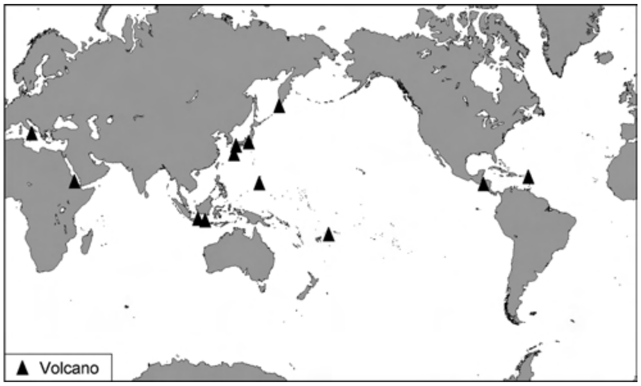
Bulletin of the Global Volcanism Network



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Anatahan

Mariana Islands, central Pacific Ocean
16.35°N, 145.67°E; summit elev. 788 m
All times are local (= UTC + 10 hours)

An explosive eruption on 10 May at Anatahan marked the first report of activity at the volcano since an earthquake swarm on 29 May 1993 that led to the evacuation of the island (*Bulletin* v.18, nos. 5 and 8). No eruptions had previously been documented in historical time from this small volcanic island in the Commonwealth of the Northern Mariana Islands (CNMI) (figure 1).

A group of scientists was near Anatahan on 10 May deploying seismographs for the Margins Mariana Subduction Factory Imaging Project, which is comprised of members from Washington University, St. Louis; Scripps Inst. of Oceanography; and CNMI Emergency Management Office. They passed Anatahan as the eruption was occurring. The island was uninhabited at the time. According to members of the research group who viewed the eruption from about 10 km away, the eruption began on 10 May around 1700. The CNMI Emergency Management Office (EMO) reported that the ash cloud produced from the eruption eventually rose to an altitude of ~ 12 km (figure 2). During an observational helicopter flight, EMO personnel discovered that the eruption was emanating from the eastern crater (figure 3). They noted that only ash was being emitted, no lava flows were seen, and no explosions were seen or heard. The scientists had visited the island on 6 May and saw no signs of any unusual activity.

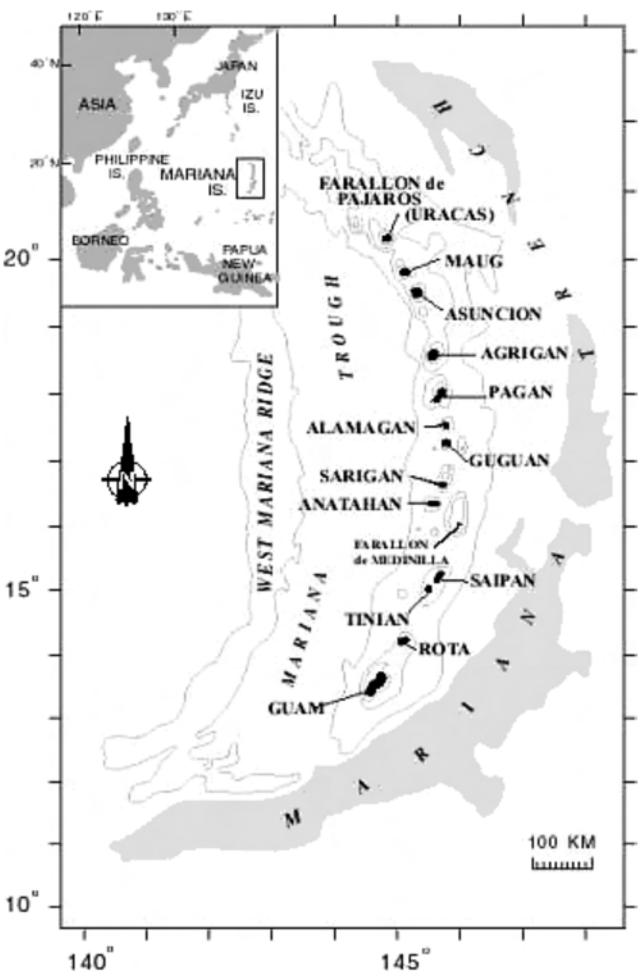

Figure 1. Map of the Mariana Islands and outline of the adjacent Mariana Trench. The Commonwealth of the Northern Mariana Islands extends from Rota in the south to Farallon de Pajaros in the north. The island of Anatahan is approximately 9 km long and 4 km wide. Courtesy of CNMI Emergency Management Office.

Figure 2. Photograph taken on 10 May 2003 of an ash cloud produced from the eruption of Anatahan that began that day. The cloud top is at ~ 4.6 km and emanates from the eastern crater. The view is toward the SW. Courtesy of CNMI Emergency Management Office.

The Washington Volcanic Ash Advisory Center (VAAC) issued an advisory about the Anatahan eruption stating that an ash cloud was visible on satellite imagery on 10 May at 2232 at an estimated altitude of 10.5 km. One layer of the ash cloud drifted south at a speed of ~ 65 km/hour, and a lower level at an altitude of ~ 4.5 km drifted W at ~ 28 km/hr. By 0655 the next day ash was seen in satellite imagery drifting in three different directions: WNW at an altitude around 5.5 km, SW around 8.5 km, and two separate and smaller ash plumes were drifting SE at altitudes around 13.4 km. At this time, a hotspot was visible on GOES-9 imagery.

On 11 May the CNMI Emergency Management Office, Office of the Director issued a special advisory stating, “Due to this active volcano eruption with high level clouds and [an] ash plume, the general public especially fishermen, tour operators and commercial pilots are advise[d] to stay away from the island of Anatahan until further notice from the Office of Emergency Management.” The eruption continued through at least 14 May, when the Washington VAAC issued an ash advisory stating that ash was visible on satellite imagery drifting W of Anatahan at an altitude of ~ 4.9 km.

Background. The elongated, 9-km-long island of Anatahan in the central Mariana Islands consists of two coalescing volcanoes with a 2.3 x 5 km, E-W-trending summit depression formed by overlapping summit calderas. The larger western caldera is 2.3 x 3 km wide and extends eastward from the summit of the western volcano, the island’s 788 m high point. Ponded lava flows overlain by pyroclastic deposits fill the caldera floor, whose SW side is cut by a fresh-looking smaller crater. The summit of the lower eastern cone is cut by a 2-km-wide caldera with a steep-walled inner crater whose floor is only 68 m above sea level. The

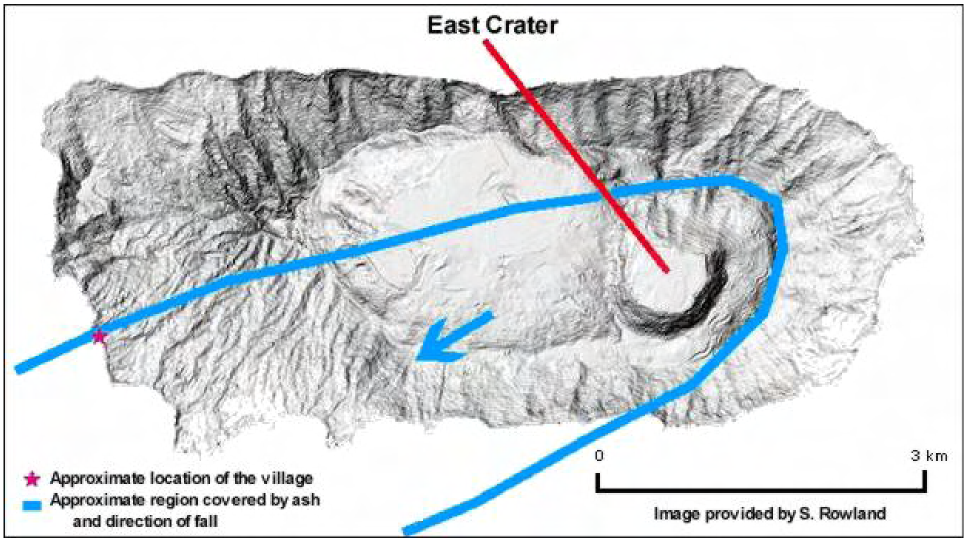

Figure 3. Map of Anatahan showing the deep pit on the eastern side of the summit, which is referred to as the East Crater, and is the source of the eruption that began on 10 May 2003. Courtesy of Scott Rowland, University of Hawaii Manoa.

sparseness of vegetation on the most recent lava flows on Anatahan indicate their probable Holocene age.

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Suwanose-jima

Ryukyu Islands, Japan
29.53ºN, 129.72ºE; summit elev. 799 m
All times are local (= UTC + 9 hours)

Though the volcano had been relatively quiet since 26 August 2002 (*Bulletin* v. 27, no. 7), the Japan Meteorological Agency reported that explosive eruptions became frequent on the morning of 12 September 2002. Rumbling was heard intermittently at a location ~ 4 km SSW of the summit, and light ashfall was observed on 12 September. Explosions occurred at 0816, 1246, 1746, and 1754 on 12 September, and at 0853, 1016, and 1027 on 13 September.

A pilot report contained in the Kagoshima Airport weather observation issued at 1000 on 5 December 2002 noted a plume estimated to be between 900 and 1,200 m altitude. The U.S. Air Force Weather Agency noted that the plume was also seen on DMSP (Defense Meteorological Satellite Program) imagery at 1034 and on NASA Terra MODIS imagery at 1055 on 5 December.

The REAL-Volc Project at the Volcano Research Center, Earthquake Research Institute, University of Tokyo, has detected several thermal anomalies on Suwanose-jima since they started an AVHRR monitoring system in 2001. Anomalies were seen on 11 October 2001, 20 November 2001, 30 December 2001, 20 April 2002, and 12 January 2003.

