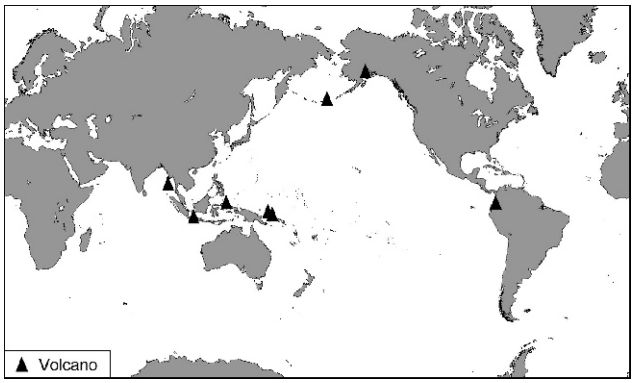
Bulletin of the Global Volcanism Network



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

Barren Island

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

As previously reported (*BGVN* 33:06), thermal anomalies on Barren Island detected by MODIS instruments and processed by the MODVOLC system ceased during 6 October 2007 to 11 May 2008 but then went on to register through the end of June 2008. Thermal anomalies remained frequent, and sometimes daily, through the end of the year (figure 1). Some days displayed five or more alerts per day, with the most active day, 20 November 2008, having 12 alert pixels. Although the likely cause of those near-daily thermal anomalies was ongoing eruptions, the island's remoteness and uninhabited setting precludes continuous eye-witness reporting. A new dissertation discusses volcanic rocks on Barren Island (Alam, 2008), and a technical paper on the topic is in review.

On 17 November 2008 the Darwin Volcanic Ash Advisory Center (VAAC) reported pilot observations of lava flows on Barren Island, but no visible incandescence or vapor. A possible low-level ash plume was seen on satellite imagery drifting W. On 19 November, a pilot reported that an ash plume rose to an altitude of ~ 2.5 km and drifted WSW. During 7-8 December, the Darwin VAAC again reported pilots observations of lava flows on Barren Island. Although thermal anomalies were detected on satellite imagery, ash plumes were not visible.

Reference: Mohammad Ayaz Alam, 2008, Geological, geochemical and geothermal studies on the Barren Island volcano, Andaman Sea, Indian Ocean: Ph.D. dissertation, Indian Institute of Technology Bombay, Mumbai, India.

Geologic Summary. Barren Island, a possession of India in the Andaman Sea about 135 km NE of Port Blair in the Andaman Islands, is the only historically active volcano along the N-S-trending volcanic arc extending between Sumatra and Burma (Myanmar). The 354-m-high island is the emergent summit of a volcano that rises from a depth of about 2,250 m. The small, uninhabited 3-km-wide island contains a roughly 2-km-wide caldera with walls 250-350 m high. The caldera, which is open to the sea on the W, was created during a major explosive eruption in the late Pleistocene that produced pyroclastic-flow and -surge deposits. The morphology of a fresh pyroclastic cone that was constructed in the center of the caldera has varied during the course of historical eruptions. Lava flows fill much of the caldera floor and have reached the sea along the western coast during historical eruptions.

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/); *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/).

Dukono

Halmahera, Indonesia
1.68°N, 127.88°E; summit elev. 1,335 m
All times are local (= UTC + 9 hours)

Thermal hotspots and minor ash plumes were reported through September and early October 2008 (*BGVN* 33:08). Dukono continued to emit minor ash plumes from early October 2008 through 9 January 2009, although MODVOLC thermal alerts have been absent since 26 May 2008. Five instances of ash plumes were noted from 11 October 2008 to 9 January 2009, as recorded by the Darwin Volcanic Ash Advisory Centre (table 1). None of the plumes rose above 3 km altitude.

Geologic Summary. Reports from this remote volcano in northernmost Halmahera are rare, but Dukono has been one of Indonesia's most active volcanoes. More-or-less continuous explosive eruptions, sometimes accompanied by lava flows, occurred from 1933 until at least the mid-1990s, when routine observations were curtailed. During a major eruption in 1550, a lava flow filled in the strait

Date (UTC)	Plume Altitude	Plume Direction (distance from vent)
11 Oct 2008	3 km	WNW (~ 110 km)
06-07 Nov 2008	2.4 km	WNW (~ 72 km)
20 Nov 2008	3 km	NW (~ 110 km)
15 Dec 2008	3 km	SE (~ 160 km)
06 Jan 2009	1.8 km	E (~ 90 km)

Table 1. Ash plumes reported from Dukono between 11 October 2008 and 9 January 2009 (UTC). Data from the Darwin Volcanic Ash Advisory Centre.

