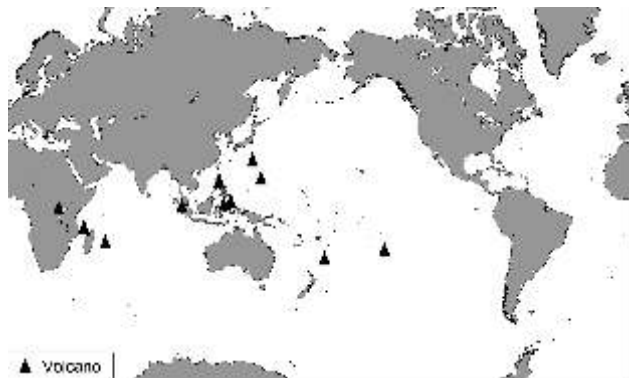


# Bulletin of the Global Volcanism Network

*Volume 32, Number 1, January 2007*



Smithsonian  
National Museum of Natural History

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The text of the *Bulletin* is also distributed through the Volcano Listserv ([volcano@asu.edu](mailto:volcano@asu.edu)).

*James F. Luhr*

Jim Luhr, director of our volcano program since 1995, passed away unexpectedly in his sleep on 1 January 2007. He was 53 years of age, and died of complications from influenza. He leaves behind his wife Karen Prestegaard, a professor at the University of Maryland, and their two school-aged daughters.

One of Jim's legacies is the greatly expanded public access to Smithsonian volcano data resulting from his promotion of the growth of our widely used website. In the mid-1990s, he helped create a new exhibit hall exposing millions of visitors each year to displays with significant emphasis on geophysics, plate tectonics, and volcanology (giving visitors electronic access to geologic and geophysical information).

Jim acted as chief editor of the graphically stunning book *Earth*. He also co-edited the book "Parícutín: The Volcano Born in a Mexican Cornfield," an outgrowth of his many detailed field and laboratory studies of Mexican volcanoes. Jim was well known for his work on the petrology of young volcanic rocks and the atmospheric impact of eruptions.

More detailed information about Jim can be found on the Global Volcanism Program website (<http://www.volcano.si.edu/>).

## Nyamuragira

Democratic Republic of the Congo, Central Africa  
1.408°S, 29.20°E; summit elev. 3,058 m  
All times are local (= UTC + 2 hours)

Jacques Durieux, the United Nations manager for Volcano Risk Reduction for the Goma Volcano Observatory (GVO), reported that at about 2000 on 26 October 2006 the observatory began to record sustained seismic activity. The activity took place in the Virunga area, located in the central part of Western arm of the East African rift valley. The swarm of long-period earthquakes was located around Nyamuragira and persisted for a month, through 1700 on 27 November 2006. The volcano was the scene of several seismic swarms in middle and late 2005 (*BGVN* 31:01).

GVO observed the beginning of a new eruption at 2000 on 27 November 2006 (figure 1). Seen from ~ 30 km S of the volcano in Goma, the eruption site appeared to be located on the S flank; intense red glow suggested typical lava fountains and lava flows.

The local security situation prevented closer field observations. GVO was attempting to organize helicopter overflights to collect more information for updates. One concern was that foraging animals could fall ill after eating ash-coated vegetation. In assessing the situation, authorities considered Goma to be safe from any potential lava flows as Mount Nyiragongo would serve as a buffer.

Based on satellite imagery, the Toulouse VAAC reported that during 29 November-2 December 2006 emissions produced ash plumes to altitudes of 3-6.1 km. Those plumes drifted W and NW. By mid-morning on 2 December, ash plumes were no longer reported.

Besides ash and possible lava, the volcano also released extensive sulfur dioxide (SO<sub>2</sub>), a feature of this volcano that has been mentioned repeatedly in the literature (see some references below). The Ozone Monitoring Instrument (OMI) on NASA's Aura satellite tracked the emission of this gas from the volcano from 28 November to 4 December 2006 (figure 2). The SO<sub>2</sub> gas was most concentrated around the eruption site and thinned as it moved away. The plume first traveled W, then curved along an arc progressing in a clockwise direction toward the NE and then E. It re-

mained clearly detectable over NW India, a distance of ~ 9,000 km.

The latest eruption of Nyamuragira was its 15th since 1980. Table 1 shows OMI's estimated SO<sub>2</sub> loadings during 28 November to 4 December 2006 as computed by Simon Carn. Carn also presented daily OMI images (like figure 2) during the same date range as table 1.

**References:** Carn, S.A., Bluth, G.J.S., and Head, E., (in progress), Virunga Volcanic SO<sub>2</sub> Emissions Research (ViSOR) project (discussed at URL: <http://userpages.umbc.edu/~scarn/virunga/index.htm>).

Carn, S.A., 2004, Eruptive and passive degassing of sulfur dioxide at Nyiragongo volcano (D.R. Congo): the 17 January 2002 eruption and its aftermath: *Acta Vulcanologica*, v. 14-15, p. 75-86.

Carn, S.A., and Bluth, G.J.S., 2003, Prodigious sulfur dioxide emissions from Nyamuragira volcano, D.R. Congo: *Geophys. Res. Lett.*, v. 30, no. 23, p. 2211, doi:10.1029/2003GL018465.

Bluth, G.J.S., and Carn, S.A., (in progress), Exceptional sulphur degassing from Nyamuragira volcano, 1979-2005: *Int. J. Remote Sensing*.



Figure 1. Aerial photograph of Nyamuragira in vigorous eruption with fire fountains venting along a broad linear zone, as seen from above the city of Goma. The photo was taken 27 November 2006 at 2300, one hour after the beginning of the eruption. Copyrighted photo provided by J. Durieux.

Tedesco, D., Vaselli, O., Papale, P., Carn, S.A., Voltaggio, M., Sawyer, G.M., Durieux, J., Kasereka, M., and Tassi, F., (in progress), The January 2002 Eruption of Nyiragongo volcano, Democratic Republic of Congo: *J. Geophys. Res.*

**Geologic Summary.** As Africa's most active volcano, Nyamuragira is classified as a massive high-potassium basaltic shield volcano that rises about 25 km N of Lake Kivu across the broad East African rift valley (NW of Nyiragongo volcano). Nyamuragira, also known as Nyamulagira, has a volume of 500 cu km, and extensive lava flows from the volcano blanket 1,500 sq km of the East African rift. The broad low-angle shield volcano contrasts dramatically with its steep-sided neighbor Nyiragongo. The 3,058-m-high summit of Nyamuragira is truncated by a small 2 x 2.3 km caldera which possesses walls approximately 100 m in height. Historical eruptions have occurred within the summit caldera (frequently modifying the morphology of the caldera floor) as well as from the numerous fissures and cinder cones on the volcano's flanks. Active since about 1921, the lava lake in the summit crater drained in 1938 (which seems to be contemporaneous with the oc-

currence of a major flank eruption). Historical lava flows extend down the flanks more than 30 km from the summit, reaching as far as Lake Kivu.

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## Karthala

Grand Comore Island, Western Indian Ocean  
11.75°S, 43.38°E; summit elev. 2,361 m

Karthala, in the Comoros Islands (figure 3), was a scene of elevated seismicity from October 2006 to January 2007. The last time an eruption of Karthala caused significant damage was in the 1970s when it destroyed a village S of the capital, Moroni. Presently, Karthala is monitored using seismic and ground deformation surveys. The seismic activity that began 28 May 2006 (BGVN 31:07) appeared to have been a singular event. Renewed seismicity on 29 October 2006 prompted authorities to warn island residents that one of the two volcanoes on the main island of Grand Comore (Karthala or La Grille) could erupt within the next few weeks.

Following earthquakes (which measured M 4 and larger on the Richter scale) that occurred on 12 January 2007, authorities again alerted the local population about hazards due to Karthala and activated a National Emergency Preparedness Plan. According to news reports, Hamidi Soule Saadi, director of the Karthala Volcano Observatory (KVO), warned that magma and gas were trapped inside the mountain.

