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2004 Volcanic Activity in Alaska and Kamchatka: Summary of Events and Response of the Alaska Volcano Observatory

by Christina A. Neal, Robert G. McGimsey,
Jim Dixon, and Dmitry Melnikov

Open-File Report 2005-1308

U.S. Department of the Interior
U.S. Geological Survey

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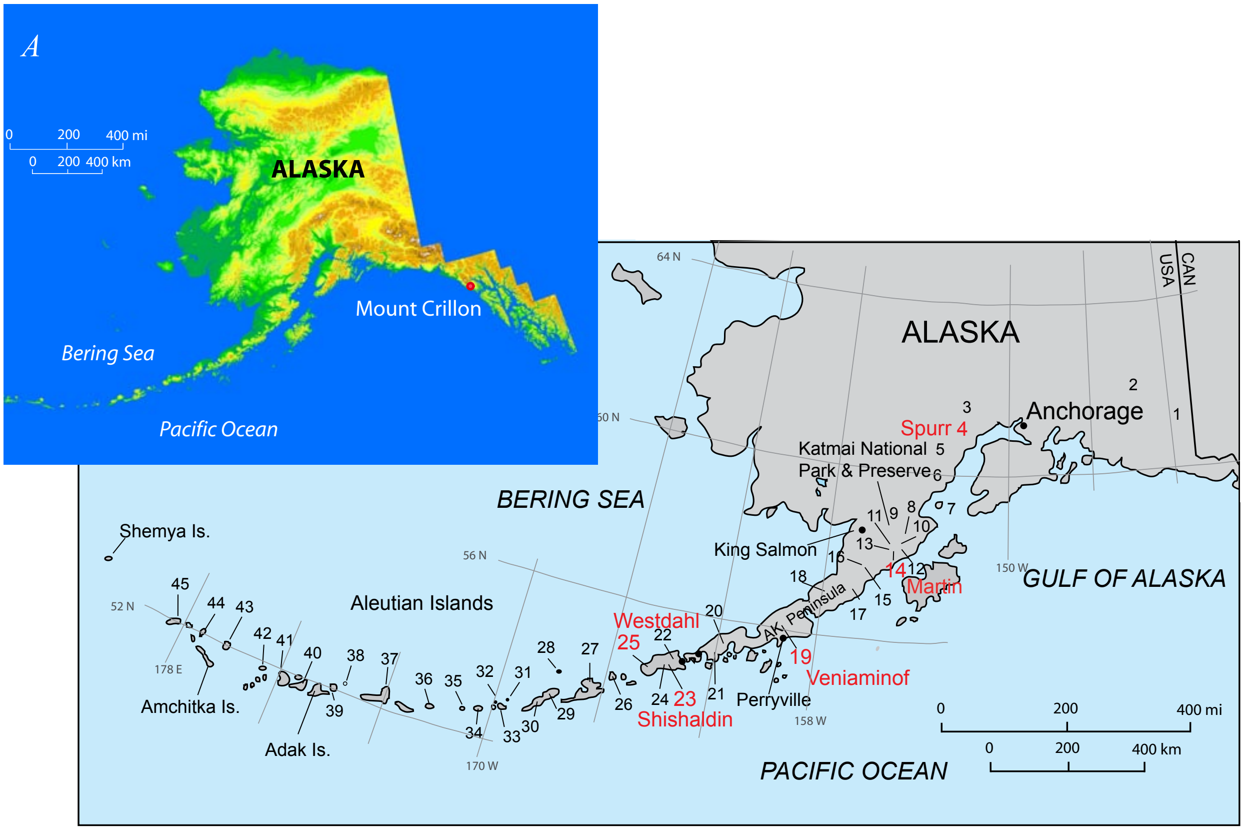
INTRODUCTION

The Alaska Volcano Observatory (AVO) is responsible for monitoring the more than 40 historically active volcanoes of the Aleutian arc (fig. 1). As of December 31, 2004, 27 of these volcanoes are instrumented with seismometers to track earthquake activity, and AVO seismologists have defined a background level of activity for each of these volcanoes (fig. 2; table 1). AVO's routine monitoring program also includes daily analysis of satellite imagery, occasional observational overflights, and compilation of pilot reports and observations of local residents and mariners. Additionally, AVO receives real-time deformation information from permanent Global Positioning System (GPS) stations at four Alaskan volcanoes (Okmok, Augustine, Akutan, and Mount Spurr).

2004 began quietly in Alaska, continuing a trend of little volcanic unrest that has persisted for several years. On January 9, AVO announced the beginning of formal seismic monitoring of Okmok Volcano following an extended period of calibration and improvement of the seismic network installed initially in 2002-2003. Gareloi and Tanaga volcanoes in the western Aleutians were added to the list of seismically monitored volcanoes in early June following determination of background seismicity. During the remainder of the year, AVO responded to volcanic unrest at three volcanoes in Alaska—Mount Spurr, Veniaminof, and Shishaldin (figs. 1, 2; table 2).

As part of a formal agreement between AVO and several scientific institutes in Petropavlovsk-Kamchatsky, Russia, AVO is responsible for disseminating information on behalf of the Kamchatkan Volcanic Eruption Response Team (KVERT; Kirianov and others, 2002). Additionally, a newly established eruption response team, tracking activity in the Kurile Islands of the Russian Far East, is also in the beginning stages of collaborative work with AVO and KVERT to develop warning communication protocols (Rybin and others, 2004). In 2004, AVO assisted in broadcasting alerts about activity at five Russian volcanoes—Sheveluch, Klyuchevskoy, Bezymianny, and Karymsky of the Kamchatka Peninsula, and Chirinkotan in the Kuriles (table 7.).



1. Bona-Churchill
2. Wrangell
3. Hayes
4. Spurr
5. Redoubt
6. Iliamna
7. Augustine
8. Snowy
9. Griggs
10. Katmai
11. Novarupta
12. Trident
13. Mageik
14. Martin
15. Peulik
16. Ukinrek
17. Chiginagak
18. Aniakchak
19. Veniaminof
20. Pavlof
21. Dutton
22. Isanotski
23. Shishaldin
24. Fisher
25. Westdahl
26. Akutan
27. Makushin
28. Bogosloff
29. Okmok
30. Vsevidof
31. Kagamil
32. Carlisle
33. Cleveland
34. Yunaska
35. Amukta
36. Seguam
37. Korovin
38. Kasatochi
39. Great Sitkin
40. Kanaga
41. Tanaga
42. Gareloi
43. Semisopochnoi
44. Little Sitkin
45. Kiska

* Mt. Crillon (see Fig. 1A)

Figure 1. Location of historically active volcanoes in Alaska and place names used in this summary. Volcanoes with no documented, significant, historical unrest but still considered hazardous based on late-Holocene eruptive activity are italicized. Volcanoes mentioned in this report are in red. 1*A*. Inset showing location of Mt. Crillon in southeast Alaska. Base is shaded digital terrain map of Alaska, courtesy Mike Flemming, USGS.

This report summarizes volcanic activity in Alaska, Kamchatka, and the Kuriles in 2004 and describes AVO's operational response. Only activity that resulted in a "significant" investment of staff time and energy (arbitrarily defined as several hours or more for reaction, tracking, and follow-up) is included. Where more extensive published documentation for an episode of unrest exists, we provide full references. In addition to actual eruption or volcanic unrest responses, AVO typically receives dozens of reports of steaming, unusual cloud sightings, or false eruption reports throughout the year. Most of these are resolved quickly and are not tabulated here as part of the response record. On rare occasion, AVO issues an information release to dispel rumors of volcanic activity; an example of this was the Mt. Crillon 'eruption' of June 2004. We use the phrase "suspect volcanic activity" (SVA) to characterize unusual activity that is subsequently determined to be normal or enhanced fumarolic activity, weather-related phenomena, or other non-volcanic event (table 3).

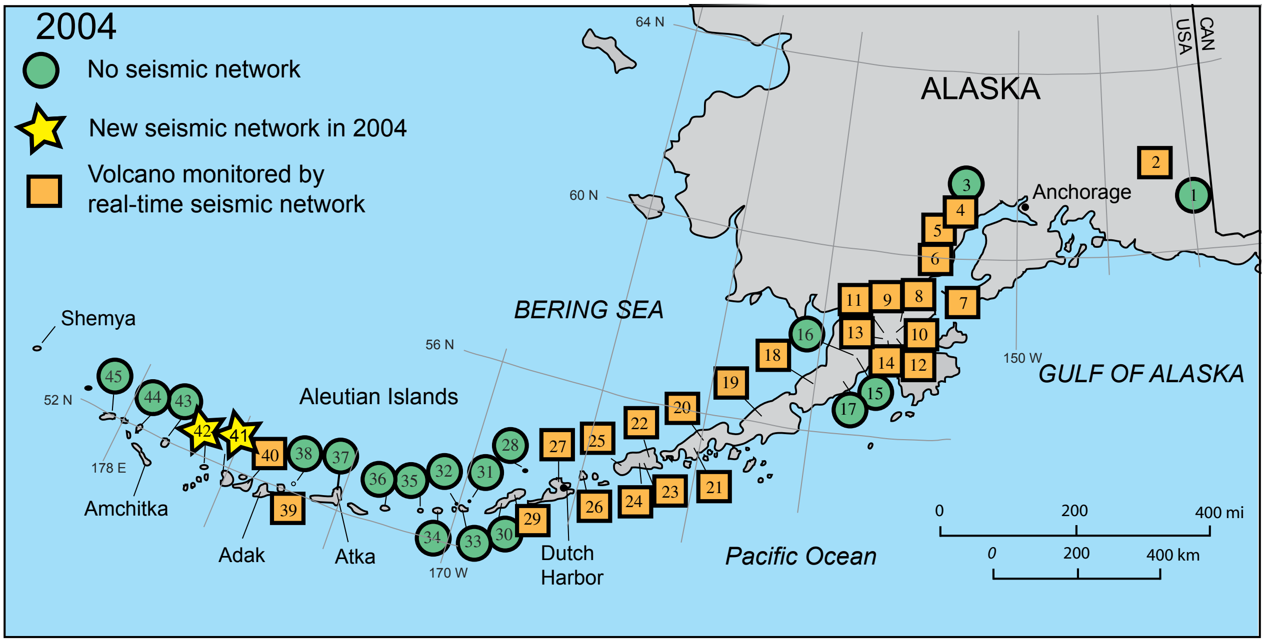


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Figure 2. Map showing seismically monitored Alaskan volcanoes as of December 31, 2004. Volcanoes with no documented, significant, historical unrest but still considered hazardous based on late-Holocene eruptive activity are italicized. Volcanoes mentioned in this report are in red. Note: Begining with this annual summary, we define a “new network” as one that became fully operational and part of AVO’s public, weekly update process. See table 1.

The extent of AVO’s response to volcanic activity in Alaska and the Russian Far East varies depending on the source, observation, and potential impacts. If our detection of unrest is based upon instrumental data (for example, from our seismic networks), evaluation of unrest occurs as rapidly as possible and, if warranted, communication protocols documented in the Alaska Interagency Plan for Volcanic Ash Episodes (Liebersbach and others, 2004) are initiated and monitoring efforts heightened. After receiving a second-hand report of activity at a non-instrumented volcano, AVO usually contacts the National Weather Service (NWS) and Federal Aviation Administration (FAA), our operational partners in Russia, or local residents for corroboration and additional information. For verified, significant eruptive activity or volcanic unrest, an established call-down procedure is initiated to formally notify other government agencies, air carriers, facilities at risk, and the media. A special information release may be distributed if eruptive activity is confirmed. Events are further summarized in the AVO weekly update widely distributed each Friday via electronic mail and facsimile to various government agencies, scientists, airlines, the media, and members of the public. If no eruption or serious unrest is confirmed, a notation is made in internal files.

On June 3, 2004, AVO began issuing daily "Current Status" reports for any Alaskan volcano in an elevated Level of Concern Color Code (for example, YELLOW, ORANGE, RED; tables 4,5). This change was prompted by the needs of other government agencies for daily operational data to inform their staff of changes or the lack of significant change in the status of a hazardous volcano. Status reports are brief and sent by email to our weekly update distribution list and by fax to the NWS Center Weather Service Unit (CWSU) at Anchorage Center as well as to the Anchorage Volcanic Ash Advisory Center (VAAC). Reports are also posted automatically on the AVO public web page: http://www.avo.alaska.edu/activity/report_intro.php. These reports are the responsibility of the AVO Duty Scientist in Anchorage.

For the 2004 summary, we have presented information in geographical order from northeast to southwest along the Aleutian volcanic arc, Kamchatka, and the Kuriles. All elevations reported are above sea level (ASL) unless noted, and time is reported as Alaska Standard Time (AST), Alaska Daylight Time (ADT), Kamchatkan Standard Time (KST), or Kamchatkan Daylight Time (KDT). We have chosen to preserve English units of measurements where they reflect the primary observations of distance or elevation such as those commonly received via pilot reports and aviation authorities in the United States. Elsewhere, measurements are presented in metric units with English units in parentheses. Information included here is compiled from AVO weekly updates and special information releases, internal bimonthly reports, AVO email and online logs, the AVO 2004 "Chron book"—an informal chronological collection of daily or weekly staff notes for a particular year—and the Smithsonian Institution Global Volcanism Network Bulletins that are available online: http://www.volcano.si.edu/reports/bulletin/index.cfm.

A note on AVO's definition of "historically active volcanoes".

AVO defines an "active volcano" as a volcanic center that has had a recent eruption or a period of intense seismic or fumarolic activity that is inferred to reflect magma at shallow levels. The "historic" period in Alaska is considered post mid-1700s when written records of volcanic activity were first compiled. We include some volcanoes on our list of 'potentially active' volcanoes that do not exactly fit this criteria because geologic evidence suggests that they have been active within the last few thousand years and as such, although not historically active, they retain a potential for hazardous activity that requires careful monitoring. As our geologic understanding of Alaska's volcanoes improves with additional fieldwork and modern radiometric dating techniques, these lists will undoubtedly evolve.

VOLCANIC ACTIVITY IN ALASKA

NORTHEAST TO SOUTHWEST ALONG ALEUTIAN ARC

MOUNT CRILLON

A non-volcanic peak
58° 40’ N 137° 50’ W
3,872 m (12,700 ft)
Glacier Bay National Park and Preserve

NON-VOLCANIC ACTIVITY
Rock avalanche activity gives rise to ‘ash cloud’ reports.

During the week of June 21, AVO received several reports of small ash clouds rising from the east face of Mount Crillon, a non-volcanic peak in the Fairweather Range of Glacier Bay National Park and Preserve in southeast Alaska (fig. 1*A*). National Park Service (NPS) staff made aerial observations on June 23 and 24 and photographed brown-gray-colored ‘smoke’ emanating from a steep rock face at about 2,590 m (8,500 ft) on the east side of Mount Crillon (fig. 3). Fine particulate material dusted surrounding snowfields and glaciers and a narrow melt water channel, considered unusual for this time of year, meandered on the surface of the glacier below the steep rock face (fig. 4). NPS was concerned that the activity represented increased thermal flux from a previously unknown fumarolic and possibly volcanic source area at Mount Crillon.

Based on NPS photos, AVO concluded that the clouds were the result of a series of rock avalanches during a period of unusually dry, warm weather. Pulverized rock debris from the avalanches was lofted into the sky and produced small particulate clouds. AVO issued a special information release on June 28 to dispel the rumor that a volcano had erupted in southeast Alaska. This is not the first time a rock avalanche in eastern Alaska has prompted concern about volcanic activity. In 1990, a large avalanche from Mt. Foresta on the Alaska-Canada border produced a debris tongue that was mistaken for a lava flow by passing aircraft and a vapor plume that also resembled a volcanic eruption cloud (AVO summer report, June 1-September 30, 1990, p. 36).

Figure 3. Aerial view of the east face of 3,872-m [12,700 ft]-high, non-volcanic Mount Crillon. A brown-gray particulate plume rises from an avalanche chute. Photo courtesy National Park Service June 24, 2004.

Figure 4. Distant aerial view of Mount Crillon and dusty plume. The faint darkening of the glacier in the middle ground shows possible particulate fallout from the plume. The meltwater channel on the surface of the glacier was considered unusual by NPS observers. Photo courtesy National Park Service June 24, 2004.

MOUNT SPURR VOLCANO

CAVW# 1103-04 [CAVW is the Smithsonian Institution Global Volcanism Program identifier from their Catalog of Active Volcanoes of the World]

61° 18' N 152° 15' W

3,374 m (11,070 ft)

MAGMATIC INTRUSION (?)

Increased seismicity, gas and heat flux at the summit of Mount Spurr and Crater Peak; melting of the summit ice cap but no eruption.

Mount Spurr is a 3,374-m-high (11,070 ft) ice- and snow-covered stratovolcano located 125 km (80 mi) west of Anchorage. Explosive historical eruptions occurred in 1953 and 1992 from Crater Peak, a satellite vent 3.5 km (2 mi) south of Spurr's summit (Keith, 1995 and references therein). Each of these eruptive phases produced ash falls on populated areas of south-central Alaska. The summit of Mount Spurr is a largely ice-covered feature interpreted as a lava dome complex (Nye and Turner, 1990); geological studies of Spurr suggest that its last significant eruption was between 5-6,000 years ago (Waythomas and Nye, 2002)

In early July 2004, AVO seismologists noted an increase in volcano-tectonic and long-period earthquake activity beneath the summit of Mount Spurr Volcano (Power, 2004; Power and others, 2004). About the same time, AVO was contacted by a long-time Alaskan pilot who flew near the volcano on July 11 and saw a small steam plume from the approximate 5,500 foot level of the east side of Crater Peak. She also reported an unusual sulfur dioxide odor. Based on this pilot report and the increase in seismicity, AVO launched a fixed-wing observation flight on July 15. Clouds prevented a view of the summit of Spurr, but Crater Peak and the lower south and east flanks of the Spurr summit dome were clear. Crater Peak appeared unchanged from previous views following the 1992 eruption and nothing unusual was noted along any of the glacier margins or termini around Crater Peak. The east flank of the Spurr summit dome, however, was marked by as many as a dozen dark debris flow lobes that emanated primarily from point-sources within the glacial cover (fig. 5; McGimsey and others, 2004).