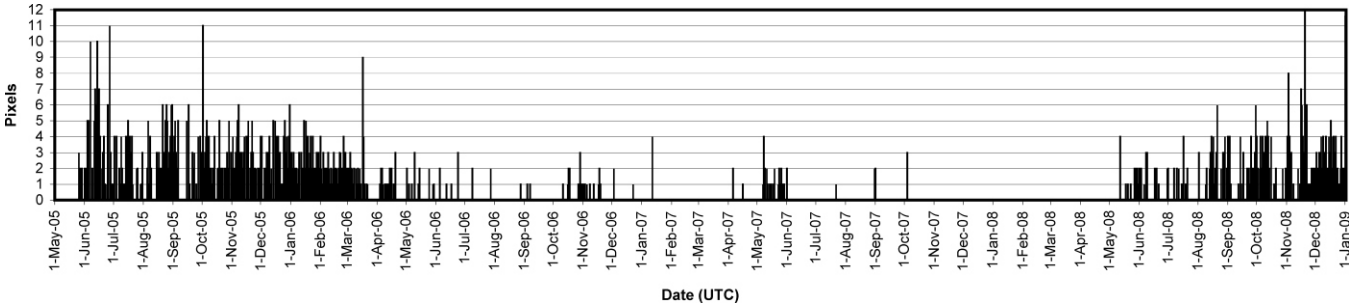

Figure 1. Daily thermal anomalies at Barren Island from the MODIS/MODVOLC satellite observations, May 2005 through December 2008. Vertical scale indicates the daily number of alert pixels detected in a specific thermal image, generally a reflection of the extent of hot lava flows. Anomalies are from both the Aqua and Terra satellites, and use UTC dates. Courtesy of the HIGP MODIS Thermal Alert System.

between Halmahera and the north-flank cone of Gunung Mamuya. Dukono is a complex volcano presenting a broad, low profile with multiple summit peaks and overlapping craters. Malupang Wariang, 1 km SW of Dukono's summit crater complex, contains a 700 x 570 m crater that has also been active during historical time.

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

Sumbing

Java, Indonesia
7.384°S, 110.070°E; summit elev. 3,371 m

The announcement of an eruption in the Smithsonian/USGS Weekly Volcanic Activity Report (30 July-5 August 2008) was later found to be false. The Darwin Volcanic Ash Advisory Center (VAAC) noted that a pilot reported an eruption plume from Sumbing on 1 August 2008. The plume allegedly rose to an altitude of 4.9 km and drifted W. However, ash was not identified on satellite imagery. Center of Volcanology and Geological Hazard Mitigation (CVGHM) observers at the local observatory saw only non-eruptive processes at the volcano, and they noted brush fires in September and October. A common problem in this active region occurs when drifting plumes become linked to the wrong volcano. After discussing the field observations, both Darwin VAAC and Indonesia's CVGHM concluded the report was in error. No thermal anomalies have been detected by the MODIS/MODVOLC satellite system for the volcano since 5 October 2006.

The area of Mt. Sumbing, close to Mt. Sundoro (also known as Sindoro) on Java (figure 2), was the subject of a recent study of people's perceptions and reactions to volcanic hazards (Lavignea and others, 2008). Note that there is another stratovolcano named Sumbing on Sumatra. In addition, one of the domes of Kelut (Java) is known as Sumbing.

Reference: Lavignea, F., De Costerb, B., Juvinb, N., Flohicb, F., Gaillardc, J-C., Texierd, P., Morine, J., and Sartohadif, J., 2008, People's behaviour in the face of volcanic hazards: Perspectives from Javanese communities, Indonesia: Journal of Volcanology and Geothermal Research, v. 172 (3-4), p. 273-287.

Geologic Summary. Gunung Sumbing is a prominent 3,371-m-high stratovolcano that lies across a 1,400-m-high saddle from symmetrical Sundoro volcano in central Java. Prominent flank cones are located on the N and SE sides of Sumbing, which are somewhat more dissected than Sundoro volcano. An 800-m-wide horseshoe-shaped summit crater breached to the NE is partially filled by a lava dome that fed a lava flow down to 2,400 m altitude. Emplacement of the dome followed the eruption of extensive pyroclastic flows down the NE flank. The only report of historical activity at Sumbing volcano, in about 1730 AD, may have produced the small phreatic craters found at the summit.

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

Rabaul

New Britain, SW Pacific
4.271°S, 152.203°E; summit elev. 688 m
All times are local (= UTC +10 hours)

This report documents ash plumes and explosions at Tavurvur, a cone on the NE flank of Rabaul caldera, from May through December 2008; our last report (*BGVN* 33:03) described activity from the end of July 2007 through early May 2008. Aviation notices were frequent from May 2008 through December 2008 (table 2); plume heights were typi-

