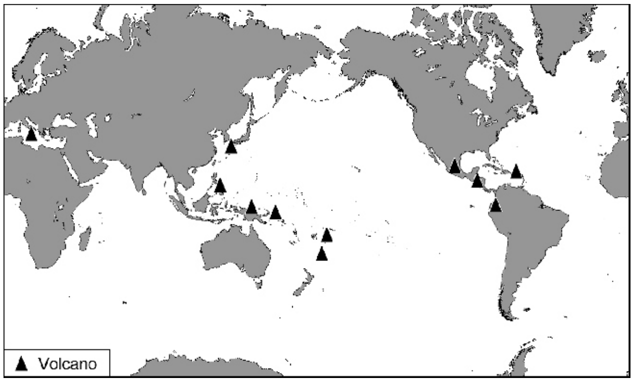
Bulletin of the Global Volcanism Network



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Sakura-jima

Kyushu, Japan
31.585°N, 130.657°E; summit elev. 1,117 m
All times are local (= UTC + 9 hours)

According to the Sakurajima Volcano Research Center (SVRC) at Kyoto University, an eruption started on 4 June 2006 at the Showa crater, a spot that differs from vents active in recent decades at the summit of Minami-dake ("south mountain"; *BGVN* 31:06 and many previous reports). The Showa crater resides on the E slope of Minami-dake at an elevation of ~ 800 m (figures 1, 2, and 3). Showa crater was formed in a 1946 eruption; the 1946 vent was the source of lava flows that spread E and then branched to travel S and ENE (figure 3).

Unfortunately, at press time many details still remained unavailable to *Bulletin* editors regarding the duration and character of the return of venting at Showa crater. It is also unclear to what extent the Minami-dake summit craters continued to participate in the emissions.

The 4 June 2006 eruption continued intermittently, including an evening eruption on 7 June which sent an ash column ~ 1 km above the crater. Figure 4 shows one such eruption on 6 June.

A series of plots describe the short- and long-term seismicity and volume of magma supplied at Sakura-jima (figures 5 and 6). The number of shallow earthquakes had increased since the middle of March 2006 (figures 4 and 5), and small volcanic tremors with a duration shorter than 2 minutes had increased since the middle of May 2006. GPS data showed continued inflation in the N part of the Aira caldera, an observation attributed to incoming magma. Kazuhiro Ishihara, director of SVRC, commented that the present eruption was considered to be related to magma accumulating in the Aira caldera and searching for an exit.

Figure 2. A sketch map focused on the geologic context of Sakura-jima, the Aira caldera, and adjacent calderas. The Kagoshima graben forms the Bay of the same name. The graben also lies coincident with several caldera margins. Sakura-jima resides at the S portion of Aira caldera. Modified slightly from Okuno and others (1998).

Table 1 presents a chronology of ash-plume observations made since the previous *Bulletin* report (*BGVN* 31:06). The table is based primarily on reports from Tokyo Volcanic Ash Advisory Center (VAAC) and covers the interval 7 June 2006 to 20 March 2007. Most of the plumes described did not exceed 3 km altitude. The tallest plume recorded on the table, an ash plume on 20 March 2007, rose to 3.7 km altitude.

Volcanic hazards research. Lee and others (2005) reported the successful remote measurement of significant amounts of ClO (as well as BrO and SO_2) in a volcanic plume from Sakura-jima during May 2004. Near the volcano they also observed halogen-catalyzed, local surface ozone depletion. The investigators employed

Figure 1. Map images showing Sakura-jima stratovolcano and environs on Japan's Kyushu island (~ 1,000 km S of Tokyo). (left) Image from Google Earth showing the S end of Kyushu Island. Population centers are labeled. Sakura-jima forms the dominant topographic feature in Kagoshima Bay. The Osumi Peninsula is to the E; the Satsuma Peninsula to the W. (right) Image from Google Earth showing terrain features looking NW towards the upper portions of Kagoshima Bay. Courtesy of Google Earth.

ground-based, multi-axis, differential optical absorption spectroscopy. Their results help document the presence of a wide range of chemical species that have potential health implications for populations living nearby.

The center of Kagoshima City (population ~ 550,000) sits ~ 10 km from Minami-dake's summit and ~ 4 km from Sakura-jima's E shore (just off figure 2, but along the trend of the arrow labeled ***KC***). According to Durand and others (2001), "Since 1955 the city has been subjected to ashfall from Sakura-jima. Until 1990 ashfalls occurred up to twice per week, although this has decreased in frequency in recent years."

Durand and others (2001) comment that "[Kagoshima City] presents a good opportunity to study the impacts of volcanic ash on key services, or 'lifelines.' In addition, the city provides a chance to see how lifelines have been adapted to counter any problems presented by ashfalls." They also noted that, "The advice from Kagoshima would seem to be that during an ashfall event, people should bring in the washing and shut the doors and windows. People who have to go out and work in ashfall should wear goggles and a face mask. In Kagoshima, umbrellas are the only form of protection for many people going to work during ashfall events."

References: Durand, M.; Gordon, K .; Johnston, D. ; Lorden, R. ; Poirot ,T. ; Scott, J. ; and Shephard, B.; 2001; Impacts of, and responses to ashfall in Kagoshima from Sakurajima Volcano–lessons for New Zealand. Science report 2001/30, Institute of Geological & Nuclear Sciences; Lower Hutt, New Zealand, November 2001 53p. (ISSN 1171-9184, ISBN 0-478-09748-4).

Fukuyama, H. and Ono, K., 1981, Geological Map of Sakura-jima, scale 1:25,000

Kobayashi, Tetsuo, 1988, Geological Map of Sakurajima Volcano, A Guidebook for Sakura-jima Volcano, *in* Kagoshima International Conference on Volcanoes, 1988 (1:50,000).

Lee, C., Kim, Y. J., Tanimoto, H., Bobrowski, N., Platt, U., Mori, T., Yamamoto, K., and Hong, C. S., 2005, High ClO and ozone depletion observed in the plume of Sakurajima volcano, Japan, Geophysical Research Letters, v. 32, L21809, doi:10.1029/2005GL023785.

Okuno, Mitsuru; Nakamura, Toshio, and Kobayashi, Tetsuo, 1998, AMS ^{14}C dating of historic eruptions of the Kirishima, Sakura-jima and Kaimon-dake volcanoes, Southern Kyushu, Japan. Proceedings of the 16th International ^{14}C Conference, edited by W. G. Mook and van der Plicht, RADIOCARBON, Vol. 40, No. 2, 1998, P. 825,832.

Geologic Summary. Sakura-jima, one of Japan's most active volcanoes, is a post-caldera cone of the Aira caldera at the northern half of Kagoshima Bay. Eruption of the voluminous Ito pyroclastic flow accompanied formation of the 17 x 23 km wide Aira caldera about 22,000 years ago. The smaller Wakamiko caldera was formed during the early

Figure 4. A photograph of Sakura-jima erupting at 1231 on 6 June 2006 from Showa crater. Courtesy of SVRC, Disaster Prevention Research Institute, Kyoto University.

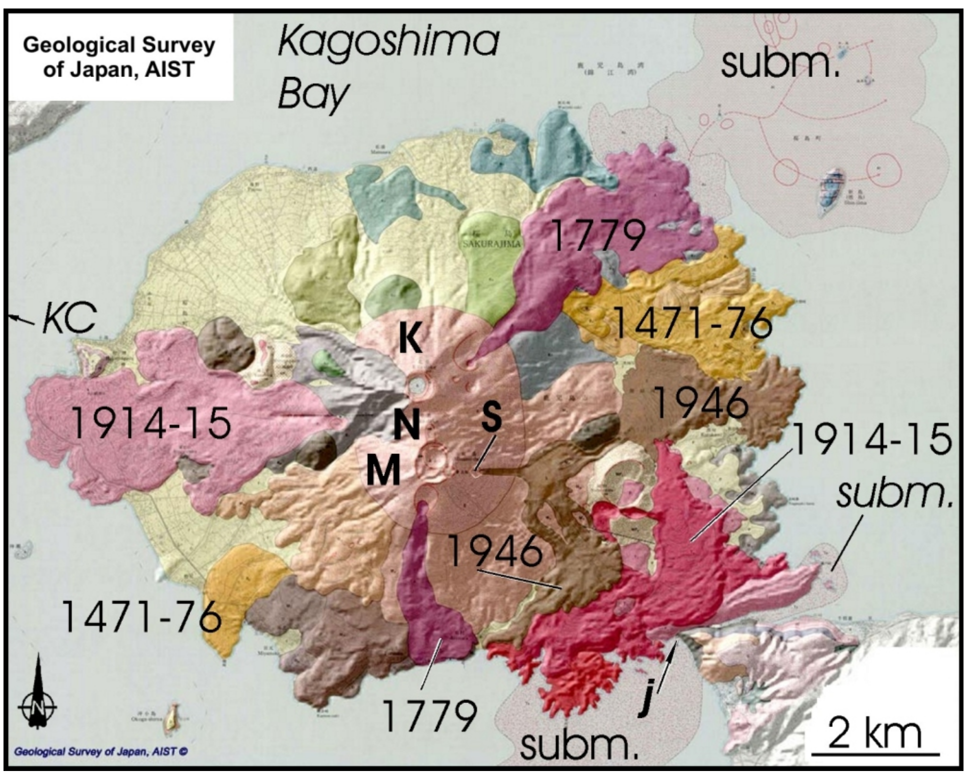

Figure 3. A geological map of Sakura-jima shown with several key features and eruptive dates labeled. Topographic highs from N to S include Kita-dake (**K**), Nika-dake (**N**), and Minami-dake (**M**). Craters at the summit of Minami-dake have been the active in past decades, but the eruption that started on 4 June eruption vented at Showa crater (**S**). An E flank lava flow (the Taisho Lava of 1914-1915) joined what had been an island's SE side to the shore (arrow at lower right labeled "***j***" aims at the zone of contact). Fringing the roughly circular former island are several areas of submarine volcanic and intrusive deposits (labeled here with the abbreviation "subm."). For example, the large area budding NE from the island consists of submarine and intrusive rocks of 1779-1780. Many of the Holocene eruptive deposits are dacites and andesites. They commonly bear pyroxene (and also sometimes, olivine). Besides lava flows, deposits include welded air-fall and pyroclastic-flow deposits (in some cases showing rheomorphosed textures indicative of movement downslope after forming a welded mass). From the Geologic Survey of Japan, AIST website (after Fukuyama and Ono, 1981 and Kobayashi, 1988).

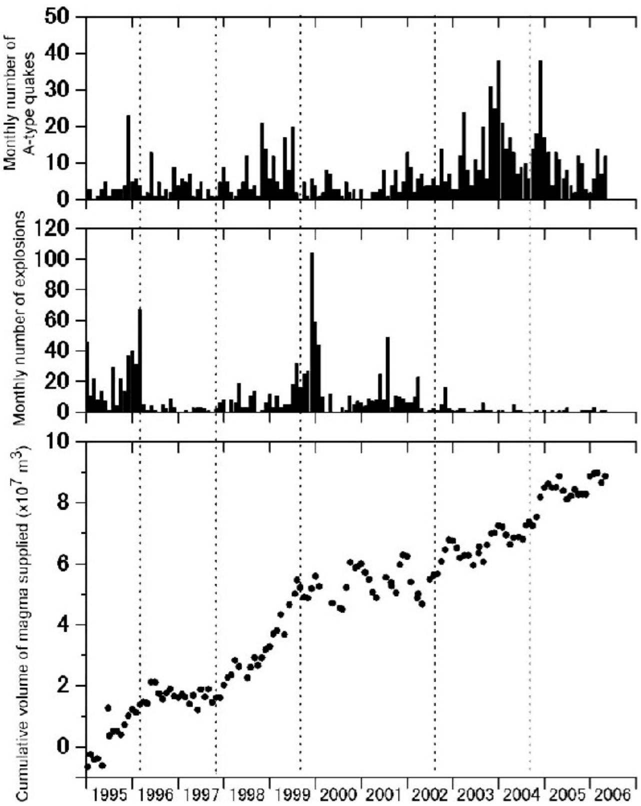

Figure 5. A multi-year (1995 to mid-2006) view of Sakura-jima's activity: (top) monthly A-type earthquakes, (middle) monthly number of explosions (determined geophysically, exact method undisclosed), and (bottom) the cumulative volume of magma supplied. Courtesy of SVRC, Disaster Prevention Research Institute, Kyoto University.

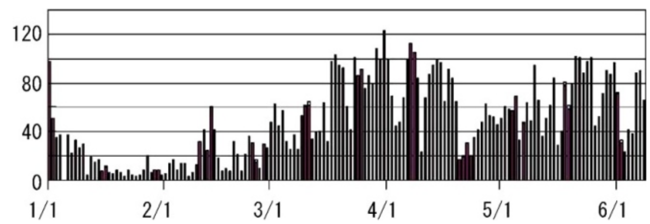

Figure 6. Plot of the daily number of volcanic earthquakes at Sakura-jima for the period 1 January-7 June 2006. Courtesy of SVRC, Disaster Prevention Research Institute, Kyoto University.

Holocene in the NE corner of the Aira caldera, along with several post-caldera cones. The construction of Sakura-jima began about 13,000 years ago on the southern rim of Aira caldera and built an island that was finally joined to the Osumi Peninsula during the major explosive and effusive eruption of 1914. Activity at the Kita-dake summit cone ended about 4,850 years ago, after which eruptions took place at Minami-dake. Frequent historical eruptions, recorded since the 8th century, have deposited ash on Kagoshima, one of Kyushu's largest cities, located across Kagoshima Bay only 8 km from the summit. The largest historical eruption took place during 1471-76.

