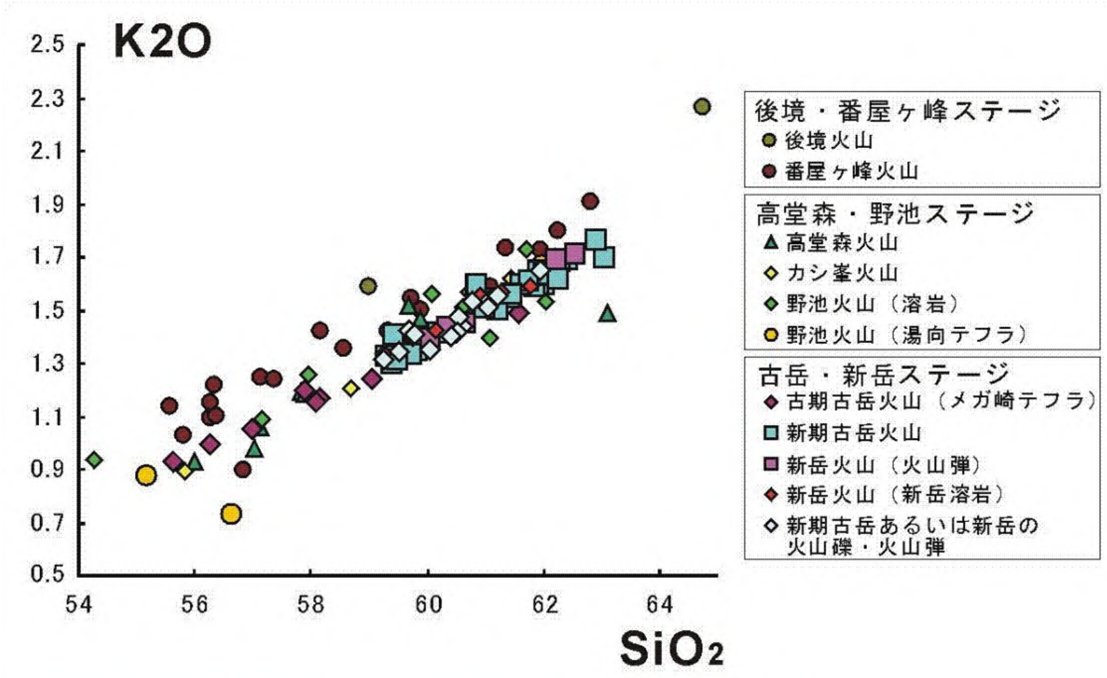


Figure 90-6 Whole rock chemical composition (Geshi and Kobayashi, 2009).

Precursory Phenomena

In the case of the Showa phreatic eruptions, volcanic plume volumes decreased, as did rumbling and weak earthquakes, immediately before the eruption began.

Although not culminating in eruptions, in recent years the number of volcanic earthquakes has increased, inflation at a shallow depth directly below the summit has been observed, and repeated fumarolic activity has occurred.

Major Volcanic Activities

・1966 Eruption

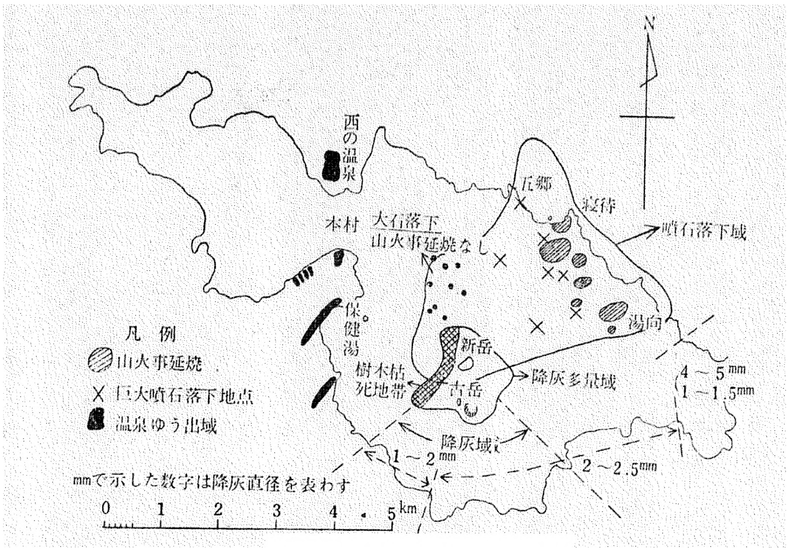


Figure 94-7 Distribution of volcanic blocks and ash fall from November 22, 1966, Kuchinoerabujima eruption (Kagoshima Local Meteorological Observatory Yakushima weather station, 1967).

Volcanic blocks were mainly scattered from the north-northeast to the east-northeast. Volcanic blocks between 0.8 and 1 min diameter were scattered over the Isato coast, 3 km north-northeast of the crater. A hole was found in a road 2 km north-northeast of the crater indicating the fall of a volcanic block 5 min diameter.

