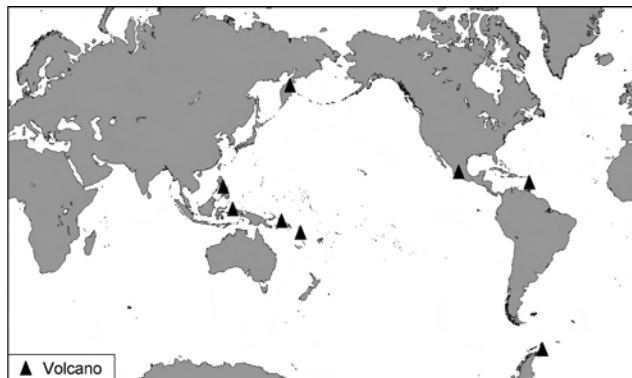


# Bulletin of the Global Volcanism Network

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## Jun Jaegyu

Antarctic Sound, Antarctica  
63.48°S, 56.43°W; summit elev. -275 m (submarine)

Jun Jaegyu is a young volcano near the Antarctic Peninsula visited in May 2004 by researchers from a group of United States and Canadian universities aboard the U.S. National Science Foundation research vessel *Laurence M. Gould* (Cruise LMG04-04). The expedition's chief scientist was Eugene Domack of Hamilton College.

Prior to this cruise, bathymetric swath maps from 2002 revealed a symmetrical volcano that had not been scoured by the advance and retreat of glaciers. The 2004 cruise dredged the volcano and found material that included fresh basalt in a flank area devoid of colonizing bottom-dwelling organisms. In contrast, observations suggested that other portions of the volcano were heavily colonized by bottom-dwelling organisms. The discovery of the volcano corroborated mariners' reports of discolored water in the area. These observations, and a thermal anomaly, were all consistent with comparatively recent volcanic activity.

The volcano is located on the Antarctic continental shelf in the southern Antarctic Sound, ~9 km N of the easternmost point of Andersson Island and NW of Rosamel Island (figure 1), N of the mapped boundary of Late Cenozoic volcanic rocks. Swath bathymetric mapping indicated that the volcano stands ~700 m above the seafloor (at a depth of ~1,000 m) and thus extends to within ~275 m of the ocean surface. The seamount has an elongate, symmetrical shape and contains ~1.5 km<sup>3</sup> of volcanic rock.

Two observed positive thermal anomalies (up to 0.052°C), recorded by temperature probes towed over the volcano from S to N, may be associated with two active volcanic centers. The more complex N temperature anomaly may also be associated with what appeared to be fresher lava flows.

The volcano lies along a NW-SE oriented fault scarp. Material dredged from the volcano have not been dated because accurately dating vesicular, partially altered, young submarine basalts is problematic at best. No gas samples were collected during this cruise.

Ashley Hatfield, a participant in the cruise and an undergraduate geology student at Hamilton College, advised by David Bailey and Eugene Domack, analyzed representative samples for whole-rock major and trace elements using XRF (X-ray fluorescence spectroscopy) and ICP-MS (inductively coupled plasma mass spectrometry). The samples are generally angular, glassy, and vesicular, having plagioclase, olivine, and clinopyroxene present as phenocryst phases, and with small rounded xenoliths being common (Hatfield and others, 2004). The samples were classified as alkali basalts and trachybasalts, and their chemical signatures were consistent with other known volcanoes throughout the northern Antarctic Peninsula.

Hatfield noted that the volcano is named in honor of Jun Jaegyu, a young Korean scientist who lost his life during the 2003 field season in the South Shetland islands. He was participating in the Korean Antarctic Program through their geophysical observatory based in the South Shetland Islands (King Sejong Station, established in 1988 on the Barton Peninsula, King George Island at 62°13.4818' S, 58°47.4744' W).

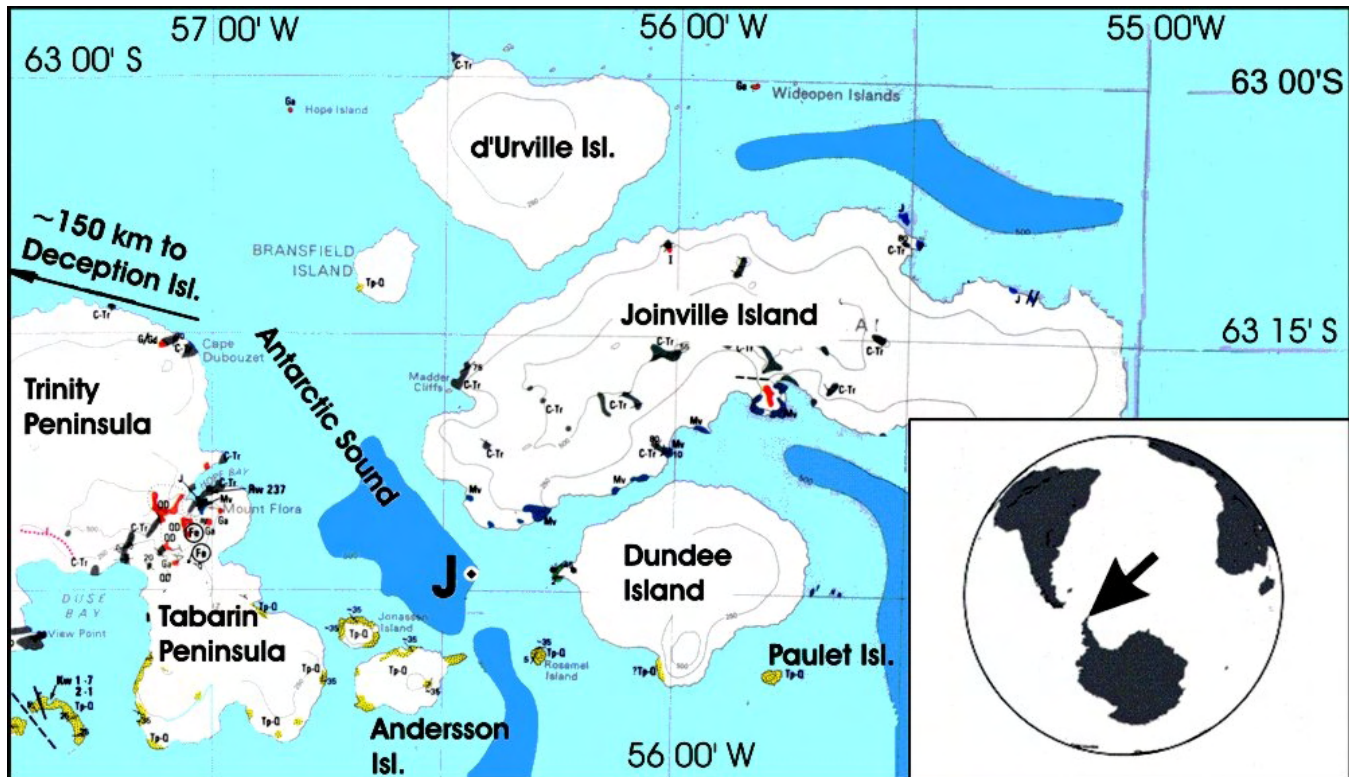


Figure 1. Jun Jaegyu submarine volcano (J) lies E of the extreme tip of the Antarctic Peninsula (see inset map) in the Antarctic sound, an area sheltered by several islands. Paulet Island, another volcano of probable Holocene age, lies just outside the Antarctic Sound on the SE side of Dundee Island. A better known Holocene volcano, Deception Island, lies to the NW (adjacent to the South Shetland Islands) as indicated by the arrow. Base map copied from *Northern Graham Land and South Shetland Island*, British Antarctic Territory Geologic Map (1:500,000) from BAS 500 G, sheet 2, edition 1, 1978. Note that map coordinates shown are in degrees and minutes (eg. 57 00', 57 degrees and 0 minutes).

