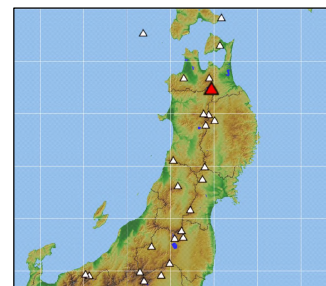


## 24. Towada

Latitude: 40°27'34" N, Longitude: 140°54'36" E, Elevation: 690 m (Ogurayama)  
(Triangulation Point - Ogurayama)

Latitude: 40°30'37" N, Longitude: 140°52'48" E, Elevation: 1,011 m (Ohanabeyama)  
(Triangulation Point - Zendana)



Overview of Towada taken from southeast side on March 23, 2008 by the Japan Meteorological Agency

### Summary

The Towada volcano is composed of pre-caldera stratovolcanoes, called the Towada caldera, and a post-caldera stratovolcano and lava domes. It became active approximately 200,000 years ago, forming pre-caldera stratovolcanoes through repeated discharges of basaltic andesite-dacite lava and explosive eruptions. Approximately 55,000 years ago it entered its caldera-forming stage, and it repeated large-scale plinian and phreatomagmatic eruptions. At least three relatively large pyroclastic flow eruptions occurred. Approximately 55,000 years ago an andesite-dacite pyroclastic flow occurred (Okuse pyroclastic flow). Approximately 36,000 years ago a rhyolite pyroclastic flow occurred (Ofudo pyroclastic flow). Approximately 15,000 years ago a dacite-rhyolite pyroclastic flow occurred (Hachinohe pyroclastic flow). These eruptions formed the Towada caldera, which is approximately 11 km in diameter. From approximately 15,000 to 12,000 years ago, intermittent lava effusions and explosive eruptions occurred in the south of the caldera, forming a small basaltic andesite-andesite stratovolcano (Goshikiwa volcano). After this, the volcanic activity shifted to dacite-rhyolite magmatic activity. At least 8 explosive eruptions occurred before 915, and the Nakanoumi crater, which measures 3km in diameter, was formed at the summit of the Goshikiwa volcano (Hayakawa, 1985; Matsuyama and Oike, 1986; Nakagawa et al., 1986; Kudo and Sasaki, 2007; Kudo, 2008, 2010a). During the post-caldera stage, the Ogurayama and Mikadoishi (Gomonishi) Lava Domes were formed. The Ogurayama Lava Dome was formed approximately 7,600 years ago (Kudo, 2010a). The formation age of the Mikadoishi Lava Dome can be estimated to be within 12,000 and 2,800 years ago on the basis of the temporal change of magma compositions in the post-caldera stage (Kudo, 2010b). The SiO<sub>2</sub> content of eruptive rocks is between 51 and 74 wt % (Hunter and Blake, 1995; Kudo, 2010a).

