

Observation of Submarine Volcanic Activities
at
the Kaitoku Seamount and the Hukutoku-Oka-no-Ba Seamount
by
the Airborne Thermal Infrared Radiometer

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 Commission VII

1. Introduction

The Izu-Ogasawara Ridge is an island arc along the Izu-Ogasawara Trench where Pacific Plate subducts beneath the Philippine Sea Plate. Many active volcanic islands and submarine volcanoes exist in a line on the Izu-Ogasawara Ridge, and form a typical volcanic front. New volcanoes have been discovered on the front caused by volcanic activities at points where volcanic activity was not reported since the dawn of history.

Recently, new volcanic eruption was recognized at the sea bottom 400 meters east from the south point of Nisi-no-Sima (27°15'N, 140°53'E), west ward of the Ogasawara Islands, in May, 1973 since the dawn of history. This eruption formed a new island called "Nisinosima-Sin To" in September, 1973.

Moreover a new submarine volcanic activity was broken out at the Minami-Hiyosi Seamount (23°35.3'N, 141°54.3'E) which situated between Minami-Io Sima and Uracas Island in August, 1975. This activity flew out discolored water till March, 1978. In addition, discolored water was reported at the Nikko Seamount (23°04.5'N, 142°18.5'E) in July, 1979, and outflow of pumice caused by submarine eruption was found at the Hukuzin Seamount (21°56.0'N, 143°28.0'E) in August, 1951. The eruptions of the Hukuzin Seamount have often occurred since then.

Figure 1 shows the distribution of active volcanoes in the Nanpo Syoto.

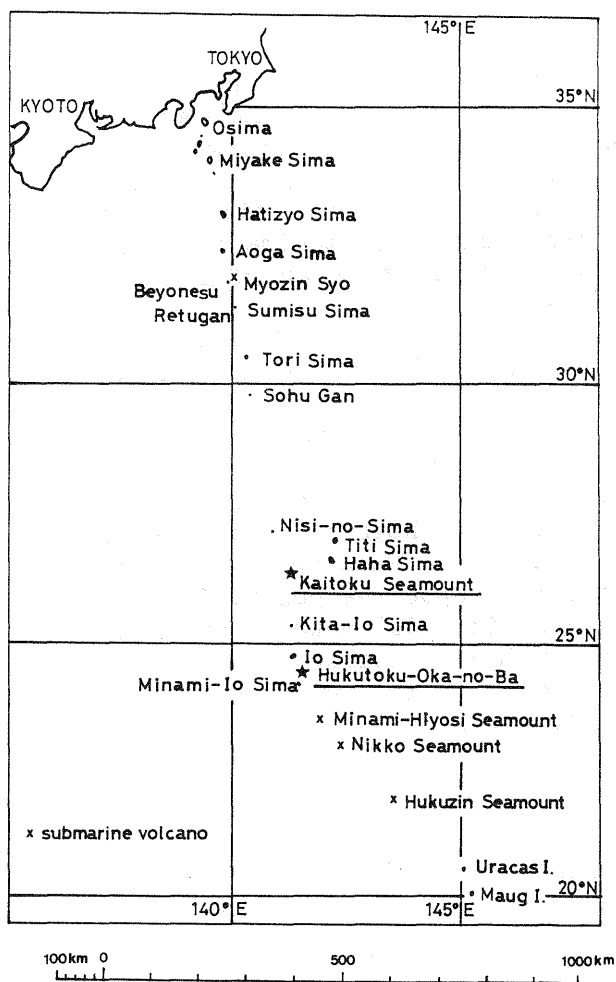


Figure 1. Distribution of Active
 Volcanoes in the Nanpo
 Syoto

2. Kaitoku Seamount

(1) The Progress of the eruption

Submarine eruption occurred at 26°07.3'N, 141°06.1'E, 75 km north of the Kita-Io Sima. As this area is a good fishing ground, many fishing boats of our country work at this ground. A fishing boat named Kaitoku-Maru (85 tons) discovered the shoal at 26°08.8'N, 141°06.6'E in April, 1927 and at 26°03.1'N, 140°56.0'E in June, 1927. Two shoals have been called the Higasi-Kaitoku-Ba and Nisi-Kaitoku-Ba, respectively.

This area has no reliable report of eruption, except one eruption report at 26°00'N, 140°46'E in 1543. Consequently the Nisi-Kaitoku-Ba is supposed a submarine volcano. Accordingly, the eruption of this time at the Higasi-Kaitoku-Ba is the first confirmation of submarine volcanic activity since the dawn of history at this area.

Submarine topographic data in this area is very few, however it is supposed one seamount having two summits of east and west. Therefore Maritime Safety Agency gave it a name to the Kaitoku Seamount.

Figure 2 shows a topography of the Kaitoku Seamount and the location of spouting point. Contour interval is 500 meters and the cross section indicates A-A' line in the topography (vertical enlargement is 5:1).

The progress of the eruption at the Kaitoku Seamount is as follows:

<u>Date</u>	<u>Observer</u>	<u>State of Activities</u>
March 7	Maritime Self Defence Force YS-11	Discovered a discolored water.
March 8	Maritime Safety Agency YS-11	Recognized the discolored water.
"	Maritime Self Defence Force P3C	About twenty volcanic blocks flew out to sea surface, the steam rose into the air from the blocks.
March 9	Maritime Safety Agency YS-11	The temperature of spouting point was 1.5°C higher than surrounding sea water, measured by the thermal infrared radiometer. (Photo. 1)

