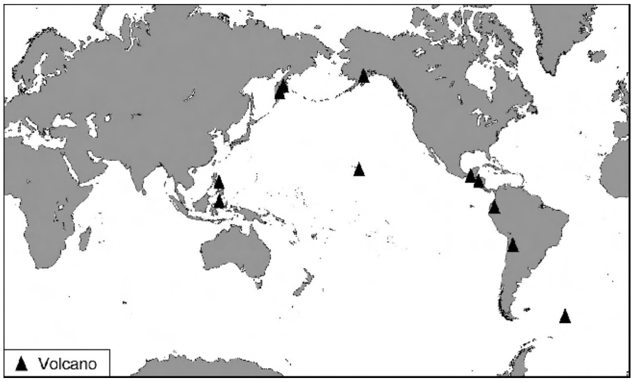
Bulletin of the Global Volcanism Network



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

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Augustine

Southwestern Alaska
59.363°N, 153.43°W; summit elev. 1,252 m
All times are local (= UTC - 9 hours)

Although the previous report (*BGVN* 31:01) noted Augustine's events through 22 February 2006, this one overlaps and further discusses some aspects of behavior during late January through 1 February 2006. This report then continues with summaries of Alaska Volcano Observatory (AVO) reports during 24 February to 26 March 2006.

After eight months of increasing seismicity, gas-and-steam emissions, and phreatic eruptions in December 2005, Augustine began magmatic eruptions on 11 January 2006 (*BGVN* 30:12). Eruptions continued throughout January, producing ash clouds up to ~ 9 km altitude. The eruption was described by Jon Dehn (University of Alaska Fairbanks, personal communication) as occurring in the following three phases: I) 11-28 January; II) 29 January-4 February; and III) 5 February and into at least late March.

During 11 January to 21 March 2006 (70 days), the Anchorage Volcanic Ash Advisory Center (VAAC) issued text reports (Volcanic Activity Advisories) on Augustine 567 times (averaging 8.1 reports per day). These alerted the aviation community to the ongoing airborne-ash hazards.

Augustine lies ~ 277 km SW of Anchorage's airport, a key hub for flights across the North Pacific. According to the US Department of Transportation, during 2003 Anchorage's airport supported the largest tonnage of any in the US, and functioned as the 8th busiest in the US by value of shipments. Augustine's eruptions can potentially impact aviation and operations at the airport, and more generally, they complicate North Pacific air travel.

Figure 2. Aerial view of Augustine during an eruption on 30 January 2006. The volcano was shrouded in ash cloud. The plume blew NE. Courtesy of Pavel Izbekov, AVO/UAF-GI.

Plumes, 28 January-1 February. AIRS SO_2 retrievals for Augustine plumes on 28 and 29 January were provided by Fred Prata (figure 1). He commented that the SO_2 "blobs" seem to spread out rather than elongate into a plume shape, possibly because of calm winds or intermittent ejections.

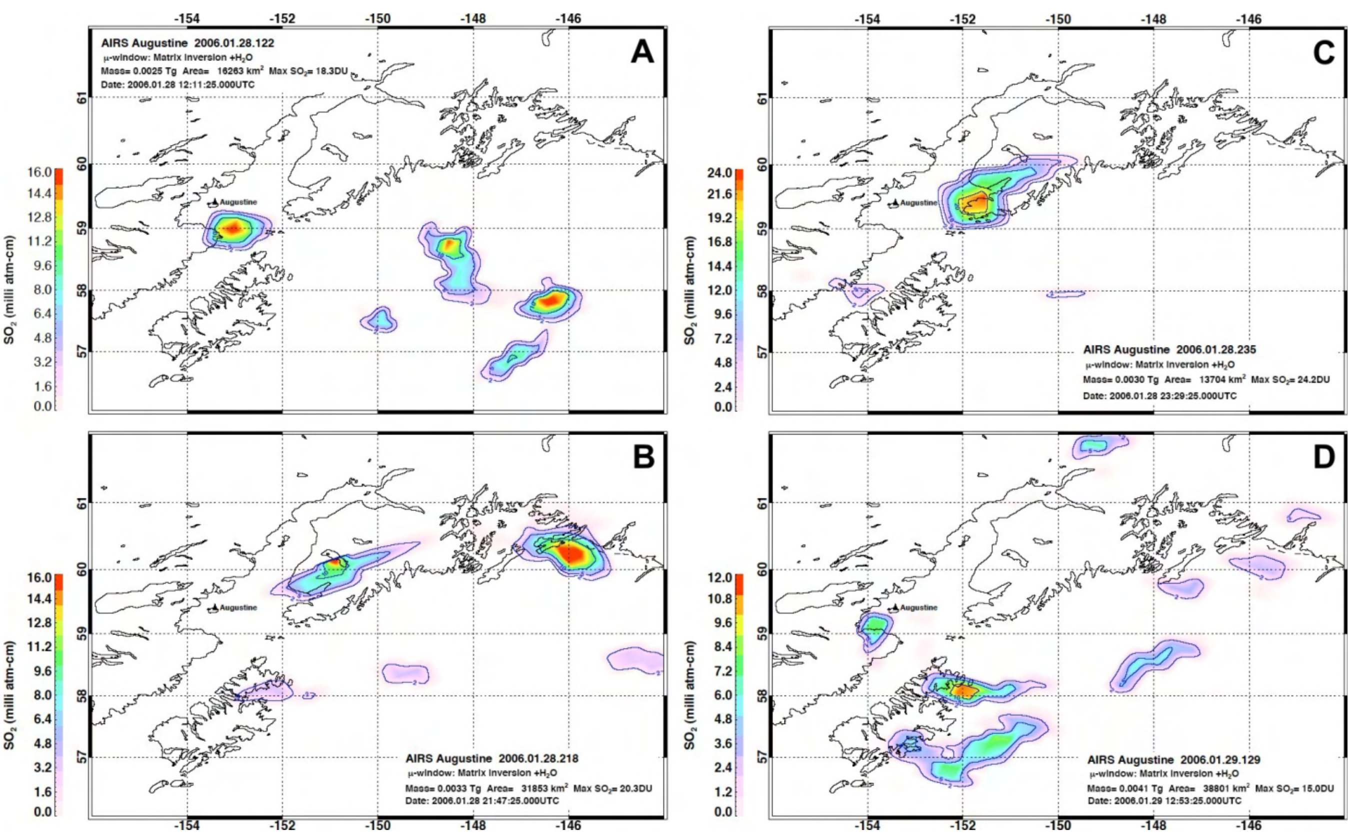

Figure 1. Atmospheric SO_2 from the AIRS instrument for Augustine plumes on 28 and 29 January 2006. Details of the processing and resulting analysis are included on the four panels, which correspond to these dates and times (UTC): a) 12:11:25 on 28 January, b) 21:47:25 on 28 January, c) 23:29:25 on 28 January, and d) 12:53:25 on 29 January. All images provided courtesy of Fred Prata (Norwegian Institute for Air Research).

Shortly after the 28-29 January plumes mentioned above, on 30 January, an overflight by AVO confirmed a ~ 5-km-tall volcanic cloud and small explosions and associated pyroclastic flows. The airborne observations indicated that a considerable amount of ash was being produced during this time period from small explosions and associated pyroclastic flows. Figures 2 and 3 show images from 30 January. AVO also presented 31 January thermal infrared images similarly indicative of vigorous eruptions and fresh pyroclastic flows (figure 4).

René Servranckx looked at several images from 1 February 2006 and sent associated messages and links to the Volcanicclouds listserv. He found a hotspot at Augustine and identified various cloud features from plumes. Using a NOAA-12 IR image taken at 1542 UTC, Servranckx could not detect an ash signature in the split window.

On 4 February, Ken Dean (UAF) posted a message on the Volcanicclouds listserv discussing Augustine for 28 January-1 February. He noted that, regarding SO_2 detection in northern Alaska, they had been monitoring the atmospheric transport direction using Puff, a modeling routine for predicting the atmospheric dispersal of ash clouds. Generally speaking, trajectories were to the N and over Fairbanks. Accordingly, lidar systems at both the UAF's Geophysical Institute and ~ 50 km N of Fairbanks at the Poker Flat Rocket Range were turned on to see if they could detect volcanic aerosols from the eruption. Lidar uses laser energy to probe the atmosphere, where it can detect suspended material such as volcanic aerosols in identifiable regions. Preliminary results indicated volcanic aerosols at 4.6-6.6 km altitude in the atmosphere above both Fairbanks and Poker Flats. There could also have been volcanic aerosols at lower altitudes in the weather clouds.

Figure 3. A MODIS satellite image for 30 January at 12:30:00 showing an Augustine ash and steam plume. This image was collected at approximately the same time as an AVO overflight, and shows the volcanic cloud moving NE at ~ 4.8 km altitude. Processing and interpretation courtesy of Dave Schneider, USGS-AVO. Image courtesy of MODIS Rapid Response Project at NASA/GSFC.

Dean also noted that ground-based event-monitoring collectors set out by Cathy Cahill (UAF) sampled volcanic aerosols and possible traces of ash at Fairbanks. He noted that these observations and trajectories were consistent with Prata's SO_2 observations and Servranckx's back trajectories.

