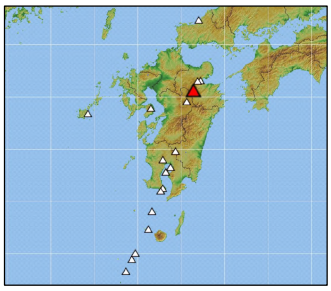
83. Kujusan



Continuously Monitored by JMA

Latitude: 33°05'09" N, Longitude: 131°14'56" E, Elevation: 1,791 m (Nakadake) (Elevation Point)
Latitude: 33°05'27" N, Longitude: 131°13'57" E, Elevation: 1,762 m (Hosshozan) (Elevation Point)

Overview of Kujusan taken from North Side on April 23, 2001 by the Japan Meteorological Agency

Summary

Kujusan is a group of over 20 volcanoes, over 1,700 meters tall, stretching 15 km east-west, from the south of Kokonoe to the north of Taketa in Kusu District, Oita prefecture. It is composed of the Kujusan mountain range, extending from Kujusan, at its west. The Taisen mountain range, with Taisenzan at its center, is located on the other side of the Bogatsuru grasslands. Many of volcanoes in Kujusan are lava domes, with some stratovolcanoes. The volcanic edifices are surrounded by gently sloping skirts composed mainly of pyroclastic flow deposits. The rock is mainly andesite and dacite, with some basalt. The latest large magmatic eruption occurred about 1,700 years ago, producing the Kurodake lava dome. The northeastern flank of Hosshozan has a group of active fumaroles, and some phreatic eruptions and violent fumarolic activities are records in historical time. On October 11, 1995 (Heisei 7), an eruption occurred on the eastern flank of Hosshozan, with ash fall reaching Kumamoto. Geothermal power plants exist on the west of the volcano, such as Hatchobaru and Odake. The SiO_2 content of the basalt - dacite is between 51.7 and 63.1 wt %.

Photos

Nakadake on October 9, 2011 by the Japan Meteorological Agency

Mimatayama on October 9, 2011 by the Japan Meteorological Agency

Volcanic Plumes from the Hosshozan at a1 Crater (right), and a2 Crater (left), taken from the Northeast on October 12, 1995 by the Japan Meteorological Agency

Volcanic Plume from the Eastern Flank of Hosshozan taken from North (Mimatayama) on October 14, 1995 by the Japan Meteorological Agency

Volcanic Plume from the Eastern Flank of Hosshozan taken from Chojabaru, Tano in Kokonoe-cho on October 12, 1995 by the Japan Meteorological Agency

Front of a small lahar deposit-taken from North on October 12, 1995 by the Japan Meteorological Agency

Topography around the Crater

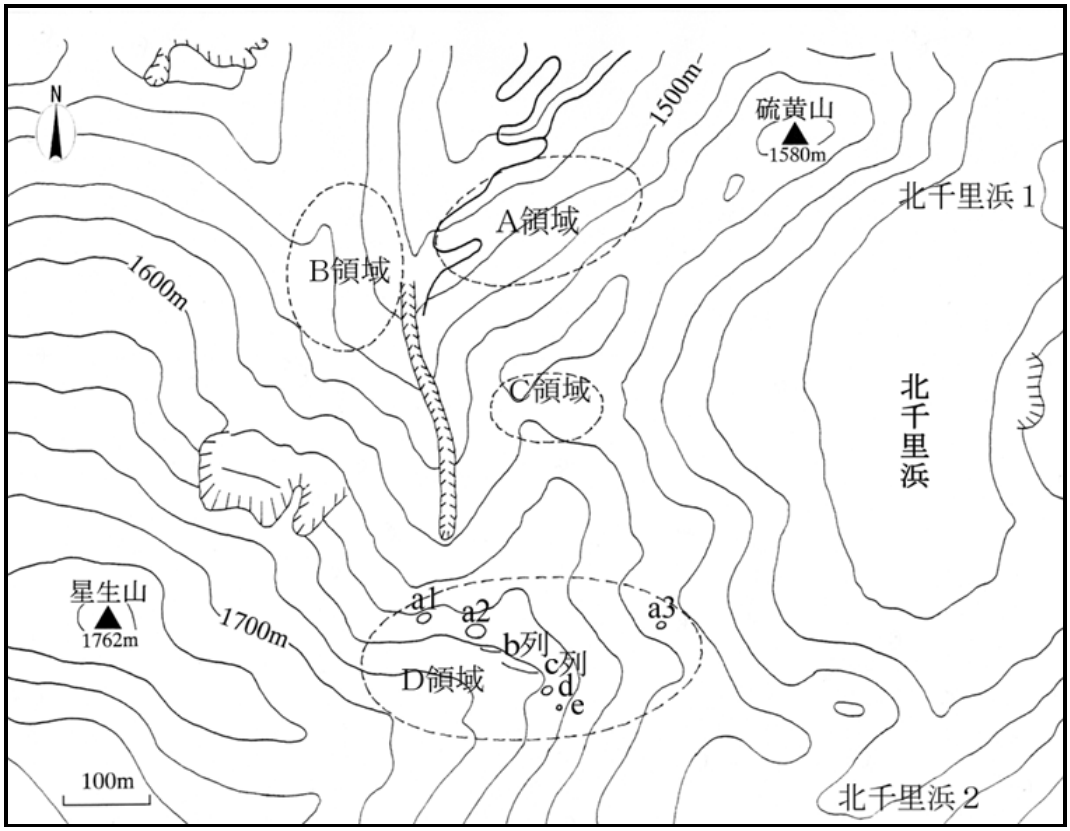


Figure 83-1 Topography around the crater.