Ash fall was distributed from the east to the south-southwest of the crater.

・1980 Eruption

On September 28, a phreatic explosion occurred on the eastern flank of Shindake. Multiple explosion craters were formed along a straight fissure running 800 m north-south on the eastern flank of Shindake (same location as Showa 20 fissure).

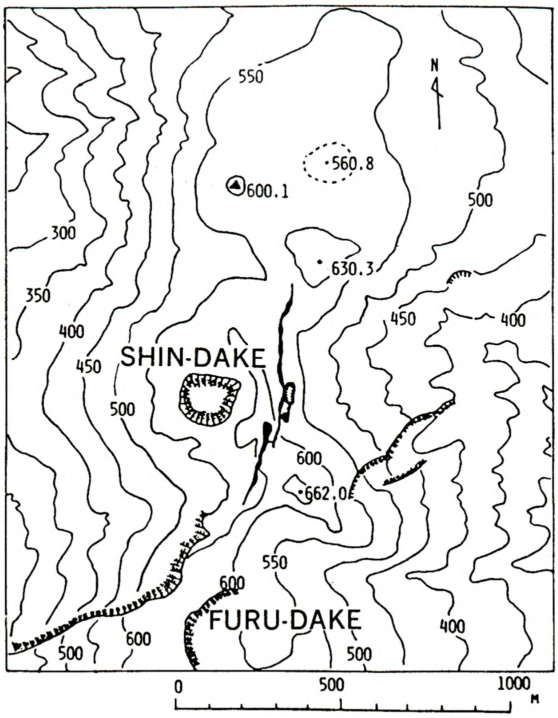


Figure 94-8 Location of 1980 Kuchinoerabujima fissure eruption (Kyoto University et al., 1981).