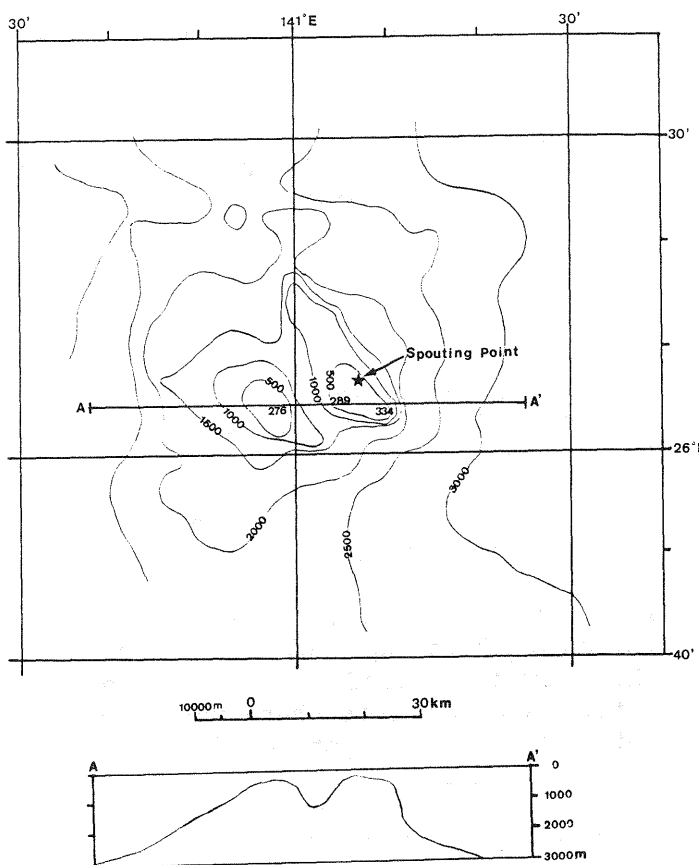


Figure 2. Topography of the Kaitoku Seamount and the Location of Spouting Point

March 12	Maritime Self Defence Force P2J	About ten volcanic blocks on the sea surface and steam from the blocks.
March 13	Maritime Safety Agency YS-11	The temperature of spouting point was more than 2°C higher than surrounding sea water, measured by the thermal infrared radiometer. (Photo. 2)
March 14	Patrol Vessel "Uruga" and her helicopter, Maritime Safety Agency	Measured the position of spouting point by Loran C; 26°07.3'N, 141°06.1'E and took a sample of discolored water.
March 15	//	Recognized the drifting of volcanic blocks and rising steam from the blocks. (Photo. 3)
March 17	//	// (Photo 4 and Photo 5)
March 29	Maritime Safety Agency YS-11	The temperature of discolored water was 0.4°C higher than surrounding sea water, measured by the thermal infrared radiometer. (Photo 6)

(2) Observation

The temperature measurements of spouting point and discolored water were made out on March 9, March 13 and March 29, 1984 by the airborne thermal infrared radiometer AGA 780 installed on an aircraft YS-11 belonging to Maritime Safety Agency. Table 1 shows a specifications of the thermal infrared radiometer AGA 780.

In case of temperature measurement using thermal infrared sensor, there needs some corrections for emissivity of the objects, for absorption of vapor of the air etc. But we made no correction because it was very difficult to get sea truth and to correct the observed data; discolored water caused by the submarine volcanic activities.

Table 1. Specifications of the Thermal Infrared Radiometer AGA 780

Item	Specification
Scanner	HgCdTe sensor thermal resolution 0.1°C spectral band 8μm-14μm
Lens	field of view 20°×20° geometrical resolution 3.4 milliradian focal distance 33mm
Monitor	black and white CRT screen size 50mm×50mm sensitivity 2°C-1000°C with isotherm function
Digital recording equipment (MT)	1/2 inch 9 tracks reel size 7 inch density 1600bpi record size 1024 characters picture elements 112×64
Monitor (visible images)	color video camera with color video monitor

A. March 9, 1984

Figure 3 shows a digital analyzed thermal map at 1030 on March 9, 1984 (altitude 300 meters). Discolored water was spouting from under the sea water at the measurement instant. So the higher temperature part was recognized circle (diameter was about 100 meters), and its circle was more than 1.5°C higher than surrounding sea water. In the circle, temperature changed from sea water to the circle, and the thermal distribution was very complex.

Figure 4 shows a digital analyzed thermal map at 1035 on March 9, 1984 (altitude 300 meters). The circular higher temperature part was

