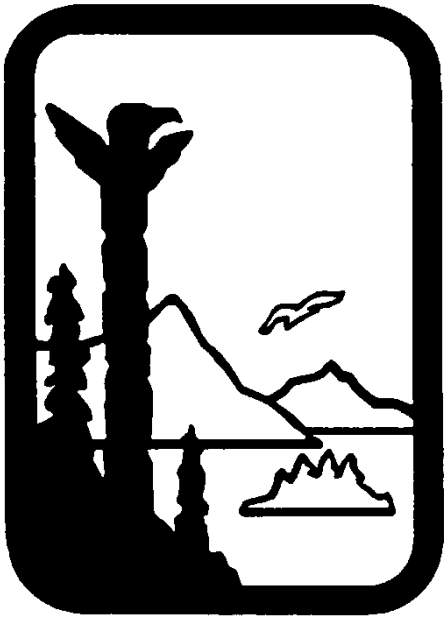
Alaska Department of Environmental Conservation



Amendments to:
State Air Quality Control Plan

Volume III: Appendix III.K.4.a

Alaska Volcano Observatory Events near Simeonoff Class 1 Area: Examples from 2002-2006

Appendix to
Section III. K: Areawide Pollutant Control Program for Regional Haze

Adopted

February 11, 2011

(This page serves as a placeholder for two-sided copying)

Alaska Volcano Observatory Events near Simeonoff Class 1 Area: Examples from 2002-2006

Eruptions

(Reports from search tool at http://www.avo.alaska.edu/volcanoes/eruptsearch.php)

Veniaminof 2002, 2004, 2004, 2005

Event Specific Information: Veniaminof - 2002

Eruption Type: Explosive
MaxVEI: 1 * Uncertain

Start: September 28, **2002** Observed
Stop: March 223, **2003** ± 1 Months Observed

Tephra plume
Phreatic

Description: From Neal and others (**2005**): "On the basis of several days of increasingly frequent, emergent seismic events on multiple stations of the new Veniaminof network (Dixon and others, **2002**), AVO announced Level of Concern Color Code YELLOW on September 11, **2002**. Following established protocols, the Anchorage Volcanic Ash Advisory Center (VAAC) issued a one-time volcanic ash advisory [see fig. 4 in original text].

"Over subsequent weeks, seismicity was characterized by periods of above-background activity alternating with quiet intervals. Telephone calls to Perryville and other nearby communities[see fig. 5 in original text] turned up no unequivocal observations of unrest until September 24 when AVO received phone reports and digital photographs from the Perryville Native Council. These images showed small, faint gray clouds rising just above the intracaldera cone that has been the source of all known historical eruptions at Veniaminof (Miller and others, 1998). One observer described 'puffs' of mixed dark and white clouds approximately every 5 minutes. Another observer described the 'puffs' as solid white and emanating from the top of the cone.

"Perryville residents next reported 'plumes of smoke' between 8 and 10 pm on October 1. Others reported 'rumbling' during the evening, however no clearly correlative signals were noted on seismograms. One and one half minutes of video taken on October 2 or 3, about 2 pm, from the vantage of the Sandy River (~45 km [28 mi] west of the active cone) showed several small, dilute, gray-brown clouds rising about 300-600 ft above the intracaldera cone and drifting a short distance to the north. In the 1.5 minutes of tape, two distinct 'puffs', about 1 minute apart, rise from the cone and drift downwind. The cone was not unusually snow free, however, a dark covering of ash was visible on the caldera ice field at the base of the cone and extending generally north. On October 6, Sandy River Lodge [see fig. 5 in original text] reported black ash and 'smoke' rising 400-500 ft above the cone, explosions, and ground shaking.

"Cloud-free satellite images of the Veniaminof caldera revealed nothing unusual until October 2 when AVO acquired a Moderate Resolution Imaging Spectroradiometer (MODIS) image that captured a localized, gray deposit on the caldera ice field [see fig. 6 in original text]. The image shows a faint, fan-shaped deposit extending generally east from the cone to the caldera boundary and perhaps just beyond. When viewed in light of reports from Perryville and the video from Sandy River, the dark fan likely represents ash fall from low-level phreatic activity on October 1. No thermal anomalies were detected in satellite imagery throughout this period and no incandescence was reported. A compilation of reports from residents and other observers through the end of the year is presented in table 3. Seismicity and reports of discolored clouds over the intracaldera cone gradually declined through the fall.

