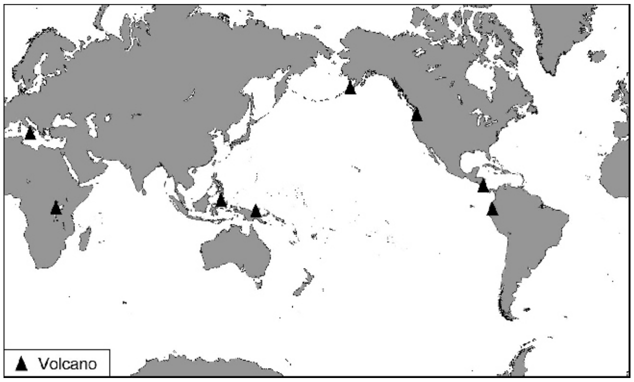
Bulletin of the Global Volcanism Network

Volume 32, Number 8, August 2007



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

Etna

Italy
37.734°N, 15.004°E; summit elev. 3350 m
All times are local (= UTC + 1 hours)

A report by members of the Istituto Nazionale di Geofisica e Volcanologia di Sezione Catania (INGV-CT), Behncke and Neri (2007), discussed Etna's 4-5 September eruption. On 6 September field work on the eastern zone of the Southeast Crater (SEC) revealed profound morphologic changes. The SEC's eastern pit crater was the source of lava flows.

The erupted material was distributed mostly to the E, covering the plateau between the base of the SEC and the western rim of the Valle del Bove with a thickness ranging from a few meters to more than 25 m (figure 1). The accumulation of welded scoria formed a mound more than 700 m long.

The scoria mound, which formed by falling material, was composed primarily of extremely light and vesicular scoria, of varying size, from less than a centimeter to meters, oxidized and reddish in color. The thickness of the scoria deposits varied from over 25 m at the base of the SEC to about 8 m in the area around the western rim of the Valle del Bove, behind hornitos at ~ 2,800 m elevation, which formed during the 2006 eruption.

The scoria appeared to have moved after landing. In addition, localized movement also occurred along some wide-opening fracturing.

During the formation of the scoria mound, lava descended as three principal streams. The streams emerged from the SE sector of the eruptive crater (venting at the Eastern pit crater) (figure 2).

The field observers saw the southern rim of the eruptive crater and the zone beneath it. To an elevation of about 2,800 m, these rocks emitted fumarolic vapors and contained hot fractures. The position of this fissure field appeared to coincide, at least in part, with what had already been identified by thermal telecamera during the helicopter survey carried out by the governmental Regional Civil Protection. Inside the 4-5 September eruptive vent (Eastern pit crater seen in figures 2 and 3), the team also saw a point of continuous and pulsating gas emissions.

Reference: Behncke, B. and Neri, M., 2007, L'eruzione del 4-5 settembre 2007 al Cratere di Sud-Est (Etna): osservazioni di terreno in prossimità della bocca eruttiva; copyrighted report of the INGV-CT (posted on their website and accessed October 2007).

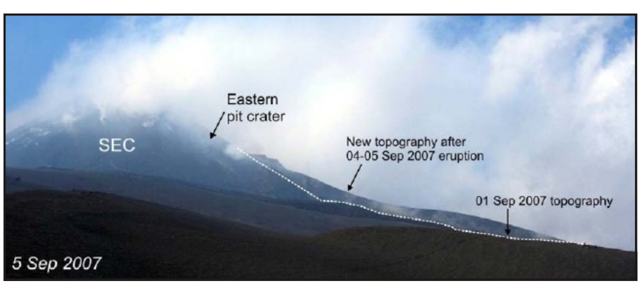

Figure 1. The Southeast Crater cone at Etna seen from the SSE. The white dotted line shows the eruption topography before the 4-5 September 2007 eruption. The photo highlights significant new material over the old topography. From Behncke and Neri (2007).

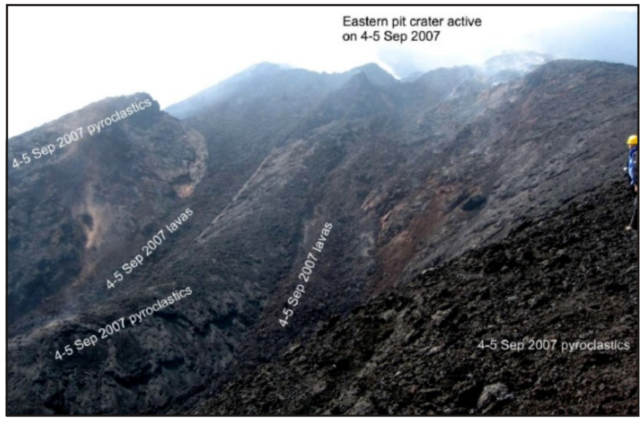

Figure 2. Lava flows and pyroclastic materials on the E flank of Etna's Southeast Crater from the 4-5 September 2007 eruption. Labels indicate lithologies. The observer (right) is on the mound of larger scoria, about 150 m from the crater. Photo from Behncke and Neri (2007).

Geologic Summary. Mount Etna, towering above Catania, Sicily's second largest city, has one of the world's longest documented records of historical volcanism, dating back to 1,500 BC. Historical lava flows of basaltic composition cover much of the surface of this massive volcano, whose edifice is the highest and most voluminous in Italy. The Mongibello stratovolcano, truncated by several small calderas, was constructed during the late Pleistocene and Holocene over an older shield volcano. The most prominent morphological feature of Etna is the Valle del Bove, a 5 x 10 km horseshoe-shaped caldera open to the east. Two styles of eruptive activity typically occur at Etna. Persistent explosive eruptions, sometimes with minor lava emissions, take place from one or more of the three prominent summit craters, the Central Crater, NE Crater, and SE Crater (the latter formed in 1978). Flank vents, typically with higher effusion rates, are less frequently active and originate from fissures that open progressively downward from near the summit (usually accompanied by strombolian eruptions at the upper end). Cinder cones are commonly constructed over the vents of lower-flank lava flows. Lava flows extend to the foot of the volcano on all sides and have reached the sea over a broad area on the SE flank.

Information Contacts: Sonia Calvari, Boris Behncke, Marco Neri, Istituto Nazionale di Geofisica e Vulcanologia (INGV), Sezione di Catania, Piazza Roma 2, 95123 Catania, Italy.

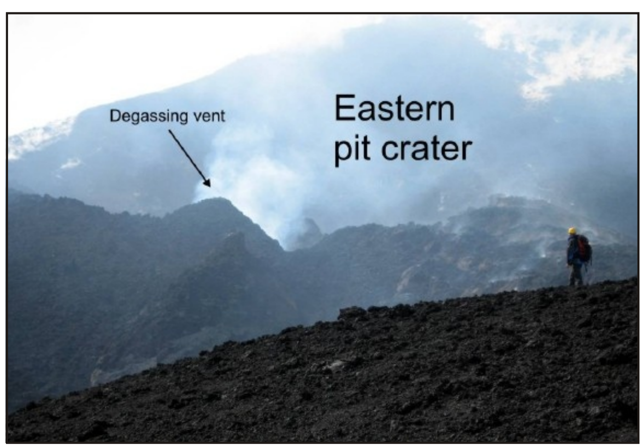

Figure 3. At Etna's SEC, this photo shows the degassing vent inside the active crater. Courtesy of INGV.

Nyiragongo

DR Congo
1.52°S, 29.25°E; summit elev. 3,470 m

As has been the case since July 2002, nearly daily thermal anomalies detected by satellite instruments continued through August 2007, confirming the presence of a lava lake in the summit crater. These anomalies were acquired from MODIS satellites and are available on the University of Hawai'i Institute of Geophysics and Planetology (HIGP) MODIS Hotspot Alert website.

The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite recorded a light-colored plume on 19 June 2007 that extended SE over Lake Kivu. NASA suggested that it consisted primarily of water vapor.

Almost daily SO_2 concentration-pathlengths for Nyiragongo (figure 4) have been reported online starting in May 2007 by the OMI Sulfur Dioxide Group. The SO_2 concentrations are spectroscopically determined primarily by the Ozone Monitoring Instrument (OMI) aboard NASA's Earth Observing System AURA spacecraft. The highest measured amounts were ~ 2.0 Dobson Units or greater on about 20 days during June-September 2007. A Dobson Unit, DU, the product of concentration and pathlength, is a function of the number of SO_2 molecules in a unit area of the atmospheric column.