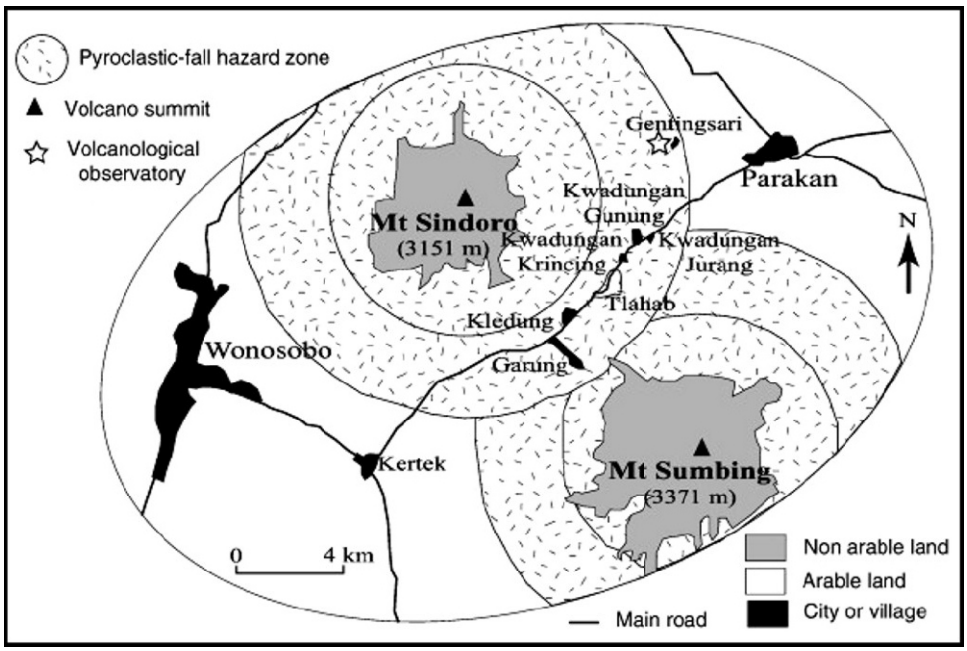

Figure 2. Area around the twin active volcanoes of Sumbing and Sundoro. Note the nearby volcanological observatory at Gentingsari. The circles around the volcano summits represent radii of ~ 4 and 6 km from the summit. From Lavignea and others (2008).

Date	Plume Height	Direction	Distances downwind (km)	Notes and Comments
07 May-08 May	3.0 km	SE	55-92	—
10 May-12 May	3.0 km	NE	37-46	—
14 May-21 May	3.0 km	SW, SE, NW	37-55	—
28 May-02 Jun	3.0 km	NNW, NW, WNW	74-111	Plumes 111 km (29 May, 1 Jun).
03 Jun-10 Jun	—	—	—	Low eruption plumes.
19 Jun-18 Jul	1.5-3.0 km	N, NW, W	27-129	Typically ~ 8- km-long plumes. Plumes 27 km (19 Jun), 129 km (3 Jul), and 111 km (7 Jul).
22 Jul-12 Aug	1.5-3.0 km	W, NW	37-185	Plumes ~ 185 km (7 and 11 Aug).
15 Aug-05 Sep	1.5-2.4 km	WNW, NW	22-111	Plume 111 km (15 Aug), 92 km (16-17 Aug).
07 Sep-08 Sep	1.8 km	W	101-129	—
09 Sep-11 Sep	1.8 km	NW, WNW	46-55	—
12 Sep-16 Sep	1.8-3.0 km	SW, S, NW	27-129	Plume 129 km (15 Sep).
17 Sep-21 Sep	1.8-2.4 km	W, NW	27-64	Typically 27- to 55-km-long plumes; Plume 64 km (18 Sep).
25 Sep-26 Sep	2.4 km	SE, NW	27-74	—
29 Sep-30 Sep	1.8 km	W	64	—
06 Oct-16 Oct	1.5-3.0 km	NW, WNW, W	74-111	Chiefly plume heights of 2.4 km. Plumes 111 km (6-7 Oct), 101 km (13 Oct).
17 Oct-28 Oct	3.0 km	SW, W, WNW, NW	46-222	Plumes 166 km (23-24 Oct), 222 km (26 Oct).
31 Oct-11 Nov	2.4 km	NW	37-120	Plume 120 km (2 Nov), 37 km (9-11 Nov).
15 Nov-06 Dec	3.0 km	W, NW, NNW	27-148	Typical plume length of 55 km. On 20 Nov and 5 Dec, Plumes 148 km (20 Nov), 129 km (5 Dec). On 2-3 Dec, minor low plumes.
07 Dec-10 Dec	2.4 km	E, ENE	27	—

Table 2. Ash plumes from Rabaul's Tavuvur cone during 7 May-16 December 2008. The table distills ~ 150 reports, mostly from the Darwin Volcanic Ash Advisory Center (VAAC). Areas affected by ashfall can generally be found described in the text.

cally to 3 km altitude or less, but they were visible considerable distances downwind, often over 100 km and in some cases during 22 July to 12 August, to 185 km. Additional details and ground observations were provided by the Rabaul Volcanological Observatory (RVO).

May 2008. Emissions were variable with some ejections being quite forceful; while at other times there were long periods of hazy emissions. Sub-continuous rumbling and roaring from the vent were reported, and was especially noticeable after heavy rain. The roaring was interpreted as a result of the interaction of water with hot rocks. Seismicity was dominated by low-frequency volcanic earthquakes, which increased from low levels at the beginning of the month to moderately high levels on and after the 15th. Ground deformation measurements continued to indicate slow subsidence. There were, however, two periods of significant uplift (1 cm each) on the 16th and 17th, each occurring over 4 hours. The speed of the uplift and then its return to 'normal' within 24 hours accompanied by increased roaring and occasional explosions, seemed to indicate this was a blockage in the vent that caused steam build up, followed by leakage and vent clearing.

