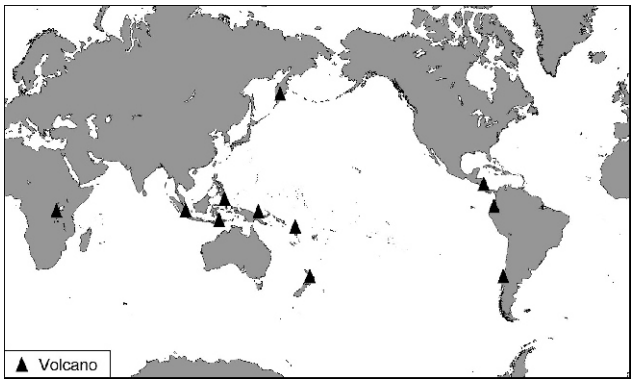
Bulletin of the Global Volcanism Network



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Koryaksky

Kamchatka Peninsula, Russia
53.320°N, 158.688°E; summit elev. 3,456 m
All times are local (= UTC + 12 hours)

Koryaksky, which had lacked fumarolic activity during the last ~ 51 years, began steaming after seven months of local seismicity. The increased seismicity became prominent in March 2008 (figure 1) and the first steaming was recorded on 6 October 2008. The first fumarole vent to appear was located at ~ 3 km elevation on the upper NW slope. Koryaksky, a large snow-laden stratovolcano, forms the most prominent feature of the Avachinskaya volcano group. Episodes of elevated seismicity have previously occurred, as reported in December 2003 (*BGVN* 28:12).

Only two earthquakes struck on 23 December 2008, both at ~ 5 km depth. Observers also heard a booming sound from the volcano at night. NOAA 17 satellite data collected at 2357 UTC on 23 December revealed that a dense ash plume extended over 60 km laterally, and an ash-poor ash plume continued beyond that for another 140 km NE. During 24-25 December observers in the Nalychevo valley saw a dark ash column rise about 200-300 m from the upper NW-flank vent.

On 28 December 2008 moderately explosive vulcanian-type eruptions occurred. Ash plumes rose to ~ 4 km altitude and extend NW. Observers also saw significant fumarolic activity at two vents. During a break in cloud cover on 30-31 December observers saw gas-and-steam plumes, which were thought to contain small amounts of ash. They drifted along the surface of the NW flank, some reaching ~ 4 km altitude. A 2 January KVERT report noted background seismicity during 31 December-6 January, with 1-7 volcanic earthquakes per day and possible episodes of tremor during 30 December to 1 January.

During 6-8 January 2009 strong fumarolic activity continued. According to visual data, gas-steam plumes extended SW from three vents. Gray deposits were visible at the area near the summit. Figures 2 and 3 illustrate the scene on 8 and 10 January 2009. Strong fumarolic activity also prevailed on 14 and 18-19 February 2009.

Figure 2. Gas and steam escaping from Koryaksky on 8 January 2009. Three vents on the NW slope trace an older fissure. Photo by Alexandr Socorenko.

KVERT issued reports on 4 March 2009 noting increased activity, with some ash-bearing plumes extending over 200 km to the NE-ENE on 3-4 March. For the previous week, seismicity was again at background. Ash deposits were identified both on the summit and in the saddle to Avachinsky. At the latter area on 4 March, the deposits reached 1-2 mm thickness.

In a 5 March report, KVERT noted plumes containing small amounts of ash rising to 3.7 km and extending over 220 km. They blew to the ENE, E, and SE on 3-5 March. Koryaksy's N flank contained fresh ash deposits ~ 4.0 cm thick. The crater contained a weak, new fumarole.

Geologic Summary. The large symmetrical Koryaksky stratovolcano is the most prominent landmark of the NW-trending Avachinskaya volcano group, which towers above Kamchatka's largest city, Petropavlovsk. Erosion has produced a ribbed surface on the eastern flanks of the 3456-m-high volcano; the youngest lava flows are found on the upper western flank and below SE-flank cinder cones. No strong explosive eruptions have been documented during the Holocene. Extensive Holocene lava fields on the western flank were primarily fed by summit vents; those on the SW flank originated from flank vents. Lahars associated with a period of lava effusion from south- and SW-flank fissure vents about 3900-3500 years ago reached Avacha Bay. Only a few moderate explosive eruptions have occurred during historical time. Koryaksky's first historical eruption, in 1895, also produced a lava flow.

