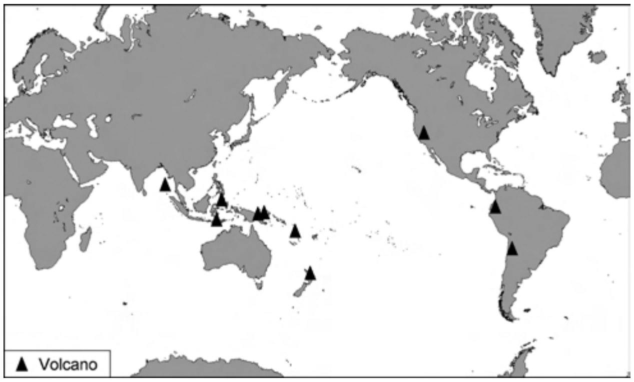
Bulletin of the Global Volcanism Network



Volume 30, Number 5, May 2005

Smithsonian
National Museum of Natural History

Editors: Rick Wunderman, Catherine Galley, Edward Venzke, and Gari Mayberry

Volunteer Staff: Robert Andrews, William Henoch, Clement Pryor, Jacquelyn Gluck, and Stephen Bentley

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/

Subscriptions are provided by the American Geophysical Union (see the box on the last page for details).

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

Ambrym

Vanuatu, SW Pacific
16.25°S, 168.12°E; summit elev. 1,334 m
All times are local (= UTC + 11 hours)

Jenifer Piatt, a meteorologist with the Air Force Weather Agency in the Satellite Applications Branch, notified *Bulletin* staff on 17 June 2005 that haze had appeared near Ambrym on MODIS imagery over the past few days. Over the past several months, this volcano had been emitting SO_2 and sometimes light ash. She informed us of several recent news articles that addressed this event and provided several satellite images (figure 1).

Tony Ligo wrote on 1 June 2005 in the Port Villa Presse that acid rain continued to fall in W Ambrym Island in Vanuatu, even after ash from the volcano had stopped falling. This prompted the provincial secretary general to discuss the need for new water sources. The Vanuatu government, through the department of Rural Water Supply, agreed to provide a drilling rig to the Malampa provincial government to drill on W Ambrym as soon as possible.

The government also recognized the value of scientific and technical data; in order to effectively respond to such environmental problems the government needs to get more young people studying in this area. The article noted that Vanuatu only has one volcanologist, Charley Douglas, with enough background to give accurate data on current activity.

Aid and food have been sent to affected areas on the western coast of the island, and a contingency evacuation plan is required for resettling people should this be necessary in the future. Health issues have been raised regarding hygiene, respiratory problems, asthma, and malnutrition over the past couple of months. Of great concern are health problems particular to children, including exposure to excess fluoride and the consequent risk of bone disease.

The National Aeronautics and Space Administration (NASA) Earth Observatory web site reported that Ambrym volcano was the strongest point source of SO_2 on the planet for the first months of 2005; it had been steadily emitting SO_2 for at least 6 months, and satellite images produced using data collected by the Ozone Monitoring Instrument (OMI) on NASA's Aura satellite during the first 10 days of March 2005 show high concentrations of SO_2 drifting NW.

The web site article noted that "Ambrym is not erupting in the traditional sense with thick ash plumes and explosive bursts of lava, rather it is leaking SO_2 gas from active lava lakes in what scientists call 'passive"or "non-eruptive" emissions. Despite these gentle names, the volcano still threatens the local population. SO_2 has a strong smell and can irritate the eyes and nose and make breathing difficult. Higher in the atmosphere, SO_2 combines with water to create rain laced with sulfuric acid. On Ambrym, acid rain has destroyed staple crops and contaminated the water supply, leaving communities in need of food aid." In the past, satellites have been able to monitor SO_2 emissions only from large eruptions or the most powerful passive degassing. All other SO_2 emissions remain at low altitudes and have low SO_2 concentrations that were hard to see from space.

On 15 July 2004, NASA launched its Aura satellite carrying the OMI, which is part of a collaboration between the Netherlands' Agency for Aerospace Programs, the Finnish Meteorological Institute, and NASA. With greater spatial resolution (the ability to "zoom-in" to see greater detail) and higher sensitivity to SO_2 than any previous space-borne sensor, OMI allows scientists to study passive volcanic degassing on a daily basis for the first time.

The image in figure 2 is an example of the instrument's preliminary, uncalibrated, and unvalidated data. This new view of passive volcanic emissions could lead to significant advances in understanding both volcanic eruptions and the impact of SO_2 on climate. Changes in passive emissions can be a precursor to explosive eruptions, and thus provide a warning signal that activity may be changing.

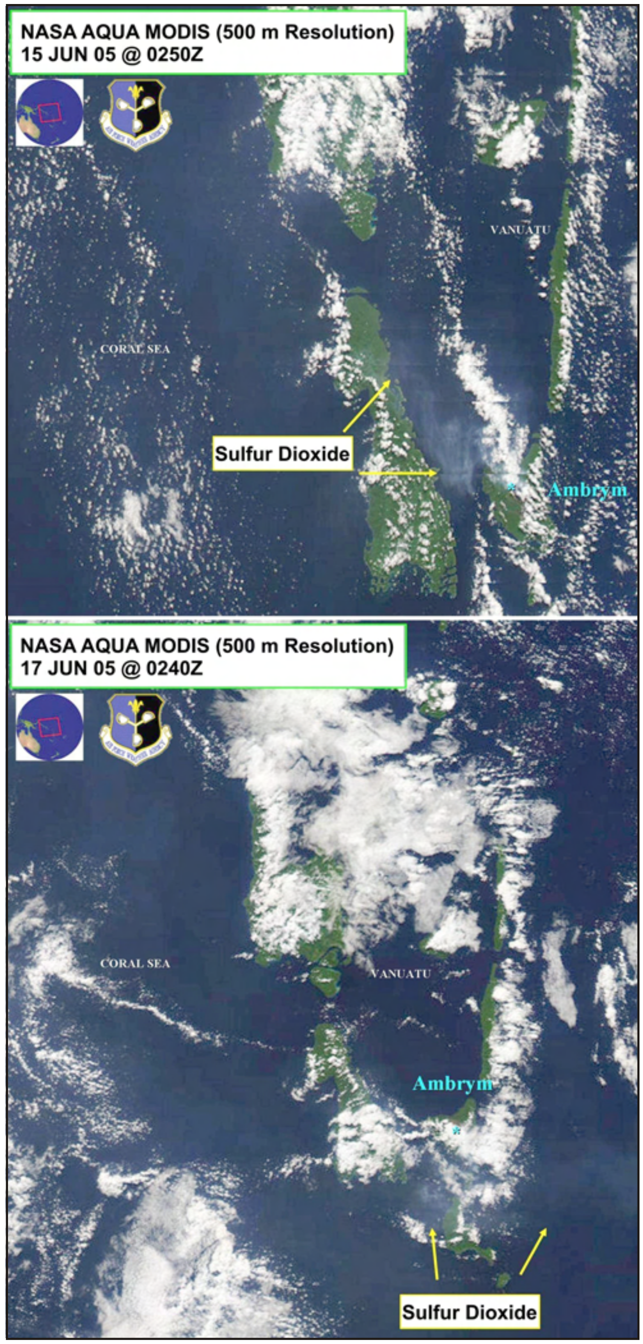


Figure 1. Images for 0250 UTC 15 June 2005 (top), and 0240 UTC 17 June 2005 (bottom) disclosing the area around Vanuatu including Ambryn. The images came from NASA's AQUA MODIS satellite with a resolution of 500 m. SO_2 plumes from Ambrym are labeled. NASA image courtesy of USAF Weather Agency.

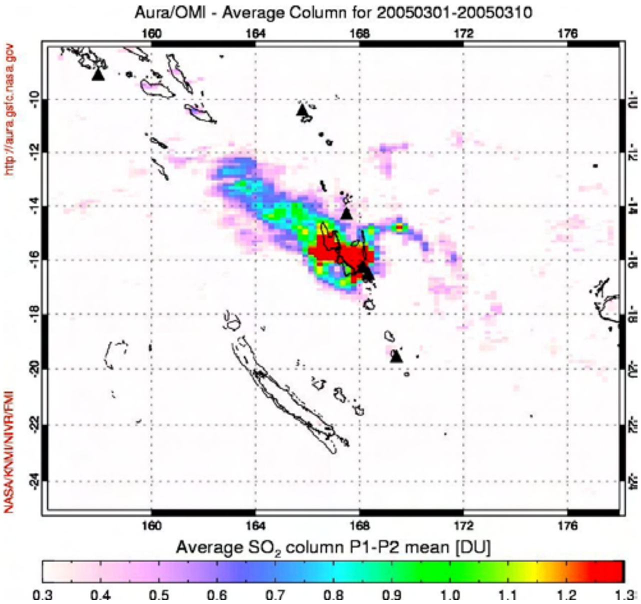


Figure 2. A zone of elevated atmospheric SO_2 from Ambrym during the interval 1-10 March 2005. The units on the scale bar reflect SO_2 in terms of Dobson Units (DU). (A Dobson Unit represents the physical thickness of the SO_2 gas if a 1 cm^2 column of the atmosphere were brought to 0°C and 1 atmosphere pressure. A value of 300 Dobson Units equals three millimeters.) To process the OMI spectrometer data, two different pairs of measured UV wavelengths are averaged. The mean of pairs 1 and 2 is written as "P1-P2 mean" on the scale bar. Courtesy of Simon Carn.

Background. Ambrym, a large basaltic volcano with a 12-km-wide caldera, is one of the most active volcanoes of the New Hebrides arc. A thick, almost exclusively pyroclastic sequence, initially dacitic, then basaltic, overlies lava flows of a pre-caldera shield volcano. The caldera was formed during a major Plinian eruption with dacitic pyroclastic flows about 1,900 years ago. Post-caldera eruptions, primarily from Marum and Benbow cones, have partially filled the caldera floor and produced lava flows that ponded on the caldera floor or overflowed through gaps in the caldera rim. Post-caldera eruptions have also formed a series of scoria cones and maars along a fissure system oriented ENE-WSW. Eruptions have apparently occurred almost yearly during historical time from cones within the caldera or from flank vents. However, from 1850 to 1950, reporting was mostly limited to extra-caldera eruptions that would have affected local populations.