Recent Volcanic Activity

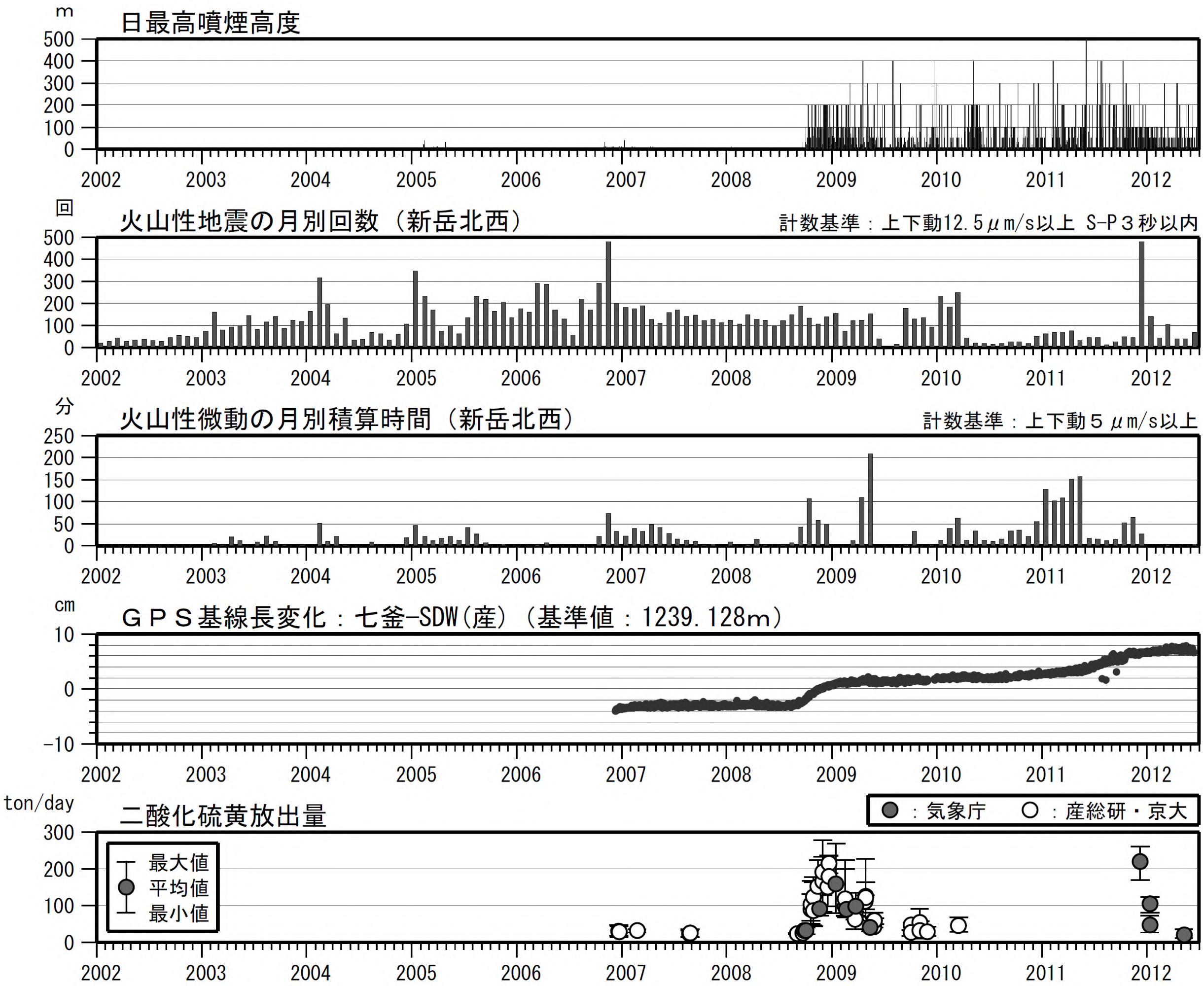


Figure 94-9 Volcano activity (January 1, 2002 to June 30, 2012). The number of earthquakes from December 15 to December 28, 2005 was counted by a Kyoto University short-period seismometer. Data is unavailable for December 22, 2002 to January 11, 2003 due to a malfunction of the equipment to the northwest of Shindake. The number of earthquakes at Furudake was used for July 9 to September 18, 2005, and November 5 to December 14, 2005, due to a malfunction of the equipment to the northwest of Shindake.

Since 1999 volcanic seismic activity has increased, and the number of earthquakes has risen repeatedly. From 2003 volcanic tremors have also been observed. Repeated crust inflation has been observed near the Shindake crater. From 2008 white volcanic plumes have been emitted continuously.

① Daily maximum volcanic plume height

② Number of volcanic earthquakes per month (northwest of Shindake)

③ Total amount of volcanic tremor time per month (northwest of Shindake)

④ GPS baseline length change: Nanakama-SDW (AIST)