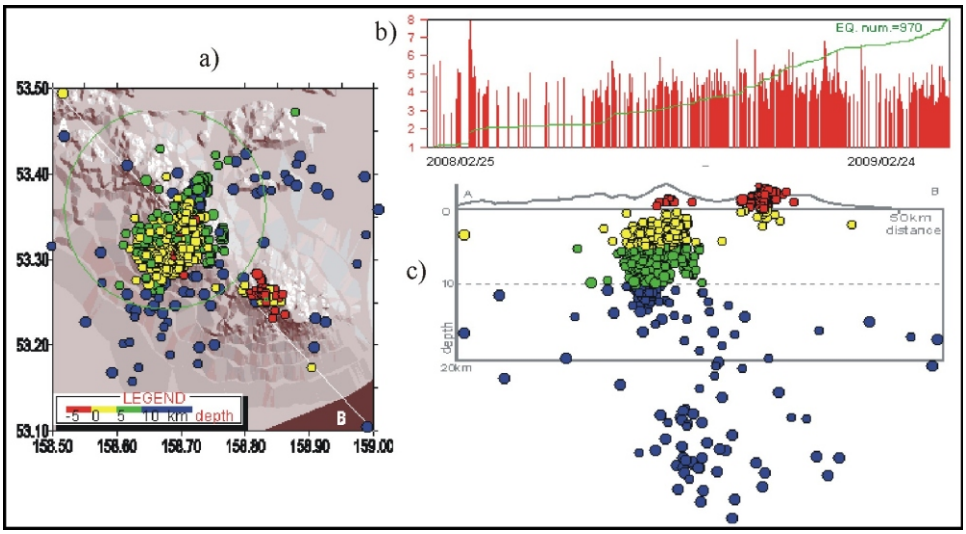

Figure 1. Seismicity of Koryaksky (and Avachinsky, to the SE) recorded during February 2008-February 2009. a) A map of the region showing location and depths of earthquakes. The white line is trace of cross section AB; a 35-km-diameter circle encloses epicenters of earthquakes plotted in c). b) Histogram showing daily earthquakes with respect to time; ascending curve is the cumulative number of earthquakes (reaching a total of 970 for the interval). c) Hypocenters projected onto the vertical plane of cross section AB. Courtesy of KB GS RAS.

Information Contacts: *Kamchatka Volcanic Eruptions Response Team (KVERT)*, Institute of Volcanology and Seismol-

Figure 3. View of Koryaksky looking W from Petropavlovsk on 10 January 2009. The photo was taken from the roof of Institute of Volcanology and Seismology. Photo by Alexandr Socorenko.

ogy (IV&S) Far East Division, Russian Academy of Sciences (FED RAS), *Kamchatka Branch of the Geophysical Service of the Russian Academy of Sciences (KB GS RAS)*, Piip Ave. 9, Petropavlovsk-Kamchatsky, 683006, Russia (Email: kvert@kscnet.ru, (URL: http://www.kscnet.ru/ivs; http://emsd.iks.ru/~ ssl/monitoring/main.htm); *Alexander Sokorenko*, IV&S; *Tokyo Volcanic Ash Advisory Center (VAAC)*, Tokyo, Japan (URL: http://ds.data.jma.go.jp/svd/vaac/data/).

Dempo

Sumatra, Indonesia
4.03°S, 103.13°E; summit elev. 3,173 m

According to a report by Indonesia's Center of Volcanology and Geological Hazard Mitigation (CVGHM), Dempo had a phreatic eruption on 1 January 2009. The event resulted in a strong sulfur odor and an ash (or cinder) rain that was noted as far as ~ 10 km from the summit. During 27 December 2008 to 1 January 2009, fog prevented direct observations of the summit; clouds over the summit area are a common occurrence. The one available photo of the eruption showed a whitish-colored plume rising perhaps a few kilometers over the summit.

On 1 January authorities raised the alert status from 1 (normal) to 2 (alert, "Waspada" in Indonesian), on a scale that ranges from 1-4. Visitors and residents were advised not to go within a 2-km radius of the summit. A 2 January report from CVGHM noted that both local volcanic and regional tectonic earthquakes were recorded during 27 December 2008 through 1 January 2009 (table 1).

As of early 2009, no thermal anomalies had been measured over Dempo by the MODVOLC infrared satellite system for at least the last 5 years. ASTER images from 2001-2007 show extensive cloud cover.

Date	Seismicity
27 Dec 2008	One local volcanic (A-type), and two tectonic
28 Dec 2008	One local volcanic (A-type), and one air blast event
29 Dec 2008	One local volcanic, five air blasts, and two tectonic
30 Dec 2008	One shallow local volcanic, one air blast, one low-frequency, and one tectonic
31 Dec 2008	One local volcanic, one air blast, and two tectonic not at the volcano
01 Jan 2009	One local volcanic related to the explosive eruption

Table 1. Highlights of Dempo seismicity recorded during 27 December 2008 to 1 January 2009. Courtesy of CVGHM.

Geologic Summary. Dempo is a prominent 3,173-m-high stratovolcano that rises above the Pasumah Plain of SE Sumatra. The andesitic Dempo volcanic complex has two main peaks, Gunung Dempo and Gunung Marapi, constructed near the SE rim of a 3 x 5 km caldera breached to the N. The one called Dempo is slightly lower, with an elevation of 3,049 m and lies at the SE end of the summit complex. The taller Marapi cone, with a summit elevation 3,173 m, was constructed within a crater cutting the older Gunung Dempo edifice. Remnants of 7 craters are found at or near the summit of the complex, with volcanism migrating to the WNW with time. The large, 800 x 1,100 m wide historically active summit crater cuts the NW side of Gunung Marapi (not to be confused with Marapi volcano 500 km to the NW in Sumatra) and contains a 400-m-wide lake located at the far NW end of the crater complex. Historical eruptions have been restricted to small-to-moderate explosive activity that produced ashfall near the volcano.

Information Contacts: *Center of Volcanology and Geological Hazard Mitigation (CVGHM)*, Jalan Diponegoro 57, Bandung 40122, Indonesia (URL: http://portal.vsi.esdm.go.id/joomla/); *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/).

Batu Tara

Lesser Sunda Islands, Indonesia
7.792°S, 123.579°E; summit elev. 748 m
All times are local (= UTC + 8 hours)

Activity at Batu Tara has been frequent since early 2007 (*BGVN* 32:12), with thermal anomalies and ash plumes continuing through August 2008 (*BGVN* 33:02 and 33:07). The volcano has remained active into early March 2009 with occasional low-level ash plumes (table 2). Based on analysis of satellite imagery, the Darwin VAAC reported ash plumes on 2 September, 3-4 October, 16-20 October, 9-10 November, and 6-7 December 2008. The plumes did not rise higher than 2.4 km altitude, and generally drifted in westerly directions. A plume during 6-7 December 2008 was visible in satellite imagery for a length of ~ 55 km. Additional ash plumes were noted during 6-7 January and 9-10 March 2009.

