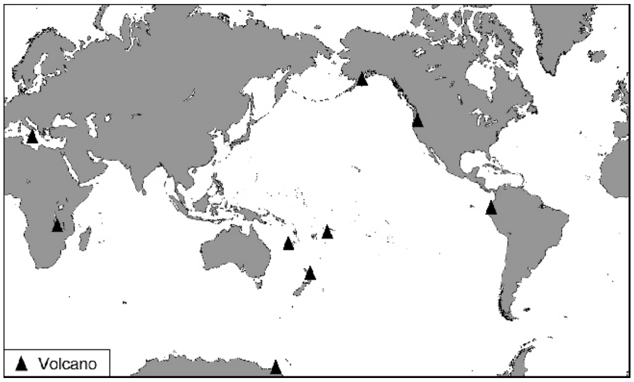
Bulletin of the Global Volcanism Network



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

Tungurahua

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

According to the Instituto Geofísico-Escuela Politécnica Nacional (IG), Tungurahua, located 180 km S of the capital Quito, erupted on 14 July 2006 (*BGVN* 31:07), and again with great intensity in mid-August, resulting in at least five deaths. The 14 July event marked the beginning of a new energetic phase of activity different from that seen since October 1999. This report was taken from the IG's *Special Reports* and *Bulletins* (Numbers 7-15) discussing events from mid-July 2006 through early January 2007.

The new phase that began in July 2006 was characterized by highly explosive activity. It was associated with the arrival of a large volume of magma and the expulsion of hot, sometimes incandescent, pyroclastic flows. These flows traveled downslope with speeds of ~ 40 km/hour from the W, NW, and N flanks of the cone and ended at the Chambo river. The primary route of the flows was via the Achupashal, Cusua, La Hacienda, Juive Grande, Mandur, and Vascún gorges (see maps and figures in *BGVN* 31:07). Some of these flows were sufficiently large and mobile as to reach the Baños-Penipe road. The settlements of Cusúa, Bilbao, and to a lesser extent Juive Grande, were affected by these flows, which devastated pastures, fields, livestock, and basic infrastructure.

Additionally, small-volume pyroclastic flows descended the Vascún valley (upslope from the western part of Baños) but ended 2.5 km upstream from the hot springs of El Salado. The emission of hot incandescent pyroclastic flows ended one week after the explosive eruptions of 14-15 July.

Volcanic activity decreased significantly several weeks after 14 July, as shown by the seismic-based indicator developed for Tungurahua by the IG (figure 1). The daily indicator value decreased after mid-July and remained consistent until a slight increase during 8-13 August.

On 1 August, a pyroclastic flow traveled W and SW down the flanks and reached the Rea gorge, where it left deposits an estimated 50 m thick consisting largely of blocks and ash. On 2 August, a small lahar traveled NW and blocked a highway. Strombolian activity was observed at night on 3 August. Small explosions were registered during 3-7 August. On 6 August, light ashfall was reported ~ 8 km SW in the town of Manzano.

During 9-15 August, small-to-moderate explosions produced plumes composed of gas, steam, and small amounts of ash that reached heights of ~ 1 km above the summit. Light ashfall was reported in nearby localities during 9-10 August. On 9 and 13 August, explosions expelled blocks of incandescent material that rolled 100 m down the W flank.

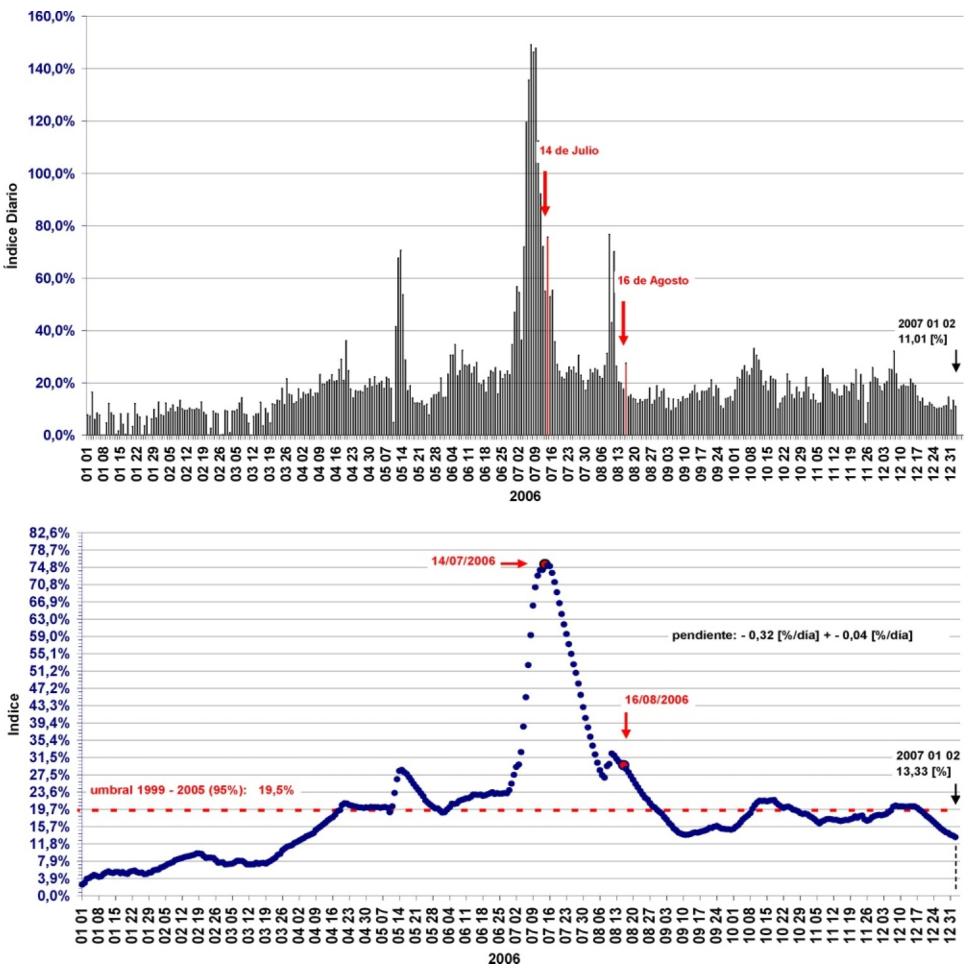

Figure 1. Index of daily seismic values (top) and index expressed in percentages (bottom) for Tungurahua from 1 January 2006 to 2 January 2007. Arrows mark the dates of the eruptions mentioned in this report. Courtesy of IG.

Bulge detected and intense explosive eruptions on 16 August. Clinometer measurements on 16 August indicated a bulge on the N flank as compared to 11 August. Seismic activity increased, as ash-and-gas plumes reached heights of 3 km above the summit and drifted W and NW. About 3,200 people were evacuated from "at-risk" areas. At 1900 on 16 August, a new, intense explosive eruption began that continued throughout the day. A large pyroclastic flow did not reach the road.

The eruption continued through 0145 on 17 August at high levels of intensity, ejecting incandescent rocks and generating pyroclastic flows. Several pyroclastic flows were reported in the Achupashal, Mandur y La Hacienda, Juive and Vascún ravines. On the 17th tephra fall (with pumice clasts ~ 3 cm in diameter) was reported from several areas in a wide zone that extended from Penipe in the SW to ~ 15 km NW. Ash plumes reached estimated heights of 10 km above the summit and covered the central part of Ecuador, forming a cloud ~ 742 km long and ~ 185 km wide trending NNW and SSE.

As of mid-August, about 20 pyroclastic flows had descended the above-mentioned ravines, and possibly others on the SW flank. At 2125 the largest pyroclastic flow of the sequence descended the Achupashal ravine and reached and dammed the Chambo river.

At 0033 on the 18th activity intensified, generating several pyroclastic flows and ashfall in several sectors from Penipe in the SW to the N; hot ashfall was reported in the villages of Pelileo, Cevallos, San Juan, and Cotaló. The large quantity of accumulated ash on roofs in the village of Pillate caused their collapse. The city of Baños lost electrical service. During this period, one of the pyroclastic flows descended near Juive Grande and crossed the Ambato-Baños. A sustained eruption column appeared incandescent and glowing at the base, with an associated ash cloud to 7 km above the crater that was blown W and SW. Continuous sprays and jets of lava rose hundreds of meters above the crater.

The explosive eruption on 16-17 August culminated around 0200 (figure 2), after which time the activity gradually decreased. The IG report stated that on 17 August, although the eruptive activity had ceased, longer lasting events including movement of magma and continuous deformation on the N flank indicated that residual magmatic fluid in the volcanic system was putting pressure on the structure. Additionally, emission of SO_2 continued to be detected in moderate amounts. This report (*Special Report #14*, 17 August 2006) also reminded authorities that the events of 1918 included five explosive eruptions interspersed with periods of reduced activity and that the entire W flank remained at risk of collapse, which could release a large volume of lava and produce much larger pyroclastic flows. Communities at most risk would be on the NW flank (Juive Grande, Los Pájaros, Cusua, Bilbao), but more distant zones at the bottom of the Chambo and Pastaza valleys (Chacauco, and eventually Puñapí) would also be affected.

Dramatic developments. On 18 August, incandescent blocks ejected from the summit descended ~ 1.7 km down the flank. Also that day, based on seismic interpretation, one of the blockages damming part of the Chambo River had been breached.

During 18-19 August, the N flank continued to inflate. During 20-21 August, steam emissions were observed during breaks in the cloud cover and the N flank exhibited deflation. On 23 August, two slow-moving lava flows were identified on the NW slope.