A photo of the summit taken from a fixed-wing aircraft in early July 2007 disclosed that a substantial portion of the outer crater wall on the W flank had collapsed, forming a large slump with an arcuate headwall (figure 5). The implication in the pilot report was that this was a recent event.

According to news media accounts, on 6 July 2007 a female Chinese tourist climbed over the crater rim of Nyiragongo for a photograph of the crater's interior. She slipped and fell more than 100 m down the steep wall of the crater to her death.

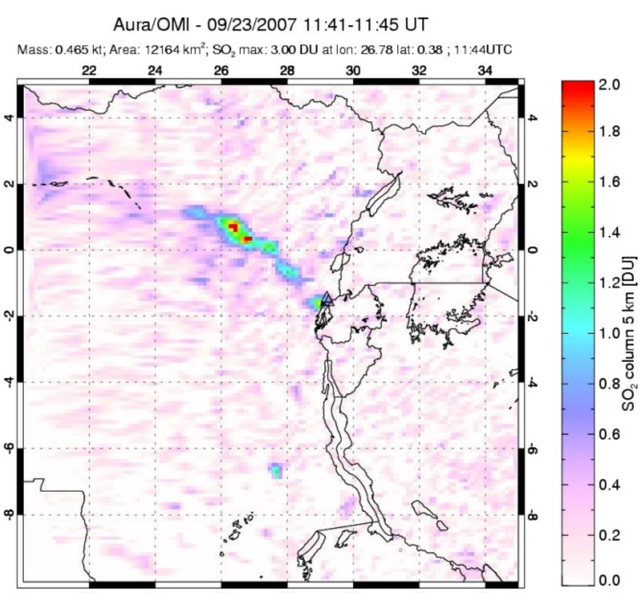

Figure 4. A profile of SO_2 concentration-pathlength seen on 23 September 2007 in the Nyiragongo-Nyamuragira area. In this case the plume covered an area of 12,164 km^2. Darker (or redder) areas represent greater SO_2, as indicated by the legend on the right. The total atmospheric SO_2 detected was 465 x 10^3 kg. Courtesy OMI Sulfur Dioxide Group.

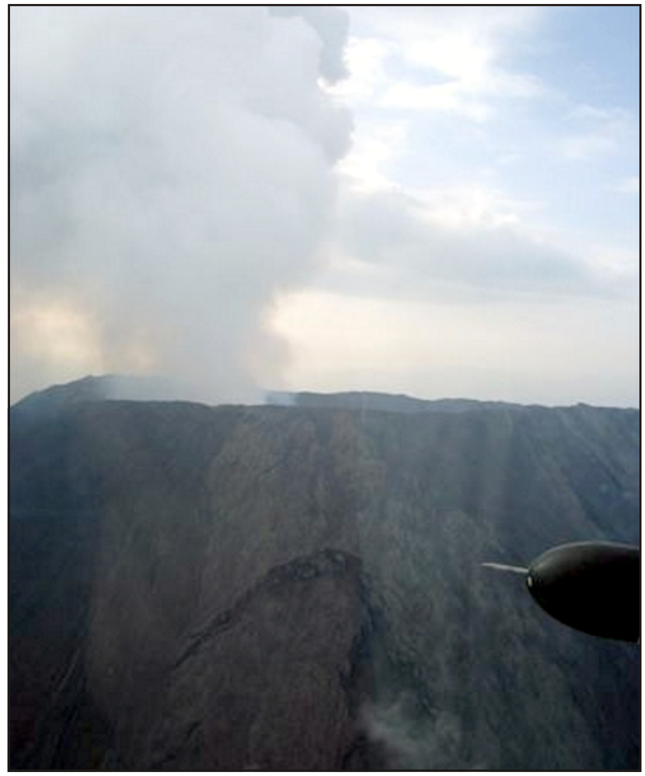

Figure 5. A photo taken in early July 2007 by pilot Sean O'Conner as he flew past the W slope of Nyiragongo. The scarp mentioned in the text apparently lies in the center of the field of view. A steam-and-gas plume rises vertically above the crater opening. One of the aircraft's wings juts across the right margin of the photo. Courtesy of Sean O'Conner (ECHO Flight).

Geologic Summary. One of Africa's most notable volcanoes, Nyiragongo contained a lava lake in its deep summit crater that was active for half a century before draining catastrophically through its outer flanks in 1977. In contrast to the low profile of its neighboring shield volcano Nyamuragira, the 3,470-m-high Nyiragongo displays the steep slopes of a stratovolcano. Benches in the steep-walled, 1.2-km-wide summit crater mark levels of former lava lakes, which have been observed since the late-19th century. Two older stratovolcanoes, Baruta and Shaheru, are partially overlapped by Nyiragongo on the N and S. About 100 parasitic cones are located primarily along radial fissures south of Shaheru, E of the summit, and along a NE-SW zone extending as far as Lake Kivu. Many cones are buried by voluminous lava flows that extend long distances down the flanks of the volcano, which is characterized by the eruption of foiditic rocks. The extremely fluid 1977 lava flows caused many fatalities, as did lava flows that inundated portions of the major city of Goma in January 2002.

Information Contacts: *NASA Earth Observatory* (URL: http://earthobservatory.nasa.gov); *OMI Sulfur Dioxide Group*, based in the Joint Center for Earth Systems Technology at the University of Maryland Baltimore County (UMBC), and at *NASA Goddard Space Flight Center* (URL: http://so2.umbc.edu/omi/); Hawai'i Institute of Geophysics and Planetology, MODIS Thermal Alert System, School of Ocean and Earth Sciences and Technology (SOEST), University of Hawai'i, 2525 Correa Road, Honolulu, HI, USA (URL: http://hotspot.higp.hawaii.edu); *Reuters* (URL: http://www.reuters.com/); *Agence France-Presse* (URL: http://www.afp.com/); *Sean O'Conner*, ECHO (European Commission's Humanitarian Aid Office) Flight, Goma, Democratic Republic of Congo (Email: sean@flarepath.co.za); *Tom Pfeiffer*, Volcano Discovery (URL: http://www.decadevolcano.net/).

Pavlof

Alaska Peninsula, USA
55.42°N, 161.887°W; summit elev. 2,519 m
All times are local (= UTC - 9 hours)

The Alaska Volcano Observatory (AVO) reported that Pavlof (figure 6) erupted on 15 August 2007 for the first time since 15 September 1996 (*BGVN* 22:09 and Waythomas, Miller, and Mangan, 2006) . Thermal anomalies and seismic activity just prior to the eruption prompted scientists at AVO to issue a warning. This report covers events reported through 3 October 2007.

According to AVO, an abrupt increase in earthquake activity began at Pavlof early on the morning of 14 August 2007. Based on patterns of unrest leading to past eruptions at Pavlof, AVO elevated the alert level and color code to 'Advisory/Yellow.' Observers from the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) in Cold Bay, Alaska, were able to see the volcano on the morning of 14 August and reported no anomalous steaming or other activity; satellite imagery from this morning also showed no obvious signs of surface activity or ash emission.

Earthquake intensity continued to increase slowly from 15 to 16 August. Strong signals at a single station SE of the summit suggested local flow activity, probably lahars (or mudflows) on that flank. Satellite images of the volcano overnight and during the morning of 16 August continued to show a strong thermal feature (figure 7). Residents of both Cold Bay and Sand Point, Alaska (105 km and 70 km, respectively, from Pavlof), observed incandescence at the summit during the night.

Persistent earthquake activity and flow events, probably lahars (mudflows), continued on 17 August 2007. Several

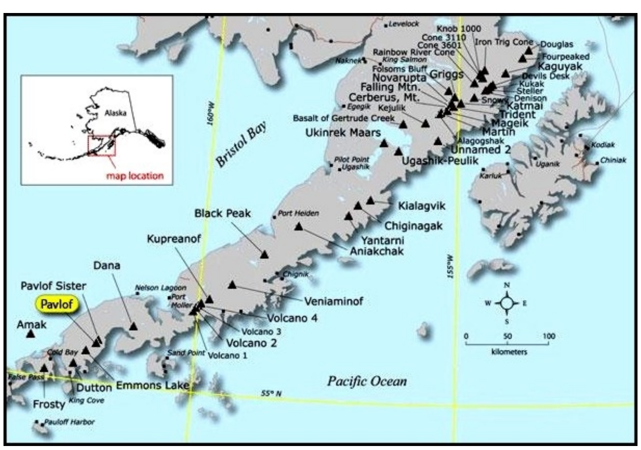

Figure 6. Index map showing the location of Pavlof and other Alaska Peninsula volcanoes. Courtesy of AVO and Alaska Division of Geological & Geophysical Surveys.