⑤ Amount of sulfur dioxide emitted

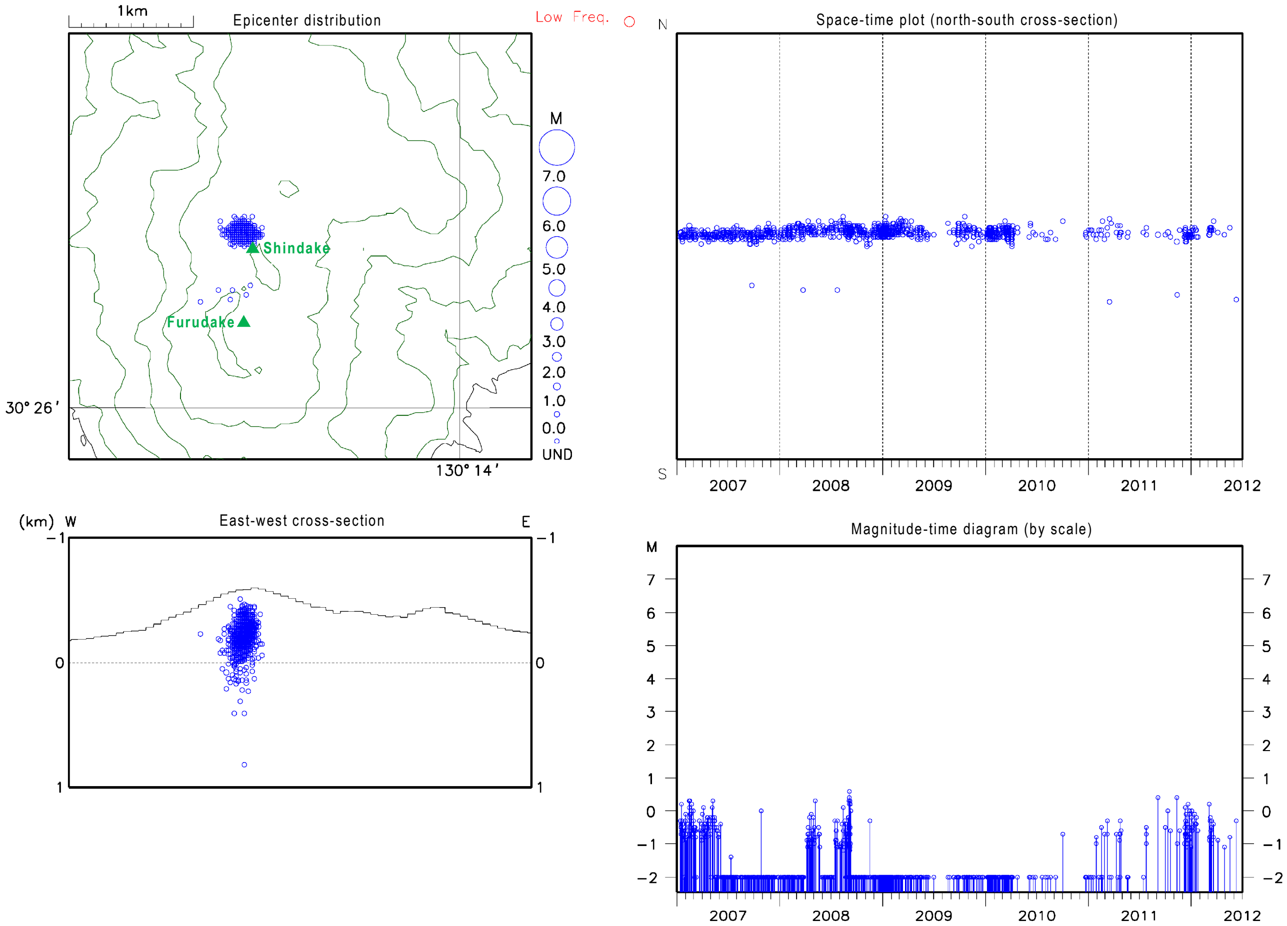


Figure 94-10 Distribution of volcanic earthquakes (January 12, 2007 to June 30, 2012).

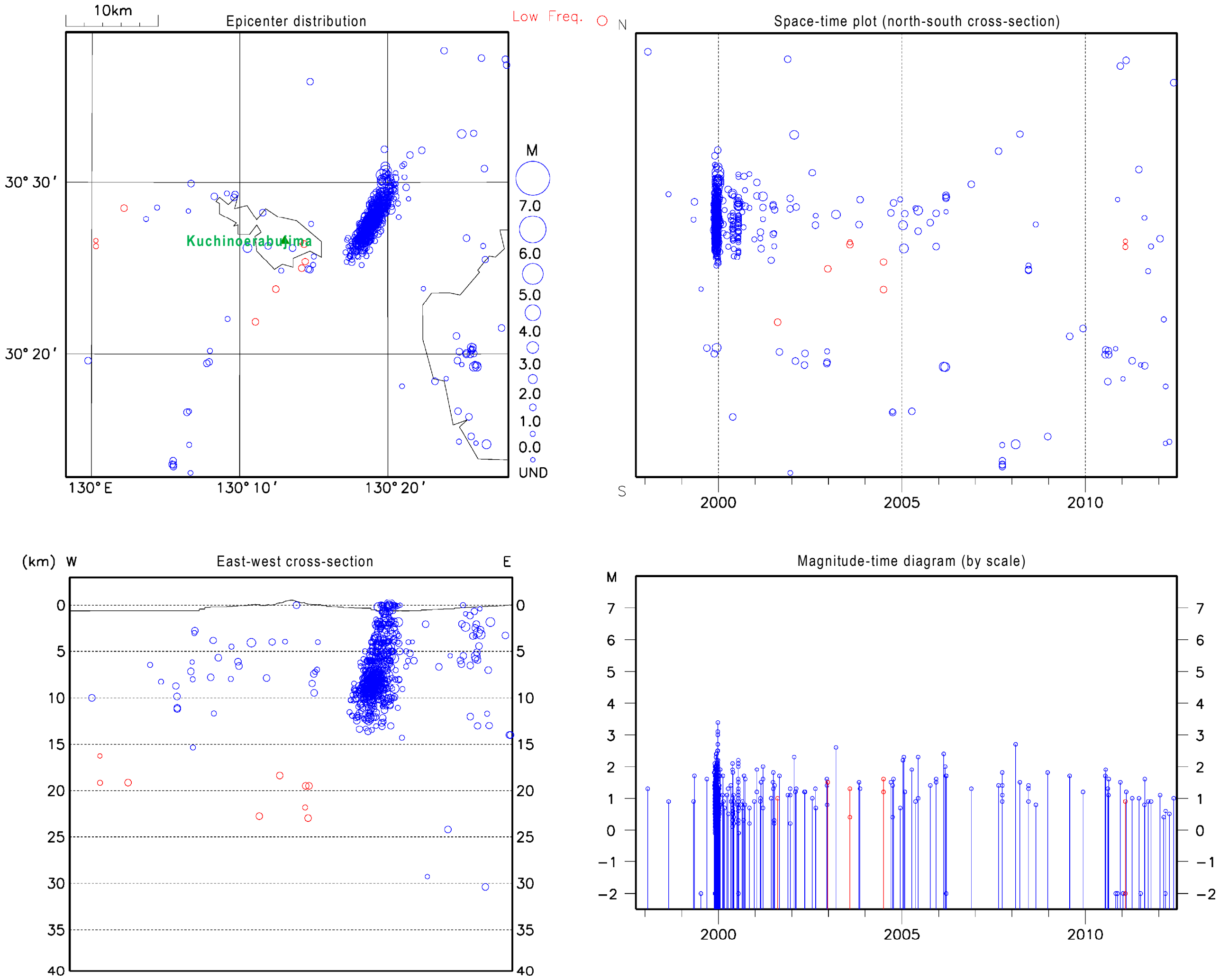


Figure 94-11

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).