Information Contacts: *Jenifer E. Piatt*, HQ Air Force Weather Agency Satellite Applications Branch (URL: Jenifer.Piatt@afwa.af.mil); *Simon Carn*, TOMS Volcanic Emissions Group, University of Maryland, 1000 Hilltop Circle, Baltimore, MD 21250, USA (Email: scarn@umbc.edu; URL: http://skye.gsfc.nasa.gov/); NASA Earth Observatory Natural Hazards web page (http://earthobservatory.nasa.gov/NaturalHazards/).

Manam

Papua New Guinea
4.10°S, 145.06°E; summit elev. 1,807 m
All times are local (= UTC + 10 hours)

Manam erupted several times during October to December 2004 and January 2005. A strong eruption on 24 October 2004, preceded by a buildup in seismicity and a felt earthquake, was described in *Bulletin* v. 29, no. 10. This eruption generated pyroclastic flows, and its plume was imaged from space. The eruption sent ash and condensed water in the form of ice to a maximum height of ~ 15 km altitude. On 10-11 November 2004, a Strombolian eruption occurred; the ash column was estimated to have risen ~ 5-6 km above the crater. On 23-24 November 2004 Manam's 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. Details and reports of eruptions in November and December 2004 were included in *Bulletin* v. 29, no.11.

The eruption at Manam on the evening of 27 January 2005 (*Bulletin* v. 30, no. 2) was more severe than the previous ones during the current eruptive period. During 27-28 January 2005 there were 14 people injured and one person killed at Warisi village. The reports of the Rabaul Volcano Observatory (RVO) and the Darwin VAAC, and an analysis of the Manam eruption clouds by Andrew Tupper of the Darwin VAAC, were summarized in *Bulletin* v. 30, no. 2. In late January, five commercial flights were cancelled from Rabaul, East New Britain, delaying about 100 passengers.

Documented occurrence of olfactory fatigue. A report received from Andrew Tupper discussed an encounter of an aircraft with an airborne gas plume that took place about 2300 UTC on 29 January (0800 on the 30th, East Timor time) reported to him by a pilot. The encounter took place at a considerable distance from Manam, and a map is helpful to visualize the region's geography (figure 3). The incident involved entry into a visibly anomalous, hazy-blue cloud that turned out to contain sulfurous odor (figure 4). Although Tupper and the pilot discussed other possibilities for

Figure 3. The airport at Dili, East Timor (Indonesia), located about 2,200 km WSW of Manam.

Figure 4. The hazy blue cloud that produced a sulfur smell in the cockpit of the plane approaching Dili. The photo was taken by the air crew (names not given).

the cloud's origin, Tupper came to the conclusion that the cloud was volcanic fog (vog) erupted from Manam.

Key portions of the pilot's message conveyed to us by Tupper follow.

"On descent into Dili, approaching 10,000 feet at 12 nautical miles [~ 3 km altitude and ~ 22 km from the airport] aircraft control levers were pulled back to flight idle just prior to entering a thin layer of smooth stratus cloud [figure 4].

"Shortly after passing into the cloud, a strange smell was soon noticed in the cockpit; once the accusations of responsibility had passed, it quickly became apparent that the smell was not the result of a bodily function. The smell became very strong, with high sulfur content. As a precaution the Captain directed the First Officer to don his oxygen mask. The smell persisted but began to weaken on descent, and landing was accomplished without incident. After landing, First Officer removed the oxygen mask and noted the smell had remained. The captain had by this time become desensitized to the smell. Upon shutdown, unloading was halted, until such time as the cargo hold could be examined for a source of the smell. No smell remained."

Tupper and the pilot discussed possible sources for the smell. The cloud displayed a distinct blue haze (Tupper commented that "it's difficult to tell from the attached photo whether the blue is all that out-of-the-ordinary, but obviously they thought it interesting enough to take a photo!"). The cloud sat on the hills and appeared to have fog-like characteristics. The pilot described the odor as sharper and more metallic than the smell of H_2S (a description consistent with SO_2, the odor of which is sometimes described as metallic or akin to a struck-match.

What caused the sulfurous-smelling stratus cloud? The sulfur content may have come from either nearby volcanoes, none of which have been reported as active, or from industrial production (possibly Kupang). Due to a serious dengue outbreak in East Timor, it may have been the result of chemical mosquito control. Many chemical methods of mosquito control are based on sulfur products. Malathion is one such product; it contains mercaptan, which has a strong noxious odor. (Organic compounds with HS bound to carbon are called mercaptans or thiols and those of low molecular weight have strong smells. Small doses of mercaptan are often used to give natural gas a distinctive odor.) One possible way to explain the sulfurous gases was morning fog moving up the hills of Dili in response to anabatic (upslope-blowing) winds, which also carried residual insecticide.

Tupper spoke to or emailed the pilot several more times to get the following other details. The aircraft was an Embraer E120, a 30 seat turbo prop, with 20-25 people on board. The cabin attendant also noticed the smell, but no passengers commented. Despite the speculation about chemicals above, this was the only trip on which the smells had been noticed by the pilot.

According to Claire Witham, human perception of SO_2 odor varies depending on the individual's sensitivity, but SO_2 is generally perceived between 0.3-1.4 ppm and is easily noticeable at 3 ppm. This is generally below the level where health effects (e.g. respiratory response) might be noted. In general an exposure limit of 1-5 ppm is the threshold for respiratory response in healthy individuals upon exercise or deep breathing, whilst at 3-5 ppm the gas is easily noticeable and may cause a fall in lung function in persons at rest, and increased airway resistance. Asthmatic individuals may respond at much lower concentrations, and prolonged exposure to low concentrations carries increased risk for those with pre-existing heart and lung diseases. A more detailed review of gas hazards and guidelines has just gone online on the International Volcanic Health Hazard Network.

Significant in this event is that the flight crew thought that the smell had dissipated. The First Officer, who was wearing an oxygen mask, remained able to detect that the smell persisted. This indicates that the others in the crew lost their ability recognize that the sulfurous odors remained, a well-know effect of sulfurous gases called olfactory fatigue ('bombarded nerve receptors'), a potentially confusing situation for pilots focused on escaping from a volcanic plume (Wunderman, 2004).

Tupper conducted dispersion modeling of the 27 January 2005 Manam eruption (figure 5). The results suggested that the SO_2 cloud from the volcano probably passed over East Timor on the night before the incident and at higher altitudes. This is supported to a limited extent by the preliminary ozone and SO_2 monitoring results (figure 6), which suggest that the bulk of the cloud went N, but that part of the cloud traveled over the Banda Sea and passed over East Timor. The low level winds are highly unlikely to have car-

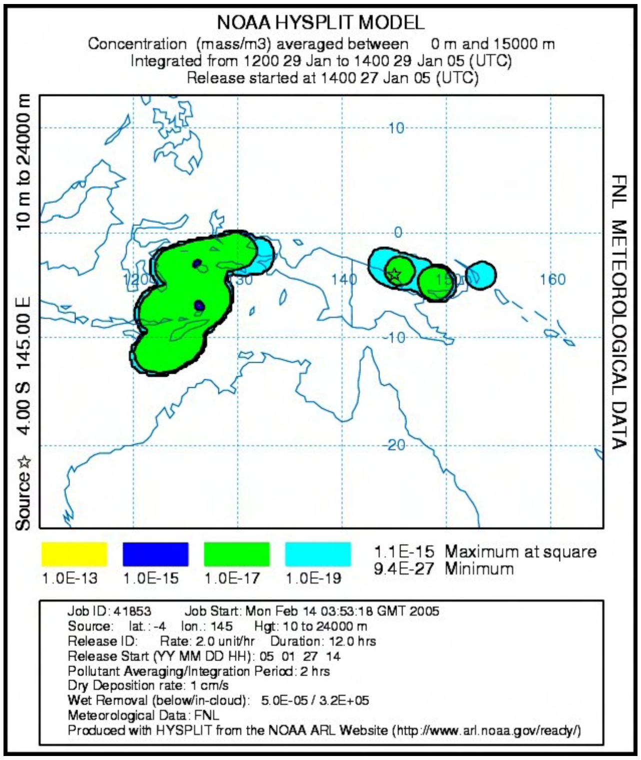


Figure 5. An ash dispersion model for the eruption cloud associated with the eruption of Manam on 27 January 2005. The model takes into account wind at various altitudes and other meteorological data, and predicts the movement of material injected in the atmosphere. The model used, NOAA hysplit, adopted the boundary condition that material was above the volcano between 10 and 24 km altitude starting at 1400 on 27 January. The results shown predict the dispersal for the interval 1200-1400 on 29 January. The model indicates that some material from Manam's 27 January eruption traveled WSW to where the aircraft-gas plume encounter took place. The model is a product of the NOAA Air Resources Lab with this particular run provided by Andrew Tupper.

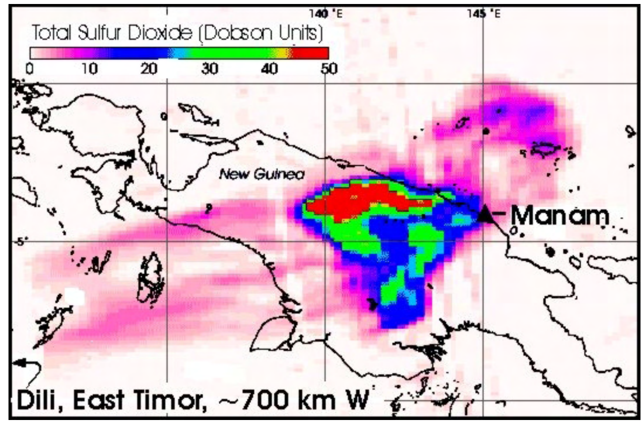


Figure 6. A satellite image of atmospheric SO_2 burden from Manam made about 12 hours after the 27-28 January 2005 eruption. The image resulted from the NASA Ozone Monitoring Instrument (OMI), which flew over the region on NASA's new Aura satellite. This image was produced from preliminary, uncalibrated data provided by the OMI. The OMI detected a large cloud of SO_2 drifting W over the island of New Guinea. The gas is measured in Dobson Units (DU), a reflection of the number of molecules in a square centimeter of the atmosphere. Darker pixels cover the areas of highest concentration, while the lowest concentrations are represented by lighter ones (red and pink, respectively, on the colored electronic version of the *Bulletin*). If you were to compress all of the SO_2 in a column of the atmosphere into a flat layer at standard temperature and pressure, one Dobson Unit would be 0.01 mm (millimeters) thick and would contain 0. 0285 grams of SO_2 per m^2. On January 28, the atmosphere over New Guinea contained up to 50 Dobson Units (red regions), or 1.425 grams of SO_2 per square meter. NASA image and caption courtesy Simon Carn, Joint Center for Earth Systems Technology.

ried the SO_2 to East Timor, but there was significant storm activity on the night when the cloud would have passed over. Excluding other explanations on the grounds that the eruption / encounter timing are unlikely to be mere coincidence, the most likely explanation for the flight crew's experience is that some eruption products from Manam were rained out over East Timor on the night of 29 January 2005. If SO_2 had been incorporated into ice particles, which then rained out, the particles would have melted and released SO_2 at about the level of the encounter, where the temperature was a bit above freezing. According to this scenario, the plane then flew through the resultant vog/stratus the next morning.