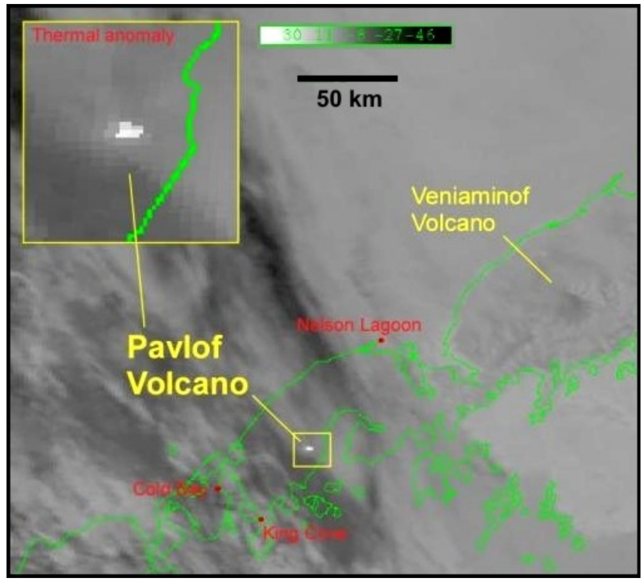

Figure 7. NOAA Advanced Very High Resolution Radiometer (AVHRR) satellite image showing a strong thermal anomaly at the summit of Pavlof on 16 August 2007 at 0750 local time (1550 UTC). In this image, white represents hot temperatures. Courtesy of the AVO/U.S. Geological Survey (USGS).

discrete explosion earthquakes were also recorded. Though clouds obscured the volcano in most satellite images, one GOES (Geostationary Observational Environmental Satellite) image documented a large thermal feature at the summit, interpreted to be lava at the surface.

Activity at Pavlof continued to increase during 17-24 August 2007, with reports that the steam-and-ash plume sometimes exceeded 3 km altitude. For example, a pilot reported the top of the plume to be 5.5 km in the late afternoon of 23 August, and a plume height of 4 km was estimated using satellite data from 1410 that day. Seismic activity remained elevated, with moderate levels of tremor occurring almost continuously and with occasional bursts of higher amplitude. The average seismic amplitude increased slowly throughout the week of 17-24 August. Many small-to-moderate explosions were recorded in the seismic record, as were events from lahars flowing down the SE flank. [Note: Pilot Jeff Linscott of JL Aviation filmed a lahar front on Pavlof's lower flanks before it hit the ocean on 18 August 2007; the film is available on the AVO website, which is listed in under Information Contacts below.] Satellite data showed strong thermal anomalies at the summit, as well as occasional ash clouds, throughout this week.

An AVO field crew visited Pavlof on 18-19 August to make FLIR (forward looking infrared) thermal observations of the ongoing eruption. These observations confirmed the existence of a new vent ~ 200 m below the summit on the SE flank. The vent, ~ 50 m across, fed a lava flow that, on 18 August, was more than 0.5 km long and ~ 25 m across. The crew also observed a lahar reaching the Pacific coast, incandescent lava, and explosions at the vent that sent 5-m-long blocks flying 50 m through the air. Figure 8 shows the plume from Pavlof on 23 August, and figure 9 shows the plume on 30 August 2007.

At about 2130 local time on 31 August, NOAA/NWS observers in Cold Bay reported a substantial plume emanating from Pavlof, along with associated lightning. The

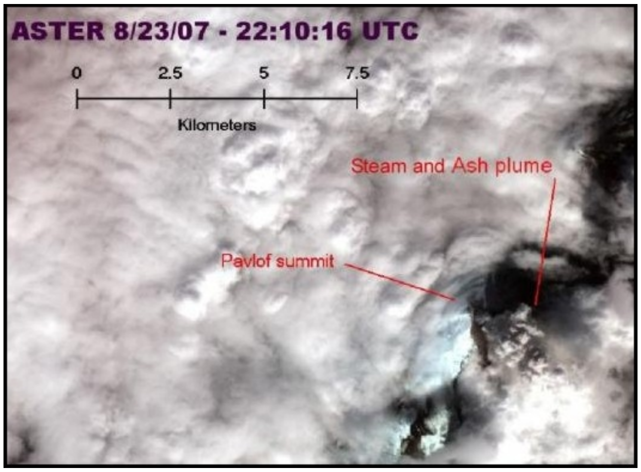

Figure 8. An Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite image on 23 August 2007 at 2210 UTC showing Pavlof with a small steam-and-ash plume emitting from the crater on the SE side of the summit. The plume in this image (having a resolution of 15 m/pixel) reached an altitude of ~ 4.0 km based on the plume's temperature. Courtesy of the AVO/USGS.

Figure 9. Pavlof volcano and eruption plume on evening of 30 August at 2120 local time. View is to the S, out of the right side of a PenAir Metro Airline plane *en route* to Anchorage from Cold Bay; plume height was approximately 5.2-5.5 km. Courtesy of Chris Waythomas and AVO/USGS.

plume, which rose to an altitude of ~ 6 km, was also visible in images from the Pavlof web camera located in Cold Bay. However, there were no indications in satellite data or ground reports of an ash plume. Seismic activity remained elevated through 31 August.

During 1-19 September 2007 the eruption continued; however, seismicity after 10 September declined markedly from levels recorded earlier. AVO pointed out that typical eruptions at Pavlof were characterized by periods of diminished activity interspersed with periods of renewed eruptive activity. Satellite observations continued to show thermal anomalies even through the clouds, as well as steam plumes up to as high as 6.1 km altitude. Table 1 shows thermal anomalies from the beginning of 2007 through 3 October measured by MODIS satellite infrared detectors and processed by the Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System called MODVOLC. Anomalies measured during 2007 began on 15 August and continued through 11 September, after which none have been reported to present (3 October). Satellite thermal anomalies are frequently masked by cloud cover.

AVO detected a strong thermal anomaly at the volcano overnight 14-15 September, and seismic activity continued to increase in both the number of events per hour and duration of individual events. Eye witnesses aboard a ship reported incandescent blocks tumbling down the ESE flank of the volcano beginning at midnight 14 September, perhaps signaling the onset of the current eruption. Satellite

Date (2007)	Time (UTC)	Number of Pixels	Satellite
1 Jan-14 Aug	—	0	—
15 Aug	0750	2	Terra
	1330	2	Aqua
16 Aug	0839	3	Terra
	1235	1	Aqua
18 Aug	2150	1	Terra
19 Aug	0725	1	Terra
	1350	2	Aqua
20 Aug	0810	2	Terra
	1210	3	Aqua
	1350	1	Aqua
23 Aug	2210	1	Terra
	2220	1	Aqua
24 Aug	0745	7	Terra
	1325	5	Aqua
25 Aug	1230	7	Aqua
28 Aug	1300	4	Aqua
29 Aug	0800	4	Terra
30 Aug	0705	2	Terra
	0845	4	Terra
	1250	3	Aqua
31 Aug	0750	3	Terra
	1155	2	Aqua
	1330	3	Aqua
01 Sep	0830	3	Terra
	1235	1	Aqua
02 Sep	0735	1	Terra
	0915	4	Terra
	1320	4	Aqua
04 Sep	2230	2	Terra
05 Sep	1210	4	Aqua
	2135	2	Terra
06 Sep	0715	1 or 2	Terra
	0850	8	Terra
	1255	5	Aqua
07 Sep	0755	4	Terra
	1200	6	Aqua
	1335	4	Aqua
08 Sep	0840	1	Terra
09 Sep	0745	2	Terra
	2115	1	Terra
	2250	1	Terra
	2300	2	Aqua
10 Sep	0825	8	Terra
	1230	2	Aqua
11 Sep	0910	2	Terra
	1315	2	Aqua
	2100	2	Terra
12 Sep-03 Oct	none (possible cloud cover)		

Table 1. MODIS/MODVOLC thermal anomalies measured at Pavlof for 2007 through 3 October. Courtesy of the HIGP Thermal Alerts System.

data confirmed the presence of lava. Pilot reports indicated that a weak ash plume extended 8 km SW of the summit at a height of ~ 2.6 km. Seismic activity continued at a high level. On 15 August 2007, AVO raised the aviation color code for Pavlof from Yellow to Orange and the Alert Level from Advisory to Watch.