Geologic Summary. The small isolated island of Batu Tara in the Flores Sea about 50 km N of Lembata (fomerly

Date	Plume top altitude (km)	Drift direction(s)	Remarks
02 Sep 2008	Low-level	W	Ash
03-04 Oct 2008	Low-level	W, NW	Ash
16-20 Oct 2008	1.5-2.4	W	Ash
09-10 Nov 2008	1.5	NW	Ash
06-07 Dec 2008	1.5	NW, SW	Plume ~ 55 km
06-07 Jan 2009	2.4	NE, ENE	Ash
09-10 Mar 2009	2.1	NE, N, NW	Plume ~ 37 km

Table 2. Summary of Volcanic Ash Advisories for Batu Tara issued by the Darwin VAAC describing ash plumes during 2 September 2008-10 March 2009. Courtesy of the Darwin VAAC.

Lomblen) Island contains a scarp on the eastern side similar to the Sciara del Fuoco of Italy's Stromboli volcano. Vegetation covers the flanks of Batu Tara to within 50 m of the 748-m-high summit. Batu Tara lies N of the main volcanic arc and is noted for its potassic leucite-bearing basanitic and tephritic rocks. The first historical eruption from Batu Tara, during 1847-1852, produced explosions and a lava flow.

Information Contacts: *Darwin Volcanic Ash Advisory Centre (VAAC)*, Bureau of Meteorology, Northern Territory Regional Office, PO Box 40050, Casuarina, NT 0811, Australia (URL: http://www.bom.gov.au/info/vaac/).

Lewotobi

Lesser Sunda Islands, Indonesia
8.542°S, 122.775°E; summit elev. 1,703 m
All times are local (= UTC + 8 hours)

On 29 May 2008, the Center of Volcanology and Geological Hazard Mitigation (CVGHM) raised the Alert Level for the Flores Island volcano Lewotobi to 2 (on a scale of 1-4) due to an increase in seismicity during 12-29 May. White plumes typically rose about 25 m above the crater and drifted E; visual observations indicated no changes.

Explosive ash eruptions and high levels of seismicity occurred during May-September 2003 (*BGVN* 28:06 and 28:10). Seismicity declined dramatically after an eruption on 31 August, and all volcanic earthquakes ceased after 3 September. The absence of reports during October 2003 until mid-May 2008 suggests Lewotobi apparently entered a protracted period of quiescence until May 2008. MODVOLC thermal surveillance of Lewotobi subsequent to the activity of October 2003 has not revealed any significant thermal activity to February 2009.

Additional details of 2003 eruption. According to an Agence France-Presse (AFP) news report, an eruption on 31 August 2003 took place at 1935. The article noted that hundreds of people from at least six villages fled E from their homes to the village of Konga. AFP said that volcanic material caused fires in forests within a 1-km radius of the crater and damaged crops on the flanks. On 1 September CVGHM reported to the Darwin Volcanic Ash Advisory Center (VAAC) that an ash plume rose ~2.5 km above the crater and drifted W, but the plume was not detected in imagery.

Following that 2003 eruption, according to the daily Jakarta Post, at least 565 villagers living on the slopes of Lewotobi were affected by sulfur and ash emissions. The residents experienced respiratory problems and skin afflictions. A 2008 Jakarta Post article indicated that an estimated 10,000 people live on the slopes of Lewotobi, most of them farming the fertile volcanic soil in the area.

Geologic Summary. The Lewotobi "husband and wife" twin volcano (also known as Lewetobi) in eastern Flores Island is composed of the Lewotobi Lakilaki and Lewotobi Perempuan stratovolcanoes. Their summits are less than 2 km apart along a NW-SE line. The conical 1584-m-high Lewotobi Lakilaki has been frequently active during the 19th and 20th centuries, while the taller and broader 1,703-m-high Lewotobi Perempuan has erupted only twice in historical time. Small lava domes have grown during the 20th century in the crescentic summit craters of both volcanoes, which are open to the north. A prominent flank cone, Iliwokar, occurs on the east flank of Lewotobi Perampuan.

Information Contacts: *Center of Volcanology and Geological Hazard Mitigation (CVGHM)*, Jalan Diponegoro 57, Bandung 40122, Indonesia (URL: http://portal.vsi.esdm.go.id/joomla/); *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/); *Darwin Volcanic Ash Advisory Centre (VAAC)*, Bureau of Meteorology, Northern Territory Regional Office, PO Box 40050, Casuarina, NT 0811, Australia (URL: http://www.bom.gov.au/info/vaac/); *Agence France-Presse* (URL: http://www.afp.com/); *Jakarta Post* (URL: http://www.thejakartapost.com/).

Karangetang [Api Siau]

Sangihe Islands, Indonesia
2.78°N, 125.40°E; summit elev. 1,784 m
All times are local (= UTC + 8 hours)

The August 2007 eruptive activity reported in *BGVN* 32:08 subsided at the beginning of September 2007. Accordingly, the Center of Volcanology and Geological Hazard Mitigation (CVGHM) lowered the hazard alert status from 4 to 3 (on a scale of 1-4). The next notable observation was a report from the Darwin Volcanic Ash Advisory Center (VAAC) of a possible eruption on 4 October 2007 based on satellite imagery of a plume that rose to 12.2 km altitude.

On 13 and 21 October 2007, the Darwin VAAC reported that pilots had observed ash plumes at altitudes near that of the summit. Minor tremor was recorded on 30 October, and the crater continued to emit diffuse white plumes up to 100 m above the crater. On 23 November CVGHM lowered the alert status from 3 to 2 due to a decrease in both seismicity and observed plume height and density.