Red Relief Image Map

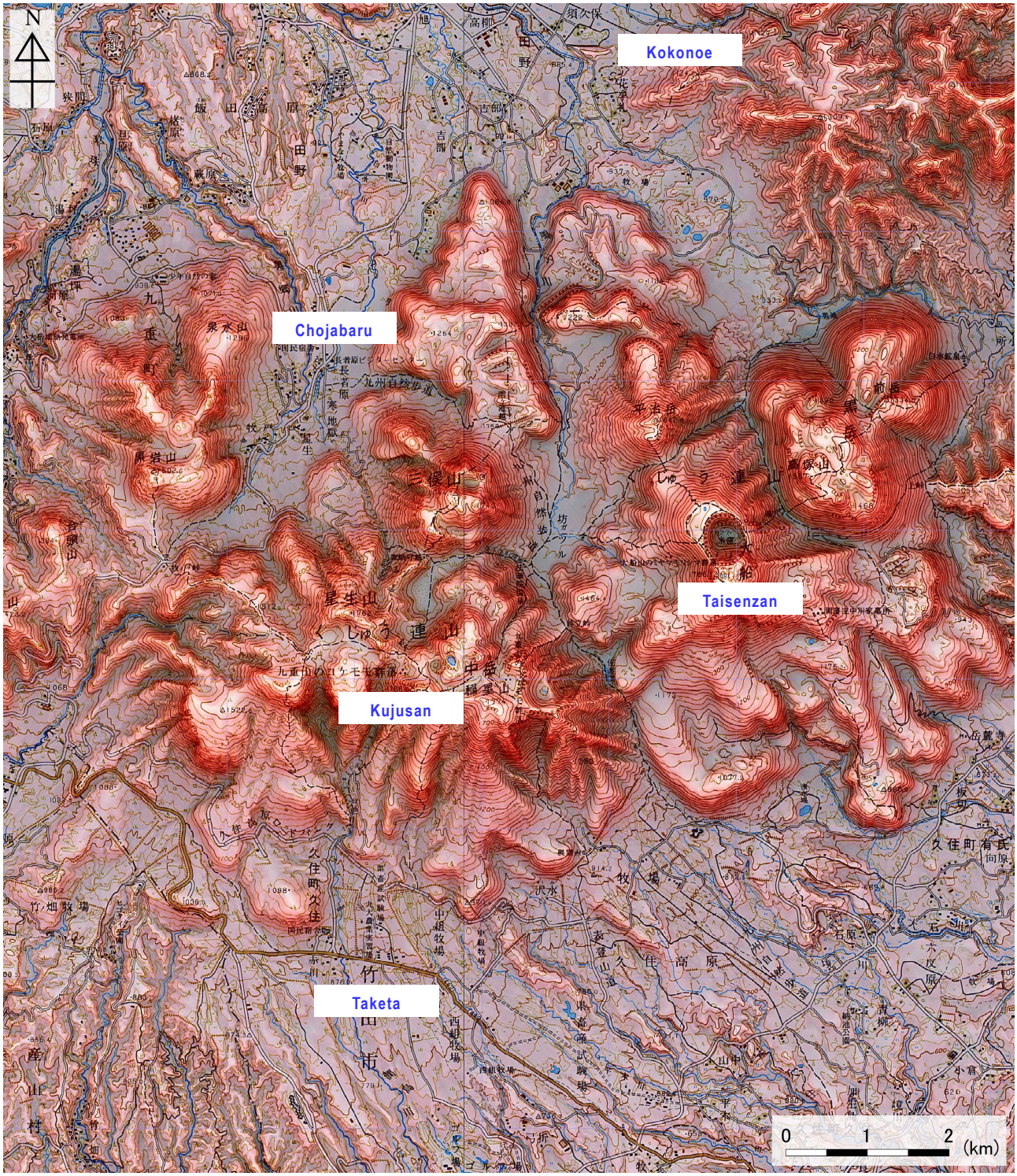


Figure 83-2 Topography of Kujusan.

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

Chronology of Eruptions

・Volcanic Activity in the Past 10,000 Years

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
7.3←→6ka	Tachusan	Magmatic eruption	Lava dome.
7.3←→6ka	Taisenzan	Magmatic eruption	Lava flow.
6.3←→6ka	Taisenzan	Magmatic eruption	Lava flow and air-fall pyroclastic material. Magma eruption volume = 0.33 km^3 DRE. (VEI 4)
5.5←→5.3ka	Danbaru crater	Magmatic eruption	Lava flow and air-fall pyroclastic material. Magma eruption volume = 0.13 km^3 DRE. (VEI 4)
5.1ka	Taisenzan	Magmatic eruption	Lava flow and lava dome.
4.9ka	?	Phreatic eruption	?
3.9←→3.7ka	Komekubo crater	Magmatic eruption	Air-fall pyroclastic material. Magma eruption volume = 0.05 km^3 DRE. (VEI 4)
3.9←→3.7ka	Near Kuju-Wakare emergency shelter	Phreatic eruption	Air-fall pyroclastic material and lahar.
2.2←→2.1ka	Komekubo crater	Phreatomagmatic eruption	Air-fall pyroclastic material. Magma eruption volume = 0.04 km^3 DRE. (VEI 4)
1.9←→1.8ka	?	Phreatic eruption	?
1.7←→1.6ka	Kurodake	Magmatic eruption	Lava dome and pyroclastic flow. Magma eruption volume = 1.61 km^3 DRE. (VEI 5)
1.7←→1.6ka	?	Phreatic eruption	?
1.5←→1.4ka	Near Ioyama	Phreatic eruption	Air-fall pyroclastic material.
1ka	?	Phreatic eruption	?
0.6ka	?	Phreatic eruption	?

* 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

・Historical Activity

Year	Phenomenon	Activity Sequence, Damages, etc.
1662 (Kanbun 2)	Fume	February 26. Emission of relatively large fume or explosion on the surface of the fumarolic area.
1675 (Enpo 3)	Fume or molten sulfur discharge	June to July. Fume emission or molten sulfur discharge.
1738 (Genbun 3)	Phreatic eruption?	August 13. Emission of relatively large fume or fumarolic area surface area explosion.
1777 (An'ei 6)	Fumarole	Change in fumarolic activity (emission of molten sulfur, etc.)?
1995 (Heisei 7)	Eruption	October 11. Eruption activity occurred on eastern flank of Hosshozan. Tephra fall reached as far as Kumamoto. Fumarolic activity remained strong thereafter. Volcanic ash emission again in December.
1996 (Heisei 8)	Eruption	Volcanic ash emission from the night of January 13 to the morning of January 14. Very small amount of tephra fall observed around Kujusan. Many earthquakes occurred in Sujiyu area, 3 to 4 km northwest of Hosshozan (hypocenter depth of 7 to 10 km).
	Volcanic plume, earthquakes, volcanic tremors	Volcanic plume activity increased in mid-March, with a very small amount of tephra fall in fumarole area. On March 24, many earthquakes occurred in and around Hosshozan, with weak tremors felt in the Chojabaru area. Volcanic tremors occurred in March (10 tremors), November (15 tremors), and December (3 tremors).
1997 (Heisei 9)	Earthquakes, volcanic tremors	Repeated increases in earthquakes 3 to 10 km northwest of Hosshozan. Volcanic tremors occurred in March (12 tremors), April (5 tremors), and September (2 tremors).
2011 (Heisei 23)	Earthquake	March. Since the 2011 off the Pacific coast of Tohoku Earthquake (March 11, 2012) earthquake activity increased temporarily on the volcanic edifice and in and around Sujiyu, to its northwest.

* 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.

Major Volcanic Activities

▪ 1995 Eruption

Figure 83-3 Photograph of Kujusan volcanic plume, taken on October 12, the day after the October 11, 1995, eruption (Ehara, 2007).