The scientific crew for this cruise included Hatfield, Bailey, and Domack, (Department of Geology, Hamilton College, Clinton, New York); Stefanie Brachfield, (Department of Earth and Environmental Sciences, Montclair State University, Upper Montclair, New Jersey); Robert Gilbert (Department of Geological Sciences, Queen’s University, Kingston, Ontario); Scott Ishman (Department of Geology, Southern Illinois University, Carbondale, Illinois); Gerd Krahnmann (Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York); and Amy Leventer (Department of Geology, Colgate University, Hamilton, New York).

**Background.** A morphologically youthful submarine volcanic center was discovered in the Antarctic Sound off the tip of the Antarctic Peninsula during oceanographic cruises in 2002 and 2004. Jun Jaegyu volcano rises to within 275 m of sea surface. It is the northernmost volcanic feature of the James Ross Island volcanic group, and lies ~ 32 km WNW of Paulet Island, a small volcano of probable Holocene age. The flanks of the newly documented volcano display fresh volcanic rocks devoid of marine organisms that blanket most of the edifice. Dredged samples included alkali basalts and trachybasaltic rocks. Mild positive thermal anomalies were detected over two possible submarine centers, and mariners’ reports had noted discolored water in this area.

**Reference:** Hatfield, A., Bailey, D., Domack, E., Brachfeld, S., Gilbert, R., Ishman, S., Krahnmann, G., and Leventer, A., 2004, Jun Jaegyu volcano; A recently discovered alkali basalt volcano in Antarctic Sound, Antarctica: *Eos*, Transactions, American Geophysical Union, 85(47), Fall Meeting Supplement, Abstract T11A-1248.

**Information Contacts:** David G. Bailey, Eugene Domack, and Ashley K. Hatfield, Department of Geosciences, Hamilton College, 198 College Hill Rd., Clinton, NY 13323, USA (Email: dbailey@hamilton.edu, edomack@hamilton.edu, and ahatfield@hamilton.edu).

## Colima

México

19.514°N, 103.62°W; summit elev. 3,850 m

All times are local (= UTC + 6 hours)

The recent extrusion of block-lava that began on 30 September 2004 continued through November 2004. Lava flows formed on the N and WNW flanks, with the respective dimensions ~ 2,400 m long by ~ 300 m wide, and ~ 600 m long by ~ 200 m wide. The total volume of erupted material, including lava and pyroclastic flows, was about  $8.3 \times 10^6 \text{ m}^3$  (*Bulletin* v. 30, no. 1). The termination of lava effusion was followed by intermittent explosive activity represented mainly by small gas-and-ash Vulcanian explosions. Their number gradually decreased during December 2004-March 2005 (figure 2).

Three relatively large explosions occurred in March (on the 10th, the 13th, and the 26th). Those of 10 and 13 March formed eruptive columns with heights of

~ 5 km above the crater and were accompanied by pyroclastic flows down the S flank. The lengths of associated pyroclastic flows did not exceed 2.8 km. The largest explosion to take place on 13 March generated fallout that included lapilli with a diameter of up to 2 cm. Ash fell at a distance of 12.5 km to the NE of the volcano (in the village of Los Mazos, Jalisco).

Scientists made E-W topographic profiles on 12 October 2004 and 18 March 2005 (figure 3). The profiles crossed an area on the summit’s S flank. They disclosed that during this intervening interval there had been a collapse over an area of ~ 2,500 m<sup>2</sup>.

**Background.** The Colima volcanic complex is the most prominent volcanic center of the western Mexican Volcanic Belt. It consists of two southward-younging volcanoes, Nevado de Colima (the 4,320 m high point of the complex) to the N and the 3,850-m-high historically active Volcán de Colima to the S. A group of cinder cones of probable late-Pleistocene age is located on the floor of the Colima graben W and E of the Colima complex. Volcán de Colima (also known as Volcán Fuego) is a youthful stratovolcano constructed within a 5-km-wide caldera, breached to the S, that has been the source of large debris avalanches. Major slope failures have occurred repeatedly from both the

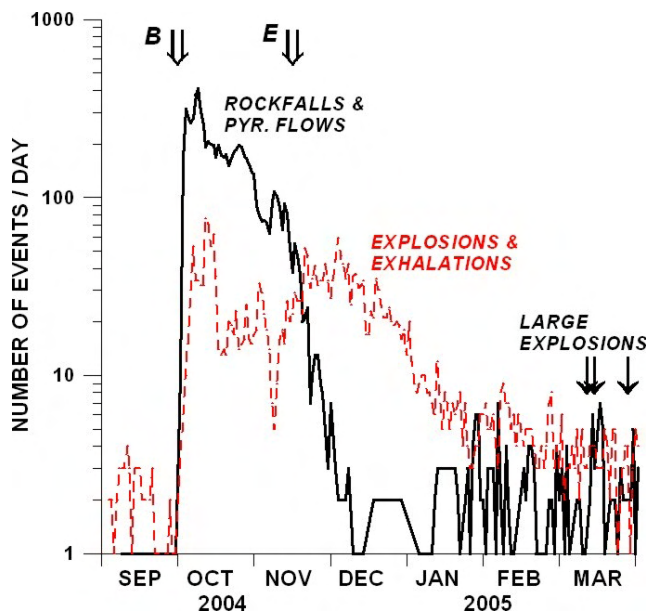


Figure 2. Eruptive activity of at Colima during September 2004-March 2005. The variations in the number of earthquakes produced by rockfalls and pyroclastic flows (heavy line) and by explosions and exhalations (dashed line) are shown. Double arrows show the beginning (B) and the end (E) of lava extrusion; three single arrows indicate the explosions of 10, 13, and 26 March. Courtesy of Colima Volcano Observatory.

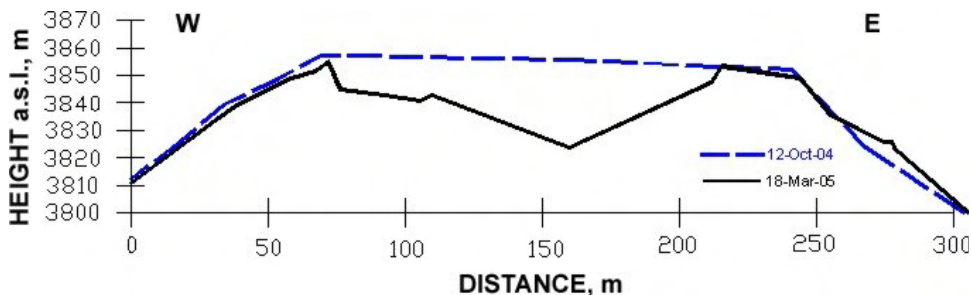


Figure 3. Two topographic profiles across the summit of Colima from the S flank made on 12 October 2004 and 18 March 2005. Courtesy of Colima Volcano Observatory.

Nevado and Colima cones, and have produced a thick apron of debris-avalanche deposits on three sides of the complex. Frequent historical eruptions date back to the 16th century. Occasional major explosive eruptions (most recently in 1913) have destroyed the summit and left a deep, steep-sided crater that was slowly refilled and then overtopped by lava dome growth.

**Information Contacts:** *Observatorio Vulcanológico de la Universidad de Colima*, Colima, Col., 28045, México (Email: [ovc@cgcic.ucol.mx](mailto:ovc@cgcic.ucol.mx); URL: <http://www.ucol.mx/volcan/>).