A pilot observation of a low-level ash plume on 12 March 2008 was reported by the Darwin VAAC. On 28 November 2008, CVGHM reported that increased seismicity indicated rockfalls, along with white plumes from summit craters I and II. On 29 November white and brownish plumes were emitted to low altitudes. Incandescent rockslides from the main crater traveled 250 m S towards

the Bahembang River, 250 m W towards the Beha Timur River, and 500-1,000 m S towards the Keting River. Thunderous noises were reported.

Fog prevented visual observations on 30 November, but the seismic network recorded 160 rockfalls. On 1 December, incandescent rockslides traveled 250 m S towards the Bahembang River, 750 m W towards the Beha Timur River, and 500-1,500 m S towards the Keting River. On 2 December, the Alert Level was raised to 3 due to the continuation of elevated seismicity, the appreciable run-out distances of incandescent rockslides, and the height of incandescent material ejected from the summit.

Based on satellite imagery and CVGHM, the Darwin VAAC reported that on 2 December 2008 an ash plume rose to 3 km altitude and drifted W. MODVOLC thermal alerts were detected during 6 August-2 September 2007 and 2 December 2008-25 February 2009.

Geologic Summary. Karangetang (Api Siau) volcano lies at the northern end of the island of Siau, north of Sulawesi. The 1,784-m-high stratovolcano contains five summit craters along a N-S line. Karangetang is one of Indonesia's most active volcanoes, with more than 40 eruptions recorded since 1675 and many additional small eruptions that were not documented in the historical record (Catalog of Active Volcanoes of the World: Neumann van Padang, 1951). Twentieth-century eruptions have included frequent explosive activity sometimes accompanied by pyroclastic flows and lahars. Lava dome growth has occurred in the summit craters; collapse of lava flow fronts has also produced pyroclastic flows.

Information Contacts: *Center of Volcanology and Geological Hazard Mitigation (CVGHM)*, Jalan Diponegoro 57, Bandung 40122, Indonesia (URL: http://portal.vsi.esdm.go.id/joomla/); *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/); *Darwin Volcanic Ash Advisory Centre (VAAC)*, Bureau of Meteorology, Northern Territory Regional Office, PO Box 40050, Casuarina, NT 0811, Australia (URL: http://www.bom.gov.au/info/vaac/); *Agence France-Presse* (URL: http://www.afp.com/).

Manam

Papua New Guinea, SW Pacific
4.080°S, 145.037°E; summit elev. 1,807 m

Ash plumes from Manam were reported intermittently between 2 April and 7 October 2008 (*BGVN* 33:09), although the volcano was generally quiet. Additional ash plumes were seen in satellite imagery and reported by the Darwin Volcanic Ash Advisory Centre on 20 November, 15 December, and 19 December 2008. Plumes rose to 3 km altitude on each of those days, and drifted 55 km downwind on 20 November. No other plumes were noted through 23 January 2009.

On most days during January 2009 when the summit area was clear, observers noted Southern Crater releasing variable white vapor. No glow was observed and no audible noises were heard. Main Crater was generally quiet with activity similar to Southern Crater's vapor emissions on most days. In contrast, diffuse blue vapor was visible on 21 and 22 January. The occasional dull, and sometimes bright, steady glow reported in previous months was observed on 1, 19-20, and 26 January. On 1 January observers heard some roaring and rumbling noises.

No seismic recording was conducted throughout the month of January due to instrumentation problems. Only one MODVOLC thermal alert was detected between 8 October 2008 and 23 January 2009. That one took place on 20 January 2009 (2 pixels).

Geologic Summary. The 10-km-wide island of Manam, lying 13 km off the northern coast of mainland Papua New Guinea, is one of the country's most active volcanoes. Four large radial valleys extend from the unvegetated summit of the conical 1,807-m-high basaltic-andesitic stratovolcano to its lower flanks. These "avalanche valleys", regularly spaced 90 degrees apart, channel lava flows and pyroclastic avalanches that have sometimes reached the coast. Five small satellitic centers are located near the island's shoreline on the northern, southern and western sides. Two summit craters are present; both are active, although most historical eruptions have originated from the southern crater, concentrating eruptive products during much of the past century into the SE avalanche valley. Frequent historical eruptions, typically of mild-to-moderate scale, have been recorded at Manam since 1616. Occasional larger eruptions have produced pyroclastic flows and lava flows that reached flat-lying coastal areas and entered the sea, sometimes impacting populated areas.

Information Contacts: *Rabaul Volcano Observatory (RVO)*, P.O. Box 386, Rabaul, Papua New Guinea; *Darwin Volcanic Ash Advisory Centre (VAAC)*, Bureau of Meteorology, Northern Territory Regional Office, PO Box 40050, Casuarina, NT 0811, Australia (URL: http://www.bom.gov.au/info/vaac/); *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/).

Ambrym

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

Thermal anomalies detected by MODIS instruments and processed by MODVOLC indicated that lava lakes in both summit craters at Ambrym have been at least intermittently active during November 2006 through February 2009 (figure 4). After MODVOLC alerts were detected on 8 and 15 November 2006 (*BGVN* 32:05), they were again frequently identified from 12 January until 11 July 2007. Another cluster occurred between 31 October and 27 December 2007. A single alert occurred on 23 May 2008. Alerts resumed again on 21 October 2008 and continued through 15 February 2009.

Observations during 31 August-8 September 2008. Arnold Binas reached the summit and observed lava lake activity during 31 August-8 September 2008, an interval without thermal alerts. Binas also reported that the lake was

largely crusted over, abundant steam was emitted, and poor weather conditions often prevented views into the craters. Such factors may have prevented satellite detection of low-level activity during those, and possibly other, times.