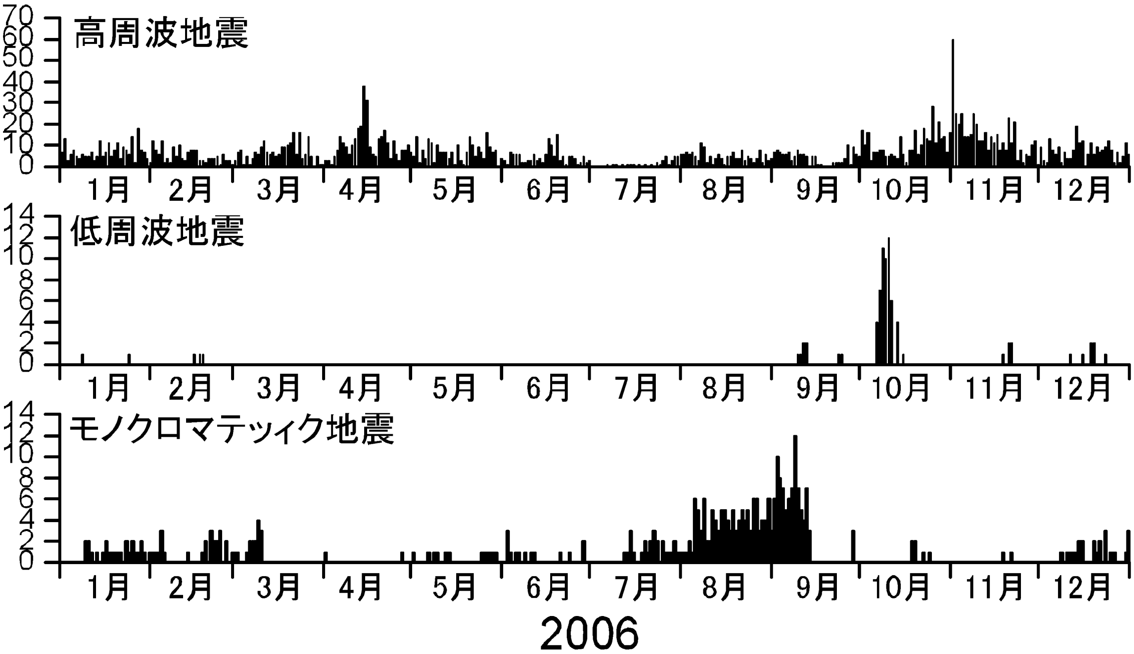


Figure 94-12 Changes in number of daily high-frequency earthquakes, low-frequency earthquakes, and monochromatic earthquakes (Iguchi, 2008).

