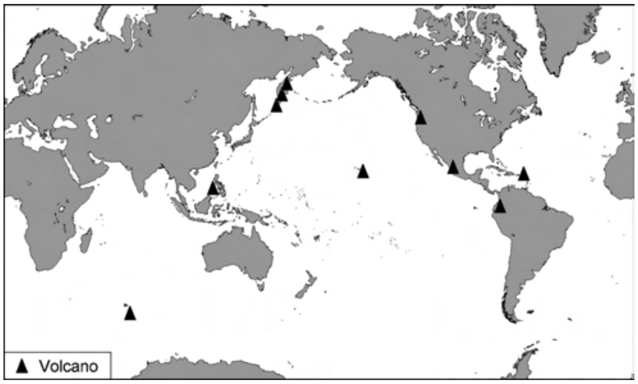
Bulletin of the Global Volcanism Network



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Colima

México
19.514°N, 103.62°W; summit elev. 3,850 m
All times are local (= UTC - 6 hours)

Small to moderate explosive eruptions have been common at Colima since 1999, some blasting material as high as 11 km altitude and at times sending pyroclastic flows to 5 km runout distances. Between these explosive eruptions, andesitic lava from the main intracrater vent sometimes formed small, short-lived lava domes. The feeder lavas, cryptodomes, and occasional domes were blasted out during subsequent eruptions. A table of significant eruptive events at Colima during July 1999 to June 2005 (Luhr and others, in press) produced this tally for the number of days where plumes went over 2 km above the summit (~ 6 km altitude): in the latter half of 1999, three days; 2000, one day; 2001, four days; 2002, four days; 2003, 15 days; 2004, ~ 24 days; and in the first half of 2005, 31 days. Eruptions discussed in aviation reports from the Washington Volcanic Ash Advisory Center (VAAC) became a significant source of data starting in 2003, and formed the basis of many entries in the subsequent years.

Extrusions during September-November 2004 formed a new lava dome in the active crater, and two lava flows descended from that crater along the N and WNW flanks (BGVN 30:01). After lava effusion ceased, intermittent explosions and exhalations followed. In the same pattern mentioned above, the dome was later destroyed by Vulcanian-style explosions that produced eruption plumes and in some cases, pyroclastic flows (BGVN 30:03).

The number of seismic events decreased during December 2004-February 2005 (figure 1), and with some important exceptions, remained under 10 events per day until as late as the end of June 2005. During this reporting interval, April-June 2005, intermittent explosions continued (figure 1). Explosions that generated pyroclastic flows were known to have continued through at least 5 July.

Comparatively large explosions began to occur starting 10 March 2005 (BGVN 30:03). The largest, accompanied by pyroclastic flows, were particularly vigorous from 24 May to 5 June. As in March 2004 the explosions consisted of Vulcanian-style gas-and-ash explosions. Some of the April-June explosions issued material that reached as high as ~ 10 km altitude, and pyroclastic flow runout distances reached up to ~ 5.1 km, an increase over those in March 2004 (when maximum runout distances only reached ~ 2.8 km).

When photographed on 25 May 2005 the dome and unconsolidated material filled much of the crater, although the intracrater area was anything but flat (figure 2). By comparison, a photo of the crater taken on 16 June 2005, following many large Vulcanian explosions, shows its upper portion to be essentially empty (figure 3).

The March-June explosive sequence removed the 2004 lava dome, and left a crater ~ 260 m across and ~ 30 m deep (figure 3). No significant deformation of the volcanic edifice was recorded before or during the large explosions (table 1). After the explosion of 5 June, residents were evacuated from Juan Barragán, a small village ~ 10 km SE of the summit. Smaller explosions at Colima typically take place at the rate of several per day.

Reference: Luhr, J., Navarro-Ochoa, C., and Savov, I., (in press), Petrology and mineralogy of lava and ash erupted from Volcán Colima, México, during 1999-2005: Special Volume on the Colima Volcano, from the University of Guadalajara (edited by Francisco Nuñez-Cornú).

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) on the N and the 3,850-m-high historically active Volcán de Colima at the S. A group of cinder cones of probable late-Pleistocene age is located on the floor of the Colima graben west and east 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

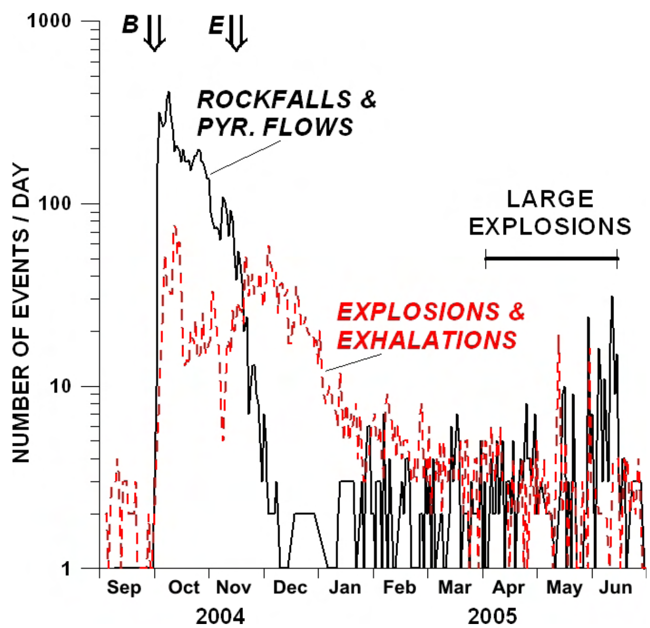

Figure 1. The number of daily earthquakes ascribed to rockfalls and pyroclastic flows (heavy line) and to explosions and exhalations (dashed line) at Colima during September 2004-June 2005. Double arrows show the beginning (B) and the end (E) of the lava extrusion in late 2004. A label indicates the period when occasional large explosions took place (an interval that began on 10 March and continued through June 2005). Courtesy of Colima Volcano Observatory.

Time of explosion (UTC)	Altitude of the column	Direction and average horizontal velocity of the ash cloud	Length of the ash cloud in km*	Length of pyroclastic flows
24 May (0009)	9.7 km	W (7.7 m/s)	204 km	3.5 km
30 May (0826)	8.5 km	SE (15 m/s)	102 km	4 km
02 Jun (0449)	6 km	S (5.1 m/s)	74 km	4.5 km
05 Jun (1920)	7.6 km	W-SE (7.7 m/s)	222 km	5.1 km

Table 1. Main characteristics of the largest explosions seen at Colima during May-June 2005. Column heights and ash cloud velocities came from remote-sensing data and reports furnished by the Washington VAAC. The highest velocity, 15 m/s, corresponds to 54 km/hour. Courtesy of Colima Volcano Observatory.

from both the 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@cgic.ucol.mx); *Washington Volcanic Ash Advisory Center (VAAC)*, NOAA-NESDES, Satellite Analysis Branch, 5200 Auth Road, Camp Springs, MD 20746 USA.

Figure 2. At Colima on 25 May 2005 the crater contained considerable dome and unconsolidated material, filling it to near the rim. Several weeks later, after further explosions had driven considerable material out, the upper crater was left with substantial open space (see next photo). Courtesy of Colima Volcano Observatory.

Figure 3. Photo of Colima's crater after the comparatively large explosions that began in March 2005. This photo was taken on 16 June looking from the S. Eruptions had removed much of the crater fill and a small dome from the upper crater. Small impact craters pocked the crater floor. An erosion channel had developed across crater's S rim, presumably due to the passage of pyroclastic flows associated with the recent explosions. The notch in the rim has been prominent since 2004 and has emptied and perhaps grown considerably since the photo taken 25 May 2005. Despite the changes seen in this photo, the explosions had left the crater walls intact and without evidence of fractures. Courtesy of Colima Volcano Observatory.

Soufrière Hills

Montserrat, West Indies

16.72°N, 62.18°W
summit elev. 915 m

All times are local
(= UTC - 4 hours)

Soufrière Hills was last reported on in BGVN 30:03, covering November 2004 to March 2005, during which time the volcano remained quiet, with seismic signals, gas emissions and rockfalls all decreasing. This report, from Montserrat Volcano Observatory (MVO), covers the period from late March 2005 to July 2005. The volcano continued to be relatively quiet through April and early May, with activity increasing somewhat through June and several explosive events in late June and in July. Table 2 summarizes the seismicity and SO_2 emissions during the period of this report.

Seismic activity at Soufrière Hills remained at low levels throughout March and most of April 2005. Beginning on 15 April, vigorous steam-and-ash venting occurred on the NW side of Soufrière Hills crater and continued throughout the period of this report. Average daily SO_2 emissions were generally lower than the long-term eruption average of 500 tons/day, but increased in July to above the average.

On 13 June at 0600 an ash plume reached a height of ~ 2.4 km altitude and drifted NE, depositing light ash in Lookout, Geralds, and St. Peters.