A status report on 3 October 2007 stated that "A pause in eruptive activity at Pavlof continues. Seismicity remains at low levels and has been relatively unchanged since about September 13. No sign of renewed volcanic activity was noted in clear satellite and web camera views today."

References: Waythomas, C.F., Miller, T.P., and Mangan, M.T., 2006, Preliminary Volcano Hazard Assessment for the Emmons Lake Volcanic Center, Alaska: Anchorage, Alaska, U.S. Geological Survey, Scientific Investigations Report 2006-5248, 33 p., 1 sheet (available online at http://www.avo.alaska.edu/pdfs/SIR2006-5248.pdf).

Linscott, J., 2007, Film of Pavlof lahar front, 18 August 2007 [on AVO website, URL: http://www.avo.alaska.edu/volcanoes/volcimage.php?volcname=Pavlof).

Geologic Summary. The most active volcano of the Aleutian arc, Pavlof is a 2,519-m-high Holocene stratovolcano that was constructed along a line of vents extending NE from the Emmons Lake caldera. Pavlof and its twin volcano to the NE, 2,142-m-high Pavlof Sister, form a dramatic pair of symmetrical, glacier-covered stratovolcanoes that tower above the Pavlof and Volcano bays. A third cone, Little Pavlof, is a smaller volcano on the SW flank of Pavlof volcano, near the rim of Emmons Lake caldera. Unlike Pavlof Sister, Pavlof has been frequently active in historical time, typically producing strombolian to vulcanian explosive eruptions from the summit vents and occasional lava flows. The active vents lie near the summit on the N and E sides. The largest historical eruption of Pavlof took place in 1911, at the end of a 5-year-long eruptive episode. During this eruption, a fissure opened on the N flank of the volcano, ejecting large blocks and issuing lava flows.

Information Contacts: *Alaska Volcano Observatory (AVO)*, a cooperative program of the U.S. Geological Survey, 4200 University Drive, Anchorage, AK 99508-4667, USA; Geophysical Institute, University of Alaska, P. O. Box 757320, Fairbanks, AK 99775-7320, USA; and Alaska Division of Geological & Geophysical Surveys, 794 University Ave., Suite 200, Fairbanks, AK 99709, USA (URL: http://www.avo.alaska.edu/); *Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System*, School of Ocean and Earth Science and Technology (SOEST), Univ. of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (URL: http://hotspot.higp.hawaii.edu/); *Jeff Linscott*, JL Aviation Helicopter Service, 8015 NE Airport Way, Portland, OR 97218 USA.

St. Helens

Washington, USA
46.20°N, 122.18°W; summit elev. 2,549 m

Lava dome growth at St. Helens (as previously reported in *BGVN* 31:12) continued through at least September 2007. Seismicity remained at low levels punctuated by M 1.5-2.5, and occasionally larger, earthquakes. Inclement weather inhibited field work and created poor visibility for much of the January-September reporting period.

In general, gas-and-steam plumes from the active lava dome, as well as dust plumes resulting from rockfalls, occasionally rose above the crater rim. A gas plume may have been seen on 3 June, and a weak gas-and-steam plume was visible rising from the lava dome on 12 June.

On 3 April, a GPS unit on an active spine showed W-ward movement at a rate of approximately 30 cm/day. Points on the active part of the dome moved away from the vent at an average rate of approximately 0.45m/day July 2007. That rate is similar to but slightly less than it was a year ago.

Growth of the lava dome and changes in crater morphology over the course of this eruption have been well documented (figures 10 and 11).

Geologic Summary. 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

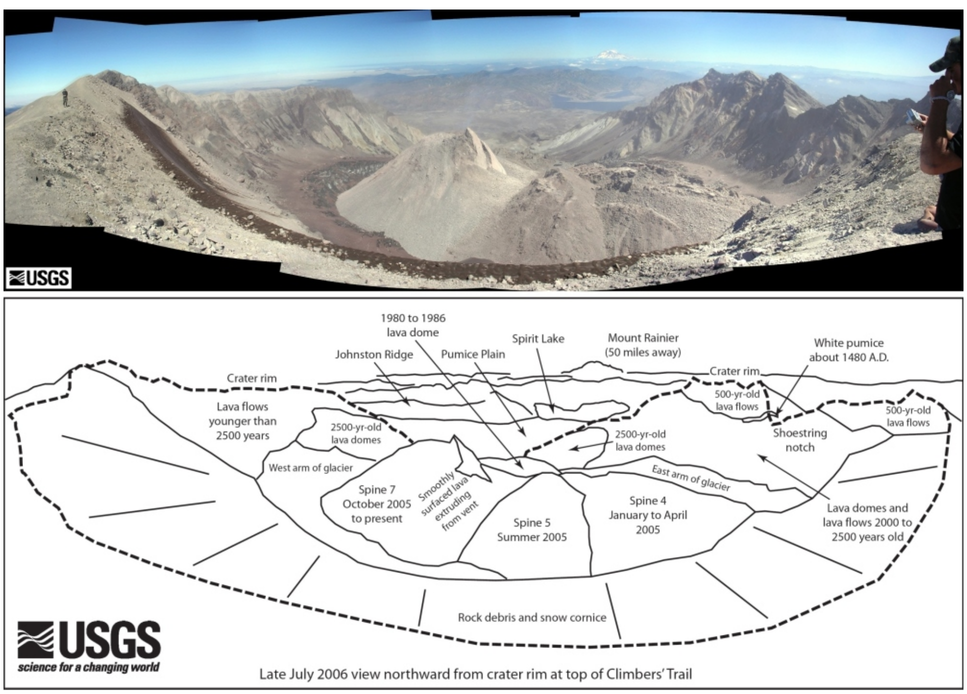

Figure 10. A panoramic wide-angle view from St. Helens' crater rim looking N on 27 July 2006. The accompanying sketch describes key features in the photo. For example, the dark rim wrapping around the lower margin of the photo represents rock debris on the snow cornice. Courtesy of Willie Scott, USGS Cascade Volcano Observatory.

Figure 11. Comparison photo taken of Mount St. Helens as seen from Harrys Ridge, 8 km N. These photos were taken 25 years apart in 19 May 1982 and 20 April 2007. Courtesy of Gene Iwatsubo, USGS CVO.

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 2,200 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).

Turrialba

Costa Rica
10.025°N, 83.767°W; summit elev. 3,340 m

Non-eruptive fumarolic activity was reported at Turrialba through August 2001 (*BGVN* 26:11). This report covers the time interval January 2002 to mid 2007. Central and W craters were both scenes of fumarolic activity, and reports mentioned generally modest seismicity.

No eruption occurred, although fumarolic and seismic activity remained elevated and some other noteworthy changes also took place. Figure 12 presents a summary of seismicity measured during 1990-2006. Seismicity increased beginning in 1996, reached a peak in 2001 and although it remained elevated, it decreased somewhat from the peak through 2006. In general seismic activity was modest and of short duration with numerous micro-earthquakes of amplitude smaller than 15 mm, and frequencies between 2.1 and 3.0 Hertz (Hz).

Fumarolic activity of 2002-2006. A summary of fumarolic activity at the central crater during the period 2002 through 2006 indicated the S, SW, NW, and N walls were collecting sulfur as a product of gas emissions. Monthly vapor temperatures at the central crater ranged from 87 to 91°C. In March 2006, a pair of cracks continued to be visible in the central crater's S, SE, and SW walls. By August 2006, a pair of cracks in the central crater were particularly significant. Visiting scientists noted that during August 2006, localized vegetation in and around the summit area had been heavily impacted by gases. Areas not affected by increased fumarolic activity in June 2005 had been burned, including a tree belt on the NW outer flank. Below the tree belt, farmers reported an intensification of gas odors. The shapes of the burned areas reflected prevailing wind directions.

From 2002 through 2006, Turrialba's W crater displayed fumarolic activity in the N, NE, W, NW, and SW sides with low levels of emission and gas temperatures remaining consistent from 88 to 93°C . New points of sulfur deposition were noted throughout the period.

An interval of increased seismicity (a pulse) recorded by station VTU located 0.5 km NE of the active crater occurred during 9 July to 14 September 2003. Through December 2003, the emissions continued to increase in the main crater, gradually generating gas columns that were carried W. Observers noted that the vegetation of the SW wall and W of the central crater continued to deteriorate, as well as effects such as heating of the ground, salt deposition at the surface, and escaping gases.

