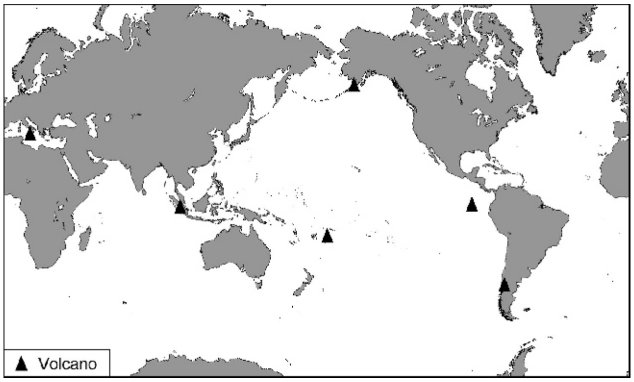
Bulletin of the Global Volcanism Network



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

Chaitén

Southern Chile
42.833°S, 72.646°W; summit elev. 1,122 m
All times are local (= UTC - 4 hours)

Our previous report discussed how Chaitén ended ~ 9,400 years of quiescence when it began erupting on the morning of 2 May 2008 (*BGVN* 33:04). This report discusses events through 30 May, in particular, summarizing reports ("Noticias") issued by Servicio Nacional de Geología y Minería (SERNAGEOMIN). News and other reports have variously stated 8,000-12,000 people evacuated.

Impacts of ashfall in Argentina also spurred a local government report (Anonymous, 2008) noting that the Argentine Atomic Energy Commission analyzed tephra (pumice and ash) from ashfalls in Argentina. Results established the tephra as a low-silica rhyolite (table 1).

Oxide	Range (wt. %)
SiO_2	71.80-73.30
Al_2O_3	13.50-14.35
Total Fe as Fe_2O_3	1.43-1.85
CaO	1.00-2.50
MgO	0.30-0.60
Na_2O	4.40-4.60
K_2O	3.15-3.30
MnO	0.04
Total	99.33-99.92

Table 1. Major element analyses (ranges for four samples) from Chaitén's ash. The samples were all from Argentina, at or near the settlements of Corovado (120 km SE of the volcano), Trevelin and Esquel (~ 100 km E), and Epuyén (~ 120 km NE). The values presented are weight percent (with total Fe shown as Fe_2O_3). In general, low silica rhyolites are typically about 69-74% SiO_2; high-silica rhyolites, about 75-84%SiO_2. Values here were measured by Laboratorio de Geoquímica de la Comisión Nacional de Energía Atómica, Regional Cuyo (unnamed, 2008).

News reports during May (and later) stated that ash in and over Argentina closed airports. Many flights were also cancelled.

Chaitén volcano is in southern Chile, at the S end of Patagonia's Lakes district (figure 1). The evacuated town of Chaitén (figure 2) served as the provincial capital of Palena. The town was home to about 4,000 people, but lahars have buried at least portions of it. That town was also the main jumping-off point for Pumalin Park, a new nature sanctuary funded by philanthropist Douglas Tompkins.

To the W of Chaitén town lies both the large (190 km long) Chiloé island and the much smaller Talcán island. Talcán island sits ~ 30 km from the town of Chaitén; it served as a staging area for monitoring efforts. Many of the larger rivers along the coast in the region reach the sea at fjords, and Chaitén town sits at the head of a fjord of the same name.

Figure 1. Map showing Chaitén volcano and other Southern Volcanic Zone volcanoes in Chile. The large island to the west is Chiloé Island. The passage at the N end of Chiloé island is called the Chacao strait; and the body of water it leads to is the Ancud gulf; farther S it becomes the Corcovado gulf. The city of Puerto Montt and major roads emphasize that the town of Chaitén lacks road access to the N. The town has an airport, but most residents evacuated by boat. Courtesy of Google Earth.

Synopsis of key events. Events during May included the month-long persistence of ash plumes; impressive electrical discharges coincident with some ash plumes; an ash blanket spanning cross-continent; some variable (and difficult to forecast) plume-dispersal patterns; small pyroclastic flows on multiple days; and lahars that progressively engulfed the town of Chaitén.

Some other highlights include the following. By 6 May, two explosion craters on the dome's N flank had united to form one large crater. By 21 May, aerial viewers saw a new dome had extruded in the N-central sector of the older rhyolite dome (figure 3). That new dome continued to grow through May, sprouting on the older dome, and later in the month, forming a large tephra cone. On 24 May, observers saw a vigorous eruption venting from an explosion crater on the old dome. They also noted that the new dome had grown taller than the old one. On 26 May, reports declared that the eruption had entered a less energetic phase (subplinean) with ash plumes rising 3-5 km in altitude.

Figure 2. A pre-eruption photograph taken in 2003 looking downward and approximately SW from the International Space Station. Chaitén volcano sits in the lower right, with the larger snow-covered Minchinmavida at lower left. The Blanco river leads from the 3-km-diameter caldera towards the sea and passes through the town of Chaitén (top right), 10 km from the volcano. Photo ISS006E42130; courtesy of NASA.

Figure 3. The dome-filled caldera of Chaitén volcano is seen in an aerial view from the S taken prior to the 2008 eruption. The elliptical 2.5 x 4 km wide summit caldera was formed during an eruption about 9,400 years ago. A rhyolitic, 962-m-high obsidian lava dome occupies much of the caldera floor. Photo by Eric Manríquez T. (Instituto Geográfico Militar).

SERNAGEOMIN began to author reports on Chaitén starting the day the eruption began (2 May 2008, *BGVN* 32:04). Ten reports discussed May events. In addition, although little discussed in this report, the advent of digital and internet technology enabled eruption observers to share unprecedented numbers of photographs and videos. Satellite data on the eruption was also impressive (eg., NASA's Earth Observatory website featured 14 reports on Chaitén's May impacts).

Activity during 4-31 May. Amid reports of tall plumes on 3-6 May (*BGVN* 33:04), Andes del Sur (OVDAS) of SERNAGEOMIN installed three non-telemetered seismic stations around the volcano. These stations were later moved to more accessible places to enable more frequent data inspection. Improved seismic stations were installed later in the month (see below).

The 5 May eruptive vigor is partly revealed by an astronaut photo (NASA-ISS, 2008). Taken from a height of 344 km, it showed a plume punching through weather clouds and manifesting powerful vertical transport. It also highlights how weather clouds then would have thwarted ground observers from seeing, and thus assessing, the height of the plume top in those conditions.

Satellite imagery acquired on 5 May and discussed by NASA's Earth Observatory website that day revealed the Chaitén plume and a fresh blanket of ash. The ash blanket stretched from the high Andes to the Atlantic coast, and the ash plume continued E beyond it. Areas of the land surface along the Andes and to the Pacific were obscured by weather clouds.

The 6 May report noted that the eruption intensified at 0820 that day, leading to vigorous explosions of rhythmic character and high sustained energy. An ash column rose to ~ 30 km altitude. At this point in time, the column was taller and wider than those seen in the earlier, initial eruptive phase.

A helicopter flight at 1000 on the 6th indicated that two explosion craters on the dome's N flank had united to form one crater ~ 800 m in diameter. The column height had decreased. Consistent with mobile ash on the ground, the amount of ash in rivers in the region had increased.

After large explosions on 6 and 7 May, earthquakes occurred that were thought to denote moving fluid associated with a magma chamber beneath the volcano. Hypocenter calculations suggested the magma chamber was at less than 5 km depth. The ambient seismicity near the volcano around that time was ~ 35 volcano-tectonic earthquakes per day.

During 8 May, despite frequent low-hanging clouds, viewers glimpsed areas E of Chaitén. Along a N-trending valley there, thin gray spirals of cloud descended into the Rayas river, and ultimately the Rayas itself also began to emit clouds. SERNAGEOMIN's 9 May report explained these phenomena as the result of small pyroclastic flows inferred to have heated the river waters, thus yielding vapor that subsequently condensed to form the spirals of cloud.

The atmosphere, which on 8 May was cloudy during the hours 0715 to 1515, cleared somewhat during 1500-1630. At 1600 viewers saw both the volcano and a NE-blowing mushroom-shaped cloud that reached 14 km altitude. Photographic evidence (not included) showed that to the W side of the column there appeared a smaller cloud that looked denser and medium to dark gray. That smaller cloud was thought to have been associated with a new vent located at the foot of the dome's W side.