According to a 15 January news article obtained from the ReliefWeb News, scientists from the KVO reported that an eruption occurred during the evening of 12 January. The news article noted Moroni residents observing jets of red flames above the summit (on the night of 12-13 January). A low eruptive tremor was detected 13 January and was accompanied by a number of M 4 earthquakes. An ash plume was observed above the volcano. Aerial obser-

Date	Sulfur dioxide, Tg (tetragram = 10 <sup>12</sup> g)
28 Nov 2006	0.21
29 Nov 2006	0.46
30 Nov 2006	0.68
01 Dec 2006	0.77
02 Dec 2006	0.78
03 Dec 2006	0.71
04 Dec 2006	0.59
<b>Total</b>	<b>4.20</b>

Table 1. Daily SO<sub>2</sub> flux at Nyamuragira, measured by OMI during 28 November to 4 December 2006. Courtesy of Simon Carn.

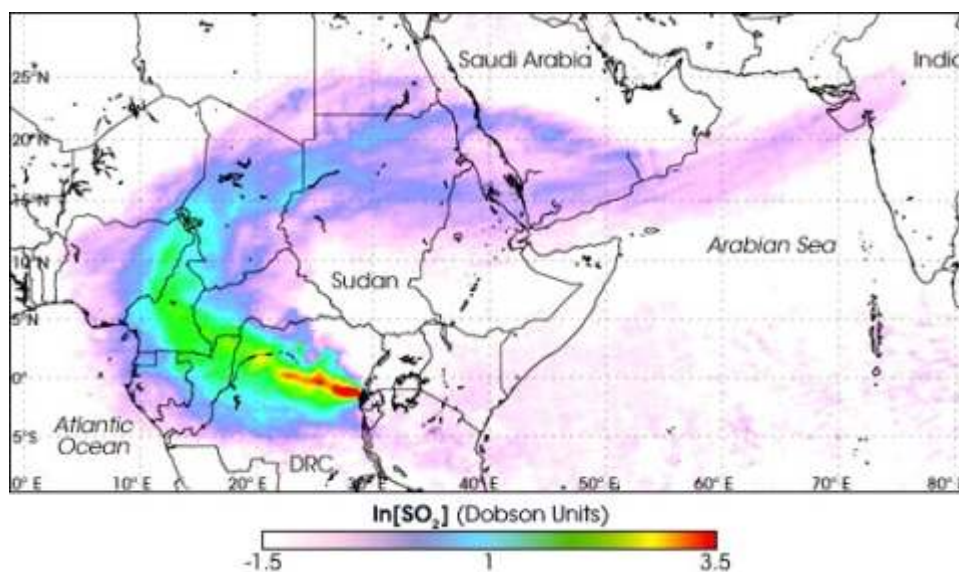


Figure 2. OMI measurements for 28 November-4 December 2006 looking at SO<sub>2</sub> emitted by Nyamuragira. OMI (which is basically a spectrometer) measured the atmospheric column daily, assessing the region between the satellite and the surface of the Earth, and this graphic depicts the average values of SO<sub>2</sub> thickness-concentration product during the multi-day interval. The thickness-concentration products are shown on a logarithmic color scale which utilizes Dobson Units (DU) [(1 milli-atm-cm = 1 DU = 10 ppm at STP (0° C, 1013.25 hPa). If all SO<sub>2</sub> in the air column were flattened into a thin layer at the Earth's surface at a temperature of 0° C, one Dobson Unit would make a layer of SO<sub>2</sub> 0.01 millimeters thick.] On the colored version of this figure, the greatest concentrations appear in red and the smallest concentrations appear in pale pinkish-lavender. Courtesy of NASA Earth Observatory and Simon Carn.

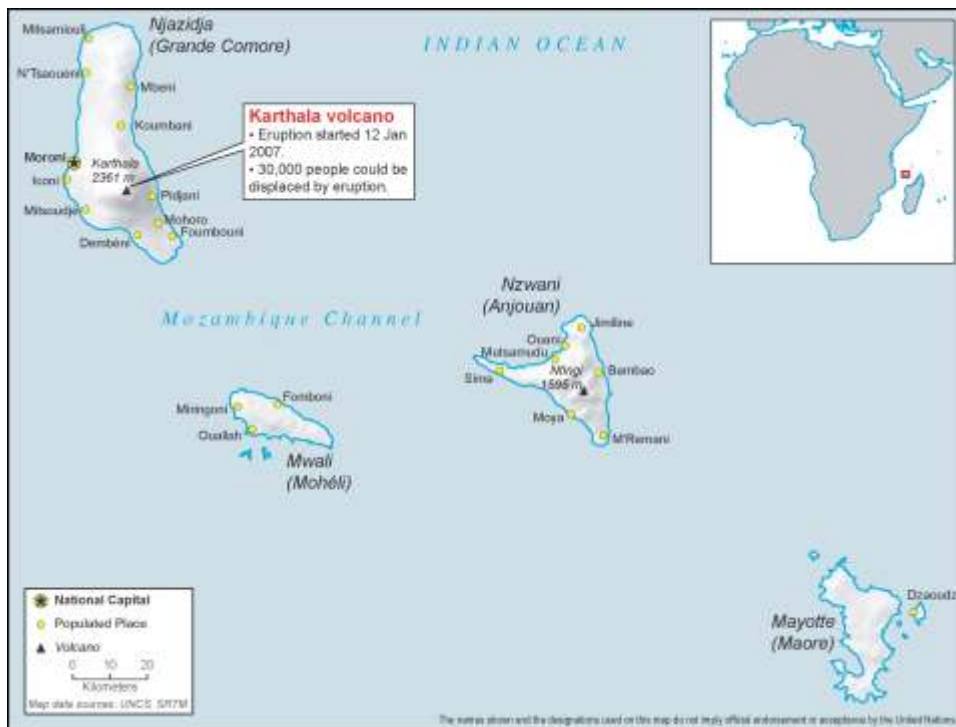


Figure 3. Map illustrating the regional setting of Karthala volcano in the Comoros Islands with comments relevant to the January 2007 crisis. Courtesy of ReliefWeb, a part of the United Nations Office for the Coordination of Humanitarian Affairs - Integrated Regional Information Networks (IRIN).

vers on 15 January saw a lava lake forming within the crater.

The KVO said there was no immediate risk of a lava flow, and that there were three scenarios to consider: (1) seismic activity could decrease, reflecting diminished volcanic activity; (2) cracks or fissures could occur on the flanks, resulting in lava flowing down the side of the mountain; or (3) seismicity could intensify and increase lava production, which could flow over the crater rim. On 18 January, the volcano shook twice more but the tremors seemed to be weakening.

No evacuations of the island's 300,000 people occurred during the elevated seismicity; however, frightened residents were sleeping outside on football fields and in their gardens, fearing collapse of their homes. UN Resident Coordinator in the Comoros, Giuseppina Mazza, later reported that "There are now fewer earthquakes and their intensity has reduced, the population is not panicking."

The IRIN news article noted that volcanic activity is common to Grande Comoro Island. Karthala erupted twice in 2005, affecting 40,000 people in April and 175,000 more in November. After an eruption on 28 May 2006 (BVG 32:07), volcanic dust and debris covered large areas of the island. Volcanic ash contaminated water supplies, raising concerns about the health of people and livestock, along with its effects on agriculture.

According to the UN Office for the Coordination of Humanitarian Affairs (OCHA), since the 12 January volcanic activity, the authorities kept the hazard status at "red alert" and "have activated the national emergency response preparedness plan. They established a crisis management cell (CMC) which includes government departments, UN agencies, the Comoros Red Crescent Society, as well as local NGOs and diplomatic missions ... [and the] partners are reviewing preparedness arrangements."