Starting around 10 June, seismic and volcanic activity were at elevated levels. The ash venting

Report date (2005)	Seismicity level	Number of earthquakes				SO_2 flux (metric tons/day)	
		Hybrid	Volcano-tectonic	Long-period	Rockfalls	Range	Daily average
25 Mar-01 Apr	low	1	5	1	—	186-369	290
01 Apr-08 Apr	low	1	7	1	—	280-650	400
08 Apr-15 Apr	low	—	19	—	—	261-1877	619
15 Apr-22 Apr	—	7	37	—	1	122-957	365
22 Apr-29 Apr	—	7	31	—	—	112-330	304
29 Apr-06 May	—	1	4	—	1	276-644	439
06 May-13 May	—	1	38	—	1	221-537	398
13 May-20 May	—	3	18	—	—	222-363	286
20 May-27 May	—	—	67	—	—	880*	—
27 May-03 Jun	—	—	8**	—	—	167-392	261
03 Jun-10 Jun	—	—	17	—	1	142-671	399
10 Jun-17 Jun	elevated	17	46	20	7	170-750	460
17 Jun-24 Jun	elevated	8	4	5	3	430-1150	627
24 Jun-01 Jul	elevated	19	15	5	—	300-700	470
01 Jul-08 Jul	elevated	15	9	11	11	241-1700	767

Table 2. Geophysical and geochemical data recorded at Soufrière Hills, 25 March 2005 to 15 July 2005. * Only measurement during report period. **12-hour system failure may have caused events to be missed. Courtesy of MVO.

that began on 13 June declined in intensity during the following week. The ash venting was caused by the rapid release of steam and other volcanic gases, possibly triggered by intense rainfall on the night of 12 June. Ash analyses from this episode did not indicate fresh magma.

On 27 June a steam and ash cloud at ~ 3 km altitude was reported to be drifting W. By 28 June satellite imagery showed a plume of ash and steam at ~ 1.8 km altitude extending NW. Periodic episodes of intense ash venting continued, culminating in an explosive event on 28 June at 1306. During the event, ballistics were ejected onto the Farrell's plain (to the NW), and a column collapse produced pyroclastic flows. The pyroclastic flows reached the sea at the Tar River delta (to the NE), and a smaller volume of material flowed into the top of Tyre's Ghaut (to the N). Ash showed no evidence of fresh magma.

Preliminary analysis of recent ground deformation data from the GPS network at the volcano showed that deflation during April to mid June 2005 had later reversed, and the volcano appeared to be inflating. Periodic ash venting continued and an explosion occurred on 3 July at 0130, which was similar to the explosion on 28 June.

An explosive event at 0301 on 18 July caused widespread ash fallout between Fogarty Hill on the island's NW and Brodericks Yard on the island's SW and almost certainly led to pyroclastic flows to the sea in Tar River. This explosion was similar to, but slightly bigger than, the explosion on 3 July, and ash venting and pyroclastic flows combined to cause dramatic ash clouds which reached to at least 6 km. Winds blew the ash plume in a NW direction causing significant ash fall in Old Towne, Iles Bay, Salem, Olveston, Woodlands and St Peters. The maximum depth of ash measured by scientists in inhabited areas was 1.5 to 2.0 mm; the deepest ash was recorded at Weekes. Activity subsequently returned to background levels.

The MVO collected ash samples from the affected areas to determine whether it was new material from depth or older material from the dome. Ash collected after the 28 June and 3 July 2005 events showed no evidence of new magmatic material.

On 28 July 2005, the Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard the Aqua satellite acquired an image of a plume of volcanic ash drifting westward in a slightly curving shape as it departs Soufriere Hills (in the middle of the image, figure 4).

Background. The complex andesitic Soufrière Hills volcano occupies the southern half of the island of Montserrat. The summit area consists primarily of a series

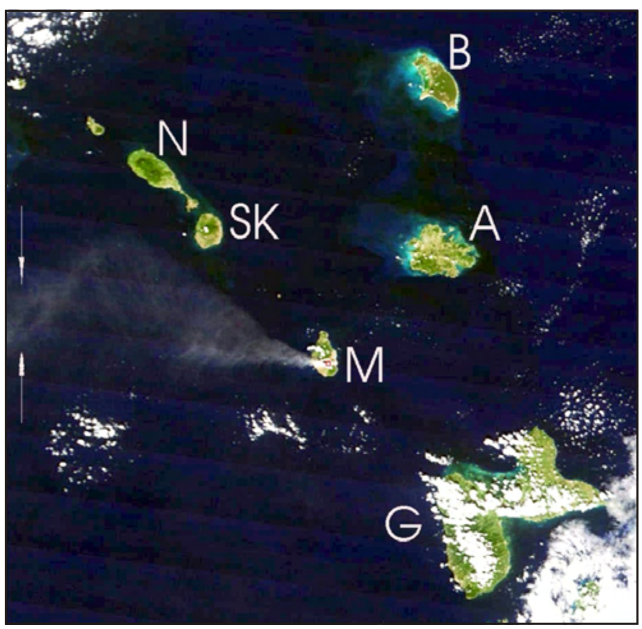

Figure 4. A MODIS image of an ash plume from Soufrière Hills acquired on 28 July 2005. N is towards the top. The plume was visible for over 100 km, but conspicuous portions of the plume continued beyond the W (left) side of this image between the arrows. A Washington VAAC report from that day suggested a plume to ~ 5 km altitude and 70-300 km long, blown W. Several islands neighboring Montserrat (M) are labeled: A, Antigua; B, Barbuda; G, Guadeloupe; N, Nevis; and SK, St. Kitts. For scale, the distance between the centers of the islands of Montserrat and Antigua is ~ 55 km. Some islands are ringed in bright blue-green, the possible result of coral reefs in shallow water, sediment, phytoplankton, or some combination of these conditions. Image and some elements of the caption courtesy of Jeff Schmaltz, MODIS Rapid Response Team, NASA.

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 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.

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

St. Helens

Washington, USA
46.20°N, 122.18°W; summit elev. 2,549 m
All times are local (= UTC - 8 hours)

Throughout the period covered by this report, March 2005 to July 2005, growth of the new lava dome inside the crater of St. Helens continued, accompanied by low rates of both seismicity and gas and ash emissions. The hazard status remained at 'Volcano Advisory' (Alert Level 2); aviation color code Orange. Results from a digital elevation model produced from imagery taken on 21 February showed the highest part of the new lava dome was 12 m higher than on 1 February; during that 3 week period the volume of dome and surrounding uplift had increased by 3 million cubic meters. The average rate of growth continued at ~2 m^3/s. Figure 5 shows four views of changes to the lava dome during the period of this report. Figure 6 shows the seismicity and the time of the larger recognized explosions.

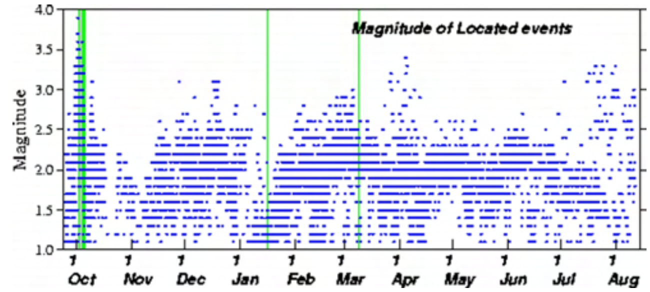

Figure 6. Magnitude of located earthquakes at Mount St. Helens through 27 July 2005 (Pacific Northwest Seismograph Network). Vertical lines represent the time of moderate explosions. Note periods of earthquakes M > 3 that accompanied dome break-ups in December, April, and July. Courtesy of CVO and the Pacific Northwest Seismograph Network.

During 2-7 March, dome growth accompanied low rates of both seismicity and gas and ash emissions. Parts of the growing lava dome continued to crumble, forming rockfalls and generating small ash clouds that drifted out of the crater. The bulging ice on the deformed E arm of the glacier in the crater continued to move rapidly N at about 1.2 m per day (figure 7).

A small explosive event began at approximately 1725 on 8 March. The eruption lasted about 30 minutes with intensity gradually declining throughout; a fine dusting of ash from this event later fell ~ 100 km to NW (in Yakima, and Toppenish, Washington). By 0200 on 9 March, the leading edge of the faint, diffuse plume had reached ~ 300 km to the E (over western Montana). After the explosion scientists found the lava dome intact. They recognized ballistics (up to ~ 1 m in diameter) as far as the N flank of the old lava dome and a lack of them along or beyond the crater rim. The explosion vented from the NNW side of the new lava dome, very near the source of the 1 October 2004 and 16 January 2005 explosions (figure 8).