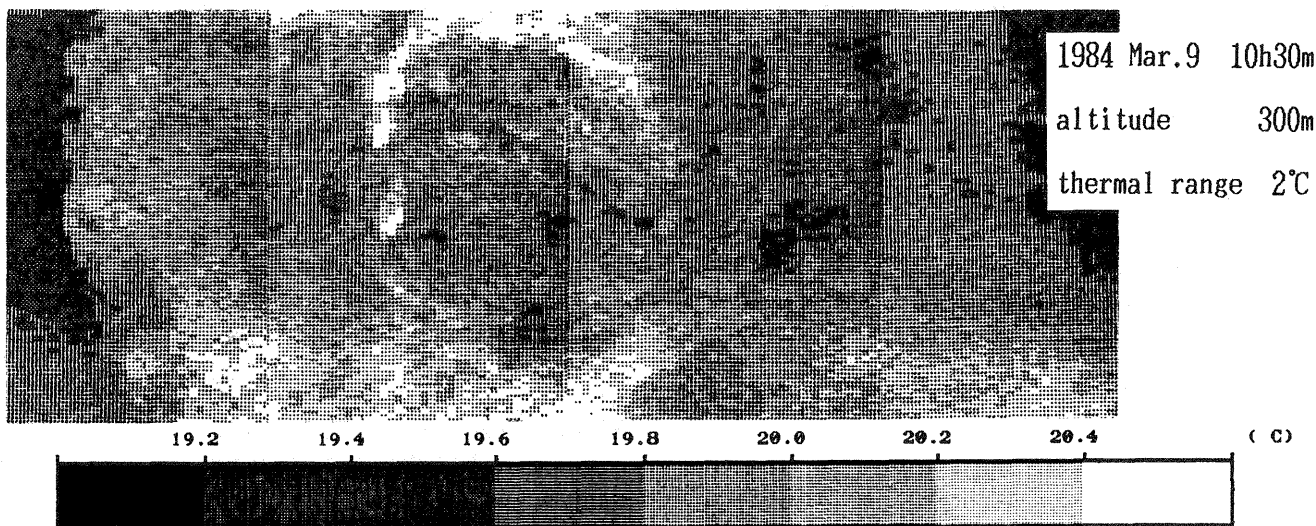


Figure 3. Digital Analyzed Thermal Map at 1030 on Mar. 9, 1984

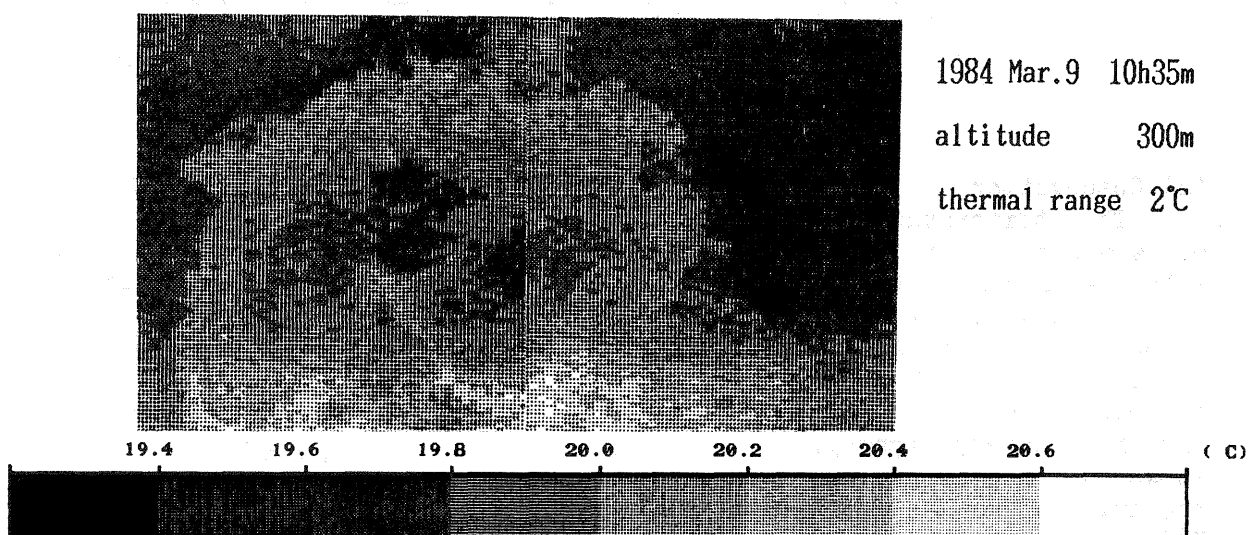


Figure 4. Digital Analyzed Thermal Map at 1035 on Mar. 9, 1984

changing to egg shape and the temperature differences between circle and sea water became smaller because of diffusion of sea water.

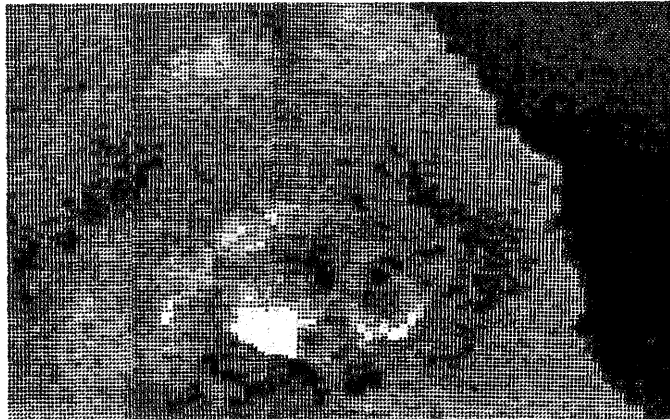
B. March 13, 1984

Figure 5 shows a digital analyzed thermal map at 620 on March 13, 1984 (altitude 1000 meters), and the measurement condition was just after the eruption occurred under the spouting point. So the spouting point was more than 2°C higher than surrounding sea water (because of using 2°C measurement range, data were saturated).

Figure 6 shows a digital analyzed thermal map at 625 on March 13, 1984 (altitude 1000 meters). Thermal distribution was much different from that of figure 5 though only 5 minutes had elapsed. The higher temperature part was small and the temperature differences were only 1°C or more. Thermal distribution was monotonous in comparison with that of figure 5.

C. March 29, 1984

Figure 7 and figure 8 show digital analyzed thermal maps at 1256 and at 1303 on March 29, 1984 (altitude 700 meters each). Volcanic



1984 Mar.13 06h20m

altitude 1000m

thermal range 2°C

17.2 17.4 17.6 17.8 18.0 18.2 18.4 (C)

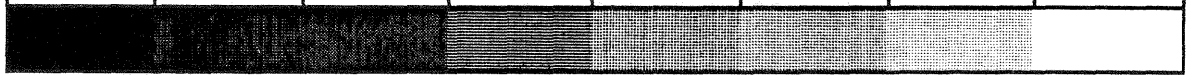


Figure 5. Digital Analyzed Thermal Map at 620 on Mar. 13, 1984



1984 Mar.13 06h25m

altitude 1000m

thermal range 2°C

17.0 17.2 17.4 17.6 17.8 18.0 18.2 (C)



Figure 6. Digital Analyzed Thermal Map at 625 on Mar. 13, 1984



1984 Mar.29 12h56m

altitude 700m

thermal range 2°C

17.2 17.4 17.6 17.8 18.0 18.2 18.4 (C)

