

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

**10 YEARS OF VOLCANIC ACTIVITY IN ALASKA:  
1983 TO 1992: A VIDEO**

(Pyre Peak, Akutan volcano, Bogoslof volcano, Westdahl volcano, Veniaminof volcano,  
Augustine volcano, Redoubt Volcano, Spurr volcano)

by

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## INTRODUCTION

From 1983 to 1992, more than 13 Alaskan volcanoes erupted resulting in approximately 45 separate eruptive events. Prior to 1988, official response to eruptions was conducted by scientists from several Federal and state agencies working informally together, resulting in widely dispersed photographic products. The Alaska Volcano Observatory (AVO), created in 1988 following the 1986 eruption of Augustine volcano, is a formal cooperative program among the U.S. Geological Survey, University of Alaska Fairbanks Geophysical Institute, and the Alaska Division of Geological and Geophysical Surveys. Scientists with the AVO assembled video footage and still photographs for this report from a variety of sources, both government and private (see acknowledgments).

Video recordings include the 1983 eruption of Veniaminof volcano, the 1989-90 eruption of Redoubt volcano, and the 1992 eruptions of Bogoslof, Westdahl, and Spurr volcanoes (fig. 1; table 1). This report documents some classic volcanic phenomena, including lakes formed when lava flows erupted into an ice-filled caldera (Veniaminof), nighttime views of the explosive strombolian eruption style (Veniaminof), pyroclastic flows descending steep flanks during plinian- and peléean-style eruptions (Augustine, slides only), hawaiian-style lava fountaining along fissures through a glacier (Westdahl), island building in the Aleutians (Bogoslof), and close-up views of a roiling, vertical, sub-plinian eruption column rising more than 18 kilometers (km) high (Spurr volcano-Crater Peak). The video provides visually dramatic as well as scientifically useful information about the power and hazards of active volcanoes. In addition, the video serves as an historic visual record of observations which can be used for comparative scientific analysis in the future.

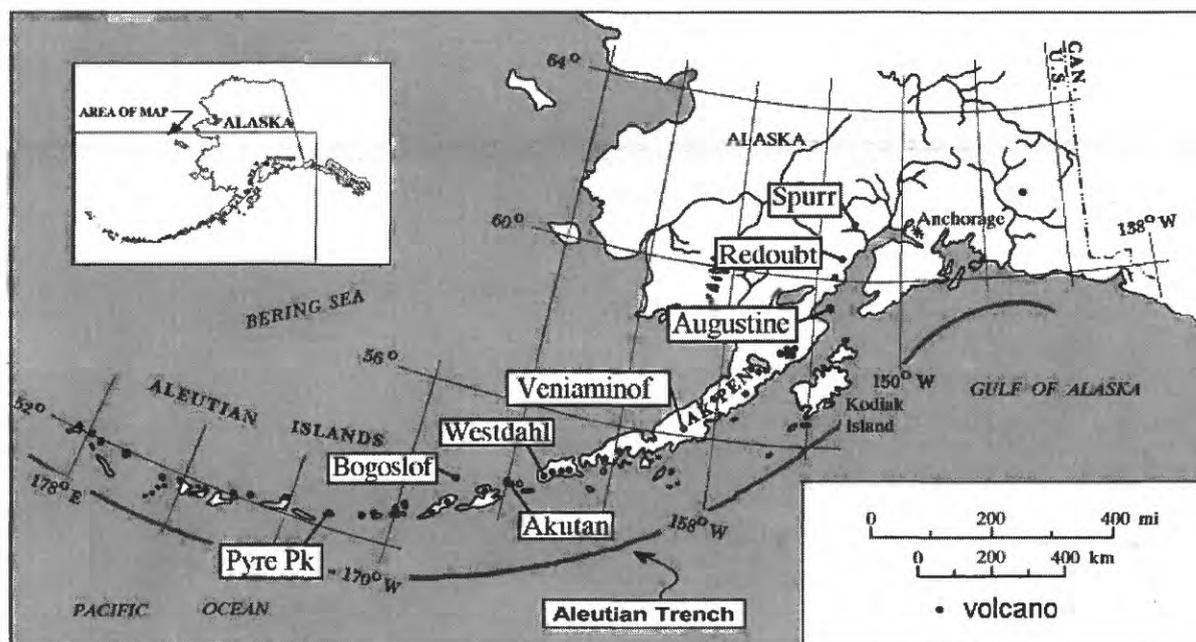


Figure 1. Index map showing location of volcanoes included in the text and video. Labeled dots, Alaskan volcanoes included in text and video; unlabeled black dots, other Alaskan volcanoes; Dark line, approximate location of the Aleutian trench (Location of trench after Wood and Kienle, 1990).

