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Redoubt Volcano and the Alaska Volcano Observatory, 10 Years Later

By Game McGimsey

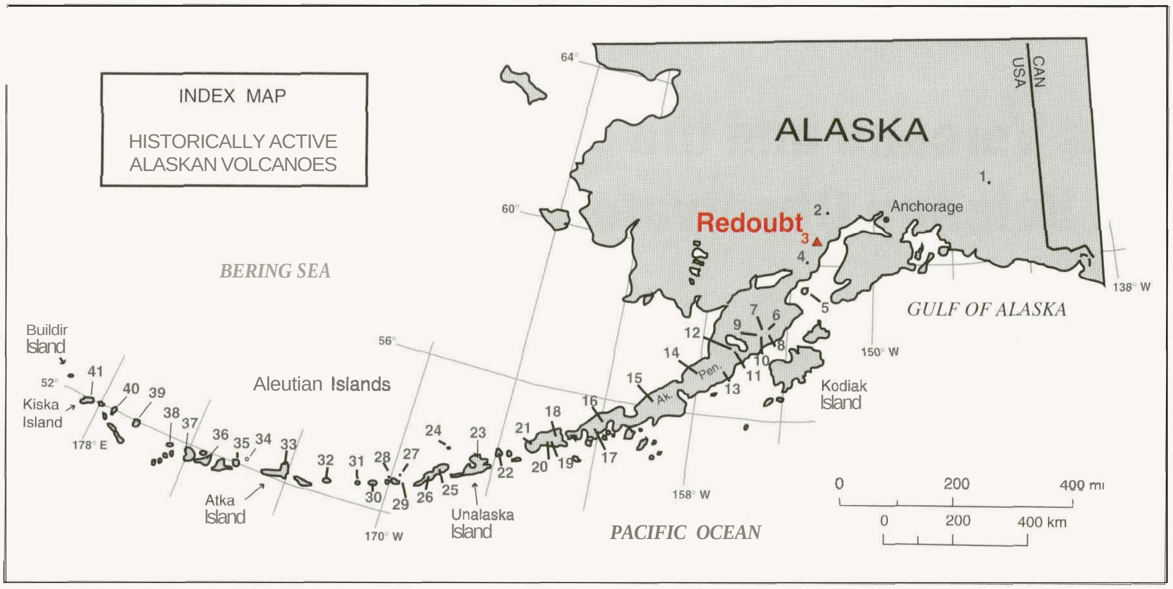
The sun was still low on the Alaska horizon late in the morning of December 15, 1989, as the 747-400 jumbo jet carrying 245 people from Amsterdam began its approach into Anchorage International Airport. As the plane descended through 26,000 ft into the regional cloud blanket over Talkeetna, day became night, and an ominous silence gripped the cabin as all four engines automatically shut down and gritty ash and sulfurous gas filled the air. The pilots had descended into a dense ash cloud produced a few hours earlier by an explosive eruption from Redoubt Volcano, 105 miles west of Anchorage (fig. 1). Fortunately, after gliding powerless for 8 frightful minutes and falling nearly 12,000 ft—to within 2,000 ft of the ground—disaster was averted when the engines were restarted and the plane landed successfully in Anchorage (Casadevall, 1994). The eruption of Redoubt Volcano and its impact on aircraft safety ushered in a new era of hazard assessment and volcano monitoring in Alaska.

December 14, 1999, marked 10 years since Redoubt Volcano began a 6-month eruption that disrupted transportation and commerce in south-central Alaska, threatened the Drift River Oil storage and loading Terminal (DROT), and caused more than $160 million in economic loss and property damage (Brantley, 1990; Miller and Chouet, 1994). Installation of the Redoubt seismic network was completed only a year prior to the eruption, allowing staff from the newly created Alaska Volcano Observatory (AVO) to monitor the activity and issue warnings. The eruption response propelled AVO from infancy to adulthood.