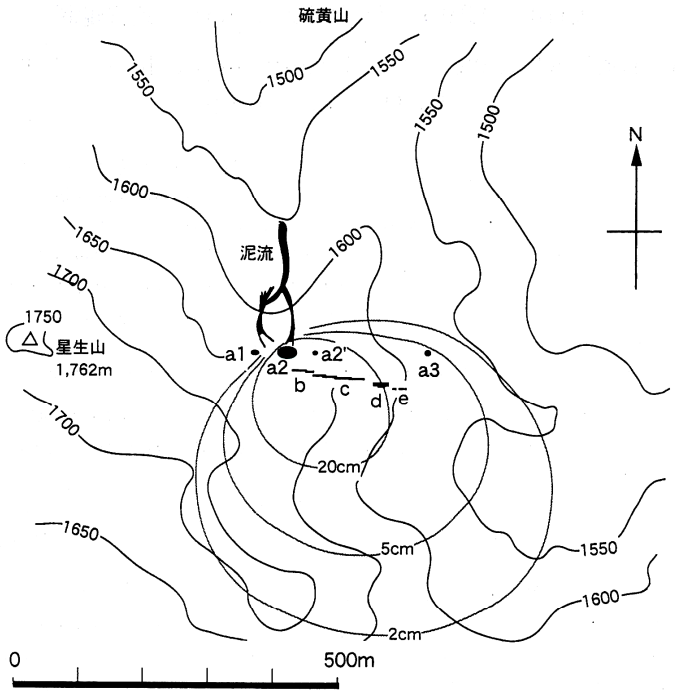


Figure 83-4 Locations of crater (The University of Tokyo, et al., 1995) and fumarole (crack) formed by October 11, 1995, Kuju eruption, and October 11 volcanic ash isopach (units: cm).
Most volcanic ash was discharged from the a2 crater.

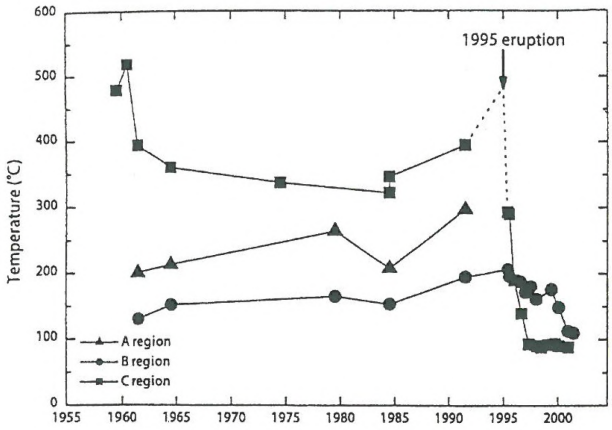


Figure 83-5 Changes in temperatures of existing fumaroles before and after eruption (Ehara, 2007).

No prominent temperature increases occurred before the 1995 eruption, but lower temperatures were observed after the eruption.

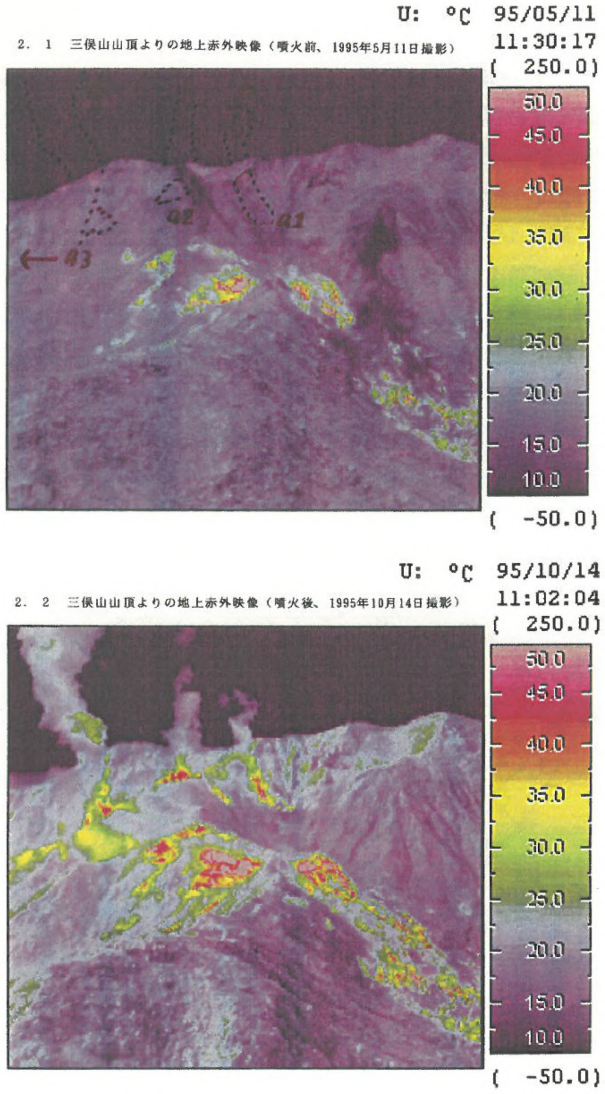


Figure 83-6 Infrared photographs before and after the 1995 eruption (Top) Before eruption (Bottom) After eruption (Ehara, 2007).

No notable thermal anomalies were observed before the eruption.

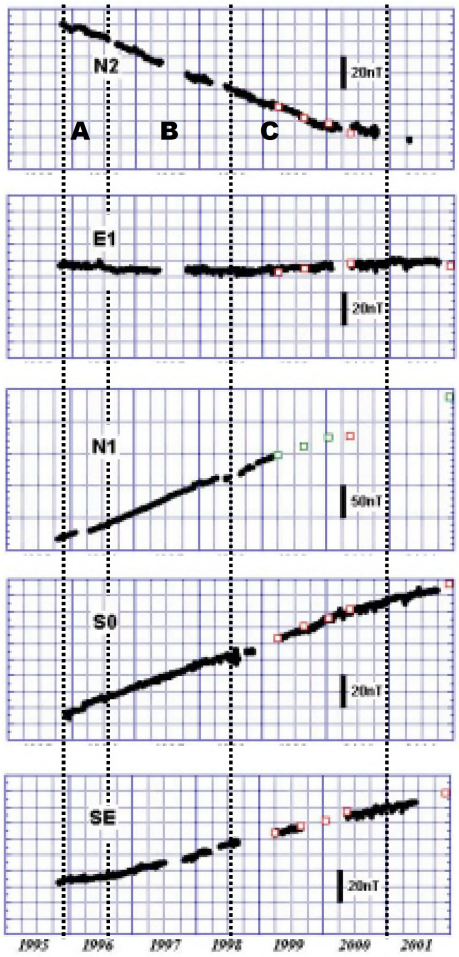


Figure 83-7 Changes in total magnetic force observed at Kujusan from 1995 to 2001 (Hashimoto et al., 2002).

Since the 1995 eruption, a tendency has existed for thermal magnetization which indicates a drop in underground temperature.

