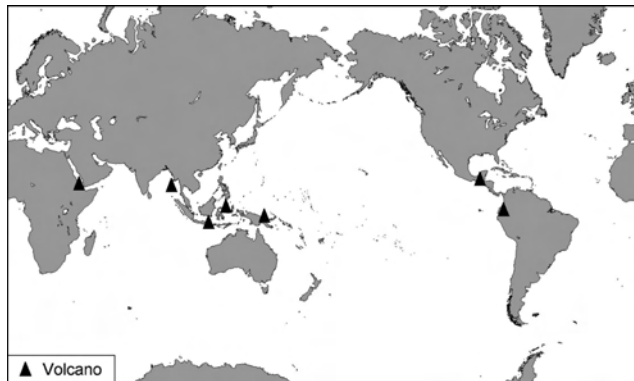


Bulletin of the Global Volcanism Network

Volume 29, Number 11, November 2004



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National Museum of Natural History

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Dedicated to victims and survivors of the 26 December 2004 earthquake and tsunami

As we go to press with this issue of the *Bulletin* our thoughts repeatedly turn to the victims and survivors of the disastrous 26 December M 9 earthquake and tsunami. Although a different geologic process than we discuss here, tsunamis are sometimes associated with volcanism. Conversely, large earthquakes can trigger eruptions. The world has much to learn about these and related geologic phenomena and about how to gauge, discuss, and prepare for infrequent but potentially devastating events. We offer our condolences and encouragement as we look towards a more integrated, educated world.

Editors: Rick Wunderman, Edward Venzke, and Gari Mayberry

Volunteer Staff: Robert Andrews, Jacquelyn Gluck, William Henoch, and Aditi Bhaskar

Global Volcanism Program · National Museum of Natural History, Room E-421, PO Box 37012 · Washington, DC 20013-7012 · USA
Telephone: (202) 633-1800 · Fax: (202) 357-2476 · Email: gvn@volcano.si.edu · URL: <http://www.volcano.si.edu/>

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Data are preliminary and subject to change; contact the original source or the Global Volcanism Program before using.

Andaman Islands

Indian Ocean, India
 12.29°N, 93.88°E; summit elev. 305 m
 All times are local (= UTC + 5 ½ hours)

False reports of volcanism surfaced describing eruptions at Barren Island and Narcondam volcanoes (figure 1) following the 26 December 2004, M 9 earthquake off the W coast of northern Sumatra. Clarification was provided by Dornadula Chandrasekharam of the Indian Institute of Technology. He reported an absence of volcanic activity at these volcanoes, and at Sumatran volcanoes, as recently as 4 January 2005.

The erroneous accounts were discovered by Chandrasekharam while watching television news. He immediately contacted people in the Andaman region. Upon learning that these reports were incorrect, he contacted media sources and the Global Volcanism Network. Many Indian news sources that proclaimed eruptions at Barren Island later withdrew their reports. The erroneous information prevailed for a day to perhaps a week, although non-Indian news agencies were slower to recognize and acknowledge the error.

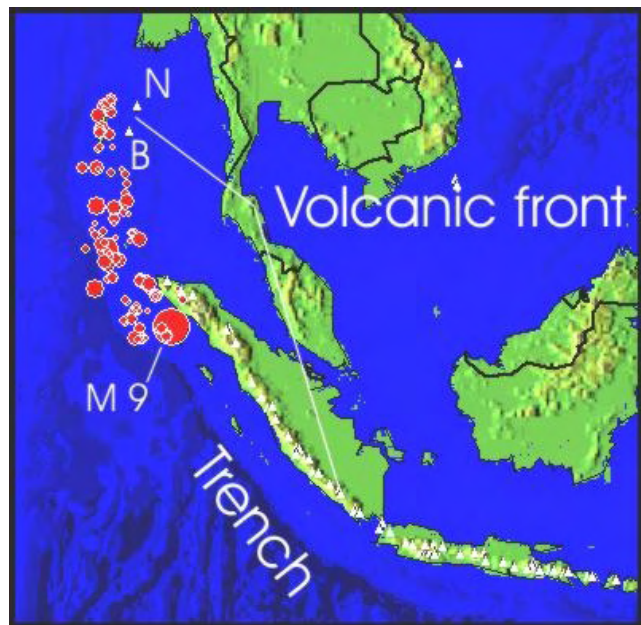


Figure 2. Map showing the broad tectonic setting on which Barren Island and Narcondam volcanoes reside. The map began with the main shock of the M 9 earthquake and the earthquakes that followed during the next 11 days. USGS preliminary tabulations computed the main shock as Mw 9.0 with a focus at 30 km depth.



Figure 1. A map of the Andaman Islands showing the only volcanoes known to have erupted during the Holocene period (past 10,000 years), Narcondam and Barren Island (N and B, respectively). Note that narrow straits break Andaman island into multiple smaller islands (eg., Middle Andaman and Baratang islands). Baratang Island contains an established, studied, active mud volcano that reactivated after the M 9 earthquake.

Regional tectonic setting. Figure 2 illustrates the rudiments of the regional tectonic setting, including the primary M 9 earthquake and aftershocks for the next 10 days. The tectonic reconstructions are far more complex than shown here, and the details are variously interpreted.

In terms of local time (in the Andaman Islands and India, i.e. India Standard Time), the epicenters shown occurred during the time interval 06:28:53 on 26 December to about 06:57 on 6 January. (In terms of UTC, this represents the interval 00:58:53 on 25 December to about 19:57 on 5 January 2004). This digital map was extracted by applying a video simulation of epicenters with time (Jones and others, 2002) to the recent seismic data.

The figure shows two prominent curving tectonic features crossing both Java-Sumatra and the Andaman Sea (the Nicobar and Andaman Islands region). One such curving feature is the volcanic front, on which lie all the active volcanoes of Java and Sumatra, and farther N, Barren Island and Narcondam. Outboard of that (to the W) is the second curving feature, the Sunda trench and islands adjacent to it (the

Andaman Islands, and islands to the W of northern Sumatra hard-hit by the M 9 earthquake and tsunami). The trench reflects the sea-floor expression of the subduction zone, and represents the region where the M 9 earthquake occurred. The offset, often termed a ‘megathrust,’ involved 1,200 km of rupture along the subduction zone, and suddenly shifted the Indian Ocean’s floor ~ 15 m towards Sumatra (Hopkin, 2005).

Regarding the M 9 earthquake, according to the USGS, the local time and date in terms of local time in N Sumatra at the epicenter was Sunday, 26 December 2004 at 07:58:53 (i.e., roughly 8 am). The USGS provided a table showing the time of the main shock in a variety of time zones.

Some excellent tutorials have provided background on the tectonic setting, the earthquake, and the tsunami. These have appeared in the press and on the web (eg. Sieh, 2004, 2005; NOAA, <http://www.noaa.gov/tsunamis.html>). Although large earthquakes may trigger volcanism (Linde and Sacks, 1998), so far this does not appear to be the case, at least at the volcanoes of Barren Island and Narcondum.

Mud volcanoes and ensuing confusion. Post-earthquake reports of active ‘mud volcanoes’ in the Andaman Islands caused panic and confusion in the region, and came at a particularly bad time. Chandrasekharam pointed out that in Andaman, like many other arc provinces, several mud volcanoes are present. These are not real volcanoes in the usual sense, but because they may build a small, low-profile cone of local extent around the hole through which the mud is thrown out, they are known as mud volcanoes (figure 3).

Some of the difficulty with the news reports was that the mud volcanoes’ locations, numbers, and impacts remained vague, and that Barren Island became intertwined with story. An extreme example came from an irresponsible report in the tabloid *India Daily* (2 January 2005), which contained the title “Volcano[es] Barren-1 and Narcondam erupt in Andaman—Seismic disturbance can cause more tsunami.” It continued with wild claims such as, “Severe seismic activities are seen in these islands . . . personnel who have reached these remote areas are facing shattering earth vibrations and high waves,” and “Some scientists are predicting severe earthquake again in the North of Andaman Nicobar Islands. The effect can be severe on Myanmar, Andaman, Indi[a]’s east coast, Bangladesh and Sumatra . . .” They added, “Andaman’s tribals strangely are unaffected as most of them somehow went [to] higher ground before the tsunami. So did the animals.” Science journalism clearly has a lot to compete with (see Oldenburg, 2005, for more discussion of these topics).

