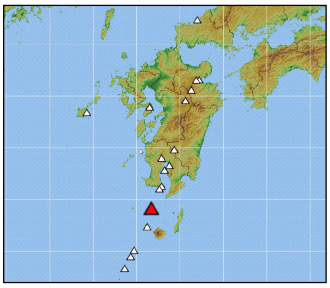
93. Satsuma-Iojima



Continuously Monitored by JMA

Latitude: 30°47'35" N, Longitude: 130°18'19" E, Elevation: 704 m (Iodake)
(Triangulation Point - Iojima)

Satsuma-Iojima on August 25, 2009, taken by the Japan Meteorological Agency
The Mountain at Rear with Heavy Fume Activity is Iodake; the Green Mountain at Front is Inamuradake

Summary

Satsuma-Iojima is a volcanic island which measures 6 km east-west and 3 km north-south. Together with Takeshima, it forms the rim of the Kikai caldera (23 km east-west, 16 km north-south). The highest peak, Iodake, is a steep stratovolcano composed of rhyolite. Fume activity is strong at the summit crater. Inamuradake is a small stratovolcano, composed of basalt - andesite stratovolcano. Eruptions within recorded history have occurred in the nearby sea floor, forming new island (Showa-Iojima). Both Iodake and Showa-Iojima are composed of rhyolite (SiO_2 content is between 69.9 and 71.9 wt %), but Inamuradake is composed of basalt and andesite. It is also known as Kikaigashima. "Tokara Iojima" has also been used as the volcano's name.

Red Relief Image Map

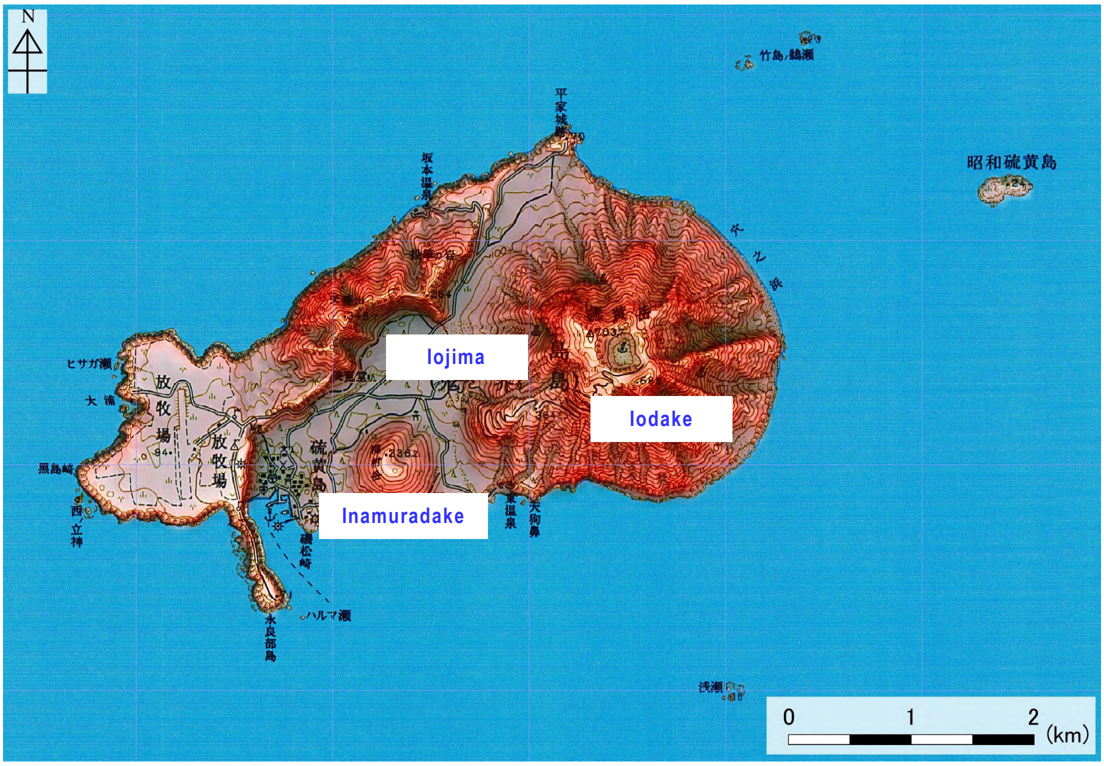


Figure 93-1 Topography of Satsuma-Iojima.

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

Submarine Topographic Map

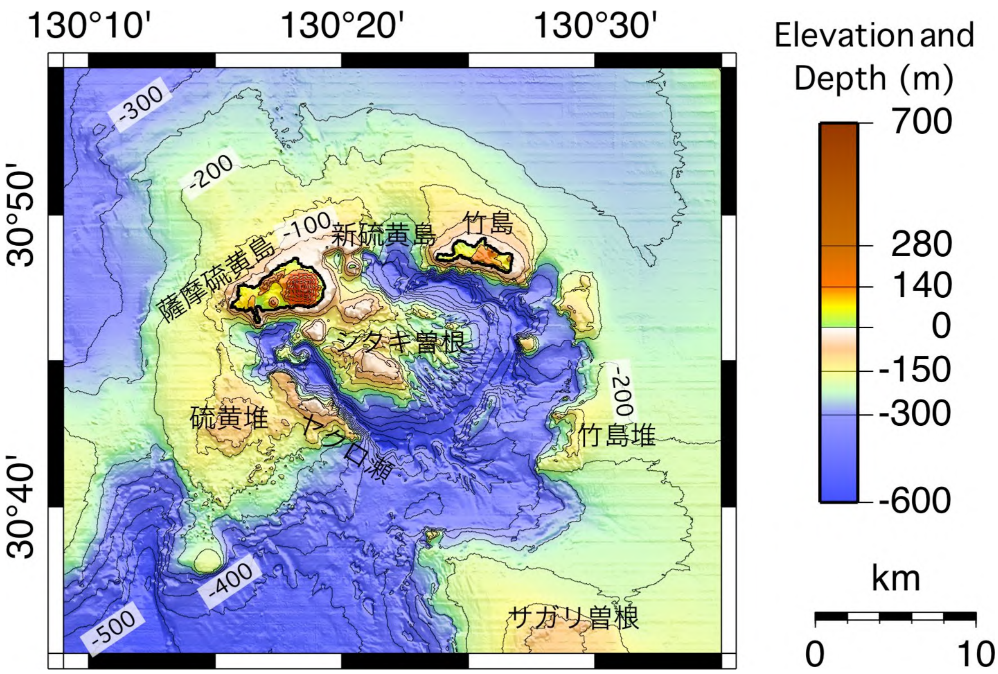


Figure 93-2 Submarine topographic map of the Satsuma-Iojima area (Japan Coast Guard).