### Red Relief Image Map

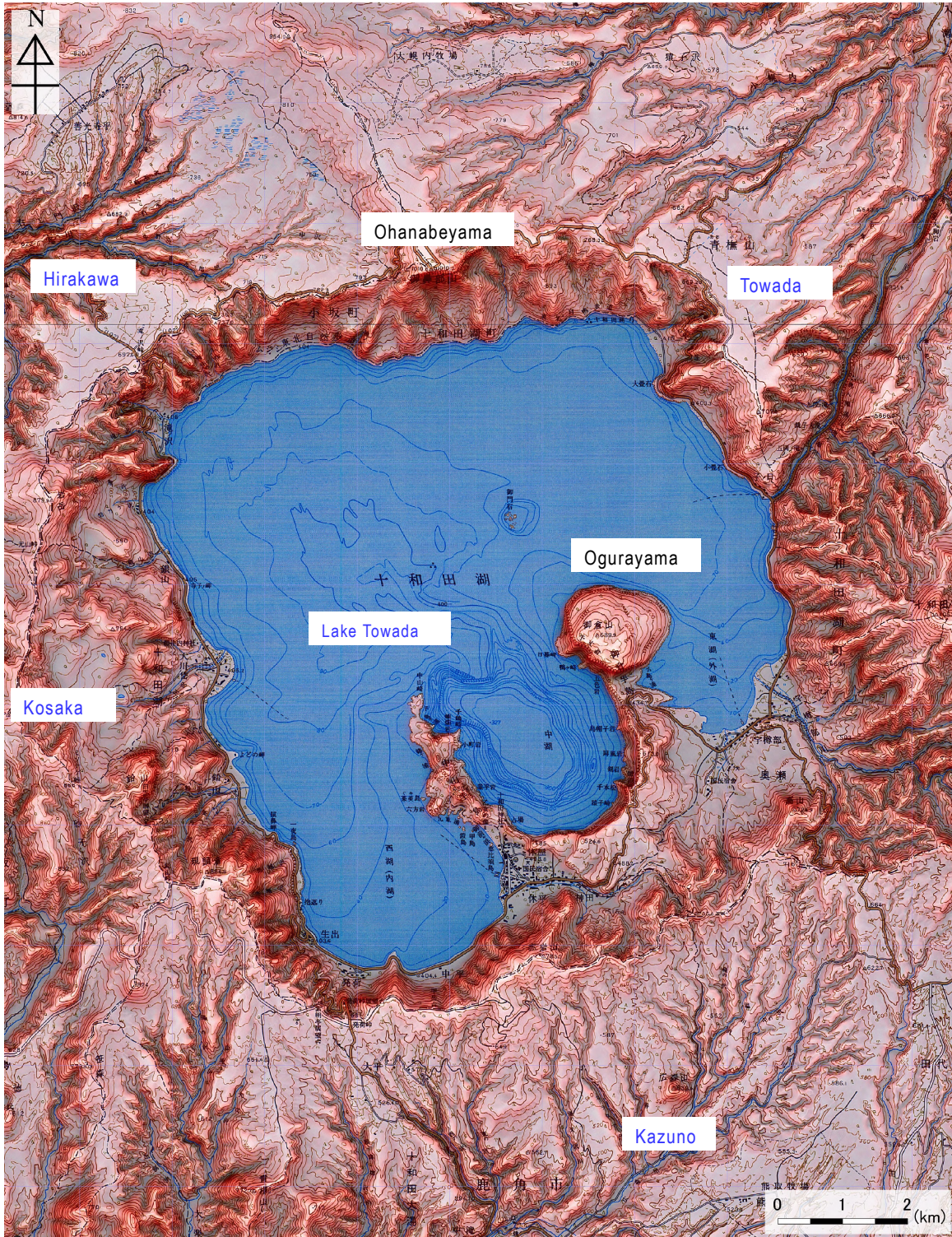


Figure 24-1 Topography of Towada.

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

## Chronology of Eruptions

### ▪ Volcanic Activity in the Past 10,000 Years

The Towada caldera was finally formed by the large-scale eruption 15,000 years ago. After the caldera formation, intermittent basaltic andesite-andesite magma eruptive activity continued for approximately 4,000 years, forming the Goshikiwa volcano. After that, at least 8 explosive plinian and phreatomagmatic eruptions of dacite-rhyolite magma occurred from 11,000 years ago to the present. The Ogurayama Lava Dome was formed approximately 7,600 years ago on the northeastern slope of the Goshikiwa volcano. The most recent eruption was during the Heian Period, approximately 1,000 years ago (915, according to ancient documents). The plinian and phreatomagmatic eruption produced air-fall pyroclastic material and a pyroclastic surge, followed by a pyroclastic flow (Kemanai Pyroclastic Flow) (Hayakawa, 1985; Hayakawa and Koyama, 1998; Matsu-ura et al., 2004; Kudo and Sasaki, 2007; Kudo, 2008, 2010a; Hiroi and Miyamoto, 2010).

Period	Area of Activity	Eruption Type	Main Phenomena / Volume of Magma
10.3ka	Goshikiwa volcano	Magmatic eruption → phreatomagmatic eruption?	Natsuzaka Scoria, Kabayama Ash: Tephra fall. Magma eruption volume: 0.37 km <sup>3</sup> DRE.
9.3ka	Goshikiwa volcano	Magmatic eruption → phreatomagmatic eruption	Nambu Pumice: tephra fall → Kaimori Ash: Tephra fall and pyroclastic surge. Magma eruption volume: 0.54 km <sup>3</sup> DRE.
8.3ka	Goshikiwa volcano	Magmatic eruption → phreatomagmatic eruption	Oguni Pumice, Nakanosawa Ash: Tephra fall. Magma eruption volume: 0.16 km <sup>3</sup> DRE.
7.6ka	Ogurayama	Phreatomagmatic eruption → magmatic eruption	Herai Ash: Tephra fall → Ogurayama Lava Dome. Magma eruption volume: 0.29 km <sup>3</sup> DRE.
6.2ka	Nakanoumi	Magmatic eruption → phreatomagmatic eruption	Chuseri Pumice, Kanegasawa Pumice: Tephra fall → Utarube Ash: Tephra fall and pyroclastic surge. Magma eruption volume: 2.5 km <sup>3</sup> DRE.
2.8ka	Nakanoumi	Magmatic eruption → phreatomagmatic eruption	Mayoigatai Pumice, Sobe Ash: Tephra fall. Magma eruption volume: 0.35 km <sup>3</sup> DRE.