Information Contacts: *Sakura-jima Volcano Research Center*, Disaster Prevention Research Institute (DPRI), Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan (URL: http://www.dpri.kyoto-u.ac.jp/~kazan/default_e.html); *Tokyo Volcanic Ash Advisory Center (VAAC)*, Japan Meteorological Agency (JMA) (URL: http://ds.data.jma.go.jp/svd/vaac/data/index.html).

Date(s)	Plume altitude (km)/drift	Other observations
07-12 Jun 2006	3.4 km	—
10 Jun 2006	—	SVRC reported increase in low-frequency earthquakes since mid-March and in small tremors with a less than 2-minute duration since mid-May 2006; thermal anomaly at the volcano grew in size after February 2006.
14, 16, 19 Jun 2006	2.1 km	—
02 Aug 2006	2.4 km/SW	explosion
09 Aug 2006	2.4 km/straight up	eruption
22, 23, and 26 Aug 2006	2.4 km/SW	eruptions
03-04 Sep 2006	2.7 km/NW and N	eruptions
06 Sep 2006	—	explosion generated eruption cloud
19 Sep 2006	3 km/straight up	eruption
20, 21 Sep 2006	2.4 km	eruptions
07, 08, and 10 Oct 2006	1.8-2.4 km/W, S, and SW	eruptions
21 Oct 2006	3.4 km/straight up	explosions
25 and 27 Oct 2006	2.1-2.4 km/SW and NE	ash plumes
04-05 Nov 2006	2.1-2.4 km/NE, SE, E	eruptions
22 Nov 2006	2.1 km/W	explosions
26 Nov 2006	unknown	eruption
12 Dec 2006	2.1 km/NE	eruption
13 Dec 2006	—	explosion
02 Jan 2007	3.4 km/SW	eruption
10 Feb 2007	not reported	explosion
13 Feb 2007	2.1 km	explosion
15 Feb 2007	1.5 km	ash plume
20 Mar 2007	3.7 km	ash plume

Table 1. Heights and drift of plumes and their character at Sakurajima from June 2006-March 2007. Some of the data during mid-June 2006 were previously reported, but new information has emerged. Courtesy of SVRC and Tokyo Volcanic Ash Advisory Center.

Bulusan

Luzon, Philippines
12.770°N, 124.05°E; summit elev. 1,565 m

Activity declined at Bulusan in late June 2006 after a series of 10 explosions that began on 19 March 2006 (*BGVN* 31:09). Between 30 August and 1 September steam plumes reached up to 350 m above the summit; the plumes drifted NW and SE. This report summarizes Bulusan's activity from 10 October 2006 through 12 May 2007 (table 2). Hazard maps created by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) illustrate the risks to the large numbers of cummunities in the vicinity of the volcano (figure 7). Review of the available MODIS data indicates no thermal alerts during the year prior to 31 May 2007.

PHIVOLCS reported an explosion from Bulusan on 10 October that produced an ash-and-steam plume that rose to 4.5 km altitude and drifted mainly SE and SSW. Light ashfall (1.5-5.0 mm thick) was reported in neighboring towns downwind. Based on seismic data, the activity lasted for 9 minutes. On 11 and 12 October, steam plumes drifted SW and SSW. Another explosion occurred on 19 October. The following day, steam plumes drifted W and WSW. On 23 October, an explosion produced a brownish ash plume that rose to about 2.6 km and drifted SE and SW. Light ashfall (trace to 0.5 mm thick) from the 19 and 23 Cctober explosions was reported from neighborhoods in the municipality of Irosin, about 7 km S of the summit.

During 25-26 October, PHIVOLCS reported a lahar that deposited sediments 15 cm thick along a tributary leading to the Gulang-gulang River. According to news articles, the lahar mobilized boulders as large as trucks and caused at least 96 people to evacuate. During 30-31 October, ash explosions generated a light gray ash-and-steam plume that rose to 2.3 km and drifted NNE. Later field inspection revealed ashfall (trace to 1 mm) N of the volcano, as well as in the municipalities of Casiguran and Gubat, about 12 km SSE and 18 km NNE, respectively, from the summit. Two explosion-type earthquakes recorded late on 31 October were followed by ashfall in Casiguran, Malapatan, and Irosin.

News articles and wire services reported that Bulusan emitted ash accompanied by rumbling noises and lightning flashes on 20 December. Clouds hindered a view of the summit. Ash deposits up to 4 mm thick were noted in several villages in the foothills. A news report in *News Balita* noted a plume of gas and "white ash" on 22 December.

In January 2007, PHIVOLCS reported that an explosion from the summit on 24 January lasted about 10 minutes, based on seismic interpretation. Observation was inhibited due to cloud cover. Ashfall was reported SW of the volcano.

On 15 March, news media reported that ash fell on Bulusan's SW slopes and nearby villages. A resident volcanologist stated that ashfall was caused by voluminous steaming during 12-15 March, not explosions. Other news articles stated that eruptions on 8 April produced ash plumes that rose to altitudes of 3.1-6.6 km.

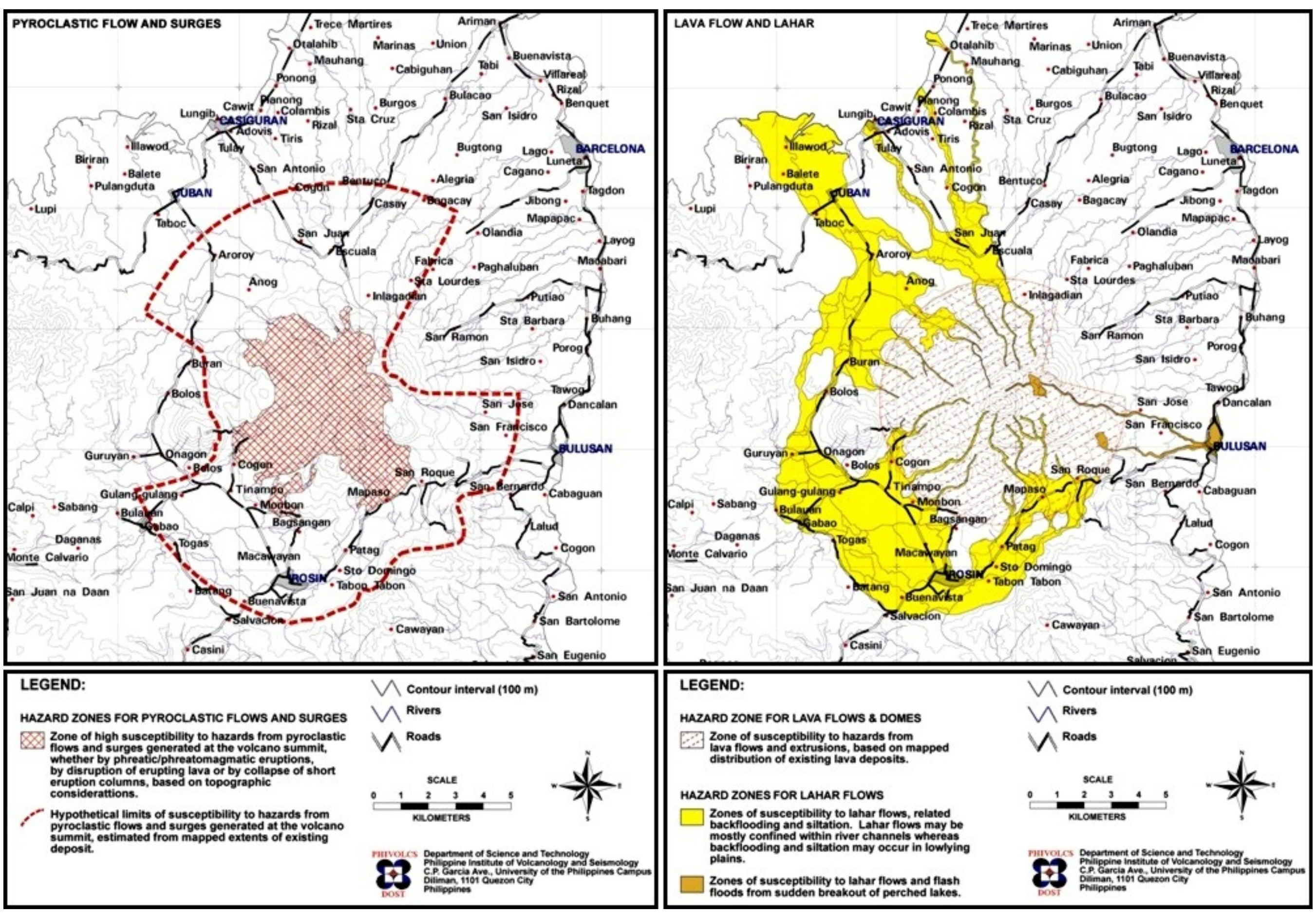

Figure 7. Hazards maps for Bulusan showing susceptibility to pyroclastic flows and surges (left), and lava flows and lahars (right). Courtesy of PHIVOLCS.

PHIVOLCS reported another ash explosion on 12 May 2007 with an eruption column reaching a maximum height of 4 km above the summit before drifting to the WSW and WNW. The activity was accompanied by rumbling sounds and was recorded by the seismic network as an explosion type earthquake that lasted for about 35 minutes. Prior to the explosion, during 9-12 May, an increase in the daily number of volcanic earthquakes was noticed, with 42, 65 and 97 events recorded.

Geologic Summary. Luzon's southernmost volcano, Bulusan, was constructed along the rim of the 11-km-diameter dacitic-to-rhyolitic Irosin caldera, which was formed about 35,000-40,000 years ago. Bulusan lies at the SE end of the Bicol volcanic arc occupying the peninsula of the same name that forms the elongated SE tip of Luzon. A broad, flat moat is located below the topographically prominent SW rim of Irosin caldera; the NE rim is buried by the andesitic Bulusan complex. Bulusan is flanked by several

Date	Column altitude	Drift direction(s)	Areas affected by ashfall or lahars	Remarks
10 Oct 2006	3 km	SSW and SE	Irosin: San Benon, Sto. Domingo, and Patag, Bulusan: Bulusan Proper, San Roque, San Rafael, San Francisco, and Dangkalan.	Accompanied by rumbling sound.
19 Oct 2006	—	—	Irosin: Monbon, Gulang-Gulang, Cogon (traces of ash); Tinampo (0.5 mm thick ash).	Not observed, but recorded as explosion-type earthquake lasting for 2 minutes.
23 Oct 2006	1 km	SE and SW	Irosin: Monbon and Tinampo (0.5 mm thick ash); Gulang-Gulang, and Tinampo (trace).	Accompanied by rumbling sounds.
25-26 Oct 2006	—	—	Irosin: Cogon (sediments 15 cm thick); Lahar (channel-confined muddy stream flow).	—
30 Oct 2006	~ 1 km	N and NW	Light ashfalls (trace to 1.0 mm): Casiguran: Inlagadian, San Juan, Casay, and Escuala; Gubat-Bentuco, Tugawe, Benguet, Rizal, Buenavista, Ariman, Tabi, Bulacao, Naagtan, Panganiban, Carriedo, and Gubat proper.	Series of three explosion explosion-type earthquakes lasting 35 minutes, accompanied by rumbling sounds.
31 Oct 2006	0.7 km	N and NE	Casiguran: Inlagadian.	Small tremor that lasted for ~ 8 minutes.
31 Oct 2006	—	—	Irosin: Patag and Mapaso.	Not observed due to thick cloud cover; recorded as explosion type earthquake.
21-28 Nov 2006	—	—	—	Seismic swarm - total of 170 events in three days; majority of epicenters more than 2 km away from the summit; 16-87 earthquakes daily.
20 Dec 2006	—	—	Irosin: ashfall at Monbon (1.5 mm), Buenavista (1.5 mm), Salvacion (2.5 mm), Casini (4.0 mm), Patag (trace), Santo (Sto.) Dmingo (trace), Tulay (3.0 mm), Poblacion (0.5 mm), and Bulan-Trece and Gate (trace).	Explosion-type earthquake for 20 minutes, accompanied by rumbling sound and lightning flashes.
24 Jan 2007	—	—	Traces of ash in Irosin: Cogon, Monbon, San Benon, Gulang-Gulang (including Sito Omagom) and Tinampo.	Explosion-type earthquake for 10 minutes.
26 Jan 2007	1.0 km	SW	Irosin: Barangay Monbon.	Explosion-type earthquake lasting for 10 minutes.
Feb-Mar 2007	—	—	Areas SW of the volcano.	Dirty white moderate to voluminous steam emission, no seismic record of ash explosion.
07 Apr 2007	—	—	—	Increase in number of volcanic earthquakes; total of 68 events for two days.
08 Apr 2007	4.0	SW	Irosin: Mombon, Tinampo, Cogon, Gulang-Gulang (including Sitio Omagom), Bolos, and Sangkayon; Juban: Bura-buran and Bacolod; Magallanes: Siuton; Bulan: Cadandanan, Busay, Palale, San Francisco, and Sumagongsong.	Explosion-type earthquake for 27 minutes.
09 Apr 2007	—	—	—	Not seen, but recorded as explosion-type earthquake lasting for 20 minutes, accompanied by rumbling sounds.
09 Apr 2007	—	—	—	Not observed, but recorded as explosion-type earthquake for 20 minutes.
17 Apr 2007	—	—	—	Increase in number of volcanic earthquakes; total of 35 events for 24 hours.
12 May 2007	4.0	WSW, WNW	Trace to 2 mm of ashfall. Irosin: Cogon, Gulang-Gulang, Tinampo, Bolos of Irosin. Juban: Bura-buran, Sangkayon, Bacolod, Puting Sapa, Aniog, and Sitio Cawayan (Bgy. Guruyan).	Event accompanied by rumbling sounds; recorded as explosion-type earthquake lasting for 35 minutes; elevated numbers of volcanic earthquakes.