## Soufrière St. Vincent

St. Vincent, West Indies  
13.33°N, 61.18°W; summit elev. 1,220 m  
All times are local (= UTC - 4 hours)

Widespread sulfurous odors and haze during mid-February 2005 on the island of St. Vincent and as far as the Grenadines (50-75 km S) led some people to conclude that the smells reflected increased output of volcanic gases from the Soufrière volcano, St. Vincent, a possible harbinger of an eruption. Sulfurous odors are common on the volcano's W flank, but less frequent on other parts of the island.

Scientists determined that typical winds diminish the sulfurous odors over much of the island, and the onset of the odors resulted from changes in wind patterns rather than increased gas output or other demonstrable changes.

The Seismic Research Unit (SRU) collaborates with a small local unit called the Soufrière Monitoring Unit (which operates from the Ministry of Agriculture in Kingstown). The following report on the subject comes from SRU's Richard Robertson.

"During the night of 16 February and most of the day of 17 February there were widespread reports of sulfurous smells throughout southern St. Vincent and as far as the Grenadines. The day of the 17th was hazy; people put these two things together and came up with the conclusion that the volcano was acting up. The sulfur smell is unusual since the wind direction is such that most of the smell from the fumaroles at the summit of the volcano gets blown out to sea and is usually only smelt by a few residents on the eastern flank of the volcano.

"[SRU] . . . worked with Ms. Aisha Samuels, the head of the local volcano monitoring unit, to first investigate the report and later to quell fears that the volcano was doing anything unusual. We determined very early on that nothing serious was happening, since we have seismic stations both on the volcano and throughout the island [figure 4], none of which had recorded any increased seismicity. Further, we had just completed a GPS campaign on the island during January 2005, which revealed nothing unusual. It also involved two days of measurements on the summit of the volcano during which scientists were in very close proximity to the vent from which future eruptions will [likely] originate.

"We quickly determined that the reported 'activity' was due to an unusual southerly wind combined with the phenomena of Sahara dust which is common around this time of the year in St. Vincent and which results in very hazy conditions. However, to completely rule out the possibility of anything unusual happening in the crater that may not

have been possibly detected by our various measurements, we advised the local Unit that they should visit the crater summit the next day (18 February)."

That visit found nothing out of the ordinary. Accordingly, SRU did not think it necessary to update their website since it was so insignificant—"a 10 day wonder" as they say in the West Indies, or a 'pseudo-crisis.'" Such reports are common for St. Vincent and the entire region.

**Background.** Soufrière St. Vincent is the northernmost and youngest volcano on St. Vincent island. The 1.6-km wide summit crater, whose NE rim is cut by a crater formed in 1812, lies on the SW margin of the 2.2-km-wide Somma crater, which is breached widely to the SW as a result of slope failure. The first historical eruption of the volcano took place during 1718; it and the 1812 eruption produced major explosions. Much of the N end of the island was devastated by a major eruption in 1902 that coincided with the catastrophic Mont Pelée eruption on Martinique. A lava dome was emplaced in the summit crater in 1971 during a strictly effusive eruption, forming an island in a lake that filled the crater prior to an eruption in 1979. The lake was then largely ejected during a series of explosive eruptions, and the dome was replaced with another.

**Information Contacts:** *Richard Robertson*, Seismic Research Unit, The University of the West Indies, St. Augustine, Trinidad (URL: <http://www.uwiseismic.com/>); *Aisha Samuel*, Soufrière Monitoring Unit, Ministry of Agriculture, St. Vincent.

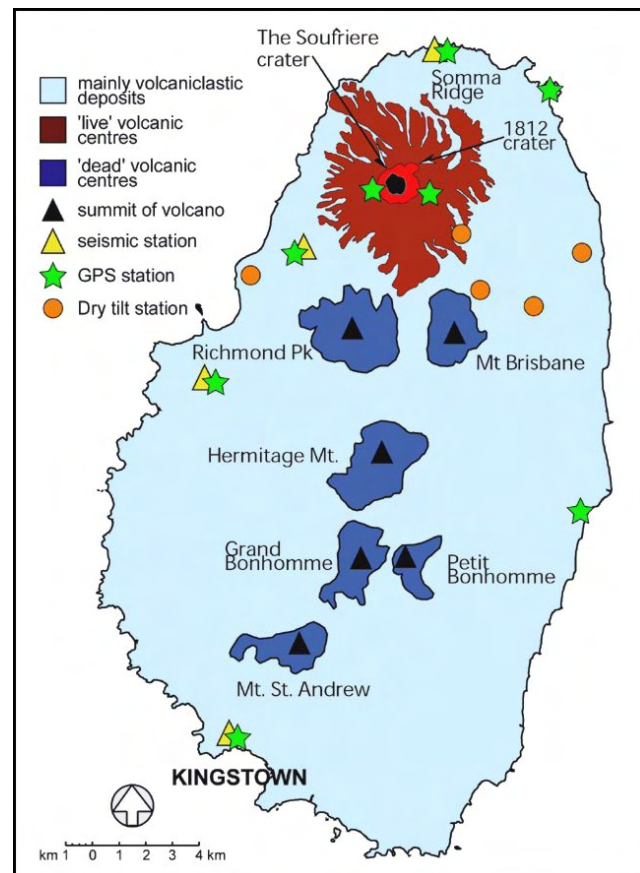


Figure 4. A sketch map showing the island of St. Vincent, including Soufrière volcano, other volcanic centers, geographic features, and Seismic Research Unit monitoring instrumentation (as of February 2004). January 2005 discussion of the instrumentation noted that it then included five seismic stations, eight GPS stations, and several dry-tilt sites. Courtesy of SRU.

## Soufrière Hills

Montserrat, West Indies  
 16.72°N, 62.18°W; summit elev. 915 m  
 All times are local (= UTC – 4 hours)

This report covers the period 26 November 2004 to 4 March 2005. Soufrière Hills volcano remained quiet after late November, with seismic signals, gas emissions, and rockfalls all decreasing (table 1 and *Bulletin* v. 29 no. 10).

While volcanic-tectonic and hybrid earthquakes (as many as 40/week) shook SHV from mid-October to late November, few were recorded between late November and early March (table 1). During the week of 25 February, winds shifted and carried the smell of sulfur to northern parts of the island. However, SO<sub>2</sub> emissions remained low and stable throughout December, January, and February. The average for this reporting period was ~ 400 tons/day, which is below the long-term average of 500 tons/day.

Rain and mudflows have also subsided. A mudflow in the Belham Valley on 15 December was the only event recorded for this reporting period.

An exceptionally clear day enabled scientists to obtain unusually clear photos on 1 February 2005 (figures 5, 6, and 7). Flights were made during November, December, and January as well. During the November-February interval, scientists saw relatively few changes in the surface morphology. Chances Pond, the pool of brownish water sitting in the explosion pit formed on 3 March 2004, still remained. MVO scientists noted around 26 November 2004 that the pond had changed from brownish to milky.

On 3 March 2005, scientists took a Fourier Transform Infrared spectrometer (FTIR) reading of the gas escaping from the crater vent at the summit (figure 6). The gas plume contained a ratio of hydrogen chloride to sulfur dioxide by mass of 0.35. This ratio showed no change since February.