\* 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.

### ▪ Historical Activity

Year	Phenomenon	Activity Sequence, Damages, etc.
915 (Engi 14)	Magmatic eruption and phreatomagmatic eruption (lahar)	Oyu Pumice and Ash: Tephra fall and pyroclastic surge → Kemanai Pyroclastic Flow: Pyroclastic flow, lahar. The eruptive activity occurred at Nakanoumi. The eruption have climaxed on August 17. Magma eruption volume = 2.1 km <sup>3</sup> DRE. (VEI 5)

\* 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

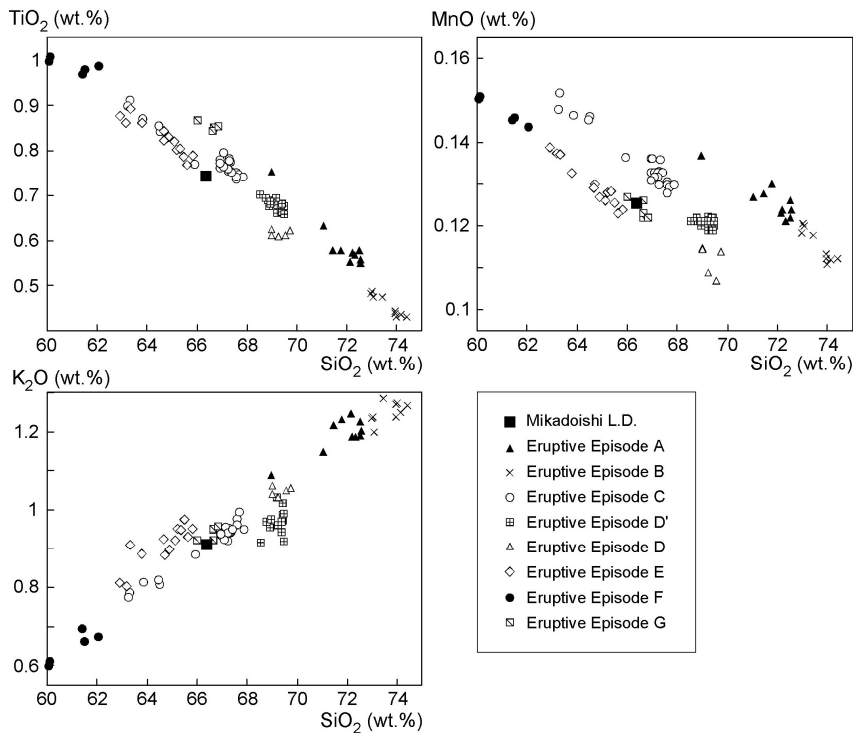


Figure 24-2 Whole rock chemical compositions of eruptive products from the post-caldera stage of Towada volcano (Kudo, 2010b).

Data for eruptive products from eruption episodes A to G are from Kudo (2010a).

