Volcanoes of the Wrangell Mountains and Cook Inlet Region, Alaska —Selected Photographs

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INTRODUCTION

Alaska is home to more than 40 active volcanoes, many of which have erupted violently and repeatedly in the last 200 years. This compact disc (CD-ROM) contains 97 digital images created from 35-mm slides scanned by a Kodak PIW film scanner. These pictures are but a small fraction of thousands taken by Alaska Volcano Observatory scientists, other researchers, and private citizens. Photographs were selected for inclusion in this collection to portray Alaska's volcanoes, to document recent eruptive activity, and to illustrate the range of volcanic phenomena observed in Alaska.

To facilitate viewing the photographs on the CD-ROM, they have been incorporated into a Portable Document Format file (DDS-39.pdf), which combines images, brief captions, and location maps. Underlined terms appear in the glossary. Hyperlinks (text outlined in blue) lead to a new image or page of text when double clicked. To move back to the previous view, click the Go Back button  in the tool bar. A slide show (slideshow.pdf) is also available that cycles through the 97 photographs at three-second or other user-defined intervals. Press the "Escape" key to exit the slide show. To return to the main document, close the slide-show window. Click here to begin the side show.

The images in this PDF file (DDS-39.pdf) have a resolution of 300 dots per inch (dpi), which allows acceptable printing at about 4"x6" on most color printers; the resolution on the slide show is only 72 dpi, which is adequate only for its intended viewing on a computer screen. Links to the World Wide Web (WWW) will access the user's connection to the Internet and browser software, if available. This CD-ROM contains a full-text index (index.pdx), that is for use in searching the .PDF files for words or sets of words using the search tool available with some .PDF readers. For more information, please see the 1_README.TXT file.

Each photograph is also stored as a Photo CD (.PCD) Image Pac in five resolutions ranging from 192x128 pixels to 3072x2048 pixels. The .PCD Image Pacs, located in the \images directory, allows users to choose the appropriate file size for print or electronic media applications. For each photograph, a single file contains all five resolution versions of the image. The file name corresponds to the photograph numbers in the .PDF file (for example, the file named "IMG0019.PCD" is the .PCD version for photograph 19). To view, manipulate, or print these images, the user must have a computer platform with software capable of reading .PCD files. When opening a .PCD file, compatible software will prompt the user to choose one of the five resolutions. Please see http://www.kodak.com/digitalImages/samples/fiveResolutions.shtml for more information.

The Alaska Volcano Observatory (AVO) was established in 1988 to carry out volcano monitoring, eruption notification, and volcano-hazard assessments in Alaska. The cooperating agencies of the Alaska Volcano Observatory (http://www.avo.alaska.edu/) are the U.S. Geological Survey (http://www.usgs.gov/), the University of Alaska Fairbanks Geophysical Institute (http://www.gi.alaska.edu/), and the Alaska Division of Geological and Geophysical Surveys (http://www.dggs.dnr.state.ak.us).

OBTAINING COPIES OF ORIGINAL IMAGES

35-mm slide reproductions of images contained on this CD-ROM may also be obtained by contacting:

U.S. Geological Survey Photographic Library
Box 25046, MS 914, Federal Center
Denver, CO 80225-0046
Telephone: (303) 236-1010
http://www.usgs.gov/fact-sheets/photographic-library/photographic-library.html

SELECTED REFERENCES

For additional information on the volcanoes represented in this collection, users are referred to the following sources:

McGimsey, R.G., and Miller, T.P., 1995, Quick reference guide to Alaska's historically active volcanoes: U.S. Geological Survey Open-File Report 95-520, 13 p.

Richter, D.R., 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, Geoscience Press, 349 p.

Wood, C.A., and Kienle, J., eds., 1990, Volcanoes of North America: Cambridge, England, Cambridge University Press, 354 p.

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Compiling a set of images from the AVO collection onto CD-ROM was first proposed by Joe Dorava. The authors have benefited greatly from the technical assistance, tenacity, and enthusiasm of John Nakata and Evelyn Newman. Michael Diggles conceived, researched, and developed the final CD-ROM architecture and produced the master. Reviews of caption text by Chris Nye, John Nakata, Jim Smith, and Lee Siebert improved their content. Map figures were generated by Anne Vanderpool and Kathy Lemke. Bernadette Johnson painstakingly labeled several sets of duplicate 35-mm slides. Mark Lohnes ably scanned the images. We thank all the photographers who shared their work with us.

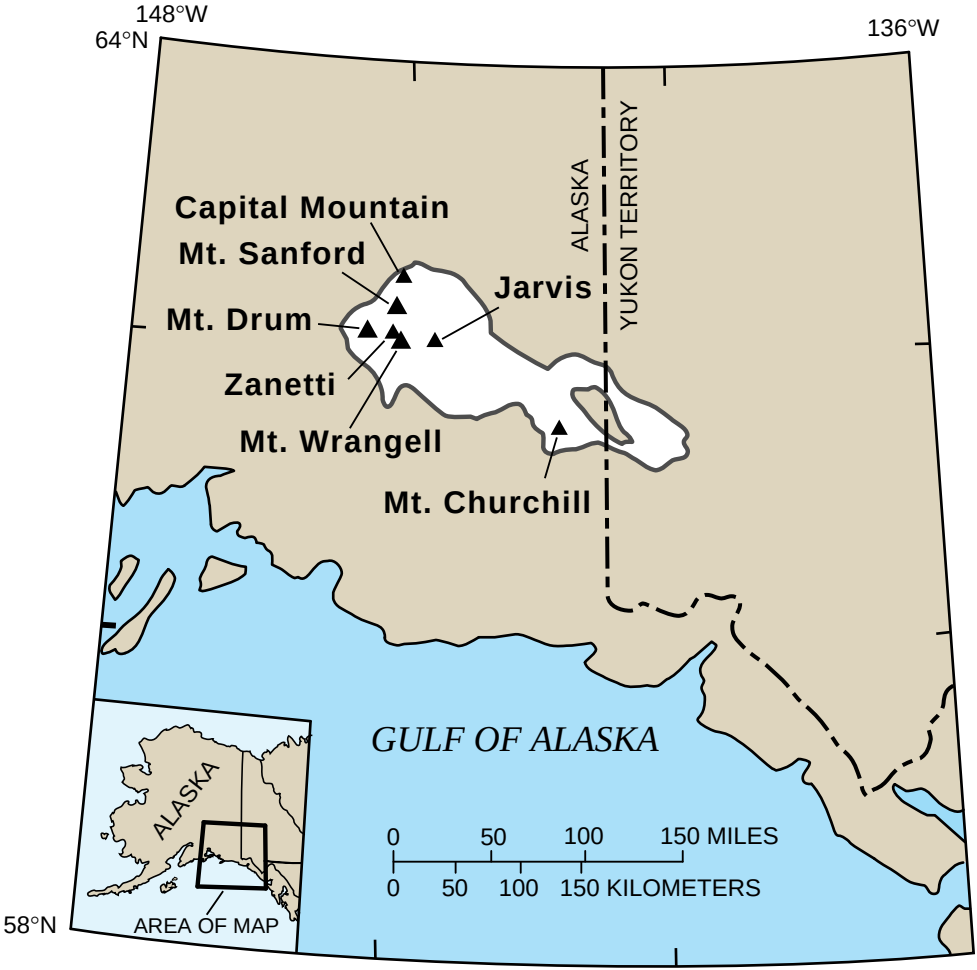


Figure 1. Map showing volcanoes of the Wrangell Mountains represented in this collection of images.

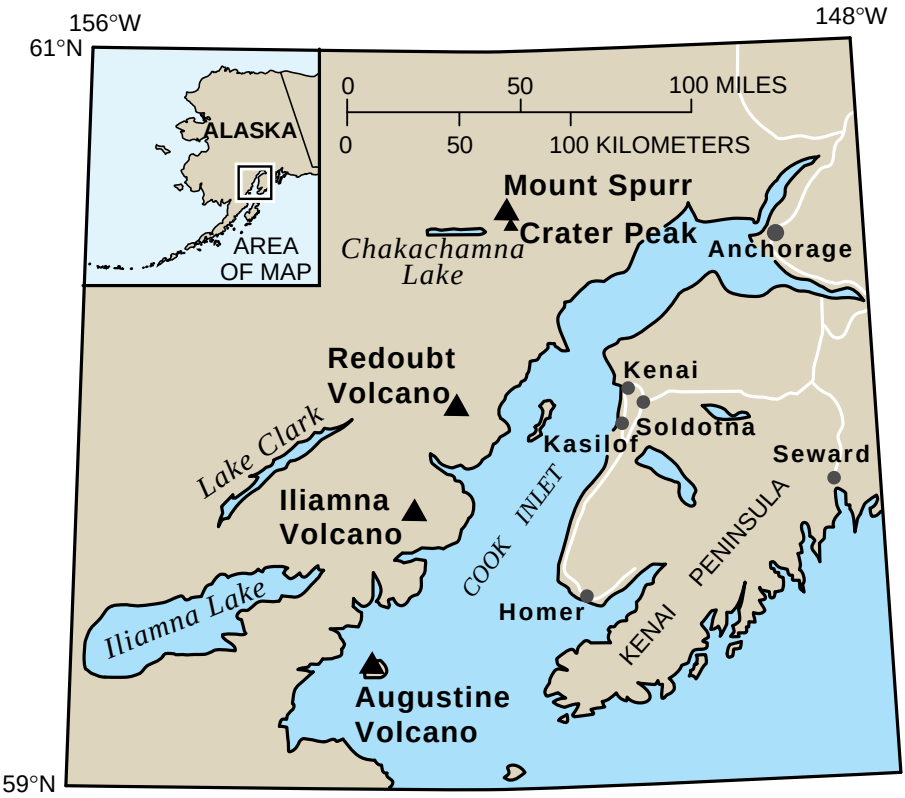


Figure 2. Map of Cook Inlet volcanoes represented in this collection of images.