The explosion on 8 March was one of the largest steam-and-ash emissions to occur since renewed activity began in October 2004. The Cascades Volcano Observatory (CVO) lost radio signals from three monitoring stations in the crater soon after the event started. The event followed a few hours of slightly increased seismicity not then interpreted as

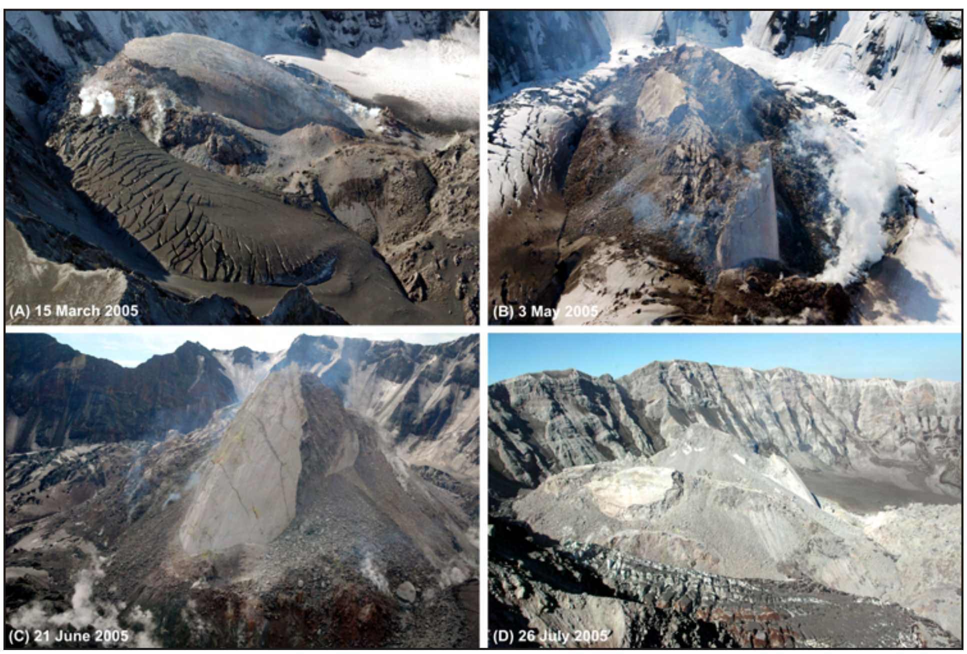

Figure 5. Four views into St. Helens's crater from different perspectives and dates, focusing on the new dome. A: 15 March 2005, view from NE. The whaleback is close to its maximum length of 500 m. Note that the glacier's heavily crevassed, half-moon shaped, E (left) arm lies squeezed between the growing dome and crater wall. Vent is steaming at lower-right whaleback. B: 3 May 2005, view from N. The whaleback has been breaking apart for several weeks. Note the large slab of smooth gouge-covered surface moving E (left). C: 21 June 2005, view from NW. Note the development of broad talus on W (right) flank of dome. An isolated body of smooth gouge-covered surface to the right of the main spine is emerging from talus. D: 26 July 2005, view from E crater rim. The smooth, gouge-covered spine continues to crumble as a result of M≥ 3 earthquakes and rockfalls. A large slab of March whaleback is visible at left. Most of the dome surface is now talus and disintegrating older whalebacks. By the end of July, the spine had been reduced to a highly fractured stump. All photos courtesy of USGS CVO.

precursory. There were no other indications of an imminent change in activity.

After the 8 March explosion, St. Helens only emitted steam, and seismicity dropped to a level similar to that during the several hours prior to the explosion. Gas emissions were very low, essentially unchanged from those measured in late February. The hazard status for the ongoing eruption, 'Volcano Advisory (Alert Level 2),' mentioned the possibility of events like the 8 March explosion occurring without warning. That assessment remained unchanged and the hazard status stayed the same.

Analysis of aerial photographs indicated that as of 10 March the topographic changes in the crater resulting from growth of the new dome and consequent glacier deformation had a combined volume of about 45 million m^3. The current eruption contributed new materials amounting to about two-thirds the volume of the old lava dome.

From March 2005 through July 2005, growth of the new lava dome continued. Rates remained low for both seismicity and gas and ash emissions. CVO noted that during such eruptions, episodic changes in the level of activity can occur over days to months. During about 26-27 March, a group of M 2 to M 3 earthquakes occurred beneath the volcano, a level of activity considered normal during dome-emplacing volcanism.

A series of large ($M \geq 3$) earthquakes occurred during 3-4 April, in addition to the typical array of smaller events. Observations on 6 April revealed that the smooth whaleback-shaped portion of the growing lava dome was broken by numerous fractures, and the edges had crumbled greatly. Several deep gashes on the E, N, and W sides frequently produced rockfalls and accompanying ash clouds. On 10 April the new dome continued to fracture and spread laterally. As a consequence, the dome's summit dropped by a few tens of meters over 2-3 weeks, leaving isolated high-standing remnants. This broken pattern was apparent in a photograph on 3 May (figure 5B).

Earthquakes steadily decreased in magnitude and number through mid-April. A GPS receiver 200 m N of the new dome crept steadily NNW at ~ 10 cm per day. The combination of the GPS measurements adjacent to the lava dome and the qualitative estimate of lateral spreading suggested that extrusion of new lava continued during April.

On the morning of 28 April there were reports of minor amounts of ashfall in the eastern part of the Portland metropolitan area, ~ 80 km SSW of St. Helens. There was no evi-

Figure 7. A view of the growing dome at St. Helens from the Sugar Bowl camera just before the 8 March 2005 explosion. The Sugar Bowl digital camera takes a picture every hour from its housing on the NE flanks. The image data are transmitted to a more accessible spot immediately after the pictures are taken. Courtesy of CVO.

Figure 8. The 8 March 2005 explosion at St. Helens viewed from the Sugar Bowl camera. This shot was taken at about 1727 hours and 42 seconds on 8 March. Courtesy of CVO.

dence of a new explosion. CVO scientists determined that large convective storms over the Cascades on 27 April entrained ash generated by the frequent hot rockfalls from the growing lava dome and kept it in suspension to fall out as far away as Portland.

During early May poor weather obscured the volcano. Seismic and ground deformation activity remained unchanged. Through much of the night of 4-5 May, however, VolcanoCam images detected intermittent glow from the new dome. The camera is mounted at the Johnston Ridge Observatory at an elevation of 1,400 m and ~ 6.5 km NNW of the volcano, a spot W of the S part of Spirit Lake. During 11-12 May images from the mouth of the crater showed the new spine of lava at the N end of the dome continuing to grow. Data from seismic and GPS instruments in the crater and on the outer flanks continued to lack significant changes over the past few weeks. Through the end of May, lava extrusion continued at the N end of the new lava dome, while the high spines continued to crumble. Other parts of the lava dome moved at the relatively low velocity of about 30 cm/day or remained stagnant. Table 3 compares the older dome with the new one as of 3 May 2005.

Around 4 June the rate of motion of a GPS unit on the NE part of the new dome slowed slightly, continuing to creep eastward and northward at a rate of several centimeters per day, but no longer rising vertically. The lava spine, however, continued to grow. Through the end of June 2005, seismic and deformation data continued trends similar to the previous few weeks, with small earthquakes approximately every 5 minutes, little to no movement of the old lava dome, minor movement of the N end of the new lava dome, and continued growth of the lava spine. Observations made on 15 June revealed that the lava spine continued to grow and that temperatures in cracks near the base of the spine were near 700°C. Thermal data from 15 June suggested that much of the W part of the dome was moving upward, as well as southward. During the last week of June, the smooth lava spine continued to grow at a rate of about 1.8-3.7 m per day. Rockfalls from the top of the spine kept its height from increasing by that same rate. Analysis of a digital elevation model made from imagery acquired on 15 June showed that the total volume addition to the crater since September 2004 had reached almost 60 million cubic meters.

Names	Unnamed (the "old" dome)	The "new" dome (unofficially called "the whaleback")
Growth period	1980-1986 (six years)	October 2004-February 2005 (and ongoing)
Size - length	~ 1.1 km in diameter	~ 475 m long
Size - width	~ 1.1 km in diameter	~ 152 m wide
Elevation / vertical height	2.2 km, nearly 267 m above the 1980 crater floor.	As of 1 February 2005, 2.3 km, nearly 415 m above the 1980 crater floor, 152 m above the top of the old 1980-86 lava dome, and 213 m above the 2000 glacier surface. The new dome's top reached an elevation ~ 40 m below Shoestring Notch on the crater's SE rim.
Volume	~ 75 x 10^6 m^3	~ 44 x 10^6 m^3

Table 3. A comparison of the old (1980-86) and new (2004-) domes at St. Helens. The new dome started in October 2004, and the reported data reflects conditions seen until 1 February 2005. Courtesy of CVO.

On 2 July at 0630 a rockfall from the growing lava dome removed a large piece of the dome's top, producing an ash plume that rose above the crater rim and generating a substantial seismic signal. Persistent smaller rockfalls from the growing lava dome built talus aprons on the W and NE flanks of the dome.

On 12 July, CVO reported that rates of seismicity and ground deformation at Mount St. Helens had declined during the previous two weeks to some of the lowest levels since the eruption began in September 2004. A similar lull occurred in December 2004.

Beginning 15 July and continuing through the end of the month, the growing spine and other high areas of the dome to the south produced numerous large rockfalls, most of which were associated with earthquakes of about M 3 (figure 9). Diffuse ash plumes that rose hundreds of meters above the rim were produced by the larger rockfalls. By the end of July most of the smooth gouge-covered surface of the spine had disintegrated, and the spine was reduced to a highly fractured, but still-extruding, stump surrounded by rapidly growing aprons of rockfall debris.

Figure 9. Rockfall and accompanying ash cloud on 26 July 2005 as viewed from station Brutus on the crater's E rim. Rockfall originated from the steep, fractured top of an inclined spine. Note boulders (light-colored specks against shadow) shooting ahead of ash cloud. Another spine is extruding from ground just behind the lower end of the ash cloud. Courtesy USGS and CVO.