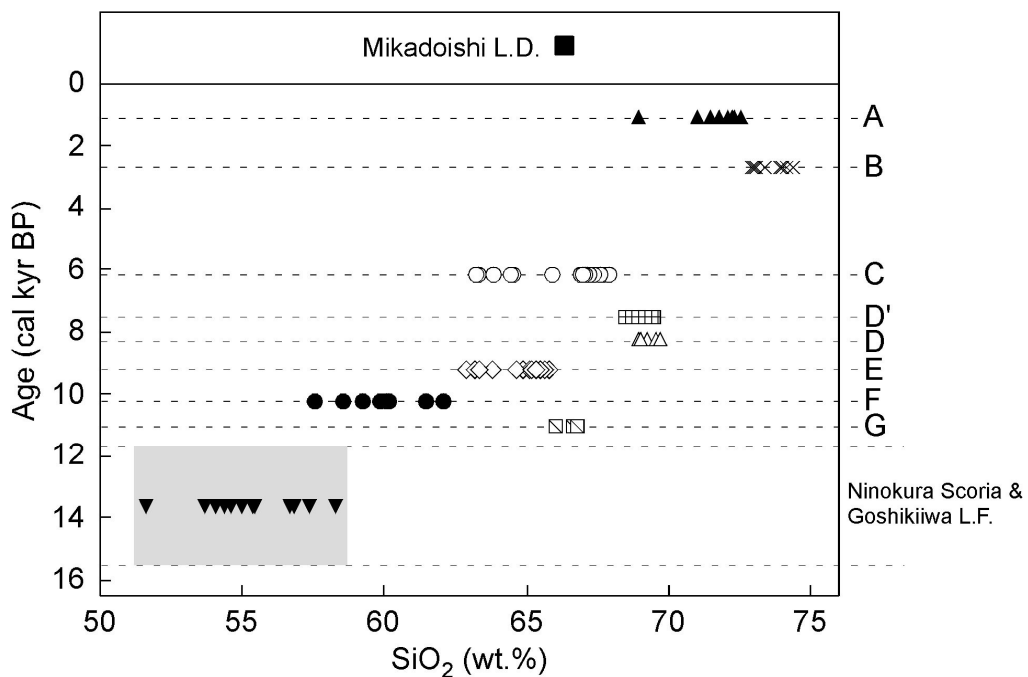


Figure 24-3 Temporal change of whole-rock SiO<sub>2</sub> contents of the eruptive rocks from the post-caldera stage of Towada volcano (Kudo, 2010b).

Data for the eruptive episodes A to G are from Kudo (2010a). Data for the Ninokura Scoria and Goshikiwa Lava Flows are from Chiba (1966), Taniguchi (1972), and Hunter and Blake (1995). L.F.: Lava flow.

### Period - Cumulative Magma Volume

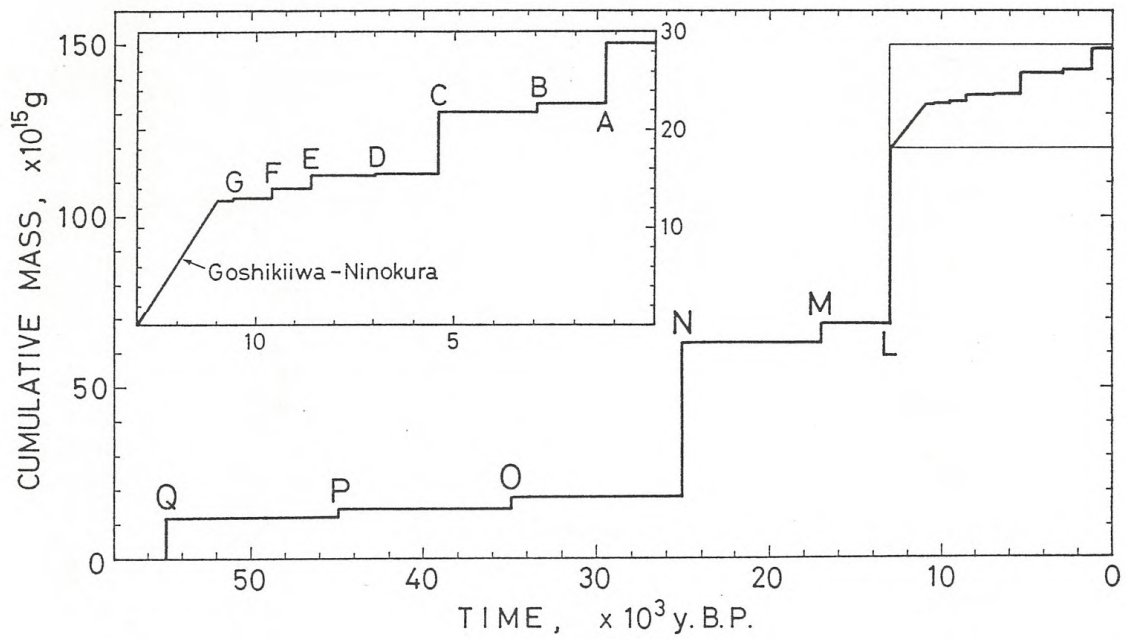


Figure 24-4 Time - cumulative magma mass of the Towada volcano(Hayakawa,1985)

Eruptive ages are based on research carried out until 1985, and are not converted into calendar years, so they vary slightly from the years presented in the Chronology of Eruptions section.