Table 2. An overview of Bulusan's activity, as noted by PHIVOLCS during 10 October 2006 through 12 May 2007. Courtesy of PHIVOLCS.

other large intracaldera lava domes and cones, including the prominent Mount Jormajan lava dome on the SW flank and Sharp Peak to the NE. The summit of 1,565-m-high Bulusan volcano is unvegetated and contains a 300-m-wide, 50-m-deep crater. Three small craters are located on the SE flank. Many moderate explosive eruptions have been recorded at Bulusan since the mid-19th century.

Information Contacts: *Philippine Institute of Volcanology and Seismology (PHIVOLCS)*, University of the Philippines Campus, Diliman, Quezon City, Philippines (URL: http://www.phivolcs.dost.gov.ph); *Tokyo Volcanic Ash Advisory Center*, Tokyo, Japan (URL: http://www.jma.go.jp/jma/jma-eng/jma-center/vaac/index/html); *Inquirer.net*, Philippines (URL: http://www.inquirer.net/); *Associated Press* (http://www.ap.org/); *News Balita*, Philippines (http://news.balita.ph/).

Manam

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

Eruptive activity at Manam has generally been low following a significant explosion in late February 2006 (*BGVN* 31:02). Between March and July 2006 the Rabaul Volcano Observatory (RVO) reported intermittent, milder, ash explosions (*BGVN* 31:06). Similar variable activity has continued into early May 2007, with plumes frequently identified on satellite imagery by the Darwin Volcanic Ash Advisory Centre (VAAC).

RVO received a report that four people were swept away by a mudflow in the early hours of 13 March following heavy rainfall on the northern part of the island. A 5th person was reportedly critically wounded and in a hospital.

Activity during August-December 2006. On 4 and 5 August, an ash plume was visible on satellite imagery extending 30 km NW. Ash plumes were emitted again during 14-15August. Over the next couple of days, the emissions became more diffuse and weak incandescence was observed at night. Based on pilot reports and satellite imagery, continuous emissions during 17-21 August eached altitudes of 3.7 km and drifted NW. Eruptive activity from Main Crater during 22-23 August consisted mainly of dark brown-to-gray ash plumes that rose 1-2 km above the summit and drifted W and NW. The Darwin VAAC reported that eruption plumes were visible on satellite imagery on 23 and 26 August, extending NW. Southern Crater continued to release only diffuse white vapor.

From the end of August to 5 September 2006, the Darwin VAAC reported that ash-and-steam plumes reached altitudes of 4.6 km and drifted W. Steam plumes with possible ash were visible on imagery below 3 km and drifted NE. RVO reported mild eruptive activity during 15-17 October that consisted of steam and ash plumes. White vapor plumes were visible from Southern Crater and intermittently from Main Crater. Main Crater produced gray ash plumes on 19 October. Weak incandescence was seen during 15-17 and 29 October.

During 1-13 November, white vapor plumes rose from Southern and Main craters. Incandescence was noted from both craters during 8-10 November and from Main Crater on 12 November. On 13 November a diffuse plume seen on satellite imagery drifted W. Steady incandescence was again observed from Main Crater during 8-10 December and bluish white vapor emissions during 6-9 December changed to a darker gray on 10 December. Weak glow continued from Main Crater during 14-18 December and a white vapor plume rose just above 2 km altitude. Based on satellite imagery, diffuse plumes drifted mainly W during 13-15 December. The daily number of volcanic earthquakes fluctuated between 700 and 1,000.

Activity during January-May 2007. RVO reported that mild eruptive activity and emissions of white vapor plumes from Main Crater were observed during 1-14 January. Brown-to-gray ash plumes accompanied emissions on 6 and 9-11 January; and nighttime incandescence was observed intermittently. White vapor clouds were occasionally released from Southern Crater. Seismic activity was at low to moderate levels; the daily number of low-frequency earthquakes fluctuated between 500 and 1,000.

Satellite imagery showed diffuse plumes drifting WSW on 15 February. Southern Crater emitted gray ash plumes during 15-19 February and white vapor plumes on 21 February. Continuous gray ash plumes from Main Crater rose to an altitude of 2.3 km and drifted SE during 19-21 February. The daily number of low-frequency earthquakes fluctuated between 400 and 500 during 22-24 February before the seismograph developed technical problems.

Mild eruptive activity continued during 22 February-10 March. Main Crater forcefully released variable gray ash clouds on 22 February that rose less than 1 km above the summit before being blown SE. Incandescence was also visible that day. Poor weather prevented observations for the remainder of the month. When the clouds cleared on 3 March, Main Crater was seen sending ash clouds less than 500 m high. Glow was visible during 2-5 and 9-10 March. Southern Crater released occasional diffuse gray ash clouds on 3-4 and 6 March, but only white vapor on 5 and 7-11 March.

Main Crater continued to release occasional low-level ash clouds through 6 April. Incandescence was visible during clear weather on the nights of 11-12 and 16-18 March. Southern Crater released diffuse white vapor on 11-12 and 15 March; however, diffuse ash clouds were reported on 16-20 March. Weak roaring noises were heard on 24 March, and on 7, 12, and 26 April. Low-level plumes were seen during 25-26 April, and a small plume was blowing W on 28 April. Weak incandescence was again visible from Main Crater on 2 and 4 May. Diffuse plumes were seen in satellite imagery on 6 and 23 May. Seismic activity was at a low level, with the daily number of volcanic earthquakes between 800 and 1,000 events.

Thermal satellite data. Thermal anomalies were not detected by Moderate Resolution Imaging Spectroradiometers (MODIS) for 9 months after events related to the 27-28 February 2006 explosion. Anomalies reappeared in December, with hot pixels detected on 5, 7, 9, 10, 12, and 14 December 2006. Another anomaly was recorded on 19 April 2007. Additional thermal anomalies were present on 16 and 23 May 2007. Most of the pixels were located near the summit, or slightly towards the NE. The May anomalies were the furthest down the NE Valley.

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.

Information Contacts: *Herman Patia* and *Steve Saunders*, Rabaul Volcano Observatory (RVO), P.O. Box 386, Rabaul, Papua New Guinea; *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/); *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/); *NASA Earth Observatory* (URL: http://earthobservatory.nasa.gov/).

Sulu Range

New Britain, Papua New Guinea
5.50°S, 150.942°E; summit elev. 610 m

New and revised information has emerged regarding the behavior of the Sulu Range (Johnson, 1971), a volcanic field adjacent to and immediately E of Walo hot springs along the coast in the N-central part of New Britain Island (*BGVN* 31:07 and 31:09; figure 8). Initial Rabaul Volcanological Observatory (RVO) reports mentioned apparent steam and ash emission during mid-July 2006, but although weak-to-moderate vapor emission occured, and a later section of this report discusses heightened hot spring activity, the reported "forceful dark emissions" have been instead linked to dust during mass wasting.

In a 12 April Email message, Steve Saunders clarified the latest RVO views on Sulu's behavior. He noted that ". . . Sulu did **not** erupt! It was purely a series of seismic cris[es]. The 'emissions' which were reported before we got there turned out to be dust from landslides."

Unusually vigorous hot springs, declining seismicity. Following the first two weeks of unrest during mid-July at Sulu Range, an RVO report discussing 31 July to 2 August activity stated that area hot springs such as those at Walo were undergoing unusually strong activity. This included expelled mud, the emergence of geysers, and abnormal quantities of steam.

RVO noted waning seismicity in late July. Seismicity had declined to relatively low levels, although small volcano-tectonic events continued to be recorded. The small earthquakes were centered around the settlements of Silanga, Sege, and Sale (figure 9; respectively, from Mt. Ruckenberg's summit, located 12.7 km to the SW; 7.2 km SW, and 5.5 km S). The 31 July to 2 August earthquakes were described as more irregular and less frequent than those in preceeding weeks.

The pattern of located earthquakes defined an irregular ellipse, with major axis 9 km E-W. Two earthquakes represented a 1-2 km extension N from the ellipse under Bangula Bay. There were also two earthquakes offshore about 4-5 km due N of Cape Reilnitz, a broad promontory the most extreme point of which lies 18 km to the W of Mt. Ruckenberg's summit. As of the end of July an area devoid of earthquakes remained; it was 2-3 km in diameter and centered on Walo village.

The RVO estimated that the top of the underlying magma body was 10-15 km deep when volcano-tectonic earthquakes began on 6 July 2006. They judged that volatiles or heat escaping from the magma were responsible for onset of the mud and water ejections at the once quiet hot springs.

Postulated intrusion. Randy White (US Geological Survey) analyzed the July seismic crisis, which in his interpretation did not follow the pattern of a tectonic earthquake with a main shock and associated aftershocks, but did follow behavior of many earthquakes accompanying the onset of volcanic unrest. He attributed the seismicity to a dike intruded to shallow depth (and confined to the subsurface). According to White, the epicenters well outboard of, but surrounding the area of intrusion, occurred in a pattern similar to those accompanying many shallow intrusions.

The elevated seismicity began after a volcano-tectonic earthquake, M ~ 6 on 19 July (*BGVN* 31:07). It was located on the N side of New Britain, slightly offshore, and a few ten's of kilometers from the Sulu Range. The focal depth was thought to be in the 10-20 km range. White noted that

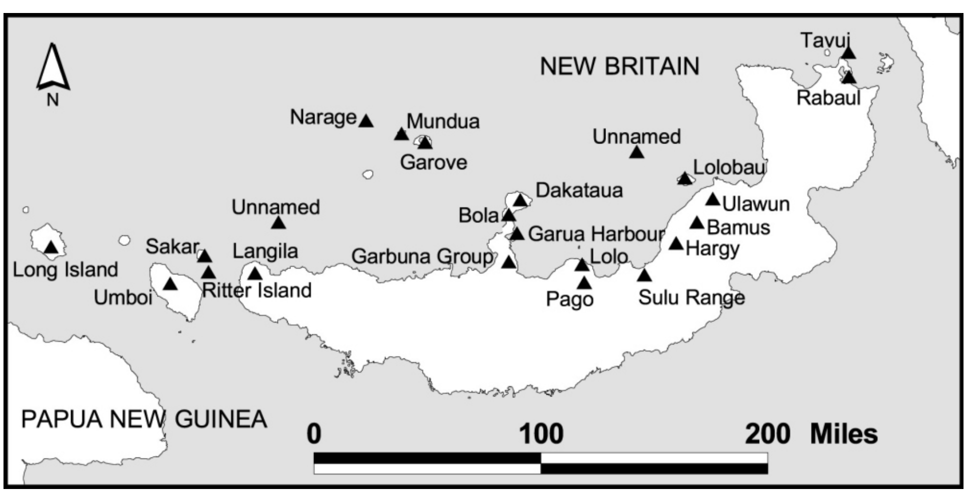

Figure 8. A sketch map of New Britain island showing a small portion of the main island of Papua New Guinea (lower left) and New Ireland (upper right). Volcanoes on or adjacent New Britain are labeled. Volcanoes active and erupting frequently in the last decade include (from the SW) Langila, Ulawun, and Rabaul. Volcanoes that have erupted or undergone anomalous unrest in the past few years include (from the SW) Ritter Island, the Garbuna group, Pago, Sulu Range, and Bamus.

soon after the 19 July earthquake, Australia provided portable seismometers. Once those arrived and began recording data, computed moment tensors indicated that subsequent earthquakes were very shallow. Epicenters occurred slightly W of the Sulu Range.

Short level-lines installed by RVO in August 2006 showed, by November, ~ 2 cm of deflation of the Kaiamu area in relation to a datum ~ 1 km E on the Kaiamu-Sulu track. By April 2006 the measured levels had returned to approximately the August datum line.

To the W of the area at Lasibu a similar pattern existed, with over 2.5 cm of deflation locally measured by November and an approximate return to the datum-line by April 2006. The center of the area delimited by seismicity is swamp and difficult to access. Google satellite images show an interesting series of raised shorelines W of Kaiamu.

Upon prompting from White, Chuck Wicks acquired satellite radar (L-band imagery) from Japanese collaborators for the Sulu Range. The radar data were taken weeks before and weeks after the July seismicity. When processed to obtain radar interferometry, the data indicated over 80 cm of vertical surface deformation. The deformation was centered in a region W of the Sulu Range along an area along the coast ~ 5 km W of Lava Point (Lara Point on some maps). It trends ENE. The data were interpreted as a shallow dike intrusion on the order of ~ 8 m wide trending out beneath Bangula Bay.

Wick's preliminary analysis suggests the intrusion's volume may be on the order of one cubic kilometer. White's qualitative estimate of the volume, from the intensity, style, and duration of the seismicity, were consistent with that analysis. In addition, the strike-slip focal mechanisms seen in the seismic data suggested the dike-intrusion episode caused movement along a nearby strike-slip fault.

Geological investigations conducted in the past several months by Herman Patia and Chris McKee indicated that Sulu Range has been quite active 'recently.' The latest eruptive phase at Kaiamu maar was radiocarbon-dated at 1,300 BP. Since that time at least seven eruptions have taken place at other vents, notably Voko, involving phreatomagmatic eruptions. Ruckenberg (Karai) appears to be the source of the most recent activity. Within the last 200 years it produced lava flows.