Topography around the Crater

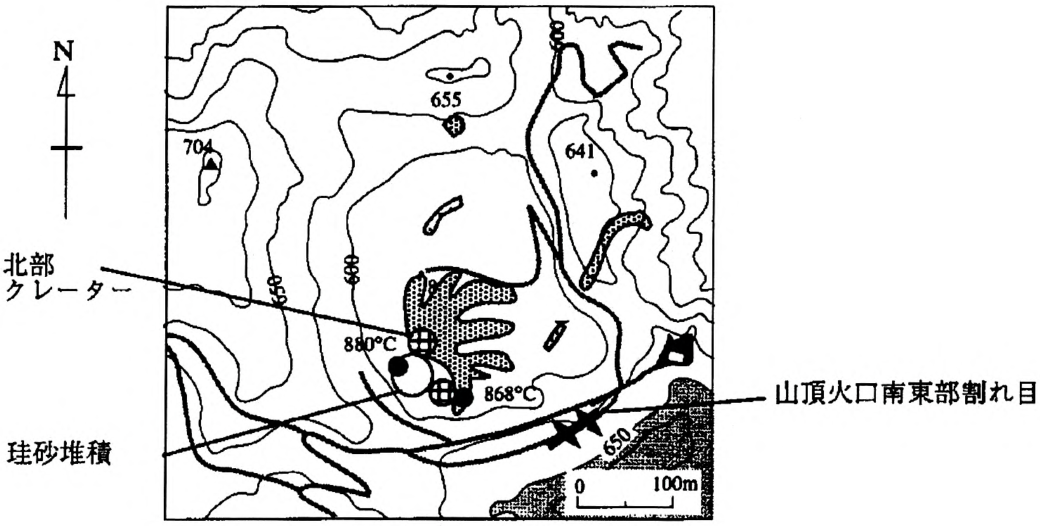
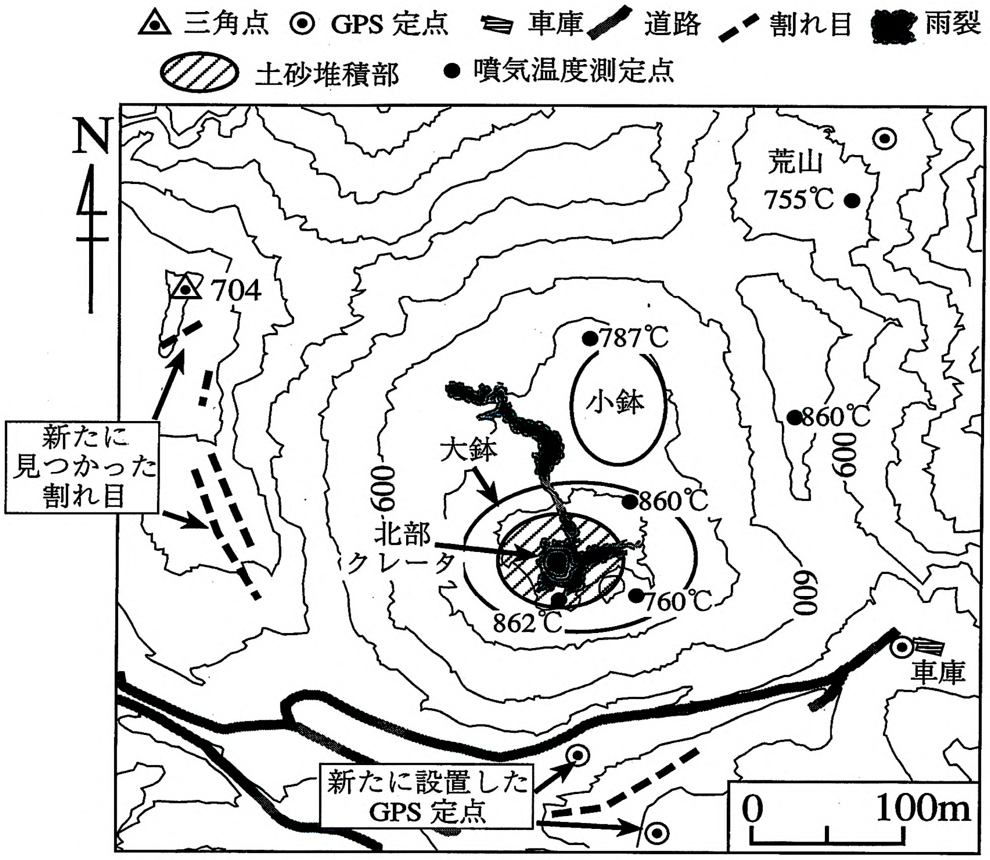


Figure 93-3 Summit crater in January, 1997
(Geological Survey of Japan, 1997).



第１図　硫黄岳山頂火口地形図（等高線は20m間隔）

Figure 93-4 Topographic map of the Iodake summit crater (contour lines at 20m intervals)
(Geological Survey of Japan and Kyoto University, 1998).

