USGS
science for a changing world

2000 Volcanic Activity in Alaska and Kamchatka: Summary of Events and Response of the Alaska Volcano Observatory

by Christina A. Neal, Robert G. McGimsey, and Olga Chubarova

Open-File Report 2004-1034

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

2000 Volcanic Activity in Alaska and Kamchatka: Summary of Events and Response of the Alaska Volcano Observatory

By Christina A. Neal[1], Robert G. McGimsey[1],and Olga Chubarova[2]

[1]Alaska Volcano Observatory, 4200 University Dr., Anchorage, AK 99508-4664

[2]Kamchatka Volcanic eruptions Response Team, Institute of Volcanic Geology and Geochemistry, Piip Blvd, 9 Petropavlovsk-Kamchatsky, 683006, Russia

AVO is a cooperative program of the U.S. Geological Survey, University of Alaska Fairbanks Geophysical Institute, and the Alaska Division of Geological and Geophysical Surveys. AVO is funded by the U.S. Geological Survey Volcano Hazards Program and the State of Alaska

Open-File Report 2004-1034

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

TABLE OF CONTENTS

Cover Photo: View, looking southeast, of 2,067-m (6,781 ft)-high Chiginagak Volcano on the Alaska Peninsula. U.S. Geological Survey photograph, date unknown.

INTRODUCTION

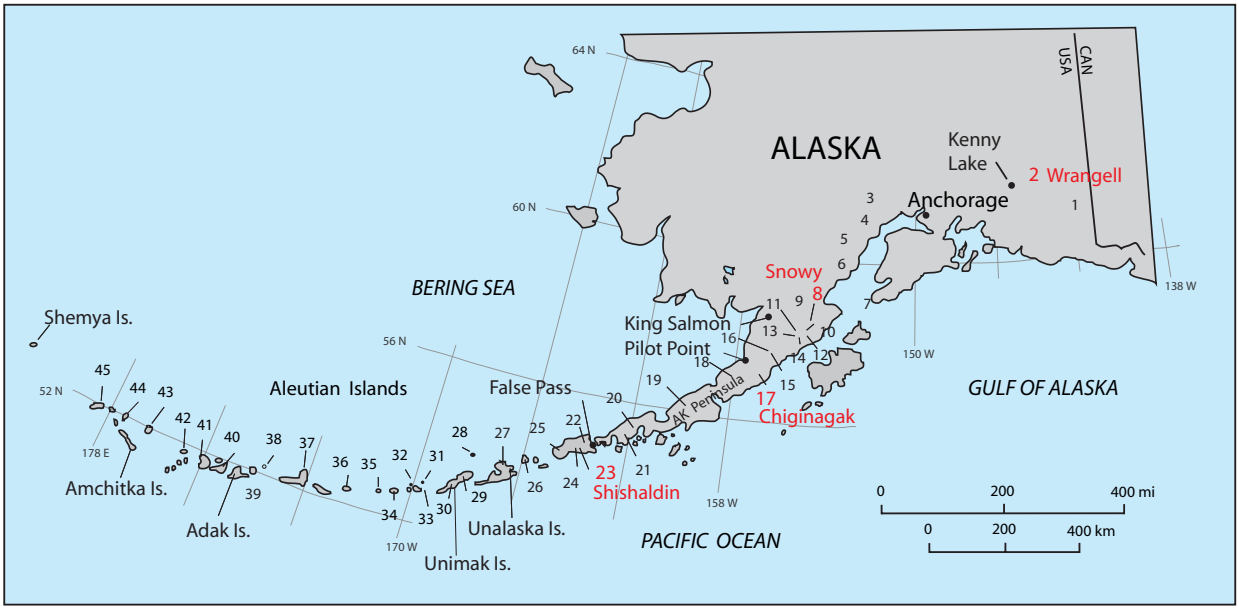
The Alaska Volcano Observatory (AVO) monitors the more than 40 historically active volcanoes of the Aleutian Arc. Of these, 22 were monitored with short-period seismic instrument networks as of the end of 2000 (figs. 1a,b). The core AVO monitoring program also includes daily analysis of satellite imagery, compilation of pilot reports, observations from local residents and mariners, and occasional overflights. In 2000, AVO responded to eruptive activity or suspect volcanic activity at 4 volcanic centers in Alaska (Wrangell, Snowy, Chiginagak, and Shishaldin; figs. 1 a,b; tables 1, 2).

In addition to responding to eruptive activity at Alaska volcanoes, AVO also assisted in the dissemination of information for the Kamchatkan Volcanic Eruption Response Team (KVERT) about activity of 5 Russian volcanoes in 2000 (Sheveluch, Klyuchevskoy, Bezymianny, Karymsky, and Mutnovsky; fig. 5; table 3).

This report summarizes volcanic activity and the AVO response during 2000. Only those reports or inquiries that resulted in a "significant" investment of staff time and energy (here defined as several hours or more for reaction, tracking, and follow-up) are included. AVO typically receives dozens of reports throughout the year of steaming, unusual cloud sightings, or eruption rumors. Most of these are resolved quickly and are not tabulated here as part of the formal response record. On rare occasion, AVO issues a public information release to dispel erroneous reports of volcanic activity. The phrase "suspect volcanic activity" (SVA) is an eruption report or report of unusual activity that is subsequently determined to be normal or slightly enhanced fumarolic activity, a weather-related phenomena, or a non-volcanic geologic event such as a landslide.

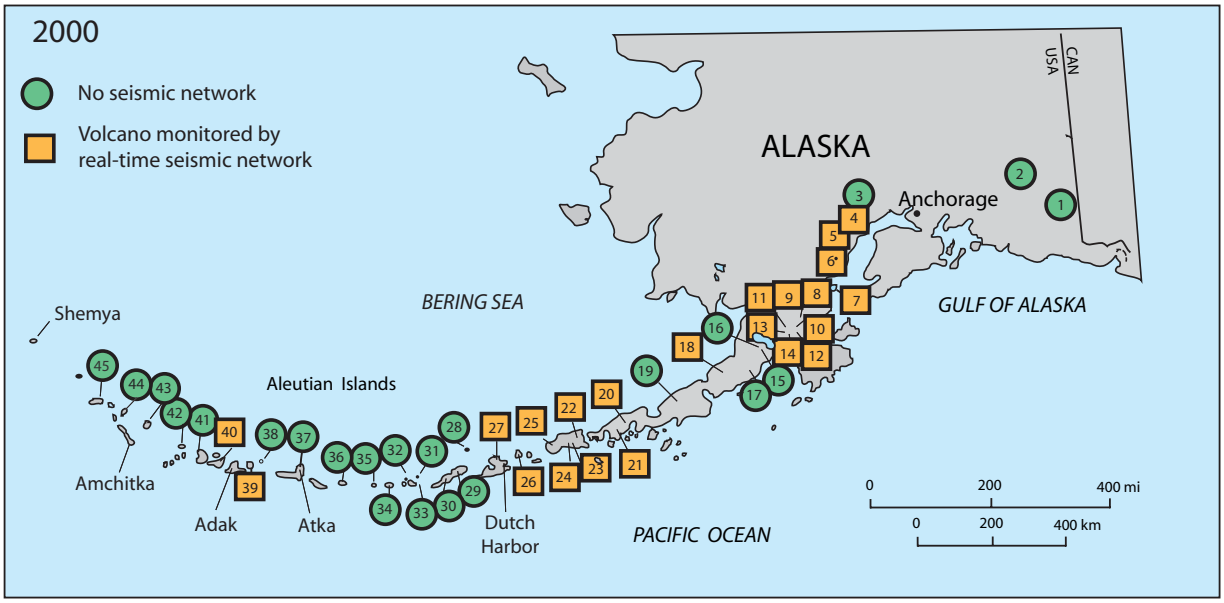
AVO's response to reported remote volcanic activity varies depending on the source and content of the observation. After receiving a report and possibly conducting follow-up investigation of the factual information, AVO usually contacts the National Weather Service (NWS) and Federal Aviation Administration (FAA) or local residents for corroboration and/or formal notification. For a verified, significant eruption or unrest, AVO initiates an established call-down and e-mail notification procedure to inform other government agencies, air carriers, and facilities at risk. If an eruption or unrest is no longer suspected, a notation is made in the internal AVO "Chron" book—a chronological collection of daily or weekly staff notes for a particular year—and no further action is taken. A special information release may be distributed if eruptive activity is confirmed, and the events are further summarized in the AVO weekly update distributed each Friday via electronic mail and facsimile.