**Geologic Summary.** The southernmost and largest of the two shield volcanoes forming Grand Comore Island (also known as Ngazidja Island), Karthala contains a 3 x 4 km summit caldera generated by repeated collapse. Elongated rift zones extend to the NNW and SE from the summit of the Hawaiian-style basaltic shield, which has an asymmetrical profile that is steeper to the S. The lower SE rift zone forms the Massif du Badjini, a peninsula at the SE tip of the island. Historical eruptions have modified the morphology of the compound, irregular summit caldera. More than twenty eruptions have been recorded since the 19th century from both summit and flank vents. Many lava flows have reached the sea on both sides of the island, including during many 19th century eruptions from the summit caldera and vents on the northern and southern flanks. An 1860 lava flow from the summit caldera traveled ~ 13 km to

the NW, reaching the western coast N of the capital city of Moroni.

**Information Contacts:** Hamidi Soule Saadi, Karthala Volcano Observatory (KVO), Observatoire Volcanologique du Karthala, Centre National de Documentation et de la Recherche Scientifique des Comores, BP 169 Moroni, République Fédérale Islamique des Comores; Giuseppina Mazza, UN Resident Coordinator in Comoros, BP 648, Moroni, Comoros (Email: fo.com@undp.org); Hamidou Nassor, Université de la Réunion, BP 7151, 15 Avenue, René Cassin, 97715 Saint-Denis, La Réunion, France (Email: hamidou.nassor@univ-reunion.fr); United Nations Office for the Coordination of Humanitarian Affairs—Integrated Regional Information Networks (IRIN), 3rd Floor, Sandton 2146, PO Box 1617, Parklands, 2121, Johannesburg, Republic of South Africa (Email: irin-sa@irin.org.sa); Reuters.

## Piton de la Fournaise

Réunion Island, Western Indian Ocean  
21.231°S, 55.713°E; summit elev. 2,632 m  
All times are local (= UTC + 4 hours)

This report extends reporting of the Observatoire Volcanologique du Piton de la Fournaise (OVVPF) and covers the period from 28 July 2006 to 22 February 2007.

At 0400 on 28 July a tremor recorded by the Bory seismic station was interpreted as the start of an eruption. Subsequent observation noted a fissure had opened between 2,380 m and 2,250 m elevation on the SW flank. A lava flow went down E of Rivals crater. At 0540 a second 50-m long fissure opened at the 2,150 m elevation on the S flank

between Rivals crater and “Château Fort” that began building a small cone, and producing a 2-km-long lava flow.

Fifteen days after the initial eruption began on 20 July, activity at the cone which was slowly developing at 2,150 m elevation on the S flank almost ceased; however it continued to emit a visible plume and the OVPF reported “a considerable” degasification. The eruption, which had started on 20 July, stopped at 2300 local time on 14 August. The total lava output was estimated to be  $2\text{--}3 \times 10^6 \text{ m}^3$ .

On 30 August, a small seismic event occurred at 1000 hours, and a summit eruption started from the SSE edge of Dolomieu Crater at 1135. A fissure opened on the crater floor, and a large portion of the crater floor was covered with lava by the afternoon. A second fissure opened just outside of the crater and produced a lava flow on the E flank. On 9 Oct, a second vent, formed about 100 m SW of the first one, which was still active.

The eruption continued through the middle of October, within the Dolomieu Crater. A new cone about 20-25 m high was formed in the SE part of Dolomieu, and lava flows up to 10 m thick filled up 75% of the crater floor. The E part of the crater was filled up to the rim and lava flowed over and down the flank for hundreds of meters.

Between 25-26 November a hornito grew in the center of Dolomieu crater. After 27 November, a new overflow of the Dolomieu crater started and a 4 to 5 m diameter lava tube drained lava to the Piton de la Fournaise east flank and fed a ~ 2.5 km long lava flow that passed south of crater Jean, but did not reach the “Grandes Pentés.”

As of 14 December, OVPF reported that the eruption, which had started on August 30, was continuing (then 3.5 months). A second 25-m-high crater, named Piton Moinama, formed within Dolomieu about 100 m SSW of the first crater, Piton Wouandzani. Abundant lava flows totally covered Dolomieu crater floor again with a 10-30 m deep and reached the eastern border of the crater. Several small lava flows overflowed the rim but never reached more than 100-200 m long.

On 22 December, tremor signals increased, and a third eruptive vent opened on the evening of 27 December between Piton Wouandzani and the Piton Moinama. On 2 January 2007 OVPDLF reported that the eruption of Piton de la Fournaise that began on 30 August 2006 was believed to have ceased on 1 January.

On 18 February, after a “seismic event” that began at 1611, and which lasted only a few minutes, the summit inclinometers indicated strong inflation. A new eruptive phase began at 1638 that afternoon. The exact location of the eruption was not determined; however, the signals recorded at the observatory most probably place it at the summit. The cessation of volcanic tremor the next day at 0155 marked the end of the eruption. A fissure that crossed Dolomieu crater from the west was seen during an aerial observation on 18 February.

On 19 February, seven small (M 0.7) seismic tremors were recorded at the summit. On 22 February, a fissure was observed halfway up the E side of the summit cone.

**Geologic Summary.** The massive Piton de la Fournaise basaltic shield volcano on the French island of Réunion in the western Indian Ocean is one of the world’s most active volcanoes. Much of its > 530,000 year history overlapped with eruptions of the deeply dissected Piton des Neiges shield volcano to the NW. Three calderas formed at about 250,000, 65,000, and less than 5000 years ago by progres-

sive eastward slumping of the volcano. Numerous pyroclastic cones dot the floor of the calderas and their outer flanks. Most historical eruptions have originated from the summit and flanks of Dolomieu, a 400-m-high lava shield that has grown within the youngest caldera, which is 8 km wide and breached to below sea level on the eastern side. More than 150 eruptions, most of which have produced fluid basaltic lava flows, have occurred since the 17th century. Only six eruptions, in 1708, 1774, 1776, 1800, 1977, and 1986, have originated from fissures on the outer flanks of the caldera. The Piton de la Fournaise Volcano Observatory, one of several operated by the Institut de Physique du Globe de Paris, monitors this very active volcano.

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## Talang

Sumatra, Indonesia

0.978°S, 100.679°E; summit elev. 2,597 m

All times are local (= UTC + 7 hours)

Indonesian volcanologists with the Center of Volcanology and Geological Hazard Mitigation (CVGHM) (previously known by other names, including the Volcanological Survey of Indonesia) maintain an observation post and seismic network at Talang. After intermittent activity during September 2001 (*BGVN* 26:10) until June 2002 (*BGVN* 27:06), there was no additional reported activity until 2005 and 2006.

**Activity during April 2005.** On 12 April 2005 an eruption at Talang during 0340-0600 produced an ash plume that rose to ~ 1 km above the crater. About 4 mm of ash fell in the village of Bukit Sileh, NE of the crater. On the afternoon of 10 April observers had noted a “grey ash cloud” rising ~ 100 m, followed the next day by a diffuse white cloud around the summit. Volcanologist Dalipa, who heads the Batu Bajanjang observation post, told *The Jakarta Post* that there had been five large eruptions and hundreds of small eruptions before 1200 on 12 April that caused ashfall as far as 10 km away. He added that between the evening of 12 April and 0600 the next morning there were only six small eruptions.

An infrared image (GOES-9) taken at 0425 on 12 April 2005, analyzed by the Darwin VAAC, showed the eruption plume. There was a weak ash signature in the small cloud for a couple of hours before it became difficult to track. Plume height was estimated to be 7.5 km because the upper part of the cloud went NW, and winds below that were more or less westerly. The height of the cloud would have been difficult to see from the ground during the peak activity before dawn.

Simon Carn reported that the Ozone Monitoring Instrument (OMI) on EOS/Aura detected an SO<sub>2</sub> plume from Talang on 12 April at 1402, and possible much weaker

emissions on 13 April. The plume on 12 April extended roughly ESE towards central Sumatra, so was presumably at a lower elevation than the upper part of the ash cloud imaged earlier by the Darwin VAAC. The preliminary estimated SO<sub>2</sub> mass was around 1,000 metric tons. Weak emissions were reported several days prior to the 12 April event, but OMI data only showed SO<sub>2</sub> emissions from nearby Kerinci volcano.