June 2008. Continuous roaring and moderate ashfall ceased in June, but periodic (hours apart) explosions produced some large amounts of ash, followed by gentle steam emissions. The explosions were interpreted as the result of the vent becoming periodically blocked, due to a lessening of volume of the gas/steam emissions, enabling debris to accumulate rather than being instantly expelled. This process enabled the gas pressure to build until it was able to explosively clear the vent. The gas pressure then dropped and the debris began to accumulate again.

Although eruptions had ceased by the 10th, loud roaring continued and night glow was visible. On the 17th a small eruption occurred. Ground deformation measurements showed that during the latter half of June, the volcano was in a deflated state with the caldera stable. Seismicity was moderate.

July 2008. Tavurvur continued to generate occasional ash emissions accompanying white vapor in July (figure 3). The ash was mostly dark and gray throughout the month with some days being lighter. Ashfall was prevalent at Rabaul Town and other areas downwind, including Namanula Hill, Malaguna, Pilapila, Volavolo, Nonga, and Watom. Night glow was usually obscured by the ash cloud. Ground deformation measurements showed a 1 cm deflation since early June. Low-frequency earthquakes resulted from movement of steam or gas and ash in the conduit. Some of the earthquakes were associated with ash emissions.

August 2008. Light to moderate winds continued to blow ash-rich plumes to the NW, while weak to moderate ash emissions continued. Rabaul Town has been the most affected, given its location along the main axis of the wind path and proximity to the volcano. The accumulated ash in Rabaul Town during the past 4-5 weeks has been very significant. Some visual change in the plume was evident shown by the slight increase in the number of light-colored ash emissions compared to previous weeks when dark emissions with more ash were dominant. Occasional roaring noises were heard, and weak to strong projections of incandescent lava fragments were present during moderate and strong explosions. Some small high-frequency earthquakes that began in late July appeared to be originating from NE of Rabaul Caldera, but exact locations could not be established.

September 2008. There was slight improvement in the conditions at Rabaul Town and the downwind areas during

September, despite continuing ash emissions from Tavurvur. This resulted from decreased ashfall, changes in wind patterns, and light rains that inhibited ash re-suspension. The areas affected by the continuing ashfall included the villages between Rapolo and Raluan as well as Namanula Hill and Korere. On 24 September, flights to Tokua were cancelled due to ashfall.

October 2008. Tavurvur continued to emit occasional light to dark gray ash plumes in October. The changing wind directions continued to blow ash plumes to the W, NW, and E of Tavurvur. Loud roaring noises were heard on the 5th and a total of eight high-frequency earthquakes that originated NE of Rabaul were recorded that day. After a period of slight decrease in ash content, the eruptive activity began to change. On the 11th forceful emissions of pale gray to dark gray ash clouds occurred. Large explosions began on the 20th with emissions of ash-rich plumes. The ash plumes rose between 1-3 km above the summit before they were blown to the NW and W. A continuous red glow was visible at night, and roaring and rumbling noises continued. Ground deformation measurements from the water-tube tiltmeter continued to show the long-term deflationary trend at the central part of the caldera since July 2007. Minor inflation was noted during 7-11 October.

November 2008. Light to pale gray ash emissions continued in November, though the ash content was relatively low. Nearly continuous glow was visible at night. Occasional projections of incandescent lava fragments were produced by forceful emissions and weak explosions. No high-frequency volcano-tectonic earthquakes were recorded. The water-tube tiltmeter continued to show downtilt towards the center of the caldera, which was interpreted as a deflation of the central part of the caldera. Heavy rains washed excess ash from the upper slopes of the caldera wall down to low lying areas, causing flood deposition. An earthquake on 1 November in the Bismarck Sea did not result in a tsunami recorded by the RVO tide gauges.

1-12 December 2008. Activity continued in the first half of December, with steady emissions of ash-rich plumes. Some of the emissions were forceful and occasional roaring/rumbling noises were heard. Villages affected by the ash plumes included Rabaul Town, Malaguna, Rapolo, Raluan, Vulcan, Karavia, Davaon, Nguvalian, Raluana, Barovo, Butuwin and inland villages in the downwind paths. The down-tilt toward the center of the caldera, reported in previous months, stopped.

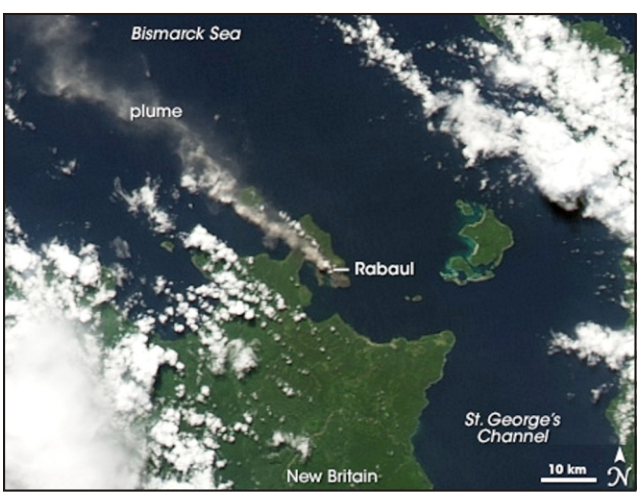

Figure 3. MODIS satellite image of a Rabaul ash plume on 3 July 2008. In this image, the volcano's plume differs from the nearby clouds in both color and form. Whereas the clouds are bright white with distinct margins, the plume is more diffuse in shape with a dingy gray-beige color. The relatively dark color of the plume suggests volcanic ash mixed with water vapor. Courtesy of NASA Earth Observatory.