Descriptions of volcanic activity and AVO responses are presented in geographical order from northeast to southwest along the Aleutian volcanic arc. All elevations reported are above sea level (ASL) unless noted, and time is reported as Alaska Standard Time (AST), Alaska Daylight Time (ADT), or Kamchatkan Standard Time (KST), Kamchatkan Daylight Time (KDT) (see glossary). We have chosen to preserve English units of measurements when used in primary observations of distance or elevation such as those commonly received via pilot reports and aviation authorities in the United States. Information contained in this report is compiled from AVO weekly updates and information releases, internal records and bimonthly reports, and the Smithsonian Institution Global Volcanism Network Bulletin (GVN).



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

Figure 1a. Location of historically active volcanoes in Alaska and place names used in this summary. Volcanoes mentioned in this report are in bold red. Volcanoes with no documented historical unrest but currently considered hazardous based on late-Holocene eruptive activity are italicized.



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

Figure 1b. Map showing those volcanoes monitored with a seismic network as of the end of 2000. Volcanoes with no documented historical unrest but currently considered hazardous based on late-Holocene eruptive activity are italicized.

VOLCANIC ACTIVITY, NORTHEAST TO SOUTHWEST ALONG ALEUTIAN ARC

WRANGELL VOLCANO
CAVW #1105-02
62°00' N 144°00' W
4,317 m (14,163 ft)

SUSPECT VOLCANIC ACTIVITY
Steam plumes sighted on March 18 and earlier in the year

AVO received word from a Trans Alaska Pipeline worker of an unusually strong, white steam plume from Wrangell between 0500 and 0600 AST on March 18, 2000. Later that day, a National Park Service employee in Kenny Lake reported robust steaming over the past month from multiple sources on the southwest flank of the volcano, between approximately 2,000-5,000 feet (600-1,500 m) below the summit. AVO found no anomalies in satellite imagery related in time to either report and concluded that no significant unrest had occurred.

Mount Wrangell is a large, glacier-covered shield volcano in the Wrangell-St. Elias National Park and Preserve of eastern Alaska (Nye, 1991; Richter and others, 1995). The summit caldera is ice-filled and rimmed by three, small, geothermally active craters on the west rim, historically the source of intermittent steam venting. Resultant steam plumes can be quite vigorous and sometimes reach thousands of feet above terrain, occasionally entraining fine fragmental debris and producing very localized deposits of dark material on the ice. This, in addition to wind redistribution of debris from the summit area, is often mistaken for eruptive activity (Neal and McGimsey, 1997; McGimsey and Wallace 1999). Two real-time seismic monitoring stations were installed on Wrangell in the summer of 2000 but AVO did not consider the volcano to be seismically monitored until 2001. In addition to these data, AVO relies on local observers, pilots, and satellite imagery to track activity at the volcano. Except for a vigorous steam and ash emission in 1902, no historical eruptions are known to have occurred at Wrangell Volcano.

SNOWY MOUNTAIN
CAVW #1102-20
58°20' N 154°44' W
2,161 m (7,090 ft)

SUSPECT VOLCANIC ACTIVITY
Steaming hole in glacier on the southeast flank of Snowy.

In mid-September 2000, AVO received a pilot report of a steam plume emanating from a depression in the surface of the upper Aguchik Glacier about 3 mi (5 km) SE of the summit peaks of Snowy Mountain, a small, andesite-dacite volcanic center in Katmai National Park and Preserve (Hildreth and others, 2001; figs. 2, 3). According to the pilot, Kodiak Air Service owner Willy Hall, this was the first time in his many years flying the region that he had seen either the depression or the accompanying steam. Hall also reported a strong sulfur smell while in the vicinity.

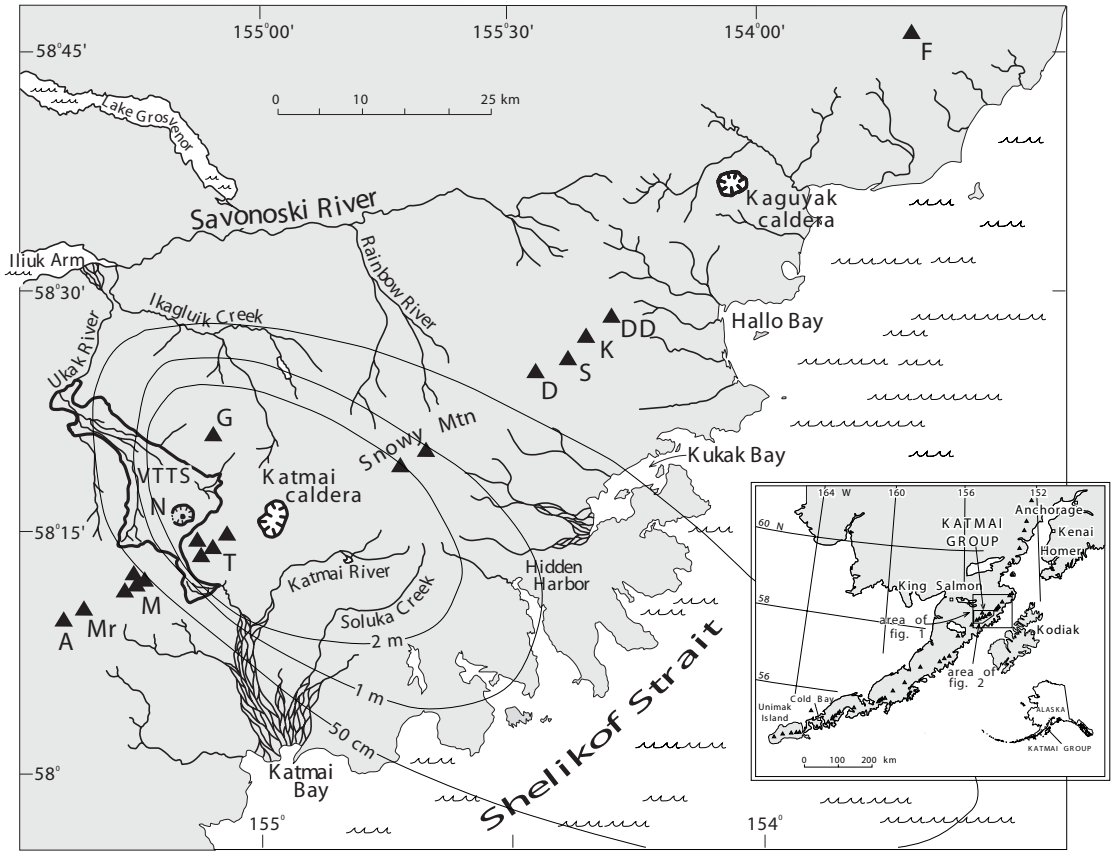


Figure 2. Location map showing Snowy Mountain with respect to adjacent volcanic centers in the Katmai region. Figure from Hildreth and others (2001). F, Fourpeaked; DD, Devils Desk; K, Kukak; S, Steller; D, Dennison; G, Griggs; VTTS, Valley of Ten Thousand Smokes; N, Novarupta; T, Trident; M, Mageik; Mr, Martin; A, Alagogshak. Isopachs represent thickness of 1912 plinian fall deposit from Novarupta.