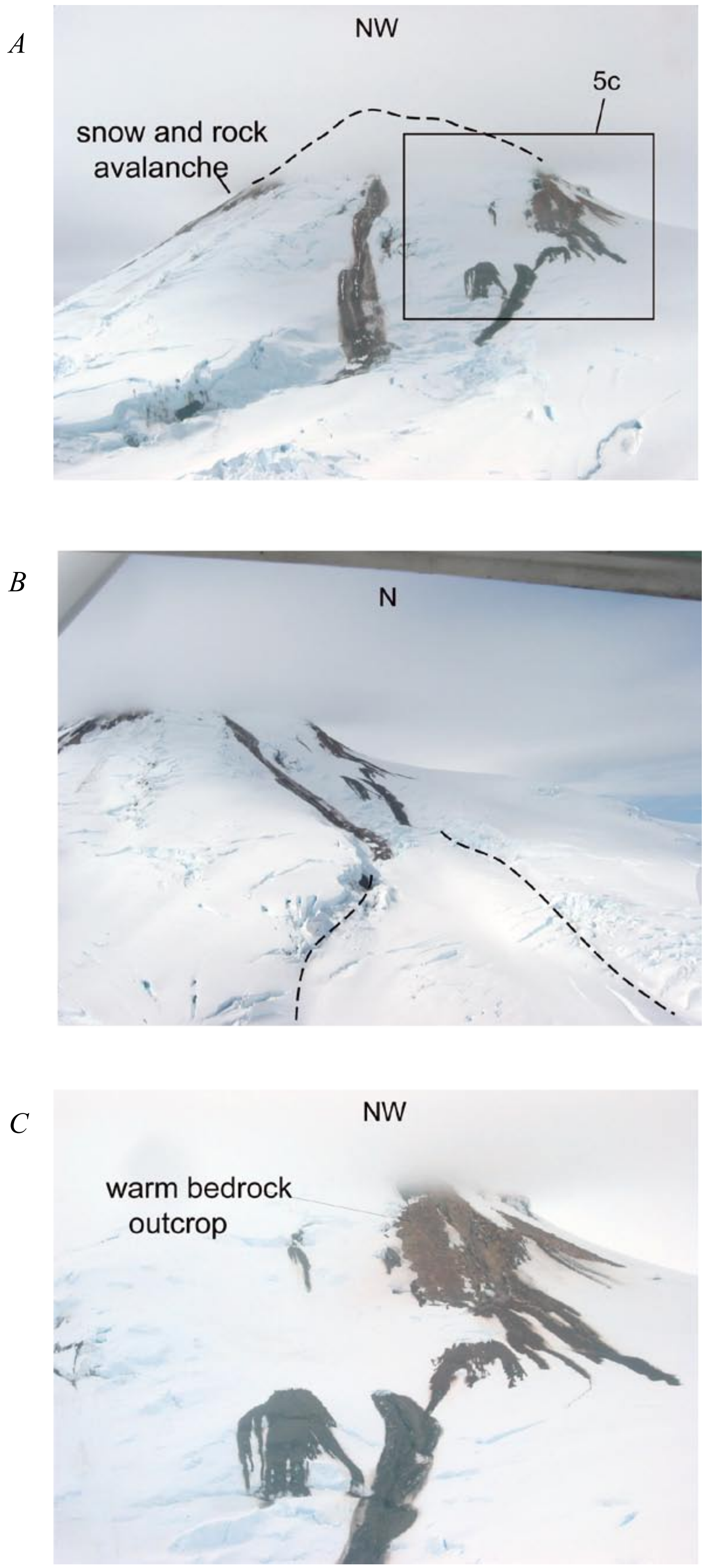

A
NW
5c
snow and rock
avalanche
B
N
C
NW
warm bedrock
outcrop

Figure 5. Debris flows on southeast flank of Spurr summit. Photographs by C. A. Neal, USGS, July 15, 2004. 5*A*. View towards the northwest, highly schematic profile of the cloud-obscured summit of Mount Spurr shown by dotted line. Fingers of dark material emanate from holes and other openings in the glacial ice. Dark area on upper left profile is an area of frequent snow and rock avalanches. 5*B*. View with north at the top showing the funneling of these debris flows into the upper reaches of the ice field that drains into the east arm of the Kidazgeni Glacier (active arm of glacier shown approximately by dashed lines). 5*C*. Close up of area enclosed by box in 5*A*. Dark area at upper right below clouds is an area of bedrock outcrop that contains diffuse boiling point fumaroles. Some debris flows coursed over this steep face. Melt water channels extend beyond the termini of several of the debris flow fingers and a central rill is visible indicating erosive, watery flow.

Increased daily counts of shallow (5-10 km or 3-6 mi below sea level) earthquake activity combined with observations of debris flows from the summit prompted concern about the possibility of volcanic unrest at Spurr. On Monday July 26, AVO elevated the Level of Concern Color Code to YELLOW. A second AVO overflight on August 2 revealed a circular depression in the Spurr summit ice cap, approximately 50-60 m (165-200 ft) in diameter and 25 m (82 ft) deep (figs. 6*A* and *B*). The pit contained an ice-encrusted pond with small areas of open water that were distinctly blue-gray in color (fig. 6*C*). This feature became known as the “ice-cauldron” following usage of the term at ice-covered Icelandic volcanoes.

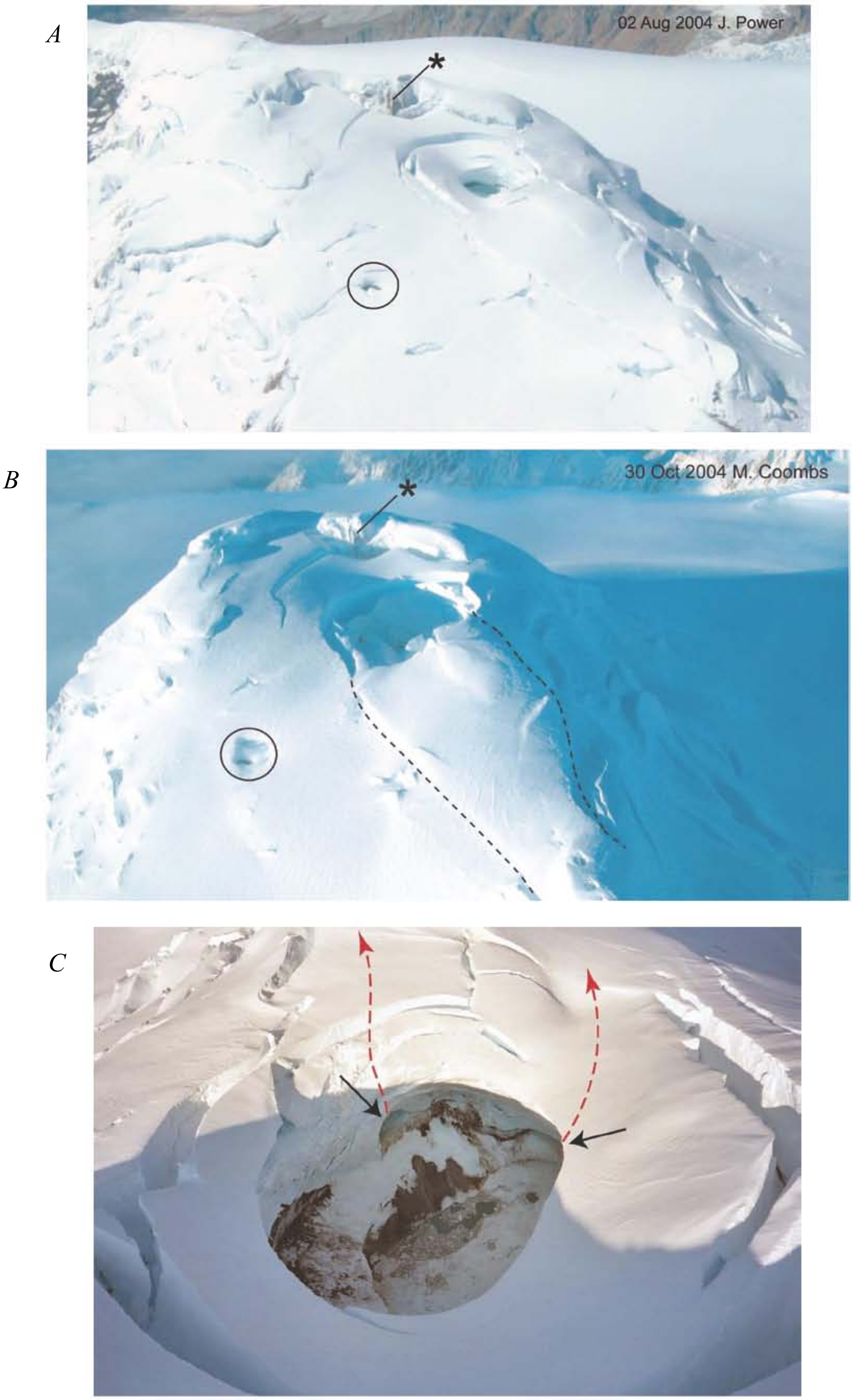

A
02 Aug 2004 J. Power
*
B
30 Oct 2004 M. Coombs
*
C

Figure 6. Oblique photographs of the summit area of Mount Spurr. 6*A*. Image taken on August 2 by J. Power, USGS. Here, the steep walled inner pit is approximately 50-60 m (165-200 ft) across. 6*B*. Image is from October 30 by M. Coombs, USGS, and the inner pit has grown to ~130 x 130 m (430 x 430 ft). Note area of exposed rock in the summit ridge (star) and a prominent, intermittently steaming orifice informally known as "Peter's Puka" (circle) below the summit cauldron. This orifice, first noted by AVO in early September, turns out to be a long-lived feature visible in aerial photography from the 1950s (R. Wessels, oral commun., 2005). Dashed line indicates a keyhole-shaped structure in the snow/ice cap; adjacent areas of ice have subsided relative to this region which lies directly above the warm bedrock face (fig. 5*C*). One possible explanation is that this area is underlain by a ridge of bedrock and hence provides a more stable substrate for the overlying ice sheet. 6*C*. Oblique view, east at the top, into the ~100 m wide summit ice cauldron on August 18, 2004. Photo by D. Eberhart-Phillips, USGS. Dark debris horizons above the lake level are most likely June 1992 tephra-fall deposits from the Crater Peak eruption (Neal and others, 1995a). Note circular ice-free patches in the lake, likely zones of thermal upwelling offshore from the snow-free bedrock outcrop. Cavernous openings (black arrows) are possible stranded outlets for a formerly higher stand of lake water during debris flow emplacement. Red dashed lines indicate possible drainage paths for lake water and debris mixture and are inferred from surface features.

From early August though early December, the summit ice-cauldron gradually enlarged as blocks of ice ringing the depression sagged and then collapsed into the pit (figs. 6*A*, *B*). Careful measurements from images taken on August 10 and October 30 indicate that the pit enlarged from about 65 x 95 m (210 x 310 ft) across to 130 x 130 m (430 ft x 430 ft) across in two months' time (M. Coombs, written commun., 2004; fig. 6). Overflights throughout the late summer and fall documented the changing size of the feature, continuing deformation and collapse of surrounding ice walls, and the variability of open water on the surface of the lake. The lake remained a dark battleship gray color, and circular ice-free zones perhaps 5-10 m (16 x 33 ft) across occurred near bedrock lake shoreline and at several points further from the shore (fig. 6*C*). By early December, the areas of exposed bedrock near the bottom of the cauldron had grown and were occasionally observed steaming. Yellow-tinted snow, ice, and rock outcrops in the vicinity of the lake reflected sulfur deposition near the lake margin.

AVO staff conducted several airborne Forward Looking Infrared Radiometer (FLIR) measurements using both a hand held and helicopter-mounted camera and video system. FLIR data confirmed the presence of at least two prominent areas of warm bedrock—with temperatures as high as ~39° C or 102° F—on the margins of the lake (fig. 7*A*) and on the outer flanks of the summit dome (fig. 5*C*). Lake surface temperatures as measured by FLIR ranged from -10° to 0° C (14° to 32° F) for areas of floating ice and snow debris as well as open water (fig. 7*B*).

AVO also gathered an extensive library of satellite imagery of the Spurr edifice and increased satellite analysis frequency using the standard AVO monitoring imagery (Geostationary Operational Environmental Satellites [GOES], Advanced Very High Resolution Radiometer [AVHRR]) and higher resolution imagery (Advanced Spaceborne Thermal Emission and Reflection Radiometer [ASTER], Moderate Resolution Imaging Spectroradiometer [MODIS]). ASTER imagery showed the first signs of a summit thermal anomaly in nighttime thermal infrared data on August 17, 2004; as the summit lake grew in size, the intensity of the ASTER thermal infrared anomaly increased (R. Wessels, oral commun., 2005).

A

B

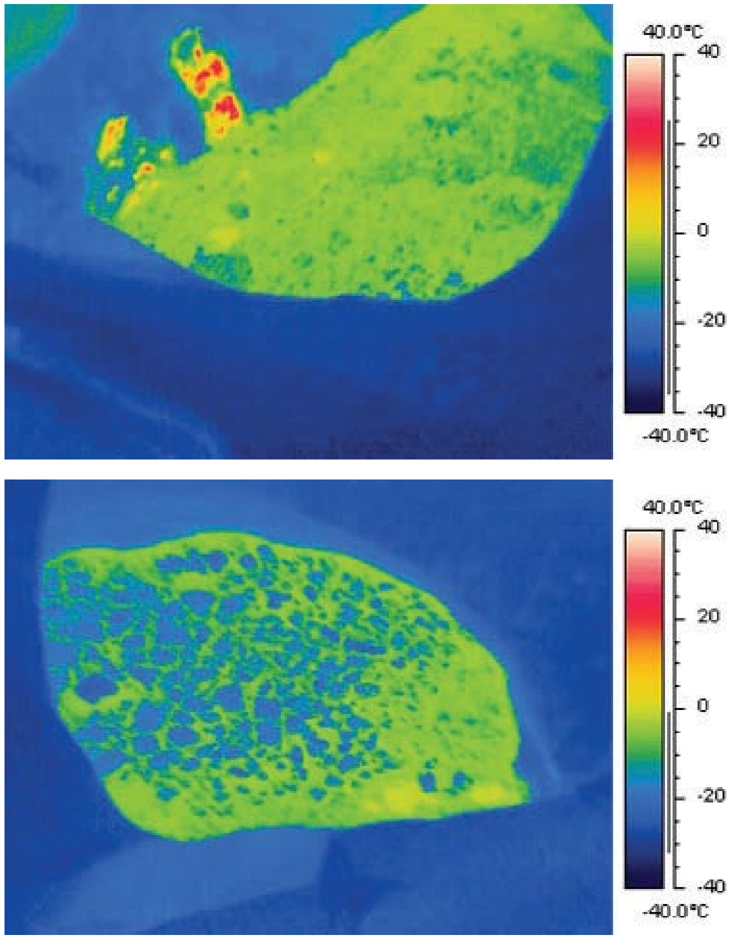


Figure 7*A*. Helicopter-mounted FLIR image of the summit ice cauldron lake on September 24, 2004. Lake surface is approximately 125 m (410 ft) across. Area of highest temperature (~39° C or ~102° F) occurs in bedrock outcrop above the east (left) shoreline of the lake. Figure 7*B*. FLIR image of the surface of the cauldron lake on September 24, 2004. Rafted ice blocks give rise to the mottled appearance of the lake surface. Warmest areas just above 0° C (32° F) in lower right are near the base of the bedrock outcrop and warmest region of Fig. 7*A*. Images courtesy Dave Schneider, USGS.

Five fixed-wing gas measurement flights of the Mount Spurr plume were conducted between early August and the end of October. Emission-rate measurements of SO_2, H_2S, and CO_2 gas were made during each of these flights following protocols developed by the USGS (Gerlach and others, 1997; Gerlach and others, 1999; McGee and others, 2001). Preliminary results show that CO_2 degassing from the summit of Mount Spurr increased from 600 tonnes/day (t/d) in August to 1,300 t/d in September and finally to 1,400 t/d in October. At Crater Peak, CO_2 emission rates were 160 t/d, 1,000 t/d and 120 t/d for the same measurement periods. Very small amounts of H_2S (≤3 t/d) were consistently measured on all of the flights at both degassing locations while no SO_2 was detected at all.

Crater Peak has consistently degassed a small amount of CO_2 since 1994 that, except for an anomalously higher value in 1997, is typically <200 t/d (Doukas, 1995; M. Doukas, pers. commun., 2004). Carbon dioxide degassing from the summit of Mount Spurr had previously not been detected, although airborne measurements directed specifically at the summit have been rare. The absence of SO_2 throughout this period is likely caused by the extremely wet environment at this glacier-clad volcano, where abundant groundwater dissolves SO_2 (Doukas and Gerlach, 1995). This scrubbing process would also be greatly enhanced by the presence of the lake at the summit, and the distinctive battleship gray color of this lake might be partly due to dissolved sulfur compounds. The low but positive values for H_2S can reflect the release of H_2S from a boiling hydrothermal system (Symonds and others, 2001). This is consistent with historical reports of pressurized fumaroles described by climbers in the summit region and the presence of diffuse boiling-point fumaroles on outcrops of bedrock on the east side of the Mount Spurr summit dome (fig. 5*C*; Turner and Wescott, 1986; C.J. Nye written commun., 2004).