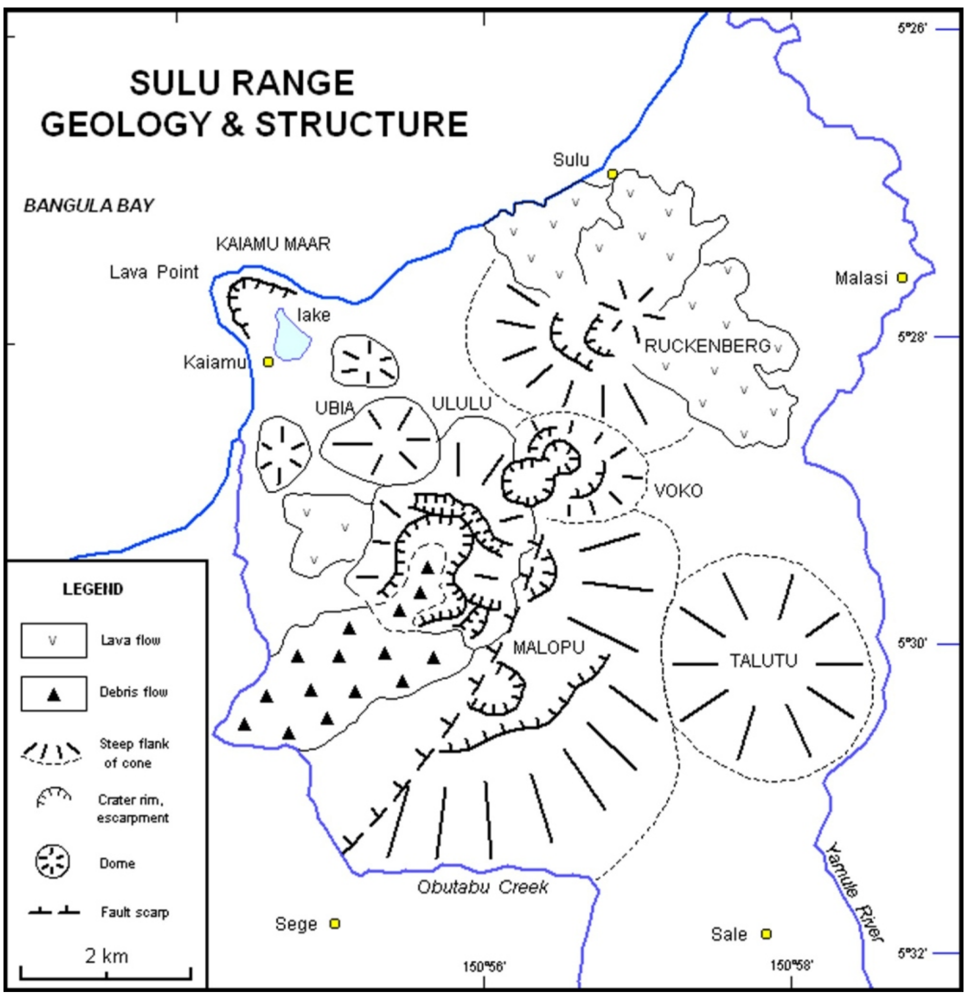

Figure 9. Geological map showing the cluster of overlapping cones of the Sulu Range. Walo village lies just off the map near the coast within a few kilometers of the map 's W margin. The thermal area by the same name lies ~ 5 km SW of Lava Point. The prominent cone on the N edge of the Range is called Mount Ruckenberg or Mount Karai. The initial "vent location" was 2 km SW of Mount Karai between Ubia and Ululu volcanoes. Part of that area is crossed by two parallel, closely spaced faults. The narrow zone between those faults was down-thrown. A SW-directed debris flow was also mapped near this area. Three centers in the N, Ruckenberg (Karai), Kaiamu maar, and Voku, are specifically mentioned in the text as areas with recently documented Holocene activity. Modified from a map by Chris McKee, RVO.

Reference: Johnson, RW., 1971, Bamus volcano, Lake Hargay area, and Sulu Range, New Britain: Volcanic geology and petrology: Australia Department of National Development, Bureau of Mineral Resources, Geology and Geophysics, Record 1971/55.

Geologic Summary. The Sulu Range consists of a cluster of partially overlapping small stratovolcanoes and lava domes in N-central New Britain off Bangula Bay. The 610-m Mount Malopu at the southern end forms the high point of the basaltic-to-rhyolitic complex. Kaiamu maar forms a peninsula with a small lake extending about 1 km into Bangula Bay at the NW side of the Sulu Range. The Walo hydrothermal area, consisting of solfataras and mud pots, lies on the coastal plain W of the SW base of the Sulu Range. No historical eruptions are known from the Sulu Range, although some of the cones display a relatively undissected morphology. At least eight eruptions have occurred during the past 1,300 years, and the most recent eruption produced lava flows from Mount Ruckenberg (Karai) within the past 200 years.

Information Contacts: *Steve Saunders*, *Herman Patia*, and *Chris McKee*, Rabaul Volcanological Observatory (RVO), Department of Mining, Private Mail Bag, Port Moresby

Post Office, National Capitol District, Papua New Guinea (Email: hguria@global.net.pg); *USGS Earthquakes Hazard Program* (URL: http://earthquakes.usgs.gov/); *Randy White* and *Chuck Wicks*, US Geological Survey, 345 Middlefield Rd., MS 977, Menlo Park, CA 94025, USA; *United Nations Office for the Coordination of Humanitarian Affairs* (URL: http://www.reliefweb.int/).

Bagana

Bougainville Island, SW Pacific
6.140°S, 155.195°E; summit elev. 1,750 m
All times are local (= UTC + 11 hours)

Brief periods of effusive activity took place during January to mid-April 2006 (*BGVN* 31:05), with ash-and-steam emissions reported as late as 18 June 2006. Activity has continued since that time through early June 2007, with evidence coming from either MODIS thermal satellite data, observations of glow, or plume observations from the ground or satellites (figure 10). It appears that there were three episodes of increased plume generation, two periods of frequent glow observations, and almost daily MODIS anomalies over that one-year time frame.

The Rabaul Volcano Observatory (RVO) noted that between 18 September and 4 December 2006 only white vapor was released; some of these emissions were forceful. Jet engine-like roaring noises were heard on 11 and 20 November. Variable glow was visible on 25-26 September, 15, 20, and 29 October, 15-21 November, and 4 December. The lava flow on the S flank was active only on 15 October.

There were no aviation warnings after June until a diffuse plume became visible on satellite imagery on 22 November. Based on satellite imagery, the Darwin Volcanic Ash Advisory Centre (VAAC) reported subsequent plumes on 5 December (ash), 21-22 December (ash-and steam), and 9 January 2007.

RVO reported that white vapor emissions from the summit crater continued during 10 January-21 May 2007. Emissions were occasionally forceful and were accompanied by ash clouds on 3 and 17 March, as well as 1 and 3-5 April. Summit incandescence was visible on 7, 8, 20, and 24 March, and 17 May. Based on satellite imagery, the Darwin VAAC reported diffuse plumes to altitudes of 2.4 and 3 km on 10 March and 20 May, respectively. Forceful, white emissions on 21 May produced plumes that rose to an altitude of 2.3 km and drifted W. Diffuse ash-and-steam plumes were seen in satellite images again on 22 and 28 May, rising to altitudes of 3.7 and 3 km, respectively.

Moderate Resolution Imaging Spectroradiometers (MODIS) satellite thermal anomaly data reported by the Hawai'i Institute of Geophysics and Planetology (HIGP) revealed frequent thermal anomalies during 20 June-24 July 2006, 16 August-3 October 2006, 9 November 2006-23 January 2007, and 13 February-2 June 2007.

Geologic Summary. Bagana volcano, occupying a remote portion of central Bougainville Island, is one of Melanesia's youngest and most active volcanoes. Bagana is a massive symmetrical, roughly 1750-m-high lava cone largely constructed by an accumulation of viscous andesitic lava flows. The entire lava cone could have been constructed in about 300 years at its present rate of lava production. Eruptive activity at Bagana is frequent and is characterized by non-explosive effusion of viscous lava that maintains a small lava dome in the summit crater, although explosive activity occasionally producing pyroclastic flows also occurs. Lava flows form dramatic, freshly preserved tongue-shaped lobes up to 50-m-thick with prominent levees that descend the volcano's flanks on all sides.

Information Contacts: *Herman Patia*, Rabaul Volcano Observatory (RVO), P.O. Box 386, Rabaul, Papua New Guinea; *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/); *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/).

Raoul Island

Kermadec Islands, New Zealand
29.27°S, 177.92°W; summit elev. 516 m
All times are local (= UTC +12 hours)

This report discusses evidence for the end of the March 2006 eruption, and press releases announcing newly acquired multibeam bathymetry that disclosed submarine calderas on the flanks of Raoul Island and some adjacent volcanoes.

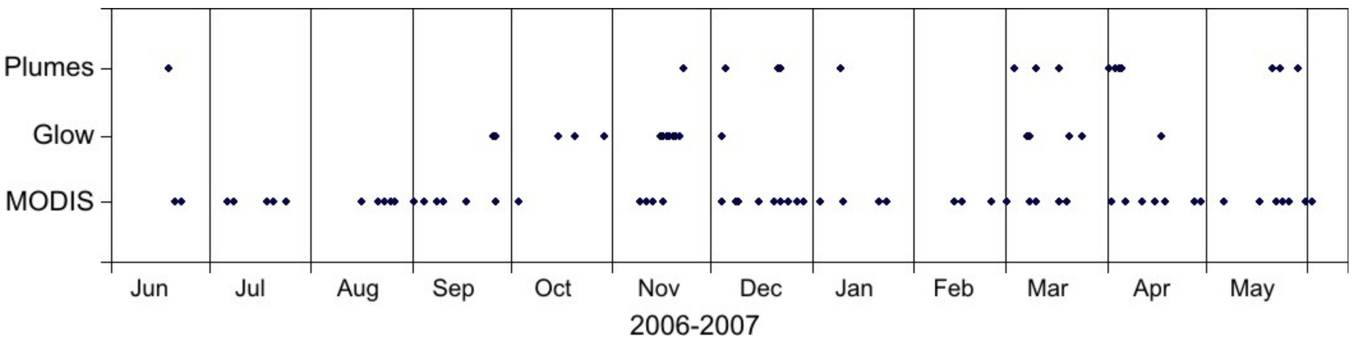

Figure 10. Summary of daily activity at Bagana, 18 June 2006-5 June 2007. Plumes are all varieties (steam or ash) reported by RVO or Darwin VAAC; glow as reported by RVO; MODIS data indicates days with at least one thermal pixel detected. Compiled from MODIS/HIGP data, Darwin VAAC reports, and RVO reports.

End of the March 2006 eruption. After the 17 March 2006 eruption (*BGVN* 31:03), volcanic activity decreased significantly. On 18 September 2006 the Alert Level was lowered to 0.

GeoNet Science (GNS) summarized the decreased activity in their *Volcano Alert Bulletin* of 18 September 2006. The report noted an absence of significant earthquakes within ~ 30 km of Raoul Island. The water level in Green Lake had continued to drop and was close to the pre-eruption level by 18 September. On 27 August the lake temperature was 20.3°C, well within the seasonal range. The level of ongoing hydrothermal activity (upwelling in Green Lake, nearby hot pools, and steaming ground) was commensurate with that expected six months after an eruption like that seen in March. Chemical analyses of samples recently collected from some of the thermal features were typical of volcano-hydrothermal features in this environment.

GNS reported that the water level in Green Lake, which had risen significantly during the week after the March 2006 eruption and had drowned several new steam vents, still remained above pre-eruption levels as of July 2006, but thereafter dropped slowly. Upwelling and bubbling of springs indicated the volcanic-hydrothermal system was still weakly active 3 months after the eruption. The water temperature, obtained from a thermal infrared satellite image taken on 11 April 2006, was 39.2 ºC, was 7 ºC above the average water temperature in April, but had returned to seasonal temperatures by August 2006.

Only 1 to 5 earthquakes were recorded per day in the months following the eruption. The number of earthquakes 30-40 km offshore was slightly higher than normal.

New submarine volcanoes discovered. Marine geologists who had investigated two volcanoes in the Kermadec Arc during May 2007, discovered two new submarine volcanoes near Raoul Island. The geologists were on a scientific expedition mounted by New Zealand's National Institute of Water & Atmospheric Research (NIWA) and the University of Auckland aboard NIWA's deepwater research vessel *Tangaroa*. They investigated volcanoes on the two largest Kermadec Islands (Raoul and Macauley) and their submerged flanks.

A 22 May 2007 press release by NIWA reported that new seafloor observations revealed for the first time the presence of two submerged calderas. Both calderas were relatively small, ~ 4 km in diameter. One caldera was very deep, measuring ~ 1 km from the rim to the crater floor. Both volcanoes appeared geologically young, on the order of thousands of years old, but laboratory analysis of sediments will be needed to better quantify their age.

The expedition took sediment samples and mapped the contours of the volcanoes both above and below sea level (the latter using multibeam sonar). A series of sediment cores taken from E and W of both islands revealed at least six eruptions from the two islands, recorded as centimeter-thick layers up to 100 km from the islands.