Background. The 8-km-long, spindle-shaped island of Suwanose-jima is occupied by a stratovolcano with two historically active summit craters. The volcano is one of the most active in Japan. Only about 50 persons live on the sparsely populated island. The summit of the volcano is truncated by a large breached crater. The breach opens and extends to the sea on the E flank; it was formed by edifice collapse. Intermittent Strombolian eruptions have taken place from On-take, the NE summit crater. The largest historical eruption took place in 1813-14, when thick scoria deposits blanketed residential areas, after which the island was uninhabited for about 70 years. The SW crater produced lava flows that reached the W coast in 1813, and lava flows reached the E coast of the island in 1884.

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Kikai

Ryukyu Islands, Japan
30.78°N, 130.28°E; summit elev. 717 m
All times are local (= UTC + 9 hours)

According to a Japanese Meteorological Agency (JMA) report on 6 June 2002, discolored plumes associated with volcanic tremor had intermittently issued from Kikai since 11 May 2002. The U.S. Air Force Weather Agency reported that plumes emanating from Satsuma-Iwo-jima (an island forming part of the NW caldera rim of Kikai) were visible on satellite imagery during 24-28 May and 1-4 June

2002. The thin plumes drifted to the S, SE, and E during May, and were estimated to be lower than 3 km altitude. Ash was seen from the island of Yaku-shima on the afternoon of 26 May. JMA noted that the number of small volcanic earthquakes increased after 29 May. The JMA report also stated that discolored plumes were observed from Mishima village in the Ryukyu Islands, and that ash fell on residential areas, during 3-5 June 2002.

Background. Kikai is a mostly submerged, 19-km-wide caldera near the northern end of the Ryukyu Islands S of Kyushu. Kikai was the source of one of the world's largest Holocene eruptions about 6,300 years ago. Pyroclastic flows traveled across the sea for a total distance of 100 km to southern Kyushu, and ashfall reached the northernmost Japanese island of Hokkaido. The eruption devastated southern and central Kyushu, which remained uninhabited for several centuries. Historical eruptions have occurred in the 20th century at or near Tokara-Iwo-Jima (also known as Satsuma-Iwo-jima), a small 3 x 6 km island forming part of the NW caldera rim. Showa-Iwo-jima (also known as Iwo-jima-Shinto), a small island 2 km E of Tokara-Iwo-jima, was formed during submarine eruptions in 1934 and 1935. Explosive eruptions have occurred during the past few decades from Iwo-dake, a rhyolitic lava dome at the eastern end of Tokara-Iwo-jima.

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Sakura-jima

Kyushu, Japan
31.585°N, 130.657°E; summit elev. 1,117 m
All times are local (= UTC + 9 hours)

An observer at Kagoshima Airport reported seeing an ash cloud from Sakura-jima at 0900 on 22 July 2002 that rose to 2.1-2.4 km altitude. An ash plume was visible on satellite imagery at 1052 (0152 UTC) that day extending to the SW.

A photograph taken by the webcam at ttp://yumemaru.com/s/index.html shows a plume of undetermined composition originating from the island on 17 April 2003 (figure 4). This type of event is common at Sakura-jima.

Figure 4. Photograph of Sakura-jima taken on 17 April 2003 showing a plume originating from the island. Courtesy of Yunemaru.

Background. Sakura-jima, one of Japan's most active volcanoes, is a post-caldera cone of the Aira caldera at the northern half of Kagoshima Bay. Eruption of the voluminous Ito pyroclastic flow was associated with the formation of the 17 x 23 km wide Aira caldera about 22,000 years ago. The smaller Wakamiko caldera was formed during the early Holocene in the NE corner of the Aira caldera, along with several post-caldera cones. The construction of Sakura-jima began about 13,000 years ago on the southern rim of Aira caldera and built an island that was finally joined to the Osumi Peninsula during the major explosive and effusive eruption of 1914. Activity at the Kita-dake summit cone ended about 4850 years ago, after which eruptions took place at Minami-dake. Frequent historical eruptions, recorded since the 8th century, have deposited ash on Kagoshima, one of Kyushu's largest cities, located across Kagoshima Bay only 8 km from the summit. The largest historical eruption took place during 1471-76.

Information Contacts: *Charles Holliday*, U.S. Air Force Weather Agency, 106 Peacekeeper Drive, Ste 2NE, Offut AFB, NE 68113-4039, USA (URL: https://afweather.afwa.af.mil/, Email: Charles.Holliday@afwa.af.mil); *Yunemaru* (URL: http://yumemaru.com/).

Miyake-jima

Izu Islands, Japan
34.08ºN, 139.53ºE; summit elev. 815 m
All times are local (= UTC + 9 hours)

Miyake-jima has remained restless since the eruption that began in June 2000 (*Bulletin* v. 25, nos. 5-7, 9; v. 26, no. 2, and v. 27, nos. 3 and 11). Small explosions with minor ash emission have been common (see *Bulletin* v. 27, no. 11). The most recent event reported by the Japan Meteorological Agency was at about 1320 on 24 November 2002, with the plume rising to an unknown height. The SO_2 gas output remained high, ~ 4,000-9,000 tons/day, as of March 2003 (figure 5). Robust degassing was ongoing through the week of 16-22 April 2003. All residents on Miyake-jima island have been evacuated since September 2000, after which time SO_2 fluxes reached extremely high values (over 80,000 tons/day in October 2000).

Background. The circular, 8-km-wide island of Miyake-jima forms a low-angle stratovolcano that rises about 1100 m from the sea floor in the northern Izu Islands about 200 km SSW of Tokyo. The basaltic volcano is truncated by a 3.5-km-wide summit caldera that was formed during a major eruption about 3000 years ago. A central cone, Oyama, rises 120 m from the floor of a nested 1.5-km-wide caldera at the eastern end of the larger caldera. Parasitic craters and vents, including maars near the coast

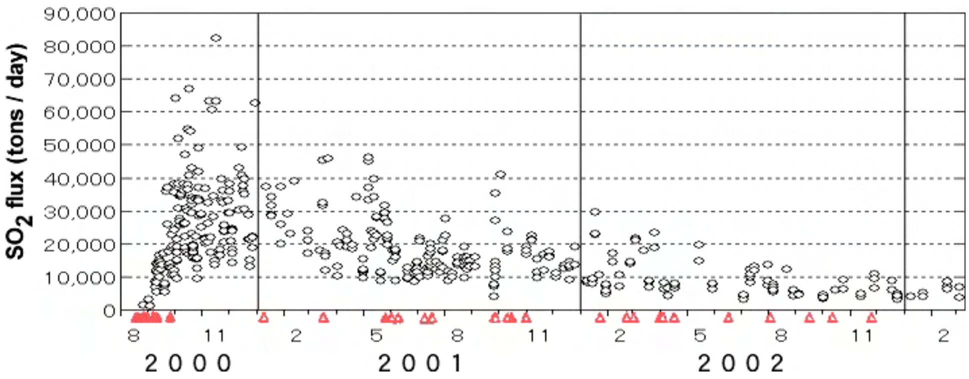

Figure 5. SO_2 flux at Miyake-jima during August 2000-March 2003. Triangles along the timeline indicate explosions. Courtesy of the Geological Survey of Japan and the Japan Meteorological Agency.

and radially oriented fissure vents, dot the flanks of the volcano. Frequent historical eruptions have occurred since 1085 AD at vents ranging from the summit to below sea level, causing much damage on this small populated island. After a three-century-long hiatus ending in 1469, activity has been dominated by flank fissure eruptions sometimes accompanied by minor summit eruptions. A 1.6-km-wide summit caldera was slowly formed by subsidence during an eruption in 2000; by October of that year the crater floor had dropped to only 230 m above sea level.

Information Contact: *Akihiko Tomiya*, Geological Survey of Japan, AIST, 1-1 Higashi, 1-Chome Tsukuba, Ibaraki 305-8567, Japan (URL: http://staff.aist.go.jp/a.tomiya/tomiyae.html; Email: a.tomiya@aist.go.jp); *Japan Meteorological Agency (JMA)*, Fukuoka, Japan (URL: http://www.jma.go.jp/).

Asama

Honshu, Japan
36.40ºN, 138.53ºE; summit elev. 2,560 m
All times are local (= UTC + 9 hours)

Asama, located near the resort town of Karuizawa ~ 150 km W of Tokyo, has been seismically active since 18 September 2000. Heightened seismicity occurred in June 2002, when the daily number of volcanic earthquakes exceeded 300 (*Bulletin* v. 27, no. 6). The Asama Volcano Observatory (ERI, University of Tokyo) and JMA reported that a new episode of elevated seismicity started around 0620 on 18 September 2002. A relatively large amount of volcanic gas trailed from the summit. The seismicity increased after 0800, 18 September, such that 243 volcanic earthquakes took place on 18 September and another 128 on the 19th, after which the seismic activity decreased. However, the temperature of the crater bottom remained at the elevated levels observed since May 2002. No change was observed in ground deformation.

According to the Japan Meteorological Agency (JMA), seismicity had been at background levels for several months, and the temperature of the crater had been rather low prior to four minor eruptions between 6 February and 18 April 2003. The first eruption occurred at about noon on 6 February as an ash cloud was seen rising to 300 m above the summit crater, with minor ashfall around the summit. Seismic tremor related to the emission started at around 1201 and lasted about 40 seconds. On 30 March at 0154 hours, a gray ash cloud rose 300 m, with minor ashfall around the summit. Then, on 7 April at 0924, an ash cloud rose 200 m. On 18 April at 0732 the volcano spewed a mixture of black smoke and pale ash ~ 300 m high. There were no reports of injuries or damage from these eruptions, and the JMA reported that more such activity is expected. All of the eruptions were brief, none having durations of more than 10 minutes. No unusual precursory seismic activity preceded these events, but plume activity has increased since the beginning of February.