Submarine Topographic Map

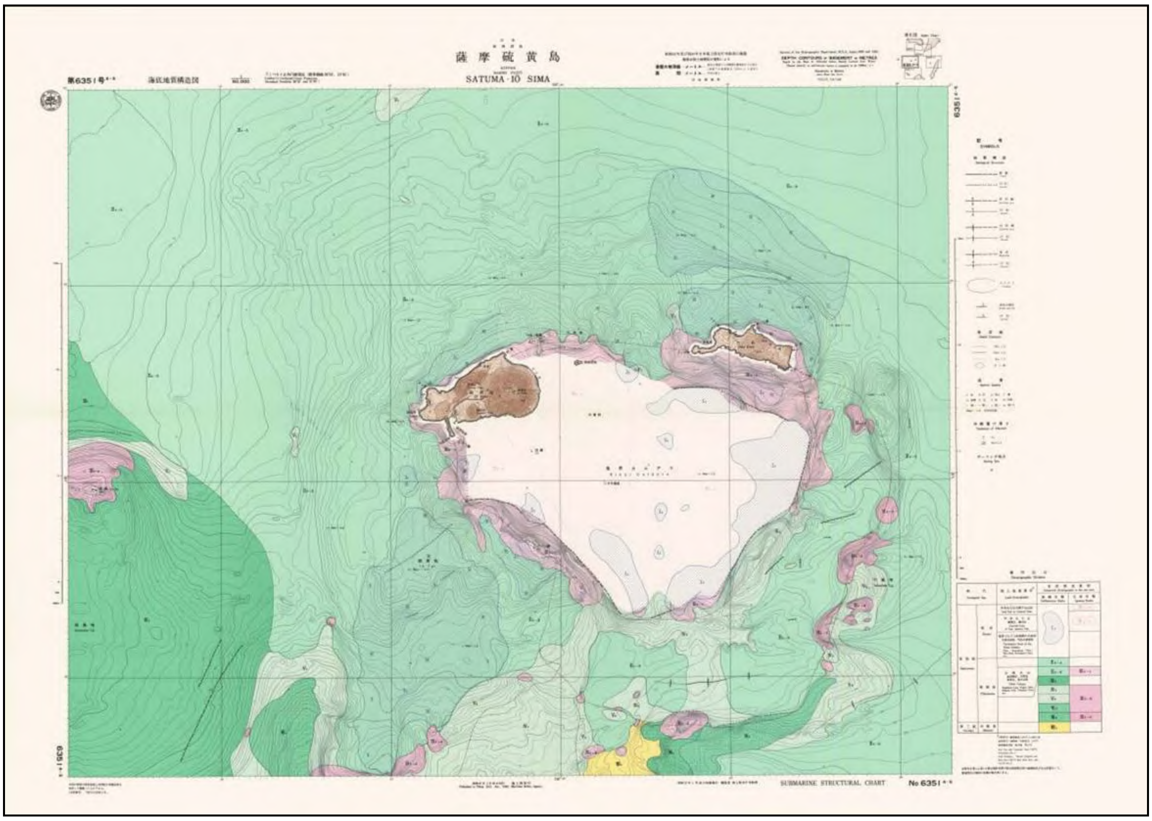


Figure 93-5 Submarine topographic map of the Satsuma-Iojima area (Maritime Safety Agency, 1982).

Geological Map

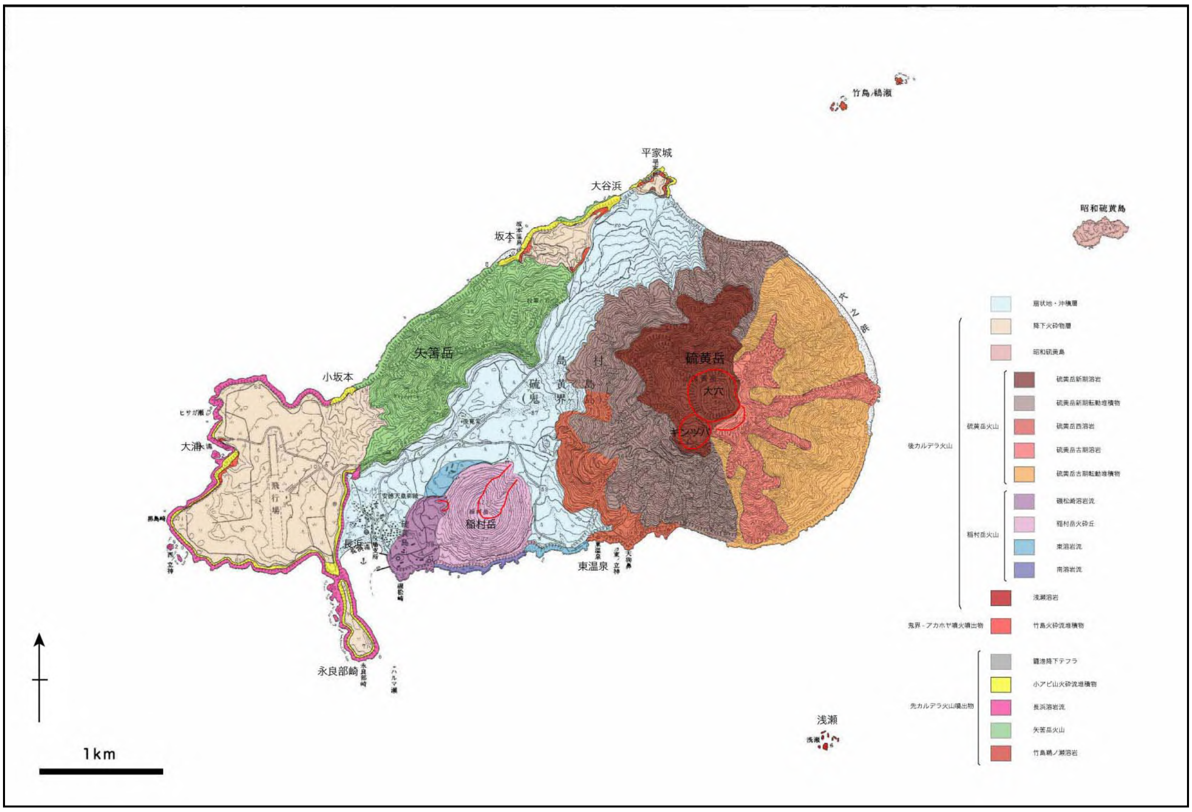


Figure 93-6 Geological map of Satsuma-Iojima (Kawanabe, 2006).