94 High-frequency earthquakes, ② Low-frequency earthquakes, ③ Monochromatic earthquakes

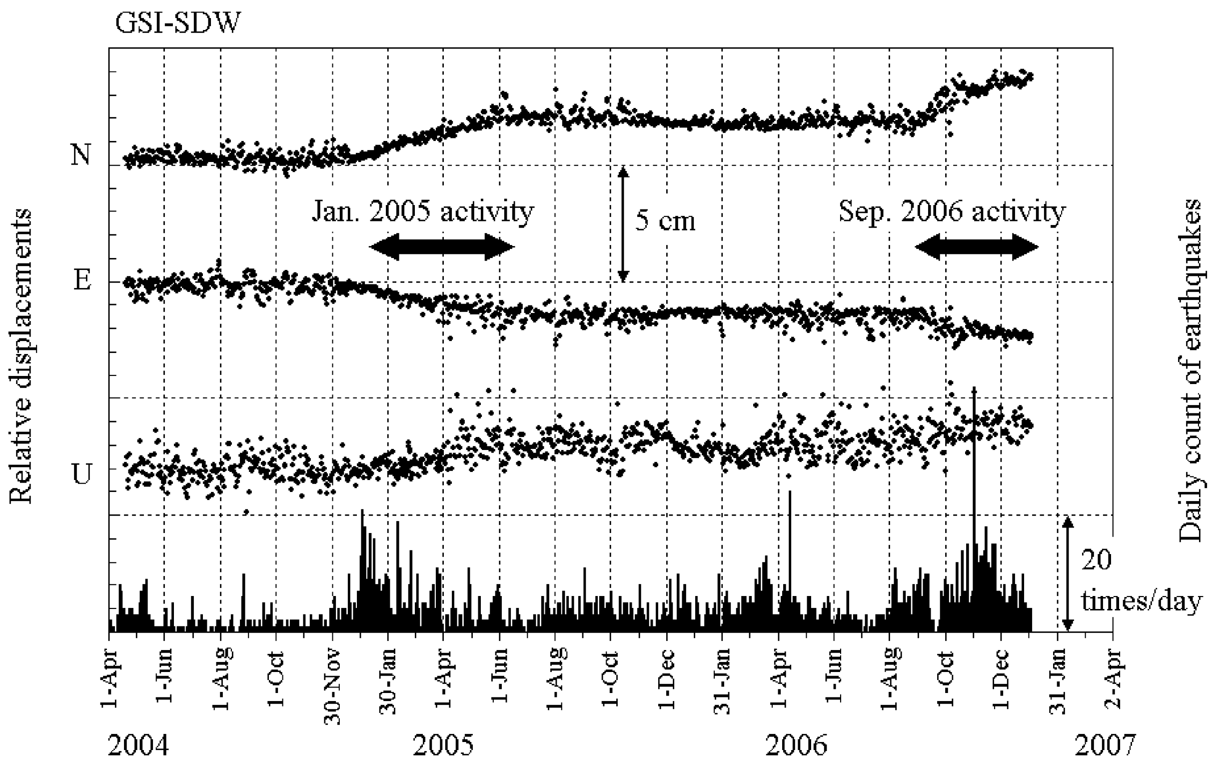


Figure 94-13 Ground deformation at Kuchinoerabujima since 2004 observed by GPS continuous measurement (Saito and Iguchi, 2007).

Between January and June, 2005, and September, 2006, and January, 2007, ground deformations were observed, which were caused by an increase in the volume of the pressure source in the shallow area of Shindake.

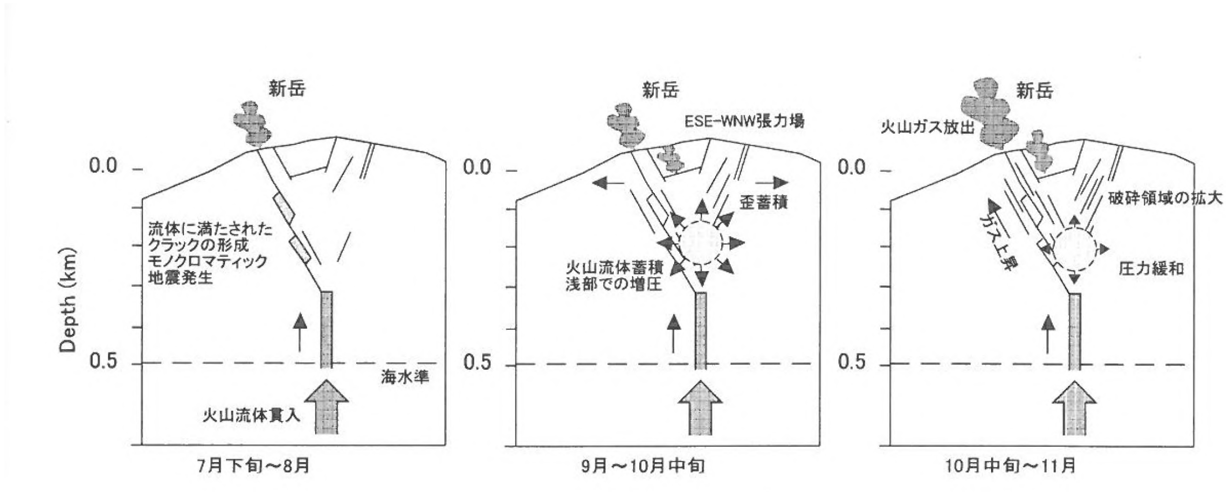


Figure 94-14 Kuchinoerabujima volcanic fluid intrusion and pressure relaxation processes hypothesized based on observations (Iguchi, 2008).

Late July to August, 2006: Volcanic fluid intrusion and increase in earthquakes.

September to mid-October, 2006: Continued volcanic fluid intrusion produces observed inflation in shallow area.

Mid-October to November, 2006: As a result of strain accumulation, rock layer is broken and accumulated volcanic fluid leaks out.

