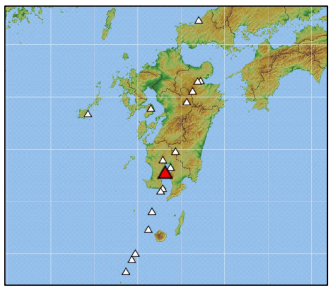
90.Sakurajima

Continuously Monitored by JMA



Latitude: 31°35'33" N, Longitude: 130°39'24" E, Elevation: 1,117 m (Ontake)
(Elevation Point)
Latitude: 31°34'38" N, Longitude: 130°39'32" E, Elevation: 1,060 m
(Minamidake)
(Elevation Point - measured by JMA)

Sakurajima taken by the Japan Meteorological Agency on July 10, 2011

Summary

Sakurajima is an andesite - dacite composite volcano located on the southern rim of the Aira caldera (17 km N-S, 23 km E-W), near the urban zone of Kagoshima City, which has a high population density. It is composed of two main volcanoes - Kitadake and Minamidake - as well as parasitic volcanoes, such as Gongenyama, Nabeyama, and Hikinohira. Central peak, Nakadake is also one of parasitic volcanoes. Historical eruptions occurred on Minamidake summit crater, or on the flanks and under the sea. The Tenpyo-hoji, Bunmei, An'ei, and Taisho eruptions were all flank eruptions which began as plinian eruptions, followed by pyroclastic flows and discharging of a large volume of lava. The Showa eruption also occurred on the eastern upper flank of the summit crater, and issued lava flows. Before the Taisho eruption in 1914, Sakurajima was a volcanic island in Kagoshima Bay, but the eastern lava flow filled the Seto strait and connected the island to the Osumi peninsula. Sakurajima is now an irregular oval-shaped small peninsula, measuring 12.2 km east-west and 9.5 km north-south, with a circumference of 52 km. The Minamidake summit crater has been very active, since October 1955, and volcanic products such as volcanic bomb, blocks and lapilli, ash and gas etc. have caused damage to its surrounding areas, as well as air shocks and lahars. Volcanic activity resumed at the Showa crater, in June 2006, the first time in 58 years. It has been highly active since 2008. It is prohibited to approach closer than 2 km to the Minamidake summit crater or the Showa crater. The SiO_2 content of the rocks is between 56.5 and 67.2 wt % (andesite - dacite).

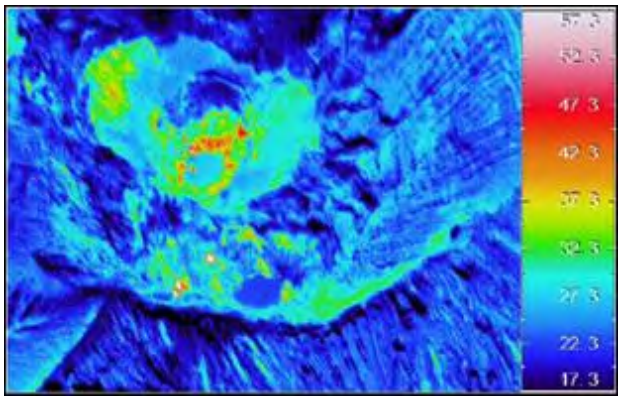
Photos (The Taisho Eruption in 1914)

Volcanic plume after 25 minutes of the onset of the eruption, as seen from Mt. Shiroyama in Kagoshima City - Courtesy of Kagoshima Prefectural Museum

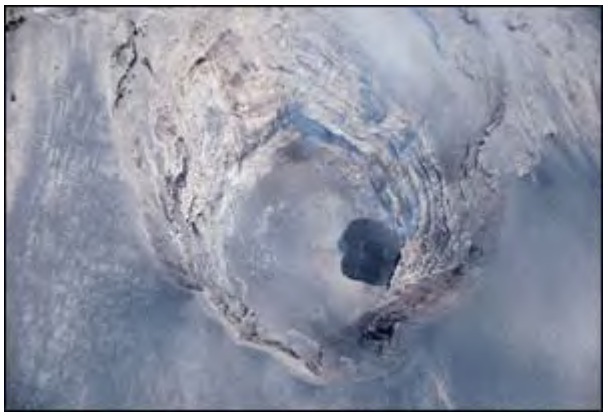
Houses in Kurokami, Sakurajima, thickly covered by pyroclastic-fall deposits
Courtesy by Kagoshima Prefectural Museum

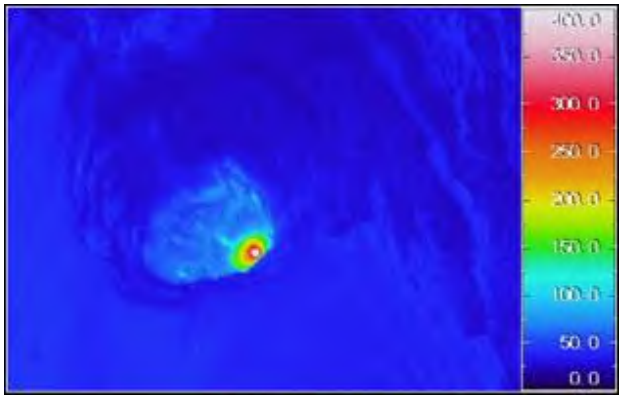
Hakamagoshi Plateau (Elevation:72 m), devastated by pyroclastic flows on the night of January 13.
Courtesy of Kagoshima Prefectural Museum

Photos (Recent Volcanic Activity)



Minamidake summit crater, taken from the northwest on May 31, 2011, by the Japan Meteorological Agency with the cooperation of the Japan Maritime Self-Defense Force.





Lava cake at the bottom of the Showa crater, taken from the northeast on May 31, 2011, by the Japan Meteorological Agency with the assistance of the Japan Maritime Self-Defense Force.

A small lava dome (or lava cake) at the bottom of the summit crater of Minami-dake.on December 22, 1988, taken by the Japan Maritime Self-Defense Force

Explosive eruption from the Minamidake summit crater on October 30, 1987, taken by the Japan Meteorological Agency

Sakurajima, taken from the east on July 28, 2008, by the Japan Meteorological Agency with the assistance of the Kyushu Regional Bureau.

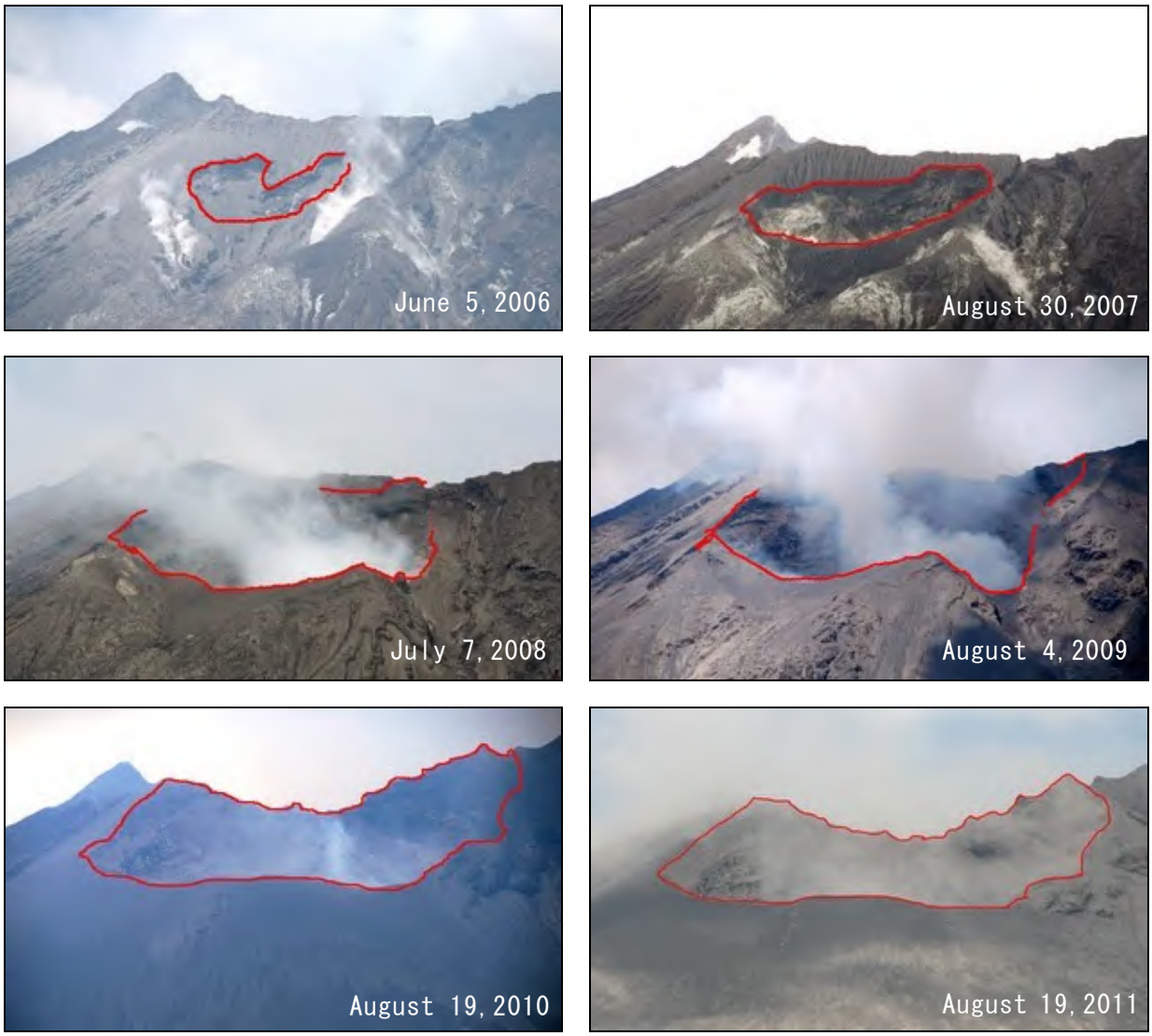
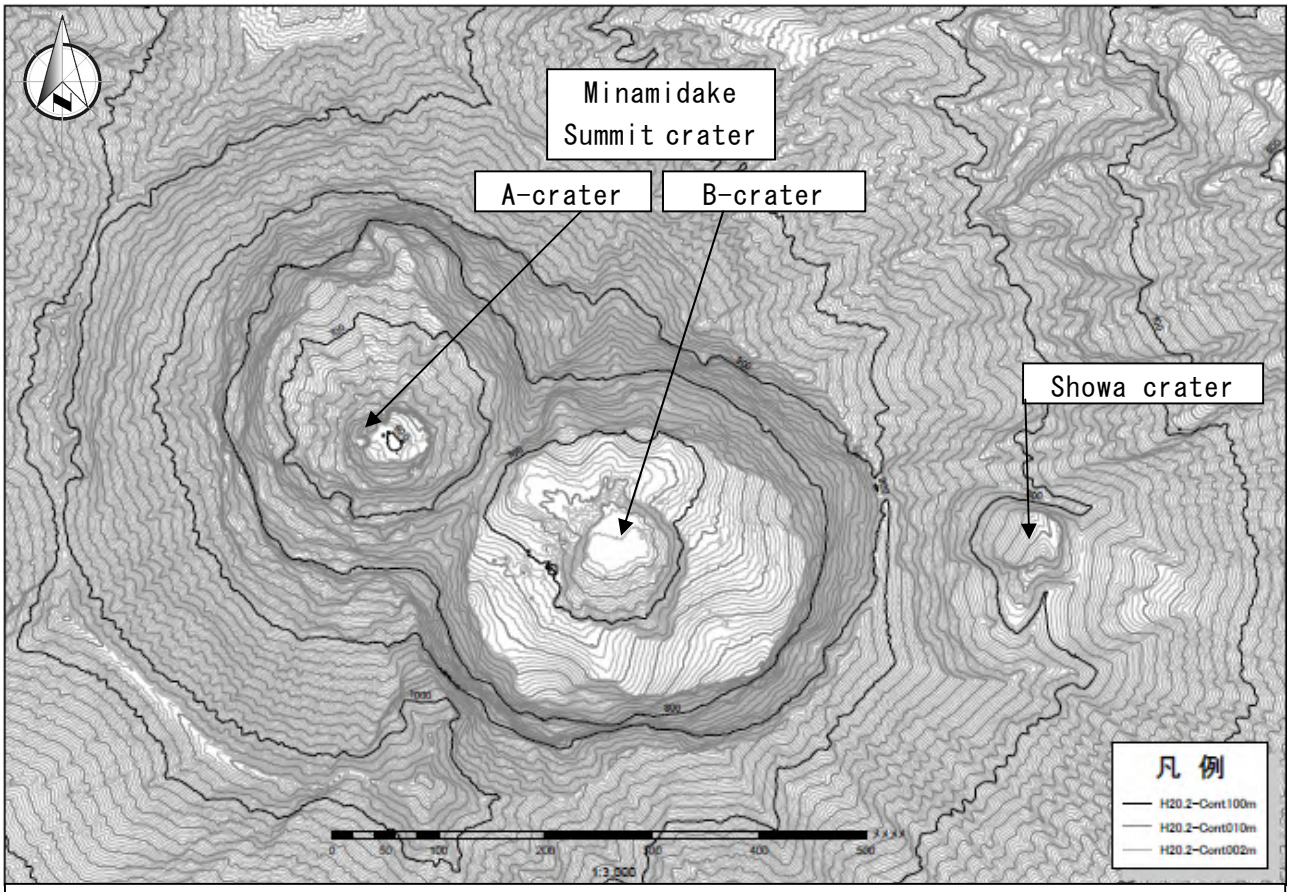


Figure 90-1 Temporal change in the shape of the Showa crater from June, 2006 to August, 2011. Photos were taken from Kurokami riverbed, 3 km east of the crater.

Topography around the Crater



Courtesy of Osumi River National Road, Ministry of Land, Infrastructure, Transport and Tourism, Kyushu Regional Bureau - Based on 2010 Aerial Laser Measurement Data

Figure 90-2 Map of the crater area of Sakurajima volcano.

Red Relief Image Map

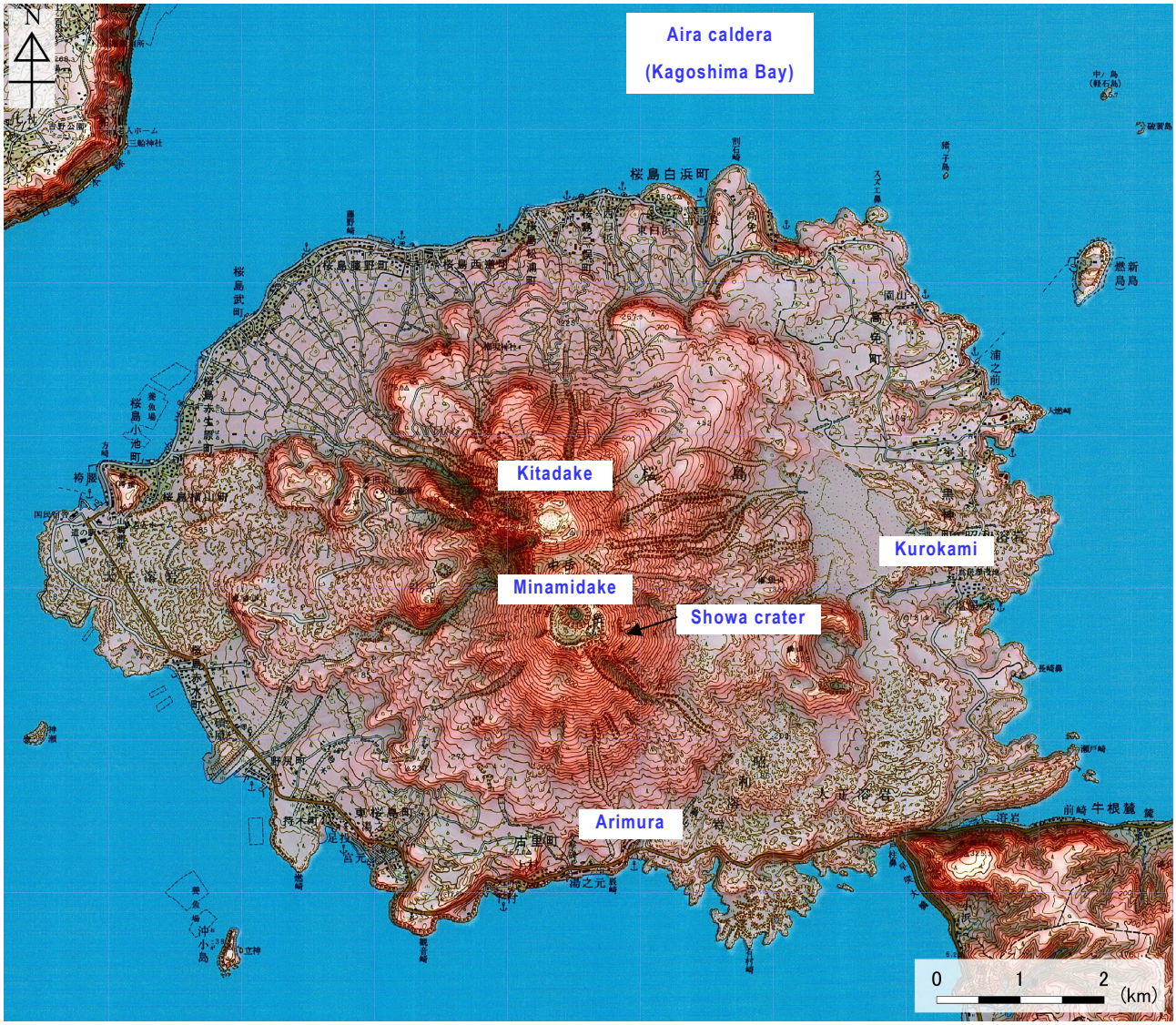


Figure 90-3 Topographical map of Sakurajima volcano.

1:50000 scale topographic map (Kagoshima) and digital map 50 m grid (elevation) published by the Geospatial Information Authority of Japan were used.