In June 2005, a significant increase in fumarolic gas emission was noted by OVISCORI-UNA and they also indicated changes in gases venting at the W crater. Chemical analysis indicated carbon dioxide gas had decreased and sulfur dioxide had increased, with the result that bushy species and minor plants that managed to survive in the open summit area (inner walls) became completely burned (figure 13). In the external walls to the N, NW, and W, the gases killed the vegetation.

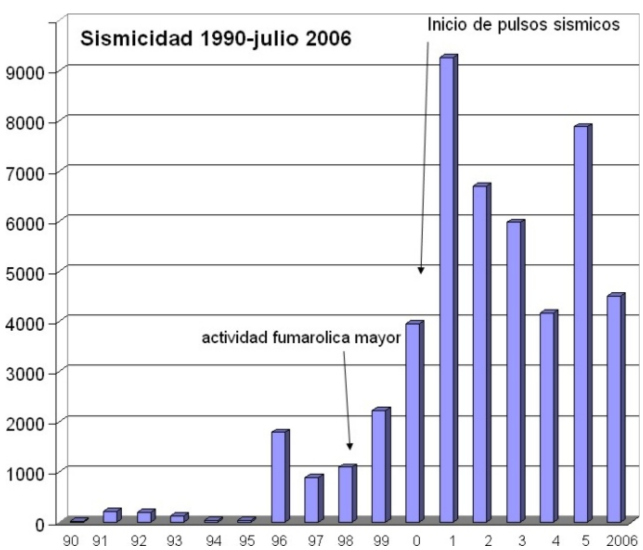

Figure 12. The numbers of earthquakes recorded at Turrialba during 1990 through 2006. Courtesy of Vilma Barboza (OVSICORI-UNA).

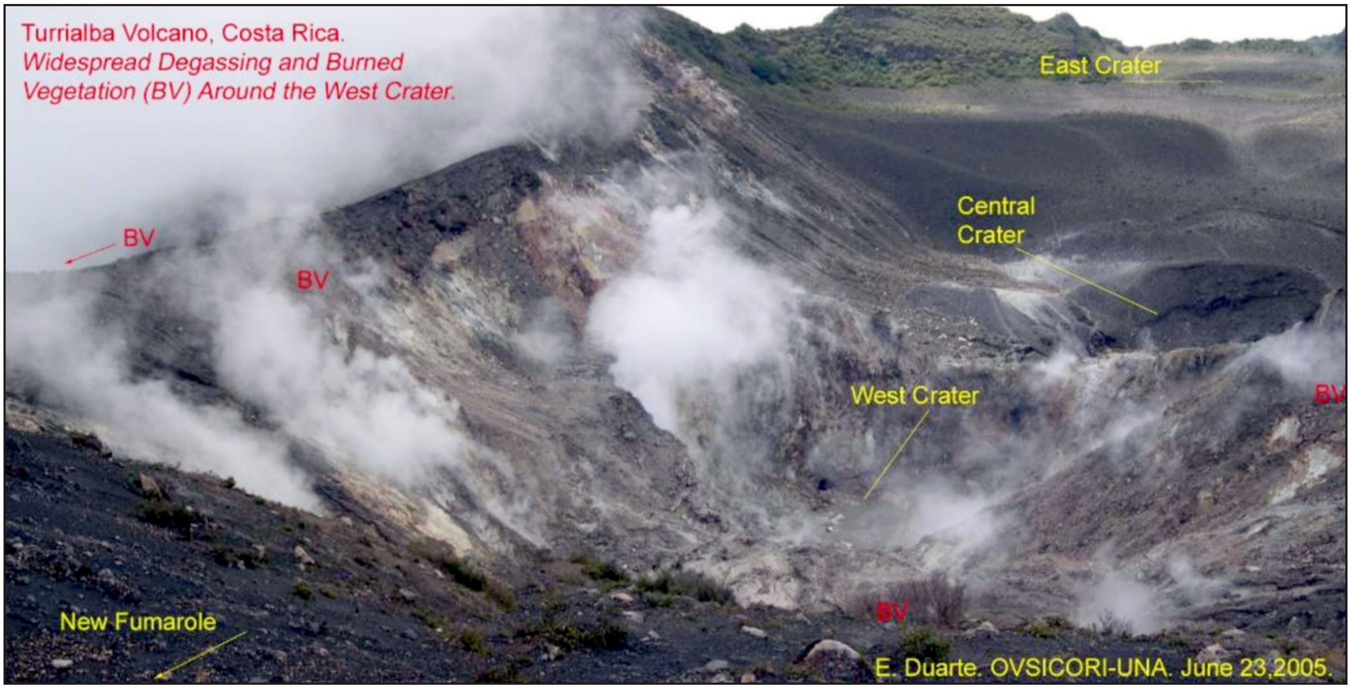

Figure 13. Increased degassing and resultant burned vegetation around Turrialba's W crater, as illustrated in this photograph from June 2005. Courtesy Eliécer Duarte, OVISCORI-UNA.

A 2006 report noted that bushy species and minor plants that had previously managed to survive in the open summit area (inner walls) had by August 2006 appeared completely burned (figure 14). The tree belt on the NW outer flanks (reported in 2005 as partially burned) contained a significant percentage of dead birch (*Alnus acuminata*). The belt, ~ 200 x 900 m in area, included species taller than 25 m, and was visible from the lower inhabited farms where residents reported increasingly potent gas odors. The shape and location of the belt correlated with the seasonal prevailing wind directions.

Behavior during January-August 2007. At the end of February 2007, a flight over Turrialba's summit revealed significant growth in the area of burned vegetation. On that day, dwarf and tall trees looked yellowish due to sustained degassing from the W crater.

On 21 April, observers measured the temperatures of fumaroles emitting steam at ~ 40ºC as far as 1.5 km SW of the summit, a spot coinciding with the well known, ENE-trending Ariete fault. Two larger fumaroles were reported on 2 May located 200 m SW from the first one along the same fault. This site released significant vapor plumes (~ 90ºC) that rose above the thick forest.

During June and July 2007, enhanced fumarolic activity was accompanied by new fractures at the summit. The fumaroles spread over a larger area and their temperatures increased to ~ 90°C. Micro-seismicity also grew.

The main fumarole at the bottom of W crater reached 138°C producing a distinctive sound similar to a high pressure valve; this sound could be heard up to ~ 500 m away. These fumaroles had melted sulfur, a phenomenon previously not seen in OVISCORI's more than 25 years continuous monitoring. Sulfur condensate colored most of the inner crater walls with a fine yellowish film.

Besides the multiple cracks associated with the expansion of the fumarolic areas around the W crater, two new ones appeared. Such cracks (longer than 100 m) oriented radially from the volcano's W and NW borders suggested a significant degree of summit instability. A wide fumarolic field between these two fractures along with the large number of vapor and gas spots on the outer walls also reflected considerable permeability in that area (figure 15).

The effect of gases on the surrounding vegetation (in a 4-km radius) expanded to areas previously protected from damage by prevailing winds (figures 16-17). Acute chemical burning of important patches of natural forest had occurred. Vegetation to the NW, W, and SW appeared yellowish to dark brown (figure 16). By mid-2007 some of the effects had reached potato fields and dairy pastures.

On 5 September 2007, OVSICORI-UNA visited Turrialba's outer NW wall to document the gas damage to vegetation in the area from the crater to the seismic station

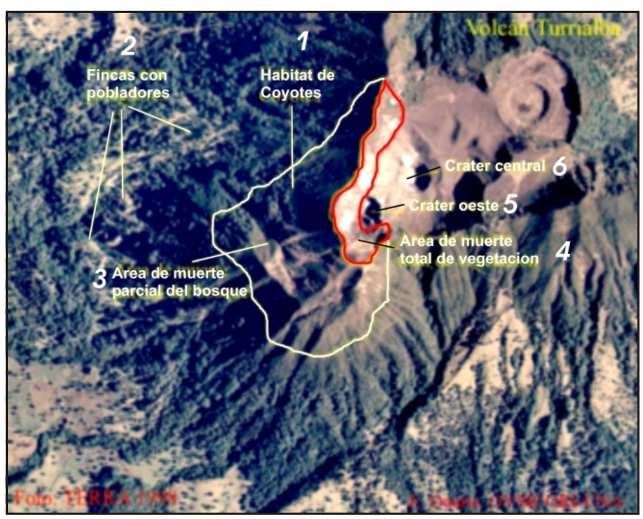

Figure 14. Aerial photograph depicting vegetation impacts at Turrialba and to its W, emphasizing zones affected by increased gas emissions from June 2005 through August 2006. Spanish labels translate as follows: 1) Coyote habitat, 2) Inhabited farms, 3) Area of partial deforestation, 4) Area of totally killed vegetation, 5) W crater, and 6) Central crater. Courtesy E. Duarte, OVISCORI-UNA.