### Recent Volcanic Activity

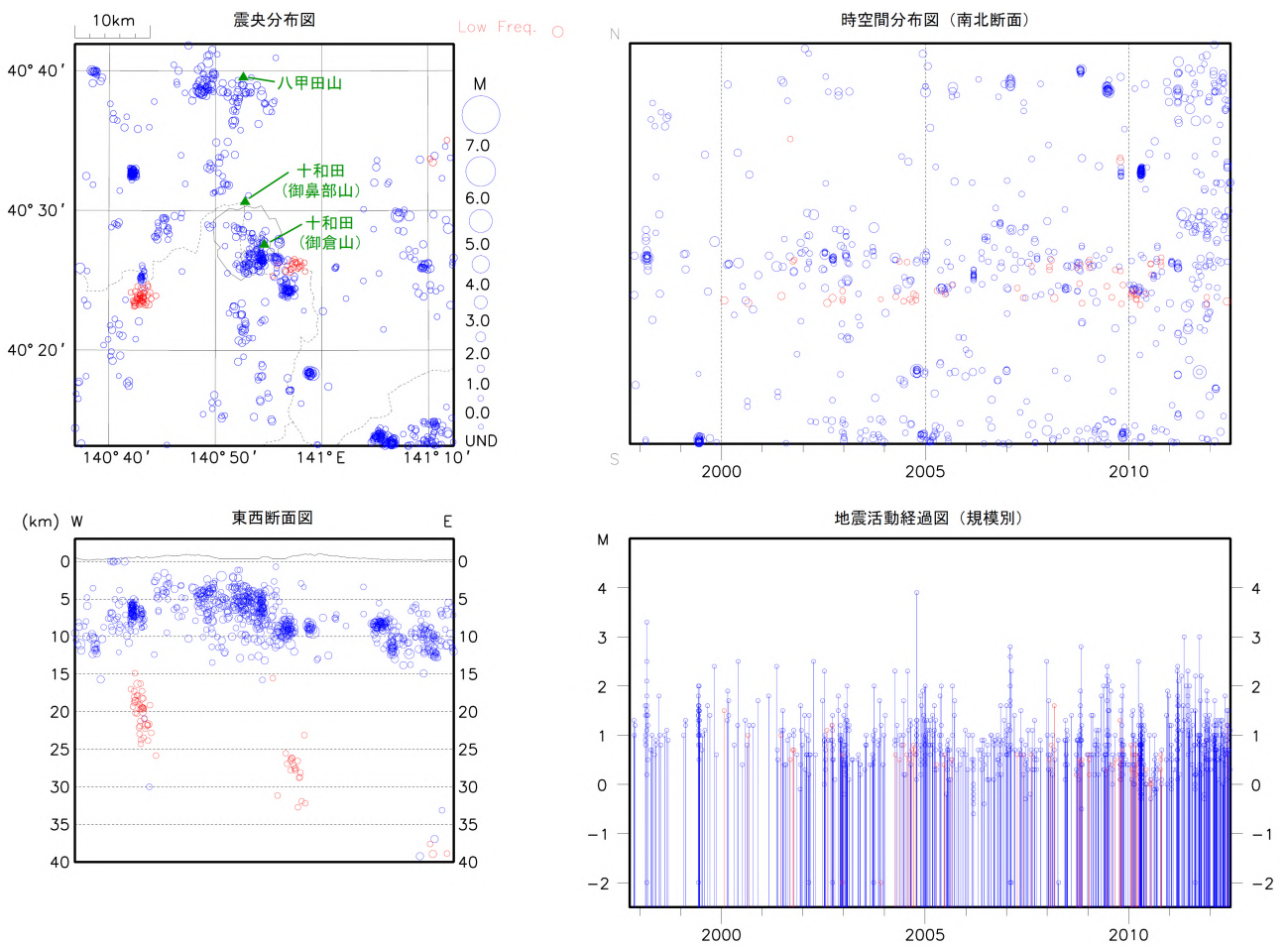


Figure 24-5 Shallow VT seismic activity (blue circles) and deep low-frequency seismic activity (red circles) observed by a regional seismometer network (October 1, 1997, to June 30, 2012). Epicenter distribution (upper left), space-time plot (N-S cross-section) (upper right), E-W cross-section (lower left) and magnitude-time diagram (lower right)