SELECTED PHOTOGRAPHS

Wrangell Volcanic Field

1. Mount Drum, the westernmost volcano in the Wrangell volcanic field. Mount Drum is 3,661 m (12,010 ft) high and was active between approximately 700,000 and 240,000 years ago. View is to the southeast. Photograph by D. Richter, U.S. Geological Survey, 1989.

Wrangell Volcanic Field

2. Mount Wrangell, a 4,317-m (14,163 ft)-high andesite shield volcano is visible to the left on the skyline; it is the only volcano in the Wrangell Mountains to have had documented historical activity. This consisted of several minor, possibly phreatic eruptions in the early 1900's. Mount Drum, 3,661 m (12,011 ft) high, is the westernmost volcano in the Wrangell volcanic field, and is visible to the right on the skyline. The Copper River is in the foreground. View is to the southeast. Photograph by D. Richter, U.S. Geological Survey, August 1981.

Wrangell Volcanic Field

3. Half moon over Mount Sanford, a dissected andesite shield volcano. At 4,949 m (16,237 ft), it is the highest volcano in the Wrangell volcanic field. Capital Mountain, a 2,356-m (7,731 ft)-high andesite shield volcano, is in the middle foreground. View is to the south. Photograph by D. Richter, U.S. Geological Survey, 1963.

Wrangell Volcanic Field

4. View, looking southeast, of 4,949-m (16,237 ft)-high Mount Sanford (left) and 4,317-m (14,163 ft)-high Mount Wrangell (right) on the skyline. Photograph by D. Richter, U.S. Geological Survey, August 1981.

Wrangell Volcanic Field

5. Mount Wrangell, a 4,317-m (14,163 ft)-high andesite shield volcano on the right skyline, is the only volcano in the Wrangell Mountains to have had documented historical activity consisting of several minor, possibly phreatic eruptions in the early 1900's. At left is Mount Zanetti, a 3,965-m (13,009 ft)-high cone. View is to the northeast. Photograph by B. Cella, U.S. National Park Service , 1987.

Wrangell Volcanic Field

6. Aerial view looking southwest of a portion of the 4–6 km ice-filled summit caldera of Mount Wrangell, a 4,317-m (14,163 ft)-high andesite shield volcano. It is the only volcano in the Wrangell volcanic field to have had documented historical activity consisting of several minor, possibly phreatic eruptions in the early 1900's. Active fumaroles exist at one of three cinder cones on the caldera rim. Photograph by R. Motyka, Alaska Division of Geological and Geophysical Surveys, 1981.

Wrangell Volcanic Field

7. Mount Jarvis, 4,091 m (13,421 ft) high, is the youngest volcano in the eastern Wrangell volcanic field. Mount Jarvis was active approximately 1 to 2 million years ago. View is to the southeast. Photograph by R. McGimsey, U.S. Geological Survey, July 15, 1991.

Wrangell Volcanic Field

8. U.S. Geological Survey climbing party ascending the Klutlan Glacier en route to 4,766-m (15,636 ft)-high Mount Churchill. This volcano was the site of two of the most voluminous explosive eruptions in North America in the past 2,000 years. View is to the southwest. Photo by R. McGimsey, U.S. Geological Survey, May 16, 1990.

Wrangell Volcanic Field

9. U.S. Geological Survey climbing party reaching the east rim of the summit caldera on 4,766-m (15,636 ft)-high Mount Churchill, site of two of the most voluminous explosive eruptions in North America in the past 2,000 years. Blocky debris in the photo consists of pumice and lithic fragments ejected 1,250 years ago. This deposit forms the eastern lobe of the White River Ash. Photo by G. Dubois, U.S. Geological Survey, May 20, 1990.

Mount Spurr Volcano

10. Mount Spurr volcano, 3,374 m (11,070 ft) high, is visible on the skyline 125 km (78 mi) west of Anchorage, Alaska. In 1992, three explosive eruptions from the Crater Peak vent of Mount Spurr blanketed south-central Alaska with several millimeters (1/16 - 1/8 inch) of ash and forced the closure of Anchorage International Airport for 20 hours. Photograph by R. McGimsey, U.S. Geological Survey, October 1, 1988.

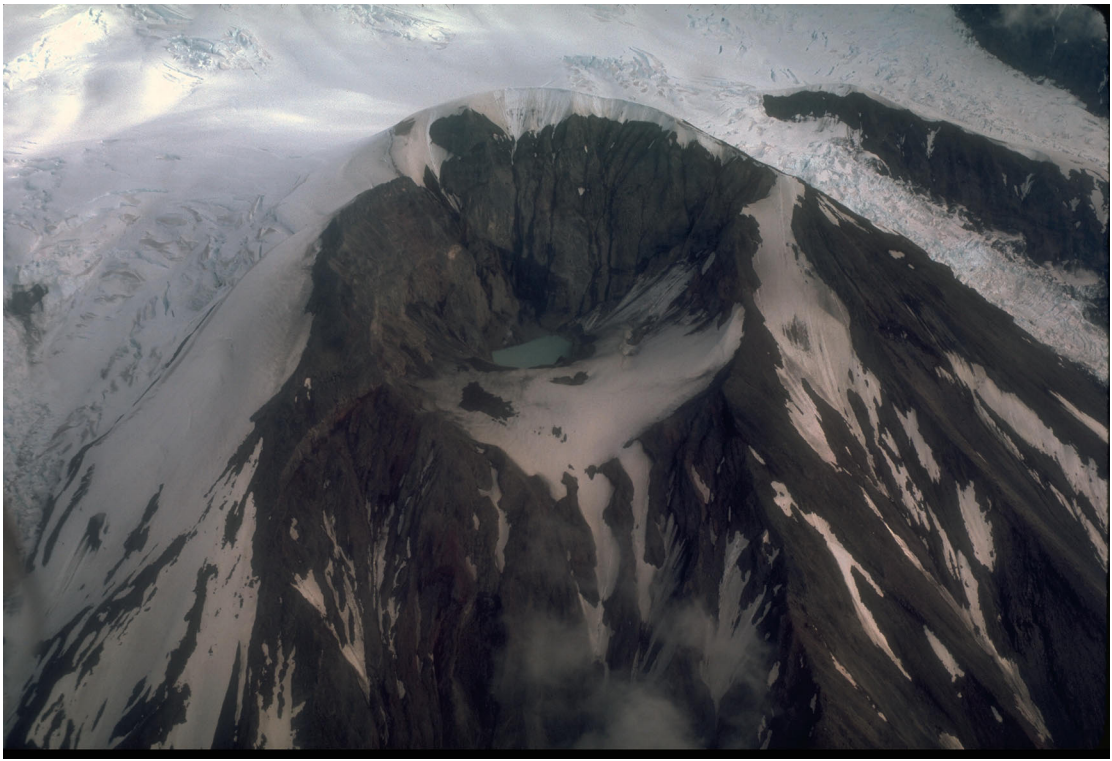
Mount Spurr Volcano

11. Crater Peak, a satellite vent, is located in a breach in the south wall of the ice-filled caldera of Mount Spurr volcano. It was the site of historical eruptions from Mount Spurr volcano in 1953 and 1992. Mount Spurr is the snow- and ice-covered peak on the skyline. View is to the north. Photograph by C. Neal, U.S. Geological Survey, June 3, 1993.

Mount Spurr Volcano

12. Crater Peak, a satellite vent of Mount Spurr volcano, and the snow- and ice-covered summit lava dome complex of Mount Spurr beyond. View is to the north. Photograph by R. McGimsey, U.S. Geological Survey, 10/9/91.

Mount Spurr Volcano



13. As shown here, prior to its 1992 eruptions, Crater Peak, a satellite vent of Mount Spurr volcano, contained a warm lake about 100 m (330 ft) across. Photograph by D. Turner, University of Alaska Fairbanks, 1986.