Background. Asama, Honshu's most active volcano, is located at the junction of the Izu-Marianas and NE Japan arcs and has an historical record dating back at least to the 11th century. The modern cone of Maekake-yama is situated east of the horseshoe-shaped remnant of an older andesitic volcano, Kurofu-yama, which was destroyed by a late-Pleistocene landslide about 20,000 years before present (BP). Growth of a dacitic and rhyolitic lava cone was accompanied by pumiceous pyroclastic flows, the largest of which occurred about 14,000-11,000 years BP, and by growth of the Ko-Asama-yama lava dome on the east flank. Maekake-yama is probably only a few thousand years old, but has had several major plinian eruptions, the last two of which occurred in 1108 and 1783 AD.

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Chikurachki

Kuril Islands, Russia
50.325°S, 155.458°E; summit elev. 1,816 m
All times are local (= UTC + 11 hours)

A new eruption that began at Chikurachki on 18 April 2003 was reported by the Kamchatkan Volcanic Eruptions Response Team (KVERT) and the Alaska Volcano Observatory (AVO). The most recent previous eruption occurred in early 2002 (*Bulletin* v. 27, nos. 1 and 4). Ash explosions were seen by observers on Paramushir Island, and at 1500 and 2000 ashfall was observed in Podgorny town and Cape Vasiliev. The Aviation Meteorological Center at Yelizovo Airport reported that on 19 April ash plumes rose 2,000 m above the crater. According to satellite data from the USA, distinct volcanic events were detected at approximately

2300 on 19 April, 0200 on 20 April, and 0430 on 20 April (1200, 1500, and 1730 UTC, 19 April), with the ash moving towards the SE. Interpretation of satellite imagery revealed plumes extending more than 50 km SE and SSE during 18-19 April, with the longest reaching more than 250 km at 1501 on the 19th.

Visual data from Vasiliev Cape and Paramushir Island on 22 April showed a white gas-and-steam plume that rose 500 m above the crater. According to satellite data from the USA and Russia, ash plumes less than 100 km long were moving SE and E during 22-25 April. Longer plumes on 25 April were directed NNE. Observers from Vasiliev Cape noted a white plume rising ~ 500 m above the crater on 27 April. On 28 April residents in Severo-Kurilsk observed a very fine layer of gray ash (less than 1 mm thick) near the city, 3 km S of the volcano. The longest plume seen in satellite imagery during April was more then 300 km long when observed at 2028 on 29 April.

Background. Chikurachki, the highest volcano on Paramushir Island in the northern Kurils, is actually a relatively small cone constructed on the high Pleistocene volcanic edifice. Oxidized scoria deposits covering the upper part of the young cone give it a distinctive red color. Lava flows from 1816-m-high Chikurachki reached the sea and form capes on the NW coast; several young lava flows also emerge from beneath the scoria blanket on the eastern flank. The Tatarinov group volcanoes are extensively modified by erosion and have a more complex structure. Tephrochronology gives evidence of only one eruption in historical time from Tatarinov, although its southern cone contains a sulfur-encrusted crater with fumaroles that were active along the margin of a crater lake until 1959.

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Cosigüina

Nicaragua
12.97°N, 87.58°W; summit elev. 859 m

In September 2002 an earthquake swarm was registered near Cosigüina. This swarm was the first to be recognized at that volcano in the 27 years of the existence of Nicaragua's seismic network. The historical seismic record contains no evidence of the type of cluster that occurred in September 2002, although there was seismic activity in 1951 that could have been of local origin (see below).

The seismicity began on 4 September, with M 2.4-3.6 events. The main earthquake occurred on 9 September with a magnitude of 3.9. The last event occurred on 16 September with a magnitude of 3.7. A total of 34 earthquakes occurred to the N of Cosigüina volcano. Unfortunately, the seismic station at the volcano failed to function due to radio signal transmission problems. Seismic readings were also obtained from the National System of Territorial Studies of El Salvador (SNET) for 31 earthquakes. Epicenters of the earthquakes, located with the readings obtained by the seismic networks of the Instituto Nicaragüense de Estudios Territoriales (INETER) and SNET, were concentrated in a zone approximately 4-5 km N and W of the crater (figure 6). The distribution, along a SW-NE axis, might be simply a product of the geometry of the configuration of seismic stations with which the events were located.

Randy White (USGS) indicated to INETER that the seismicity seems to have been of the volcano-tectonic type, caused by an intrusion of magma, based on several observations: 1) the two stages of the cluster on 4-6 and 9 September showed a release of similar seismic energy; 2) In the two stages there were many similarly sized events; 17 with a magnitude of 3.0 or less, but none greater than 3.9; 3) The maximum magnitude increased several times; and 4) The distribution of energy was highly unusual for tectonic seismicity. Apparently there were several groups of one or a few events in intervals of 5-7 hours. Regular pulsations are typical for volcanic earthquake swarms that last more than several hours.

INETER volcanologist Pedro Perez investigated the volcano on 12 September, but saw nothing anomalous. He also conducted interviews with local residents, went to the summit crater, and took measurements of thermal waters at the foot of the volcano. Within the crater walls, landslides were observed in the E, S, and W portions. Residents in the Marañonal, Potosí, End Ñata, and Apascali sectors did not feel the earthquakes.

Seismicity in August 1951. The following description is based on news reports compiled by INETER (The News, 1951 Ago. 07; The Press, 1951 Ago. 04, 05, 07, 09, 18).

In August 1951 there was strong seismic activity in western Nicaragua and southwestern Honduras. On 2 August one of a series of strong events produced a 200-m-long crack near Cosigüina that spewed large amounts of water, flooding the region. The seismic shocks also demolished three houses in Chinandega. These earthquakes were

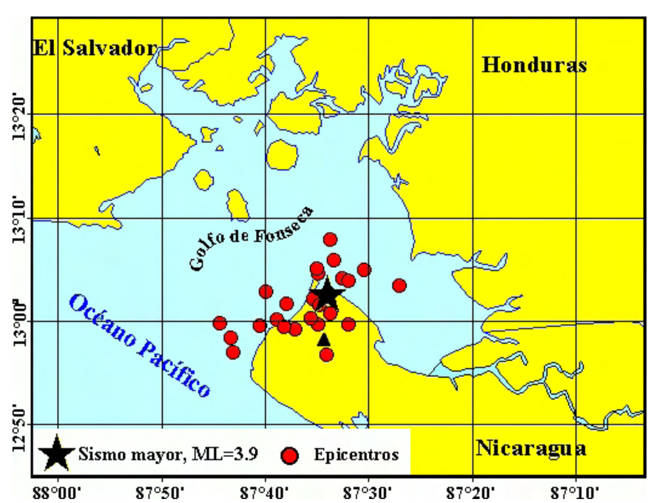

Figure 6. Epicentral map of the earthquakes located N of Cosigüina volcano. September 2002. Black triangle indicates approximate summit location. Courtesy of INETER.

felt more strongly to the W and diminished to the N and in the direction of Managua. The population in these areas slept outside their homes for many days. The people of these sectors, mainly the western population, felt continuous and violent seismic shocks until 8 August. On 17 August a strong tremor shook the western region and Managua. Apparently, this seismic activity produced more than 100 events, not all of which were felt by all residents.

Background. Cosigüina is a low basaltic-to-andesitic composite volcano that is isolated from other eruptive centers in the Nicaraguan volcanic chain. The 872-m-high stratovolcano forms a large peninsula extending into the Gulf of Fonseca at the western tip of the country. Cosigüina (also spelled Cosegüina) has a pronounced somma rim on the northern side; a young summit cone of Cosigüina rises 300 m above the northern somma rim and buries the rim on other sides. The younger cone is truncated by a large elliptical prehistorical summit caldera, 2 x 2.4 km in diameter and 500 m deep, with a lake at its bottom. Lava flows predominate in the caldera walls, although lahar and pyroclastic-flow deposits surround the volcano. In 1835 Cosigüina was the source of a brief, but powerful explosive eruption that was Nicaragua's largest during historical time. Ash fell as far away as Mexico, Costa Rica, and Jamaica, and pyroclastic flows reached the Gulf of Fonseca.

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Soufrière Hills

Montserrat, West Indie
16.72°N, 62.18°W; summit elev. 915 m
All times are local (= UTC - 4 hours)

During 1 March through 2 May 2003, the dome continued to grow, producing numerous rockfalls and moderate pyroclastic flows. Most activity was concentrated on the northern flanks, producing numerous pyroclastic flows in White's Ghaut, the Tar River Valley, and Tuitt's Ghaut. Pyroclastic flows and rockfalls traveled down all flanks of the dome at some time during the period. On 20 March, the greatest dome height recorded to date was measured, 1,098 m. A prominent extrusive lobe was established on the E and SE sides of the summit at the beginning of April. On 22 April, a large spine, inclined to the E, was observed on the summit, the top of which was at an elevation of 1,163 m.

Date (2003)	Rockfall signals	Hybrid events	Long-period (LP) events	Long-period rockfalls	Volcano tectonic (VT) events
28 Feb-07 Mar	997	0	79	71	4
07 Mar- 14 Mar	1050	5	87	108	0
14 Mar-21 Mar	1050	2	93	152	2
21 Mar-28 Mar	1097	16	99	138	7
28 Mar-04 Apr	754	7	74	101	2
04 Apr-11 Apr	332	1	66	77	--
11 Apr-18 Apr	393	7	72	56	--
18 Apr-25 Apr	966	4	83	88	1
26 Apr-02 May	813	4	168	121	1

Table 1. Summary of weekly seismicity at Soufrière Hills during 28 February 2003-2 May 2003. Courtesy MVO.

Date (2003)	SO_2 emission (tons/day)
28 Feb	1020
28 Feb-07 Mar	500-1020
07 Mar-14 Mar	220-355
14 Mar-21 Mar	285-380
21 Mar-28 Mar	31-497
25 March	31
28 Mar-04 Apr	230-770
04 Apr-11 Apr	151-780
06 Apr	151
11 Apr-18 Apr	220-550
18 Apr-25 Apr	450-550
25 Apr-02 May	390-1550
01 May	1550

Table 2. Average daily SO_2 emission rates at Soufrière Hills during 28 February 2003-2 May 2003. Courtesy MVO.