Background. Prior to 1980, Mount St. Helens formed a conical, youthful volcano sometimes known as the Fuji-san of America. During the 1980 eruption the upper 400 m of the summit was removed by slope failure, leaving a 2 x 3.5 km horseshoe-shaped crater now partially filled by a lava dome. Mount St. Helens was formed during nine eruptive periods beginning about 40-50,000 years ago and has been the most active volcano in the Cascade Range during the Holocene. Prior to 2200 years ago, tephra, lava domes, and pyroclastic flows were erupted, forming the older St. Helens edifice, but few lava flows extended beyond the base of the volcano. The modern edifice was constructed during the last 2200 years, when the volcano produced basaltic as well as andesitic and dacitic products from summit and flank vents. Historical eruptions in the 19th century originated from the Goat Rocks area on the N flank, and were witnessed by early settlers.

Information Contacts: *Cascades Volcano Observatory* (CVO), U.S. Geological Survey, 1300 SE Cardinal Court, Building 10, Suite 100, Vancouver, WA 98683-9589, USA (URL: http://vulcan.wr.usgs.gov/; Email: GSCVOWEB@usgs.gov); *Pacific Northwest Seismograph Network* (PNSN), Seismology Lab, University of Washington, Department of Earth and Space Sciences, Box 351310, Seattle, WA 98195-1310, USA (URL: http://www.pnsn.org/; Email: seis_info@ess.washington.edu).

Ebeko

Kurile Islands, Russia
50.68°N, 156.02°E; summit elev. 1,156 m
All times are local (= UTC +11 hours)

A few gas-and-steam plumes from Ebeko were reported during February-April 2004 (BGVN 29:04). The most recent previous eruption was in January 1991. On 30 January 2005 the Kamchatka Volcanic Eruptions Response Team (KVERT) raised the Concern Color Code at Ebeko from Green to Yellow after reports of a strong smell of sulfur on 27 and 28 January in the town of Severo-Kurilsk, ~ 7 km from Ebeko.

Observations by Leonid and Tatiana Kotenko in Severo-Kurilsk during May-July 2004 included occasional gas-and-steam plume rising as high as 250 m above the volcano during clear weather and fumarolic plumes moving close to the ground. There was no visible activity in August, but a few plumes were seen again from September to November.

During 28 January, a white gas-and-steam plume was seen from Severo-Kurilsk rising 400 m above the volcano. Summit observations the next day revealed a yellow-gray, 5-m-diameter, column rising 300 m from a vent on the NE side of the active crater. Three ash layers 2-3 mm thick were noted 10 m from the vent, and ash extended ~ 500 m E into the crater. At this time a new 7 x 12 m turquoise lake had developed in the SW part of the active crater. The lake disappeared on 30 January, and there was intensive fumarolic activity where it had been. Shallow earthquakes were recorded at the Severo-Kurilsk seismic station.

On 1 February gas-and-steam plumes rose to 450 m above Ebeko's crater and drifted NE. On 7 February a small emission of steam, gas, and possibly ash rose ~ 1 km above the crater and drifted ~ 12 km SE. On 8 and 9 February plumes rose to 600 m and thin ash deposits were noted in the town of Severo-Kurilsk.

The following information came to KVERT from observers in Severo-Kurilsk (Leonid and Tatiana Kotenko). On 15-16 February a dark-gray column rose up to 500 m above the crater. A dark-gray plume extended 6 km E and a light-gray plume 7 km SE. On 16 February ashfall together with snowfall was noted over the strait to the E of Paramushir Island. On 17 February a white column up to 250 m above the crater was observed. On 12 February and 16-17 February a strong smell of a H_2S was noted at Severo-Kurilsk. On 18-19 February white gas-and-steam columns 5 m in diameter rose from the two vents up to 450 m above the crater and a new lake (10 x 10 m) on the floor of the active crater was observed. On 25 February white gas-and-steam plumes rose to 450 m and 1,000 m above the crater. Gas-and-steam plumes were also observed on 1-2, 4-5, and 9 March. No ash was seen. A strong smell of H_2S was noted at Severo-Kurilsk on 25 February and 2 March.

About 20 seismic events of less than M_l 2.0 were observed during 1-9 March at the Severo-Kurilsk seismic station. No seismic activity was observed from 12 to 14 March. On 15 March two seismic events were noted. There was no seismicity during 18-25 March, so KVERT reduced the hazard status from Yellow to Green, the lowest level.

The Russian Emergency Situations Ministry's Sakhalin department reported renewed activity on 27 June in the form of emission clouds rising to a maximum height of 200 m above the crater and drifting SW. KVERT did not report any activity, and the Concern Color Code for Ebeko remained at Green.

Background. The flat-topped summit of the central cone of Ebeko volcano, one of the most active in the Kuril Islands, occupies the northern end of Paramushir Island. Three summit craters located along a SSW-NNE line form Ebeko volcano proper, at the northern end of a complex of five volcanic cones. Blocky lava flows extend W from Ebeko and SE from the neighboring Nezametnyi cone. The eastern part of the southern crater of Ebeko contains strong solfataras and a large boiling spring. The central crater of Ebeko is filled by a lake about 20 m deep whose shores are lined with steaming solfataras; the northern crater lies across a narrow, low barrier from the central crater and contains a small, cold crescent-shaped lake. Historical activity, recorded since the late-18th century, has been restricted to small-to-moderate explosive eruptions from the summit craters. Intense fumarolic activity occurs in the summit craters of Ebeko, on the outer flanks of the cone, and in lateral explosion 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); *Alaska Volcano Observatory* (AVO), 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), the Geophysical Institute, University of Alaska, P.O. Box 757320, Fairbanks, AK 99775-7320, USA (Email: 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).

Shiveluch

Kamchatka, Russia
56.653°N, 161.360°E; summit elev. 3,283 m
All times are local (= UTC + 12 hours [+ 13 hours in March-June])

Following explosions from Shiveluch during 25 February to 4 March 2005 ash fell in Ust'-Hairyuzovo, about 250 km W (BGVN 30:02). From March 2005 until July 2005, Shiveluch remained at Concern Color Code Orange. Throughout March 2005 the lava dome at Shiveluch continued to grow and on several days ash-and-gas plumes and gas-and-steam plumes rose to a maximum of ~ 2.8 km above the dome. Satellite imagery showed a thermal anomaly at the dome during the first week of March and a large thermal anomaly over the recent pyroclastic-flow deposit during 11-12 March. Between 5-28 March a new lava extrusion added ~ 50 m height to the SW part of the dome.

During April 2005, intensive growth of the new extrusion at the W part of the dome continued, and the E and W parts of the lava dome became nearly level. Gas-and-steam plumes rose to a maximum of ~ 1.2 km above the dome during April 2005. Satellite imagery showed a large thermal anomaly at the dome during mid-April and a small anomaly associated with a pyroclastic flow on 19 April. On 25 April, a hot avalanche on the dome's W side produced an ash plume that rose ~ 2 km above the 2.5-km-high lava dome. Growth of the dome continued during May 2005 with a new extrusion to the W. Ash-and-gas plumes, some rising 2 km above the dome, were frequent. Satellite imagery showed a persistent thermal anomaly at the lava dome throughout May.

The dome continued to grow during June 2005. During 3-10 June, two shallow M 1.6-1.7 earthquakes occurred 0-5 km beneath the active dome. Gas-and-steam plumes rose as high as 400 m above the dome during June. A persistent thermal anomaly was visible throughout June. Fumarolic activity was reported during the week of 18-24 June. During the last week of June, satellite imagery showed a persistent thermal anomaly, and fumarolic activity produced steam to 4-5 km altitude. On 30 June, ash-and-gas plumes rose 3-5 km altitude. and drifted NW. Hot avalanches of volcanic material were also recorded. On 6 July ash-and-gas plumes rose to ~ 7 km altitude and drifted NW. On 7 July an 11-minute-long seismic event occurred, and ash-and-gas plumes may have reached a height of 10 km altitude. Around 8 July, KVERT raised the Concern Color Code from Orange to Red, the highest level. On 8 July 2005, video footage showed weak gas-and-steam plumes rising to ~ 5 km altitude. On 9 July 2005, the Concern Color Code was reduced to Orange.

Background. The high, isolated massif of Shiveluch volcano (also spelled Sheveluch) rises above the lowlands NNE of the Kliuchevskaya volcano group. The 1300 cu km Shiveluch is one of Kamchatka's largest and most active volcanic structures. The summit of roughly 65,000-year-old Strary Shiveluch is truncated by a broad 9-km-wide late-Pleistocene caldera breached to the south. Many lava domes dot its outer flanks. The Molodoy Shiveluch lava dome complex was constructed during the Holocene within the large horseshoe-shaped caldera; Holocene lava dome extrusion also took place on the flanks of Strary Shiveluch. At least 60 large eruptions of Shiveluch have occurred during the Holocene, making it the most vigorous andesitic volcano of the Kuril-Kamchatka arc. Widespread tephra layers from these eruptions have provided valuable time markers for dating volcanic events in Kamchatka. Frequent collapses of dome complexes, most recently in 1964, have produced debris avalanches whose deposits cover much of the floor of the breached caldera.

Information Contacts: *Olga A. 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), 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), the Geophysical Institute, University of Alaska, P.O. Box 757320, Fairbanks, AK 99775-7320, USA (Email: 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).