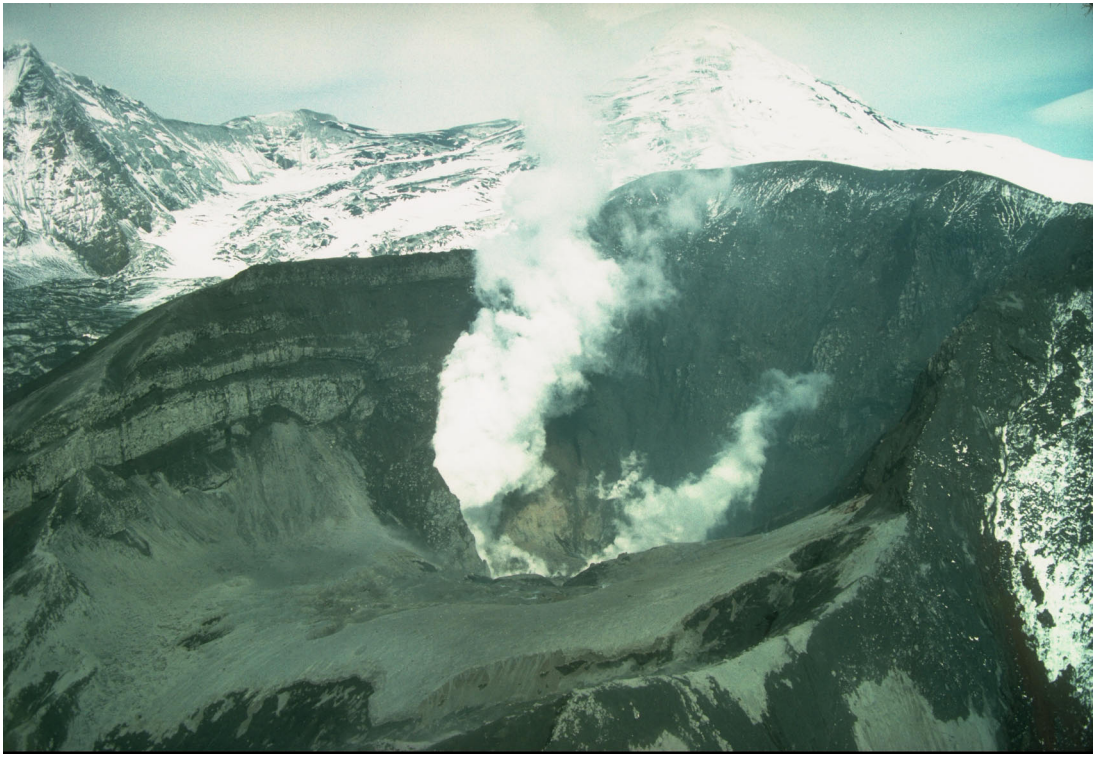
Mount Spurr Volcano

14. In early June, 1992, this lake inside Crater Peak vent at Mount Spurr volcano had a temperature of 49.7°C (121°F) and a pH of 2.5. Note a circular upwelling zone about 5 m (16 ft) across at the middle right, and the vigorously steaming talus pile on the far shore. Photograph by R. McGimsey, U.S. Geological Survey, June 11, 1992.

Mount Spurr Volcano

15. Alaska Volcano Observatory scientist (upper right) observing hydrothermal activity inside the Crater Peak vent of Mount Spurr volcano stands on a rampart of pyroclastic debris deposited during the 1953 eruption. Photograph by R. McGimsey, U.S. Geological Survey, June 11, 1992.

Mount Spurr Volcano



16. Following a brief, violent eruption on June 27, 1992, the interior of the Crater Peak vent steams vigorously. Newly deposited pyroclastic debris covers the interior of the crater and the preeruption crater lake shown in photograph 14 is completely gone. View is to the north. Photograph by C. Nye, Alaska Division of Geological and Geophysical Surveys, June 28, 1992.

Mount Spurr Volcano

17. Vertical eruption column and spreading eruption cloud from the Crater Peak vent, Mount Spurr volcano (top to right). View is to the north. Photograph by S. Walker, August 18, 1992.

Mount Spurr Volcano

18. Vertical eruption column and spreading eruption cloud from the Crater Peak vent, Mount Spurr volcano. A light-tan cloud ascending from pyroclastic flows is visible at right. The summit lava dome complex of Mount Spurr volcano, 3,374-m (11,070 ft)-high, is visible at lower left. View is to the north. Photograph by R. McGimsey, August 18, 1992.

Mount Spurr Volcano

19. Close aerial view, looking east, of the base of the vertical eruption column from the Crater Peak vent, Mount Spurr volcano. Photograph by R. McGimsey, U.S. Geological Survey, August 18, 1992.

Mount Spurr Volcano

20. Aerial view, looking north, of the eruption column from the Crater Peak vent, Mount Spurr volcano. A light-tan cloud ascending from pyroclastic flows is visible at right. The 3,374-m (11,070 ft)-high summit lava dome complex of Mount Spurr is visible at left. Photograph by R. McGimsey, U.S. Geological Survey, August 18, 1992.

Mount Spurr Volcano

21. Avalanches of pyroclastic debris ejected during the August 18, 1992, eruption of the Crater Peak vent, Mount Spurr volcano, formed overlapping, lobate tongues of material that blanketed the lower southeastern slopes of Crater Peak. Bombs ejected from Crater Peak during the eruption produced impact craters which dot the surface; some craters reached up to 5 m (16 ft) in diameter. Photograph by C. Neal, U.S. Geological Survey, September 3, 1992.

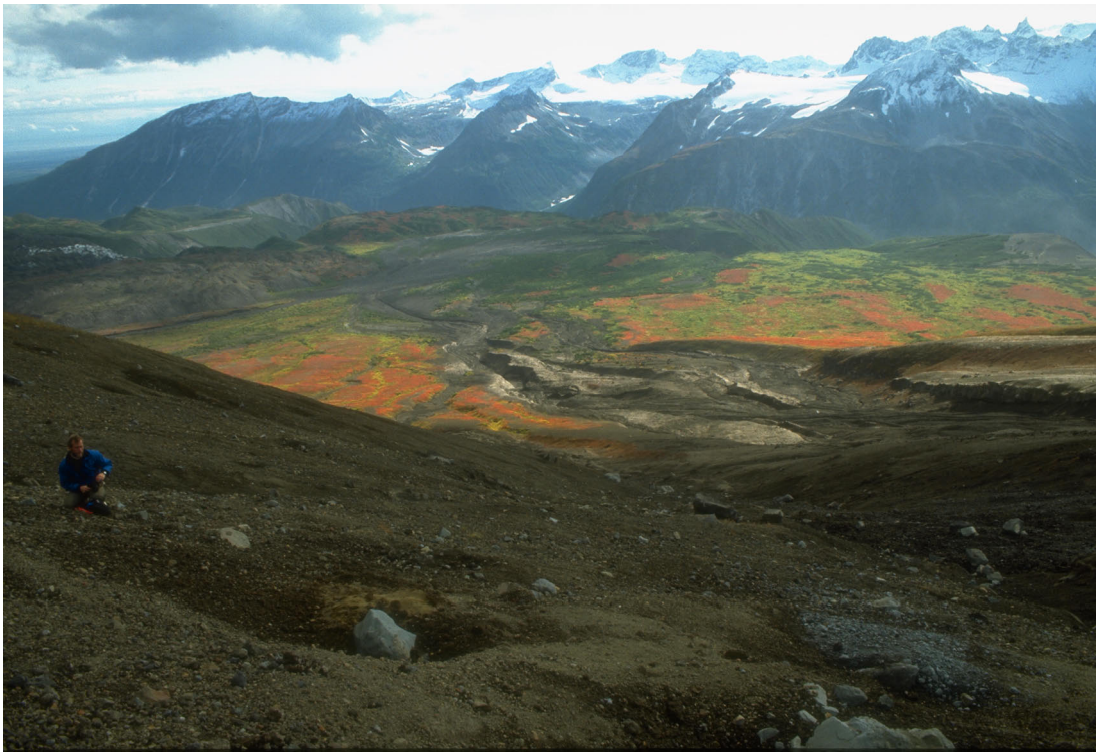
Mount Spurr Volcano

22. Alaska Volcano Observatory scientist sampling the pyroclastic flow deposit from the August 18, 1992, eruption of Crater Peak, a satellite vent of Mount Spurr volcano. View is to the northwest looking up the southeast flank of Crater Peak. Photograph by R. McGimsey, U.S. Geological Survey, September 9, 1992.

Mount Spurr Volcano

23. Juvenile material ejected during the August 18, 1992, eruption of Crater Peak, a satellite vent of Mount Spurr volcano. Ejecta that fell near the volcano consisted principally of these poorly inflated, brown “cauliflower”-textured andesite bombs. Field notebook (14x20 cm; [6x8 in]) shows scale. Photograph by C. Neal, U.S. Geological Survey, September 3, 1992.

Mount Spurr Volcano



24. Impact crater formed by a dense lithic block ejected during the August 18, 1992, eruption of the Crater Peak vent of Mount Spurr volcano. View is to the southeast. Photograph by C. Neal, U.S. Geological Survey, September 9, 1992.