At 1300 on 12 May observers on Talcán island saw the upper portion of an ash column, which rose to 8.0 km altitude. Helicopter flights found strong SW winds aloft, blowing 80-100 km/hour to the NE. Despite the wind, during the flight about four explosions rose to similar (8 km) altitudes, thus sustaining the plume.

Aerial inspection of the caldera and dome at 1430 on 12 May revealed that small pyroclastic flows had burned multiple hectares of native forest in the headwaters of the Rayas river on the caldera's N flank and as far as the Austral highway. Similar processes had also devastated vegetation both everywhere within the caldera and on parts of the outer NE flanks. A wide, vertically oriented ash column originated from a vent extending from a crater on the older dome's N flank to its summit.

A photo of the caldera provided in the 13 May report showed a powerful billowing eruption. Incandescent areas spread along the dome's upper SE side, and a blanket of fresh fragmental deposits covered much of the upper dome.

On 12 May a helicopter crew found Chaitén town flooded by lahars traveling down the Blanco river. Based on the two photos in the report, the lahars at that point had covered roughly the lower half of single-story structures closest to the river and as far back as perhaps 3-5 buildings from those closest to the river's former margin. Some buildings closest the river were dislodged, a few had only their uppermost walls and roofs exposed. Significant portions of the town farther from the river still stood above the level of inundation.

Subsequent to 12 May, the river rose yet farther, and lahars took out a bridge. The lahars stretched ~ 200 m farther into the town reaching ~ 40 homes and numerous vehicles. Scenes of the town of Chaitén became the subject of many news reports and some videos posted on the web.

NASA's Earth Observatory posted an image acquired on 12 May (figure 4). Ash was again visible across the entire continent, spreading in a band trending ENE of the volcano. The ash is more visible in this image as the plume is blowing well S of the ash blanket.

The 16 May report noted that the eruption was clearly plinean in nature and the source of continuous plumes. But, in the past two days, the plumes had not risen above 5 km altitude. Seismicity during 14-16 May included swarms of hybrid earthquakes.

At 0730 on 15 May observers saw the upper part of an ash plume reach 4 km altitude. The plume was swept NE in 140 km/hr winds. That day, a helicopter took observers over the town of Chaitén and the Amarillo and Michinmahuida rivers. Wide areas of the region were covered by white tephra. Lahars continued, apparent both to Chaitén's S and along the Blanco river to the coast. Lahars covered the Chaitén airfield and invaded the dock areas, as well as its main plaza, swamping government buildings. The lahars continued rising as the river bed and flood plains filled with sediments. Discolored water was seen widely (including N of Chaitén town in Pumalín bay,). Some elongate pumice rafts were floating in the Corcovado gulf.

In response to the crisis at Chaitén, during mid-May, the United States gave Chile several radio-telemetered seismic stations. Three members of the US Geological Survey (USGS) also joined SERNAGEOMIN and other agencies in Chile to install two stations. The visiting team, there during mid-May to early June, also discussed instrument operations, maintenance, and data interpretation.

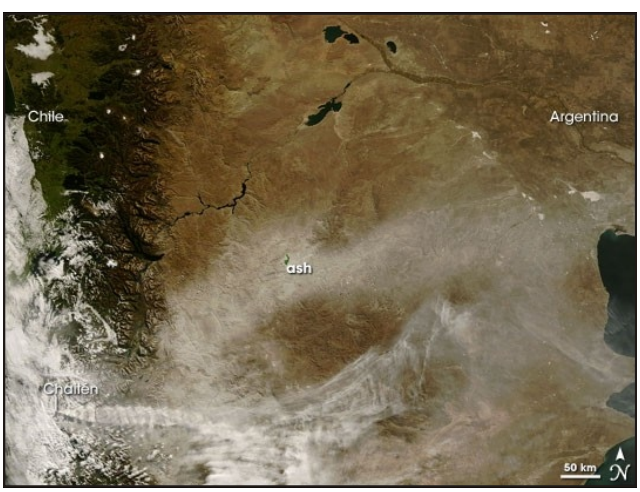

Figure 4. Chaitén's plume crosses the bottom of this Terra satellite image from 12 May 2008, becoming more diffuse before reaching the Atlantic coast. The ashfall blanket in an E-W cross-continent band. Courtesy of NASA Earth Observatory by Jeff Schmaltz and Michon Scott (their 12 May report).

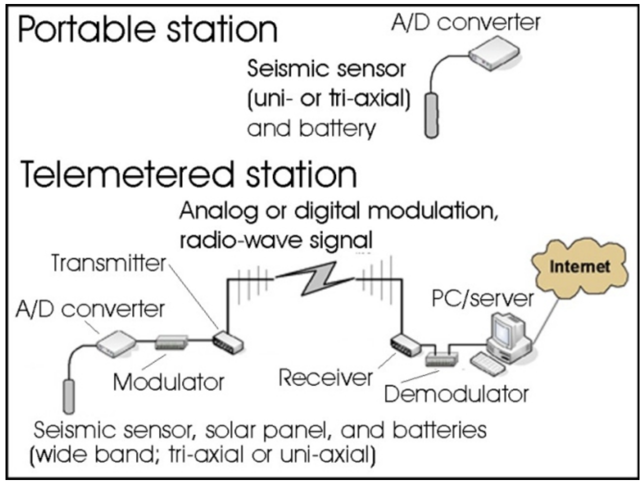

Figure 5. Diagrams comparing seismic stations and related components. At Chaitén, the portable stations were replaced by telemetered seismic stations during mid-May 2008. The A/D converter changes continuouos (Analog) signals to a stream of discrete (Digital) numbers. A "wideband" (broadband) seismic sensor can detect ground motions over wide frequency ranges compared to the narrower ranges typical of older instruments. These instruments also have a more uniform response across these varied frequencies, easing data interpretation. Courtesy of SERNAGEOMIN (from their 20 May report).

The diagram in figure 5 indicates the key components of the portable seismic station initially used (without telemetry) and the new seismic stations installed (with digital instrumentation, telemetry, and linkage to the Internet). Both of the new seismic stations were installed on the mainland, broadcasting to a site on Chiloé island. Photographs of the area were taken during fieldwork (figures 6-8).

At midday on 15 May, the authors described a cold wind that carried fine ash W. Ash fell on the ship *Aquiles* and on Talcán island, reaching 0.5-1.0 mm thick. In the same time frame, ash fell at the Blanco and Rayas rivers at least as far W as the Chaitén fjord's mouth.

Favorable weather, including strong wind, enabled scientists to assess the caldera on 21 May (figure 9). They

Figure 6. Chaitén eruption plume seen looking E across the gulf on 19 May 2008. The snow-covered flanks of Michimahuida volcano appear in the background. Courtesy of J.N. Marso (USGS).

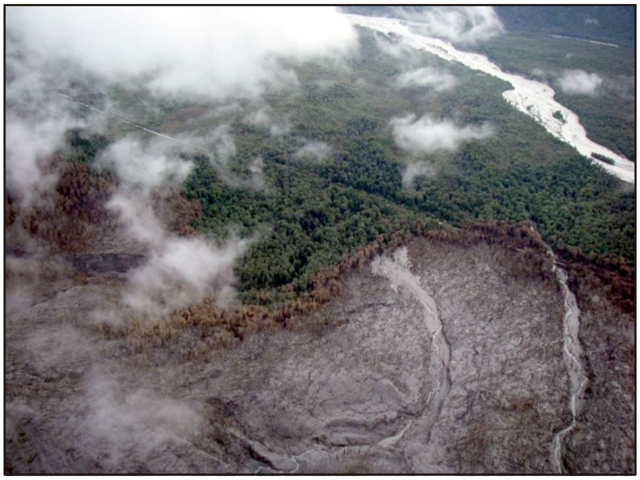

Figure 7. Native forest destroyed by pyroclastic surges on the flanks of Chaitén during mid-May to early June 2008. Note the singed band located between the zone of total destruction (bottom) and unaffected forest (top). A road is visible across much of the photo. Photo by A.B. Lockhart, USGS.