In September 2004, the Scientific Advisory Committee on Montserrat Volcanic Activity (SAC) joined MVO staff at the Montserrat Volcano Observatory to discuss recent activity (SAC, 2004). “Few signs of surface activity” was their appraisal of the period since March 2004. There had



Figure 5. Montserrat from the NNE at an altitude of ~ 1,500 m, clearly showing the island's three main volcanic centers: the oldest and extinct Silver Hills (more than a million years old) in the foreground; the highest, densely foliated Centre Hills (also extinct, 0.5-1 million years old), and the steaming Soufrière Hills (220,000 years old), furthest away. Courtesy of MVO.

been little gas venting, ash venting, or tremor in six months, and no lava extrusion in 15 months. This pause in activity, the SAC predicted, will last ~ 26 months, but could last as long as 170 months. SAC estimated risks for a variety of circumstances.

Readers can access full reports issued by the SAC at the MVO website. The main report summarizes conclusions drawn from the meeting, while the technical report includes long-term monitoring data and risk assessments.

**Background.** The complex andesitic Soufrière Hills volcano occupies the southern half of the island of Montserrat. The summit area consists primarily of a series of lava domes emplaced along an ESE-trending zone. Prior to 1995, the youngest dome was Castle Peak, which was located in English's Crater, a 1-km-wide crater breached widely to the E. Block-and-ash flow and surge deposits associated with dome growth predominate in flank deposits. Non-eruptive seismic swarms occurred at 30-year intervals in the 20th century, but with the exception of a 17th-century eruption, no historical eruptions were recorded on Montserrat until 1995. Long-term small-to-moderate ash

Date (2004-2005)	Seismicity level	Hybrid earthquakes	Mixed earthquakes	Volcano-tectonic earthquakes	Long-period earthquakes	SO <sub>2</sub> flux (metric tons/day)	Rockfalls
26 Nov-03 Dec	—	9	—	7	—	130-590	4
03 Dec-10 Dec	—	7	—	—	—	250-370	1
10 Dec-17 Dec	—	6	—	7	—	290-450	—
17 Dec-24 Dec	—	6	—	1	—	200-500	—
24 Dec-31 Dec	—	6	—	2	1	300-550	—
31 Dec-07 Jan	—	4	—	—	—	310-400	—
07 Jan-14 Jan	—	5	—	5	—	180-511	—
14 Jan-21 Jan	—	2	—	—	—	300-3801	2
21 Jan-28 Jan	—	5	—	—	1	350-6701	—
28 Jan-04 Feb	—	2	—	1	7	4101	—
04 Feb-11 Feb	low	-	—	—	—	—	—
11 Feb-18 Feb	low	-	—	—	—	—	—
18 Feb-25 Feb	low	-	—	—	—	280-9801	—
25 Feb-04 Mar	low	6	—	3	—	6721	2

Table 1. Geophysical and geochemical data recorded at Soufrière Hills, 26 November 2004 to 4 March 2005. Wind directions or trouble with gas-monitoring equipment prevented measurement of SO<sub>2</sub> fluxes on some days. Courtesy of MVO.

eruptions beginning in that year were later accompanied by lava dome growth and pyroclastic flows that forced evacuation of the southern half of the island and ultimately destroyed the capital city of Plymouth, causing major social and economic disruption to the island.

**Reference:** Scientific Advisory Committee on Montserrat Volcanic Activity (SAC), 2004, Assessment of the hazards and risks associated with the Soufrière Hills volcano, Montserrat: Second Report of the Scientific Advisory Committee on Montserrat Volcanic Activity, parts I (Main Report, 24 p.) and II (Technical Report, 26 p.).

**Information Contacts:** *Montserrat Volcano Observatory (MVO)*, Fleming, Montserrat, West Indies (URL: <http://www.mvo.ms/>).



Figure 6. A photo of Soufrière Hills volcano taken from the NE showing the dome within the breached summit crater, and the SW-flank morphology. Much of the steam discharging was attributed to fumaroles. Photographed on 1 February 2005. Courtesy of MVO.

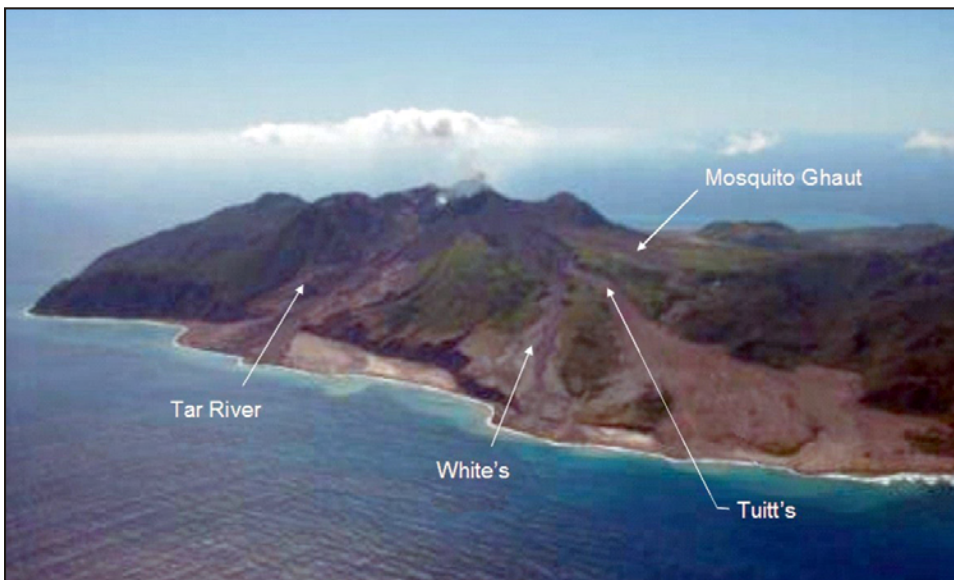


Figure 7. Recent deposits on the SW flank of Soufrière Hills as viewed from the NE on 1 February 2005. Prominent deltas appear at the mouths of the drainages shown, particularly at the mouth of the Tar River Valley. Courtesy of MVO.

## Kliuchevskoi

Kamchatka Peninsula

56.057°N, 160.638°E; summit elev. 4,835 m

All times are local (= UTC + 12 hours)

From April to November 2004, the hazard status (Concern Color Code) remained at Yellow, with seismicity at background levels throughout this time, and occasional fumarole activity. Around 26 November 2004, the status was reduced from Yellow to Green, the lowest level. During November 2004, seismicity remained at background levels. Gas-and-steam plumes were seen up to 5 km altitude

on 24 November 2004 and weak fumarolic activity was observed on several days. Kliuchevskoi was last reported on in April 2004 (*Bulletin* v. 29, no. 4) and this report covers the interval through 31 March 2005.

On 14 January 2005 the Kamchatkan Volcanic Eruption Response Team (KVERT) raised the status at Kliuchevskoi from Green to Yellow as seismic activity at the volcano increased. On 12 January, around 21 shallow earthquakes of M 1.0-1.7 and weak volcanic tremor were recorded. According to visual observations, weak gas-and-steam plumes were noted during 6-8 and 12 January. The plumes extended E from the volcano on 7 January and SW for 5 km on 12 January.

On 16 January 2005 KVERT raised the status again, from Yellow to Orange, as seismic activity increased significantly. During 13-14 January, 15 shallow earthquakes of over M 1.25 were recorded, along with an increase in the amplitude of volcanic tremor. Visual observations on 14 January noted a weak gas-and-steam plume that extended N from the volcano. Satellite data showed a bright thermal anomaly over the summit on 15 January.

During the third week of January, the total number of shallow earthquakes continued to increase. Gas-and-steam plumes rose to ~ 800 m above the lava dome. Incandescence was visible in the volcano's crater on several nights.