One alleged mud volcano ‘Barren-1’ has a name so close to the volcano’s name (Barren Island) that it was frequently confused. The mud volcano’s name (if there is one) appears to be absent from the technical literature at the Geological Survey of India’s website.

On a positive note, one mud volcano received consistent mention in a number of news articles and provided coverage generally congruent with geological data posted by the Geological Survey of India. According to an article in *India News* (with the leader, “Port Blair, 30 December”), “A mud volcano at the inhabited Baratang Island in Middle Andaman has erupted but the administration said there was no cause for concern. ‘Mud keeps bubbling in the volcano, but on December 28, the eruption was up to three meters and there was considerable heat,’ Inspector General of Police S. B. Deol said here.”

“He [also] said the mud volcano was located on one side of the Baratang Island, which was about 100 km from Port Blair. People live on the other side, but there is no cause for concern.”

A report in the *India Daily* was nearly identical. Details on a Geological Survey of India website noted that the Baratang mud volcano began erupting on 27 December 2003 (figure 3 and caption). Mud volcanoes may have also occurred elsewhere in the region, but the available news reports consistently failed to disclose locations.

Often associated with active faults and with petroleum fields, mud volcanoes on land consist of low-lying surface mud extrusions that vary in size from meters to several kilo-



Figure 3. A 2003 photograph showing about a quarter to one half of a mud volcano on Baratang island (top) and its largest crater (~ 20 cm in diameter, ~ 28 cm in depth) (bottom). This site was known as a minor fissure prior to 1983; but in that year the largest outburst occurred, chiefly emitting warm (~ 30°C) mud. Mud again began emerging in February 2003. The dominant feature was a sub-circular mound of mud, ~ 30 m in diameter with a height of ~ 2 m at the center. Observers noted a colorless, sulfurous smelling gas. The mud contained angular to sub-rounded rock fragments from underlying strata. No photos nor similarly detailed technical reports have been received showing alleged recent activity that began 27 December 2004 (see text for news report). All photos and data courtesy of the Geological Survey of India, Eastern Region.

meters across. They emit mud at temperatures significantly below magmatic, which are typically at least 800°C. Eruptions from mud volcanoes can reach heights of several hundred meters and consist of mud, fluids and gases, and sometimes burning hydrocarbons. Although in submarine environments mud volcanoes can be extensive, deadly mud volcano eruptions are extremely rare because their eruptions seldom move far enough to affect large areas of the land surface. Their greatest danger may be to curious on-lookers who venture too close.

References. Jones, A., Siebert, L., Kimberly, P., and Luhr, J.F., 2002, *Earthquakes and Eruptions*, v. 2.0 (CD-ROM): Smithsonian Institution, Global Volcanism Program, Digital Information Series, GVP-2.

Hopkin, M., 2005, Triple slip of tectonic plates caused seafloor surge: *Nature*, v. 433, no. 3 (06 Jan 2005).

Linde, A.T., and Sacks, I.S., 1998, Triggering of volcanic eruptions: *Nature*, v. 395, p. 888-890.

Oldenburg, D., 2005, A sense of doom: Animal instinct for disaster—Scientists investigate wildlife's possible warning systems: *The Washington Post* (8 January 2005), p. C1, C3 (URL: <http://www.washingtonpost.com/>).

Sieh, K., 2004, The science behind the Aceh earthquake: Caltech Media Relations (30 December 2004), (URL: http://pr.caltech.edu/media/Press_Releases/PR12628.html).

Sieh, K., 2005, In Sumatra: Notes From a Geologist in the Field: *Caltech Today* (1 January 2005; URL: <http://today.caltech.edu/today/>).

U.S. National Earthquake Information Center (NEIC) (URL: <http://earthquake.usgs.gov/>).

U.S. National Oceanic and Atmospheric Administration (NOAA) (URL: <http://www.noaa.gov/tsunamis.html>).

Background. Barren Island, a possession of India in the Andaman Sea about 135 km NE of Port Blair in the Andaman Islands, is the only historically active volcano along the N-S-trending volcanic arc extending between Sumatra and Burma (Myanmar). The 354-m-high island is the emergent summit of a volcano that rises from a depth of about 2,250 m. The small, uninhabited 3-km-wide island contains a roughly 2-km-wide caldera with walls 250-350 m high. The caldera, which is open to the sea on the W, was created during a major explosive eruption in the late Pleistocene that produced pyroclastic-flow and -surge deposits. The morphology of a fresh pyroclastic cone that was constructed in the center of the caldera has varied during the course of historical eruptions. Lava flows fill much of the caldera floor and have reached the sea along the western coast during eruptions in the 19th century and more recently in 1991 and 1995.

Narcondam volcano, an island possession of India in the Andaman Sea, is part of a volcanic arc that continues northward from Sumatra to Burma (Myanmar). The small 3 x 4 km wide conical island, located about 130 km east of North Andaman Island, rises to 710 m, but its base lies an additional 1,000 m beneath the sea. The island is densely vegetated, bounded by cliffs on the southern side, and capped by three peaks. No evidence of historical volcanism is present, although the summit region is less densely vegetated and volcanism at the andesitic volcano is considered to have continued into the Holocene. The island's name means "pit of hell," although the name could have been mistakenly transferred from the historically active Barren Island volcano, 140 km to the SSW.

Information Contacts: *Dornadula Chandrasekharam*, Department of Earth Sciences, Indian Institute of Technology, Bombay 400076, India (URL: <http://www.geos.iitb.ac.in/dchandra/biexp/>, Email: dchandra@iitb.ac.in); *India News* (URL: <http://news.newkerala.com/india-news/>); *India Daily* (URL: <http://www.indiadaily.com/>); *The Washington Post*, Washington DC, USA (URL: <http://www.washingtonpost.com/>); *Geological Survey of India*, 27 Jawaharlal Nehru road, Kolkata (Calcutta) 700016, India.

Ijen

eastern Java, Indonesia

8.058°S, 114.242°E; summit elev. 2,386 m

All times are local (= UTC + 7 hours)

The Chief of the local National Park has been quoted as having reported an increase in activity beginning on 17 June 2004. This resulted in closing the area to visitors. Reuters quotes him as having said "There have been sulfuric rocks coming out of the edge of the crater and the fluid in it (the crater lake) has turned from green to white and has emitted hot foam. There are also increasing tremors."

Background. The Ijen volcano complex at the eastern end of Java consists of a group of small stratovolcanoes constructed within the large 20-km-wide Ijen (Kendeng) caldera. The N caldera wall forms a prominent arcuate ridge, but elsewhere the caldera rim is buried by post-caldera volcanoes, including Gunung Merapi stratovolcano, which forms the 2,799-m-high point of the Ijen complex. Immediately W of Gunung Merapi is the renowned historically active Kawah Ijen volcano, which contains a nearly 1-km-wide, turquoise-colored, acid crater lake. Picturesque Kawah Ijen is the world's largest highly acidic lake and is the site of a labor-intensive sulfur mining operation in which sulfur-laden baskets are hand-carried from the crater floor. Many other post-caldera cones and craters are located within the caldera or along its rim. The largest concentration of post-caldera cones forms an E- to W-trending zone across the southern side of the caldera. Coffee plantations cover much of the Ijen caldera floor, and tourists are drawn to its waterfalls, hot springs, and dramatic volcanic scenery.