Figure 8. (top) Town of Chaitén overrun by lahars during mid-May to early June 2008. Lahars had began to accumulate as a delta at the river mouth. Owing to sedimentation, the river (seen in background) had changed course and was then flowing through the town. The airport is on photo's right side between the town and the steep hill in background. (bottom) This closer view illustrates variable amounts of lahar damage affecting Chaitén town. This town was completely evacuated within several days of the eruption's onset. Photos by A.B. Lockhart, USGS.

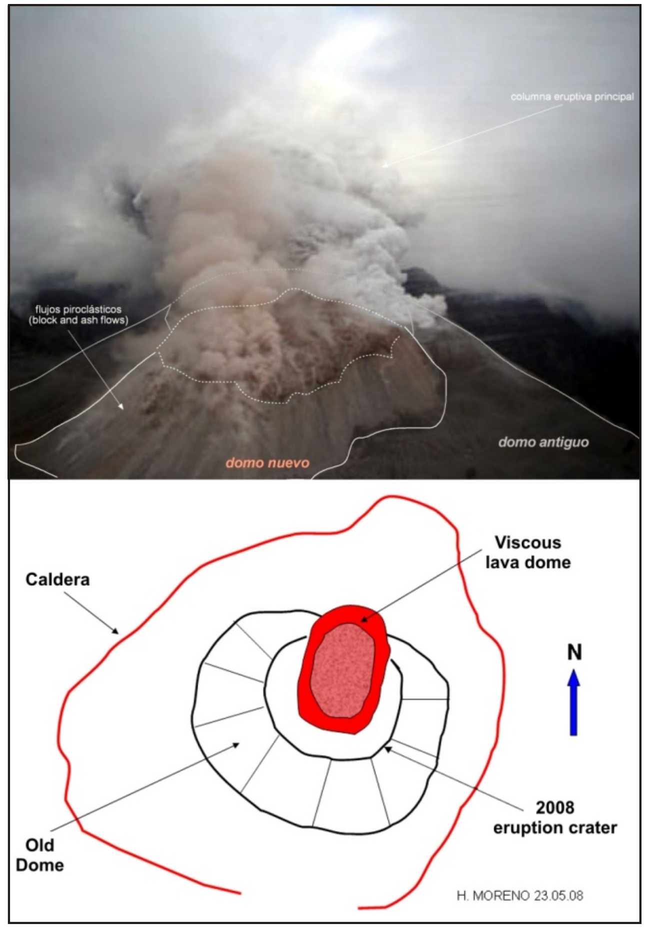

Figure 9. (top) An annotated photo from a helicopter on 21 May 2008 looking S into the erupting Chaitén caldera documenting the emergence of a new dome on the N side of the old one. The old dome (dark color, lower right) emitted a white plume; the new one (pale rose in colored versions of this photo, center) emitted a pale rose plume. Small block-and-ash flows descended the new dome's N side. The dark material in the background is the far (S) caldera wall. The venting ash column delivered considerable ashfall downwind. (bottom) A schematic (plan view) of the caldera seen that day (composed 23 May 2008 by H. Moreno). Both courtesy of SERNAGEOMIN.

found a new dome had emerged, already of significant size. It extruded from an area in the old dome. The eruption at the time was vigorous, though marked by sporadic explosions.

An overflight on 24 May revealed the new dome had slightly higher elevation than the old dome. Airborne observers saw the cone's 200-m-diameter crater vigorously expelling gas and ash. This vent was on the higher parts of the old dome in an area just to the S of the active dome.

The eruption, although unceasing, was described in the 26 May report as having decreased to subplinean. It remained in this lower energy state through at least month's end. On 25 May, ash columns reached ~ 3.5 km in altitude, with occasional explosions prompting plumes up to 5 km. Plumes often blew NE.

The 22 May report mentioned a swarm of hybrid earthquakes, in this case with considerable 3 Hz content. Volcano-tectonic earthquakes diminished progressively during 22-26 May, both in number and magnitude. These accompanied a reduction in volcanism.

A substantial tephra cone had developed on top of the new and old domes by 26 May (figure 10). The new dome, pink in color, was still present but lay directly behind the collar of tephra composing the new tephra cone. A summit crater vented plumes of different color. Although a dome had emerged, vigorous ash plume emission continued.

A 26 May Terra image showed some areas of ashfall, but also several unusual features attributed to the eruption. These were described in the 26 May Earth Observatory report. First, rivers and lakes around the volcano were a distinct blue-green color, and this discoloration persisted into the Corcovado gulf, presumably from the waters' high suspended loads.

Second, although views of ridges (topographic highs) were clear and unobstructed in the image, a dendritic pattern of clouds, fog or mist hugged the valleys (topographic lows) for at least 200-300 km N and NE of the volcano. These white, opaque clouds originated from Chaitén.

On 28 May the ash column rose to 3.5-4 km altitude, blowing N to NW. It affected localities hundreds of kilometers away. Chilean airports closed in Puerto Montt, Osorno, Valdivia, and as far as 300 km N in Temuco. Lower altitude winds blew ash farther W, affecting coastal areas between the town of Chaitén and Chumildén, including Talcán island. In these areas, suspended ash appeared as a dense mist, grounding aircraft, including those used for vol;cano inspections.

During the last few days May, the number and magnitude of volcano-tectonic earthquakes diminished, and both low-frequency and hybrid earthquakes were absent. These changes coincided with a drop in the altitudes of eruption columns over the course of about a week.

Reference. Anonymous, 2008, Análisis químicos realizados en la contingencia del Volcán Chaitén: Municpalidad de Lago Puelo, 4 p. Accessed July 2008 (URL: http://www.lagopuelo.gov.ar/extras/riesgos/Analisis_quimicos_realizados_contingencia_Volcan_Chaiten[1].pdf).

Naranjo, J.A., and Stern, C.R., 2004, Holocene tephrochronology of the southernmost part (42°30'-45°S) of the Andean Southern Volcanic Zone: Revista Geológica de Chile, v. 31, no. 2, p. 225-240.

NASA-ISS, 2008, Astronaut photo from the International Space Station taken at 2027 on 5 May 2008 UTC. (Frame 6214, Mission ISS 017; file name, ISS017-E-6214.JPG). Image Science and Analysis Laboratory, NASA-Johnson Space Center (URL: http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS017&roll=E&frame=6214>)

Figure 10. Chaitén seen from a helicopter on 26 May with the camera aimed NE. A tephra cone stood atop the new and old dome complex. The cone's steep upper walls discharged a broad plume from an unusually ample summit crater. The plume was two-toned, with distinctively shaded material on its left and right sides. Lumpy areas on the middle to lower cone correspond to the obsidian on the now buried older dome. Some burned vegetation exists in the bottom center of the photo along the outflowing Blanco river. Photo by J.N. Marso (USGS).

Geologic Summary. Chaitén is a small, glacier-free caldera with a Holocene lava dome located 10 km NE of the town of Chaitén on the Gulf of Corcovado. A pyroclastic-surge and pumice layer that was considered to originate from the eruption that formed the elliptical 2.5 x 4 km wide summit caldera was dated at about 9400 years ago. A rhyolitic, 962-m-high obsidian lava dome occupies much of the caldera floor. Obsidian cobbles from this dome found in the Blanco River are the source of prehistorical artifacts from archaeological sites along the Pacific coast as far as 400 km away from the volcano to the N and S. The caldera is breached on the SW side by a river that drains to the bay of Chaitén, and the high point on its southern rim reaches 1,122 m. Two small lakes occupy the caldera floor on the W and N sides of the lava dome.

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Cerro Azul

Isabela Island, Ecuador
0.92°S, 91.408°W; summit elev. 1,640 m
All times are local (= UTC - 6 hours)

Equador's Instituto Geofísico (IG) reported that Cerro Azul began to erupt late on the night of 29 May 2008. The report was based on satellite data, network seismic data, and eye-witness reports. In repose for 10 years (*BGVN* 23:08), this shield volcano forms the extreme SW end of the elongate island (figure 11). Cerro Azul contains a 4 x 5 km summit crater. The eruption from the SE flank (figure 12) prevailed during 29 May to 11 June and with few exceptions emitted lava flows with `a`a textured surfaces. The flows reached 2-3 km wide and up to 10 km long. Some lava also emerged from a vent in the NE wall of the caldera. Eruptions appeared to have ceased during 2 June, breaking the time line into two eruptive phases.