According to news reports, falling ash and debris caused fires and severe damage to five villages. An estimated 20,000 hectares of crops were destroyed. At least five people were dead or missing, and several more were injured. An estimated 4,000 people relocated to shelters.

Relative quiet, late August-October. During 23-27 August, visual observations of Tungurahua were impaired due to inclement weather. Based on seismic interpretation, lava continued to slowly flow NW towards Cusúa and La Hacienda. Seismicity was low and dominated by long-period earthquakes. Inclinometer measurements indicated no additional inflation on the flanks.

During September, seismicity remained low. On 1 September, lava flows on the NW flank were confirmed to have ceased. On 7 September lahars descended the NW gorges of Chontapamba and Mandur. During the month, there were several steam-and-gas plumes with little or no ash content. The emission heights ranged from ~ 0.1 to 2 km above the summit, and the primary wind drift was to the NW and W. Incandescence at the summit was observed at night. On the afternoon of 21 and on 22 September, moderate ash emissions occurred. Three more emissions on 23 September caused ashfall in Penipe; one plume rose 3 km and another 4 km above the summit. Ash plumes were seen again on 25 September.

No ash emissions were reported between 27 September and 2 October; however, on 2 October a slow-moving lava flow was seen descending the NNW flank and some fumarolic activity from the crater was observed. On 3 October an explosion resulted in ash falling in nearby communities to the W. According to the IG and aviation sources, the plume rose to at least 5 km above the summit.

During 4-5 October, Tungurahua's N flank fumaroles were active and steam emissions with minor ash content rose to 1 km above the summit and drifted W. Additional steam plumes possibly originated from the recent lava-flow's front. The IG again reported an increase in emissions and seismicity on 11 and 12 October, when steam plumes with slight to moderate amounts of ash reached 9-12 km altitude. Light ash fell in areas to the NW and W. During 13-17 October, seismicity decreased and plumes reached 7-8 km altitude.

On 16 October a small lava flow spalled off incandescent blocks; gas plumes were observed. Lahars traveled N toward Baños and down the Vazcún and Ulba gorges.

During 18-19 October, ash emissions increased in intensity and seismic tremor was continuous. During the night, lava fountains reached heights of 1 km above the crater rim and blocks rolled 800 m down the flanks. According to the Washington VAAC, around this time a pilot reported an ash plume to an altitude of 8.5 km. Ash plumes drifted NE and E and generated ashfall about 50 km E, in Puyo. According to news articles, about 300 villagers were evacuated.

Emissions continued during 20-24 October, producing plumes to 7-8 km. Ashfall was reported from towns on the N, NW, W, SW, and E flanks. On 28 October, incandescent blocks were expelled from the summit and rolled about 500 m down the W and E flanks. The next day, a lahar traveled NNW down the Mandur drainage and muddy water swelled

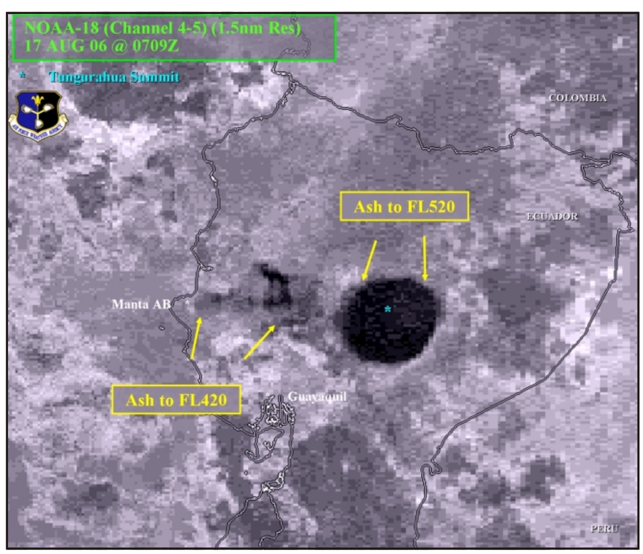

Figure 2. An interpreted satellite image of a tall Tungurahua eruption column. The satellite was NOAA-18 (Channel 4-5) (1.5 nautical mile resolution) at 0209 (0709 UTC) on 17 August 2006. Courtesy of the Air Force Weather Agency.

in the Vazcún drainage. Incandescence from the crater was seen during most of October.

Ash plumes of steam and gas, and moderate ashfalls, were reported from several downwind towns on 5 and 6 November, including Bilbao (8 km W), Cotaló (13 km NW), and Manzano (8 km SW). On 2 November incandescent blocks were expelled from the summit and rolled 700 m down the W and E flanks. Nighttime incandescence was observed during 2-4 November.

On 7 November, a voluminous lahar traveled down gorges to the W and reached as far as the Chambo river, ~ 7 km from the summit. On 8 November, blocks expelled from the summit rolled down the flanks and ashfall was reported from areas including Casúa (7 km NW) and Baños (8 km NE). On 10, 11, and 13 November, ash fall was reported from areas including Penipe (8 km SW). During 12-13 November, lahars traveled down W and NW drainages and the Vazcún river swelled with muddy water.

On 17 November, an ash plume reached an altitude greater than 10 km and drifted NW and NE. During 26-27 November, Strombolian activity propelled incandescent material up to 600 m above the summit. Blocks rolled 2 km down the flanks. Lightning was visible in an ash plume that reached 7 km altitude and ashfall was reported from areas 8 km WSW. On 27 November, an ash plume rose to 9 km and drifted W. These conditions continued on into early December. On 6 December, plumes reached an altitude of 10 km. Ashfall was reported in areas including Cotaló, about 13 km NW, Pillate, about 7 km to the W, and Puela, about 8 km SW. On 9 December, ashfall up to 1 mm thick was reported about 12 km N in Baños.

Around this time seismicity was minimal in both intensity and duration. The plumes drifted in multiple directions. On 14 December, a lahar traveled SW down the Mapayacu gorge. On 21 December, lahars from Tungurahua traveled NW down the Mandur gorge resulting in a road closing and W down the Bilbao gorge. Gas-and-steam emissions produced small plumes on 22, 23, and 25 December. During 27 December-2 January, seismicity at Tungurahua remained moderate to low. On 27 and 28 December, lahars traveled down drainages including Bilbao to the W, Mandur to the NNW, and Mapayacu to the SW. During 3-9 January, seismicity at Tungurahua remained low to moderate.

Correction. One or more previous “Geologic Summaries” incorrectly gave the eruption’s start date as 1995; that was a typographical error. The correct start date is October 1999.

Geologic Summary. Tungurahua is a steep-sided andesitic-dacitic stratovolcano that towers more than 3 km above its northern base. It is one of Ecuador’s most active volcanoes. Three major volcanic edifices have been sequentially constructed since the mid-Pleistocene period over a basement of metamorphic rocks. Tungurahua II was built within the past 14,000 years following the collapse of the initial edifice. Tungurahua II itself collapsed about 3,000 years ago and produced a large debris-avalanche deposit and a horseshoe-shaped caldera open to the W, inside which the modern glacier-capped stratovolcano (Tungurahua III) was constructed. Historical eruptions have all originated from the summit crater. They have been accompanied by strong explosions and sometimes by pyroclastic flows and lava flows that reached populated areas at the volcano’s base. Prior to a long-term eruption beginning in 1999 that caused the temporary evacuation of the city of Baños at the N foot of the volcano, the last major eruption had occurred from 1916 to 1918 with minor activity continuing until 1925.

Information Contacts: *Geophysical Institute (IG)*, Escuela Politécnica Nacional, Apartado 17-01-2759, Quito, Ecuador (URL: http://www.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/); *International Federation of Red Cross And Red Crescent Societies (IFRC)* (URL: http://www.reliefweb.int/); *Agence France-Presse* (URL: http://www.afp.com/); *Associated Press* (URL: http://www.ap.org/).

St. Helens

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

The current and ongoing eruption of the St. Helens started on 11 October 2004. Extrusion of the growing dacitic lava dome has continued in the same quiescent but sustained mode exhibited throughout the first half of 2006 (*BGVN* 31:07) . Levels of seismicity have remained generally low, with low emissions of steam and volcanic gases and minor production of ash.

From 26 July through 3 October 2006, the lava dome continued to grow and produce small rockfalls accompanied by minor earthquakes. M 3-3.6 earthquakes occurred on 26, 28, and 31 July. Resulting dust plumes rose well above the crater rim. A steam plume was observed rising from the growing lava dome on 13 August. During 16-22 August, based on interpretations of seismic data, spine extrusion from the dome continued in conjunction with small earthquakes and rockfalls. By mid-August 2006 the dome’s volume was about 85 million cubic meters growing at an average rate of less than 1 m^3/s. The lava dome’s height above the 1986-crater floor started at 396 m. On 9 and 10 September, five shallow earthquakes greater than M 2 occurred in association with the growing dome. A period of relatively low seismic activity followed.

From 20 September through 3 October, lava extruded slowly from the vent onto the S crater floor; there was only low seismicity that generated occasional rockfalls as talus sloughed off the flanks of the growing dome. The rate of dome deformation was low. There was no change in rock chemistry, suggesting little to no change in eruptive style. The lack of explosive activity coupled with continuing low number of earthquakes and small quantities of volcanic gas indicate that the risks posed by the hazards are currently relatively low.

During October, lava continued to extrude onto the S crater floor of St. Helens and observations and data from deformation-monitoring instruments showed the dome continued to grow. Low seismicity and slight tilting of the crater floor produced small rockfalls. A small steam plume was visible on 9 October. On 22 October, an M 3.5 earthquake triggered the collapse of material from the largest of the lava-dome spines. The resulting ash plume rose to about 3.2 km and quickly dissipated to the W. On 29 October, a M 3.2 earthquake was accompanied by a rockfall that produced a small plume. The plume filled the crater to just above the rim and quickly dissipated.

