VOLCANIC ASH AND AVIATION SAFETY:
Proceedings of the First International Symposium
on Volcanic Ash and Aviation Safety
U.S. GEOLOGICAL SURVEY BULLETIN 2047

VOLCANIC ASH–AIRCRAFT INCIDENTS IN ALASKA PRIOR TO THE REDOUBT ERUPTION ON 15 DECEMBER 1989

By **Juergen Kienle**

ABSTRACT

Commercial and military propeller-driven and jet aircraft have encountered airborne volcanic ash in the Cook Inlet region three times prior to the near crash of a Boeing 747-400 jet downwind from Redoubt Volcano on 15 December 1989. Aircraft flew into ash plumes in 1953 when Mt. Spurr erupted and in 1976 and 1986 when Augustine Volcano erupted. Damage to aircraft in all incidents was restricted to severe sandblasting, and no engine failures occurred.

INTRODUCTION

The volcanoes of the Cook Inlet region, Alaska, make up the eastern end of the Aleutian volcanic arc. Air routes connecting Europe and North America with the Far East follow great-circle routes, which parallel much of the volcanic chain. Three volcanoes in Cook Inlet, Mt. Spurr, Redoubt Volcano, and Augustine Volcano (fig. 1), have erupted several times this century for a total of 10 eruptions between 1900 and 1992, or about once every 10 years on average. In recent decades, the eruption rate has almost doubled. Since 1950, Augustine erupted three times, Redoubt twice, and Spurr twice, totaling seven eruptions in the past 43 years or once every 6 years on average. Each eruptive cycle of the three volcanoes produced multiple explosions and associated ash plumes. Iliamna Volcano, located between Redoubt and Augustine Volcanoes (fig. 1), has not had an ash eruption in historic times, although large steam plumes have been reported frequently to the Alaska Volcano Observatory (AVO).

The Alaska Volcano Observatory gives special attention to the four Cook Inlet volcanoes, which are west and southwest of Anchorage (fig. 1). AVO operates remote, continuously recording, radio-telemetered seismic stations on all four Cook Inlet volcanoes and slow-scan television cameras, which are focused on Spurr and Redoubt. For the recent eruptions of Spurr (1992), Redoubt (1989–90), and Augustine (1986), this has allowed scientists to forecast eruptive activity and to give adequate warnings to the commercial aircraft industry and to the U.S. military, either before or at the onset of explosive, ash-producing eruptions. Because ash is mainly advected by tropospheric winds, plume-path predictions issued in recent years by AVO have been used by carriers to avoid aircraft-ash encounters (Casadevall, in press).

This paper gives a brief description of aircraft-ash incidents over Cook Inlet between 1953 and 1986, before the near-fatal encounter of a Boeing 747-400 jet with a Redoubt ash plume on 15 December 1989.

AIRCRAFT-ASH ENCOUNTERS OVER COOK INLET, 1953–86

MT. SPURR, 1953

On 9 July 1953, at about 17:00 local time, the Crater Peak vent on the southern flank of Mt. Spurr erupted suddenly, without much warning, sending a dark, ash-rich column to a height of 21 km (70,000 ft). Juhle and Coulter (1955) report that the ash cloud, carried by gentle westerly winds, drifted over Anchorage by noon. Heavy ash fall lasted for about 3 hours and darkened the skies so much that the city lights had to be turned on from noon until 15:00. Eventually 3 to 6 mm (114 inch) of fine dust settled over the city, including Anchorage Airport and Elmendorf Air Force Base, disrupting air traffic for 2 days.

By chance, the eruption was witnessed at close range by pilots of two U.S. Air Force planes on a reconnaissance mission near the volcano (Juhle and Coulter, 1955; Wilcox, 1959). The following pilots' account is quoted from an Air Force press release of 10 July 1953 (taken from Wilcox, 1959):

> At 05h 05m Lieutenant Metzner noticed a column of smoke 60 miles ahead that was about 15,000 ft high and one-eighth mile wide. As he approached the smoke it was apparent that the eruption causing it was becoming increasingly severe with the smoke growing rapidly in height. At about 25 miles distance, the volcano was recognized as the 11,070-foot high Mt. Spun: Both planes approached the mountain at about 15,000 ft and circled the volcano at about 05h 25m. They noticed the continuing increase in the intensity and size of the column of smoke with lightning flashes through its core every 30 seconds. Smoke issued from the volcano in violent billows at

the 7,000-foot level of the mountain caused by huge subterranean explosions. Tremors on the mountainsides were visible from the aircraft and were followed by snow slides on the mountain. The smoke had by now reached the 30,000-foot level, rolling upward and assuming the shape of the atomic bomb mushroom. Clouds of smoke were every shade of gray from black at the crater to pure white at the top. By this time the width had increased to about a mile at the base and 30 miles at its widest part.