Seismicity at Mount Spurr remained consistently above the pre-July 2004 background level for the remainder of the year, although daily rates of seismicity varied considerably from several to several tens of volcano-tectonic (VT) events per day (fig. 8). The largest tally of identifiable earthquakes in one day was 80 on October 26. Particularly energetic swarms of VT earthquakes located within 20 km (12 mi) of Mount Spurr occurred on October 26 (6.6 earthquakes per hour), November 4 (5.8 earthquakes per hour), August 14 (2.6 earthquakes per hour), and August 21 (1.8 earthquakes per hour). Throughout the unrest in 2004, VT seismicity was concentrated within 5 km (3 mi) of the Mount Spurr summit, in stark contrast to the pre-1992 seismicity (Power, 2004; Power and others, 2004). Located long-period (LP) events occurred at an average depth of approximately 7 km (4 mi) and at variable rates, peaking in November. Deep earthquakes (> 20 km or 12 mi) were located beneath and south of Crater Peak in the same area as the deep seismicity associated with the end of the 1992 eruption of Crater Peak.

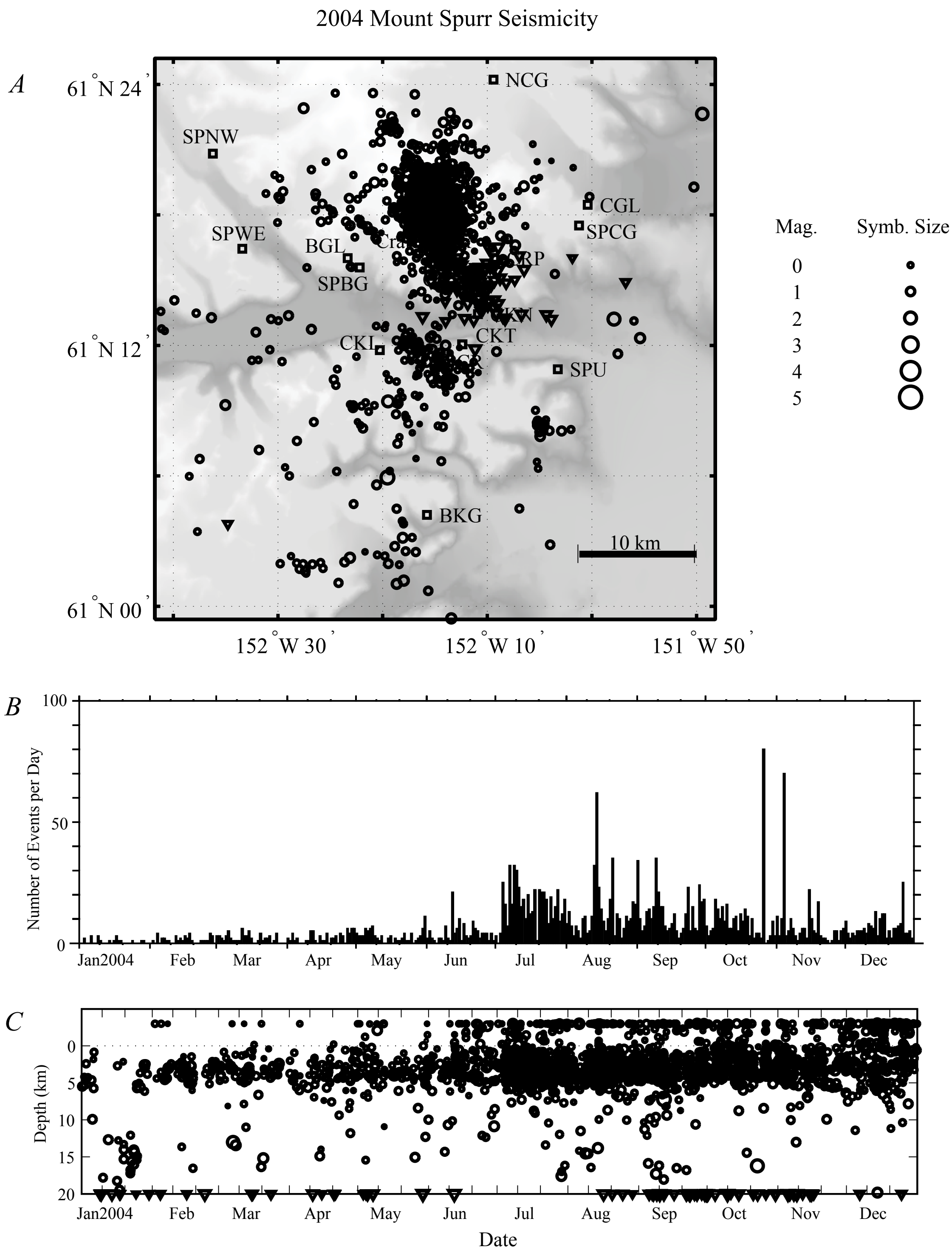


Figure 8*A*. Epicenters for located earthquakes in the vicinity of Mount Spurr Volcano during 2004. Inverted triangles indicate earthquakes deeper than 40 km (25 mi). Seismic stations indicated by open squares. 8*B*. Time series of located earthquakes per day in the vicinity of Mount Spurr during 2004. Note significant increase in early July. 8*C*. Hypocenters for located 2004 earthquakes from Mount Spurr indicating strong concentration of seismicity in the 0-5 km (0-3 mi) below sea level depth range. Figure courtesy J. Power, USGS.

Although no eruptive activity ensued in 2004, AVO did experience an eruption response drill. A pilot report of possible ash from Mount Spurr on August 12, followed by a public ash fall advisory issued by the NWS, prompted a daylong flurry of calls, inquiries, and media attention. AVO issued a special Information Release stating that no eruption had occurred. This event—certainly not the first or last of its kind in AVO history—underscored the level of public concern regarding the situation at Mount Spurr and likely reflected a fresh memory of ash fall in 1992. The drill also facilitated review and improvement of communication protocols between AVO and its partner in ash warnings, the National Weather Service.

How unusual is this drastic change in the summit morphology at Mount Spurr? To our knowledge, this is the first documented episode of significant geothermal heating and generation of a substantial lake at the summit, as well as the first known occurrence of watery debris flows from the summit. Historical reports and aerial photographs from the 1950s, 60's and 70's, however, document significant variability in the snow and ice cover at the Mount Spurr summit. During periods of lower-snow levels, a crater-like structure becomes visible. This feature was described in March and others (1997) as a ~200 to 300 m (650-1,000 ft) diameter feature open to the east-northeast (fig. 9). In this same 1957 aerial photograph, a steep-walled, snow and ice pit, 20-30 m (65-100 ft) wide, is located in the ice cap near the base of the north summit crater wall. No open water can be seen in the bottom of the pit, however, several dark patches occur and could possibly represent warm bedrock.

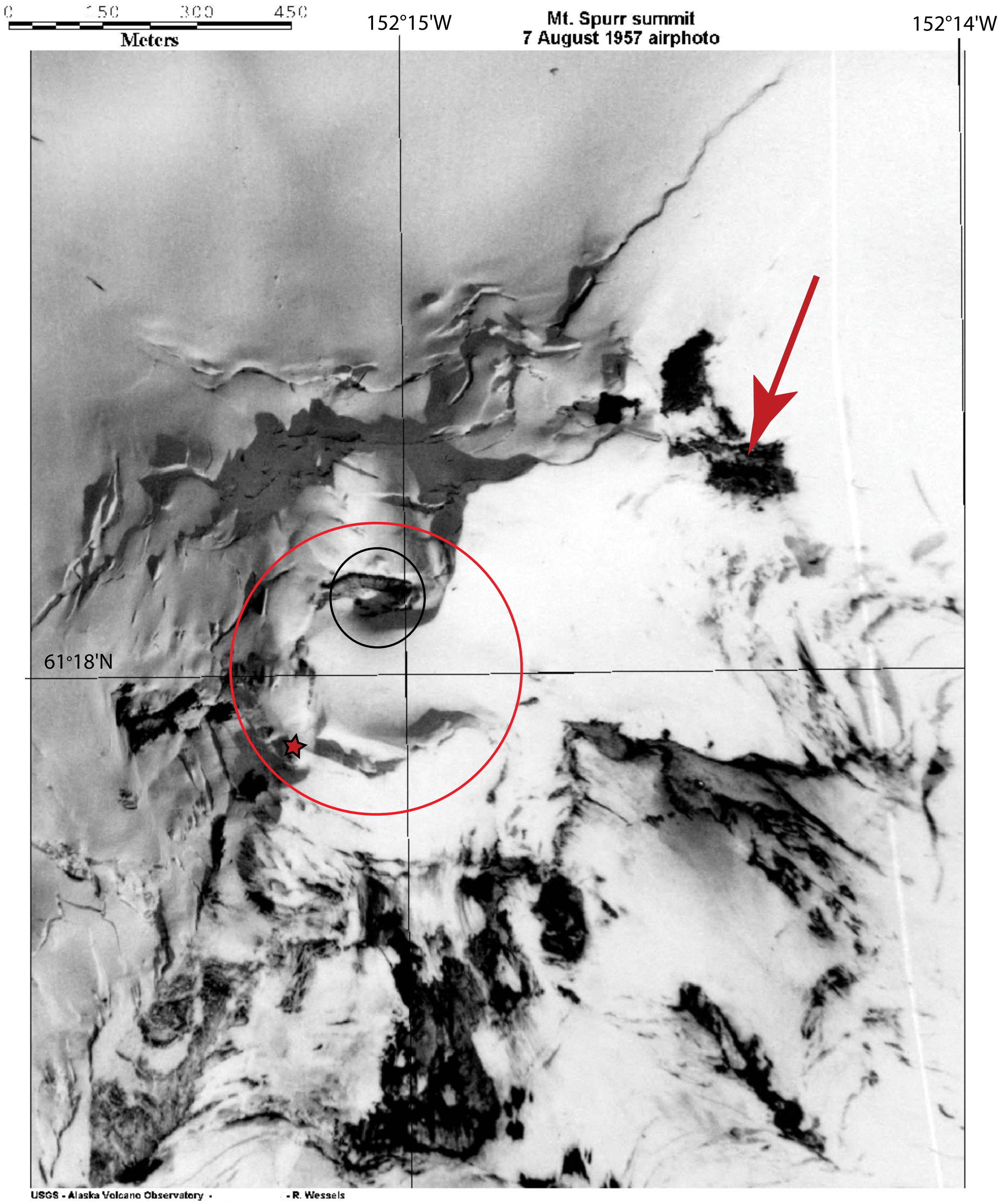


Figure 9. USGS aerial photograph from August 7, 1957. Large red circle encloses a 200 to 300-m-wide (660 to 980 ft) crater-form that indents the summit of Mount Spurr Volcano. The crater is bounded on the west and north by outcrops of volcanic rock and fragmental deposits visible through the snow and ice cover. The eastern sector of the crater rim appears breached. Area of warm bedrock documented in the 1970s (Turner and Westcott, 1986; fig. 5*C*) is marked by red arrow. Black circle encloses a perforation in the summit ice at the base of the north crater wall that may mark the site of long-term melting and water accumulation. Star marks actual topographic summit. Image annotation courtesy Rick Wessels, USGS.

AVO interprets this 2004 period of elevated seismicity and heat flux, summit melting, debris flow generation, and magmatic gas emission from both Spurr and Crater Peak to be the result of new injection of magma to a shallow level beneath the Spurr edifice (Power, 2004; Power and others, 2004). Magmatic gas flux from both Crater Peak and Mount Spurr suggests an open connection to the surface from the zone of intrusion or magma storage along two conduits. An alternative interpretation invokes release of volatiles from the still-cooling intrusions from the 1992 eruption series (Power and others, 1998; 2002).

Mount Spurr remained at Level of Concern Color Code YELLOW through the end of the year. Nearly all information release statements, weekly summaries, and daily status reports emphasized that despite the departure from background activity at Spurr, there were no signs of imminent eruptive activity. As part of this response, AVO mounted a number of observation flights, gas measurement and FLIR imaging flights, increased the frequency of satellite analysis, and installed six new seismometers and 3 permanent, continuous GPS receivers to improve seismic monitoring and track deformation of the volcanic edifice. On October 8, AVO announced the public availability of Internet web camera images of Mount Spurr on the AVO web site (http://www.avo.alaska.edu; fig. 10).

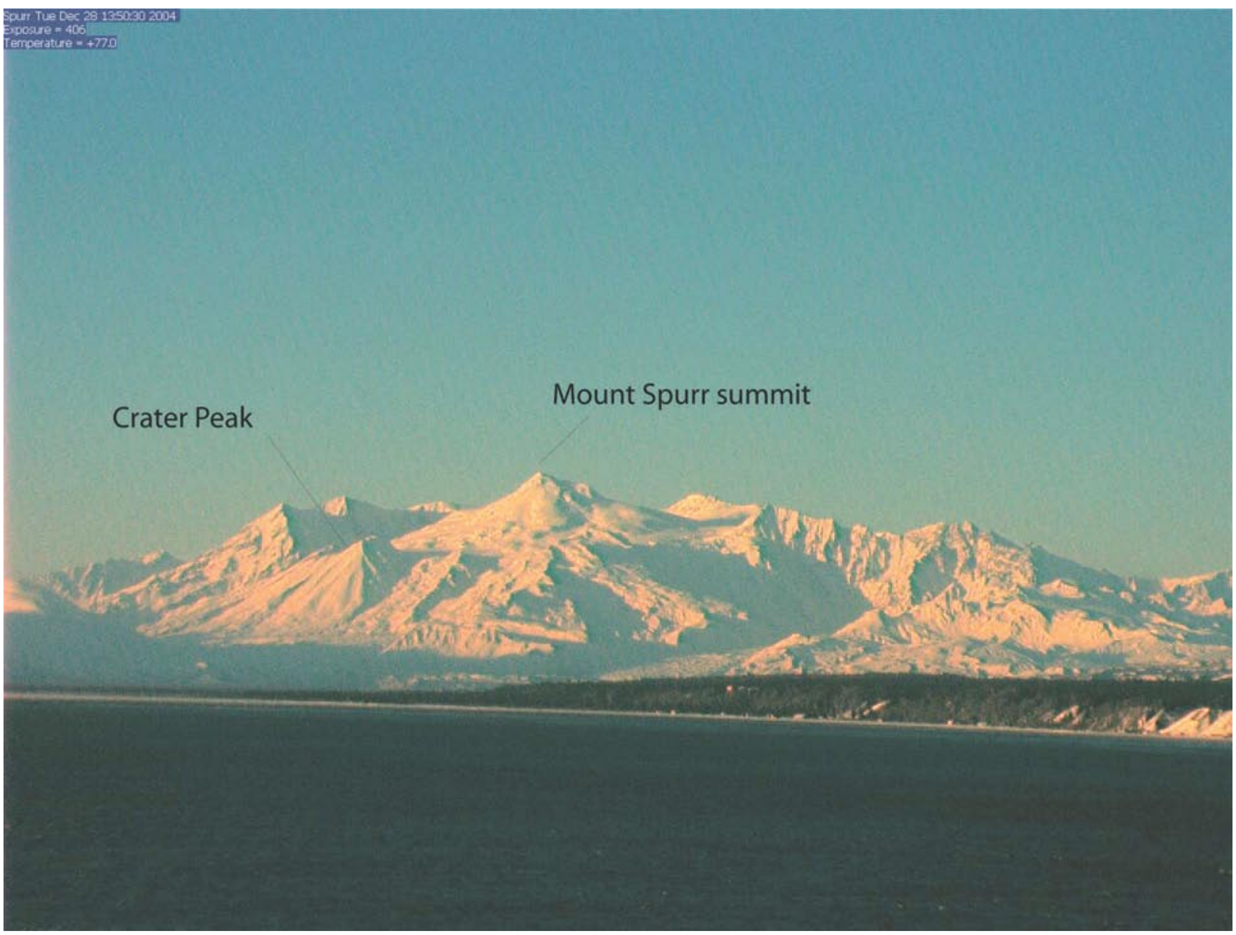


Figure 10. Representative image from the AVO web camera located on UNOCAL Platform Anna in Cook Inlet. View is to the northwest and Mount Spurr is approximately 38 miles (61 km) from the camera. The Spurr summit is the prominent conical peak in the image center. Crater Peak is visible to the lower left on the outer caldera margin. Image date December 28, 2004. AVO gratefully acknowledges the assistance of UNOCAL Corporation who installed and is maintaining this camera.

AVO issued three Information Releases on Mount Spurr activity in 2004 in addition to summarizing the Spurr situation in standard weekly updates on all Alaskan volcanoes. A number of articles appeared in the Anchorage Daily News (Anchorage Daily News 2004a, b). In response to the YELLOW Level of Concern Color Code declaration, NWS issued a one-time Volcanic Ash Advisory (VAAS) and the FAA issued a Notice to Airmen (NOTAM) on July 26 (fig. 11). The NOTAM was cancelled on November 9 (NOTAM 4/2284; B. Brown, FAA, pers. commun., 2005).

VAA issued by Anchorage VAAC

Subject: FVAK20 PANC 262116
FVAK20 PANC 262116
VAAAK0
VOLCANIC ASH ADVISORY - WATCH
ISSUED 2004JUL26/2115Z VAAC: ANCHORAGE
VOLCANO: SPURR 1103-04
LOCATION: N6118W15215
AREA: ALASKA
SUMMIT ELEVATION: 11,070 FT (3,374 M)
ADISORY NUMBER: 2004/01
INFORMATION SOURCE: ALASKA VOLCANO OBSERVATORY
AVIATION COLOR CODE: UPGRADED FROM GREEN TO YELLOW

REMARKS:
AVO HAS IDENTIFIED AN INCREASE IN EARTHQUAKE ACTIVITY BENEATH THE SUMMIT OF MOUNT SPURR VOLCANO LOCATED ABOUT 130 KM (80 MILES) WEST OF ANCHORAGE. THERE ARE NO INDICATIONS THAT AN ERUPTION IS IMMINENT. OFTEN THIS TYPE OF SEISMICITY WILL DECLINE WITHOUT PRODUCING AN ERUPTION. HOWEVER, AN ERUPTION IS STILL POSSIBLE IN THE NEXT FEW WEEKS AND MAY OCCUR WITH LITTLE OR NO WARNING.

NEXT ADVISORY:
NO ADDITIONAL WATCHES WILL BE ISSUED AT THIS TIME.