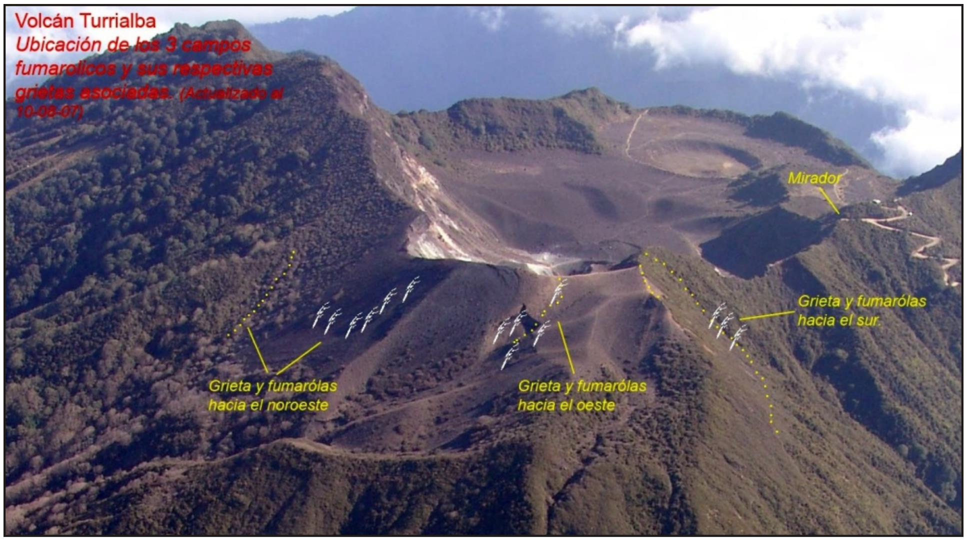

Figure 15. The three fumarolic fields and their associated cracks on Turrialba's NW outer wall, as seen 10 August 2007. Fumaroles are indicated by patten of white lines; cracks ("grietas") indicated by rows of dots. From left to right, the three fields are associated with cracks aligned approximately NW-SE, W-E, and S-N. The latter site contains two N-trending cracks adjacent new fumaroles. Courtesy OVISCORI-UNA.

Figure 16. Acute effects of gases on vegetation are easily visible on Turrialba's steep NW outer wall (25 July 2007). Burns on leaf tissue diminish with distance from the source. Zones of dead climbing vines are visible at closest range in the photo's lower right corner. Courtesy OVISCORI-UNA.

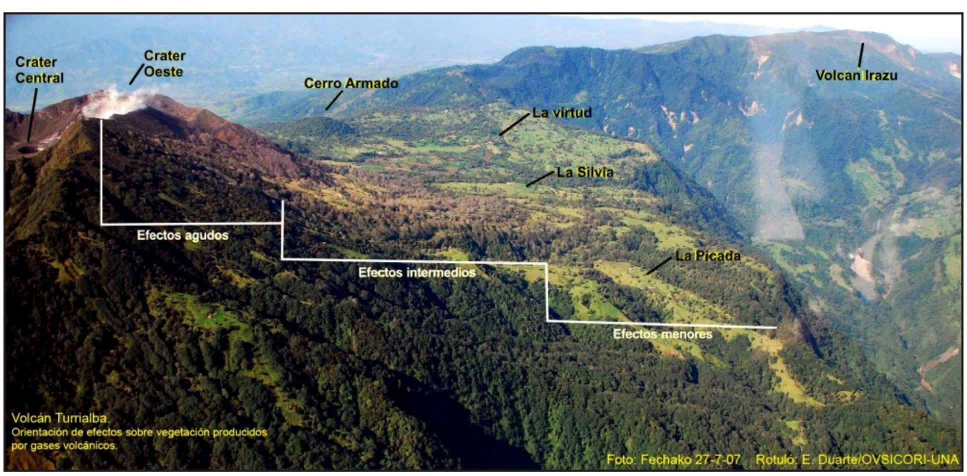

Figure17. Despite the rainy season at Turrialba, the impact of volcanic gases on both exotic and native vegetation increased during June and July 2007. This 27 July 2007 photo identifies three zones of chemical burning, *efectos agudo* (acute effects), *efectos intermedios* (intermediate effects), and *efectos menores* (minor effects). Courtesy E. Duarte, OVISCORI-UNA.

PICA, a distance of 2.5 km. The observers found three bands of severe damage: across an upslope area, a forested zone, and dairy-farm fields.

The upslope band contained a smaller, dense zone of sparse, dwarfed, woody bushes abutting the forest in a fine loose soil in steep terrain. Plants here were very dry and showed a surface layer of white-yellowish material. This effect was most intense within 100 m of the crater, but still partly visible up to 400 m away in patches. A second section with very dense growth was dead.

The mid-slope band through primary forest contained several tree species, including Jaúl and oak. Although all the trees in portions of this band had apparently died, they did so episodically with varying species seemingly more or less resistant to volcanic gases. The upper parts of the trees showed the greatest visible changes. Among the other plant species killed was a climbing vine that where killed turned an intense coffee color.

The topographically lowest band, consisting of pastures with occasional trees, had burned completely over a zone 400 m from the lower line of the forest, leaving grasses a straw-yellow color, and sufficiently brittle to be easily broken by contact. Gasses had also strongly corroded relatively new barbed wire in the ESE sector, and in lower parts of this zone they reacted with fixtures on buildings and damaged gardens.

The August 2007 OVSICORI-UNA report described ongoing fumarolic activity at Turrialba. At the Central and W craters, the respective maximum temperatures were 91°C and 176°C (up from 138°C during late July). Deposition at the fumaroles included sulfur and sulfurous sublimates, in some cases draping walls and forming minor flows up to 2 m from the point of emission. Small landslides were apparent on many sides of the W crater's walls, and these too were places where sulfur or sulfurous sublimates were seen. One of two major fracture directions trended SW; it was visible as a crack 100 m in length and underwent a maximum opening of 1 to 3 cm between 28 July and 16 August.

Geologic Summary. Turrialba, the easternmost of Costa Rica's Holocene volcanoes, is a large vegetated basaltic-to-dacitic stratovolcano located across a broad saddle NE of Irazú volcano overlooking the city of Cartago. The massive 3,340-m-high Turrialba is exceeded in height only by Irazú, covers an area of 500 sq km, and is one of Costa Rica's most voluminous volcanoes. Three well-defined craters occur at the upper SW end of a broad 800 x 2,200 m wide summit depression that is breached to the NE. Most activity at Turrialba originated from the summit vent complex, but two pyroclastic cones are located on the SW flank. Five major explosive eruptions have occurred at Turrialba during the past 3,500 years. Turrialba has been quiescent since a series of explosive eruptions during the 19th century that were sometimes accompanied by pyroclastic flows. Fumarolic activity continues at the central and SW summit craters.

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Tungurahua

Ecuador
1.467°S, 78.442°W; summit elev. 5023 m
All times are local (= UTC - 5 hours)

Ecuador's Instituto Geofisico (IG) wrote that significant though variable eruptions and lahars occurred at Tungurahua during mid-2007. Our previous report (*BGVN* 32:04) focused on early January to 2 March 2007, noting some variations in the pace of eruptive activity then. This report summarizes IG reports for March-July 2007. The substantial eruptions of July and August 2006 left abundant pyroclastic-flow deposits on the mountains slopes, potential source materials for new lahars (mudflows). The abundant seismicity during that interval punctuated a longer-term variable pattern (table 2 and figure 18).

The IG report for March stated that a relatively energetic eruptive phase began on 24 February 2007 and continued throughout the month. That phase included abundant, ash emissions, sometimes discharging incandescent material, numerous, sometimes large explosions, and frequent noteworthy ashfall. The ash emissions and ashfalls were sometimes sustained. Blocks ejected in Strombolian outbursts fell up to 1 km below the crater rim.