Prior to 1988, only one of the four Cook Inlet volcanoes was considered seismically monitored—Augustine—where a network was maintained by the University of Alaska Geophysical Institute (UAFGI). A few seismic stations were also maintained on two other volcanoes, Spurr and Iliamna, by U.S. Geological Survey (USGS) seismologists from Menlo Park, Calif., working through the National Earthquake Hazard Reduction Program (J.A. Power, oral commun., 2000). In the vicinity of Redoubt, two UAFGI stations had been operating since the early 1970's (Power and others, 1994). The combined efforts involved about 13 seismic stations. AVO was created in 1988, following the 1986 eruption of Augustine Volcano, to focus Federal and State scientific expertise, monitoring resources, hazard assessment, and eruption response toward the 41 historically active volcanoes in Alaska. Efforts to increase seismic coverage in Cook Inlet began in earnest during the summer of 1988 with installation of three more stations to complete the Redoubt network and additions or upgrades to the equipment on Spurr, Iliamna, and Augustine. The AVO monitoring program at Redoubt began in October 1989—2 months prior to the eruption—as the new stations became operable.

When Redoubt erupted, AVO consisted of a skeletal staff of about one full-time and three to five part-time individuals who relied primarily on occasional reports from pilots and local observers to learn of volcanic activity outside of the Cook Inlet area. During the Redoubt eruption response, the juvenile AVO became a fully functional organization with permanent staff, new and upgraded equipment, and a resolve to fulfill its mission of monitoring all of Alaska's active volcanoes. With an average of one to two eruptions per year in the Aleutian volcanic arc (46 documented eruptions since 1986), and cargo and passenger flights steadily increasing along the North Pacific air corridor (fig. 2; table 1), the need for improved monitoring capabilities beyond Cook Inlet became imperative. In 1996, with Congressional funding provided through the Federal Aviation Administration (FAA), AVO expanded its seismic monitoring program to volcanoes down the Alaska Peninsula and in the Aleutian Islands. At the close of 1999, AVO had about 103 seismic stations in 13 networks capable of monitoring the seismicity at 21 volcanoes (fig. 3). Daily analysis of satellite imagery spanning the north Pacific from the Kurile Islands to the Cascade Range of the United States (fig. 4) allows the tracking of ash plumes and the surveillance of thermal activity at restless and erupting volcanoes. Ground-based geologic studies have accompanied the seismic installations, thus providing the basis for hazard evaluation and interpretations of future and ongoing eruptive activity.

AVO staff have gained valuable experience in the 10 years following the Redoubt eruption. In addition to responding to an average of one to two eruptions and two to three volcanogenic seismic crises (intense seismic swarm beneath a volcano that may or may not culminate in an eruption) in the Aleutian arc per year, including the 1992 eruption of Spurr Volcano and the 1996 seismic swarm at Iliamna Volcano, AVO scientists have participated in seismic station installation and hazard assessment at Pinatubo (Philippines), Soufriere Hills (Montserrat), Guagua Pichincha (Ecuador), Tungarahua



1. Wrangeil	8. Trident	15. Veniaminof	22. Akutan	29. Cleveland	36. Kanaga
2. Spurr	9. Mageik	16. Pavlof	23. Makushin	30. Yunaska	37. Tanaga
3. Redoubt	10. Martin	17. Dutton	24. Bogoslof	31. Amukta	38. Gareloi
4. Iliamna	11. Peulik	18. Isanotski	25. Okmok	32. Seguarn	39. Cerberus
5. Augustine	12. Ukinrek	19. Shishaldin	26. Vsevidof	33 Korovin	40. Little Sitkin
6. Katrnai	13. Chiginagak	20. Fisher	27. Kagamil	34. Kasatochi	41. Kiska
7. Novarupta	14. Aniakchak	21. Westdahl	28. Carlisle	35. Great Sitkin	

Figure 1. Location of historically active volcanoes in Alaska (Miller and others, 1998).