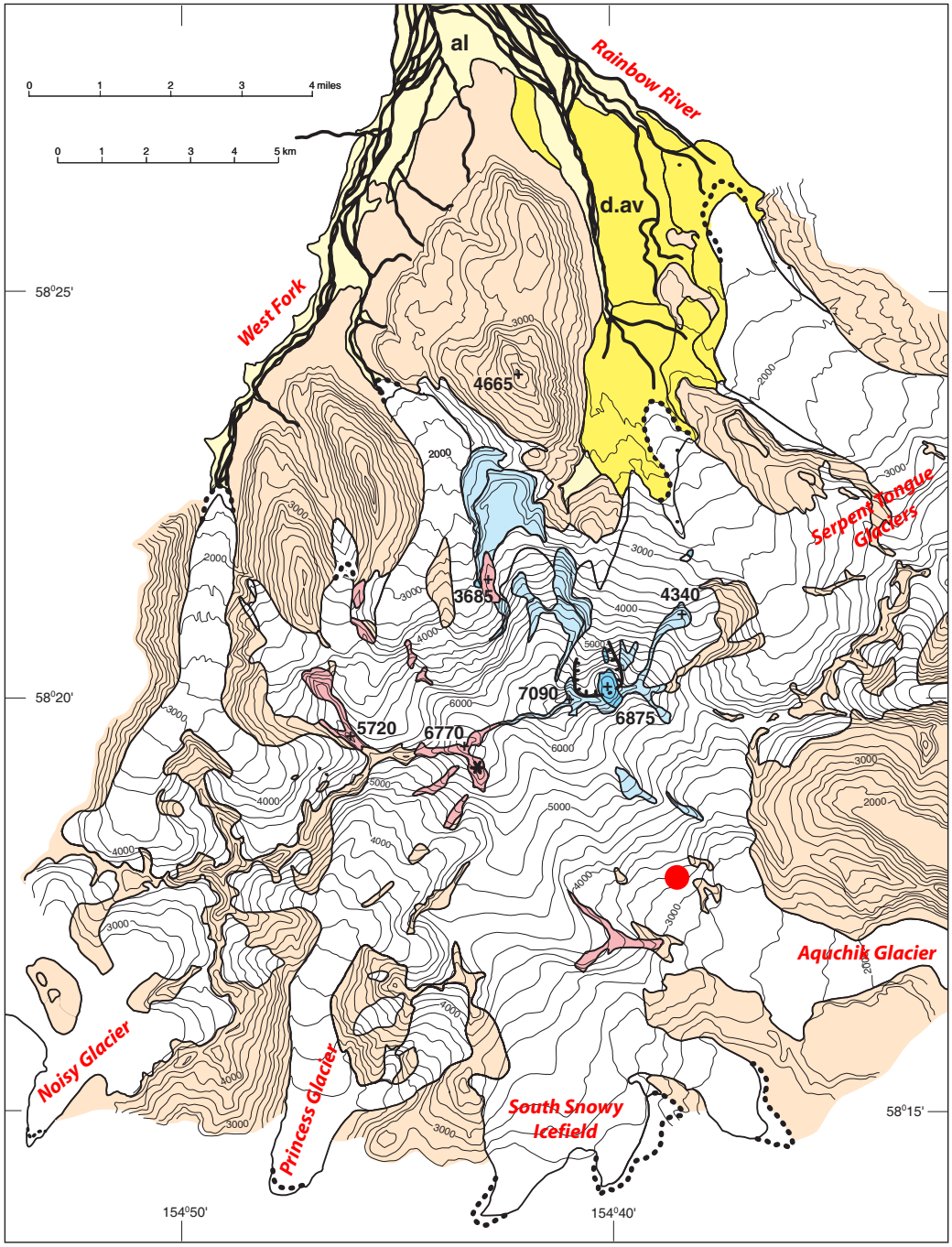


Figure 3. Simplified geologic map of the Snowy Mountain volcanic center from Hildreth and others (2001). Approximate location of steaming hole through the upper Aguchik Glacier marked with bold red dot. Contour interval 200 ft. Spot elevations given in ft. Exposed lavas of SW Snowy Volcano in red, NE Snowy Volcano in blue. Holocene dome in darker blue. Glacial ice white, basement rocks beige. Active alluvium pale yellow and debris avalanche deposit bright yellow. See Hildreth and others (2001) for more detail.

At AVO's request, NPS Unit Manager and pilot John Bundy photographed the area from the air on September 29 and again on October 8 (fig. 4). The anomalous depression is roughly circular in shape, several hundred meters in diameter, and marked by concentric, nested crevasses that enclose a steep-walled opening of unknown depth. The crevassed ice defining the depression slopes towards the hole with increasing severity until nearly vertical ice-walls define the opening, also roughly circular in shape. Based on crude estimates of crevasse scale, we estimate the opening to be about 15-30 m (60-100 ft) across. This feature occurs on a portion of the icefield that flows generally to the southeast with a slope of about 8°; meltwater from this glacier eventually drains into Kukak Bay. Geographic coordinates first reported by Willy Hall are 58°17.69' N, 154°38.78' W, placing the hole at an elevation of about 975 m (3,200 ft).

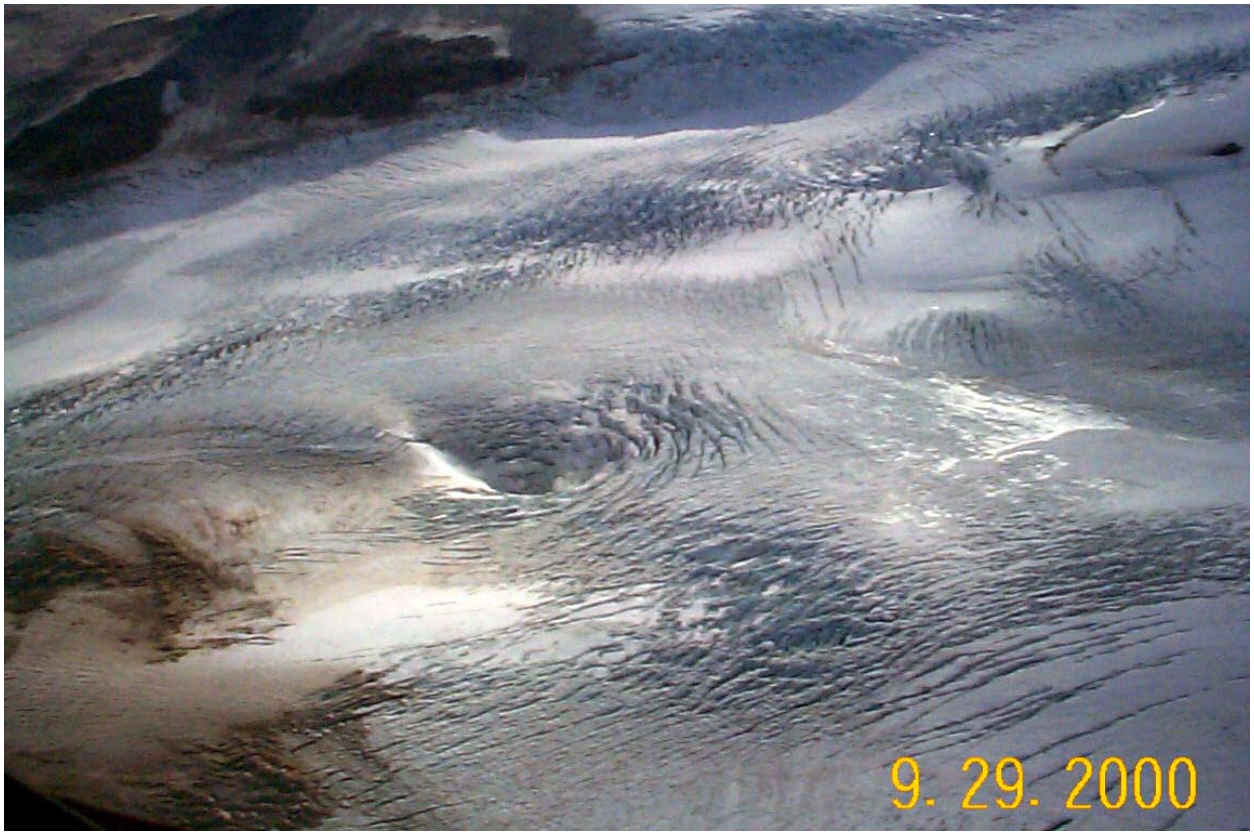


Figure 4a. View to the southwest. Curving, concentric crevasses in center of photo enclose an opening not visible from this perspective. Photograph by John Bundy, National Park Service (NPS), September 29, 2000.

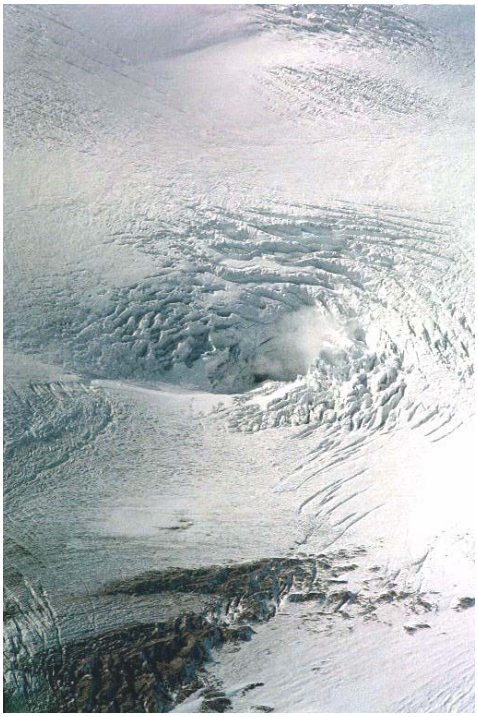


Figure 4b. View to the west (?) across the depression which is an estimated 100-200 m across. The central orifice (15-30 m across) is steaming slightly. Moraine debris visible in foreground. Photograph by John Bundy, NPS, October 8, 2000.