Geological Map

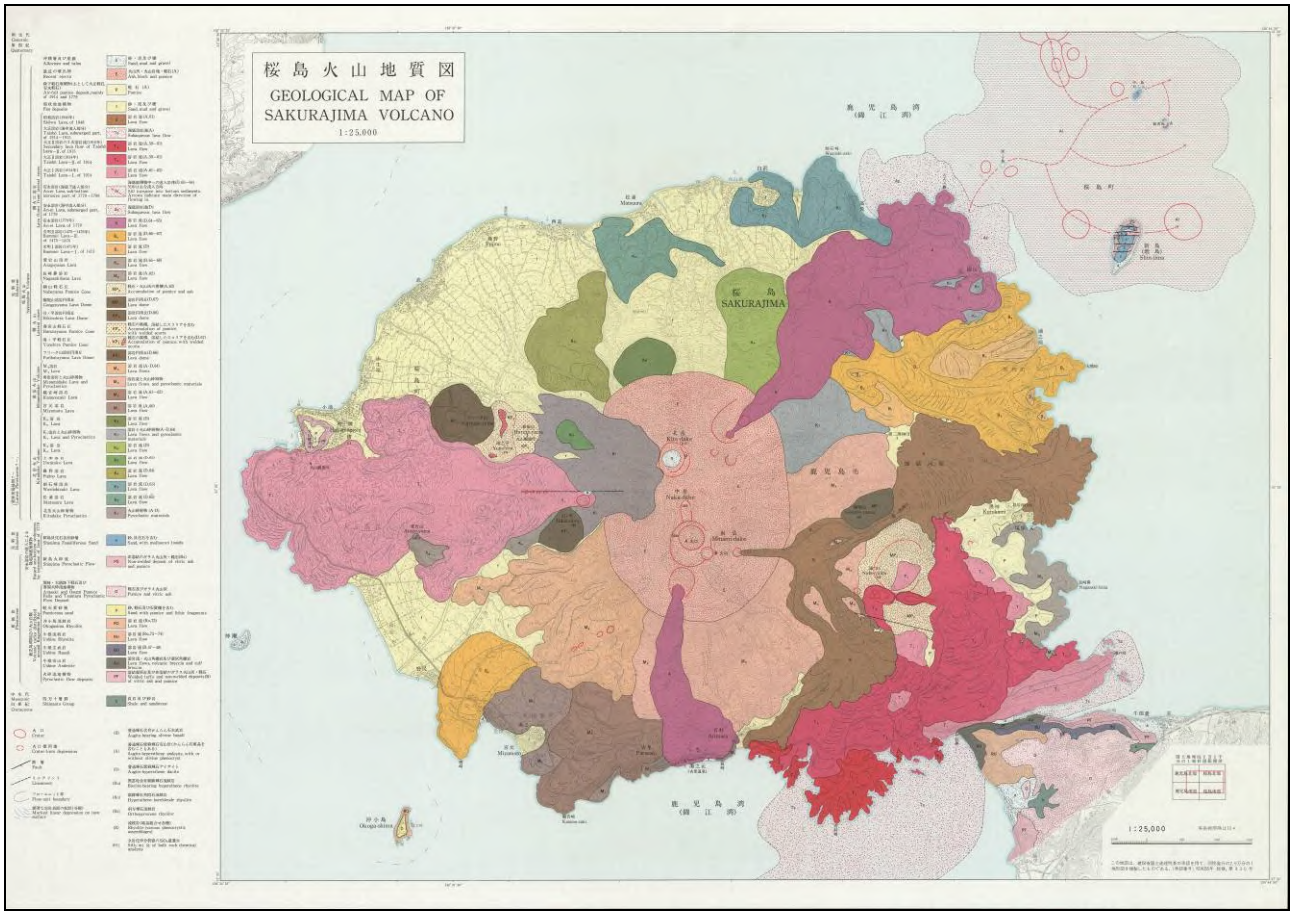


Figure 90-4 Geological map of Sakurajima volcano (Fukuyama and Ono, 1981).

Chronology of Eruptions

▪ Volcanic Activity in the Past 10,000 Years

The eruptive history of Sakurajima volcano is divided into three stages: Old Kitadake, New Kitadake, and Minamidake.stages. Activity of the Old Kitadake (from approximately 26,000 to 24,000 years ago) was followed a long dormant period for about 10,000 years. The New Kitadake stage began at 13,000 years ago, and, at least 10 plinian eruptions occurred until about 5,000 years ago. After that, main vent shifted to south forming the Minamidake, and 4 plinian eruptions occurred only in histrical time (Kobayashi and Tameike, 2002).

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
9ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice)
8ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice), 1 km^3 DRE of magma ejected
8ka	Kitadake	Magmatic eruption	Falling pyroclastic material (pumice)
8ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice)
7ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice)
5ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice)0.7 km^3 DRE of magma ejected
5ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice)
5ka	Kitadake	Magmatic eruption	Pyroclastic fall (pumice), pyroclastic flow
5→2ka	Minamidake	Magmatic eruption	Pyroclastic fall (ash)
4ka	Minamidake	Magmatic eruption	Lava flow
3ka	Minamidake	Magmatic eruption	Lava flow
3→1ka	Minamidake	Magmatic eruption	Lava flow
3→1ka	Minamidake	Magmatic eruption	Lava 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: Indicates a continuous chain of eruption events beginning in year A and ending in year B.

▪ Historical Activity

The following papers were referred for major eruptions in and before the Taisho era, in addition to Kobayashi (1986) and Kobayashi and Tameike (2002). Tenpyo-hoji eruption (Kobayashi, 1982, Miki, 1999; Okuno et al., 1997, 1998), An'ei eruption (Imura, 1998, Kobayashi, 2009), Taisho eruption in 1914 (Central Disaster Management Council, 2011). Other eruption records have been taken from JMA records such as records from the Fukuoka District Meteorological Observatory (1965).

Year	Phenomenon	Activity Sequence, Damages, etc.
708 (Wado 1)	Eruption?	
716 (Reiki 2)	Eruption?	
717 (Yoro 1)	Eruption?	
764 (Tenpyo-hoji 8)	phreatomagmatic eruption→Magmatic eruption	Large scale: Tenpyo-hoji eruption: eruption site located on east side of Minamidake. Nabeyama appeared, and Nagasakibana lava (Seto lava) in front of it. Magma eruption volume = 0.27 km^3 DRE.
766 (Tenpyo-jingo	Eruption	Earthquake swarm

Year	Phenomenon	Activity Sequence, Damages, etc.
Approximately 950	Magmatic eruption	Minamidake crater. Taihei lava flow.
Approximately 1200	Magmatic eruption	Pyroclastic cone, pyroclastic fall. Nakadake.
1468 (Onin 2)	Eruption	
1471 to 76 (Bunmei 3 to 8)	Large scale: Magmatic eruption	Great Bunmei eruption: eruption occurred on northeast side of Kitadake, and southwest side of Minamidake. Lava flow in direction of Kurokami, volcanic blocks, and tephra fall in November 1471 (Bunmei 3), with a large number of fatalities. 1473 (Bunmei 5) eruption: September 1475 (Bunmei 7): ash fall sand, creation of Moezaki in direction of Nojiri. October 1476 (Bunmei 8): Large flow of lava on northeast side of island. Many houses were buried by volcanic blocks and ash fall sand, and many people and animals were killed. Total magma eruption volume = 0.77 km^3 DRE. (VEI 5)
1478 (Bunmei 10)	Eruption?	Tephra fall.
1642 (Kan'ei 19)	Eruption	April.
1678 (Enpo 6)	Eruption	March.
1706 (Hoei 2)	Eruption	
1742 (Kanpou 2)	Eruption	April.
1749 (Kan'ei 2)	Eruption	Tephra fall.
1756 (Horeki 6)	Eruption	
1779 to 82 (An'ei 8 to Tenmei 1)	Large scale: Magmatic eruption	November 8, 1779 (An'ei 8) "Great An'ei Eruption": The eruptive activity occurred at (the summit of Minamidake), the southern flank of Minamidake, and the area from the northeastern flank of Kitadake to the sea floor to the northeast (1780, 1781). Earthquakes occurred frequently for several days before the eruption, and on the morning of the eruption, wells on the coast boiled and overflowed, and the sea water turned purple. A white volcanic plume began rising from the Minamidake summit crater at approximately 11:00. At approximately 14:00 an explosion occurred on the south side of Minamidake, emitting a black volcanic plume. This was followed shortly by eruptions on the northeast side of the volcano. Lava was discharged from early the next morning. At night a submarine eruption began in the sea to the northeast. Submarine eruptions caused tsunamis and damage such as capsizing boats until 1781. An uplift in the submarine eruption area caused the formation of 8 small islands in the sea to the northeast of Sakurajima, which later fused and sank, leaving 5 islands. After the Taisho eruption, one island disappeared, leaving only 4 at present. Over 150 people were killed. Magma eruption volume = 1.86 km^3 DRE. (VEI 5)
1780 (An'ei 9)	Eruption	September and October. Tsunami generated by undersea eruption.
1781 (Tenmei 1)	Eruption	April. Eruption occurred on island off the coast of Komen. It produced a tsunami which killed 8, injured 1, and left 7 people missing. 6 ships were destroyed. In May another undersea eruption occurred off the coast of Komen.
1782 (Tenmei 1)	Eruption	January. Undersea eruption off the coast of Komen.
1783 (Tenmei 3)	Eruption	September. Minamidake summit crater.
1785 (Tenmei 5)	Eruption	November. Tephra fall.
1790 (Kansei 2)	Eruption	July. Rumbling, large volume of tephra fall, crop damage.
1791 (Kansei 3)	Eruption	September. Tephra fall.
1792 (Kansei 4)	Eruption	Tephra fall.
1794 (Kansei 6)	Eruption	Tephra fall.
1797 (Kansei 9)	Eruption	Large volume of tephra fall, crop damage.
1799 (Kansei 11)	Eruption	March. Tephra fall, crop damage.
1860 (Man'en 1)	Eruption	Tephra fall.
1899 (Meiji 32)	Volcanic plume	September. Tephra fall.
1913 (Taisho 2)	Volcanic gas	Volcanic gas killed a mother and her child in Arimura, Higashi Sakurajima.

Year	Phenomenon	Activity Sequence, Damages, etc.
1914 (Taisho 3)	Large scale: Magmatic eruption	January 12 "Great Taisho Eruption": The eruptive activity occurred on the western and eastern flanks of Minamidake. Well water levels dropped in some villages on Sakurajima 1 to 2 months before the eruption. Earthquakes began January 10, with frequent felt-earthquakes on January 11. On January 12, at 08:30, hot water gushingoccurred on the south coast of the island in areas such as Arimura. White volcanic plumes were emitted from the summit and flanks of Minamidake two hours before the eruption began. At roughly 10:00, an eruption began from the west flank (elevation approx. 350 m). Roughly 10 minutes later, an eruption also began on the southeast flank (elevation approx. 400 m). Black volcanic plumes, volcanic lightning, and air shocks were especially frequent between 22:00 and 1:00 of January 13. Lava flow began at 20:00 on January 13. A lava flow to the west reached the sea, swallowing Karasujima. The flow stopped roughly 2 weeks later. A lava flow to the southeast covered Waki, Arimura, and Seto, blocking Seto Pass on January 29. Tephra fall reached as far as Sendai. Magma eruption volume = 1.58 km^3 DRE (VEI 5). Ground deformation accompanied by this eruption was large. At 18:29 on January 12 (approximately 8 hours after the eruption began), a strong earthquake of magnitude 7.1 occurred, causing severe damage, especially in Kagoshima City. It produced a small tsunami. The earthquake and eruption killed 58 and injured 112. The eruption buried or burnt down approximately 2,140 buildings and caused severe crop damage. The earthquake caused the total collapse of approximately 120 buildings.
1935 (Showa 10)	Eruption	September. Large volume of tephra fall, crop damage. Eruption site was the Minamidake summit crater. Eruption cloud was observed also in October.
1938 (Showa 13)	Eruption	March. Eruption cloud, falling ash.
1939 (Showa 14)	Eruption	October and November. Eruptions occurred on middle-slope east-southeast of Minamidake, Showa crater. On October 26 an eruption occurred onmiddle-slope of east-southeast of Minamidake (elevation 750 m). On October 29, small glowing clouds (nuee ardent) were generated. On November 3, ash fell over a wide area outside the island, and activity stopped on November 12.
1940 (Showa 15)	Eruption	Eruption occurred at the Showa crater. Eruption cloud volume increased from April. Small explosions occurred in June, causing crop damage due to tephra fall.
1941 (Showa 16)	Eruption	April to June. Eruptions occurred at the Showa crater east-southeast of Minamidake. Occasional explosions occurred on east-southeast of Minamidake, with falling of volcanic blocks and ash, etc. Explosions and tephra falling occurred in August.
1942 (Showa 17)	Eruption	July. Volcanic blocks, tephra falling, air shocks.
1943 to 45 (Showa 18 to 20)	Eruption	Volcanic plume, rumbling.
1946 (Showa 21)	Medium scale: Magmatic eruption	Showa eruption: January to November. Eruption occurred at the Showa crater, east side of Minamidake. From January, ash occasionally fell as far Kagoshima city. In March, it occurred almost every day. On the night of March 9 lava began flowing from the Showa crater (elevation 800 m). It forked at the foot of the volcano to the northeast and the south. The northeast flow reached the Kurokami coast on April 5, and the southern flow reached the Arimura coast on May 21. The activity caused small mountain forest fires, major crop damage, and 1 death. In June, the eruption weakened, but ash continued to fall occasionally until November. Magma eruption volume = 0.096 km^3 DRE.
1948 (Showa 23)	Eruption	Late July. Eruption occurred at the Showa crater.
1950 (Showa 25)	Eruption	June to September. Eruptions occurred at the Minamidake summit crater. Occasional small explosions and tephra fall.
1954 (Showa 29)	Eruption	December. The eruptive activity occurred at the Minamidake summit crater. From early November the amount of white smoke increased slightly, and a gray-white volcanic plume between 200 and 400 m high was emitted from the crater on December 3, December 7, December 14, and December 15.
1955 (Showa 30)	Vulcanian eruption	October. Eruptions occurred at Minamidake summit. Explosion occurred on October 13 at 14:52 at summit of Minamidake, resulting in 1 death, 7 injuries, and a large amount of tephra fall (total of 500,000 tons of ejecta), causing crop damage. October 15 15:08 explosion also resulted in 2 injuries at Minamidake.

Year	Phenomenon	Activity Sequence, Damages, etc.
1956 (Showa 31)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Year-round repeated explosions at summit of Minamidake. Tephra fall, volcanic lightning, volcanic blocks
1957 (Showa 32)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Occasional explosions at Minamidake. None were large enough to cause damages.
1958 (Showa 33)	Vulcanian eruption	Eruptions occurred at Minamidake summit. They were roughly equivalent in scale to that of previous year.
1959 (Showa 34)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Small mountain forest fire caused in January by Minamidake explosions and volcanic blocks. Mud wall of a Japanese inn partially destroyed on December 21.
1960 (Showa 35)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Record number of explosions at Minamidake. On January 20, volcanic blocks caused damage to roof tiles in Kurokami-cho, and tephra fall caused a power outage.
1961 (Showa 36)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Occasional explosions year-round at Minamidake. Many panes of glass damaged in Higashisakurajima-cho on March 6.
1962 (Showa 37)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Occasional explosions at Minamidake.
1963 (Showa 38)	Vulcanian eruption	Eruptions occurred at Minamidake summit. They were roughly equivalent in scale to that of previous year.
1964 (Showa 39)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Explosions continued to occur on Minamidake, with 8 mountain climbers sustaining light injuries on Nakadake on February 3.
1965 (Showa 40)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Slight decrease in number of explosions at Minamidake.
1966 (Showa 41)	Vulcanian eruption	Eruptions occurred at Minamidake summit. They were roughly equivalent in scale to that of previous year.
1967 (Showa 42)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions increased from January, accompanied by tephra fall, volcanic blocks, rumbling, volcanic lightning, and fires. Lava rises observed at Minamidake summit crater in May, July, October, and November. Window of Kanoya Japan Maritime Self-Defense Force vehicle damaged on November 1.
1968 (Showa 43)	Vulcanian eruption earthquake	Eruptions occurred at Minamidake summit. Slight decrease in number of explosions at Minamidake. On the early morning of May 29, a swarm of felt-earthquakes occurred in the east of Sakurajima (Kyoto University observed 47 felt-earthquakes between 2:00 and 7:30).
1969 (Showa 44)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Explosions at Minamidake stopped since October of previous year, but resumed for first time in 124 days on February 18. Explosions occurred occasionally thereafter. In July a large amount of ash fell, and in August the level of lava in the crater was observed to rise.
1970 (Showa 45)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Small number of explosions at Minamidake. In November, a small mountain forest fire was caused by volcanic blocks.
1970 (Showa 45)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Small number of explosions at Minamidake. In November, a small mountain forest fire was caused by volcanic blocks.

Year	Phenomenon	Activity Sequence, Damages, etc.
1971 (Showa 46)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions at Minamidake decreased, with no explosions from May.
1972 (Showa 47)	Vulcanian eruption	Eruptions occurred at Minamidake summit. On March 2, explosions occur at Minamidake for first time in 308 days. Activity gradually increased, with airplane glass being damaged on July 4, and on September 13 a large amount of volcanic smoke was emitted, and crops were damaged by tephra fall. The explosion on October 2 was accompanied by a large explosion sound and air shocks, and a large volume of red-hot volcanic blocks were scattered as far as the 3rd station, causing many small mountain forest fires.
1973 (Showa 48)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Volcanic scoria injured one person and damaged a car window on June 1, and damaged another car window on November 28. Large amount of tephra fall caused crop damage and vehicular accidents due to car slippage.
1974 (Showa 49)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of eruptions increased during summer. Large volume of tephra fall caused significant crop damage. Secondary disasters such as lahar and flash floods occurred, killing 8 between June 17 and August 9. Volcanic blocks damaged a vinyl greenhouse, windowpanes, and car windows on February 8.
1975 (Showa 50)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions rose particularly from February to April, and in November. Earthquake swarms occurred on March 12 and June 23, with felt-earthquakes of JMA scale seismic intensity 1 to 2 in the area around the crater. Frequent volcanic glowing from August. Strong rumbling in October and November was also observed by the Kagoshima Local Meteorological Observatory. Explosions could be heard in Miyakonojo city in February and December, and in Miyakonojo city and Miyazaki city in March and November. On March 13, tephra fall reached as far as Nichinan city (70 km east-southeast of the crater). On July 5, tephra fall (called "red ash") caused crop damage in Komen-cho and Kurokami-cho. A large volume of tephra fall fell on Kagoshima city in November. Airplane glass cracked on April 8. Lahar caused by heavy rains on April 17 and September 17. In April, the river overflowed in Sakurajima-cho, blocking a prefectural road. In September, the Nojiri and Furusato rivers overflowed, causing damage to bridge blocks and sweeping away cars, blocking a national road.
1976 (Showa 51)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Explosions increased from May, and amount of volcanic ash ejected also increased. Explosion sounds could be heard in Miyakonojo city in September and December. Large volume of tephra fall in Kagoshima city in May and June. On May 13, tephra fall fell as far as Nichinan city and Kushima city, and volcanic blocks in Kurokami-cho and Ushine, Tarumizu city caused damage to 48 car windows and crop damage in the Osumi Peninsula. On May 17, air shocks caused damage to 24 windowpanes in a hotel in Furusato-cho and over 100 windowpanes in an elementary school in Kaigata, Tarumizu city, located to the south and southeast of Sakurajima. Volcanic scoria caused damage to 4 car windows in Arimura-cho. Avalanche at Sakurajima Shirahama Nita riverbed on June 9 and on sides of Harutayama on June 10. Felt-earthquake in Sakurajima-cho and Yoshino-cho, Kagoshima city at 22:25 on August 30 (JMA scale seismic intensity 1). Hypocenter located near Fujino, Sakurajima-cho. Large volume of tephra fall in Sakurajima-cho on September 7 (called "red ash"). Crop damage caused by volcanic gas from September 9 to September 12. Volcanic blocks caused damage to windows of 1 car each in Shiogamoto,Kurokami-cho and Utsu on December 11 and 13, respectively.
1977 (Showa 52)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Large number of explosions from May. Large amount of volcanic ash ejected from May to September. Many strong explosions in November and December. Large volume of tephra fall in Kagoshima city from May to September. Explosions could be heard in Miyazaki city, Miyakonojo city, and Nichinan city in November and December. Air shocks caused damage to 56 windowpanes in an elementary school in Kaigata, Tarumizu city on February 1, and 3 windowpanes in Furusato-cho on December 8. On November 30, volcanic blocks as large as soccer balls ell in Arimura-cho. 3 fires were caused by volcanic blocks in Furusato-cho and Arimura-cho. Air shocks caused damage to a large number of windowpanes (over 100). Volcanic scoria caused damage to the window of one vehicle in Arimura-cho. Damage caused to windows of 2 cars on May 2, and 1 car on May 4. Airplane glass cracked on December 25.