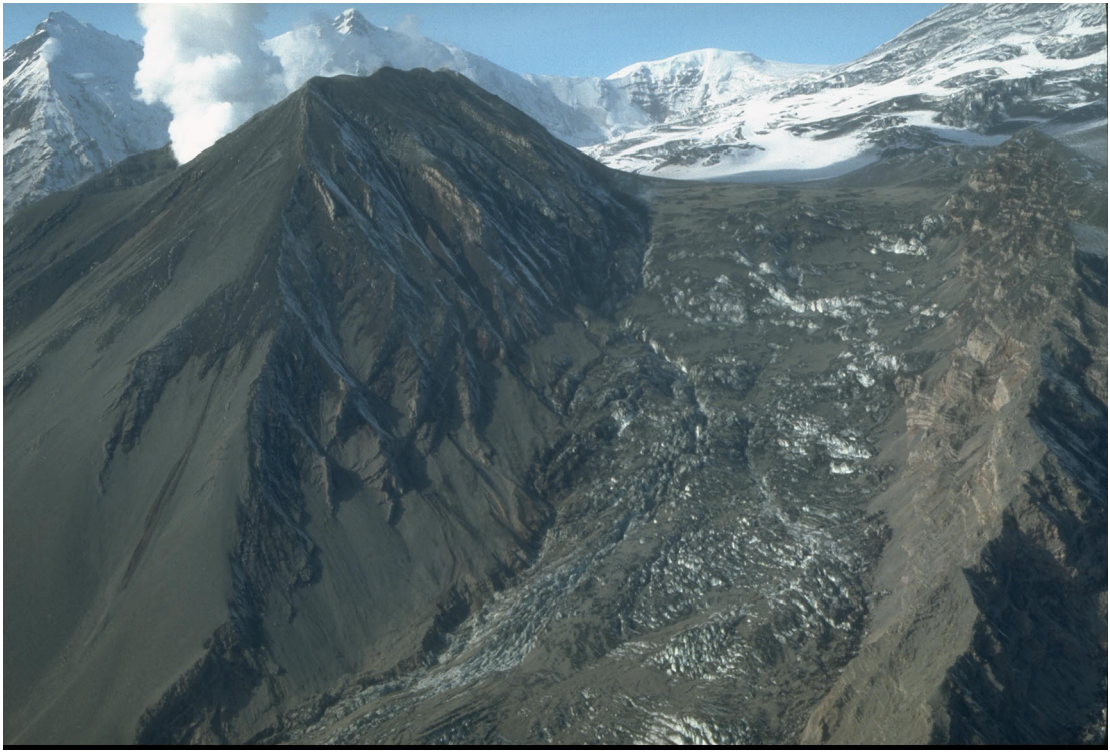
Mount Spurr Volcano

25. Tephra from the 1992 eruptions of the Crater Peak vent, Mount Spurr volcano, blanketed narrow swaths of the surrounding countryside. In this view, about 15 cm (6 in) of coarse sand to gravel-sized tephra is exposed in the pit. The surface is dotted with cobble-sized bombs from the September 16 to 17, 1992, eruption. Photograph by R. McGimsey, U.S. Geological Survey, September 23, 1992.

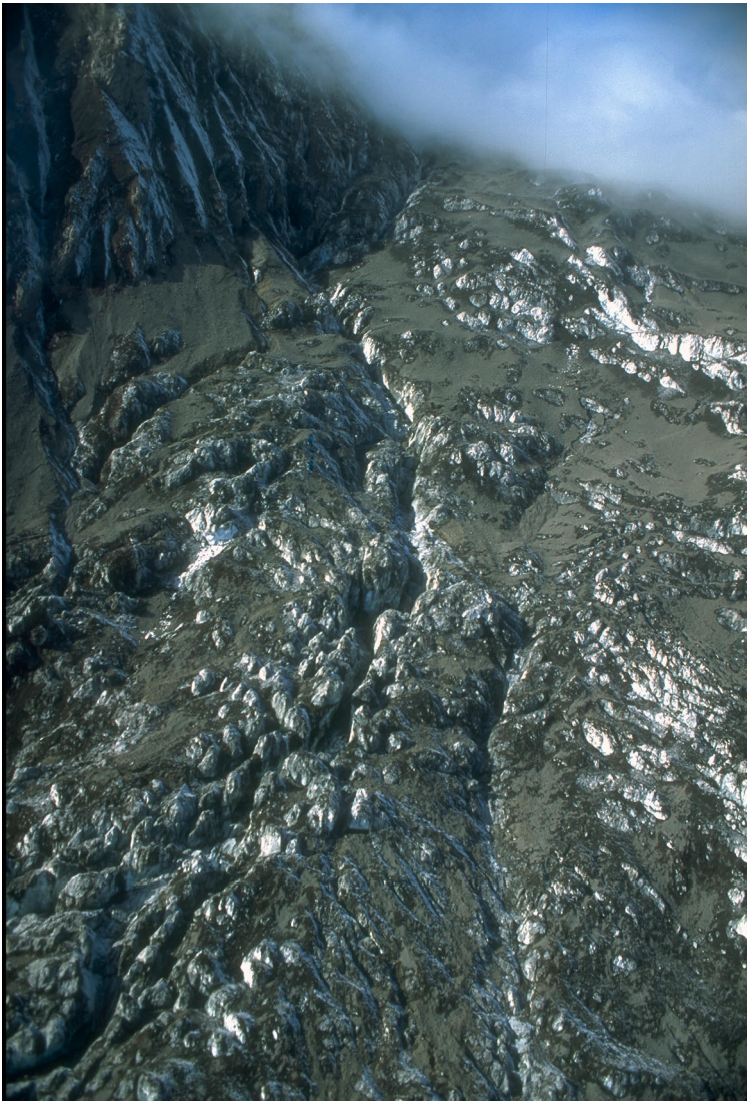
Mount Spurr Volcano

26. Within several kilometers of the Crater Peak vent, Mount Spurr volcano, tephra-fall from the 1992 eruptions stripped bark from woody vegetation (bush is about 1.5 m [5 ft] across). Photograph by C. Neal, U.S. Geological Survey, September 9, 1992.

Mount Spurr Volcano



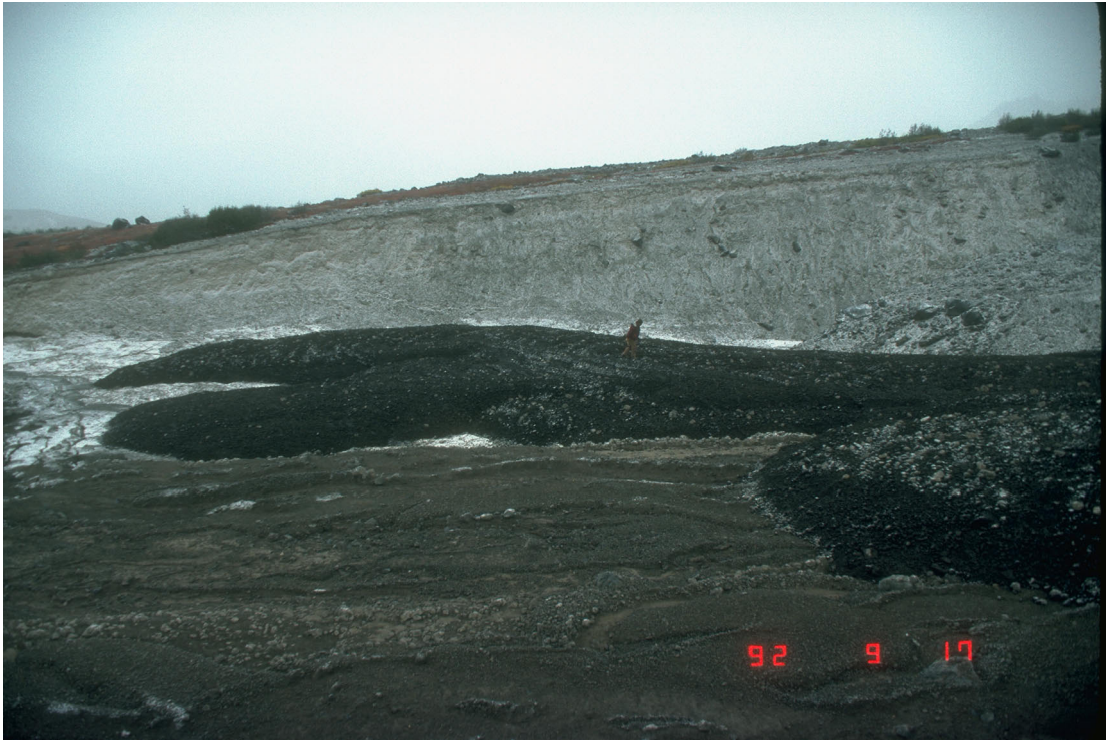
27. The final 1992 eruption of the Crater Peak vent, Mount Spurr volcano, showered hot debris onto the Kidazgeni Glacier immediately east of Crater Peak. In this view, steam billows from Crater Peak. Dark pyroclastic material blankets the flanks of Crater Peak and the adjacent glacial ice. Photograph by C. Gardner, U.S. Geological Survey, September 23, 1992.



Mount Spurr Volcano

28. Hot pyroclastic debris from the September 16 to 17, 1992, eruption of the Crater Peak vent, Mount Spurr volcano, melted deep channels into the crevassed Kidazgeni Glacier. The debris combined with meltwater to produce mudflows or lahars that reached the Chakachatna River, 7 km (4 mi) distant. Photograph by C. Neal, U.S. Geological Survey, September 24, 1992.