Throughout November and December, data from deformation-monitoring instruments showed that during 1-7 November, the lava dome continued to grow. Inclement weather prohibited visual observation during most of the reporting period. On 5 and 6 November, acoustic flow monitors recorded rain-induced debris flows within the crater and in the upper part of the North and South Fork Toutle River valleys. Seismicity continued at low levels, punctuated by M 1.5-2.5, and occasionally larger, earthquakes. On 21 November, views from an aircraft and a crater camera showed that an active spine continued to extrude. On 18 December, a steam plume rose several hundred meters above the rim and was visible from the Portland area, about 80 km away.

Scientists working on the "old part" of the new lava dome found evidence to suggest that the lava dome was essentially solidified within several hundred meters beneath the crater floor. The outer 2-3 m of the lava dome was composed of ground rock that transitions to solid rock with numerous fractures. These findings support the stick-slip model of lava dome extrusion. If the model is correct, it may help explain the origin of many of the million plus small, shallow earthquakes as the result of numerous sub-surface slips that created the ground and fractured rock. Scientists have also noted that for short periods (hours to perhaps a day) part of the growing lava dome appears to stick (no movement detected in photographs) and then restarts again after high-M 2 to low-M 3 earthquakes.

Alert Level terminology. On October 1, the alert-level system for all volcanoes monitored by the USGS was changed to a descriptive system (table 1). In the new system, "Normal" indicates background conditions are stable; this is equivalent to aviation color-code Green. The previous alert levels of Volcanic Unrest (Alert Level 1), Volcano Advisory (Alert Level 2) and Volcano Alert (Alert Level 3) have changed to "Advisory," "Watch," and "Warning," respectively. There is a minor additional change for the aviation color-code definitions in that there is no longer an ash-plume threshold given for either Orange or Red. The ash-plume height threshold of 25,000 ft. or less for aviation warning condition "Orange" is no longer mandatory; condition "Red" was for ash above 25,000 ft. Now the height threshold can be adjusted for each case.

Throughout the period covered by this report, the hazard status for St. Helens remained at Volcano Advisory Alert Level (2) "Watch;" aviation color code Orange. The alert-level "Watch" is used for two different situations: (1) heightened or escalating unrest indicating a higher potential that an eruption is likely, but still not certain; or (2) an eruption that poses only limited hazard. Descriptor definition "Watch" fits the current lava-dome eruption at St. Helens.

Geologic Summary. Prior to 1980, Mount St. Helens formed a conical, youthful volcano sometimes known as the Fuji-san of America. During the 1980 eruption the upper 400 m of the summit was removed by slope failure, leaving a 2 x 3.5 km horseshoe-shaped crater now partially filled by a lava dome. Mount St. Helens was formed during nine eruptive periods beginning about 40-50,000 years ago and has been the most active volcano in the Cascade Range during the Holocene. Prior to 2200 years ago, tephra, lava domes, and pyroclastic flows were erupted, forming the older St. Helens edifice, but few lava flows extended beyond the base of the volcano. The modern edifice was constructed during the last 2200 years, when the volcano produced basaltic as well as andesitic and dacitic products from summit and flank vents. Historical eruptions in the 19th century originated from the Goat Rocks area on the north flank, and were witnessed by early settlers. This volcano is well known for its ash explosions and pyroclastic flows.

Volcano Alert Level Nomenclature

Old Numerical Level	New Descriptor	Aviation Color Code
Background conditions are stable		Green
1 "Unrest"	"Advisory"	Yellow
2 "Advisory"	"Watch"	Orange
3 "Alert"	"Warning"	Red

Table 1. Revised volcano Alert Levels for all volcanos in the Cascade range. Courtesy USGS-CVO.

Information Contacts: *Cascades Volcano Observatory (CVO)*, U.S. Geological Survey, 1300 SE Cardinal Court, Building 10, Suite 100, Vancouver, WA 98683-9589, USA (URL: http://vulcan.wr.usgs.gov/, Email: gscvoweb@usgs.gov).

Augustine

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

During the latter half of 2006 and through January 2007, Augustine experienced low-level activity, in stark contrast to the energetic eruptions of January and February 2006 (*BGVN* 31:04). Five ocean-bottom seismometers were deployed on 8 February 2006 around Augustine Island in Cook Inlet to assist the Alaska Volcano Observatory (AVO) in monitoring activity on the island. Figure 3 shows new deposits as of April 2006. This report covers the declining volcanism from April 2006 through January 2007.

Activity during mid-2006. The frequency of rock falls, avalanche events, and hot block-and-ash flows consistently decreased during April to August 2006. One exception was a minor spike consisting of 17-18 April avalanche signals that were larger relative to those seen in previous weeks. Based on aerial observations on 19 April, an active rock fall and avalanche chute developed near the margin of the new lava flow/dome complex in the NW summit area. Associated rockfalls contributed to an ash blanket visible on the SW flank.

Steaming was consistently seen during periods of visibility (figure 4). Visible growth of the lava dome continued, and the new dome and lava flows remained highly unstable through June 2006. Web camera views showed a low-level steam plume during the first two weeks of June 2006. According to the Anchorage VAAC, on 27 July 2006 around midnight, a pilot reported an ash emission that reached ~ 1.5 km altitude and drifted SSE. There was no seismic evidence for the event.

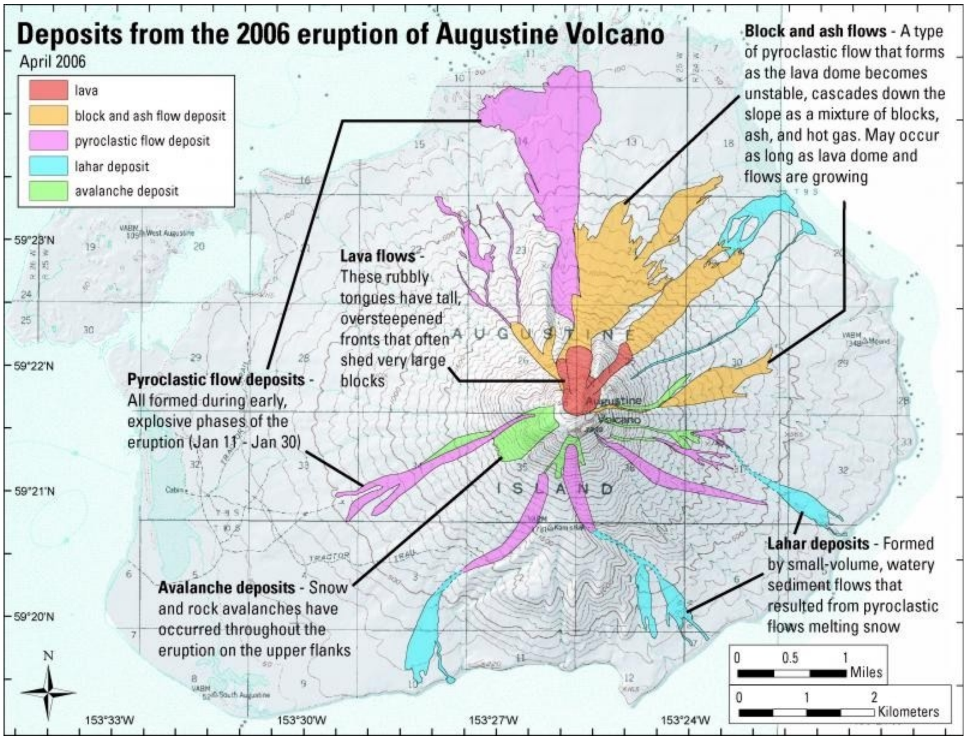

Figure 3. New deposits from the current Augustine eruption, as of mid-April 2006. This map was created using aerial observations, photos, satellite images, and limited field work. Courtesy of Alaska Volcano Observatory.

On 28 April, AVO lowered the Concern Code level from orange to yellow where it remained until August. Satellite images indicated declining thermal output consistent with the decrease in activity during April 2006. Airborne sulfur dioxide gas measurements showed continued high levels of magmatic gas emission that could be associated with degassing of lava at the summit in April 2006. Weak thermal anomalies persisted in satellite data through August 2006, and seismic levels decreased to background by this time. On 9 August 2006, it lowered the level of Concern Color Code from yellow to green (the lowest level).

Activity during late 2006-early 2007. Since 9 August 2006, seismicity remained at or near background and AVO did not detect ash plumes or significant temperature fluctuations.

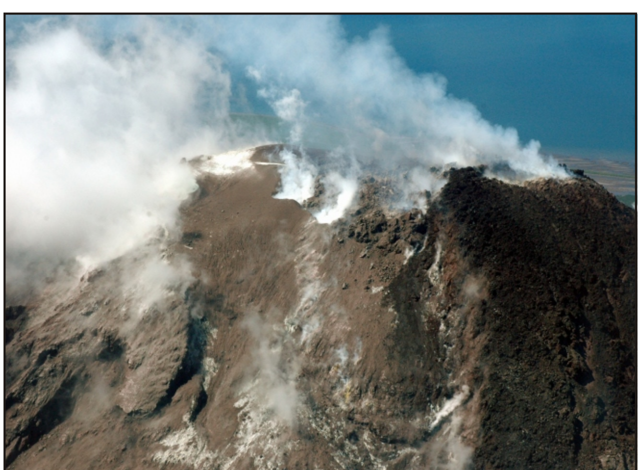

Figure 4. Photograph taken on the afternoon of 12 July 2006 from the E, showing the upper NE flank of Augustine volcano and the new lava dome. Courtesy of AVO and Game McGimsey.