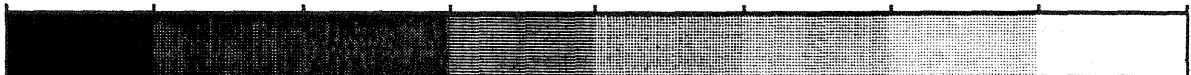


Figure 7. Digital Analyzed Thermal Map at 1256 on Mar. 29, 1984



1984 Mar.29 13h03m

altitude 700m

thermal range 2°C

17.6 17.8 18.0 18.2 18.4 18.6 18.8 (C)



Figure 8. Digital Analyzed Thermal Map at 1303 on Mar. 29, 1984

activities of the Kaitoku Seamount became low and the spouting point was not clear (refer to Photo 6), so there was no circle showing of high temperature, which had detected on March 9 and 13. The temperature of discolored water was only 0.4°C higher than surrounding sea water and the thermal distribution of discolored water was very monotonous.

(3) Results

Measurements of thermal distribution of discolored water caused by the volcanic activities of the Kaitoku Seamount were carried out on March 9, March 13 and March 29, 1984.

Results are as follows:

- The temperature of discolored water was about 0.5°C higher than surrounding sea water.
- The temperature of spouting point was more than 2°C higher than surrounding sea water.
- The thermal distribution of discolored water was very complex just after the spouting, then became monotonous according to the time elapsed.
- The thermal distribution of discolored water changed fast. Especially changing was fast just after the spouting, and thermal distribution pattern of 5 minutes after the spouting entirely showed another one. So the thermal distribution might be analyzed some varieties according to the measurement time.
- There was a low temperature part adjacent to the spouting point. This meant that sea water under the sea was pulled up by the spouting discolored water.
- High temperature water by the spouting diffused like a concentric circle.

3. Hukutoku-Oka-no-Ba Seamount

(1) The progress of the eruption

The birth of a new volcanic island was recognized on 20 January, 1986 at the summit of a seamount called the Hukutoku-Oka-no-Ba Seamount. The Hukutoku-Oka-no-Ba Seamount is a submarine volcano on southern part of the Sitito-Io Sima Ridge. The Hukutoku-Oka-no-Ba locates at 24°17.0'N, 141°29.1'E; NNW 2.6 nautical miles off Minami-Io

Sima, Ogasawara Islands.

This submarine volcano formed a volcanic island two times; in November, 1904 and in January, 1914. These new islands were vanished within one year in both cases. The Hukutoku-Oka-no-Ba Seamount is one of the most active submarine volcanoes in Japan and discolored water has been found incessantly more than ten years.

Figure 9 shows a topography around the Hukutoku-Oka-no-Ba Seamount surveyed by the survey vessel "Takuyo" in 1986. Contour interval is 100 meters and two cross sections indicate B-B' line and C-C' line each in the topography (vertical enlargement is 5:1).

The progress of the new-born volcanic island at the Hukutoku-Oka-no-Ba Seamount is as follows:

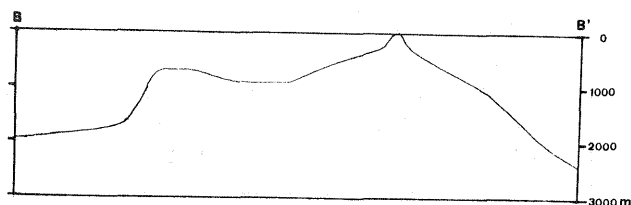
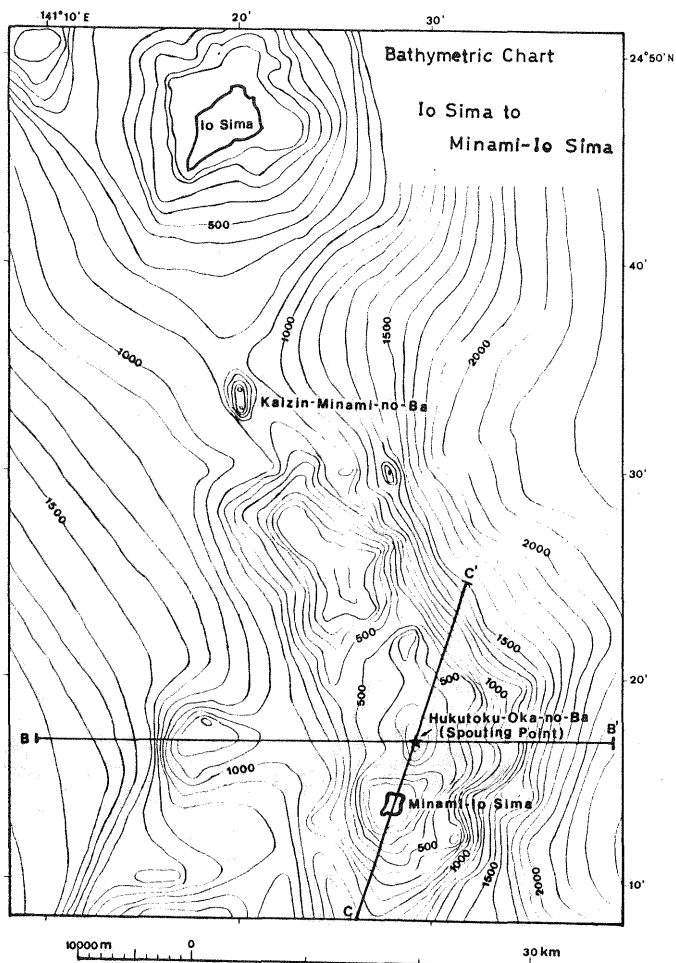


Figure 9. Topography of the Io Sima to Minami-Io Sima and Location of Spouting Point

Date	Observer	State of Activities
Jan. 19	Maritime Self Defence Force	Discovered smoke above the Hukutoku-Oka-no-Ba from Io Sima.
Jan. 20	Survey Vessel "Takuyo" Maritime Safety Agency	Recognized a new volcanic island in eruption. (Photo 7)
Jan. 21		Acme of eruption. (Photo 8)
Jan. 22	Patrol Vessel "Uruga" Maritime Safety Agency	Recognized eruption of the New island came to termination. After Jan. 22, the new island became small caused by wave erosion.
Mar. 26	Maritime Safety Agency YS-11	Recognized the new island vanished. (Photo 12)

(2) Observation

The temperature measurements of a new-born volcanic island were made out on January 21, January 23, January 29 and February 14, 1986 by the airborne thermal infrared radiometer AGA 780 on the YS-11.