Time interval	Total earthquakes	Long-period	Volcano-tectonic	Hybrid	Emission signals	Explosion signals
Total for Jul 2006	3482	3475	5	2	1185	6442
Daily average for Jul 2006	112	112	0.16	0.06	38	208
Total for Aug 2006	2546	2518	19	9	467	1643
Daily average for Aug 2006	82.1	81.2	0.61	0.29	15.1	53.0
Total for Sep 2006	2189	2149	35	5	111	0
Daily average for Sep 2006	73.0	71.6	1.16	0.16	3.7	0
Total for Oct 2006	3159	3131	20	8	1023	4
Daily average for Oct 2006	102	101	0.64	0.25	33.0	0.12
Total for Nov 2006	1849	1846	3	0	1049	1
Daily average for Nov 2006	61.6	61.5	0.1	0	35.0	0.03
Total for Dec 2006	2172	2168	5	0	648	0
Daily average for Dec 2006	70.1	69.9	0.16	0	22.8	0
Total for Jan 2007	829	817	12	0	10	0
Daily average for Jan 2007	26.7	26.4	0.38	0	0.32	0
Total for Feb 2007	983	966	15	2	312	54
Daily average for Feb 2007	35.1	34.5	0.53	0.07	11.1	1.9
Total for Mar 2007	1126	1125	1	0	1215	334
Daily average for Mar 2007	36.3	36.3	0.03	0.0	39.2	10.7
26 Feb-04 Mar	427	427	0	0	364	51
05 Mar-11 Mar	235	235	0	0	269	87
12 Mar-18 Mar	134	133	1	0	203	112
19 Mar-25 Mar	241	241	0	0	356	86
26 Mar-01 Apr	465	465	0	0	300	47

Table 2. Summary of Tungurahua seismicity recorded during July 2006 through Mar 2007. Courtesy of IG.

During March, there were rises in both tremor amplitude and the number of long-period (LP) earthquakes (the later during March averaging 36 per day). SO_2 gas fluxes averaged ~ 1,050 metric tons/day (t/d). Flank deformation was minimal. March ash falls came from frequent sustained ash plumes 2-6 km over the summit (figure 19). Seismically detected eruptions took place 29 times per day, including some of large size. Tremor nominally took place around 1 Hz, but its frequency remained irregular, non-harmonic, and pulsating. Intervals of pulsing emissions in mid-March had cycle times of ~ 10 minutes.

An explosion on 27 March caused an “overflow” of incandescent material that traveled 800 m down from the head of the Mandur drainage. Other similar eruptions may have occurred but cloudy conditions forestalled clear observations. Hot lahars, however, traveled down the Mandur and Chontapampa drainages. Ash falls were common on the cone’s N and NW sectors, and in addition, observers noted a small pyroclastic flow.

Figure 20. A lahar in the La Pampa sector of Tungurahua showing an active, steep sided erosional channel down the axis of the deposit. Photographed 13 June 2007 by P. Ramón (IG). Courtesy IG.

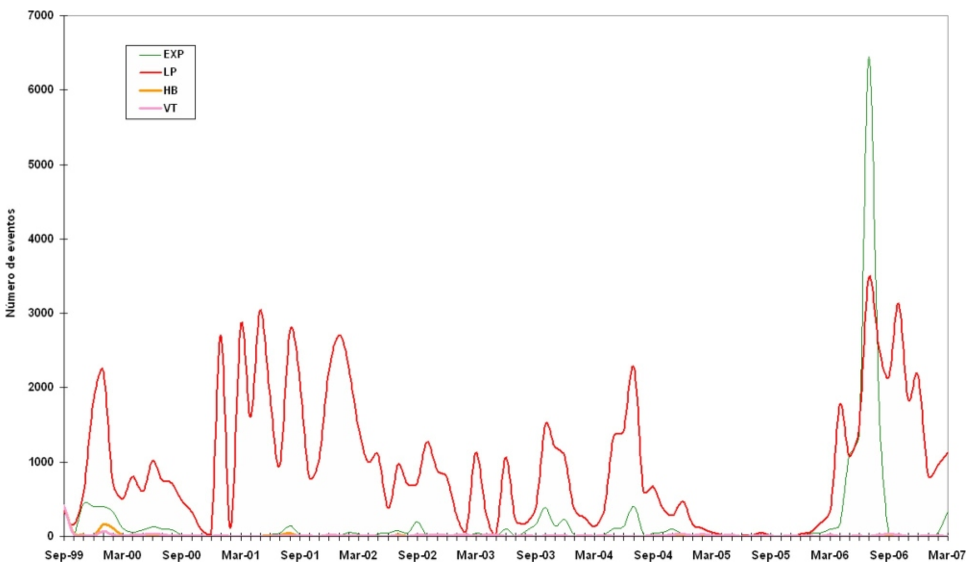

Figure 18. Tungurahua seismicity during September 1999 to March 2007 plotting the number of both explosion (EXP) and long-period (LP) earthquakes. Other kinds of earthquakes also took place but after 2001 were rarely seen. Courtesy of IG.

Figure 19. Tungurahua emitting an ash plume on 9 March 2007. Sustained plumes were seen during much of the month. Photo taken from Pondoa, on the N flank by Patty Mothes (IG).

During the first weeks of April 2007 the IG noted continuous, strong emissions with a very high ash content. These emissions accompanied conspicuous lava fountains, visible at night, and strong roars that made windows vibrate. Ash columns reached 6 km above the crater (~ 11 km altitude). Activity decreased notably during the last 10 days of April (but were even lower in late May). Seismometers recorded an average of ~ 10 daily low-amplitude LP earthquakes. A differential optical absorption spectroscopy (DOAS) instrument measured SO_2 fluxes of 3,600 and 3,700 t/d during the last 10 days of April.

During May, seismicity was low (table 2), with the average number of registered earthquakes each day averaging about 20. The Seismic Activity Index at the beginning of the month indicated a level 5 (moderate-high activity), which later on fell to a level 3 (moderate-low activity). This was the lowest Seismic Activity Index registered since February 2007. Ash emissions were low to moderate with a westerly direction. The SO_2 levels were approximately 800 t/d. With the exception of the frequent formation of lahars, the level of volcanic activity was low in May.

The vigor of June 2007 eruptions from Tungurahua remained at moderate to low levels. Seismicity at the start of the month was low, chiefly LP earthquakes. Eruptions columns were modest and charged with moderate to low

Date (2007)	Drainage	Relative size and comments
01 June	Bilbao	Small
06 June	Bilbao	Small
07 June	Vazcún	Small
	La Pampa	Small; caused road closure
	Bilbao	Small
	Motilones	Small
	Pingullo	Small
	Rea	Small
	Viejo Minero	Muddy water
11 June	Mandur	Muddy water
	La Pampa	Small
12 June	La Pampa	Muddy water
	Viejo Minero	Muddy water
13 June	La Pampa (2)	Large and medium; a truck remained stuck
	Viejo Minero	Muddy water
14 June	Mandur	Small
	La Pampa	Small
	Bilbao	Small
	Pingullo	Small
	Motilones	Small
15 June	Mandur	Small
	Mapayacu	Small
	Motilones	Small
	Pingullo	Small
	La Pampa	Small
	Rea	Small
	Choglontus	Small
	Cusúa	Small
	Vazcun	Small
	Viejo Minero	Muddy water
16 June	La Pampa	Muddy water
20 June	La Pampa	Medium; closing the road
	Mandur	Small
	Viejo Minero	Small
	Achupashal	Small
	Bilbao	Small
	Motilones	Small
21 June	La Pampa	Large, closing the road
	Viejo Minero	Large
	Mandur	Large
	Vazcún	Large
	Nueva Cusúa	Large
	Achupashal	Large
	Motilones	Large
	Pingullo	Large
	Bilbao	Large
	Rea	Large
	Confesionario	Large
	Ulba	Growing
22 June	Vazcún	Growing
	Ulba	Growing
	La Pampa	Muddy water
	Viejo Minero	Small
	Mandur	Small
24 June	La Pampa	Muddy water

Table 3. List of Tungurahua's main lahars during June 2007. A map and table of Tungurahua drainages (quebradas) appeared previously (*BGVN* 29:01). Courtesy of IG.

amounts of ash. June SO_2 fluxes were comparatively high, ~ 2,900 t/d; observers heard light roaring noises similar to a turbine engine. Seismicity increased slightly towards the end of the month.

June brought prolonged intervals of low intensity rain, but heavy rains also occurred. The result was lahars (mud flows) that were numerous and in some cases large (table 3). The 21st of June was particularly noteworthy (table 3). Figure 20 shows one such lahar, which was partly eroded resulting in extension of lahars farther downslope. The lahars sometimes closed the route along the N side of the volcano between Baños and Pelileo and also the route from Baños around the volcano's W flank to Penipe (~ 15 km SW of the summit). No fatalities were reported.