Chronology of Eruptions

・Volcanic Activity in the Past 10,000 Years

The Kikai caldera was the site of the largest eruption in the nation in the Holocene epoch 7,300 years ago (the Akahoya eruption). Satsuma-Iojima is a volcanic island that was formed on the rim of the Kikai caldera, appearing above sea level approximately 6,000 years ago.

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
14→7.3ka	?	Magmatic eruption	Air-fall tephra.
7.3ka	Kikai caldera	Magmatic eruption, phreatomagmatic eruption	Air-fall tephra, pyroclastic surge, pyroclastic flow. Magma eruption volume = 68 km^3 DRE. (VEI 7)
7.3ka>	Kikai caldera	Magmatic eruption	Lava dome.below the surface. Magma eruption volume = 17* km^3 DRE. (VEI 6) *Maximum volume deduced from submarine topography
5.2←→3.9ka	Near Iodake?	Magmatic eruption	Air-fall tephra and pyroclastic surge.
5.2←→3.9ka	Iodake	Magmatic eruption	Air-fall tephra and pyroclastic surge.
3.9←→3.7ka	Inamuradake	Phreatic eruption	Air-fall tephra and lava flow.
3.9←→2.2ka	Inamuradake	Magmatic eruption	Air-fall tephra and lava flow.
3.9←→2.2ka	Inamuradake	Phreatic eruption	Air-fall tephra and pyroclastic surge.
3.9←→2.2ka	Inamuradake	Phreatomagmatic eruption	Lava flow.
2.2←→0.9ka	Iodake	Phreatic eruption	Air-fall tephra.
2.2←→0.9ka	Iodake	Magmatic eruption, phreatomagmatic eruption	Air-fall tephra, lava flow, lava dome, pyroclastic surge.
1←→0.9ka	Iodake	Phreatic eruption	Air-fall tephra and pyroclastic flow.

* 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

Iodake has also experienced a magmatic eruption, accompanied by a pyroclastic flow, 500 to 600 years ago (within the historic period). In 1934 a submarine eruption occurred, accompanied by an emission of lava, in the sea just east of Satsuma-Iojima, creating Showa-Iojima (Maeno and Yaguchi, 2005; Kawanabe and Saito, 2002; Okuno, 1996, 2002; Ono et al., 1982).

Year	Phenomenon	Activity Sequence, Damages, etc.
15th to 16th century	Phreatic eruption	Air-fall pyroclastic material and pyroclastic flow. The eruption occurred at the Iodake summit crater.
1934 to 1935 (Showa 9 to 10)	Large: Magmatic eruption	September, 1934 to March, 1935. Eruption occurred at Showa-Iojima. An earthquake swarm began on September 6. On September 20 an undersea eruption occurred 2 km to the east. In December, the present Iojima Shinto (Showa-Iojima) was created. Magma eruption volume = 0.276 km^3 DRE. (VEI 4)
1936 (Showa 11)	Earthquake and volcanic plume	From October 26, the volume of volcanic plume from Iodake increased, and rumbling occurred from the bottom of the crater. This activity caused the island to subside by 30 cm.
1988 (Showa 63)	Volcanic plume?	Volcanic plumes rose 4 times on January 18 (possibly rising of materials from collapse within crater).
1996 (Heisei 8)	Topographic change	Observation in October confirmed an opening crack in a road to the southeast of the summit crater, running northeast to southwest.
1997 (Heisei 9)	Fumarole formed	A steep fumarole with a diameter of approximately 20 m was found at the bottom of the crater.
1998 (Heisei 10)	Phreatic eruption?	Eruption at Iodake. A short-period seismometer installed on the island found a rapid increase in volcanic earthquakes, too small for a person to feel, beginning in April. The number of earthquakes per day, which had been 60 to 80 before, passed 100 on some days. From June, the number gradually declined, with 20 or fewer earthquakes per day from late June. The number began increasing again in September, reaching 80 to 110 per day in late October. In early November, the number again fell to just a few per day, but from mid-November, the number increased to 60 to 100 per day. A local survey in early May found approximately 5 mm of volcanic ash deposited around the crater. Volcanic ash is considered to have been ejected from late April to early May. Volcanic ash analysis by the Geological Survey of Japan (now the National Institute of Advanced Industrial Science and Technology) found the main component of the volcanic ash to be silicified altered Iodake lava fragments. The volume of fresh magma material was not large. According to the Mishima City Hall, rain mixed with ash fell on May 14. Occasional light ash fall also occurred on the island beginning in August, as well as ash fall on Takeshima on August 11. According to the Kagoshima Central Police Station Iojima substation, several small amounts of ash fell in October. The Geological Survey of Japan performed a site survey in November, and confirmed that volcanic ash was occasionally being ejected from the crater, and that ash fall reached as far as the observation platform (halfway down the southeast flank of Iodake).
1999 (Heisei 11)	Eruption	The eruption occurred at the Iodake summit. According to the Mishima City Hall, small amounts of ash fell on the island in January, February, May to August, and November, as well as sightings of colored volcanic plumes.
2000 (Heisei 12)	Eruption	The eruption occurred at the Iodake summit. According to the Mishima City Hall, small amounts of ash fell on the island in January, May, June, July, and September to December.
2001 (Heisei 13)	Eruption	The eruption occurred at the Iodake summit. According to the Mishima City Hall, small amounts of ash fell on the island in February and April to December.
2002 (Heisei 14)	Eruption	The eruption occurred at the Iodake summit. Volcanic activity increased slightly from May to July, and occasional ash fall was confirmed at a local village (approximately 3 km west of Iodake).