We made no data correction because of same reason as the Kaitoku Seamount.

A. January 21, 1986

Figure 10 shows a digital analyzed thermal map at 1331 on January 21, 1986 (altitude 2300 meters). Small eruption had occurred just before the measurement, so the circular pattern in the center of the figure indicates volcanic smokes and the surface ground temperature of a new-born island, shown below and under the smokes in the figure, was lower than smokes. Temperature of smokes was 25.7°C-47.8°C, surface of new island was 28.2°C-34.8°C and sea water was 23.9°C.

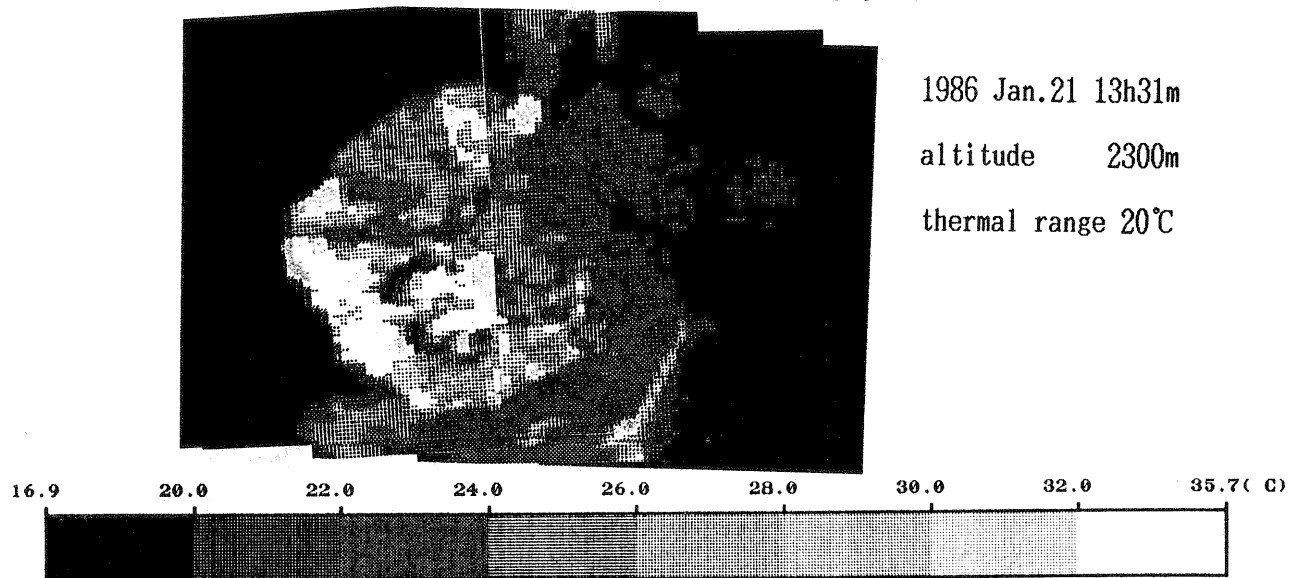


Figure 10. Digital Analyzed Thermal Map at 1331 on Jan. 21, 1986

B. January 23, 1986

Figure 11 shows a digital analyzed thermal map at 1334 on January 23, 1986 (altitude 1000 meters). Eruption was terminated and the vent was covered with sea water, but the temperature of sea water near above the vent was 0.5°C higher than surrounding sea water. So the volcanic activity still continued in the sea. Temperature of a new-born island was 24.2°C-26.3°C, discolored water was 23.0°C-23.6°C and sea water was 22.7°C.