Information Contact: *Reuters News Service.*

Soputan

Sulawesi, Indonesia

1.11°N, 124.73°E; summit elev. 1,784 m

All times are local (= UTC + 8 hours)

Soputan erupted again on 12 December 2004. The Directorate of Volcanology and Geological Hazard Mitigation (DVGHM) noted that an eruption on 18 October 2004 sent a cloud ~ 600 meters above the crater. The previous eruptive episode occurred during July and August 2003 (*Bulletin* v. 28, nos. 8, 10, and 11). A summary of ash plumes from mid-2003 through 12 December 2004 appears in table 1. Large discrepancies appeared in reported ash column heights; with the satellite estimates about 10 times larger than ground-based estimates.

Date	Height (km) (comment)	Source
18 Jul 2003	~ 2 km above summit	DVGHM
02 Sep 2003	~ 2 km altitude	Darwin VAAC
04 Sep 2003	~ 3 km altitude (extending ~ 75 km N of the summit)	Satellite imagery, Darwin VAAC
18 Oct 2004	~ 600 m above summit	DVGHM
12 Dec 2004	~ 1 km above summit	DVGHM
12 Dec 2004	~ 10.7 km altitude	Darwin VAAC

Table 1. Reported ash plume altitudes recorded from Soputan, 18 July 2003-12 December 2004. Courtesy of DVGHM and Darwin VAAC.

The earliest details mentioned by DVGHM regarding the 2004 activity discussed 11 December 2004, a time when the tremor tended to rise, attaining peak-to-peak amplitudes of 0.5-3.0 mm. Observers also saw incandescence at the crater's rim.

At 0046 on 12 December tremor again registered with maximum peak-to-peak amplitudes of ~ 45 mm. At 0050 on 12 December Soputan erupted, sending an ash cloud up to 1 km. This was followed by discharge of a "hot cloud" (pyroclastic flow ?) to a distance of ~ 200 m E (from 'Aeseput,' a prominent NE-flank vent that formed in 1906). A lava flow spread W and S of Soputan. Observers could hear rumbling noise and thunder from their monitoring station ~ 11 km from the crater.

White-to-gray ash went E. At 0130 on 12 December a problem arose with the seismic sensors, perhaps because the solar panel was covered with ash. By 0600 the sensor was down. At 0500 that day a hot cloud occurred with a run out distance of ~ 150 m and a height of 200 m. Activity persisted until 1030. Soputan's summit then became visually obscured by clouds, but observers could still make out a white thin-to-medium plume to 70-80 m above the crater, and incandescence.

On the 13 December at 1752 observers felt an earthquake with a magnitude of MM I-II. The seismograph was then still inoperable.

News reports. A 13 December news report in *The Daily Reform Voice* stated that hundreds of hectares of paddy-fields and other agricultural land to the W of the Soputan was seriously impacted by tephra.

Thomas Dobat, a German expatriate living in Indonesia and concerned about the situation, sent *Bulletin* editors a translation of a 13 December 2004 article on Soputan taken from the Indonesian Journal *Komentar*. Similar to the above report, it also noted that hundreds of villages in 13 districts in Central Minahasa and in South Minahasa suffered from tephra fall emitted on 11-12 December. These eruptions of Soputan were accompanied by heavy thunder and lightning, which were heard in the town of Amurang.

Ash fell in nearly all of Central Minahasa and in parts of South Minahasa. The result was that in all areas of Central Minahasa, especially in the town of Tondano, houses, rice-fields, and roads were ash-covered up to 2 cm thick.

Background. The small Soputan stratovolcano on the southern rim of the Quaternary Tondano caldera on the northern arm of Sulawesi Island is one of Sulawesi's most active volcanoes. The youthful, largely unvegetated volcano rises to 1784 m and is located SW of Sempu volcano. It was constructed at the southern end of a SSW-NNE trending line of vents. During historical time the locus of eruptions has included both the summit crater and Aeseput,

a prominent NE-flank vent that formed in 1906 and was the source of intermittent major lava flows until 1924.

Information Contacts: Directorate of Volcanology and Geological Hazard Mitigation, Jalan Diponegoro 57, Bandung 40122, Indonesia (Email: dali@vsi.dpe.go.id; URL: <http://www.vsi.esdm.go.id/>); Darwin Volcanic Ash Advisory Centre, Australian Bureau of Meteorology (URL: <http://www.bom.gov.au/info/vaac/>); *The Daily Reform Voice*; *Komentar*; Thomas Dobat, Lorong Jerman, Kauditan II, 95372, Sulawesi Utara, Indonesia.

Manam

Papua New Guinea, Northeast of New Guinea
4.10°S, 145.061°E; summit elev. 1,807 m
All times are local (= UTC - 10 hours)

Several periods of eruption took place on the island of Manam during the last months of 2004. Rabaul Volcano Observatory (RVO) noted outbursts during 24-31 October (*Bulletin* v. 29, no. 10), 10-12 November, and on 6 December. Several other plumes were noted as well. Satellite-based alerts (MODVOLC) were noteworthy during this interval, having been absent for over 9 months.

On 6 December, the newspaper *The National* reported that these eruptions had killed five people, whose deaths were primarily related to respiratory complications from inhaling volcanic material. Volcanic ash damaged crops, water supplies, and houses. News accounts discussed evacuations, with the possibility of evacuating all or most of the island (figure 4). The news also mentioned food shortages after the 24 October eruption.

The government of Papua New Guinea presented a new website, *The National Disaster Center*, which broadly disseminates government disaster information including volcano reports and updates (see URL under Information Con-



Figure 4. Geography of the area around Manam showing two named villages on the island and numerous settlements on the main island of New Guinea. For scale, Manam Island is ~ 10 km in diameter. The volcano is sometimes referred to as Mount Iabu in the regional press. The city of Wewak lies off the map, ~ 160 km W of Manam; the city of Madang lies ~ 150 km to the E. The large meandering river at left is the Sepik. The island's residents, a total of 9,467 people, rely on subsistence farming and fishing for food, and copra and cocoa as a source of income. Map courtesy of Jorgen Aabech.

tacts, below). The website contained a Manam hazards map. Other documents on that site noted shifting winds and the lack of a clearly safe area on the island during the late 2004 crisis. It said that the government would sponsor large-scale evacuations beginning on 27 November 2004.

The eruptive episode that began on 24 October continued at least a week (figure 5). By 31 October, the eruption at Main Crater consisted of Strombolian activity, with ash and scoria emissions. Tephra of ~ 1 cm diameter were deposited in Warisi village on the SE side of the island. Small pyroclastic flows were generated, and fresh lava flowed into the NE radial valley. The lava flow followed the Boakure side of the valley, covering older flows from the 1992-1994 eruption. Beginning on the morning of the 31st, the amount of continuous volcanic tremor increased to moderate-to-high levels, so the Alert Level was increased from Stage 1 to Stage 2. Villagers were advised to remain away from Manam's four main radial valleys.

The Darwin Volcanic Ash Advisory Center reported the 24 October outburst (*Bulletin* v. 29, no. 11). On 31 October during 0813-1449 they noted a plume at ~ 13.7 km altitude drifting SE on visible satellite imagery. The Aviation Color Code was at Red, the highest level.

According to a news report, "... [~ 0.3 m] of ash with hot pumice" landed on the roofs of houses, and ash drifted as far W as Wewak, ~ 100 km away. Reportedly, ~ 4,000 villagers moved to safer areas.

On 2 November around 2325 a possible eruption may have produced a plume to ~ 7.6 km altitude, which drifted SE. Ash was visible on satellite imagery on 8 and 9 November at an altitude of ~ 3 km; on 9 November the plume extended, ~ 55 km to the NE.

A Strombolian eruption occurred during 10-11 November 2004. The ash column from the eruption was estimated to have risen ~ 5-6 km above the crater, and perhaps rose as high as ~ 9 km above the crater, according to an Air Niugini pilot. The activity was accompanied by continuous weak to moderate roaring and rumbling noises and frequent loud explosions. Light ash and scoria fall was reported near local vil-

lages. As of 2130 on 10 November ash reached 7 km altitude and 147 km to the SW. As of 12 November, the ash emissions reached 10 km altitude and extended laterally 74 km W to NW of the volcano.