24 February-26 March 2006. On 24 February, AVO noted repeated and ongoing unrest during the past week. This included relatively low but above-background seismicity that indicated small, intermittent rockfalls and ava-

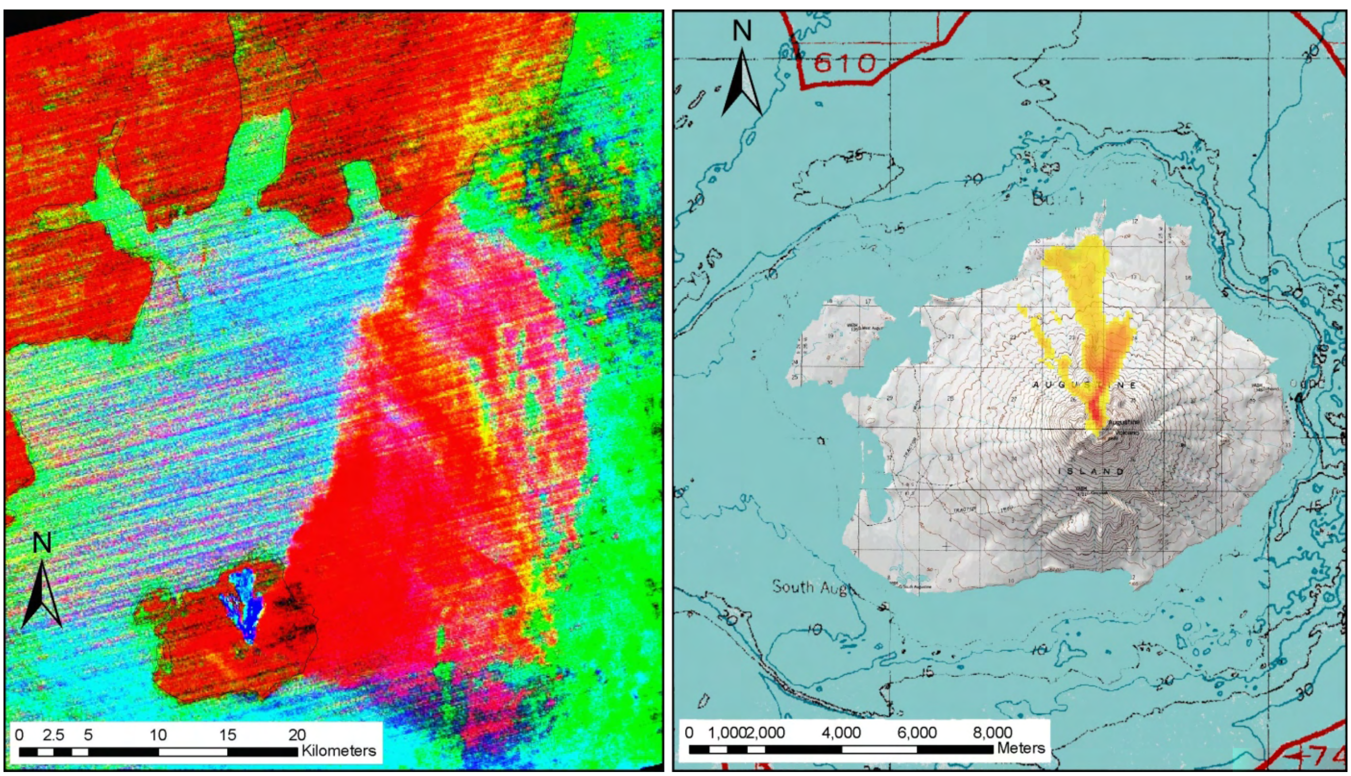

Figure 4. Two 31 January 2006 (at 22:50:44 AST; 1 February 2006 UTC) night-time ASTER thermal infrared (TIR) images showing hot pyroclastic flow deposits on Augustine's N flank. The image on the left also shows a broad ash and SO_2 plume extending ENE. Image processing and interpretation courtesy of Rick Wessels (AVO-USGS); ASTER data courtesy of NASA/GSFC/METI/ERSDAC/JAROS, and US/Japan ASTER Science Team.

lanches from the lava dome. Satellites detected a persisting thermal anomaly in the summit area. These data, along with a 20 February visit to the island, indicated continued slow growth at the summit lava dome. A veil of fresh, light ash dressed Augustine's flanks. The ongoing AVO reports into March noted similar processes and observations, and soon included mention of ash plumes, a lava flow, and a pyroclastic flow.

An overflight of the volcano on 1 March revealed a short, stubby lava flow that extended NE from the dome, terminating at ~ 1 km elevation. AVO noted a small dilute ash plume as well as a 20-minute interval of elevated seismicity at 1010 on 5 March, interpreted as a small explosion with associated ash emission, although low clouds obscured web-camera views. On 6 March AVO reported seismic signals and the low-light camera in Homer suggested rockfalls and avalanches. Although Augustine's plumes in this time frame were generally characterized as local, dilute, and under ~ 1 km above the summit, pyroclastic flows were also seen on 6 March.

Early on the morning of 8 March, AVO's seismometers began recording periods of discrete, repetitive, small events. These signals were taken to indicate ongoing dome growth, observations consistent with those from web cameras, which revealed minor ash emissions and mass wasting. Reports on 8 and 9 March discussed seismicity sufficiently elevated as to sometimes saturate several instruments. In addition, cameras portrayed two areas of high thermal flux. AVO initially interpreted these observations as including elevated rates of lava extruding into the dome, possibly with vigorous lava movement, and block-and-ash flows.

Later reports disclosed further details from around 9 March. AVO's 8-10 March reports noted that the summit was steaming more vigorously than the previous 3-4 weeks. A brownish-orange plume rose from the top of the summit lava dome. Fumaroles on the S and W side of the dome were the source of the most vigorous steaming. Areas of bare ground on the upper W and S flanks had substantially enlarged since 1 March. The greatest amounts of steam came from bare areas on the upper NW flank. Web-camera images and observations from overflights on 8 and 9 March indicated regular small-scale collapses of the summit lava dome. Usually these collapse events produce block-and-ash flows and small diffuse ash clouds. Block-and-ash flows to the E to NE sectors extended to within about 1 km of the coastline. Dilute ash clouds were observed rising from the block-and-ash flows to about the level of the summit and drifting away with the wind.

10 March seismicity included prolonged volcanic tremor and an increase in the frequency of small volcano-tectonic earthquakes. Block-and-ash flows, rock avalanches, and rockfalls originating from the summit lava dome continue to be recorded by the seismic network, particularly at the E flank station.

The 10 March report stated that "Satellite and low-light camera images obtained intermittently throughout the week show that thermal anomalies in the summit area and on the upper NE flank persist. On several evenings this past week, a low-light camera at the AVO site in Homer captured hot avalanches in progress and prolonged periods of incandescence. AVO also received several reports from observers in Homer and Nanwalek of summit glow in the evening hours. Airborne measurements of gas emissions made on March 9 indicate both SO_2 and CO_2 gas in the plume. This is the first time since the fall of 2005 that CO_2 has been a component of the gas plume and likely indicates the presence of new magma entering the volcanic system."

The AVO report for 17 March chronicled low-level eruptive activity. It said that the past week's seismicity changed from periods of prolonged tremor and closely spaced discreet events to episodic short-duration events. Observers interpreted the change as indicating that steady effusion of lava and dome growth had given way to slower effusion of lava and intermittent block-and-ash flows, rock avalanches, and rock-falls from the summit lava dome. On several evenings during the week, clear atmospheric conditions enabled low-light cameras at the AVO site in Homer to capture hot avalanches and prolonged periods of incandescence in both the summit area and on the upper NE flank. Satellite images also showed thermal anomalies.

The 17 March report said that overflights indicated two lava flows were seen on the N and NE flanks. They advanced slowly. Occasional collapses of the lava flow fronts shed hot blocks and produce minor ash emissions. Estimates using photographs indicated that the new lava dome stood ~ 70 m higher than the one formed in 1986.

Little new information was discussed in AVO reports issued on 20-26 March. The 26 March report included the remark that satellite views were then obscured by cloud cover; however, vigorous steaming from the summit was visible with the on-island web camera.

Correction. A previous Augustine report (*BGVN* 30:12; issued in early 2006) had a typographic error in the title: "Eruptions begin 11 January 2005 and eight outbursts occur by late January)." The year has since been changed on our website to 11 January 2006.

Geologic Summary. Augustine volcano, rising above Kamishak Bay in the southern Cook Inlet about 290 km SW of Anchorage, is the most active volcano of the eastern Aleutian arc. It consists of a complex of overlapping summit lava domes surrounded by an apron of volcaniclastic debris that descends to the sea on all sides. Few lava flows are exposed; the flanks consist mainly of debris-avalanche and pyroclastic-flow deposits formed by repeated collapse and regrowth of the volcano's summit. The latest episode of edifice collapse occurred during Augustine's largest historical eruption in 1883; subsequent dome growth has restored the volcano to a height comparable to that prior to 1883. The oldest dated volcanic rocks on Augustine are more than 40,000 years old. At least 11 large debris avalanches have reached the sea during the past 1,800-2,000 years, and five major pumiceous tephras have been erupted during this interval. Historical eruptions have typically consisted of explosive activity with emplacement of pumiceous pyroclastic-flow deposits followed by lava dome extrusion with associated block-and-ash flows.

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Road, Trans-Canada Highway, Dorval, Quebec, H9P 1J3 Canada; *Alaska Volcano Observatory (AVO)*, a cooperative program of the *U.S. Geological Survey*, 4200 University Drive, Anchorage, AK 99508-4667, USA (URL: http://www.avo.alaska.edu/), *Geophysical Institute*, University of Alaska, P.O. Box 757320, Fairbanks, AK 99775-7320, USA, and *Alaska Division of Geological & Geophysical Surveys*, 794 University Ave., Suite 200, Fairbanks, AK 99709, USA.

Santa María

Guatemala
14.756°N, 91.552°W; summit elev. 3,772 m
All times are local (= UTC - 6 hours)

This summary of activity at Santa María's Santiaguito lava-dome complex, taken largely from Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia (INSIVUMEH) reported for October 2005 to January 2006. During this interval Santa María continued to emit occasional ash plumes.

During 26-31 October 2005, several explosions took place and plumes rose to a maximum of ~ 5 km altitude on 28 October. In early November, several explosions occurred producing ash plumes to an altitude of ~ 5 km. A few weak avalanches of volcanic material were observed SW of the lava dome.

Explosions produced several ash plumes to ~ 5 km altitude during 11-14 November 2005. Several small pyroclastic flows traveled down the SW, NE, and S flanks of Caliente dome. Frequent avalanches of volcanic material occurred off of the fronts of active lava flows mostly to the W of Caliente dome, and less frequently to the S and NE. An ash-and-gas emission on 14 November produced a cloud that was visible on satellite imagery.

During 17-21 November, Santa María produced weak-to-moderate explosions, sending ash plumes to an altitude of ~ 4.6 km. Several small pyroclastic flows traveled down the SW and NE flanks of Caliente dome, stopping at the base of the dome. Avalanches spalled off of the fronts of active lava flows and traveled SW.

On 24 November at 0955, an eruption produced an ash cloud to an altitude of ~ 4 km accompanied by a pyroclastic flow to the S. Fine ash fell 6-7 km S of the volcano, impacting properties in the area.

Moderate-to-strong explosions in December produced ash plumes that rose ~ 1.5-2.5 km. Pyroclastic flows occasionally accompanied explosions and traveled towards the SW. Several avalanches of volcanic material also occurred during the report period.

Throughout January 2006, explosions continued to occur sending resultant ash emissions to the SW. Lava avalanches originated from the SW edge of the Caliente dome and from the fronts of active lava flows on the SW flank. An explosion on the morning of 11 January 2006 generated a small pyroclastic flow that traveled down Caliente dome to the NE. INSIVUMEH reported on 16 January that a slight decrease in explosive activity was observed during the previous month. On 16 January there were reports of a small amount of ashfall 25 km SW in the urban area of San Felipe Retalhuleu.