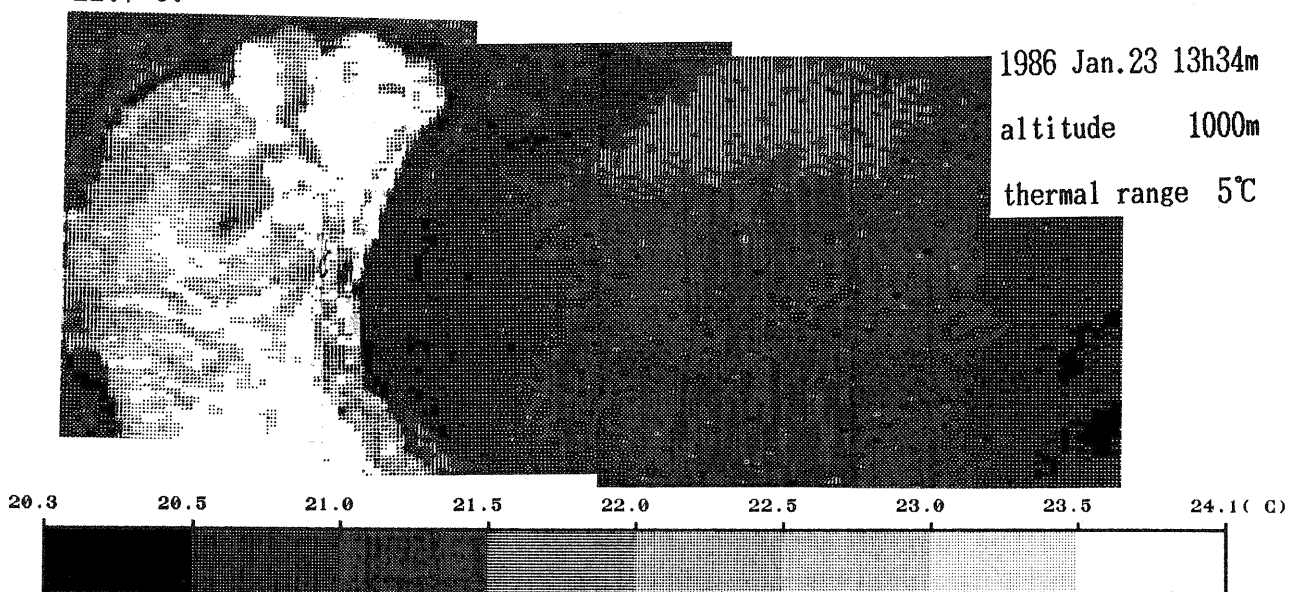


Figure 11. Digital Analyzed Thermal Map at 1334 on Jan. 23, 1986

C. January 29, 1986

Figure 12 shows a digital analyzed thermal map at 1304 on January 29, 1986 (altitude 2400 meters). Thermal range was set to 5°C, then the thermal map showing the temperature of a new-born island was saturated because surface temperature of the island might be more than 20°C still.

Figure 13 shows a digital analyzed thermal map at 1307 on January 29, 1986 with thermal range 10°C (altitude 2400 meters). Surface temperature of a new-born island was recognized in detail but sea water temperature became monotonous and could not discriminate between discolored water and surrounding sea water.

Temperature of a new-born island was 23.8°C-28.7°C, discolored water was 23.2°C-23.5°C and sea water was 23.0°C.