Infrasound reports. The Comprehensive Nuclear Test Ban Treaty Organisation (CTBTO) is installing a world-wide network of 60 infrasound stations as part of the International Monitoring System (IMS) for detection of nuclear tests. The stations, some of which are already functioning, use microbarographs (acoustic pressure sensors) to detect very low-frequency (0.01-10 Hz) sound waves in the atmosphere produced by natural and anthropogenic events.

The eruption at Manam on 27 January at ~ 1400 UTC was detected at several infrasound stations around the Pacific (table 1). In one case a signal was received at a distance exceeding 10,000 km. The sound of the explosion took more than ten hours to reach that most distant station, located in Washington state (USA). The difference in the calculated and measured signal azimuths is likely caused by high atmosphere winds, and is reasonable given the great distances that the signal traveled.

Subsequent RVO observations. Although it remained active, Manam calmed considerably during February-May 2005. During the first two weeks of February 2005, emissions from Manam continued. On 15 February 2005, the

CTBTO Infrasound Station	Calculated great circle path, station to volcano		Measured signal azimuth (°E of N)	Date	Arrival time
	Azimuth (°E of N)	Distance (km)			
I07AU Warramunga, Central Australia	35	2079	32	27 Jan 2005	16:00 UTC
I22FR New Caledonia	311	3091	n/a	n/a	Not observed
I05AU Tasmania, Australia	356	4270	350	27 Jan 2005	18:30 UTC
I55US Windless Bight, Antarctica	336	8303	335	27 Jan 2005	22:07 UTC
I53US Fairbanks, Alaska	247	9358	252	27 Jan 2005	23:12 UTC
I56US Newport, Washington	273	10920	276	28 Jan 2005	00:34 UTC

Table 1. Arrival times and great circle paths for infrasound signal from Manam eruption on 27 January 2005 received at CTBTO infrasound stations. Courtesy of Robert North.

alert level was reduced from 3 to 2. Mild eruptive activity was observed from Manam's Southern crater during the third week of February. Weak-to-moderate ash explosions rose a few hundred meters above the crater and drifted E and SE, depositing fine ash in areas downwind. Throughout February, seismicity was at low levels, with small low-frequency earthquakes occurring and no volcanic tremor. Throughout March, weak-to-moderate emissions from both the Main and Southern craters continued to produce occasional ash clouds during most days. On 15 March, a thin plume from Manam was visible on satellite imagery. On 24 March, emissions from Main crater rose to ~ 1 km above the summit. On 28 March, a moderate explosion produced an ash plume to a height of ~ 1.2 km above the summit. Ash plumes drifted N, depositing ash on the island. Seismic activity fluctuated between low and moderate, with low-frequency earthquakes recorded.

During April and May 2005, mild eruptive activity continued at the volcano. Manam remained at alert level 2 from February 2005 through at least late May. A thin plume extending 55 km NW on 4 May was seen on satellite imagery by the Darwin VAAC. The ash cloud remained below 3 km altitude.

Background. 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. 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.

Reference: Wunderman, R., 2004, Sulfurous odors: A signal of entry into an ash plume–perhaps less reliable for escape, Second International Conference on Volcanic Ash and Aviation Safety (Alexandria, Virginia, USA), 21-24 June 2004 (Plenary Session 1: Encounters, Damage, and Socioeconomic Consequences, poster P 1.2, Socioeconomic consequences) (http://www.ofcm.gov/ICVAAS/Proceedings2004/ICVAAS2004-Proceedings.htm).

Information Contacts: *Andrew Tupper*, Darwin Volcanic Ash Advisory Centre, Australian Bureau of Meteorology (URL: http://www.bom.gov.au/info/vaac); *Rabaul Volcano Observatory* (RVO), P.O. Box 386, Rabaul, Papua New Guinea; *David Innes*, Flight Safety Office, Air Niugini, PO Box 7186, Boroko, Port Moresby, National Capital District, Papua New Guinea (Email: dinnes@airniugini.com.pg or deejayinnes@yahoo.com, URL: http://www.airniugini.com.pg/); *International Volcanic Health Hazard Network* (URL: http://www.ivhhn.org/); *Simon Carn*, TOMS Volcanic Emissions Group, Univ. of Maryland, 1000 Hilltop Circle, Baltimore, MD 21250, USA (Email: scarn@umbc.edu; URL: http://skye.gsfc.nasa.gov/); *Claire Witham*, Meteorology Office, FitzRoy Road, Exeter, EX1 3PB, UK (Email: claire.witham@metoffice.gov.uk); *Robert North*, SAIC Monitoring Systems Division, 1953 Gallows Rd., Vienna, VA 22182, USA (Email:robert.g.north@saic.com); *NOAA Air Resources Lab (ARL)*, Room 3316, 1315 East-West Highway, Silver Spring, MD 20910, USA (URL: http://www.arl.noaa.gov/ready/).

Langila

Papua New Guinea
5.525°S, 148.42°E; summit elev. 1,330 m
All times are local (= UTC + 10 hours)

Langila was last reported on in *Bulletin* v. 29, no. 6, as part of a MODIS data summary, although the last prominent event there was on 18 January 2003, when a large explosion produced a thick dark ash column that penetrated the weather clouds over the summit area (*Bulletin* v. 28, no. 3).

A plume from Langila was visible on satellite imagery on 17 December 2004 according to the Darwin VAAC. The plume reached an unknown height and extended NW.

Between 28 April 2005 and 4 May 2005 the Rabaul Volcano Observatory (RVO) received reports of activity at Langila characterized by forceful emissions of thick white to gray ash-laden clouds rising ~ 700-800 m above the summit crater. Occasional continuous rumbling and explosive noises were heard and incandescence was visible at night. During early May, incandescent lava fragments were ejected. Ac-

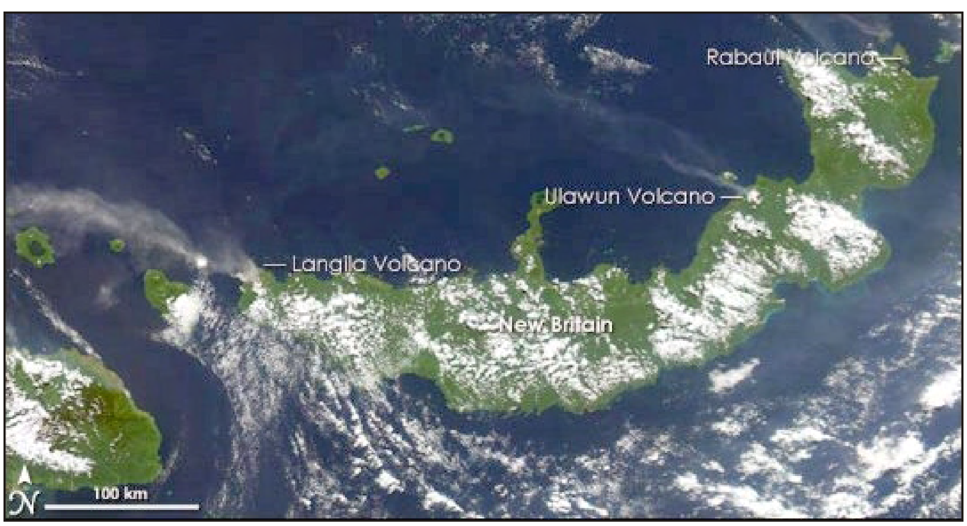


Figure 7. On 21 June 2005 the Moderate Resolution Imaging Spectroradiometer (MODIS), flying on NASA's Aqua satellite, captured this image of Langila, Ulawun, and Rabaul. At the time MODIS captured this image, Langila showed the biggest plume of volcanic ash, followed by Ulawun. In all cases, winds pushed the ash clouds NW over the ocean. NASA image courtesy Jesse Allen, based on data from the MODIS Rapid Response Team at NASA.

tivity increased at about 1300 on 4 May 2005, when white-to-gray ash emissions changed to dark ash clouds. Explosions became frequent, with incandescent lava fragments ejected again, and very bright glow was visible during the night. Around 1200 on 5 May 2005 the color of the ash emissions changed from dark gray to white-to-gray. A lava flow was produced but no further detail is available. Based on information from RVO, the Darwin VAAC reported that ash emissions from Langila rose to ~ 2.1 km altitude on 3 May. A very small plume and a hot spot were visible on satellite imagery. Ash clouds from the eruption were blown generally NW towards Kilenge ~ 100 km away, where light to moderate ashfall was reported.

According to the Darwin VAAC, low-level ash plumes emitted from Langila were visible on satellite imagery during 8-13 June 2005. RVO reported to the Darwin VAAC that moderate eruptive activity was expected to continue.

The International Federation of Red Cross and Red Crescent Societies (IFRC) reported that eruptive activity occurred at Langila on 2 June with more ash than normal being emitted from the volcano. Prevailing winds carried most of the initial ashfall to the sea, but lower-level winds redirected the ash back onto the island. About 10,000 people live near the volcano, and there were reports of increased cases of respiratory problems and eye irritation. During an aerial inspection of the area on 6 June 2005, IFRC determined that ~ 3,490 people had been affected by the eruption, mainly in the villages of Aitavala, Masele, Kilenge, Ongaea, Potne, and Sumel, but also to a lesser extent in Vem, Galegale, Tauale, and Laut. Ashfall damaged small food gardens and contaminated some water sources. The provincial government encouraged voluntary evacuation of affected areas.

During 16-17 June 2005, ash plumes from Langila were visible on satellite imagery (figure 7). The heights of the plumes were not reported.

Background. Langila, one of the most active volcanoes of New Britain, consists of a group of four small overlapping composite basaltic-andesitic cones on the lower eastern flank of the extinct Talawe volcano. Talawe is the highest volcano in the Cape Gloucester area of NW New Britain. A rectangular, 2.5-km-long crater is breached widely to the SE; Langila volcano was constructed NE of the breached crater of Talawe. An extensive lava field reaches the coast on the N and NE sides of Langila. Frequent mild-to-moderate explosive eruptions, sometimes accompanied by lava flows, have been recorded since the 19th century from three active craters at the summit of Langila. The youngest and smallest crater (no. 3 crater) was formed in 1960 and has a diameter of 150 m.