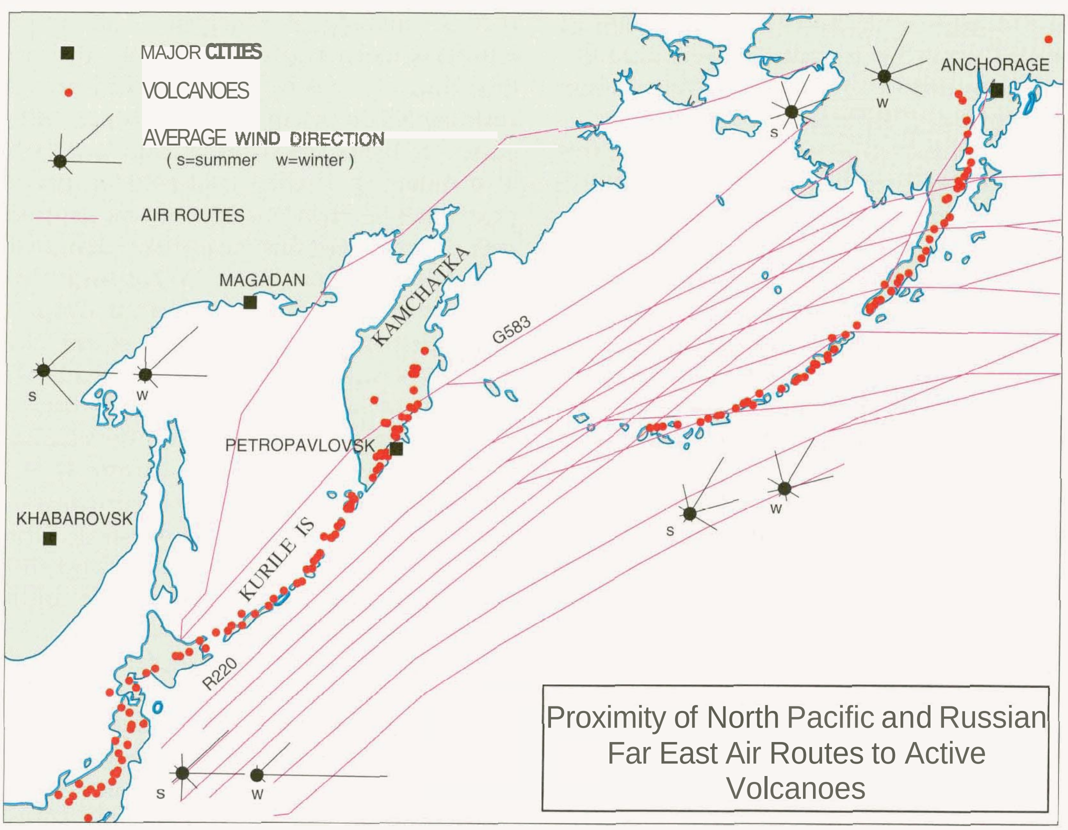


Figure 2. North Pacific (NOPAC) air routes and the 100 active volcanoes in Alaska, Kamchatka, and the Kurile Islands; windrose diagrams show that most of these air routes are downwind or cross the belt of active volcanoes. In 1998, more than 20,000 passengers and millions of pounds of cargo were being transported daily over these routes, including more than 90 percent of the all-cargo flights between Asia and North America. From Miller and Casadevall (2000).