Geologic Summary. The low-lying Rabaul caldera on the tip of the Gazelle Peninsula at the NE end of New Britain forms a broad sheltered harbor utilized by what was the island's largest city prior to a major eruption in 1994. The outer flanks of the 688-m-high asymmetrical pyroclastic shield volcano are formed by thick pyroclastic-flow deposits. The 8 x 14 km caldera is widely breached on the east, where its floor is flooded by Blanche Bay and was formed about 1400 years ago. An earlier caldera-forming eruption about 7100 years ago is now considered to have originated from Tavui caldera, offshore to the north. Three small stratovolcanoes lie outside the northern and NE caldera rims of Rabaul. Post-caldera eruptions built basaltic-to-dacitic pyroclastic cones on the caldera floor near the NE and western caldera walls. Several of these, including Vulcan cone, which was formed during a large eruption in 1878, have produced major explosive activity during historical time. A powerful explosive eruption in 1994 occurred simultaneously from Vulcan and Tavurvur volcanoes and forced the temporary abandonment of Rabaul city.

Information Contacts: *Steve Saunders* and *Herman Patia*, Rabaul Volcanological Observatory (RVO), Department of Mining, Private Mail Bag, Port Moresby Post Office, National Capitol District, Papua New Guinea (Email: hguria@global.net.pg, URL: http://www.pngndc.gov.pg/Volcano%20Bulletins.htm); *NASA Earth Observatory* (URL: http://earthobservatory.nasa.gov/).

Bagana

Bougainville Island, SW Pacific
6.140 S, 155.195 E; summit elev. 1,750 m
All times are local (= UTC +11 hours)

Lava flows, pyroclastic flows, and repeated forceful ash emissions were noted at Bagana (figure 4) from June 2007 through March 2008 (*BGVN* 33:03). Lava flows and ash emissions continued from the end of May 2008 through 16 December 2008. No reports were received for April 2008.

In May 2008 the Rabaul Volcanological Observatory (RVO) noted that sluggish lava flowed from the summit towards the S and the Torokina River, along with small ash emissions from the summit that rose a few hundred meters. Smaller dust clouds formed from the lava flow fronts. Night glow was common, as were booming and rumbling noises. On 15 May 2008 the lava flows accelerated and the glow brightened. Activity was low during June. RVO noted variable volumes of white vapor from the summit crater. Occasional loud booming noises were heard, and on the night of 8 June, a weak glow was visible. RVO reports for August through much of December were absent.

Based on observations of satellite imagery, the Darwin Volcanic Ash Advisory Center published aviation adviso-

ries for Bagana. From May through December, eight low level ash plumes were observed (table 3). The highest was noted on 22 May, when the plume rose to 3.7 km altitude and drifted S at about 23 km/hour.

MODVOLC. These satellite-derived infrared alerts were consistent with ongoing Bagana eruptions. As previously reported, MODIS/MODVOLC thermal alerts were abundant during 2006-2007 (*BGVN* 32:04) and through March 2008 (*BGVN* 33:03). Thermal alerts continued to be detected from April through the end of December 2008. During this time, the alerts were issued 4-12 times per month. The system, using MODIS (the Moderate Resolution Imaging Spectroradiometer) and the MODVOLC algorithm, is processed by the staff at the Hawaii Institute of Geophysics and Planetology (HIGP).

References. Sillitoe, R. H., 1997, Characteristics and controls of the largest porphyry copper-gold and epithermal gold deposits in the circum-Pacific region: Australian Journal of Earth Sciences, v. 44, no. 3, p. 373-388.

Date	Altitude	Drift	Remarks
22 May 2008	3.7 km	S	~ 23 km/hour
16 Sep 2008	2.4 km	SW	—
22 Sep 2008	2.4 km	SW	—
08 Oct 2008	3 km	WSW	Extended 55-110 km
20 Nov 2008	3 km	SW	Extended 75 km
26 Nov 2008	—	W	—
02 Dec 2008	3 km	NW	—
16 Dec 2008	3 km	SW	—

Table 3. Darwin VAAC advisories describing ash plumes from Bagana during May 2008 to December 2008.

Lightbody, M., and Wheeler, T., 1985, Papua New Guinea, a travel survival kit: Lonely Planet Publications, 256 p., ISBN 0 908086 59 8.

Geologic Summary. Bagana volcano, occupying a remote portion of central Bougainville Island, is one of Melanesia's youngest and most active volcanoes. Bagana is a massive, symmetrical, roughly 1,750-m-high lava cone largely constructed by an accumulation of viscous andesitic lava flows. The entire lava cone could have been constructed in about 300 years at its present rate of lava production. Eruptive activity at Bagana is frequent and is characterized by non-explosive effusion of viscous lava that maintains a small lava dome in the summit crater, although explosive activity occasionally producing pyroclastic flows also occurs. Lava flows form dramatic, freshly preserved tongue-shaped lobes up to 50-m-thick with prominent levees that descend the volcano's flanks on all sides.