There was a minor increase in seismicity during the month of July. Distribution of events was variable: 240-330 events per week the first and last week of the month; 50-70 events during each of the other two weeks. They were primarily LPs ~ 2 km below the summit.

The rate of SO_2 emission averaged 1,071 t/d with a high of 2,050 t/d. Ashfall was semi-continuous, reaching areas W and SW of the summit, near communities like Bilbao (8 km W of the summit), Chogluntus (SSW of the summit), and El Manzano (7 km WSW). The plume headed toward Manta once the column reached 4 km above the summit.

During July, the road to Baños-Las Juntas was temporarily closed six times due to small-to-moderate lahars.

Geologic Summary. 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 3,000 years ago and produced a large debris-avalanche deposit and a horseshoe-shaped caldera open to the W, 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 1999 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 Contact: *Geophysical Institute (IG)*, Escuela Politécnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: http://www.igepn.edu.ec/).

Karangetang [Api Siau]

Sangihe Islands, Indonesia
2.78°N, 125.40°E; summit elev. 1,784 m

The previous *Bulletin* report (*BGVN* 32:05) discussed periodic activity at Karangetang from January 2004 through April 2007. This report updates activity through August 2007. The island (Ulau Siau, or Siau) has a tear-drop-shape, widest at the N end with the tail bent E. The island's maximum E-W extent is about 10 km.

During April through mid August 2007, the Center of Volcanology and Geological Hazard Mitigation (CVGHM) recorded mild activity with periodic tremor activity registering at 0.5-2 mm and "thick-white-ash" periodically being ejected 25-750 m above the Main crater.

On 25 June 2007, an incandescent explosion 750 m high was observed and a lava avalanche traveled 1,000 m down the to Nawitu river and 400 m down the Bahambang river. Some materials descended into the Batuawang Valley.

Beginning 5 August 2007, the CVGHM recorded tremors with amplitude 4 mm in the vicinity of Karangetang. On 8 August, tremor amplitude increased to 23 mm and a lava fountain rose up to 25-75 m above the summit. Additional lava and pyroclastic flows observed on 10 August prompted authorities to evacuate more than 500 people from villages on the flanks.

On 11 August, because observers witnessed increased eruptive activity, and seismicity included tremors increasing to 46 mm in amplitude, the CVGHM raised the alert status from 2 to 3 (on a scale of 1-4). The alert status was again raised on 18 August from 3 to 4 as the CVGHM reported tremor (45-47 mm amplitude), lava emission, and a debris-flow about 2 km down the S flank. "Booming" noises were also heard and thick ashfall covered villages, farms, and trees on the flanks. Based on these advisories the Darwin Volcanic Ash Advisory Center notified aviation interests of the potential for a major eruption.

On 19 August, Karangetang erupted again several times. An avalanche of lava and hot ash poured down the flanks. Avalanches reportedly reached the coastal villages of Karalung (several kilometers SE of the summit) and Hiung (several kilometers NW of the summit). After 19 August eruptive activity decreased and on 30 August the hazard status was dropped to 3.

Thermal anomalies were detected by MODIS beginning 6-8 August with major activity occurring on 10 August and nearly continuous activity from 13 August through 2 September.

Geologic Summary. Karangetang (Api Siau) volcano lies at the northern end of the island of Siau, N of Sulawesi. The 1,784-m-high stratovolcano contains five summit craters along a N-S line. Karangetang is one of Indonesia's most active volcanoes, with more than 40 eruptions recorded since 1675 and many additional small eruptions that were not documented in the historical record (Catalog of Active Volcanoes of the World: Neumann van Padang, 1951). Twentieth-century eruptions have included frequent explosive activity sometimes accompanied by pyroclastic flows and lahars. Lava dome growth has occurred in the summit craters; collapse of lava flow fronts has also produced pyroclastic flows.

Information Contacts: *Center of Volcanology and Geological Hazard Mitigation (CVGHM)*, Saut Simatupang, 57, Bandung 40122, Indonesia (URL: http://portal.vsi.esdm.go.id/joomla/); *Hawai'i Institute of Geophysics and Planetology (HIGP) Hot Spots System*, University of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (URL: http://hotspot.higp.hawaii.edu/); *Darwin Volcanic Ash Advisory Centre (VAAC)*, Bureau of Meteorology, Northern Territory Regional Office, PO Box 40050, Casuarina, Northern Territory 0811, Australia (URL: http://www.bom.gov.au/info/vaac/); Jakarta Post, Indonesia (URL: http://www.thejakartapost.com/).

Manam

NE of New Guinea, Papua New Guinea
4.080°S, 145.037°E; summit elev. 1,807 m

Our previous Manam report (*BGVN* 37:04) discussed activity from August 2006 into May 2007. Throughout May and into September 2007, Manam continued to show activity, but the emissions were mild and the seismicity, ever present, was very subdued. The Main Crater continued to release occasional pale gray ash clouds (table 4).

Thermal anomalies were detected at Manam by the Moderate Resolution Imaging Spectroradiometer (MODIS) on 16 and 23 May 2007. These anomalies were located down the NE Valley.

On 25 May the Rabaul Volcano Observatory (RVO) reported diffuse plumes from Manam. Based on satellite imagery and information from the Darwin VAAC, these plumes rose to an altitude of 3 km and drifted SW and W.

On those occasions in May where incandescence was visible, area residents heard no noises. The Southern Crater continued releasing diffuse white vapor; however, area residents noted the absence of any noise or glow.

Seismicity throughout May and into early June was low-to-moderate. Through 19 June 2007, low-frequency earthquakes occurred, but no noises were heard. On 23 June, based on satellite observations, the Darwin VAAC reported a low-level eruption that emitted a narrow plume of gas and vapor. It extended 40 km WNW and ascended to an altitude of ~ 3.4 km. The presence of ash was not discernable from the satellite data.

During 1-4 and 12 July 2007, the RVO reported that mild eruptions continued to release occasional diffuse white vapor from Main Crater. Occasional pale gray ash clouds emerged during 16-17, 22-23, and 26-27 July 2007. The ash clouds rose to less than a kilometer above the summit before being blown NW, resulting in fine ashfall. Incandescence was occasionally visible during July. The Southern Crater continued to release diffuse white vapor throughout July with an absence of glow or noise.

Throughout August, Manam continued low level activity. Visual observation of the summit was hampered by

Month (2007)	Emissions		Thermal		Seismicity (events)
	Vapor	Ash	Anomalies	Incandescence	
May	25 May (diffuse)	10-16 May (pale gray)	16-23 May	8, 10, 12-13, 29 May	500-1000
Jun	23 Jun	—	—	—	600-1050
Jul	1-4, 12 Jul (white)	16-17, 22-23, 26-27 Jul (pale gray)	—	4, 7, 12-13, 16-20, 23, 26-27 Jul	600-1050
Aug	8-9 Aug (blue); 10 Aug	21 Aug	—	2-3, 21 Aug	800-1000
Sep	—	17 Sep	—	—	—

Table 4. Manam activity mid-May into September; the only data source for 17 September is the Darwin VAAC.

clouds most of the time; however, when clear, both craters were releasing primarily thin white vapor. Blue vapor accompanied the white vapor emission from Main Crater on 8-9 August. Based on satellite image observations and information from the RVO, the Darwin VAAC reported that an eruption plume from Manam rose to an altitude of 3 km a.s.l. on 10 August and drifted W. Seismic activity in August remained low and dominated by low-frequency earthquakes. Manam generally lacked significant activity continuing through the end of August and into September 2007. On 17 September, the Darwin VAAC reported that ash plumes from Manam rose to an altitude of 3.7 km a.s.l.

Geologic Summary. The 10-km-wide island of Manam, lying 13 km off the northern coast of mainland Papua New Guinea, is one of the country's most active volcanoes. Four large radial valleys extend from the unvegetated summit of the conical 1,807-m-high basaltic-andesitic stratovolcano to its lower flanks. These "avalanche valleys," regularly spaced 90 degrees apart, channel lava flows and pyroclastic avalanches that have sometimes reached the coast. Five small satellitic centers are located near the island's shoreline on the northern, southern and western sides. Two summit craters are present; both are active, although most historical eruptions have originated from the southern crater, concentrating eruptive products during the past century into the SE avalanche valley. Frequent historical eruptions have been recorded at Manam since 1616 and it has erupted at least 30 times since. A major eruption in 1919 produced pyroclastic flows that reached the coast, and in 1957-58 pyroclastic flows descended all four radial valleys. Lava flows reached the sea in 1946-47 and 1958.

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