Brief seismic activity occurred during 11 September-4 October 2006. During that time period, the number of earthquakes rose from zero to seven, followed by a plunge of activity that persisted through January 2007. AVO web camera views showed typically light steaming from the summit from September 2006 to January 2007.

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.

Information Contacts: *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.

Home Reef

Tonga Islands, SW Pacific
18.992°S, 174.775°W; summit elev. -2 m
All times are local (= UTC + 13 hours)

The island built by the eruption from Home Reef in early August (*BGVN* 31:09 and 31:10, table 2) was directly observed on 14 November and 7 December. No additional information about the eruption site has been received after 7 December.

Paul Taylor reported that the Home Reef island was observed on 14 November by a Tongan Defence Force patrol boat. The island was reported to be ~ 40 m high, roughly

300 x 300 m at that time, and looked quite consolidated with pumice on the outside, while the center looked "more substantial." Although not in eruption, a considerable plume of smoke/steam was being emitted.

Date	Activity / Phenomena
05 Aug 2006	MODIS satellite image shows no activity.
08 Aug 2006	At 1020 local time (2120 UTC on 7 Aug) MODIS image shows eruption plume surrounded by roughly 8-km-diameter circular pumice raft (55 km^2). The diffuse eruption plume was seen in imagery extending 80 km SSW and 70 km SSE. MODIS image at 1445 (0145 UTC) showed larger pumice raft still attached to vent, and diffuse plume visible to 300 km S. SO_2 first detected by OMI on Aura satellite. Late in the afternoon a continuous rumbling like thunder was heard from Vava'u; red glow was seen on the horizon that evening.
09 Aug 2006	Continuous rumbling like thunder to the S of Vava'u, large mushroom-shaped eruption plume was being ejected above the vent in the morning. MODIS imagery at 1103 local time (2203 UTC on 8 Aug) showed that the pumice raft was still attached to vent, but had drifted to the W and was approximately 150 km2. White eruption plume quickly lost in cloud cover. SO_2 mass (determined by OMI) detected E of Tonga was ~ 25 kilotons.
10 Aug 2006	Continuous rumbling like thunder to the S of Vava'u. MODIS imagery at 1432 (0132 UTC) shows that a large pumice raft has moved N of Late Island (20 km NE). Some pumice remains around vent site, but is hidden by eruptive plume. Submarine plume of discolored water extends to Late Island. Diffuse plumes extend at least 100 km SE and 330 km NW.
11 Aug 2006	Continuous rumbling like thunder to the S of Vava'u, large eruption plume above the vent. MODIS imagery at 1052 (2152 UTC on 10 Aug) showed a thin white eruption plume directed 25 km SW before being lost in cloud cover. No significant pumice raft seen near the vent, but there was an extensive area (150 km^2) of discolored water surrounding the site.
12 Aug 2006	Eruption column moving NW reported by crew of the yacht Maiken. Surtseyan explosive jets being emitted, producing projectiles that fell to the sea around the vent area. Multiple peaks had formed around a central crater that was open to the sea on one side. The island was about 1.5 km in diameter. OMI detection of SO_2 shows 3.3 kilotons in the area.
14 Aug 2006	MODIS image at 1405 (0105 UTC) shows small E-directed white plume, probable island, and large area of strongly discolored water (30 km2) E of the island. Sinuous submarine plume of discolored water extends 60 km NW.
16 Aug 2006	Island was completely covered by clouds in a MODIS image at 1110 (2210 UTC on 15 Aug), but a plume of discolored water stretched more than 50 km N to some pumice rafts.
17 Aug 2006	MODIS imagery at 1435 (0135 UTC) revealed meteorological clouds streaming from Late Island and Home Reef. Discolored water throughout the area N towards Late, and extending 80 km N to large pumice rafts. No significant pumice rafts seen near the island.
19 Aug 2006	No eruption plume seen from island in MODIS imagery at 1425 (0125 UTC). Weakly discolored water patches extending NNW.
22 Aug 2006	Small whitish cloud attached to island seen in MODIS image at 1030 (2130 UTC on 21 Aug) may be meteorological (similar clouds attached to Late). Strongly discolored water in narrow submarine plume very coherent to 8 km NE before diffusing and moving NW.
23 Aug 2006	MODIS imagery at 1115 (2215 UTC on 22 Aug) very cloud-covered, but large zone of discolored water located N of the island.
27 Aug 2006	Island present on MODIS image at 1050 (2150 UTC on 26 Aug) with a coherent submarine plume being dispersed to the N.
mid-Sep 2006	Island reported present at the site of Home Reef by Tongan fishing vessel.
20 Sep 2006	"Strong sulfur odor" noted by a yacht passing W of the volcano.
04 Oct 2006	Several submarine plumes observed on ASTER images. The island present was oval in shape, with the long axis orientated NE-SW. The island measured about 800 x 400 m and covered an area of 0.23-0.26 km2. Several small lakes were present within the island.
12 Nov 2006	No activity observed on ASTER images. Island was still present but with no crater lakes. The island was triangular in shape and covered an area of 0.146 km^2.
14 Nov 2006	Island observed by Defence Force patrol boat was ~40 m high, d square in shape, 300 m on a side. The island looked quite consolidated. Plume of smoke/steam, but no eruptive activity.
07 Dec 2006	Overflight by a RNZAF Orion revealed a roughly circular island, 450 m in diameter, at 18°59.4'S 174°45.4'W. The crew estimated the height as "up to 240 ft" (75 m). Minor fumarolic activity was occurring in the crater and there was a noticeable smell of sulfur. Sediment/hydrothermal plumes were present in the surrounding waters.

Table 2. Summary of activity at Home Reef, August-December 2006. Only near-source observations are included, not dispersed pumice sightings. Revised area calculations were made using a Google Earth tool. Data supplemented, especially with additional satellite observations, from a table originally prepared by Paul Taylor.

The island was photographed on 7 December 2006 (figure 5) by the Royal New Zealand Air Force (RNZAF) at the request of volcanologists from the Institute of Geological & Nuclear Sciences (IGNS). Satellite imagery on 4 October showed an island about 0.24 km^2, which decreased by about one-third to 0.15 km^2 by 12 November. The RNZAF Orion crew reported that the roughly circular island was 450 m in diameter (0.16 km^2), with a maximum height of 75 m (figure 6). The position was reported as 18°59.4'S, 174°45.4'W (18.99°S, 174.757°W). Minor fumarolic activity was occurring in the crater and there was a noticeable smell of sulfur. Plumes of discolored water were present in the surrounding area. The higher-angle views of the island showed an area that had eroded to just below the ocean surface, possibly reflecting the previous extent of the island.

Floating pumice observations. Pumice from the Home Reef eruption was identified in Terra and Aqua MODIS satellite images as well as being reported by sailors and Fijians (*BGVN* 31:09 and 31:10). A compilation of all of these sources (figure 7) seemed to indicate that two major tracks were taken by most of the pumice. Initially, all of the pumice went N, then WNW across the ocean towards Fiji. Approximately midway to Fiji, some of the pumice turned on a more westerly course then moved south before impacting Vatoa and passing the southern Lau Islands enroute to Kadavu and Vanua Levu. Another batch of pumice continued on a WNW course, penetrating the northern Lau Islands to Taveuni, the Koro Sea, and Viti Levu. Both groups of pumice eventually passed W of Fiji, with some getting to Vanuatu in November. Most of the pumice appears to have been generated during 8-10 August, but there may have been smaller pumice-creating eruptions that were not documented.

Satellite imagery revealed not only the paths taken by pumice rafts, but also their changing morphology. Although cloud-cover was a problem, the MODIS images did show enough pumice zones to allow their areas to be sketched (figure 8). Note that all

Figure 5. Low-angle aerial photographs of Home Reef, 7 December 2006. The top view is looking NNE towards Late Island in the background. The bottom view is looking S. Courtesy of the RNZAF and IGNS.

Figure 6. High-angle aerial photographs of Home Reef, 7 December 2006. The top view is looking approximately W, showing that the northern end of the island has eroded to just below sea level. Submarine plumes of sediment are also obvious. The bottom view is looking approximately SE, showing a close-up of the eroding remnant of the island. Courtesy of the RNZAF and IGNS.

dates and times in this section are UTC. During the early stages of the eruption pumice built up and remained in the immediate vicinity of the vent (2120 on 7 August through 2203 on 8 August UTC) (figure 8A). Though clouds prevented a view of the entire raft, at it's greatest extent pumice covered about 140 km^2 while still attached to the vent.

By 0132 on 10 August the main mass of pumice had moved to the N side of Late island (figure 8A). The raft generally remained as a single large coherent feature in that area for at least 20 hours. Over those 20 hours the raft spread from covering about 300 km^2 to almost 400 km^2 in a contiguous irregular area, more than double the area of Washington D.C. When it began moving NE towards another unnamed submarine volcano, by 0120 on 12 August UTC, the main mass was reduced in size by about 50% and left a "tail" looping towards Vava'u with smaller stray pumice rafts throughout the area.

Between 0105 on 14 August and 0135 on 17 August (UTC) the pumice began moving NE and ENE (figure 8B). Pieces of the large raft began to shear off, with currents carrying smaller rafts away and often leaving a trail of connected pumice fragments in the wake. However, a contiguous mass of almost 150 km^2 remained 60 km N of Late Island. Over the next couple of days all of the pumice drifted N and continued to string out ENE across the ocean towards northern Fiji (figure 8C). By 2215 on 22 August (UTC) there was still pumice 25 km W of Fonualei volcano, but the farthest identifiable rafts of pumice were 270 km E and ENE of Fonualei. The pumice appeared to form a continuous, connected stream for most of that distance. In other locations the strand of pumice fragments had broken and individual segments had turned, creating multiple parallel lines of pumice spread across the water.