During this reporting interval Darwin VAAC noted that a SE-drifting plume was visible on satellite imagery on 31 October during 0813-1449 at an altitude of ~ 13.7 km.



Figure 5. Image of Manam and vicinity acquired on 24 October 2004 by the Moderate Resolution Imaging Spectroradiometer (MODIS), an instrument on the Terra satellite of the National Aeronautics and Space Administration (NASA). Dark ash rising from Manam drifted NW along and then away from the N coast of the main island, New Guinea. Courtesy NASA Earth Observatory.



Figure 6. Manam image acquired 15 November 2004 from Moderate Resolution Imaging Spectroradiometer (MODIS) passing overhead on the National Aviation and Space Agency (NASA) Terra satellite. Dark ash rises from Manam and drifts SW over New Guinea. Courtesy NASA Earth Observatory.

A satellite image from the Terra Moderate Resolution Imaging Spectroradiometer (MODIS) on 15 November shows a large brown ash plume blowing SW (figure 6).

According to RVO scientists, on 23-24 November Main Crater ejected glowing lava and discharged an ash cloud that rose ~ 10 km high. A lava flow was also reported to be heading for two villages on the island. At 1850 on 23 November, a phase of strong Strombolian eruption began producing a continuous, thick ash column that rose about 10 km above the summit. The ash cloud emissions were accompanied by projection of glowing lava fragments, loud roaring and rumbling noises, and occasional loud and banging noises that produced shock waves. A continuous bright red glow visible down the NE valley indicated emplacement of a lava flow.

The lava flow was reported heading NE towards villages of Kolang and Bokure 1. In addition to the lava, Manam emitted large rocks. Around this time the aviation red alert issued for aircraft noted that the ash plume extended 130 km SE of Manam.

Press accounts stated that emergency officials said an area was being cleared on the mainland for a possible full-scale evacuation of Manam's ~ 9,500 islanders. Evacuation was to become compulsory if activity intensified from Stage 3 (which was set by 22 November) to Stage 4. Some 20 bush homes had collapsed due to 'mud rain' (presumably, falling tephra), and five people had been injured.

RVO reported that a slight increase in eruptive activity from Main Crater began after 1600 on 26 November, which continued until 0800 on the 29th. Summit activity consisted of continuous forceful emission of thick dark gray ash clouds that rose less than 1 km above the summit before being blown NW. Fine ashfall to the NW at Zogari and Iassa villages was reported from about 1700. A single weak roar was heard between 0600 and 0700 on the 27th.

Seismicity was moderate to moderate-high at 2300 on the 26th and 0800 on the 27th. Volcanic tremors continued to be recorded suggesting the system remained dynamic and capable of ongoing variable eruptions, with sporadic more vigorous phases.

On 28-29 November, RVO reported that ash clouds were rising less than 1 km above the summit before being blown by the shifting NNE and NNW winds. Fine ashfall was reported at Warisi. Weak roaring noises were heard between 1900-2400 on the 28th. A weak glow with weak projections of incandescent lava fragments was visible during the night of the 28th, and Southern Crater released thin white vapor only.

Some press reports described 7,900 persons evacuated from Manam. According to the *Planet Diary* web site, about 9,000 people were evacuated by 1 December 2004 as the eruption grew more violent.

Mid-afternoon on 5 December RVO noted a slight change in activity at Southern Crater marked by commencement of sub-continuous weak to moderate roaring and rumbling noises. The noises continued until 1000 that day. As darkness fell, intervals of visibility occurred (eg., during 1800-1808, 2030-2108, and 2130-2200); observers saw sub-continuous lava fountaining. Meanwhile, from Main Crater there came a series of sub-continuous, forceful, moderately thick, gray-brown ash-laden clouds, which were occasionally visible above the weather clouds. The ash plume rose between about 600 and 900 m above the summit and drifted to the E and NE. Light ashfall and fine

scoria fell at the villages Abaria and Bokure 1. Fluctuating audible noises consisted of low roars, 'jet engine' roars, and occasional still-louder roars. Although visibility was generally poor due to volcanic ash clouds from both craters, observers could still make out variable glow coming from the craters.

On 8 December 2004, *The National* reported that, according to RVO, Manam erupted starting on the morning of 6 December. Fist-sized scoria were thrown out of the vent into the air, hitting houses in the villages below. The eruption began at 0800 and peaked at 1150 with "seismicity continuing."

The National also reported that a pyroclastic flow occurred in the SE valley during the 6 December eruption, with ash and cloud directed NW. On the 6th, residents of Madang (~ 150 km E of Manam) described feeling tremor or ground motion; those in Wewak (~ 160 km to the W) reported similar sensations and also noted volcanically derived dust. Although ash from 6 December was apparently widespread, Googling for news of Manam ash in Irian Jaya failed to turn up any reports from there.

The Darwin VAAC reported ash plume sightings from satellites during 12-14 December, and the RVO reported moderate eruptions continuing in that period.

Fatalities. An article by Bonney Bonsella in *The National* showed pictures of Manam Islanders in evacuation. They waded through shallow surf to board through the open bow of a large beached landing craft. The article discussed fatalities during the eruption.

"The volcanic eruption on Manam Island in the Madang province has so far claimed five lives—two elderly women and three children between the ages of 5-13. The coordinator of the Manam evacuation exercise Camillus Dugumi confirmed the deaths, adding that the deaths were linked to respiratory complications resulting from inhaling volcanic ashes and dust. Mr Dugumi, who is also the district health programme manager, said one of the deaths was that of an elderly woman from Bokure village recorded early last week at the Bogia District hospital. The woman died after being admitted to the hospital for respiratory complications. One child, a little boy, died on Friday at the Asuramba care centre after suffering pneumonia."

"Three others—an adult women and two other children—had died during earlier volcanic activity on Manam."

Displaced residents. The above-mentioned article related that three State-owned plantations (called Asuramba, Potsdam, and Magem (and Daigul?)) were set aside, ". . . at least for the time being[,] to accommodate a speedy resettlement of the displaced Manam islanders." Another news article noted that these plantations are near the town of Bogia (figure 4). *The National Disaster Center* website noted that "The three plantations were bought off from the lessee in 1995 for K1.25 million following a National Executive Council decision for the purpose of resettlement of Manam Islanders displaced by volcanic activity." Controversies remain with respect to land issues. Still, that website noted that the long-term solution advocated by the President, Manam Local Level Government is to resettle the people of Manam on the mainland. For this purpose the Provincial Disaster Committee has identified State land to resettlement the Manam Island people.

MODVOLC. The MODIS infrared instrument flown on the NASA Terra and Aqua satellites showed an impressive set of thermal alerts beginning 21 October 2004 (figure 7).

Since the beginning of MODVOLC operations (*Bulletin* v. 28, no. 1) thermal alerts occurred at Manam during only two periods. The first, 7 April–21 May 2002, was related to increased Strombolian activity (*Bulletin* v. 27, no. 5). The second period, 21 October until at least 14 December 2004, was associated with the current crisis and was a time when alert ratios and summed radiances reached higher values than during the first period. These parameters are consistent with a highly active vent and/or lava flows, and in accord with vigorous Strombolian emissions seen in the field.

This analysis of MODIS thermal alerts (using the MODVOLC alert-detection algorithm) is based on data extracted from the MODIS Thermal Alerts website maintained by the University of Hawaii HIGP MODIS Thermal Alerts team.

Thermal alerts are based on an ‘alert ratio,’ and an alert is triggered whenever this ratio has a value more positive than -0.8. This threshold value was chosen empirically by inspection of images containing known volcanic sites at high temperature, and is the most negative value that avoids numerous false alarms. There are also some day-time alerts, which are based on the same algorithm but incorporating a correction for estimated solar reflection and a more stringent threshold whereby the alert ratio is required to be more positive than -0.6 in order to trigger an alert.