A local government official told news media on 14 April that 25,150 residents from five villages in Lembang Jaya and Gunung Talang districts, located within a 5-km radius from the danger zone, had been evacuated. Winds were reportedly carrying ash downslope along with volcanic gases.

On 13 April volcanic and seismic activity decreased in comparison to the previous day. A “white-gray ash plume” rose 250 m from three points inside Kawah Mati crater, and white gas was emitted from Gabuo Atas crater. There was a decrease in the number of deep volcanic, shallow volcanic, and explosion earthquakes. By 0600 on 14 April the only reported activity was a diffuse “white ash” plume rising 250-300 m above the crater. However, news media quoting a government geologist reported that Talang “sent out fresh clouds of dust and continued to rumble” on 15 April.

By 17 April, activity had decreased and volcanologists lowered the hazard status to 3 (on a scale of 1-4). People were permitted to return their homes near the volcano, but no one could enter within 1 km of the summit. Due to a continued decrease in seismicity during 24-28 April (less than 10 volcanic events per day), the Alert Level was dropped to 2 on 28 April. Due to the hazards of minor phreatic eruptions, unstable land, and toxic gases, the area within a 1-km radius of the crater remained closed.

**Activity during July 2005.** Small phreatic eruptions occurred on 2 and 3 July 2005. The eruptions occurred at the main crater and a crater on the S slope. Ash columns reached 300-500 m above the volcano and caused 0.5-1 mm of ashfall around Kampung Batu, 2 km S of the summit. On the N slope, the Gabuo Atas, Gabuo Bawah, and Kapundan Panjang craters emitted “white-brown steam” to low altitudes. The temperature of Batu Bajanjang hot spring, located below the summit, was 41.9-61.3°C. The hazard status remained unchanged at Alert level 2 (on a scale of 1-4).

Increased seismicity on 18 July prompted an change in the Alert Level to 3. During 15-18 July, the seismic network recorded 93 deep volcanic earthquakes, one low-frequency tremor, and three “felt shocks” around the N slope of the crater. Minor phreatic activity occurred at the S and N slope craters, with dark gray ash plumes rising 0.5-1.5 km above the crater on 18 July.

Activity during September 2006. Increasing seismicity and gas emissions led to the hazard status being raised to Alert Level 3 on 9 September 2006. The next day “brownish smoke” was being emitted to heights of 250 m. The daily number of volcanic earthquakes and tremor fluctuated over the next few months, reaching a high of 33 events on 23 November. After that date seismicity showed a decreasing trend through late January 2007. Weak gas emissions continued during this period from both South Crater and Main Crater. Due to the lowered levels of activity, the hazard status was once again dropped to Alert Level 2 on 27 January.

**Geologic Summary.** Talang, which forms a twin volcano with the extinct Pasar Arbaa volcano, lies ESE of the

major city of Padang and rises NW of Dibawah Lake. Talang has two crater lakes on its flanks; the largest of these is 1 x 2 km wide Danau Talang. Most historical eruptions have not occurred from the summit of the volcano, which lacks a crater. Historical eruptions from Gunung Talang volcano have mostly involved small-to-moderate explosive activity first documented in the 19th century that originated from a series of small craters in a valley on the upper NE flank.

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## Soputan

Sulawesi, Indonesia

1.108°N, 124.73°E; summit elev. 1,784 m  
All times are local (= UTC + 8 hours)

Growth of the lava dome at Soputan began in 1991 (*BGVN* 16:06), eventually overtopping the crater rim and generating rockfalls to distances of 2-4 km downslope. Phreatic eruptions since that time have been triggered during the rainy season, and ash explosions have been frequent since 2000. An eruption and dome collapse in July 2005 sent a pyroclastic flow to a distance of 3 km from the summit. The nearest residents are at a distance of 8 km, so none of these events created hazards to the local population. Following pyroclastic avalanches and Strombolian activity in late December 2005 (*BGVN* 31:04), the Centre of Volcanology and Geological Hazard Mitigation (CVGHM) did not report further activity at Soputan until December 2006.

Lava dome volume in early December 2006 was reported to be 34 million cubic meters. Rockfall signals from the lava dome typically occur at a rate of about 75 per day, but the number of these events increased to 153 on 11 December, and remained high over the next two days: 120 on 12 December and 126 on the 13th. Volcanic tremor amplitude also increased on 11 December. Although thick fog hampered observations, “white smoke” was seen rising 25-30 m above the summit. At 1400 on 14 December a “thunderous” eruption was heard at the CVGHM observation post 8 km from the summit. Gray ash plumes rising 250 m above the summit caused ashfall within a 15-km radius. On 15 December the Alert Level was raised from 2 to 3 (on a scale of 1-4) due to this increase in activity.

A precautionary aviation advisory was issued by the Darwin VAAC on 18 December based on information from the CVGHM. A few hours later a plume was detected on an MTSAT image taken at 1933. The high-level eruption may

have reached an altitude of 12 km altitude with the plume extending 37 km to the W.

**Geologic Summary.** The small Soputan stratovolcano on the southern rim of the Quaternary Tondano caldera on the northern arm of Sulawesi Island is one of Sulawesi's most active volcanoes. The youthful, largely unvegetated volcano rises to 1784 m and is located SW of Sempu volcano. It was constructed at the southern end of a SSW-NNE trending line of vents. During historical time the locus of eruptions has included both the summit crater and Aesepu, a prominent NE-flank vent that formed in 1906 and was the source of intermittent major lava flows until 1924.

**Information Contacts:** *Centre of Volcanology and Geological Hazard Mitigation (CVGHM)*, Diponegoro 57, Bandung, Jawa Barat 40122, Indonesia (URL: <http://portal.vsi.esdm.go.id/joomla/>); *Jenny Farlow*, Darwin Volcanic Ash Advisory Centre, Bureau of Meteorology, Australia (URL: <http://www.bom.gov.au/info/vaac/>; Email: [j.farlow@bom.gov.au](mailto:j.farlow@bom.gov.au)).

## Dukono

Halmahera, Indonesia

1.68°N, 127.88°E; summit elev. 1,335 m

All times are local (= UTC + 9 hours)

Situated on Halmahera Island in northern Indonesia, Dukono released an ash plume 5 December 2006. The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard NASA's Terra satellite captured the 5 December plume (figure 4) drifting E away from meteorological clouds. NASA affiliate Jesse Allen has interpreted the plume as ash bearing.

As of early 2007, the Darwin Volcanic Ash Advisory Center (VAAC) reported that plumes from Dukono were visible on satellite imagery several times during 2006, and once in January 2007 (see table 2). Satellite images suggested modest successive plumes with ash concentrations varying from diffuse to dense.

Thermal anomalies were detected by MODIS (table 3) on 13 December 2006 and then on four days in February



Figure 4. Inferred ash plume of Dukono volcano streaming E and then S on 5 December 2006. NASA image created by Jesse Allen, Earth Observatory, using data provided courtesy of the MODIS Rapid Response team.

Date	Plume top (altitude)	Plume drift direction	Comment
12 Jan 2006	3 km	SW	ash
23 Aug 2006	—	NNE	diffuse ash
05 Dec 2006	3 km	ENE	ash
22 Dec 2006	—	SE	diffuse ash
16 Jan 2007	—	SSE	diffuse

Table 2. Summary of plumes reported from Dukono, January 2006-January 2007. Courtesy of the Darwin VAAC.

Date (UTC)	Time (UTC)	Pixels	Satellite
04 Oct 2004	1350	2	Terra
13 Dec 2006	1350	1	Terra
13 Feb 2007	1405	1	Terra
13 Feb 2007	1700	1	Aqua
15 Feb 2007	1350	1	Terra
18 Feb 2007	1715	1	Aqua
24 Feb 2007	1345	1	Terra

Table 3. Thermal anomalies at Dukono based on MODIS-MODVOLC retrievals and processing from October 2004 through February 2007. Courtesy of Hawai'i Institute of Geophysics and Planetology Thermal Alerts System.