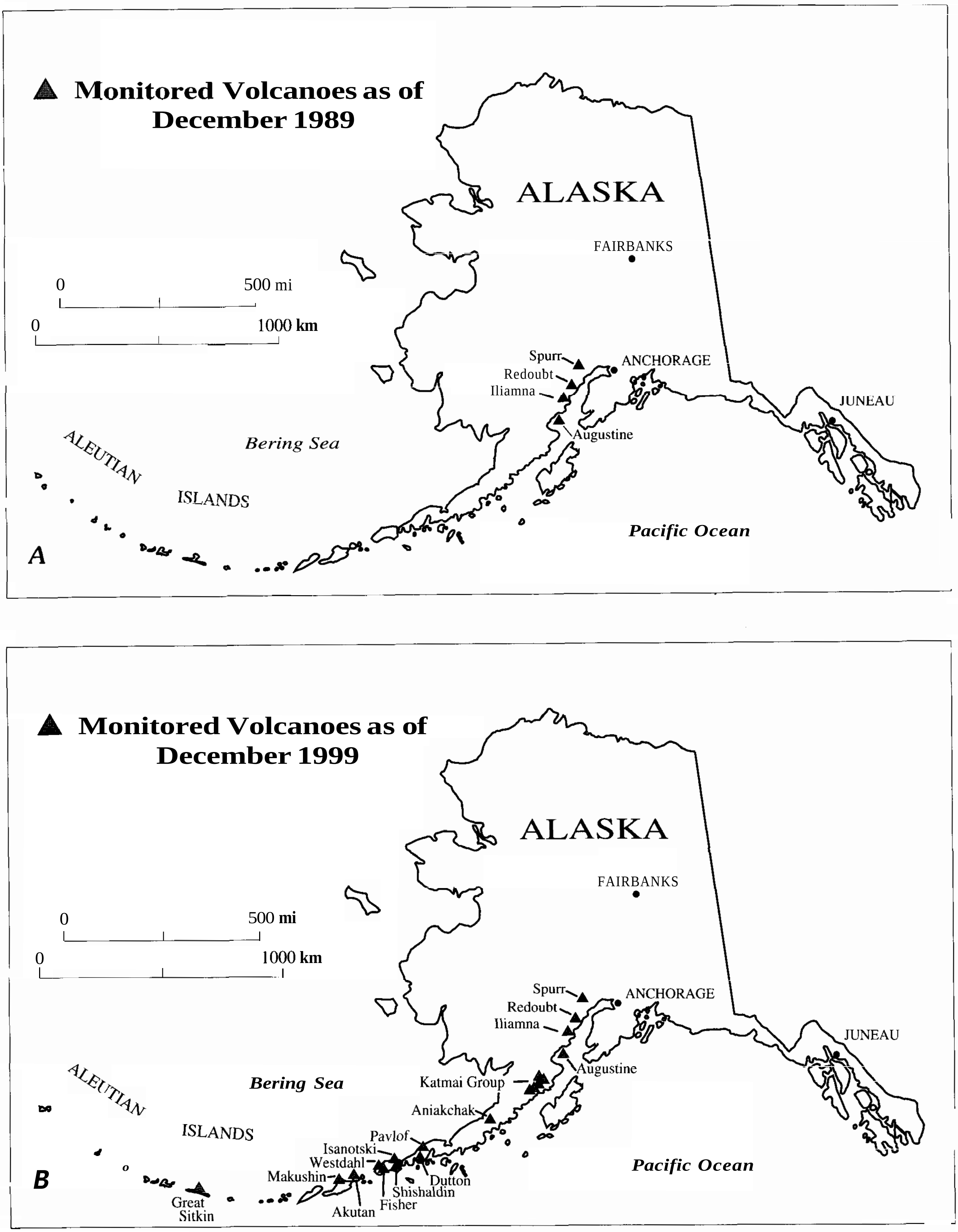


Figure 3. A, Seismically monitored volcanoes in Alaska as of 1989. *B*, Seismically monitored volcanoes in Alaska as of 1999. The Katmai group network monitors seven closely spaced young volcanic centers: Griggs, Katmai, Novarupta, Trident, Mageik, Martin, and Snowy.