Karymsky

Kamchatka, Russia
54.05°N, 159.43°E; summit elev. 1,536 m
All times are local (= UTC + 12 hours)

During 1 January to mid-April 2004 (BGVN 29:04), ash-and-gas explosions and gas plumes were observed and seismicity remained generally above background levels. From May to the beginning of September 2004, seismic activity remained above background levels, varying over this time from 100-800 small shallow earthquakes per day. Ash-and-gas explosions and gas plumes to a maximum height of 7.5 km were frequent. On 1 September 2004 an increase in activity led the Kamchatka Volcanic Eruptions Response Team (KVERT) to raise the Concern Color Code from Yellow to Orange. From September to December 2004, seismicity remained above background levels, and ash-and-gas explosions and ash plumes were frequent. On 12 November the hazard status was lowered to Yellow.

Increasing seismicity, rock avalanches and possible ash plumes to 2.5 km altitude led KVERT to raise the Concern Color Code to Orange again on 7 December 2004. On 28 December, an observed eruption at Karymsky produced a plume composed primarily of gas and steam, but with some ash, that rose to ~ 1 km above the crater. Thermal anomalies were also visible on satellite imagery on 27 and 28 December. On 30 December the Tokyo VAAC reported that a plume was present up to ~ 8 km altitude extending SW.

There were no seismic data from 12 December 2004 till late January 2005. Through January and February thermal anomalies were frequently visible on satellite imagery. Seismicity remained above background levels from February 2005 through July 2005.

Through March and April 2005, ash-and-gas explosions and gas plumes were frequent. Ash deposits extended

10-15 km S and SW of the volcano. On 20 April, volcanic bombs rose to 50 m above the crater, and ash fell to the NE on 21 April. On 26 and 27 April, Strombolian activity was seen in two of the volcano's craters; volcanic bombs rose to ~ 300 m above the craters. Ash fell to the SE on 22-23 April and pyroclastic-flow deposits were seen on the NNW flank of the volcano. During May 2005, ash-and-gas explosions and plumes were again frequent, and a thermal anomaly continued to be visible on satellite imagery.

Due to a decrease in seismic and volcanic activity during 3-10 June, KVERT decreased the alert level from Orange to Yellow. Seismic activity increased starting on 22 June. Ash explosions up to 3,000 m altitude traveling SW were observed by pilots. According to seismic data, about 10 ash-and-gas plumes and avalanches occurred at the volcano. On 23 June KVERT increased the alert level to Orange. Satellite imagery of Karymsky showed a narrow ash-and-gas plume at a height of ~ 3.5 km altitude on 30 June. Based on interpretations of seismic data, ash-and-gas plumes may have reached 3 km above the crater.

The Tokyo VAAC posted four messages on Karymsky during the 90 days prior to 8 August 2005; in each, ash was not identifiable from satellite. The earliest, 18 May was similar to the last one, on 23 June. Both noted a reported plume to FL100 ('flight level 100' signifies 10,000 feet; 3. 05 km altitude). Reports on 22 and 24 May both noted ash to FL 120 (3.65 km altitude).

Background. Karymsky, the most active volcano of Kamchatka's eastern volcanic zone, is a symmetrical stratovolcano constructed within a 5-km-wide caldera that formed during the early Holocene. The caldera cuts the south side of the Pleistocene Dvor volcano and is located outside the north margin of the large mid-Pleistocene Polovinka caldera, which contains the smaller Akademia Nauk and Odnoboky calderas. Most seismicity preceding Karymsky eruptions originated beneath Akademia Nauk caldera, which is located immediately S of Karymsky volcano. The caldera enclosing Karymsky volcano formed about 7600-7700 radiocarbon years ago; construction of the Karymsky stratovolcano began about 2000 years later. The latest eruptive period began about 500 years ago, following a 2300-year quiescence. Much of the cone is mantled by lava flows less than 200 years old. Historical eruptions have been vulcanian or vulcanian-strombolian with moderate explosive activity and occasional lava flows from the summit crater.

Information Contacts: *KVERT* (see Shiveluch); *Tokyo Volcanic Ash Advisory Center (VAAC)*, Japan Meteorological Agency, Tokyo Aviation Weather Service Center, Haneda Airport 3-3-1, Ota-ku, Tokyo 144-0041, Japan (URL: http://www.jma.go.jp/JMA_HP/jma/jma-eng/jma-center/vaac/; Email: vaac@eqvol.kishou.go.jp).

Canlaon

central Philippines
10.412°N, 123.132°E; summit elev. 2,435 m
All times are local (= UTC + 8 hours)

Throughout May 2005, PHIVOLCS noted that ash-and-steam emissions from Canlaon produced plumes to 500-1,000 m above the volcano. The hazard status remained at Alert Level 1. The SO_2 flux remained above the 'normal' level of 500 metric tons/day (t/d) with values of 2,700 t/d on 1 May, 2,080 on 22 May, and 1,400 on 26 May. According to news reports, flights to and from nearby Kalibo airport were suspended on 3 May due to reduced visibility.

Although voluminous white steam continued to be discharged from the active vent early in June 2005, after 25 May ash ejections stopped and ash contents in the steam plume were significantly reduced. On 3 June PHIVOLCS lowered the hazard status of Canlaon from Alert Level 1 to Alert Level Zero, listing a variety of reasons. For one, they noted the downtrend in the SO_2 gas emission rate from a high of about 4,900 t/d, to the prevailing level of 1,500 t/d. For another, they noted the absence of significant seismic activity before, during, and after the ash emissions. And finally, they cited a lack of significant observations indicating near-surface hydrothermal activity. Since Canlaon has a history of sudden outbursts, the public was reminded to refrain from entering the 4-km-radius Permanent Danger Zone (PDZ) and to coordinate with PHIVOLCS and Disaster Management Councils in any attempt to climb the volcano.

Background. Canlaon volcano (also spelled Kanlaon), the most active of the central Philippines, forms the highest point on the island of Negros. The massive 2435-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 south. 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); *Philippine Star* (URL: http://www.philstar.com/).

Kilauea

Hawaiian Islands, USA
19.425°N, 155.292°W; summit elev. 1,222 m
All times are local (= UTC - 10 hours)

Activity at Kilauea through October 2004 was previously reviewed in reports that included maps showing the extent of key lava flows through most of August 2004 (*BGVN* 29:09). During November 2004 through January 2005, lava flows were abundant and made complex patterns. Their overall advance can be seen by comparing maps of the extent of the lava flows as of late August 2004 (figure 10) and 2 February 2005 (figure 11).

On 4 November 2004 lava from the Prince Kuhio Kalaniana `ole (PKK) flow entered the sea, forming a new delta seaward of the E end of the old Lae'apuki delta. The PKK flow has been continuously active since 26 July 2004, and lava continued to enter the sea through 26 November 2004. This was the first time lava entered the sea since the Banana lava flow ceased in early August 2004. The Banana flow developed from breakouts when lava escaped from the confines of the Mother's Day lava tube, emerging near the former Banana Tree kipuka. This flow stagnated early in September 2004, and the Mother's Day tube ceased carrying lava late in 2004.

During the first week in December 2004, the lava flow at Lae'apuki abated. Activity resumed during the second week along all areas of the PKK flow from high on the Pulama pali fault scarp. By 13 December lava again entered the sea at the East Lae'apuki delta. The flow moderated during the second half of December with only several areas of visible surface lava apparent on the Pulama pali fault scarp and on the coast.

New vents opened at the southern base of Pu`u `O`o on 19 January 2004 and fed the Martin Luther King (MLK) flows (figure 11). The PKK flow originated from two vents ~ 250 m S of the base of Pu `u `O`o. By 2 February 2005 the PKK flow had entered the sea at West Highcastle, Lae'apuki, and Ka`ili`ili (figure 11).

During January 2005, surface lava was visible along the three main arms of the PKK flow as they advanced downslope towards the coast (figure11). The middle arm of the PKK flow was comparatively small, and it failed to reach the ocean during this reporting interval; it remained high on Pulama pali. In contrast, lava from the E and W arms of the PKK flow began to enter the ocean on 31 January. The large E arm of the PKK lava flow fed the larger Ka`ili`ili entry. The W branch of the PKK lava flow once supplied lava to Lae'apuki (an E branch of the W arm), but later also began feeding the West Highcastle ocean entry (the W branch of the W arm, figure 11).