About 05h 40m Lieutenant Metzner climbed in order to estimate the height of the mushroom. The top of the stalk, or the bottom of the mushroom, was 30,000 ft and the top of the mushroom had climbed to 70,000 ft. Lightning was now flashing from top to bottom of the mushroom at three-second intervals.

At about 6h 00m volcanic ash began falling from the mushroom on all sides and finally made the entire area hazy. A clear definition of the volcano and the mushroom rapidly faded and the patrol returned to its base.

Another pilot report confirmed that ash was still being erupted vigorously 4 hours later, at 09:00. The activity declined toward noon but resumed at 15:30; other eruptions took place later that day (Wilcox, 1959). Wilcox further states that, on the next day, 10 July, the vent was only steaming, except for a strong ash-laden surge at 15:30, which rose to 6 km (20,000 ft). Juhle and Coulter were in the field at the volcano from 11 to 14 July and again on 16 July, during which time they observed steam clouds to heights of 6 km, with occasional puffs of black dust (Wilcox, 1959).

One of the two F-94 jet aircraft that were flying near Mt. Spurr on the morning of 9 July flew through the cloud and had its Plexiglas cockpit canopy frosted by the "sandblasting" action of the ash (Juhle and Coulter, 1955). The following information is summarized from a U.S. Air Force report on the Mt. Spurr eruption (U.S. Air Force, 1955):

During the peak of eruptive activity, three jet aircraft of the 66th Fighter-Interceptor Squadron were dispatched through the ash plume to bring back first-hand, eyewitness accounts of the eruption. [There is a conflict with the report of Juhle and Coulter (1955), which says that only one jet flew through the eruption cloud.] Upon return to Elmendorf AFB, all three jets had sandblasted wing leading edges, windshields, side panels, and front portions of the canopies, greatly reducing pilot visibility. Some panels later had to be replaced.

As a precaution, all aircraft of the U.S. Air Force's 5039th Air Transport Squadron in flyable condition (26 planes) were evacuated to Laird and Eielson Air Force Bases near Fairbanks. However, only four F-94 interceptors were able to engage in the evacuation; loss of power in the dusty air on take-off grounded the other interceptors. These were hangared in time, except for several large C-124 transport aircraft (Globe Trotters). Float-equipped L-28's of the 5th Liaison Squadron were moved from Anchorage to Lake Louise. Wheel-equipped Beavers were placed inside hangars. Two radar stations in the Anchorage area, one on Fire Island, were taken off the air to prevent damage to the antenna drive and generators.

Most seriously affected by the ash fall were the propeller-driven C-124 transport aircraft stored outside, which required 10 days of cleanup to remove the fine volcanic ash from the aircraft. From 9 to 13 July, tactical aircraft were unable to take to the air over Elmendorf because of dusty conditions and remobilized ash on runways and taxiways. The 10th Air Division of the Alaska Air Command lost its ability to meet its air defense mission and it passed the responsibility for fighter interception and radar control to the 11th Air Division at Laird AFB. It was only on 17 July, eight days after the eruption, that the three Elmendorf fighter-interceptor squadrons returned to normal operations. For all practical purposes, Elmendorf AFB was closed to air traffic from 9 to 17 July. The east-west runway was cleared for emergency flying only. Aircraft landed, but had to immediately cut off engines while on the runway before being towed to the hangar. The reverse procedure was used for emergency takeoffs to reduce exposure of the airplanes to the pervasive dust.

The cleanup operation produced many engineering headaches. The soft, clinging ash first had to be cleared from all aircraft surfaces, taxiways, runways and parking ramp',. All moving parts, air intakes, accessory cases, filters and screens required thorough cleaning to prevent corrosion and contamination.

A truck-mounted jet engine, originally designed to remove ice from railroad tracks, proved to be the most useful tool in clearing ash from large swaths of ground; for example, within 40 hours this jet-blower cleared some 440,000 m^2 of pavement at the Anchorage International Airport.

There are no known records of commercial aircraft being affected by the 9 July eruption of Mt. Spurr. As became clear after encounters between volcanic ash and aircraft at Galunggung, Indonesia, in 1982, and more recently at Redoubt, propeller-driven airplanes that operate at low engine temperatures fare much better than jets in severe, dusty conditions.