Strombolian eruptions occurred during 20-23 and 27 January. Explosions sent volcanic bombs 50-300 m above the crater on several nights. Gas-and-steam plumes rose to a maximum height

of 1.5 km above the crater. On 21 January a gas-and-steam plume with small amounts of ash extended as far as 23 km NE of the volcano. Throughout January seismicity was above background, with a large number of shallow earthquakes recorded daily. Gas-and-steam plumes that rose to ~ 1 km above the volcano's crater drifted SW on 29 January and NW on 31 January. A small amount of ash fell in the town of Klyuchi, about 25 km to the NE, on 31 January.

On 1 February around 1000, a mudflow carrying large blocks and trees traveled ~ 6 km down Kliuchevskoi's NW flank into the Kruten'kaya River. The mudflow reached a height of a few meters and trees were covered with mud to ~ 1.5 m. On 6, 8, and 9 February, ash plumes rose ~ 2.5 km above the volcano's crater. Gas-and-steam plumes rose to ~ 3 km during 6-9 February. A cinder cone was noted in the volcano's crater on 6 February. Fresh ash deposits were seen on the SW flank of Ushkovsky volcano (NW of Kliuchevskoi) on 7 February, and in Klyuchi on 9 February.

Throughout the first week of February there were Strombolian eruptions in the terminal crater of Kliuchevskoi, and a lava flow traveled into Krestovsky channel on the volcano's NW flank. Phreatic bursts occurred in this channel when the lava contacted glaciers during 6-9 February and 12-13 February. Ash plumes rose ~ 3 km above the volcano's crater during 12-14 February. During 12-16 February, volcanic bombs were hurled 300-500 m above the crater, Strombolian eruptions occurred in the crater, and lava again traveled into the Krestovsky channel. On 16 February, a mudflow extended 27 km. According to a news report, a lava flow from Kliuchevskoi melted a large section of Ehrman glacier on 21 February 2005.

Moderate seismic and volcanic activity continued at Kliuchevskoi during 24 February to 4 March. On 24 February lava continued to travel down the Krestovsky channel. Strombolian activity during this time sent plumes to ~ 1 km above the volcano. Ash fell in the village of Icha, about 275 km to the SW on 26 February, and in Kozyrevsk, about 25 km to the W, on 1 March. Ash plumes were visible on satellite imagery on several days. During the first two weeks of March 2005, eruptions continued. Strombolian explosions occurred intermittently from a cinder cone in the summit crater. Lava flows extend from this cone down the NW flank. Occasional vigorous explosions from the summit crater and along the path of the lava flow produced ash plumes as high as 7-8 km and traveled many tens or hundreds of kilometers downwind. Ash-and-gas plumes rose up to 3.2 km above the crater on 10-16 March and extended up to 150 km in various directions. Ash fell at Kozyrevsk on 11 March. Strombolian bursts rose about 500-1,000 m above the summit crater. Two lava flows were observed on the volcano's NW slope on 15 March. Clouds obscured the volcano at other times. According to satellite data, a large thermal anomaly was registered at the volcano during the second week of March.

During 11-18 March, Strombolian explosions occurred intermittently from a cinder cone in the summit crater. Lava flows extended from this cinder cone down the NW flank. Occasional vigorous explosions from the summit crater and along the path of the lava flow produced ash plumes that reached as high as 7-8 km altitude and drifted many tens or hundreds of kilometers downwind. Seismicity was above background at this time. On 11-12 March ash-and-gas plumes rose to 3.2 km above the crater. Ash fell in the town

of Kozyrevsk, 30 km to the W, on 11 March. Strombolian bursts rose 500-1,000 m above the summit crater. On 15 March two lava flows were observed on the NW slope. The amplitude of volcanic tremor was about  $12-13 \times 10^{-6}$  m/s on 18-21 March and increased to about  $46.0 \times 10^{-6}$  m/s on 22 March. From 1730 till 1900 on 23 March it was up to  $62 \times 10^{-6}$  m/s.

On 24 March KVERT raised the hazard status to Red (the highest level) due to increased seismic and volcanic activity. A gas-and-steam plume containing ash rose to ~ 7.5 km altitude on 22 March and ~ 8.5 km altitude on 23 March, extending NW. Ash fell in the town of Klyuchi during 23-24 March. According to data from AMC (Airport Meteorological Center) at Yelizovo, 340 km S, an ash plume that rose to ~ 7 km altitude and extended 70-80 km to the NW was observed by pilots on 23 March. The amplitude of volcanic tremor decreased from  $62 \times 10^{-6}$  m/s on 23 March to  $26-22 \times 10^{-6}$  m/s on 25-26 March. Satellite data indicated a 2- to 6-pixel (through the clouds) thermal anomaly over the volcano throughout the last week of March. Ash-and-gas plumes extended from the volcano 35 km N and 80 km W on 25 March. Seismometers detected a great number of shallow earthquakes and 27 earthquakes of  $M_1 = 1.5-2.1$ .

During about 27-28 March seismic activity at Kliuchevskoi decreased, leading KVERT to reduce the status to Orange. According to visual and video data during 27-28 March, a gas-and-steam plume containing some ash rose ~ 200 m above the crater and extended W. Ash-and-gas plumes rose to 2,500-3,000 m above the crater and extended SE on 28 March, and NE on 29 March. Incandescence above the summit crater was observed on 28 March. According to the data from the AMC at Yelizovo, an ash-and-gas plume rising about 2,000 m above the crater at 1420 on 31 March was observed by pilots. Ash-and-gas plumes extended 250 km SE on 28 March, 270 km NE on 29 March, and 100 km NW on 31 March.

**Background.** Kliuchevskoi is Kamchatka's highest and most active volcano. Since its origin about 6,000 years ago, the beautifully symmetrical, 4,835-m-high basaltic stratovolcano has produced frequent moderate-volume explosive and effusive eruptions without major periods of inactivity. Kliuchevskoi rises above a saddle NE of sharp-peaked Kamen volcano and lies SE of the broad Ushkovsky massif. More than 100 flank eruptions have occurred at Kliuchevskoi during the past roughly 3,000 years, with most lateral craters and cones occurring along radial fissures between the unconfined NE-to-SE flanks of the conical volcano between 500 m and 3,600 m elevation. The morphology of its 700-m-wide summit crater has been frequently modified by historical eruptions, which have been recorded since the late-17th century. Historical eruptions have originated primarily from the summit crater, but have also included numerous major explosive and effusive eruptions from flank craters.

**Information Contacts:** Olga Girina, Kamchatka Volcanic Eruptions Response Team (KVERT), a cooperative program of the Institute of Volcanic Geology and Geochemistry, Far East Division, Russian Academy of Sciences, Piip Ave. 9, Petropavlovsk-Kamchatskii 683006, Russia (Email: girina@kcs.iks.ru), the Kamchatka Experimental and Methodical Seismological Department (KEMSD), GS RAS (Russia), and the Alaska Volcano Observatory (USA); Alaska Volcano Observatory (AVO), co-

operative program of the U.S. Geological Survey, 4200 University Drive, Anchorage, AK 99508-4667, USA (URL: <http://www.avo.alaska.edu/>; Email: [tlmurray@usgs.gov](mailto:tlmurray@usgs.gov)), the Geophysical Institute, University of Alaska, P.O. Box 757320, Fairbanks, AK 99775-7320, USA (Email: [eisch@dino.gi.alaska.edu](mailto:eisch@dino.gi.alaska.edu)), and the Alaska Division of Geological and Geophysical Surveys, 794 University Ave., Suite 200, Fairbanks, AK 99709, USA (Email: [cnye@giseis.alaska.edu](mailto:cnye@giseis.alaska.edu)).