"A re-invigorated hydrothermal system beneath the intracaldera cone may account for these intermittent ejections of diffuse, ash-bearing clouds. It seems unlikely that this was prompted by a new magmatic intrusion at depth based on the lack of volcano-tectonic earthquakes. Increased hydrothermal activity may have been related to what was,

according to some long time residents of the area, one of the rainiest autumns in memory. Although precipitation falling at the elevation of the intracaldera cone would have been in the form of snow (C. Searcy, NOAA, oral.commun., **2003**), precipitation in Cold Bay [see fig. 1 in original text] was approximately 80% above normal for the month of October, according to long term climate records maintained by NWS (National Oceanic and Atmospheric Administration: http://www.arh.noaa.gov/climate.php). King.Salmon, the other nearby long-term weather station, recorded approximately 45% and 60% more precipitation than normal in the months of September and October, respectively."

The **2002** activity continued into **2003**. From McGimsey and others (**2005**): "On January 3, **2003**, AVO belatedly received a report from the caretaker of a lodge located northwest of the volcano describing his observations from about mid-December, **2002**, during clear weather, of distinct puffs of steam coming from the intracaldera cone. AVO upgraded the Level of Concern Color Code to YELLOW on Monday, January 6, **2003**. Several weeks of poor weather conditions followed before clear views revealed that intermittent episodes of steam and diffuse ash emissions from the active cone continued [see fig. 15 in original text]. AVO seismologists detected the onset of small, volcano-tectonic earthquakes on Veniaminof seismic stations beginning on the morning of January 29, **2003** and a commensurate decline in amplitudes and numbers of low-frequency events (S. Moran, written communication). Elevated seismicity continued, and on March 11, a 4-hour period of continuous seismic tremor was observed followed by 17 hours of discrete seismic events and 3-4-minute-long tremor bursts. This culminated with another 4-hour period of continuous tremor on March 12, which was followed by a distinct decline in seismicity over the next several days. The last report of emissions from the active cone was from Mark Battaion in Perryville on March 23, **2003** [see fig. 16 in original text].

From Neal and others (**2005**): "In the summer of **2003**, AVO geologists visited the summit caldera of Veniaminof and examined the intracaldera cone for evidence of the **2002** activity (K. Wallace, written.commun., **2003**). Within 50 m (160 ft) of the east side of the cone, the ice surface was dusted with fine wind blown debris derived from the cone. A crevasse at the base of the cone revealed a prominent, 1-cm-thick (0.4 in), black, scoriaceous deposit 1 m (3 ft) beneath the surface [see fig. 7a, b, in original text]. Scoria fragments ranged from fine ash to medium lapilli (with a maximum diameter of 5 mm [0.2 in]). The base of the crevasse was not visible, however no other debris layers were recognized over a thickness of at least 10 m (33 ft) suggesting that this type of depositional event was not common (e.g. wind reworking of cone debris). In hand sample, the tephra consists of abundant black iridescent, glassy scoria; hydrothermally altered scoria (with native sulfur and secondary minerals); and rare individual crystals. Microscopic investigation showed all glass fragments to be devitrified. Wallace and co-workers concluded that this deposit represented recycled cone material ejected during low-level phreatic explosions in October **2002**.

"In response to the **2002** unrest at Veniaminof, AVO staff conducted outreach to communities in the vicinity of the volcano and compiled contact phone lists of observers and others who would be helpful in tracking activity on our behalf. We were in frequent telephone contact with people in Perryville, regional airlines, and our colleagues at U.S. Fish and Wildlife Service (USFWS) and the Alaska State Troopers who were often flying in the area. At least one private lodge near the volcano contacted AVO for information on potential hazards. AVO posted a 'Frequently-Asked-Questions' about Veniaminof on our web site, a first in the history of AVO.

"Interestingly, the change in Level of Concern Color Code to YELLOW for Veniaminof occurred on September 11, **2002**, during a time when the Department of Homeland Security had recently established a Threat Level of ORANGE. It is therefore possible that reaction to our initial information release on September 11 may have been more pronounced than usual, and confusion over the two color designations may explain why some residents of the Peninsula thought AVO had declared an 'imminent' eruption.

"From September 11 to November 18, **2002**, AVO issued three special information release notices on the increased seismicity and its eventual decline at Veniaminof. The volcano was mentioned in weekly updates from September 13 through November 22. AVO reverted to color code GREEN on November 18. During the time of heightened activity, the AVO seismology and remote sensing groups increased the frequency of analysis of Veniaminof seismicity and relevant satellite imagery."