Table 1. Dates and style of eruptions, volcano type and elevation of volcanoes in this report.

Volcano	Eruption Date	Eruption Style	Volcano Type	Volcano Elevation (meters)
Pyre Peak	12 / 1992	Flank, strombolian	Stratovolcano with caldera	1,054
Akutan	12 / 1992	Summit, strombolian	Stratovolcano with caldera	1,300
Bogoslof	07 / 1992	Summit, lava dome	Stratovolcano	100
Westdahl	11 / 1991	Summit, strombolian fissure	shield	1,560
Veniaminof	06/1983 07 / 1993	Summit, strombolian	Stratovolcano with caldera	2,507
Augustine	03 / 86	Summit, explosive, sub-plinian to peléean, lava plug, spine	Stratovolcano	1,282
Redoubt	12 / 1989	Summit, explosive, sub-plinian, lava dome	Stratovolcano	3,108
Spurr-Crater Peak	06 / 1992	Flank, explosive, sub-plinian	Stratovolcano with caldera	3,374

Active Alaskan volcanoes are in the Aleutian volcanic arc which extends 2,500 km along the southern edge of the Bering Sea and Alaska mainland (fig. 1). The arc contains approximately 80 Quaternary age stratovolcanoes and calderas (Wood and Kienle, 1990) including 44 historically active volcanoes. Aleutian arc volcanism is the result of active subduction of the Pacific Plate beneath the North American Plate. The 3,400-km-long Aleutian trench that extends from the northern end of the Kamchatka trench in eastern Russia to the Gulf of Alaska marks the boundary between the two plates (fig. 1). In the Aleutian arc, 44 volcanoes have erupted historically, several repeatedly, since 1741 when the written record begins in Alaska (Kienle and Nye, 1990; Miller and others, in review). In the past decade, hardly a year has gone by without a reported volcanic eruption in the Aleutians. Most of the following information has been gathered from notes and observations from scientists working in Alaska.

**Pyre Peak (Seguam):**

Seguam Island is located in the central Aleutian Islands 645 km from the tip of the Alaska Peninsula. Pyre Peak, one of three Holocene cones that make up the island, occupies the center of a caldera-like topographic feature and was the site of eruptive activity in 1977 (Smithsonian Institution, 1977) and 1992. On December 27, 1992, U.S. Coast Guard pilots reported that an ash cloud rose to approximately 1,200 m above Pyre Peak and drifted to the north (Smithsonian Institution, 1992, no. 12). Intermittent localized bursts of ash rising 100-200 m were observed several days later, and the activity apparently subsided soon thereafter.

Seguam Island is remote and uninhabited. The nearest village is Atka, 120 km to the west. The major hazard is that posed to aircraft flying near the island. AVO responded by

contacting the Coast Guard to verify the location and eruptive activity observed, analyzing satellite images and hypothetical plume trajectory plots based on local wind data to determine whether or not the ash cloud would be a hazard to aircraft. AVO then issued an information release to Federal, state, and local authorities and the media. AVO determined that the ash clouds were localized and rapidly dissipating, thus posing little hazard. The staff continued daily monitoring of pilot reports, satellite images, and weather data until the activity subsided (Smithsonian Institution, 1993, nos. 5, 7-8).

A short video segment shows one of a series of small brief explosions of ash from vents on the flank of Pyre Peak.

### **Akutan:**

Akutan is one of the most active volcanoes of the Aleutian arc and frequently produces low-level eruptive activity. It has erupted at least ten times since 1848. The volcano is a 1,300-m-high stratocone with a nearly circular summit caldera, located 185 km southwest of the tip of the Alaska Peninsula; a 200-m-high cinder cone within the caldera is the source of historic activity (Miller and others, in review). From March 8 to April 26, 1992 and in mid-December 1992, Akutan volcano intermittently produced localized steam and ash plumes to various altitudes up to 4,600 m (Smithsonian Institution, 1991, no. 11); 1992, nos. 3-4,11).