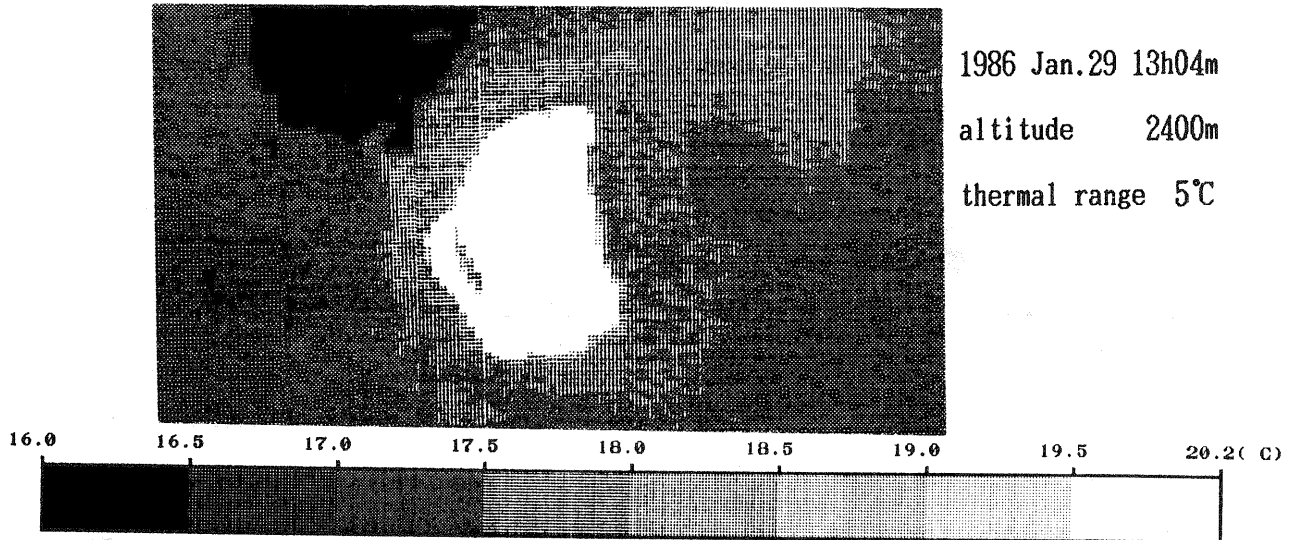


Figure 12. Digital Analyzed Thermal Map at 1304 on Jan. 29, 1986

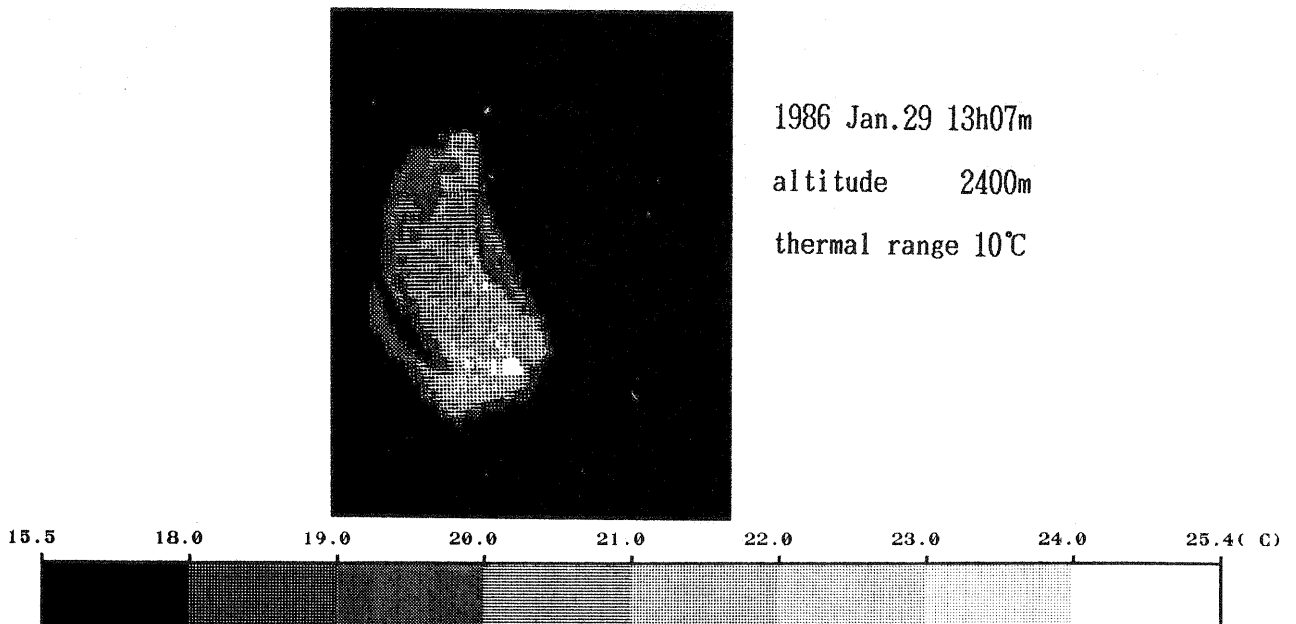


Figure 13. Digital Analyzed Thermal Map at 1307 on Jan. 29, 1986

D. February 14, 1986

Figure 14 shows a digital analyzed thermal map at 1357 on February 14, 1986 (altitude 2200 meters). Thermal distribution became monotonous. Temperature of a new-born island was 25.4°C-28.3°C, discolored water was 23.2°C and sea water was 23.0°C.

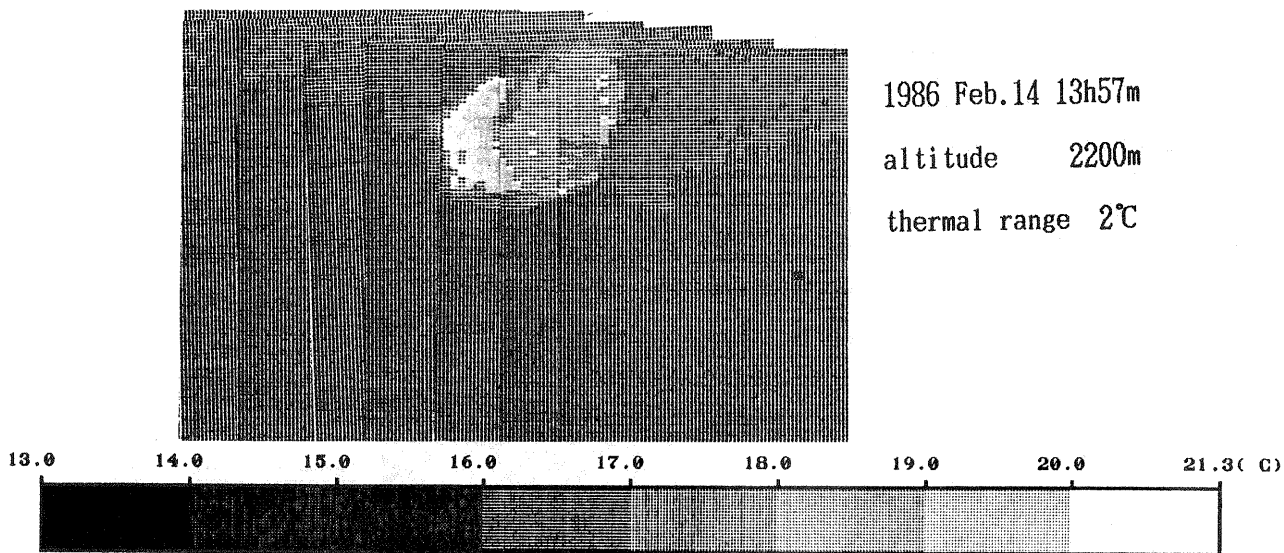


Figure 14. Digital Analyzed Thermal Map at 1357 on Feb. 14, 1986

(3) Results

Observation of volcanic activity of a new-born island were carried out using airborne thermal infrared radiometer and vertical multi-band camera installed on an aircraft YS-11 belonging to Maritime Safety Agency. Changing of the new island's topography and surface temperature are shown in figure 15.

Results are as follows:

- Period of volcanic activity was very short (only three days) and no lava erupted above sea surface was observed.
- Area of the new island was continuously decreased after the eruption terminated (figure 15).
- Surface temperature of the new-born volcanic island by the airborne thermal infrared radiometer was 30°C at the time of eruption. And after the eruptions surface temperature decreased to about 25°C.
- The temperature of discolored water was 0.2°C-1.0°C higher than surrounding sea water.

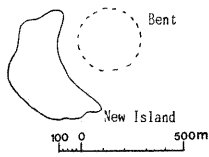

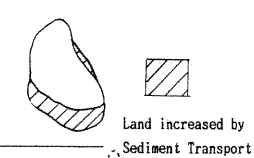



Date	Topography	Area	Temperature
1986. Jan.21		130,000m ²	Smoke 25.7-47.8 New Island 28.2-34.8 Sea Water 23.9
1986. Jan.23		126,000m ²	New Island 24.2-26.3 Discolored Water 23.0-23.6 Sea Water 22.7
1986. Jan.29		134,000m ²	New Island 23.8-28.7 Discolored Water 23.2-23.5 Sea Water 23.0
1986. Feb.14		80,400m ²	New Island 25.4-28.3 Discolored Water 23.2 Sea Water 23.0
1986. Mar.6		8,020m ²	
1986. Mar.9		2,150m ²	

Figure 15. Changing of Topography Area and Surface Temperature

- New-born island vanished because of no lava flows above sea surface. It was assumed that lava extended just below the sea surface, because very low area washed out always by wave existed more than two weeks before the extinction of the new-born island.