Seismicity. After seven months of relative quiescence renewed seismicity and numerous small long-period (LP) events again became visible in November 2004 on the North Pit seismogram. Elevated activity began on 16 November, peaking at over 2,000 events a day by late November (figure 12). Nearly all of these earthquakes were too small to catalog. To obtain this plot, a daily event count was extrapolated from a representative part of the North Pit (NPT) seismogram. Scientists combined the counts for two shallow (0-5 km deep) earthquake types, those designated by HVO as short-period summit or short-period caldera (SPC) and those designated as shallow, long-period (long-period caldera A, LPC-A) earthquakes. The similar frequency content of these two kinds of earthquakes make them difficult to distinguish on the drum record. In addition, small-magnitude deeper earthquakes, designated as long-period earthquakes originat-

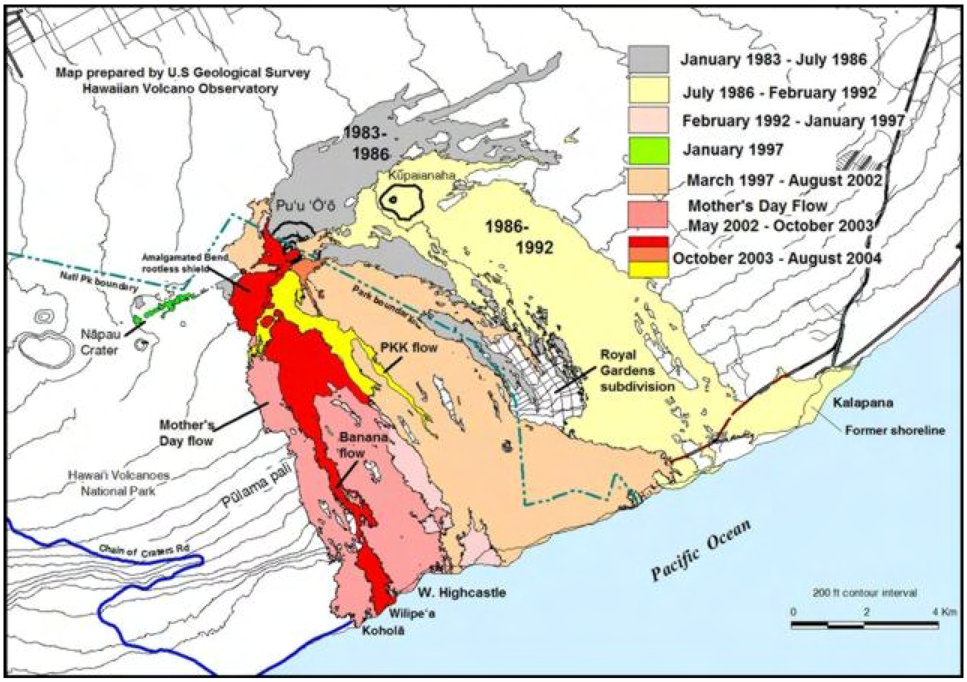

Figure 10. Kilauea lava flows erupted during activity from 1983-August 2004 of Pu`u `O`o and Kupaianaha. Note the location of Kupaianaha, the active vent area during 1986-1992, ~ 4 km ENE of Pu`u `O`o. Courtesy of the U.S. Geological Survey's Hawaiian Volcano Observatory.

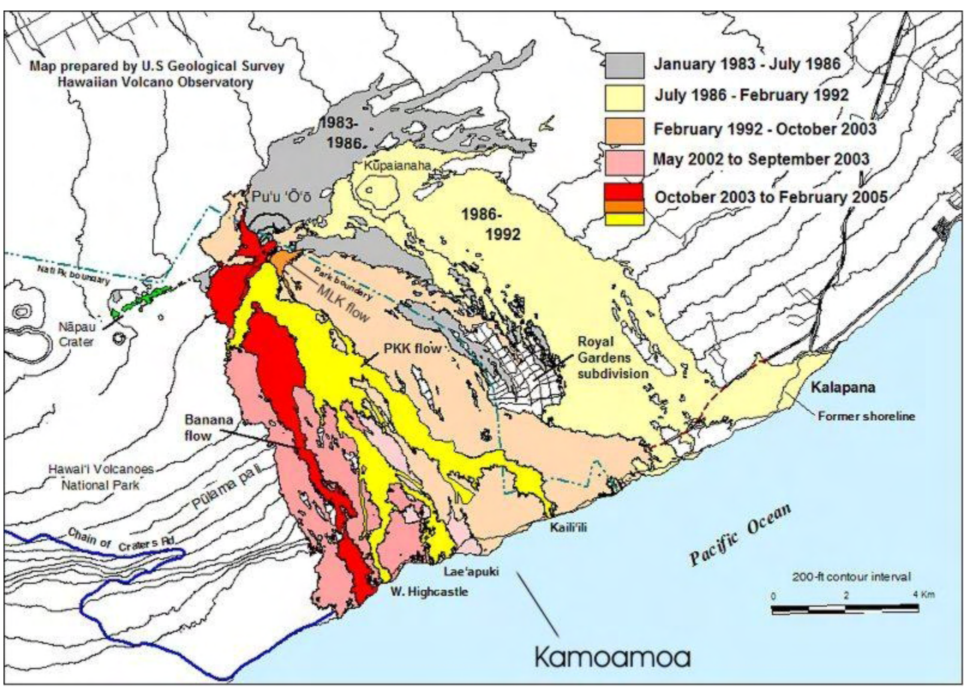

Figure 11. Kilauea lava flows erupted during activity from 1983-2 February 2005 of Pu`u `O`o and Kupaianaha. Courtesy of the U.S. Geological Survey's Hawaiian Volcano Observatory.

ing at depths over 5 km, may have also registered within the summit caldera to appear on the plot, although they would be expected to contain a lower dominant frequency of oscillation than the LPC-A earthquakes. Tremor episodes were rare or absent.

A minor peak in seismicity occurred in later January, during the two days before and after the 25 January inflation-deflation event. Most of the events on 25 January appeared to be of the SPC variety.

Tilt and deformation. The tiltmeter record at Kilauea summit (UWE) and Pu`u `O`o (POC) showed numerous correlated tilt changes, with a short time delay between UWE and POC stations and larger magnitude delays at POC (figure 13). One of the largest of these deformations took place on 25-26 November and resulted in about 3 microradians of tilt at UWE, and 5 microradians at POC. This was similar in character to the tilt events of recent months, starting with fairly rapid deflation, followed by a similar rate and magnitude of inflation. Though they differ in character from the deflation-inflation-deflation (DID) cycles of the past few years, they seem to be originating from the same shallow storage area near Halemaumau, the crater at Kilauea's summit.

Kilauea continued to inflate over this reporting period. The extension rate across the summit increased dramatically in early January 2005, from an average rate of about 8 cm/yr to over 40 cm/yr. There was a short inflation-deflation event on 25 January, followed by about 2-3 days of extremely rapid movement of the S flank; continuous GPS stations on the S coast were displaced by up to 2 cm. The pattern and rate of motion are very similar to the slow earthquake of November 2000. The slip event occurred during a swarm of earthquakes (see seismic section above), but the cumulative magnitude of these earthquakes was not nearly as great as the estimated equivalent moment magnitude of the slip.

Other large episodes of correlated multistation tilt occurred on 14 December 2004 and 25 January 2005. In December, both UWE and POC recorded deflationary tilts of about 4 and 2.5 microradians, respectively, over about 12 hours. In mid-January, the summit started showing a high rate of inflationary tilt, coinciding with the increase in cross-summit extension, measured by continuously recording GPS. In the early morning of 25 January, summit tiltmeters and POC recorded a rapid inflation (about 5.5 microradians in an hour at UWE, 2 at POC) followed by an equal amount of deflation over the next day. The event was similar to the fairly frequent deflation-inflation-deflation (DID) events at Kilauea. Similarities included the apparent source regions of the inflation, the seismic signature, the delay time between the summit and the rift zone, and the timing of increased activity.

SO_2 emission rate measurements. Summit SO_2 emission rates for October/November ranged from 80 to 130 metric tons per day (t/d) with an average of 105 t/d (standard deviation, s.d.=20 t/d for 36 measurements made over 6 days). Although this represents a slight decrease over emission rates measured during the previous reporting period, it does not represent a significant change. Correlation spectrometer (COSPEC) SO_2 measurements along the Chain of Craters Road yielded SO_2 flux rates of 1,080-1,660 t/d with a mean value of 1,270 t/d (s.d. of 260 t/d for 27 measurements made over 4 days). The drop in emissions, which began in May 2004, had continued

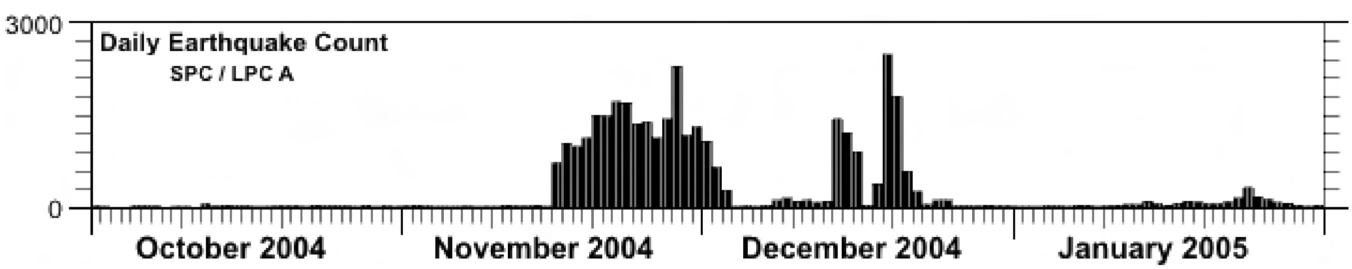

Figure 12. A time series of Kilauea's daily earthquakes (SPC, LPC-A, and possibly LPC-C types) registered at the summit during October 2004 through January 2005. Courtesy of U.S. Geological Survey's Hawaiian Volcano Observatory.