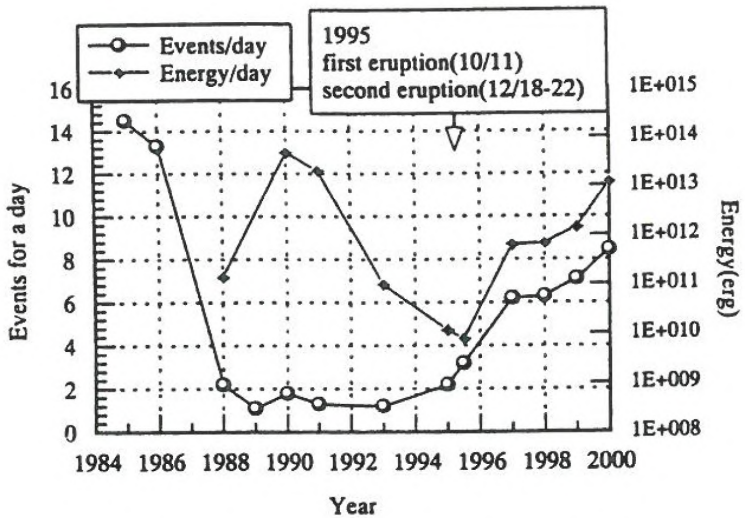


Figure 83-8 Pre- and post-eruption changes in Kuju-Ioyama earthquake activity (Ehara, 2007).

Seismic activity was calm before the eruptions, but immediately before the eruptions earthquake swarms occurred, and seismic activity increased. seismic activity gradually tailed off after the eruptions.

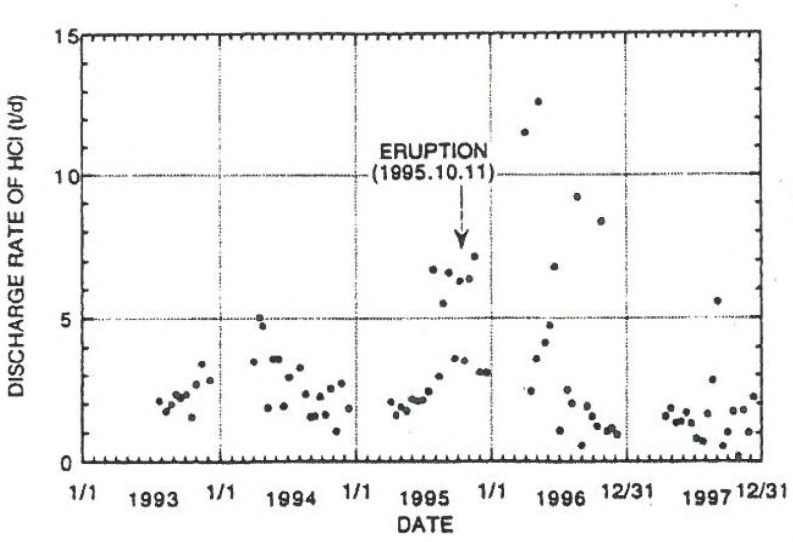


Figure 83-9 Changes in amount of hydrogen chloride emitted by Kuju-Ioyama (Itoi et al., 2002).

From April to August, 1995, before the eruption, the amount of hydrogen chloride, inferred to be magmatic gas, increased..

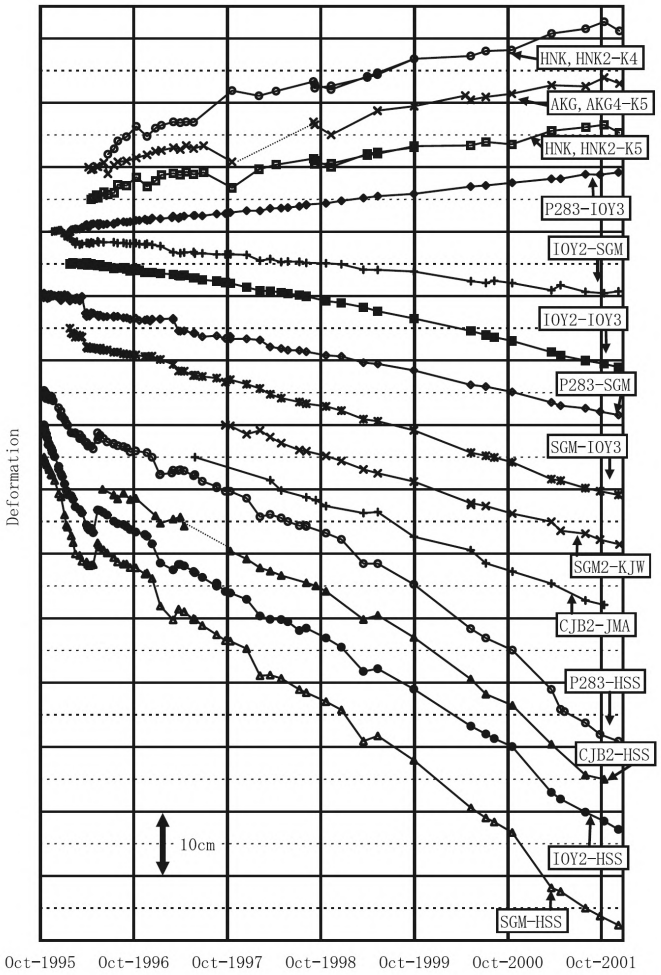


Figure 83-10 Ground deformation after the Kokonoe 1995 eruption (Nakaboh et al., 2003).

Since the 1995 eruption, ground deformation indicating shallow area deflation has been ongoing.

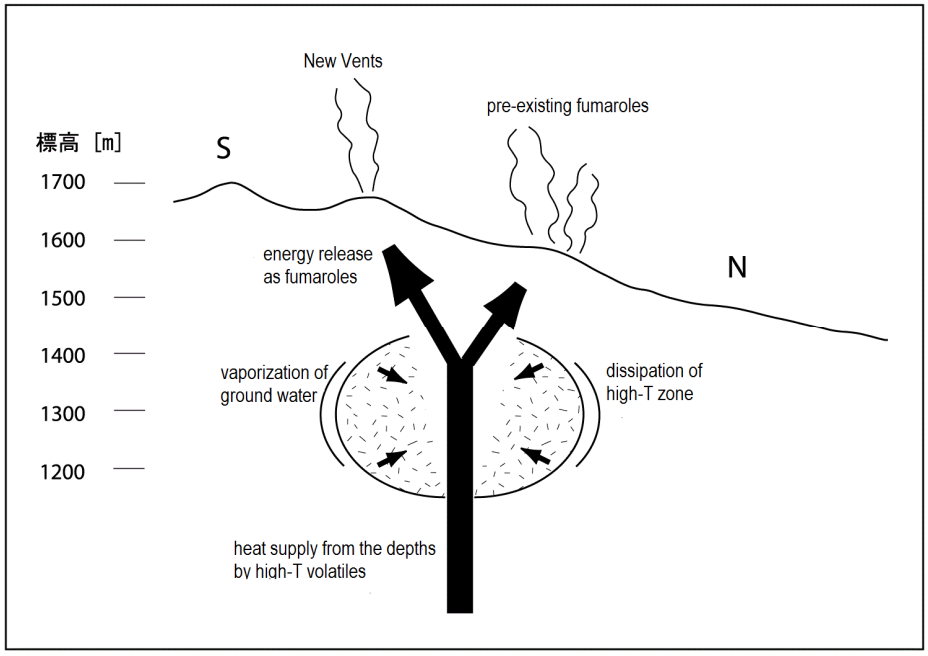


Figure 83-11 Schematic image of head discharging process of Kuju-loyama as inferred from geomagnetic changes (Hashimoto et al. (2002))

Since 1995, cooling has been progressing at the shallow part of underground.