By 2150 on 26 August there were three distinct areas of pumice still visible (figure 8D), though they were all greatly diminished in area and starting to be difficult to distinguish through intermittent cloud cover. One area was still a connected, or semi-connected, strand about 250 km long directed to the NE. Another area of pumice about 60 km N-S was within 100 km of the central Lau Islands. The second pumice zone was encountered on 28 August by the Yacht KB1LSY as it approached the islands. Pumice from one or both of these sources had penetrated into the northern Lau Islands and the Koro Sea by 14 September, landing on Taveuni, Naitauba, and Vanua Levu. Pumice was then reported around Koro Island and in the "Bligh Triangle" area between Vanua Levu and Viti Levu starting on 20 September. At least some of this pumice drifted through the passage to Yasawa Island, N of Viti Levu, by early November.

The third distinct set of pumice rafts seen in imagery on 26 August extended across an 80-km distance directed SE-NW and was drifting towards the southern Lau Islands. This batch of pumice was encountered on 30 August by the *Soren Larsen* just W of the central Lau Islands, and is most likely the same pumice that was reported by the *Endeavor* extending 90 km NE from Vatoa Island on 16 September. On 30 September large volumes of pumice were landing on Kadavu Island, another 350 km from Vatoa. That same day pumice was seen an additional 200 km NW, on the western side of Viti Levu.

Although pumice was seen on Efate Island in Vanuatu during early October, it was thought to be from the

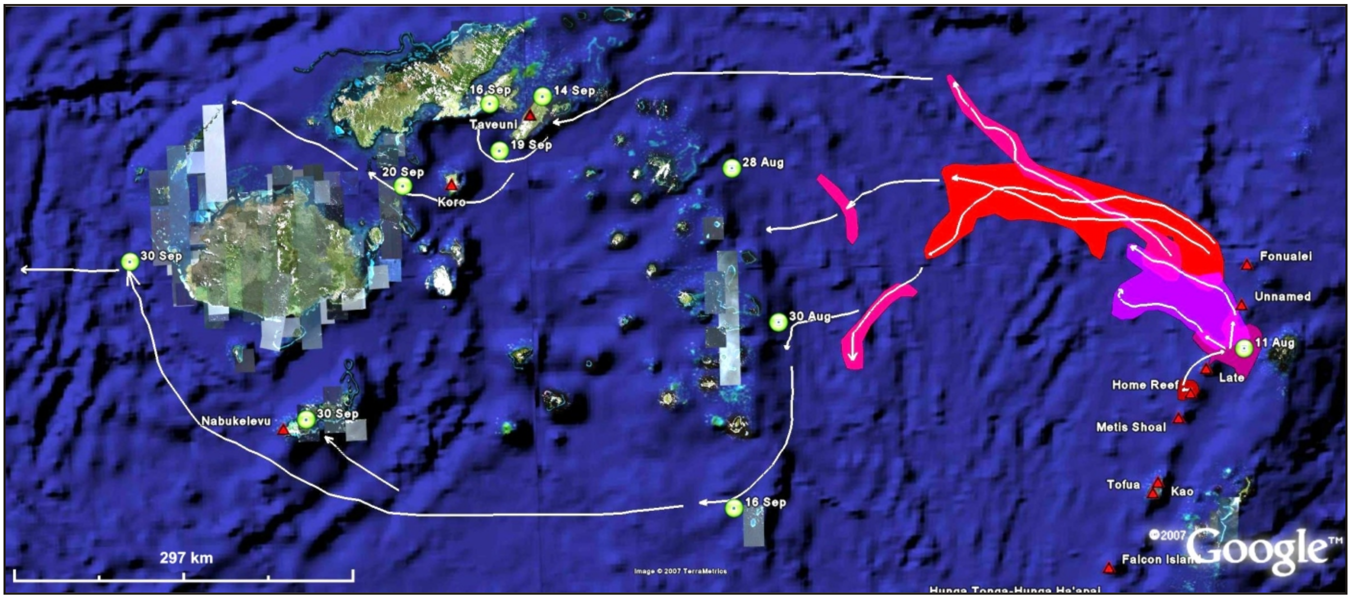

Figure 7. Map showing approximate paths taken by pumice generated by the Home Reef eruption in August 2006. Paths between Tonga and Fiji during 8-26 August (shaded areas) are based on MODIS satellite imagery (see text for further explanation). Paths through Fiji are more speculative, being based on point observations by sailors and reports of pumice washing into bays and on beaches. Base map from Google Earth. Prepared by GVP.

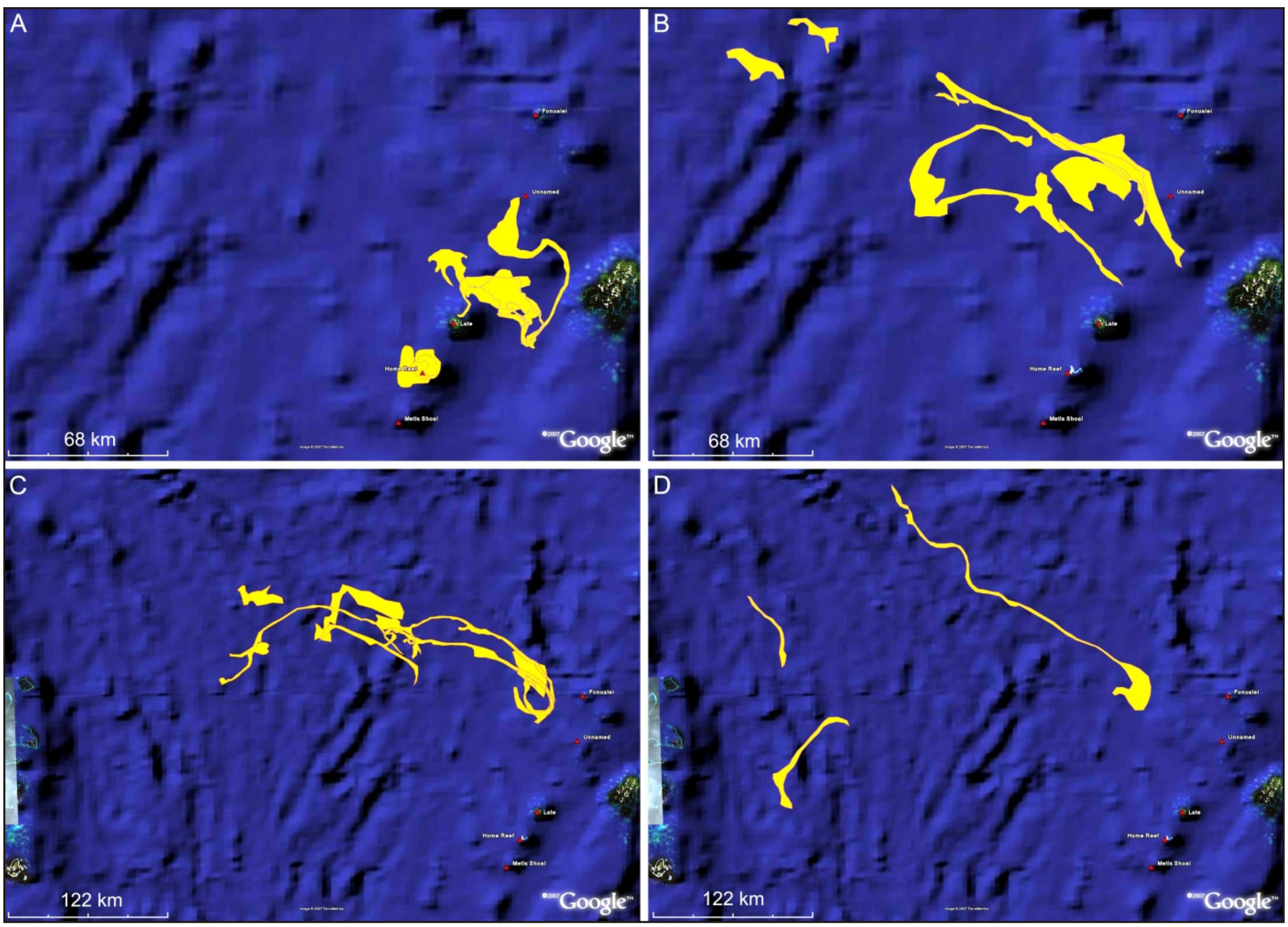

Figure 8. Sketches of pumice areas on various dates in August 2006 from the eruption at Home Reef. Areas depicted may not be filled with pumice, but have observable pumice scattered within them. Sketch maps show pumice areas (in UTC) on 7-8 August (A, SW section), 10-12 August (A, NE section), 14-17 August (B), 19-22 August (C), and 26 August (D). See text for additional information. The areas were determined by overlaying geographically registered MODIS satellite imagery into Google Earth and using a polygon creation tool to manually determine the pumice extents. Base map from Google Earth. Prepared by GVP.

Figure 9. Pumice from Home Reef floating in Shark Bay on Tanna Island, Vanuatu, on 19 December 2006. Residents told the photographer that the pumice had appeared about a month earlier. Courtesy of George Kourounis.

Ambrym-Lopevi area. Pumice from Home Reef was seen on the W coast of Efate Island on 4 November. Floating pumice was also seen in Shark Bay on the E side of Tanna Island around mid-November (figure 9).