Figure 4c. View, nearly vertical, into the depression and slightly steaming opening (estimated to be 15-30 m across) in the ice. Glacier is generally flowing towards the bottom of photo. Photograph by John Bundy, NPS, October 8, 2000.

In Bundy's photos from both September 29 and October 8, a faint wisp of steam emerging from the orifice is visible. High winds and turbulence quickly dissipated the steam during the Bundy flights, but the original pilot report estimated the steam plume to rise 100-200 ft (30-60 m). Neither Bundy nor Hall observed other fumaroles in the area, including the nearby summit peaks of Snowy Mountain. Actively steaming fumaroles had been recorded at the highest Snowy peak in 1982 (Kienle and Swanson, 1983; Motyka and others, 1993), however, over the past several summers, USGS geologists Judy Fierstein and Wes Hildreth noted no sulfur smell or trace of fumarolic activity anywhere on the Snowy edifice.

AVO shared coordinates of the feature with the Alaska State Troopers and asked that they attempt to video the feature and capture FLIR imagery of the region as well; due to poor weather and scheduling, images were not obtained. Following the October 8 overflight by the National Park Service, AVO received no further reports of the hole or steaming for the remainder of 2000.

Based on several lines of evidence, the depression, central orifice, and minor, transient steam plume appear to be new features. We are not able to locate a similar structure on air photos from 1984 nor on Landsat images from 6 September 1999. It is uncertain exactly when the feature developed or became visible, however, based on Hall's comments, it was likely sometime during summer 2000. The gradual 'sag' towards the central orifice indicated by crevassing patterns suggests the depression developed slowly (perhaps over years?) rather than suddenly during a rapid deformation or melting event that would have produced steep ice walls (John Paskievitch, pers. comm. 2000). On the other hand, the feature is quite similar in appearance to the 'subsidence bowl' that developed over eruptive vents at Vatnajokull, Iceland, in 1996.

AVO detected no significant change in background seismicity in the area over the course of the year, arguing against an intrusive event or significant acceleration of hydrothermal activity. However, the southeast Snowy edifice is not well-captured within the Katmai area seismic net and very small events may have gone undetected (John Power, pers. comm. 2003). It is possible that changes in the surface of the glacier—retreat or other mass balance changes—have allowed an older feature to become more prominent at the surface. Retreat of glacier termini in the area (principally glaciers whose protective cover of 1912 ash has been stripped by erosion) is well documented by comparing aerial photographs from the mid-century with more recent photographs (Hildreth and others, 2001).

In the wake of publicity regarding the feature, AVO responded to a number of inquiries by phone and email. AVO staff also kept in contact with National Park Service office in King Salmon to discuss observations and interpretations and AVO staff consulted colleagues who were more familiar with the area's geology and history. AVO did not issue any special information releases or mention the observation in its weekly updates.

CHIGINAGAK VOLCANO
CAVW #1102-11
57°08' N 157°00' W
2,135 m (7,005 ft)

POSSIBLE CONTINUATION OF ELEVATED FUMAROLIC ACTIVITY
Steam emissions from fumarole field

In late December 2000, Navigation Officer Daniel Karlson contacted AVO to report observations of steaming from Chiginagak Volcano in late July and early August during NOAA operations off the Pacific coastline of the Alaska Peninsula. By their estimate, the steaming emanated from a source at approximately 5,200 ft (1,580 m) on the north flank of the volcano, approximately the position of the well-known fumarole long described for Chiginagak. Karlson noted that the cloud was white and constant much of the time, with a few episodes of increased output that extended "several miles" downwind. He reported that the activity appeared to diminish in intensity over time, ceasing altogether in early August.

Chiginagak began what may be a period of increased fumarolic activity in the fall of 1997 (McGimsey and Wallace, 1999; McGimsey and others, 2003). Over the next few years, AVO continued to receive intermittent reports of robust steam emission and, on one occasion, clouds of "black smoke" as viewed from the community of Pilot Point. A single flight to measure sulphur dioxide emission (resulting in a flux of 200-300 tonnes per day) was conducted in the fall of 1998, however with no prior or subsequent measurements we are unable to evaluate the true significance of this value.

Chiginagak is a symmetric stratovolcano located 175 km (110 mi) south of King Salmon on the Alaska Peninsula (cover photo). The nearest settlement is Pilot Point, 60 km (37 mi) to the northwest. The upper half of the volcano is snow-and ice-covered, and a prominent fumarole located high on the north flank at about 5,500 ft (~1,675 m) constantly emits steam and sulfur gases (Miller and others, 1998). Historic eruptive activity has been minor and remains poorly documented, however, the volcano is surrounded by late-Holocene pyroclastic deposits and lava flows. Chiginagak is unmonitored by seismic instruments.

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

MINOR ERUPTIVE ACTIVITY; PERIODS OF INCREASED SEISMICITY
Small steam and ash plumes occasionally prompt pilot reports

Following anomalous, post-eruption seismicity of late December 1999, a series of seismic events caused by small explosions were identified on January 15, 2000. No associated plumes or thermal anomalies appeared on satellite images. Re-analysis of seismic data for the previous several months revealed that similar small "explosion" seismic signals had been occurring intermittently since September 1999, several months after the end of the main phase of the 1999 eruptive activity (Nye and others, 2002). The January events were low-level and difficult to discern during the frequently inclement weather when background noise was high. The explosions prompted AVO to mention the change in the weekly update, however, the level of concern color code remained GREEN (table 4.) On January 28 and 29, vigorous steam plumes were observed rising up to about 3,000 ft (1,000 m) over Shishaldin. By early February, the frequency and amplitude of the overall seismicity, including the explosion events, had increased (up to 200 per day) and were accompanied by reports of vigorous steam plumes. The activity was interpreted to be small phreatic explosions within the cone's deep central crater. Noting that a similar pattern had developed in February 1999 prior to the onset of strombolian eruptive activity, AVO upgraded the color code to YELLOW on February 3. Fortuitously, the number of seismic events abruptly decreased the next day. The color code was lowered to GREEN on February 18. A small steam plume was observed in satellite images on February 22 that extended 15-20 km (9-12 mi) east of the volcano, and small, low-frequency seismic events continued through the spring.

Satellite analysis detected a few weak thermal anomalies in the summit crater through the spring and summer of 2000. On occasion, steam plumes extended up to 15 km (9 mi) from the summit. In early May, a significant increase in the number of small, low-frequency earthquakes was recorded, however no attendant change in thermal character or visual observations was noted, and seismicity declined by the end of summer. AVO mentioned both the seismicity and thermal anomalies in weekly updates for a period of one month, but remained at Level of Concern Color Code GREEN for the remainder of the year.

Shishaldin Volcano, located about 1,100 km (680 mi) southwest of Anchorage near the center of Unimak Island, is a spectacular, symmetric stratocone that forms the highest peak in the Aleutian Islands. 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, producing a sub-Plinian ash cloud to at least 14 km (~45,000 ft) on April 19, 1999 (Nye and others, 2002). Subsequently, during strombolian phases of the eruption, ash plumes reaching 20,000 ft (6 km) extended as far as 800 km (500 mi) from the volcano. The last confirmed magmatic activity occurred on May 27, 1999. 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.

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

Twenty-nine active volcanoes on Russia's Kamchatka Peninsula pose a serious threat to aircraft in the North Pacific (fig. 5). By agreement with the Institute of Volcanic Geology and Geochemistry (IVGG) and the Kamchatka Experimental and Methodical Seismology Department (KEMSD), both Institutes of the Russian Academy of Sciences, AVO assists with global distribution of information about eruptions in Russia (Kirianov and others, 2002). The Kamchatkan Volcanic Eruption Response Team (KVERT), consisting of scientists from both IVGG and KEMSD, issues via e-mail a weekly information release which AVO posts to our website and disseminates via facsimile and e-mail to recipients of our Alaska Volcanoes weekly updates. When volcanic activity intensified at any Kamchatkan volcano requiring notification of aviation interests, KVERT sends updates during the week as needed. Standard KVERT weekly updates—called Information Releases—are traditionally rebroadcast by AVO on Fridays.