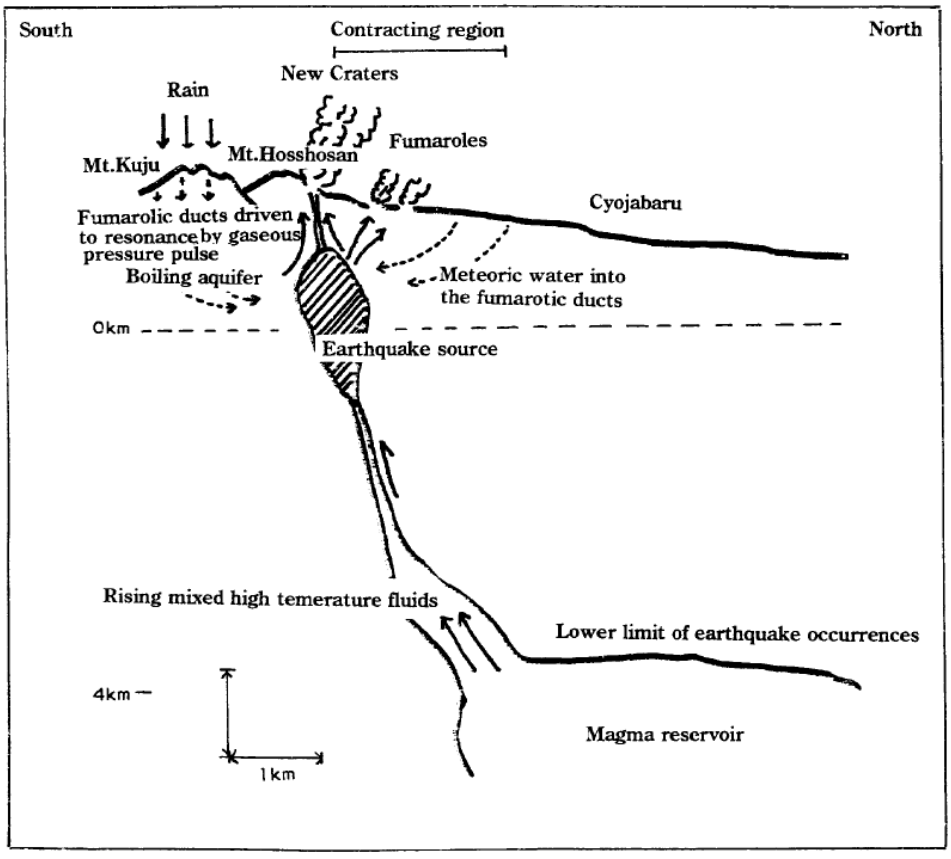


Figure 83-12 Conceptual model of shallow seismic process underneath Kuju-loyama (Sudo (1997)).

Recent Volcanic Activity

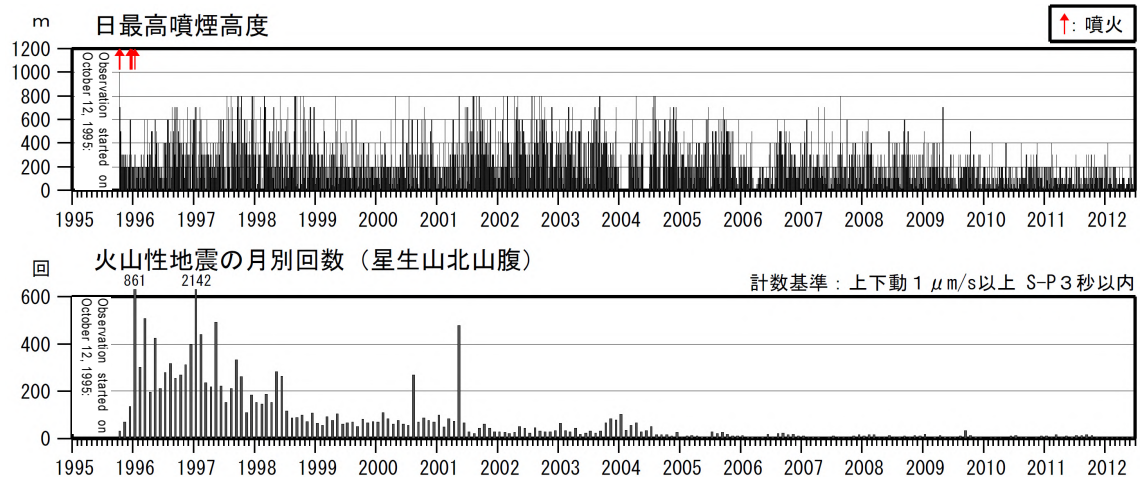


Figure 83-13 Volcanic activity (October 12, 1995 to June 30, 2012).

①Daily maximum volcanic plume height

②Number of volcanic tremors per month (North flank of Hosshozan)

Fume activity has been observed, but few earthquakes occur, and volcanic activity is calm.