The first eruptive phase involved a rapid emission of lava during 29 May-1 June. Outside the caldera, the eruptive fissures were oriented in directions either tangential (circumferential) or radial to the volcano's symmetry. During this first phase, on 30 May, lava also extruded inside the summit caldera (figure 12).

The second eruptive phase emitted lavas over nine days (3-11 June). The lavas escaped from a separate fissure at a lower elevation than the first and oriented radially ("fissura 3" on figure 12). The flatter terrain near fissure 3 led to

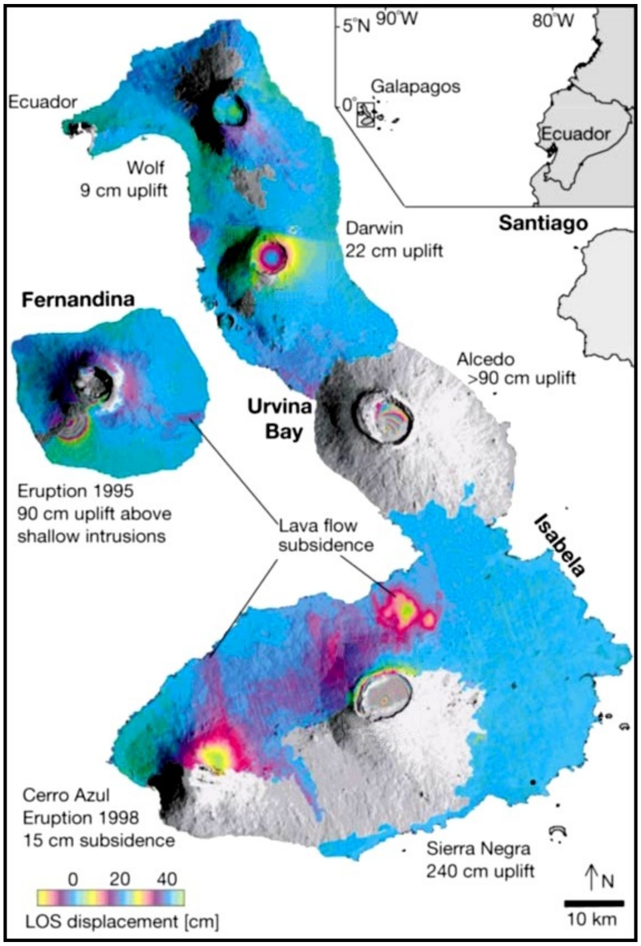

Figure 11. Satellite radar interferometry (InSAR) maps showing line-of-sight (LOS) ground displacements in centimeters for Fernandina and Isabela islands. For Cerro Azul (and the volcanoes Darwin, Alcedo, and Sierra Negra) the InSAR data covered 6.4 years, 1992-1998. To produce the interferograms, the phase difference between radar echoes from two satellite passes is calculated. Index map shows the Galapágos islands (~ 1,000 km W of mainland Ecuador). Maps are from Amelung and others (2000).

lavas forming an equant flow field. This contrasted with the first-phase lavas, which erupted on higher, steeper ground where they developed elongate distribution patterns.

A seismic station in the Galapagos (PAYG) suggested that activity began at 2143 hours on 29 May (local time). Signal amplitude emerged slowly at first (figure 13). Starting about an hour after that and for the next 7 hours the station registered 40 earthquakes near Cerro Azul.

The largest, M ~ 3.7, took place at 0051 on 30 May (local time), centered in the N caldera at shallow depth. Satellite thermal anomalies measured by MODIS/ MODVOLC showed a hot spot on the S flank at 2300 (local time). At the same time a red glow was observed in the direction of the volcano from Puerto Villamil, the capitol of Isabela Island ~ 50 km E.

According to IG, a satellite image from a Volcanic Ash Advisory Center (VAAC) showed an emission column at 0715 on 30 May 2008, probably with a low ash content, extending 140 km NW from the volcano. On the morning of 31 May, a white plume ~ 2 km high, with no visible ash,

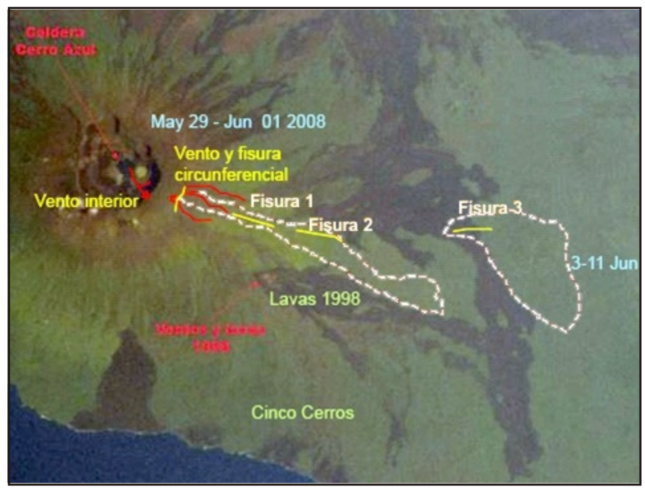

Figure 12. Annotated satellite image of Cerro Azul showing first-order estimates of fissure vents, the approximate margins of frequently complex flow fields, as well as eruption dates. The base image is from before the 2008 eruption. The 2008 flows generally followed similar routes as those during the SE-flank eruptions of 1978 and 1998. N is towards the top right; for scale, the distance from the crater rim to the sea directly W is ~ 8 km. Background image, Image Science and Analysis Laboratory, NASA-Johnson Space Center. Annotations and fieldwork by Andrés Gorki Ruiz, Patricio Ramón, and Nathalie Vigoroux.

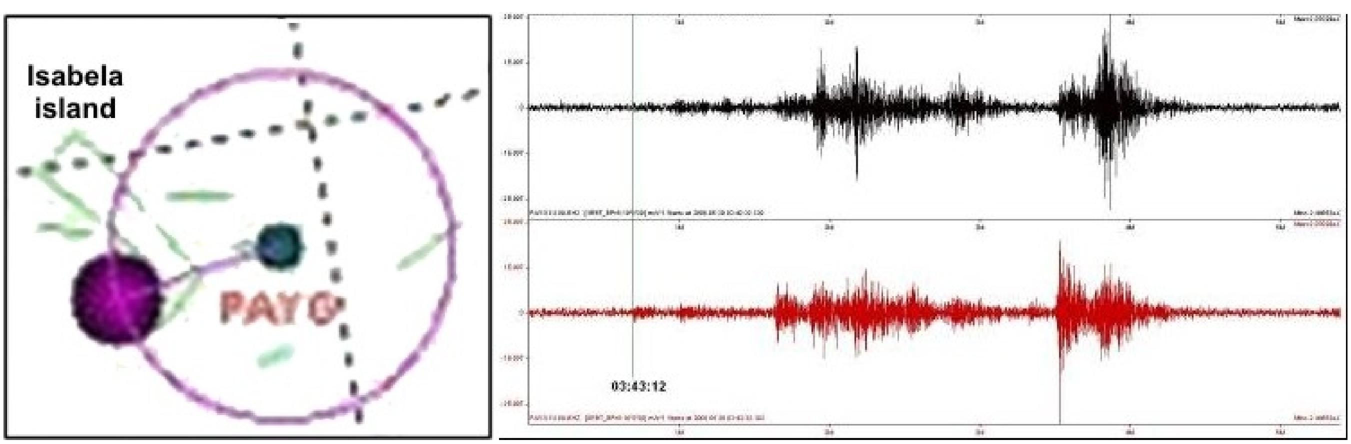

Figure 13. Seismic data portraying Cerro Azul's earthquakes and eruption. The left panel shows a map of the islands and station PAYG to the E, where the large dot (left) represents an epicenter near the caldera. The right panel shows the seismic traces associated with the initial signals associated with the eruption (upper is orthogonal horizontal and the lower, vertical). The vertical line at left represents 03:43:12 local time on 30 May. Courtesy of IG.

Figure 14. Lava spewing from part of the uppermost fissure of Cerro Azul on 1 June 2008. Photo by IG.

could be seen rising above the cloud cover from a point on the coast SE of the eruption site. Cloud cover then prevented further observation of the plume.