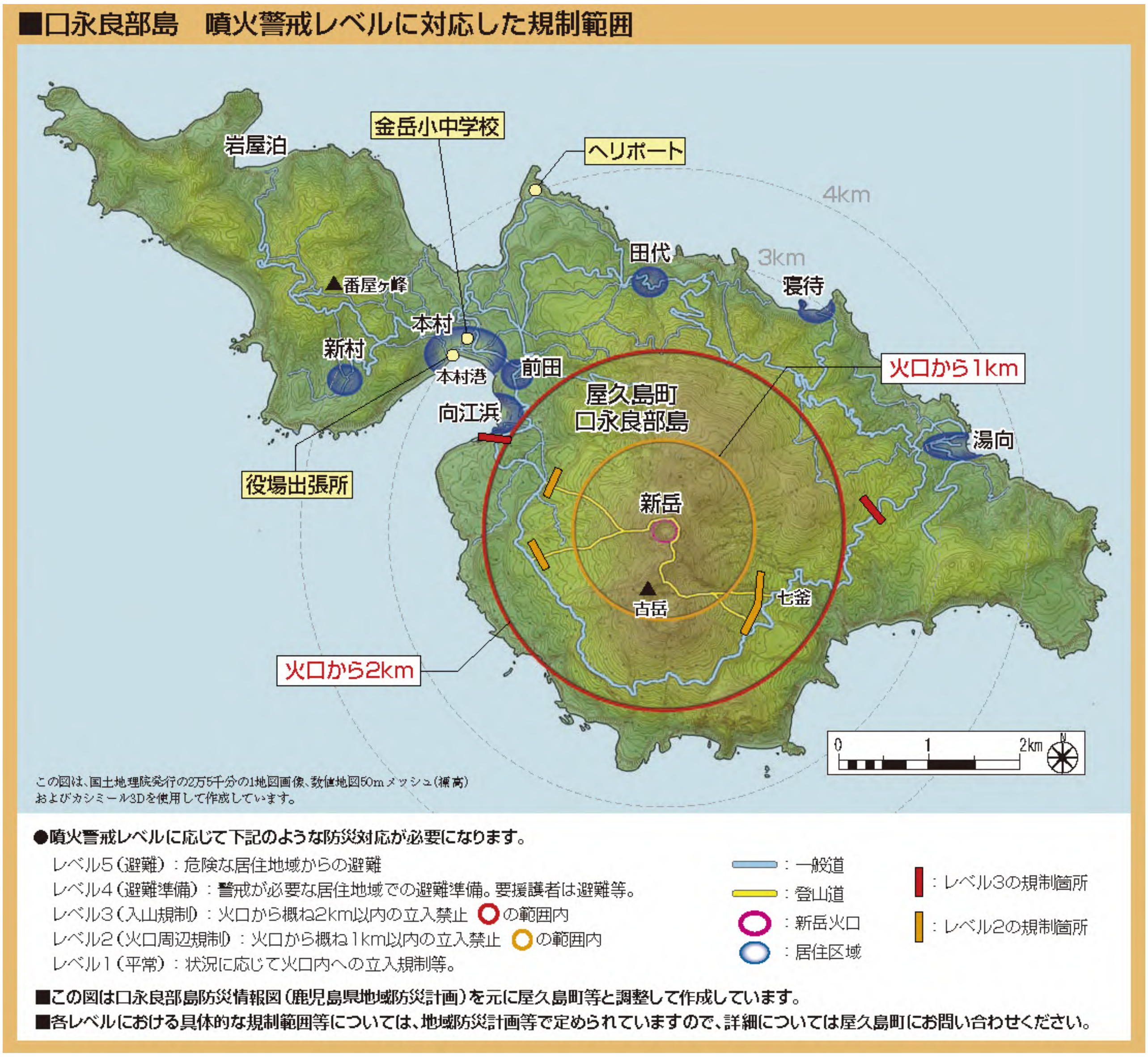
Information on Disaster Prevention

①Hazard Map

- "Kuchinoerabujima Volcano Disaster Danger Area Forecast Map"
- "Kuchinoerabujima Disaster Prevention Information Map"
- Both created by Kagoshima Prefecture in 1996

  URL:http://www.pref.kagoshima.jp/aj01/bosai/sonae/keikaku/h23/documents/24696_20120419165713-1.pdf

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



Volcanic Alert Levels for the Kuchinoerabujima 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**	●Eruption or imminent eruption, with volcanic blocks, pyroclastic flow, and/or lava flow reaching residential areas. Past Examples November, 1966: Volcanic blocks were scattered approximately 3.5 km from the crater.
		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.**	●Eruption expansion with possibility of volcanic blocks, pyroclastic flow, and/or lava flow reaching residential areas. Past Examples April, 1931. Volcanic blocks were scattered approximately 2 km from the Shindake crater. August, 1841: Volcanic blocks were scattered approximately 2 km from the Shindake crater.
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.**	●Possibility of volcanic blocks being scattered within approximately 2 km of crater, or scattering caused by growth of small eruption. Past Examples December, 1968 to March, 1969: Scattered volcanic blocks. November, 1945 and December, 1933: Fissure eruption at Shindake, with volcanic blocks scattered approximately 1.9 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 activities as normal. Access to crater area restricted, etc.**	●Small eruption, with scattering of volcanic blocks within a distance of approximately 1km from the crater. September, 1980, Eruption: Fissure eruption at Shindake, with volcanic blocks scattered approximately 700 m from the crater. ●Possibility of small eruption. Past Examples September, 2006, volcanic edifice inflation: Increase in volcanic earthquakes in March, 1996, August, 1999, January, 2000, and February to April, 2003. July, 1932: Increased volcanic plume 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 discharge which may affect summit crater interior. Past Examples Status between November, 2003 to January, 2004.