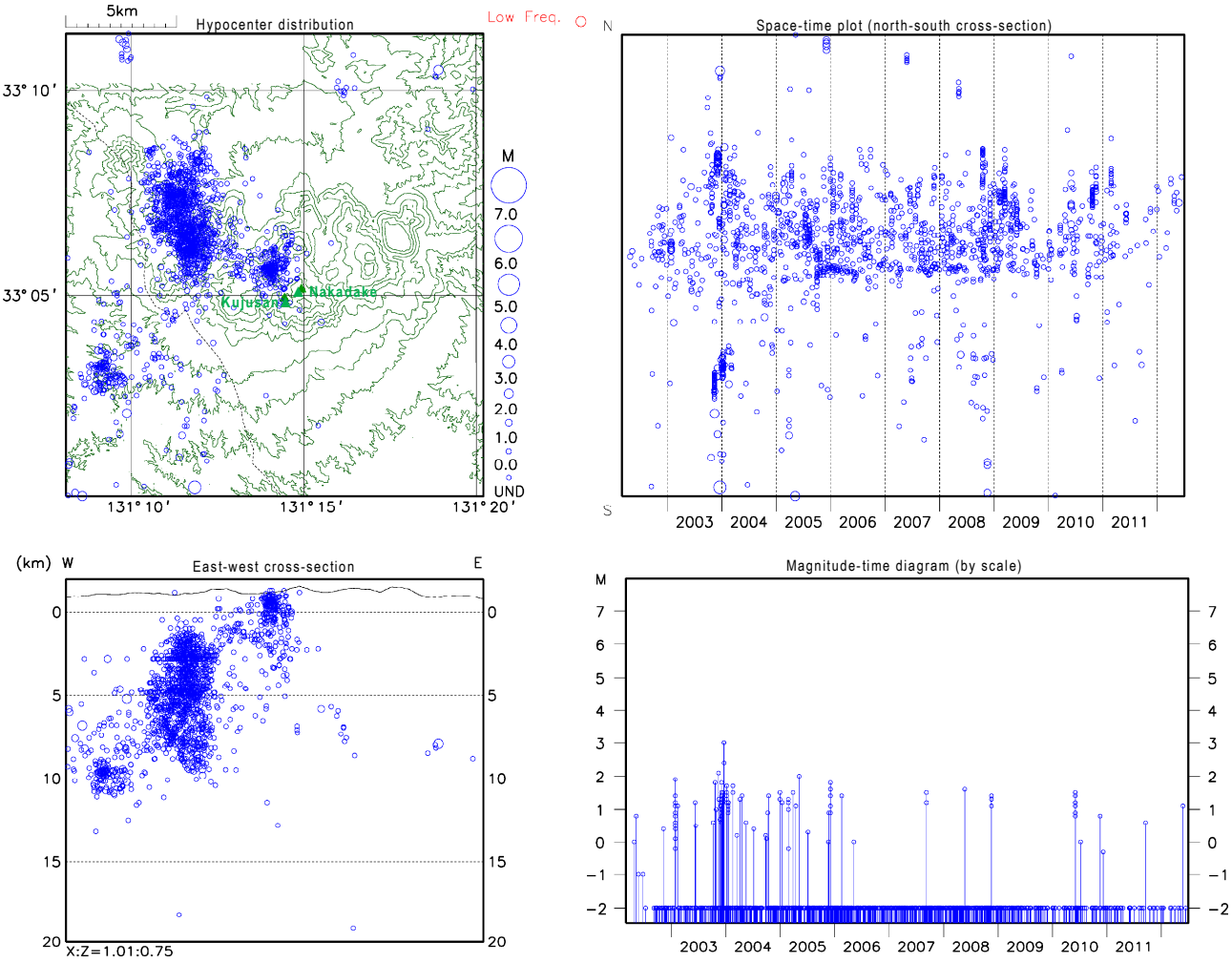


Figure 83-14 Distribution of volcanic earthquakes at Kujusan (2002 to June 30, 2012).