Binas climbed to the Benbow crater rim once, but thick steam prevented visual observation of the inner cone; however, strong degassing was noted, often in pulses. At Marum, low rain clouds on the SE side limited observations to periods of a few seconds at a time.

The Marum cone has three active sub-craters with distinct names. The name Mbwelesu describes the main crater; Niri Mbwelesu, a secondary crater close to Mbwelesu's rim; and Mbogon Niri Mbwelesu, a small collapse-pit to the S of Niri Mbwelesu. (The collapse pit Mbogon Niri Mbwelesu is also sometimes called Niri Mbwelesu Taten.)

During the visit, partial views into the Mbwelesu crater were rare through small gaps in constant rain clouds and strong steam emissions. A small lava lake was visible in the main vent, and another nearby opening often spattered small chunks of lava (figure 5). It appeared that both openings were holes through a crusted-over lava lake. The width of the visible portion of the larger opening, measured in digital image pixels at a given focal length and an assumed distance of 350-400 m, was determined to be on the order of 7.5-8.5 m. Waves rolled back and forth along the surface of the covered lake almost constantly, splashing lava through the holes, to a maximum height of about 30-35 m. Degassing also caused small explosions. Noises from the lava lake could be heard throughout the night from within the tent ~ 15 m from the crater rim, despite strong winds and rain.

Strong gas emissions took place in Niri Mbwelesu, with only very rare views of the crater floor, on which a small lake of brownish water was present next to a steaming vent. Mbogon Niri Mbwelesu displayed mostly strong but silent gas emissions from fumaroles on the crater floor, occasionally clearing enough to enable views of the bottom. Sometimes small rockfalls were heard, but not seen, inside the crater.

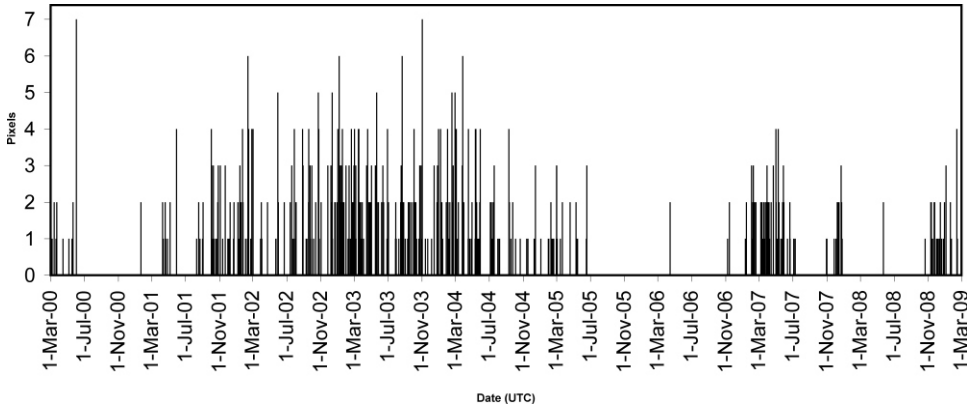

Figure 4. Maximum number of daily thermal alert pixels at Ambrym as identified by the MODVOLC system, March 2000-February 2009. Mapping of the pixels revealed thermal activity at both summit craters. Data comes from MODIS instruments on both Aqua and Terra satellites; the total shown is the maximum pixels per satellite per pass on a given day (UTC). Courtesy of Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System.

Figure 5. View into the Mbwelesu crater on the Marum cone at Ambrym, captured 7 September 2008. Lava can be seen through two gaps in the crusted-over lava lake (enlarged insets). Courtesy of Arnold Binas.

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

Information Contacts: *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/); *Arnold Binas*, Toronto, Canada (Email: abinas@gmail.com; URL: http://www.summitpost.org/user_page.php?user_id=42443, http://www.flickr.com/photos/hshdude/collections/72157600584144439/).

Tongariro

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

Our most recent report on Tongariro (*BGVN* 31:12) discussed elevated seismicity during May-October 2006. The M < 2 long-period seismic event occurred near Ngauruhoe, the youngest cone of the Tongariro volcanic complex.

Between 1 November 2006 and January 2008, elevated, low-level volcanic earthquakes continued at Ngauruhoe. The number of events per day typically ranged between 5 and 30. Then, on 6 January 2008, the number of events per day began to increase, and by 9-10 January the number had shot up to 80 per day, before decreasing slightly. The larger events ranged between M 1.2 and 1.5.

In response to these changes, volcanologists from GeoNet visited on 17 January 2008 and measured gas concentrations, temperatures, and soil gas flux at the summit area of Ngauruhoe. The resulting data were similar to measurements made in 2006-2007. The maximum fumarole temperature near the summit remained about 86°C. No other signs of unrest were found. The data suggested that the earthquakes were occurring within about 1 km of the surface beneath the N flank.

GeoNet noted that the number of volcanic earthquakes since mid-2008 has declined to background levels. Regular measurements of volcanic gas levels and the temperature of the summit gas vent have showed no changes over the previous two and a half years. Consequently, on 2 December 2008, the Alert Level was lowered from 1 to 0 (typical background activity). No thermal anomalies have been measured by MODIS/MODVOLC satellites (HIGP Hot Spots System) in the at least the past 5 years.

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 2,500 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 collaboration between the Earthquake Commission and GNS Science, Wairakei Research Centre, Private Bag 2000, Taupo 3352, New Zealand (URL: http://www.geonet.org.nz/); *Hawai'i Institute of Geophysics and Planetology (HIGP) Hot Spots System*, University of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (URL: http://hotspot.higp.hawaii.edu/).