During 1-3 February, weak-to-moderate explosions took place at Santiaguito's lava-dome complex, producing plumes that rose to a maximum height of 1 km above the volcano. On 1 February at 0657 and 0708, moderate explosions were accompanied by pyroclastic flows. Lava extrusion at Caliente dome produced block-and-ash flows that descended the dome's S, E, and W sides. Several explosions on 9 February also produced small pyroclastic flows that traveled down the SW and SE sides of Caliente dome. On 15-17 February, pyroclastic flows traveled SW and NE, associated with avalanches of incandescent volcanic material spalled off of active lava-flow fronts.

On 4, 6, and 7 March, satellite imagery showed small ash plumes emitted from the lava-dome complex. The plumes reached ~ 3 km above the volcano. On 6 March around 0733, a moderate explosion produced an ash plume and pyroclastic flows. A strong explosion later that day, at 1025, sent an ash plume ~ 3 km above the volcano that deposited ash throughout the volcanic complex. The explosion was accompanied by pyroclastic flows down the NE and SW flanks. Fine ash drifted S falling on properties in that area. On 12 March, there were avalanches of volcanic blocks and ash. On 13 March, a pyroclastic flow traveled down the S flank of Caliente dome.

Geologic Summary. Symmetrical, forest-covered Santa María volcano is one of the most prominent of a chain of large stratovolcanoes that rises dramatically above the Pacific coastal plain of Guatemala. The 3,772-m-high stratovolcano has a sharp-topped, conical profile that is cut on the SW flank by a large, 1.5-km-wide crater. The oval-shaped crater extends from just below the summit of Volcán Santa María to the lower flank and was formed during a catastrophic eruption in 1902. The renowned plinian eruption of 1902 that devastated much of SW Guatemala followed a long repose period after construction of the large basaltic-andesite stratovolcano. The massive dacitic Santiaguito lava-dome complex has been growing at the base of the 1902 crater since 1922. Compound dome growth at Santiaguito has occurred episodically from four westward-younging vents, the most recent of which is Caliente. Dome growth has been accompanied by almost continuous minor explosions, with periodic lava extrusion, larger explosions, pyroclastic flows, and lahars.

Information Contacts: Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia (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/).

Masaya

Nicaragua
11.984°N, 86.161°W; summit elev. 635 m
All times are local (= UTC - 6 hours)

Previously reported behavior at Masaya through 22 September 2003 consisted primarily of incandescence from Santiago crater (*BGVN* 28:10). Monthly reports prepared by the Instituto Nicaragüense de Estudios Territoriales (INETER) since that time noted continuing seismicity and incandescence through March 2005. A small explosions was reported on 29 November 2003. Masaya Volcano National Park workers also reported two ash-and-gas explosions at 0121 on 12 December 2003. A collapse event within the crater was noted on 22 June 2004. A report from the Washington Volcanic Ash Advisory Center (VAAC) noted that on 4 July 2004 at 0015 local time, a narrow plume of steam and/or ash from Masaya was visible on satellite imagery extending to the SW. An hour later the plume had extended ~ 12 km from the summit. The report below notes changes induced in Santiago crater after a landslide in early March 2005. A magnitude 1.9 earthquake at a depth of 2.2 km below Masaya on 30 March 2005 was followed by rumbling noises and gas-and-ash emissions.

Field work during February-March 2005. Patricia Nadeau and Glyn Williams-Jones sent us a report of an intensive, multi-component field campaign conducted at Masaya from 16 February 2005 to 12 March 2005. Two

Figure 5. A photo taken from the tourist parking lot on 1 March 2005 showing the inner crater at Masaya emitting a large plume prior to the 2-3 March 2005 landslide. The diameter of the crater in this view is estimated to be 150-200 m. Courtesy of Patricia Nadeau and Glyn Williams-Jones.

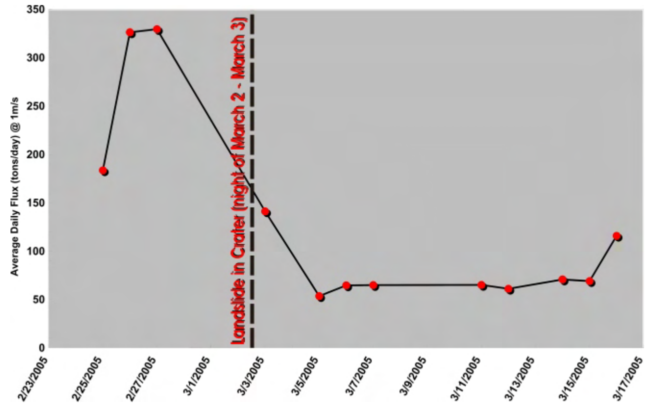

Figure 7. Graph showing Masaya's daily SO_2 fluxes during 25 February 2005-17 April 2005 (normalized to a wind speed of 1 m/s) before and after the landslide during the night of 2-3 March 2005. Courtesy of Patricia Nadeau and Glyn Williams-Jones.

FLYSPEC ultraviolet spectrometers were used in tandem with two Microtops sun photometers to constrain passive SO_2 and aerosol fluxes and also to evaluate potential downwind loss of SO_2 by conversion to aerosols. Additionally, self-potential geophysical measurements were performed at Masaya's summit in a preliminary attempt to delineate the hydrothermal system of the volcano.

On the morning of 3 March, Park workers reported that a landslide had occurred within Santiago crater the previous night. A visibly diminished plume from the crater's active vent suggested that the landslide may have caused a blockage that reduced the escape of SO_2 (figures 5 and 6).

The visual observations were supported by subsequent SO_2-flux measurements, which confirmed a significant drop in SO_2 emissions from an average of ~ 300 tons/day prior to the landslide to an average of ~ 80 tons/day following the landslide (figure 7). This decrease in emissions led to concerns over the possibility of a small vent-clearing explosion such as the one that occurred on 23 April 2001

Figure 6. A view into the Santiago Crater at Masaya and its diminished plume rising from the inner crater, as taken from the tourist parking lot on 3 March 2005. The diameter of the outer crater is approximately 500 m; the inner crater is about 200 m across. Courtesy of Patricia Nadeau and Glyn Williams-Jones.

Figure 8. A photo taken from the second parking lot overlooking Masaya's Santiago Crater captured the scene at two vents within the inner crater on 10 March 2005. The younger, actively degassing vent and plume are in the foreground; the older, non-degassing vent is in the background. The latter vent was incandescent at night. The diameter of the active vent in this view is estimated to be 30-40 m. Courtesy of Patricia Nadeau and Glyn Williams-Jones.

(*BGVN* 26:04). That explosion was preceded by a similar drop in SO_2 emissions for several weeks due to a blockage of the vent that was active at the time. The 2001 explosion resulted in the opening of a new vent, which has since been the site of Masaya's degassing. After the 2001 explosion, the previously active vent no longer degassed and was assumed to be completely inactive.

In the days following the 2 March 2005 landslide, gas output was monitored closely, both visually and with the FLYSPEC, for any further decreases, which could have been indicative of further blockage and possible pressurization. Visual observations of the crater on the nights of 4 March and 11 March revealed that while the currently degassing vent was not incandescent, the older vent (believed to be inactive after the April 2001 explosion) was indeed incandescent, though not degassing (figure 8).

As of 10 March, the visible gas emissions were the lowest seen, despite the apparent open conduit, as indicated by incandescence in the old vent. Rumbling and sloshing sounds from within the crater had increased from sporadic to nearly constant. However, the days following were marked by a decrease in acoustical noise, as well as the apparent beginning of a climb back to higher SO_2 emission rates (~ 120 tons/day on 16 March). These observations were consistent with devlopments in the upper conduit.

Geologic Summary. Masaya is one of Nicaragua's most unusual and most active volcanoes. Masaya lies within the massive Pleistocene Las Sierras pyroclastic shield volcano and is a broad, 6 x 11 km basaltic caldera with steep-sided walls up to 300 m high. The caldera is filled on its NW end by more than a dozen vents erupted along a circular, 4-km-diameter fracture system. The twin volcanoes of Nindirí and Masaya, the source of historical eruptions, were constructed at the southern end of the fracture system and contain multiple summit craters, including the currently active Santiago crater. A major basaltic plinian tephra was erupted from Masaya about 6,500 years ago. Historical lava flows cover much of the caldera floor and have confined a lake to the far eastern end of the caldera. A lava flow from the 1670 eruption overtopped the N caldera rim. Masaya has been frequently active since the time of the Spanish conquistadors, when an active lava lake prompted attempts to extract the volcano's molten "gold." Periods of long-term vigorous gas emission at roughly quarter-century intervals have caused health hazards and crop damage.

References: Williams-Jones, G., Horton, K. A., Elias, T., Garbeil, H., Mouginis-Mark, P. J., Sutton, A. J., and Harris, A. J. L., Accurately measuring volcanic plume velocity with multiple UV spectrometers: Bulletin of Volcanology, in press.

Williams-Jones, G., Delmelle, P., Baxter, P., Beaulieu, A., Burton, M., Garcia-Alvarez, J., Gaonac'h, H., Horrocks, L., Oppenheimer, C., Rymer, H., Rothery, D., St-Amand, K., Stix, J., Strauch, W., and van Wyk de Vries, B., (2001?), Projecto Laboratorio Geofisico-Geoquimico Volcán Masaya, Geochemical, geophysical, and petrological studies at Masaya volcano (1997-2000), on INETER website at <http://www.ineter.gob.ni/geofisica/vol/masaya/doc/gases-glyn2000/gases-glyn2000.html>.

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Sangay

Ecuador
2.002°S, 78.341°W; summit elev. 5,230 m
All times are local (= UTC - 5 hours)

Our previous report was in 1996 (*BGVN* 21:03); this report covers the time interval January 2004 to January 2006. According to a 2004 annual summary on the Instituto Geofísico (IG) website, Sangay was one of the most active volcanoes in Ecuador, and has been in eruption for ~ 80 years. Its isolated location (figure 9) has meant it has been thought of as a relatively small hazard risk. For this reason, monitoring has been less than for other Ecuadorian volcanoes. Thermal, visual, and satellite monitoring during 2002-2004 confirmed the central crater as the source of frequent explosions and continuing steam-and-gas emissions.