ERW JUL 04

NOTAM issued by FAA
FDC 4/7470
A) ZAN
B) WIE
C) UFN
E) AK.. SEISMIC ACTIVITY ADVISORY FOR MOUNT SPURR VOLCANO AK. /6118N15215W/. ALASKA VOLCANO OBSERVATORY HAS REPORTED INCREASED SEISMIC ACTIVITY IN THE VICINITY OF MOUNT SPURR VOLCANO, WHICH INDICATES THE POSSIBILITY OF A VOLCANIC ERUPTION. AIRCRAFT SHOULD REMAIN ALERT FOR POSSIBLE ERUPTIONS, STEAM OR ASH CLOUDS AND REPORT ANY SIGHTINGS TO ATC IMMEDIATELY. CONTACT ANCHORAGE ARTCC 907-269-1103 FOR ADDITIONAL INFORMATION.

Figure 11. Volcanic Ash Advisory issued by the Anchorage VAAC and NOTAM issued by the FAA when AVO declared Level of Concern Color Code YELLOW. These formal warning notices to aviation are required as part of the Interagency Operating Plan for Volcanic Ash Episodes in Alaska (Liebersbach and others, 2004).

KATMAI GROUP: Mount Martin

CAVW# 1102-14
58° 10' N 155° 21' W
1,860 m (6,102 ft)

SUSPECT VOLCANIC ACTIVITY
Ground observer report of anomalously large steam plume from Mount Martin

On February 17, AVO received a call from the Bristol Bay Fire Chief Alan Williams who reported a "steam column, all white, rising vertically above mountains to the east (of Naknek, 25 km [16 mi] west of King Salmon; fig. 1)…bigger than normal, and dissipating with altitude." Williams had been a resident of the area for some years and felt this was a much larger a steam plume than was typical for the Katmai group. Williams' photos (fig. 12) show the plume rising from Mount Martin, one of the Katmai Group of volcanoes with a very active and robust fumarolic area near its summit. AVO checked the seismic records for the Katmai area and noted no unusual signals for several hours before or after the time of this sighting.

Fig. 12. Distant view of steam plume (indicated by arrow) from Mount. Martin, one of the Katmai Group volcanoes. Photograph taken on February 17, 2004, used courtesy Alan Williams from Naknek, Alaska.

On October 7, AVO received a pilot report from NWS describing 'a volcano spewing steam and ash' approximately in the location of Martin or Mageik; seismicity was normal and this information was relayed back to NWS who took no further action.

Martin and adjacent volcanic peak Mageik are adjacent, mostly ice-covered stratovolcanoes within Katmai National Park and Preserve on the Alaska Peninsula (fig. 1). Other than fumarolic activity from summit craters, there are no credible reports of historical eruptive activity at either volcano (Fierstein and Hildreth, 2000). Steaming from the 500-meter-wide (1,640 ft) summit crater of Martin is vigorous and nearly continuous, with plumes occasionally rising 600 m (2,000 ft) or more above the vent and extending downwind for up to 20 km (12 mi). Steam plumes rising from the summit crater of Mageik are also common. This activity at both volcanoes results in frequent telephone calls to AVO, and SVAs regarding these two Katmai Group volcanoes appear regularly in the AVO annual summary reports (McGimsey and others, 2005b; Neal and others, 2005; McGimsey and Wallace, 1999; Neal and McGimsey, 1997; McGimsey and Neal 1996; Neal and others, 1995b).

MOUNT VENIAMINOF VOLCANO

CAVW# 1102-07
56° 10' N 159° 23' W
2,507 m (8,225 ft)

WEAK PHREATIC AND STROMBOLIAN ERUPTION
Intermittent, small, ash-poor plumes from the intracaldera cone. Ash fall limited to ice-filled summit caldera

In mid-February, residents of Perryville, located 35 km (22 mi) south of Veniaminof, reported small ash clouds rising several hundred feet above the intracaldera cinder cone of the volcano. At other times, vigorous, ash-free steam plumes were reported. On February 19, AVO received a pilot report of a small black ash cloud rising approximately 300 ft (90 m) above the cone and fresh ash on the snowfield east of the cone (fig. 13). A satellite image from the same day showed a dark deposit within the Veniaminof summit caldera. Seismic activity coincident with these reports was insignificant and AVO considered these small explosions to be typical of background activity at Veniaminof where ground water within the active cone occasionally flashes to steam producing a small explosion. The volcano had last produced such activity over a several month-period in late 2002 and early 2003 (Neal and others, 2005; McGimsey and others, 2005b). On February 23, AVO described this activity in a special Information Release but remained at Level of Concern Color Code GREEN. AVO received no reports of activity over the next two weeks. Satellite imagery did not indicate increased surface temperatures or further ash deposits and seismicity remained low. AVO ceased special mention of Veniaminof in its weekly updates on March 5.

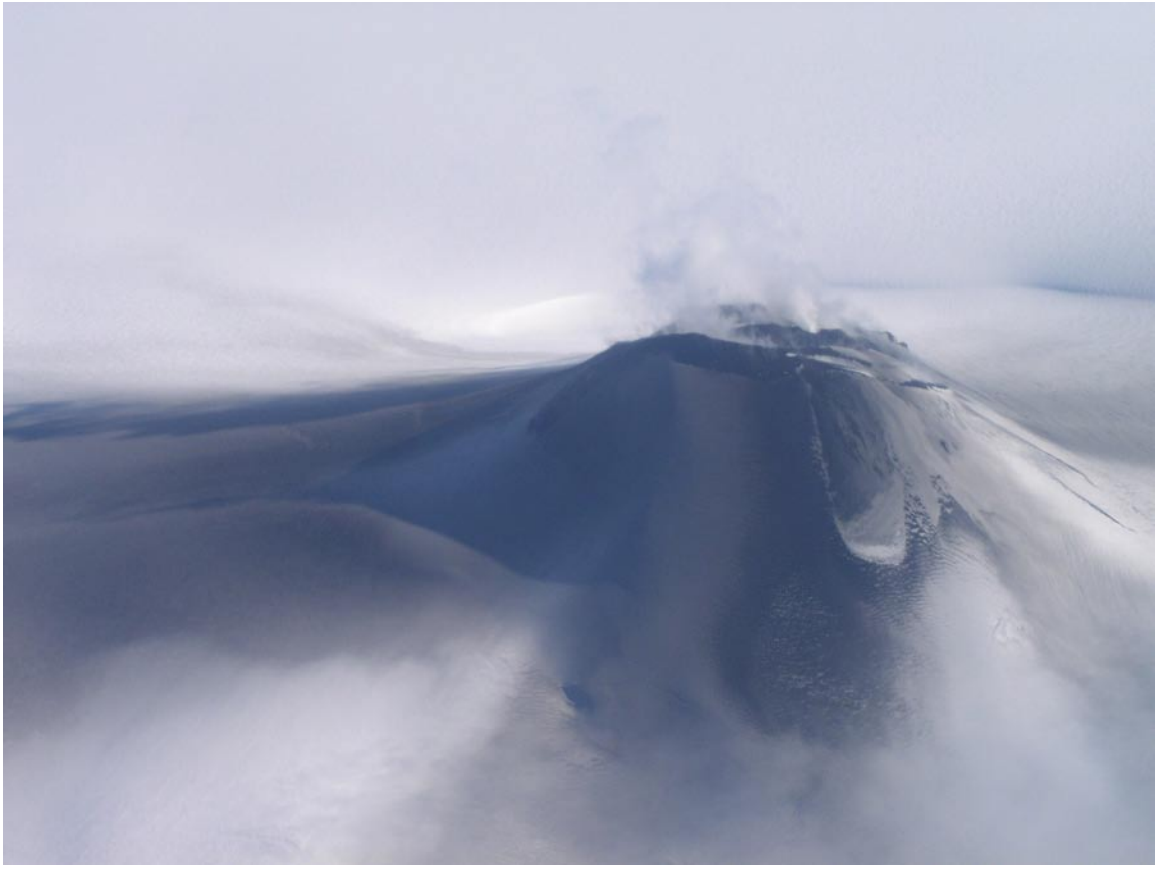


Figure 13. Oblique aerial view of the intracaldera cone of Veniaminof Volcano. The cone is about 330 m (1,080 ft) high and 1.3 km (4,300 ft) across at its base. Dark, discolored area extending to the left of the cone is fallout from earlier ash-rich explosions. Photo courtesy Peninsula Airways taken on February 21, 2004.

In mid-April, seismicity beneath Veniaminof began to increase and several episodes of volcanic tremor and isolated volcano-tectonic earthquakes were recorded. Tremor pulses were several minutes in duration and the largest were recorded on most stations in the network. On April 19, residents of Perryville reported a steam emission from the intracaldera cone that had occurred on April 18, possibly containing a small amount of ash. This burst rose an estimated 2,000 ft (610 m) above the intracaldera cone. Based on this renewed activity and elevated seismicity, AVO elevated the Level of Concern Color Code for Mount Veniaminof to YELLOW. NWS issued a VAA and the FAA issued a temporary flight restriction from the surface to 14,000 ft ASL (4,270 m) within a 10 nautical mile (18.5 km) radius of the center of the volcano.

Over the next few weeks, Perryville residents reported vigorous steam plumes (often described as mushroom-shaped clouds) over the intracaldera cone. AVO received few reports of small ash emissions until April 25 when, using a newly installed remote video camera, as many as 25 small steam and ash emissions were observed over an 8-hour period, most rising about 2,000 ft (610 m) above the active cone (fig. 14).

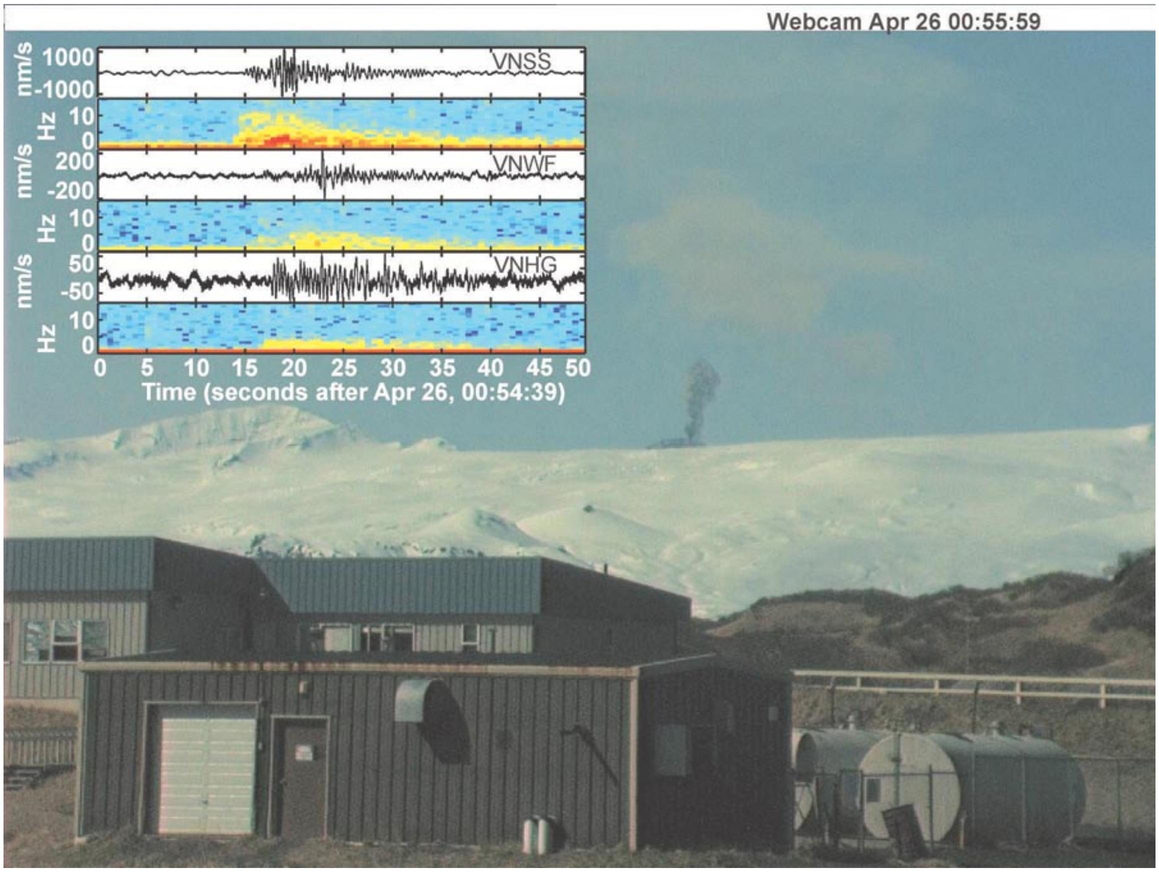


Figure 14. AVO web camera image of a small ash burst rising roughly 2,000 ft above the summit cone (cone is just visible in this image as a dark lenticular shape at the base of the ash column). Perryville buildings in the foreground. In the upper left is a portrayal of the time-correlative frequency content of the seismic signals at three Veniaminof network stations, VNSS, VNWF, and VNHG. The small explosion onset is marked by the sudden change in amplitude and frequency content (seismic data courtesy John Sanchez.) Date and time of image and seismogram—April 26, 2004, 0055:59 UTC.

Through the remainder of spring and into summer, passing pilots, Perryville residents, personnel at Wildman Lake Lodge, and the AVO internet camera continued to record occasional steam plumes and steam and ash bursts, at times reaching as much as 915 m (3,000 ft) above the intracaldera cone and drifting as far as 16-32 km (10-20 mi). Poor weather obscured views of the volcano on many days, however bursts of tremor recorded on the seismic network likely reflected the continuation of small ash emissions, or ‘puffs’. On May 5, a pilot spotted ash to 610 m (2,000 ft) above the cone and drifting east-southeast; on May 18, a pilot reported ash up to 3,000 ft (915 m) above the cone and drifting 32 km (20 mi) downwind. On May 26, satellite images of the volcano showed ash deposits on the north and southeast caldera floor.

Aerial views on June 27 revealed that much of the caldera floor was covered by a thin, dark layer of ash. On July 10, an AVO crew flying inside the caldera on a clear, calm day witnessed one of these ash bursts and captured it on video. As the helicopter approached the cone, only a faint wisp of steam and volcanic gas emerged from the summit of the intracaldera cone that consists of a series of coalescing craters each several 10s to 100 m wide. Suddenly, two closely spaced (20-30 seconds apart) vigorous explosions of gray-tan ash emerged from one of the central craters. The discrete puffs were followed by at least 2.5 minutes of continuous roiling of ash from the crater. Ash rose several hundred m (700-1,000 ft) above the cone and drifted downwind; ballistics and incandescence are not visible in this video clip. On July 22, an AVO field crew within the Veniaminof caldera witnessed another typical ash burst rising a few hundred ms (less than 1,000 ft) above the summit of the cone (fig. 15). Fallout was largely confined to the area around the base of the cone.

Figure 15. View to the southwest (?) of the 330-m-high (1,080 ft) intracaldera cone of Veniaminof Volcano during a minor ash emission. Here, the ash is rising perhaps 150 m (500 ft) above the cone. A very faint dusting of ash, some likely wind-blown, has discolored the surface of the glacier around the base of the cone. Photo by K. Wallace, USGS, July 22, 2004.

AVO geologists visited the ice field by helicopter in late July and reported a discontinuous, 1- to 2-mm thick ash blanket. They observed no large bombs or ballistics beyond the base of the cone, suggesting that recent ash emissions had not been accompanied by energetic explosions of large rock fragments. Further, they reported no changes in the ice field that would indicate subglacial melting. Additional observations of the cone were made in early August and photographs capture ash-poor puffs rising from one of several summit craters on the cone (figs. 16, 17). On August 7, geologists recorded 6-10 puffs over the course of about 10 minutes of focused observation. They reached about 150 m (500 ft) above the summit of the cone in fairly calm wind conditions.

Figure 16. Ash emissions were observed up-close during geological field studies of Veniaminof Volcano by USGS scientists during summer of 2004. Here, the active vent is but one of several pits or craters in the summit area of the intracaldera cone. The ash emissions are light in color reflecting their fairly low concentration of ash, and they are not very energetic rising only ~100 meters (330 ft) above the surface of the cone. View is towards the northeast from the southwestern caldera rim. Crab Glacier outlet is in the background. Photo by A. Calvert, USGS, August 7, 2004.

Figure 17. View from the caldera rim looking towards the east at the active intracaldera cone of Veniaminof Volcano. In this view, ash fall from repeated small explosions has blanketed the normally white field of ice and snow. Regular 'puffs' of ash and steam are erupting from the intracaldera cone, rising to about 100 m or less (<330 ft) above the cone and drifting north with the wind. These puffs occurred at approximately 5-second intervals over a period of about 15 minutes. Photo by C. R. Bacon, USGS, August 11, 2004.

Steam and ash emissions and correlative tremor bursts continued sporadically through the summer of 2004 but with decreasing frequency and intensity. Cloudy weather precluded any visual observations for much of September and October, however seismic signals continued to record small tremor bursts similar to those correlated with confirmed ash emissions earlier in the year. At times, only weak steaming was visible above the intracaldera cone. The last ash emission with localized ash fall was noted on the web camera images in early September. The pilot of a small aircraft reported 'light to moderate smoke' from Veniaminof on September 13. On October 26, AVO lowered the level of concern color code to GREEN based on a decline in the level of activity and an accompanying decrease in seismicity.

In response to the 2004 unrest at Veniaminof, AVO staff conducted outreach to communities in the vicinity of the volcano and revised existing contact phone lists of observers and others in the area. To track and document activity, a web-camera system was installed in Perryville in April (with assistance from the Perryville School and Perryville Village Council, gratefully acknowledged.) These images along with other graphical and text information were made available to the public via the AVO web site. AVO issued seven special Information Releases on the activity at Veniaminof.