## Bezymianny

Kamchatka Peninsula

55.978°N, 160.587°E; summit elev. 2,882 m

All times are local (= UTC + 12 hours)

Bezymianny was reported on in Bulletin v. 29, no. 5, covering the June 2004 eruption that was characterized by viscous lava flows and large ash plumes. This report covers the interval from July 2004 through February 2005. From July 2004 to December 2004, unrest and fumarolic activity were virtually continuous. The Concern Code Color (hazard status) remained at Yellow throughout much of this time, and seismicity was at or below background levels. The lava dome of the volcano continued to grow, and satellite data frequently indicated a thermal anomaly over the dome. Gas-steam plumes were observed almost daily from Klyuchi about 50 km away, rising to 3-5 km altitude, and extending in various directions for 10-15 km.

KVERT raised the hazard status from Yellow to Orange on 7 January as seismicity increased. On 11 January, KVERT raised the status from Orange to Red (the highest level). An explosive eruption, inferred from seismic data, began at 2002 on 11 January 2005 and was believed to have produced an ash column to 8-10 km altitude. No visual or satellite data were available as dense clouds obscured the volcano. Seismic activity was above background levels during the first week of January and increased continuously. About 60 earthquakes of magnitude 1.25-2.25, and numerous weaker, shallow events registered during 7-11 January. Intermittent volcanic tremor was recorded on 10 January.

The hazard status was lowered from Red to Orange on 12 January when seismic activity returned to background levels following the eruption of 11 January. Seismicity remained at background levels so the status was lowered from Orange to Yellow on 14 January.

During February 2005 gas-steam plumes were observed frequently, rising 50-1,000 m above the dome and drifting 10-15 km in various directions. Satellite data frequently indicated a thermal anomaly over the dome. The status remained at Yellow as of 29 April 2005.

**Background.** Prior to its noted 1955-56 eruption, Bezymianny volcano had been considered extinct. The modern Bezymianny volcano, much smaller in size than its massive neighbors Kamen and Kliuchevskoi, was formed about 4,700 years ago over a late-Pleistocene lava-dome complex and an ancestral volcano that was built between about 11,000-7,000 years ago. Three periods of intensified activity have occurred during the past 3,000 years. The latest period, which was preceded by a 1,000-year quiescence, began with the dramatic 1955-56 eruption. This eruption, similar to that of Mount St. Helens in 1980, produced a

large horseshoe-shaped crater that was formed by collapse of the summit and an associated lateral blast. Subsequent episodic but ongoing lava-dome growth, accompanied by intermittent explosive activity and pyroclastic flows, has largely filled the 1956 crater.

**Information Contacts:** Olga Girina, Kamchatka Volcanic Eruptions Response Team (KVERT), a cooperative program of the Institute of Volcanic Geology and Geochemistry, Far East Division, Russian Academy of Sciences, Piip Ave. 9, Petropavlovsk-Kamchatskii 683006, Russia (Email: [girina@kcs.iks.ru](mailto:girina@kcs.iks.ru)), the Kamchatka Experimental and Methodical Seismological Department (KEMSD), GS RAS (Russia), and the Alaska Volcano Observatory (USA); *Alaska Volcano Observatory* (AVO), a cooperative program of the U.S. Geological Survey, 4200 University Drive, Anchorage, AK 99508-4667, USA (URL: <http://www.avo.alaska.edu/>; Email: [tlmurray@usgs.gov](mailto:tlmurray@usgs.gov)), the Geophysical Institute, University of Alaska, P.O. Box 757320, Fairbanks, AK 99775-7320, USA (Email: [eisch@dino.gi.alaska.edu](mailto:eisch@dino.gi.alaska.edu)), and the Alaska Division of Geological and Geophysical Surveys, 794 University Ave., Suite 200, Fairbanks, AK 99709, USA (Email: [cnye@giseis.alaska.edu](mailto:cnye@giseis.alaska.edu)).

## Canlaon

central Philippines

10.412°N, 123.132°E; summit elev. 2,435 m

All times are local (= UTC + 8 hours)

Ash emissions and sporadic seismicity at Canlaon between March 2003 and March 2004 were reported in *Bulletin* v. 29, no. 12. A brief ash emission began at Canlaon around 0930 on 21 January 2005. The eruption cloud rose ~ 500 m above the active crater and drifted WNW and SW. No coincident volcanic earthquakes were recorded. Fine ash was deposited in the city of Cabagnaan, ~ 5.5 km SW of the crater. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) advised the public to avoid entering the 4-km-radius Permanent Danger Zone around Canlaon.

Ash emissions began again on 20 March around 1300. Small amounts of ash fell in the town of Guintubdan 5 km W of the volcano. During 24 March to 4 April, sporadic ash emissions rose to a maximum of 1 km above the volcano. During this time ash fell in the towns of La Castellana (16 km SW of the crater), Upper Sag-ang, Yubo (5-6 km SW), and Guintubdan (5-6 km WNW). Due to this unrest, PHIVOLCS raised the Alert Level from 0 to 1 (on a scale of 0-5) on 30 March. According to a news article, pilots were advised to avoid flying near Canlaon.

On March 22 the Provincial Disaster Management Team (PDMT) warned it would apprehend trekkers and faith healers who ventured to Mount Canlaon during Holy Week. Trekking to Mount Canlaon has become a practice by some faith healers and mountaineers who believe that the volcano is a source of supernatural powers.

On 31 March at 0601 and 1715, two mild ash ejections reached heights of about 200-300 m above the summit before drifting NW and SW. Ash was deposited at Guintubdan, Upper Sag-ang, and Upper Mansalanao. A low-energy ash emission on 7 April at 1429 generated a



cloud which rose to a height of ~ 100 m above the crater and drifted SW. According to PHIVOLCS, the seismic monitoring network around the volcano did not record any earthquakes during this event. During 13-14 April, mild ash emissions produced plumes to a height of ~ 700 m above the crater. During 15-17 April, moderate-to-strong emissions produced ash plumes to ~ 2 km above the crater and deposited ash in villages as far as La Castellana. None of these ash emissions was associated with seismicity, indicating that the activity is likely hydrothermal in nature, and taking place at shallow levels in the crater.

Throughout this period Canlaon remained at Alert Level 1. As of the end of April 2005, the 4-km-radius Permanent Danger Zone (PDZ) was restricted and all treks to the summit remained suspended.

**Background.** Canlaon volcano (also spelled Kanlaon), the most active of the central Philippines, forms the highest point on the island of Negros. The massive 2,435-m-high stratovolcano is dotted with fissure-controlled pyroclastic cones and craters, many of which are filled by lakes. The summit of Canlaon contains a broad elongated northern caldera with a crater lake and a smaller, but higher, historically active crater to the S. The largest debris avalanche known in the Philippines traveled 33 km to the SW from Canlaon. Historical eruptions, recorded since 1866, have typically consisted of phreatic explosions of small-to-moderate size that produce minor ashfalls near the volcano.

**Information Contacts:** *Philippine Institute of Volcanology and Seismology* (PHIVOLCS), Department of Science and Technology, PHIVOLCS Building, C.P. Garcia Avenue, Univ. of the Philippines Campus, Diliman, Quezon City, Philippines (URL: <http://www.phivolcs.dost.gov.ph/>); Chris Newhall, USGS, Box 351310, University of Washington, Seattle, WA 98195-1310, USA (Email: [cnewhall@ess.washington.edu](mailto:cnewhall@ess.washington.edu)); *Philippine Star* (URL: <http://www.philstar.com/>).