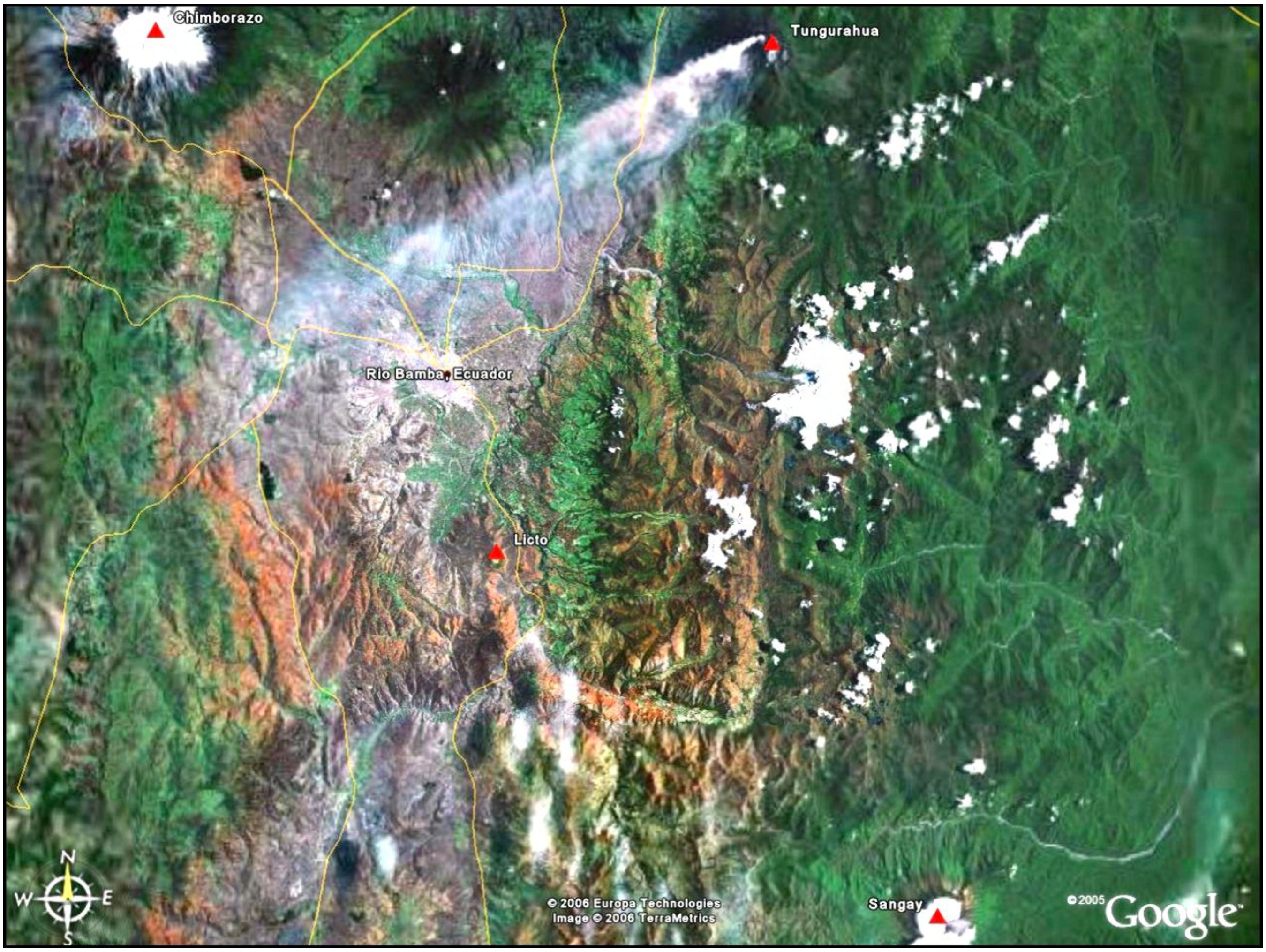

Figure 9. Satellite imagery showing the region around the city of Riobamba (center) in Ecuador), including Sangay (lower right), Chimborazo (upper left), Tungurahua (upper right), and Licto (center) volcanoes. An eruption plume can be discerned coming from Tungurahua, but the date of the image is unknown. The city of Riobamba is about 50 km NW of Sangay. Courtesy of Google Earth.

During 2004 observers did not see lava flows or pyroclastic flows. An abnormally large eruption cloud was detected on 14 January 2004; it contained dominantly steam and gases, with minor ash content. Although only clearly detected and reported then, such events are thought to occur with considerable frequency.

Figure 10. A vista of Sangay at nightfall in early January 2006. Direction of view is approximately WNW. Photo credit to Boeckel and Rietze.

Ramon and others (2006) summarized Sangay's activity as continuously erupting since 1934. Thermal images taken during the last three years showed that only one of the three summit craters was active and documented a lack of new, visible lava flows.

Figure 11. Photograph documenting the climbers tent camp high on the snowbound slopes of Sangay during their descent. Exact location on Sangay unknown; this was labeled "day 4/5," and should correspond to 7 or 8 January 2006. Photo credit to Boeckel and Rietze.

Figure 12. A topographic high forming part of the Sangay structure, gently steaming, apparently seen from the summit. This corresponds to 7 or 8 January 2006. Photo credit to Boeckel and Rietze.

Figure 13. A crater on Sangay as seen by the climbers from the summit or upper flanks, described by them as the "snow covered east crater." This photo corresponds to 7 or 8 January 2006. Photo credit to Boeckel and Rietze.

On 14 January 2004 a plume from Sangay was observed around 0500. The plume extended about 45 km E and most likely contained ash. During this time a hotspot was also visible on the satellite imagery. On 27 January 2004 a narrow ash plume emitted by Sangay rose to 6 km altitude and drifted SW.

On 1 May 2004, based on a pilot's report, the Washington VAAC noted that ash from an eruption at Sangay produced a plume to a height of ~ 6 km altitude at 1750. Ash was not visible on satellite imagery.

On 28 December 2004 around 0715 a plume from Sangay, most likely composed of steam with little ash, was detected. The plume was E of the volcano's summit at a height of ~ 6.4 km altitude. A hotspot was prominent on satellite imagery, but ash was more difficult to distinguish.

On 16 October 2005 around 0645 Sangay emitted an ash plume. The plume moved SSW very slowly, corresponding to a possible height of ~ 6.7 km altitude. By 0900 the plume was too thin to be visible on satellite imagery and thunderstorms developed in the area, further obscuring the ash cloud. Based on information from the IG, on 26 October 2005 the Washington VAAC noted that ash was seen over Sangay at 0758. No ash was visible on satellite imagery.

Climber's photo journal. Climbers Thorsten Boeckel and Martin Rietze created a website briefly describing a trek to Sangay's summit during 4-12 January 2006. Several of their posted photos from that trip appear here (figures 10-13; unfortunately, the photos, which are strikingly beautiful, were generally presented without much geographic context). The team included at least one local guide and was aided by horses. Settlements on the approach and return included the mountain village St. Eduardo, which they described as ~ 50 km S of Riobamba.

Except for some degassing, the group saw no other activity. Although local residents indicated that the last eruption had occurred about 2 months prior to their visit, intermittent eruptions pose hazards to climbers; in 1976 two climbers were killed by explosions from Sangay (*SEAN* 01:10).

Geologic Summary. The isolated Sangay volcano, located E of the Andean crest, is the southernmost of Ecuador's volcanoes, and its most active. The dominantly andesitic volcano has been in frequent eruption for the past several centuries. The steep-sided, 5,230-m-high glacier-covered volcano grew within horseshoe-shaped calderas of two previous edifices, which were destroyed by collapse to the E, producing large debris avalanches that reached the Amazonian lowlands. The modern edifice dates back to at least 14,000 years ago. Sangay towers above the tropical jungle on the E side; on the other sides flat plains of ash from the volcano have been sculpted by heavy rains into steep-walled canyons up to 600 m deep. The earliest report of a historical eruption was in 1628. More or less continuous eruptions were reported from 1728 until 1916, and again from 1934 to the present. The more or less constant eruptive activity has caused frequent changes to the morphology of the summit crater complex.

Reference: Ramón, P., Rivero, D., Böker, F., and Yepes, H., 2006, Thermal monitoring using a portable IR camera: results on Ecuadorian volcanoes in "Cities on Volcanoes IV"; 23-27 January 2006.

Information Contacts: *P. Ramón*, Instituto Geofísico-Departamento de Geofísica (IG), Escuela Politécnica Nacional, Casilla 17-01-2759, Quito, Ecuador (Email: pramon@igepn.edu.ec); *Washington Volcanic Ash Advisory Center (VAAC)*, Satellite Analysis Branch (SAB), NOAA/NESDIS E/SP23, NOAA Science Center Room 401, 5200 Auth Rd, Camp Springs, MD 20746, USA (URL: http://www.ssd.noaa.gov/VAAC/); *Thorsten Boeckel* and *Martin Rietze*, c/o Kermarstr.10, Germerswang, D-82216, Germany (URL: http://www.tboeckel.de/, Email: tboeckel@tboeckel.de).

Lascar

Northern Chile
23.37° S, 67.73° W; summit elev. 5,592 m

Lascar's eruption on 4 May 2005 (*BGVN* 30:05) was followed by a new eruptive cycle, which began on 18 April 2006 and lasted 5 days. Observers familiar with Lascar judged this eruptive episode unusual compared to those observed previously in terms of eruptive character, frequency,

Figure 14. Lascar's first explosion of 18 April 2006 as photographed from El Abra copper mine, 220 km NW from volcano. Courtesy of personnel at the El Abra copper mine.

and duration time. The Volcanic Ash Advisory Center (VAAC) in Buenos Aires and Servicio Metererológico Nacional of Argentina detected the eruption from satellite images, and aircraft warnings were posted. All of the times cited are in UTC (local time = UTC - 4 hours).

Eruptions start, 18 April. Four explosions registered (at 1520, 1722, 1900, and 2100 hours UTC). The first explosion, the largest of four, was visible from El Abra cooper mine (220 km NW) and reached ~ 10 km above the summit crater (figure 14). The shape of the eruptive column suggested that it reached the tropopause (~ 15 km altitude in this region). The white to gray plume, containing little ash but a large amount of water, dispersed to the NNE.

The second explosion reached 3 km above the summit crater, while the third and fourth explosions reached 800 m. These latter eruptive plumes were gray colored, had higher contents of ash than the first explosion, and were dispersed NNE. Only slight ash fall was registered on the N side of the volcano. No seismic activity or eruption noises were registered. Analysis of GOES satellite images (figure 15) indicated that for the first and second eruptive plumes the mean horizontal velocities were 70 and 85 km/hour, respectively, while the maximum plume areas were ~ 8,240 and 1,074 km^2, respectively. Minimum volumes erupted were ~ 4.1 x 10^6 and ~ 0.54 x 10^6 m^3 assuming a hypothetical ash fall deposit of 0.5 mm over the stated areas. The third and fourth explosions were not detected by satellite.