2007. These were the first anomalies detected by the MODVOLC system since October 2004 (BGVN 31:06).

**Geologic Summary.** Reports from this remote volcano in northernmost Halmahera are rare, but Dukono has been one of Indonesia's most active volcanoes. More-or-less continuous explosive eruptions (sometimes accompanied by lava flows) occurred from 1933 until at least the mid-1990s, when routine observations were curtailed. During a major eruption in 1550, a lava flow filled in the strait between Halmahera and the N flank cone of Gunung Mamuya. Dukono is a complex volcano presenting a broad, low profile with multiple summit peaks and overlapping craters. Malupang Wariang, 1 km SW of Dukono's summit crater complex, contains a 700 x 570 m crater that has also been historically active.

**Information Contacts:** *Center of Volcanology and Geological Hazard Mitigation (CVGHM)*, Jalan Diponegoro 57, Bandung 40122, Indonesia (URL: <http://www.vsi.esdm.go.id/>); *Darwin Volcanic Ash Advisory Center (VAAC)*, Bureau of Meteorology, Darwin, Australia (URL: <http://www.bom.gov.au/>); *Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System*, School of Ocean and Earth Science and Technology (SOEST), Univ. of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (URL: <http://hotspot.higp.hawaii.edu/>).

## Taal

Luzon, Philippines

14.002°N, 120.993°E; summit elev. 400 m

All times are local (= UTC + 8 hours)

On 26 September 2006, the Philippine Institute of Volcanology and Seismology (PHILVOLCS) announced ongoing seismic unrest at Taal (a low lying caldera ~ 45 km S of Manila). The Main Crater Seismic Station recorded 29

volcanic earthquakes during the 24 hours after 0600 on 25 September 2006. Five (5) of these occurred at 0233, 0234, 0242, 0247, and 0249 and were felt at Intensities II to III by residents on Volcano Island (figure 5 and 6). These earthquakes were accompanied by rumbling sounds. Initial computations showed epicenters generally dispersed toward northerly locations in the vicinity of Daang Kastila (NE), Tibag (N), Tablas (NE), Mataas na Gulod (NE), and Panikihan (NW).

This seismic activity was notably higher than usual, which during quiet periods is generally only five or less events detected in 24 hours. Surface thermal observations, however, did not indicate significant change in the thermal and steam emission manifestations in the Main Crater Lake area. The increase in seismicity reflected a low-level epi-

sode of unrest. However, there is still no indication of an impending eruption.

Taal manifested a sustained moderate level of seismic activity since 18 November 2006, characterized by occasional large amplitude volcanic earthquakes. During one 24-hour period, 10 volcanic earthquakes were detected. Ground deformation surveys conducted during 28 November-6 December 2006 revealed the edifice inflated 14.0 mm, suggesting possible magma intrusion. The Main Crater lake water became more acidic since 12 September 2006, and the newly formed mud geyser, which is now merged with the Crater Lake due to increase in water level, continues to be very active. The increasing acidity and hydrothermal activity are probably caused by the injection of hot gases and fluids coming from below the crater floor.

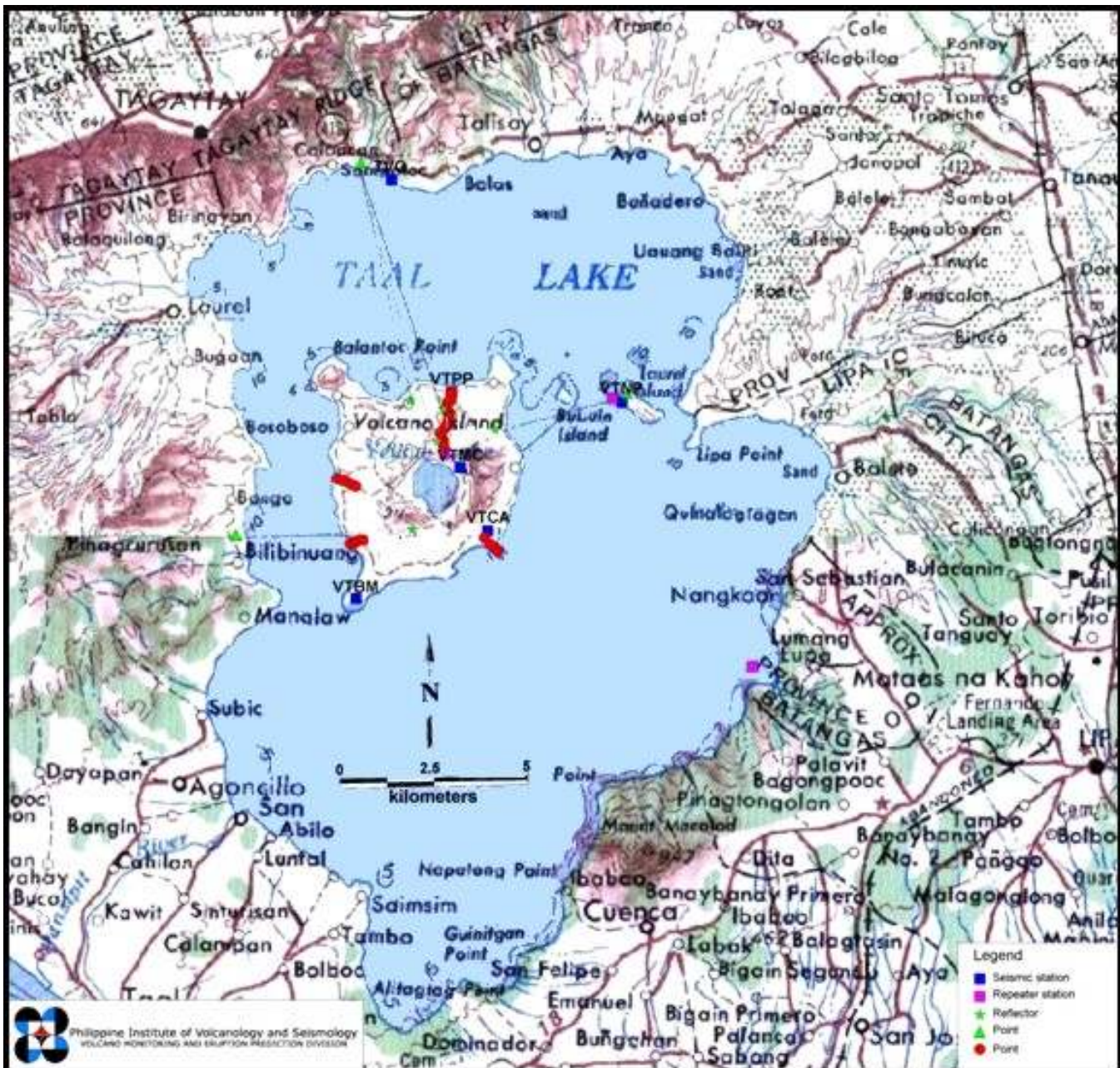


Figure 5. A map of Taal volcano indicating the location of components of the monitoring network (seismic stations, telemetry repeater stations, reflector, and various kinds of survey and measuring points). Volcano island (the large island in the N-central part of the caldera lake) is the site of all historical eruptions. Contour interval is 100 m. Courtesy of PHIVOLCS.



Figure 6. Photograph taken from the top of the N topographic margin of Taal, looking S across Lake Taal and Volcano Island, 28 May 2001. The topographic high on the far side of the lake is Mt. Macolod. Copyrighted photograph by Franck Landais (provided by Panoramio.com).

According to PHIVOLCS in its Taal Volcano Advisory of 14 December 2006, the above observations indicated a significant increase in activity although no eruption is imminent. Alert Level 1 continued, making the Main Crater off-limits to the public because of the chance of sudden steam explosions and high toxic gas concentrations.