Vent areas. Aerial images taken by scientists of the Galápagos National Park on 30 May 2008 between 1400 and 1600 revealed an absence of radial fissures at that time. Lava from the higher elevation circumferential vents covered the area located at ~ 1 km elevation. Fissures 1 and 2 were therefore thought to have formed sometime between the afternoon of 30 May and morning of 1 June.

IG reports indicated that in late May into early June field visits were made by Gorki Ruiz, Oscar Carvajal, Freddy Mosquera, and Nathalie Vigouroux (and possibly others). According to Dennis Geist, they encountered sometimes foggy conditions. They inspected the area of initial eruption from Cinco Cerros, and made some key observations (figure 12) and photographs (figures 14 and 15).

Fissure 1 emitted multiple lava flows; some of these reached 15 m thick. Fissure 2 lay farther out on the SE flank in an area of lower slope.

The circumferential fissure emitted six separate lava flows, some up to 5 m thick. These descended rapidly down the SE flank. Scientists were able to visit the new lava flows at an elevation of ~ 1,100 m on 2 June 2008. One of the lava flows was thin (under 1 m) with variable plagioclase and minor amounts of olivine (or pyroxene) crystals. At ~ 1,000-m elevation the flows from the circumferential fissure were overlain by tephra and lava from the upper radial fissure (fissure 1). At this location, the slope of the terrain lessened and the morphology changed to more blocky \`a\`a. There, the flows piled up behind the flow front.

The size of the cones built up by lava fountaining on the upper radial fissure decreased with distance from the summit. The lowest cone, at ~ 800 m elevation, was under 5 m high and emitted a small pahoehoe flow that extended a few ten's of meters downslope, but with little to no tephra.

The onset of the second eruptive phase was reported in various ways. MODVOLC alerts and related thermal images showed new hot spots at the SE end of the volcano on 3 June. They later increased in intensity and migrated E. On the night of 4 June, observers at Cinco Cerros saw a red glow. Observers on a 4 June flight spotted fissure 3. As shown below, on 5 June a huge increase in MODIS thermal anomalies occurred.

When seen on 4 and 5 June, fissure 3 emitted a lava curtain hundreds of meters long. Aerial observations suggested the height of lava fountaining was ~ 60 m with large blocks also thrown that high. The venting fed a SE-directed lava flow. Owing to the relatively flat terrain found in the saddle between Cerro Azul and Sierra Negra volcanoes, the lava flow appeared to be progressing very slowly. Part of the new flow spread over portions of the 1998 flow. A plume ~ 50 km long moving N was visible from the airplane, as well as in satellite images.

Sulfur-dioxide fluxes. Simon Carn provided satellite information on sulfur dioxide (SO_2) burdens measured from the Ozone Monitoring Instrument (OMI) on NASA's Aura satellite (figures 16 and 17). The SO_2 fluxes were measured once per day from 29 May to 8 June 2008. The map shown is for 31 May (UTC), the day with highest flux, ~ 35,000 tons/day. In general, the plumes blew SW from the source. The histogram (figure 16) indicates the daily SO_2 fluxes emitted during this eruption period, with the highest flux on 31 May. Low fluxes occurred during 2-4 June, corresponding with the eruptive lull of 2 June.

Satellite thermal anomalies. The most recent previous eruption of the volcano took place in September 1998 (*BGVN* 23:08 and 23:09). In accord with the 10-year quiet period, thermal anomalies at Cerro Azul were absent at least as far back as 1 January 2000 and onward through 29 May 2008. The current eruption's anomalies appeared during 30 May-17 June 2008 (table 2) and were distributed broadly around lavas associated with fissure 3. There was a

Figure 15. A view at Cerro Azul on 2 June 2008 looking W from 980 m elevation, showing the complexity of some of the flow fields in the vicinity. The foreground captures the rough-textured \`a\`a surface. Courtesy of Ruiz, IG.

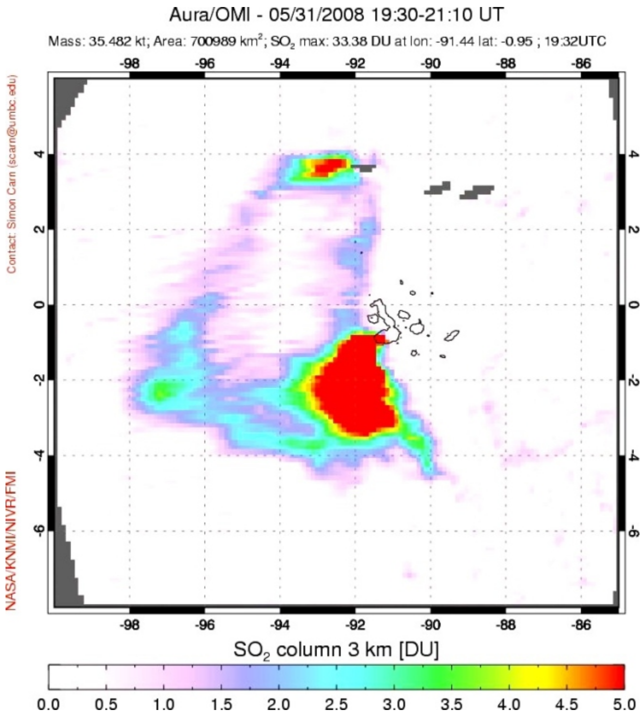

Figure 16. One of several available maps of sulfur dioxide (SO_2) plumes measured from Aura/OMI satellite images. Data acquisition for this map occurred during 1930-2110 on 31 May UTC. Gray areas indicate regions where meteorological clouds may be obscuring the satellite view of the lower atmosphere. Courtesy of Simon Carn.

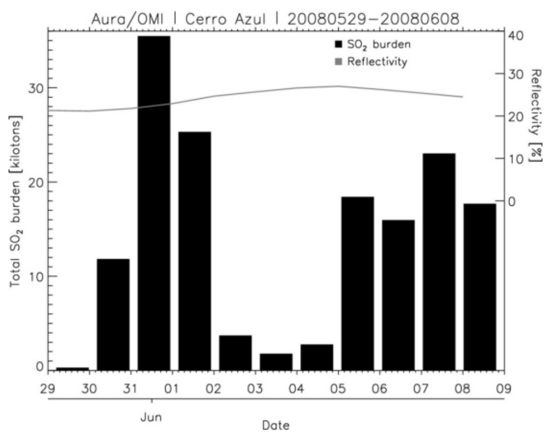

Figure 17. Histogram showing daily sulfur dioxide (SO_2) burdens measured by the Ozone Monitoring Instrument (OMI) on NASA's Aura satellite between 29 May and 8 June 2008 UTC. These burdens were calculated based on an assumed SO_2 altitude of 3 km and should be considered preliminary estimates. Courtesy of Simon Carn.

90-pixel anomaly at 0420 on 5 June 2008; later that day there were only 5 pixels.

Environmental concerns and a bathymetric map. According to Galapagos National Park officials on 3 June 2008 (as reported by Agence France-Presse, AFP) the lava did not affect the islands' famed giant tortoises. Isabela, the largest island in the archipelago, is home to rare and unique flora and fauna, including the Galapagos giant tortoise, which can reach more than 230 kg in mass and live more than 100 years. The Galapagos archipelago, which consists of about 30 islands, islets, and standing rocks, is a UNESCO World Heritage Site. In 2007, UNESCO declared the archipelago's environment in danger due to the increase of tourism and the introduction of invasive species. The archipelago has a population of ~ 40,000.

William Chadwick has merged all available datasets (as of 1994) for bathymetry in the Galápagos region. Cerro Azul sits adjacent a steep drop-off to the W, with water adjacent the shore reaching ~ 3.5 km depth. In contrast, much of the island cluster is on a broad shallow platform. Chadwick offers this compiled map on his website (see Information Contacts).

Reference: Amelung, F., Jónsson1, S., Zebker, H., and Segall, P., 2007, Widespread uplift and 'trapdoor' faulting on Galápagos volcanoes observed with radar interferometry: Nature, v. 407, p. 993-996 (26 October 2000).