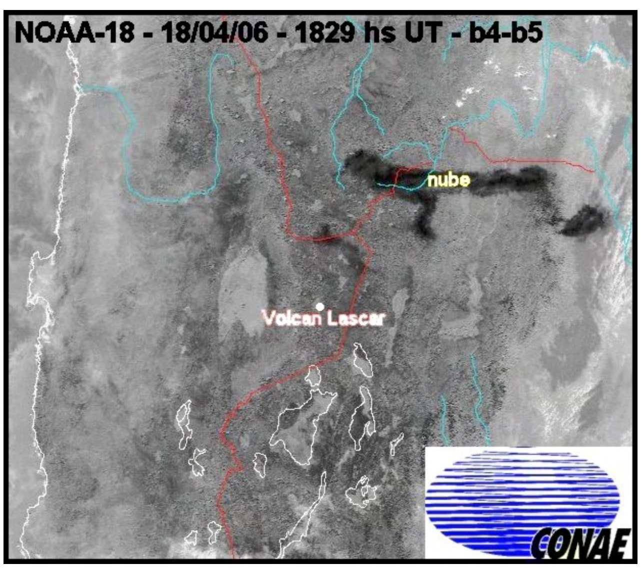

Figure 15. GOES satellite image capturing Lascar's first and second eruptive plumes. Rivers and international borders are also shown. Image is for 1829 UTC on the 18 April 2006. The first plume (oblong black area labeled 'cloud' in Spanish–'nube') stretched over N Argentina and S Bolivia. A second plume appears as a much smaller dark area between Lascar and the first plume. It lay over the NE Chilean border. Courtesy of Comisión Nacional de Asuntos Espaciales (CONAE), Argentina.

19-22 April eruptions and comparative calm that followed. On 19 April 2006 at 1504 hours (UTC) an explosion generated a gray-colored eruptive column that reached 3 km above the summit crater and was dispersed NNE. Slight ash fall was noted on the N side of the volcano. Neither seismic activity nor eruption noises were reported. Two explosions were recorded 20 April at 1505 and 1739 hours (UTC). The first eruptive plume reached 2.5 km above the summit crater and contained a small amount of ash. The plume from the second explosion, the larger of the pair, reached 7 km above the crater. The eruption lasted 1 hour and 50 min. Both plumes were dispersed N and slight ash fall was registered on the N side of the volcano. No seismic activity or eruption noises were registered.

Analysis of satellite data from the sequence of GOES images (figure 16) indicated that the first and second eruptive plumes had mean horizontal velocities of 40 km/h, while the maximum areas were ~ 430 and ~ 800 km^2, respectively. Minimal volumes erupted were ~ 0.4 x 10^6 and ~ 0.2 x 10^6 m^3, again assuming a hypothetical 0.5 mm ash-fall deposit.

Two explosions were recorded on 21 April 2006 at 1248 and 1547 UTC, each lasting ~ 15 minutes. Their eruptive columns reached 3 km above the summit crater and rapidly dispersed ESE. Seismic activity and eruption noises were not noted.

On 22 April at 1518 UTC an explosion generated an eruptive column that reached 3 km above the summit crater; it was blown SE. Local inhabitants heard subterranean noises. On 23 April at 1600 UTC an explosion generated a gray-colored eruptive column that reached 2.5 km above the summit crater and dispersed NNW (figure 17). Seismic activity and eruption noises were not registered. During the

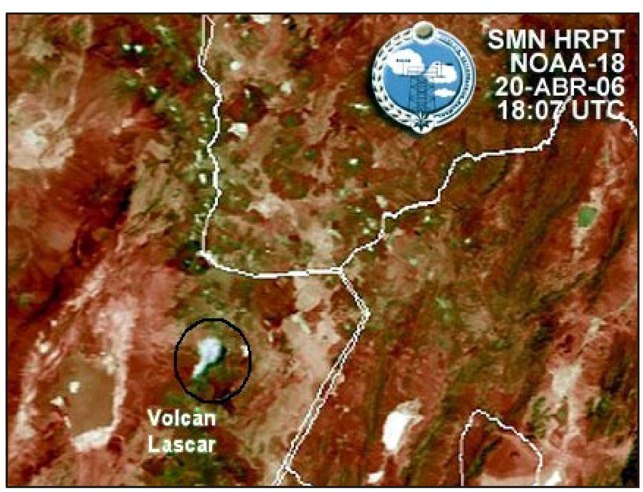

Figure 16. GOES satellite image of Lascar showing the second eruptive plume (black circle) at 1807 hours (UTC) of 20 April eruption dispersed to NE. Courtesy of Servicio Meteorológico Nacional and Comisión Nacional de Asuntos Espaciales (CONAE), Argentina.

Figure 17. Photograph of Lascar taken 23 April 2006 from the SW border of the Atacama salar (salt pan), ~ 40 km SW of the volcano. Courtesy of Gabriel González.

following 2 days, the color of the plume was white and it's top remained ~ 1.5 km above the crater.

Other studies. After the 4 May 2005 eruption (*BGVN* 30:05), a team of scientists from Universidad Católica del Norte (UCN) carried out a gas sampling campaign on new fumaroles around the S edge of the central active crater. They used the direct sampling of fumaroles technique described by Giggenbach (1975) and Giggenbach and Goguel (1989). Gas data showed increasing amounts of H_2O, H_2S, and CH_4 with respect to samples taken in 2002 from inside the active crater (Tassi et al., 2004). However, acid gases also displayed very high values. During December 2005 a team of scientists from UCN and Universidad Autónoma de México (UNAM) carried out field investigations to generate hazard maps.

Scientists from Università degli Studi di Firenze (Italy) and Universidad Católica del Norte (Chile) are conducting a systematic gas sample campaign at Lascar and other active volcanoes in the Central Volcanic Zone (e.g. Putana, Lastarria, and Isluga). Finally, scientists from the Universidad Católica del Norte, the Universidad Nacional de Salta and SEGEMAR (Argentina) are processing data from Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images, with the objective of understanding the behavior of Lascar volcano during the 1998-2004 period.

References: Giggenbach, W., 1975, A simple method for the collection and analysis of volcanic gas sample: Bulletin of Volcanology, 39, 132–145.

Giggenbach, W., and Goguel, R., 1989, Collection and analysis of geothermal and volcanic water and gas discharges: DSIR Chemistry, Rept. No. 2401.

Matthews, S., Gardeweg, M., and Sparks, R., 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.

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

Viramonte, J., Aguilera, F., Delgado, H., Rodríguez, L., Guzman, K., Jiménez, J., and Becchio, R., 2006, A new eruptive cycle of Lascar Volcano (Chile): The risk for the aeronavigation in northern Argentina. Garavolcan 2006, Tenerife, Spain.

Geologic Summary. 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 east, 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 9000 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.

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Michael

Antarctica
57.78°S, 26.45°W; summit elev. 990 m

The last reported activity of Mount Michael was noted in the SI/USGS Weekly Report of 12-18 October 2005. At that time the first MODVOLC alerts for the volcano since May 2003 indicated an increased level of activity in the island's summit crater and a presumed semi-permanent lava lake that appeared confined to the summit crater. Those alerts occurred on 3, 5, and 6 October 2005. Since that time there has been no additional information concerning Mount Michael and presumably little to no activity.

Geologic Summary. The young constructional Mount Michael stratovolcano dominates glacier-covered Saunders Island. Symmetrical 990-m-high Mount Michael has a 700-m-wide summit crater and a remnant of a somma rim to the SE. Tephra layers visible in ice cliffs surrounding the island are evidence of recent eruptions. Ash clouds were reported from the summit crater in 1819, and an effusive eruption was inferred to have occurred from a N-flank fissure around the end of the 19th century and beginning of the 20th century. A low ice-free lava platform, Blackstone Plain, is located on the N coast, surrounding a group of former sea stacks. A cluster of parasitic cones on the SE flank, the Ashen Hills, appears to have been modified since 1820 (LeMasurier and Thomson 1990). Vapor emission is frequently reported from the summit crater. AVHRR and MODIS satellite imagery, the most recent from October 2005 has revealed evidence for lava lake activity in the summit crater of Mount Michael.

Information Contacts: *Matt Patrick*, *Luke Flynn*, *Harold Garbeil*, *Andy Harris*, *Eric Pilger*, *Glyn Williams-Jones*, and *Rob Wright*, HIGP Thermal Alerts Team, Hawai'i Institute of Geophysics and Planetology (HIGP) / School of Ocean and Earth Science and Technology (SOEST), University of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (http://hotspot.higp.hawaii.edu/, Email: patrick@higp.hawaii.edu); *John Smellie*, British Antarctic Survey, Natural Environment Research Council, High Cross, Madingly Road, Cambridge CB3 0ET, United Kingdom (URL: http://www.antarctica.ac.uk/, Email: jlsm@pcmail.nerc-bas.ac.uk).

Soputan

Sulawesi, Indonesia
1.108°N, 124.725°E; summit elev. 1,784 m
All times are local (= UTC + 8 hours)

Our last report covered events through July 2005 (*BGVN* 30:08); this report includes activity that took place in late December 2005 and also presents a discussion of the wide discrepancy of cloud-height estimates between ground, aircraft, and satellite remote-sensing observations.

Activity during 21-27 December 2005. A phreatic eruption began at Soputan on 26 December 2005 around 1230 following heavy rain. Observers concluded that rainwater contacted lava at the volcano's summit. On 27 December at 0400, a Strombolian eruption began that lasted about 50 minutes. Incandescent material was ejected ~ 35 m, and avalanches spalling off the margins of the summit traveled as far as 750 m E. Booming noises were heard 5 km from the summit. The Darwin VAAC reported that an ash plume reached a height of ~ 5.8 km altitude and drifted SE.

As of 28 December, eruptive activity continued, producing ash plumes to a height of ~ 1 km above the volcano. Strombolian eruptions ejected incandescent material up to 200 m above the summit. Pyroclastic avalanches traveled ~ 500 m E and SW. This was Soputan's fourth event in 2005, with previous activity on 14 and 20 April, and on 12 September. The Alert Level remained at 2, since the volcano is about 11 km from the nearest settlement. Visitors were prohibited from climbing Soputan's summit and from camping around Kawah Masem.