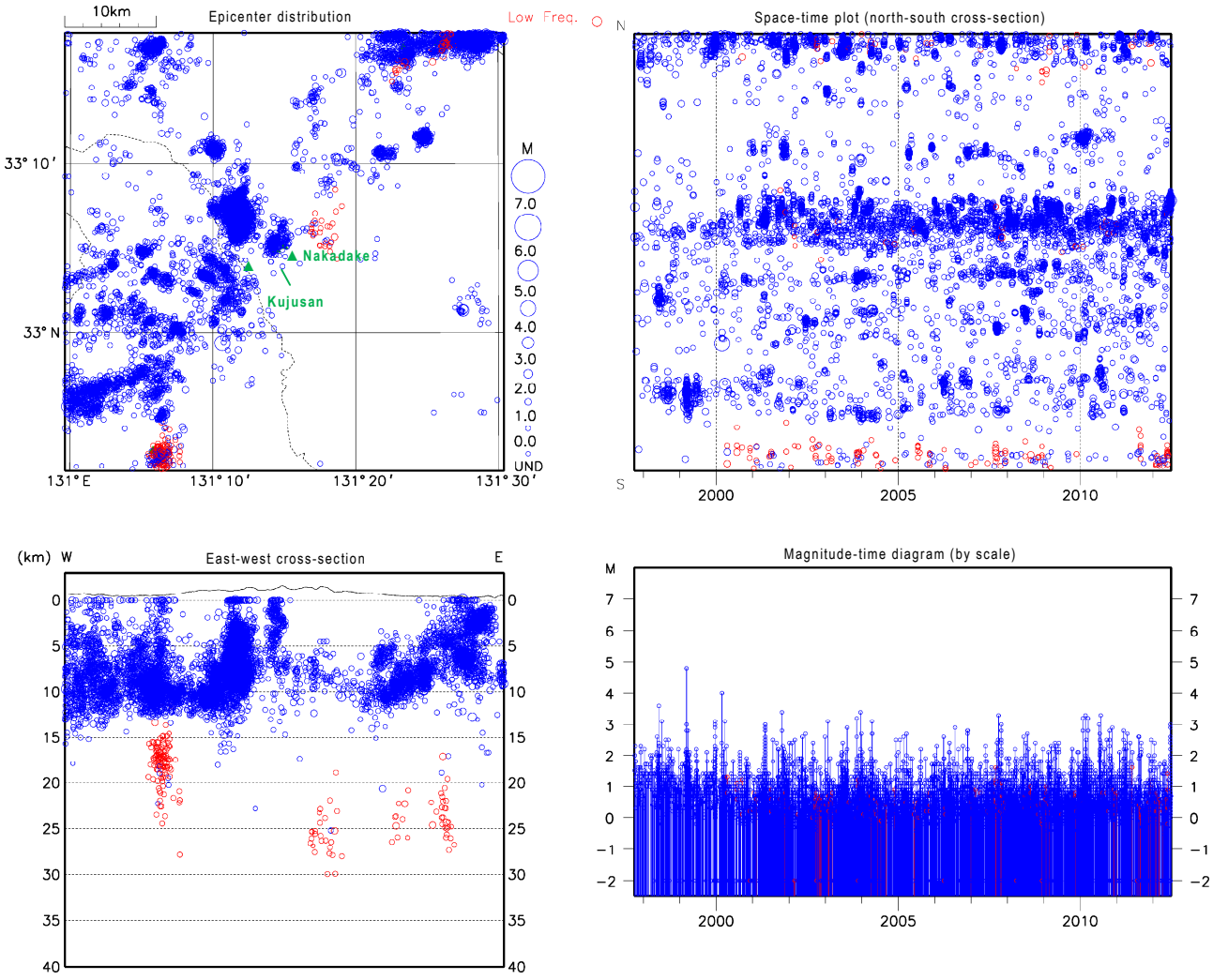


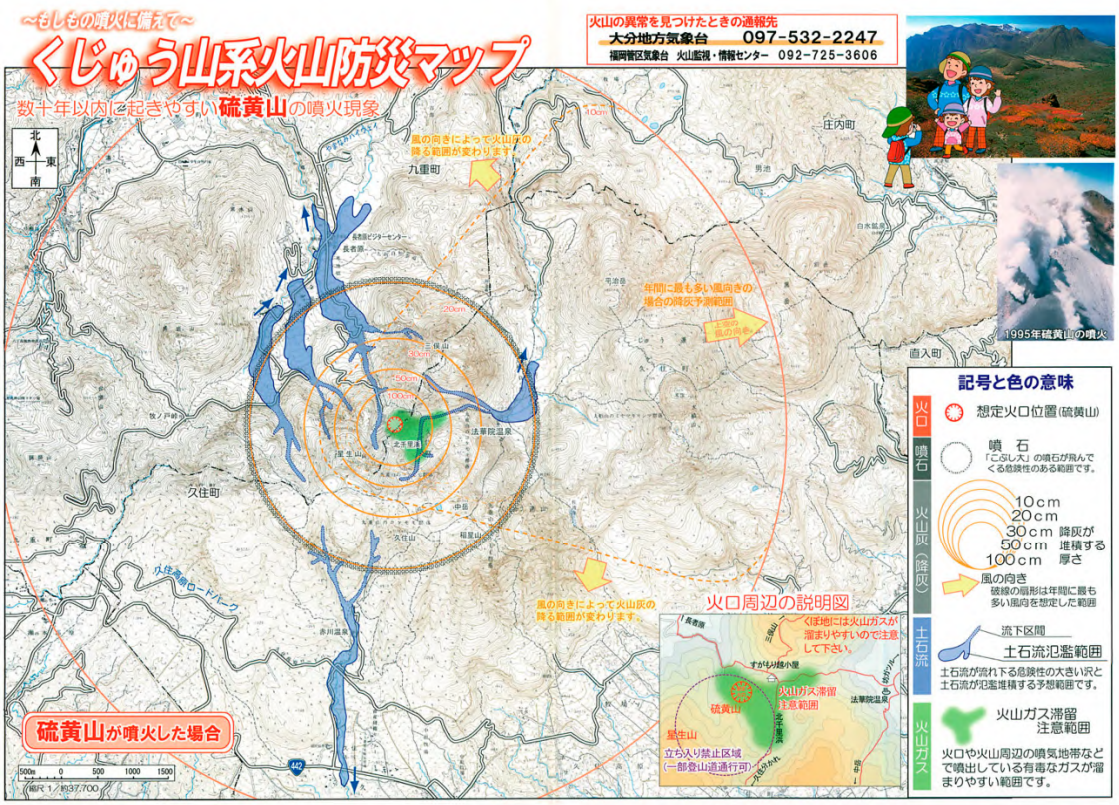
Figure 83-15 Activity of shallow VT earthquakes (blue circles) and deep low-frequenc y earthquakes (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter di stribution (upper left), space-time plot (N-S cross-sec tion) (upper right), E-W cross -section (lower left) and magnitude-time diagram (lower right).

Information on Disaster Prevention

①Hazard Map

Kuju Mountains Volcano Disaster Prevention Map 2004 (Heisei 16) March - Published by Sabo Division, Civil Engineering and Construction Department, Oita Prefectural Government.

http://www.pref.oita.jp/site/sabo/volcano.html



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

■九重山　噴火警戒レベルと必要な防災対応

●噴火警戒レベルに応じて下記のような防災対応が必要になります。

レベル5（避難）：
危険な居住地域からの避難
・2km以内で、法華院温泉は避難、長者原は避難準備、やまなみハイウェーは長者原から牧ノ戸間は通行止め

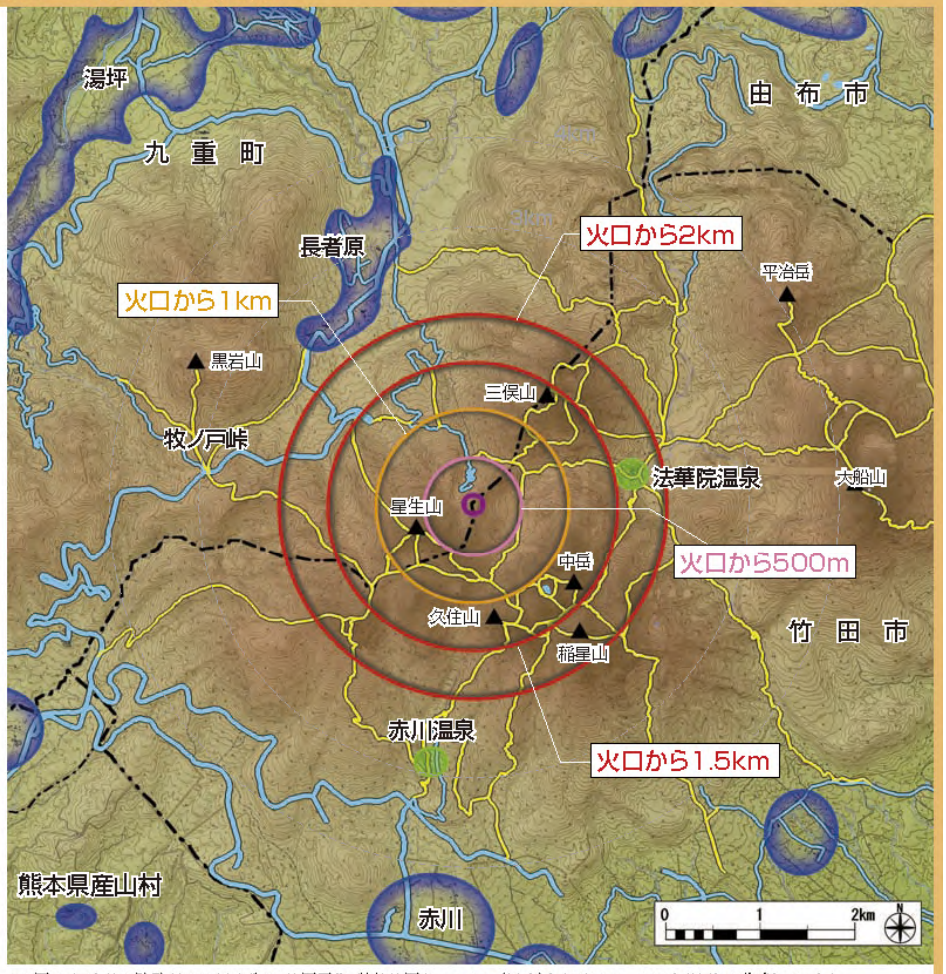
レベル4（避難準備）：
警戒が必要な居住地域での避難準備。要援護者は避難等。
・2km以内で、法華院温泉は避難準備、長者原は注意喚起、範囲内のやまなみハイウェーは駐停車禁止

レベル3（入山規制）：
火口から概ね1.5km以内立入禁止。○（1.5km）の範囲内
・法華院温泉は注意喚起
・主な登山口に通行できない登山道を示した看板の設置

レベル2（火口周辺規制）：
火口から概ね1km以内の立入禁止。○の範囲内
・主な登山道に通行できない登山道を示した看板の設置

レベル1（平常）：
火口から概ね500mの立入規制等。○の範囲内

：一般道
：登山道
：硫黄山
：居住区域（特定地域）
：居住区域



この図は、国土地理院発行の2万5千分の1地図画像、数値地図50mメッシュ（標高）およびカシミール3Dを使用して作成しています。

■この図は、大分県による九重山防災マップをもとに、くじゅう山系（硫黄山）火山防災協議会及び地元自治体と調整して作成しています。
■各レベルにおける具体的な規制範囲等については、地域防災計画等で定められていますので、詳細については地元自治体（九重町、竹田市、由布市）にお問い合わせください。

Volcanic Alert Levels for the Kujusan Volcano (Valid as of December 1, 2007)