Veniaminof is an andesitic stratovolcano with an ice-filled, 10-km diameter (6 mi) summit caldera located on the Alaska Peninsula, 775 km (480 mi) southwest of Anchorage and 35 km (22 mi) north of Perryville (fig. 1). Veniaminof is one of the largest and most active volcanoes in the Aleutian Arc and has erupted at least 12 times in the past 200 years (Miller and others 1998). Low-level and phreatic (?) ash explosions from the intracaldera cone occurred in 2002 (Neal and others, 2005; McGimsey and others, 2005b). The last significant magmatic eruption occurred in 1993-95 from the prominent cinder and spatter cone in the northwest sector of the caldera (Neal and others, 1995b; Neal and others, 1996; McGimsey and Neal, 1996). The 1993-95 eruption was characterized by intermittent, low-level emissions of steam and ash, and production of a small lava flow that melted a pit in the caldera ice field. Previous historical eruptions have produced ash plumes that reached 6,000 m (20,000 ft) ASL and ash fallout that affected areas within about 40 km (25 mi) of the volcano.

SHISHALDIN VOLCANO

CAVW# 1101-36
54°45' N 163°58' W
2,857 m (9,373 ft)

PERIODS OF INCREASED SEISMICITY
Small steam and ash plumes occasionally prompt pilot reports

Since its last eruption in 1999, the background level of seismic activity at this frequently active volcano has remained relatively high and consists of many small, discrete, volcano-tectonic earthquakes, small explosion signals, and short (2-6 min) periods of tremor-like signals. Typically, this activity is interpreted to reflect either hydrothermal or magmatic processes occurring high in the conduit and deep in the summit crater of Shishaldin (Caplan-Auerbach and Petersen, 2005). Reports of ash emission or other eruptive phenomena that may have been related to this seismicity were few. However, on February 17, a Peninsula Airlines pilot noted a hazy ash layer above Shishaldin (R. Hazen, written commun., 2004). On February 20, a pilot report reached AVO describing an ash cloud to 16,000-18,000 ft ASL (4.8-5.5 km) above Shishaldin [note: AVO also received an incorrect pilot observation of ash from Mt. Dutton on February 20; this was later corrected to be Shishaldin.]. AVO seismologists identified no correlative seismicity or anything unusual on associated satellite images. NWS issued a one-time SIGMET based on the pilot report per operational protocols. A similar report from a long-time Cold Bay resident arrived via email on February 26 stating that Shishaldin was emitting steam and ash to 2,000-3,000 ft (600-900 m) above the summit; seismic and satellite data indicated no eruptive activity.

In late April and early May of 2004, seismicity at Shishaldin intensified and volcanic tremor similar to that observed during the eruption in 1999 reappeared. A thermal anomaly over the summit was noted on May 3 in MODIS imagery. Airwaves detected by acoustic pressure sensors suggested a shallowing of the source of this tremor over time (Petersen and others, 2004). In response, AVO raised the Level of Concern Color Code to YELLOW on May 3. On May 16, a pilot reported an ash plume rising 1,000 feet above the summit. Satellite data showed a vigorous steam plume possibly containing a minor amount of ash. Volcanic tremor and small explosions recorded on a pressure sensor continued into the summer and satellite images continued to record an intermittent, weak thermal anomaly into mid-August (S. Smith, written commun., 2005). On July 24, an AVO field crew approached the volcano by helicopter and observed vigorous steaming from the summit crater and recent (?) ash on the upper slopes of the volcano (figs. 18-20).

Figure 18. Aerial view of the west flank of Shishaldin Volcano. A plume of steam and volcanic gas (including SO_2; D. Schneider, oral commun. 2005) issues from its summit crater. Ash, possibly reworked by wind, dusts the surface of ice and snow on the cone. Photograph by D. Schneider, USGS, July 24, 2004.

Figure 19. Aerial view of the summit area of Shishaldin Volcano. View is towards the northeast. Snow-mantled spatter agglutinate, perhaps from the 1999 eruption (Nye and others, 2002) is visible on the upper portion of the cone. Photograph by D. Schneider, USGS, July 24, 2004.

Figure 20. Aerial view the ~200-m-diameter summit crater of Shishaldin Volcano. View is towards the west. Steam and volcanic gas billow out of the crater. Dark lobate area extending down from the rim may be debris remobilized by snowmelt or may reflect a zone of elevated temperature. Photograph by D. Schneider, USGS, July 24, 2004.

Low-level volcanic tremor continued at Shishaldin with little variation from late summer through the end of the year. AVO received at least two additional pilot reports of 'smoke' and 'steam' from Shishaldin, both on September 24. After more than five months at Color Code YELLOW, AVO downgraded Shishaldin to GREEN on October 26 based on the lack of any confirmed ash emission or other eruptive activity. Unlike most other Alaskan volcanoes, Shishaldin appears to have a high level of background seismicity, at least during the period following an eruption sequence (Caplan-Auerbach and Petersen, 2005; Nye and others 2002).

Shishaldin Volcano, located about 1,100 km (~680 mi) southwest of Anchorage, near the center of Unimak Island, is a symmetric stratocone that forms the highest peak in the Aleutian Islands. Largely basaltic in composition, Shishaldin is one of the most active volcanoes in the Aleutian arc with at least 27 eruptions since 1775 (Miller and others, 1998). The most recent eruptive period began in mid-February 1999, and produced a sub-Plinian ash cloud to at least 45,000 ft ASL on April 19, 1999 (Nye and others, 2002). During subsequent strombolian eruptions, ash plumes as high as 6 km (20,000 ft) ASL extended as far as 800 km (500 mi) from the volcano. The last eruptive activity occurred on May 27, 1999, however continued phreatic activity giving rise to intermittent seismicity and significant steam plumes containing minor amounts of ash persists. Even during non-eruptive periods, nearly constant fumarolic activity within the summit crater produces a steam plume that can occasionally be quite vigorous and typically results in numerous false eruption reports. The nearest community is False Pass, 32 km (20 mi) east-northeast of the volcano.

WESTDAHL VOLCANO

CAVW# 1101-34
54°31' N 164°39' W
1,560 m (5,118 ft)

SEISMIC SWARM
90 earthquakes recorded below Westdahl Peak over a 12-hour period

On January 7, 2004, 90 earthquakes occurred over a period of 12 hours beneath Westdahl Volcano on Unimak Island in the eastern Aleutians (fig. 21*A*.) Since the short-period seismic network was installed on this volcano in 1998, the majority of background seismicity has occurred in the vicinity of Faris Peak, a young, intracaldera cone 4 km (2.5 mi) east-northeast of Westdahl Peak (fig. 21*B*.) The 2004 swarm consisted of earthquakes ranging in size from M_L (local or Richter magnitude) = 0.2 to M_L = 1.6. The largest earthquakes (M_L = 1.6) occurred during the second half of the swarm. Depths ranged from sea level to 8 km (5 mi) below sea level. Over the next 10 months, AVO detected several deep, long-period events below the volcano. Given the location of this swarm beneath the general area of the most recent historical eruptions and the subsequent swarm of deep, long-period earthquakes, this seismicity most likely represents a magmatic intrusion. Due to the short duration and abrupt termination of this swarm, AVO did not raise the level of concern color code for Westdahl, nor did AVO mention the activity in its weekly updates.

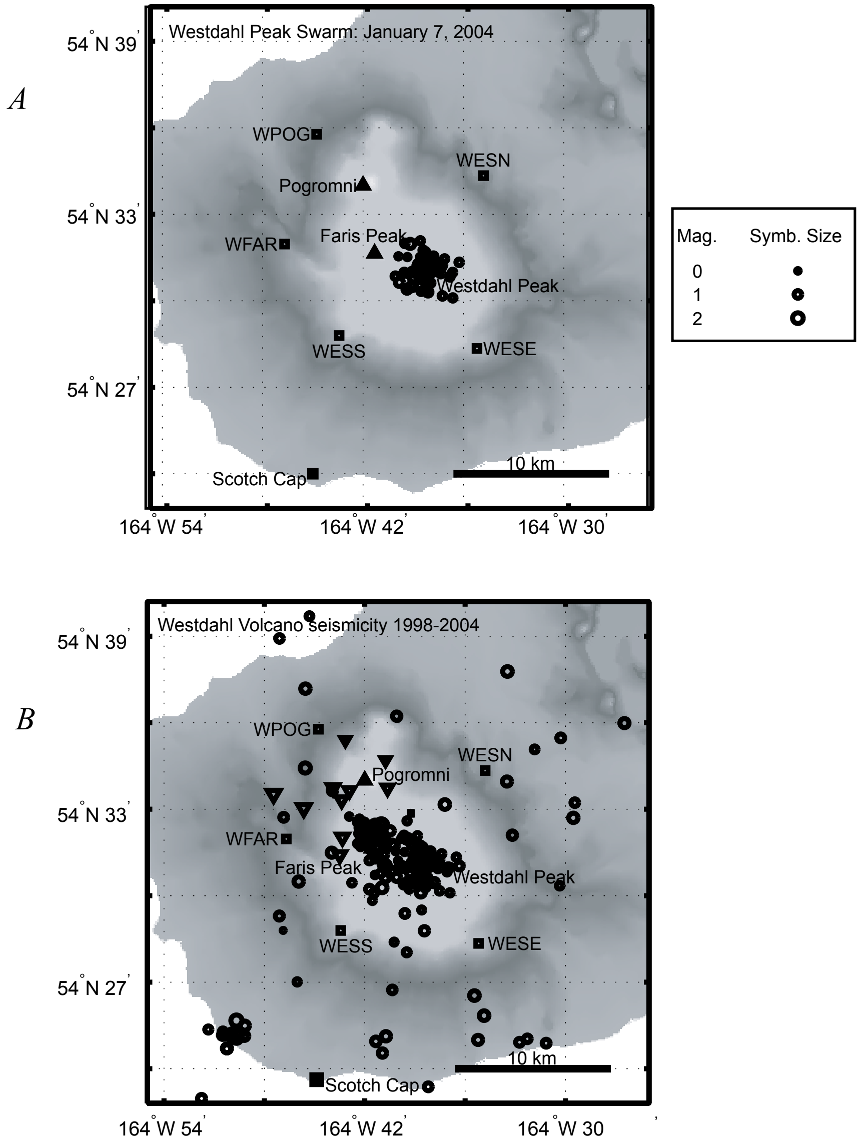


Figure 21. Seismicity at Westdahl Volcano. *A*. Plot of earthquakes epicenters during the swarm of January 7, 2004. Seismic stations are shown by small boxes. Topographic peaks are labeled triangles. *B*. Total seismicity recorded on the AVO seismic network from the time of network installation (1998) through 2004 (includes the period of the January 7, 2004 swarm). Earthquake epicenter symbols are as follows: small circles = earthquakes with depths 0-20 km below sea level; upside down triangles = earthquakes with depths of 20 km or greater. Note that pre-2004 earthquakes were concentrated below Faris Peak. For more information, see Dixon and others, 2005.

Westdahl Volcano is a broad, gently sloping, ice-capped volcano on the west end of Unimak Island. It is inferred that the summit ice cap fills an older caldera structure. Faris and Westdahl Peaks are the youngest of the post-caldera vents within the caldera. Pogromni is a satellitic vent that likely predates caldera formation (Calvert and others, in press.) Most known historical eruptions including the 1991 event have included an explosive phase involving the interaction of lava and ice followed by production of a blocky lava flow (Miller and others, 1998; McGimsey and others, 1995).

VOLCANIC ACTIVITY, KAMCHATKA PENINSULA, and the NORTHERN KURILE ISLANDS, RUSSIA

Active volcanoes on Russia's Kamchatka Peninsula pose a serious threat to aircraft in the North Pacific. Since the mid-1990s, by agreement with the Institute of Volcanic Geology and Geochemistry (IVGG) and the Kamchatka Experimental and Methodical Seismology Department (KEMSD, Geophysical Service), both Institutes of the Russian Academy of Sciences, AVO assists with global distribution of information about eruptions in Russia (Kirianov and others, 2002). In the spring of 2004, a reorganization of Russian scientific Institutes occurred and IVGG became part of the new Institute of Volcanology and Seismology (IVS), also of the Russian Academy of Sciences. The Kamchatkan Volcanic Eruption Response Team (KVERT), now consisting of scientists from IVS and KEMSD, continues to issue via email a weekly information release that is rebroadcast by AVO to hundreds of recipients by facsimile and email and also posted to the AVO web site. When volcanic activity intensifies at any Kamchatkan volcano requiring notification of aviation and other interests, KVERT sends additional updates as needed.

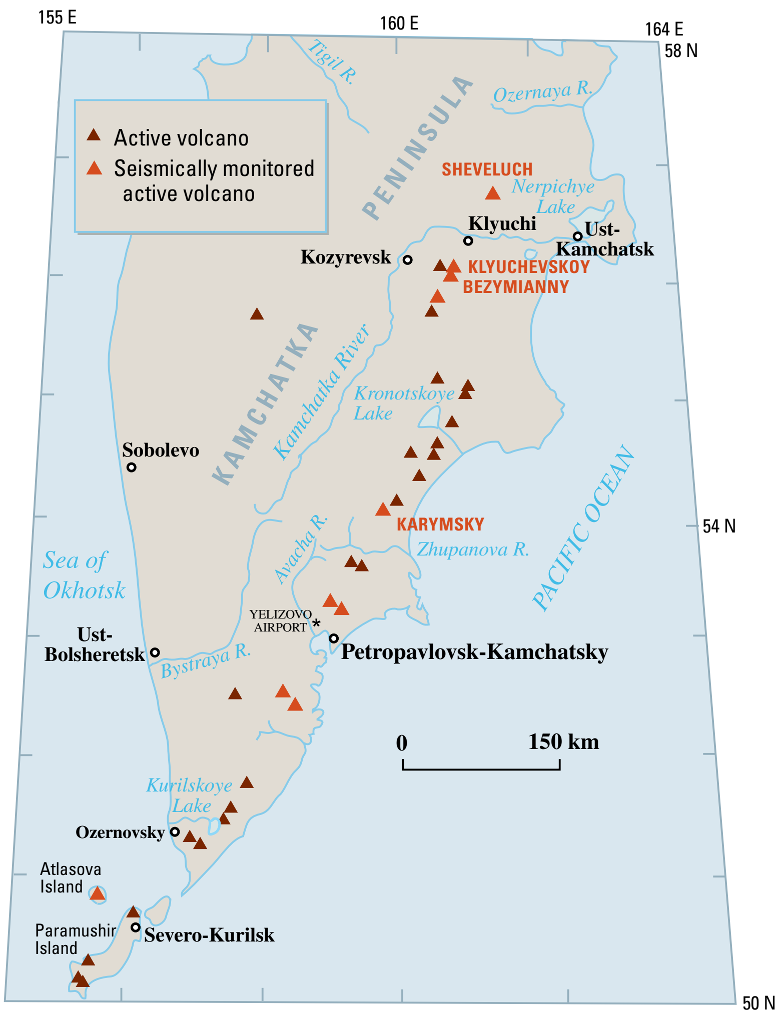


Figure 22. Map of Kamchatka Peninsula and the Northern Kuriles Islands. Volcanoes discussed in this report are labeled with bold red type.

Scientists with the KEMSD monitor most of the frequently active volcanoes in Kamchatka with one or more short period seismometers (fig. 22, table 6). In addition, KVERT and KEMSD receive visual reports of activity from scientific observers in the communities of Klyuchi (pop. ~10,000-15,000, ~46 km [29 mi] south of Sheveluch) and Kozyrevsk (pop. ~2,000-3,000, ~50 km [30 mi] west of Klyuchevskoy) to the north and west of the Klyuchevskaya group of volcanoes (this group consists of active volcanoes Klyuchevskoy, Bezymianny, Plosky Tolbachik, Ushkovsky and inactive volcanoes Kamen, Krestovsky, Sredny, Ostry Tolbachik, Bolshaya Udina, Malaya Udina,Ostraya Zunina, Ovalnaya Zimina, and Gorny Zub; O. Girina written commun., 2004). On occasion, KVERT also receives reports from scientific field parties near Karymsky Volcano, and pilot reports are increasingly available from the local Civil Aviation Meteorological Center at Yelizovo Airport. Near real-time web camera images of Sheveluch, Klyuchevskoy, and Bezymianny volcanoes are also part of the routine monitoring data used by KVERT and AVO.

Since the late 1990s, AVO satellite remote sensing scientists have made available to KVERT and KEMSD selected images of Kamchatka volcanoes as well as AVO internal reports on analysis of these images. Now, KEMSD scientists routinely retrieve and analyze NOAA 16 and 17 images in Petropavlovsk-Kamchatsky through agreement between KEMSD and Federal State Unitary Enterprise "Kamchatkan Center of Communication and Monitoring" that manages a NOAA receiving station. KVERT also receives daily MODIS images from colleagues at the Russian Geological Fund (formerly the Far East Geological Information Center) of the Ministry of Natural Resources in Yuzhno-Sakhalinsk. Although these MODIS images are received as processed JPEG files and cannot be further evaluated for quantitative thermal information, they are useful in delineating some ash cloud features, ash fall deposits, and the presence of thermal anomalies.

In 2004, AVO relayed KVERT information about unrest at four Kamchatkan volcanoes, all of which continued periods of unrest extending over several years (tables 7, 8). For each of these periods of heightened activity, AVO relayed information from KVERT to aviation and weather authorities and hundreds of other recipients through standard notification procedures. In addition, AVO staff communicated directly with KVERT to clarify and verify information and assist users in interpreting data coming from KVERT. In 2004, KVERT began to send informal email alerts of volcanic activity directly to the NWS and Anchorage VAAC. This was an attempt to shorten the timeframe for official notification of significant volcanic activity in Russia.

The following summaries contain reported events according to Kamchatkan local dates and Coordinated Universal Time (UTC), which equals ADT+8 hrs and AST+9 hrs. The equivalent local Kamchatkan time (herein referred to as Kamchatkan Daylight or Standard time) is 21 hours ahead of Alaska Time. This compilation is derived from a number of sources including KVERT weekly updates, unpublished AVO internal files and documentation, Global Volcanism Program Volcanic Activity reports and other information available online http://www.volcano.si.edu/reports/index.cfm).