Year	Phenomenon	Activity Sequence, Damages, etc.
2003 (Heisei 15)	Eruption	The eruption occurred at the Iodake summit. Volcanic activity increased slightly from June to October, with occasional eruptions. During the rest of the period, 2 eruptions occurred in April, and 1 in May, but activity was comparatively calm overall.
2004 (Heisei 16)	Eruption	The eruption occurred at the Iodake summit. Eruptions occurred in March, April, June, and August to October. Ash fall was occasionally confirmed in the village.

* 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

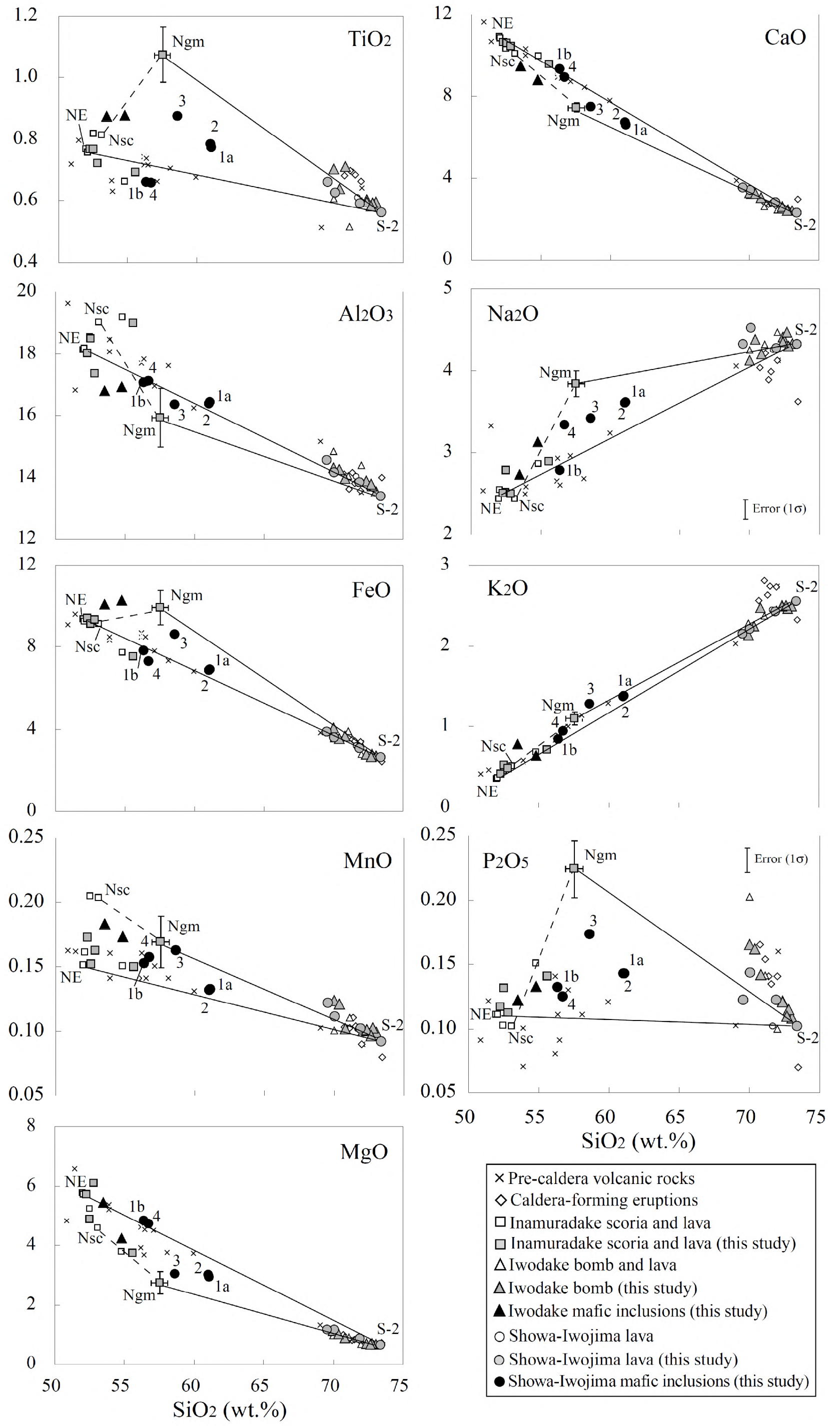


Figure 93-7 Whole rock chemical composition Harker diagram (Saito et al., 2002).

Includes data from ono et al. (1982) and ujiie et al. (1986).

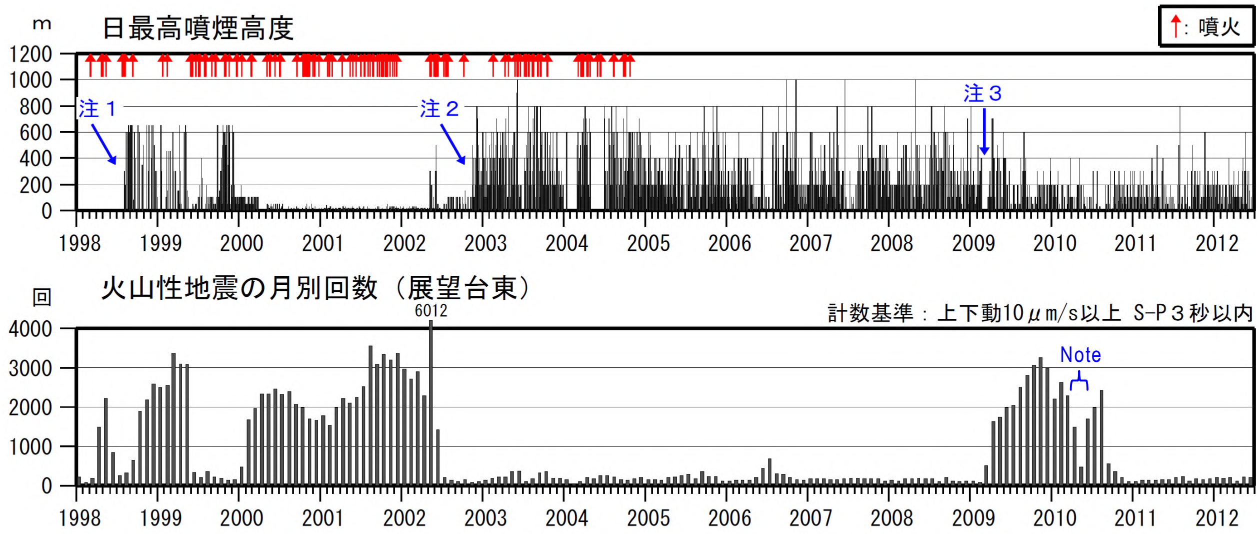
Ngm (symbols with error bars): Inamuradake scoria foundation stone chemical composition (Saito *et al.*, 2001)