Pumice description. Scott Bryan received some pumice samples from Roman Leslie via Peter Colls at the University of Queensland, who made some thin sections of the pumices. Initial observations are that the Home Reef pumice sampled are very similar to the 2001 pumice from the unnamed volcano along a submarine plateau south of Fonualei (volcano number 0403-091), about 85 km NE of Home Reef. The pumice is similar in terms of color (darkish gray-green), vesicularity (highly vesicular), and phenocryst content (low, mostly fine-grained). The pumice has the same mineralogy as the 2001 pumice: plagioclase, two pyroxenes (cpx dominant, and probably relatively Fe-rich), and Ti-magnetite. However, the Home Reef pumice has slightly higher abundances of plagioclase microphenocrysts (~ 0.1-1 mm). Small polymineralic clots of plagioclase, pyroxene, and magnetite are distinctive, and most readily visible to the naked eye in the pumice samples; similar polymineralic aggregates were also present in the 2001 pumice. The pumice observed in thin-section have high vesicularities (> 60%). The pumice would have similar bulk compositions to the 2001 pumice of ~ 65-70 wt% SiO_2.

Eruptive history. The August 2006 eruption is the third confirmed eruptive episode in historical time, with earlier eruptions in 1852 and 1984 (*SEAN* 09:02). In addition, there may have been activity in 1857, but no eruption was confirmed. Paul Taylor noted that there may have also been another eruption that was occurring when some aerial photos were taken in 1990. No eruption was reported, so any activity probably didn't reach the surface or was not observed. The photos seemed to show a small submarine plume being dispersed to the NW.

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

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Metis Shoal

Tonga Islands, SW Pacific
19.18°S, 174.87°W; summit elev. 43 m

On 7 December 2006 the Royal New Zealand Air Force (RNZAF) flew over the Home Reef and Metis Shoal area of Tonga at the request of volcanologists from the Institute of Geological & Nuclear Sciences (IGNS). At that time an island was present (figure 10), but it is not known if this is a remnant of the island built in 1995 (*BGVN* 20:06) or the result of later undocumented eruptions. Areas of discolored water were present adjacent to the island, the result of either erosion or fumarolic activity. Discolored water extending about 5 km SW from the location of the island was also observed in an Aqua MODIS satellite image taken on 15 September 2005 (figure 11).

Geologic Summary. Metis Shoal, a submarine volcano midway between the islands of Kao and Late, has produced a series of ephemeral islands since the first confirmed activity in the mid-19th century. An island, perhaps not in eruption, was reported in 1781 and subsequently was eroded away. During periods of inactivity following 20th-century eruptions, waves have been observed to break on rocky reefs or sandy banks with depths of 10 m or less. Dacitic tuff cones formed during the first 20th-century eruptions in 1967 and 1979 were soon eroded beneath the sea surface. An eruption in 1995 produced an island with a diameter of

Figure 10. Photograph of Metis Shoal, 7 December 2006. Courtesy of the RNZAF and IGNS.

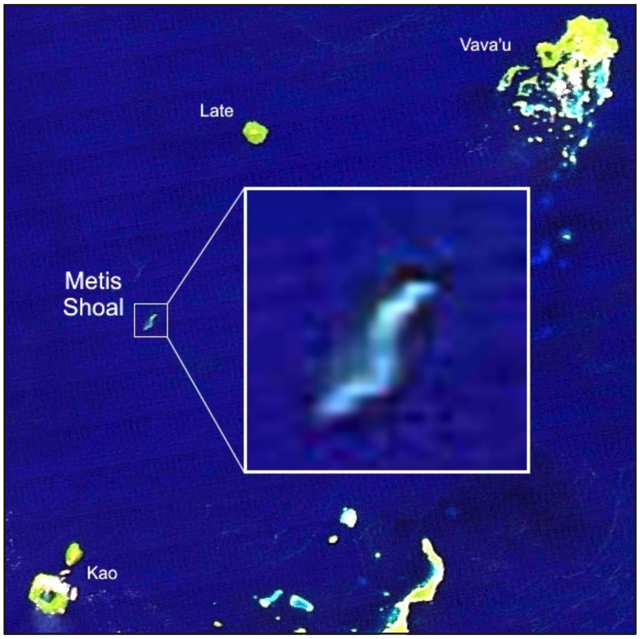

Figure 11. Satellite image (Aqua MODIS) from 15 September 2005 showing discolored water extending about 5 km SW from Metis Shoal. Image has been color-adjusted to enhance water discoloration. Base image courtesy of NASA Earth Observatory.

280 m and a height of 43 m following growth of a lava dome above the surface.

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Aoba

Vanuatu, SW Pacific
15.40°S, 167.83°E; summit elev. 1,496 m
All times are local (= UTC + 11 hours)

The Aura/OMI satellite detected elevated SO_2 concentrations above Aoba volcano during July and August 2006. Comparison of MODIS imagery between 3 June and 31 August 2006 (figure 12) revealed the effects of emissions on vegetation around the crater. The conditions in the field were investigated by a scientific team from Institut de Recherche pour le Développement (IRD). They concluded that a significant area of the summit (30 to 40 km^2) was burned by acid gas emissions.

When IRD scientists conducted a visit to Aoba in late November 2006 vegetation surrounding the crater lake had been recently defoliated (figure 13), with trees completely burned and dead, due to plumes of acidic gas and aerosols during June-August 2006. They also concluded that heavy rainfalls since September 2006 diluted the acidity of plumes. Occasional green spots seen during the November visit were where new growths of ferns and tree ferns had become established. The acid effects were more extensive than previously seen since the early 1990s. This new behavior may reflect increased degassing from the source vent inside the ring-shaped tephra (or tuff) cone.

On 25 November 2006 an IRD team measured an SO_2 flux of 3,000 tons/day. This value coincided with the measurement provided by the ozone monitoring instrument (OMI on the EOS Aura satellite). The value represented a marked reduction in SO_2 degassing compared to that measured on 10 June 2006.

The team noted that the main lake in the crater, Lake Voui, was still a red color, an effect due to oxidation of the iron in its large mass of water (*BGVN* 31:05). Within that larger lake resides the ring-shaped island, which largely formed during the late 2005-early 2006 eruptions (*BGVN* 31:01). The island's form had been that of an unbroken ring, but by the time of their 25 November visit, the preceding month's heavy rains had eroded the smaller islands wall, allowing water in the two lakes to easily mix (figure 14). The W shore of Lake Voui has also been eroded, and fumaroles were observed in the lake. The breach in the tephra ring coincided with gas emissions ceasing.

The IRD team implemented the first permanent real-time temperature monitoring during their visit. Due to

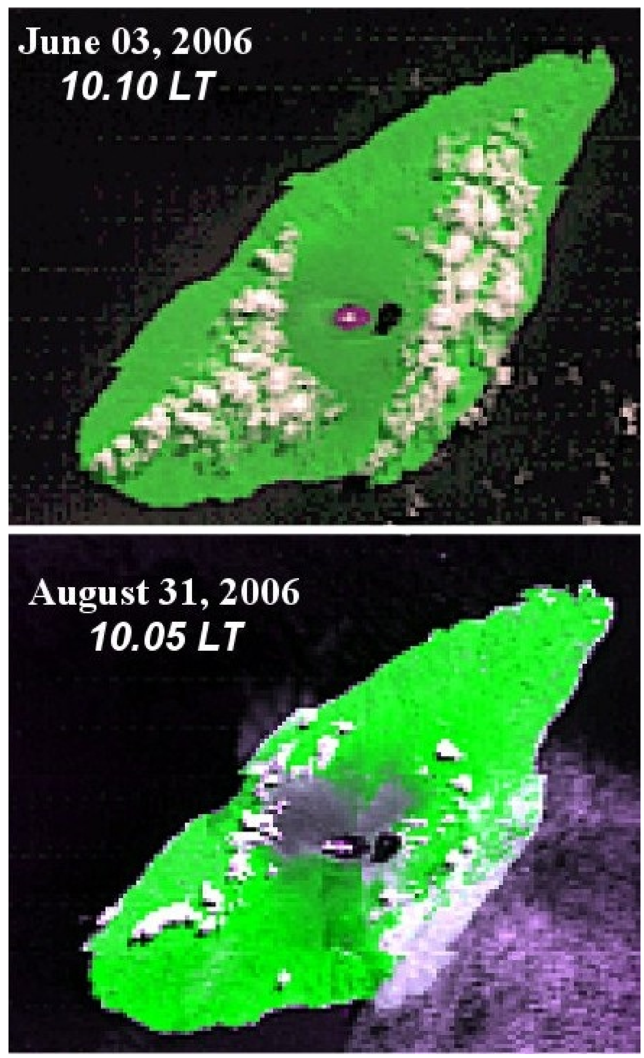

Figure 12. Satellite moderate resolution imaging spectroradiometer (MODIS) views of Aoba volcano summit lakes (Voui and Lakua). (a) A view taken at 1010 on 3 June 2006, before the last phase of gas emissions. (b) A view taken at 1005 on 31 August 2006 shows a large (15-20 km^2) gray area around the lakes where the reflectance from vegetation has significantly decreased. Courtesy of Alain Bernard.

Figure 13. Aerial view of the vegetation downwind of Lake Voui at Aoba as of 25 November 2006. The scene was one of dead, completely defoliated trees. Courtesy of Michel Lardy, IRD.

Figure 14. Aerial view of Lake Voui at Aoba as of 25 November 2006. The vent is now open to the lake and plume degassing stopped. Image courtesy of Michel Lardy, IRD.

the heavy rainfall since June 2006 and the lowered levels of evaporation associated with the lowered average lake temperature (~ 25°C on 25 November 2006), the lake level remained high. In addition, the average level of Lake Voui is higher due to volcanic material (ash, scoria) deposited between December 2005 and January 2006, and it should continue to fluctuate seasonally, as in the past.