Background. The 10-km-wide island of Manam, lying 13 km off the northern coast of the 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. 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: *Rabaul Volcano Observatory* (RVO), P.O. Box 386, Rabaul, Papua New Guinea; *National Disaster Centre*, Department of Provincial Affairs and Local Level Government (Ministry of Inter-Government Relations), PO Box 4970, Boroko, National Capital District, Papua New Guinea (URL: <http://www.pngndc.gov.pg/>); *David Innes*, Flight Safety Office, Air Niugini (Email: dinnes@airniugini.com.pg or deejayinnes@yahoo.com); *Andrew Tupper*, Darwin Volcanic Ash Advisory Centre, Australian Bureau of Meteorology (URL: <http://www.bom.gov.au/info/vaac/>); *Jorgen Aabech*, Skogbrynet 40B, N-1709 Sarpsborg, Norway (Email: Jorgen.aabech@eunet.no; URL: <http://www.vulkaner.no/>); *MODIS Thermal Alert System*, Hawaii Institute of Geophysics and Planetology (HIGP), School of Ocean and Earth Science and Technology, University of Hawaii at Manoa (URL: <http://www.modis.higp.hawaii.edu/>); *David Rothery* and *Charlotte Saunders*, Department of Earth Sciences, The Open University, Milton Keynes, MK7 6AA, United Kingdom (Email: d.a.rothery@open.ac.uk); *Kevin Pamba* and *Bonney Bonsella*, The National (URL: <http://www.thenational.com.pg/1206/>).

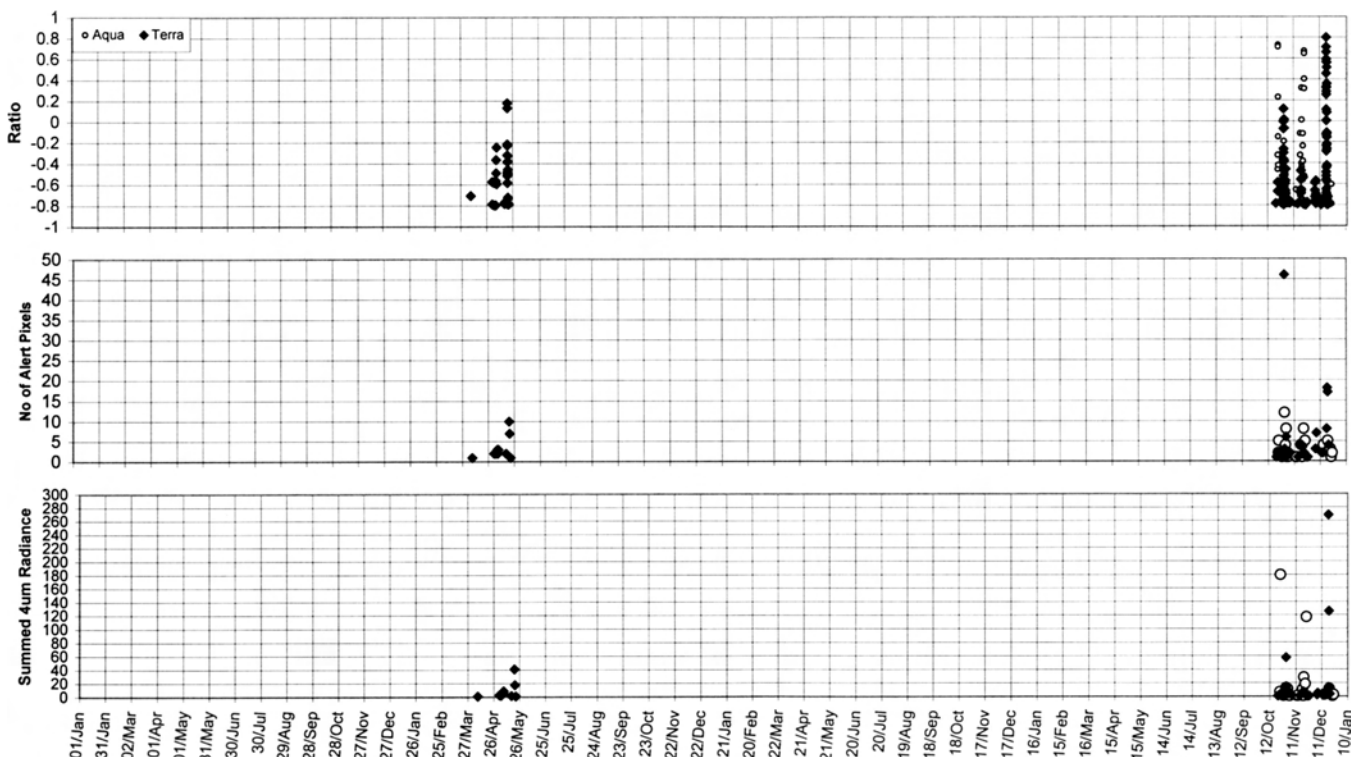


Figure 7. MODVOLC thermal alert ratios, number of alert pixels, and summed 4 μm radiance plots for Manam from 1 January 2001 until 31 December 2004. Alerts occurred only between 7 April and 21 May 2002 and between 21 October and 14 December 2004. Thermal alerts collated by Charlotte Saunders, and David Rothery; data courtesy of the Hawaii Institute of Geophysics and Planetology’s MODIS thermal alert team.

Erta Ale

Ethiopia

13.60°N, 40.67°E; summit elev. 613 m

Two teams sent reports on Erta Ale's behavior in December 2004. On 1-5 December the visiting team included Jacques-Marie Bardintzeff and a group from Ushuaia Nature, and on 4-5 December the team consisted of the volcanology travel group SVE-SVG. Both groups submitted similar reports and commented on substantial changes they observed compared to conditions described in past reports (most recently, *Bulletin* v. 29, no. 8). Although Erta Ale frequently contains a lava lake with an open surface of molten lava, that was not the case this time.

The lava lake's surface had chilled within the small (~ 200-m-diameter) S pit crater (figure 8). A solidified lava crust covered the crater floor. The crust's surface sat ~ 15 m below the W crater rim, and ~ 30 m below the E crater rim. On top of this crust stood four coalesced hornitos in the SE part of the S crater (figure 9). They were ~ 10 m high and represented the only portion of the crust where molten material was in evidence. Two hornitos emitted high temperature (more than 500°C) SO₂-rich gas. Another hornito contained glowing molten lava. During the night of 4 December the SVE-SVG group saw degassing and incandescent lava at the summit of two of these hornitos. Bardintzeff described sampling molten material from 12 m depth, in one of the hornitos using a cable and an iron mass (figure 9).

The SVE-SVG team noted recent activity within the North crater, where an uplifted area termed a 'lava bulge' had solidified. It covered ~ 80% of the crater floor and rose to about 20-25 m below the crater rim. In the lava bulge's central area, strong and noisy degassing of SO₂ spouted from several small hornitos. At the bulge's periphery the observers saw ten small incandescent vents. Subsequently, two plumes rose above the volcano.

Background. Erta Ale is an isolated basaltic shield volcano that is the most active volcano in Ethiopia. The broad,



Figure 8. The small S pit crater at Erta Ale as viewed from the E on 5 December 2004. Hornitos had grown on the W part of the crater floor; except for these windows into the molten material at depth, the rest of the lava lake surface had completely solidified. Photo provided by J. M. Bardintzeff.



Figure 9. The S pit crater at Erta Ale as seen from the W on 5 December 2004, with the 4 hornitos in the center of the photo. Two hornitos on the left emitted high temperature SO₂. The hornito in the right foreground contained molten lava (which was sampled). Photo provided by J. M. Bardintzeff.