Information Contacts: *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/); *Rabaul Volcano Observatory* (RVO), P.O. Box 386, Rabaul, Papua New Guinea; *International Federation of Red Cross And Red Crescent Societies (IFRC)*, Langila Volcano Information Bulletin No. 1 (URL: http://www.reliefweb.int/).

Egon

Lesser Sunda Islands (Indonesia)
8.67°S, 122.45°E; summit elev. 1,703 m
All times are local (= UTC + 8 hours)

Table 2 below tabulates the seismic activity by date of the volcano prior to and subsequent to its eruption on 6 February 2005, but little was reported concerning that event. The volcano erupted again on 7 February. That eruption was accompanied by a strong smell of SO_2 or H_2S in the villages of Hebing and Hale and apparently rendered a villager unconscious.

On 8 February 2005 a fissure about 1 km long appeared along the southern slope. Vegetation along the fissure's margins had died, indicating that a gas blow out had occurred there. On 14 February 2005 at 1830 another explosion occurred. It was accompanied by significant seismic activity (see table 2). This latest eruption ejected ash and glowing material as high as 50 m above the summit. Volcanic earthquakes were frequent.

Distances increased for electronic distance measurements (EDM) during April, July, and October 2004 and during February 2005 (the last four measurements). During 25-27 February 2005 ash plumes rose to 50 m high. Volcano status remained at alert level 4 (the highest hazard status).

Background. Gunung Egon volcano sits astride the narrow waist of eastern Flores Island. The barren, sparsely vegetated summit region has a 350-m-wide, 200-m-deep crater that sometimes contains a lake. Other small crater lakes occur on the flanks of the 1,703-m-high volcano. A lava dome forms the southern 1,671-m-high summit. Solfataric activity occurs on the crater wall and rim and on the upper southern flank. Reports of historical eruptive activity prior to explosive eruptions in 2004 were inconclusive. A column of "smoke" was often observed above the summit during 1888-1891 and in 1892. Strong "smoke" emission in 1907 reported by Sapper (1917) was considered by the Cat-

Date	Volcanic B	Volcanic A	Emission	Low Frequency	Tectonic	Tremor amplitude	Alert Level
05 Jan 2005	16	1	7	6	8	2-3 mm	3
06 Jan 2005	48	—	3	—	7	1-2 mm	3
Week of 24 Jan	48	1	1	53	18	—	3
Week of 01 Feb	152	3	—	109	76	—	—
14 Feb 2005	32	17	—	—	5	30 mm	4
25-27 Feb 2005	61	4	24	2	19	1 mm	4

Table 2. A summary of counts for different earthquake types (type B volcanic, type A volcanic, emission, low frequency, and tectonic), tremor, amplitude, and Alert Level at Egon volcano. Unreported data indicated by "—". Courtesy of the Directorate of Volcanology and Geological Hazard Mitigation (DVGHM) DVGHM.

alog of Active Volcanoes of the World (Neumann van Padang, 1951) to be an historical eruption, but Kemmerling (1929) noted that this was likely confused with an eruption on the same date and time from Lewotobi Lakilaki volcano.

Information Contacts: *Dali Ahmad*, *Hetty Triastuty*, *Nia Haerani*, and *Sri Kisyati*, Directorate of Volcanology and Geological Hazard Mitigation (DVGHM), Jalan Diponegoro No. 57, Bandung 40122, Indonesia (Email: dali@vsi.esdm.go.id; URL: http://www.vsi.esdm.go.id/).

Karangetang [Api Siau]

Siau Island, Indonesia
2.47°N, 125.29°E; summit elev. 1,784 m
All times are local (= UTC + 8 hours)

Ongoing seismicity continued at Karangetang during January-February 2005. Lava avalanches were noted on 3 January and during the week of 17-23 January. The volcano was last discussed in a report on thermal alerts and a pilot's report of an ash plume to 7.5 km altitude (*Bulletin* v 29, no. 3, which updated through May 2004). Table 3 presents a summary of the reported seismic and other data during January and February 2005.

Background. Karangetang (Api Siau) volcano lies at the northern end of the island of Siau, N of Sulawesi. The 1784-m-high stratovolcano contains five summit craters along a N-S line. Karangetang is one of Indonesia's most active volcanoes, with more than 40 eruptions recorded since 1675 and many additional small eruptions that were not documented in the historical record (Catalog of Active Volcanoes of the World: Neumann van Padang, 1951). Twentieth-century eruptions have included frequent explosive activity sometimes accompanied by pyroclastic flows and lahars. Lava dome growth has occurred in the summit craters; collapse of lava flow fronts has also produced pyroclastic flows.

Information Contacts: *DVGHM* (see Egon).

Date	Volcanic A	Volcanic B	Multi-phase	Emission	Tremor	Lava Avalanches	Tectonic	Alert Level
03 Jan	3	10	2	2	0.5-3 mm	5	8	3
04 Jan	9	4	—	—	0.5-1 mm	—	7	3
05 Jan	2	11	1	—	—	—	3	3
17-23 Jan	61	125	6	—	—	36	36	3

Table 3. A summary of observations made at Karangatang during 3 January-February 2005. Courtesy of DVGHM.

Barren Island

Andaman Islands, Indian Ocean
12.278°N, 93.858°E; summit elev. 354 m
All times are local (= UTC + 5 ½ hours)

Members of the Indian Coast Guard observed a new eruption on the morning of 28 May 2005. An ash plume originated from a vent on the W side of the summit of the central cone; fresh black lava flows did not reach the sea (figure 8). The eruption continued through at least 6 June. Fresh lava emissions had been noted by Indian Coast Guard personnel who patrol the area regularly. A large amount of steam was emitted due to heavy rainfall onto the hot lava surfaces. Heavy monsoon rains prevented access to the island. However, the Geological Survey of India (GSI) was planning a monitoring program and field expedition to the island.

Dornadula Chandrasekharam (Indian Institute of Technology) noted on 6 July that by that date the eruption had ceased, with only steam emissions continuing after three weeks of heavy monsoon rains. The Indian Coast Guard also confirmed to Chandrasekharam that the eruption was first noticed on 28 May, contrary to some press reports indicating that activity was seen on the 27th. Patrol helicopters saw no activity on 25 and 26 May, and did not observe the island on the 27th.

Press reports. A report in the 31 May edition of *The Hindu* stated that defense forces witnessed intermittent billowing smoke and "flame" from the volcano. The same article referenced a *Press Trust of India* (PTI) report that military forces that landed on the island "experienced a hot breeze and found themselves stepping on fresh lava" where earlier patrol teams had been able to reach the crater. Another article from *The Hindu* reported that on 2 June teams of the Indian Coast Guard vessel *CG Sagar* landed on the island in an inflatable raft while a helicopter hovered overhead. The report described eruptive activity consisting of lava and "fireballs" from the crater every few seconds. The purpose of the expedition was to "collect samples of the lava flowing into the rough sea" that would be given to scientists. Coast Guard members and various other government officials made an aerial survey of the island on 3 June according to a PTI report published in *The Hindu* the next day. The Lt. Governor of Andaman, Ram Kapse, saw "smoke and lava rising from the crater." Coast Guard sources stated that the volume of "smoke" had increased and lava was still flowing out of the crater.

A report in *The Daily Telegrams* on 17 February 2005 quoted K.N. Mathur, Director General of the GSI, regarding a scientific visit to Barren Island on 16 February. At that time, Mathur noted, the team observed "no serious volcanic activities on the island." A similar report in the 18 February edition of the *Trinity Mirror* carried a quote from Mathur that "There is no activity in the crater and it remained as it was found during GSI's last visit in 2003." These media reports were reproduced on the GSI website.

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

Figure 8. Photograph of Barren Island erupting on 28 May 2005 taken from a helicopter. The black lava in the foreground is of 1994-95 eruption. A lava flow that did not reach the sea issues from a steaming flank vent. View is towards the ESE. Courtesy of the Indian Coast Guard.

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.

Information Contacts: *Dornadula Chandrasekharam*, Department of Earth Sciences, Centre of Studies in Resources Engineering, Indian Institute of Technology, Bombay 400076, India (Email: dchandra@geos.iitb.ac.in); *Geological Survey of India*, 27 Jawaharlal Nehru road, Kolkata 700016, India (URL: http://www.gsi.gov.in/barren.htm); *The Daily Telegrams*, India (URL: http://www.and.nic.in/telegrame.htm); *Trinity Mirror*, Chennai, India; *The Hindu*, 859 and 860 Anna Salai, Chennai 600002, Tamil Nadu, India (URL: http://www.hinduonnet.com/); *Press Trust of India*, PTI Building, 4, Parliament Street, New Delhi 110001, India (URL: http://www.ptinews.com/); *Indian Coast Guard*, National Stadium Complex, New Delhi 110 001, India (URL: http://indiancoastguard.nic.in/indiancoastguard/RegionNews/volcono.HTML).

Long Valley

California, USA
37.70°N, 118.87°W; summit elev. 3,390 m
All times are local (= UTC - 8 hours)

The relative quiescence in Long Valley caldera that began in early 1999 persisted through 2004 according to the U.S. Geological Survey's weekly reports and the 2004 annual summary of the Long Valley Observatory. Those manuscripts provide the basis for this synopsis. Seismicity in the adjacent Sierra Nevada block S of the caldera gradually died away over the same period, although background levels remained somewhat higher than within the caldera.

The resurgent dome continued to undergo minor fluctuations in deformation as reflected in changes in the lengths of baselines onto the dome. Over the past 6 years, the center of the resurgent dome has sustained the roughly 75-cm uplift that accumulated during the recurring unrest from 1979 through 1999.

Seismicity within both the caldera and the Sierra Nevada block to the S remained low through 2004. The two most notable earthquake sequences within the caldera were a minor swarm at the end of January and the first few days of February in the S moat, and a M 3.0 earthquake on 20 September located at the S margin of the caldera just N of Convict Lake. The latter was the first earthquake greater than M 3.0 within the caldera since the cluster of earthquakes on 4 November 2002, events centered beneath the S moat just S of the Highway 395-203 junction. The swarm in early February 2004 was located in the same general area of the S moat, but the epicenters fell along a SW trend in contrast to the WNW trend shown by most earthquake sequences in that area.