Villarrica

Central Chile
39.42°S, 71.93°W; summit elev. 2,847 m

Our last report on Villarrica (*BGVN* 31:08) discussed the nearly continuous thermal anomalies between 1 January 2005 through 4 September 2006. This report updates this information through 10 February 2009 and suggests ongoing activity from the lava lake inside Villarrica's small, deep summit crater. Seismic and textural insights on the volcano are discussed by Gurioli and others (2008).

MODVOLC thermal alerts were issued nearly continuously during September 2006. Alerts then followed during 26 October 2006 through 18 February 2007, during 29 April 2007 through 5 June 2007, during 9-11 July 2007, and during 6 September 2007 through 25 December 2007 (24 December local time). The gaps between these periods may be due to cloud cover or other phenomena that obscured satellite observations.

From 26 December 2007 to as late as 10 February 2009, only two thermal anomalies were detected. One (MODIS) was on 2 June 2008, the other (ASTER) on 25 June 2008.

Villarrica has been relatively quiet since 4 September 2006. However, there have been reports of minor activity. According to the the Buenos Aires Volcanic Ash Advisory Center (VAAC), on 14 November 2007 an eruption plume rose to an altitude of 3.8 km and drifted E. Ash was not detected on satellite imagery.

On 26 October 2008, according to the Observatorio Volcanológico de los Andes del Sur-Servico Nacional de Geologia y Mineria (SERNAGEOMIN), three gray plumes containing a small amount of ash were discharged from the main crater and rose 100 m above the crater rim. These plumes quickly dispersed E. A fourth and larger darker gray plume rose 200 m above the crater rim and, according to the Projecto Observación Visual Volcán Villarrica (POVI), deposited a thin layer of tephra several kilometers long on the E flank. Incadescence was not detected.

A SERNAGEOMIN report on 30 October 2008 characterized seismic activity during the previous several months as weak background tremor and small earthquakes. The report commented that this seismicity might be caused by shallow degassing in the main conduit, glacial melting increasing the volume of water in the hydrothermal systemand causing explosions, or conduit obstructions.

Reference. Gurioli, L., A. J. L. Harris, B. F. Houghton, M. Polacci, and M. Ripepe, 2008, Textural and geophysical characterization of explosive basaltic activity at Villarrica volcano: J. Geophys. Res., v. 113, p. B08206, doi:10.1029/2007JB005328.

Geologic Summary. Glacier-clad Villarrica, one of Chile's most active volcanoes, rises above the lake and town of the same name. It is the westernmost of three large stratovolcanoes that trend perpendicular to the Andean chain. A 6-km wide caldera formed during the late Pleistocene. A 2-km-wide caldera that formed about 3,500 years ago is located at the base of the presently active, domi-

nantly basaltic to basaltic-andesitic cone at the NW margin of the Pleistocene caldera. More than 30 scoria cones and fissure vents dot Villarrica's flanks. Plinian eruptions and pyroclastic flows that have extended up to 20 km from the volcano have been produced during the Holocene. Lava flows up to 18 km long have issued from summit and flank vents. Historical eruptions, documented since 1558, have consisted largely of mild-to-moderate explosive activity with occasional lava effusion. Glaciers cover 40 sq km of the volcano, and lahars have damaged towns on its flanks.

Information Contacts: *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/); *Buenos Aires Volcanic Ash Advisory Center (VAAC)*, Servicio Meteorológico Nacional-Fuerza Aérea Argentina, 25 de mayo 658, Buenos Aires, Argentina (URL: http://www.meteofa.mil.ar/vaac/vaac.htm); *Observatorio Volcanológico de los Andes del Sur-Servico Nacional de Geologia y Mineria (OVDAS-SERNAGEOMIN)*, Avda Sta María No. 0104, Santiago, Chile (Email: oirs@sernageomin.cl, URL: http://www2.sernageomin.cl/ovdas/); *Projecto Observación Visual Volcán Llaima (POVI)* (URL: http://www.povi.cl/llaima/).

Date (UTC)	Time (UTC)	Pixels	Satellite
27 Mar 2008	0320	1	Terra
08 Apr 2008	0345	1	Terra
26 Sep 2008	0325	1	Terra
26 Sep 2008	0625	1	Aqua
28 Sep 2008	1535	1	Terra
03 Oct 2008	0630	1	Aqua
05 Oct 2008	0320	1	Terra
15 Oct 2008	0355	1	Terra
15 Oct 2008	0655	1	Aqua
19 Oct 2008	0330	2	Terra
13 Nov 2008	0325	1	Terra
18 Nov 2008	0345	1	Terra
18 Nov 2008	0645	1	Aqua
04 Dec 2008	0345	1	Terra

Table 3. Thermal anomalies at Sangay based on MODIS-MODVOLC imaging during 1 January to 19 October 2008 (continued from the list in *BGVN* 33:03). No thermal anomalies were noted in 2008 prior to 27 March. Courtesy of Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System.

University of Hawai'i, 2525 Correa Road, Honolulu, HI 96822, USA (http://hotspot.higp.hawaii.edu/).

Sangay

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

Ash plumes were reported between October 2006 and December 2007 (*BGVN* 33:03). Thermal anomalies have been detected between 27 March and 4 December 2008 (table 3). A minor ash plume was seen on satellite imagery and by pilots drifting WNW on 24 September 2008.