October 2005 eruption plume height discussion. The Darwin Volcanic Ash Advisory Centre and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin – Madison collaborated to compare various estimates for the height of the 27 December cloud (*BGVN* 30:08). The eruption height had been initially reported at less than 6 km altitude on the 27th by an airline pilot, and 1 km above the summit (~ 2.8 km altitude) by ground observers on the 28th. Darwin VAAC, on reviewing hourly MTSAT imagery on the 27th, estimated the plume top at 15 km altitude operationally and then 12.5 km altitude in post-analysis studies.

Michael Richards of CIMSS used an established remote-sensing technique known as "CO_2 slicing" (Menzel et al., 1983, Richards et al., 2006), to obtain heights of the cloudscape around Soputan after the eruption. The technique takes advantage of the fact that the emissive infrared CO_2 bands available on the MODIS satellite become more transmissive with decreasing wavelength, as the bands move away from the peak wavelength of CO_2 absorption at 15 µm. There were two good MODIS images obtained over the eruption on the 27th, with the first, at 0210 UTC or 1010 local time. These images were taken at close to the time of the peak cloud height observed on MTSAT imagery, and the CO_2 slicing technique appears to validate the post-analyzed VAAC height of ~ 12.5 km altitude.

The different results for the height of the eruption cloud illustrate the difficulty that observers would have had viewing the cloud from any angle. Weather clouds in the tropics typically extend up to 16 km or more altitude. Cirrus cloud from a storm complex can obscure the view of a satellite for hours. On the other hand, middle-level clouds, such as altostratus, will typically lie between aircraft cruising altitudes and the ground, meaning that pilots at cruising altitude may not associate any eruption cloud with a volcano on the ground, unless the cloud is obviously volcanic. Ground observers are completely unable to view the full height of the cloud if it is penetrating through the middle-level clouds.

The appearance of the cloud on true-color, near-infrared and infrared imagery is consistent with an ice-rich (glaciated) volcanic cloud, in-line with the CVGHM account of water interactions at the ground, and also with a high water loading in the atmosphere. The extensive areas of cloud in the area hindered satellite detection of the eruption until after the pilot report of the eruption had been received.

Geologic Summary. 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.

References: Menzel, W. P., Smith, W. L., and Stewart, T. R., 1983, Improved cloud motion wind vector and altitude assignment using VAS: Journal of Applied Meteorology, v. 22, p. 377-384.

Richards, M. S., Ackerman, S. A., Pavolonis, M. J., Feltz, W. F., and Tupper, A.C., 2006, Volcanic ash cloud

heights using the MODIS CO_2-slicing algorithm: AMS 12th, conference on aerospace and range meteorology, Atlanta, Georgia, USA (http://ams.confex.com/ams/pdfpapers/104055.pdf).

Information Contacts: *Centre of Volcanology and Geological Hazard Mitigation*, Jalan Diponegoro 57, Bandung 40122, Indonesia (Email: dali@vsi.esdm.go.id; URL: http://www.vsi.esdm.go.id/); *Andrew Tupper* and *Rebecca Patrick*, Darwin Volcanic Ash Advisory Centre (VAAC), Australian Bureau of Meteorology (URL: http://www.bom.gov.au/info/vaac/soputan.shtml); *Michael Richards* and *Wayne Feltz*, Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin, 1225 West Dayton Street, Madison, WI 53706, USA.

Bulusan

Luzon, Philippines
12.770°N, 124.05°E; summit elev. 1,565 m
All times are local (= UTC + 8 hours)

Bulusan, after remaining relatively quiet since 1995, erupted multiple times during March and April 2006. There were no casualties or damage from these eruptions. On 21 March at 1044 the summit crater erupted, sending a column of ash 1.5 km into the sky accompanied by lightning and rumbling noises. Ash drifted N, W, and SW of the volcano and an hour after the event light ash fell on neighborhoods such as Barangays Cogon, Tinampo, Gulang-Gulang, and Bolos in the town of Irosin, as well as Barangays Puting Sapa and Bura-Buran in the town of Juban.

Ash ejected at 1058 on 22 March coincided with an explosion-type earthquake. Three other earthquakes were recorded at 2330, 2332, and 2337. The hazard status had been raised to Alert Level 1; the area within a 4 km radius of the summit is a Permanent Danger Zone.

On 29 April the volcano erupted in a similar fashion, emitting ash nearly 1.6 km into the air. There was no sign of lava and no reports of rumbling noises. It was reported that ash rained on nearby communities.

Geologic Summary. Luzon's southernmost volcano, Bulusan, was constructed within the 11-km-diameter dacitic Irosin caldera, which was formed more than 36,000 years ago. A broad, flat moat is located below the prominent SW caldera rim; the NE rim is buried by the andesitic Bulusan complex. Bulusan is flanked by several other large intracaldera lava domes and cones, including the prominent Mount Jormajan lava dome on the SW flank and Sharp Peak to the NE. The summit of Bulusan volcano is unvegetated and contains a 300-m wide, 50-m-deep crater. Three small craters are located on the SE flank. Many moderate explosive eruptions have been recorded at Bulusan since the mid-19th century.

Information Contacts: *R. Punongbayan* and *E. Corpuz*, Philippine Institute of Volcanology and Seismology (PHIVOLCS), Department of Science and Technology, PHIVOLCS Building, C.P. Garcia Avenue, Univ. of the Philippines Campus, Diliman, Quezon City, Philippines (URL: http://www.phivolcs.dost.gov.ph/); *Inq7.net*, a venture between The Philippine Daily Inquirer Inc., and GMANetwork Inc. (http://news.inq7.net/).

Kilauea

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

This report covers the interval 31 January 2005 to 7 February 2006 and is drawn exclusively from U.S. Geological Survey Hawaiian Volcanic Observatory (USGS HVO) sources. During this interval, active lava flows during tended to remain along the W to central portions of the existing field (figures 18 and 19). On 31 January 2005, lava from Kilauea began pouring into the ocean at two entry points. The Ka`ili`ili entry to the E of the flow field was the largest and was fed by the large W arm of the Prince Kuhio Kalaniana (PKK) lava flow. The West Highcastle ocean entry was supplied by the W branch of the W arm of the PKK lava flow.

From 7 February 2005 to 20 February 2005, lava flows were visible on the Pulama pali fault scarp and on the coastal flat. Instruments recorded a few small earthquakes and no tremor at Kilauea's summit. At Pu`u `O`o, volcanic tremor remained moderate. Small amounts of deformation were recorded.

On 21 February 2005 a new ocean entry formed, named E Lae`apuki. The entry was located between the other two ocean entries (Ka`ili`ili and West Highcastle) that had been active since 31 January 2005. This was the first time there had been three ocean entries active since early 2003 (figures 18-20).

During 23-26 February 2005, lava from Pu`u `O`o entered the sea at three ocean entries–West Highcastle, East Lae'apuki, and Ka`ili`ili–spots along 4.7 km of the island's SE coast (figure 21). Lava may have stopped flowing into the sea at the W entry (West Highcastle) on 26 February 2005. The number of surface lava flows diminished in comparison to the previous weeks, and small earthquakes continued to occur at Kilauea's summit without accompanying tremor. Tremor remained at moderate levels at Pu`u `O`o, and as of 28 February 2005, deflation had occurred at Pu`u `O`o for more than a week and at the summit since 24 February 2005.

During the month of March 2005, lava from Kilauea continued to enter the ocean at the Ka`ili`ili and E Lae`apuki, but there were no signs of activity at the West Highcastle entry. Surface lava flowed down the Pulami pali fault scarp and the coastal flat. Small earthquakes occurred at Kilauea's summit, and no tremor was recorded. Tremor remained at moderate levels at Pu`u `O`o.

On 29 March 2005, lava from Kilauea entered the ocean at five areas. The largest, named Kamoamoa, consisted of six or more places where lava entered the water along the front of a growing lava delta (figure 22). At one of the two Highcastle entries, a cascade of lava streamed down the old sea cliff. A bright glow came from Ka`ili`ili entry, and a weak glow from E Highcastle entry. Seismicity remained above background levels at Kilauea's summit, consisting mainly of tremor and some long-period earthquakes. Surface waves from an M 8.7 earthquake on 28 March 2005 off Sumatra, Indonesia disturbed tilt measurements at Kilauea but otherwise the tilt change was small.

Lava from Kilauea continued to flow into the ocean at several points during 1-13 April 2005. Seismicity remained above background levels at Kilauea's summit, consisting mainly of tremor and some long-period earthquakes. Volcanic tremor was at moderate levels at Pu`u `O`o. During 14-19 April, surface lava flows from Kilauea were visible on the Pulama pali fault scarp but lava was not seen entering the ocean.

Seismicity remained above background levels at Kilauea's summit during 14-19 April 2005, consisting mainly of tremor and some long-period earthquakes. Volcanic tremor was at moderate levels at Pu`u `O`o. Episodes of inflation and deflation occurred during the week.

During 21-25 April, there were fewer surface lava flows visible at Kilauea than during the previous week. On 24 April a small amount of lava again began to enter the sea. Seismicity remained above background levels at Kilauea's summit, consisting mainly of tremor and some long-period earthquakes.

During 27 April-3 May 2005, lava entered the ocean at the Kamoamoa entry. Numerous surface lava flows were visible on the coastal flat. Seismicity remained above background levels at Kilauea's summit, consisting of both tremor and long-period earthquakes.

A third ocean entry, in the E Lae`apuki area, became active on 5 May 2005. That entry and the Far E Lae`apuki entry were both being fed by lava falls down the old sea cliff and were relatively small. Based on the brighter glow, the Kamoamoa entry was thought to be more substantial. By the morning of 9 May lava was streaming over the old sea cliff in four locations: two falls went into the sea and two other falls landed on an old delta. The branch of the PKK flow feeding E Lae`apuki sprung numerous new lava flows on 9 May. The next day, the middle branch of the PKK flow developed an open-channel stream on the Pulama pali; it was 10-20 m wide, 500-600 m long, and moving rapidly.