**Geologic Summary.** Taal volcano is one of the most active volcanoes in the Philippines and has produced some of its most powerful historical eruptions. In contrast to Mayon volcano, Taal is not topographically prominent, but its pre-historical eruptions have greatly changed the topography of SW Luzon. The 15 x 20 km Taal caldera is largely filled by Lake Taal, whose 267 sq km surface lies 700 m below the S caldera rim and only 3 m above sea level. The maximum depth of the lake is 160 m, and several eruptive centers lie submerged beneath the lake. The 5-km-wide Volcano Island in N-central Lake Taal is the location of all historical eruptions. The island is a complex volcano composed of coalescing small stratovolcanoes, tuff rings, and scoria cones. Taal has grown about 25% in area during historical time. Powerful pyroclastic flows and surges from historical eruptions of Taal have caused many fatalities.

**Information Contacts:** *Philippine Institute of Volcanology and Seismology (PHIVOLCS)*, University of the Philippines Campus, Diliman, Quezon City, Philippines (URL: <http://www.phivolcs.dost.gov.ph>); *Panoramio.com*, Calle Rosa Zaragoza 8, 03360 Callosa de Segura (Alicante), Spain (URL: <http://www.panoramio.com/photo/40914>).

## Fukutoku-Okanoba

Volcano Islands, Japan  
24.28°N, 141.485°E; summit elev. -14 m

Oliver Hyvernaud twice notified the *Bulletin of Notice to Mariners* reports of discolored sea water observed on 4 October and 15 November 2006 at about 24°17'N, 141°29'E. Both warnings referred to the same general location, encompassing an area of ocean 93 km SSW of Iwo Jima. In reality, the two positions noted below are ~ 1.3 km

apart, perhaps overlapping each other. The warnings were as follows:

1) Discolored water with submarine volcanic activity reported within 1,700 m of 24°17.5' N, 141°29.4 E at 0400 UTC on 4 October 2006 [ref. *Notice to Mariners*, 14 October 2006 (no. 41), HYDROPAC Warning 1921/06(97) North Pacific, issued 1009 UTC on 4 October 2006].

2) Discolored water with submarine volcanic activity reported within 2,000 m of 24°17.1' N, 141°28.8 E at 0236 UTC on 15 November 2006 [ref. *Notice to Mariners*, 2 December 2006 (no. 48), HYDROPAC Warning 2225/06(97) North Pacific, issued 1133 UTC on 16 November 2006].

For the locations given for warnings 1 and 2, the respective deviations from coincidence with Fukutoku-Okanoba (at the coordinates given above) are 1.4 and 0.8 km. That seamount frequently produces discolored seawater and is known to erupt on occasions as well, and is thus the probable source for the discolored water.

According to the Japan Meteorological Agency, observations on 15 November 2006 by the Japan Maritime Self Defense Force and aerial observations on 21 November 2006 by the Japan Coast Guard revealed areas of discolored water on the sea surface above the volcano. Those cases seemed to be caused by volcanic activities.

**Geologic Summary.** Fukutoku-Okanoba is a submarine volcano located 5 km NE of the pyramidal island of Minami-Iwo-jima. Water discoloration from the volcano is frequently observed and several ephemeral islands have formed in the 20th century. The first of these formed Shin-Iwo-jima ("New Sulfur Island") in 1904, and the most recent island was formed in 1986. Fukutoku-Okanoba is part of an elongated edifice with two major topographic highs trending NNW-SSE and is a trachyandesitic volcano geochemically similar to Iwo-jima.

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## Pagan

Mariana Islands, Central Pacific  
18.13°N, 145.80°E; summit elev. 570 m  
All times are local (= UTC + 10 hours)

At 1800 on 4 December 2006 scientists from the Hawaiian Volcano Observatory (HVO) and Emergency management Office (EMO) were advised by Pagan residents of ashfall at their camp. They continued to report light ashfall (through an unreported date), with up to a centimeter per day accumulating 3 km SW of the summit and a plume rising about 60 m above the vent. There were no felt earthquakes or noise from the volcano, but occasional sulfur smells wafted through the camp.

Visible satellite imagery interpreted by the Washington VAAC showed a small gas plume, possibly with minor ash,

at 0733 on 5 December. Cloud cover made satellite observations difficult, but during 5-6 December plumes could be distinguished extending as far as 185 km W. A Terra MODIS image on 6 December (figure 7) showed the plume near the island to be light brown in color, indicating ash content. A serpentine-shaped plume at 0833 on 7 December extended 140 km WSW from the island. Later that day, at 1300, a faint narrow plume could still be seen to a distance of about 300 km W. The last visible imagery that showed an ash plume was at 1633 on 8 December; the plume was very narrow and at low altitudes.

Although significant eruptive activity seemed to have ended on 8 December, observations from the International Space Station revealed a plume on 11 January 2007 (figure 8). The very diffuse plume was most likely steam. There



Figure 7. Terra MODIS image showing a light brown ash plume blowing W from Pagan, 6 December 2006. Courtesy of NASA Earth Observatory and the MODIS Rapid Response Team at Goddard Space Flight Center.



Figure 8. Photograph showing a thin plume extending SW from Pagan on 11 January 2007. [Astronaut photograph ISS014-E-11872 was acquired with a Kodak 760C digital camera using a 180 mm lens.] Courtesy of NASA Earth Observatory, the ISS Crew Earth Observations experiment, and the Image Science & Analysis Laboratory, Johnson Space Center.



Figure 9. Ash plume erupting from Pagan, 30 April 1994. View is to the S. Courtesy of Frank Trusdell, USGS.

were no reports of ash plumes from the island or warnings to aviators based on satellite data after 8 December 2006.

Eruption during 1993-94. The eruption that began around mid-January 1993 (*BGVN* 18:03) continued through at least 30 April 1994 (figure 9). Fieldwork by USGS and EMO scientists during April and May 1994 was not previously reported in the *Bulletin*. Trusdell and others (2006) noted that following the eruption in 1981 (*SEAN* 06:04), “Intermittent light ejection of chiefly phreatic ash continued until 1996, with maximum post-1981 accumulation estimated at as much as 1-2 m on the source cone.”

**Geologic Summary.** Pagan Island, the largest and one of the most active of the Mariana Islands volcanoes, consists of two stratovolcanoes connected by a narrow isthmus. Both North and South Pagan stratovolcanoes were constructed within calderas, 7 and 4 km in diameter, respectively.

The 570-m-high Mount Pagan at the NE end of the island rises above the flat floor of the northern caldera, which probably formed during the early Holocene. South Pagan is a 548-m-high stratovolcano with an elongated summit containing four distinct craters. Almost all of the historical eruptions of Pagan, which date back to the 17th century, have originated from North Pagan volcano. The largest eruption of Pagan during historical time took place in 1981 and prompted the evacuation of the sparsely populated island.

**References:** Sako, M.K., Trusdell, F.A., Koyanagi, R.Y., Kojima, G., and Moore, R.B., 1995, Volcanic investigations in the Commonwealth of the Northern Mariana Islands, April to May 1994: U. S. Geological Survey Open-File Report 94-705, 57 p.

Trusdell, F.A., Moore, R.B., and Sako, M.K., 2006, Preliminary geologic map of Mount Pagan volcano, Pagan Island, Com-

monwealth of the Northern Mariana Islands: U. S. Geological Survey Open-File Report 2006-1386, 32 p.

**Information Contacts:** *Emergency Management Office of the Commonwealth of the Northern Mariana Islands (EMO-CNMI)*, PO Box 100007, Saipan, MP 96950, USA (URL: <http://www.cnmiemo.org/>); *U.S. Geological Survey, Hawaiian Volcano Observatory (HVO)*, PO Box 51, Hawaii National Park, HI 96718, USA (URL: <http://hvo.wr.usgs.gov/cnmi/>; Email: [trusdell@usgs.gov](mailto:trusdell@usgs.gov)); *NASA Earth Observatory* (URL: <http://earthobservatory.nasa.gov/>).