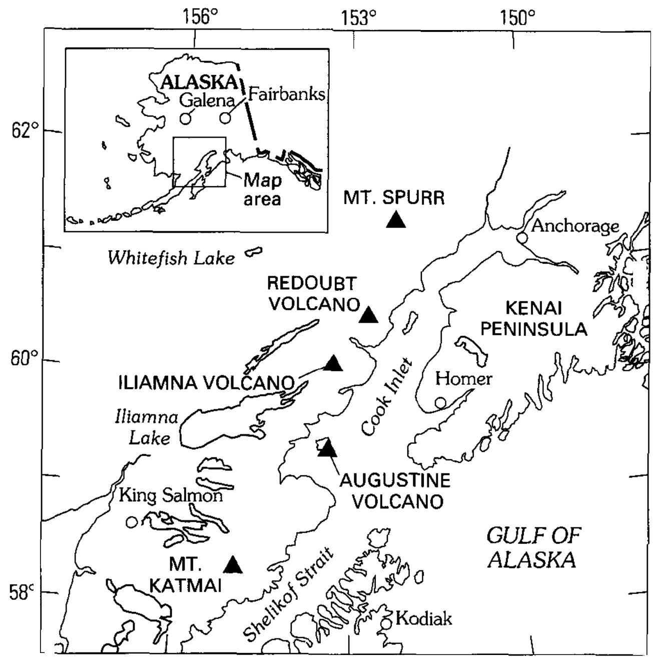

Figure 1. Location of volcanoes in the area of Cook Inlet (solid triangles) and places mentioned in the text. Elmendorf Air Force Base is located near Anchorage.

AUGUSTINE VOLCANO, 1976

Augustine Volcano, located in lower Cook Inlet (fig. 1), erupted in January 1976 after 12 years of dormancy (fig. 2). Sub-Plinian eruptions occurred from 22 to 26 January and spread ash generally northward and eastward over the Kenai Peninsula, with fine ash falling as far away as Sitka, 1,100 km (684 mi) downwind (Kienle and Shaw, 1979).