Year	Phenomenon	Activity Sequence, Damages, etc.
1978 (Showa 53)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Strong explosions (especially from January to March) and frequent volcanic ash ejections occurred. Explosions could occasionally be heard as far as Miyazaki city and Miyakonojo city, and, on May 22, at Yakushima and Makurazaki city. Air shocks damaged one windowpane in Ushine, Tarumizu city on January 19, 3 windowpanes in Furusato-cho on January 20, 1 windowpane in Furusato-cho on March 4, 19 windowpanes in Furusato-cho on March 28, and 25 windowpanes at an elementary school in Kaigata, Tarumizu city on May 22. 1 windowpane was damaged at the Higashisakurajima branch on August 10. A large volume of tephra fall fell on Kagoshima city in May, and between July and October. On July 31, a large volume of volcanic scoria (up to 3 cm in diameter) fell in Yoshino-cho, Kagoshima city, and ash fell on Minamata city. In Sakurajima-cho, 3 people were injured, and 77 car windows and 151 house windowpanes were damaged. In Kagoshima city, 7 car windows were damaged. Streetcar traffic was disrupted, and power outages occurred in Yoshino-cho. In July and August, crops were damaged in Sakurajima and Kagoshima city. Damage caused to window of 1 car on March 12 near Arimura-cho. Airplane glass cracked on December 4.
1979 (Showa 54)	Vulcanian eruption	Eruptions occurred at Minamidake summit. No explosions between May and July in Minamidake. Explosions occurred during all other months. The number of explosions was particularly high between October and December. A large volume of ash fell in the Furusato-cho direction on November 12, resulting in crop damage and power outages. A large volume of tephra fell on Kagoshima city between September and November. Between June 29 and July 3, volcanic gas was released in Kurokami-cho, and on June 4, tephra fall (called "red ash") caused crop damage. On January 5, the windows of 5 or more cars in Kaigata, Tarumizu city were damaged. On November 10, 1 car window was damaged. On November 18, several car windows were damaged in Kurokami-cho. On November 18, 2 incidents of airplane glass cracking occurred, as well as one incident each on December 18 and 24.
1980 (Showa 55)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Especially high level of activity in May. Large volume of tephra fall in Kagoshima city in April and May. Tephra fall and volcanic gas in Kurokami-cho on March 21. On May 8, tephra fall caused a streetcar derailment and power outage in Kagoshima city. On May 2, a streetcar was derailed. On May 12, avalanche in Kurokami-cho and Mochiki-cho, and damage to guard rails and blocks at Mochiki River. Damage caused to windows of 5 car on November 8 in Arimura-cho. Air shocks caused damage to windows of 2 cars on November 28 in Furusato-cho.
1981 (Showa 56)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Large volume of volcanic ash from June, and large number of explosions from August. Large volume of tephra fall in Kagoshima city in June, August, and September. A volcanic block made a crater measuring 1.3 m wide and 0.5 m deep in Arimura-cho, at the foot of the mountain, on January 20, and caused small mountain forest fire. Small mountain forest fire on side of mountain near Furusato-cho on November 16. Damage caused to windows of several cars on November 21 in Arimura-cho.
1982 (Showa 57)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions was particularly large in March. Damage caused to 1 car window and 1 house windowpane in Kurokami-cho on June 14. Avalanche on July 24 swept away bridges over Mochiki River. Large volume of tephra fall in Sakurajima-cho and Kagoshima city on August 24. 5.3 kg/m^2 of tephra fall on roof of city hall, and disruptions to traffic. On November 23, cracking caused in airplane glass, and damage caused to window of 1 car near Sakurajima-guchi.

Year	Phenomenon	Activity Sequence, Damages, etc.
1983 (Showa 58)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions was particularly high in February. Windows of 4 or 5 cars damaged on January 26 between Sakurajima-guchi and Arimura. On February 2, a lahar occurred in a river south of Sakurajima, a concrete soil erosion prevention wall in Furusato area collapsed, 500 m of national road 224 were buried, and mudslide entered hotels, stores, and houses. On February 18 volcanic blocks fell on Arimura-cho, and a storage shed was burnt down. Damage caused to windows of 4 cars near Arimura-cho on February 21. On March 2, lahars occurred in east and south of Sakurajima, Kurokami River and Arimura River flooded, and national road was temporarily cut off. On May 22 volcanic lightning in Kurokami-cho caused power outage and television and air conditioner failures. On May 26, windows of 23 or more cars were damaged in Mochiki-cho and Higashisakurajima-cho, 20 cracks were made in a gymnasium roof, and damage was caused to one glass greenhouse roof. On August 2 volcanic block between 50 and 60 cm wide fell on Disaster Prevention Research Institute Kyoto University Mt. Haruta observation office grounds. Damage caused to windows of 16 cars on August 14 in Nojiri-cho. Windowpanes of 2 houses were damaged, 3 Takiron roof solar water heaters mounted on shed roofs were damaged, and windows of 3 cars in Kamoikeshinmachi, Kagoshima city, across the bay, were damaged. On August 16, in Mochiki-cho and Higashisakurajima-cho, 26 car windows were damaged and 4 solar water heaters were damaged. Damage caused to windows of 1 car on August 17 in Arimura-cho. On August 27, 2 solar water heaters were damaged in Nishi Shirahama, Sakurajima-cho. On September 19, tephra fall caused streetcar derailment in Kagoshima city. On September 20, air shocks caused damage to several windowpanes in temple in Kamoikeshinmachi, Kagoshima city (approx. 10 km west of crater), and volcanic scoria caused damage to 1 solar water heater in Shirahama, Sakurajima-cho. On same day, lahar occurred in Nojiri River in Nojiri-cho, temporarily cutting off national road. Damage caused to windows of 2 cars on October 10 in Mochiki-cho and Nojiri-cho. Damage caused to window of 1 car on December 7 in Ushine, Tarumizu city. 9 or more windowpanes damaged in Furusato-cho on December 13.
1984 (Showa 59)	Vulcanian eruption	Eruptions occurred at Minamidake summit. The number of explosions was particularly high in December. Damage caused to the window of 1 car on January 4 in Arimura-cho. On January 10, volcanic scoria caused damage to one sliding glass door at Kurokami Elementary School. On January 11, damage was caused to 1 windowpane in a home in Higashisakurajima-cho, and 2 glass doors in a hotel in Furusato-cho. The February 4 explosion caused 38 volcanic lightning, and a 700 m fire column. Whitish volcanic scoria with a diameter of 6 to 7 mm fell on the Arimura observation station on February 28. Damage caused to window of 1 car on March 8 in Arimura-cho. On April 12, damage was caused to 2 glass doors in a hotel in Furusato-cho, 1 windowpane at Kurokami Elementary School, and 1 windowpane each in the Kagoshima Port waiting area and prefectural police headquarters. On April 19, a lahar occurred at Furusato River, fires started in a hotel and seven houses, and national road 224 was covered by avalanche debris. On April 29, 1 windowpane was damaged in Kamoike-cho, Kagoshima city. On May 4, 1 windowpane was damaged in Yasui-cho, Kagoshima city. On May 8, 1 pane of wire-reinforced glass was cracked in a hospital in Nojiri-cho. On June 3, windowpanes were damaged in Yokoyama, Sakurajima-cho, injuring one. 2 windowpanes were damaged in Fujino Junior High School in Yokoyama, Sakurajima-cho, as well as 1 windowpane in a house in Koike, Sakurajima-cho. On June 8, lahar occurred in and around the Kurokami River. A fire engine was knocked over, the national road was temporarily blocked, and both railings and sewer pipes were damaged. On July 21, volcanic blocks fell on the Arimura area. 37 roof tiles in 11 houses were damaged, with volcanic blocks punching holes in roofs, causing small fires. Road damage occurred in 5 locations, and crop field damage occurred in 3 locations. On August 25, a large avalanche occurred in Nojiri River, temporarily blocking national road, damaging railing and forcing residents to evacuate. Air shocks were felt on December 13 in Nobeoka city, and on December 20 and 27 in Uwajima. Damage caused to several car windows on December 20 between Arimura and Sakurajima-guchi. 11 hotel windowpanes damaged in Furusato-cho on December 31.

Year	Phenomenon	Activity Sequence, Damages, etc.
1985 (Showa 60)	Vulcanian eruption	Eruptions occurred at Minamidake summit. The number of explosions was particularly high in July and December, reaching a total of 474 explosions over the course of the year. Air shocks could be felt in Miyazaki city, Miyakonojo city, Nichinan city, Nobeoka city, Hita city, Iizuka city, and Uwajima city. Damage caused to 1 windowpane on January 29 in Arimura-cho. On February 24, damage caused to 28 car windows near Arimura, one windowpane on a telephone box in Sakurajima-guchi, and damage to 53 houses in Ushinefumoto, Tarumizu city, such as roof tile and solar water heater damage. Damage caused to windows of 3 cars on March 31 near Arimura-cho. Small scale of Nuée ardente appeared on April 9. On April 13, near Arimura, damage to windows of 5 cars, and an accident caused by car slippage. On June 8, volcanic blocks measuring 50 to 70 cm in diameter fell on the Yuno, Higashisakurajima-cho climbing trail, caving in asphalt pavement. On June 13, 26 solar water heaters and 13 car windows were damaged in Sakurajima-cho Akamizu and Nojiri-cho. 11 streetcar crossing gates damaged by tephra fall. On June 22, windowpanes damaged in Furusato-cho, and one car window damaged in Komen. On June 30, volcanic block fell in field in Nojiri-cho, with diameter of 3.7 m at its widest point, creating a 1 m deep hole, damaging the roofs of 2 nearby stables. 25 cm diameter volcanic blocks fell on a climbing trail in Mochiki, causing damage to asphalt paving. 11 car windows damaged in Higashisakurajima. On July 2, lahars occurred in Nojiri River and Kurokami River, temporarily blocking national road, and forcing residents to evacuate. On July 6, a volcanic block fell on a shed in Arimura-cho (approx. 3 km away from the crater), making 2 m wide hole, and breaking through floor of first floor, starting a small fire. On July 10 a volcanic block fell behind a home in Arimura-cho (approx. 3 km from the crater), with fragments damaging 16 roof tiles, as well as damaging window shutters and cutting a power line. On July 21 tephra fall caused a JR crossing gate in Kagoshima city to malfunction, resulting in an accident. It also caused damage to 5 windowpanes in Kagoshima's Korai-cho, and 1 windowpane in Kagoshima's Kamifukumoto-cho. Damage caused to window of 1 car on September 12 in Kurokami-cho. Clouds identified as possible Nuée ardente were seen on November 25. 8 entryway windows and 180 windowpanes damaged in 22 locations inside Kagoshima city and 3 locations in Sakurajima were damaged on December 3. Damage caused to window of 1 car on December 5 near Arimura. Damage caused to window of 1 car on December 16 near Arimura. In the early morning of December 19, 85 windowpanes were damaged in 57 houses in Futagawa and Ushinefumoto in Tarumizu city, and 1 car window was damaged in Kurokami-cho. In the evening, a volcanic block fell in the tea garden of a housing site in Arimura-cho, making a hole measuring 1 m in diameter.

Year	Phenomenon	Activity Sequence, Damages, etc.
1986 (Showa 61)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Slight decrease in explosions in July and December. Air shocks could be felt in Miyazaki city, Miyakonojo city, Nichinan city, Hita city, Nobeoka city, and Yakushima. Damage caused to the windows of 6 cars on January 1 near Arimura. On February 6, in Tarumizu city 82 windowpanes were damaged, a television fell and was damaged, and a clock mounted on a beam fell and was damaged. In Furusato-cho, 4 windowpanes were damaged. In Kurokami-cho, 1 windowpane was damaged, and in Yojiro Beach, Kagoshima city, 1 windowpane was damaged. On April 16, in Higashisakurajima-cho 1 windowpane was damaged, in Arimura-cho 1 windowpane was damaged, and in Furusato-cho 1 windowpane was damaged. Several windowpanes in houses were damaged, and a falling volcanic block severed the avalanche warning device cable. Damage caused to 1 car window in Kurokami-cho and 7 car windows in Ushinefumoto, Tarumizu city on April 23. Damage caused to windows of 3 cars on June 10 from Mochiki-cho to Nojiri-cho. 1 car window damaged in Higashisakurajima Koike on June 12. On June 24, in Komen, damage occurred to 1 solar water heater, the slate roofs of 10 offices and warehouses, 60 slate roofing panels in 16 cow pens, 3 roofs of residences, and the glass of an airplane flying over Kokubu city. Damage caused to windows of 3 cars on October 30 in Arimura, and 3 in other areas. Damage caused to windows of 3 cars on November 21 in Sakurajima-guchi. On November 23, multiple volcanic blocks fell on Furusato-cho. One crashed through the roof and steel reinforced concrete floor of a 1 story hotel, punching a hole measuring approximately 3 m across. 6 people (staff and guests) were injured. Volcanic blocks falling near a cow pen 700 m to the northwest of the hotel caused a feed drying room to completely burn down. Damage caused to window of 1 car on December 19 in Ushinefumoto, Tarumizu city. Volcanic blocks with diameters of 4 cm to 4 cm fell from Kurokami-cho to Sakurajima-guchi on December 30, causing damage to windows of 6 cars in Kurokami-cho, and 8 cars in area between Ushinefumoto and Futagawa, Tarumizu city.
1987 (Showa 62)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions decreased from February to August (for first time in 8 years). On July 17, lahar occurred at Mochiki River, damaging river embankment and forcing residents to evacuate. On September 24, damages were caused to windows of 6 cars, 14 solar water heaters, and 1 car in Sakurajimatake. Damage caused to 1 Takiron roof, 1 windowpane, and, in Aira-cho, 1 car window. Large explosions continued for two hours on the night of November 17. A 1000 m high fire column was observed, and multiple pyroclastic flows occurred. There were also a large amount of volcanic lightning. The ejecta consisted mainly of pumice, but also contained a large amount (less than 5 %) of foreign material vesiculated into pumice form. The eruption emitted a total of approximately 400,000 tons of discharge material. A volcanic block fell in a car junkyard in Yuno, Higashisakurajima-cho, causing a fire burning 10 junked cars. In Tarumizu city and Kihoku-cho, 10 car windows and 23 solar water heaters were damaged. In Oosumi-cho, Soo District, a car accident occurred as a result of loss of wheel traction. On November 28, 8 windowpanes were damaged in 5 locations in Tarumizu city, and 1 windowpane was damaged in a hotel in Furusato-cho.
1988 (Showa 63)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Slight decrease in number of explosions in the latter half of the year. Air shocks could be felt in Miyazaki city, Miyakonojo city, Nichinan city, and Uwajima city. Damage caused to 34 windowpanes in 3 hotels in Furusato-cho, and 1 windowpane in a home, on January 30. Damage caused to windows of 2 cars and 4 windowpanes on February 3 in Sakurajima-guchi. Damage caused to window of 1 car on February 9 near Shindai Bay. Damage caused to window of 1 car on February 10 in Arimura-cho. On March 27, damage caused to 2 car windows in Kurokami-cho, and 2 windowpanes in a hotel in Furusato-cho. From June 15 to June 16, a large amount of volcanic smoke was emitted, including three explosions, with 2.67 kg/m^2 per day of tephra falling at the Kagoshima Local Meteorological Observatory. On June 20, a Kagoshima city streetcar was derailed. 3 lahar occurred in Nojiri River on August 22 and 23, temporarily blocking national road, and forcing residents to evacuate.

Year	Phenomenon	Activity Sequence, Damages, etc.
1989 (Heisei 1)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Number of explosions per month fell to 1 to 3 from January to September. Damage caused to the windows of 8 cars on January 28 near Furusato-cho.
1990 (Heisei 2)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Explosion damages included 21 panes of glass in buildings on May 1, 2 car windows on August 28, 13 or more car windows and 4 building windows on November 30 at 8:30, 5 building windows, 15 Takiron roofs, and 7 car windows on November 30 at 15:04, and 1 car window on December 25.
1991 (Heisei 3)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Explosion damages included 1 windowpane on May 10, 6 roofs and 2 car windows on June 29, an airplane window on August 5, 1 car window on August 20, one car window on November 18, and 1 building glass door on December 5. A total of 295 explosions occurred throughout the year.
1992 (Heisei 4)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Damage caused by the explosion included damage to 1 car window on January 2, 7 on February 1, and 2 on February 2. 165 explosions over the course of the year.
1993 (Heisei 5)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Explosion damages included 1 car window on April 7. 91 explosions over the course of the year.
1994 (Heisei 6)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Damage caused to windshields of 2 cars on February 2. 148 explosions over the course of the year.
1995 (Heisei 7)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Eruption activity level was particularly high from August 23 to August 25, traffic disruptions, and tephra fall as far as northern Kyushu. 226 explosions over the course of the year.
1996 (Heisei 8)	Vulcanian eruption	Eruptions occurred at Minamidake summit. High level of volcanic activity continued from January to March, with 69 explosions in March (5th highest number ever). Low level of activity from April, with zero eruptions in August. Total of 20 earthquakes and tremors in October, the lowest number since observation started in January of 1965 (Showa 40). 171 explosions over the course of the year. No damage was caused this year by volcanic activity.
1997 (Heisei 9)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Volcanic activity remained calm throughout the year. In March, the number of earthquakes increased slightly. An explosion on May 11 sent volcanic blocks as far as the 4th station. Number of explosions over the course of the year was a low 35, the fifth smallest number since Sakurajima began eruptive activity in 1955 (Showa 30). No damage was caused this year by volcanic activity.
1998 (Heisei 10)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Over the course of the year, volcanic activity was slightly higher, with volcanic earthquake swarms on May 19, and eruptive activity over the two weeks that followed. Swarms of earthquakes began after 17:00 on the 19th and continued until approximately 0:00 on the 20th, lasting 7 hours. Total of 334 earthquakes, with a maximum earthquake amplitude of 6μm at Point A. Before these earthquake swarms, A-type earthquakes with their hypocenters directly below the Minamidake summit crater occurred on May 4 and 9. After the earthquake swarms, Minamidake eruptive activity increased, with 5 explosions on the 20th, and 6 explosions on the 21st. Eruptions and explosions occurred repeatedly over a two week period. 103 explosions over the course of the year. No damage was caused this year by volcanic activity.