4. Summary

Thermal distribution of submarine volcanic activities at the Kaitoku Seamount and the Hukutoku-Oka-no-Ba Seamount was analyzed.

Volcanic activities at the Kaitoku Seamount had continued till June, 1984. After June 9, 1984, they have not been confirmed more than three years.

Discolored water from the Hukutoku-Oka-no-Ba Seamount has been continuously observed and sometimes the summit under sea water was discerned from discolored water.

Fortunately, we got samples of floating pumice and discolored water from both seamounts in active stage. Then chemical analysis was made and some important information on submarine volcanic eruptions became clear.

We detected that the temperature of spouting point just after the eruption was more than 2°C higher than surrounding sea water, but few minutes later its temperature decreased to 1°C or so. Accordingly, observations must be made timely and be continued for a long time.

However, many active submarine volcanoes around Japan locate in the distance from a observation base, so it is very difficult to make continuous observation or timely observation. In addition, submarine volcanoes rarely erupt and obtained data are precious.

We will conduct an investigation on submarine volcanic activities to get precious data.

Kaitoku Seamount



Photo 1.
Discolored water from the Kaitoku Seamount on Mar.9, 1984 (Around the Spouting Point)



Photo 2.
Discolored Water from the Kaitoku Seamount on Mar.13, 1984 (Spreading Center)



Photo 3.
Discolored Water from the Kaitoku Seamount on Mar.15, 1984

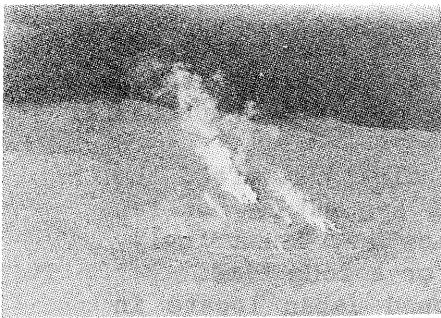


Photo 4.
Discolored Water from the Kaitoku Seamount on Mar.17, 1984



Photo 5.
Steam from the ejecta spouted by the Kaitoku Seamount volcanic activity on Mar.17, 1984

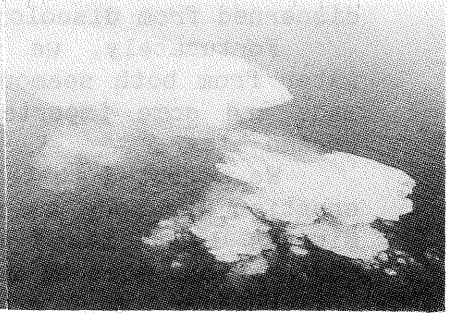


Photo 6.
Discolored Water from the Kaitoku Seamount on Mar.29, 1984

Hukutoku-Oka-no-Ba Seamount

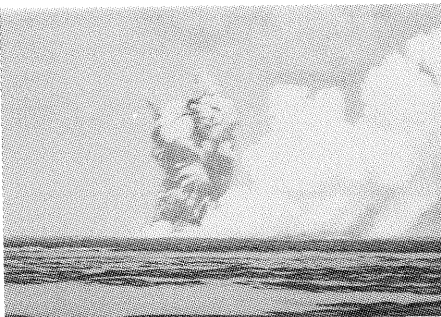


Photo 7.
Volcanic Eruption of the Hukutoku-Oka-no-Ba on Jan.20, 1986

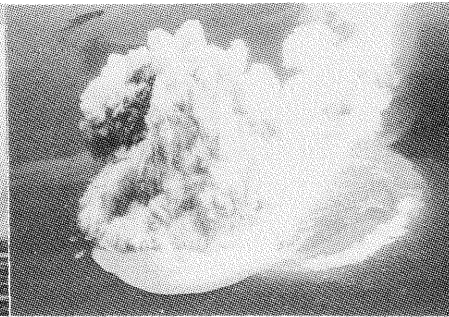


Photo 8.
Hukutoku-Oka-no-Ba on Jan.21, 1986 (just after the small eruption)

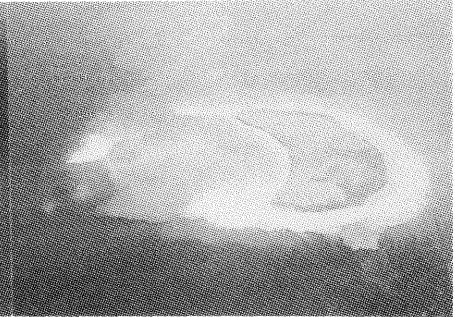


Photo 9.
New-born Island and Discolored Water on Jan.23, 1986



Photo 10.
New-born Island and Discolored Water on Jan.29, 1986

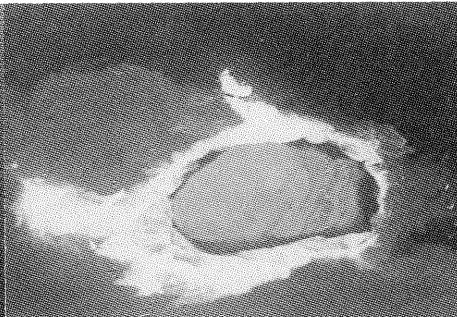


Photo 11.
New-born Island and Discolored Water on Feb.14, 1986

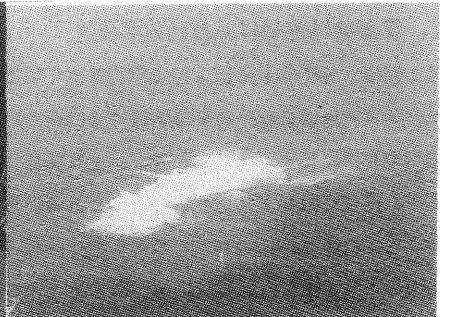


Photo 12.
Extinction of New-born Island on Mar.26, 1986