Geologic Summary. Anvil-shaped Raoul Island is the largest and northernmost of the Kermadec Islands. During the past several thousand years volcanism has been dominated by dacitic explosive eruptions. Two Holocene calderas are found at Raoul. The older caldera cuts the center of Raoul Island and is about 2.5 x 3.5 km wide. Denham caldera, formed during a major dacitic explosive eruption about 2,200 years ago, truncated the western side of the island and is 6.5 x 4 km wide. Its long axis is parallel to the tectonic fabric of the Havre Trough that lies west of the volcanic arc. Historical eruptions at Raoul during the 19th and 20th centuries have sometimes occurred simultaneously from both calderas, and have consisted of small-to-moderate phreatic eruptions, some of which formed ephemeral islands in Denham caldera. A 240-m-high unnamed submarine cone, one of several located along a fissure on the lower NNE flank of Raoul volcano, has also erupted during historical time, and satellitic vents at Raoul are concentrated along two parallel NNE-trending lineaments.

Information Contacts: *Steve Sherburn*, GeoNet Science (GNS), Wairakei Research Centre, Private Bag 2000, Taupo, New Zealand; *Ian Wright*, Ocean Geology group, National Institute of Water & Atmospheric Research (NIWA), PO Box 14901, Wellington, New Zealand (URL: http://www.niwascience.co.nz); *Roger Matthews*, North Shore City Council, 1 The Strand, Takapuna Private Bag 93500, Takapuna, North Shore City, New Zealand (URL: http://www.northshorecity.govt.nz/).

Home Reef

Tonga Islands, SW Pacific
18.992°S, 174.775°W; summit elev. -2 m

The new island at Home Reef that was constructed by the 8-11 August 2006 felsic shallow marine explosive eruption (*BGVN* 31:09) was visited on 18 February 2007 by Scott Bryan (Kingston University, United Kingdom), Alex Cook (Queensland Museum, Australia), and Peter Colls (University of Queensland, Australia). The initial aim of field research was to map and describe the volcanic geology of the new island at Home Reef and to collect samples for comparison to floating pumice generated by the eruption (Bryan, 2007).

Island observations. Satellite imagery on 4 October 2006 showed an 800-m-long elongate island (0.23-0.26 km^2), which was being rapidly modified by wave erosion (*BGVN* 31:10). An overflight by the RNZAF on 7 December 2006 revealed a roughly circular island, 450 m in diameter and up to 75 m above the water line (*BGVN* 31:12). Upon arrival on 18 February 2007, the scientists found that only a small (50-75 m diameter) <5 m high low-relief wave-reworked "pumice mound" remained at the southern windward end of the Home Reef shoal (figure 11). Due to strong winds and large swells, landing on the tidally-exposed mound was not possible and it could only be viewed from a couple of hundred meters offshore. The location of the mound (18.993°S 174.758°W) is close to that reported for the circular island observed on 7 December 2006. Swells 2-m high or greater were strongly impacting the mound, with the largest waves almost completely engulfing and sweeping over the mound at half-tide.

The morphology of the island suggests that no primary subaerial island-building deposits remain from the eruption and that complete reworking has occurred of the previously observed cone. On the southern side of the pumice mound were scattered large (>1 m diameter), outsized blocks (10-20 in number) on the mound surface (figure 11) that were largely immobile in the waves. Slopes of the mound reflected wave run-up and the pumiceous material comprising the mound appeared to be relatively coarse and well-sorted. There was little entrained particulate material in the water column downwind and downcurrent, but considerable amounts of material within the surf zone surrounding the island, coloring the water brown. A considerable area of discolored water (green, translucent milky) extended N of the mound for more than 500 m. Several smaller lobes or plumes extended off the W side of the main body of discoloration.

A strong sulfurous odor was detected downwind (NW) of the mound, indicating that magma was continuing to cool and degas at shallow levels in the seamount seven months after the eruption; no surface plume was visible. Surface water temperature measurements did not detect any thermal anomalies, recording ambient water temperatures (28-29°C).

Local pumice sightings. Downwind and downcurrent of the mound were small scattered pumice stringers forming orange-brown slicks a few meters to tens of meters long, characterized by low pumice clast abundance and size (usually 0.5-1 cm diameter). The pumice fragments were generally moderate to high sphericity grains, but some more platy pumice fragments were also sampled. Some clasts had orange to brown surface stains, reflecting hydrothermal alteration since the eruption. Most grains showed some signs of abrasion. Orange-brown algal clumps or coagulates floating on the ocean surface were associated with the stringers.

Small pumice rafts were also encountered around some of the islands at the SW end of the Vava'u Group during the week of 17-24 February (figure 12). The pumice rafts had lateral extents of tens of meters, but other flotsam (leaf, twig, sea grass and plastics) was also present. Pumice clast sizes ranged from ~ 2 mm up to 6 cm, and some of the gray pumice possessed orange-brown surface hydrothermal staining. Some rafts had abundant attached fauna, dominated bygoose barnacles (*Lepas* sp.) ~ 2-7 mm long. Much of these pumice rafts reflected remobilization of previously stranded material from neighboring beaches, and many SE-facing beaches had been stripped of pumice by strong SE trade winds.

Many beaches had several pumice strandline deposits, the lowermost of which reflected tidal sorting. Dominantly lapilli-sized gray pumice formed the deposits, whereas a black glassy, moderately vesicular pumice of higher density was a notable feature of the highest strandlines. There were also abundant pumice clasts with an orange-brown staining on clast surfaces.

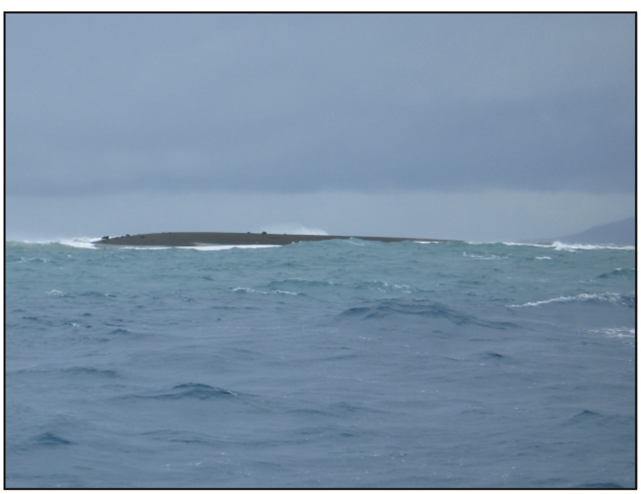

Figure 11. View to the NW of the wave-reworked pumice mound at Home Reef, as seen on 18 February 2007. The diameter of the mound is ~ 75 m. Note the scattered large blocks on the upper surface of the mound. Late Island is in the background at right. Courtesy of Scott Bryan.

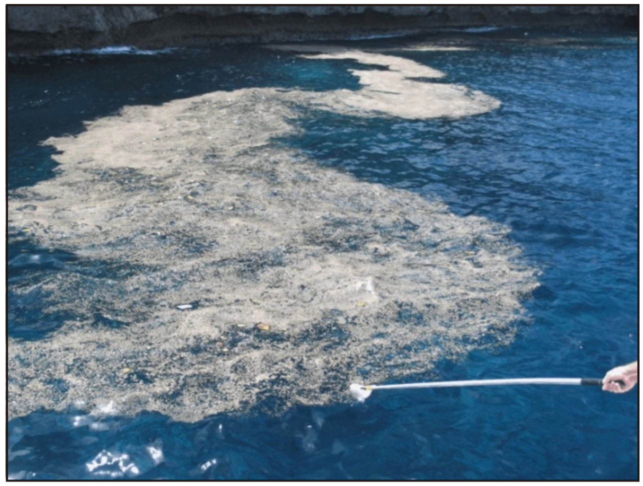

Figure 12. Pumice slick from Home Reef found on the W side of Nuatapu Island, 21 February 2007. Note other flotsam (leaves, plastic) within the slick. Courtesy of Scott Bryan.

Floating pumice reaches Australia. Pumice rafts and beach strandings were reported previously as the pumice drifted westward past the Lau and Fiji islands and on to Vanuatu in November 2006. A major influx of pumice reached the E coast of northeastern Australia during March and April 2007, seven to eight months after the eruption. Pumice was first noticed passing the offshore islands of Willis Island (16.30°S, 149.98°E) in early February, and Lizard Island (14.66°S 145.47°E) the last week of February. Pumice strandings along the eastern Australian coast began in March in northern Queensland, with a substantial stranding occurring in mid-April corresponding to a change to easterly and northeasterly onshore wind conditions and king tides. This stranding event extended for more than 1,300 km along the Queensland and northern New South Wales coast.

Most stranded pumice clasts ranged in size from 1-4 cm diameter, with the largest clasts up to 17 cm diameter. Pumice clasts were fouled by a variety of organisms, primarily goose barnacles (*Lepas* sp.) up to 2.7 cm long, molluscs, bryozoa, and dark green algae (figure 13), with serpulids, oysters and other species of algae (e.g., Halimeda) less abundant. A substantial proportion of stranded pumice material remains on beaches inshore from the Great Barrier Reef. However, little stranded material has remained on exposed beaches south of 25°S, to the extent that some beaches still have more pumice preserved from the 2001 eruption of an unnamed Tongan seamount about 85 km NW of Home Reef.

Seismicity. Although no seismicity has been reported that was detected during the eruption, Robert Dziak identified seismic signals from Home Reef in March 2006. The East Pacific hydrophone array maintained by NOAA recorded 52 earthquakes over a 12-hour period beginning at 1700 UTC on 12 March 2006. The arrivals were all very clear and had medium to low T-wave amplitudes.

Reference: Bryan, S.E., 2007, Preliminary Report: Field investigation of Home Reef volcano and Unnamed

Figure 13. Closeup of a pumice clast from Home Reef that reached Marion Reef (19.095°S, 152.390°E), Australia, fouled by goose barnacles (*Lepas* sp.), bryozoa, and mollusc. Coin is 2 cm in diameter. Courtesy of Scott Bryan.

Seamount 0403-091: Unpublished Report for Ministry of Lands, Survey, Natural Resources and Environment, Tonga, 9 p.

Geologic Summary. Home Reef, a submarine volcano midway between Metis Shoal and Late Island in the central Tonga islands, was first reported active in the mid-19th century, when an ephemeral island formed. An eruption in 1984 produced a 12-km-high eruption plume, copious amounts of floating pumice, and an ephemeral island 500 x 1500 m wide, with cliffs 30-50 m high that enclosed a water-filled crater. Another island-forming eruption in 2006 produced widespread dacitic pumice rafts.

Information Contacts: *Scott Bryan*, School of Earth Sciences & Geography, Kingston University, Kingston Upon Thames, Surrey KT1 2EL, United Kingdom (Email: s.bryan@kingston.ac.uk); *Peter Colls*, School of Physical Sciences, University of Queensland, St Lucia, Queensland 4072, Australia (Email: p.colls@mailbox.uq.edu.au); *Robert Dziak*, NOAA Pacific Marine Environmental Laboratory (PMEL), Hatfield Marine Science Center, 2115 SE Oregon State University Drive, Newport, OR 97365, USA (Email: Robert.p.dziak@noaa.gov).

Tungurahua

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

This report covers the time interval early January to 2 March 2007, based on Special Reports of the Ecuadorian Geophysical Institute (IG). This reporting interval was mainly one of relative quiet. In contrast, our previous report (*BGVN* 32:12), covered IG reports describing energetic eruptions of July and August 2006. Those IG reports also mentioned eruption-related fatalities and the discovery of a new growing bulge on the volcano's N flank. A map and geographic background were tabulated in *BGVN* 29:01.

Relative quiet prevails and some residents return. As touched on in *BGVN* 32:12, after August 2006, the volcanic vigor at Tungurahua was minimal and of low energy. The decrease in activity was gradual through mid-December 2006. The vigor remained low until mid-January 2007. Ash emissions did occur but were consistently minor.

IG reports noted that the relative tranquility at Tungurahua could reflect a pattern similar to that seen there in 1918. That was a case when various months of volcanic quiet occurred, only to be followed by explosive eruptions of large size. The latter generated pyroclastic flows.

During the quiet that followed the July and August 2006 eruptions, residents who had evacuated from the margins of the volcano returned to their properties. The IG noted that, unfortunately, these returning residents became more vulnerable to volcanic hazards and made emergency response more difficult.

Vigor increases. Between 20 January and 5 February 2007 internal seismic activity resumed, behavior consisting of a few earthquakes inferred as associated with fractures (volcano-tectonic earthquakes, VTs). On 13 February the volcano emitted an eruptive column with moderate ash content. After 19 February there was a reoccurrence of seismic VTs. These were of shorter duration but higher intensity than those that occurred during the previous period.

During 23-24 February 2007, volcanic tremors and seismic LP's were registered at the Volcanic Observatory of Tungurahua (VOT). At 0310 on 24 February, VOT staff and local observers reported continuous roars of moderate intensity, and discharge of incandescent material that both rose to ~ 800 m above the summit and descended ~ 1000 m down the volcano's flanks.

The emission column headed NW. Fine tephra fell, followed by a thick ashfall that was black in color. It left a deposit 3 mm thick in the towns of Pillate and San Juan. Reports received from Cotaló, Bilbao, Manzano, and Choglontús that indicate a thick, dark ashfall in those spots left a deposit 2 mm thick. Ashfall was also reported in the area of Quero.

Seismic activity decreased on 24 February as well as the intensity and frequency of the roars. As of 2 March, sporadic explosions of ash and incandescent material had been observed. Around this time some bad weather prevented clear views of the upper volcano; however, some reporters noted minor ashfall along the SW portion of the crater. Additionally, the SO_2 flux increased to ~ 2,000 metric tons a day for the first time since the beginning of the year. The IG's "Seismic Activity Index" indicated an increase of the volcano's internal activity.