Geologic Summary. Located at the SW tip of the J-shaped Isabela island, Cerro Azul (Blue Hill) contains a steep-walled 4 x 5 km nested summit caldera complex that is one of the Galápagos Islands' smallest in terms of diameter, but at 650 m deep, it represents one of the region's deepest. The 1,640-m-high shield volcano is the second highest of the archipelago. A conspicuous bench occupies the SW and W sides of the caldera, which formed during several episodes of collapse. Youthful lava flows cover much of the caldera floor, which has also contained ephemeral lakes. A prominent tuff cone located at the ENE side of the caldera is evidence of episodic hydrovolcanism at Cerro

Date, 2008 (UTC)	Time (UTC)	Number of pixels	Satellite
30 May	0500	6	Terra
30 May	0755	12	Aqua
31 May	0405	14	Terra
31 May	0700	4	Aqua
31 May	1625	5	Terra
01 Jun	0445	9	Terra
01 Jun	0745	14	Aqua
02 Jun	n/a	none	n/a
03 Jun	0435	7	Terra
04 Jun	0815	25	Aqua
04 Jun	1600	8	Terra
05 Jun	**0420**	**90**	**Terra**
05 Jun	0720	41	Aqua
05 Jun	1645	14	Terra
05 Jun	1940	5	Aqua
06 Jun	0505	1	Terra
07 Jun	0410	3	Terra
09 Jun	0355	2	Terra
09 Jun	1620	2	Terra
10 Jun	0440	17	Terra
10 Jun	0735	5	Aqua
10 Jun	1700	2	Terra
12 Jun	0430	3	Terra
12 Jun	0725	4	Aqua
14 Jun	0415	1	Terra
14 Jun	1935	1	Aqua
16 Jun	0405	1	Terra
17 Jun	0445	1	Terra
17 Jun	0745	5	Aqua

Table 2. MODVOLC thermal anomalies measured by MODIS instruments at Cerro Azul from 30 May through 17 June 2008. All anomalies were located E of the crater, with the farthest seen ~ 28 km due E. Courtesy of the Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System.

Azul. Numerous spatter cones dot the western flanks of the volcano. Fresh-looking lava flows, many erupted from circumferential fissures, descend the NE and NW flanks of the volcano. Historical eruptions date back only to 1932, but Cerro Azul has been one of the most active Galápagos volcanoes since that time. Solfataric activity continues within the caldera.

Information Contacts: *Andres "Gorki" Ruiz, Freddy Mosquera*, and *Patricio Ramón*, Instituto Geofísico, Escuela Politécnica Nacional *(IG)*, AP 17-01-2759, Quito, Ecuador (URL: http://www.igepn.edu.ec; Email: geofisico@accessinter.net); *Nathalie Vigouroux*, Department of Earth Sciences, Simon Fraser University, Burnaby, Canada; *Oscar Carvajal*, The Galápagos National Park Service, Isla Santa Cruz, Galápagos, Ecuador; *Dennis Geist* and *Gorki Ruiz*, Geological Sciences, Box 3022, University of Idaho, Moscow ID 83844; *Simon Carn*, Joint Center for Earth Systems Technology, University of Maryland Baltimore Campus (UMBC), 1000 Hilltop Circle, Baltimore, MD 21250 (URLs: http://so2.umbc.edu/omi/; http://www.knmi.nl/omi/research/project/science_team_us.html); *Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System*, School of Ocean and Earth Science and Technology (SOEST), 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/); *William Chadwick*, CIMRS, Oregon State University, NOAA/PMEL VENTS Program, Hatfield Marine Science Center, 2115 S.E. OSU Dr., Newport, OR 97365 (URL for map: http://www.pmel.noaa.gov/vents/staff/chadwick/galapagos.html).

Veniaminof

Alaska Peninsula
56.17°N, 159.38°W; summit elev. 2,507 m
All times are local (= UTC - 9 hours)

Our previous report on Veniaminof (*BGVN* 31:08) noted the relative quiescence of the volcano through 15 September 2006, with the seismicity remaining low, but above earlier background levels. We received no subsequent reports of seismicity until 11 February 2008, when the Alaska Volcano Observatory (AVO) noted sporadic increases in seismic activity, including tremor episodes that lasted 1-2 minutes and occurred several times per hour.

On 22 February several minor ash bursts from Veniaminof were recorded by the seismic network and observed on web camera footage. The bursts rose to an altitude below 2.7 km; fallout was confined to the crater. Steam plumes emitted from the intra-caldera cone were seen on video footage during 23-25 February and seismic levels were elevated during 23-26 February.

On 27 February, web camera views showed steaming from the cone and occasional small ash bursts that rose to 200 m above the crater. The Aviation color code was raised to Yellow and the Alert Level was raised to Advisory. During 28 February-3 March, views were obscured by cloud cover. However, the elevated seismic activity continued to 4 March and low-level steaming was seen on 29 February during a break in the weather.

Subsequent to the February-March activity, the volcano returned to its quiescent state. AVO reported on 3 May that the Volcanic Alert Level for Veniaminof was lowered to Normal and the Aviation Color Code was lowered to Green due to the absence of ash emissions and elevated surface temperatures in satellite data and webcast imagery. Seismicity was still above past background levels, but the rate and intensity had declined over the previous several weeks.

Web camera imagery of Veniaminof volcano showed that occasional light steaming continued.

Geologic Summary. Massive Veniaminof volcano, one of the highest and largest volcanoes on the Alaska Peninsula, is truncated by a steep-walled, 8 x 11 km, glacier-filled caldera that formed around 3700 years ago. The caldera rim is up to 520 m high on the north, is deeply notched on the west by Cone Glacier, and is covered by an ice sheet on the south. Post-caldera vents are located along a NW-SE zone bisecting the caldera that extends 55 km from near the Bering Sea coast, across the caldera, and down the Pacific flank. Historical eruptions probably all originated from the westernmost and most prominent of two intra-caldera cones, which reaches an elevation of 2156 m and rises about 300 m above the surrounding icefield. The other cone is larger, and has a summit crater or caldera that may reach 2.5 km in diameter, but is more subdued and barely rises above the glacier surface.

Information Contacts: *Alaska Volcano Observatory (AVO)*, a cooperative program of the U.S. Geological Survey, 4200 University Drive, Anchorage, AK 99508-4667, USA; 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 (URL: http://www.avo.alaska.edu/).

Kerinci

Sumatra, Indonesia
1.697°S, 101.264°E; summit elev. 3,800 m
All times are local (= UTC + 7 hours)

Kerinci last erupted on 6 August 2004. Following that, the volcano was relatively quiet through January 2005 (*BGVN* 30:01). This report discusses events through 11 May 2008. Satellite thermal imaging has not shown any "hot-spots" for the past several years, but the behavior there has been characterized by emissions of billows of thin white smoke that rose to ~ 200 m above the crater.

On 8 September 2007, a number of minor seismic events occurred. On 9 September, vapor emissions increased, pulsing at ~ 5-minute intervals, and accompanied by inky black ash. The plume rose ~ 700-800 m above the crater rim and ash fell within ~ 8 km vent.

The Center of Volcanology and Geological Hazard Mitigation (CVGHM) reported that the Alert Status was raised to 2 (on a scale of 1-4). Visitors and tourists were not permitted to approach the crater closer than 1 km.

Activity in the following months did not show any significantly abnormal behavior until 14-18 February 2008, when more voluminous thick white plumes rose ~ 500 m above the crater rim.

According to CVGHM, the seismicity increased during 17-24 March 2008. On 24 March, an ash-and-gas plume rose to an altitude of 4.3 km. Another increase in seismicity occurred during 10-11 May, when thick white plumes rose to altitudes of 4.3-4.5 km and drifted E. The Alert Status remained at 2.

Geologic Summary. The 3,800-m-high Gunung Kerinci in central Sumatra forms Indonesia's highest volcano and is one of the most active in Sumatra. Kerinci is capped by an unvegetated young summit cone that was constructed NE of an older crater remnant. The volcano contains a deep 600-m-wide summit crater often partially filled by a small crater lake that lies on the NE crater floor, opposite the SW-rim summit of Kerinci. The massive 13 x 25 km wide volcano towers 2400-3300 m above surrounding plains and is elongated in a N-S direction. The frequently active Gunung Kerinci has been the source of numerous moderate explosive eruptions since its first recorded eruption in 1838.

Information Contacts: *Center of Volcanology and Geological Hazard Mitigation (CVGHM)*, Jalan Diponegoro 57, Bandung 40122, Indonesia (Email: dali@vsi.esdm.go.id; URL: http://www.vsi.esdm.go.id/); *Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System*, 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/).