Event Specific Information: Veniaminof - 2004

Eruption Type: Explosive
ColHeight: 3500 m
MaxVEI: 2

Start: February 19, **2004** Observed
Stop: September **2004** Observed

Tephrafall
Tephra plume
Central eruption
Phreatic

Description: From Neal and others (**2005**): "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 [see fig. 13 in original text]. 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, **2005**). 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.

"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 [see fig. 14 in original text].

"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.

"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 [see figs. 16, 17 in original text]. 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.

"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."

Event Specific Information: Veniaminof - 2004

Eruption Type: Explosive
ColHeight: 3500 m
MaxVEI: 2

Start: February 19, **2004** Observed
Stop: September **2004** Observed

Tephrafall
Tephra plume
Central eruption
Phreatic

Description: From Neal and others (**2005**): "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 [see fig. 13 in original text]. 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, **2005**). 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.

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"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.

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level of concern color code to GREEN based on a decline in the level of activity and an accompanying decrease in seismicity.

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Event Specific Information: Veniaminof - 2005

Eruption Type: Explosive
Duration: About 2 months * Intermittent, low-level ash emissions
MaxVEI: 1
ColHeight: 3000 m * Maximum height

Start: September 7, 2005 Observed
Stop: November 4, 2005 Observed

Tephrafall
Tephra plume
Minor explosive eruption

Description: From McGimsey and others (2007): "Veniaminof remained relatively quiet [since February, 2005] until early September when several minor bursts of ash were observed by Perryville residents and visible on the web camera (see fig. 34 in original text). This and an increase in seismicity prompted AVO to elevate the Level of Concern from Green to Yellow on September 7. The minor unrest continued only for a couple of weeks when seismicity once again decreased to background level and there were no observations of emissions. AVO reduced the Level of Concern from Yellow to Green on September 28.

"Then, on November 4, a low-level, minor ash emission visible in the webcam prompted AVO to raise the Level of Concern from Green to Yellow. Slightly elevated seismicity persisted for the next few weeks but poor weather conditions precluded visual observations. By mid-December, seismic levels were again down to background level, and on December 30, the Level of Concern was downgraded from Yellow to Green, the 8th Color Code change of the year for Veniaminof (see table 6 in original text)."

From the Smithsonian Institution (2006, v. 31, n. 3): "On 7 September 2005, the Alaska Volcano Observatory (AVO) noted several minor bursts of ash from the volcano during the afternoon. Ash bursts continued to occur through at least 9 September, with ash rising less than 3 km altitude, and with the ash confined to the caldera. Over the following 2 weeks, minor ash emission continued at a rate of 1-5 events per day based on interpretations of seismic data. AVO reported that it was likely that diffuse ash plumes rose to heights less than ~ 3 km and were confined to the summit caldera. Cloudy weather during 16-23 September prohibited web-camera and satellite observations of Veniaminof, but seismic data indicated diminishing activity. On 28 September seismicity had remained at background levels for over a week, and there was no evidence to suggest that minor ash explosions were continuing.

"On 4 November 2005, a low-level minor ash emission occurred from the intracaldera cone beginning at 0929. Ash rose a few hundred meters above the cone, drifted E, and dissipated rapidly. Minor ashfall was probably confined to the summit caldera. During the previous 2 weeks, occasional steaming from the intracaldera cone was observed. Very weak seismic tremor and a few small discrete seismic events were recorded at the station closest to the active cone. However, AVO reported that there were no indications from seismic data that a significantly larger eruption was imminent."

Shishaldin 2004.

Event Specific Information: Shishaldin - 2004

Eruption Type: Explosive
Duration: Intermittent for 3 months
MaxVEI: 1
ColHeight: 5500 m * 4800-5500 m, reported from Cold Bay on Feb. 26, **2004**.

Start: February 17, **2004** Observed
Stop: May 17, **2004** Observed

Steam
Tephra plume
Central eruption

Description: From Neal and others (**2005**): "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 [See figures 18-20 in original text].

"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."

Augustine 2005

Event Specific Information: Augustine - 2005

Eruption Type: Explosive
Duration: About 3 months * Includes explosive and extrusive phases
Eruption Product: andesite
MaxVEI: 3
ColHeight: 9000 m * higher than

Start: December **2005** Observed
Stop: March 31, 2006 Observed

Lava flow
Tephrafall
Pyroclastic flow, surge, or nuee ardente
Lava dome
Fumarolic or hydrothermal activity
Steam
Tephra plume
Phreatic

Description: From Power and others (2006): The 2006 eruption of Augustine consisted of four phases defined by the character of unrest or eruptive activity, which are described below. These phases are the precursory (May **2005** to 11 January 2006), the explosive (11 to 28 January), the continuous (28 January to 2 February), and the effusive (2 February to late March).