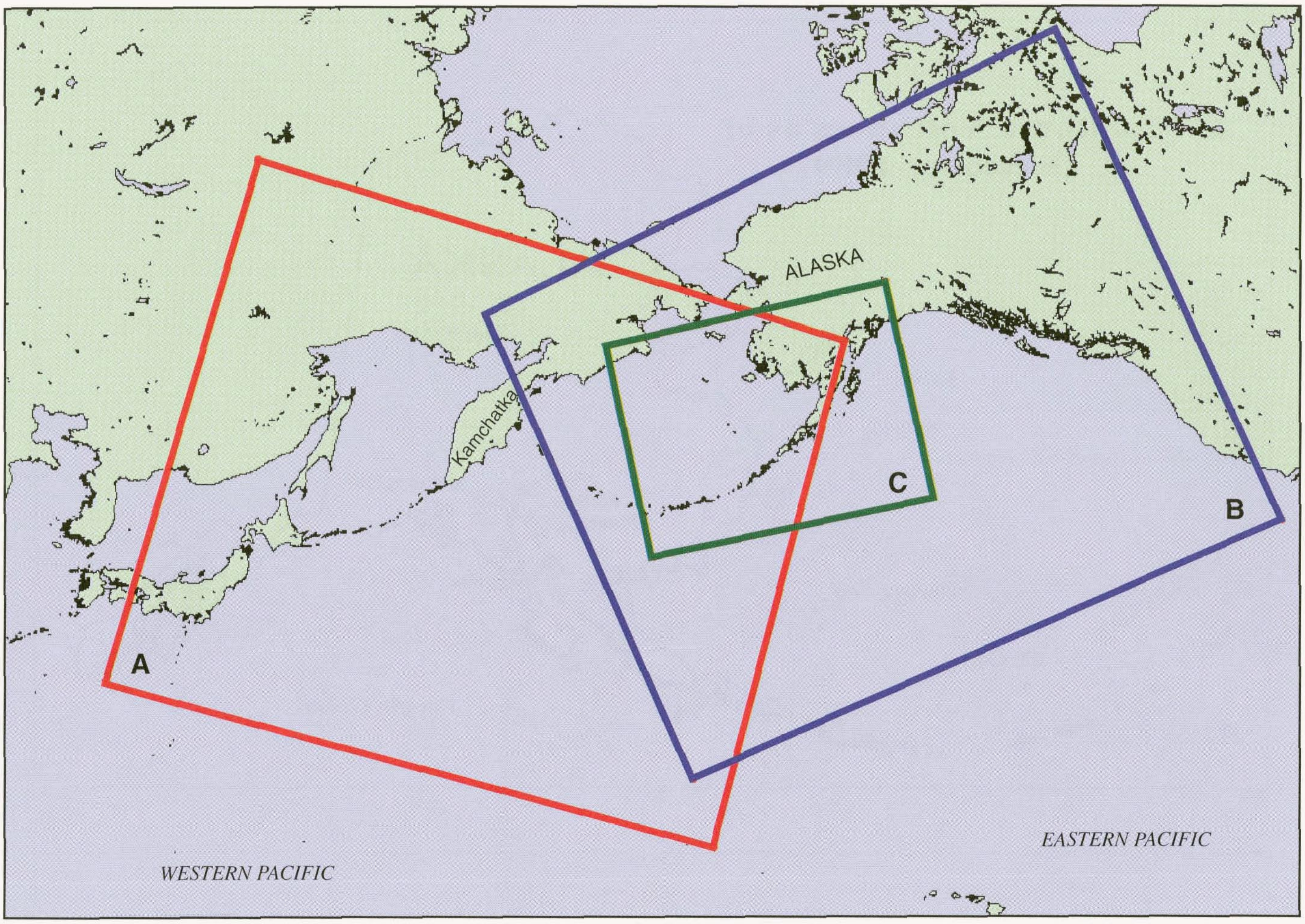


Figure 4. Map showing AVO satellite coverage used to monitor volcanic activity. Box A shows Geostationary Meteorologic Satellite coverage, 8-km resolution, 24 images/day. Box B shows Geostationary Orbiting Environmental Satellite (GOES) coverage, 8-km resolution, 48 images/day. Box C shows GOES, daytime only, 2-km resolution, 48 images/day in summer and 10 images/day in winter; polar orbiting Advanced Very High Resolution Radiometer satellite coverage is 1 km resolution, 4 images/day of the western Pacific (Kamchatka), and 10 images/day of the eastern Pacific (Alaska).

Table 1. Airtraffic (number of flights) along the North Pacific and Russian Far East air routes.

[Data courtesy Gail Ferguson, FAA Anchorage Center Traffic Management Supervisor, oral commun. ND, no data. Air traffic is projected to increase by a factor of 3 by the year 2017 (Miller and Casadevall, 2000)]