Seismicity within the adjacent Sierra Nevada block continued to be somewhat elevated compared to that in the cal-

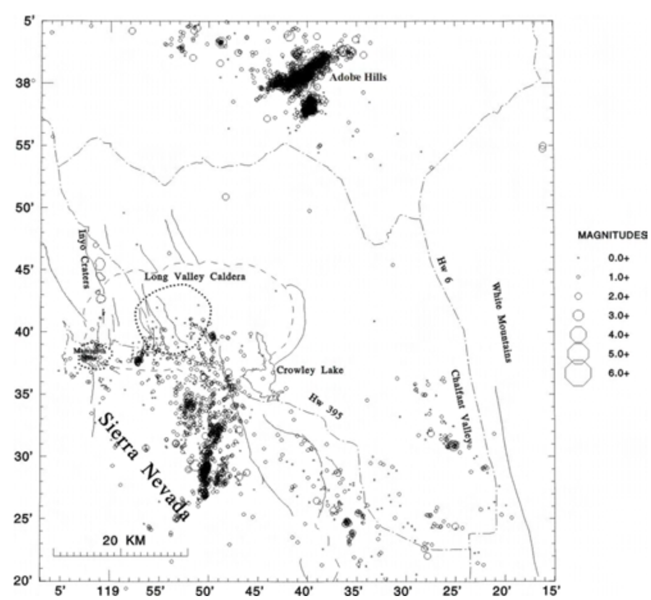


Figure 9. All earthquake epicenters detected in the Long Valley region for 2004. Courtesy of U.S. Geological Survey, Long Valley Observatory (2005).

dera through 2004. The Sierra Nevada activity included about seven earthquakes over M 3, the largest of which was an M 3.7 earthquake on 12 January 2004 located 2 km E of Red Slate Mountain (19 km S of the caldera and 15 km WSW of Tom's Place). Most of the activity remained concentrated in the NNE-trending aftershock zone associated with the three earthquakes over M 5 during June and July 1998 and May 1999.

The most noteworthy seismic activity in the general vicinity of Long Valley caldera during 2004 was the prolonged earthquake swarm in the Adobe Hills centered roughly 20 km E of Mono Lake and 20 km NNE of Long Valley caldera (figure 9). Its onset was marked by a M 2.3 earthquake at 0002 on 18 September, followed by M 3.2 and 4.1 earthquakes at 0007 and 0008, respectively. Activity intensified through mid-afternoon of 18 September, with M 5.5 and M 5.4 earthquakes at 1602 and 1643, respectively. These produced widely felt shaking in the area from Bridgeport to Bishop. Seismicity declined gradually through the remainder of the year and into early 2005. By the end of December 2004, this Adobe Hill swarm had produced well over 1,000 detectable earthquakes including ~ 48 over M 3 and 6 equal or over M 4.

The mid-crustal long-period (LP) volcanic earthquakes, which began beneath the SW flank of Mammoth Mountain during the 1989 Mammoth Mountain earthquake swarm, continued through 2004 but at a much reduced rate compared with the peak in LP activity from early 1997 through mid-1998.

In early 2005 seismicity was generally minor (up to M 2.5) in and around the caldera. An M 4.2 earthquake occurred S of Long Valley caldera on 13 March 2005 at 1409. The event, which produced light shaking in Mammoth Lakes and Bishop was located in the Sierra Nevada ~ 12 miles SW of Toms Place near Grinnell Lake. It was followed by a series of 18 aftershocks, the largest which were M 2.8 and M 2.3. The last earthquake of similar magnitude in this area occurred in 1999 on 17 May. In addition to the M 4.2 main shock/aftershock sequence, two other significant earthquakes occurred in the Adobe Hills area E of Mono Lake, and a third occurred on 13 March in the Sierra Nevada S of the caldera, near Mount Baldwin. All three had magnitudes under M 2.0. From that time to mid-June 2005, seismicity was generally in the range of M 1-2, with a very few occurring to M 3.

Carbon dioxide (CO_2) concentrations measured in the Horseshoe Lake tree-kill area on the S flank of Mammoth Mountain showed no significant changes for 2004 with respect to the past several years. A survey of scattered areas of vegetation die-off and diffuse CO_2 flux on the resurgent dome completed in 2004 indicated anomalous CO_2 emissions from the kill areas were ~9 metric tons/day (compared with ~ 300 tons/day from Mammoth Mountain). The $d^{13}C\text{-}CO_2$ values of the diffuse emissions were similar to values previously reported for CO_2 from hot springs and thermal wells around Long Valley, indicating a common source. The areas of elevated CO_2 flux tend to be associated with locally elevated soil temperatures. Some of the older areas near the Casa Diablo power plant are likely related to geothermal power production, but development of new areas may reflect a delayed response of the hydrothermal system to the 1997 unrest episode (including an additional 10-cm uplift of the resurgent dome accompanied by intense earthquake swarm activity in the S moat).

Thermal spring discharge in Hot Creek Gorge, which had dropped by about 20% in the last half of 2003, followed by a recovery beginning in January 2004, reached normal discharge values by June 2004. Fluid levels in key monitoring wells continued to decline, with some wells reaching their lowest values since records began in 1985.

Background. The large 17 x 32 km Long Valley caldera E of the central Sierra Nevada Range formed as a result of the voluminous Bishop Tuff eruption about 730,000 years ago. Resurgent doming in the central part of the caldera occurred shortly afterwards, followed by rhyolitic eruptions from the caldera moat and the eruption of rhyodacite from outer ring fracture vents, ending about 50,000 years ago. During early resurgent doming the caldera was filled with a large lake that left strandlines on the caldera walls and the resurgent dome island; the lake eventually drained through the Owens River Gorge. The caldera remains thermally active, with many hot springs and fumaroles, and has had significant deformation, seismicity, and other unrest in recent years. The late-Pleistocene to Holocene Inyo Craters cut the NW rim of the caldera, but are chemically and tectonically distinct from the Long Valley system.

Reference: U.S. Geological Survey–Long Valley Observatory, 2005, Long Valley Observatory Quarterly Report, October-December 2004 and Annual Summary for 2004 (URL: http://lvo.wr.usgs.gov/).

Information Contacts: *Long Valley Observatory*, U.S. Geological Survey, 345 Middlefield Rd., MS 977, Menlo Park, CA 94025, USA (URL: http://lvo.wr.usgs.gov/).

Reventador

Ecuador
0.078°S, 77.656°W; summit elev. 3,562 m
All times are local (= UTC- 5 hours)

Crisis escalates. Instituto Geofisico (IG) members noted that eruptions at Reventador in Ecuador's eastern cordillera continued into at least early July 2005. Observers documented thick blocky lava flows, occasional Vulcanian explosions, new fumarolic activity on the N flank of the cone, and venting of vapor, gases, and fine ash. This followed a spate of increased seismicity during April to early June 2005. Lava flows had extended 4 km from the summit vent toward the SE, in the direction of the main highway across this region, a route that links the important oilfields in the Amazon basin with Quito, the capital. The lava flows were sequentially numbered (Lava #3, #4, etc.).

Lava #3, a flow that began in November 2004 (*Bulletin* v. 29, no. 11), advanced slowly and ceased movement by early January 2005. Following relatively low seismic activity in late 2004 and early 2005, the IG monitoring network began to register bands of harmonic tremor starting 1 April (figure 10). Through 8 April 2005, instruments recorded 45 tremor episodes, each lasting 10 to 60 minutes. Dominant frequency peaks were between 1 and 1.5 Hz. Given that strong incandescence was observed by a guard of PetroEcuador from 14 km away, the tremor was interpreted to signal the rise of magma into the upper part of the cone through an open conduit.

Lava #4 erupted coincident with this strong tremor and was the most important surface manifestation. It was first observed in an overflight on 12 April, escaping from a summit crater conduit that had formed a carapace. It was seen flowing down the SW crater notch onto the cone's flanks and then onto the SW and SE caldera floor. The flow partially covered Lava #3 (figure 11), resulting in layers of recent lava in some places reaching more than 50 m thick. This emplacement was observed during several days of work on the seismic instrumentation and sampling within the caldera carried out by IG personnel during 19-22 April. During the same overflights, a new fumarole field was observed on the lower S flank of the cone, a spot very close to the upper Reventador River, in the same place where thermal anomalies were observed on 11 March 2005.

Starting on 15 May there was an important increase in the intensity of harmonic tremor, often preceded by low frequency (< 1 Hz) long-period events, a conspicuous aspect of behavior that was absent in April. Many of the long-period events, particularly those occurring during 17-21 May, were of such magnitude that they registered at seismic stations on other volcanoes (e.g., Cerro Negro and Guagua Pichincha) more than 100 km distant.

After this elevated activity in mid May, there was a decrease in the number of events, dropping to an average of 88 per day. During this period Lava #4 continued to flow, moving at the rate of about 20 m/day, advancing particularly strongly along the caldera's S wall in a stream channel (Rió Marker) cut through the 2002 pyroclastic deposits. Lava reached 25 meters thick when seen during a 22-23 May visit, during which time strong roars and the sounds of 'many jet planes' blared from the vent. These sounds indicated a strong gas flux, although little vapor was observed. At this time, there was an absence of both explosions and incandescence in the summit crater.

An overflight on 25 May confirmed the emergence of a new flow (Lava #5). It followed the same route as #4, but was comprised of three principal lobes. The middle lobe, which represented the most conspicuous and largest volume, advanced down the Río Marker's channel (figure 12).

Reventador's activity in June 2005 began with an important swarm of volcano-tectonic and hybrid seismic events–starting on the 2nd and continuing through the 3rd. Of particular note, tremor continued for more than 10 hours, and provided background to the discrete volcano-tectonic and hybrid events Hybrid events had not been registered since November 2004. Following these important swarms, instruments registered strong, full-amplitude bands of spasmodic tremor, comprised to some extent by packages of long-period events lasting for hours to days on end.

During these early days of June, there was an intensification of incandescence in the crater and later, the emission of gases and slight ash. On 8 June, a 100 km long vapor/ash column extended from the volcano into the S part of Quito at ~ 7 km altitude and caused a very slight powdering of ash, which was brought down by a gentle rain and left cars dappled with circular spots.

A trip by IG volcanologists into the caldera on 11-12 June disclosed strong Strombolian fountaining in the summit crater. Lava #5 continued to flow atop the stalled Lava #4. Measurements of SO_2 flux with a mini-DOAS (differential optical absorption spectroscopy) resulted in an estimate of ~ 2,500 metric tons/day.