Ocean entries remained active during 11-17 May 2005 in the E Lae`apuki and Kamoamoa areas. By 16 May the E Lae`apuki and E

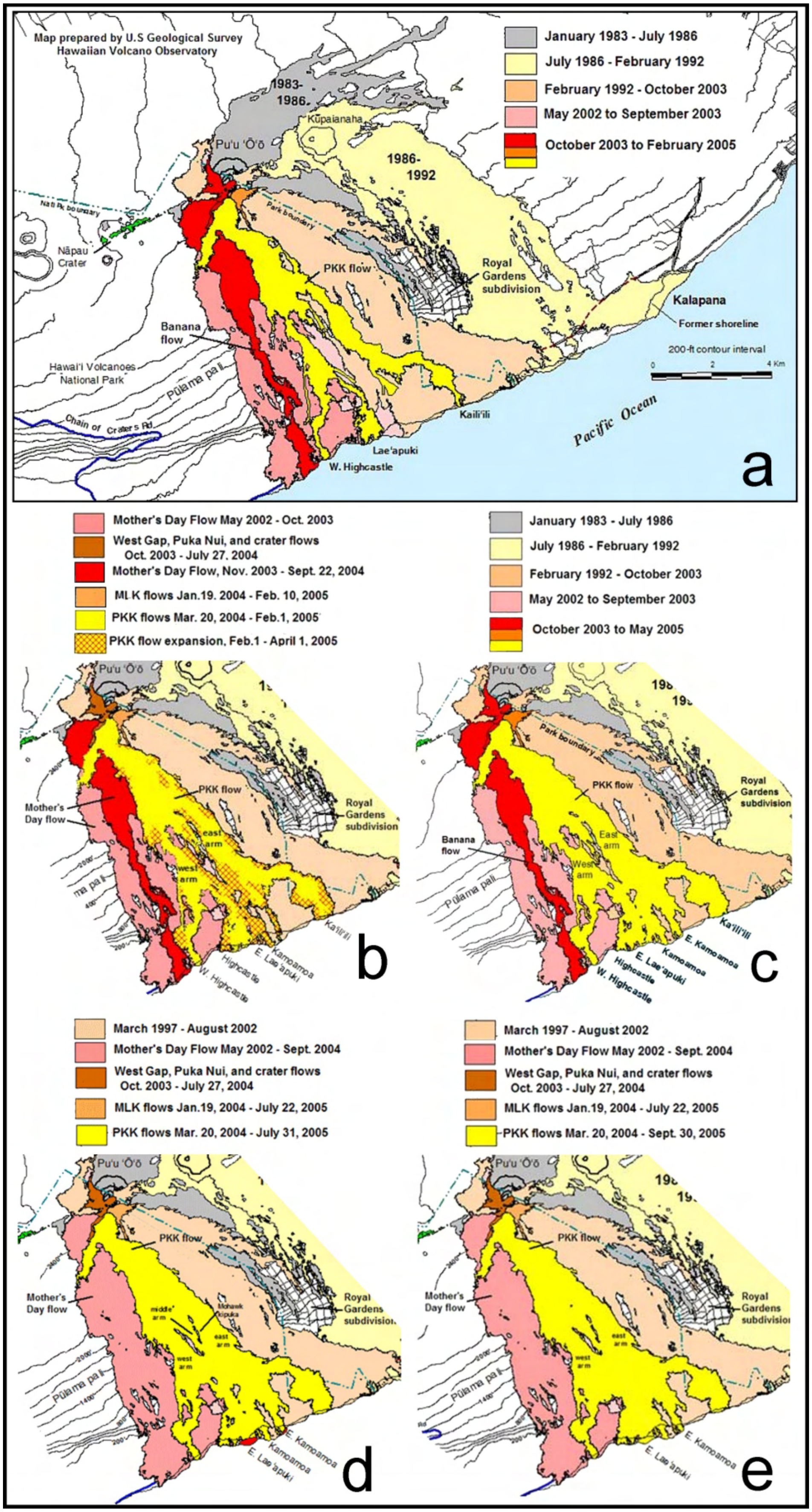

Figure 18. A series of maps portraying Kilauea's surface lava flows at various times during 31 January 2005 to 7 February 2006. New vents opened at the southern base of Pu`u `O`o on 19 January 2004. Map panels are as follows: a) A map with features as of February 2005, b) as of April 2005, c) as of May 2005, d) as of 31 July 2005, and e) as of 30 September 2005. Courtesy of Christina Heliker, USGS HVO.

Kamoamoa entries both had benches ~ 350 m long and up to 75 m wide. A large plume from West Highcastle on 10 May probably recorded a collapse of part of that lava delta, which has been inactive for the past several weeks following growth in March and April. The middle branch of the PKK flow remained active and extended down Pulama Pali. The E branch reached out farther but was narrower and contained fewer breakouts. The W branch was reduced to a cluster of breakouts about halfway down the pali. Glow was seen from all of the Pu`u `O`o crater vents, as well as the MLK vent at the SW foot of the cone.

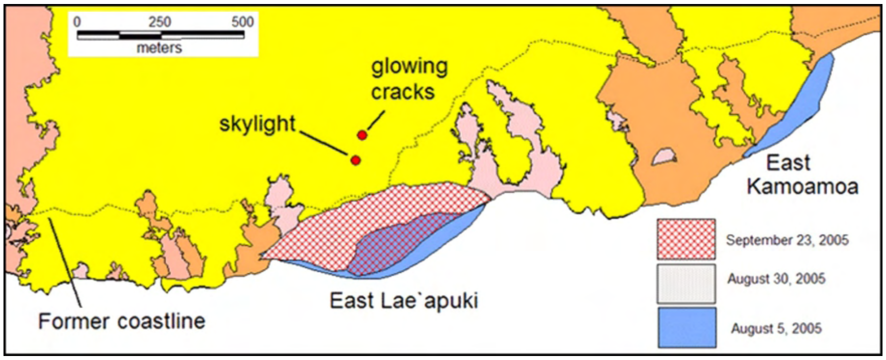

Figure 19. Map portraying Kilauea's near-shore and coastal lava flows areas in the vicinity of East Lae'apuki and East Kamoamoa as of 23 September 2005. Courtesy of Christina Heliker, USGS HVO.

During 18-31 May 2005, lava from Kilauea continued to enter the sea at three areas. Surface lava flows were visible on the coastal plain and on the Pulama pali fault scarp. During 1-4 June 2005 lava entered the sea at three points along the S flank of Kilauea, and then at only two points through 7 June. Small surface lava flows were visible on the Pulama pali fault scarp and the coastal flat.

Lava again entered the sea at three points on 13 June. During the 14-21 June lava continued to enter the sea and there was a small number of lava flows on the Pulama pali fault scarp. On 22 June lava in the W branch of the current flow descended onto the coastal flat for the first time in several months. On 24 June it was noted that Kilauea's summit continued its inflation, while Pu`u `O`o was deflating during the same period.

On 27 June part of the active E Lae`apuki lava delta collapsed. Lava stored within the delta gushed out onto the surface and into the water. Fountains of lava reported to be about 25 m high spurted from the central part of the delta soon afterward. Lava also entered the sea during 4-5 July and a few surface flows were on Pulama pali.

Figure 20. Photos of Kilauea activity taken along the coast on 21 February 2005. (A) A photo showing the walls of a large crack into which lava pours at E Lae`apuki. Sea cliff is to the right, at shelf's edge beyond the glow. (B and C, respectively) The top and bottom of lava falls at E Lae`apuki ocean entry looking W. (D) A closer view focused on showing the base of the lava falls. The sea cliff's height is ~ 12 m. Courtesy of HVO.

Figure 21. A Kilauea photograph taken on 23 February 2005 depicting active lava delta construction at E Lae`apuki ocean entry. Note the fan building outward from the sea cliff and the person (upper right) for scale. Courtesy of USGS HVO.

Figure 22. A photo taken 25 March 2005 showing Kilauea's new Kamoamoa ocean entry, located just NE of East Lae'apuki. Descending lava poured over an old sea cliff to land upon, and flow across, an old delta; it then dropped into the sea, forming a new delta. Courtesy of USGS HVO.

During 6-19 July 2005, lava continued to enter the sea at E Kamoamoa and E Lae`apuki. The latter entry was much larger, with several entry points. E Kamoamoa barely glowed. Surface lava was visible along the PKK lava flow throughout the month of July. Background volcanic tremor remained above normal levels at Kilauea's summit and at moderate levels at Pu`u `O`o. Slight inflation and deflation occurred at the volcano. An M 4.5 earthquake occurred on 25 July at 2209 along the SE edge of Kilauea's SW rift zone at a depth of ~ 30 km.

Up to seven ocean-entry points were visible off the W-facing front of the E Lae`apuki lava delta during 3-9 August; still others were hidden from view off the E-facing front. On Pulama pali, the W branch of the PKK flow reached its greatest extent of the week on 5 August, when it broadened to include hundreds of meters of scattered breakouts and reached from 460 m down to 260 m elevation. During 15-16 August 2005, surface lava at Kilauea was again visible on the W and E branches of the PKK lava flow. Lava continued to enter the sea at the E Lae`apuki entry through 5 September. Background volcanic tremor was near normal levels at Kilauea's summit and at moderate levels at Pu`u `O`o cone. There were small periods of inflation and deflation at Kilauea's summit and Pu`u `O`o. By 22 August, surface lava on the W branch of the PKK lava flow was no longer visible. On 27 August, part of a lava-bench collapsed.

Throughout September, lava entered the sea at the E Lae`apuki area with surface lava flows visible on the Pulama Pali fault scarp. Lava filled a scar left by the lava-bench collapse on 27 August. Background volcanic tremor continued to remain around normal levels at the summit. Volcanic tremor was at moderate levels at Pu`u `O`o. On 11 September, substantial deflation at the volcano was followed by sharp inflation. On 19 September, several small shallow earthquakes occurred along the Kao`iki fault system with small amounts of inflation and deflation.

In October 2005, lava from Kilauea continued to enter the sea at the E Lae`apuki area, and surface lava flows were visible along the PKK lava flow. Lava flows continued to enter the sea at E Lae`apuki area, mostly NE of the point of the lava delta. On 18 October, weak surface lava flows were visible at Kilauea and one cascade of lava flowed off of the western front of the E Lae`apuki delta.

Activity during November 2005 was similar to the previous month. Lava continued to enter the sea at the E Lae`apuki area and surface lava flows were visible on the Pulama pali fault scarp. Background volcanic tremor was near normal levels at Kilauea's summit.

A lava-bench collapse in the E Lae`apuki area on 29 November 2005 was the largest bench collapse of the current eruption, which began in January 1983. The collapse lasted several hours, sending the 137,588 m^2 of bench and an additional 40,467 m^2 of adjacent cliff, into the sea. The collapse left a 20-m-high cliff, from which a 2 m thick stream of lava was emitted from an open lava tube. Cracks had been observed on the inland portion of the bench several months earlier; visitors were not allowed near the bench, but a viewing area was provided ~ 3 km away. Growth of the new delta at E Lae`apuki was continuing as of 6 December 2005. At that time breakouts were also active on Pulama Pali.