Nsc: Inamuradake scoria whole rock chemical composition

Precursory Phenomena

The 1934 submarine eruption (Showa-Iojima formation) was preceded by felt-earthquake swarms and a rise in the temperature of well water in nearby islands from 14 days before the eruption.

Recent Volcanic Activity



Note 1 - August 1, 1998: Mishima City Hall Iojima office began reporting notifications to the Japan Meteorological Agency.
Note 2 - November 16, 2002: Japan Meteorological Agency began observation using installed monitoring camera.
Note 3 - February 23 to March 21, 2009: Volcanic plume unknown due to long-range camera failure.
Note 4 - There are periods where the numbers of volcanic earthquakes and volcanic tremors are unknown due to short-period seismometer failures.

Figure 93-8 Volcano activity (January, 1998 to June 30, 2012).

① Daily maximum volcanic plume height

② Number of volcanic earthquakes per month (east observation platform)

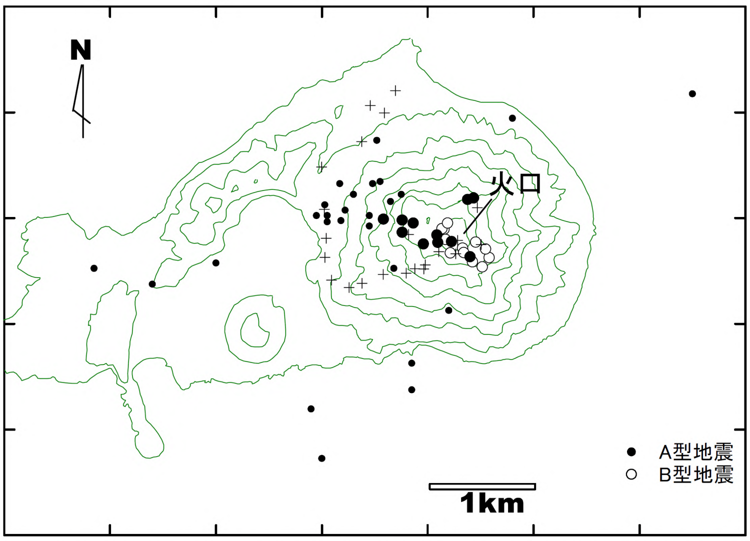


Figure 93-9 Distribution of A-type and B-type earthquake hypocenters (iguchi et al.. 2002).

Black circle: A-type earthquake, white circle: B-type earthquake. Large black circles indicate hypocenters determined by this source. Small black circles indicate hypocenters determined by Kamo (1976, 1977, 1978). + symbols indicate observation points.

A-type earthquake hypocenters have been determined to be located at depth of 1 km below sea level at northwestern and northern foot of Iodake.

B-type earthquake hypocenters have been determined to be extremely shallow, and concentrated in a very small area within the crater.