## Monowai Seamount

Kermadec Islands, SW Pacific  
25.887°S, 177.188°W; summit elev. -100 m

According to Dominique Reymond and Olivier Hyvernaud (affiliates of Laboratoire de Geophysique, in Saint Martin d' Heres, France), activity at Monowai from 2005-2006 was remarkable because of the more than 1,650 events recorded as hydroacoustic waves (also called T-phase waves or T-waves) on the Polynesian Seismic Network (Réseau Sismique Polynésien, or RSP). Such waves are generated by submarine earthquakes and/or volcanic

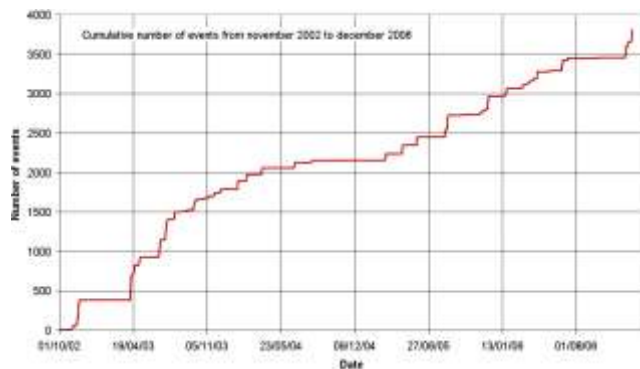


Figure 10. Cumulative number of events recorded by the RSP for Monowai from 1 November 2002 to 31 December 2006. Courtesy of Dominique Reymond and Olivier Hyvernaud.

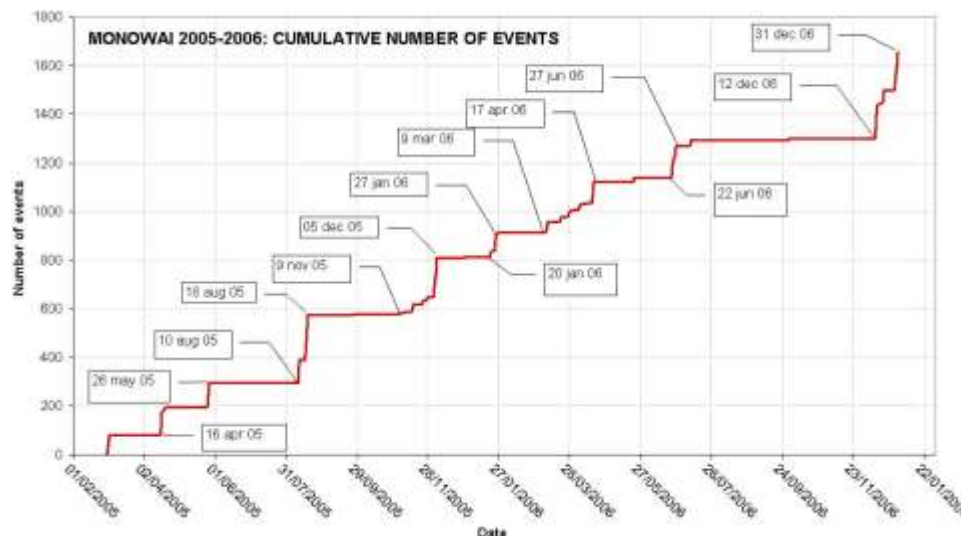


Figure 11. Cumulative number of T-waves at Monowai recorded by the RSP over the period 2005-2006, with dates indicating the start and end of each swarm. The duration of the swarms varied between 1 day and 3 weeks. Courtesy of Dominique Reymond and Olivier Hyvernaud.

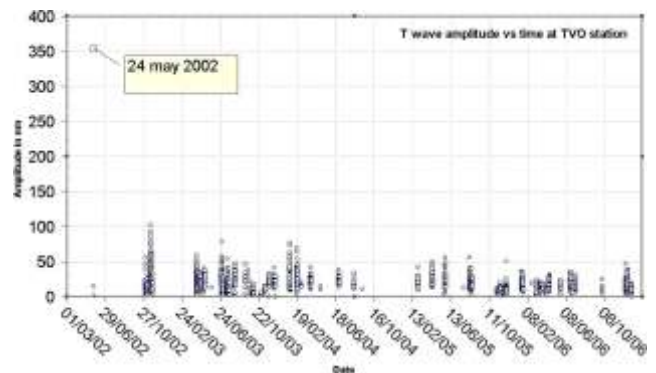


Figure 12. Amplitude (in nanometers of ground motion) for Monowai T-waves recorded at the TVO station over the last 4 years (2002-2006). While the average values are in the range of 5- 50 nm, only one exceptional value of 350 nm was recorded on 24 May 2002 (BGVN 27:05). Courtesy of Dominique Reymond and Olivier Hyvernaud.

eruptions that can be monitored at great distances via seismic stations close to the shore and/or by hydrophones. The amplitudes of T-waves are related to the strength or intensity of submarine volcanism at the seamount.

The T-wave activity after 2002 appeared in two main stages (figure 10). The initial stage extended from early 2003 to August 2004, followed by a period of repose that lasted until March 2005. A second stage of T-wave activity then continued until July 2006, followed by another six months of quiet. Reymond and Hyvernaud noted that individual T-wave swarms typically had durations varying between 1 day and 3 weeks.

It appears that another cycle started 12 December 2006 (figure 10), continuing at least until the end of the month. The average number of events from the end of 2002 until the end of 2006 was about 950 per year. In the last two years (2005-2006), a slightly lower rate of 825 events per year was measured (figure 11).

The amplitudes of T-waves recorded during 2005-2006 at the TVO seismic station in Tahiti never reached 1/3 of the amplitude that was recorded on 24 May 2002. It was that day when amplitudes of 350 nm were reached (figure 12). The average values for T-wave amplitudes during the period shown in figure 12 are in the 5-50 nm range.

### Geologic Summary.

Monowai seamount, also known as the Orion seamount, rises within 100 m of the sea surface, located roughly halfway between the Kermadec and Tonga island groups. The volcano lies at the S end of the Tonga Ridge and is slightly offset from the Kermadec volcanoes. Small parasitic cones occur on the N and W flanks of the basaltic submarine volcano, which rises from a depth of about 1,500 m and was named for the New Zealand Navy bathymetric survey ship that documented its morphology. A large 8 x 13 km wide submarine caldera with a depth of more than 1,500 m lies to the NNE. Numerous eruptions

from Monowai have been detected from submarine acoustic signals since it was first recognized as a volcano in 1977. A shoal that had been reported in 1944 may have been a pumice raft, or alternatively, a water disturbance caused by degassing. Surface observations have included water discoloration, vigorous gas bubbling, and areas of upwelling water, sometimes accompanied by rumbling noises.

**Information Contacts:** *Dominique Reymond and Olivier Hyvernaud*, Laboratoire de Géophysique, Commissariat à l’Energie Atomique, CEA/DASE/LDG, PO Box 640, Papeete, Tahiti, French Polynesia (Email: reymond.d@labogeo.pf, hyvernaud@labogeo.pf).

## Macdonald

Austral Islands, Central Pacific  
28.98°S, 140.25°W; summit elev. -27 m  
All times are local (= UTC - 9 hours)

After more than 17-years in quiescence, Macdonald seamount entered into a short phase of hydroacoustic activity starting at 1400 UTC on 13 October 2005. The seamount is ~ 6,000 km S of Honolulu, Hawaii (figure 13). When hydroacoustic activity has been of sufficient amplitude and duration, it has often been inferred to suggest submarine eruptions. In this case the signals were relatively weak and of modest duration, indicating seismic swarms without a clear association with volcanism.

Over five days the Polynesian Seismic Network (RSP for Réseau Sismique Polynésien) recorded 423 small- and medium-amplitude T-wave events from the seamount (figure 14). The best inland seismic station recording the event was at East Tuamotu, ~ 750 km from Macdonald. The ground response there was in the range of 50-300 nanometers.