## Information on Disaster Prevention

### ① Hazard Map

None

## Social Circumstances

### ① Populations

- Aomori Prefecture

Towada City: 65,726 (as of October 31, 2011)

Hirakawa City: 33,829 (as of October 31, 2011)

Shingo Village: 2,979 (as of November 1, 2011)

- Akita Prefecture

Kosaka Town: 6,577 (as of April 1, 2007)

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

- Towada Hachimantai National Park - Towada

- Number of sightseers per year: 2,555,000

(total number for Towada Hachimantai National Park, according to Aomori Prefecture sightseeing statistics from 2009)

: Approximately 983,00 (according to 2010 Akita Prefecture sightseeing statistics)

### ③ Facilities

- Aomori Prefecture, Towada City

Towada Science Museum

# 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 topographic maps (Aomori, Hirosaki, Noheji and Hachinohe) published by the Geospatial Information Authority of Japan were used.

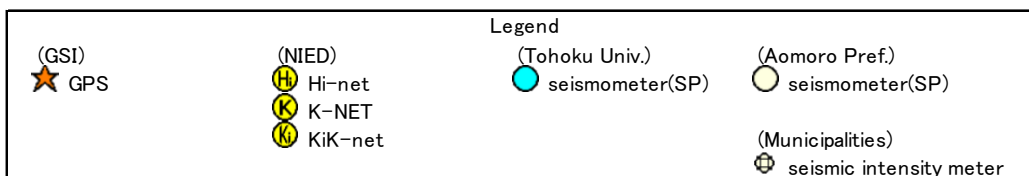


Figure 24-6 Regional monitoring network.



## Bibliography

- Chiba, M. (1966) Genesis of magmas producing pumice flow and fall deposits of Towada Caldera, Japan. *Bull. Volcanol.*, **29**, 545-558.
- Hayakawa, Y. (1985) Pyroclastic geology of Towada volcano. *Bull. Earthq. Res. Inst.* **60**, 507-592.
- Hayakawa, Y. and Koyama, M. (1998) Dates of Two Major Eruptions from Towada and Baitoushan in the 10th Century. *Bull. Volcanol. Soc. Japan*, **43**, 403-407 (in Japanese with English Abstract).
- Hiroi, Y. and Miyamoto, T. (2010) Reexamination of eruptive sequence of Heian eruption in Towada volcano, northeast Japan. Japan Geoscience Union Meeting 2010, SVC063-P35.
- Hunter, A. G. and Blake, S. (1995) Petrogenetic evolution of a transitional tholeiitic – calc-alkaline series: Towada volcano, Japan. *J. Petrol.*, **36**, 1579–1605.
- Kudo, T. (2008) Radiocarbon ages of the eruptive products from the eruptive episodes E and G, Towada volcano, Northeast Japan. *Bull. Volcanol. Soc. Japan*, **53**, 193-199 (in Japanese with English Abstract).
- Kudo, T. (2010a) Eruption age and sequence of Ogurayama Lava Dome at Towada volcano, Northeast Japan arc. *Bull. Volcanol. Soc. Japan*, **55**, 89-107 (in Japanese with English Abstract).
- Kudo, T. (2010b) Considerations on the formation age of Mikadoishi Lava Dome at Towada volcano, Northeast Japan. *Bull. Geol. Surv. Japan*, **61**, 477-484 (in Japanese with English Abstract).
- Kudo, T. and Sasaki, H. (2007) High-precision chronology of eruptive products during the post-caldera stage of Towada volcano, Northeast Japan. *Jour. Geogr. (Chigaku Zasshi)*, **116**, 653-663 (in Japanese with English Abstract).
- Matsu'ura, T. et al. (2004) Eruptive process of Towada-a tephra and emplacement temperature of proclastic flows. *Proceedings of the General Meeting of the Association of Japanese Geographers*, **66**, 195 (in Japanese with English Abstract).
- Matsuyama, C. and Oike, S. (1986) Eruptive products and volcanic activity of Towada volcano. *Towada Science Museum*, **4**, 1-64 (in Japanese).
- Nakagawa, H., et al. (1986) Distribution and features of eruptive products from Towada volcano. *Tohoku Regional Agricultural Administration Office*, 47p (in Japanese).
- Taniguchi, H. (1972) Petrological study on Towada volcano. *Jour. Japan. Assoc. Mineral. Petrol. Econ. Geol.*, **67**, 128-138 (in Japanese with English Abstract).

(Takarada, S.)