Year	Phenomenon	Activity Sequence, Damages, etc.
1999 (Heisei 11)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Volcanic activity remained calm overall through the first half of the year, but increased from July. On March 10 an earthquake swarm occurred, with a high level of eruptive activity for the following week, but eruptive activity stayed relatively low from then to mid-July. During the May to July period the number of A-type earthquakes increased to 10 to 20 per month, and eruptive activity was high from late July. An earthquake swarm continued from the night of October 30 to the morning of October 31, and activity levels remained high thereafter. On December 10 at 5:00 an explosion produced a fire column 1000 m high, scattering a large number of volcanic blocks as far as the 4th station. Volcanic scoria with diameters as large as 4 to 5 cm fell along the prefectural road in Kurokami-cho. Fortunately, the explosion happened in the early morning, and the streets were free of cars or pedestrians, so no damage was reported as a result of the volcanic scoria. In December 88 explosions occurred, the second highest number recorded, with activity remaining high until the middle of February of the following year. 237 explosions over the course of the year. No damage was caused this year by volcanic activity.
2000 (Heisei 12)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Eruptive activity, which began during the previous year, remained high until mid-February. From March relatively little activity occurred, but on October 7 at 16:42 an explosion produced a volcanic plume which rose up to 5,000 m above the crater rim, and volcanic scoria up to 3 or 4 cm in diameter damaged over 35 car windows and tore the film of a greenhouse near Hakamagoshi, Sakurajima-cho. Strong eastern winds scattered a large volume of ash from central to northern Kagoshima city, and volcanic scoria 2 to 3 mm in diameter near Kita-Futo. Eruptive activity levels rose relatively for a period between mid-October and early November. 169 explosions over the course of the year.
2001 (Heisei 13)	Vulcanian eruption	Eruptions occurred at Minamidake summit. Volcanic activity remained relatively high throughout the course of the year, with an increase in August, during which 44 explosions occurred. 110 explosions over the course of the year. No damage was caused this year by eruptive activity.
2002 (Heisei 14)	Vulcanian eruption	Eruptions occurred at Minamidake summit. The volcano was relatively quiet. 59 explosions occurred over the course of the year, the second lowest number in ten years. However, eruptive activity was moderately high in early April and mid-November. Few volcanic earthquakes or volcanic tremors occurred. No damage was caused this year by eruptive activity.
2003 (Heisei 15)	Vulcanian eruption	Eruptions occurred at Minamidake summit. The volcano was relatively quiet. 17 explosions occurred over the course of the year. This was the third lowest since summit eruptions began in 1955 (Showa), following 1955 (6 eruptions) and 1971 (Showa 46) (10 eruptions). The number of A-type earthquakes increased in mid- and late November, and on December 31. Overall, few volcanic earthquakes or volcanic tremors occurred. No damage was caused this year by eruptive activity.
2004 (Heisei 16)	Vulcanian eruption	Eruptions occurred at Minamidake summit. The volcano was relatively quiet. 11 explosions occurred over the course of the year. No damage was caused by eruptive activity.
2005 (Heisei 17)	Vulcanian eruption	Eruptions occurred at Minamidake summit. The volcano was relatively quiet. 12 explosions occurred over the course of the year. No damage was caused by eruptive activity.
2006 (Heisei 18)	Vulcanian eruption	Eruptions occurred at the Showa crater on the summit of Minamidake. The volcano was relatively quiet. A new eruption began on the east flank of Minamidake on June 4 (The Showa crater), continuing until June 20. 15 explosions occurred over the course of the year (all at the Minamidake summit crater). No damage was caused by eruptive activity.
2007 (Heisei 19)	Vulcanian eruption	Eruptions occurred at the Showa crater on the summit of Minamidake. The volcano was relatively quiet. From May to June eruptive activity resumed at the Showa crater. 10 explosions occurred over the course of the year (all at the Minamidake summit crater). No damage was caused by eruptive activity.

Year	Phenomenon	Activity Sequence, Damages, etc.
2008 (Heisei 20)	Vulcanian eruption	Eruptions occurred at the Showa crater on the summit of Minamidake. The Showa crater was active. On February 3 an explosive eruption occurred at the Showa crater. On February 6 another explosive eruption occurred, accompanied by pyroclastic flow which extended 1.5 km east of the Showa crater. From April to September, eruptions and explosions occurred repeatedly at the Showa crater. The eruption on July 28 resulted in tephra fall in the Ashikita area of Kumamoto Prefecture. 4 explosions occurred over the course of the year at the Minamidake summit crater, and 35 at the Showa crater.
2009 (Heisei 21)	Vulcanian eruption	Eruptions occurred at the Showa crater on the summit of Minamidake. Eruptive activity was high from February 1 to 2 at the Showa crater, continuing on until February 5. Eruptive activity was also high at the Showa crater from March 1 to 2, and on March 10 at 5:22 an explosive eruption occurred, sending large volcanic blocks as far as the 2nd station (2 km from the Showa crater). On April 9 at 15:31 an explosive eruption occurred at the Showa crater producing a volcanic plume that reached more than 4,000 m above the crater rim, as well as a pyroclastic flow. In late June, eruptive activity resumed at the Showa crater. On October 3 at 16:45, an explosive eruption occurred at the Minamidake summit crater. A volcanic plume extended 3,000 m above the edge of the crater, and large volcanic blocks reached as far as the 4th station. From October the number of explosive eruptions at the Showa crater increased further. 3 explosions occurred over the course of the year at the Minamidake summit crater, and 545 at the Showa crater.
2010 (Heisei 22)	Vulcanian eruption	Eruption occurred at the Showa crater. Eruptive activity levels remained high at the Showa crater. 896 explosions occurred over the course of the year (all at the Showa crater). The number of A-type earthquakes increased in July.
2011 (Heisei 23)	Vulcanian eruption	Eruptions occurred at the Minamidake summit crater and the Showa crater. Eruptive activity levels remained high at the Showa crater. On February 7, 2 explosive eruptions occurred at the Minamidake summit crater. 2 explosions occurred over the course of the year at the Minamidake summit crater, and 994 at the Showa crater.
2012 (Heisei 24)	Vulcanian eruption	Eruptions occurred at the Minamidake summit crater and the Showa crater. Eruptive activity levels remained high at the Showa crater. On July 24 at 19:15 an explosive eruption occurred at the Minamidake summit crater. 1 explosion occurred between January and June at the Minamidake summit crater, and 599 at the Showa crater.

* 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

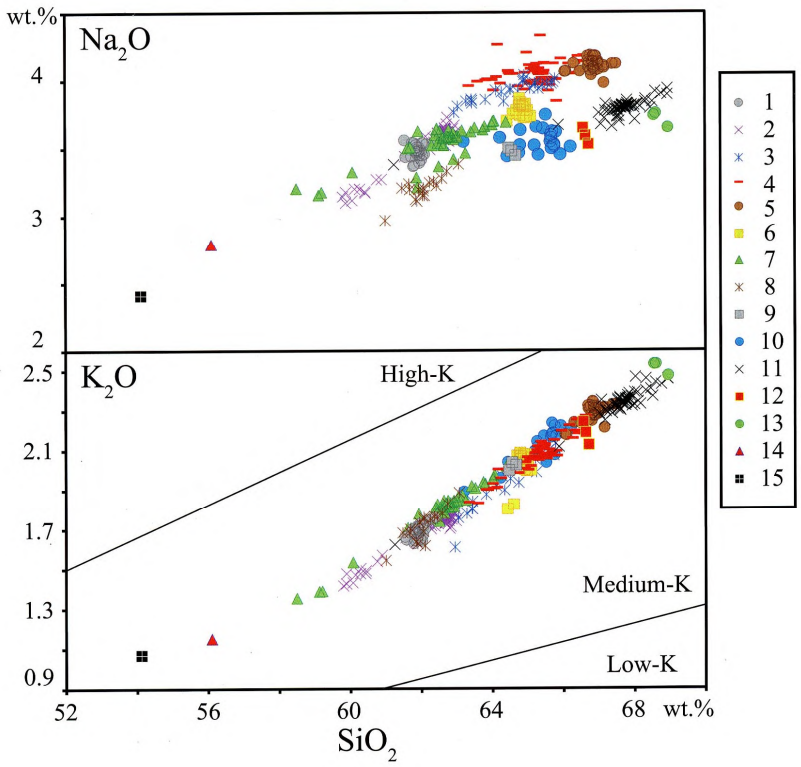


Figure 90-5 Whole rock chemical composition (Takahashi, et al, 2011).

1: Showa lava, 2: Taisho lava, 3: An'ei lava (undersea), 4: An'ei lava (on land), 5: Bunmei lava,

6: New stage Minamidake lava, 7: Tenpyo-hoji (Nagasakibana) lava, 8 and on are ejecta from early stage Minamidake lava and before

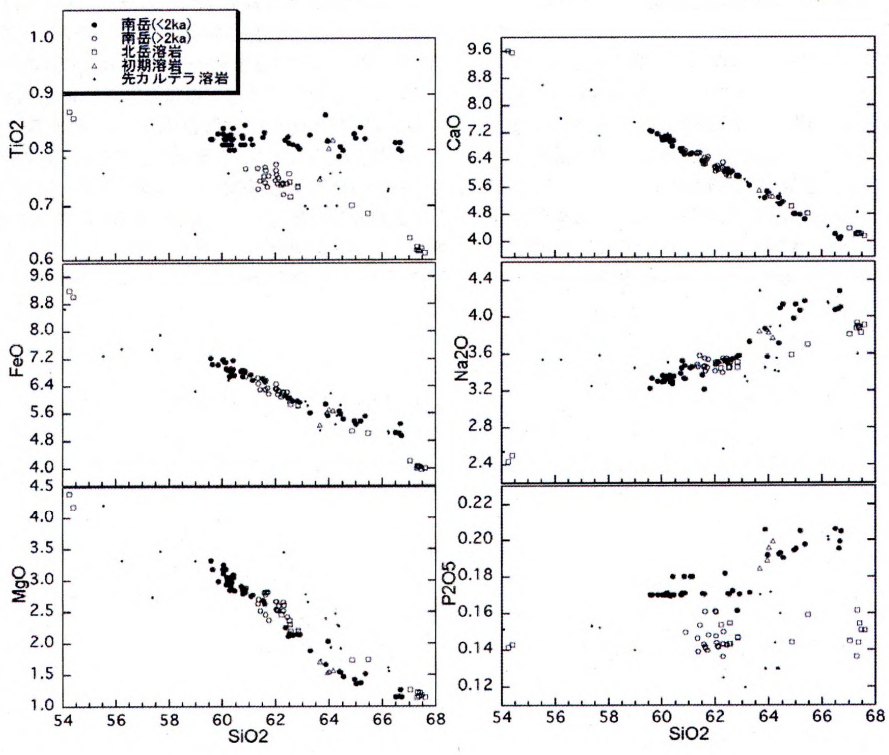


Figure 90-6 Whole rock chemical composition (Uto, et al, 2005).

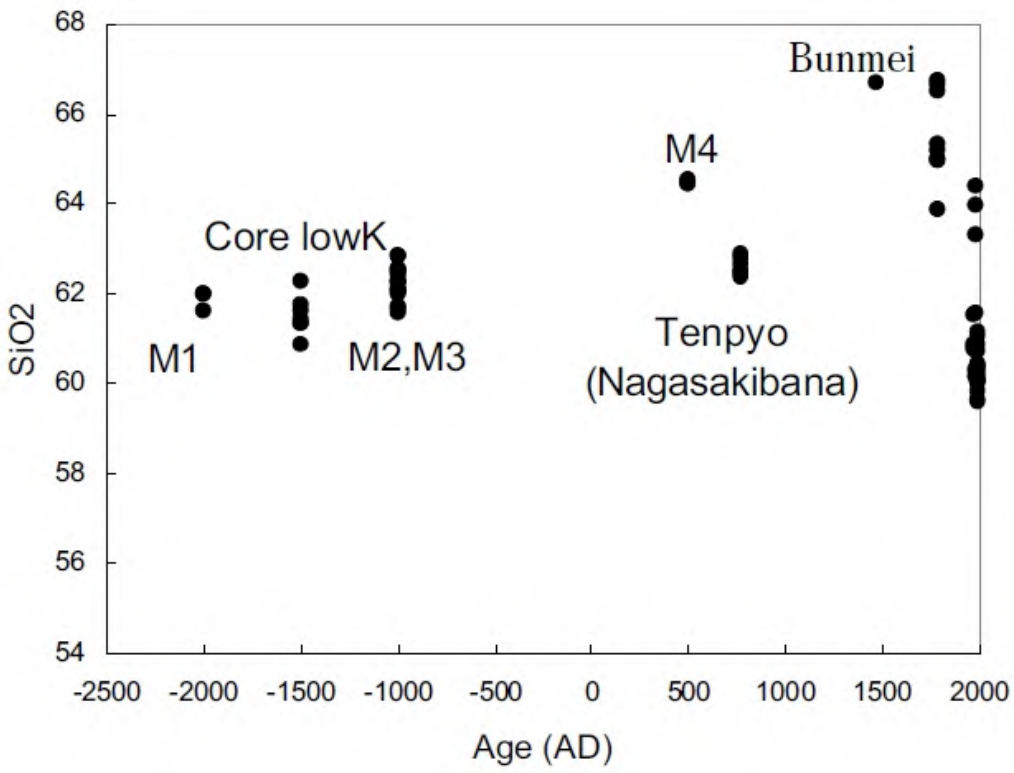


Figure 90-7 Temporal whole rock chemical composition (Uto, et al, 2005).

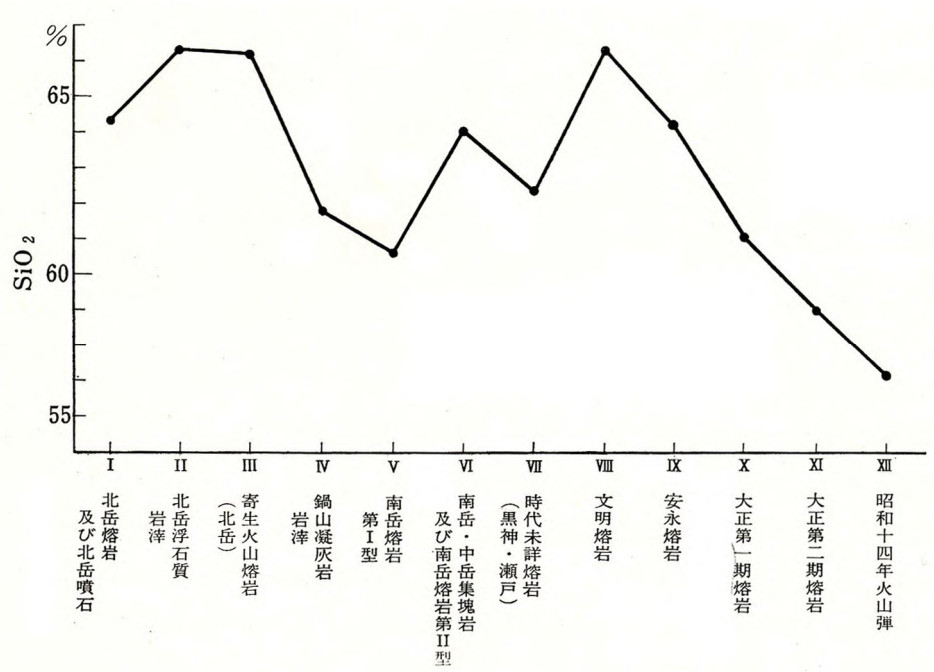


Figure 90-8 Whole rock chemical composition over time (Yamaguchi, et al, 1975).

SiO_2 chemical composition during the historical period is known to have decreased gradually from the Bunmei eruption to the 1939 eruption.

Precursory Phenomena

The large scale eruptions, such as the Taisho eruption of 1914 were preceded by an increase in felt-earthquakes, as well as changes in well water levels and water temperatures, anywhere from several days before the eruption to the day before the eruption. No prominent signs were observed immediately before the Showa eruption (1946), but eruptive activity ws high for several years leading up to the eruption.

Eruptive activity at the summit of Minamidake has frequently been preceded by A-type earthquakes, a large number of BH-type earthquakes, swarms of BL-type earthquakes, and C-type earthquakes. Before the increase in eruptive activity at the Showa crater in 2006, discharges and geothermal anomalies occurred at the Showa crater. Before each eruption, dilation of the ground was also observed.

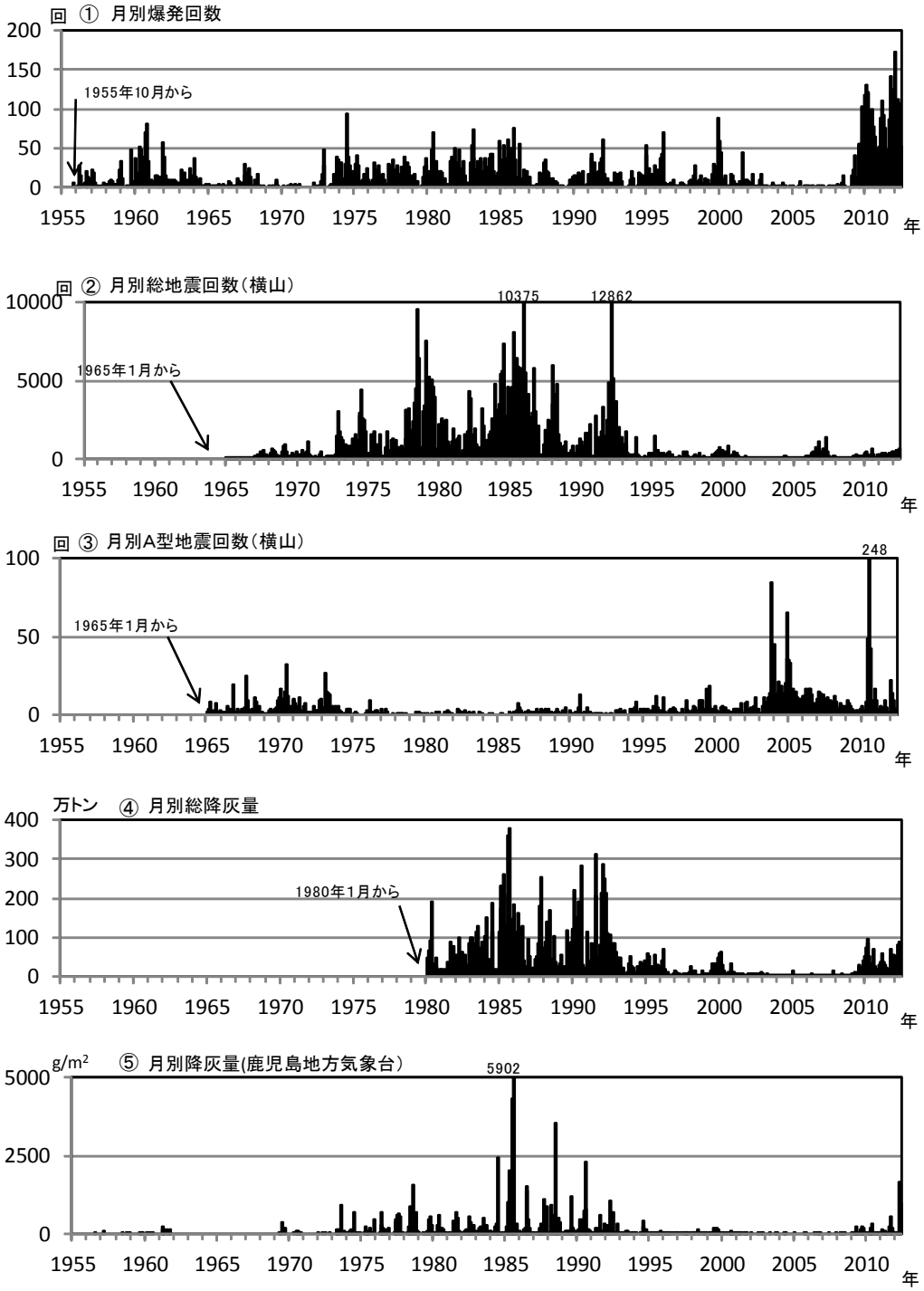
A deeper magma reservoir is considered to exist in the north of Sakurajima, at a depth of 10km below the center of Aira caldera, and a shallow magma reservoir about 4km beneath the Sakurajima volcano. The rate of magma supply to the deeper magma reservoir is estimated to be 10^7 cubic meters per year. The amount of magma stored after the 1914 eruption is estimated to be 1 billion cubic meters or more, with additional magma being stored even now.