Mount Spurr Volcano



29. Alaska Volcano Observatory scientist examining lahar deposits formed during the September 16 to 17, 1992, eruption of the Crater Peak vent, Mount Spurr volcano. Photograph by R. McGimsey, U.S. Geological Survey, September 17, 1992.

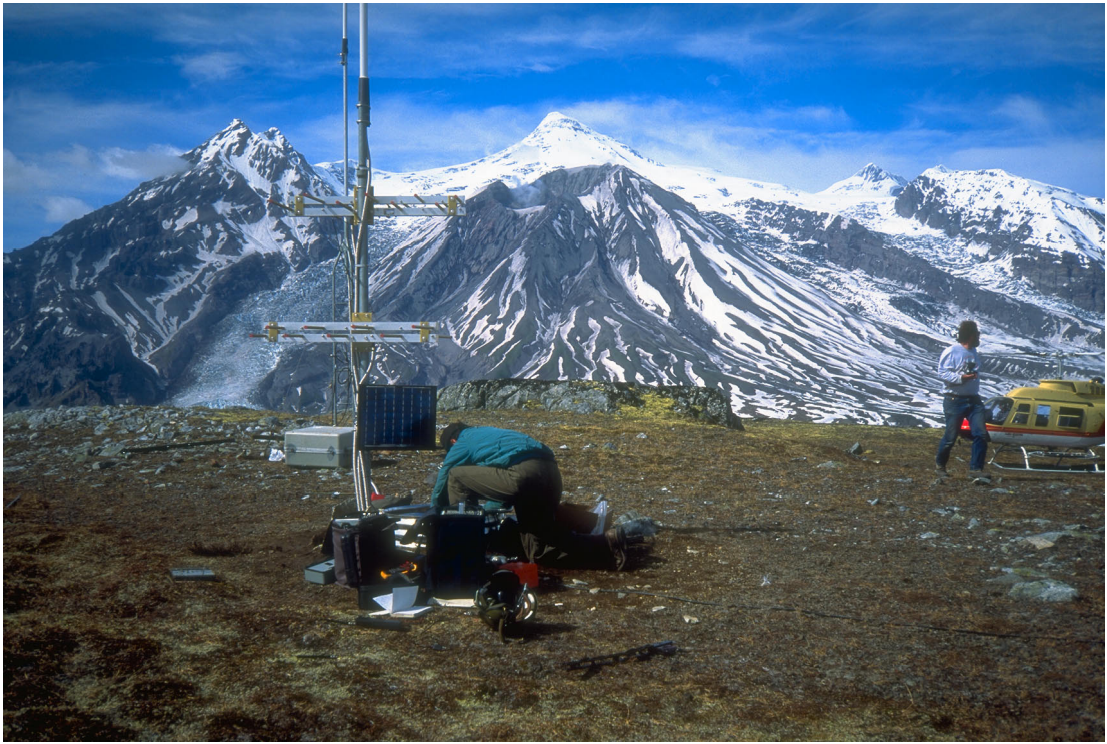
Mount Spurr Volcano

30. In this sunset view (westward) from the rooftop of the Alaska Volcano Observatory in Anchorage, a prominent steam and gas plume rises from the Crater Peak vent, Mount Spurr volcano. Photograph by M. Doukas, U.S. Geological Survey, October, 1992.

Mount Spurr Volcano

31. Aerial view of Crater Peak vent, Mount Spurr volcano. Following the three eruptions of 1992, the interior of Crater Peak was partially filled with pyroclastic debris to a thickness of more than 20 m (65 ft). A plume of steam and volcanic gas, at times vigorous, continued to emanate from the vent for several years. Photograph by C. Gardner, U.S. Geological Survey, September 26, 1992.

Mount Spurr Volcano



32. Seismometers such as this one installed near Mount Spurr volcano (on skyline in background) provide the Alaska Volcano Observatory with a continuous, radio-telemetered record of volcanic earthquakes. These data are used to monitor the state of activity at the volcano and are critical to the ability of the Observatory to issue timely warnings of eruptions. View is to the north. Photograph by C. Neal , U.S. Geological Survey, June 3, 1993.

Redoubt Volcano

33. Redoubt Volcano, 3,108 m (10, 197 ft) high, is one of the active volcanoes of the Cook Inlet region. Steam and volcanic gas rise above the summit crater of the volcano following the 1989 to 1990 eruptions. Iliamna volcano, 55 km (34 mi) south, is in on the skyline at left. View is to the southwest. Photograph by C. Neal, U.S. Geological Survey, August 13, 1990.

Redoubt Volcano

34. Redoubt Volcano, 3,108 m (10, 197 ft) high, is one of the active volcanoes of the Cook Inlet region. Steam and volcanic gas rise above the summit of the volcano following the 1989 to 1990 eruptions. View is to the west. Photograph by C. Gardner, U.S. Geological Survey, July 6, 1990.

Redoubt Volcano

35. Redoubt Volcano, 3,108 m (10, 197 ft) high, is one of the active volcanoes of the Cook Inlet region. The breached summit crater is drained by Drift glacier, which empties into the Drift River valley forming a piedmont lobe. View to the south. Photograph by A. Till, U.S. Geological Survey, September 1, 1980.

Redoubt Volcano

36. Aerial view, looking southeast, at the summit of Redoubt Volcano. Prior to the onset of the 1989 to 1990 eruptions of Redoubt Volcano, melting of the summit crater ice cap caused by heat from rising magma produced a vigorous steam plume. Photograph by H. Twitchell, National Park Service, December 14, 1989.

Redoubt Volcano

37. Aerial view, looking northeast, of Redoubt Volcano during a continuous, low-level eruption of steam and ash. Photograph by W. White, U.S. Geological Survey, December 18, 1989.

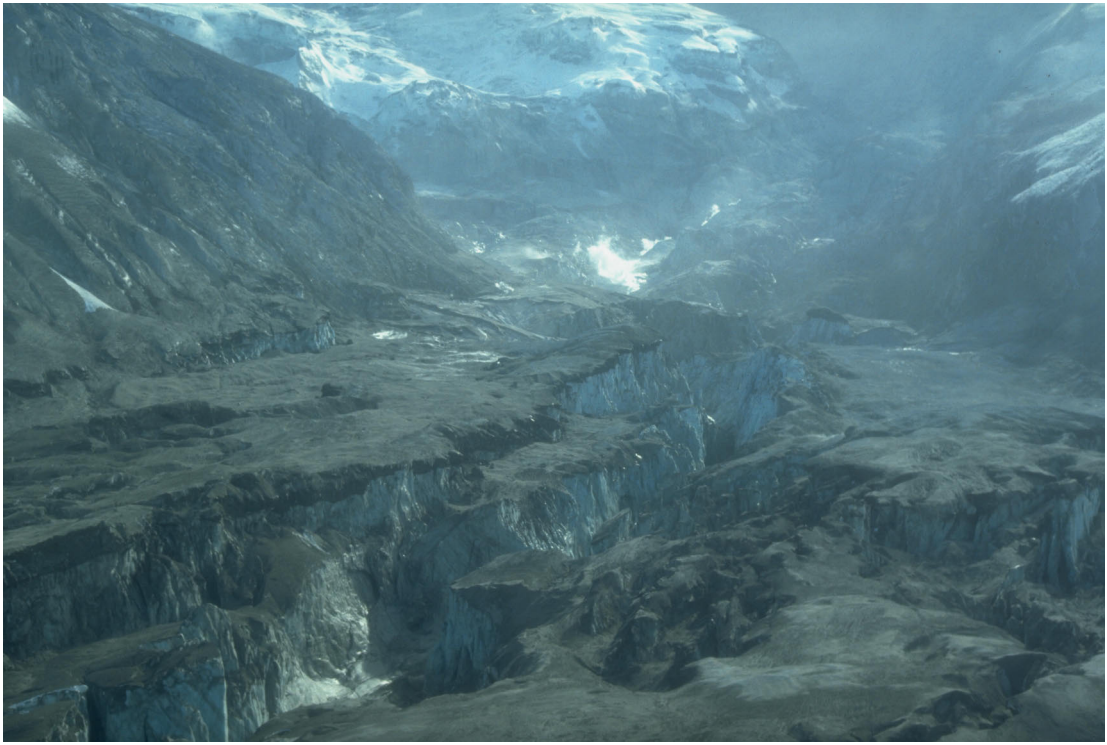
Redoubt Volcano

38. Aerial view, looking north, of Redoubt Volcano during a continuous, low-level eruption of steam and ash. Photograph by W. White, U.S. Geological Survey, December 18, 1989.

Redoubt Volcano

39. The 1989 to 1990 eruptions of Redoubt Volcano were characterized by repeated growth and destruction of lava domes in the summit crater. This view shows the north face of the second largest lava dome, which was destroyed during an explosive eruption on February 15, 1990. Photograph by R. McGimsey, U.S. Geological Survey, February 2, 1990.

Redoubt Volcano



40. The 1989 to 1990 eruptions of Redoubt Volcano were characterized by repeated growth and destruction of lava domes in the summit crater. Avalanching of hot debris from disintegrating lava domes caused extensive melting of the glacier draining the summit crater and produced deeply incised channels with steep ice walls. View is to the north. Photograph by T. Miller, U.S. Geological Survey, April 7, 1990.