The Washington VAAC issued notices daily to the aviation community regarding ash clouds emanating from the summit. Seismicity during the report period was dominated by rockfalls (table 1). Average daily SO_2 emission rates varied throughout the report period (table 2) with a low of 31 tons/day on 25 March to a maximum of 1,550 tons/day on 1 May.

Throughout the period, access to all areas S of the Belham Valley, to Waterworks, Happy Hill, Lower Friths and Old Towne, and to Bramble airport and beyond was prohibited and a maritime exclusion zone around the S part of the island extended 3.7 km beyond the coastline from Trant's Bay in the E to Lime Kiln Bay on the W coast.

Activity during March 2003. Activity remained at levels similar to that of the previous few weeks (*Bulletin* v. 28, no. 2), with continued dome growth and moderate pyroclastic-flow activity. Lava extrusion was accompanied by rockfall activity and pyroclastic flows that were focused, during 1-7 March, on the NE and N slopes and valleys. Pyroclastic flows occurred most frequently in Tuitt's Ghaut with a few on Farrell's Plain with run-out distances up to 1 km.

During 8-14 March, rockfalls and pyroclastic flows occurred down all flanks. Dome growth continued and lava extruding into the center of the summit dome complex continued to increase the dome height. Dome glow at night was spectacular in the Tar River Valley and on the NW in Tuitt's Ghaut and the N talus slopes. Small rockfalls and pyroclastic flows occurred infrequently on the W flank and at the top of Gage's Valley. Ash venting was continuous in the summit area.

Lava extrusion during 15-21 March formed a series of spines and ridges. Theodolite measurements on 20 March indicated a dome height of 1,098 m, the highest recorded to date. Activity was dominated by rockfalls and pyroclastic flows mainly in the Tar River Valley, with several small pyroclastic flows in White's and Tuitt's Ghaut and one observed in the upper part of Tyre's Ghaut on 20 March. Ash venting continued.

Dome growth continued through the end of the month. Rockfalls and pyroclastic flows spilled off the active summit in a broad arc extending from the S around the E flanks to the NW. Most activity was towards the NE, with pyroclastic flows in the Tar River Valley and small flows on the N flanks of the dome in White's Ghaut, Tuitt's Ghaut, the upper reaches of Tyre's Ghaut and on Farrell's Plain. Most volcano-tectonic earthquakes (see table 1) occurred in a small swarm late in the evening of 25 March. On the same day, following a brief, intense rainstorm, a 4-5 hour period of increased pyroclastic-flow and rockfall activity occurred on the N and NW flanks of the dome. Observation flights on 27-28 March indicated that rockfalls and small pyroclastic flows were spilling onto the S flanks of the dome.

Activity during April 2003. A prominent extrusive lobe was established on the E and SE sides of the summit at the beginning of April and a large vertical spine, extruded at the back of this lobe on the night of 1-2 April, was the highest point on the dome. During 1-12 April, rockfalls and pyroclastic flows occurred mainly on the E side of the dome in the Tar River Valley. Rockfall activity also continued on the S side of the dome and some pyroclastic flows occurred on the NE flanks in White's Ghaut and Tuitt's Ghaut, and on the NW flank; several of the latter flowed into the upper reaches of Tyre's Ghaut. On 10 April torrential rainfall produced mudflows in the Belham River and triggered pyroclastic flows on the E, N, and NW flanks of the dome.

Helicopter observations during 15 April indicated that the lobe extrusion continued on the ESE side of the dome summit above the Tar River Valley. Vigorous gas venting also was observed on the S side of the summit during this flight. Rockfall and pyroclastic-flow activity occurred throughout the week of 12-18 April on the E and SE sides of the dome with some rockfall activity on the N flanks. On 15 April a small pyroclastic flow occurred in the upper part of Tyre's Ghaut.

On 22 April a large spine was observed on the dome summit, positioned slightly S of the center and inclined at a high angle towards the E. The top of the spine was at an elevation of 1,163 m as compared to the ~ 1,090 m height of the general summit region of the dome. During 19-25 April, most of the rockfall and pyroclastic-flow activity occurred on the E and SE flank of the dome in the Tar River Valley. A few flows occurred to the NE in White's Ghaut and Tuitt's Ghaut, and to the N and NW onto Farrell's Plain and into the top of Tyre's Ghaut. Observations on 22 April indicated that rockfall debris was starting to spill S into the White River area. On 23 April several large rockfalls were observed on the W side of the dome in the Gages area.

During the last week of April, the prominent spine seen on the summit of the dome the previous week had partly disintegrated. Most of the rockfalls and pyroclastic flows into the Tar River Valley began along the face of the well-developed extrusion lobe present on the ESE side of the summit region. Rockfall debris spilled off the S side of the lobe into the upper reaches of White River, and some flows occurred towards the NE in White's Ghaut and Tuitt's Ghaut, and towards the N and NW on the top of Farrell's Plain and in the top of Tyre's Ghaut. Vigorous pulses of ash-venting occurred on the summit throughout this week.

Background. The complex andesitic Soufrière Hills volcano occupies the southern half of the island of Montserrat. The summit area consists primarily of a series of lava domes emplaced along an ESE-trending zone. Prior to 1995, the youngest dome was Castle Peak, which was located in English's Crater, a 1-km-wide crater breached widely to the east. Block-and-ash flow and surge deposits associated with dome growth predominate in flank deposits. Non-eruptive seismic swarms occurred at 30-year intervals in the 20th century, but the first historical eruption on Montserrat did not take place until 1995. Long-term small-to-moderate ash eruptions were accompanied by lava dome growth and pyroclastic flows that initially forced evacuation of the southern half of the island and then destroyed the capital city of Plymouth.

Information Contacts: *Montserrat Volcano Observatory (MVO)*, Mongo Hill, Montserrat, West Indies (URL: http://www.mvo.ms/); Washington Volcanic Ash Advisory Center (VAAC), Satellite Analysis Branch (SAB), NOAA/NESDIS E/SP23, NOAA Science Center Room 401, 5200 Auth Road, Camp Springs, MD 20746 USA (URL: http://www.ssd.noaa.gov/).

Stromboli

Aeolian Islands, Italy
38.79°N, 15.21°E; summit elev. 926 m
All times are local (= UTC+ 2 hours)

On the morning of 5 April, scientists from INGV-CT were conducting a daily helicopter flight with a portable thermal camera, surveying the active lava flow field on the upper sector of the Sciara del Fuoco, above a flat zone at the base of the 28 December 2002 eruptive fissure. Three vents along this surface were feeding small lava flows, and the summit craters were producing a very diluted gas cloud. A few minutes after the start of the survey, which began about 0900, the gas plume from the craters being blown W was suddenly crossed by a reddish ash emission, which was interpreted as resulting from further collapses within the craters. However, the red ash was soon replaced by darker juvenile material coming from Crater 1 (the NE crater) that formed a hot jet with a cauliflower shape rapidly growing above the crater. A few seconds later, Crater 3 also produced a hot jet of juvenile material. Data from the seismic network confirmed that the explosion began at 0912.

The eruptive process then evolved very rapidly, with jets from craters 1 and 3 joining together. A very powerful explosion pushed the helicopter away from the crater. A mushroom-shaped dark cloud rose from the craters, expanding vertically to an altitude of ~ 2 km, 1 km above the volcano's summit (figure 7). The eruptive cloud was surrounded at its base by a dark-gray cloud, while it was still expanding vertically and assuming the mushroom shape. Bombs, ash, and blocks fell on the NE flank above 400 m elevation, burning vegetation. Most of the ejecta drifted W, falling on Ginostra (~ 1.5 km from the summit) and destroying two houses; no people were injured.

Continuing the helicopter survey after the eruption, observers saw that the lava-flow field on the upper Sciara del Fuoco was completely covered by a brown carpet of debris ejected from Crater 1 during the initial phase of the event. A thick steam cloud rose above the debris due to vaporization from the wet material by the underlying lava flows. Meanwhile, several alternating black and reddish pulses oc-

Figure 7. Photograph of the expanding eruption plume at Stromboli on 5 April 2003. Courtesy of INGV.

curred, mainly from Crater 3. Several fingers of light-brown debris were expanding from the NW flank of Crater 1 along the mid-section of the Sciara del Fuoco. The upper part of the volcano above 700 m elevation was completely covered by pyroclastic products. Within a few minutes after the start of the eruption, the upper Sciara del Fuoco had active flows emerging from the layer of debris covering the lava-flow field. The explosive event caused abundant emission of pumice mixed with small brown scoria. The pumice contained small crystals and was very vesiculated. Lithic fragments of lava with light-gray groundmass and centimeter-sized crystals of pyroxene were common in the pumice.

A helicopter survey on 8 April showed four active vents pouring lava onto the upper Sciara del Fuoco at 590 m elevation. Two of the flows were expanding along the middle Sciara del Fuoco, causing detachment of blocks from the flow front and small rockfalls that reached the sea. Within the summit craters a thick layer of debris had accumulated following the event of 5 April.

Background. Spectacular incandescent nighttime explosions at Stromboli volcano have long attracted visitors to the "Lighthouse of the Mediterranean." Stromboli, the NE-most of the Aeolian Islands, has lent its name to the frequent mild explosive activity that has characterized its eruptions throughout much of historical time. The small, 926-m-high island of Stromboli is the emergent summit of a volcano that grew in two main eruptive cycles, the last of which formed the western portion of the island. The Neostromboli eruptive period from about 13,000 to 5000 years ago was followed by formation of the modern Stromboli edifice. The active summit vents are located at the head of the Sciara del Fuoco, a prominent horseshoe-shaped scarp formed about 5000 years ago as a result of the most recent of a series of slope failures that extend to below sea level. The modern volcano has been constructed within this scarp, which funnels pyroclastic ejecta and lava flows to the NW. Essentially continuous mild strombolian explosions, sometimes accompanied by lava flows, have been recorded at Stromboli for more than a millennium.