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

Information Contacts: *Washington Volcanic Ash Advisory Center*, Satellite Analysis Branch (SAB), NOAA/NESDIS E/SP23, NOAA Science Center Room 401, 5200 Auth Rd, Camp Springs, MD 20746, USA (URL: http://www.ssd.noaa.gov/VAAC/); *Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System*, School of Ocean and Earth Science and Technology (SOEST),

Poás

Costa Rica
10.20°N, 84.233°W; summit elev. 2,708 m
All times are local (= UTC - 6 hours)

On 8 January 2009, at 1321, the M 6.2 Chinchona earthquake shook Poás volcano, killing 23 people and injuring 100 in nearby communities. Another seven people were missing. A reported 1,087 houses were destroyed or damaged, with level VII damage on the Modified Mercalli intensity scale. The epicenter (figure 6) was on the Vara Blanca Fault at the village of Vara Blanca, 6-10 km E of Poás. Over 1,500 aftershocks were recorded during 8-9 January. Eruptive activity did not increase around that time, although a small phreatic eruption took place on 12 January. As of early March 2009, no thermal alerts had been detected by MODVOLC.

The morning before the earthquake volcanologists from the Observatorio Vulcanologico Sismologica de Costa Rica-Universidad Nacional (OVSICORI-UNA) and the University of New Mexico had entered the crater to sample fumaroles and the lake. The lake color at that time was a light blue-gray with yellow rings of sulfur 30-m wide that sank within minutes. The lake temperature was 52°C with a pH of 0. A 1-m-thick gas layer hovered over the lake surface. Fumarolic activity from an area S of the crater lake had increased, with a plume rising 150 m (figure 7).

The earthquake triggered significant landslides from the crater walls (figure 8), destroying part of the access trail to the bottom of the crater. There was a distinct shift in the color of the ground surface in many places where mass wasting had occurred. The older surface was commonly gray, whereas the freshly mobile material appeared in shades of brown to ochre. Rockslides carried blocks over a meter in size (figure 9) down the N and E crater walls. The

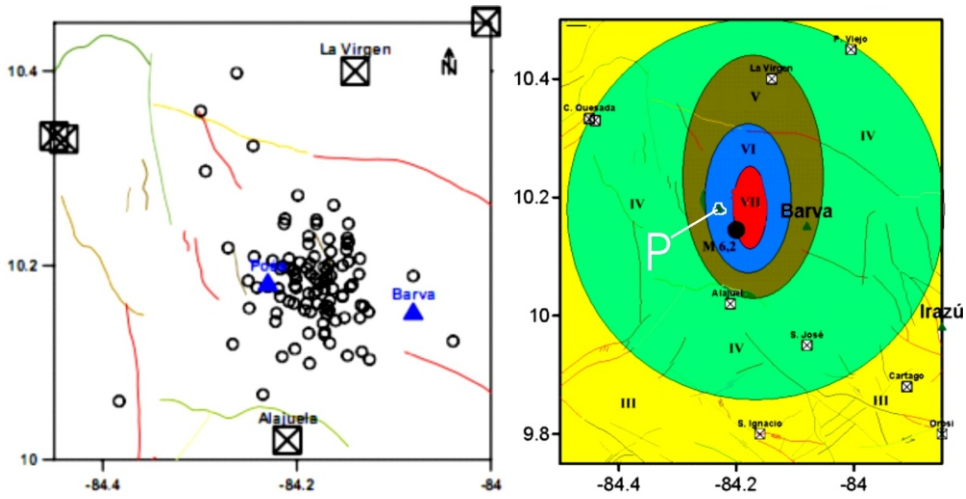

Figure 6. (left) Earthquake epicenters at Poás on 7-8 January 2009. (right) Mapping of the 8 January 2009 earthquake's Modified Mercalli intensity. Poás (P) was in region VI just W of the center of the intensity VII region and NW of the main-shock's epicenter (heavy dot). Both maps courtesy of the University of Costa Rica.

Figure 7. The acidic lake and degassing dome at Poás as seen on 8 January 2009. Courtesy of Univ. of Costa Rica and Univ. of New Mexico.

volcanologists were able to escape the crater at the end of the day through the SSW wall ascending toward Botos lake.

On 12 January 2009, scientists observed rising black sediment in the crater lake. A small phreatic eruption from a 50-m-diameter area at the center of the lake ejected sediment and water about 15 m high. Small phreatic eruptions had also been reported on 16 December 2006 and 13 January 2008 (*BGVN* 32:09 and 32:12).

On 11 February, a month after the earthquake, OVSICORI officials who visited the volcano saw abundant concentric-shaped landslides along the crater walls. According to Eliecer Duarte and others, the landslides numbered in the hundreds and ranged greatly in size. Gravitationally unstable areas were the most affected, but many other rockslides occurred along walls previously thought to be stable. A previously unstable area, E and near the lake, collapsed almost completely, burying a fumarolic area that had been active for about nine years. Vigorous degassing returned to the dome, and vapor covered the hot lake. Compared to recent years, fumarolic activity from the dome appeared stronger and more sustained.

Geologic Summary. The broad, well-vegetated edifice of Poás, one of the most active volcanoes of Costa Rica, contains three craters along a N-S line. The frequently visited multi-hued summit crater lakes of the basaltic-to-dacitic volcano, which is one of Costa Rica's most prominent natural landmarks, are easily accessible by vehicle from the nearby capital city of San José. A N-trending fissure cutting the 2,708-m-high complex stratovolcano extends to the lower northern flank, where it has produced the Congo stratovolcano and several lake-filled maars. The southernmost of the two summit crater lakes, Botos, is cold and clear and last erupted about 7,500 years ago. The more prominent geothermally heated northern lake, Laguna Caliente, is one of the world's most acidic natural lakes, with a pH of near zero. It has been the site of frequent phreatic and phreatomagmatic eruptions since the first historical eruption was reported in 1828. Poás eruptions often include geyser-like ejections of crater-lake water.