Three other seismic stations were installed around the caldera with the helicopter help of the pe-

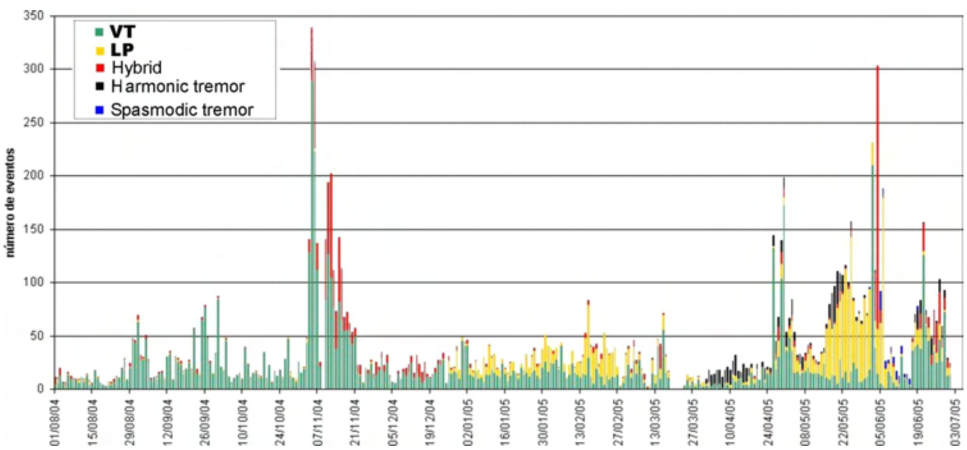


Figure 10. Seismic events registered at Reventador since August 2004. Courtesy of IG.

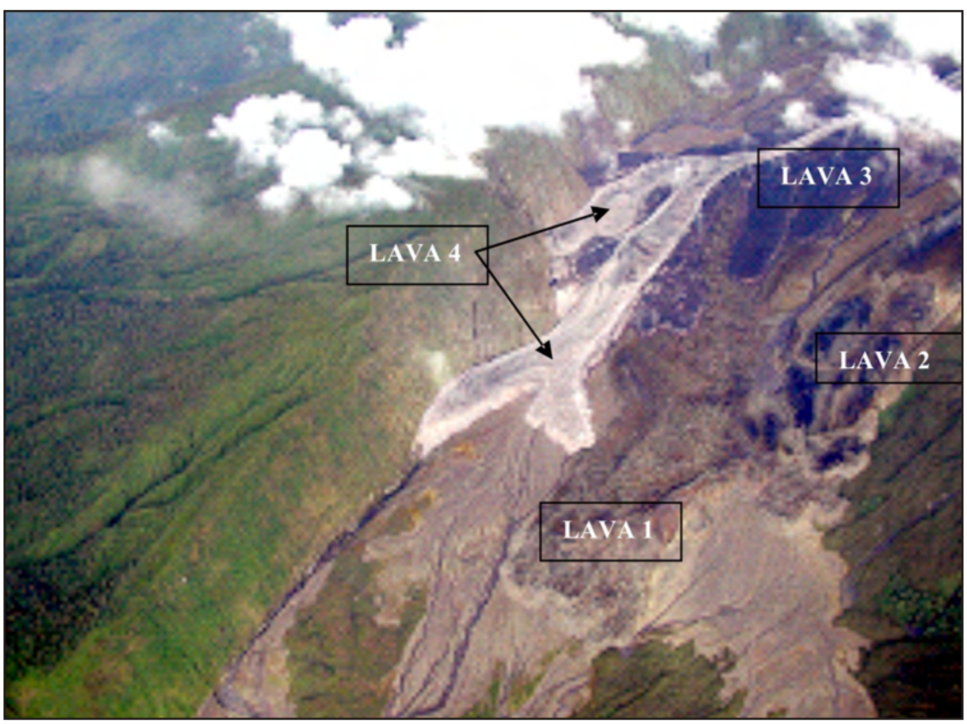


Figure 11. Location of lava flows related to eruptive activity within the Reventador caldera since 2002. Photo taken looking at the SE flank on 6 May 2005 by P. Ramón. Provided courtesy of IG.

troleum company OCP during 16-19 June. One broad-band seismograph and infrasound system was also installed, thanks to collaboration with Jeff Johnson of the University of New Hampshire. During this period no Strombolian activity was observed, but Vulcanian explosions (figure 13) occurred with little warning. A 24-hour period during 18-19 June included at least seven discrete explosions, producing strong infrasound and seismic responses. Many of these explosions discharged columns that rose 2-3 km above the summit (and some, up to as high as ~ 6 km above the summit) and were clearly heard within the caldera. Large incandescent blocks could be seen thrown several hundreds of meters into the air, falling on the cone's upper slopes. Ash content in the columns was moderate. Explosions were discrete and often terminated within 4 minutes. Thermal alerts were identified by the Hawaii Institute of Geophysics and Planetology (HIGP). Observations on 30 June and 1 July noted recent lava flows in the upper Marker river valley (figure 14).

Figure 12. Lavas 4 and 5 flowing down the Marker's stream channel along the SE margin of Reventador's caldera. Photo taken on 17 June 2005 by P. Ramón. Provided courtesy of IG.

Figure 13. One of Reventador's discrete Vulcanian explosions observed during a 19 June 2005 helicopter flight. The view is from the E of Reventador caldera looking toward the W. Photo taken on by P. Ramón; provided courtesy of IG.

Figure 14. A photo of Reventador's Lava #4 flow front (which had reddish hues) overtopped by Lava #5 (more nearly white). The shot was taken in the Río Marker at 1100 on 30 June 2005. By 1 July, Lava #5 had still not advanced beyond the terminus of Lava #4. Photo by P. Ramón, provided courtesy of IG.

The 4-6 discrete explosive degassing events/day observed in June led the IG authors to surmise that there were a series of temporary plugs in the upper part of the conduit. This behavior was thought to reflect magma becoming more crystal rich.

As of 6 July, harmonic tremor, occasional explosions, and long-period and volcano-tectonic signals all continued to register at Reventador on the IG's telemetered monitoring network. Strong Strombolian fountaining was observed from distances of 6.5 and 14 km during the evening and one of the lobes of Lava #5 was advancing down the caldera wall (following the Río Marker), but abruptly slowed to perhaps only ~ 20 m/day. In comparison, this flow-front velocity had earlier attained ~ 70 m/day (during 19-23 June) and ~ 50 m/day (during 23-30 June). The diminished rate of advance and continuing high-amplitude tremor suggested that perhaps a new lava flow (Lava #6) had broken out high on the flanks, a conjecture yet to be confirmed by press time. Lava #5 was still 1.2 km from the steep incline, a point where it could begin rapid descent to the alluvial fan where the highway and petroleum pipeline are located.

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 caldera. 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: *Patricia Mothes*, *Patricio Ramón*, *Pete Hall*, *Daniel Andrade*, and *Liliana Troncoso*, Geophysical Institute (IG), Escuela Politécnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: http://www.igepn.edu.ec/; Email: pmothes@igepn.edu.ec; pramon@igepn.edu.ec; mhall@igepn.edu.ec; dandrade@igepn.edu.ec; ltroncoso@igepn.edu.ec); *Jeffrey B. Johnson*, Dept. of Earth Sciences, James Hall University of New Hampshire, Durham, NH 03824, USA (Email: jeff.johnson@unh.edu).

Lascar

northern Chile
23.37°S, 67.73°W; summit elev. 5,592 m
All times are local (= UTC - 4 hours)

The 4 May 2005 early morning eruption of Lascar was described in *Bulletin* v. 30, no. 4. Note that the time conversion in that issue was in error by 1 hour. The following information is based on a report prepared for *Bulletin* staff by Jose Viramonte of the Universidad Nacional de Salta, and Lizzette Rodriguez of Michigan Technological University.

Viramonte and Rodriguez estimated that the 4 May 2005 eruption column rose to a height of ~ 10-11 km, based on numerical models of temperature and wind measurements from the Servicio Metereológico Nacional, Argentina at different altitudes at the time of the eruption. The column traveled rapidly to the SE under the influence of the strong tropospheric winds with predominant direction from the NW to the SE.

Residents of the towns of Talabre (located 15 km W of the volcano) and Jama (located 60 km ENE of the volcano) did not report earthquakes or explosions. The Instituto GEONORTE of the Universidad Nacional de Salta reported very fine ashfall at 0545 in the city of Salta, located ~ 285 km SSE of the volcano. Ash sample collection, carried out by GEONORTE personnel for 2.5 hours, measured a rate of 0.4 g/ (m^2h). Grain size analyses of the ash showed a strong mode at diameters of 4-8 phi (0.062-0.003 mm) (figure 15); the ash was composed predominantly of andesitic lithic fragments and broken crystals of two pyroxenes (hyperstene and augite) and plagioclase, with very scarce glass shards.

The Buenos Aires VAAC and the Comisión Nacional de Actividades Espaciales (CONAE) processed different bands from MODIS data: b29-b32 for SO_2, b31-b32 for ash, and b30-b32 for SO_4. The first two band combinations showed the Lascar plume in coincidence with the b5-b4 band combination from NOAA-17 (figure 16).

The grain size and shape of the ash, its composition, and the interpretation of the satellite data, suggest that Lascar volcano had a short phreato-vulcanian eruption.

On May 25, Felipe Aguilera of the Universidad Católica del Norte, Antofagasta, Chile, climbed up to the crater of Lascar volcano (figure 17). He reported three new strong fumaroles a few meters from the S border of the crater, and sampled the sulfur sublimates (figure 18). No new bombs or blocks were seen around the crater area.

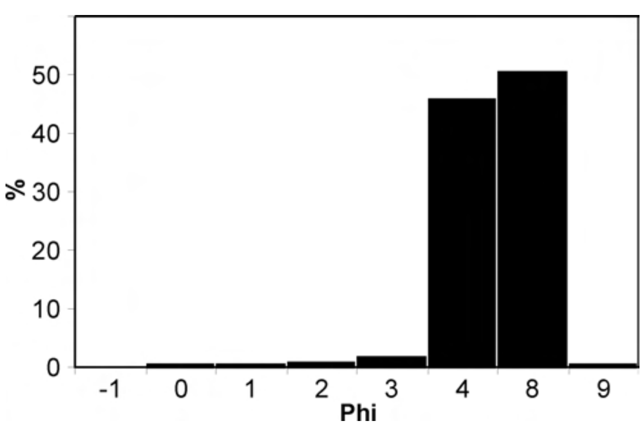


Figure 15. Histogram of the grain size of ash deposited at the city of Salta by the 4 May 2005 Lascar eruption. Courtesy of Jose Viramonte and Lizzette Rodriguez.