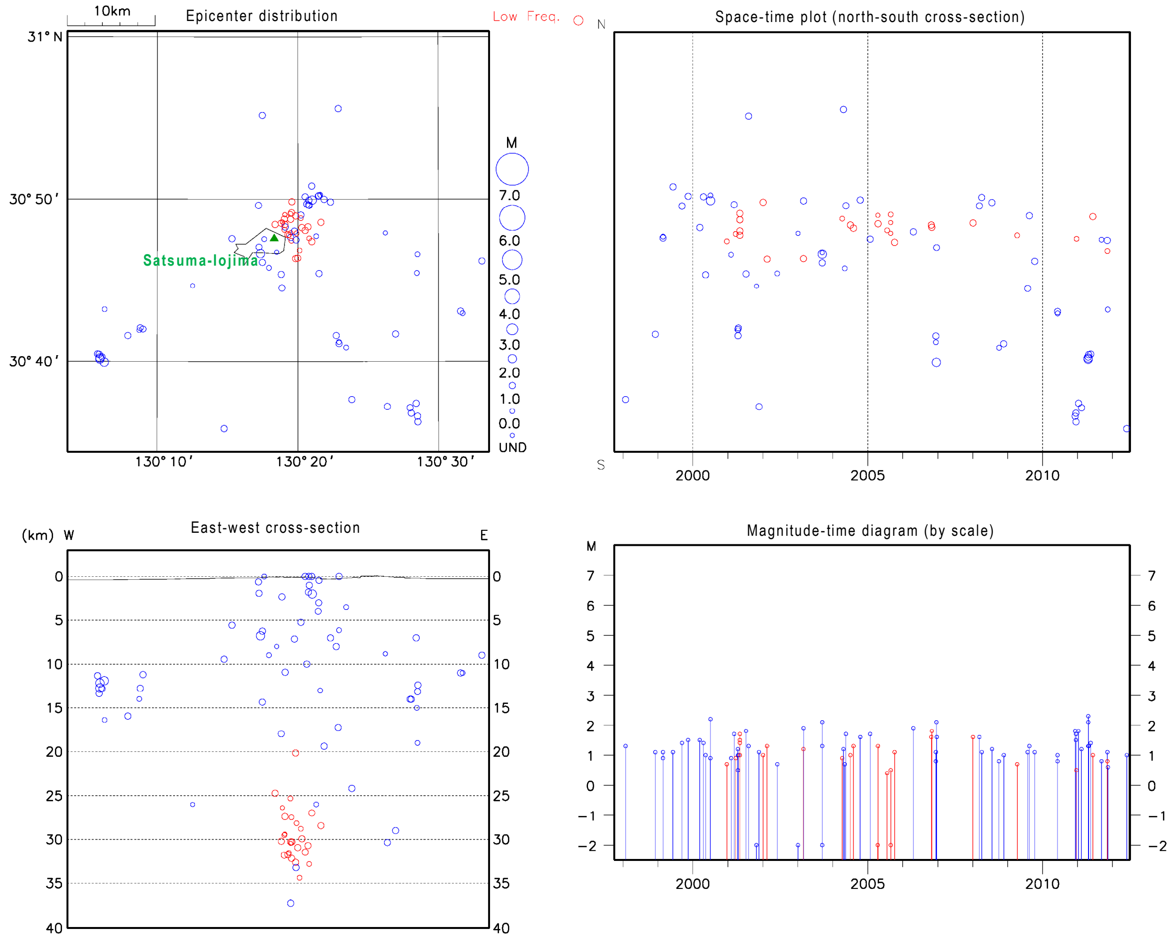


Figure 93-10 Activity of shallow VT earthquakes (blue circles) and deep low-frequenc y earthquakes (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter distribution (upper left), space-time plot (N-S cross-sec tion) (upper right), E-W cross -section (lower left) and magnitude-time diagram (lower right).

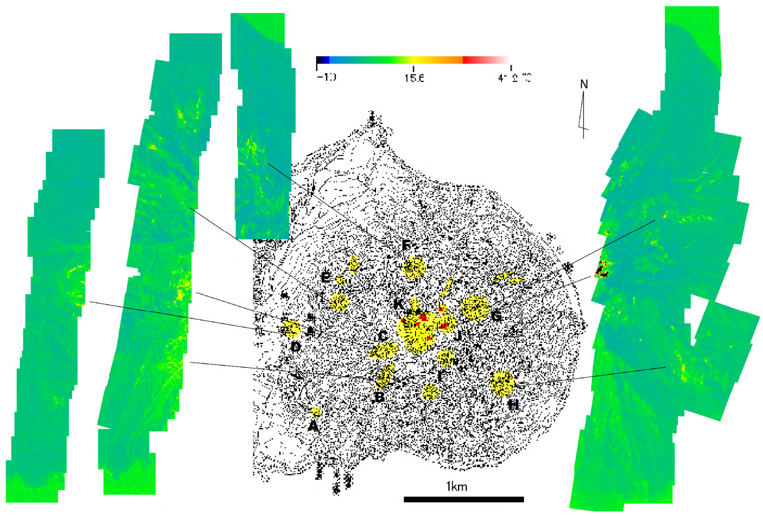


Figure 93-11 Distribution of geothermal anomaly areas in and infrared images of Satsuma-lojima lodake (iguchi and kagiyama, 2002).

Yellow indicates thermal anomalies with surface temperatures of less than 100°C. Red indicates thermal anomalies with temperatures of 100°C or more.

Temperatures were low compared to the summit, but many thermal anomalies were observed on the mountain flanks as well, which correspond to fume areas.

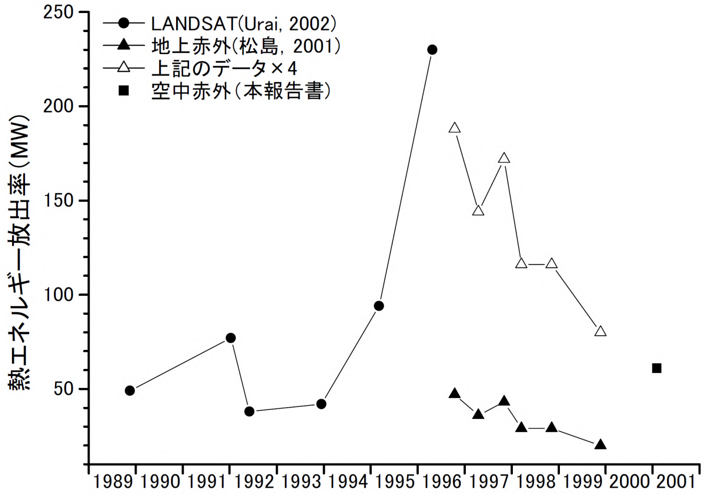


Figure 93-12 Change in rates of release of thermal energy from Iodake summit crater (iguchi and kagiyama, 2002).

The thermal energy release rate peaked in 1996, declining thereafter and returning to pre-1993 thermal levels.

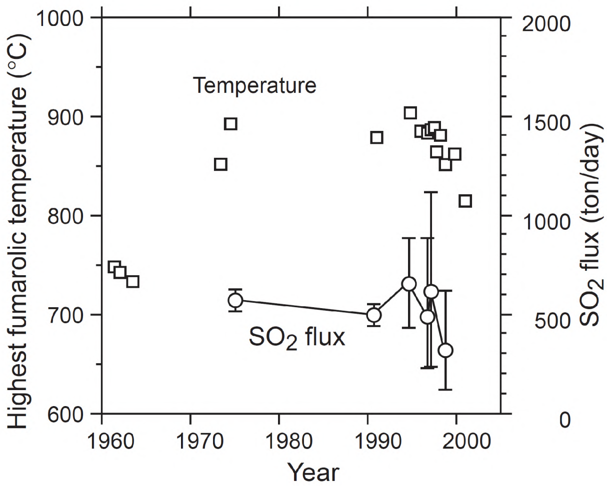


Figure 93-13 Changes in volcanic gas maximum temperatures and sulfur dioxide release volume (shinohara et al., 2002).

As new fumaroles were formed, the amount of sulfur dioxide released slightly increased in the mid-1990s, and appears to have been declining since then.