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Erta Ale

Ethiopia
3.60°N, 40.67°E; summit elev. 613 m

Over the last few years the Afar National Regional State has allowed a program of visitation to Erta Ale volcano by natural science field workers. As a result, numerous expeditions have visited the volcano since November 2000 and January-February 2001 (*Bulletin* v. 26, no. 12). The following brief reports are a result of some of these visits during January, February, and April 2002, November-December 2002, and January 2003. Typical lava lake activity was commonly reported, but some changes, such as a significant changes of the lake level, were also noted.

Activity during January 2002. Members of the Société de Volcanologie Genève (SVG) visited Erta Ale at the end January 2002. The lava lake remained elliptical with a N-S axis of ~ 130-133 m and an E-W axis of ~ 104-111 m; the width had increased ~ 10 m as a result of crumbling of the terrace along the lake edge. The size of the pit-crater was the same, with an E-W diameter of ~ 170 m, while the height of the vertical E wall was 46 m. Attempts to measure CO_2 and SO_2 concentrations inside the crater on 27 January 2002 were unsuccessful because the gas concentrations were below the detection limits of the Dräger tubes (10 ppm SO_2 and 0.5% CO_2).

Activity during February 2002. During a 14-19 February 2002 stay on Erta Ale by a team that included Roberto Carniel and Jürg Alean (Stromboli Online), the lava lake was active and produced spectacular fountains of lava. The lake level oscillated by several meters during their observation period. Seismic measurements were conducted along with thermal and video recordings of the lake.

Activity during April 2002. During 12-21 April 2002 a group from SVG led by Franck Pothé and Evelyne Pradal visited the volcano and reported significant changes in the morphology and activity of the lava lake since January 2002. The level of the lake had risen ~ 15 m and its surface area had decreased by ~ 33%. Over a 36-hour period the level varied intermittently by 1-2 m, the variation sometimes occurring within several minutes. Activity on the lake was intense, with continuous degassing and small lava fountains ~ 15 m high.

Activity during November-December 2002. A German group from Volcano Expeditions International visited the volcano during November-December 2002. They reported that the S crater was ellipsoidal with dimensions of ~ 130 m N-S and ~ 160 m E-W (figure 8). The lava lake occupied about half of the crater, and the lake surface was ~ 90 m below the W rim of the S pit. The remaining area in the E was covered by basalt that had a terrace ~ 45 m below the crater rim (figure 8). Previous observations had located the terrace at ~ 70 m below the rim. It was widely covered with talus; hence, the lava lake must had risen up to the present terrace level between spring 2002 and this visit. Almost no talus was found on the terrace, indicating that the lava cover was not old. Lava fountaining up to 20 m high occurred mainly in the W, S, and center areas of the crater lake. GPS measurements were used to accurately map part of the caldera rim and locate some key points (figure 9).

Several earthquakes were felt during the visit. No seismic equipment was present, but five events were felt on 4 and 5 December 2002. No significant change in the lava lake was noticed during these events. Strong fumarolic activity was observed inside and outside the NW crater as well as on the outside of the caldera rim. The surface near the crater rim was broken by cracks in concentric circles, and the crater walls were formed of very unstable material. On 6 December three large rockfalls from crater wall collapses occurred along ~ 50 m of the crater wall circumference within a few minutes. About 40 m of the wall height collapsed with an estimated average thickness of 10 m, thus ~ 20,000 m^3 of material slid into the lake, creating a large cloud of orange-brown dust that filled the pit and generated large amounts of Pélé's Hair.

Activity during January 2003. French teams from Terra Incognita visited the summit on 4 and 13-14 January 2003. The ~ 120 m long by 80 m wide lava lake was still in the W portion of the S pit crater; its surface was ~ 100 m below the crater rim (figure 10). The new platform, located ~ 50 m below the rim, was in the E part of the crater and covered ~ 25% of the crater floor. Gas emissions were abundant, and were assumed to be rich in SO_2 based on their blue color and strong odor. The lava lake exhibited convection and lava fountains.

Background. Erta Ale is an isolated basaltic shield volcano that is the most active volcano in Ethiopia. The broad, 50-km-wide volcano rises 500 m from below sea level in

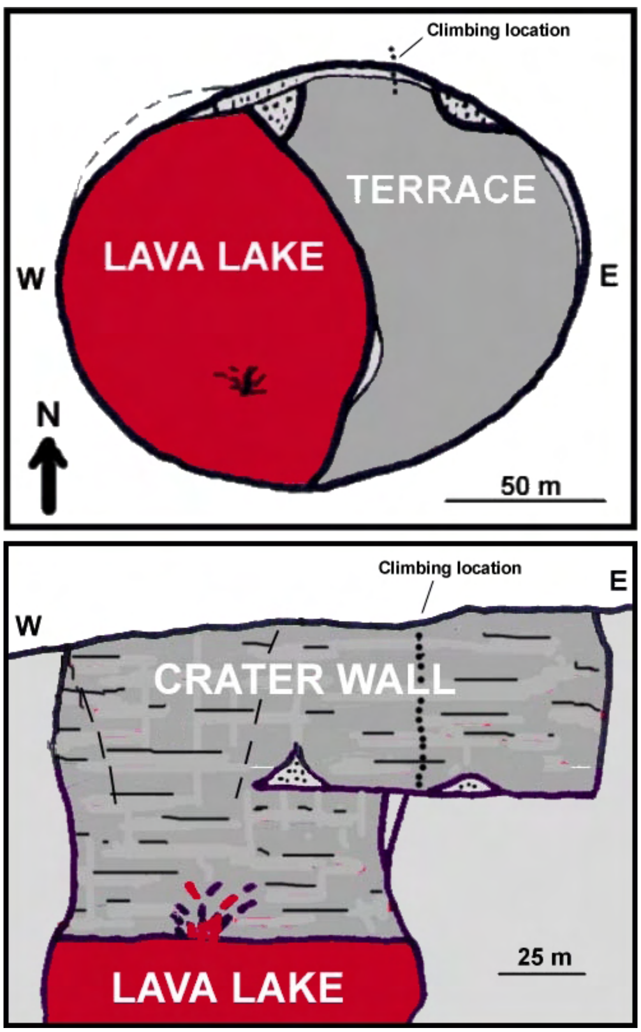

Figure 8. A sketch map (top) and E-W cross-section (bottom) of the active S crater at Erta Ale on 4 December 2002.Courtesy of C. Weber.

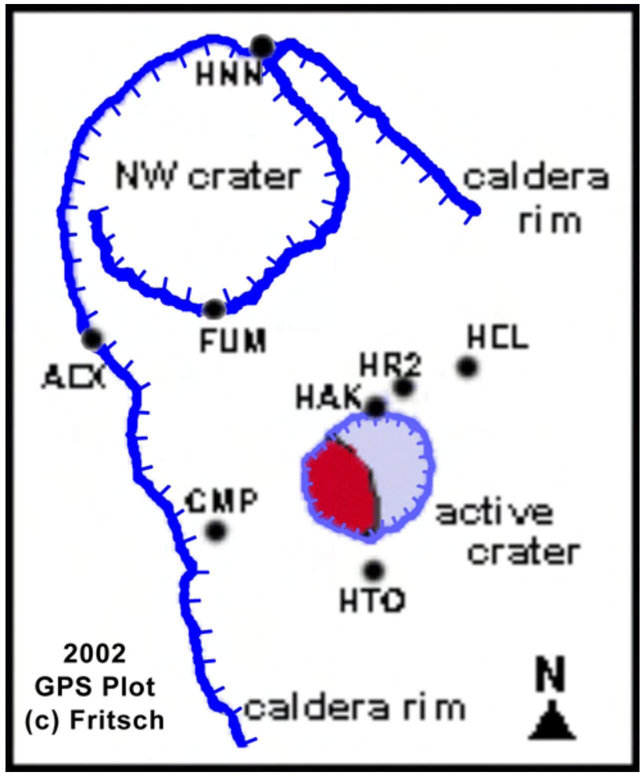

Figure 9. Partial survey of the Erta Ale caldera measured using a 12-channel GPS receiver. GPS reception was excellent due to the exposed nature of Erta Ale, where signals are shaded only when the receiver is close to the caldera wall inside the caldera. The GPS point HAK is the climbing location at 13.60402°N, 40.66401°E, and elevation 563.0 m. The highest point was a hornito on the N caldera rim, location HNN, at 13.60829°N, 40.66222°E, elevation 594.9 m. Courtesy of Lothar Fritsch.

the barren Danakil depression. Erta Ale is one of the most prominent features of and supplies its name to the Erta Ale Range. It contains a 0.7 x 1.6 km, elliptical summit crater housing steep-sided pit craters. One, or sometimes two lava lakes have been active since at least 1967, or possibly since 1906. Another larger depression is located to the SE of the summit. Recent fissure eruptions have occurred on the northern flank.Annual observations during 1967-73 documented overflows from the N lava lake (70-200 m across) that filled the N part of the 700 x 1,600 m summit-crater complex to 100 m depth by January 1973. Continuous overflows from the S lava lake (100 m across) beginning in 1971 had covered the entire crater floor, and lava flowed down the S flank by late 1973. During fieldwork by Getahun Demisse (Ethiopian Geological Survey) in February 1976, the N lake was ~ 100 m in diameter and the S lake had grown to ~ 200 m across. Difficult access prevented fieldwork between 1976 and November 1992.