"The precursory phase began as a steady increase in microearthquakes beneath the volcano, ranging from one to two per day in May **2005** to 15 per day in mid-December [see Figure 3 in original text]. In July **2005**, geodetic baselines began to lengthen, indicative of pressurization at sea level centered beneath the edifice (Cervelli et al., 2006). On 2 December **2005**, seismometers began recording signals from small phreatic explosions; the largest signals occurred on 10, 12, and 15 December. An overflight on 12 December revealed vigorous steaming, a new vent on the summit's southeastern side, and a dusting of ash on the volcano's southern flanks. The ash was a mix of weathered and glassy particles; the latter appear to be remobilized 1986 tephra. An explosion on 15 December disabled the telemetery for the two highest seismic stations [see figure 2 in original text].

"Augustine then entered an explosive phase, which lasted from 11-28 January 2006. A strong swarm of volcano-tectonic (VT) earthquakes began at 0030 UTC on 11 January, culminating in explosive eruptions at 1344 and 1412 UTC. These explosions produced ash plumes, reported by the U.S. National Weather Service (NWS) to have reached heights greater than nine kilometers above sea level (asl), which moved slowly to the north and northeast. Ash sampled on 12 January was primarily dense or weathered fragments, suggesting little juvenile magma. Over the next 36 hours, several sequences of small, regularly spaced VT earthquakes, many with identical waveforms, occurred at rates as high as three to four per minute. Similar earthquakes, referred to as clones or drumbeats, have been associated at other volcanoes with the emplacement of lava domes (Dzurisin et al., **2005**).

"Monitoring instruments also recorded six powerful explosions that occurred between 1324 UTC on 13 January and 0914 UTC on 14 January [see figure 3 in original text]. The first explosion destroyed the seismometer and CGPS

high on the volcano's northeastern flank [see figure 2 in original text]. Plumes reached altitudes of 14 kilometers asl and deposited traces of ash on southern Kenai Peninsula communities. Ash from these eruptions was more heterogeneous and contained dense particles as well as fresh glass shards, indicating the eruption of new magma. Satellite imagery tracked these plumes as they moved eastward and disrupted commercial airline traffic to and from Alaska.

"A 16 January overflight revealed a small, new lava dome at the summit. An explosive eruption at 1658 UTC on 17 January sent ash to 13 kilometers asl that moved westward. The eruption left a 20- to 30-meter-diameter crater in the new dome and produced ballistic fields on the volcano's western flanks. Data transmission from the west flank CGPS station stopped coincident with this explosion [see figure 2 in original text]. Additionally, the eruptions of 13-17 January generated pumiceous pyroclastic flows, snow avalanches, and lahars that moved down the volcano's flanks [see figure 2 in original text].

"The volcano then entered a period of more continuous eruptive activity that began at 0534 UTC on 28 January and that lasted until 2 February. The phase began with four explosive eruptions that generated ash plumes to heights of nine kilometers asl [see figure 3 in original text]. Ash moved southward and fell in trace amounts on Kodiak Island. These explosions generated substantial pumiceous pyroclastic, block, and ash flows that destroyed seismic and CGPS stations on the west and north flanks of the volcano [see figure 2 on original text]. Destruction of these seismometers compromised AVO's ability to assign reliable hypocentral depths to earthquakes.

"Data from the remaining CGPS stations indicated that the volcano reversed its long inflationary trend (during which accumulating magma caused a swelling of the volcano's surface) and began a sharp deflation that continued until 10 February [see figure 3 in original text]. Modeling suggests the locus of deflation, which results from the removal of magma, was much deeper (~10 kilometers) than the precursory signal. On 29 January, the seismic network began to detect numerous block and ash flows - generated by small failures of the growing lava dome - cascading down the volcanos northern flanks [see figure 2 in original text].

"Augustine then entered an effusive phase, which lasted through late March. From 2 February through 6 March, block and ash flow signals continued to dominate the seismic record. Geodetic data showed inflation from 10 February until 1 March, when the volcano again reversed and entered an 11-day period of deflation [see figure 3 in original text]. On 7 March, seismic activity again shifted to small, mostly identical repetitious earthquakes. These events increased in rate and size, forming a continuous signal early on 8 March that lasted until 14 March. They then began a slow decline and disappeared by 16 March. Lava extrusion at the summit increased markedly in association with these repetitive earthquakes, and two blocky lava flows moved down the north and northeastern flanks [see figures 1 and 2 in original text]. Observations indicate that the effusion of lava stopped in late March. The volcano entered a final period of inflation between 12 and 31 March. The estimated volume of effusively erupted material is currently 30 million cubic meters."