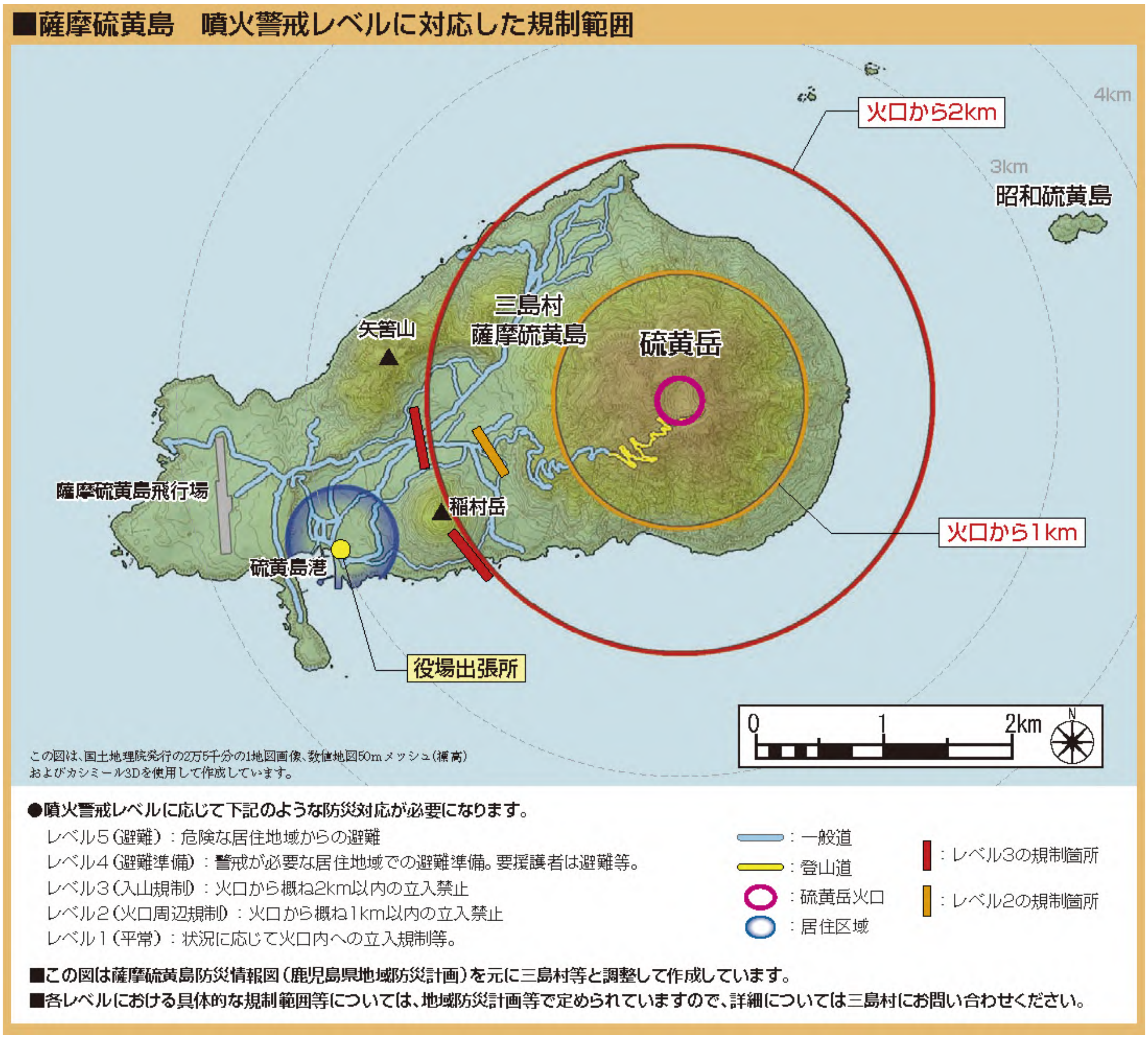
Information on Disaster Prevention

①Hazard Map

- "Satsuma-Iojima Volcano Disaster Danger Area Forecast Map"
- "Satsuma-Iojima Disaster Prevention Information Map"
- Both created by Kagoshima Prefecture in 2010
- Source URL

http://www.pref.kagoshima.jp/aj01/bosai/sonae/keikaku/h23/documents/24696_20120419165518-1.pdf

③Volcanic Alert Levels (Used since December 1, 2007)



Volcanic Alert Levels for the Satsuma-Iojima 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**	●Discharge of pyroclastic flow. Past Examples 500 to 600 years ago: Pyroclastic flow to west from summit crater. (Distance unknown) ●Eruption or imminent eruption, with volcanic blocks and/or lava flow reaching residential areas. Past Examples No examples in historical times.
		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 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.**	●Possibility of volcanic blocks being scattered within approximately 2 km of crater, or scattering caused by growth of small 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.**	●Small eruption, with scattering of volcanic blocks within a distance of approximately 1 km from the crater. Past Examples No observed examples in historical times. ●Possibility of small eruption. Past Examples 1998 to October, 2004: Very small-scale eruption. 1936: Increase in volcanic earthquakes and volcanic plumes. ●Eruption at sea, far away from residential areas. Past Examples 1934: Submarine eruption approximately 2 km to east (forming Showa-Iojima).
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 1990 and 1997.

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) Pyroclastic flows may result in alert levels between 3 and 5, depending on their direction.

Note 3) Submarine eruptions have occurred in the past at Satsuma-Iojima, but because eruption sites cannot be predicted, they are not included herein. In the event of a submarine eruption, the alert level will be decided taking into consideration the distance to the areas to be protected.

Social Circumstances

①Populations

Mishima Village: 377 (Satsuma-Iojima: 121) (Mishima Village Hall: as of November 1, 2011)

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

National Parks, Quasi-National Parks: None designated.

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 (Satsuma-Iojima) published by the Geospatial Information Authority of Japan was used.

Legend

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

(GSI)
- GPS

(DPRI)
- seismometer(SP)
- infrasonic microphone

(Municipalities)
- seismic intensity meter

Figure 93-14 Monitoring network.

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