Two scenarios envisioned. Given the available data, the IG concluded that the volcano had received a new influx of magma. They proposed two potential scenarios: (1) the current levels of activity will continue and constant emissions of ash, (potentially more intense) will be generated. Ash clouds will be blown by winds that at this time of the year are predominantly westerly, with occasional S and NW variations. These ash clouds could generate heavy ashfall in the towns downwind from the volcano; or (2) the volume and speed of ascent of the magmatic gases originating from the new magma will increase dramatically, in which case, new explosive eruptions of pyroclastic flows similar to those on 14 July and 16 August could occur.

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 3000 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 Contacts: *Geophysical Institute (IG),* Escuela Politécnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: http://www.igepn.edu.ec/).

Santa Ana

El Salvador
13.853°N, 89.630°W; summit elev. 2,381 m

Our last report (*BGVN* 31:01) discussed post-eruption lahars following the sudden 1 October 2005 eruption (*BGVN* 30:09). This report contains two sections. The first section addresses regional processes such as vegetation loss, ash accumulation, and lahars on and beyond the E flank of Santa Ana (also known as Ilamatepec) to the shores of Lake Coatepeque. Those lahars began soon after the 1 October 2005 eruption. The information on these lahars chiefly came from a report (SNET, 2006) authored by El Salvador's Servicio Nacional de Estudios Territoriales (SNET).

The second section addresses monitoring and observations such as extensive steaming and drop in the surface elevation of the lake in the summit crater. Material for this section, primarily found on the SNET website, covers January-April 2006, when activity was fumarolic with no large eruptions.

The 1 October 2005 eruption was possibly followed by a second one two days later on 3 October (SNET, 2006). A 3 October eruption was not mentioned in previous *Bulletin* reports.Carlos Pullinger explained that the evidence for the second eruption was tremor that day, but that could stemmed from other causes such as geysers in the summit crater lake, so the evidence for a 3 October eruption remains equivocal.

E-flank issues. October 2005 volcanism took place coincident with unusually high rains during tropical storm Stan (1-10 October 2005). On the E flank, the October 2005 eruptive episode killed extensive vegetation and left loose ash deposits covering the upper slopes (figure 14).

Based on a rain gauge 5 km W of the crater (national meteorological station Los Naranjos), rainfall in October averages 193 mm; the yearly average is 2,155 mm. In the months prior to October 2006, rainfall at that station remained at normal values, always below 460 mm per month. In contrast, rainfall reached 865 mm during October 2006. During the peak of the storm, 3-6 October 2005, the Los Naranjos rain gauge collected more than 100 mm per day; the highest reading of 320 mm was on 5 October.

Figure 14. A November 2005 photo looking southward showing Santa Ana in the foreground, along with denuded, ash-laden vegetation. A wisp of steam escapes the summit crater, a basin hosting an acidic crater lake. Santa Ana's plumes and October 2005 ash deposits, coupled with other factors such as steep slopes, stress to vegetation, the lack of surviving permeable soils, and regional rainfall have led to a rash of new E-flank lahars. Peaks beyond Santa Ana include its satellitic cone Cerro Verde and then Izalco (sharp peak beyond the notch). Photo from SNET (2006).

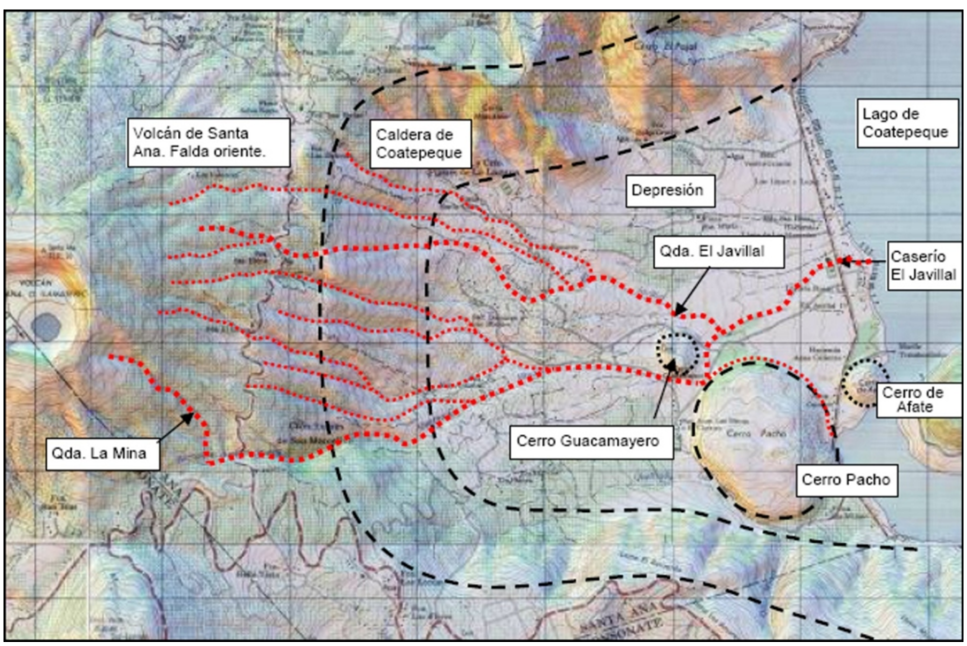

Figure 15. Lahars displayed as trains of heavy dots on a topographic base map of the E-central side of Santa Ana and the adjacent W side of Lake Coatepeque. (N is towards the top; light grid-lines are 1 km apart, so the distance from the summit on the W to the large lake on the E is ~ 6.5 km.) In general, the lahars descended from W to E. Coatepeque is a 7 x 10 km caldera and the series of dashed lines across the map indicate the caldera's steep-sided topographic margin in. Several caldera domes are labeled, including Cerro Pacho and Cerro Afate. Note the lahar entering the settlement adjacent Lake Coatepeque ("Caserío El Javillal"). From SNET (2006).

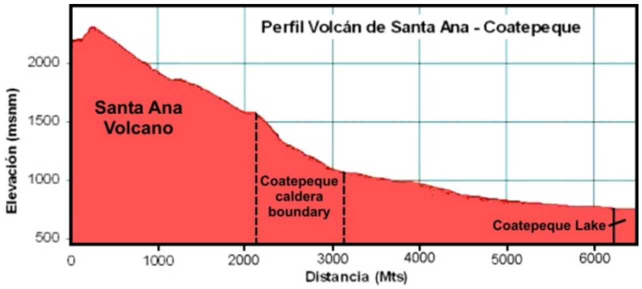

Figure 16. An E-W topographic profile with Santa Ana on the W across to the E side of Lake Coatepeque on the E. Dashed lines indicate the location of Coatepeque's caldera wall. From SNET (2006).

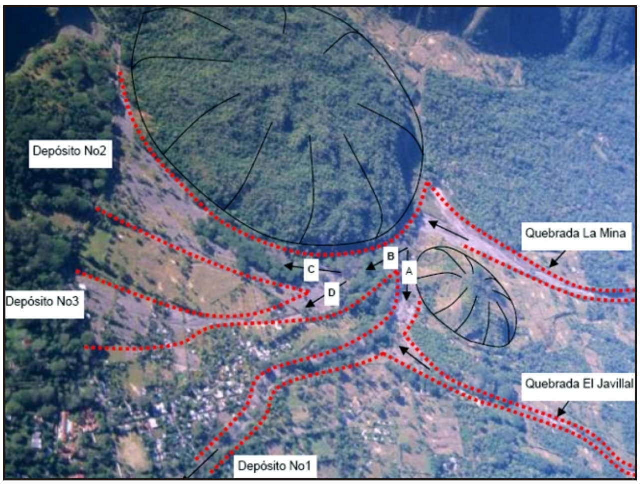

Figure 17. Annotated aerial photo at unknown date showing part of Coatepeque's Planes de Laguna, W of Santa Ana, taken looking roughly S. The view illustrates lahars in and around El Javillal.The lahars entered the area along two drainages (Quebradas La Mina and El Javillal), both flowing from right to left (arrows). Adjacent to the domes and settlements, the flow patterns become quite complex (as indicated by flow directions A, B, C, and D). Lake Coatepeque appears at the upper left. The steep caldera wall lies along the photo's margin from the upper center to right corner. The large circular dome is Cerro Pacho; the smaller dome to the right is Cerro Guacamayero. Photo from SNET (2006).

The lahars on Santa Ana's E slope consisted of both material from the October 2005 eruption as well as previous deposits. The first lahar seen by local witnesses took place on the night of 2 October 2005. It carried material up to 2 m in diameter. The lahars that produced most of the damage were those that occurred immediately after the eruption and reached a maximum thickness of 1.5 m. Other lahars descended later in the storm, persisting well into 2006.

The 2006 rainy season did not generate damaging lahars, just heavy runoff with minor sediment. In all, SNET seismically registered 22 lahar events, all of which were confirmed by local residents. The communities used tractors used to keep the main drainages open and to build levees, which confined the lahars inside main drainage areas. The SNET website mentioned several lahar episodes during 2006. Some of these episodes occurred in May, June, and July 2006.

A large scallop in the topographic margin of Coatepeque caldera results in Planes de la Laguna (an area of ~ 10 km^2), which was where lahars eventually deposited (figures 15 and 16). This area of less steeply sloped, and in places comparatively level, ground contains numerous coffee plantations and small settlements. The largest settlement is El Javillal (figure 15, adjacent Lake Coatepeque).

The upslope areas contained numerous channels carrying lahars (figure 15). Several kilometers into the caldera the channels merge as they cross the less steeply sloped Planes de Laguna. The channels eventually grow into two

Figure 18. Photos showing October 2005 lahar deposits from Santa Ana in El Javillal. Deposits included lava blocks of differing sizes, and a mixture of soil, tree parts, mud, and water. Photos from SNET (2006).

Figure 19. Photo showing the crater lake at Santa Ana volcano. The decrease in the water level has revealed an island of rocks and sediments that was previously covered by the crater lake. Photo taken on 17 February 2006 and provided courtesy of SNET.

primary channels, La Mina on the S and El Javillal on the N (figure 17). The La Mina channel led directly towards the Cerro Pacho dome, where the lahars proceeded to branch into multiple routes (A, B, C, and D) before entering El Javillal (figure 18).

Given the lack of soils and the state of vegetation, lahars were viewed as a potential ongoing hazard. To control lahars, SNET (2006) proposed excavating two channels from the vicinity of the domes to Lake Coatepeque, to carry sediment farther towards the lake. The proposed artificial channels are 2 m deep, with sides that slope at 45° outwards, and with a flat floor 5 m across. One proposed channel follows the S margin of the Cerro Pacho dome, the other follows a path similar to arrow A on figure 17.

Pullinger noted that the jocote de corona crop harvest was not affected because it came out just after the eruption. However, coffee was damaged wherever ash fell. Lahars did not directly hurt coffee plantations, but access roads were damaged and labor for harvesting was minimal, after much of the population had fled.

Monitoring. Moderate seismic activity and steam emissions continued during 2006. During 2006, seismicity was slightly above normal levels. Small earthquakes were interpreted as being associated with gas pulses.

Degassing continued in January 2006 with sporadic gas-and-steam emissions which rose approximately 200 m before dispersing. The SO_2 flux ranged between 163 and 1,578 metric tons/day.

On 2 February, there was an increase in seismicity, possibly related to an earthquake on the coast of Guatemala. From 1-7 February the SO_2 flux averaged 2,000 metric tons per day. A drop in the water level of the steaming, green-colored acidic lake in the summit crater revealed a local topographic high in the lake's center, which took the form of an irregular island (figure 19).

Intense bubbling and fumarole activity during 27 February-23 March disturbed the lake's surface and made it difficult to assess the level of the water. During April, instability in the crater led to periodic landslides. One significant landslide deposited material in the SW section of the beach of the crater lake.

Reference: Servicio Nacional de Estudios Territoriales (SNET), 2006, Flujos de escombros en la Ladera Oriente del Volcán Ilamatepec, Departamento de Santa Ana: Perfil de Obras de Mitigacion, Enero de 2006, 12 p.

Background. Santa Ana, El Salvador's highest volcano, is a massive, 2,381-m-high andesitic-to-basaltic stratovolcano that rises immediately W of Coatepeque caldera. Collapse of the volcano during the late Pleistocene produced a voluminous debris avalanche that swept into the Pacific Ocean, forming the Acajutla Peninsula. Reconstruction of the volcano subsequently filled most of the collapse scarp. The broad summit of the volcano is cut by several crescentic craters, and a series of parasitic vents and cones have formed along a 20-km-long fissure system that extends from near the town of Chalchuapa NNW of the volcano to the San Marcelino and Cerro la Olla cinder cones on the SE flank. Historical activity, largely consisting of small-to-moderate explosive eruptions from both summit and flank vents, has been documented since the 16th century. The San Marcelino cinder cone on the SE flank produced a lava flow in 1722 that traveled 13 km to the E.

Information Contacts: *Carlos Pullinger*, Servicio Nacional de Estudios Territoriales (SNET), Alameda Roosevelt y 55 Avenida Norte, Edificio Torre El Salvador, Quinta Planta, San Salvador, El Salvador (URL: http://www.snet.gob.sv).