Cleveland 2005

Event Specific Information: Cleveland - 2005

Eruption Type: Explosive
MaxVEI: 2
ColHeight: 4600 m * detached from volcano?

Start: April 27, **2005** Observed
Stop: September 27, **2005** ± 3 Months Observed

Tephrafall
Lahar, debris-flow, or mudflow
Tephra plume
Minor explosive eruption

Description: From McGimsey and others (2007): "After several years of quiescence following an explosive eruption in 2001, AVO remote sensors observed a 3-pixel thermal anomaly at the summit of Cleveland on March 13, **2005** (see fig. 38 in original text). On April 27, **2005**, the FAA alerted AVO of a pilot report of eruptive activity - "ash cloud * * * 15,000 to 18,000 ft high" - in the vicinity of Cleveland (based on coordinates from the pilots). Satellite images showed no evidence of activity. AVO seismologists checked seismic data from the nearest stations (Nikolski, located 75 km [45 mi] east, and at Okmok Volcano, 150 km [93 mi} east of Cleveland), and found nothing unusual. CWSU issued a one-time Urgent Pilot Report, and AAWU issued a one-time SIGMET. Although time-series thermal data did not record any evidence of activity, short-lived minor explosive activity would not be considered unusual for Cleveland and could go undetected if it occurred during periods between acquisitions of satellite images or if concealed within the frequent cloud cover.

"Following the detection of a 1-pixel thermal anomaly at the summit on June 28, evaluation of before and after satellite images suggested the presence of a lahar deposit on the northeast flank, inferring that minor activity persisted at Cleveland. Then, on July 5, the entire upper flanks of the volcano were observed dusted with ash in a satellite image (see fig. 39 in original text). AVO rasied the Level of Concern Color Code from Unassigned (UA) to Yellow in an Information Release on July 7, **2005** (see table 6 in original text). The presence of ash, minor blocky avalanche-like deposits, and thermal anomalies was consistent with low-level Strombolian eruptive activity (D. Schneider, AVO logs).

"Thereafter, although a thermal anomaly was observed on August 11, the activity appeared to wane. AVO reduced the Color Code from Yellow back to UA on August 27. But the volcano remained restless, and a summit thermal anomaly again was observed on August 31. By mid-September, AVO was ready to test a new automated system that detects thermal anomalies and raises an alert. On September 21, this new system successfully detected a thermal anomaly at the summit of Cleveland. For the next few weeks, the volcano remained quiet. Then, on the morning of October 7, AVO detected in satellite images a small drifting ash cloud located about 150 km (90 mi) east-southeast of Dutch Harbor. On the basis of regional seismic data at Nikolski (75 km [45 mi] east of the volcano), and backtracking the ash cloud, AVO concluded that a small eruption had occurred at Cleveland at approximately 01:45 ADT (0945 UTC). AVO and the NWS worked together to determine that the ash cloud was at an altitude of no more than 15,000 ft (4,600 m). No ash fell in Nikolski. AVO immediately raised the Color Code from UA to Orange and NWS issued a SIGMET indicating that the ash cloud was moving east. The next day, October 8, ther was no sign of ash emission or a summit thermal anomaly, and on October 10 the Color Code was downgraded from Orange to Yellow. The last thermal anomaly was seen on November 6, and steam plumes were occasionally visible in satellite data for the next several weeks. Because there was no evidence of ash emissions on November 25, AVO reduced the Color Code for Cleveland from Yellow to UA. As fate would have it, a few days later, evidence for minor eruptive activity was observed; however, the activity did not continue and the volcano remained quiet for the rest of the year. AVO issued five special Information Releases about Cleveland activity between July 7 and November 25, **2005**."

A chronology of this event is available at: http://www.avo.alaska.edu/archives/Cleveland**2005**.php

From the Smithsonian Institution (**2005**): "Mount Cleveland produced significant ash plumes during March 2001 (BGVN 26:04). Volcanic unrest continued through 4 May 2001, and signals consistent with volcanic seismicity were detected by an Alaska Volcano Observatory (AVO) seismic network 230 km E. By the end of May, neither eruptive activity nor thermal anomalies were observed. Until July **2005**, no alert level was assigned, and AVO monitoring produced no reports on Cleveland.