Redoubt Volcano

41. Hot debris avalanching down the steep north flank of Redoubt Volcano during the 1989 to 1990 eruptions mixed with water derived from melted snow and ice to form lahars. These sediment-rich floods carried steaming debris as far as 35 km (22 mi) down the Drift River valley. Photograph by T. Miller, U.S. Geological Survey, February 15, 1990.

Redoubt Volcano

42. Lahars formed during the 1989 to 1990 eruptions of Redoubt Volcano accumulated in the Drift River valley. The largest lahars, such as this one from the February 15, 1990 eruption, covered the valley floor nearly wall to wall and extended more than 35 km (22 mi) to the Cook Inlet. View is to the west. Photograph by T. Miller, U.S. Geological Survey, February 15, 1990.

Redoubt Volcano

43. Large blocks of glacial ice were carried many kilometers downstream by lahars during the 1989 to 1990 eruptions of Redoubt Volcano. Photograph by T. Miller, U.S. Geological Survey, January 5, 1990.

Redoubt Volcano

44. One of the principal facilities at risk during the 1989 to 1990 eruptions of Redoubt Volcano was the Drift River Oil Terminal located at the mouth of the Drift River, 35 km (22 mi) northeast of the volcano. This aerial view, looking southwest, shows the 1.9 billion-barrel capacity oil storage tanks. Redoubt Volcano is on the skyline at left. Photograph by R. McGimsey, U.S. Geological Survey, April 13, 1990.

Redoubt Volcano

45. The February 15, 1990 eruption of Redoubt Volcano produced a lahar that overtopped the containment berm at the Drift River Oil Terminal but did not damage the storage tanks. Photograph by T. Miller, U.S. Geological Survey, February 15, 1990.

Redoubt Volcano

46. Geologists view an unusual flowing mixture of water and ice in the upper Drift River. The flow was produced by a sudden release of impounded water from the upper reaches of the Drift River canyon which drains the summit crater of Redoubt Volcano. Photograph by R. McGimsey, U.S. Geological Survey, March 15, 1990.

Redoubt Volcano

47. Lahars from the 1989 to 1990 eruptions of Redoubt Volcano inundated this structure near the mouth of Drift River, 35 km (22 mi) from the volcano. Photograph by C. Gardner, U.S. Geological Survey, June 1, 1990.

Redoubt Volcano

48. Where exposed by subsequent stream downcutting, lahar deposits from the 1989 to 1990 eruptions of Redoubt Volcano consisted of layers of sand- to boulder-sized debris. Photograph by R. McGimsey, U.S. Geological Survey, June 15, 1990.

Redoubt Volcano

49. Aerial view, looking southwest, of the Drift River valley following the 1989 to 1990 eruptions of Redoubt Volcano. Two bedrock islands (informally called the “Dumbbell Hills”) are visible at bottom center. Lahar deposits cover the valley floor. Photograph by C. Gardner, U.S. Geological Survey, June 28, 1990.

Redoubt Volcano

50. During the eruption of Redoubt Volcano on December 15, 1989,), hot ejecta falling onto the upper flanks of the volcano produced avalanches of snow, ice, meltwater, and pyroclastic debris to form an unusual ice-rock diamict. In this view, the diamict is approximately 4.5 m (15 ft) thick and caps ice of the piedmont lobe of Drift glacier . Overlying the ice-rock diamict are sand to gravel-sized pyroclastic flow deposits from eruptions between January and March of 1990. Photograph by C. Gardner, U.S. Geological Survey, May 19, 1990.

Redoubt Volcano

51. Oblique aerial view of the upper portion of the piedmont lobe of Drift glacier. White towers of glacial ice are capped by about 10 m (33 ft) of ice-rock diamict (dark brown) from the December 15, 1989, eruption of Redoubt Volcano. The ice-rock diamict is overlain by tan, sand to gravel-sized pyroclastic flow and lahar deposits from the more than 20 eruptions that occurred through April 21, 1990. Photograph by C. Neal, U.S. Geological Survey, August 12, 1990.

Redoubt Volcano

52. Geologists examining steaming pyroclastic-flow deposits from the March 23, 1990, eruption of Redoubt Volcano that came to rest on the margin of the piedmont lobe of Drift glacier. Darker areas were wet and reflected melting of glacial ice incorporated into the deposit. The collapse pits seen here resulted from funneling of debris into crevasses and holes in the buried surface of the glacier. Photograph by R. McGimsey, U.S. Geological Survey, March 23, 1990.

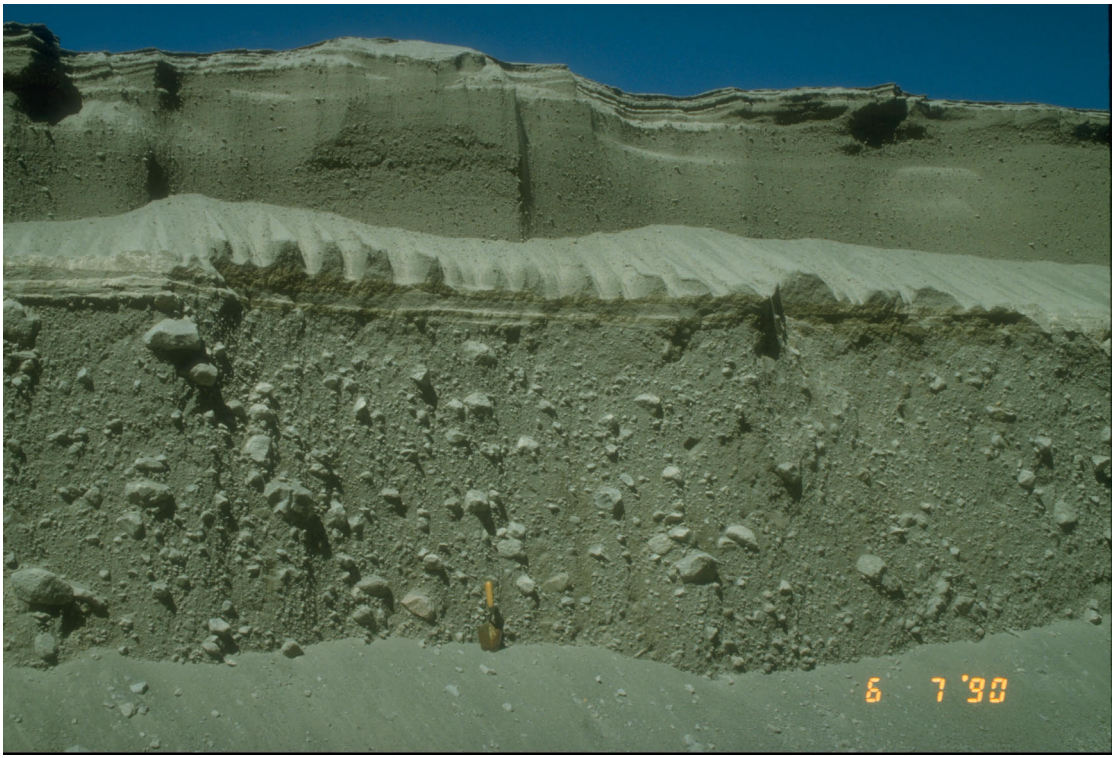
Redoubt Volcano

53. Geologists examining 1990 pyroclastic-flow and pyroclastic-surge deposits on the surface of the piedmont lobe of Drift glacier at Redoubt Volcano. Photograph by C. Gardner, U.S. Geological Survey, August 3, 1990.

Redoubt Volcano

54. Geologist examining 1990 pyroclastic-flow and pyroclastic-surge deposits on the surface of the piedmont lobe of Drift glacier at Redoubt Volcano. Photograph by C. Gardner, U.S. Geological Survey, July 20, 1991.

Redoubt Volcano



55. Pyroclastic-flow deposits from the April 15 (lower two thirds of section) and April 21 (upper one third of section), 1990 eruptions of Redoubt Volcano exposed in a gully along the western margin of the piedmont lobe of Drift glacier. Shovel at base of section shows scale. Photograph by C. Neal, U.S. Geological Survey, June 7, 1990.

Redoubt Volcano

56. Steam billows from newly exposed, hot pyroclastic debris in the canyon draining the summit crater of Redoubt Volcano. More than 30 meters (100 ft) of coarse sand to boulder sized material accumulated in this canyon during the 1989 to 1990 eruptions of the volcano. Subsequent downcutting by meltwater occasionally caused steam explosions as water came into contact with hot pyroclastic material. Photograph by C. Gardner, U.S. Geological Survey, July 16, 1990.

Redoubt Volcano

57. Tephra-fall deposits from some of the larger eruptions of Redoubt Volcano between December 15, 1989 and April 21, 1990. Above the dark vegetation mat is about 8 cm (3 in) of gravel-sized pumice and lithic lapilli from the December 15, 1989 eruption. This is overlain by about 8 cm (3 in) of coarse ash from several subsequent eruptions in 1990. Ruler, 15 cm (6 in) long, shows scale. Photograph by R. McGimsey, U.S. Geological Survey, August 20, 1990.