Home Reef

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

Pumice from Home Reef has become one hypothesis for some mid-2007 observations on beaches in eastern Papua New Guinea, about 250-350 km NE of Milne Bay. The Rabaul Volcano Observatory (RVO) received a report about quantities of pumice on Woodlark Island beaches on 21 August 2007. The report was from the Deputy Administrator (DA) of Milne Bay Province who had been on election duty in a PNG Naval Patrol boat. The DA and the captain saw an echo sounder profile as they were sailing out of a lagoon at Budibudi Island (Lachland Islands) ~ 100 km ESE of Woodlark Island on the evening of 18 July 2007. They interpreted the profile as a possible submarine volcano. Later, they observed pumice clasts lying on the beaches of the Woodlark Islands. Recalling what they had seen on the echo sounder profile at Budibudi Island the previous day, the DA was very concerned that any activity the area would be a threat to the local population.

Additional information was gathered by RVO from the DA, government officers on Woodlark Island, and people from Budibudi Island. That investigation revealed no evidence of a pumice raft on Budibudi. Pumice clasts were only observed on Woodlark beaches, and images of pumice clasts showed that they were rounded and had incrustations. The lagoon at Budibudi also has no history of hydrothermal activity. There was also no evidence of continuous local earthquakes prior to or during July.

Simon Carn of the University of Maryland Baltimore County confirmed no evidence of anything unusual in the SO_2 imagery. The UK Hydrographic Office provided scans of nautical charts of the remote islands, confirming that the site of the reported "eruption" was less than 35 m deep, so any activity would have been vigorous at the surface and obvious to Islanders.

It is assumed that the "submarine volcano" was a patch reef and the pumice was from the Home Reef eruption. Another alternative was that the pumice represented re-mobilized clasts from strand lines around the Solomon Sea, possibly a result of the 2 April Solomon Islands tsunami.

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

Information Contacts: *Herman Patia*, Rabaul Volcano Observatory (RVO), P.O. Box 386, Rabaul, Papua New Guinea; *Simon Carn*, Joint Center for Earth Systems Technology, University of Maryland Baltimore County (UMBC), 1000 Hilltop Circle, Baltimore, MD 21250, USA (Email: scarn@umbc.edu, URL: http://www.volcarno.com/, http://so2.umbc.edu/omi/); *Guy Hannaford*, United Kingdom Hydrographic Office, Admiralty Way, Taunton, Somerset TA1 2DN, United Kingdom (Email: research@ukho.gov.uk).

Etna

Italy
37.734°N, 15.004°E; summit elev. 3,330 m
All times are local (= UTC + 1 hours)

After several months of eruptive activity at the summit craters, on 13 May a new eruptive fissure opened between 3,050 and 2,650 m elevation on Etna's upper E side, feeding lava flows into the Valle del Bove (figure 18). This took place without threatening inhabited areas. It was preceded by several months of sporadic ash emissions, a brief period of Strombolian activity, and a powerful eruptive phase from Southeast Crater (SEC) on 10 May. As of 20 June, modest Strombolian activity continued from two vents along the fissure at approximately 2,800 m elevation, accompanied by lava emission from a third vent, with lava advancing ~ 5 km to the E.

This report was compiled from contributions by the staff of the Istituto Nazionale di Geofisica e Vulcanologia, sezione di Catania (INGV-CT), which are available as pdf files on the Institute's wesite (see Information Contacts).

Activity during January-April 2008. During this time interval, periodic emissions of ash occurred from a vent located on the E flank of the SEC cone (hereafter named SEC-E), which had been the site of two strong eruptive episodes on 4-5 September and 23-24 November 2007 (see *BVGN* 32:08, 32:09 and 33:01). This activity apparently ejected mostly lithic ash, and no incandescence was seen through mid-April. A period of weak Strombolian activity occurred between 23 and 28 April (figure 19), when explosions ejected incandescent bombs up to 100 m above the vent, and some material fell to the base of the SEC cone. The area was quiet between 29 April and 10 May.

Event of 10 May 2008. A sharp increase in the volcanic tremor amplitude at 1400 UTC on 10 May announced the onset of a new paroxysmal eruptive episode at the SEC. Observation was difficult, due to inclement weather conditions. During the first stages of activity, eyewitnesses in the summit area observed explosive activity at several locations within and around SEC-E, and lava overflows feeding several branches of lava toward the Valle del Bove (figure 20). While lava descended very rapidly into the Valle del Bove, explosive interaction with patches of remaining snow repeatedly occurred along the path of the lava flows. The lava advanced across the Valle del Bove floor toward Monte Calanna down to an elevation of ~ 1,370 m, reaching a total length of 6.4 km from its source. This is one of the longest lava flows fed by a summit eruption of Etna in recorded history. A preliminary estimate of the lava volume yields ~ 4.5 x 10^6 m^3, which was emitted at peak rates exceeding 300 m^3/s (in comparison, peak eruption rates calculated for the violent fire-fountaining episodes at the SEC in 2000 were consistently below 200 m^3/s; Behncke et al. 2006). Tephra fallout occurred mostly to the N and later to the NE (Andronico et al. 2008). The activity came to an abrupt halt at about 1800, after which no appreciable activity occurred for the following 2.5 days. Figure 20 is an aerial view of the SEC with its SEC-E vent, taken during a period of complete quiescence on 28 May.

Start of flank eruption, 13 May 2008. The intrusion of a dike into the upper portions of the Etna's edifice was marked by a seismic swarm starting at 0840 UTC (Unità Funzionale Sismologia, 2008). Eruptive activity started from a fissure segment ("A" in figures 18 and 22 and shown close-up in figure 21) located roughly at 3,000 m elevation at the E base of the Northeast Crater (NEC) cone, where fire-fountaining produced a thick scoria deposit and generated sheet flows 2.5 km E toward Monte Simone. This activity probably lasted only a few hours and was followed by the propagation of new fissures to the SE ("B" in figures 18 and 22), down to an elevation of ~ 2,650 m, into the Valle del Leone, in the opposite direction of the initial dike intrusion, which apparently came to a halt during the early afternoon.

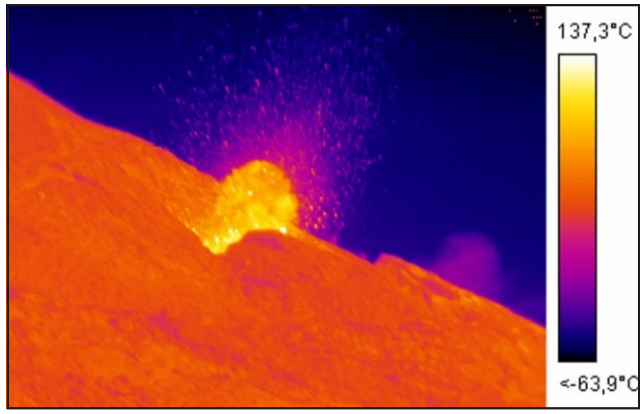

Figure 19. Thermal camera image of a Strombolian explosion from the active eastern vent of the Southeast Crater (SEC-E) on 23 April 2008. Courtesy of INGV-CT.

Visual observations were severely hampered by poor weather conditions, but heavy scoria falls were noted on the N flank during the early afternoon, and satellite imagery showed a narrow plume extending NNE (Coltelli et al. 2008). INGV staff visiting the summit area later that day stated that explosive activity occurred from multiple vents along an eruptive fracture to the E of the summit, and lava was flowing toward the Valle del Bove. Fieldwork carried out during the following days revealed that an extensive fracture field had formed around the NEC and beyond toward the upper N flank of Etna (Neri, 2008).