Information Contacts: *E. Duarte*, *E. Fernández*, *T. Marino*, *R. Mora*, and *C. Ramirez*, Observatorio Vulcanologico Sismologica de Costa Rica-Universidad

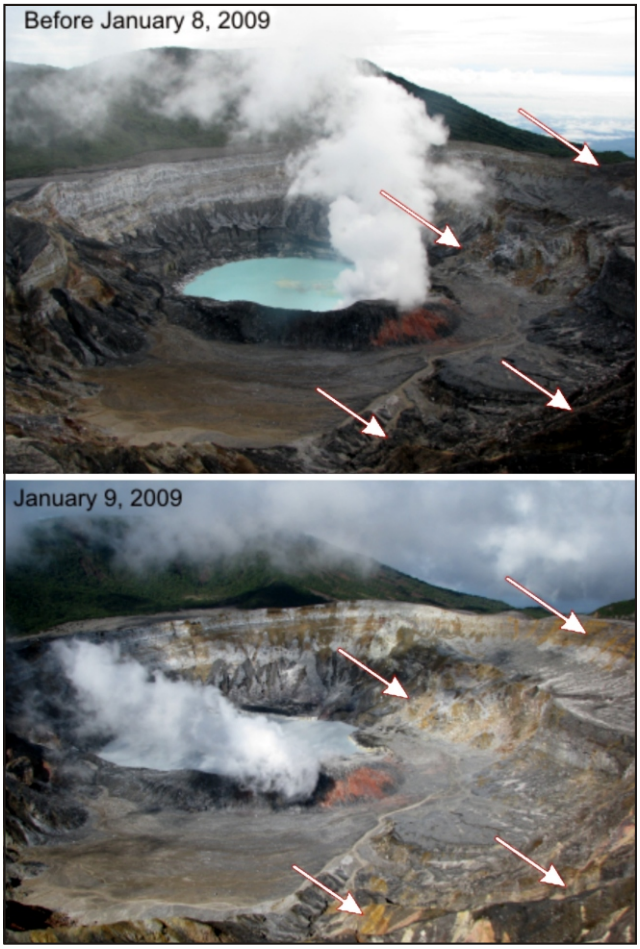

Figure 8. Poás crater before, and the day after, the earthquake of 8 January 2009. Arrows show zones where rockslides ultimately took place on the E crater walls. Courtesy of Univ. of Costa Rica and Univ. of New Mexico.

Figure 9. Photo of the east terrace that partially collapsed as the result of the 8 January 2009 earthquake. Many of these blocks were over a meter in diameter (inset) . Freshly exposed surfaces had ochre to brown to rust colors. Courtesy of OVSICRI-UNA.

Nacional (OVSICORI-UNA), Apartado 86-3000, Heredia, Costa Rica (URL: http://www.ovsicori.una.ac.cr/); *Tobias Fischer*, *Maarten de Moor*, *Kareen Prade*, *Danielle Lord*, and *Jody Weikart*, University of New Mexico, Department of Earth and Planetary Sciences, Northrop Hall, 200 Yale Blvd. NE, Albuquerque, NM 87131, USA.

Nyiragongo

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

Previous evidence and observations indicated continued activity at Nyiragongo's summit crater lava lake through August 2007 (*BGVN* 32:08). MODVOLC thermal alerts have been detected over Nyiragongo nearly daily for at least the past 5 years, as late as January 2009, an indication of the persistence of the summit crater's lava lake.

John Seach climbed to the summit crater in August 2008 and saw the active lava lake, including surface currents and fountaining.

In a *Die Welt* news story, Kasereka Mahinda, director of the the Goma Geophysical Observatory, stated that during a visit to the crater in October 2008, a noticeable rise in the magma level of the lava lake was observed, and recent earthquakes had been felt. Much of the observatory's monitoring equipment has been looted by local civil war combatants, Mahinda explained. The war thus made instrument-based assessments impossible and prevents new instrument installations.

Gas analyses. Sawyer and others (2008) discuss the composition and flux of gas from Nyiragongo by ground-based remote-sensing techniques during mid-2005 through mid-2007. Ultraviolet spectroscopic measurements in May/June 2005 and January 2006 indicated respective average SO_2 emission rates of 38 and 23 kg/s. Open-path Fourier transform infrared spectroscopic measurements obtained in May/June 2005, January 2006, and June 2007 indicated respective average molar proportions of 70, 24, 4.6, 0.87, 0.26, 0.11, and 0.0016% for H_2O, CO_2, SO_2, CO, HCl, HF, and OCS (carbonyl sulfide). The plume compositions were similar in a 24-month span during 2005-2007, with little temporal variation in CO_2, SO_2, and CO proportions. This stability persisted despite variable degassing from the lava lake, including Strombolian bursts and lava fountains, and variations in the SO_2 emission rate.

Reference. Sawyer, G. M., Carn, S. A., Tsanev, V.I., C. Oppenheimer, C., and Burton, M., 2008, Investigation into magma degassing at Nyiragongo volcano, Democratic Republic of the Congo: Geochem. Geophys. Geosyst., v. 9, Q02017, doi:10.1029/2007GC001829.

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

Information Contacts: *John Seach*, New South Wales, Australia (URL: http://www.volcanolive.com/); *Observatoire Volcanologique de Goma*, Departement de Geophysique, Centre de Recherche en Sciences Naturelles, Lwiro, D.S. Bukavu, DR Congo (Email: jdurieux@chello.fr); *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/); *Die Welt* (URL: http://www.welt.de/welt_print/article2721874/Ein-Vulkan-kurz-vor-dem-Ausbruch.html).