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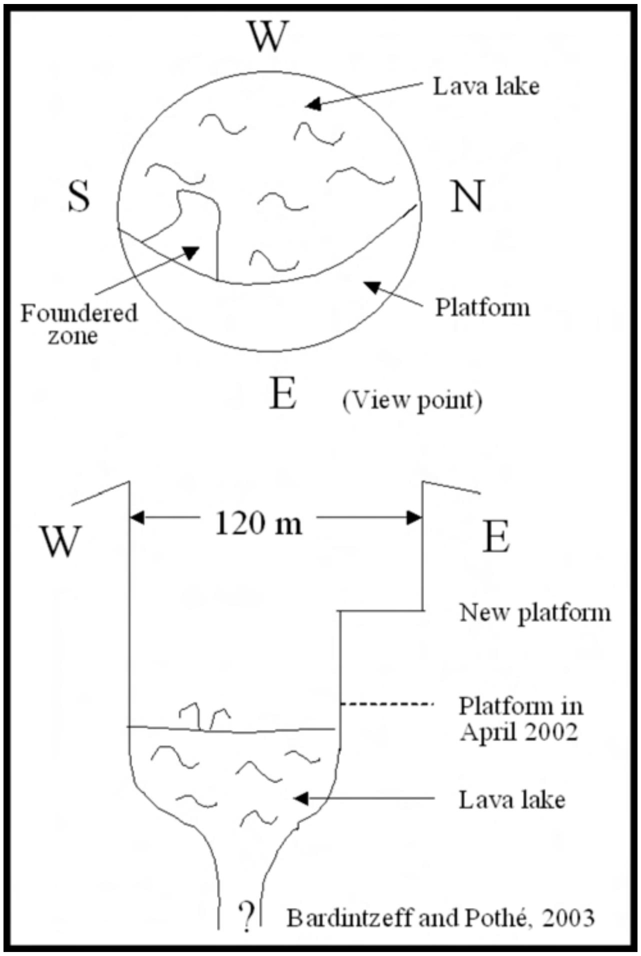

Figure 10. Sketch map and cross-section of the Erta Ale lava lake, January 2003. Courtesy of Jacques-Marie Bardintzeff and Franck Pothé.

Terra Incognita, CP 701, 36 quai Arloing 69256 Lyon Cédex, France (Email: ti@terra-incognita.fr).

Guntur

Java, Indonesia
7.13°S, 107.83°E; summit elev. 2,249 m

During December 2002, the Volcanological Survey of Indonesia (VSI) reported that activity at Guntur was higher than normal. As a result, the Alert Level was raised to 2 (on a scale of 1-4). No plume was observed, but deep and shallow volcanic earthquakes were registered, as well as tectonic earthquakes, through at least mid-May 2003. Tremor was also reported occasionally (table 3). On 28 December a "white ash plume around Guntur crater and Kabuyutan crater reached 3 m high." No ashfall was reported. The temperature at Guntur crater was 79.7°C and at Kabuyutan was 92.7°C. EDM deformation measurements taken on 22 November, 14 December, and 28 December 2002 revealed 11 cm of inflation. On 13 January 2003, an earthquake (MM 2-3) was felt in surrounding areas. Elevated tremor was noted during the first week of April 2003. Guntur remained at Alert Level 2 throughout mid-May.

Background. Guntur is a complex of several overlapping stratovolcanoes about 10 km NW of the city of Garut in western Java. Young lava flows, the most recent of which was erupted in 1840, are visible on the flanks of the erosionally unmodified Gunung Guntur, which rises about 1,550 m above the plain of Garut. Guntur is one of a group of younger cones constructed to the SW of an older eroded group of volcanoes at the NE end of the complex. Guntur, whose name means "thunder," is the only historically active center, with eruptions having been recorded since the late-17th century. Although Guntur produced frequent explosive eruptions in the 19th century, making it one of the most active volcanoes of western Java, it has not erupted since.

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Date	Deep volcanic (A-type)	Shallow volcanic (B-type)	Tectonic
01 Dec-08 Dec 02	8	8	19
09 Dec-15 Dec 02	5	12	23
16 Dec-22 Dec 02	2	6	16
23 Dec-29 Dec 02	—	5	14
30 Dec-05 Jan 03	8	24	15
06 Jan-12 Jan 03	3	6	12
13 Jan-19 Jan 03	2	11	12
20 Jan-26 Jan 03	3	23	20
27 Jan-02 Feb 03	5	5	22
03 Feb-09 Feb 03	5	4	11
10 Feb-16 Feb 03	4	5	22
17 Feb-23 Feb 03	3	11	17
24 Feb-02 Mar 03	6	4	19
03 Mar-09 Mar 03	3	10	30
10 Mar-16 Mar 03	4	5	20
17 Mar-23 Mar 03	1	3	28
24 Mar-30 Mar 03	4	4	24
31 Mar-06 Apr 03	13	6	23
07 Apr-13 Apr 03	5	2	17
14 Apr-20 Apr 03	3	3	22
21 Apr-27 Apr 03	6	3	31
28 Apr-04 May 03	4	2	18
05 May-11 May 03	2	—	24
12 May-18 May 03	3	1	19

Table 3. Seismicity at Guntur during 1 December 2002-18 May 2003. Courtesy of VSI.

Semeru

Java, Indonesia
8.11°S, 112.92°E; summit elev. 3,676 m
All times are local (= UTC + 7 hours)

At Semeru, the end of December 2002 was characterized by high numbers of explosions and pyroclastic flows (*Bulletin* v. 27, no. 12). The 29 December pyroclastic flow at Besuk Bang (figures 11 and 12) traveled ~ 9 km from the summit. During January through 23 March 2003, the Volcanological Survey of Indonesia (VSI) reported that seismicity was dominated by explosions and avalanches (table 4). A "white-gray ash" column rose 300-700 m above the summit. Activity was especially high during 1-12 January, when tens of ash explosions were visually observed per week (figures 13 and 14). Continuous tremor occurred on 8 January, with an amplitude of 11-12 mm. The Alert level remained at 2.

Lava avalanches in January 2003 extended up to 750 m from the crater rim and sometimes entered the Besuk Kembar river. One pyroclastic flow traveled 1,500 m and also entered Besuk Kembar. Pyroclastic flows were more numerous in February, travelling between 2.5 and 4 km from the summit into the Besuk Bang drainage. Lava avalanches were continuous during 17-23 February towards Besuk Kambar. Several pyroclastic flows in March moved toward Besuk Bang (up to 4 km long) and Besuk Kembar (up to 2 km long).

Infrared satellite data, January 2001-March 2003. Between January 2001 and March 2003, MODIS detected quasi-continuous thermal alerts at Semeru (figure 15). During January 2001-March 2002, the anomalies were characterized by 1-2 alert-pixels with a maximum alert ratio of -0.567 (4 May 2001). The Darwin VAAC reported ash plumes and clouds on several occasions throughout this period, and VSI reported numerous seismic events representing explosions and other phenomena (*Bulletin* v. 26, no. 8).

Figure 11. The edge of 29 December 2002 Semeru pyroclastic-flow deposit at Besuk Bang in January 2003. This pyroclastic flow extended ~ 9 km from the summit. Courtesy of I. Mulyana, H. Triastuty, M. Hendrasto, and MA Purbawinata (VSI).

Figure 12. Boulders from the Semeru pyroclastic-flow deposit at Besuk Bang around December 2002-January 2003. Courtesy of I. Mulyana, H. Triastuty, M. Hendrasto, and MA Purbawinata (VSI).

Figure 13. View toward the summit of Semeru looking NW from G. Sawur (observatory post) around December 2002-January 2003. Courtesy of I. Mulyana, H. Triastuty, M. Hendrasto, and MA Purbawinata (VSI).

Figure 14. Eruptive plumes rise from two different vents at the summit of Semeru around December 2002-January 2003. Courtesy of I. Mulyana, H. Triastuty, M. Hendrasto, and MA Purbawinata (VSI).

From April 2002 until the end of the year, MODIS thermal alerts for Semeru increased in frequency and magnitude. This period was characterized by continuous explosions, avalanches and pyroclastic flows, and is related to seismicity increases beginning in March 2002 that prompted VSI to raise the Alert Level to 2 (*Bulletin* v. 27, no. 6). Thermal alerts reached a maximum amplitude on 16 August (two alert pixels with a maximum alert ratio of -0.364) and 1 September (one alert pixel with alert ratio of -0.389). VSI reported that seismic activity was higher than normal during June-September 2002 (*Bulletin* v. 27, no. 9), and the explosions produced plumes that reached 300-500 m above the crater. Observers reported that lava avalanches traveled toward the Besuk Kembar river to distances of ~ 750 m from the crater rim, and an ash explosion ejected glowing material ~ 150 m toward the upper Besuk Kembar drainage. Center coordinates of alert pixels were concentrated in four adjacent pixels close to Semeru's summit, especially on the S side.

Background. Semeru, the highest volcano on Java, and one of its most active, lies at the southern end of a volcanic massif extending N to the Tengger caldera. The steep-sided volcano, also referred to as Mahameru (Great Mountain), rises abruptly to 3,676 m above coastal plains to the S.

Gunung Semeru was constructed S of the overlapping Ajek-ajek and Jambangan calderas. A line of lake-filled maars was constructed along a N-S trend cutting through the summit, and cinder cones and lava domes occupy the eastern and NE flanks. Summit topography is complicated by the shifting of craters from NW to SE. Frequent 19th and 20th century eruptions were dominated by small-to-moderate explosions from the summit crater, with occasional lava flows and larger explosive eruptions accompanied by pyroclastic flows that have reached the lower flanks of the volcano. Semeru has been in almost continuous eruption since 1967.

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Niuafo'ou

Tonga Islands, Pacific Ocean
15.60°S, 175.63°W; summit elev. 213 m

Niuafo'ou is Tonga's most active volcano with at least 10 periods of activity, both explosive and effusive, since the early 1800s. The most recent period of activity in 1946 (Taylor 1999) resulted in the complete evacuation of the island. This volcanic center, ~ 450 km N of Tongatapu, is an isolated volcanic island located in the N-central Lau Basin (figure 16). In May 1999 a vent was producing hot water and H_2S, and dead fish were observed near the vent (*Bulle-*

Date (2003)	Deep volcanic (A-type)	Shallow volcanic (B-type)	Explosion events	Avalanches	Tremor earthquakes	Pyroclastic flows
01 Jan-05 Jan	—	4	354	89	7	0
06 Jan-12 Jan	—	—	382	84	38	1
13 Jan-19 Jan	—	1	554	89	7	0
20 Jan-26 Jan	1	2	641	50	15	0
27 Jan-02 Feb	18	—	739	84	9	3
03 Feb-09 Feb	2	—	777	58	9	14
10 Feb-16 Feb	3	4	641	53	13	5
17 Feb-23 Feb	4	9	700	105	10	9
24 Feb-02 Mar	6	—	629	33	8	10
03 Mar-09 Mar	—	4	794	18	4	0
10 Mar-16 Mar	2	—	550	89	20	21
17 Mar-23 Mar	—	—	563	57	9	13

Table 4. Summary of weekly seismicity at Semeru during 1 January-23 March 2003. Courtesy VSI.