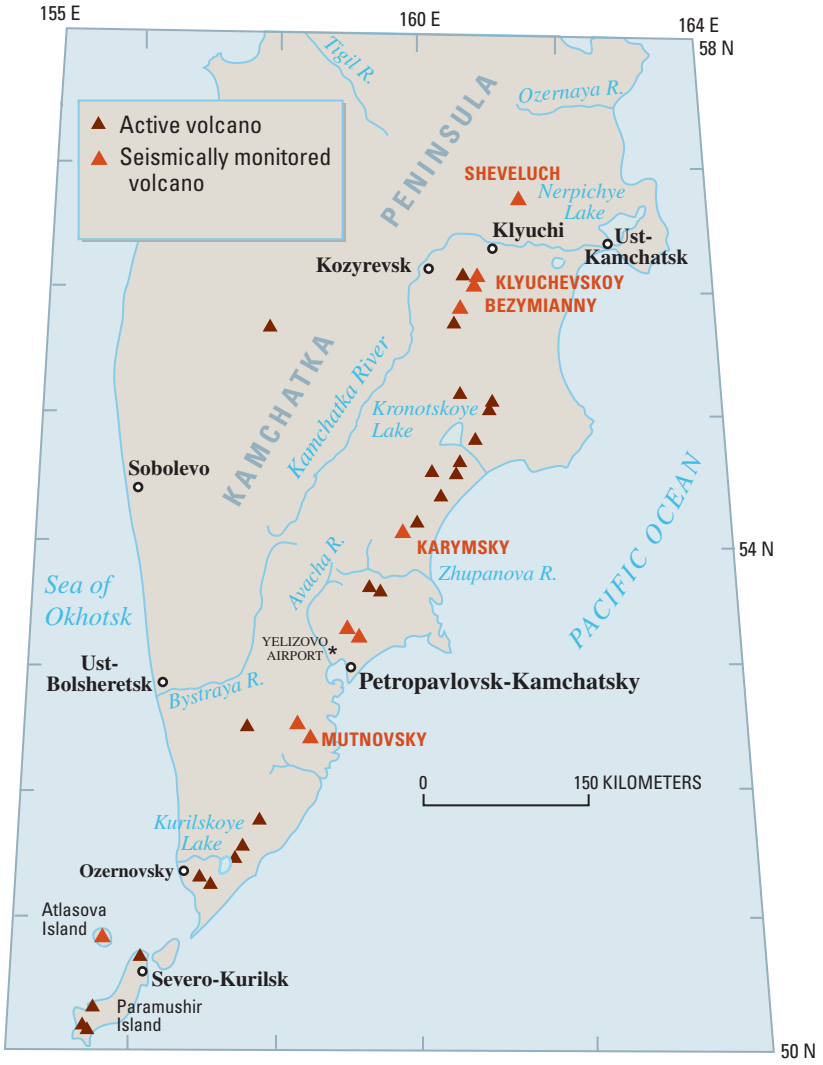


Figure 5. Map of the Kamchatka Peninsula and northern Kurile Islands. Volcanoes discussed in this report are labeled in red.

The KEMSD portion of KVERT monitors most of the frequently active volcanoes in Kamchatka with one or more short period seismometers. In addition, KVERT receives visual reports from scientific observers in the communities of Klyuchi and Kozyrevsk to the north and west of the Klyuchevskoy group of volcanoes. On occasion, KVERT also receives reports from observers near Karymsky Volcano. AVO shares with KVERT satellite information on the presence of thermal anomalies or ash plumes when detected as part of AVO's daily satellite monitoring program. In late 2000, AVO began to share daily interpretations of satellite imagery with KVERT by email. This information was then interpreted in the context of locally available information and included, as appropriate, in KVERT analyses of eruptive activity and in their public information releases. In its 2000 weekly reports, KVERT routinely reported on Sheveluch, Klyuchevskoy, Bezymianny, Karymsky, Avachinsky, and Koryaksky, and (beginning in March, 2000) Mutnovsky and Gorely Volcanoes. A key change in KVERT monitoring was the installation of a remote video camera system for Klyuchevskoy Volcano (online as of October 9, 2000). Images became available on the internet in near real-time at this url: http://data.emsd.iks.ru/video/video.htm

NOTE: Due to in interruption in funding, KVERT had to suspend reporting operations from April 28 through June 9. During this time, AVO kept in contact with KVERT staff, however no formal information releases were issued.

In 2000, AVO processed information about eruptions and volcanic unrest at 5 Kamchatkan volcanoes, 4 of which continued periods of unrest now spanning several years. Of note is the mid-March eruption of Bezymianny which produced an ash cloud that traveled west of the volcano out over the Sea of Okhotsk. Although not the first time this has occurred, this particular cloud underscores the fact that not all Russian volcano plumes travel east into US airspace, and air traffic routes to the west of Kamchatka (particularly the Polar Routes) are also at risk from explosive eruptions.

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 always 21 hours ahead of Alaska time. This compilation of summary descriptions is derived from a number of sources including KVERT weekly updates (available online at: http://www.avo.alaska.edu/avo4/updates/kvertarch.htm), unpublished AVO internal files and documentation, AVO bimonthly reports, and the Volcanic Activity Reports of the Bulletin of the Global Volcanism Network (available online http://rathbun.si.edu/gvp). Readers are referred to the publicly available sources listed above for more details.

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

CONTINUED DOME GROWTH AND COLLAPSE
Occasional fumarolic plumes rising 50-1000 m (~160-3,300 ft) over the volcano, periods of shallow seismicity and volcanic tremor. Short-lived explosions send ash as high as 10 km (~33,000 ft).

Lava dome growth at Sheveluch Volcano continued intermittently through 2000. During periods of relative quiet, background seismicity consisted of scattered small earthquakes and occasional volcanic tremor. At other times, seismicity varied in intensity as indicated by the number of shallow earthquakes or the amplitude of tremor. KVERT changed the level of concern color code for Sheveluch 18 times during the year. For most of the year, Sheveluch was in YELLOW status.

During periods of background seismicity, a fumarolic plume was occasionally visible over the lava dome rising to altitudes of 50-1000 m (~160-3,300 ft) above the dome (fig. 6). These plumes were visible downwind as far as 5-10 km (~3-6 mi).

Figure 6. Photograph of the active lava dome at Sheveluch Volcano. Dome is approximately 335 m high and contains an estimated 190 x 106 m^3 of blocky lava (Yuri Demyanchuk, unpublished data). Photograph taken on August 4, 2000 by Yuri Demyanchuk, KESMD.

A number of short-lived explosions producing transient ash plumes were either observed directly by personnel in Klyuchi or inferred from seismic data sent by the single seismometer operating near the volcano. Some plumes were subsequently verified using satellite imagery by AVO staff. When seen, these ash plumes rose typically to heights of 400-6,500 m above the dome (~10,000-30,000 ft). Minor ash fall was noted on the dome or adjacent volcano flanks on several occasions.

The largest explosions occurred on May 31, June 30 and August 6 (ash to 8 km (~26,000 ft), August 23, August 29; fig. 7), and September 13 when ash was estimated to reach 8-10 km (~26-33,000 ft). KVERT instituted Level of Concern Color Code ORANGE for the periods of unrest in August. Following the September 13 event, ash was seen on satellite imagery 300 km (~190 mi) east of the volcano.