"Cleveland lacks a real-time seismic network. Accordingly, even during times of perceived quiet there is an absence of definitive information that activity level is at background. AVO's policy for volcanoes without seismic networks is to not get assigned a color code of Green.

"Satellite imagery of Cleveland taken during 24 June to 1 July **2005** showed increased heat flow from the volcano and a possible debris flow. AVO stated that although observations were inhibited by cloudy weather, they indicated the possibility of increased volcanic activity. AVO did not assign a Concern Color Code to Cleveland due to the lack of seismic monitoring and limited satellite observations.

"Satellite images during 1-8 July showed increased heat flow, thin ash deposits, and possible debris flows extending ~ 1 km down the flanks from the summit crater. AVO assigned a Concern Color Code of Yellow on 7 July. On 18

July satellite imagery showed steam emanating from Cleveland's summit and evidence of minor ash emissions. Meteorological clouds obscured Cleveland during the third week of July. During 22-29 July satellite images showed minor steaming from the summit, possible fresh localized ash deposits, and a weak thermal anomaly.

"On 4 August satellite images showed a thermal anomaly. On 27 August AVO reduced the Concern Color Code at Cleveland from Yellow to "Not Assigned" because there had been no evidence of activity since a thermal feature was observed on satellite imagery from 11 August. A thermal feature was detected on several satellite images obtained on 31 August, and one on 19 September, but there was no evidence of eruptive activity.

"On 7 October, AVO raised the Concern Color Code to Orange after detecting a small drifting volcanic ash cloud. The cloud was seen in satellite data at a spot ~ 150 km ESE of Dutch Harbor at 1700 UTC. Based on data from a regional seismometer at Nikolski, AVO concluded that the ash came from a small Cleveland eruption at approximately 0145. AVO, in consultation with the National Weather Service, estimated the top of the ash cloud to be no more than 4,600 m altitude. The ash cloud dissipated and was not detected via satellite after 1800 UTC. Three days passed during which there were no new observations of eruptive activity at Cleveland from satellite data, pilots, or ground-based observers. Accordingly, on 10 October the Concern Color Code was reduced to Yellow."

Korovin 2005

Event Specific Information: Korovin - **2005**

This is a questionable event.

Eruption Type: Explosive
MaxVEI: 1
ColHeight: 300 m

Start: February 23, **2005** 19:00:00 Observed
Stop: May 7, **2005** ± 14 Days Observed

Steam:
Tephra plume:
Minor explosive eruption:

Description: From McGimsey and others (2007): "On the morning of February 24, **2005**, AVO received a report from residents of Atka Village that Korovin had erupted the previous evening, producing a large steam and ash cloud. February 23 was a clear day and local residents had noticed minor steaming from Korovin about noon (see fig. 40 in original text). Then, about 7 p.m. HST (8 p.m. AST), they witnessed a dark plume over Korovin, rising several thousand feet high, drifting east, that had ash visibly falling out near the base, presumably confined to the flanks of Korovin (see fig. 41 in original text). Several minutes later, three or four smaller, gray puffs occurred. Although they watched, no further activity ensued during the calm, clear, moonlit night.

"Satellite data from about the time of the reported activity indicated the presence of a 1-2 pixel thermal anomaly and a small steam plume, possibly with localized minor ash. Height of the steam plume was estimated to be about 10,000 ft (~3 km), corroborating the observer account. AVO issued an Information Release on February 24 and raised the Level of Concern Color Code to Yellow. With no further reports of continuing activity, nothing evident in subsequent satellite data, and no unusual seismicity from a seismic station in Atka Village, AVO reduced the Color Code from Yellow to UA in the March 4, **2005**, Weekly Update (see table 6 in original text). Evidence of similar activity has been identified in **2002** and **2004** satellite images and observed by field crews in **2004** (see fig. 42 in original text).

"A PIREP of steam reaching several thousand feet above Korovin on March 19 was the next report of activity, and then in early May observational data indicated that the lake had drained in the south summit crater of Korovin and that incandescence was visible in the about 100-m (~325 ft) - wide pit. The next several months were quiet.

Non-Eruption Events
(Reports from search tool at http://www.avo.alaska.edu/volcanoes/eruptsearch.php)

Event Specific Information: Wrangell - 2003

Eruption Type: Not an eruption.