SHEVELUCH VOLCANO

CAVW# 1000-27
56°38' N 161°21' E
3,283 m (10,768 ft)
Kamchatka Peninsula

LAVA DOME GROWTH CONTINUES.
Repeated ash explosions and/or dome collapse and associated pyroclastic flows, ash plumes, gas plumes, ash falls. Sudden, short-lived explosive ash plume reaches 8 – 11 km (~26,000-36,000 ft) ASL on May 9; significant pyroclastic flow, mudflows, and airport closure in Ust-Kamchatsk

Eruptive activity related to growth of the lava dome at Sheveluch Volcano continued intermittently through 2004. A nearly constant thermal anomaly in AVHRR satellite images (varying in size from 1 to as many as 20 pixels) coincided with the active lava dome inside the summit amphitheater. Seismicity remained above background for nearly the entire year with many weak, shallow earthquakes recorded each day at depths of 0-5 km (0-3 mi) below the volcano and frequent periods of spasmodic volcanic tremor.

The volcano began 2004 at Level of Concern Color Code YELLOW but this was elevated to ORANGE on January 16 following an increase in shallow earthquakes and accompanying explosive collapse of the growing dome that sent ash to 5.5 km (18,000 ft) ASL and produced small pyroclastic flows on the southern debris apron of the volcano. Over subsequent weeks, continued explosions, often several per day, were detected seismically or visually on the KEMSD camera or by observers in Klyuchi. Such events were sudden, short-lived, sent ash as high as 6-10 km (19,700-33,000 ft) ASL and produced small pyroclastic flows (fig. 23).

Figure 23. A small pyroclastic flow descends from the active lava dome at Sheveluch Volcano during a partial collapse event on February 12, 2004. View to the north. Photograph by Y. Demyanchuk, KEMSD.

During times of quiescence, a gas and steam plume, occasionally containing minor amounts of ash, drifted from several tens to as far as several hundred km downwind from the lava dome, sometimes reaching 6-7 km (19,700-22,400 ft) in altitude. These plumes were often clearly visible on satellite images.

A sudden series of explosions on May 9 sent ash to 11 km (36,000 ft) ASL where it drifted to the southeast. Pyroclastic flows traveled as far as 10 km (6 mi) from the volcano and mudflows were also produced (Girina and others, 2004). KVERT announced color code RED following the event but reverted to ORANGE the next day. A light ash fall occurred in Ust-Kamchatsk (fig. 22) where the airport was temporarily closed. Prior to this May 9 eruption, the active lava dome had an estimated volume of 0.3 x 10^6 m^3 and was 520 m (1,700 ft) high with a diameter of 1,350 m (4,430 ft) at its base narrowing to 240-270 m (790-885 ft) near the summit (N. Zharinov and O. Girina, written commun. 2004).

Following this explosion, Sheveluch remained at ORANGE until year's end. Seismicity remained above background and occasional collapse avalanches from the lava dome occurred as effusion continued. On May 21, IVS field crews working in the area noted a small viscous lava flow lobe on the top of the active dome. They estimated that by May 28 the lobe had advanced 100 m (330 ft) down slope; following the collapse of this lobe, another lobe had developed in the same area by late September (fig. 24). Strong winds between October 10 and 12 re-suspended ash from the ground to create an impressive 300 to 400-km (190-250 mi) long plume visible in satellite imagery (fig. 25). This happened again in late November.

Figure 24. Photograph of the active lava dome of Sheveluch Volcano, October 26, 2004. The actively extruding, dark gray lava lobe descending the face of the dome (approximate outline shown by white dashed line) was estimated to cover 1.4 x 10^5 m^2. Photograph by Y. Demyanchuk, KEMSD.

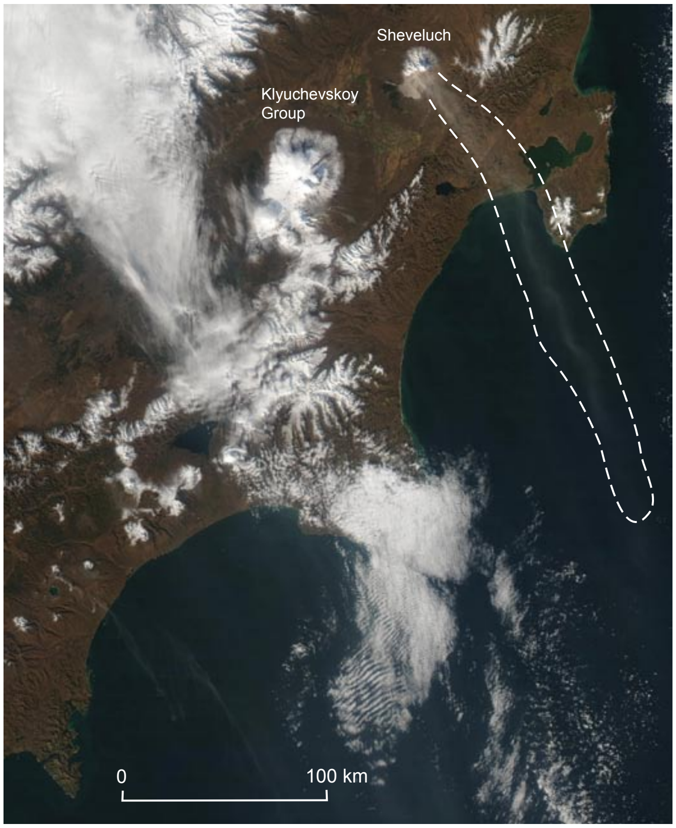


Figure 25. October 12, 2004 (0210 UTC) MODIS Aqua image showing plume of ash (dashed enclosure) caused by high winds and re-suspension of fine-grained tephra from recent eruptions at Sheveluch Volcano. The altitude of the plume is unknown but likely below 5 km (16,400 ft) based on wind models at the time. Note light-colored, fresh pyroclastic flow apron to the southwest of Sheveluch. Snow-covered Klyuchevskaya Group of volcanoes is visible southwest of Sheveluch. Image from the Goddard Space Flight Center courtesy S. Smith, UAFGI.

Sheveluch Volcano is one of the largest and most active volcanoes in Kamchatka with at least 60 large eruptions during the Holocene (Bogoyavlenskaya and others, 1985; Ponomareva and others, 1998). The northernmost active volcano on the Peninsula, historical eruptive activity has been characterized by lava dome growth and explosive collapse, often producing debris avalanches. Its most recent catastrophic collapse event in 1964 formed the modern amphitheater in which the active lava dome is now growing (Zharinov and others, 1995). The current, protracted phase of lava dome growth began in late September of 1980 and continues into 2005.

KLYUCHEVSKOY VOLCANO

CAVW# 1000-26
56°03' N 160°38' E
4,750 m (15,589 ft)
Kamchatka Peninsula, Russia

STROMBOLIAN/VULCANIAN EXPLOSIONS DECLINING THROUGH THE YEAR
Weak strombolian activity through January; declining ash-bearing explosions and weak fumarolic activity through the remainder of the year

Klyuchevskoy Volcano remained restless in early 2004, however, by year's end the Level of Concern Color Code had been downgraded from ORANGE to YELLOW and then to GREEN.

In the first three months of the year, seismicity remained mostly above background. KEMSD reported episodes of continuous to intermittent spasmodic tremor and many (100-200) shallow earthquakes per day within and below the volcano. Explosions that contained ash were observed throughout January and would occasionally reach heights of up to 1 km (3,300 ft) above the summit. Strombolian activity was evident within the summit crater in mid- and late-January and satellite images picked up a corresponding 1- to 7-pixel thermal anomaly over the summit area. On January 25, a gas and steam plume containing minor amounts of ash was detectable 75 km (50 mi) downwind on satellite imagery.

During more quiescent periods, a gas-steam plume emanated from the Klyuchevskoy crater and trailed several to tens of km downwind, occasionally rising several km above the summit (fig. 26). Visible strombolian activity and ash-bearing explosions decreased in frequency through February and on March 5, KVERT lowered the Level of Concern Color Code to YELLOW. In subsequent months, seismicity remained at background levels with occasional periods of tremor. No significant ash plumes or strong thermal anomalies were detected on satellite images. Observers and the KEMSD web camera noted only weak fumarolic activity or steam and gas emissions from the summit crater. Minor ash bearing plumes confined to the immediate vicinity of the volcano were noted on April 8 and September 15. Based on low-level activity over the course of 8.5 months, KVERT lowered the color code to GREEN on November 27, where it remained through year's end.

Figure 26. January 24, 2004 web camera image of Klyuchevskoy Volcano. The 4,750 m (15,589 ft) volcano is producing a vigorous gas plume that rises high above the summit. Image courtesy KEMSD.

Klyuchevskoy is a classic, symmetrical stratovolcano and, at 4,750 m (15,580 ft), it is the highest of the active European and Asian volcanoes. Klyuchevskoy is frequently active with vulcanian to strombolian explosions and occasional lava flow production from the main vent in the steep-walled summit crater or from flank vents (Khrenov and others, 1991). Explosive eruptions are recorded in nearly every decade and at multiple times during most years since the early 1700s (Simkin and Siebert, 1994). Its most recent significant ash-producing eruption was September 30-October 1, 1994.

BEZYMIANNY VOLCANO
CAVW# 1000-25
55°58' N 160°36' E
2,800 m (9,187 ft)
Kamchatka Peninsula, Russia

LAVA DOME GROWTH
Two periods of accelerated lava dome growth and related, short-lived explosions send ash to 8-10 km (26,000-33,000 ft) ASL.

Bezymianny Volcano continued slow, relatively quiet lava dome growth through 2004 punctuated by two significant explosive pulses and accompanying dome collapse. After beginning the year at Level of Concern Color Code GREEN with low levels of seismicity, a strong explosive pulse lasting 3 hours occurred without warning on January 13. Explosive collapse of the lava dome produced an ash column that reached 6-8 km (19,700-26,200 ft) ASL based on video imagery; KVERT immediately declared color code RED. The cloud drifted to the east-northeast and was visible on satellite imagery for the next two days, extending as far as 300 km (190 mi) downwind; no significant impacts on air traffic were reported. An intermittent thermal anomaly was visible over the lava dome for several weeks. A pyroclastic flow accompanying the dome collapse was inferred based on past observations of similar eruptions at Bezymianny. KVERT downgraded the volcano to ORANGE within about 7 hours of the explosive event, and to YELLOW based on declining seismicity on January 17. KVERT did, however, infer that effusion of new lava at the volcano continued, despite its YELLOW status.

Intermittently through the winter and into spring, strong volcanic tremor at neighboring Klyuchevskoy Volcano masked the seismic signal from the single station nearest Bezymianny. Video images often captured a gas and steam plume rising as high as 4.4 km (14,400 ft) ASL and drifting up to tens of km downwind. AVHRR satellite images continued to show a small thermal anomaly several pixels in size in the vicinity of the active lava dome. Based on this information and occasional increases in shallow seismicity, KVERT continued to report that active lava effusion was likely occurring.

Seismicity began to increase slightly in early May and on June 16, KVERT raised the Level of Concern Color Code to ORANGE based on an elevated number of earthquakes and the appearance of weak volcanic tremor. Two days later, the second strong eruptive pulse of 2004 began and sent ash as high as 8-10 km (26,200-33,000 ft) ASL prompting a change to color code RED. This event lasted for 2 hours after which seismicity dropped and KVERT downgraded the volcano to ORANGE. Satellite images showed the ash cloud 200 km (125 mi) downwind in the direction of Bering Island (fig. 27). On June 20, two days after the eruption, the detached ash cloud was visible in the vicinity of Atka Island in the central Aleutians.

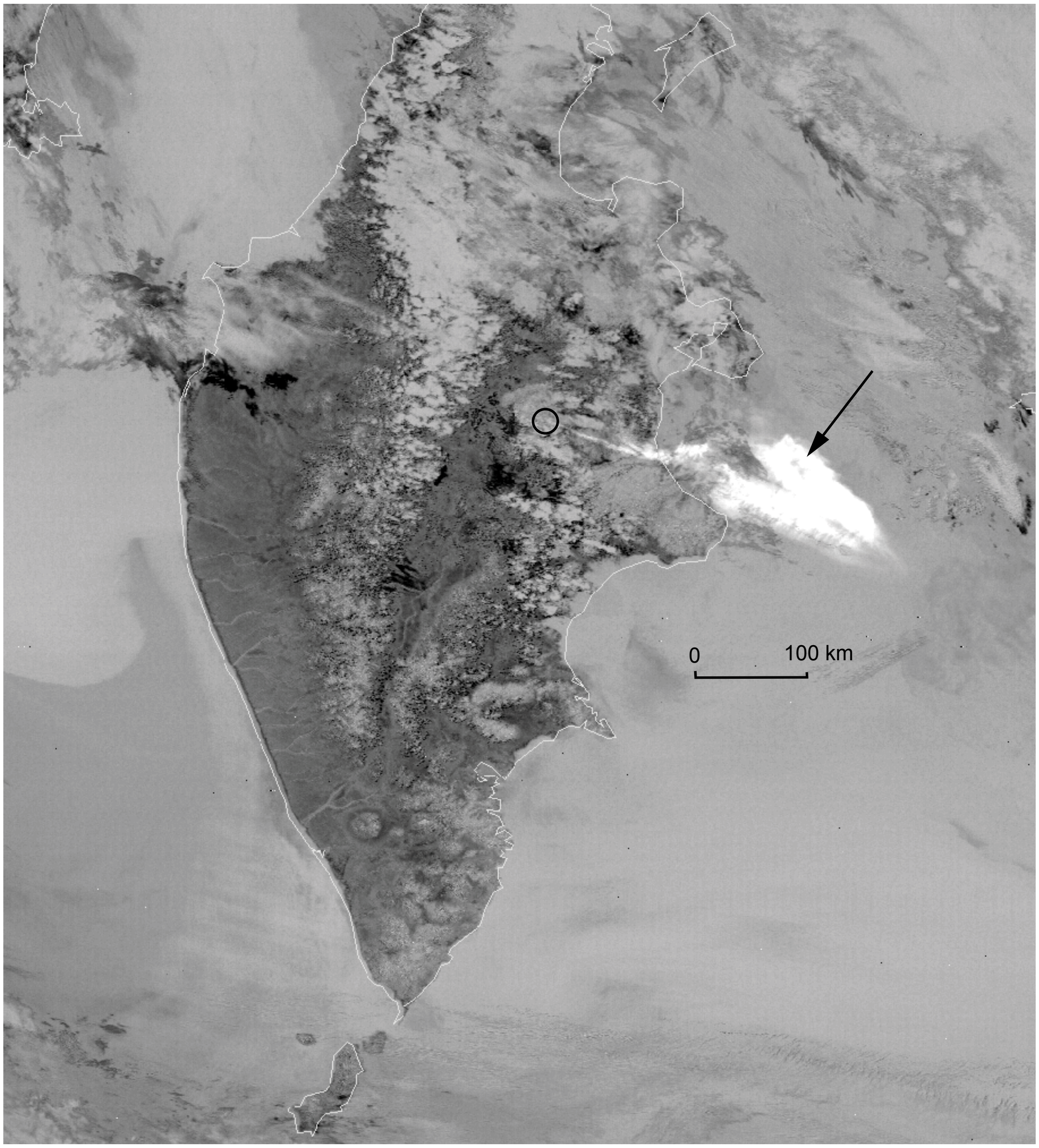


Figure 27. NOAA 17 satellite image from June 19, 2004 at 0016 UTC. Bright white region (arrow) is the remnants of an ash cloud from a 2-hour eruption at Bezymianny Volcano (black circle). Image courtesy KEMSD.

KVERT declared color code YELLOW on June 25 where the volcano remained through the end of the year. Seismicity was at or below background levels and a weak gas and steam plume was frequently visible above the lava dome. A weak thermal anomaly of 1-3 pixels persisted and KVERT reported that the lava dome continued to grow. On December 25, an increase in earthquake activity was noted heralding the resumption of explosive activity early in 2005.

In October 1955, Bezymianny Volcano emerged from a 900-1,000 year period of quiescence commencing an explosive eruption that culminated on March 30, 1956, with the catastrophic failure of the eastern flank and accompanying debris avalanche and lateral blast similar to what occurred at Mount St. Helens in 1980 (Voight and others, 1981). Since then, lava extrusion has produced a dome that periodically collapses generating pyroclastic flows and short-lived ash plumes (Girina and others, 1993); the most recent significant ash-producing explosion was in August of 2001 (McGimsey and others, 2005a).