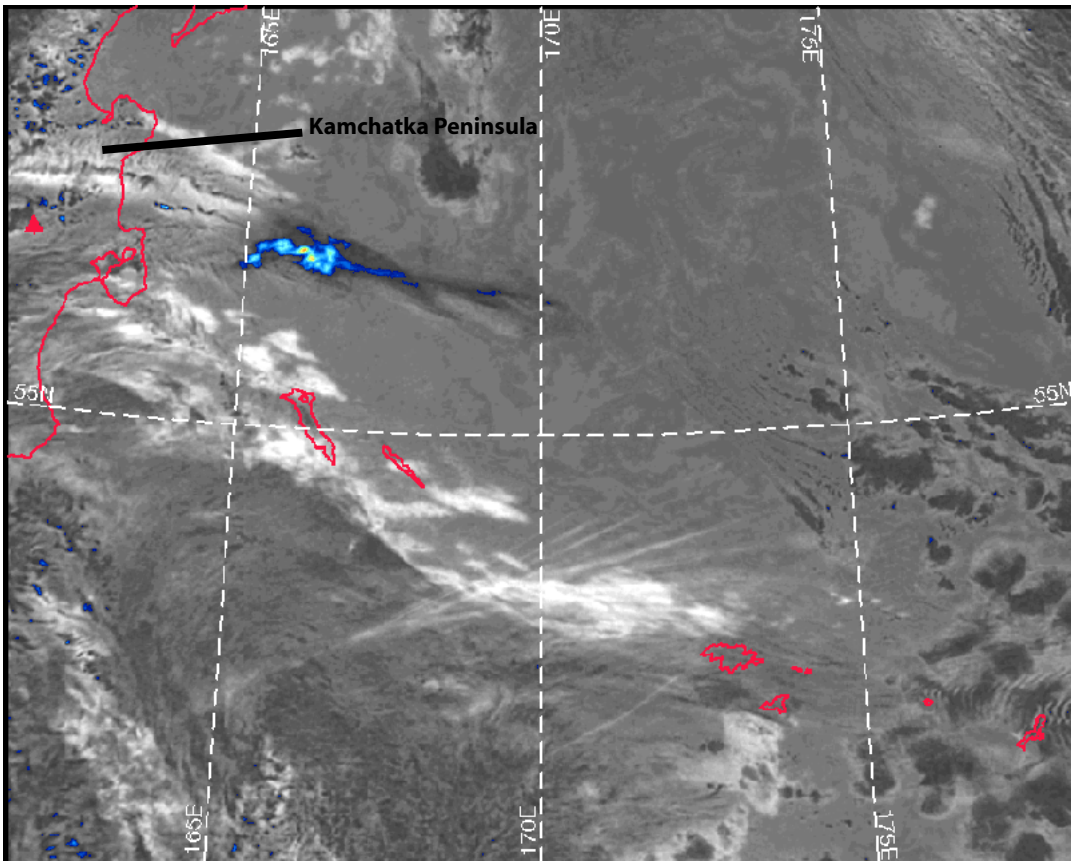


Figure 7. AVHRR satellite image, processed to show Band 4 minus Band 5 from 0339Z on August 29, 2000. Brightly colored area offshore from the Kamchatka Peninsula indicates coherent ash cloud detached from Sheveluch Volcano (red triangle) and drifting over the Bering Sea. Image courtesy Dave Schneider, AVO.

Sheveluch Volcano is one of the largest and most active volcanoes in Kamchatka with at least 60 large eruptions during the Holocene (Ponomerava and others, 1998; Belousov and others, 1999). 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 current protracted, episodic phase of lava dome growth began in August of 1980.

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

VULCANIAN EXPLOSIONS
Periods of elevated seismicity, persistent fumarolic plume from summit crater. Several explosive events send ash as high as 8-9 km (~26,000-29,500 ft).

Klyuchevskoy Volcano remained restless in 2000 with brief periods of elevated seismicity, occasional ash explosions, and strong fumarolic emissions from the summit crater. KVERT changed the level of concern color code from GREEN to YELLOW 4 times during the year, largely on the basis of sudden increases in seismicity or direct observation of explosive activity.

In addition to periods of minor gas and steam explosions from the crater, episodes of more vigorous explosive activity at Klyuchevskoy produced ash plumes or robust steam and gas plumes visible to overflying aircraft. On January 29, AVO responded to a pilot report (confirmed from the air later by AVO geologist Tom Miller en route to Petropavlovsk on a commercial airliner) of a 8-10-km-high (~26,000-33,000 ft), vigorous steam plume from Klyuchevskoy. On February 3, KVERT received a pilot report of a similar ash-poor cloud to 8-9 km (~26,000-29,500 ft). This cloud was confirmed by KEMSD staff on the ground in Klyuchi (fig. 8). This report coincided with a time of elevated seismicity and, using satellite data, AVO was able to detect an ash-bearing plume extending 40 km (~25 mi) southeast from the volcano. This event was short-lived and the ash cloud soon dissipated.

Figure 8. Ash plume rises over Klyuchevskoy Volcano. Photograph by Yuri Demyanchuk, KESMD, February 3, 2000.

On July 28, as KVERT elevated the Level of Concern Color Code to YELLOW based on increasing seismicity, observers in Klyuchi noted short-lived explosions of ash to an estimated 8 km (~26,000 ft). Additional explosions occurred on July 31 and August 7 based on seismicity. Earthquake activity increased sharply again on September 17, but no explosions ensued. During periods of quiet, an intermittent fumarolic plume ascended 50-2,500 m (~160-8,200 ft) above the summit and drifted downwind as much as 40 km (~25 mi).

Klyuchevskoy is a classic stratovolcano and, at 4,750 m (15,580 ft), the highest of the active European and Asian volcanoes. It 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 et al., 1991). Explosive eruptions are recorded in nearly every decade and at multiple times during most years since the early 1700s (Simkin and Siebert, 1994).

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

CONTINUED DOME GROWTH
Explosive eruption March 14, 2000, rock avalanches.

Bezymianny Volcano was relatively quiet for the first few months of 2000. This changed dramatically in mid-March. In the pre-dawn hours of March 14, strong tremor began at the volcano. AVO detected a 4-pixel thermal anomaly in the vicinity of the young lava dome and a small ash cloud on satellite images nearly coincident with the onset of tremor. KVERT elevated the Level of Concern Color Code to RED. By 0742 KST, a significant ash cloud estimated to reach 5.5-6.7 km (~18-22,000 ft) was drifting west, dropping ash on Kozyrevsk 50 km (~30 mi) west-northwest of the volcano. Seismicity began to decrease by 1000 KST and KVERT declared color code YELLOW. By 1100 KST, the ash cloud was visible 225 km (~140 mi) away. A second significant ash cloud was produced on March 16 reaching an estimated 7 km (according to the Tokyo Volcanic Ash Advisory Center [VAAC]) and detected up to 140 km (~87 mi) west of the volcano, prompting KVERT to return to Color Code ORANGE. AVO continued to track a thermal anomaly of increasing intensity on satellite imagery. Subsequent seismicity was also indicative of multiple avalanches of debris off the Bezymianny lava dome, occasionally associated with ash plumes (fig. 9). Seismicity returned to background by late March and the thermal anomaly was greatly diminished by late April.

Figure 9. Bezymianny Volcano, October 12, 2000. Ash rises from the active lava dome. Photograph by Andrei Nikiforov. Used with permission.

For the middle months of 2000, little or no seismicity was detected at the volcano. A short-lived explosive eruption was noted from Kozyrevsk on July 18. During periods of relative quiet, a fumarolic plume rose intermittently 50-2,000 m (~160-6,600 ft) above the dome and trailed as much as 60 km (~ 37 mi) downwind.

AVO detected the reappearance of the dome thermal anomaly in late September. On the basis of increasing anomaly size and past patterns of explosive dome collapses following recurrence of a persistent thermal anomaly, KVERT elevated the Level of Concern Color Code to YELLOW on October 18. Rock avalanche signals began to be detected on October 25 and on October 30, with the number and energy of shallow earthquakes increasing, KVERT declared ORANGE. Seismicity continued to increase and at 1800 UTC on October 30, ash was visible on satellite imagery 80 km (~50 mi) southeast of the volcano. Ash emission continued intermittently and ash clouds were tracked with satellite data. On November 2, a plume 6,500 m (~21,000 ft) high and extending at least 250 km (~155 mi) downwind was captured by satellite. This episode of eruption at Bezymianny prompted a high level of interest among air carriers and aviation authorities regarding status of the ash cloud and volcano and tested evolving communication protocols among all parties (KVERT, AVO, Tokyo VAAC, Anchorage Air Route Traffic Control Center, etc.). Over the next week, seismicity and the size of the thermal anomaly had decreased and remained low through the end of the year.

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 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; Belousov and others, 2002). Bezymianny is one of the most active volcanoes on the Kamchatka Peninsula.

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

VULCANIAN AND STROMBOLIAN ERUPTION
Continuation of 1996-99 activity; low-level vulcanian and strombolian eruptions, explosions, avalanches, degassing.