Popocatépetl

México

19.023°N, 98.622°W; summit elev. 5,426 m

Centro Nacional de Prevencion de Desastres (CENAPRED) reported only sporadic, modest activity at Popocatépetl during early 2006 through April 2007. Based on information from the Mexico City Meteorological Watch Office (MWO), and the Washington Volcanic Ash Advisory Center (VAAC), there were five occasions when ash plumes rose substantially. On 25 and 27 July 2006 ash plumes rose to an altitude of ~ 9.8 km. On 18 and 20 December 2006, ash plumes rose to an altitude of ~ 6.7 km and 7.9 km, respectively. In April 2007, ash plumes rose to ~ 7. 6 km on the 1st, and to ~ 7.3 km on the 3rd.

In August 2006, the lava dome that had been irregularly growing since July 2005 covered the floor of the internal crater and began a piston-like growth on the top of the previous dome. The enlarged dome can be seen in an aerial photography taken in 24 November 2006 (figure 20). This formation of the dome was the twenty-sixth such event since 1996.

On 4-5 August and 1-3 November 2006 episodes of large-amplitude harmonic tremor (figure 21) were believed to reflect an increased rate of dome growth. The accumulated volume of the lava dome between November of 2005 and November of 2006 was estimated to be 1,299,000 m^3. The average rate growth over that interval is around 0.04 m^3/s. Assuming that the dome grows only during the tremor episodes, the rate would be ~ 6.75 m^3/s.

Incandescence at the summit was recorded by the CENAPRED camera on 3 August and 4-5 September 2006. Over 27-29 October 2006, eigth small explosions ejected incandescent debris on the slopes surrounding the crater.

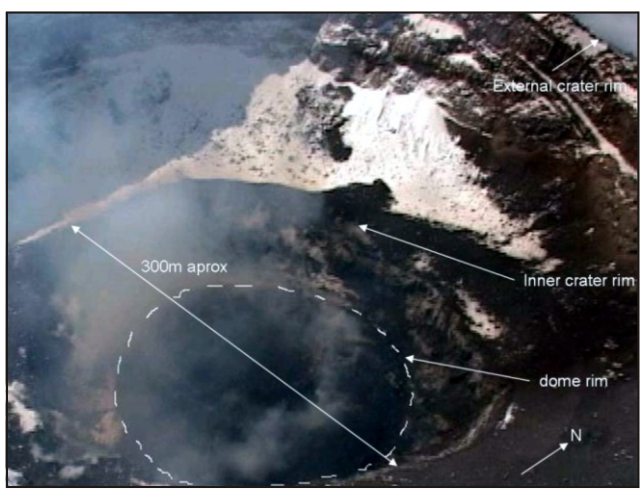

Figure 20. Aerial photo taken 24 November 2006 showing the growing lava dome at Popocatépetl.The dashed white line defines the dome edge. The lava dome that started growing in July 2005 has covered the floor of the internal crater and began growing on the top of the previous dome. The white areas outside the inner-crater rim are snow cover. Courtesy of the government of the State of Puebla, Mexico.

During November and December 2006, more episodes of low amplitude tremors were recorded. From August to December 2006, 77 volcano-tectonic micro-earthquakes were detected, with magnitudes ranging between 2.0 and 3.0. From these, 66 were located below the crater at depths ranging between 3 and 7 km (figure 22).

Hot spots at the summit were detected on satellite imagery by the Washington Volcanic Ash Advisory Center (VAAC) on 7-8 January 2007. According to the Washington VAAC, a puff with little ash content emitted from Popocatépetl was reported from the MWO and visible from the camera operated by CENEPRED on 14 February 2007. A very diffuse plume was seen drifting to the E on satellite imagery. Base on an aerial photograph taken on 24 January 2007, CENEPRED reported that the lava-dome dimensions have slightly increased since 24 November 2006.

Geologic Summary. Volcán Popocatépetl, whose name is the Aztec word for smoking mountain, towers to 5426 m 70 km SE of Mexico City to form North America's 2nd-highest volcano. The glacier-clad stratovolcano contains a steep-walled, 400 x 600 m wide crater. The generally symmetrical volcano is modified by the sharp-peaked Ventorrillo on the NW, a remnant of an earlier volcano. At least three previous major cones were destroyed by gravitational failure during the Pleistocene, producing massive debris-avalanche deposits covering broad areas south of the volcano. The modern volcano was constructed to the south of the late-Pleistocene to Holocene El Fraile cone. Three major plinian eruptions, the most recent of which took place about 800 AD, have occurred from Popocatépetl since the mid Holocene, accompanied by pyroclastic flows and voluminous lahars that swept basins below the volcano. Frequent historical eruptions, first recorded in Aztec codices, have occurred since precolumbian time.

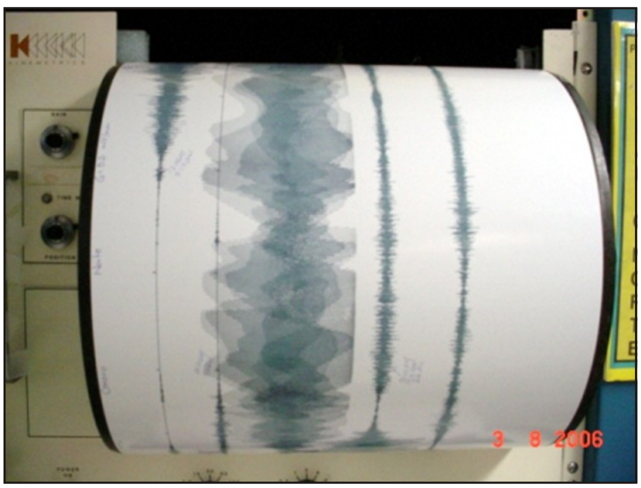

Figure 21. Evidence of a large-amplitude, multiband harmonic tremor, showing clear frequency peaks in its spectrum detected in August 2006 at Popocatépetl. The combination of the frequencies appear as moiré shadows in the paper recording.Courtesy of CENAPRED.

Information Contacts: *Centro Nacional de Prevención de Desastres* (CENAPRED), Av. Delfín Madrigal No.665. Coyoacan, México D.F. 04360, México (Email: amb@cenapred.unam.mx gvazquez@cenapred.unam.mx; (URL: http://www.cenapred.unam.mx/), *Alicia Martinez Bringas* and *Angel Gómez Vázquez*, CENAPRED (see above); *Servando de la Cruz Reyna*, Insituto de Geofisica UNAM. Ciudad Universitaria, s/n. Circuito Institutos . Coyoacan México D.F. México; *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/).

Soufrière Hills

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

Activity returned to normal levels following the strong explosive episode of 10 September 2006 (*BGVN* 31:09). Activity after September included an occasional minor explosions, rockfalls, minor pyroclastic flows, venting of ash and gases and steam with emissions reaching up to 3 km altitude, minor ashfalls, and mudflows during heavy rains. In September and October, the minor pyroclastic flows primarily moved down the N and NE flanks of the dome. In January, pyroclastic flows traveled down the Gages Valley, Tyres Ghaut, Belham Valley, Tuits Ghaut, Farrells Plain, and especially the lower Tar River Valley E of the volcano.

Lava-dome growth slowed in March, and by the end of April it appeared to have ceased. On 1 June Montserrat Volcano Observatory (MVO) (figure 23) warned that, while the lava extrusion had ceased and the dome may not be actively growing, it remains as a large mass of partially molten lava capable of collapsing or exploding. According to MVO, the amount of material above Tyres Ghaut to the NW was sufficient to generate pyroclastic flows and surges capable of affecting the lower Belham Valley and other areas.

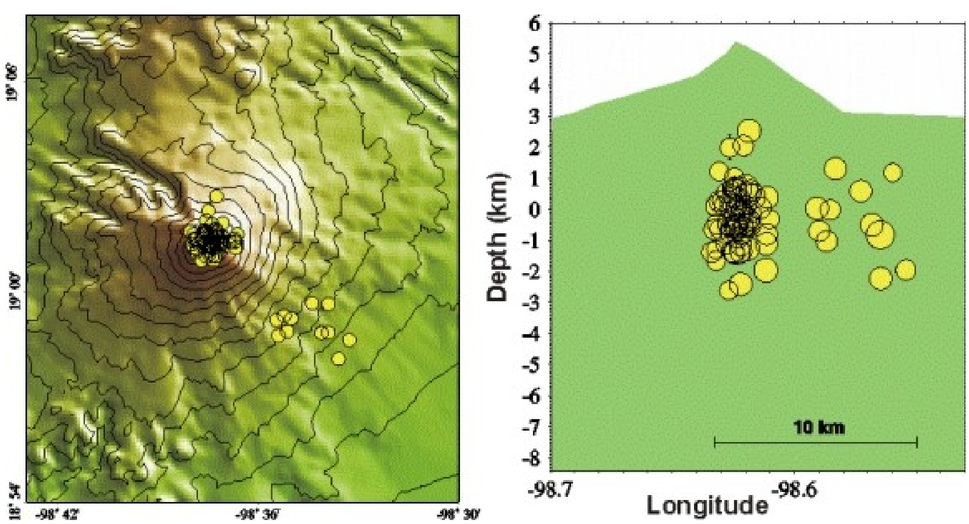

Figure 22. Location and depth of micro-earthquakes on Popocatépetl recorded during August to December 2006. Courtesy of CENAPRED.

Data provided by MVO (table 3) shows the elevated seismicity (hybrid earthquakes and rockfall signals) related to the increased activity in late August and early September (*BGVN* 31:09). The high number of long-period earthquakes in late June reflects the dome collapse at that time (*BGVN* 31:05). The dramatic decrease in long-period events and rockfalls in mid-March corresponds to the observed reduction in dome growth.

Strong activity during mid-September 2006. On 9 and 10 September, vigorous ash venting from the Gages Wall was accompanied by small explosions. Pyroclastic flows from fountain collapse occurred on all sides of the dome and reached 1 km W down Gages valley. On 11 September, the collapse of an overhanging lava lobe produced pyroclastic flows NE down the Tar River valley. One pyroclastic flow in the same area on 13 September reached the sea. On 14 September, vigorous ash venting resumed. Continuous ash and gas emissions during 13-19 September produced plumes that reached altitudes of 2.4-3.7 km. The Gages Wall vent continued to produce ash and gas emissions into mid-October.

Activity during September-December 2006. During 15 September-6 October the lava dome continued to grow at a moderate rate in the summit area and on the S and E sides of the dome. On 22 September the volume of the dome was about 80 million cubic meters. Lava-dome growth was concentrated on the NE part of the edifice from 6 October until 15 December, when growth moved to the SW part of the dome. A new E-facing shear lobe with a smooth, curved back enlarged during 13-20 October.

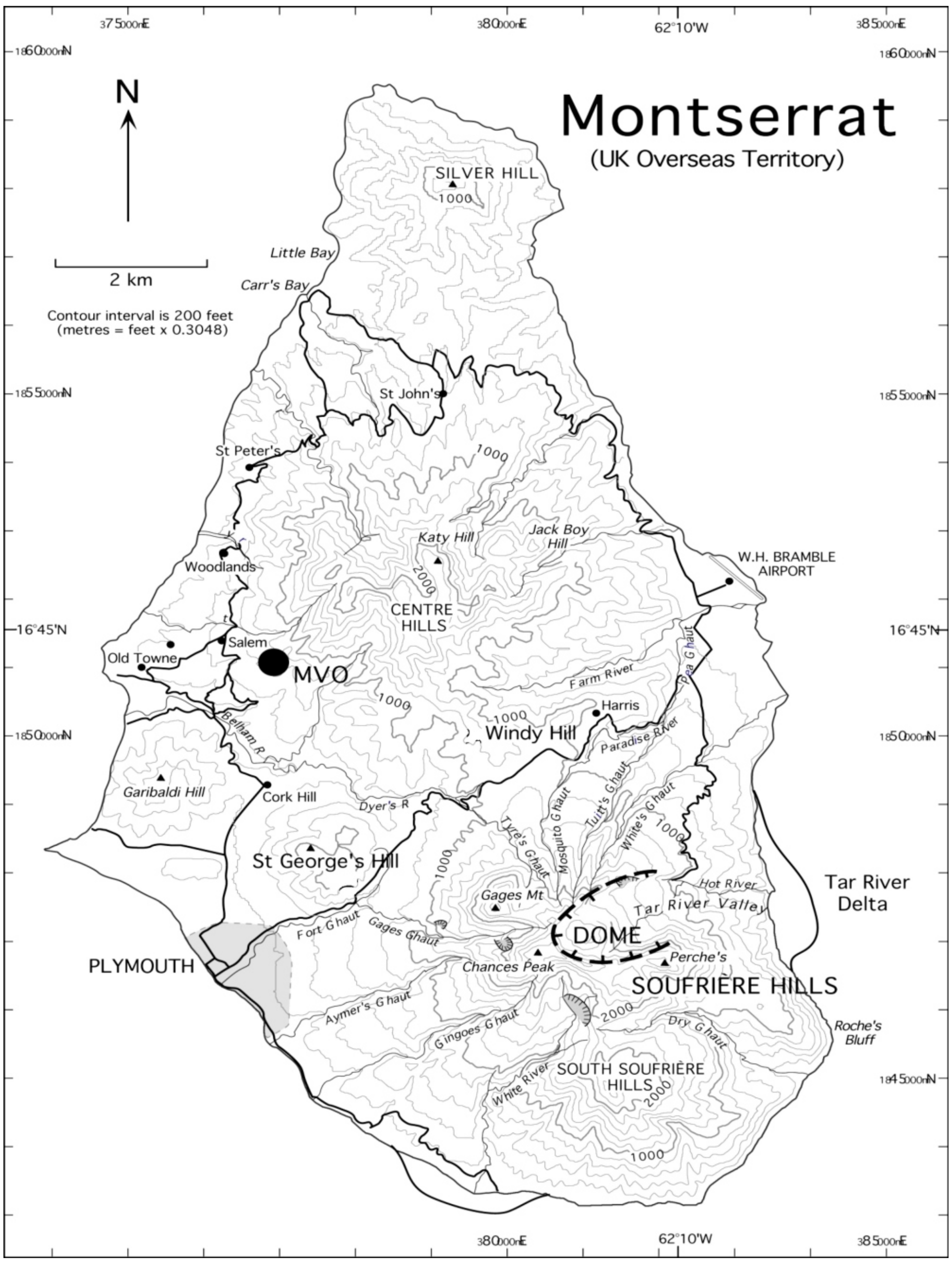

Figure 23. Map of Montserrat showing the pre-eruption topography of Soufrière Hills. The black circle shows the location of the MVO. The approximate outline of the Tar River delta in July 2004 is shown. Courtesy of Wadge and others (2005).