Warning and Forecast	Target Area	Levels & Keywords	Expected Volcanic Activity	Actions to be Taken by Residents and Climbers	Expected Phenomena and Previous Cases
Eruption Warning	**Residential areas and areas closer to the crater**	**5 Evacuate**	**Eruption or imminent eruption causing significant damage to residential areas**	**Evacuate from the danger zone**	●Eruption or imminent eruption, with volcanic blocks, pyroclastic flow, and/or lava flow reaching residential areas. Past Examples 1,700 years ago Eruption at Kurodake, with pyroclastic flow extending approximately 4 km from crater, and lava flow extending approximately 2 km from crater.
		4 Prepare to evacuate	**Possibility of eruption causing significant damage to residential areas (increased probability).**	**Those within the alert area should prepare for evacuation. Those requiring protection in the event of an disaster must be evacuated.**	●Possibility of scattering of volcanic blocks, pyroclastic flow, and/or lava flow, with eruption extending to residential areas in the event of expansion. Past Examples 2,000 years ago Lava flow extended approximately 4 km from the Komekubo crater.
Crater Area Warning	**Non-residential areas near the volcano**	**3 Do not approach the volcano**	**Eruption or prediction of eruption causing significant damage to areas near residential areas (entering area is life threatening).**	**Residents can go about daily activities as normal. When necessary, evacuation preparations should be performed for those requiring protection in the event of a disaster. Access restrictions for dangerous areas, including mountain climbing and mountain access prohibitions, etc.**	●Scattering of volcanic blocks within a distance of approximately 1.5 km from the crater. Past Examples No observed examples in historical times.
	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. 1995 Eruption Example Very small-scale eruption on flank of Hosshozan.
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 area within 500 m.

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) Levels 1 through 3 are envisioned for eruptions at Ioyama (eastern flank of Hosshozan).

Social Circumstances

①Populations

(According to basic counts, such as 2010 national population census (Bureau of Statistics of the Ministry of Internal Affairs and Communications: released October 26, 2011))

Kokonoe Town population: 10,421

Taketa City population: 24,423 (Former Kuju: 4,317, former Naoiri: 2,381)

Yufu City population: 34,702 (Former Shonai: 8,366)

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

Aso Kuju National Park - Kuju area

Number of mountain-climbers per year: 103,985

(Reference value: Number of people accessing mountain, counted by counter at Makinoto Toge trail entrance)

(Kuju ranger office, Kyushu regional environmental office, Period: November, 2010 to October, 2011)

③Facilities

・Kokonoe Town

Chojabaru Visitor Center

Monitoring Network

Wide Area

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

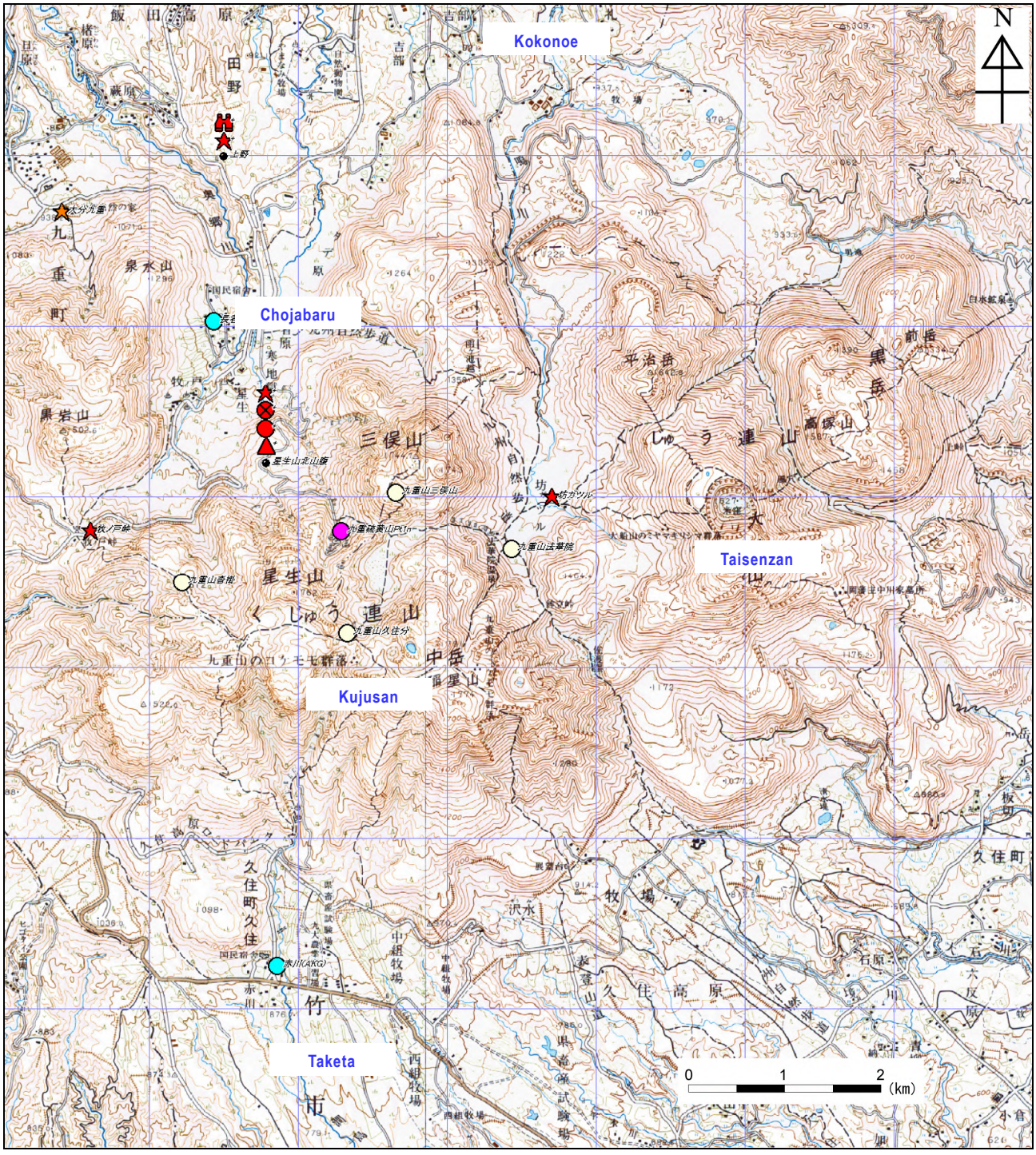
1:200,000 scale regional map (Oita) published by the Geospatial Information Authority of Japan was used.

Legend

(JMA)	(GSI)	(NIED)	(AVL.)	(Oita Pref.)
seismometer(SP)	GPS	Hi-net	seismometer(SP)	seismometer(SP)
GPS		K-NET		
tiltmeter		KiK-net		
infrasonic microphone			(Kyushu Univ.)	(Municipalities)
visual camera			seismometer(SP)	seismic intensity meter

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 (Miyahara and Kuju) published by the Geospatial Information Authority of Japan were used.

Legend

(JMA)	(GSI)	(AVL.)	(Oita Pref.)
seismometer(SP)	GPS	seismometer(SP)	seismometer(SP)
GPS			
tiltmeter		(Kyushu Univ.)	
infrasonic microphone		seismometer(SP)	
visual camera			

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