Continuing activity, 14 May to present. Improved weather conditions on 14 and 15 May permitted the first overviews of the eruption area (figure 22), and revealed that lava flows from the still active fissure segment at ~ 2,700-2,800 m elevation had descended approximately 6 km to 1,300 m elevation, but movement of the lava flow fronts had slowed significantly. Intense Strombolian activity occurred from a number of vents, and lava issued from

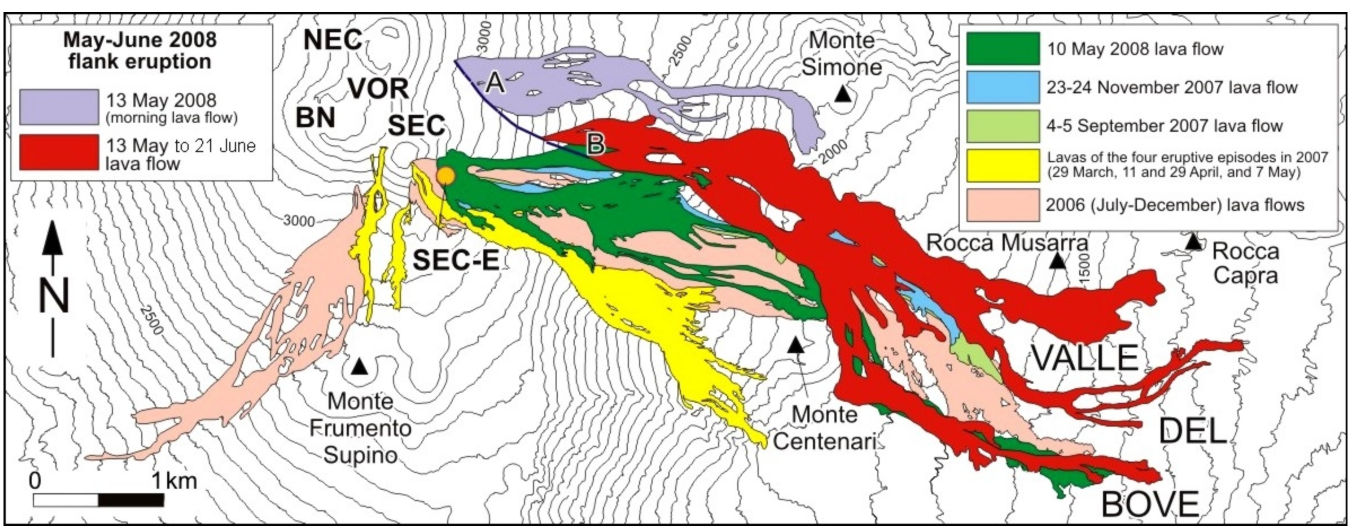

Figure 18. Map showing extent of lava flows from Mount Etna, 2006-2008, including the lava flow field of the 2008 flank eruption as of 21 June 2008. Summit craters are Northeast Crater (NEC), Voragine (VOR), Bocca Nuova (BN), and Southeast Crater (SEC), whose recently active vent on the E flank is labelled SEC-E. The upper E flank fissure system is distinguished by two segments: one (A) active on 13 May morning; and the other (B) starting on the afternoon of 13 May and continuing through June. Courtesy of INGV-CT.

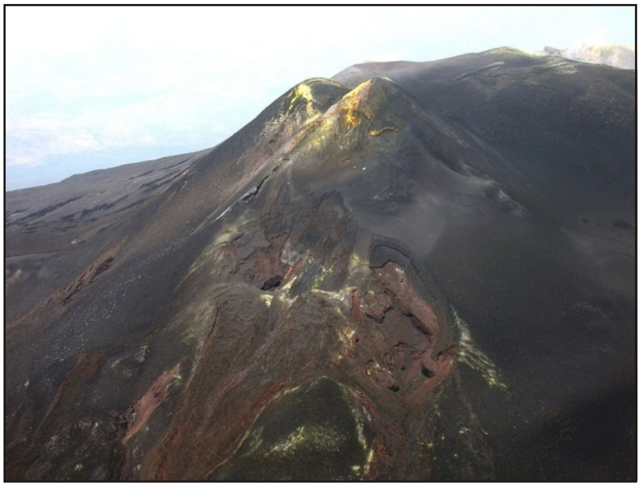

Figure 20. Oblique aerial view of the Southeast Crater and its E flank vent (SEC-E, in the foreground) in a state of total quiescence, taken from a helicopter of the Italian Civil Defence Department on 28 May 2008. Courtesy of INGV-CT.

at least two main locations. The uppermost fissure segment, first active on the morning of 13 May, showed little activity except for degassing and occasional emissions of dilute ash plumes. Ash was also emitted periodically from SEC-E.

On 16 and 17 June, ash emissions from that vent became more vigorous, and ash was also emitted from several vents in the upper portion of the still-active fissure segment on the upper E flank. The active lava flows, however, showed a significant reduction in their length compared to the first few days of eruption. During the following days, the ash emissions at the SEC stopped, and activity at the E flank fissure showed a marked diminution. Throughout late May and into early June, Strombolian activity was confined to one or two vents at about 2,800 m elevation, and lava emission from a single vent located a few tens of meters downslope fed small flow lobes that advanced to ever decreasing distances, reaching a minimum of ~ 0.4 km on 4 June.

A gradual but clear increase in the volcanic tremor amplitude and changes in the gas geochemistry heralded a revival of both the explosive and effusive activity on 8 June, which created a fresh surge of lava into the Valle del Bove. On 18 June, little more than one month after the start of the flank eruption, the lava fronts reached an elevation of about 1,350 m between Rocca Musarra and Rocca Capra (figure 18) and a distance of 5 km from the vents. Mild Strombolian activity continued from two vents located at ~ 2,800 m elevation.

After extending 5 km down through the Valle del Bove in mid-June, lava flows remained much shorter until the last few days of the month, when a new lobe advanced 4.8 km E, somewhat southward of the mid-June lava lobe. The late-June lobe was seen stagnant on 1 July. On the afternoon of 4 July, ash emissions from a point of the eruptive fissure upslope from the recently active vents (at 2,800 m elevation) marked the reactivation of a vent that had been inactive since mid-May. Vigorous Strombolian activity occurred from this vent during the following days, alternating with periods of ash emission. As of 6 July, lava was traveling further S, extending less than 4 km from the vents.

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Budetta, G., Ciraudo, A., Currenti, G., Del Negro, C., Ganci, G., Greco, F., Herault, A., Napoli, R., Scandura, D., Sicali, A., and Vicari, A., 2008, Aggiornamento dello stato di attività dell'Etna: Osservazioni gravimetriche e magnetiche, (URL: http://www.ct.ingv.it/Report/UFGMET20080513.pdf).

Figure 21. Close-up aerial view of fissure segment "A," formed on the morning of 13 May 2008, and its rheomorphic lavas, taken from a helicopter of the Italian Civil Defence Department on 15 May 2008. Lava fountaining from this fissure segment lasted only for a few hours at the start of the eruption, but weak ash emissions continued for several days. Note fracture pattern created by the dragging along of freshly fallen tephra deposits along the margins of moving lava flows. Courtesy of INGV-CT.

Figure 22. Photomosaic composed of about 10 frames taken from a helicopter of the Italian Civil Defence Department on 15 May 2008, showing eastern sector of Etna with the active eruptive fissure just below the summit craters at right, and extent of active lava flows in the Valle del Bove, in the center and at left. Courtesy of INGV-CT.

Coltelli, M., Prestifilippo, M., Scollo, S., and Spata, G., 2008, Rapporto tecnico del 13 Maggio 2008 – Osservazione da satellite e simulazione dell'emissione di cenere (URL: http://www.ct.ingv.it/Report/Rapporto_UPNV_CT_%2020080513.pdf)

Neri, M., 2008, Eruzione dell'Etna: Fratture non eruttive sul fianco settentrionale del Cratere di Nord-Est; Aggiornamento al 28 Maggio 2008 (URL: http://www.ct.ingv.it/Report/RPTVGSTR20080528.pdf).

Puglisi, G., Gambino, S., Mattia, M., and Aloisi, M., 2008, Monitoraggio Geodetico delle Deformazioni del suolo all'Etna: Aggiornamento 14 maggio 2008 – 09:00 (URL: http://www.ct.ingv.it/Report/UFDG-RA_2008-08.pdf).

UnitàFunzionale Sismologia (edited by D. Patanè), 2008, Quadro di sintesi e aggiornamento al 19 Maggio 2008 sullo stato di attivitàsismica dell'Etna (URL: http://www.ct.ingv.it/Report/REPUFS20080519.pdf).

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 Mongibello stratovolcano, truncated by several small calderas, was constructed during the late Pleistocene and Holocene over an older shield volcano. 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 (usually accompanied by strombolian eruptions at the upper end). 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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