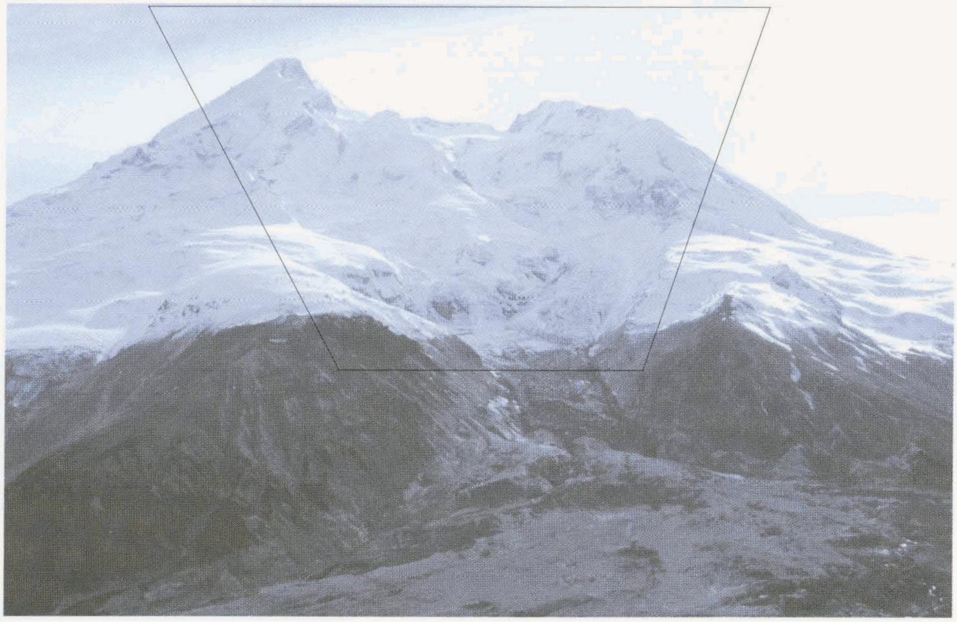
Year	Number of flights	
	North Pacific air routes	Russian Far East air routes
1990	39,800	ND
1995	48,324	1,039
1999	62,009	5,774

(Ecuador), and several restless volcanoes in Nicaragua. At this writing, AVO has about 17 full-time scientists and technicians and 27 part-time staff divided between offices in Anchorage and Fairbanks.

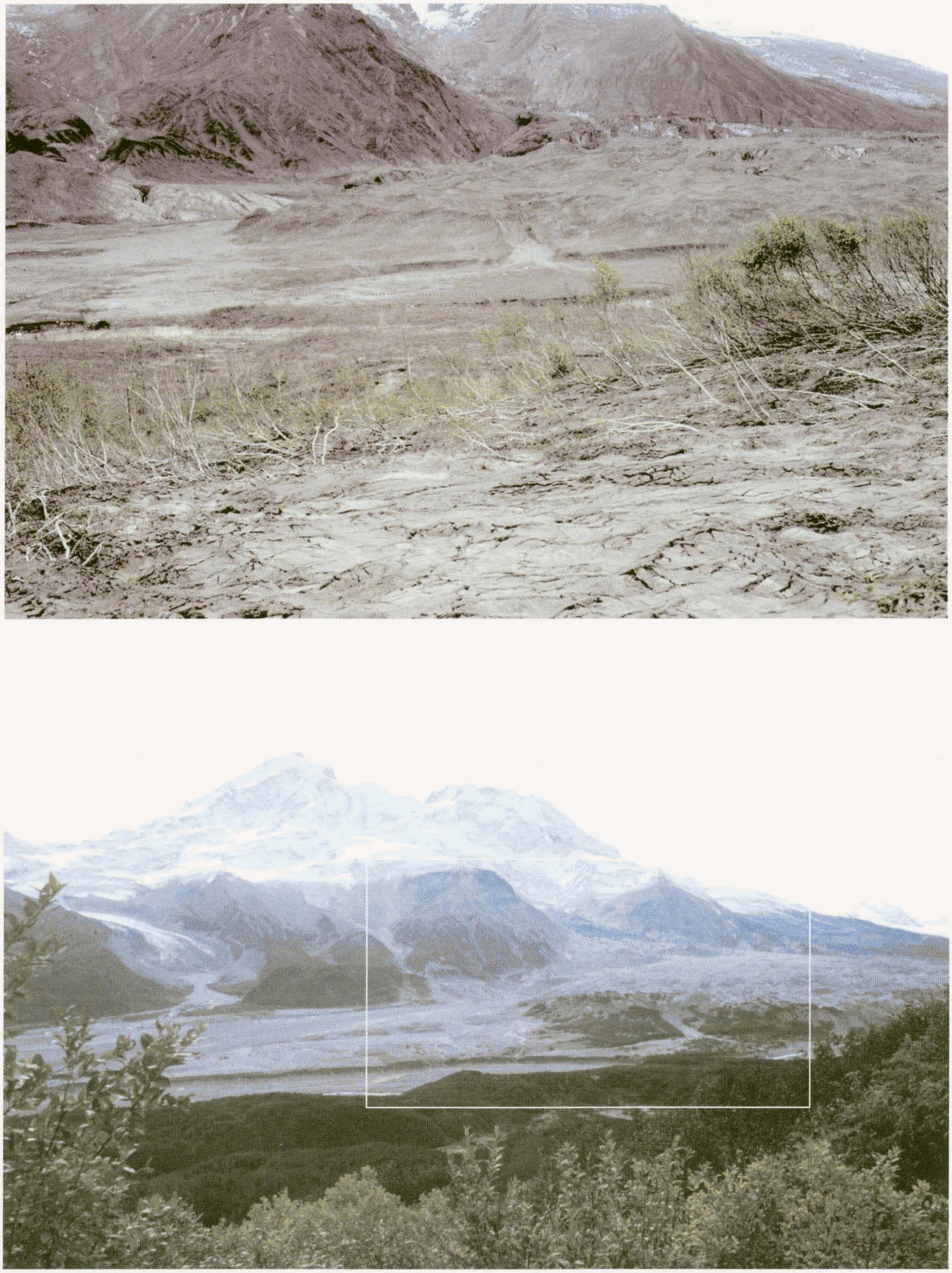
Ten years after the last eruption at Redoubt, snow and ice accumulation have refilled the upper Drift Glacier canyon on the north flank and nearly buried the lava dome emplaced in the summit crater by the last eruption (figs. 5*A*, 5*B*). A new glacial tongue extends down from the canyon and has merged with, and overridden, the beheaded piedmont lobe of Drift Glacier (figs. 5*B*). Vegetation has reclaimed the lower flanks, tributary valleys, and Drift River valley walls, mostly covering the proximal tephra accumulations (figs. 5*C*), which were as deep as 25 cm. Rust Slough, which once threatened oil storage tanks at DROT when the Drift River changed course during one of the early eruption-induced mud flows, is now sediment filled and readjusted to a seasonal braided flow regime. As surface vegetation gains a foothold, only the dozens of acres of dead spruce trees—trunks buried as deep as 2 m—remain as a testament to the muddy flood waters that once inundated the area. Reinforced dikes now guard the storage tanks and an