Information Contacts: *Rabaul Volcanological Observatory (RVO)*, Dept of Mining, Private Mail Bag, Port Moresby Post Office, National Capitol District, Papua New Guinea (Email: hguria@global.net.pg, URL: http://www.pngndc.gov.pg/Volcano Bulletins.htm); *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/).

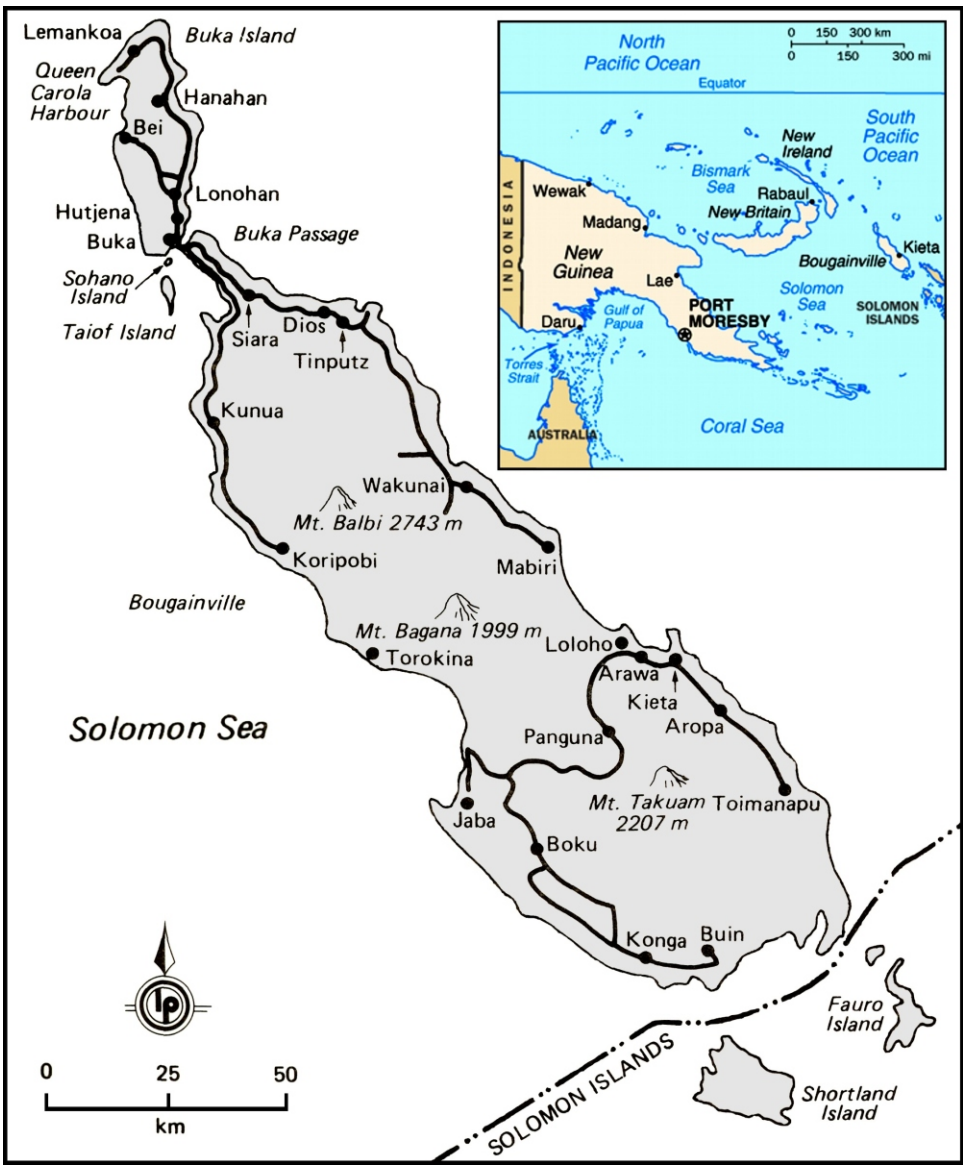

Figure 4. Map of Bougainville Island showing adjacent islands and key cities, including Arawa, the disputed capital and largest settlement of the province. Panguna is the location of an enormous gold- and silver-bearing porphyry-copper deposit in the volcanic highlands (Sillitoe, R. H., 1997), and the site of an open-pit mine which closed in 1989. A decade of civil war surrounding the mine hampered reporting on Bougainville's volcanoes. Base map modified from Lightbody and Wheeler (1985).

Galeras

Colombia
1.22°N, 77.37°W; summit elev. 4,276 m
All times are local (= UTC - 5 hours)

The most recent report on Galeras (*BGVN* 33:03) discussed activity between September 2006 and April 2008 that included a number of minor earthquakes and plumes (mostly ash) that rose generally between 4.4 and 7.2 km in altitude. One eruption during that interval sent a plume up to 11 km altitude. In early April 2008, seismicity decreased. This report reviews September through 9 December 2008.