No seismometers are maintained on the island and the nearest village is Akutan, 16 km east of the cinder cone. The main hazard is possible interaction of ash with aircraft, which pass close to the volcano on approach to Dutch Harbor, a regional airport located 45 km southwest of the crater. AVO responded to reports of eruptive activity by monitoring pilot reports and satellite imagery, making daily inquiries to observers in Akutan and Dutch Harbor, studying video footage provided by commercial and private pilots, and issuing the information to Federal and state agencies and the media.

### **Bogoslof:**

Bogoslof volcano is composed of a cluster of small, low-lying islands located 40 km north of Umnak Island behind the main axis of the Aleutian arc about 100 km west of Dutch Harbor. The islands are remote and uninhabited and are the emergent summit of a large, submarine stratovolcano that rises more than 1,500 m above the Bering Sea floor. The main island, Bogoslof, has undergone dramatic changes in size and shape during historic time, an evolution which has been unusually well observed and recorded (Wood and Kienle, 1990).

The first historic eruptive activity was reported in 1796 and eight periods of explosive eruptions, including episodes of lava extrusion, have occurred since (Miller and others, in review). The most recent eruption began in early July 1992, and was first reported by pilots (Smithsonian Institution, 1992, nos. 6-7). Steam and ash plumes rose up to 8 km above the main island and U.S. Coast Guard observations and photography on July 24 confirmed that a new 100-m-high lava dome had been constructed on the north tip of the island. Except for residual steaming of the dome, activity had subsided by late July. U.S. Fish and Wildlife Service scientists, who approached the island by ship several times later in the summer to assess the impact on sea mammals and birds, also photographed the new dome.

The new lava dome was hot and formed a mound above the vent that slopes down to the coast. This type of eruption of lava was responsible for the formation of many of the islands in

the Aleutian chain and elsewhere along the Pacific Ring of Fire. Although Bogoslof volcano frequently erupts, the activity usually poses no threat to high flying aircraft.

The video footage shows the island in 1988 prior to the most recent eruption and then shows the 1992 steaming lava dome on the tip of the island.

### **Westdahl:**

Westdahl volcano is a broad, 1560-m-high, glacier-covered, shield volcano on Unimak Island, 85 km southwest from the tip of the Alaska Peninsula. The volcano is about 18 km in diameter at the base, and is built upon a large ancestral stratocone.

Since the late 1700's, Westdahl has erupted at least eight times, most recently in late 1991 and early 1992 (Miller and others, in review). On November 29, 1991, pilots reported the beginning of a fissure eruption through the ice resulting in a lava flow approximately 3-km wide, as much as 10-m thick, and about 7-km long extending down the northeast flank (Smithsonian Institution, 1991, nos. 11-12). Debris flows resulting from the interaction of hot material and ice reached the sea 17 km from the vent. Dramatic fountaining and phreatic activity produced ash plumes that rose to 7 km altitude, prompting the Federal Aviation Administration (FAA) to divert air traffic. Most of the ash was narrowly confined and remained at lower altitudes, dissipating harmlessly over the Bering Sea or North Pacific Ocean. However, light ashfalls occurred on Unimak Island including the village of False Pass, located 90 km east of the vent. The activity subsided by mid-January 1992 (Smithsonian Institution, 1992, no. 1). Westdahl volcano is unmonitored seismically and air traffic is commonly diverted away from the area whenever eruptive activity is reported.

The video footage shows a long fissure in the ice emitting ash and fountains of lava. Ash rose several thousand meters above the vent and molten rock was spewed up several hundreds of meters.

### **Veniaminof:**

Veniaminof is a large stratovolcano located 760 km southwest of Anchorage on the Alaska Peninsula. The cone is 35-km wide at the base with a spectacular, steep-walled, ice-filled summit caldera 8-by-11 km in diameter. The high point on the caldera rim is 2,507 m and an active intracaldera cone stands 330 m above the surrounding ice field. Ash-flow tuffs from the caldera-forming eruption approximately 3,700 years ago partially fill many of the valleys on the north slope of the volcano and extend as far away as 50 km from the caldera rim (Miller and Smith, 1987).