50-km-wide volcano rises more than 600 m from below sea level in the barren Danakil depression. Erta Ale is the namesake and most prominent feature of the Erta Ale range. The 613-m-high volcano contains a 0.7 x 1.6 km, elliptical summit crater housing steep-sided pit craters. Another larger 1.8 x 3.1 km wide depression elongated parallel to the trend of the Erta Ale range is located to the SE of the summit and is bounded by curvilinear fault scarps on the SE side. Fresh-looking basaltic lava flows from these fissures have poured into the caldera and locally overflowed its rim. The summit caldera is renowned for one, or sometimes two long-term lava lakes that have been active since at least 1967, or possibly since 1906. Recent fissure eruptions have occurred on the northern flank of Erta Ale.

Information Contacts: Jacques-Marie Bardintzeff, Laboratoire de Pétrographie-Volcanologie, Bât. 504, Université Paris-Sud, F-91405, Orsay, France (Email: bardintzeff@geol.u-psud.fr, URL: <http://www.lave-volcans.com/bardintzeff.html>); Henry Gaudru, Société Volcanologique Européenne (SVE), C.P.1-1211 Geneva 17- Switzerland (Email: HgaudruSVE@compuserve.com; URL: <http://www.sveurop.org/>).

Cotopaxi

Ecuador

0.677°S, 78.436°W; summit elev. 5,911 m
All times are local (= UTC - 5 hours)

Seismicity at Cotopaxi during December 2003 through December 2004 yielded averages that generally remained within normal levels (table 2). Steam emissions continued, and sulfurous odors were occasionally reported. A plot of total seismicity each week during 2001-July 2004 portrayed numerous peaks and valleys in the range 50-200 events per week. Occasional excursions took the weekly totals to several hundred events in late 2001 and early 2002 (peaking at over 700 events per week during mid-October 2001). The 2004 data lacked such dramatic excursions.

Year	Volcano-tectonic	Hybrid	Long-period	Tornillo	Tremor	Total
2001	3.1	1.0	10.2	0.1	0.2	11.3
2002	2.9	3.0	14.6	0.1	0.4	18.2
2003	1.2	3.7	9.3	0.0	1.4	14.2
2004	0.41	3.59	11.10	0.0	1.56	15.11

Table 2. Annual summaries showing typical daily averages of various kinds of seismicity at Cotopaxi during 2001-2004. Courtesy of IG (shown on their website in the January 2005 report).

Planning for emergency water supplies. Although seismicity and other monitored parameters were moderate to low during most of 2003 (*Bulletin* v. 28, nos. 11 and 12), local authorities worked on a contingency plan for emergency drinking water in the event of a crisis at Cotopaxi.

The Quito metropolitan sanitation and drinking water company (EMAAP-Q) prepared a contingency plan for residents around Cotopaxi. The challenge was to provide for sufficient amounts of potable and sanitation water for some half a million people in the event of an eruption that contaminates their normal water supplies. This contingency plan was drawn up using experience gained from the operational emergency plan used to recover from the eruption in 1998-99 and the Reventador eruption in 2002.

During the Guagua Pichincha eruption, pyroclastic material impacted Quito, and ash fell into the water treatment plants and threatened the water supply systems. EMAAP-Q developed an operational and emergency plan. The plan was tested in 1999 when the volcano had two major eruptions that heat dropped ash on Quito and its infrastructure.

Background. Symmetrical, glacier-clad Cotopaxi stratovolcano is Ecuador's most well-known volcano and one of its most active. The steep-sided cone is capped by nested summit craters, the largest of which is about 550 x 800 m in diameter. Deep valleys scoured by lahars radiate from the summit of the andesitic volcano, and large andesitic lava flows extend as far as the base of Cotopaxi. The modern conical volcano has been constructed since a major edifice collapse sometime prior to about 5,000 years ago. Pyroclastic flows (often confused in historical accounts with lava flows) have accompanied many explosive eruptions of Cotopaxi, and lahars have frequently devastated adjacent valleys. The most violent historical eruptions took place in 1744, 1768, and 1877. Pyroclastic flows descended all sides of the volcano in 1877, and lahars traveled more than 100 km into the Pacific Ocean and western Amazon basin. The last significant eruption of Cotopaxi took place in 1904.

Information Contact: *Geophysical Institute (IG), Escuela*

Politécnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: <http://www.igepn.edu.ec/>).

Reventador

Ecuador

0.078°S, 77.656°W, summit elev. 3,562 m

All times are local (= UTC - 5 hours)

A 16 December 2004 report from the Instituto Geofísico (IG) of the Escuela Politécnica Nacional calls attention to renewed lava effusion from the crater that lies within Reventador's large summit cone (figure 10). A block-lava flow escaped the cone's crater. It ran out at a breach in the S wall, and by 16 December it had advanced ~ 2 km farther. The flow advanced SE along a narrow, E-curving path, remaining atop lavas from 2002. Thus far in 2004, lava flows remained well within the larger caldera.

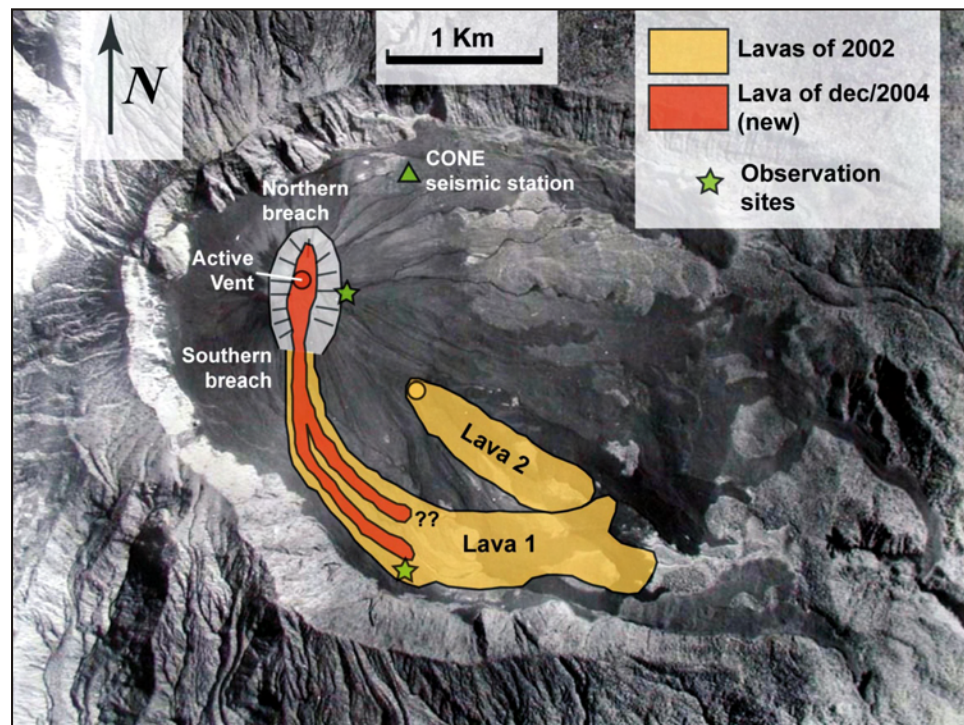


Figure 10. An aerial photo of Reventador's 4-km-diameter caldera as a base for mapping the lava flows of 2002 and those of 2004 through mid-December. The 2002 flows are labeled Lava 1 and Lava 2. The 2004 lava flow followed and partly covered Lava 1. At a distance of ~ 1 km from the vent, the 2004 lava flow bifurcated into two closely spaced parallel lobes. The caldera has an E-tilting floor, is open on its E side, and contains a prominent cone on its W side. The cone forms the volcano's summit, and contains an elongate crater that hosts the 2004 vent ("active vent"). The crater has a rim that is indicated by a solid curving line; the crater's inward-sloping walls are indicated by light shading and lines resembling the trends of gullies. The cone's floor at its southern breach lies at ~ 3,200 m elevation. The aerial photo was taken by Instituto Geográfico Militar in 1983. Figure courtesy of IG.