According to the Instituto Colombiano de Geologia y Mineria (INGEOMINAS) seismic activity at Galeras was low during April through August 2008, although a few small earthquakes occurred and emissions of steam, sometimes mixed with ash, were frequent. Some emission clouds reached greater than 1 km above the summit. Sulfur dioxide (SO_2) levels were moderate, sometimes ranging above 8,000 tons per day. On 21 July, SO_2 levels reached 10,800 tons per day.

The INGEOMINAS reported that an M 2 earthquake located S of Galeras occurred on 9 September at a depth of less than 1 km. Seismicity in September was dominated by long-period and tremor events (table 4). The SO_2 emission rate fluctuated between 3,200 and 6,800 tons during 11-16 September, but jumped to 14,500 tons on the day after the earthquake. Gas plumes drifted W and NW.

A 19 September overflight revealed incandescence coming from the main crater. Thermal images revealed that parts of the cone in the main crater measured 550°C; other anomalies on the cone's flanks measured 270°C. SO_2 fluxes were near 8,200 tons per day. Further measurements during 19-23 September revealed temperatures between 500 and 600°C and SO_2 fluxes between 3,000 and 5,200 tons per day. Gas emissions could be seen from the city of San Juan de Pasto on 2 and 4 October 2008 (figure 5).

According to INGEOMINAS, during the latter half of October and first week of November, white plumes (occasionally tinged gray or blue) rose from Galeras to altitudes of 4.5-7.4 km and drifted S, NW, and W. On 20 October, an M 2.3 earthquake located 600 m SSW of the main crater occurred at a depth of less than 1 km. During an overflight on 30 October, incandescence was observed on some parts of the lava dome.

On 11 November, INGEOMINAS reported that during the previous week, pulsating white plumes, occasionally tinged gray, rose to altitudes of 4.5-5.7 km and drifted W. On 30 November, ash emissions from Galeras were associated with seismic tremor that lasted about 30 minutes. The resultant ash plumes drifted 6-12.5 km S and SSW.

Figure 5. Photos of gas emissions from Galeras taken from the city of San Juan de Pasto on 2 and 4 October 2008. Courtesy of INGEOMINAS.

Date (UTC)	Time (UTC)	Pixels	Satellite
05 Aug 2008	0350	1	Terra
05 Aug 2008	0645	2	Aqua
13 Sep 2008	0655	1	Aqua
24 Sep 2008	0340	1	Terra
24 Sep 2008	0635	1	Aqua
04 Dec 2008	0645	1	Aqua

Table 5. Thermal anomalies at Galeras based on MODVOLC imaging between 1 April and 4 December 2008 (continued from the list in *BGVN* 33:03). Courtesy of Hawai'i Institute of Geophysics and Planetology (HIGP) Thermal Alerts System.

During an overflight on 11 December, thermal images of the lava dome in Galeras's crater were taken. The images revealed temperatures as hot as 530°C on the N side of the dome and near 80°C on the W side. Temperatures had declined compared to thermal images taken in October 2008. On 16 December, INGEOMINAS reported that during the previous few days, gas plumes rose to altitudes of 5.9-6.7 km and drifted NW.

During October, November, and December low seismicity and moderate gas emissions continued. Maximum SO_2 emissions ranged from 780 to 5,300 tons per day.

MODVOLC. During 2008, MODVOLC registered several thermal alerts on Galeras's summit to NE sides (table 5). The MODVOLC thermal imaging system uses Modis instruments on the Aqua and Terra satellites. The MODVOLC thermal alert prior to those on table 5 took place on 30 December 2005.

As of 9 December, the level of activity of the volcano remained at 3 (Yellow), signifying that "changes in the behavior of volcanic activity have been noted." (Note: On the established local scale, Alert Level 1 is highest state of alert.)

Geologic Summary. Galeras, a stratovolcano with a large breached caldera located immediately W of the city of Pasto, is one of Colombia's most frequently active volcanoes. The dominantly andesitic Galeras volcanic complex has been active for more than 1 million years, and two major

Week (2008)	Long-period	Hybrid	Volcano-tectonic	Tremor	Other
01 Sep-07 Sep	116	0	6	138	2124
08 Sep-14 Sep	75	2	7	51	1572
15 Sep-21 Sep	78	11	12	108	1718
22 Sep-28 Sep	146	9	8	234	1681
29 Sep-05 Oct	144	5	7	366	1580

Table 4. Volcanic events at Galeras in September 2008. Courtesy of INGEOMINAS.

caldera collapse eruptions took place during the late Pleistocene. Long-term extensive hydrothermal alteration has affected the volcano. This has contributed to large-scale edifice collapse that has occurred on at least three occasions, producing debris avalanches that swept to the W and left a large horseshoe-shaped caldera inside which the modern cone has been constructed. Major explosive eruptions since the mid-Holocene have produced widespread tephra deposits and pyroclastic flows that swept all but the southern flanks. A central cone slightly lower than the caldera rim has been the site of numerous small-to-moderate historical eruptions since the time of the Spanish conquistadors.