As with many of the remote volcanoes on the Alaska Peninsula and Aleutian Islands, reports of historic activity are often few and incomplete. The earliest reported historic eruptive activity at Veniaminof occurred in the 1830's and ten eruptive episodes have occurred since then (Miller and others, in review). The most recent eruption began July 30, 1993 and continues intermittently (Smithsonian Institution, 1993, nos. 7, 10-11).

During an eruption in 1983, lava flowed from the summit crater of the intracaldera cone and adjacent subglacial activity melted one tenth of a cubic kilometer of ice to form a 1-by-2 km, 120-m-deep, water-filled ice pit (Yount and others, 1985; Wood and Kienle, 1990). Semi-circular crevasses surrounding the lake are visible in the video and are indicative of substantial subglacial melting.

The 1983 eruption was also recorded at night and a spectacular fountain of lava was observed pulsing from the summit vent. This hot, glowing material rose several hundreds of meters above the summit of the cone, fell back to coalesce into a lava flow which then flowed down from the volcano's crater rim.

### **Augustine:**

Augustine volcano forms an island located 290 km southwest of Anchorage in lower Cook Inlet. Captain James Cook discovered and named Saint Augustine Island in 1778 as he sailed into Cook Inlet. The 8-by-11 km island is composed of a central steep-sided cluster of domes surrounded by pyroclastic debris that form the flanks. The summit is 1,260 m above sea level. The irregular shoreline around the island is mainly the result of summit dome collapses that produced large debris avalanches down the flanks and into the sea. At least eleven debris avalanche deposits emplaced during the past 2000 years have been identified (Beget, 1986; Beget and Kienle, 1992).

Augustine is the most frequently active, as well as the youngest, of the Cook Inlet volcanoes. Since its discovery in 1778, Augustine has had seven known eruptions: 1812, 1883, 1908, 1935, 1963-64, 1976, and 1986 (Miller and others, in review). The most violent historical eruption occurred in 1883 when a partial collapse of the summit resulted in a debris avalanche down the north flank that plummeted into Cook Inlet, extending the coastline by 2 km (Kienle and others, 1987; Smithsonian Institution, 1986). The up-to-10-m-high tsunami that was generated, wreaked havoc along the east coastline of Cook Inlet for as much as 100 km from the volcano.

The most recent eruption of Augustine began in late March of 1986 and continued for five months, ending in August. U.S. Geological Survey scientists responded to the eruption and documented the eruptive activity during numerous fixed-wing observation flights. A nearly continuous ash-rich plume emanated from the volcano during the eruptive period and pyroclastic flows cascaded down the flanks during the early stages of the eruption. During the later stages, lava extrusion began and culminated with emplacement of a large summit lava dome and a short flow down the upper northwest flank. The lava dome was visible at the upper end of the crater breach on the north side of the island. The steep flanks of the volcano were covered with numerous pyroclastic and ash deposits.

Augustine is closely monitored seismically, and innovative monitoring of ground deformation using Global Positioning System techniques is currently underway at the volcano to help evaluate the possibility of a summit collapse during the next eruption.

### **Redoubt:**

One of three active volcanoes along the western side of Cook Inlet, Redoubt volcano is located 170 km southwest of Anchorage in the Aleutian Range. The volcano is a snow and ice covered stratocone that rises 3,108 m above sea level. An ice-filled summit crater is breached to the north by a deep gorge that drops steeply down to a wide river valley, which extends about 40 km to Cook Inlet. During interim noneruptive periods, glacial ice fills the crater and flows down the gorge to form a broad lobe across the bottom of the river valley. The historic eruptive activity at Redoubt has occurred within the summit crater resulting in extensive melting of ice in the crater and gorge.