## Ibu

Halmahera, Indonesia

1.48°N, 127.63°E; summit elev. 1,325 m

The Directorate of Volcanology and Geological Hazard Mitigation (DVGHM) released ten nearly identical weekly reports on Ibu during 31 May-29 August 2004. They noted that Ibu emitted “white ash” (steam plumes) reaching ~ 50-150 m above the crater rim. Continued growth of the intracrater lava dome was either recognized or assumed. Ibu lacked a working seismic instrument. Its hazard status remained at Level II (Yellow, a condition meaning ‘caution or on guard’ (*‘waspada’* in Indonesian)).

Our last few reports discussed mild ash explosions in 1999 (*Bulletin* v. 24, no. 5), thermal alerts during 28 May-3 October 2001 and the fact that activity during much of 2002 was likely just below the detection threshold (*Bulletin* v. 28, no. 3).

**Background.** The truncated summit of Gunung Ibu stratovolcano along the NW coast of Halmahera Island has large nested summit craters. The inner crater, 1 km wide and 400 m deep, contained several small crater lakes through much of historical time. The outer crater, 1.2 km wide, is breached on the N side, creating a steep-walled val-

ley. A large parasitic cone is located ENE of the summit. A smaller one to the WSW has fed a lava flow down the western flank. A group of maars is located below the northern and western flanks of the volcano. Only a few eruptions have been recorded from Ibu in historical time, the first a small explosive eruption from the summit crater in 1911. An eruption producing a lava dome that eventually covered much of the floor of the inner summit crater began in December 1998.

**Information Contacts:** *Directorate of Volcanology and Geological Hazard Mitigation (DVGHM)*, Jalan Diponegoro No. 57, Bandung 40122, Indonesia (URL: <http://www.vsi.dpe.go.id/>).

## Kavachi

Solomon Islands

9.02°S, 157.95°E; summit elev. -20 m (submarine)

All times are local (= UTC + 11 hours)

The Solomon Islands’ government-supported web service, the *People First Network (PFnet)* reported in March 2004 that Corey Howell of The Wilderness Lodge, Gatokae Island, observed Kavachi erupting (figure 8). Kavachi is among the world’s few regularly erupting submarine volcanoes that sends material above the ocean surface in witnessed (and reported) eruptions.

The figure caption on *PFnet* notes an 8-month period of Kavachi inactivity, which was also confirmed in brief correspondence with Howell. A report that summarized the interval between the summer of 2001 and the end of 2003 (*Bulletin* v. 29, no. 1) lacked any mention of an eruption during mid-August 2003, eight months before the recent eruption.

**Background.** Kavachi, one of the most active submarine volcanoes in the SW Pacific, occupies an isolated position in the Solomon Islands far from major aircraft and shipping lanes. Kavachi, sometimes referred to as Rejo te Kvachi (“Kavachi’s Oven”), is located S of Vangunu Island only about 30 km N of the site of subduction of the Indo-Australian plate beneath the Pacific plate. The shallow submarine basaltic-to-andesitic volcano has produced ephemeral islands up to 1 km long many times since its first recorded eruption during 1939. Residents of the nearby is-



Figure 8. A photo of Kavachi erupting as seen on 15 March 2004. The original caption on *PFnet* was “Kavachi awoke on Monday in spectacular fashion after an eight-month slumber . . .” Courtesy of Corey Howell.

lands of Vanguna and Nggatokae (Gatokae) reported “fire on the water” prior to 1939, a possible reference to earlier submarine eruptions. The roughly conical volcano rises from water depths of 1.1–1.2 km on the N and greater depths to the S. Frequent shallow submarine and occasional subaerial eruptions produce phreatomagmatic explosions that eject steam, ash, and incandescent bombs above the sea surface. On a number of occasions lava flows were observed on the surface of ephemeral islands.

**Information Contacts:** Corey Howell, The Wilderness Lodge, P.O. Box 206, Honiara, Solomon Islands (Email: peava@thewildernesslodge.org; URL: <http://www.thewildernesslodge.org/>); People First Network (PFnet), Rural Development Volunteers Association, Ministry of Provincial Government and Rural Development, PO Box 919, Honiara, Solomon Islands (Email: pfnet@pipolfastaem.gov.sb; URL: <http://www.peoplefirst.net.sb/>).

## Lopevi

Central Islands, Vanuatu  
16.507°S, 168.346°E; summit elev. 1,413 m  
All times are local (= UTC + 11 hours)

Previously, *Bulletin* reports for 2003 chiefly discussed either aviation-related reports about ash plumes or satellite data, such as the spectroscopic sensing of SO<sub>2</sub> or infrared data in the form of MODVOLC thermal alerts (*Bulletin* v. 27, no. 12; v. 28, nos. 1 and 6; v. 29, no. 6). Since those reports more first-hand observations of conditions on the ground have emerged regarding Lopevi during 2003. Numerous thermal anomalies were detected by the MODIS satellite at Lopevi during July 2003 to March 2005 (table 2). Other observations also indicate activity continuing in 2005. Lopevi erupts nearly continuously, but, because it is an uninhabited island, activity often goes unreported.

Lopevi remains a danger for the region, and particularly for Paama Island, the closest inhabited island (6 km away). The explosive eruption of 2001 turned day into night for several hours, and the ashfall polluted the islanders’ water supply to the point where the Australian Navy had to send a ship to bring residents drinking water. Since then, wells equipped with hand-operated pumps have been installed on Paama’s N side, the flank threatened most directly. Lardy suggested that evacuating 1,633 inhabitants (the number cited in a 1999 census) is not realistic, but that the population could be supplied with dust-filtering face masks prior to the next eruption. The majority of Paama Island residents live on the W coast and even for the closest residents on Paama’s N coast, the view of Lopevi is often limited.

**Observations during 2003.** Michel Lardy summarized the activity during 2003. The major volcanic events of June 2001 (*Bulletin* v. 26, no. 8) and of June 2003 (*Bulletin* v. 28, no. 6) appear to have originated at the adventive crater and through fractures in the island’s N and W sides (figures 9 and 10). In particular, vents on the N, NW, and W opened in 2001 and 2003. Vent opening in 2001 occurred at 16° 31. 879’ S, 168° 19.846 E. A 2001 lava flow was prominent on the N flank. Radar interferometry depicted lava in 2001 on the volcano’s N side, in the crater, and at several places on the N and W flanks.

**Observations during 2004.** During September 2004 thermal anomalies were detected four times, as many times as any month during the interval shown on table 2. However, none of the 28 September anomalies were unusually strong ( $\sim 1 \text{ W m}^{-2} \text{ sr}^{-1} \mu\text{m}^{-1}$ ) and the spectral radiance of some other observations were several-fold larger (up to  $\sim 3.8 \text{ W m}^{-2} \text{ sr}^{-1} \mu\text{m}^{-1}$ ).

Volcano tour guide John Seach visited SE Ambrym volcano in November 2004. At that time he received reports from residents about previously unreported eruptions of Lopevi that occurred during 2004. Specifically, during September 2004, five large booming noises were heard coming from Lopevi by villagers in S Ambrym. Explosions were separated by 2 minutes. The next day there was ashfall on N and W Ambrym.

**Observations during 2005.** According to Seach, local observers in Vanuatu indicated ongoing eruptive activity at Lopevi beginning at the end of January 2005 and continuing into February. The Wellington VAAC is the key group providing aviators with reports on Lopevi eruptions and ash plumes. Their website posted all Volcanic Activity Advisories during 90 days prior to 28 March, but there were no reports for Lopevi during that interval. This absence of re-



Figure 9. Lava flows down Lopevi’s N flank and entering the sea during June(?) 2003. Note multiple lava flows, distinct vent areas, and the presence of at least two active points of entry into the ocean at the time of the photo. Photo credit, Shane Cronin (Massey University).