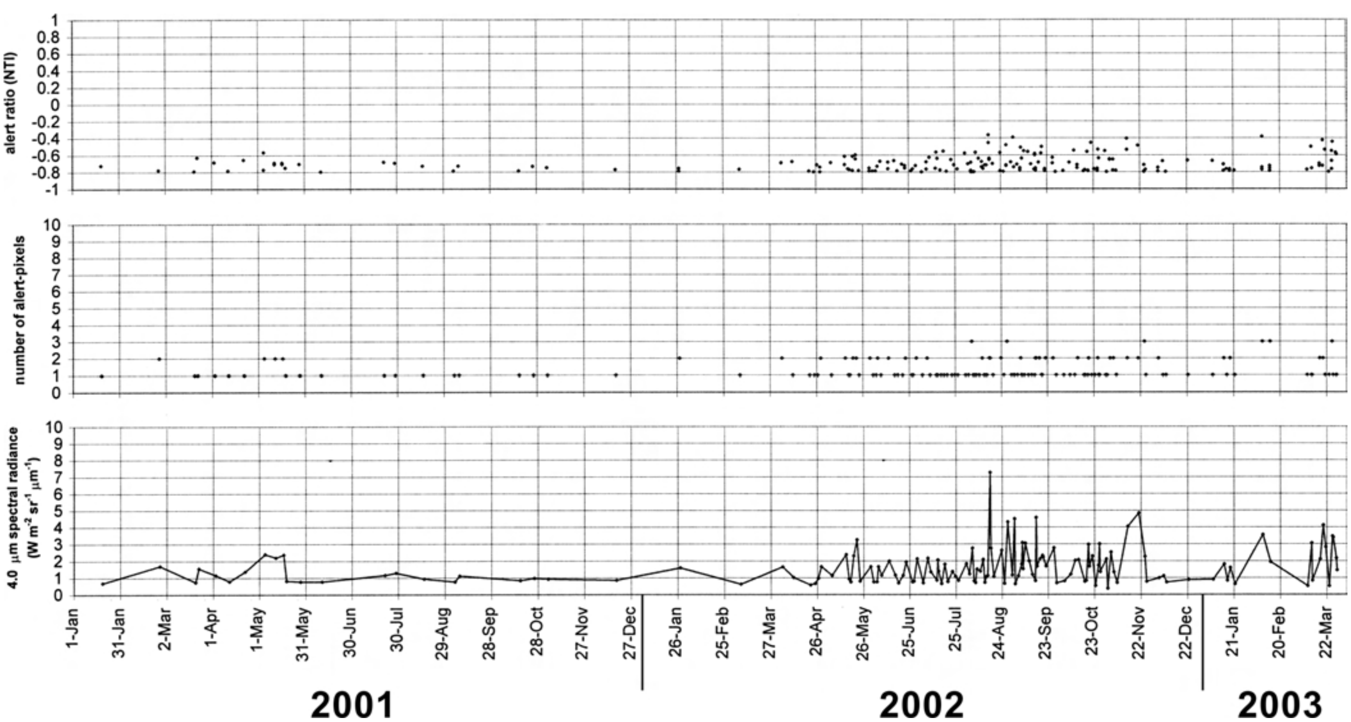

Figure 15. MODIS thermal alerts on Semeru during January 2001-March 2003. Thermal alerts collated by Diego Coppola and David Rothery; data courtesy of the Hawaii Institute of Geophysics and Planetology's MODIS Thermal Alert Team.

tin v. 26, no. 5). Paul W. Taylor visited the volcano in October 2002 and noted fumarolic activity in two areas of the central caldera. On 20 October fumarolic and hot spring activity was noted in the NE part of the caldera.

Form and structure. Niuafo'ou is a subaerial shield volcano formed by submarine explosive and effusive activity during the Holocene. The island is approximately 8 km in diameter with a central caldera ~ 4 km in diameter with two lakes, Vai Lahi and Vai Si'i (figures 17 and 18). Periods of explosive activity have formed several small cinder cone complexes within the caldera. A detailed description of the geological features of Niuafo'ou is provided in Taylor (1991). Niuafo'ou rises to a height of 213 m above sea level at a point on the N rim of the caldera, a point known to the Niuafo'ouans as Piu Ofahifa.

Activity during October 2002. During a visit to Niuafo'ou in October 2002 to conduct a series of community workshops, it was noted that fumarolic activity was occurring in two areas of the central caldera. On 14 October Cecile Quesada (a French anthropologist) and Chris Simard visited the Vai Kona and Vai Sulfa areas along the S edge of the caldera (figure 18) and observed continued activity at the site. On 20 October, Taylor, Alejandra Meija-restrepo, Quesada, and Simard visited the *Vai Si'i* area in the NE part of the caldera and observed continued fumarolic and hot spring activity.

Vai Kona/Vai Sulfa Area. The Vai Kona/Vai Sulfa area of Niuafo'ou has been the site of persistent fumarolic and hot spring activity for many years. Activity was reported in 1958 (Richard, 1962) and again during 1982-83 and 1984 (Taylor, 1991). The level of Vai Kona fluctuates periodically. When Quesada and Simard visited the site on 14 October 2002, areas of persistent activity were observed.

Activity at Vai Kona was concentrated along the S shores of the lake (figure 19). Quesada and Simard observed numerous active vents on the floor of the lake, with large quantities of bubbles reaching the surface. The water temperature was estimated to be 25-30°C. Thick dark mud was present on the bottom of the lake and the temperature of the mud around the vents was estimated to be 35-40°C. Several active hot springs were also observed along the W shore of Vai Kona. These observations suggest that activity at the site has intensified since observed in 1958 and 1983.

Vai Sulfa occupies a small depression W of the southern end of Vai Kona (figure 19). The entire feature covers an area of about 30 m^2 and consists of two sections. The W part of the depression is occupied by a small lake, while the E section is dry. At the center of this dry area is a vent ~ 40 cm across and 20-30 cm deep filled with mud and leaves. When leaves were removed from the hole during the visit it began to fill with water, and a boiling sound was heard. Extensive deposits of sulfur existed around the entire depression, and a strong smell of sulfur was present. Similar activity was also occurring when Quesada and Simard visited the area during July and September 2001. However, activity was less intense at those times.

Vai Si'i Area. A new site of fumarolic activity was first reported during May 1999 and observed during June 1999 (*Bulletin* v. 26, no. 5). When the site was visited on 20 October the focus of activity had moved to an area along the E

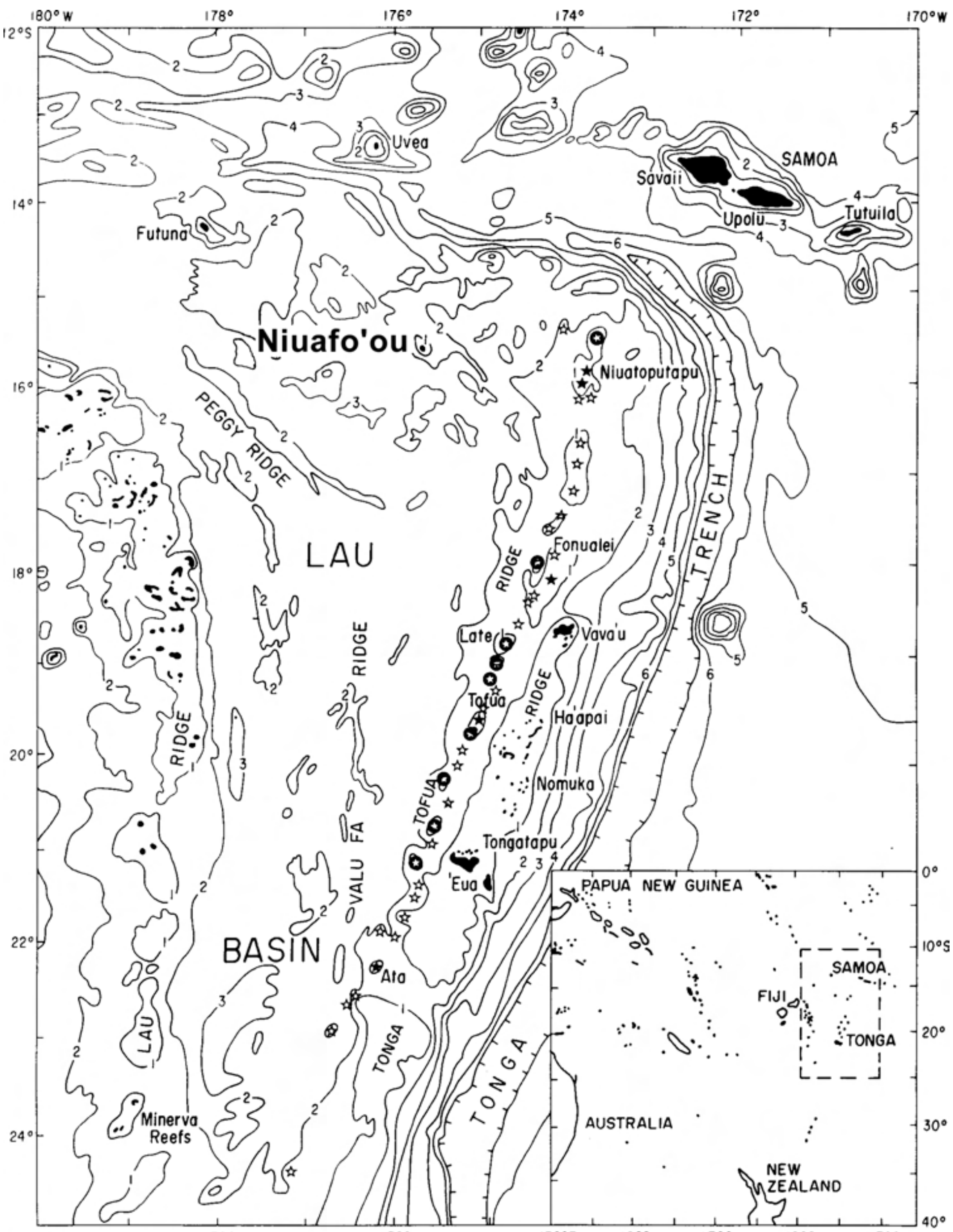

Figure 16. Locality map of the Lau Basin region, showing the location of Niuafo'ou. The symbols indicate centers with recorded eruptions (circles with stars); centers with no recorded activity (black stars); and probable submarine centers (white stars). Bathymetric contours are in kilometers. Courtesy of Paul Taylor.