Reports in 2003 chiefly discussed events outside the caldera. A road, one gas pipeline, and two oil pipelines traverse Reventador's flanks 7 km ESE of the active vent. All of these installations were affected in 2003 (but not appreciably since then). The pipelines were destroyed due to heavy lahars coming down the Reventador river on 6 May 2003 (*Bulletin* v. 28, no. 6). Our last report (*Bulletin* v. 28, no. 11) discussed events during July through most of November 2003.

Lava venting in the crater likely began in early November 2004, a time when seismic station CONE registered dramatic increases in volcano-tectonic events (figure 11). In response to the elevated seismicity, the IG-EPN began more intensive monitoring, including overflights with thermal imaging, repeat visits to the remote volcano, and on 9 November 2004, installation of the additional short-period seismic station LAV3, ~ 2 km from the crater's vent.

A helicopter overflight by IG-EPN staff on 10 November 2004 confirmed the presence of a small lava dome, which appeared then to be confined to the crater floor. This feature was not present on photos taken during an IG overflight on 19 October 2004. During the 10 November overflight, a continuous 2.5 km-high gas column escaped from the crater, accompanied by sulfurous odors detected by personnel in the helicopter.

The date when lava began escaping the crater was not precisely known, but it was thought to have been around 22 November, coincident with the emergence of distinct seismic signals not previously observed at Reventador (figure 11). The signals occurred in swarms and consisted of low-frequency (1-10 Hz) waves of relatively low-amplitude. Their seismic records were emergent (i.e. growing in amplitude with time) and of long duration (up to 60 seconds). They are thought to have been possibly associated with rock falls from lava flowing down the cone's southern flank. As many as 200 of these events were recorded each day at station CONE.

A return visit to the crater rim on 28 November (this time on foot) documented abundant fresh lava in the crater (figure 12), a dramatic increase in the volume of lava there. At least $0.5 \times 10^6 \text{ m}^3$ of new lava then covered the entire crater floor and appeared to be already flowing out of the



Figure 12. Reventador's 2004 lava flow/dome as seen on 28 November 2004. The photo was taken looking W and downward from the cone's eastern crater rim (see vantage point indicated by the star on figure 11). Courtesy of IG.

southern breach and into the surrounding caldera. Because of cloudy weather, the exact extent of the flow remained indeterminate. The surface of this lava flow also extended to the N and reached a level ~ 20 m below the northern breach. Continuous lava extrusion or flowing or both were heard within the crater, making sounds akin to glass breaking, and vigorous roaring gas emissions originated from the crater's western margin. These gas emissions and other smaller fumaroles contributed to a plume that was continuously present, extending at least 1 km above the vent.

IG observers estimated that the total mid-December lava flow volume was $\sim 3 \times 10^6 \text{ m}^3$. The inferred 22 November date of flow onset would imply a steady-state extrusion rate of $\sim 0.1 \times 10^6 \text{ m}^3$ per day and a flow front advancing at $\sim 80 \text{ m}$ per day. These observations appear to conform with satellite thermal infrared observations, which noted no significant anomalies until the end of November, due presumably in large part to the lava being confined within the steep-walled crater. Inclement weather occurred and also may have impeded some of the satellite thermal observations.

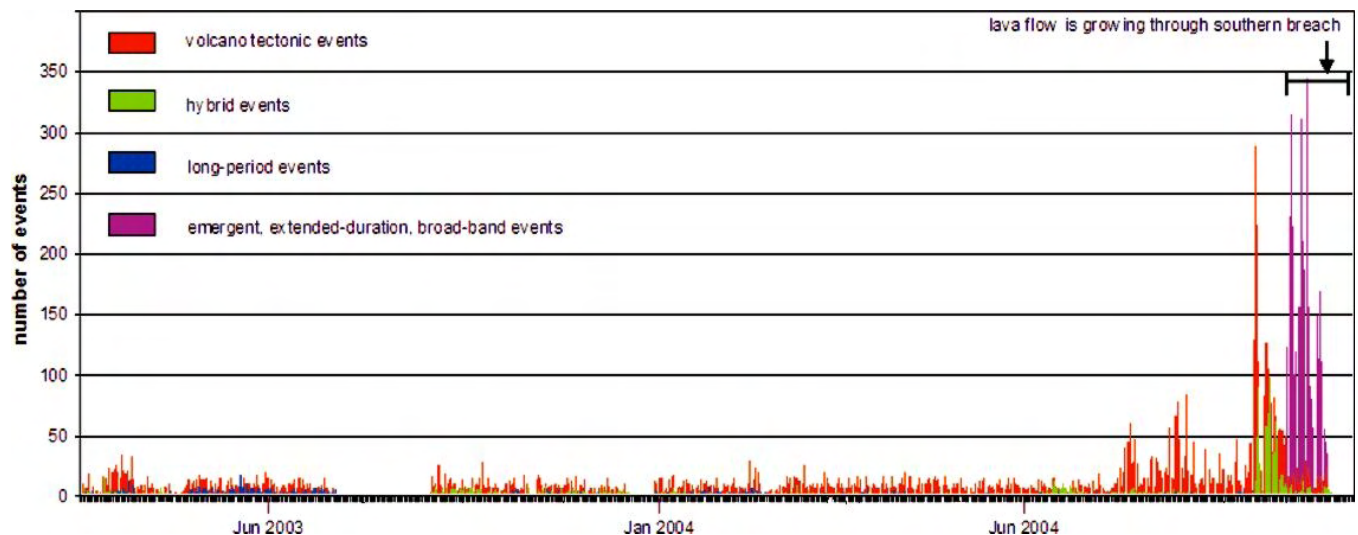


Figure 11. Seismicity (number of earthquakes) versus time registered at Reventador (station CONE) during mid-February 2003 through mid-December 2004. Anomalous elevated seismicity consisting mainly of volcano-tectonic began in August 2004. Activity increased on 4 November 2004 and included hybrid events. Previously unseen emergent, extended-duration, broad-band earthquakes began on 22 November 2004. Courtesy of IG.

The most recent visit to the crater rim, on 11 December 2004, traced the source of degassing and lava outflow to the most elevated portion of a small dome-like feature at the central western margin of the crater. Figure 13 shows how instrumentally aided nighttime incandescence observations disclosed both the vent area and surficial flow-textures extending S towards the southern breach of the cone. Figure 14 also documents a comparatively narrow arm of lava trending towards the cone's northern breach. Nighttime incandescence from the lava flow was also visible from local communities such as El Chaco, ~ 20 km distant.

Figure 14 illustrates the scene on 12 December 2004 during a visit to the front of the most advanced lobe of lava (for location, see star at end of flow lobe, figure 9). IG-EPN staff estimated the flow front at ~ 20 m high and saw incandescent blocks falling off of it.

Background. Reventador is the most frequently active of a chain of Ecuadorian volcanoes in the Cordillera Real, well E of the principal volcanic axis. The forested dominantly andesitic stratovolcano rises to 3,562 m above the remote jungles of the western Amazon basin. A 4-km-wide caldera widely breached to the E was formed by edifice collapse and is partially filled by a young, unvegetated stratovolcano that rises about 1,300 m above the caldera floor to a height above the caldera rim. Reventador has been the source of numerous lava flows as well as explosive eruptions that were visible from Quito in historical time. Frequent lahars in this region of heavy rainfall have constructed a debris plain on the eastern floor of the cal-

dera. The largest historical eruption at Reventador took place in 2002, producing a 17-km-high eruption column, pyroclastic flows that traveled up to 8 km, and lava flows from summit and flank vents.

Information Contacts: *Patricio Ramón, Daniel Andrade, David Rivero, Alexandra Alvarado, Sandro Vaca, and Pete Hall*, Geophysical Institute (IG), Escuela Politécnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: <http://www.igepn.edu.ec/>; Email: pramon@igepn.edu.ec; dandrade@igepn.edu.ec; mhall@igepn.edu.ec); *Jeffrey B. Johnson*, Dept. of Earth Sciences, James Hall University of New Hampshire, Durham, NH 03824 (jeff.johnson@unh.edu); *MODIS Thermal Alert System*, Hawaii Institute of Geophysics and Planetology (HIGP), School of Ocean and Earth Science and Technology, University of Hawaii at Manoa (URL: <http://www.modis.higp.hawaii.edu>).