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Redoubt

Southwestern Alaska, USA
60.485°N, 152.742°W; summit elev. 3,108 m
All times are local (= UTC - 9 hours)

In late July 2008 field crews from the Alaska Volcano Observatory (AVO) working around the summit of the volcano smelled hydrogen sulfide (H_2S) gas. Then, on 16 September 2008, a pilot flying downwind of Redoubt reported smelling a strong sulfur-dioxide (SO_2) odor. A week later, residents of a cabin near Wadell Lake (25 km NE) reported loud noises coming from the direction of Redoubt.

During an overflight on 27 September 2008, scientists observed several fractures and circular openings in the upper Drift glacier that had not been seen before. They also noted that fumaroles atop the 1968 and 1990 lava domes were more vigorous than when last observed in mid-August. A distinct H_2S odor was also evident, though no SO_2 was detected by onboard instrumentation. The seismic network at Redoubt did not detect any abnormal earthquake activity.

Satellite thermal instrumentation detected warming near the summit craters on 13 October. Fumarolic activity and water flowing beneath Drift glacier on the N flank had produced a 45-m-wide melt or collapse hole at an elevation of about 1,700 m on Drift glacier.

On 2 November a slushy debris-flow originated near the 1966-68 vent. On 5 November AVO raised the Aviation Color Code for Redoubt from Green to Yellow and the Volcano Alert Level from Normal to Advisory because of significant changes in gas emission and heat output during the previous several months. The changes were a departure from the long-observed background activity. In early November, AVO staff began to install additional geophysical equipment and a web camera on the volcano.

Since November, seismic activity has remained low, although the number of low-frequency earthquakes during the previous several months had increased modestly. On 16 December a short-lived steam cloud, rising no higher than the volcano's summit, was reported by an observer in Kenai, 82 km E of the volcano. Clear satellite views during 12-16 December showed nothing unusual. As of 23 December 2008, the Current Aviation Color Code and Vocano Alert Level remained at Yellow and Advisory, respectively.

Geologic Summary. Redoubt is a 3,108-m-high glacier-covered stratovolcano with a breached summit crater in Lake Clark National Park about 170 km SW of Anchorage. Next to Mount Spurr, Redoubt has been the most active Holocene volcano in the upper Cook Inlet. The volcano was constructed beginning about 890,000 years ago over Mesozoic granitic rocks of the Alaska-Aleutian Range batholith. Collapse of the summit of Redoubt 10,500-13,000 years ago produced a major debris avalanche that reached Cook Inlet. Holocene activity has included the emplacement of a large debris avalanche and clay-rich lahars that dammed Lake Crescent on the S side and reached Cook Inlet about 3,500 years ago. Eruptions during the past few centuries have affected only the Drift river drainage on the N. Historical eruptions have originated from a vent at the N end of the 1.8-km-wide breached summit crater. The 1989-90 eruption of Redoubt had severe economic impact on the Cook Inlet region and affected air traffic far beyond the volcano.

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Cleveland

Aleutian Islands, USA
52.825°N, 169.944°W; summit elev. 1,730 m
All times are local (= UTC -10 hours)

Satellite images acquired during the night of 23 December 2008 showed a persistent thermal anomaly near the summit of Cleveland, a stratovolcano forming the western half of the remote and uninhabited Chuginadak Island in the E-central Aleutian Islands. Cloud cover prevented satellite observations during 25-27 December, but a small thermal anomaly was observed on 28 December 2008. The Alaska Volcano Observatory (AVO) raised the aviation color code to Yellow and the alert level to Advisory on 24 December 2008.

AVO reported that on the morning of 2 January 2009, a short-lived but explosive ash emission occurred. The resulting plume reached to an altitude of ~ 6 km. The plume was first observed in a satellite image obtained at 1645 UTC and was visible in subsequent images for several hours. The plume drifted ~ 240 km ESE, but then dispersed rapidly and could no longer be detected. Satellite views of the volcano were obscured by clouds most of the week; however, a minor thermal anomaly was observed in satellite views of the summit on the morning of 4 January. During this event no active lava flows were observed, as compared with events of July-August 2008 (*BGVN* 33:07).

Cleveland lacks seismic instrumentation; satellite data and pilot reports are the primary information sources. Thermal anomalies were absent after the cluster of events during 22-29 July 2008 (*BGVN* 33:07).

Geologic Summary. Beautifully symmetrical Mount Cleveland stratovolcano is situated at the western end of the uninhabited, dumbbell-shaped Chuginadak Island. It lies SE across Carlisle Pass strait from Carlisle volcano and NE across Chuginadak Pass strait from Herbert volcano. Cleveland is joined to the rest of Chuginadak Island by a low isthmus. The 1,730-m-high Mount Cleveland is the highest of the Islands of the Four Mountains group and is one of the most active of the Aleutian Islands. The native name for Mount Cleveland, Chuginadak, refers to the Aleut goddess of fire, who was thought to reside on the volcano. Numerous large lava flows descend the steep-sided flanks of the volcano. It is possible that some 18th-to-19th century eruptions attributed to Carlisle should be ascribed to Cleveland (Miller et al., 1998). In 1944 Cleveland produced the only known fatality from an Aleutian eruption. Recent eruptions from Mount Cleveland have been characterized by short-lived explosive ash emissions, at times accompanied by lava fountaining and lava flows down the flanks.

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