During December, lava from Kilauea continued to enter the sea at the E Lae`apuki area and surface lava flows were visible on the Pulama pali fault scarp.

From 28 December 2005 to 9 January 2006, lava from Kilauea continued to enter the sea at the E Lae`apuki area building a new lava delta with surface lava flows visible on the Pulama pali fault scarp. Background volcanic tremor was near normal levels at Kilauea's summit. Volcanic tremor reached moderate levels at Pu`u `O`o. Small amounts of deformation occurred. On 10 January, the summit deflation switched abruptly to inflation after a loss of 5. 2 μrad. Relatively high tremor occurred at this time. The tremor quickly dropped, becoming weak to moderate when deflation ended, with seismicity punctuated by a few small earthquakes. By 13 January, background volcanic tremor was near normal levels at Kilauea's summit and reached moderate levels at Pu`u `O`o. On 14 January, the lava delta was about 500 m long (parallel to shore) and still 140 m wide. By the end of the month the lava delta was 615 m long and 140 m wide. Background volcanic tremor was near normal levels at Kilauea's summit, with numerous shallow earthquakes occurring at the summit and upper E rift zone during several days.

During 2-7 February 2006, lava from Kilauea continued to enter the sea at the E Lae`apuki area and surface lava flows were visible on the Pulama pali fault scarp. Background volcanic tremor was near normal levels at Kilauea's summit, with numerous shallow earthquakes continuing to occur at the summit and upper E rift zone. Volcanic tremor reached moderate levels at Pu`u `O`o. Small amounts of inflation and deflation were reported. From mid-to-late February, surface lava flows were not visible on Kilauea's Pulama pali fault scarp due to lava traveling underground through the PKK lava tube until reaching E Lae`apuki lava delta and flowing into the sea. Observations on 7 February 2006 revealed that the lava delta had broadened 120 m W since 30 January 2006.

Geologic Summary. Kilauea volcano, which overlaps the east flank of the massive Mauna Loa shield volcano, has been Hawaii's most active volcano during historical time. Eruptions of Kilauea are prominent in Polynesian legends; written documentation extending back to only 1820 records frequent summit and flank lava flow eruptions that were interspersed with periods of long-term lava lake activity that lasted until 1924 at Halemaumau crater, within the summit caldera. The 3 x 5 km caldera was formed in several stages about 1500 years ago and during the 18th century; eruptions have also originated from the lengthy East and SW rift zones, which extend to the sea on both sides of the volcano. About 90% of the surface of the basaltic shield volcano is formed of lava flows less than about 1100 years old; 70% of the volcano's surface is younger than 600 years. A long-term eruption from the East rift zone that began in 1983 has produced lava flows covering more than 100 sq km, destroying nearly 200 houses and adding new coastline to the island.

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Karymsky

Kamchatka, Russia
54.05°N, 159.43°E; summit elev. 1,536 m

Karymsky was last reported on in *BGVN* 30:11. After frequent explosions from December 2004 to June 2005 (*BGVN* 30:06) a brief decrease in seismic and volcanic activity took place but this ended in late June when ash and gas plumes rose to 3 km above the crater. Seismicity remained above background levels throughout August-December 2005. During this period, ash and gas plumes and thermal anomalies were observed at the volcano.

Seismic activity indicated that ash explosions from the summit crater of Karymsky continued during 14-20 January 2006. Ash plumes extending 6-9 km S from the volcano were observed on 12 January and a thermal anomaly over the dome was observed during 13-15 January. According to seismic data, two possible ash plumes rose to 3.0-3.4 km altitude on 14-15 January.

According to reports from pilots of local airlines, ash emissions from Karymsky rose to 4-5 km altitude during 30-31 January. The ash plumes extended 13-29 km to the SW and SE, respectively. A thermal anomaly was visible at the lava dome during 27 January to 3 February, except when the volcano was obscured by clouds on 28 January. KVERT warned that activity from the volcano could affect nearby low-flying aircraft.

Strombolian activity continued through April 2006. During 10 February to 10 March, a large thermal anomaly was visible at the crater and numerous ash plumes were visible on satellite imagery extending as far as 140 km. On 9 March, a pilot reported an ash plume at a height of ~ 3 km altitude.

During 17-24 March, several ash plumes were visible on satellite imagery at a height of ~ 4 km altitude and extending SE and E. A thermal anomaly was seen at the volcano during periods of visibility. About 40-450 small earthquakes occurred daily.

During 7-14 April satellite imagery showed ash plumes extending ~ 40-145 km E and SE of the volcano, and a large thermal anomaly at the crater. Karymsky remained at Concern Color Code Orange from January to April 2006.

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

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Bezymianny

Kamchatka Peninsula, Russia
55.98°N, 160.59°E; summit elev. 2,882 m
All times are local (= UTC + 13 hours)

This report describes a substantial eruption on 9 May 2006, and events before and shortly afterwards. Bezymianny was last reported on in *BGVN* 30:11, covering a series of events during mid-January through late December 2005.

An explosive eruption occurred on 30 November 2005. Seismicity decreased subsequently and from January to the end of April 2006, Bezymianny remained comparatively calm; fumarolic activity and a small thermal anomaly were observed during periods of good visibility. A 1 April aerial photo of the summit area appears as figure 23.

During 28 April to 5 May, Bezymianny's lava dome continued to grow. Seismicity was above background levels during 30 April to 3 May. Incandescent avalanches were visible on 4 May. At the lava dome, fumarolic activity occurred and thermal anomalies were visible on satellite imagery. Bezymianny was at Yellow on the four stage Concern Color Code (low to high–Green, Yellow, Orange, Red).

On 7 May the Concern Color Code was raised to Orange due to an increase in seismicity and the number of incandescent avalanches (14 occurred on 6 May in comparison to 4-6 during the previous 2 days). Intense fumarolic activity occurred, with occasional small amounts of ash. KVERT reported that an explosive eruption was possible in the next 1 or 2 weeks.

9 May eruption. On 9 May around 1935, the Concern Color Code was raised to Red, the highest level, due to increased seismicity and incandescent avalanches. A gas plume rose higher than 7 km altitude and a strong thermal anomaly was visible on satellite imagery.

An explosive eruption occurred on 9 May during 2121 to 2145. The explosion produced an ash column that rose to a height of ~ 15 km altitude. A co-ignimbrite ash plume was about 40 km in diameter and mainly extended NE of the volcano. Ash plumes extended more than 500 km ENE from the volcano. Pyroclastic flows deposits extended 7-8 km from the volcano.

On 10 May around 0100, seismicity returned to background levels and the Concern Color Code was reduced to Orange. Small fumarolic plumes were observed during the early morning of the 10th and lava probably began to flow at the lava dome.

By 11 May seismic activity was still at background levels. Gas and steam plumes were visible above the volcano. A thermal anomaly was noted at the volcano on 10-11 May. Lava effusion was probably occurring at the lava dome. This was interpreted to mean that the likelihood of a large, ash-producing eruption had diminished.

Geologic Summary. Prior to its noted 1955-56 eruption, Bezymianny volcano had been considered extinct. The modern Bezymianny volcano, much smaller in size than its massive neighbors Kamen and Kliuchevskoi, was formed about 4700 years ago over a late-Pleistocene lava-dome complex and an ancestral volcano that was built between about 11,000-7000 years ago. Three periods of intensified activity have occurred during the past 3000 years. The latest period, which was preceded by a 1,000-year quiescence, began with the dramatic 1955-56 eruption. This eruption, similar to that of Mount St. Helens in 1980, produced a large horseshoe-shaped crater that was formed by collapse of the summit and an associated lateral blast. Subsequent episodic but ongoing lava-dome growth, accompanied by intermittent explosive activity and pyroclastic flows, has largely filled the 1956 crater.

Information Contacts: *KVERT* and *AVO* (see Karymsky).

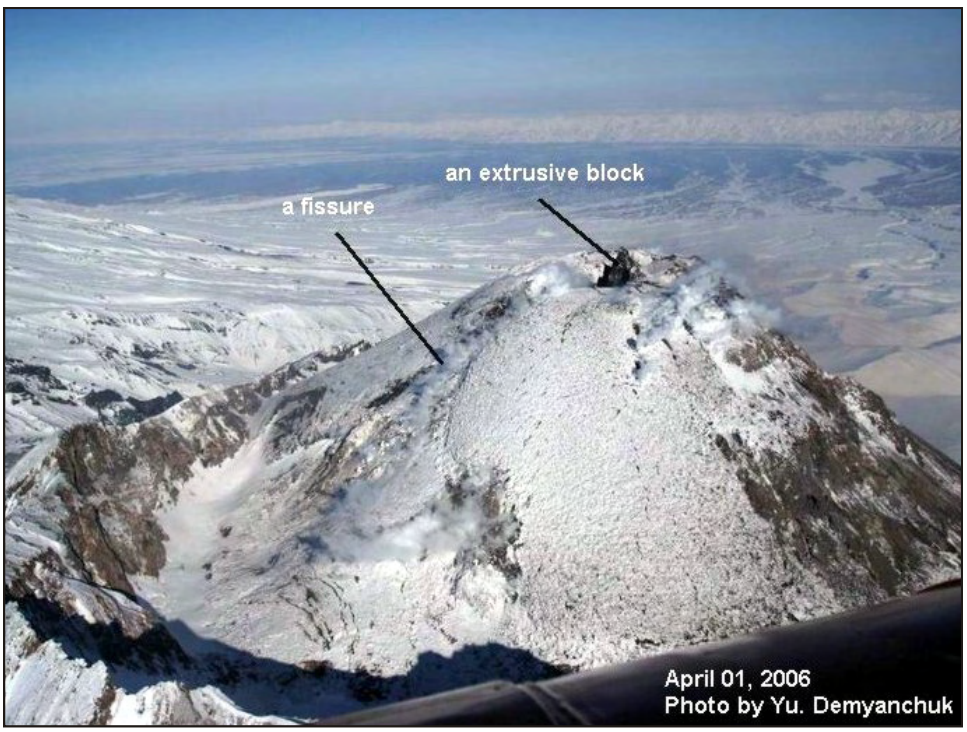

Figure 23. Bezymianny aerial photo taken on 1 April 2006, showing the large dome within the breached summit crater. Labels indicate both a fissure on the dome's flank and a large extrusive block (or spine) on the dome's top. Considerable areas discharged light steam. Photo by Yu. Demyanchuk and provided courtesy of KVERT.