Redoubt Volcano

58. Gray ash from the February 21, 1990, eruption of Redoubt Volcano blankets the snow in Indian, Alaska, a community about 32 km (20 mi) southeast of Anchorage and 200 km (124 mi) northeast of Redoubt Volcano. Photograph by R. McGimsey, U.S. Geological Survey, February 21, 1990.

Redoubt Volcano

59. The final lava dome of the 1989 to 1990 series of eruptions of Redoubt Volcano was emplaced in the summit crater by summer, 1990. It measures approximately 350 to 400 m (980 to 1,300 ft) across and represents an estimated 10 million cubic meters (353 million cubic feet) of material. Photograph by C. Neal, U.S. Geological Survey, July 17, 1990.

Redoubt Volcano

60. Aerial view of the highly irregular, steep north face of the final lava dome of the 1989 to 1990 series of eruptions of Redoubt Volcano. The surface consists of blocks of slightly vesicular to dense andesite lava up to 30 m (100 feet) across. Yellow sulfur deposits are visible on a block of lava at center of view. Photograph by C. Neal, U.S. Geological Survey, July 17, 1990.

Redoubt Volcano

61. The south face of the final lava dome of the 1989 to 1990 series of eruptions of Redoubt Volcano as it appeared during the waning phases of eruption. A fractured lobe of blocky lava is visible at center. Steam from the interaction of meltwater with hot rock billows from the margins of the lava dome. Remnants of glacial ice with a coating of gray ash surround the dome. Photograph by C. Gardner, U.S. Geological Survey, June 1, 1990.

Redoubt Volcano

62. Final lava dome of the 1989 to 1990 series of eruptions of Redoubt Volcano as it appeared approximately one year after the end of the eruption. It measures approximately 350 to 400 m (980 to 1,300 ft) across and represents an estimated 10 million cubic meters (353 million cubic feet) of material. By the time this photograph was taken, snow had accumulated on the cooling lava blocks. Locally, hydrothermal activity continued to produce intermittent steam plumes. View is to the south. Photograph by R. McGimsey, U.S. Geological Survey, June 21, 1990.

Redoubt Volcano

63. Ascending eruption cloud from Redoubt Volcano and its reflection in the waters of Cook Inlet. View is to the west from the Kenai Peninsula. Photograph by J. Warren, April 21, 1990.

Redoubt Volcano

64. Ascending eruption cloud from Redoubt Volcano and its reflection in the waters of Cook Inlet. View is to the west from the Kenai Peninsula. Photograph by J. Warren, April 21, 1990.

Redoubt Volcano

65. Ascending eruption cloud from Redoubt Volcano as viewed to the west from the Kenai Peninsula. The mushroom-shaped plume rose from avalanches of hot debris (pyroclastic flows) that cascaded down the north flank of the volcano. A smaller, white steam plume rises from the summit crater. Photograph by R. Clucas, April 21, 1990.

Redoubt Volcano

66. Geologist using a laser surveying instrument to measure distances to reflective prisms or targets installed on the flanks of Redoubt Volcano in the distance. Minute changes in distances to the targets can indicate ground deformation that may be related to subsurface magma movement. View is to the south. Photograph by R. McGimsey, May 4, 1990.

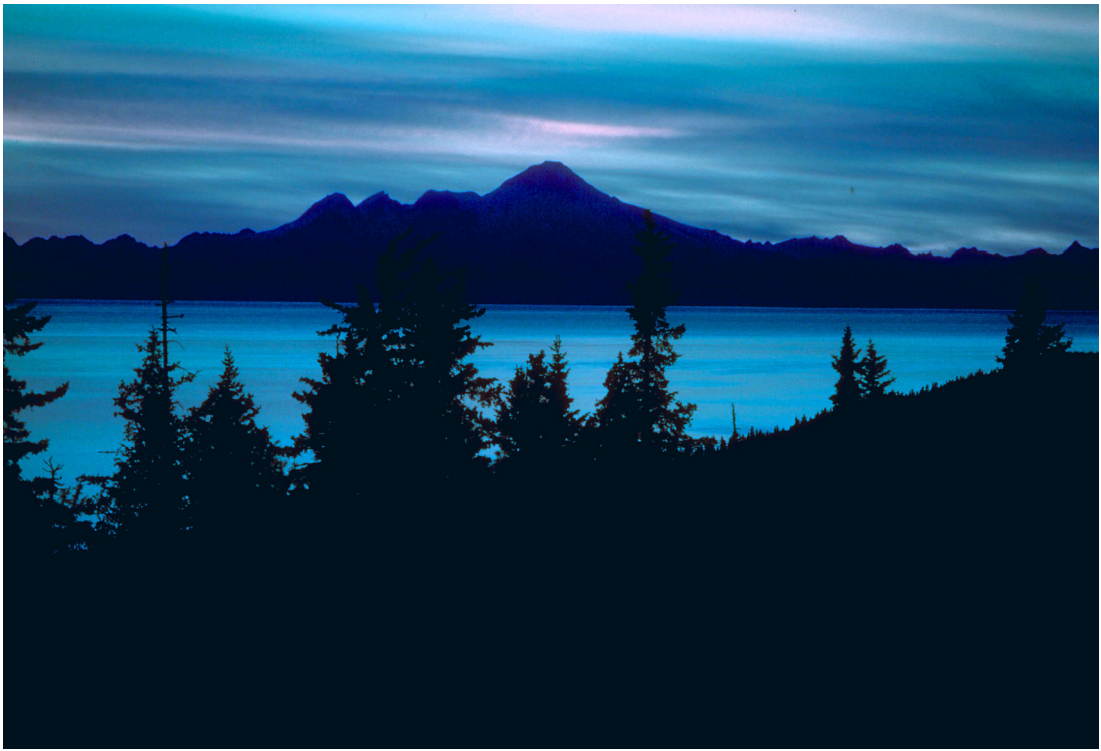
Redoubt Volcano

67. Geologist setting up GPS (Global Positioning System) instrumentation on the north flank of Redoubt Volcano. The GPS receiver calculates an extremely accurate position on the Earth's surface through satellite-based triangulation. View is to the northeast. Photograph by R. McGimsey, June 21, 1991.

Iliamna Volcano

68. Steam and volcanic gas rising from the nearly continuously active fumaroles high on north face of 3,053-m (10,016 ft)-high Iliamna Volcano. Iliamna Volcano is one of the four Cook Inlet volcanoes monitored by the Alaska Volcano Observatory. Photograph by R. McGimsey, U.S. Geological Survey, May 6, 1986.

Iliamna Volcano



69. Iliamna Volcano, 3,053 m (10,016 ft) high, as seen at sunset from the Kenai Peninsula. Iliamna Volcano is one of the four Cook Inlet volcanoes monitored by the Alaska Volcano Observatory. View is to the west. U.S. Geological Survey photograph, 1977.

Iliamna Volcano

70. Iliamna Volcano, 3,053 m (10,016 ft) high, as seen from Augustine Island, 75 km (47 mi) to the south. Iliamna Volcano is one of the four Cook Inlet volcanoes monitored by the Alaska Volcano Observatory. Photograph by R. McGimsey, U.S. Geological Survey, July 29, 1994.

Augustine Volcano

71. Steam rising from the newly formed summit lava dome at 1,282-m (4,206 ft)-high Augustine Volcano. View is to the south. Photograph by T. Miller, U.S. Geological Survey, April 19, 1986.

Augustine Volcano

72. Steam rising from the summit lava dome complex at 1,282-m (4,206 ft)-high Augustine Volcano. Note the symmetrical apron of pyroclastic debris that extends from the summit to sea level. View is to the east. Photograph by T. Miller, U.S. Geological Survey, June 6, 1989.

Augustine Volcano

73. A symmetrical apron of pyroclastic debris extends from the summit of 1,282-m (4,206 ft)-high Augustine Volcano to sea level. The western shore of Cook Inlet can be seen in the distance. View is to the west. Photograph by C. Neal, U.S. Geological Survey, June 4, 1990.

Augustine Volcano

74. Steam plume rising from 1,282-m (4,206 ft)-high Augustine Volcano as seen from Anchorage, Alaska, at sunset. Redoubt Volcano is on the skyline at right. View is to the southwest. Photograph by B. Gamble, U.S. Geological Survey, August 30, 1986.

Augustine Volcano

75. Augustine Volcano, 1,282 m (4,206 ft) high, seen at sunset from near Homer, Alaska. Steam and volcanic gas trails downwind from the summit lava dome complex. View is to the west. U.S. Geological Survey photograph, 1977.

Augustine Volcano

76. A vigorous eruption column rising over the summit of 1,282-m (4,206 ft)-high Augustine Volcano. At the time of this photograph, a new lava dome was growing at the summit. At upper right, ash can be seen falling from the eruption cloud as it travels downwind away from the volcano. Photograph by M.E. Yount, U.S. Geological Survey, March 31, 1986.

Augustine Volcano

77. A vigorous eruption column rising over the summit of 1,282-m (4,206 ft)-high Augustine Volcano. Photograph by M.E. Yount, U.S. Geological Survey, March 31, 1986.