Recent Volcanic Activity

- Seismicity is low.
- Since 2002, eruptive activity has decreased at the Minamidake summit crater, with the number of explosions occurring each year declining to below 20 since 2003. Ever since volcanic activity at the Showa crater increased the number of explosive eruptions at the summit crater has dropped dramatically, but 4 occurred in 2008, 3 in 2009, 0 in 2010, and 2 in 2011, so eruptive activity is still ongoing.
- On June 4, 2006, the Showa crater resumed its eruption activity for the first time in 58 years. The number of eruptions has increased rapidly since 2009, with 896 in 2010 and 994 in 2011, indicating a sustained high level of eruptive activity.

Table 90-1 Number of Explosions at Sakurajima, According to Japan Meteorological Agency (1955 to June, 2012)

Year	Month	Crater	1	2	3	4	5	6	7	8	9	10	11	12	total
1955	Showa 30	Minami-dake crator										6	0	0	6
1956	31	Minami-dake crator	3	2	28	15	4	0	5	4	20	13	11	10	115
1957	32	Minami-dake crator	23	19	5	0	0	1	0	3	0	0	6	0	57
1958	33	Minami-dake crator	4	4	7	9	0	8	2	4	4	9	9	23	83
1959	34	Minami-dake crator	33	11	0	0	0	1	3	0	48	4	8	1	109
1960	35	Minami-dake crator	36	11	19	52	48	39	22	0	69	80	34	4	414
1961	36	Minami-dake crator	6	10	8	8	15	15	4	10	13	12	57	38	196
1962	37	Minami-dake crator	15	0	10	10	6	9	7	9	9	7	1	6	89
1963	38	Minami-dake crator	0	22	5	7	18	8	10	5	24	14	14	9	136
1964	39	Minami-dake crator	37	13	2	1	9	12	2	2	2	1	4	3	88
1965	40	Minami-dake crator	4	0	2	3	2	1	3	3	4	3	2	2	29
1966	41	Minami-dake crator	4	1	0	3	4	7	5	3	2	2	1	12	44
1967	42	Minami-dake crator	4	7	2	6	5	29	15	19	3	24	13	0	127
1968	43	Minami-dake crator	0	3	10	2	16	3	1	0	0	2	0	0	37
1969	44	Minami-dake crator	0	1	2	0	2	1	0	6	9	1	0	0	22
1970	45	Minami-dake crator	0	2	0	0	0	1	1	4	3	1	3	4	19
1971	46	Minami-dake crator	2	3	1	4	0	0	0	0	0	0	0	0	10
1972	47	Minami-dake crator	0	0	5	1	0	0	2	1	8	16	47	28	108
1973	48	Minami-dake crator	0	0	0	1	2	4	2	17	14	38	35	31	144
1974	49	Minami-dake crator	30	32	12	1	30	93	49	38	28	15	21	13	362
1975	50	Minami-dake crator	11	29	41	27	8	7	3	9	16	15	24	9	199
1976	51	Minami-dake crator	5	4	6	9	31	23	6	19	27	14	15	17	176
1977	52	Minami-dake crator	10	2	4	3	29	22	28	35	23	19	21	27	223
1978	53	Minami-dake crator	17	7	25	14	20	39	25	32	25	15	1	11	231
1979	54	Minami-dake crator	15	16	7	7	0	0	0	1	13	26	28	36	149
1980	55	Minami-dake crator	12	20	10	48	69	12	16	34	21	4	21	10	277
1981	56	Minami-dake crator	18	5	11	2	4	3	1	34	38	35	50	32	233
1982	57	Minami-dake crator	27	15	47	15	24	34	13	14	2	6	4	32	233
1983	58	Minami-dake crator	53	73	36	22	22	33	31	33	36	21	16	37	413
1984	59	Minami-dake crator	22	26	36	25	43	42	21	12	13	14	19	59	332
1985	60	Minami-dake crator	20	35	54	37	10	33	60	20	49	47	34	75	474
1986	61	Minami-dake crator	35	8	13	55	8	12	4	22	20	21	12	6	216
1987	62	Minami-dake crator	13	0	1	0	1	3	4	3	18	16	16	31	106
1988	63	Minami-dake crator	29	35	21	19	12	6	11	6	3	8	5	0	155
1989	Heisei 1	Minami-dake crator	2	2	1	3	0	0	0	1	2	10	10	13	44
1990	2	Minami-dake crator	14	14	5	12	19	12	16	20	0	1	2	4	119
1991	3	Minami-dake crator	16	10	37	42	17	31	18	19	21	32	15	37	295
1992	4	Minami-dake crator	60	16	10	12	8	2	6	0	6	18	15	12	165
1993	5	Minami-dake crator	16	15	19	7	0	0	0	0	0	3	10	21	91
1994	6	Minami-dake crator	5	11	0	0	2	19	14	17	4	14	8	54	148
1995	7	Minami-dake crator	41	12	24	13	17	10	1	28	7	23	14	36	226
1996	8	Minami-dake crator	42	31	69	5	1	4	0	0	5	2	9	3	171
1997	9	Minami-dake crator	1	0	3	1	6	5	4	2	3	0	2	8	35
1998	10	Minami-dake crator	10	0	14	8	27	5	7	10	15	0	1	6	103
1999	11	Minami-dake crator	11	3	9	3	4	4	16	30	15	26	28	88	237
2000	12	Minami-dake crator	58	44	11	0	15	0	0	2	1	17	15	6	169
2001	13	Minami-dake crator	7	4	4	2	7	4	7	44	4	10	9	8	110
2002	14	Minami-dake crator	4	5	3	16	1	0	1	2	0	9	17	1	59
2003	15	Minami-dake crator	1	1	2	2	0	0	1	1	6	2	1	0	17
2004	16	Minami-dake crator	1	1	0	0	5	1	1	0	0	0	2	0	11
2005	17	Minami-dake crator	1	0	0	0	0	1	8	0	0	0	1	1	12
2006	18	Minami-dake crator	1	3	0	1	1	1	0	0	2	3	3	0	15
2007	19	Minami-dake crator	1	3	0	0	0	2	0	1	0	1	0	2	10
2008	20	Minami-dake crator	1	0	0	0	1	0	1	1	0	0	0	0	4
		Showa crator	0	4	0	2	4	14	1	0	0	0	0	0	25
2009	21	Minami-dake crator	1	1	0	0	0	0	0	0	0	1	0	0	3
		Showa crator		14	23	41	1	13	55	53	55	101	72	117	545
2010	22	Minami-dake crator	0	0	0	0	0	0	0	0	0	0	0	0	0
		Showa crator	131	120	121	100	31	99	77	64	38	13	50	52	896
2011	23	Minami-dake crator	0	2	0	0	0	0	0	0	0	0	0	0	2
		Showa crator	88	108	57	92	76	25	48	86	141	91	57	125	994
2012	24	Minami-dake crator	0	0	0	0	0	0							0
		Showa crator	172	93	112	107	64	51							599



爆発回数は1955年10月からの、地震回数は1965年1月からのデータ

降灰量(鹿児島地方気象台)は1955年～1994年2月24日は鹿児島市荒田(南岳山頂火口から西約10km)、1994年2月25日以降は同市郡元(南岳山頂火口の西南西約11km)で観測している。なお、1961年11月～1969年3月は観測所を桜島町袴腰に移転したためデータは中断している。

総降灰量は鹿児島県の降灰観測データをもとに鹿児島地方気象台で解析して作成。

Figure 90-9 Temporal change in Sakurajima volcanic activity (June, 1955 to June, 2012).

①Number of explosions per month, ②Total number of earthquakes per month

③Number of A-type earthquakes per month, ④Total ash fall per month

⑤Volume of ash fall at Kagoshima Local Meteorological Agency per month.

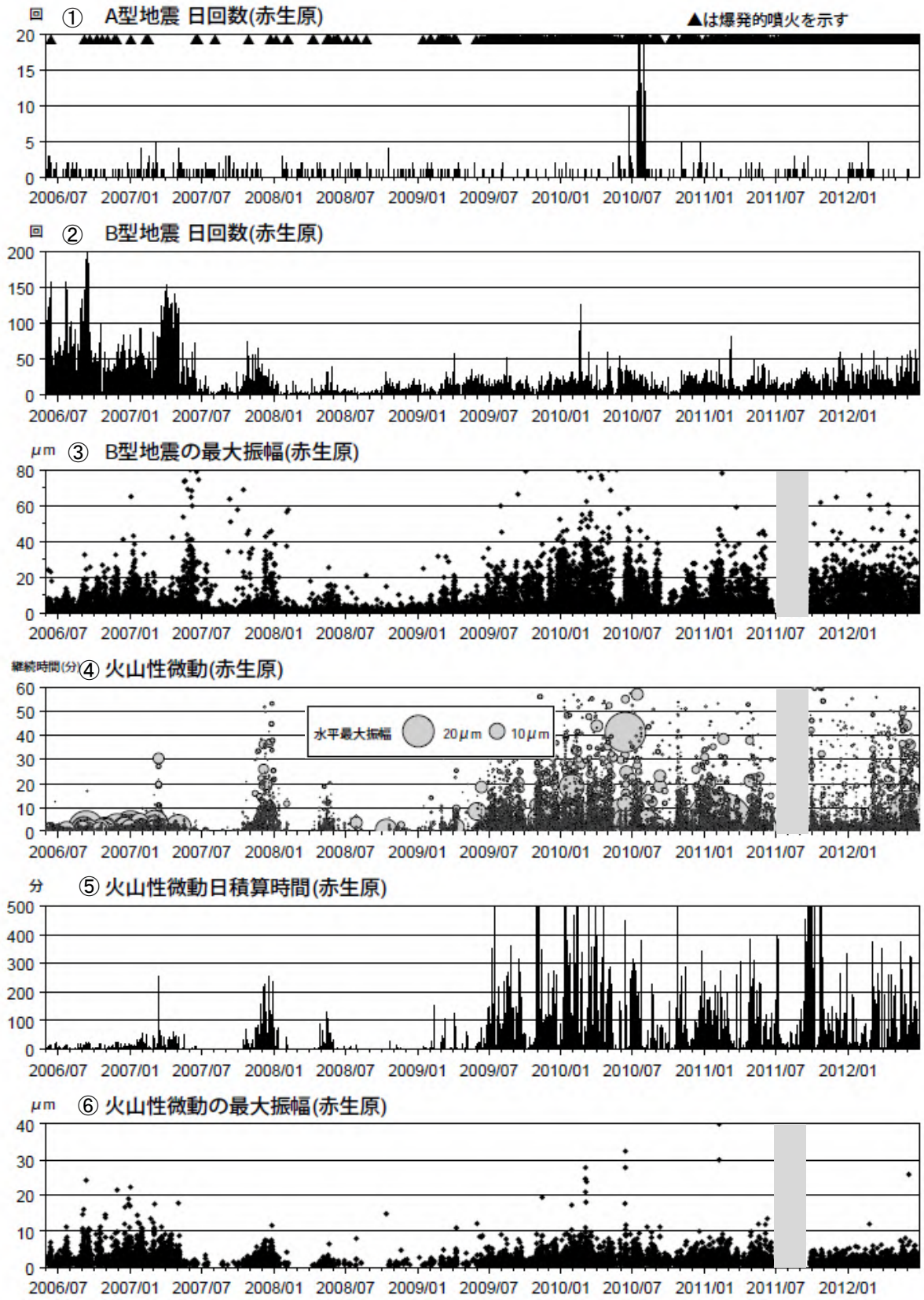


Figure 90-10 Earthquakes and tremors since the resumption of the Showa crater eruptive activity in June, 2006. (June, 2006 to June 30, 2012) Gray areas indicate lack of observation data.

①Number of A-type earthquakes per day (Akobaru), ②Number of B-type earthquakes per day (Akobaru)

③Maximum amplitude of B-type earthquakes (Akobaru), ④Volcanic tremors (Akobaru)

⑤Cumulative hours per day of volcanic tremors (Akobaru), ⑥Maximum amplitude of volcanic tremors (Akobaru)

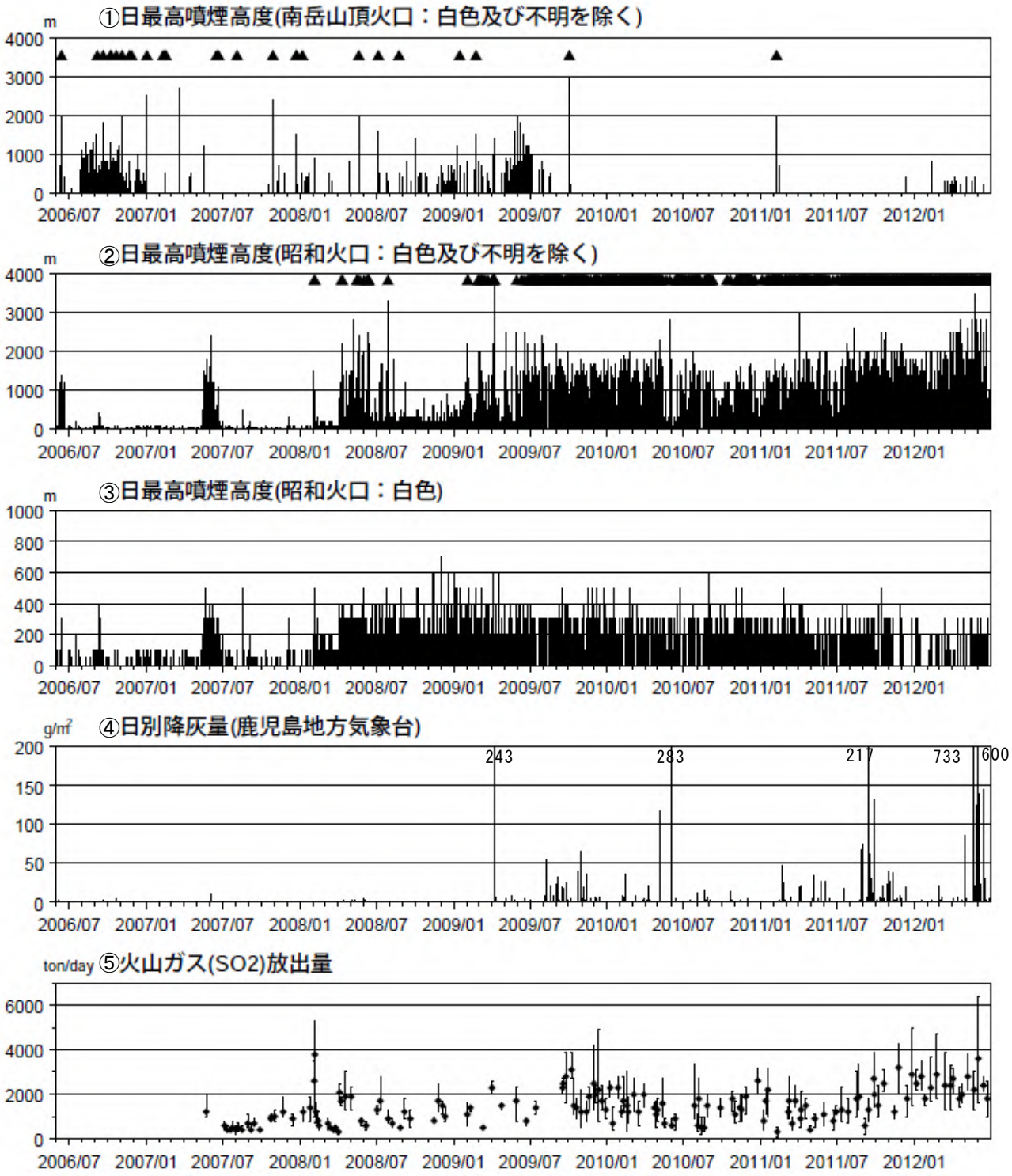


Figure 90-11 Volcanic plume, ash fall volume, and SO_2 flux since resumption of the Showa crater eruptive activity (June, 2006).

(June, 2006 to June 30, 2012)

①Daily maximum volcanic plume heights at Minamidake

②Daily maximum volcanic plume heights at the Showa crater

③Daily maximum fume heights at the Showa crater

④Daily volume of ashfall at Kagoshima Local Meteorological Agency and

⑤Results of gas emission measurements.

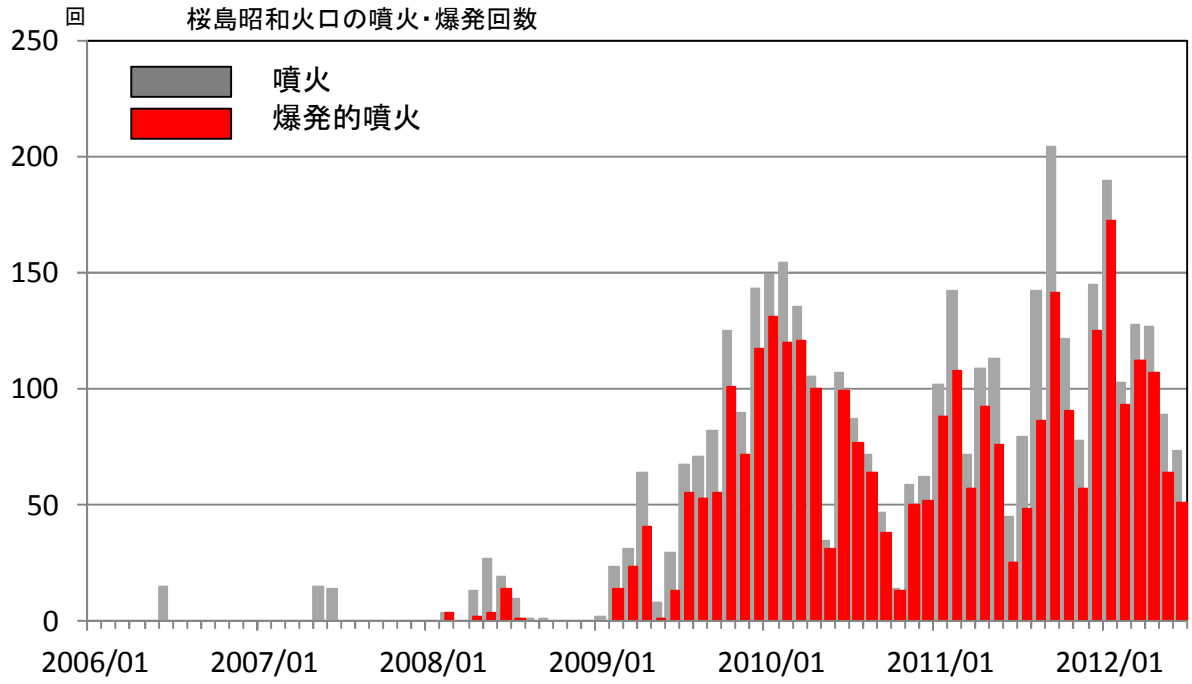


Figure 90-12 Monthly number of eruptions and explosions at the Showa crater (January, 2006 to June 30, 2012). Gray bars indicate the number of eruptions. Red bars indicate the number of explosive eruptions.