Figure 10. A closer look at the vents feeding lava flows down Lopevi’s N flank during June(?) 2003. The vents formed along radial fractures. Photo credit, Shane Cronin (Massey University).



Figure 11. Annotated, N-looking view of Lopevi showing summit crater and adventive crater, and two other islands in the background. Copyrighted photo taken 21 March 2005 by P. Bani, IRD.



Figure 12. A photo of Lopevi's adventive NW-flank crater taken looking S from an altitude of ~ 1 km. White deposits occur along considerable portions of the larger crater's rim. The color version of this photo indicates a yellow region lies on the internal crater (the crater inside the larger crater and in the middle of the photo). Other areas of yellow color were also visible farther to the right, although in this shot it was masked by a hazy plume. The yellow color was attributed to sulfur deposits. Copyrighted photo taken 21 March 2005; provided courtesy of M. Lardy, IRD.

ports could be for a variety of reasons, such as relatively few if any plumes during that interval. Other reasons might also include extensive weather clouds screening satellite and pilot observations, or an absence of reports from pilots or people in the field to pass observations to the VAAC.

On 21 March 2005 IRD staff members observed Lopevi in usually clear weather conditions (figures 11 and 12). These two photos highlight Lopevi's summit crater and its off-axis NW-flank (adventive) crater. The adventive crater has been a feature of the edifice since the early 1960s (*Bulletin* v. 24, nos. 2 and 7; the latter issue contains a map showing the then-recent crater).

The close-up photo (figure 12) shows a circular fracture along the crater's rim and circumferential fractures along its walls, probably the result of subsidence caused by the constant release of gas from the magma reservoir. White hydrothermal deposits were thought to have been associated with this gas release. The observers also saw yellow sulfur deposits near the internal crater and between it and the northern rim (to the right on the photo).

The perpendicular fractures visible just outside the crater (bottom center on the photo) were also judged most likely related to this subsidence associated with gas release.

The small inner crater was a zone of active deposition (building up that crater). This pattern, apparently cyclical, has been visible since 1998, when Lopevi resumed an active phase following a quiet period of about fifteen years during which only fumaroles were observed. The summit crater (1,367 m elevation, figure 12) appears little changed when compared with the same crater 1995 photos taken in 1995. The major volcanic events of June 2001 (*Bulletin* v. 26, no. 8) and of June 2003 (*Bulletin* v. 28, no. 6) originated in the adventive crater and through fractures in the island's N and W sides.

Lardy also commented that "observations made since the 19th century suggest an activity cycle of 15 to 20 years, yet it remains difficult to forecast the occurrence of major

Date (mo/dy/ yr)	Time (UTC)	Sensor	Spectral radiance
02/16/2005	0245	A	2.813
02/05/2005	1355	A	0.983
02/05/2005	1355	A	1.426
01/30/2005	1130	T	0.710
01/03/2005	0220	A	2.560
12/15/2004	1115	T	3.425
11/18/2004	0210	A	2.771
11/13/2004	1115	T	0.886
10/04/2004	2300	T	3.009
09/28/2004	1410	A	0.937
09/28/2004	1410	A	1.052
09/17/2004	1125	T	1.123
09/10/2004	1115	T	1.186
08/07/2004	1130	T	1.015
07/19/2004	1400	A	0.362
07/07/2004	2305	T	2.883
05/28/2004	1125	T	1.797
05/28/2004	1125	T	3.012
05/12/2004	1425	A	1.353
05/12/2004	1125	T	2.332
04/22/2004	1150	T	0.930
04/17/2004	1130	T	0.949
03/27/2004	1415	A	2.314
03/27/2004	1415	A	0.740
03/02/2004	1120	T	1.636
02/28/2004	1350	A	0.965
02/28/2004	1350	A	1.017
02/17/2004	1410	A	1.218
02/01/2004	1405	A	0.917
01/15/2004	0230	A	4.117
11/02/2003	1125	T	1.154
11/02/2003	1125	T	2.527
10/08/2003	1130	T	2.212
10/04/2003	0225	A	3.680
09/02/2003	0225	A	3.815
08/21/2003	1130	T	2.143
08/18/2003	1400	A	0.917
08/16/2003	1410	A	1.100

Table 2. MODVOLC thermal anomalies as observed from the MODIS satellite for Lopevi volcano for the period July 2003 to March 2005. The third column gives the MODIS sensor that detected the hot spot; T = Terra-MODIS, and A=Aqua MODIS. The fourth column shows radiance in watts per square meter, per steradian, per micron ( $W m^{-2} sr^{-1} \mu m^{-1}$ ) in MODIS band 21 (central wavelength of 3.959  $\mu m$ ). Courtesy of the Hawaiian Institute of Geophysics and Planetology.

eruptive phases within the cycle. Although there appears to be a recurrence of events in the month of June, it would be rash to attempt to predict the next eruption given the current state of our knowledge. Since November 2004, a micro-barometer has been set up on Paama Island. It is connected to the SSI network (which monitors compliance with the international ban on nuclear explosions) and has been recording the explosive volcanic events occurring on Lopevi and Ambrym Islands. Real time measurements should complement this monitoring system.”

**Reference:** Le Pichon, A., and Drob, D., 2005, Probing high-altitude winds using infrasound from volcanoes: *Jour. of Geophys. Res.* (in press)

**Background.** The small 7-km-wide conical island of Lopevi is one of Vanuatu’s most active volcanoes. A small summit crater containing a cinder cone is breached to the NW and tops an older cone that is rimmed by the remnant of a larger crater. The basaltic-to-andesitic volcano has been active during historical time at both summit and flank vents, primarily along a NW-SE-trending fissure that cuts across the island, producing moderate explosive eruptions and lava flows that reached the coast. Historical eruptions at the 1,413-m-high volcano date back to the mid-19th century. The island was evacuated following eruptions in 1939

and 1960. The latter eruption, from a NW-flank fissure vent, produced a pyroclastic flow that swept to the sea and a lava flow that formed a new peninsula on the W coast.

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### Obituary

Our friends at the Philippine Institute of Volcanology and Seismology (PHIVOLCS), and indeed all in volcanology, have suffered a grievous loss in the 28 April 2005 helicopter crash that took the lives of four Air Force crew members, four PHIVOLCS scientists, and its former director Ray Punongbayan. They were inspecting landslide-prone areas about 110 km ENE of Pinatubo, looking for areas to resettle communities affected by the 2004 typhoons.

PHIVOLCS staff were Jessie Daligdig, Norman Tungol, Dindo Javier, and Orlando Abengoza, all in their 40s. Ray Punongbayan, 67, joined PHIVOLCS at its start in 1982, and served as its director from 1983 through 2002. This was a time of great growth for PHIVOLCS, and Ray placed major emphasis on hazard mitigation—through maps, education, monitoring, a quick response team, and linkages with volcanologists around the world. Their success at Pinatubo set a standard for all of us, and this loss saddens the full international community.

**Subscriptions:** The *Bulletin of the Global Volcanism Network* (ISSN: 1050-4818) is available by subscription from the American Geophysical Union (2000 Florida Avenue NW, Washington, DC 20009, phone 202:462-6900 or 800:966-2481, fax 202:328-0566, Email: [service@agu.org](mailto:service@agu.org)). Annual subscription price (2005) is \$26 to US addresses and \$43 to all other countries. Back issues can be ordered through AGU Separates; contact AGU for current pricing information. Orders must be prepaid; make checks payable to AGU; VISA/MC are accepted. The Smithsonian does not handle any *Bulletin* orders.

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