*Text continues on **page 12***

Figures 5A. Redoubt Volcano, north flank. Snow and ice accumulation in the summit crater and upper canyon of Drift Glacier. Photo on top taken April 11,1990; photo on bottom taken September 28,1999.



Figures 5*B*. Upper canyon of Drift Glacier. Photo on top taken on April 25,1990 (Steve Brantley); photo on bottom taken September 28,1999. Inset box shows approximate area shown in top photo. Note the advancing glacial tongue (immediately below box) that merges with, and laps onto, the piedmont lobe of Drift Glacier.



Figures 5C. Lower north flank and piedmont glacier. Photo on top, taken May 30,1990, shows damage to vegetation from 25 cm of tephra accumulation. Photo on bottom, taken September 28,1999, shows revegetation. Inset box shows area portrayed in top photo.

elevated "safe" house has been constructed at DROT to protect personnel from high water. The lower Drift River has reestablished its main channel to Cook Inlet and the upper and middle sections of Drift River continue to adjust and redistribute the massive amount of sediment and debris delivered during the eruption.

The seven-station seismic network at Redoubt continues to record normal background seismicity (approximately one to two magnitude-0.5 and higher volcanic earthquakes per week, a level sustained since 1991—S. McNutt, oral commun., 2000). Fumaroles on and around the dome still emit steam, which occasionally forms a wispy cloud over the summit. These steam clouds can be seen from Anchorage and the Kenai Peninsula during favorable weather conditions and often prompt calls to AVO from concerned citizens.

Due largely to the efforts of AVO during the past 10 years, aircraft traversing Alaskan skies are far less likely to plunge into a gritty ash cloud. As for Redoubt, the volcano presently sleeps under the watchful eyes of AVO. With three eruptions during the past 100 years, Redoubt will likely wake from its slumber sometime during the new century and once again put AVO to the test.

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