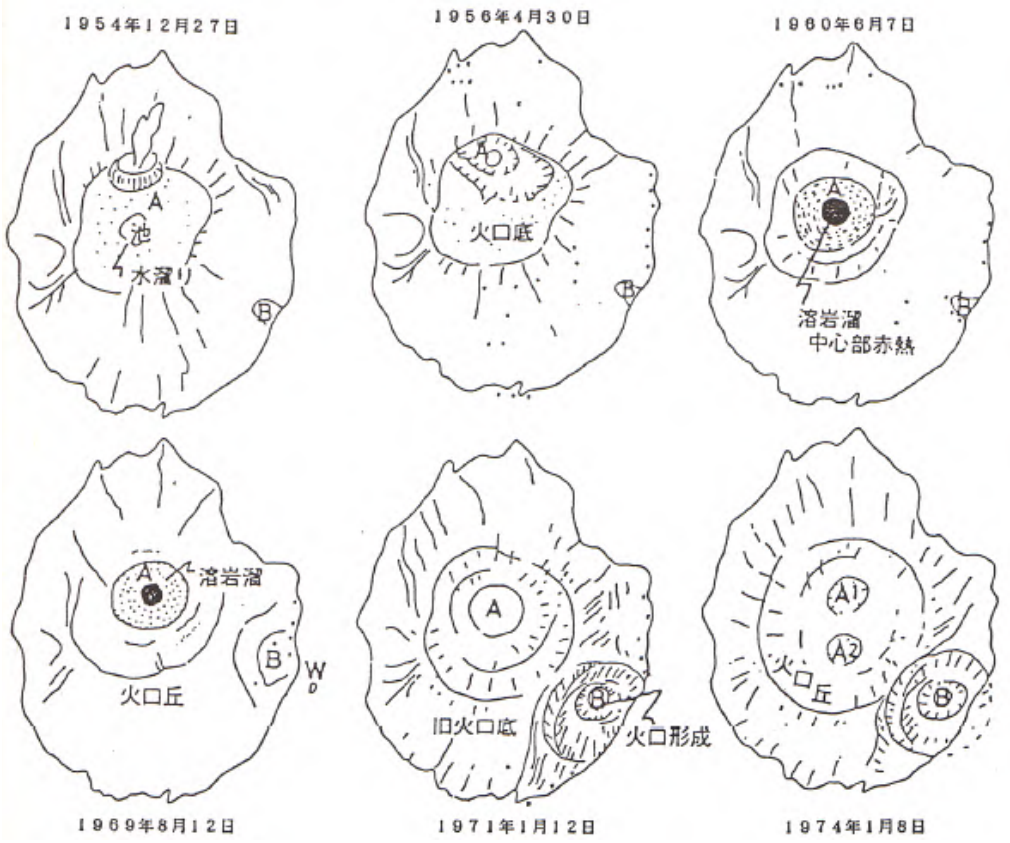


Figure 90-13 Morphological changes in Minamidake summit crater from December, 1954 to January, 1974 (Uhira, 1994).

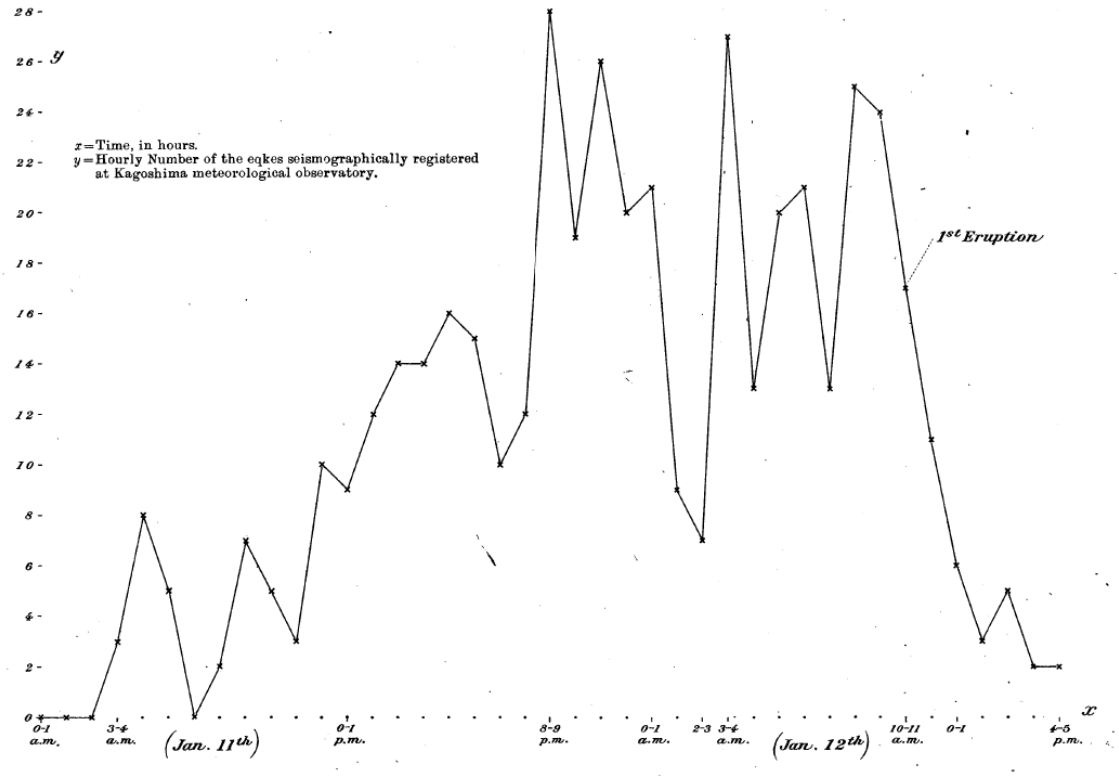


Figure 90-14 Hourly number of earthquakes registered by standard seismograph at Kagoshima Meteorological Observatory before 1914 eruption (Ohmori, 1914).

Horizontal axis indicates time. Vertical axis indicates number of earthquakes per hour.

Felt-earthquakes became prominent from the early morning of January 11, with maximum number of earthquakes being reached between the afternoon of 11th and the early morning of 12th.

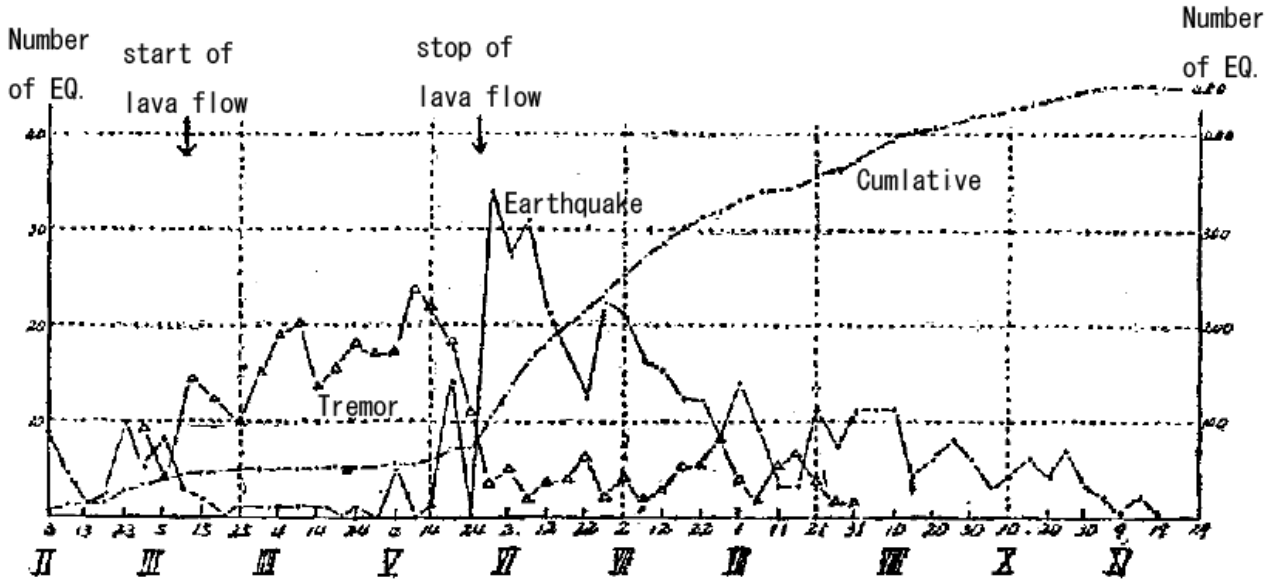


Figure 90-15 Number of earthquakes and tremors per pentad at time of 1946 Showa Eruption, Recorded by Weichert Seismograph located in Kagoshima Meteorological Observatory (Kagoshima Meteorological Observatory,1951, partially modified).

The number of volcanic earthquakes gradually increased leading up to May, and dramatically increased after initial lava flow stopped.

Start of volcanic tremors and lava ejection correspond with number of volcanic tremors falling after the end of lava ejection.

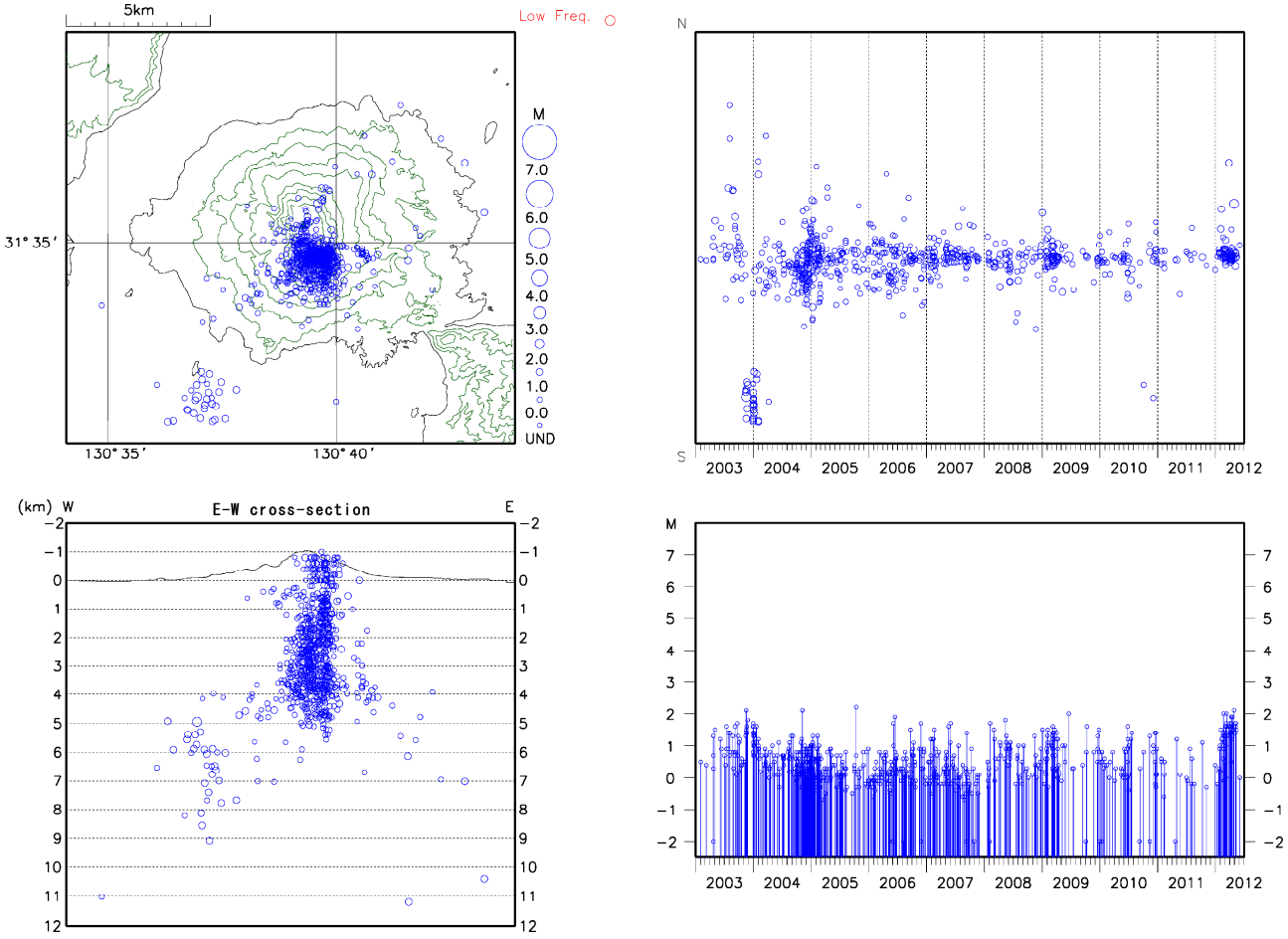


Figure 90-16 Distribution of volcanic earthquakes at Sakurajima (2003 to June 30, 2012).

Epicenter distribution (left), Space-time plot (upper right), Magnitude-time diagram(bottom right)

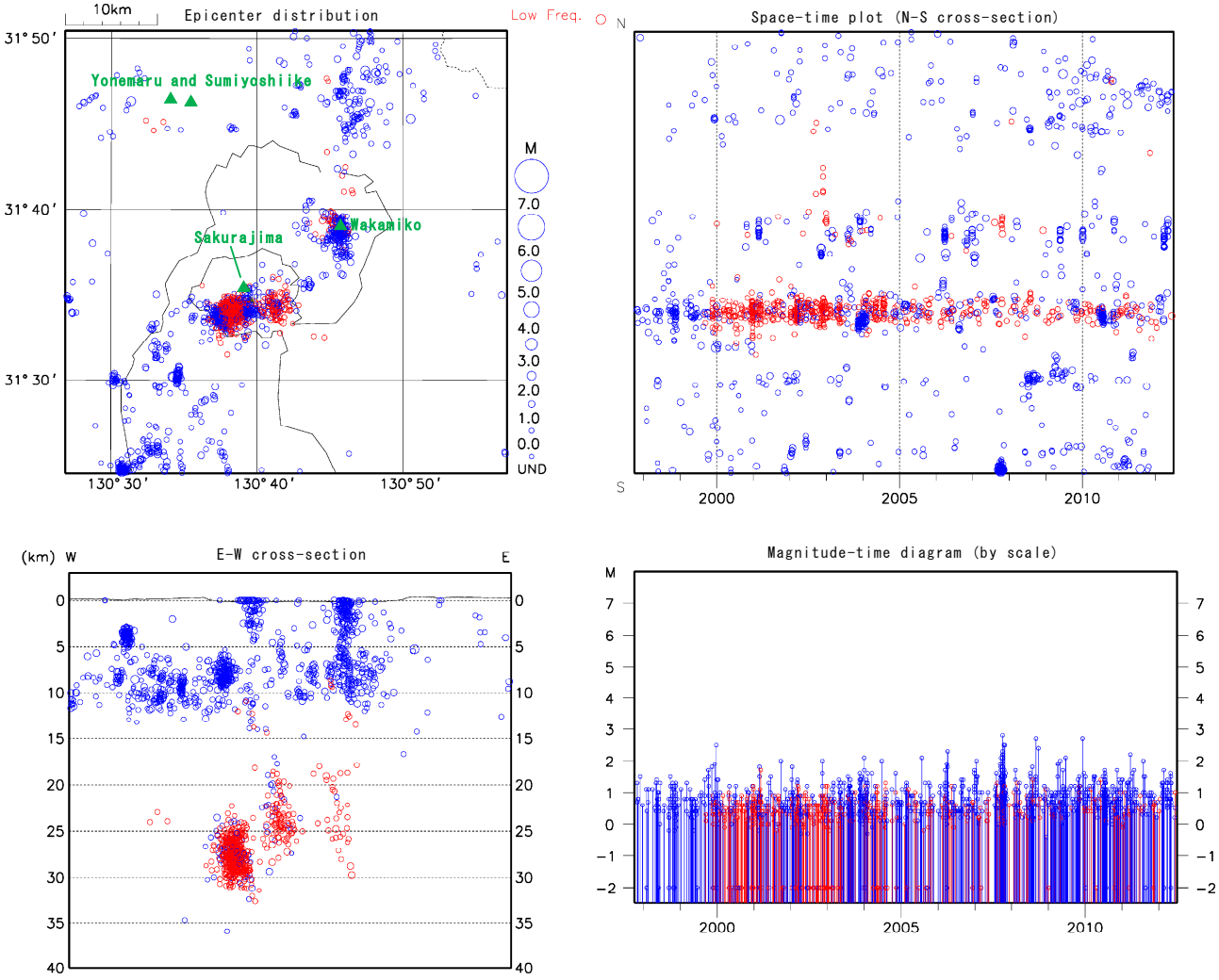


Figure 90-17 Activity of shallow VT earthquakes (blue circles) and deep low-frequency earthquakes (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter distribution (upper left), space-time plot (N-S cross-section) (upper right), E-W cross-section (lower left) and magnitude-time diagram (lower right).

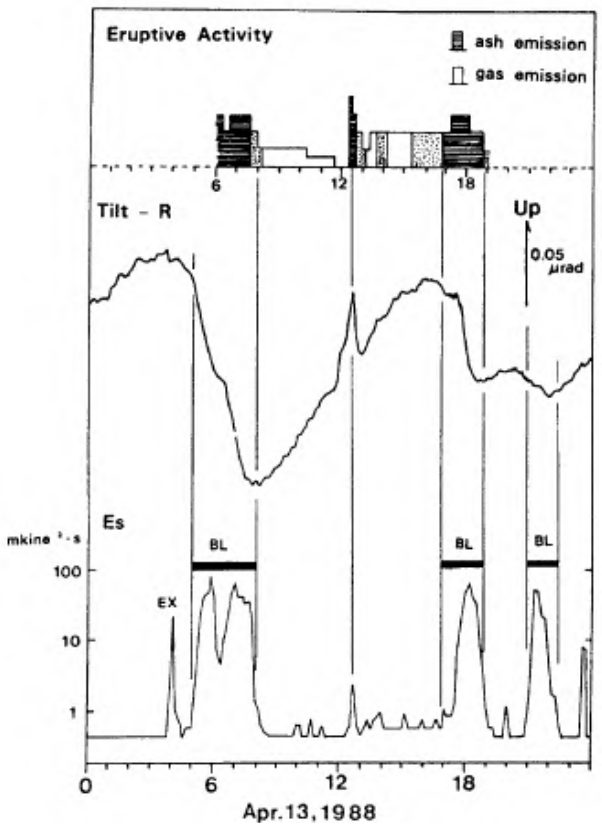


Figure 90-18 Relationship between Sakurajima surface phenomena and earthquakes / ground deformation (Ishihara, and Iguchi, 1989).

Swarms of BL earthquakes are often weak preceding eruption phenomena following rises of magma. Ground rising and deformation is detected in advance of this phenomenon.