KARYMSKY VOLCANO

CAVW# 1000-13
54°03' N 159°27' E
1,486 m (4,876 ft)
Kamchatka Peninsula, Russia

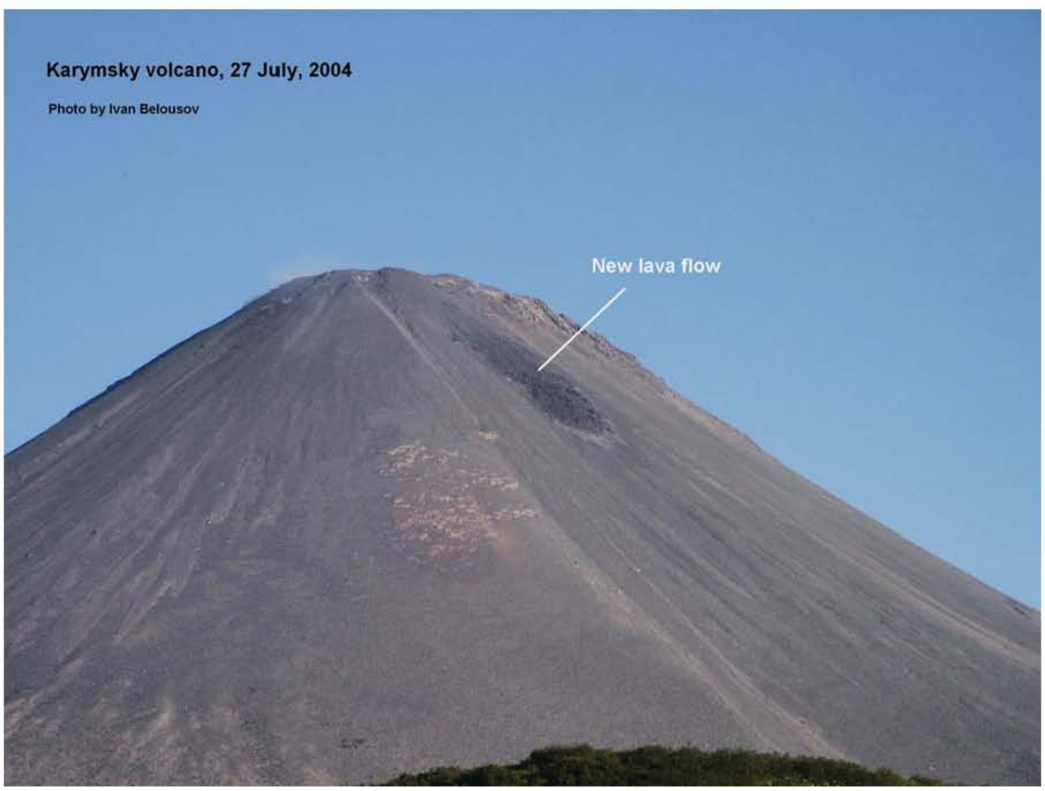
STROMBOLIAN / VULCANIAN ERUPTION CONTINUES.
Intermittent, low-level vulcanian and strombolian eruptions, explosions, localized ash fall, lava extrusion, rock avalanches, degassing.

Karymsky Volcano began 2004 at ORANGE and with the exception of two, approximately month-long downgrades to YELLOW, remained at a high level of concern for most of 2004 as it completed the ninth year of its current eruption cycle.

Intermittent ash-rich explosions, at times only minutes apart, were detected at the volcano based on seismic signals for much of the first eight months of the year. Only small agglutinate lava flows confined to the upper flanks of the cone were produced in 2004 (fig. 28*A* and 28*B*), and activity was dominated by explosive vulcanian bursts from the summit crater and associated avalanching of debris down the flanks of the cone. Overall, seismicity remained above background with sometimes 200-300 or more earthquakes detected per day. AVHRR satellite imagery showed a thermal anomaly over the summit crater and upper flank region, ranging in size from 1 to 15 pixels (the highest values were seen in mid-summer and likely reflect solar heating rather than a large volcanic heat source; S. Smith, written commun., 2004). When observed, these explosions rose as high as 7 km (23,000 ft) ASL, but more commonly only 2.5-5 km (8,200-16,400 ft) ASL. Frequently, ash fall was visible on the snow-covered ground around the volcano. Pilot reports of ash also reached KVERT frequently, as Karymsky is easily visible on both domestic and international flight routes over that portion of Kamchatka.

A

B



Figurer 28. Distant (*A*.) and telephoto (*B*.) views of a new lobe of spatter-fed lava extending down the east-northeast flank of Karymsky Volcano. Faint steam plume issues from the summit crater, site of the intermittent strombolian and vulcanian explosions that have characterized this eruption. Photographs by I. Belousov, late July, 2004.

During quiescence, a steam and gas plume often rose from the summit crater and was sometimes visible up to 100 km (60 mi) or more downwind on satellite images. Based on a decline in daily seismicity, KVERT downgraded Karymsky to Color Code YELLOW on August 5, but reverted to ORANGE when more energetic explosions resumed on September 1. KVERT instituted another brief period of YELLOW from November 11 though December 7 when seismicity and the energy of explosions increased again and prompted a return to ORANGE. Equipment problems led to a seismic data gap from December 12 though year's end, however a weak thermal anomaly continued and field crews in the area on December 16 and December 28 observed explosions every 5-6 minutes.

Karymsky is the most active volcano on the Kamchatkan Peninsula (Simkin and Siebert, 1994). Explosive and effusive-explosive eruptions of andesitic tephra and lava flows alternating with periods of repose are typical of Karymsky (Ivanov and others, 1991). The current phase of unrest began in mid-April 1995 with increasing seismicity and culminated in an explosive eruption that began on January 1, 1996, simultaneously at Karymsky volcano and from a vent at the north part of Karymsky Lake about 10 km (6 mi) distant (Belousov and Belousova, 2001; Fedotov 1998). For the next several years, periods of explosive eruptions of ash and small blocks alternated with periods of lava flow production (Neal and McGimsey, 1997; McGimsey and Wallace, 1999.)

CHIRINKOTAN VOLCANO

CAVW# 0900-26
48°59' N 153°28' E
724 m (2,375 ft)
Central Kurile Islands, Russia

SMALL ASH EMISSION
Brief, low-level ash eruption, poorly constrained at this remote island volcano

On the afternoon of July 20, 2004, scientists at the Russian Geological Fund (formerly the Far East Geological Information Center) of the Ministry of Natural Resources in Yuzhno-Sakhalinsk on Sakhalin Island detected an ash plume from Chirinkotan Volcano in the North Central Kurile Islands during routine analysis of MODIS satellite imagery (figs. 29, 30). The small, low-level ash and volcanic gas plume drifted southeast from the volcano. Retrospectively, the plume was first visible in an 0012 UTC AVHRR image. Based on comparisons with PUFF simulations, it appeared that the plume was less than 5 km (16,400 ft) ASL and approximately 120 km (75 mi) in total length (J. Dehn, written commun., 2004).

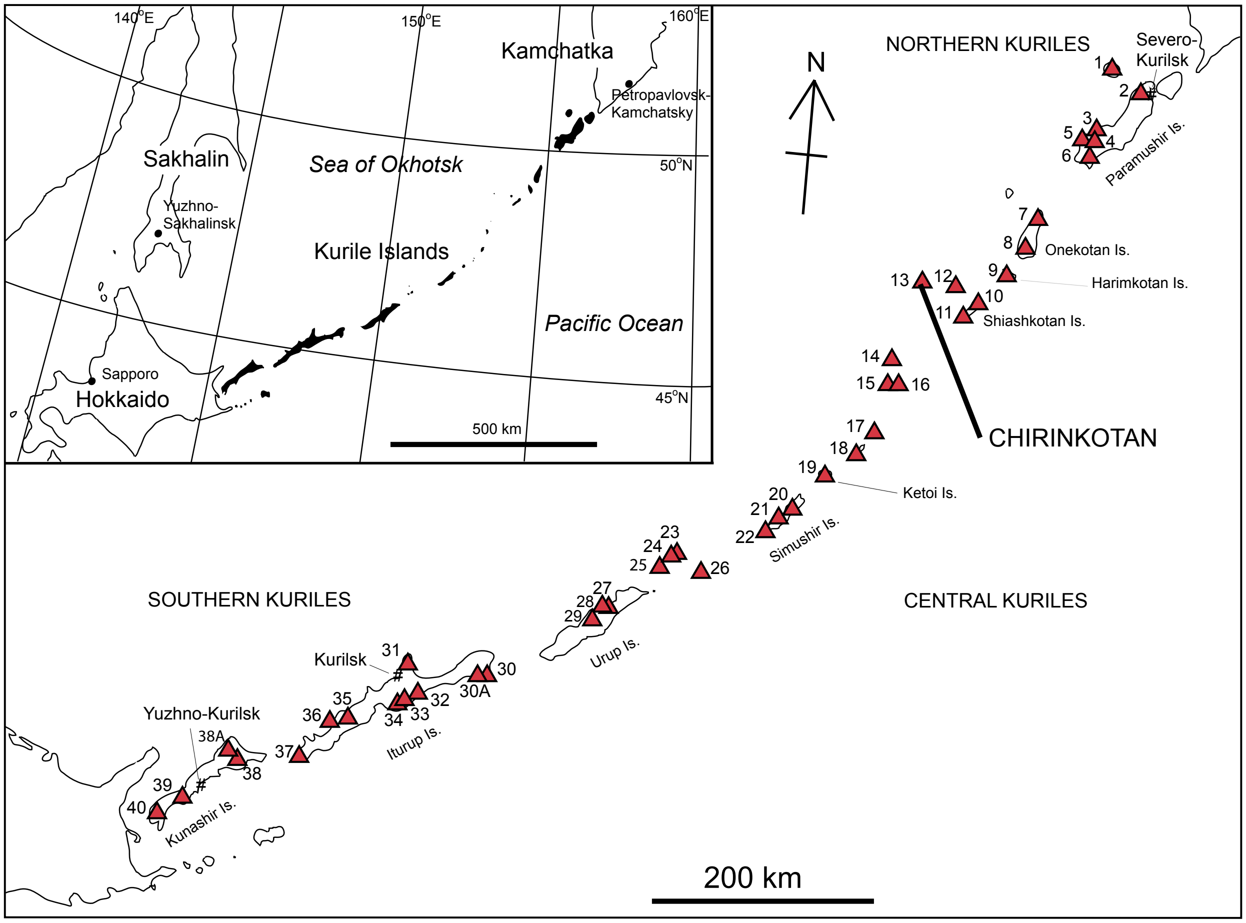


Figure 29. Map of Kurile Islands showing location of Chirinkotan Volcano to the northwest of Shiashkotan Island.

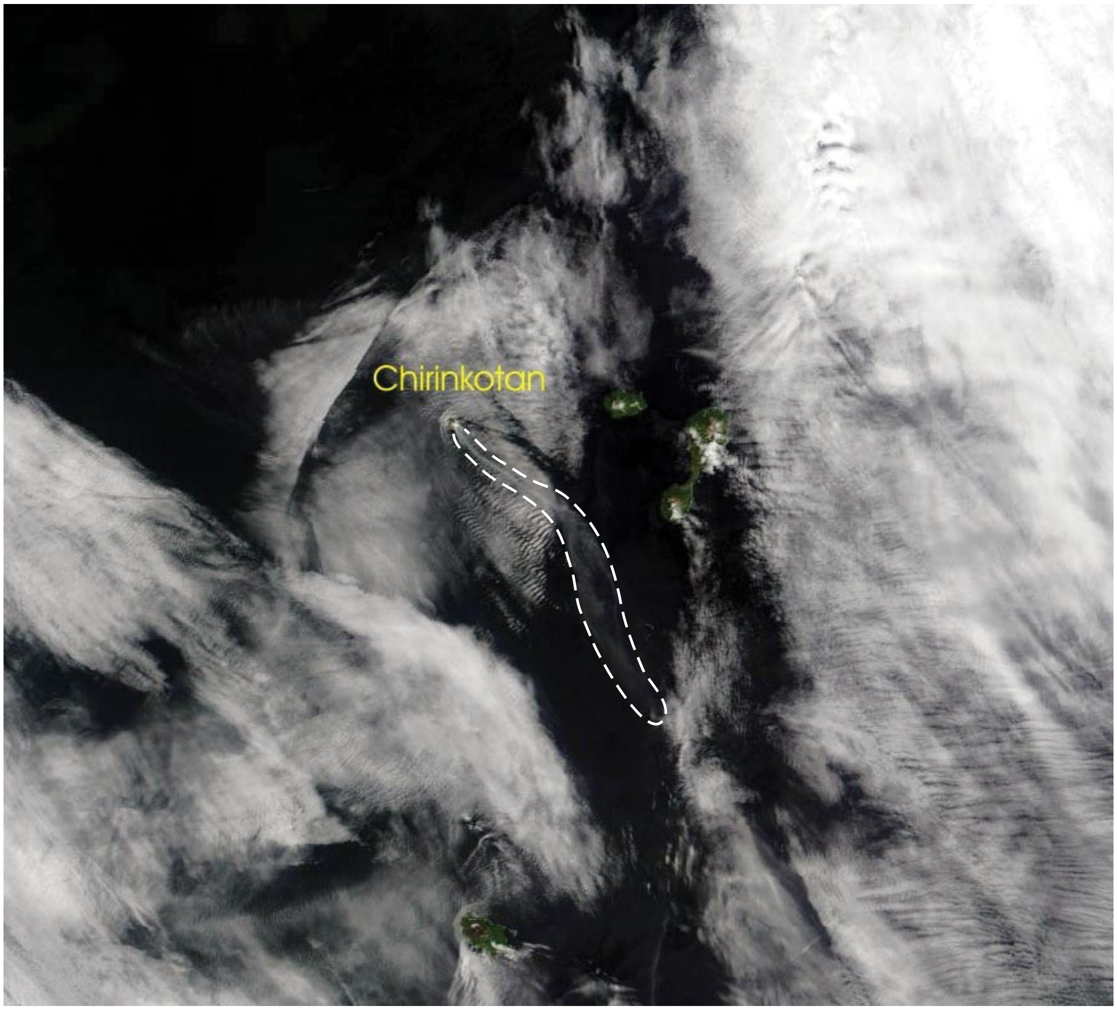


Figure 30. MODIS image from 0050 UTC on July 20, 2004 showing a faint, narrow gas plume containing a minor amount of ash extending about 120 km (75 mi) downwind from Chirinkotan Volcano in the north central Kurile Islands (plume enclosed by dashed line). Wind models suggested the ash was less than 5 km (16,400 ft) ASL.

The Institute of Marine Geology and Geophysics (IMGG), the host Institute for the newly formed Sakhalin Volcanic Eruption Response Team (SVERT; Rybin and others, 2004), contacted AVO by email providing notification of the ash event. AVO in turn contacted both the Anchorage and Tokyo VAACs and checked satellite imagery sources. Since protocols for communication among these groups regarding Kurile eruptions had not yet been developed, AVO quickly established some interim guidelines and shared these with IMGG in case additional information became available. The Anchorage VAAC issued a one-time SIGMET (fig. 31). Cloudy weather prevailed in the region over the next several days, and no additional activity was detected on subsequent satellite images of Chirinkotan. Thus, the event was short-lived and fairly minor and did not disrupt air traffic in any way.

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MODIS SATELLITE IMAGERY INDICATED AN ERUPTION OF
CHIRINKOTAN VOLCANO (48 59N 153 28E).  THE TERRA
IMAGE OF 0050 UTC SHOWS A VOLCANIC PLUME...
POSSIBLY CONTAINING ASH...EXTENDING
APPROXIMATELY 120 KM TO THE SE.
THE NARROW PLUME APPEARS TO BE LOW LEVEL AND NO
PLUME TOP INFORMATION IS CURRENTLY AVAILABLE.
WINDS AT LOW LEVELS ARE LIGHT NORTHWEST AND
BECOME WEST-NORTHWEST 10 TO 15 KTS ABOVE FL100.
BASED UPON WIND DATA...THE ASH IS NOT EXPECTED TO
IMPACT THE ALASKA FIR.
THIS IS A ONE TIME SIGMET.
JMO JUL 04
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Figure 31. SIGMET issued by the National Weather Service in Anchorage, Alaska following the report of a possible eruption at Chirinkotan Volcano. Although the Kuriles are outside the area of responsibility for the Anchorage Meteorological Watch Office (MWO), the potential hazard to aircraft operating downwind of the volcano and lack of any other International aviation alert prompted this release.

Upon further examination of the MODIS imagery from July 20, IMGG staff described the visible portion of the ash cloud as approximately 60 km (37 mi) in length and divided into three parts: (a) near-vent ash cloud, elliptical in shape within about 3 km (1.8 mi) of the SSW part of the volcano; (b) a thin cloud (about 2 km or 6,500 ft wide) extending to the SE 35 km (22 mi); (c) a fan-shaped widening of the cloud up to 6 km (3.7 mi) and turning to the SSE an additional 25 km (16 mi). They estimated the cloud to be between 1-3 km (3,300-10,000 ft) ASL.

Chirinkotan volcano is a 724-m-(2,374-ft) high, mostly unvegetated stratovolcano with a basal diameter of about 3 km (10,000 ft) at sea level (Gorshkov, 1970; fig. 32). The edifice rises about 3 km (10,000 ft) above the Okhotsk Sea floor and is part of a roughly east-west trending volcanic chain that extends about 50 km (30 mi) west of the main axis of the central Kurile volcanic islands. Andesites and andesitic basalts predominate and 4 or 5 significant eruptions have been documented in historical time. The last strong eruption in 1979-1980 was mainly andesitic and consisted of lava effusion from the 1-km-wide (3,300 ft) and 300- to 400-m-deep (980-1,300 ft) summit crater. Lava flows were accompanied by ash explosions to 2.5 km (8,200 ft) ASL (Simkin and Seibert, 1994). Since then, only intense fumarolic activity has been observed. The island is very remote, unpopulated, and therefore is relatively poorly studied. The nearest seismic stations are located on Atlasova and Paramushir Islands 250 km (155 mi) distant, and thus, only very strong eruption seismicity is likely to be detected.

Figure 32. Oblique aerial photo of Chirinkotan Volcano. A steam plume rises from the summit crater filled with andesite lavas erupted in 1979-80. Photograph by A. Rybin, Institute of Marine Geology and Geophysics. Date unknown.

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SELECTED SOURCES OF PHOTOGRAPHS IN THIS REPORT AND OTHER IMAGES OF ALASKAN AND RUSSIAN VOLCANOES

Online sources of digital images:

http://libraryphoto.er.usgs.gov/
http://www.avo.alaska.edu/downloads/searching.php
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Table 1. History of seismic monitoring of Alaskan volcanoes through December 31, 2004.

[“First station installed” is defined as the receipt of real-time data from the station. This date can be many months following initial fieldwork at the volcano. AVO considers the seismic network “complete” following installation and data transmission from a minimum of four seismic stations. Typically, AVO seismologists wait several months to understand background rates of seismicity before declaring a volcano seismically monitored. We note here the first mention of the seismic status of each monitored volcano in the AVO weekly update. These written information statements began during the Redoubt eruption in 1989-90 and first mentioned all Cook Inlet volcanoes in April 1991. The Magnitude of Completeness is the lowest magnitude that can confidently be located. Compiled by J. Dixon, USGS.]