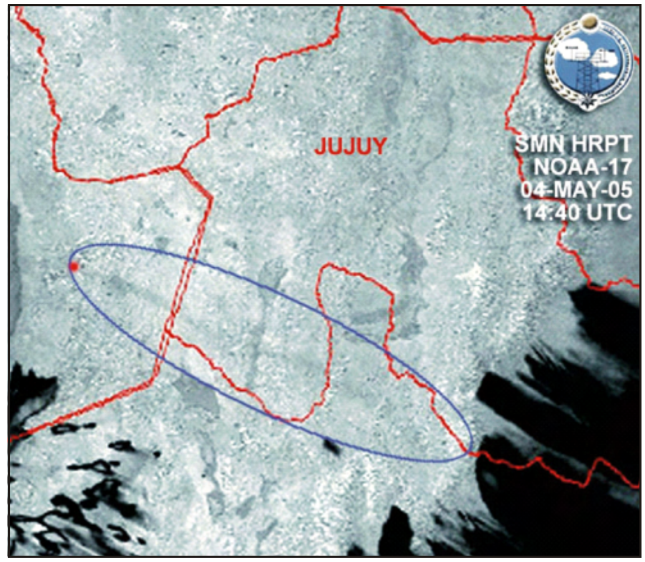


Figure 16. NOAA-17 image of a SE-directed plume from Lascar at 1440 UTC (1040 local time), obtained with the difference of channels 4 and 5 from the AVHRR sensor. The plume can be better identified withing the ellipse on higher resolution reproductions. Courtesy of Jose Viramonte and Lizzette Rodriguez.

Recent and future work. A team of scientists from Michigan Technological University, the University of Hawaii, the Universidad Nacional de Salta, the Universidad de Chile, and the Universidad Nacional de Córdoba, conducted a field campaign at Lascar from 29 November to 8 December 2004. During this period, SO_2 emissions were measured using two mini-UV spectrometers; aerosols were measured using two Microtops II sun photometers, and temperatures of the vent fumaroles were measured using a Forward Looking IR Radiometer (FLIR). Preliminary processing of the gas data showed a decrease since 2003 in the emissions, with SO_2 fluxes around 500 tons/day (Rodríguez et al., 2005). This contrasts with the fluxes determined by Mather et al. (2004) on January 2003, which were on the order of 2,300 tons/day. Observations of the SO_2 index, using ASTER TIR images, have shown a decrease in the size of the SO_2 anomaly from 2000 to the first half of 2004 (Castro Godoy and Viramonte, 2004).

Temperature measurements made at the crater on 2 December 2004 by University of Hawaii scientists using a FLIR indicated low temperatures for the fumarole field, which represented a decrease when compared with the results of direct measurements conducted in October 2002 by Franco Tassi and others (Tassi et al., 2004; *Bulletin* v. 28, no. 3). Similar observations have been made using ASTER SWIR and TIR images (Silvia Castro, GEOSAR-AR program), which have shown a decrease in the absolute temperatures and the size of the thermal anomaly since October 2002 (Castro Godoy and Viramonte, 2004). Images during the month of April 2005 showed a slight increase in the area and maximum temperature of the anomaly at the beginning of the month, followed by a decrease at the end of April, prior to the eruption. Decreases in the thermal activity have been observed in previous eruptive cycles, prior to explosive events (Oppenheimer et al., 1993; Matthews et al., 1997).

The data collected during the 2004 field campaign will help in the understanding of the pre-eruptive conditions at Lascar. SO_2 emission rates on 7 December 2004 will be used to ground truth the satellite data from an ASTER overpass at 1436 UTC (1036 local time), and recently acquired ASTER data will be used to investigate SO_2 emissions during the period close to the 4 May 2005 eruption. Scientists from Università degli studi di Firenze (Italy), Universidad Católica del Norte (Chile), and Universidad Nacional de Salta (Argentina) are conducting a systematic gas sample campaign at Lascar and other active volcanoes on the Central Volcanic Zone. Finally, scientists from the Universidad Católica del Norte and the Universidad Nacional de Salta are processing data from Landsat TM and ETM+ images, with the objective of understanding the behavior of Lascar volcano during the 1998–2004 period.

References: Castro Godoy, S. and Viramonte, J.G., 2004, Micro FTIR field measurement for volcanic mapping, SO_2 and temperature monitoring using ASTER images in Lascar Volcano, southern central Andes: IAVCEI General Assembly, Book of Abstracts, Pucón, Chile, 14-20 November.

Mather, T.A., Tsanev, V.I., Pyle, D.M., McGonigle, A. J.S., Oppenheimer, C., and Allen, A.G., 2004, Characterization and evolution of tropospheric plumes from Lascar and Villarrica volcanoes, Chile: Journal of Geophysical Research, v. 109.

Matthews, S.J., Gardeweg, M.C., and Sparks, R.S.J., 1997, The 1984 to 1996 cyclic activity of Lascar volcano, northern Chile: cycles of dome growth, dome subsidence, degassing and explosive eruptions: Bulletin of Volcanology, v. 59, p.72-82.

Oppenheimer, C., Francis, P., Rothery, D., Carlton, D., and Glaze, L., 1993, Interpretation and comparison of volcanic thermal anomalies in Landsat Thematic Mapper infrared data: Volcán Lascar, Chile, 1984-1991: Journal of Geophysical Research, 98, p. 4269-4286.

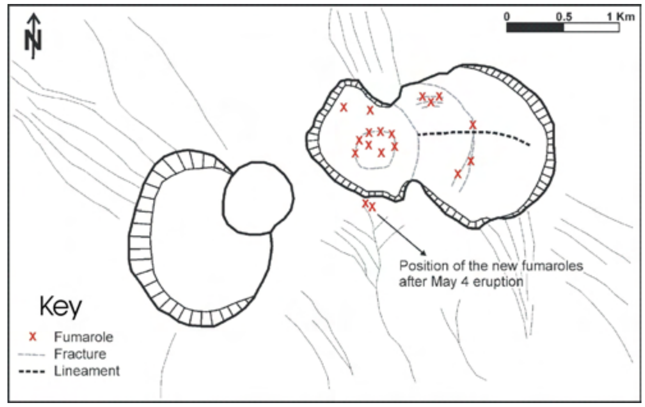


Figure 18. Schematic diagram showing the position of fumaroles on Lascar after the eruption on 4 May 2005. Also indicated are several new post-eruption fumaroles that developed on the S crater margin. Courtesy of Jose Viramonte and Lizzette Rodriguez.

Rodríguez, L.A., Watson, I.M., Viramonte, J., Hards, V., Edmonds, M., Cabrera, A., Oppenheimer, C., Rose, W. I., and Bluth, G.J.S., 2005, SO_2 conversion rates at Lascar and Soufriere Hills volcanoes: 9th Gas Workshop, Palermo, Italy, May 1-10.

Tassi, F., Viramonte, J., Vaselli, O., Poodts, M., Aguilera, F., Martínez, C., Rodríguez, L.A., and Watson, I. M., 2004, First geochemical data from fumarolic gases at Lascar volcano, Chile: 32nd International Geological Congress, Florence, August 20-28, 2004.

Background. Lascar is the most active volcano of the northern Chilean Andes. The andesitic-to-dacitic stratovolcano contains six overlapping summit craters. Prominent lava flows descend its NW flanks. An older, higher stratovolcano 5 km to the E, Volcán Aguas Calientes, displays a well-developed summit crater and a probable Holocene lava flow near its summit (de Silva and Francis, 1991). Lascar consists of two major edifices; activity began at the eastern volcano and then shifted to the western cone. The largest eruption of Lascar took place about 26,500 years ago, and following the eruption of the Tumbres scoria flow about 9,000 years ago, activity shifted back to the eastern edifice, where three overlapping craters were formed. Frequent small-to-moderate explosive eruptions have been recorded from Lascar in historical time since the mid-19th century, along with periodic larger eruptions that produced ashfall hundreds of kilometers away from the volcano. The largest historical eruption of Lascar took place in 1993, producing pyroclastic flows to 8.5 km NW of the summit and ashfall in Buenos Aires.

Figure 17. View of Lascar's NE crater, looking NE (see arrow, upper left) with fumaroles present along a number of fractures to the N and E sides. The active crater is just out of view in the image foreground. Picture taken by Felipe Aguilera on 25 May 2005. Courtesy of Jose Viramonte and Lizzette Rodriguez.

Information Contacts: *Raúl Becchio* and *José G. Viramonte*, Instituto GEONORTE and CONICET, Universidad Nacional de Salta, Buenos Aires 177, Salta 4400, Argentina (Email: viramont@unsa.edu.ar; URL: http://www.unsa.edu.ar/natura/); *Lizzette A. Rodríguez* and *Matthew Watson*, Michigan Technological University, Houghton, MI 49931, USA (Email: larodrig@mtu.edu; URL: http://www.geo.mtu.edu/volcanoes/); *Felipe Aguilera*, Universidad Católica del Norte, Avenida Angamos 0610, Antofagasta, Chile (Email: faguilera@ucn.cl; URL: http://www.ucn.cl/FacultadesInstitutos/Fac_geologia.asp); *Silvia Castro Godoy*, GEOSAT-AR Project, SEGEMAR, Buenos Aires, Argentina (Email: silvia_castro_godoy@hotmail.com, URL: http://www.segemar.gov.ar/sensores/sensoresremotos.htm); *Matt Patrick* and *Rob Wright*, HIGP-University of Hawaii, Honolulu, HI 96822, USA (Email: patrick@higp.hawaii.edu; URL: http://www.higp.hawaii.edu/volcanology.html); *Sergio Haspert* and *Ricardo Valenti*, VAAC Buenos Aires - Div. VMSR, Servicio Meteorologico Nacional, Argentina (Email: vmsr@meteo.edu.ar, URL: http://www.meteofa.mil.ar/).

Rotorua

New Zealand
38.08°S, 176.27°E; summit elev. 757 m
All times are local (= UTC + 11 hours)

Bulletin v. 26, no. 3 reported hydrothermal activity at Rotorua on 26 January 2001 involving the ejection of mud and ballistic blocks. *Bulletin* v. 28, no. 12 reported that the New Zealand Institute of Geological and Nuclear Sciences reported two subsequent hydrothermal eruptions in Rotorua caldera at Kuirau Park around 1100 on 6 November 2003 (figure 19). The eruptions occurred just meters from the site of the large blowout in 2001. The area is known for this kind of geothermal activity. The following information is primarily from Ashley Cody.

In late May 2004 a geothermal well ~ 40 m deep at Tokaanu on Lake Taupo (~ 100 km S of Rotorua) blew out suddenly, erupting mud and scalding waters to ~ 15 m high and flooding surrounding properties for several days until it could be quenched and a new headworks fitted. This well may have been standing open and just suddenly began boiling, since its casing seemed to be intact.