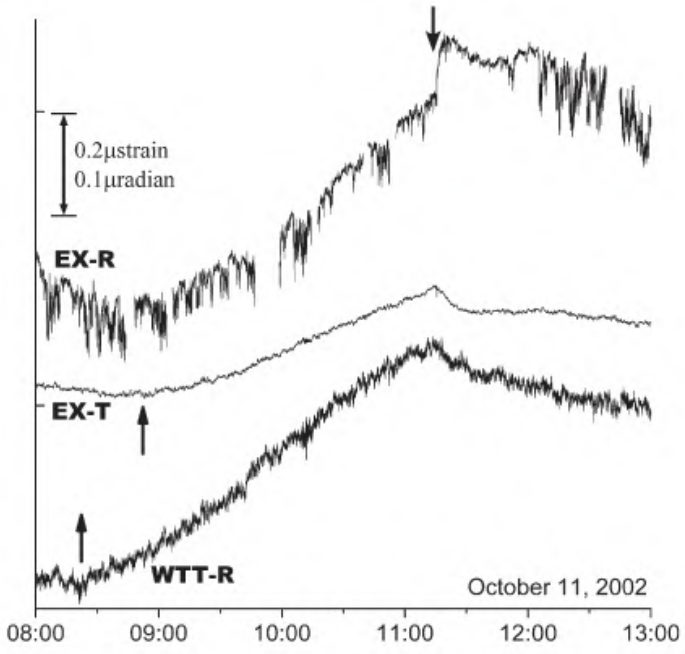


Figure 90-19 Ground deformation in advance of Sakurajima Minamidake eruption (Iguchi et al., 2008).

Slight ground deformation (0.01 to 0.2 μrad. of uplift in the direction of the crater) is often observed between 10 minutes to several hours in advance of eruptions with a large volume of ejecta.

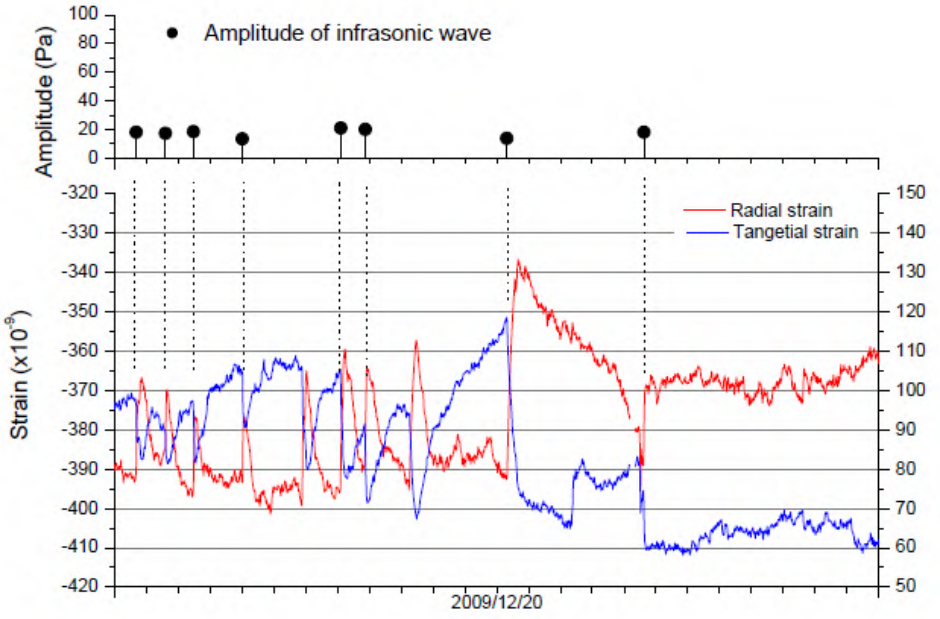


Figure 90-20 Strain change in Sakurajima Arimura Observatory (Iguchi, et al, 2010).

Strain change indicating expansion of the area immediately below the crater was observed in advance of the Showa crater eruption.

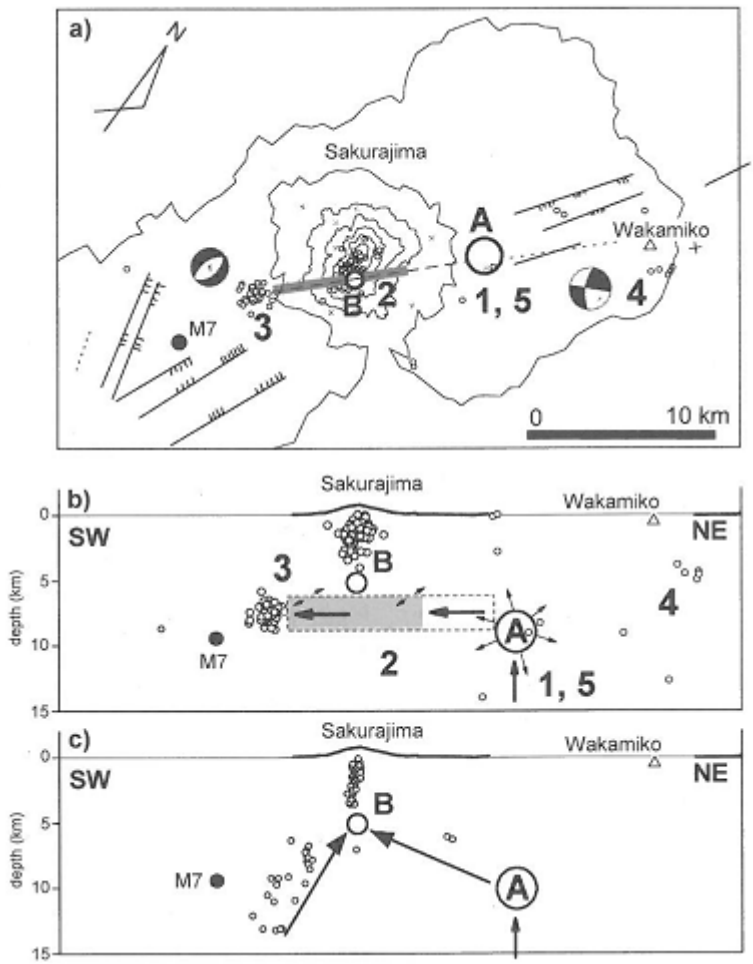


Figure 90-21 A hypothetical model of the magma supply system at Sakurajima volcano. a) Horizontal plane. (b) Vertical cross-section in SW-NW direction. (c) Previous model modified from Kamo(1989). (Hidayati et al., 2007).

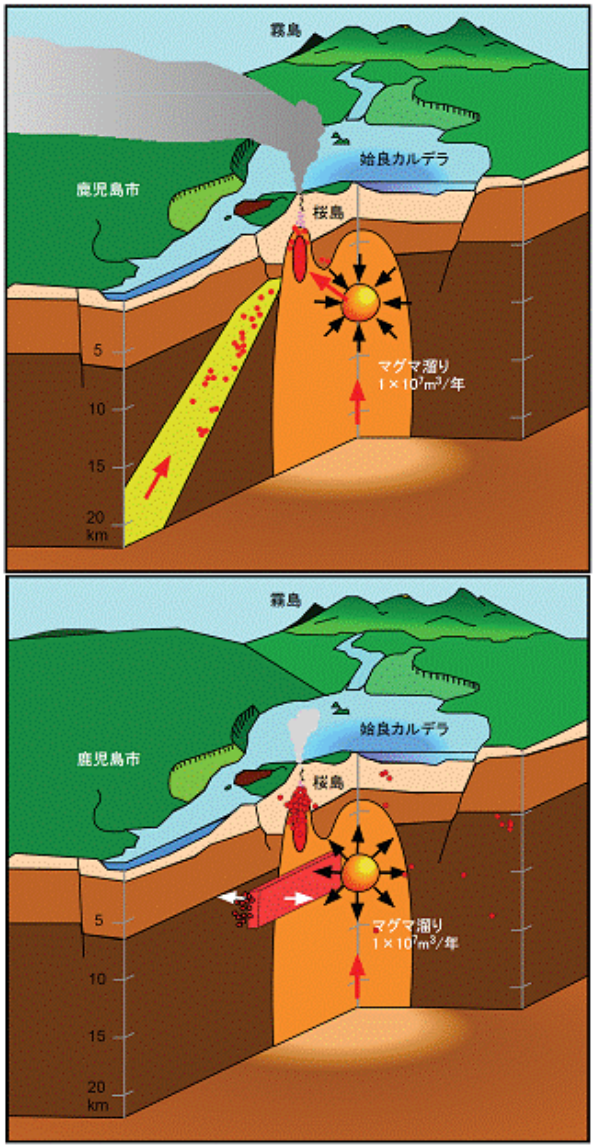


Figure 90-22 Conceptual image of Sakurajima magma supply system (Iguchi, 2008).
Top: 1974-1992, Bottom: Since 1993

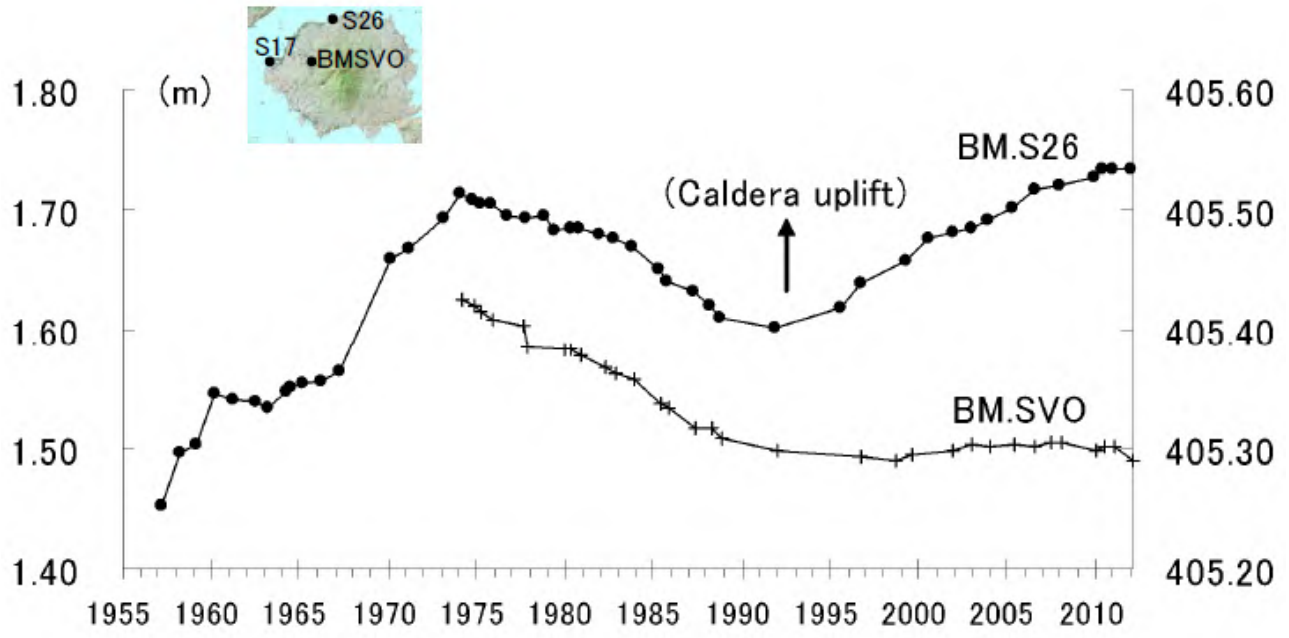


Figure 90-23 Change over time of relative heights of BM.S26 and BM.SVO with respect to Sakurajima BM.S17 (March, 1957 to November, 2011) (Disaster Prevention Research Institute Kyoto University, et al, 2012).

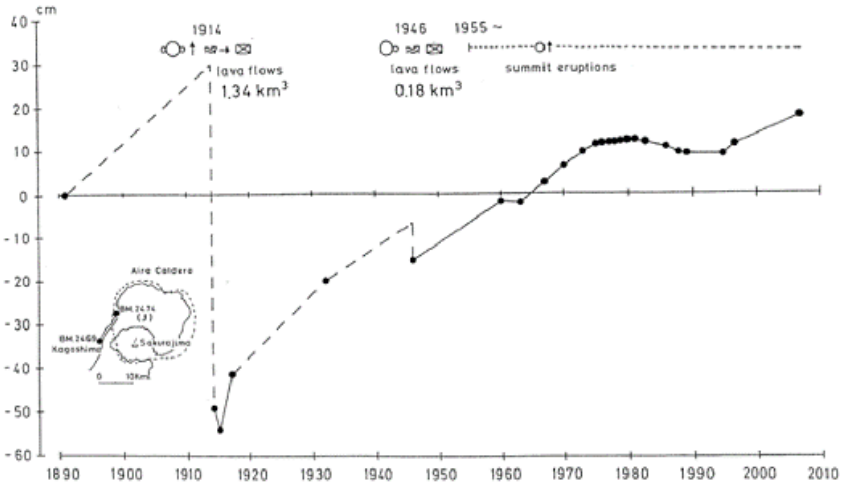


Figure 90-24 Relative upheaval of BM2474, on west edge of Aira caldera (Iguchi, 2008).
BM2469, remains of Kagoshima Prefecture Office, used as reference.
Eto, et al (1997), adjusted to reflect results of measurements by Geospatial Information Authority of Japan in October, 2006.

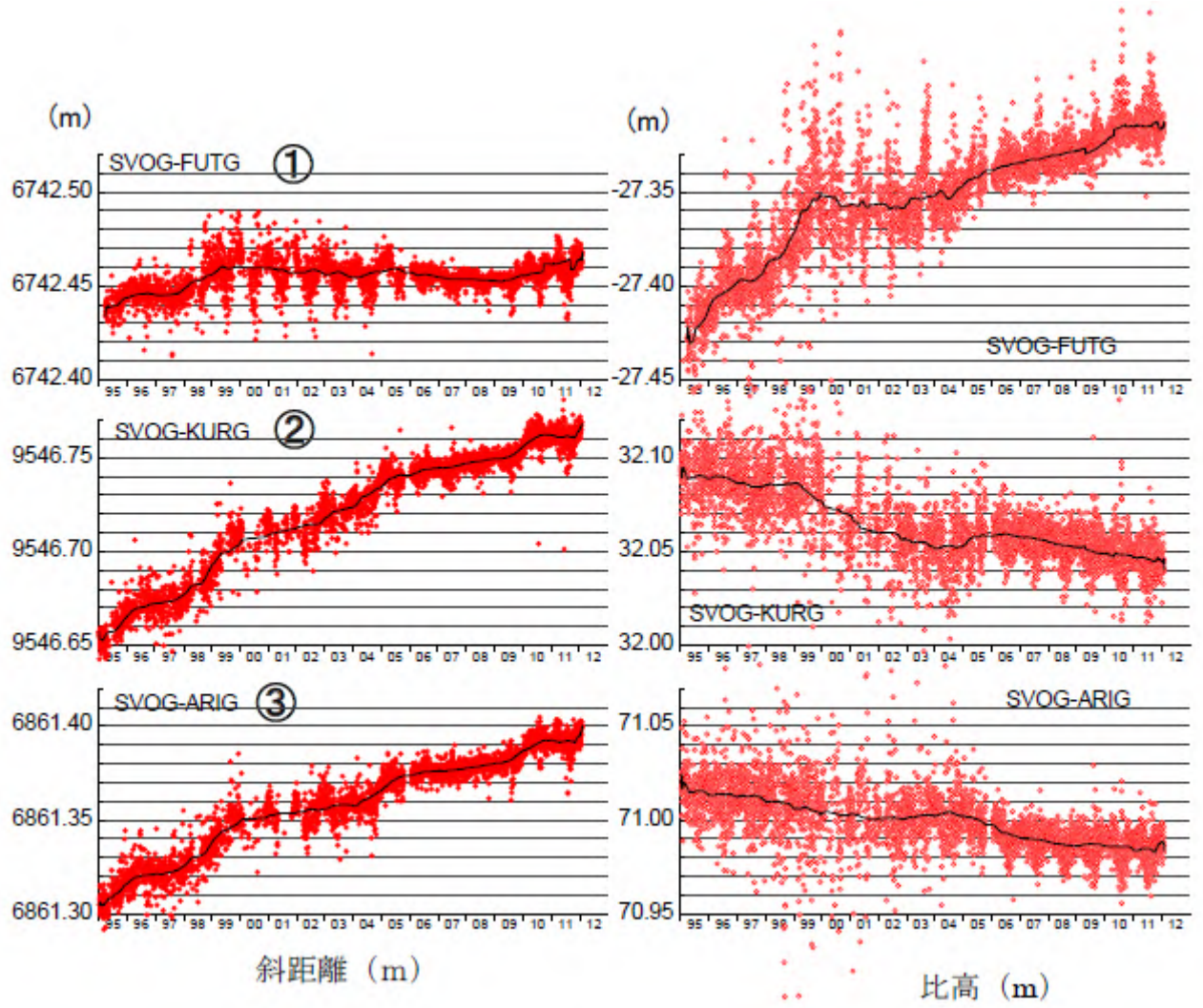


Figure 90-25 GPS continuous measurement of Sakurajima (to January, 2012) (Disaster Prevention Research Institute Kyoto University, 2012).

Data acquisition: 24 hours / day, Sampling: 1 sec/measurement line (since June, 2005)

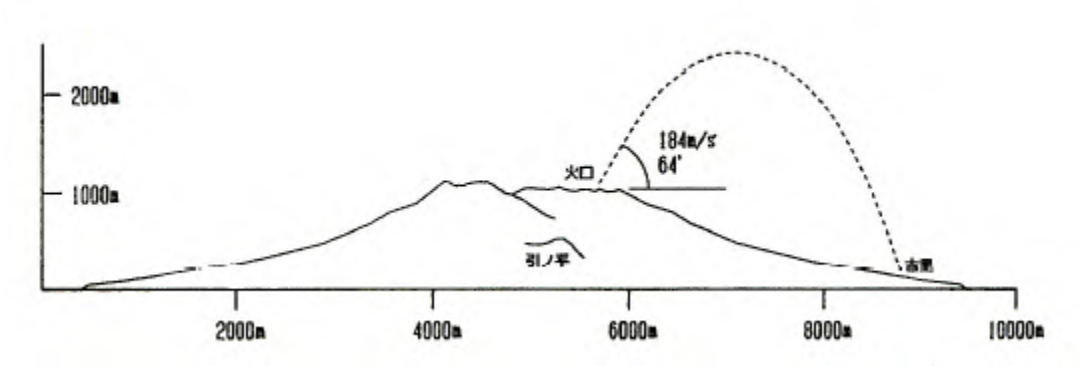


Figure 90-26 Estimated trajectory of volcanic block ejected by Sakurajima Minamidake November 23, 1986 explosion (Fukuoka District Meteorological Observatory, 1990).
On November 23, 1986 (Showa 61), a volcanic block fell on a hotel in Furusato-cho.
This trajectory was calculated based on the offset between the holes made in the roof and the floor.