More than 30 ash layers from Redoubt in the last 10,000 years have been identified in the Cook Inlet area (Riehle, 1985). The volcano has erupted three times historically (Miller and others, in review). An eruption in 1902 produced widespread ashfall over the Cook Inlet area, and a period of eruptive activity during 1966-1967 caused extensive flooding down the gorge and in the Drift River Valley with debris flows reaching and spilling into Cook Inlet. The most recent eruption of Redoubt occurred during a five-month period beginning in mid-December 1989 (Brantley, 1990; Miller and Chouet, 1994). More than 21 explosive eruptive events deposited ash on most of south-central Alaska, caused repeated flooding in the Drift River Valley interrupting oil production in Cook Inlet, seriously impacted commercial air traffic, and disrupted commerce in Anchorage and the Kenai Peninsula.

This was the first eruption monitored by the newly formed Alaska Volcano Observatory whose scientists documented eruptive activity and the effects along the flanks and Drift River Valley. More than 100 million cubic meters of ice was eroded from the glacier draining the summit of the volcano during the 1989-90 eruption (Trabant and others, 1994). Individual eruptive events were difficult to document at Redoubt due to limited light conditions during the winter, poor weather conditions, and the great distance between Anchorage and Redoubt volcano. The proximity of the Drift River Oil Terminal, located near the mouth of the Drift River, and the potential for large volcanically generated floods down the Drift River increased the urgency for monitoring and field investigations at the volcano.

Video footage of one of the early eruptions in mid-December 1989 shows the summit vent spewing ash, and the ice-filled gorge on the north flank below the vent. Also shown are the lava domes in the summit vent area which were repeatedly destroyed during the eruptive period.

### **Spurr:**

Spurr volcano is a Quaternary stratocone located 130 km west of Anchorage at the southwestern end of the Alaska Range and is the easternmost and highest (3374 m) historically active volcano in the Aleutian volcanic arc. Spurr volcano is composed of an ice-filled caldera about 6 km in diameter with a resurgent cone or dome forming the high point (Mt. Spurr). The caldera is breached to the south where landslide deposits are overlain by pyroclastic deposits and several glacial tongues extend down the flank toward the Chakachatna River. Crater Peak, a small satellite composite cone 3.5 km south of Mt. Spurr's summit, is situated on the breach and has been the site of all the historic eruptive activity.

Spurr has been the most active Cook Inlet volcano during the past 10,000 years producing at least 35 identifiable tephra layers (Riehle, 1985). Two eruptions have occurred during historic times. In July 1953, a vigorous, short-lived eruption blanketed Anchorage with a half centimeter of ash and generated debris flows down the south flank causing a temporary damming of the Chakachatna River that backed up water more than 3 m deep (Juhle and Coulter, 1955; Wilcox, 1959).

The most recent eruption cycle began in June 1992, and three explosive eruptive events occurred over the next three months (Alaska Volcano Observatory, 1993; Eichelberger and others, in review). Spurr was the most intensively monitored volcano in Cook Inlet and AVO seismologists closely followed the slow but steady seismic buildup prior to the first eruption on June 27. This event was similar to that which occurred in 1953, and a dramatic drop in the level of seismicity after the event seemed to indicate that the eruptive cycle was over. Poor weather prevented visual observation of the eruption and northerly winds carried ash harmlessly over the

uninhabited Alaska Range. Video footage taken June 28 and 29 shows the steaming vent of Crater Peak with Mt. Spurr summit in the background.

Almost 7 weeks later, on August 18, 1992, with virtually no precursory activity, Crater Peak roared back to life with another blast. This time clear weather permitted an AVO crew to arrive on the scene by plane shortly after onset of the eruption and capture the action on video (McGimsey and Dorava, 1994). Westerly winds carried the ash cloud over Anchorage where up to 5 mm of ash accumulated, disrupting commerce and closing Anchorage International Airport for 20 hours. Video footage taken during the August 18 eruption shows a dark ash-rich cloud rising above Crater Peak to an altitude of about 18 km. The expanding ash cloud rose above the white weather clouds in a vertical column up to a wide anvil-shaped top which expanded in all directions. Spectacular shock waves were visible in the near vent area where gas and ash erupted through the weather clouds. Finally, the ash plume is shown rapidly moving eastward producing an artificial sunset over Cook Inlet. The third and final eruption occurred one month later during the night of September 16-17. This event was similar to the previous two eruptions and southwesterly winds carried the ash cloud north of Anchorage over the Matanuska Valley.