About 0100 on Saturday 29 June 2004 the blowout of a geothermal well in Rotorua blew muddy water and rubbly debris to ~ 15 m high and showered muck over houses and cars to a radius of ~ 100 m accompanied by noise "like a jet aircraft." It went on until about 0400 on 30 June 2004 when it was quenched with a pumped cold water supply. It was cement-grouted shut a few days later. The well was 100 m deep and cased to 47.5 m.

Starting 18 July 2004 in the early afternoon, many earthquakes were strongly felt by many people in the area ~30 km N of Rotorua and ~20 km NW from Kawerau, in the northern North Island, or central Bay of Plenty. By 23 July more than 200 earthquakes were recorded in this area, most at less than 10 km depth.

In Lake Rotoehu, about 20 km N of Rotorua city, eyewitnesses reported a water column 100 m high that occurred at the same time as a strongly-felt ML 5.4 earthquake at about 1600 on 18 July 2004 at ~5 km depth. Shortly afterward a big series of waves occurred on the lake, and swept up beaches much higher than ever seen before.

Ground rupturing was reported at several sites along southern shores of Lake Rotoehu. Many houses were evacuated due to damage such as walls breaking apart and houses shifting off their foundations. The main road was blocked in many places and more than 200 houses were evacuated due to their becoming unsafe to live in. Several people were killed by trees falling down banks onto cars and houses during the earthquakes.

On Thursday 17 March 2005 at about 1435, a blowout was observed from the northern end of Ruapeka Bay on Lake Rotorua, at Ohinemutu. It shot dark grey muddy waters and steam to ~ 6 m for 3-4 minutes. An eyewitness called the council safety inspector, Peter Brownbridge. On 18 March at about 1500, the safety inspector saw two more shots each ~ 1 m high from the same spot in the lake. This

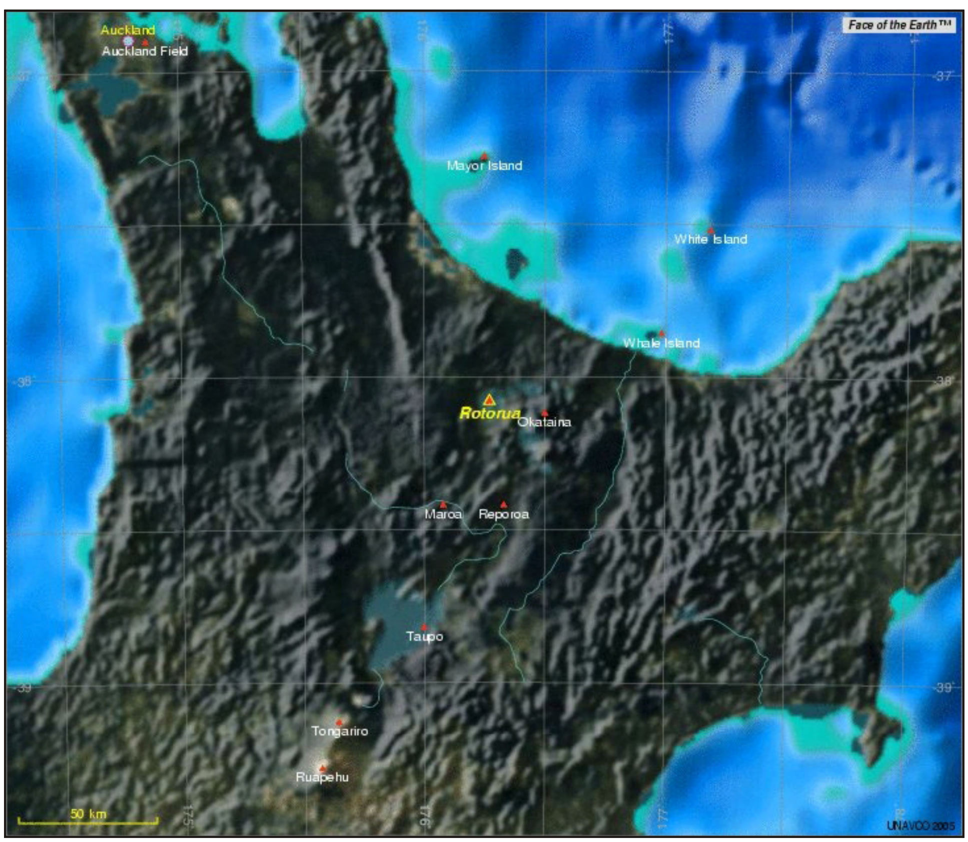


Figure 19. Rotorua is the NW-most caldera of the Taupo volcanic zone, in the Bay of Plenty region of New Zealand's North Island. Courtesy of UNAVCO.

previously unknown vent is ~ 25 m NW from a clear flowing hot spring known simply as S1233, in the bed of the lake just 10 m W of the tip of Muruika Point. This is where a prehistoric account relates of a sunken village, where a sudden disturbance occurred one night and many people were killed. From verbal genealogy records, this event may have occurred about early 1700s-1720s. Today rows of timber posts are still standing below water level in the lake here.

According to a report in *The Dominion Post* by Mike Watson on 21 April 2005, one of the largest hydrothermal eruptions in the Rotorua area since 1948 took place about 1030 on 19 April 2005 and was witnessed by two farmers (figure 20).

A huge column of hot steam, mud and rocks was thrown 200 m in the air. The eruption happened in an inaccessible area at Ngatamariki scenic reserve, close to the Waikato River, and about 8 km from Orakei Korako geothermal springs, roughly halfway between Taupo and Rotorua. The column was visible 10 km away and left a 50 m-wide crater and two hectares of debris. With the energy now taken out of the vent, no further eruption was expected.

The major part of the eruption lasted about two hours but it was still spewing steam up to 10 m high five hours later. The eruption sent out 7,000-10,000 m^3 of material. Mud and 50 cm-diameter rocks covered a 70-100 m radius from the crater site, which had previously been covered by 2 m-high blackberry bushes and fallen trees (figure 21). The ground may take months to cool. According to Ashley Cody, the site had been heating up in the past year, with three new hot springs forming.

Figure 20. The geothermal eruption roughly midway between Rotorua and Taupo on 19 April 2005 left a 50-m wide crater. Courtesy of Ashley Cody.

Figure 21. The hydrothermal eruption roughly halfway between Taupo and Rotorua left ash and mud covering the surrounding area to a depth of 4 m (light-colored material on ground surface, coating some trees, and choking the stream). Courtesy of Ashley Cody.

Background. The 22-km-wide Rotorua caldera is the NW-most caldera of the Taupo volcanic zone. Rotorua is the only single-event caldera in the Taupo volcanic zone and was formed about 220,000 years ago following eruption of the >340 km^3 rhyolitic Mamaku Ignimbrite. Although caldera collapse occurred in a single event, the process was complex and involved multiple collapse blocks. The major city of Rotorua lies at the S end of the lake that fills much of the caldera. Post-collapse eruptive activity, which ceased during the Pleistocene, has been restricted to lava dome extrusion without major explosive activity. The youngest eruptive activity at Rotorua consisted of the eruption of three lava domes less than 25,000 years ago. The major thermal areas of Takeke, Tikitere, Lake Rotokawa, and Rotorua-Whakarewarewa are located within the caldera or outside its rim. Whakarewarewa contains New Zealand's last remaining active geyser field.

Information Contacts: *Ashley Cody*, Consulting Geologist, 10 McDowell Street, Rotorua, New Zealand; *Ron Keam*, Physics Department, The University of Auckland, Private Bag 92-019, Auckland, New Zealand (Email: r.keam@auckland.ac.nz); *Mike Watson*, The Dominion Post.

White Island

New Zealand
37.52°S, 177.18°E; summit elev. 321 m
All times are local (= UTC + 11 hours)

White Island was last reported on in *Bulletin* v. 29 no. 3, covering the period to March 2004. At that time, approximately two years had passed since any significant eruption, but the New Zealand Institute of Geological and Nuclear Sciences (GNS) continues to monitor White Island. This report is a summary of their brief reports.

From April 2004 until June 2005, seismicity and hydrothermal activity at White Island remained at low levels, with some brief periods of weak to moderate volcanic tremor recorded during September to November of 2004. The level of the crater lake has risen significantly over this period, from 12-13 m below the overflow level in April 2004 to only 3-4 m below overflow level in June 2005 (figure 22). Some of this increase was caused by landslides in July 2004 and by heavy rains in May 2005. Steam and gas emissions have been minor, with the exception of a large plume visible from the mainland on 15 October 2004. The alert level remained at 1 (on a scale of 0-5), indicating some degree of unrest but no threat of eruption.

Background. Uninhabited 2 x 2.4 km White Island, one of New Zealand's most active volcanoes, is the emergent summit of a 16 x 18 km submarine volcano in the Bay of Plenty about 50 km offshore of North Island. The 321-m-high island consists of two overlapping andesitic-to-dacitic stratovolcanoes; the summit crater appears to be breached to the SE because the shoreline corresponds to the level of several notches in the SE crater wall. Volckner Rocks, four sea stacks that are remnants of a lava dome, lie 5 km NNE of White Island. Intermittent moderate phreatomagmatic and strombolian eruptions have occurred at White Island throughout the short historical period beginning in 1826, but its activity also forms a prominent part of Maori legends. Formation of many new vents during the 19th and 20th centuries has produced rapid changes in crater floor topography. Collapse of the crater wall in 1914 produced a debris avalanche that buried buildings and workers at a sulfur-mining project.

Figure 22. The crater lake on White Island, taken 9 January 2005, when the lake level was about 5 m below the overflow level and rising. Courtesy of Franz Jeker.

Information Contacts: *Institute of Geological and Nuclear Sciences (GNS)*, Private Bag 2000, Wairakwi, New Zealand (URL: http://www.gns/cri.nz); *GeoNet*, a project sponsored by the New Zealand Government through these agencies: *Earthquake Commission (E.C.)*, *Geological and Nuclear Sciences (GNS)*, and *Foundation for Research, Science and Technology (FAST)*. Geonet can be contacted at the above GNS address (URL: http://www.geonet.org.nz/contact.htm); *Franz Jeker*, Rigistrasse 10, 8173 Neerach, Switzerland (Email: franz.jeker@swissonline.ch).

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

Email Access: The text of the *Bulletin* is distributed through the VOLCANO Listserv (volcano@asu.edu) maintained by Jonathan Fink at Arizona State University (subscribe via listserv@asu.edu).