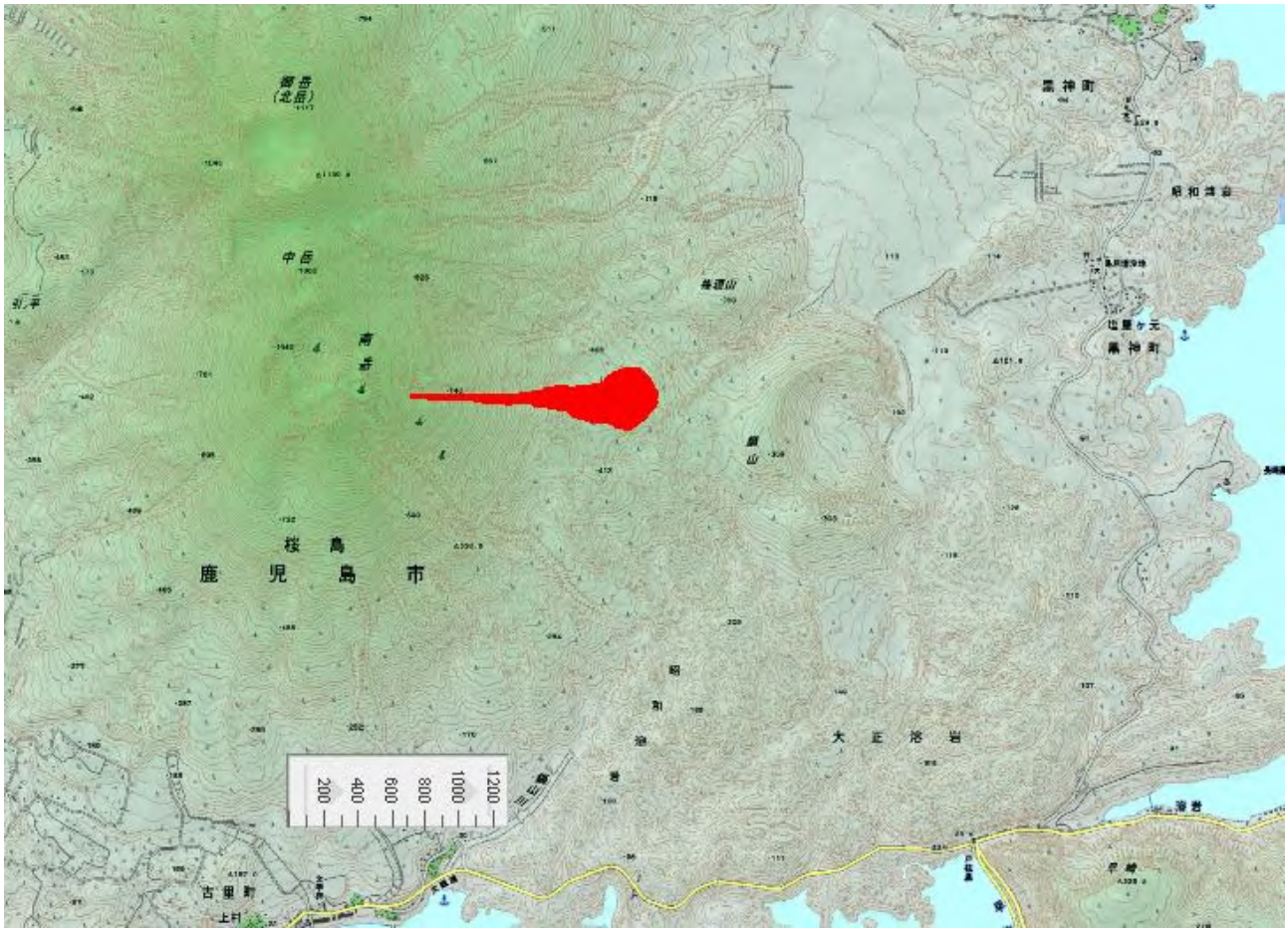


Figure 90-27 Area of pyroclastic flow in explosive eruption at the Showa crater at 11:25 on February 6, 2008.
The flow extended approximately 1.5 km to the east of the Showa crater.

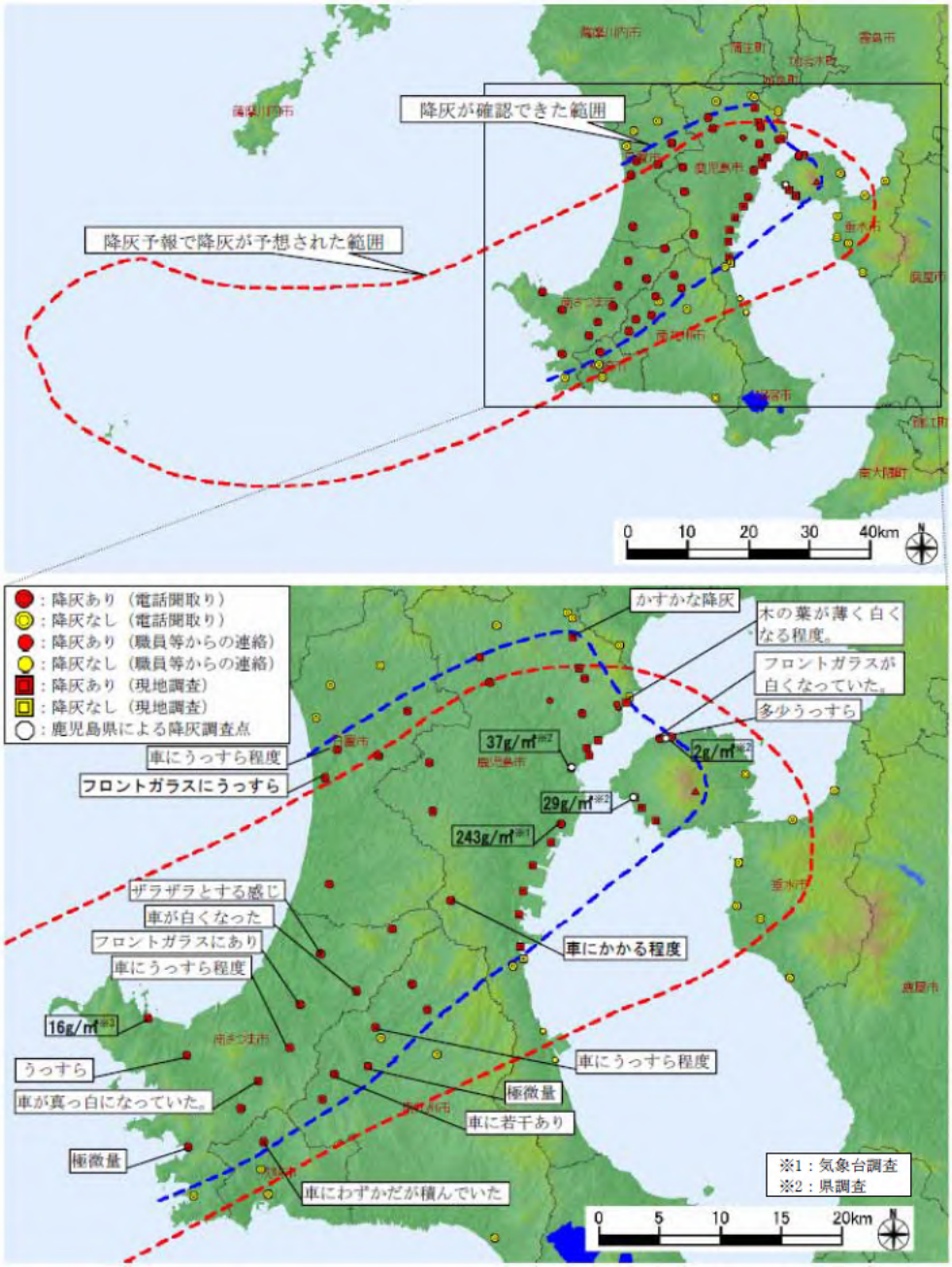


Figure 90-28 April 9, 2009 15:31 the Showa crater explosive eruption ash fall distribution and ash fall forecast area.
Ash fall studies in and around Kagoshima city, together with random telephone sampling, confirmed ash fall in a wide area around the Satsuma Peninsula.

Information on Disaster Prevention

①Hazard Map

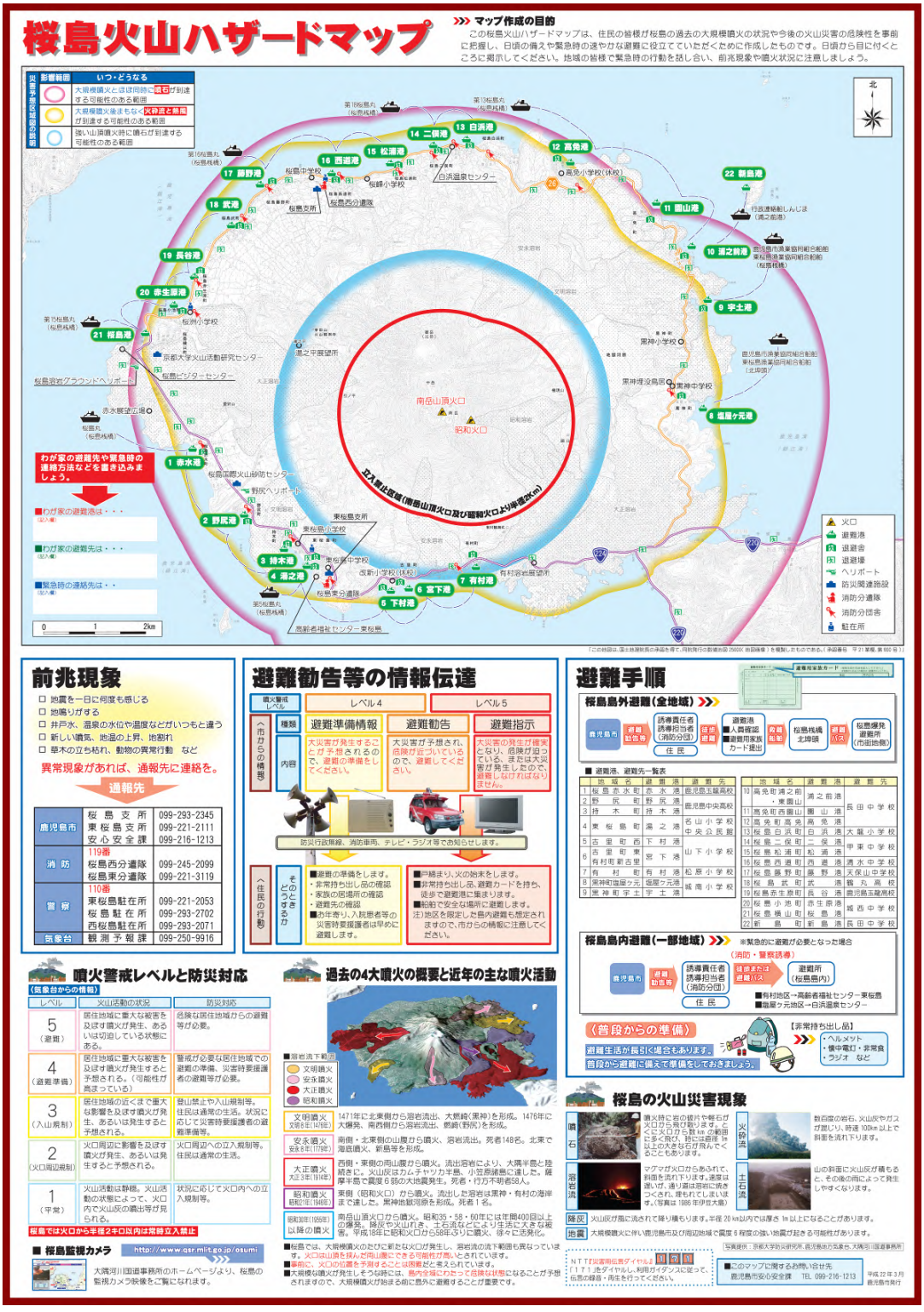
"Sakurajima Volcano Disaster Prevention Map"

・Created by Kagoshima city in March, 2010

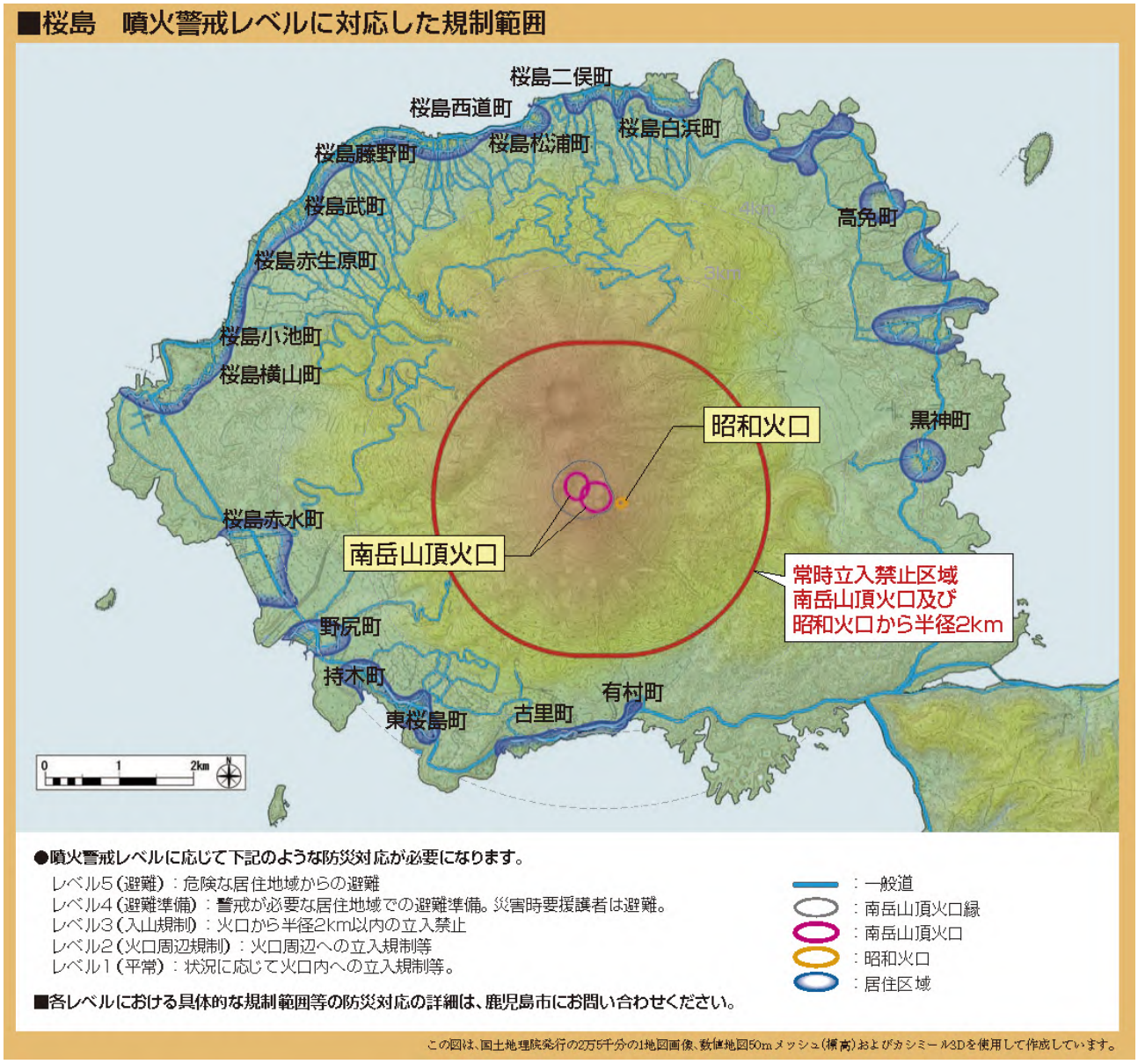
Sakurajima Volcano Disaster Prevention Map URL

http://www.city.kagoshima.lg.jp/_1010/shimin/1kurashi/safe/1-1-1bosai/_29062/_39166/_39168/_39228/sakurajimahm.html

(Kagoshima city website)



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



Volcanic Alert Levels for the Sakurajima 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**	●Lava flow, pyroclastic flow, and scattering of volcanic blocks affecting entire island. Past Examples Tenpyo eruption (768), Bunmei eruption (1471 to 1476), An'ei eruption (1779 to 1782), Taisho eruption of 1914 ●Eruption or imminent eruption, with pyroclastic flow and lava flow reaching some residential areas. Showa Eruption (1946) Example Lava flow reached Kurokami and Arimura coasts.
		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.**	●Increased eruptive activity, large number of felt-earthquakes, and/or prominent crustal deformation, etc. result in possibility of eruption ejecting volcanic blocks, pyroclastic flow, and/or lava flow reaching residential areas. Taisho eruption of 1914 Example One day before start of eruption: Large number of felt-earthquakes Showa Eruption (1946) Example Several hours before lava flow: Increased eruptive activity.
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.**	●Scattering of volcanic blocks within a distance of approximately 2 km from the crater. Past Examples Eruptions in late 1970s and 1980s, October 7, 2000, eruption, etc. ●Pyroclastic flow within a distance of approximately 2 km from the crater. Past Examples July 21, 1984: Reached approximately 1.2 km from the Minamidake summit crater November 20, 1979: Reached approximately 1.2 km from the Minamidake summit crater August 22, 1967: Reached approximately 1.3 km from the Minamidake summit crater October 29, 1939: Reached approximately 1 km from the Showa crater ●Earthquake swarm and crustal deformation, etc. results in possibility of eruption scattering volcanic blocks within approximately 2 km of the crater. Past Examples Many past 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 activity as normal. Access to crater area restricted, etc.**	●Scattering of volcanic blocks within a distance of approximately 1 km from the crater. Past Examples Many past examples.
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. Past Examples Dormant Year between 1950 and 1955.

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) Alert levels 1 through 3 are envisioned for eruptions occurring at the Minamidake or Showa craters.

Note 3) Submarine eruptions have occurred in the past, 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.

Note 4) For alert levels 1 through 3, it is prohibited to approach within a 2 km radius of the Minamidake or Showa craters.

Social Circumstances

①Populations

- Kagoshima City (608,219 as of November 1, 2011, according to Kagoshima city website)
  * Sakurajima area (76.8 km^2): 5,262 (69 people/km^2) as of January 1, 2011
- Tarumizu City (17,348 as of November 1, 2011, according to Tarumizu city website)

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

March, 1964 - Kirishima-Yaku National Park

March, 2012 - Kirishima-Kinkowan National Park

Mountain climbing prohibited

Number of tourists in 2010 (staying overnight: 3,702,000 * For whole Sakurajima / Kagoshima City area. Statistic from prefecture tourism bureau)

③Facilities

- Ministry of the Environment Sakurajima Visitor Center (Kagoshima City)
- Ministry of Land, Infrastructure, Transport and Tourism Sakurajima International Volcanic Sabo Center (Kagoshima City)
- Sakurajima Volcano Research Center, DPRI, Kyoto University: http://www.dpri.kyoto-u.ac.jp/~kazan/

Monitoring Network

Wide Area

* Includes Yonemaru - Sumiyoshi-ike and Wakamiko observation networks.

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

Legend

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

(For earthquakes and tsunamis)

(GSI)
- GPS

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

(DPRI)
- seismometer(SP)
- GPS
- tiltmeter
- waterlevel gauge
- thermometer

(MILT)
- visual camera

(Kagoshima Univ.)
- seismometer(SP)

(Municipalities)
- seismic intensity meter

Figure 90-29 Regional monitoring network.

* Monitoring sites with multiple observation instruments are indicated by small black dots, and other symbols indicate types of monitoring. The area enclosed in the black rectangle is shown in detail in the smaller scale summit area map in Fig. 90-30.

Monitoring Maps

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 (Tarumizu, Kanoya, Kagoshima and Iwakawa) published by the Geospatial Information Authority of Japan were used.

Legend

(JMA)
- seismometer(SP)
- GPS
- tiltmeter
- infrasonic microphone

(GSI)
- GPS

(DPRI)
- seismometer(SP)
- seismometer (broadband)
- GPS
- tiltmeter
- extensometer
- infrasonic microphone
- waterlevel gauge
- thermometer
- gas sensor

(Kagoshima Univ.)
- seismometer(SP)

(Municipalities)
- seismic intensity meter

(MILT)
- seismometer(SP)
- seismometer (broadband)
- tiltmeter
- extensometer
- visual camera
- infrasonic microphone

Figure 90-30 Regional monitoring network.

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