VOLCANO (East to West)	APPROXIMATE START DATE OF SEISMIC MONITORING	MAGNITUDE OF COMPLETENESS
Wrangell	First station installed – Jul 2000 Network complete – **Aug 2001** Added to monitored list in weekly update – Nov 2001	0.8
Spurr	First station installed – Aug 1971 Network complete – **Aug 1989** Added to monitored list in weekly update – Apr 1991	0.2
Redoubt	First station installed – Aug 1971 Network complete – **Aug 1988** Added to monitored list in weekly update – Apr 1991	0.2
Iliamna	First station installed – Sep 1987 Network complete – **Sep 1994** Added to monitored list in weekly update – Apr1991	-0.4
Augustine	First station installed – Oct 1976 Network complete – **Aug 1978** Added to monitored list in weekly update – Apr 1991	0.0
Katmai-North (Snowy)	First station installed – Aug 1988 Network complete – **Oct 1998** Added to monitored list in weekly update – Dec 1998	0.6
Katmai-Central (Griggs, Katmai, Novarupta, Trident)	First station installed – Aug 1988 Network complete – **Jul 1991** Added to monitored list in weekly update – Nov 1996	0.6

VOLCANO (East to West)	APPROXIMATE START DATE OF SEISMIC MONITORING	MAGNITUDE OF COMPLETE-NESS
Continued		
Katmai-South (Martin, Mageik)	First station installed – Aug 1988 Network complete – **Jul 1996** Added to monitored list in weekly update – Nov 1996	0.6
Aniakchak	First station installed – Jul 1997 Network complete – **Jul 1997** Added to monitored list in weekly update – Nov 1997	1.7
Veniaminof	First station installed – Feb 2002 Network complete – **Feb 2002** Added to monitored list in weekly update – Sep 2002	1.1
Pavlof	First station installed – Jul 1996 Network complete – **Jul 1996** Added to monitored list (in weekly update – Nov 1996	0.7
Dutton	First station installed – Jul 1988 Network complete – **Jul 1996** Added to monitored list in weekly update – Nov 1996	0.5
Shishaldin (and Isantoski)	First station installed – Jul 1997 Network complete – **Jul 1997** Isantoski to list in weekly update – Dec 1998 Shishaldin added to list in weekly update – Nov 1997	1.0
Westdahl (Fisher)	First station installed – Aug 1998 Network complete – **Oct 1998** Added to monitored list in weekly update – Dec 1998	0.6
Akutan	First station installed – Mar 1996 Network complete – **Jul 1996** Added to monitored list in weekly update – Nov 1996	1.2
Makushin	First station installed – Jul 1996 Network complete – **Jul 1996** Added to monitored list in weekly update – Nov 1996	1.1
Okmok	First station installed – Jan 2003 Network complete – **Jan 2003** Added to monitored list in weekly update – Jan 2004	n/a

VOLCANO (East to West)	**APPROXIMATE START DATE OF SEISMIC MONITORING**	**MAGNITUDE OF COMPLETE-NESS**
Continued		
Great Sitkin	First station installed – Sep 1999 Network complete – **Sep 1999** Added to monitored list in weekly update – Dec 1999	0.6
Kanaga	First station installed – Sep 1999 Network complete – **Sep 1999** Added to monitored list in weekly update – Dec 2000	0.9
Tanaga	First station installed – Aug 2003 Network complete **– Aug 2003** Added to monitored list (in weekly update – Jun 2004	n/a
Gareloi	First station installed – Aug 2003 Network complete – **Sep 2003** Added to monitored list in weekly update – Jun 2004	n/a

Table 2. Summary of 2004 VOLCANIC ACTIVITY in Alaska, including actual eruptions, possible eruptions, and unusual increases in seismicity or fumarolic activity. Location of volcanoes shown in Figure 1.

Volcano	Date of Activity	Type of Activity
Mount Spurr	Early July through the end of the year	Increased shallow seismicity, deep long-period seismicity, heat flux, magmatic degassing, and development of a summit ice-cauldron at Spurr. AVO declares Color Code YELLOW on July 26.
Veniaminof	Intermittently throughout the year	Minor steam and ash plumes; persistent seismicity indicative of phreatic (?) activity from the intracaldera cinder and spatter cone. AVO declares Color Code YELLOW on April 19; GREEN on October 26.
Shishaldin	Intermittently throughout the year	Minor steam and ash plumes; persistent seismicity indicative of phreatic (?) activity within the summit crater. AVO declares Color Code YELLOW on May 3; GREEN on October 26.
Westdahl	January 7, 2004	Seismic swarm; likely related to a magmatic intrusion

Table 3. Summary of SUSPECT VOLCANIC ACTIVITY (SVA) in 2004.

[SVA is defined as a report of eruption or possible eruption that is found to be normal fumarolic activity or non-volcanic phenomena, such as weather related. Localities shown in Figure 1.]

Volcano	Date of Activity	Type of Activity
Mt. Crillon	Week of June 21	Rockfall produces series of particulate plumes mistaken for ash clouds and volcanic activity
Katmai Group (Martin)	February 17, October 7	Observations of large steam plumes; normal fumarolic activity at Martin

Table 4. Periods of Elevated Color Code status for Alaskan Volcanoes, 2004.

MOUNT SPURR

GREEN	1/1/04 – 7/26/04
YELLOW	7/26/04 – 12/31/04

VENIAMINOF

GREEN	1/1/04 – 4/19/04
YELLOW	4/19/04 – 10/26/04
GREEN	10/26/04 – 12/31/04

SHISHALDIN

GREEN	1/1/04 – 5/3/04
YELLOW	5/3/04 – 10/26/04
GREEN	10/26/04 – 12/31/04

Table 5. Level of Concern Color Code for volcanic activity used in Alaska and Kamchatka.

LEVEL OF CONCERN COLOR CODE

To more concisely describe our level of concern about possible or ongoing eruptive activity at an Alaskan volcano, the Alaska Volcano Observatory uses the following color-coded classification system. Definitions of the colors reflect AVO's interpretations of the behavior of the volcano. Definitions are listed below followed by general description of typical activity associated with each color.

GREEN	**No eruption anticipated.** Volcano is in quiet, "dormant" state.
YELLOW	**An eruption is possible in the next few weeks and may occur with little or no additional warning.** Small earthquakes detected locally and (or) increased levels of volcanic gas emissions.
ORANGE	**Explosive eruption is possible within a few days and may occur with little or no warning. Ash plume(s) not expected to reach 25,000 feet above sea level.** Increased numbers of local earthquakes. Extrusion of a lava dome or lava flows (non-explosive eruption) may be occurring.
RED	**Major explosive eruption expected within 24 hours. Large ash plume(s) expected to reach at least 25,000 feet above sea level.** Strong earthquake activity detected even at distant monitoring stations. Explosive eruption may be in progress.

Table 6. Seismically monitored volcanoes of Kamchatka as of December 2004.

[Compiled by Sergey Senyukov, Kamchatka Experimental and Methodical Seismology Department (KEMSD), and C. Neal, Alaska Volcano Observatory. Prior to 1979, other Russian scientific institutes maintained programs of volcano monitoring in Kamchatka (a partial listing includes: 1961-1971, Pacific Seismological Department of Institute of Earth Physics; 1972-1978—Institute of Volcanology)]

VOLCANO	APPROXIMATE START DATE OF CONTINUOUS SEISMIC MONITORING BY KEMSD	OTHER MONITORING TECHNIQUES USED ROUTINELY
Sheveluch	Seismic station – Feb 1987; Telemetered data – 1980; Digital format – Sep 1996; Near-real time processing – 1999	Near real-time video system (2002); direct observation from nearby Klyuchi; satellite imagery
Klyuchevskoy	Seismic station – 1961; Telemetered data– 1987; Digital format – Sep 1996; Near-real time processing – 1999	Near real-time video system (2000); direct observation from nearby Klyuchi and Kozyrevsk; satellite imagery
Bezymianny	Seismic station – 1961; Telemetered data – Oct 1988; Digital format – Sep 1996; Near-real time processing – 1999	Direct observation from nearby Kozyrevsk; satellite imagery
Plosky Tolbachik	Seismic station – Jan 1977; Telemetered data – Nov 1990; Digital format – Sep.1996; Near-real time processing – 1999	Direct observation from nearby Kozyrevsk; satellite imagery
Karymsky	Telemetered data – Sep 1989; Digital format – Jan 1996; Near-real time processing – 1996	Field observation; satellite imagery
Koryaksky	Seismic station – Apr 1963; Telemetered data – 1975; Digital format – Jan 1996; Near-real time processing – 1996	Direct observation from PK; satellite imagery
Avachinsky	Seismic station – Apr 1963; Telemetered data – Jul 1976; Digital format – Jan 1996; Near-real time processing – 1997	Direct observation from PK; satellite imagery
Gorely	Telemetered data – Jul 1980; Digital format – Jan 1996; Near-real time processing – 1996	Direct observation from PK; satellite imagery
Mutnovsky	Telemetered data – Jul 1980; Digital format – Jan 1996; Near-real time processing – 1996	Direct observation from PK; satellite imagery
Alaid	Telemetered data – Aug 2001; Digital format – Aug 2001; Near-real time processing – Aug 2001	Satellite imagery

Table 7. Summary of volcanic ACTIVITY on Kamchatka Peninsula and the Kurile Islands, Russia, 2004. Location of volcanoes shown in Figure 22.

Volcano	Date of Activity	Type of Activity
Sheveluch	Intermittently throughout the year	Lava dome growth, short-lived, explosive episodes, pyroclastic flows, mudflows, localized ash fall.
Klyuchevskoy	Intermittently throughout the year	Periods of elevated seismicity
Bezymianny	Intermittently throughout the year	Short-lived explosive eruption on January 13 and June 18. Periods of gas and steam plume generation.
Karymsky	Intermittently throughout the year	Periods of increased seismicity continuation of low-level vulcanian and strombolian explosions, avalanches, degassing.
Chirinkotan	July 20	Brief, low-level steam, gas, ash emission.

Table 8. Summary of Color Code status for Russian Volcanoes, 2004.

SHEVELUCH

YELLOW	1/1/04 – 1/16/04
ORANGE	1/16/04 – 5/9/04
RED	5/9/04
ORANGE	5/10/04 – 12/31/04

KLYUCHEVSKOY

ORANGE	1/1/04 – 3/5/04
YELLOW	3/5/04 – 11/27/04
GREEN	11/27/04 – 12/31/04

BEZYMIANNY

GREEN	1/1/04 – 1/9/04
RED	1/13/04
ORANGE	1/13/04 – 1/16/04
YELLOW	1/16/04 – 6/16/04
ORANGE	6/16/04 – 6/18/04
RED	6/18/04 – 6/19/04
ORANGE	6/19/04 – 6/25/04
YELLOW	6/25/04 – 12/31/04

KARYMSKY

ORANGE	1/1/04 – 8/8/04
YELLOW	8/5/04 – 9/1/04
ORANGE	9/1/04 – 11/12/04
YELLOW	11/12/04 – 12/7/04
ORANGE	12/7/04 – 12/31/04

GLOSSARY OF SELECTED TERMS AND ACRONYMS

AAWU:
"Alaska Aviation Weather Unit" of the National Weather Service

'a'a:
Hawaiian term for lava flows characterized by a rough, jagged, blocky surface, typically difficult to walk upon

ADT:
"Alaska Daylight Time"

AEIC:
"Alaska Earthquake Information Center"

ASL:
"above sea level"

AST:
"Alaska Standard Time"

ASTER:
"Advanced Spaceborne Thermal Emission and Reflection Radiometer"

AVO:
"Alaska Volcano Observatory"

AVHRR:
"Advanced Very High Resolution Radiometer"; AVHRR provides one form of satellite imagery

andesite:
volcanic rock composed of about 53 to 63 percent silica (SiO2, an essential constituent of most minerals found in rocks)

ash:
fine fragments (less than 2 millimeters across) of lava or rock formed in an explosive volcanic eruption

basalt:
general term for dark-colored igneous rock, usually extrusive, containing about 45 to 52 weight percent silica (SiO2, an essential constituent of most minerals found in rocks)

bomb:
boulder-size chunk of partly solidified lava explosively ejected from a volcano

caldera:
a large, roughly circular depression usually caused by volcanic collapse or explosion

CAVW:
Smithsonian Institute's "Catalog of Active Volcanoes of the World"

cinder cone:
small, steep-sided conical hill built mainly of cinder, spatter, and volcanic bombs

COSPEC:
"Correlation Spectrometer"; device for measuring sulfur dioxide emissions

CWSU:
"Center Weather Service Unit" of the National Oceanic and Atmospheric Administration, stationed at the Air Route Traffic Control Center

FAA:
"Federal Aviation Administration"

fallout:
a general term for debris which falls to the earth from an eruption cloud

fault:
a fracture or zone of fractures along which there has been displacement of the sides relative to one another

FIR:
"Flight Information Region"

FLIR
"Forward Looking Infrared Radiometer"; used to delineate objects of different temperature

fissure:
a roughly linear or sinuous crack or opening on a volcano; a type of vent which commonly produces lava fountains and flows

fumarole:
a small opening or vent from which hot gases are emitted

glaciolacustrine:
pertaining to sediments deposited in glacial lakes, and resulting landforms

GMS:
"Geostationary Meteorological Satellite"

GOES:
"Geostationary Operational Environmental Satellite"

GVN:
"Global Volcanism Network" of the Smithsonian Institution

Holocene:
geologic epoch extending from the present to 10,000 years ago

incandescent:
glowing red or orange due to high temperature

intracaldera:
refers to something within the caldera

IMGG:
Russian "Institute of Marine Geology and Geophysics"

IVGG:
Russian "Institute of Volcanic Geology and Geochemistry"

IVS:
Russian Institute of "Volcanology and Seismology"

JMA:
"Japanese Meteorological Agency"

JPEG:
"Joint Photographic Experts Group"; type of digital photographic file

Ka:
Thousands of years before the present

KDT:
"Kamchatkan Daylight Time", which = ADT + 21 hrs.

KEMSD:
Russian "Kamchatka Experimental and Methodical Seismology Department"

KST:
"Kamchatka Standard Time"

KVERT:
"Kamchatkan Volcanic Eruption Response Team"

lapilli:
pyroclasts that are between 2 and 64 mm in diameter

lava:
when molten material reaches the earth's surface, it is called lava

magma:
molten material below the surface of the earth

MODIS:
Satellite-based"Moderate Resolution Imaging Spectroradiometer"

MWO:
"Meteorological Watch Office"

NOAA:
"National Oceanic and Atmospheric Administration"

NOPAC:
"North Pacific Air Corridor"

NOTAM:
"Notice to Airmen", a notice containing information [not known sufficiently in advance to publicize by other means] concerning the establishment, condition, or change in any component [facility, service, or procedure of, or hazard in the National Airspace System] the timely knowledge of which is essential to personnel concerned with flight operations

NPS:
"National Park Service"

NWS:
"National Weather Service"

phreatic activity:
an explosive eruption caused by the sudden heating of ground water as it comes in contact with hot volcanic rock or magma

phreatic ash:
fine fragments of volcanic rock expelled during phreatic activity; this ash is usually derived from existing rock and not from new magma

PIREP:
"Pilot Weather Report" —A report of meteorological phenomena encountered by aircraft in flight

pixel:
contraction of "picture element". A pixel is one of the many discrete rectangular elements that form a digital image or picture on a computer monitor or stored in memory. In a satellite image, resolution describes the size of a pixel in relation to area covered on the ground. More pixels per unit area on the ground means a higher resolution

Pleistocene:
geologic epoch extending from 2-3 million years ago to approximately 10,000 years before present

PUFF:
a volcanic ash tracking model (see: http://pafc.arh.noaa.gov/puff/index.html)

pumice-rich lapilli:
particles ejected during a volcanic eruption that are composed mostly of pumice and between 2 and 64 mm in size

pyroclast:
an individual particale ejected during a volcanic eruption; usually classified by size, for example, ash, lapilli

regional earthquake:
earthquake generated by fracture or slippage along a fault; not caused by volcanic activity

RFE:
"Russian Far East"

SAB:
"Synoptic Analysis Branch" of NOAA

SAR:
"Synthetic Aperture Radar"

satellite cone:
a subsidiary volcanic vent located on the flank of a larger volcano

seismic swarm:
a flurry of closely spaced earthquakes or other ground shaking activity; often precedes an eruption

shield volcano:
a broad, gently sloping volcano usually composed of fluid, lava flows of basalt composition (for example, Mauna Loa, Hawaii)

SIGMET:
"Significant Meteorological information statement", issued by NWS

stratovolcano:
(also called a stratocone or composite cone) a steep-sided volcano, usually conical in shape, built of interbedded lava flows and fragmental deposits from explosive eruptions

strombolian:
type of volcanic eruption characterized by intermittent bursts of fluid lava, usually basalt, from a vent or crater as gas bubbles rise through a conduit and burst at the surface

sub-plinian:
style of explosive eruptions characterized by vertical eruption columns and widespread dispersal of tephra

SVA:
"suspect volcanic activity"

SVERT:
"Sakhalin Volcanic Eruption Response Team" monitoring and reporting on Kurile Island volcanoes

tephra:
a general term covering all fragmental material expelled from a volcano (ash, bombs, cinders, etc.)

TFR:
"Temporary Flight Restriction", issued by FAA

USCG:
"United States Coast Guard"

USGS:
"United States Geological Survey"

UUA:
"Urgent pilot report"

UTC:
"Coordinated Universal Time"; same as Greenwich Mean Time (GMT)

VAAC:
"Volcanic Ash Advisory Center"

VAAS:
"Volcanic Ash Advisory Statement"

vent:
an opening in the earth's surface through which magma erupts or volcanic gasses are emitted

volcano-tectonic earthquakes:
earthquakes generated within a volcano from brittle rock failure resulting from strain induced by volcanic processes

vulcanian:
style of explosive eruption consisting of repeated, violent ejection of incandescent fragments of viscous lava, usually in the form of blocks, along with volcanic ash. Sometimes, vulcanian eruptions involve water mixing with erupting magma.

UAFGI:
"University of Alaska Fairbanks Geophysical Institute"