2000 was a relatively quiet year in the ongoing eruptive period at Karymsky. On February 13, KVERT upgraded the Level of Concern Color Code to YELLOW following an increase in seismicity indicative of explosions and vigorous gas emission from the summit crater. On February 15, 40-60 explosive events were detected each hour, along with seismicity related to possible pyroclastic flows and low frequency tremor. No ash plume was detected or reported, although AVO noted a 4-pixel thermal anomaly on February 17. Over the course of the next six weeks, the

rate of explosion signals varied in number from tens to hundreds per day, and pilots reported ash rising up to 1,500 m (~4,900 ft) above the cone. AVO continued to recognize elevated surface temperatures in satellite data through late March. A pilot report of a dilute ash plume reaching 5 km (~16,000 ft) was reported on April 1. KVERT reverted to GREEN on April 14, returning briefly to YELLOW for one week from December 22-29 in response to increasing shallow earthquakes, explosions, and a pilot report of new ash and lahars on the volcano's flanks.

Explosive and effusive-explosive eruptions of andesitic tephra and lava flows alternating with periods of repose are typical of eruptive activity Karymsky (Ivanov and others, 1991). The current phase of unrest began with increasing seismicity below the volcano in mid-April, 1995, culminating in an explosive eruption that began on January 1, 1996, at the north end of Karymsky Lake and then shifted to the volcano's summit (Belousov and Belousov, 2001). For the remainder of 1996, periods of explosive eruptions of ash and small blocks alternated with periods of lava flow production (Neal and McGimsey, 1997). The eruption continued intermittently through 1997-98. Karymsky usually issues a continuous steam plume and is the most active volcano on the Kamchatkan Peninsula (Simkin and Siebert, 1994).

MUTNOVSKY
CAVW #1000-06
52°27' N 158°12' E
2,324 m (7,625 ft)
Kamchatka Peninsula, Russia

GAS AND STEAM EXPLOSION
Plume of gas and steam rises 1 km (~3,300 ft) above Mutnovsky Volcano on March 17. Accompanied by shallow seismic event and low frequency tremor.

KVERT reported a short-lived explosive eruption apparently from Gorely Volcano on March 17 and raised the level of Concern Color Code to YELLOW for both Gorely and Mutnovsky, located only 15 km apart and monitored by a single seismic station. Two transient gas-steam plumes were observed rising to ~ 3 km (~9,800 ft) from Petropavlovsk, 70 km (43 mi) distant at 0700 and 1300 local time. A shallow seismic event was detected associated with the explosion(s). Upon further examination of the data, KVERT corrected this report to indicate Mutnovsky Volcano as the source of the plume. Helicopter observations indicated the source of the eruption to be the north crater of the summit crater complex; ejecta included ash and blocks of altered rock (Smithsonian Institution, 2000). The Color Code reverted to GREEN one week later, although low frequency volcanic tremor continued into early July. A second phreatic eruption inferred from seismicity was reported on June 30. For the remainder of the year, intermittent fumarolic activity produced steam plumes rising hundreds of meters above the summit of Mutnovsky. Small phreatic explosions in early October produced gas and steam plumes as high as 1,000 m above Mutnovsky.

Mutnovsky Volcano is composed of four overlapping stratovolcanoes, (fig. 10) the youngest of which is early Holocene in age. Simkin and Siebert (1994) record 11 eruptions in the 20th century, most of which were small phreatic explosions except for a lava-flow-producing event in

1904. Commerical development of the volcano for geothermal power is underway. Gorely Volcano is about 15 km northwest of Mutnovsky and consists of a large multiple stratovolcano complex within a Pleistocene caldera. Historical eruptions from Gorely have been largely phreatic and vulcanian explosions from a central crater (Simkin and Siebert, 1994).

Figure 10. Photograph of Mutnovsky Volcano, July 1995, by Michael Zelensky. Used with Permission.

REFERENCES

Belousov, A., Belousova, M, and Voight, B., 1999, Multiple edifice failures, debris avalanches and associated eruptions in the Holocene history of Shiveluch volcano, Kamchatka, Russia: Bulletin of Volcanology, v. 61, n. 5, p. 324-342.

Belousov, A. and Belousov, M., 2001, Eruptive process, effects, and deposits of the 1996 and the ancient basaltic phreatomagmatic eruptions in Karymsky lake, Kamchatka, Russia: Special Publications International Association of Sedimentology, v. 30, p. 35-60.

Belousov, A., Voight, B., Belousova M., and Petukhin, A., 2002, Pyroclastic surges and flows from the 8-10 May 1997 explosive eruption of Bezymianny volcano, Kamchatka, Russia, Bulletin of Volcanology, v.64, p. 455-471.

Girina, O.A., Bogoyavlenskaya, G.E., and Demyanchuk, Yu. V., 1993, Bezymyannyi eruption of August 2, 1989: Volcano Seismology, v. 15, n. 2, p. 135-144.

Hildreth, W, Fierstein, J., Lamphere, M. A., and Siems, D.F., 2001, Snowy Mountain: A pair of small andesite-dacite stratovolcanoes in Katmai National Park: in Geologic Studies in Alaska by the U.S. Geological Survey, Larry P. Gough and Frederic H. Wilson, eds., U.S. Geological Survey Professional Paper 1633, p. 13-34.

Ivanov, B., Braitseva, O.A., and Zubin, M.I.m 1991, Karymsky Volcano, Chapter 21 in: Active Volcanoes of Kamchatka, S.A. Fedotov and Yu. P. Masurenkov, (eds.), Moscow Nauka Publishers (Moscow), Volume 2, p. 202-203.

Kienle J., and Swanson, S., 1983, Volcanism in the eastern Aleutian arc: Late Quaternary and Holocene centers, tectonic setting, and petrology: Journal of Volcanology and Geothermal Research, v. 17, p. 393-432.

Kirianov, V.Y., Neal, C.A., Gordeev, E.I., and Miller, T.P., 2002, KVERT (Kamchatkan Volcanic Eruptions Response Team): USGS Fact Sheet 064-02 in English and Russian. Also online: http://geopubs.wr.usgs.gov/fact-sheet/fs064-02/

Khrenov, A.P., Dvigalo, V.N., Kirsanov, I.T., Fedotov, S.A., Gorel'chik, V.I., and Zharnov, N.A., 1991, Klyuchevskoy Volcano, Chapter 6 in: Active Volcanoes of Kamchatka, S.A. Fedotov and Yu. P. Masurenkov, (eds.), Moscow Nauka Publishers (Moscow), Volume 1, p. 146-163.

McGimsey, R.G., and Wallace, K.1999, 1997 Volcanic Activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 99-448, 42 p.

McGimsey, R.G., Neal, C.A., and Girina, O., 2003, 1998 Volcanic Activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 03-423, 35 p.

Miller, T.P., McGimsey, R.G., Richter, D.H., Riehle, J.R., Nye, C.J., Yount, M.E., and Dumoulin, J.A., 1998, Catalog of the historically active volcanoes of Alaska: U.S. Geological Survey Open-File Report 98-582, 104 p.

Motyka, R.J., Liss, S.A., Nye, C.J., and Moorman, M.A., 1993, Geothermal Resources of Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 114, 17 p.

Neal, C.A., and McGimsey, R.G., 1997, 1996 volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 97-433, 34 p.

Nye, C. J., 1991, Mount Wrangell, in: Volcanoes of North America, Wood, C.A., and Kienle, J., eds., Cambridge University Press, p. 88-89.

Nye, C.J., Keith, T.E.C., Eichelberger, J.C., Miller, T.P., McNutt, S.R., Moran, S., Schneider, D.J., Dehn, J., and Schaefer, J.R., 2002, The 1999 eruption of Shishaldin Volcano, Alaska: monitoring a distant eruption: Bulletin of Volcanology, v. 64, n. 8, p. 507-519.

Ponomoreva, V.V., Pevzner, M.M., and Melekestsev, I.V., 1998, Large debris avalanches and associated eruptions in the Holocene eruptive history of Shiveluch Volcano, Kamchatka, Russia, Bulletin of Volcanology, v. 59, n. 7, p. 490-505.

Richter, D.H., Rosenkrans, D.S., and Steigerwald, M.J., 1995, Guide to the volcanoes of the western Wrangell Mountains, Alaska: U.S. Geological Survey Bulletin 2072, 31 p.

Simkin, T., and Siebert, L., 1994, Volcanoes of the world, Tucson, Arizona, Geoscience Press, Inc., 349 p.