Start: June 11, 2003 Observed
Stop: September 18, 2003 Observed

Fumarolic or hydrothermal activity
Steam

Description: From McGimsey and others (2005): "Danny Rosenkrans, geologist for the Wrangell-St. Elias National Park and Preserve, contacted AVO on June 13, 2003 with photographs taken by a local resident on June 11, 2003 showing an unusual, towering, cloud over the summit area of Mt. Wrangell (fig. 4). Although the cloud might simply have been a common cumulus cloud fortuitously located at or near the summit, the lack of other cumulus clouds in the area over nearby Mts. Drum and Sanford suggest that instead, calm weather conditions permitted steam emissions from the known summit fumaroles to coalesce and form the plume-like cloud over Wrangell. AVO receives several reports per year from pilots and local residents who observe what they consider to be larger than normal steam clouds situated over the summit."

"On September 18, 2003 the Center Weather Service Unit (CWSU) called at 12:50 pm ADT with a Pilot Weather Report (PIREP) of a '2,000-to 2,300-foot-high steam plume' over Mt. Wrangell. The pilot reported no ash or sulfur smell. AVO scientists checked satellite imagery and seismograms and found nothing unusual."

Event Specific Information: ??

Eruption Type: Not an eruption.

Start: September 9, 2003 Observed
*Not an eruption - fumarolic activity only

Fumarolic or hydrothermal activity
Steam

Description: From McGimsey and others (2005): "AVO received a pilot report through Kenai Flight Service of increased steaming at Augustine volcano about mid-day on September 9, 2003. Concomitant to this report we received an inquiry about Augustine from the Homer Police Department. A check of the seismograms and spectrograms revealed nothing unusual."

Event Specific Information: Hague, Mt - 2003

Eruption Type: Not an eruption.

Start: July 2003 Observed

Fumarolic or hydrothermal activity:

Description: From McGimsey and others (2005): "On July 7, 2003, AVO scientists conducting seismic network maintenance near Mt. Hague on the rim of Emmons Lake Caldera noticed that the crater lake typically present was almost completely gone and all that remained was a few isolated pools surrounded by several vigorously venting fumaroles, and yellow sulfur deposits in the center of the crater. Mud cracks suggested that the lake had drained or evaporated rather recently. A photograph taken a week later, August 16, 2003, shows a full lake. Photographs taken of the crater lake on August 16, 2002 also show the lake filled with water.

"The Hague crater lake apparently has a history of draining and refilling. Sporadic checks of the crater since 1973 have found it empty about as often as full (T. Miller, written communication, 2003). The most recent observations [2003] verify that the lake is capable of reforming within days or weeks."

Event Specific Information: Pavlof - 2003

Eruption Type: Not an eruption.

Start: March 16, 2003 Observed

Fumarolic or hydrothermal activity:
Eruption re-assigned to another volcano:

Description: From McGimsey and others (2005): "A barge operator reported seeing Pavlof volcano erupting about 10 AM AST on March 16, 2003. A check of spectrograms revealed no activity. CWSU staff was informed of the report; they had already reviewed the latest satellite imagery and saw no ash signature (the area was cloudy with a ceiling of around 3,000 ft.). AVO remote sensing specialists corroborated that there was no indication of activity. Strong fumaroles on the flank, and in the crater, of nearby Mt. Hague vent of Emmons Lake Caldera occasionally produce steam clouds that from certain vantage points appear to originate at Pavlof. A similar occurrence [at Hague] was documented in 2001 (McGimsey and others, 2005) and in 2002 (Neal and others, 2005)."

Event Specific Information: Veniaminof - 2006

Eruption Type: Explosive
MaxVEI: 1
ColHeight: 2300 m * Ash and steam plume height was less than 2.3 km

Start: March 3, 2006 Observed
Stop: September 7, 2006 Observed

Tephra plume:
Central eruption:
Phreatic:
Minor explosive eruption:

Description: From the Smithsonian Institution (2006, v. 31, n. 3): "On the morning of 3 March 2006 ash again rose a few hundred meters above the intracaldera cone, drifted E, and dissipated rapidly. Ashfall was expected to be minor and confined to the summit caldera. Seismicity was again low and did not indicate that a significantly larger eruption was imminent. Over the week of 5-10 March, seismicity was low but slightly above background.