shore of Vai Si'i. Numerous vents were present on the floor of the lake along the shoreline. The affected area stretched along the shoreline for ~ 25-30 m from where the vents were concentrated (figure 19). Active vents were aligned along the shoreline. Although the temperature of the lake water was an estimated 30°C (the prevailing air tempera-

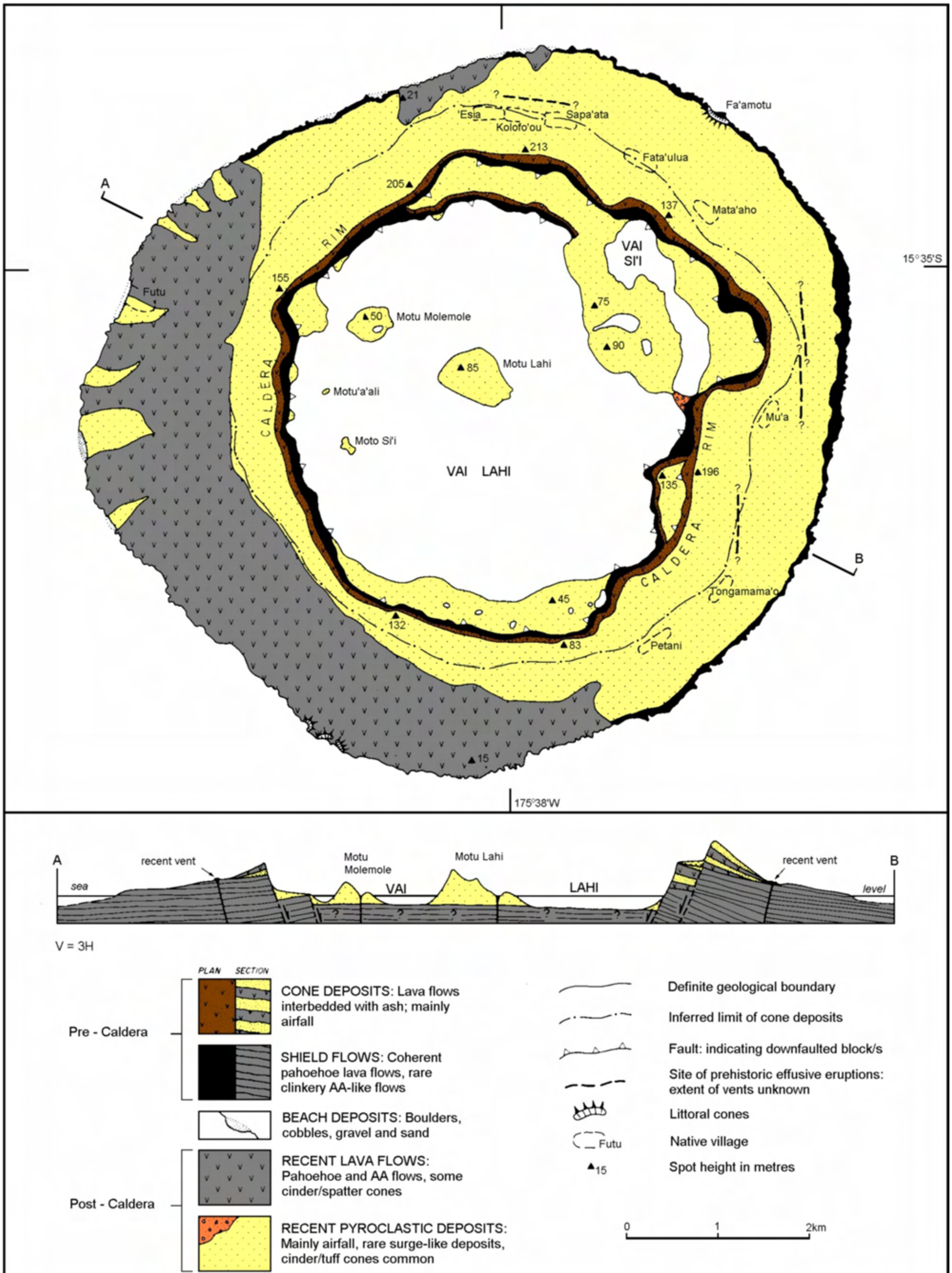

Figure 17. Geological map of Niuafo'ou (after Taylor, 1991) showing the major features of the island. Courtesy of Paul Taylor.

ture), the temperature just below the surface of the sediment around the vents had increased to an estimated 65-75°C.

The vents were producing gas that was bubbling to the surface. A strong sulfur smell was noted, and large deposits of sulfur were present in the mud that comprised the floor of the lake around the vents. The deposits formed three elongated lobes that stretched S from the vents. The lobe-like distribution was probably the result of wind-induced currents. Vegetation along the shoreline was dead and encrusted with white sulfur (?). The observations suggests a net increase in activity at the Vai Si'i site since June 1999.

Conclusions. The observed fumarolic activity on Niuafo'ou indicates that the volcanic system is still active. Although not widespread, the fumarolic manifestations observed during 1999-2002 probably represent a net increase in the activity of the system since the last eruption in 1946. At this stage the level of activity is not of concern, but it should be monitored for signs of increase.

Figure 18. Photograph of Niuafo'ou looking appriximately W across the caldera. Both caldera lakes, Vai Lahi (background) and Vai Si'i (foreground) are visible. Courtesy of Paul Taylor.

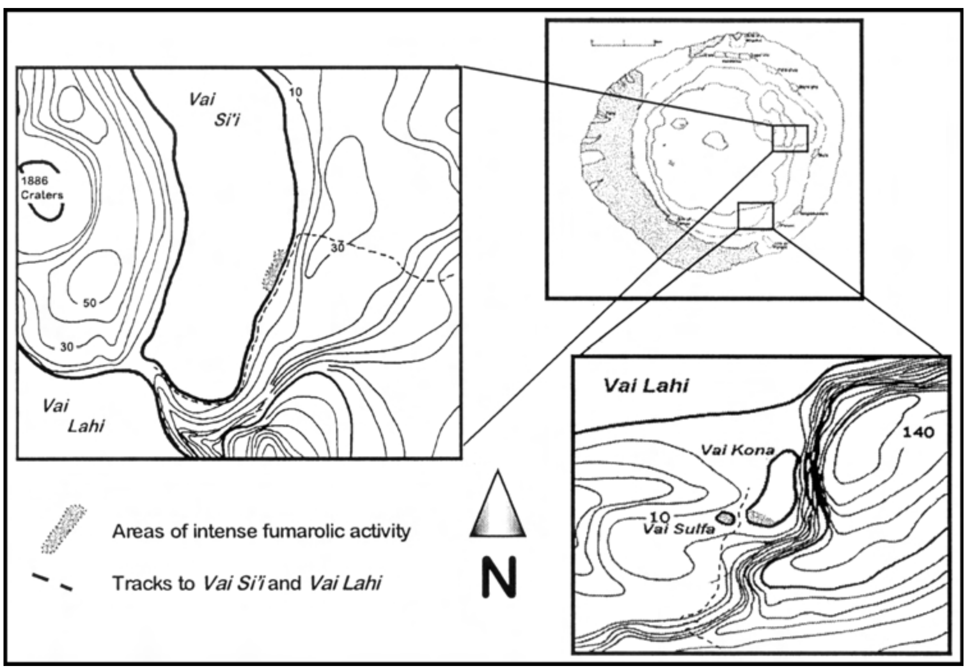

Figure 19. Niuafo'ou Island showing the location of fumarolic activity observed during October 2002. Courtesy of Paul Taylor.

References: Richard, J.J., 1962, Kermadec, Tonga and Samoa: Catalogue of Active Volcanoes of the World, part 13.

Taylor, P.W., 1991, The Geology and Petrology of Niuafo'ou Island, Tonga: Subaerial Volcanism in an Active Back-arc Basin: Unpublished MSc thesis, Macquarie University, AVI Occasional Report, No. 91/01.

Taylor, P.W., 1999, The 1946 Eruption of Niuafo'ou: AVI Occasional Report, No. 99/03.

Background. Niuafo'ou ("Tin Can Island") is a low, 8-km-wide island that forms the summit of a largely submerged shield volcano. The circular island encloses a 5-km-wide caldera that is mostly filled by a lake whose bottom extends to below sea level. The inner walls of the caldera drop sharply to the caldera lake, named Big Lake (or Vai Lahi), which contains several small islands and pyroclastic cones on its NE shore. Historical eruptions, mostly from circumferential fissures on the west-to-south side of the island, have been recorded since 1814 and have often damaged villages on this small ring-shaped island. A major eruption at Niuafo'ou in 1946 forced evacuation of most of its 1200 inhabitants.

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