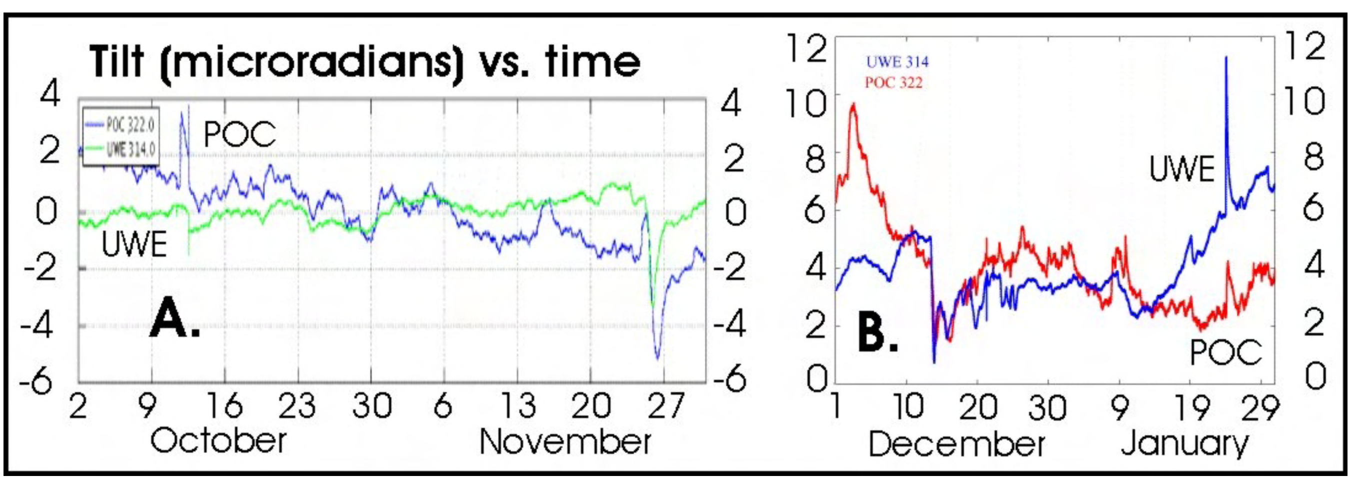

Figure 13. Electronic tiltmeter records from the N flank of Pu`u `O`o cone (POC) and NW rim of Kilauea caldera (UWE) for (A) October and November 2004 and (B) December 2004 through January 2005. Only the radial component is plotted, i.e., the direction that maximizes signal from the most common sources of tilt at both locations. Courtesy of U.S. Geological Survey's Hawaiian Volcano Observatory.

through November 2004. A lack of trade winds hindered SO_2 flux measurements during November and December. Six traverses on 6 December yielded an emission rate of 105 t/d (s.d.=10 t/d) consistent with the more frequent measurements made during September-October 2004. The return of the tradewinds in early February allowed measurements to resume and showed that summit emissions had decreased markedly, likely due to the heavy rainfall on 4 February.

Background. Kilauea volcano, which overlaps the E flank of the massive Mauna Loa shield volcano, has been Hawaii's most active volcano during historical time. Eruptions of Kilauea are prominent in Polynesian legends; written documentation extending back to only 1820 records frequent summit and flank lava flow eruptions that were interspersed with periods of long-term lava lake activity that lasted until 1924 at Halemaumau crater, within the summit caldera. The 3 x 5 km caldera was formed in several stages about 1500 years ago and during the 18th century; eruptions have also originated from the lengthy East and SW rift zones, which extend to the sea on both sides of the volcano. About 90% of the surface of the basaltic shield volcano is formed of lava flows less than about 1,100 years old; 70% of the volcano's surface is younger than 600 years. A long-term eruption from the East rift zone that began in 1983 has produced lava flows covering more than 100 km^2, destroying nearly 200 houses and adding new coastline to the island.

Information Contact: *Hawaiian Volcano Observatory (HVO)*, U.S. Geological Survey, PO Box 51, Hawaii National Park, HI 96718, USA (URL: http://hvo.wr.usgs.gov/; Email: hvo-info@hvomail.wr.usgs.gov).

Tungurahua

Ecuador
1.467°S, 78.442°W: summit elev. 5,023 m
All times are local (= UTC - 5 hours)

The eruption of Tungurahua that began at the end of December 2003 (BGVN 28:11) continued through January 2004 (BGVN 29:01). Figure 14 shows an ash plume emitted on January 2004 in a Moderate Resolution Imaging Spectroradiometer (MODIS) image.

On 5 February 2004 there was a slight increase in seismic activity at Tungurahua; steam emissions rose to low levels, and small lahars traveled down the volcano's W flank via the Achupashal and Chontapamba gorges. On 9 February emissions of steam, gas, and moderate amounts of ash occurred, deposited to the W in the sectors of Pillate and San Juan. During mid February, several avalanches of incandescent volcanic blocks traveled ~ 1 km down the volcano's flank. During late February through mid April 2004, degassing continued at Tungurahua with occasional explosions of steam, gas, and ash, producing plumes to ~ 500 m above the volcano.

On 2, 11, and 15 March lahars traveled through the Pampas sector. During the night of 28-29 March incandescent material was observed avalanching on the upper slopes. From 30 March to 3 April, volcanic activity was at relatively low levels, but emissions of steam and ash occurred, and incandescence was visible in the crater. On 4 April at 1902 an explosion produced a plume containing a moderate amount of ash that rose to 800 m above the crater, and on the evenings of 10 and 11 April, incandescence was visible in the crater.

Sulfur-dioxide flux measurements taken on 11 April were the highest measured for several weeks; 1,600-1,700 metric tons per day. Heavy rain during the afternoon and night of 13 April triggered a lahar that cut the La Pampa section of the Baños-Pelileo road.

Volcanic activity at Tungurahua at the end of April 2004 was at moderate levels. On 21 April, a column of steam, gas, and ash rose to a height of ~ 1 km above the volcano and drifted NW. Ash fell in Bilbao, Cusúa, San Juan, Cotaló, Pillate, and Juive sectors. A plume reached ~ 0.5 km on 22 April and deposited ash in the towns of Ambato (to the NW) and Baños (to the N). During the evening of 24 April, incandescence was visible in the crater, and incandescent blocks rolled a few meters down the volcano's NW flank.

Volcano-tectonic earthquakes on 27 and 28 April preceded a slight increase in the number of

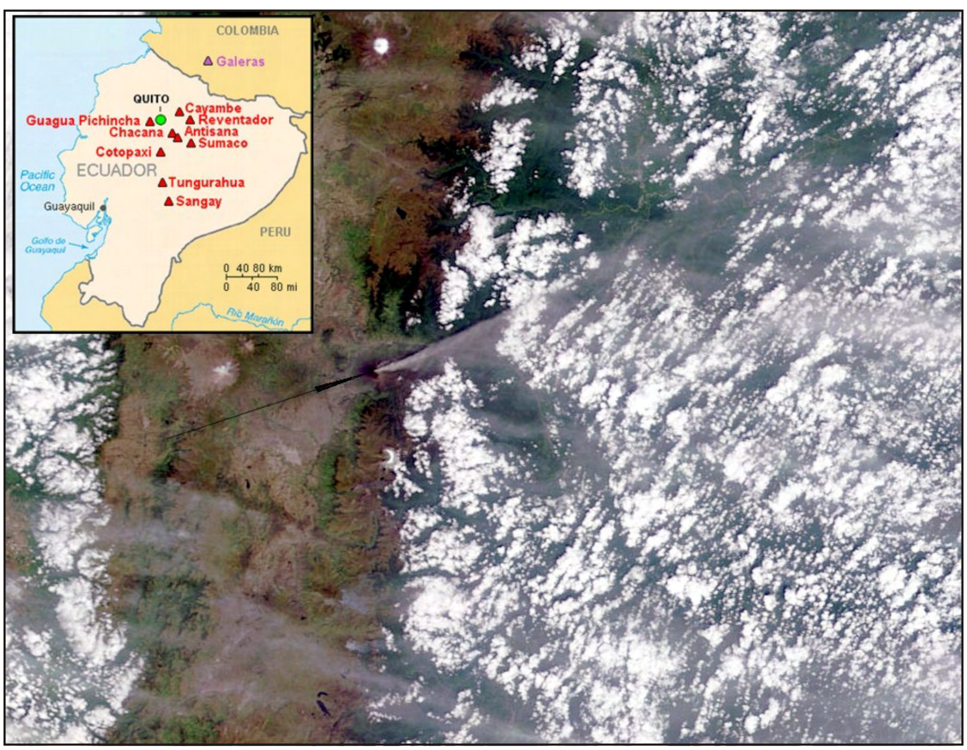

Figure 14. A NASA MODIS image showing an ash plume from Tungurahua acquired 14 January 2004. N is up; the plume's height and length were undisclosed. Arrow points to Tungurahua and is along the approximate trend of the densest portion of the plume. The plume blew NE across the Andes and remained visible well over the thickly vegetated lowlands farther E. (Visible Earth v1 ID 26233.) Courtesy of NASA. Inset map showing major active Ecuadorian volcanoes courtesy of the USGS.

sudden explosions at Tungurahua on 30 April. According to news reports, ash fell in the towns of Cotaló, and San Juan (W of the volcano) on 1 and 2 May. The level of seismicity at Tungurahua decreased on 4 May. On 12 May, an explosion produced an ash cloud to ~ 3 km above the volcano that drifted SW, and on 13 May seismicity increased moderately, related to the increased numbers of emissions. Incandescence was visible at the lava dome during some nights.