Smithsonian Insitution, 2000, Bulletin of the Global Volcanism Network, v. 25, n. 5.

Voight, B., Glicken, H., Janda, R.J., and Douglass, P.M., 1981, Catastrophic rockslide avalanche of May 18, in Lipman, P.W., and Mullineaux, D.R., eds., The 1980 eruptions of Mount St. Helens, Washington: U.S. Geological Survey Professional Paper 1250, p. 347-378.

ACKNOWLEDGMENTS

We thank Jim Dixon and Judy Fierstein for helpful reviews. Steve Smith, Andrea Steffke, and Courtney Kearney assisted compiling Kamchatka images. Christy Severtson was responsible for final publication layout.

Table 1. Summary of 2000 VOLCANIC ACTIVITY in Alaska, including actual eruptions, possible eruptions, and unusual increases in fumarolic activity. Location of volcanoes shown in Figure 1.

Volcano	Date of Activity	Type of Activity
Snowy Mountain	mid-September	Steaming hole in glacier on the southeast flank.
Chiginagak Volcano	late July-early August	Continuation of vigorous steaming from fumarole field on north flank.
Shishaldin Volcano	January 15 through	Minor eruptive activity; Periods of increased seismicity.

Table 2. Summary of SUSPECT VOLCANIC ACTIVITY (SVA) in 2000. 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. Location of volcanoes shown in Figure 1.

Volcano	Date of Activity	Type of Activity
Wrangell Volcano		Steam plumes sighted on March 18 and earlier in the year

Table 3. Summary of VOLCANIC ACTIVITY on Kamchatka Peninsula, Russia, 2000. Location of volcanoes shown in figure 10.

Volcano	Date of Activity	Type of Activity
Sheveluch Volcano		Occasional fumarolic plumes and periods of shallow seismicity and volcanic tremor. Short-lived explosions send ash as high as 10 km (~33,000 ft).
KlyuchevskoyVolcano		Periods of elevated seismicity, persistent fumarolic plume from summit crater. Several explosive events send ash as high as 8-9 km (~26,000-29,500 ft).
Bezymianny Volcano		Explosive eruption and rock avalanches.
Karymsky Volcano	Continuation of 1996-99 activity	Low-level vulcanian and strombolian eruptions, explosions, avalanches, degassing.
Mutnovsky Volcano	March 17, 2000	Plume of gas and steam rises 1 km (~3,300 ft) accompanied by shallow seismic event and low frequency tremor.

Table 4. Level of Concern Color Code for Volcanic Activity

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.

FOR PHOTOGRAPHIC IMAGES OF VOLCANOES IN THIS REPORT:

Duplicate 35-mm slides and prints of some volcanoes discussed in this report are available from:
The Photo Library
U.S. Geological Survey
MS 914 Box 25046 Federal Center
Denver, CO 80225-0046
303-236-1010

Also, for digital images of Alaskan and Russian volcanoes, please see the following web sites:
www.avo.alaska.edu
http://volcanoes.usgs.gov/
http://www.volcano.si.edu/gvp/

PHOTOGRAPHS OF THE 1989-90 ERUPTIONS OF REDOUBT VOLCANO, ALASKA, USGS Open-file Report 96-689, 20 slides, 10 p. text and glossary, by A.L. Roach, C.A. Neal, and R.G. McGimsey.

PHOTOGRAPHS OF THE 1992 ERUPTIONS OF CRATER PEAK, SPURR VOLCANO, ALASKA, USGS Open-file Report 93-707, 20 slides, 8 p. text and glossary, by Christina A. Neal, Robert G. McGimsey, Michael P. Doukas, and Inyo Ellerseick, 1993. 20-slide set illustrating aspects of the 1992 eruptions. Includes captions and glossary.

VOLCANOES OF THE WRANGELL MOUNTAINS AND COOK INLET REGION, ALASKA-SELECTED PHOTOGRAPHS, U.S. Geological Survey, Digital Data Series 96-039, 1996, CD-ROM. Also available for download via the internet: http://wrgis.wr.usgs.gov/dds/dds-39/

VOLCANOES OF THE ALASKA PENINSULA AND ALEUTIAN ISLANDS, ALASKA-SELECTED PHOTOGRAPHS, U.S. Geological Survey, Digital Data Series 96-040, 1996, CD-ROM. Also available for download via the internet: http://wrgis.wr.usgs.gov/dds/dds-40/

The publications listed above are available from:

U.S. Geological Survey ESIC-Open-File Report Section
Box 25286, MS 517
Denver, CO 80225-0046
303-236-7476

OTHER MULTI MEDIA PRODUCTS OF INTEREST

"VIDEO OF THE AUGUST 18,1992, ERUPTION OF CRATER PEAK VENT ON SPURR VOLCANO, ALASKA", by Robert G. McGimsey and Joseph M. Dorava, 1994, USGS Open-File Report 94-614. This 25-minute, narrated video presents dramatic scenes of the second of three 1992 eruptions of Crater Peak, a satellite vent on Spurr volcano, Alaska. Favorable weather conditions permitted scientists from the Alaska Volcano Observatory to photograph the eruption from a fixed-wing aircraft flying as close as 2 km to the vent. The video includes close-up views of the roiling, 18-kilometer-high eruption column, shockwaves emanating from the column base, ash clouds from pyroclastic flows on the southeast flank, and ash fallout downwind.

"10 YEARS OF VOLCANIC ACTIVITY IN ALASKA: 1983 TO 1992: A VIDEO", by Michael P. Doukas, Robert G. McGimsey, and Joseph M. Dorava, 1995, USGS Open-File Report 95-61. This 28-minute video presents eruption images from eight Alaskan volcanoes during the ten-year period: Veniaminof (1983-84), Augustine (1986), Redoubt (1989-90), Akutan (1991), Bogoslof (1992), Westdahl (1992), Spurr (1992), and Seguam (1992). Classic volcanic phenomena are documented, including meltwater lakes formed when lava flows advanced into an ice-filled caldera (Veniaminof), nighttime views of explosive strombolian activity (Veniaminof), pyroclastic flows descending steep flanks during plinian-and peleean-style eruptions (Augustine), hawaiian-style lava fountaining through glacial ice (Westdahl), island building in the Aleutians (Bogoslof), shock waves and close-up views of a roiling, sub-plinian eruption column rising more than 18 kilometers (Mount Spurr volcano-Crater Peak vent).

The videotapes are available from:

U.S. Geological Survey
ESIC-Open-File Report Section
Box 25286, MS 517
Denver, CO 80225-0046
(303) 236-7476
US or Canada 1-800-684-3368
FAX (907) 273-9192

AND

Action Video
Attn: Karl Augestad
430 W. 7th Ave., Suite 100
Anchorage, AK 99501
(907) 277-8115
FAX (907) 274-8115
e-mail: actvid@alaska.net

GLOSSARY OF SELECTED TERMS

ADT:
: "Alaska Daylight Time"

AEIC:
: "Alaska Earthquake Information Center"

ASL:
: "above sea level"

AST;
: "Alaska Standard Time"

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 (SiO_2, 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 45-52 weight percent silica (SiO_2, 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

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"

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"

GVN:
: "Global Volcanism Network"

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

incandescent:
: glowing red or orange due to high temperature

intracaldera:
: refers to something within the caldera

IVGG:
: Russian "Institute of Volcanic Geology and Geochemistry"

JMA:
: "Japanese Meteorological Agency"

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

KST:
: Russian “Kamchatkan Standard Time”, which = AST + 21 hrs.

KEMSD:
: Russian “Kamchatka Experimental and Methodical Seismology Department”

KVERT:
: Russian “Kamchatkan Volcano Eruption Response Team”

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

magma:
: molten material below the surface of the earth

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

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

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 (e.g. Mauna Loa, Hawaii)

SIGMET:
: “Significant Meteorological information statement”, issued by FAA

stratovolcano:
: (also called a stratocone or composite cone) a steep-sided volcano, usually conical in shape, built of 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

subplinian:
: style of explosive eruptions characterized by vertical eruption columns and widespread dispersal of tephra

SVA:
: “suspect volcanic activity”

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

TFR:
: “Temporary Flight Restriction”, issued by FAA

UAFGI:
: “University of Alaska Fairbanks Geophysical Institute”

USCG:
: “U.S. Coast Guard”

USGS:
: “U.S. Geological Survey”

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

VAAC:
: “Volcanic Ash Advisory Center”

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