Augustine Volcano

78. A vigorous eruption column rising over the summit of 1,282-m (4,206 ft)-high Augustine Volcano. Steam can be seen rising from the margins of the summit crater. U.S. Geological Survey photograph, March 27, 1986.

Augustine Volcano

79. A vigorous eruption column rising over the summit of 1,282-m (4,206 ft)-high Augustine Volcano. Steam can be seen rising from the margins of the summit crater and from other areas where groundwater has been heated by the eruption. Photograph by M.E. Yount, U.S. Geological Survey, March 27, 1986.

Augustine Volcano

80. A vigorous eruption column rising over the summit of 1,282-m (4,206 ft)-high Augustine Volcano. Ash is falling in dark tendrils that extend downward from the eruption cloud. U.S. Geological Survey photograph, March 27, 1986.

Augustine Volcano

81. A pyroclastic flow sweeping down the north flank of 1,282-m (4,206 ft)-high Augustine Volcano. Photograph by M.E. Yount, U.S. Geological Survey, March 27, 1986.

Augustine Volcano

82. A pyroclastic flow sweeping down the north flank of 1,282-m (4,206 ft)-high Augustine Volcano. A light-colored ash cloud can be seen rising from the moving flow. Photograph by M.E. Yount, U.S. Geological Survey, March 30, 1986.

Augustine Volcano

83. A pyroclastic flow sweeping down the north flank of 1,282-m (4,206 ft)-high Augustine Volcano. The eruption cloud is carried to the east by prevailing winds. Photograph by M.E. Yount, U.S. Geological Survey, March 30, 1986.

Augustine Volcano

84. Steam rising from the cooling lava dome fills the summit crater at Augustine Volcano. U.S. Geological Survey photograph, July 24, 1986.

Augustine Volcano

85. Steam rising from the summit lava dome complex of Augustine Volcano. In this picture, the lava dome, formed in 1976, is enclosed within a steep-walled crater roughly 500 m (1,640 ft) across and breached to the north. This crater formed during an explosive eruption in 1964. The surface of the lava dome consists of rough, irregular blocks of andesite lava. A coating of fine ash is visible. Photograph by C. Nye, Alaska Division of Geological and Geophysical Surveys, 1982.

Augustine Volcano

86. The summit lava dome complex at Augustine Volcano. Steam rises from the base of the lava dome formed in 1986. U.S. Geological photograph, August 24, 1986.

Augustine Volcano

87. The summit lava dome complex at Augustine Volcano. The apron of pyroclastic debris extending from the lava dome accumulated during the 1986 eruptions. View is to the south. Photograph by T. Miller, U.S. Geological Survey, April 28, 1986.

Augustine Volcano

88. Geologist examining pyroclastic-flow deposits from the 1986 eruptions of Augustine Volcano. Photograph by T. Miller, U.S. Geological Survey, May 6, 1986.

Augustine Volcano

89. Geologist sampling blocks from the lava dome formed in 1986 at Augustine Volcano. Photograph by T. Miller, U.S. Geological Survey, May 6, 1986.

Augustine Volcano

90. A large fragment of the lava dome that was carried about 5 km (3 mi) in a pyroclastic flow during the 1986 eruptions of Augustine Volcano. Photograph by M.E. Yount, U.S. Geological Survey, May 6, 1986.

Augustine Volcano

91. A large fragment of the lava dome in pyroclastic-flow deposits from the 1986 eruptions of Augustine Volcano. The 1282-m (4,206 ft)-high volcano is in the background. Hammer shows scale. U.S. Geological Survey photograph, April 19, 1986.

Augustine Volcano

92. Apron of pyroclastic-flow deposits emplaced during the 1986 eruptions of 1282-m (4,206 ft)-high Augustine Volcano. In the background is the steaming summit lava dome complex. U.S. Geological Survey photograph, April 30, 1986.

Augustine Volcano

93. Light-colored pyroclastic-flow deposits from the 1986 eruptions of Augustine Volcano. Pyroclastic flows entered the sea along the northeast shoreline of the island, visible in this view. U.S. Geological Survey photograph, August 22, 1986.

Augustine Volcano

94. Debris-avalanche deposits from the 1883 eruption of Augustine Volcano entered the sea along the north shoreline of the island (darker area at top of photograph.) Light-colored areas are pyroclastic-flow deposits from the 1976 and 1986 eruptions U.S. Geological Survey photograph, April 25, 1986.

Augustine Volcano

95. Debris avalanche deposits from the 1883 eruption of Augustine Volcano entered the sea along the north shoreline of the island forming hummocky topography. U.S. Geological Survey photograph, April 27, 1986.

Augustine Volcano

96. Debris avalanche deposits from the 1883 eruption of Augustine Volcano form small hills and islets at Burr Point on the north shore of Augustine Island. Photograph by S. McNutt, Geophysical Institute, University of Alaska, July 31, 1992.

Augustine Volcano

97. View of the southwest flank of Augustine Volcano. Note the steep-sided lava dome complex forming the summit of the volcano. Photo by R. McGimsey, U.S. Geological Survey, July 29, 1994.

GLOSSARY OF SELECTED TERMS

ash:
Fine fragments (less than 2 mm [1/16 in] across) of lava or rock formed in an explosive volcanic eruption.

andesite:
Volcanic rock containing about 52 to 63 percent SiO_2, which is an essential constituent of most minerals found in rocks.

bombs:
Fragments of lava or rock larger than 64 mm (2.5 in) across ejected during a volcanic eruption.

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

cinder cone:
A steep-sided volcanic vent composed of loose, frothy ejecta.

crater lake:
A lake formed by the accumulation of groundwater, rainwater, or snowmelt in a volcanic crater or caldera. Sometimes the lake water is highly acidic.

debris avalanche:
Rapid downslope movement of a large mass of rock (for example, the flank of a volcano); resulting deposits are often characterized by a hummocky surface.

diamict:
A general term for a poorly sorted sedimentary rock or deposit.

dissected:
Sculptured by erosion due to the action of wind, water, or ice.

eruption cloud:
A cloud of gas and ash that forms during an explosive volcanic eruption and is carried away from the volcano with the prevailing wind.

eruption column:
The portion of the eruption cloud that rises vertically above a volcanic vent.

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

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

glacier:
Compacted mass of ice formed from accumulation, compaction, and recrystallization of snow. Glaciers often moves downslope under the influence of gravity and are a powerful erosive agent.

Global Positioning System:
A system of Earth-orbiting satellites, which allow an electronic receiver on the ground to calculate a precise position (latitude/longitude) on the Earth's surface by triangulation.

groundwater:
Water that is below the Earth's surface (for example, water contained within the porous rock of a volcano).

hydrothermal:
Of or pertaining to the movement and chemical action of hot groundwater.

juvenile:
Material erupted in a molten state as opposed to an accidental, older rock fragment ejected from a volcano.

lahar:
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 steep slopes.

lapilli:
Fragments of lava or rock between 2 and 64 mm (1/16 and 2.5 in) across ejected during a volcanic eruption.

lava:
Molten rock that reaches the Earth's surface.

lava dome:
A steep-sided mass of viscous and often blocky lava extruded from a vent; typically has a rounded top and roughly circular outline.

lava dome complex:
An overlapping series of generally rounded piles of lava extruded onto the Earth's surface from a volcanic vent (see lava dome).

lithic:
Synonym for "rock"; in volcanic deposits, it refers to fragments of preexisting rock as opposed to newly erupted juvenile material.

magma:
Molten rock beneath the Earth's surface; molten rock that erupts onto the Earth's surface is called lava.

pH:
A measure of the acidity or basicity of a solution (neutral is 7; the lower the number, the more acidic the solution).

phreatic:
In volcanology, a term that refers to the explosive interaction of groundwater or surface water with hot volcanic deposits or erupting magma.

piedmont lobe:
In referring to glaciers, a piedmont lobe occurs where a glacier emerges from a valley at the base of a mountain and, no longer constricted, spreads out into a lobate shape.

pumice:
Highly vesicular volcanic ejecta. It is often buoyant enough to float on water.

pyroclastic:
A general term applied to volcanic products or processes that involve explosive ejection and fragmentation of erupting material.

pyroclastic flow:
A dense, hot, and chaotic avalanche of rock fragments, gas, and ash that travels rapidly away down the flanks of a volcano.

pyroclastic surge:
A dilute , rapidly moving, hot cloud of rock fragments, gas, and ash that travels above the ground away from an explosive eruption.

satellite vent:
A volcanic cone that forms on the side of a volcano; a secondary vent.

seismometer:
An instrument that measures ground movement and earthquake activity.

shield volcano:
A broad, gently sloping volcano usually built up by many fluid lava flows of basalt or andesite composition (for example, Mount Wrangell, Alaska, or Mauna Loa, Hawaii).

talus:
Rock fragments, usually coarse and angular blocks, that accumulate into a loose pile at the base of a steep slope or rock wall.

tephra:
A general term for all fragmental volcanic material (for example, ash and bombs.)

vesicular:
The texture of a volcanic rock characterized by abundant holes or cavities that result from escaping gas (pumice is very vesicular).

vent:
An opening in the Earth's surface through which magma erupts or volcanic gases are emitted.