"On the morning of 10 March, AVO received a report from a pilot of low-level ash emission from the intracaldera cone. Clear web-camera views on 9 March showed small diffuse plumes of ash extending a short distance from the intracaldera cone. The Anchorage Volcanic Ash Advisory Center (VAAC) reported a steam/ash plume noted on web-cam and satellite on 13 March 2006 at 0500Z (12 March 2006 at 2000 hours local), moving NNW at 9.2 km/hr and falling to the land surface. Web-cam images on 22 March showed a very diffuse steam-and-ash plume that was confined to the summit caldera, and on 24 March showed a steam-and-ash plume drifting from the summit cone at a height of less than 2.3 km. This level of activity was similar to that on 23 March, but higher than activity on 21 and

22 March, when a very diffuse steam-and-ash plume was confined to the summit caldera.

"The flow of seismic data from Veniaminof stopped on the evening of 21 March 2006, and the problem was expected to continue until AVO staff could visit the site to repair the problem. Absent seismic data, the volcano could potentially still be monitored in other ways such as using web-camera and satellite images. Imagery was obscured by cloudy weather after 21 March. On 26 March 2006, a pilot reported a small ash plume rising above the volcano. Low-altitude ash emissions from Veniaminof were visible during 31 March to 7 April. On 6 April, a pilot reported an ash plume at a height of 3 km. AVO stated in its weekly report of 14 April 2006 that the seismicity at Veniaminof remained low but above background. Internet camera and satellite views had been obscured by cloudy weather, and AVO lacked new information about ash clouds or activity."

Continued activity was summarized by the Smithsonian Institution (2006, v. 31, n. 8): "Intermittent, very small-volume steam and ash bursts from the intra-caldera cone have been typical of this volcano intermittently over the past few years, and this pattern continued. The previous report mentions several minor bursts of ash, particularly on 13 June 2006 and 7 September, and minor white plumes through mid-September. This report discusses the interval 8 April through 15 September. Seismicity during this interval was nearly always low, although it often rose above background.

"Clouds obstructed visibility during 7-14 April. For the duration of April and June, activity remained low with few steam plumes containing minor amounts of ash. On 30 May a weak daytime thermal anomaly was recorded, possibly due to solar heating inside the dark intra-caldera cone. Intermittent clear weather on the week ending 9 June indicated weak steam plumes.

"On 13 June an ash emission rose to a height estimated at ~ 600 m above the summit area, as reported by a passing aircraft. Transient plumes were seen on satellite imagery during the week ending 21 July.

"During the week ending 28 July, an AVO field party flew over the summit and observed typical steaming from the intra-caldera cone with no signs of recent ash emissions. Satellite and web camera views during occasional clear periods showed no other signs of activity. Occasional satellite views during clear weather failed to disclose new ash emissions during 28 July through 15 September.

"AVO noted a slight increase in seismicity starting 2 August but in the subsequent weeks it again returned to low levels. Available satellite and camera views continued to reveal occasional small white plumes through 15 September."

Steam plumes without ash emission continue to be observed at Veniaminof, as of this writing (March 21, 2007).

Event Specific Information: Veniaminof - 2006

Eruption Type: Explosive
MaxVEI: 1
ColHeight: 2300 m * Ash and steam plume height was less than 2.3 km

Start: March 3, 2006 Observed
Stop: September 7, 2006 Observed

Tephra plume:
Central eruption:
Phreatic
Minor explosive eruptio

Description: From the Smithsonian Institution (2006, v. 31, n. 3): "On the morning of 3 March 2006 ash again rose a few hundred meters above the intracaldera cone, drifted E, and dissipated rapidly. Ashfall was expected to be minor and confined to the summit caldera. Seismicity was again low and did not indicate that a significantly larger

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"The flow of seismic data from Veniaminof stopped on the evening of 21 March 2006, and the problem was expected to continue until AVO staff could visit the site to repair the problem. Absent seismic data, the volcano could potentially still be monitored in other ways such as using web-camera and satellite images. Imagery was obscured by cloudy weather after 21 March. On 26 March 2006, a pilot reported a small ash plume rising above the volcano. Low-altitude ash emissions from Veniaminof were visible during 31 March to 7 April. On 6 April, a pilot reported an ash plume at a height of 3 km. AVO stated in its weekly report of 14 April 2006 that the seismicity at Veniaminof remained low but above background. Internet camera and satellite views had been obscured by cloudy weather, and AVO lacked new information about ash clouds or activity."

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"Clouds obstructed visibility during 7-14 April. For the duration of April and June, activity remained low with few steam plumes containing minor amounts of ash. On 30 May a weak daytime thermal anomaly was recorded, possibly due to solar heating inside the dark intra-caldera cone. Intermittent clear weather on the week ending 9 June indicated weak steam plumes.

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Steam plumes without ash emission continue to be observed at Veniaminof, as of this writing (March 21, 2007).

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