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

Yakushima Town: 13,732 (Kuchinoerabujima: 156) (as of October 31, 2011: according to Yakushima Town basic resident register)

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

・National Parks, Quasi-National Parks: Yakushima National Park (special protection area, special area, regular area, marine park area)
・Number of visitors per year: 2,148 (2010: according to survey by Yakushima Town)

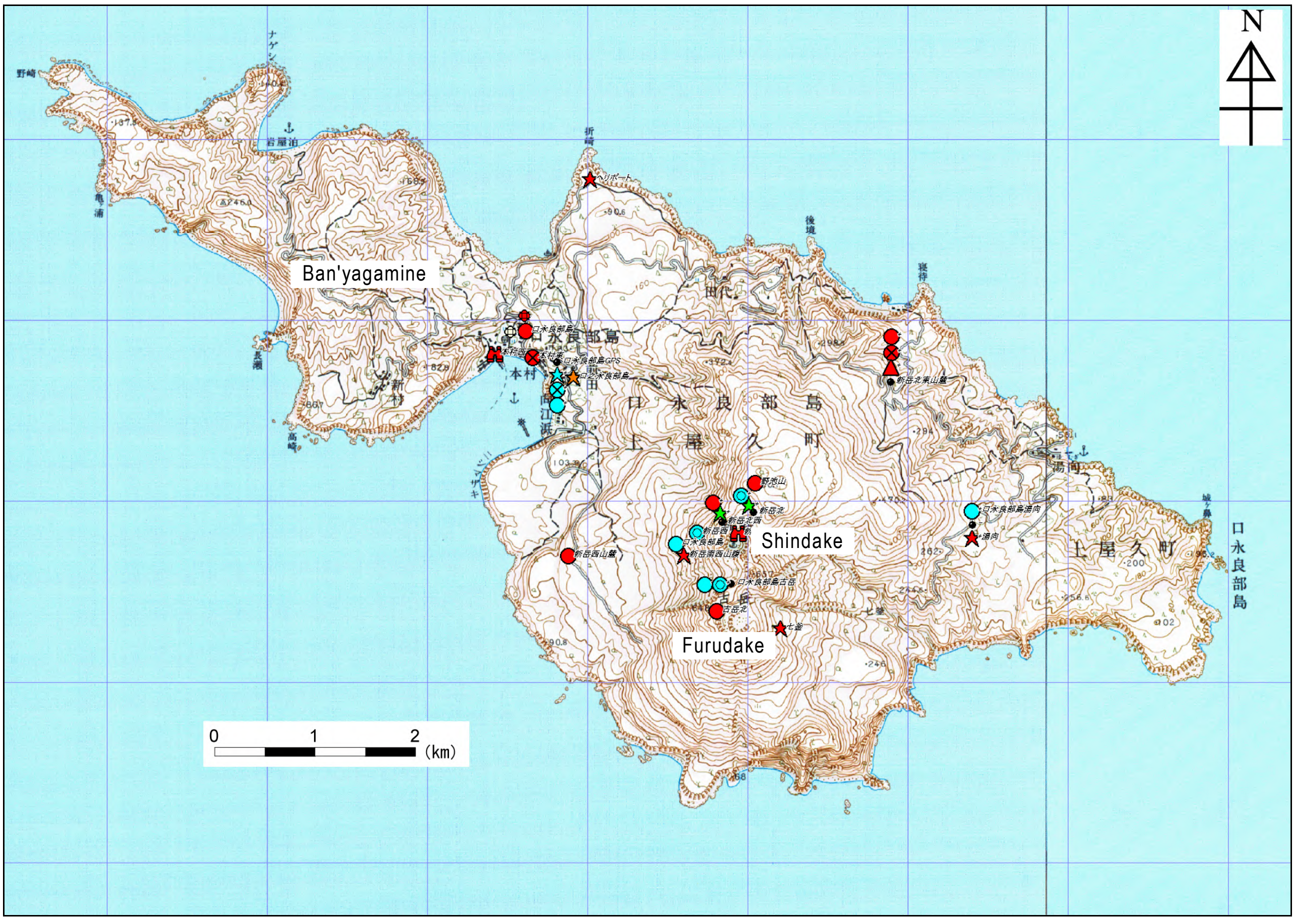
③Facilities

None

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 map (Kuchinoerabujima and Northwest Yakushima) published by the Geospatial Information Authority of Japan were used.

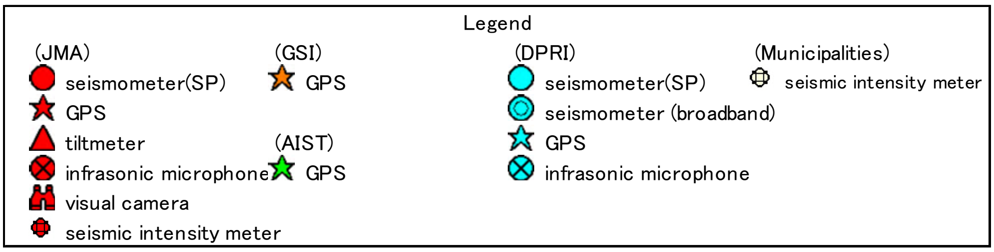


Figure 94-15 Monitoring network.

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(Iguchi, M., and Ito, K.)