Fuego

Guatemala

14.47°N, 90.88°W; summit elev. 3,763 m

All times are local (= UTC - 6 hours)

Explosions and lava flows at Fuego continued after October 2003 (*Bulletin* v. 28, no. 10). Similar activity prevailed through 2003 and 2004. This report discusses events during November-December 2003 and includes a table summarizing Fuego's 2003 behavior (table 3). A future report will discuss 2004 activity and will include a map showing critical place names. Several pyroclastic flows occurred in 2003.

Tremor was common and at times abundant during 2003, including in the last two months of the year. On 21 November, almost continuous harmonic tremor was detected for a span of 21 hours. On 23 November intervals of tremor lasted between 0.5 and 3 hours.

The Washington VAAC archive contains 48 ash advisories

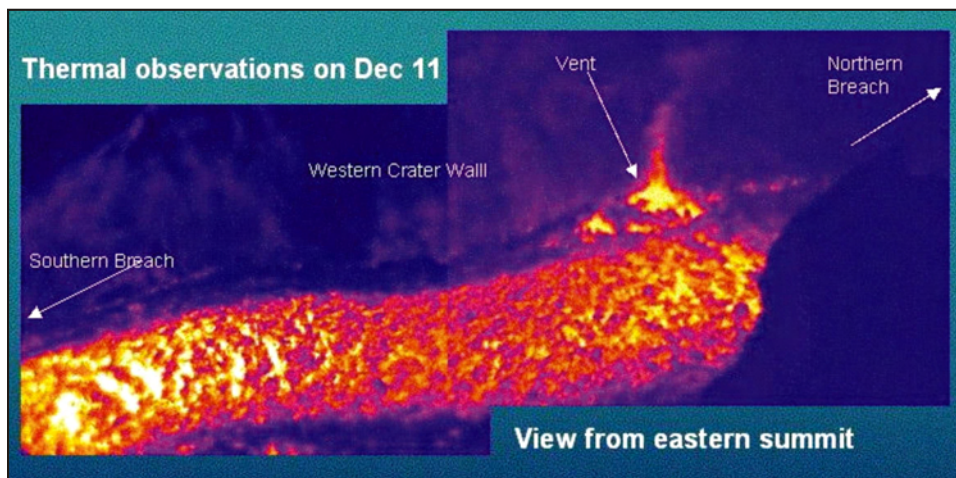


Figure 13. Thermal image of the lava flow in the interior of Reventador crater taken with a Forward Looking Infrared (FLIR) imager at 2000 on 11 December 2004. Courtesy of IG.



Figure 14. A N-looking view of Reventador's gray-colored lava-flow front taken on 12 December 2004 at ~2,600 m elevation. Person at right indicates scale of the advancing flow front. The lava flow emanated from the breach in the S side of the cone's crater, a spot seen in the photo's upper left. Courtesy of IG.

Date	Lava flows, incandescent avalanches, and pyroclastic flows (PFs)	Ash column and ash fall	Data source(s)
08 Jan 2003	Lava flows. Two PFs (down Sta. Teresa drainage).	Steam-and-ash to ~ 5.7 km a.s.l., drifted W.	INSIVUMEH, CONRED, Washington VAAC, EFE via COMTEX, Prensa Libre
Mid Jan 2003	Incandescent avalanches down flanking canyons.	~ 2 km above summit, drifting S and SW, depositing fine ash.	INSIVUMEH, Washington VAAC
28 Apr-01 May	Incandescent avalanches.	Intermittent ash eruptions, One ash plume reached ~ 7 km a.s.l., blown SW at 20-30 km/hour; some puffs visible over the coast.	INSIVUMEH, Washington VAAC; US Air Force Weather Agency
29 Jun 2003	Lava flows and avalanches down E flank (incandescence seen from city of Antigua and the coast). PFs extended ~ 1.5 km down the W flank.	Ash fell in villages to W and SE; Ash clouds to ~ 900 m.	INSIVUMEH
09 Jul 2003	Lava dome collapse PFs.	Strong explosions sent ash to ~ 2 km above summit; ash fell to W and SE of summit.	Washington VAAC, Prensa Libre
07 Aug 2003	–	A small ash emission seen on satellite imagery. The ash cloud drifted NW and covered an area about 3.5 by 3.5 km.	Washington VAAC
08 Sep 2003	–	Ash plumes; one drifted S and covered an area of 5 x 5 km; another rose to ~ 6 km a.s.l.	Washington VAAC
09 Oct 2003	–	A pilot saw Fuego ash reaching ~ 4.6 a.s.l. No ash was visible on satellite imagery.	Washington VAAC
17 Oct 2003	Small incandescent avalanche down the Sta. Teresa valley.	A 33-minute-long eruption sent a gas-and-ash plume to ~ 1.5 km above the crater.	INSIVUMEH
Nov-Dec 2003	Incandescent avalanches.	4 November explosions threw material 150 m above crater rim; 18-19 November, gas-and-ash plumes up to 1.2 km above the crater; 28 Nov.-1 Dec, 700-900 m above the crater; 7-9 December, 500 m above crater; 10-16 December, 200-1000 m above the crater, and 18-22 and 30 December, 'low-level plumes.'	INSIVUMEH

Table 3. Representative examples of reported volcanism at Fuego during 2003. Courtesy of INSIVUMEH.

on Fuego. The number of these advisories were as follows, during the stated months of 2003: 14 advisories in January (on the 8th, 9th, 11th, 12th, and 20th); 11 in April (on the 17th, 28th, 29th, and 30th); eight in May (1st and 2nd); three in June (30th), six in July (1st, 9th, and 10th), two in August (7th), two in September (29th); and two in October (9th). The most impressive plumes depicted in satellite-based graphics were for 28 April-1 May 2003, when they often stretched well out to sea, reaching ~ 160 km SW from Fuego. Otherwise, the graphics generally depicted much smaller plumes, in some cases very local ones. The graphic for 28 September showed small plumes from Fuego as well as simultaneous ones from Pacaya and Santa María.

Background. Volcán Fuego, one of Central America's most active volcanoes, is one of three large stratovolcanoes overlooking Guatemala's former capital, Antigua. The scarp of an older edifice, Meseta, lies between 3,763-m-high Fuego and its twin volcano to the N, Acatenango. Collapse of the ancestral Meseta volcano about 8,500 years ago produced the massive Escuintla debris-avalanche deposit, which extends about 50 km onto the Pacific coastal plain. Growth of the modern Fuego volcano

followed, continuing the southward migration of volcanism that began at Acatenango. In contrast to the mostly andesitic Acatenango volcano, eruptions at Fuego have become more mafic with time, and most historical activity has produced basaltic rocks. Frequent vigorous historical eruptions have been recorded at Fuego since the onset of the Spanish era in 1524, and have produced major ashfalls, along with occasional pyroclastic flows and lava flows.

Information Contacts: *Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (INSIVUMEH)*, Unit of Volcanology, Geologic Department of Investigation and Services, 7a Av. 14-57, Zona 13, Guatemala City, Guatemala (URL: <http://www.insivumeh.gob.gt/>); *Washington Volcanic Ash Advisory Center (VAAC)*, Satellite Analysis Branch, NOAA/NESDIS E/SP23, NOAA Science Center Room 401, 5200 Auth Road, Camp Springs, MD 20746 USA (URL: <http://www.ssd.noaa.gov/>); *Charles R. Holliday*, Air Force Weather Agency, Offutt Air Force Base, Nebraska 68113 USA; *Prensa Libre* (newspaper), 13 calle 9-31 zona 1, 01001 Guatemala City, Guatemala (URL: <http://www.prensalibre.com/>).

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