During 24 November-1 December, the two cracks in the curved back of the shear E-facing lobe on the summit propagated downward and divided the lobe into three blocks. The dome overtopped the NE crater wall and fresh rock and boulder deposits were observed in that region. During 22-29 December, lava-dome growth was focused on the W, where gas-and-ash venting occurred. A high whaleback lobe directed SW was observed on 26 December.

Aviation notices reported continuous ash and gas emissions almost every day from 15 September through 14 November, with plumes rising above 2 km to a maximum of 4.6 km altitude. Plumes extended 140 km W on 2-3 October. During 17-24 November, ash venting originated from the westernmost of two cracks in the curved back of the shear E-facing lobe on the summit. An explosion produced an ash plume that rose to altitudes of 1.5-1.7 km.

Pyroclastic flows occurred regularly as collapses from the dome sent material in all directions. Pyroclastic flows reached both the upper region of Tuitts Ghaut (N) and the sea via the Tar River Valley (E) on 23 November.

Activity during January-March 2007. Rapid lava-dome growth, pyroclastic flows, and ash venting increased during 3-9 January. Dome growth was concentrated in the NW, the highest part of the dome. Pyroclastic flows were observed in Tyres Ghaut (NW), Gages Valley (W), and N, behind Gages Mountain and accompanied by ash venting. On 4 January, simultaneous pyroclastic flows descended Tyres Ghaut and Gages Valley, and a resultant ash cloud reached an altitude of 2.5 km. The maximum distance for the Gages Valley flow was 4 km. During 6-9 January, distances of pyroclastic flows increased in Tyres Ghaut and possibly exceeded 1.5 km.

During 10-16 January, lava-dome growth was focused on the NW quadrant. During 10-11 January, one pyroclastic flow was observed to the W in Gages Valley and one to the NW in Tyres Ghaut. On 15 January, a relatively large pyroclastic flow traveled E down the Tar River Valley. After 15 January, measurable activity was low. Gas and ash venting that originated from the W side of the dome continued. A clear view on 22 January revealed that the collapse scar from the 8 January event was filled in. A small spine was noted on the W side. On 23 January, a large

Report Date (2006-2007)	Hybrid Earthquakes	VT Earthquakes	LP Earthquakes	Rockfall Signals	Average SO_2 Flux (metric tons/day)
16 Jun-23 Jun	—	—	32	51	—
23 Jun-30 Jun	54	4	1236	100	—
30 Jun-07 Jul	17	6	448	194	593
07 Jul-14 Jul	2	1	49	61	468
14 Jul-21 Jul	9	—	341	293	523
21 Jul-28 Jul	12	—	190	144	—
28 Jul-04 Aug	—	2	162	166	120
04 Aug-11 Aug	5	1	100	165	230
11 Aug-18 Aug	8	1	69	253	222
18 Aug-25 Aug	142	—	124	280	150
25 Aug-01 Sep	30	12	61	588	351
01 Sep-08 Sep	154	1	39	366	160
08 Sep-15 Sep	210	5	38	413	405
15 Sep-22 Sep	17	1	11	279	232
22 Sep-29 Sep	1	—	21	383	450
29 Sep-06 Oct	—	3	83	616	144
06 Oct-13 Oct	—	1	107	585	150
13 Oct-20 Oct	—	2	107	807	—
20 Oct-27 Oct	2	2	88	732	356
27 Oct-03 Nov	1	—	110	487	420
03 Nov-10 Nov	1	—	162	346	520
10 Nov-17 Nov	—	1	209	565	332
17 Nov-24 Nov	1	1	124	452	845
24 Nov-01 Dec	—	2	101	298	465
01 Dec-08 Dec	—	—	81	121	524
08 Dec-15 Dec	—	—	9	100	574
15 Dec-22 Dec	—	—	29	257	—
22 Dec-29 Dec	3	6	163	396	200
29 Dec-05 Jan	3	3	22	231	152
05 Jan-12 Jan	—	2	24	348	159
12 Jan-19 Jan	1	1	2	52	156
19 Jan-26 Jan	—	7	22	53	204
26 Jan-02 Feb	—	2	101	57	213
02 Feb-09 Feb	—	3	69	108	153
09 Feb-16 Feb	—	3	127	370	—
16 Feb-23 Feb	—	2	219	353	271
23 Feb-02 Mar	1	1	189	608	157
02 Mar-09 Mar	—	—	141	594	150
09 Mar-16 Mar	—	3	61	383	157
16 Mar-23 Mar	1	3	1	124	135
23 Mar-30 Mar	—	8	5	16	158
30 Mar-05 Apr	—	17	1	45	1035
06 Apr-13 Apr	—	—	1	8	3114
13 Apr-20 Apr	—	—	3	8	203*
20 Apr-27 Apr	—	—	1	3	476
27 Apr-04 May	—	—	—	9	223
04 May-11 May	—	—	—	4	125
11 May-18 May	—	—	—	2	143
18 May-25 May	—	1	—	1	216

Table 3. Seismicity at Soufrière Hills between 16 June 2006 and 25 May 2007. * Data for the first 4 days only. VT: volcanic tectonic; LP: long-period. Courtesy of MVO.

pyroclastic flow traveled down Gages Valley. The Washington VAAC reported that ash plumes were visible during 26-27 January. On 28 January, a large pyroclastic flow traveled down the Tar River Valley and reached the sea. A diffuse plume rose to an altitude of 1.5 km on 31 January.

During 7-13 February, growth of the lava dome continued on the W side, then was concentrated on the E and N sides for the rest of the month. The lava-dome volume in mid-February was estimated at 200 million cubic meters based on LIDAR data. Previous measurements over-estimated the lava-dome volume due to the perceived location of the dome and the lack of data from inside the crater. Small pyroclastic traveled in multiple directions throughout February. Moderate pyroclastic flows traveled down the Tar River Valley during 24-25 and 27 February. Continuous ash emissions were reported during 14 February-6 March, with plumes to altitudes of 2.1-6.1 km.

Lava-dome growth during 2-9 March was concentrated on an E-facing lobe topped with blocky, spine-like protrusions. Rockfalls affected the E and NE flanks. Pyroclastic flows traveled 2 km in the Tar River Valley. Heightened pyroclastic activity on 7 March resulted in an ash plume that rose to an estimated 2.4 km. On 11 March, a pyroclastic flow traveled down the NE flank into White's Ghaut.

During 9-26 March, lava-dome growth was concentrated on the NE side. Intermittent pyroclastic flows traveled E down the Tar River valley and produced ash plumes. One plume on 12 March rose to 3 km altitude. Pyroclastic flows were observed NW in Tyre's Ghaut and ashfall was reported from the Salem /Old Towne areas. During 23 March-3 April, dome growth apparently stopped.

MODIS thermal data indicated hot pixels at the dome and from pyroclastic flows on 24 March. Another thermal anomaly from a pyroclastic flow Tar River was detected on 29 March. No futher anomalies had been recorded by the HIGP Hotspot system through May. However, the Washington VAAC reported that a SW-drifting, diffuse plume and a hotspot were visible on satellite imagery on 2 April.

During 30 March-13 April, small, intermittent pyroclastic flows from the E-facing shear lobe occurred in the Tar River valley (figure 24). Incandescent rockfalls were seen at night during 5-9 April. On 17 April, a small pyroclastic flow was observed to the NW in the upper part of Tyres Ghaut. In mid-April MVO estimated that the lava-dome volume was about 208 million cubic meters.

The sulfur dioxide (SO_2) flux rate during 6-13 April was high, with an average value of 3,114 metric tons per day (t/d), well above the long-term average for the eruption. The previous week averaged 1,035 t/d, from a low of 71 to a high of 3,818 t/d. The three days from 8 to 10 April showed markedly elevated emissions: 3,550, 7,396 peaking at 7,471 t/d, whereas the remaining days' emissions were extremely low, some below 100 t/d.

During 13-20 April, material originating from the lava dome's E-facing shear lobe was shed down the Tar River Valley. A bluish haze containing sulfur dioxide was observed flowing down the N flanks on 18-20 April. Pyroclastic activity was ongoing on the E and NE sides of the dome during 27 April-4 May. After 4 May the overall structure of the dome changed very little. Low-level rockfall and pyroclastic-flow activity continued into late May.

Geologic Summary. The complex, dominantly andesitic Soufrière Hills volcano occupies the southern half of the island of Montserrat. The summit area consists primarily of a series of lava domes emplaced along an ESE-trending zone. English's Crater, a 1-km-wide crater breached widely to the east, was formed during an eruption about 4000 years ago in which the summit collapsed, producing a large submarine debris avalanche. Block-and-ash flow and surge deposits associated with dome growth predominate in flank deposits at Soufrière Hills. Non-eruptive seismic swarms occurred at 30-year intervals in the 20th century, but with the exception of a 17th-century eruption that produced the Castle Peak lava dome, 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.

Reference: Wadge, G., Macfarlane, D.G., Robertson, D.A., Hale, A.J., Pinkerton, H., Burrell, R.V., Norton, G.E., and James, M.R., 2005, AVTIS: a novel millimetre-wave ground based instrument for volcano remote sensing: J. Volcanology and Geothermal Research, v. 146, no. 4, p. 307-318.

Figure 24. Photograph taken 4 April 2007 of southern Montserrat and Soufrière Hills from the NE, showing from left the Tar River Delta and the debris fans spilling from Tuitts and Whites Ghauts. Courtesy MVO.

Information Contacts: *Montserrat Volcano Observatory (MVO)*, Fleming, Montserrat, West Indies (URL: http://www.mvo.ms/); *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/); *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://modis.higp.hawaii.edu/).

Stromboli

Italy
38.789°N, 15.213°E; summit elev. 924 m
All times are local (= UTC + 1 hour)

According to Sonia Calvari of Istituto Nazionale di Geofisica e Vulcanologia (INGV-CT), a flank eruption started on Stromboli volcano on 27 February 2007 and continued to at least 15 March. Compared to the previous flank eruption during 2002-2003, lava effusion was about an order of magnitude greater. Initially, a NE fissure opened on the NE flank of the NE-crater, and lava emitted from the fissure formed three branches and rapidly reached the sea (figure 25).

Late on the eruption's first day, the three initial flows stopped and a new vent opened at the E Margin of the Sciara del Fuoco at about 400 m elevation. In a few days, this vent emitted sufficient lava to build a lava bench several tens of meters wide, which significantly modified the coastline. These lava emissions stopped for a few hours on 9 March, after which another vent opened at about 550 m elevation on the N flank of the NE-crater, almost in the same position as one of the vents of the 2002-2003 eruption. The 550-m vent was active for less than 24 hours and, when it ceased emitting lava, the 400-m vent reopened, again feeding lava to the sea.

On 15 March 2007, while the effusion from the 400-m vent continued, a major explosion occurred at 2137 (2037 UTC). This event, similar to that on 5 April 2003 (*BGVN* 28:04), was recorded by all the INGV-CT monitoring web cams. As in 2003, the 2007 event occurred during a flank effusive eruption, when the summit craters were obstructed by debris fallen from the crater rims. Still images and videos can be downloaded from the INGV-CT webpage dedicated to the 2007 Stromboli eruption.

Satellite imagery. Satellite imagery revealed an ash plume fanning SSE from the eruption site beginning at 1215 UTC on 27 February 2007. Another eruption was observed on MET-8 split-window IR (infrared) imagery on the same day at 1830 UTC. Ash then blew SSE at 46-56 km/hour.

Geologic Summary. Spectacular incandescent nighttime explosions at Stromboli volcano have long attracted visitors to the "Lighthouse of the Mediterranean."

Figure 25. Lava from Stromboli reaching the sea on 27 February 2007. Courtesy of the INGV-CT 2007 Stromboli eruption web site.

Stromboli, the NE-most of the Aeolian Islands, has lent its name to the frequent mild explosive activity that has characterized its eruptions throughout much of historical time. The small, 924-m-high island of Stromboli is the emergent summit of a volcano that grew in two main eruptive cycles, the last of which formed the western portion of the island. The Neostromboli eruptive period from about 13,000 to 5,000 years ago was followed by formation of the modern Stromboli edifice. The active summit vents are located at the head of the Sciara del Fuoco, a prominent horseshoe-shaped scarp formed about 5,000 years ago as a result of the most recent of a series of slope failures that extend to below sea level. The modern volcano has been constructed within this scarp, which funnels pyroclastic ejecta and lava flows to the NW. Essentially continuous mild strombolian explosions, sometimes accompanied by lava flows, have been recorded at Stromboli for more than a millennium.

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