From mid May through June, small-to-moderate emissions of gas, steam, and ash continued at Tungurahua. The highest rising plume reached ~ 2.5 km above the volcano on 23 May. On the morning of 19 May a mudflow occurred in the Pampas sector, but it did not affect the highway. Strombolian activity was visible in the crater on the evening of 23 May. During 2-8 June, activity remained moderate with several weak to moderate explosions recorded per day. Sporadically observed gas-and-ash and gas-and-steam plumes rose up to 1 km above the summit. A strong explosion on 5 June produced a gas-and-ash plume that rose 2 km above the summit. All plumes drifted W. Seismicity remained at moderate levels. On 3 June, possible lahars were noted on the N and NW flanks.

Several explosions occurred on 10 June, with the largest rising ~ 3 km above Tungurahua's summit and drifting W. A small amount of ash fell in the Pillate area, and a lahar destroyed a bridge in the Bibao zone. During mid to late June, there was a slight increase in volcanic activity at Tungurahua in comparison to the previous weeks. There were several emissions of steam, gas, and moderate amounts of ash, and 5-10 explosions occurred daily. Seismicity was characterized by long-period earthquakes.

From July through December 2004 the level of volcanic and seismic activity diminished at Tungurahua, with sporadic moderate explosions of ash and gas. The highest rising plume reached ~ 1.5 km above the volcano. Seismicity was at relatively low levels. Incandescence in the crater was observed at night on several occasions. Some explosions on 20 September generated plumes with ash, causing ashfall in Bilbao and Pondoa, and on the evening of 21 September, Strombolian activity was seen, with volcanic blocks thrown as high as 200 m above the volcano. On 27 October an explosion produced an ash column to a height of ~ 3.5 km above the volcano. During the evening, ash fell in the towns of Baños, Runtón, and El Salado. Explosions on 31 October also deposited small amounts of ash in Bilbao and Motilone, and on 15 November, incandescence was observed in the crater of the volcano and explosions generated steam columns with moderate ash content that rose ~ 2 km above the crater and drifted S. During 22-27 December, activity at Tungurahua consisted of small-to-moderate explosions, several long- period earthquakes, and episodes of tremor. Emissions of steam, gas, and small amounts of ash rose a maximum of 1.5 km on 22 December.

Increased seismicity and volcanic tremor registered at Tungurahua during early January 2005. There were eleven signals suggesting volcanic emissions and one small explosion. Seismicity then returned to a low level. On 11 January, steam plumes rose ~ 300 m above the volcano and extended WNW, and incandescence was observed emanating from the crater during 12-13 January. On 14 January, a white column of steam-and-gas was observed that reached a height of 500 m above the crater and extended to the NW. A steam- and-gas plume reached a height of 200-300 m above the crater on 16 January, and extended SE.

The Washington Volcanic Ash Advisory Center (VAAC) reported 18 January that an ash plume reached ~ 5.5 km altitude and extended to the E of Tungurahua's summit for ~ 15 km. During 19-24 January 2005, there were several emissions from Tungurahua of steam, gas, and ash. The plumes that were produced rose to a maximum height of ~ 1 km above the volcano and drifted in multiple directions, small amounts of ash falling in the sectors of Agoyán, San Francisco, Runtón, Pondoa, and Baños. Seismicity was at relatively low levels. Ash emission from Tungurahua on the evening of 25 January 2005 deposited a small amount of ash in the sector of Puela; ash was deposited on the volcano's N and W flanks on 26 January. The character of the eruption changed on 30 January to low-energy emissions of predominately steam. This type of activity continued through 31 January.

Volcanic and seismic activity was at low levels at Tungurahua during the period of February-mid July 2005. Low- energy plumes were emitted, and long-period earthquakes were recorded. Ashfall was reported in towns near the volcano, including Puela (SW of the volcano), San Juan de Pillate, Cusúaua, and Quern. On 23 February the daily sulfur-dioxide flux was 1,200 tons/day. On 27 and 28 February, rains generated lahars in the W zone of the volcano into the gorges of Cusúa and Bilbao. A moderate explosion occurred 18 April at 2057 that sent incandescent volcanic blocks rolling down the volcano's flanks. Ash fell S of the city of Ambato. On 20 and 21 April rain generated lahars that traveled down the volcano's W flank near the settlement of Bilbao (8 km W). An emission on 19 May around 1200 produced an ash-and- steam plume to ~ 500 m altitude that drifted N. On 7 June fine ash fell in the Puela sector, ~ 8 km SW of the volcano. On 24 June a narrow plume was

Month/Year	Long -period	Volcano-tectonic	Emission	Explosions	Hybrid
Jan 2004	365	6	217	28	0
Feb 2004	255	8	147	16	0
Mar 2004	123	7	123	2	0
Aug 2004	620	5	142	22	0
Sep 2004	674	9	119	43	0
Oct 2004	390	14	168	53	0
Jan 2005	138	8	92	6	0
Feb 2005	113	20	29	0	0
Mar 2005	54	20	1	0	0

Table 4. Summary of available seismicity (number of events) at Tungurahua during January 2004-March 2005 as published in IG monthly reports of March 2004, October 2004, and April 2005. Courtesy of the Instituto Geofisico-Escuela Politecnica Nacional (IG).

identified in multispectal satellite imagery about an hour after an ash eruption was observed by the Instituto Geofisica. The ash plume was at an altitude of ~ 5.5 km and extended 35-45 km W from the summit. On 4 July 2005, low-energy plumes were emitted that rose to a maximum of ~ 5.8 km altitude.

Table 4 gives examples of some seismic statistics for several months during the reporting period from the Instituto Geofisico-Escuela Politecnica Nacional (IG).

Background. Tungurahua, a steep-sided, andesitic-dacitic stratovolcano that towers more than 3 km above its northern base, is one of Ecuador's most active volcanoes. Three major volcanic edifices have been sequentially constructed since the mid-Pleistocene over a basement of metamorphic rocks. Tungurahua II was built within the past 14,000 years following the collapse of the initial edifice. Tungurahua II itself collapsed about 3000 years ago and produced a large debris-avalanche deposit and a horseshoe-shaped caldera open to the west, inside which the modern glacier-capped stratovolcano (Tungurahua III) was constructed. Historical eruptions have all originated from the summit crater. They have been accompanied by strong explosions and sometimes by pyroclastic flows and lava flows that reached populated areas at the volcano's base. Prior to a long-term eruption beginning in 1995 that caused the temporary evacuation of the city of Baños at the foot of the volcano, the last major eruption had occurred from 1916 to 1918, although minor activity continued until 1925.

Information Contacts: *Geophysical Institute (IG)*, Escuela Politecnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: http://www.igepn.edu.ec/); *Washington Volcanic Ash Advisory Center (VAAC)*, Satellite Analysis Branch (SAB), NOAA/NESDIS E/SP23, NOAA Science Center Room 401, 5200 Auth Rd., Camp Springs, MD 20746 USA (URL: http://www.ssd.noaa.gov/); *Jacques Descloitres*, MODIS Rapid Response Team, NASA/GSFC, 8800 Greenbelt Road, Greenbelt, MD 20771, USA (URL: http://earthobservatory.nasa.gov/NaturalHazards/; http://rapidfire.sci.gsfc.nasa.gov/).

McDonald Islands

Southern Indian Ocean
53.03°S, 72.60°E; summit elev. 230 m

The following report comes from Matt Patrick of the HIGP Thermal Alerts Team. Two night-time ASTER images (Band 10, 8.3 microns, at 90 m pixel size) of McDonald Island show activity centered on the NW shore of the island. The December 2002 image was examined some months ago, but it was not determined whether the long-wave infrared (IR) anomaly was genuine, since it was relatively low intensity and there was no anomaly in the shortwave IR. The most recent ASTER image (12 July 2005) shows a somewhat larger long-wave IR anomaly, but more importantly, there are five pixels in the shortwave IR (Band 9, 2.4 microns; not shown) which are saturated, indicating this is a significantly hot target. Based upon McDonald's typical activity, the anomaly probably reflects low-level effusive activity.

The first and only MODVOLC alert pixel showed up in November 2004 (BGVN 29:12). These ASTER images show that recent activity is centered around the NW flank of the island, very close to shore. Comparing the July 2005 image with the December 2002 image, there might be an indication of the shoreline growing westward, but it is hard to tell for sure with this resolution (90 meters). The location of this activity is generally consistent with recent BGVN reports: in 1999 steaming was observed on the N-NE part of the island (BGVN 24:01), and a recent Landsat ETM image indicated that island construction over the last two decades has expanded the northern portion of the volcano (BGVN 26:02 and 27:12).

Andrew Tupper noted that he found the hot spot identification plausible. The question of edifice collapse and possible tsunami generation associated with McDonald Islands has recently been a subject of interest but little technical information is available on topics such as edifice morphology and slope stability.

Background. Historical eruptions have greatly modified the morphology of the McDonald Islands, located on the Kerguelen Plateau about 75 km west of Heard Island. The largest island, McDonald, is composed of a layered phonolitic tuff plateau cut by phonolitic dikes and lava domes. A possible nearby active submarine center was inferred from phonolitic pumice that washed up on Heard Island in 1992. Volcanic plumes were observed in December 1996 and January 1997 from McDonald Island. During March of 1997 the crew of a vessel that sailed near the island noted vigorous steaming from a vent at the northern side of the island along with possible pyroclastic deposits and lava flows. A satellite image taken in November 2001 showed the island to have more than doubled in area since previous reported observations in November 2000. The high point of the island group had shifted to the northern end of McDonald Island, which had merged with Flat Island.

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