According to Robert Dziak, hundreds of medium to large amplitude T-wave events were also recorded on the NOAA/PMEL hydrophone array in the eastern Equatorial Pacific located some 2,200 km away from Macdonald. There was an absence of Pn and Sn seismic phases (the P- and S-wave phases that propagate at the base of ocean crust along the Moho discontinuity) suggesting the swarm was composed of comparatively low-magnitude events. Accordingly, geophysicists from both the RSP and NOAA/PMEL all interpreted the activity as a modest seismic swarm.

Many of the October 2005 T-wave signals were well located, with an error ellipse of less than 1 km in diameter. The strongest signals were seen on Tahiti, Rangiroa, and parts of the East Tuamotu networks; and consequently, these yielded the smaller error ellipses. The weakest T waves were seen on parts of the

East Tuamotu network, resulting in the large NE-trending error ellipses.

The signals stopped at 0700 UTC on 17 October 2005. Dominique Reymond and Olivier Hyvernaud of the RSP were not aware of any witnessed eruptive signs or any detected hydroacoustic activity at or near Macdonald following the 2005 episode through 2006.

**Additional research.** Our previous reports on Macdonald seamount discussed activity during the 1980s, most recently during January 1989 (*SEAN* 14:01). Since then, several papers have shed light on the region (including Stoffers and others, 1989; McNutt and others, 1997; Sleep, 1997). McNutt and others (1997) presented high-resolution swath bathymetry in the Southern Austral islands, and noted more than one lone seamount in the area of Macdonald. The seamounts at Macdonald were morphologically distinct from their neighbors to the W along the Austral island chain in both their tall form and their slopes, which curved concave-upward.

**References:** Bonneville, A., (undated-post 2002), The Cook-Austral volcanic chain, URL: <http://www.mantleplumes.org/Cook-Austral.html>.

McNutt, M.K., Caress, D.W. Reynolds, J., Jordahl, K. A., and Duncan, R.A., 1997, Failure of plume theory to explain midplate volcanism in the southern Austral islands: *Nature*, v. 389, p. 479-482.

Sleep, N., 1997 (2 October), Earth Science: The puzzle of the South Pacific: *Nature*, v. 389, p. 439-440.

Stoffers, P., Botz, R., Cheminée, J-L., Devey, C.W., Froger, V., Glasby, G.P., Hartmann, M., Hékinian, R., Kögler, F., Laschek, D., Larqué, P., Michaelis, W., Mühle, R.K., Puteanus, D., and Richnow, H.H., 1989, Geology of Macdonald Seamount region, Austral Islands: Recent hotspot volcanism in the south Pacific: *Journal Marine Geophysical Researches*, v. 11, no. 2/June, p. 101-112.

**Geologic Summary.** Discovered by the detection of teleseismic waves in 1967, Macdonald seamount (also known as Tamarii seamount, and sometimes incorrectly written “MacDonald”) rises from a depth of about 1,800 m to within 27 m of the sea surface at the eastern end of the Austral Islands. The alkali-basaltic submarine volcano marks the site of a hotspot that was the source of the Aus-

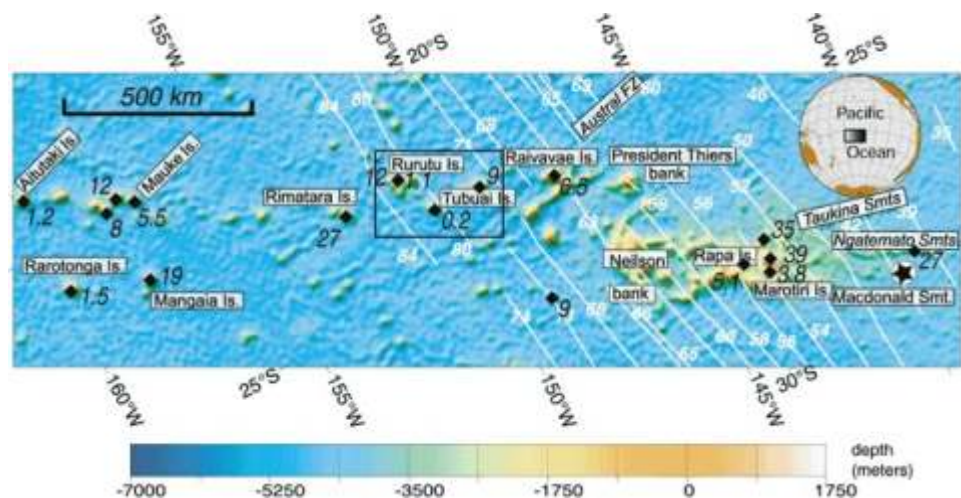


Figure 13. Shaded view of seafloor topography for the Cook-Austral island chains (see upper inset for location). Map projection is made along direction of the present motion of Pacific plate (which moves from right to the left). White lines correspond to crustal magnetic anomalies, and their corresponding ages, in millions of years (Ma), are in white numerals. Black diamonds represent places where K-Ar or Ar/Ar ages are known. These ages, in Ma, are printed in black. From A. Bonneville (undated, post-2002 website, see References below).

tral-Cook island chain that extends to the NW for about 2,200 km from Macdonald. The summit of the seamount, named after volcanologist Gordon Macdonald, consists of a flat plateau about 100 x 150 m wide with an average depth of about 40 m. The summit plateau is capped with spatter cones that form steep-sided pinnacles. Most eruptions of Macdonald have been seismically detected, but in 1987 and 1989 pumice emission was observed from research vessels. Pumice rafts observed in the South Pacific in 1928 and 1936 may also have originated from Macdonald seamount.

**Information Contacts:**

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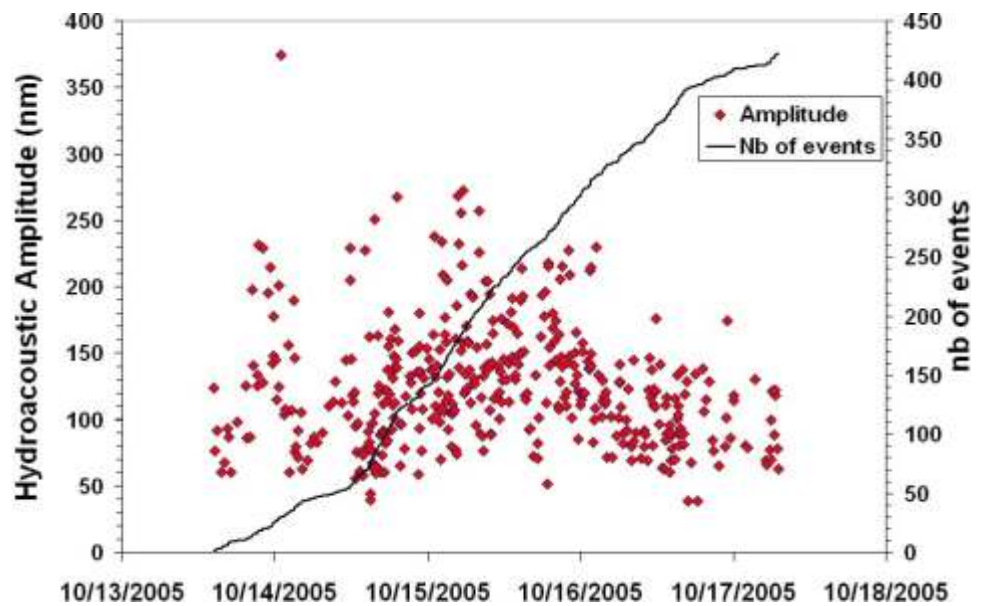


Figure 14. A plot of the cumulative number and amplitude of T-wave events from Macdonald seamount during 13-17 October 2005. The x-axis shows the date. The y-axis scale is on the right and indicates the cumulative number of events (for the curve labeled Nb), which ultimately totaled 423. The y-axis scale is on the left and gives the amplitudes of ground motion for each of the 423 events (diamonds, some of which may be superimposed). Courtesy of Dominique Reymond and Olivier Hyvernaud, Laboratoire de Géophysique, CEA/DASE/LDG, Tahiti.