Geologic Summary. Aoba, also known as Ambae, is a massive 2,500 cu km basaltic shield volcano that is the most voluminous volcano of the New Hebrides archipelago. A pronounced NE-trending rift zone dotted with scoria cones gives the 16 x 38 km island an elongated form. A broad pyroclastic cone containing three crater lakes is located at the summit of the Hawaiian-style shield volcano within the youngest of at least two nested calderas, the largest of which is 6 km in diameter. Post-caldera explosive eruptions formed the summit craters of Lake Voui (also spelled Vui) and Lake Manaro Ngoru about 360 years ago. A tuff cone was constructed within Lake Voui about 60 years later. The latest known flank eruption, about 300 years ago, destroyed the population of the Nduindui area near the western coast.

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White Island

New Zealand
37.52°S, 177.18°E; summit elev. 321 m

Between June 2005 and December 2006, seismic activity remained low at White Island. According to the Institute of Geological and Nuclear Sciences (GNS), observers have occasionally seen elevated levels of sulfur gases (sulfur dioxide, hydrogen sulfide) and carbon dioxide, as well as periods of micro-earthquakes and steam plumes. Minor changes in fumarole activity have also occurred. The crater lake has remained well below the overflow level. As of 15 December 2006, White Island remained at Alert Level 1 (some signs of volcano unrest).

Franz Jeker visited White Island on 9 January 2005 and took a series of photos showing some crater features (fig-

Figure 15. Native sulfur deposits in a fumarolic environment at White Island, 9 January 2005. Courtesy of Franz Jeker.

Figure 16. Visitors standing on a high point in the crater at White Island, 9 January 2005. Courtesy of Franz Jeker.

Figure 17. Photo of the crater at White Island looking SE towards the ocean, 9 January 2005. Courtesy of Franz Jeker.

Figure 18. Webcam image taken from the crater rim at White Island, 9 February 2007. Courtesy of GeoNet.

ures 15-17). Images from a web camera located on the crater rim show that no significant change in activity has occurred as of 9 February 2007 (figure 18).

Geologic Summary. 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.

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) (URL: http://www.geonet.org.nz/); *Franz Jeker*, Rigistrasse 10, 8173 Neerach, Switzerland (Email: franz.jeker@swissonline.ch).

Tongariro

New Zealand
39.13°S, 175.642°E; summit elev. 1,978 m

Ngauruhoe is the youngest and highest volcanic cone (figure 19) of the Tongariro volcanic complex on the North Island of New Zealand. According to New Zealand GeoNet Project volcanologists, the number of small (less than magnitude 2), low-frequency earthquakes near Ngauruhoe recorded by seismometers increased from less than five per day at the beginning of May 2006 to more than 20/day by the end of May. Typically, only a few earthquakes of any type are recorded in the vicinity of Ngauruhoe each year. In 1983, 1991, and 1994 there were clusters of similar earthquakes recorded near Ngauruhoe, but there have been very few recorded since then. Due to the increased seismicity, the Scientific Alert Level was raised to Alert Level 1 (some signs of unrest) on 6 June. Earthquakes of this type are commonly interpreted as being related to the movement of magma and/or volcanic gases.

Earthquakes peaked in early June at about 50/day and then declined to about 10-20/day by the 14th, with the largest about magnitude 1. Seismic activity has remained elevated through the middle of December 2006. Initial observations suggested that hypocenters were 1-4 km deep, slightly N or E of the summit. By mid-June volcanologists had installed three additional seismographs around the base of Ngauruhoe, including one that could be monitored in real-time. Between 14 June and 3 July the number of volcanic earthquakes recorded near Ngauruhoe has varied between approximately 20 and 40 per day. Using data from the additional seismographs, volcanologists were able to refine the location of the earthquakes to within about 1 km of the surface beneath the N flank; the largest events were ap-

Figure 19. Snow covered Mt. Ngauruhoe as seen on 28 July 2006. Photo credit to University of Auckland Snowsports Club.

proximately magnitude 1. Elevated seismicity continued at up to 30 events/day through October 2006.

As of the last GeoNet report on 1 November, no other signs of unrest had been recorded. Multiple measurements showed that temperatures and volcanic gas concentrations have not changed since the increased seismicity began in May, and were similar to measurements made in 2003. Carbon-dioxide release through the soil (from degassing magma) is also similar to measurements in 2003. The maximum fumarole temperature near the summit is about 85°C. Reports of steaming in the summit area were investigated, but because no new features were seen that could have caused emissions, the sightings were attributed to clouds rather than volcanic activity.

Geologic Summary. Tongariro is a large andesitic volcanic massif, located immediately NE of Ruapehu volcano, that is composed of more than a dozen composite cones constructed over a period of 275,000 years. Vents along a NE-trending zone extending from Saddle Cone (below Ruapehu volcano) to Te Mari crater (including vents at the present-day location of Ngauruhoe) were active during a several hundred year long period around 10,000 years ago, producing the largest known eruptions at the Tongariro complex during the Holocene. North Crater stratovolcano, one of the largest features of the massif, is truncated by a broad, shallow crater filled by a solidified lava lake that is cut on the NW side by a small explosion crater. The youngest cone of the complex, Ngauruhoe, has grown to become the highest peak of the massif since its birth about 2500 years ago. The symmetrical, steep-sided Ngauruhoe, along with its neighbor Ruapehu to the south, have been New Zealand's most active volcanoes during historical time.

Information Contacts: *New Zealand GeoNet Project*, 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) (URL: http://www.geonet.org.nz/) (URL: http://data.geonet.org.nz/geonews/sab); *University of Auckland Snowsports Club*, University of Auckland, New Zealand (URL: http://www.uasc.co.nz/).

Erebus

Antarctica
77.53°S, 167.17°E; summit elev. 3,794 m

The Mt. Erebus Volcano Observatory (MEVO) website contains a graph showing activity measured at the volcano since 1992 (figure 20). The most substantial peaks in the number of eruptions recorded appeared in 1995, 1997, 1998, 2000, and a broad peak beginning in late 2005 that continued into late 2006. It is important to note that the graph reports events of all sizes, including periods of extremely frequent and small (<1 Pa) bubble bursts. It also does not differentiate between eruptions from the Lava Lake, Ash Vent, or Werner's Vent.

The older records are based on interpretation of short-period seismographs, and many of the events could have been icequakes (seismic events related to the stick and slip nature of glacial ice movement) and not eruptions. In recent years the use of a video camera, infrasound, and broadband seismic records have allowed better recognition of eruptions. Because of extreme weather, the seismic network is subject to power loss during the darkness of winter.

The MEVO activity log gives information on each eruption measured and shows daily activity that usually includes several eruptions. Erebus eruption sizes are based on the infrasonic overpressure at Station E1S.IS1, measured in pascals (Pa) (see references articles on infrasound measurements). This eruption index scale is divided into small (0-19), medium (20-39), large (40-59), and very large (60) events. Although the total number of eruptions remained high during most months of 2006, large or very large events were rarely recorded after 1 June (table 3). The largest event had an index of 116.6 on 26 February.

Thermal anomalies over Erebus, determined from the MODIS (Moderate Resolution Imaging Spectroradiometer) satellite images analyzed by the Hawai'i Institute of Geophysics and Planetology (HIGP) MODVOLC algorithm, commonly appear throughout the year due to the molten lava lake within the crater.

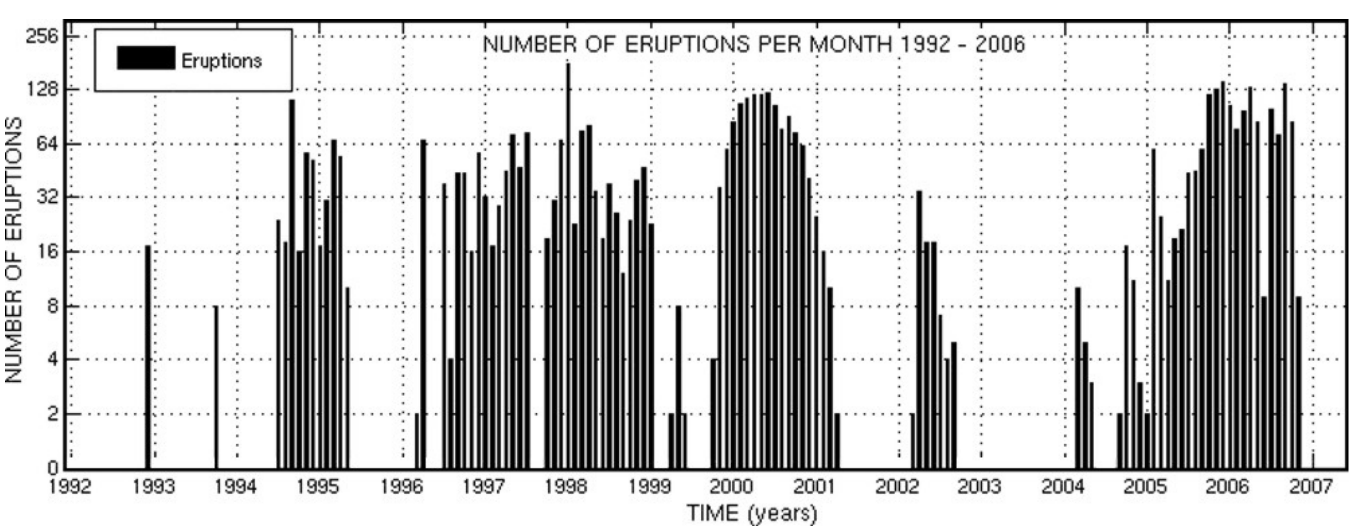

Figure 20. Collective vent and lava lake eruptions per month from January 1992 to September 2006 at Erebus (plotted on a vertical log scale). Note that significant incompleteness may exist due to variable reporting criteria and/or instrumentation outages. Quantitative assessment of eruption sizes using infrasonic recordings started in 2006. Courtesy of MEVO web site ("Current Erebus Activity Plot").