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Spurr: U.S. Geological Survey

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## **GLOSSARY OF SELECTED TERMS USED DURING OBSERVATIONS OF VOLCANIC ERUPTIONS**

**Ash:** fine fragments (less than 4 millimeters across) of lava or rock formed in an explosive volcanic eruption.

**Avalanche:** mass of moving material consisting of varying amounts of water (less), volcanic ash and rocks, ice and snow.

**Bombs, volcanic:** fragments (greater than 64 than millimeters across) of lava or rock formed in an explosive volcanic eruption.

**Caldera:** a large, more or less circular, more-than-a-mile-in-diameter, depression formed by summit collapse of a volcano. (Veniaminof, Spurr)

**Cinder Cone:** A steep, cone-shaped hill formed by the accumulation of cinders and other material ejected from a volcanic vent.

**Cinders:** a general term applied to loose, volcanic ejecta 4-32 mm in diameter.

**Clast:** an individual fragment of rock produced by mechanical weathering or volcanic explosion.

**Cloud, volcanic:** detached mass of vapor and ash ejected from volcanic vent. Usually travels down wind from vent.

**Crater lake:** Small lake that occupies the inactive vent of a volcano. Typically is turquoise in color and may show vapor clouds near surface.

**Crater, volcanic:** a steep-walled depression at the top or on the flank of a volcanic cone.

**Crater, bomb:** pits caused by impact of ballistic material erupted from vent.

**Dome complex:** an overlapping cluster of extruded lava flows.

**Ejecta:** a general term for anything thrown into the air from a volcano during an eruption; synonymous with pyroclast which means "fire" and "broken piece".

**Fissure eruption:** an eruption in which lava or pyroclastic material issues from a narrow linear vent.

**Flows, debris:** masses of ash, rock and ice which move rapidly down the flanks of volcanoes. May be hot and steamy and occupy stream valley bottoms.

**Fumarole:** a small opening or vent from which fumes or hot gases are emitted. Usually identified by wisps or clouds of vapor at opening.

**Hawaiian Style eruption:** non-explosive, passive effusion of lava. Usually produces broad lava flow fields, spatter cones, and ramparts around the vent.

**Lahar (la-har):** a water-saturated mixture of mud and debris that flows rapidly downslope; often formed when hot volcanic material falls on snow and ice or, when rain saturates loose volcanic debris on the flanks of a volcano.

**Lava:** Molten rock extruded from a volcano or volcanic fissure.

**Lava dome:** a steep sided mass of viscous and often blocky lava extruded from a vent; normally has a rounded top and roughly circular outline.

**Lava fountain:** a jetlike eruption of lava issuing vertically from a fissure or central vent.

**Magma:** molten rock within the earth; molten rock that erupts onto the surface is called "lava".

**Peléean:** Moderate to violent ejection of solid or very viscous hot fragments of new lava. commonly accompanied by pyroclastic flows (glowing avalanches). Usually produces ash and pumice cones, and lava domes around the vent.

**Plinian (variety, sub-plinian):** Explosive, sustained ejection of large volumes of ash commonly accompanied by pyroclastic flows. Similar to peléean but with widespread pumice and ash beds with no cone building.

**Plume, volcanic:** Column of vapor and/or ash extending above an active vent and downwind from the volcano. Height and direction of plume dependent on style of eruption, temperature of gases, and wind direction. Weather conditions may cause white plume from non-erupting vent.

**Pyroclastic flow:** a dense, hot, chaotic avalanche of rock fragments, gas, and ash that travels rapidly away from an explosive eruption column, often down the flanks of the volcano.

**Shield volcano:** a broad, gently sloping volcanic cone composed chiefly of overlapping flows of basaltic lava.

**Stratovolcano:** (also called a stratocone or composite cone) a steep-sided volcano, usually conical in shape, built of lava flows and fragmental materials.

**Strombolian eruption:** Weak to moderate ejection of viscous fragments of incandescent lava. Fragments may coalesce into a lava flow. Usually produces a spatter or cinder cone around the vent.

**Vent:** an opening in the earth's surface through which volcanic eruptions occur.

**Volcanic dome:** an accumulation of viscous lava forming a more or less steep-sided, dome-shaped mass in a volcanic vent.