Month (2006)	Large Eruptions	Very Large Eruptions
Jan	22	0
Feb	18	5
Mar	13	7
Apr	11	9
May	12	3
Jun	1	0
Jul	0	0
Aug	0	1
Sep	1	0
Oct	1	0
Nov	0	0

Table 3. Large and very large eruptions recorded at Erebus, January-November 2006. Data courtesy of MEVO.

Geologic Summary. Mount Erebus, the world's southernmost historically active volcano, overlooks the McMurdo research station on Ross Island. The 3,794-m-high Erebus is the largest of three major volcanoes forming the crudely triangular Ross Island. The summit of the dominantly phonolitic Mount Erebus has been modified by one or two generations of caldera formation. A summit plateau at about 3,200-m altitude marks the rim of the youngest caldera, which formed during the late-Pleistocene and within which the modern cone was constructed. An elliptical 500 x 600 m wide, 110-m-deep crater truncates the summit and contains an active lava lake within a 250-m-wide, 100-m-deep inner crater. The glacier-covered volcano was erupting when first sighted by Captain James Ross in 1841. Continuous lava-lake activity with minor explosions, punctuated by occasional larger strombolian explosions that eject bombs onto the crater rim, has been documented since 1972, but has probably been occurring for much of the volcano's recent history.

General References: Wilson, C.R., J.V. Olson, D.L. Oborne, and A. Le Pichon, 2003 (December), Infrasound from Erebus Volcano at 155US in Antarctica, Inframatics-The Newsletter of Subaudible Sound, no. 04, p. 1-8.

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Information Contacts: *Philip R. Kyle* and *Kyle Jones*, Mt. Erebus Volcano Observatory, New Mexico Institute of Mining and Technology, Socorro, NM 87801, USA (Email: kyle@nmt.edu; URL: http://ees.nmt.edu/Geop/mevo/mevo.html and http://ees.nmt.edu/kyle/); *Hawai'i Institute of Geophysics and Planetology (HIGP) MODIS Thermal Alerts*, School of Ocean and Earth Science and Technology (SOEST), Univ of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (URL: http://hotspot.higp.hawaii.edu/).

Nyiragongo

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

Due to political turmoil and civil unrest, expeditions to Nyiragongo's summit lava lake are rare. Two expeditions to the summit were successful in January and July 2006. Photos of the lava lake provided by expedition leader Marco Fulle and crew are posted on the Stromboli Online website. These photos document the changes in the lake over a six-month period. Thermal anomalies measured with the MODIS satellite and associated with this volcano were nearly continuous at this time due to the lava lake within the summit crater.

Two terraces created from a 1977 (upper) lake and a 2002 (lower) lake are evident in photos from January 2006. Closer views of the lava lake showed bubbles breaking through the very dynamic lake surface. Bubbles continuously bursted through the lake's surface. Near the SW shore line, white sulfur deposits and fumaroles were observed. Lava from fountains at the N shoreline splashed on the E lake shore. By July 2006, the lava lake was smaller and seemingly more crusted over. A large fountain was continuously active on the lake's N shore, generating waves up to 10 m high (figure 21).

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

Figure 21. Photo of the Nyiragongo lava lake showing a chimney-like fountain agitating the surface and generating waves on the shore at left, 23 July 2006. Courtesy of Stromboli Online.

1977 lava flows caused many fatalities, as did lava flows that inundated portions of the major city of Goma in January 2002.

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Etna

Italy
37.734°N, 15.004°E; summit elev. 3,350 m

Roberto Clocchiatti and colleagues have provided information on the chemical composition of Etna lavas discharged during the recent eruptive period. Results of 18 major-element analyses on lavas erupted beginning 24 October 2006 are presented below.

The violent 2001 and 2002-2003 flank eruptions were fed by both trachybasaltic ("hawaiite") and basaltic magmas from various erupting vents (e.g. Clocchiatti and others, 2004). Conversely, the summit activity resuming from September 2004 to March 2005 produced only trachybasalt, which came from the upper levels of the magmatic system (Corsaro and Miraglia, 2005). After 16 months of calm characterized by mild gas venting, new lava emission began on 14 July 2006 at the summit SE Crater (SEC), lasting 10 days (*BGVN* 31:07). Since 31 August the SEC area exhibited a number of Strombolian episodes and lava flows, either from the SEC cone itself or from fissure vents which opened eastward at 2,800 m elevation (13 October), then southward at 3,000 m (23, 25 October), and finally westward at 3,050 m (26 October) and 3,180 m (8 November, internal reports from the INGV-Catania and the Omega-Acireale observatory) (figure 22).

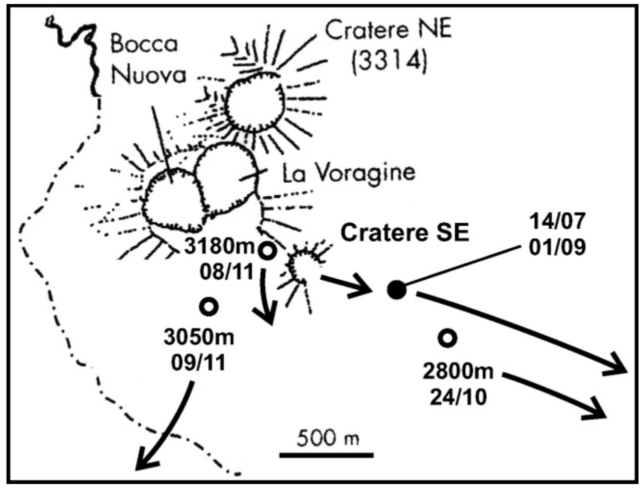

Figure 22. Location and elevation of various fissure vents that appeared in the area of Etna's SE Crater during October and November 2006. Samples were collected from the SEC flow on 14-23 July and 1 September, the 2,800-m flow on 24 October, 3,180-m flow on 8 November, and the 3,050-m flow on 9 November 2006. Courtesy of Roberto Clocchiatti and colleagues.

Whole-rock analyses from 24 October onward show a significant increase of the MgO content and of the CaO/Al_2O_3 ratio (figure 23). The higher MgO and CaO, as compared to lower Al_2O_3 and alkalis, indicate a larger content of olivine and Ca-rich clinopyroxene at the expense of less plagioclase, so that the last analyzed lava is very close to a basalt composition (5.7% MgO, 10.7% CaO, 11.6% total Fe as Fe_2O_3, and 5.8% $Na_2O + K_2O$).

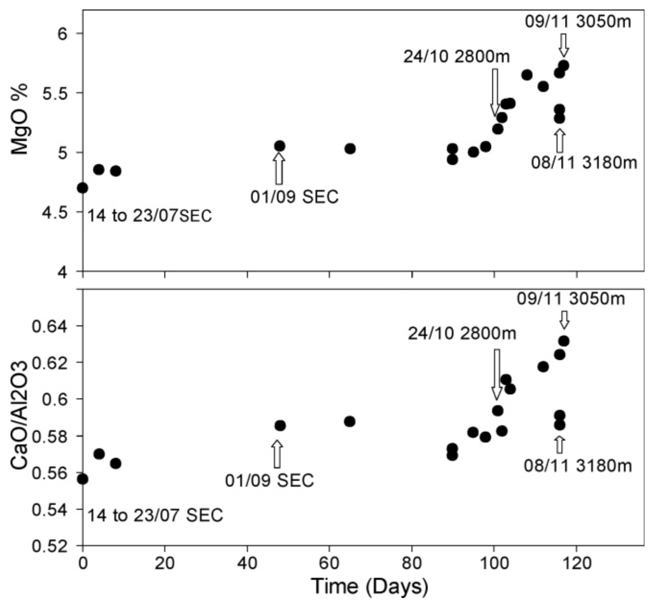

Figure 23. Plots showing increases through time of the MgO content and the ratio of CaO to Al_2O_3 at Etna beginning on 24 October 2006. Courtesy of Roberto Clocchiatti and colleagues.

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Corsaro, R.A., and Miraglia, L., 2005, Dynamics of the 2004-2005 Mt. Etna effusive eruption as inferred from petrologic monitoring: Geophys. Res. Lett. vol. 32, L13302.

Geologic Summary. Mount Etna, towering above Catania, Sicily's second largest city, has one of the world's longest documented records of historical volcanism, dating back to 1500 BC. Historical lava flows of basaltic composition cover much of the surface of this massive volcano, whose edifice is the highest and most voluminous in Italy. The most prominent morphological feature of Etna is the Valle del Bove, a 5 x 10 km horseshoe-shaped caldera open to the east. Two styles of eruptive activity typically occur at Etna. Persistent explosive eruptions, sometimes with minor lava emissions, take place from one or more of the three prominent summit craters, the Central Crater, NE Crater, and SE Crater (the latter formed in 1978). Flank vents, typically with higher effusion rates, are less frequently active and originate from fissures that open progressively downward from near the summit. Cinder cones are commonly constructed over the vents of lower-flank lava flows. Lava flows extend to the foot of the volcano on all sides and have reached the sea over a broad area on the SE flank.

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