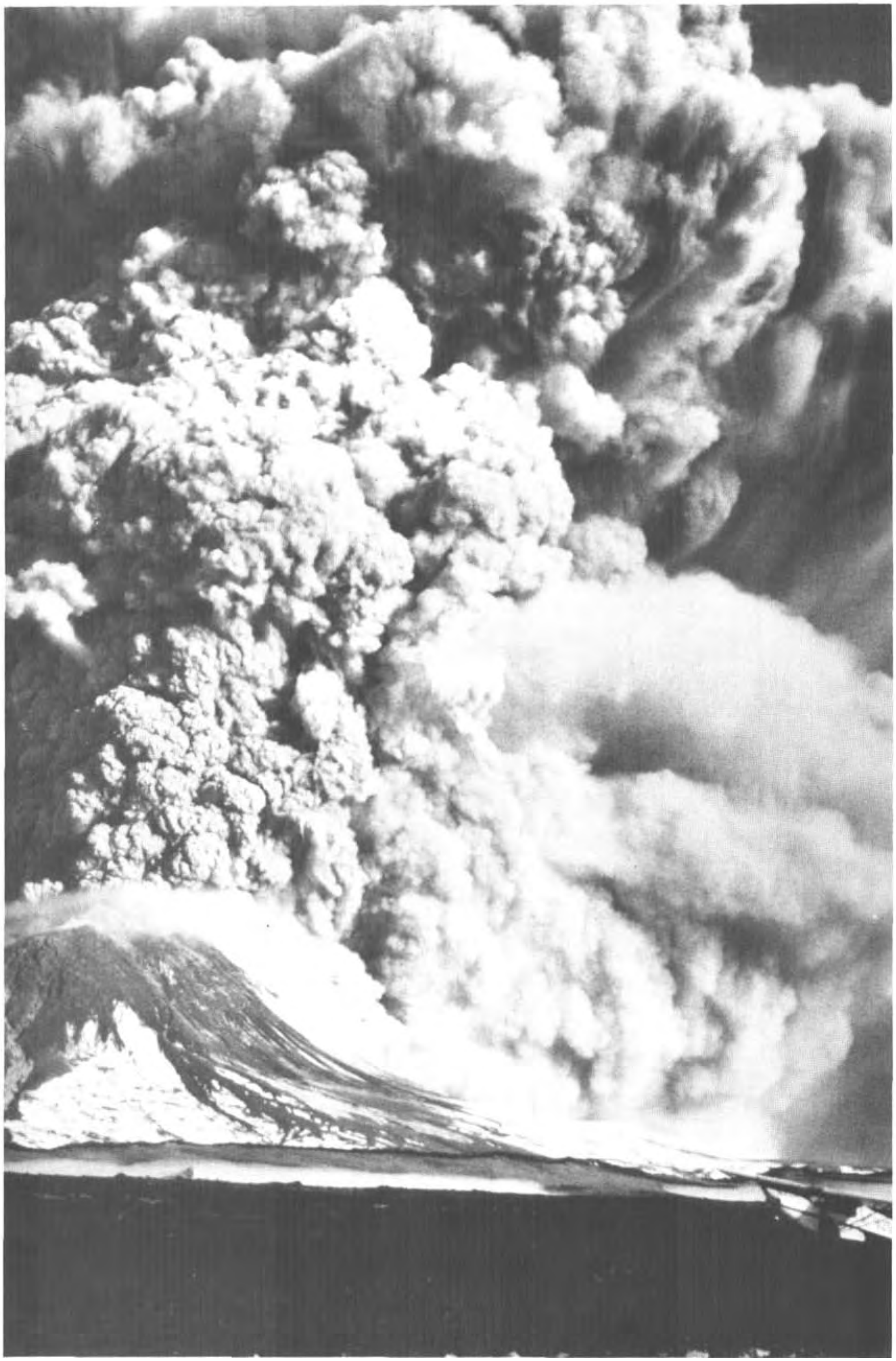

Figure 2. Augustine Volcano in eruption on 6 February 1976. Photograph from the west coast of Augustine Island, courtesy of Gary Gunkel.

One of the 22 January Augustine eruptions occurred in the midst of a U.S. Air Force defense exercise. Reports of greatly reduced visibility were received from pilots in two F-4E Phantom jets flying in formation through an eruption cloud. These observations were used by Kienle and Shaw (1979) to estimate the minimum mass concentration of particulate material contained in that eruption cloud. No mechanical problems or serious power loss were reported by the pilots. The following is an excerpt of a report by the two F-4E Phantom jet pilots who had taken off from Galena, Alaska, on 22 January 1976, heading south for King Salmon (from Kienle and Shaw, 1979; U. S. Air Force, 1976):

> The two jets were flying in clouds, cruising at 9 km (31,000 ft). We were still in the weather when suddenly at 14:30 AST the ordinary gray clouds slightly darkened for a moment or two, then there was instant complete darkness. There was no turbulence associated with this darkness. The two jets were flying in close formation about 10 meters apart. Had the lead plane not immediately turned on its lights, the following pilot would have lost contact; he could barely see the lead plane 10 meters away with its lights on. Upon landing in King Salmon, the canopy of the aircraft was seen to be scoured, and the paint at the wing tips was sandblasted off. Very fine, jewelers-rouge-colored material was ingested into the cockpit through the engine air intakes. The material was sticky and was found in every nook and cranny of the planes.

A second incident concerns three Japan Airline jet airplanes en route to Tokyo on the afternoon of 25 January 1976. As recounted by Mr. K. Noguchi of Japan Airlines (Kienle and Shaw, 1979):

> After cargo flight JL 672 took off from Anchorage at 16:00 AST, the DC-8 was about to reach its cruising altitude of 10 km (33,000 ft), 25 minutes after takeoff, traveling along air route J-501 when it suddenly encountered an ash cloud near Whitefish Lake (25 km southeast of Sparrevohn). Upon landing in Tokyo the scoured center windshield had to be replaced. Much ash had adhered to the plane and slight abrasion damage was found on external radio parts, landing gears and the air-conditioning system, but none of these parts needed to be replaced.

Two other passenger planes, a Boeing 747 and a DC-8, also bound for Tokyo and departing within 1 hour after flight JL 672, reported ash suddenly adhering to the planes at cruising altitude (about 10 km) near Sparrevohn, which also caused minor damage but not as extensive as that to the DC-8 flight JL 672.

Kienle and Swanson (1985), in a report on volcanic hazards for Augustine Volcano, discussed the hazard of volcanic ash to aircraft and delineated very high risk, high-risk, moderate, and low-risk hazard zones in the vicinity of Augustine Island.

AUGUSTINE VOLCANO, 1986

Augustine erupted again in 1986, with strong eruptive activity concentrated in the period between 27 and 31 March. The sequence of events was similar to the 1976 eruption, with an initial, highly explosive vent-opening phase lasting 4 days, followed later in the year by less explosive activity associated with the extrusion of a new lava dome (Swanson and Kienle, 1988). The eruptive cycle ended in September 1986, but from April on, the eruption did not present a substantial hazard to aircraft.

During the March 1986 eruption of Augustine Volcano, airborne ash again presented a hazard to aircraft operations throughout the Cook Inlet basin and to airports in Anchorage because of predominantly southerly winds (Yount and others, 1987). The eruption was anticipated by Alaskan volcanologists (Kienle and others, 1986; Kienle, 1986), and T. Miller and M. E. Yount of the U.S. Geological Survey office in Anchorage held briefings with the Federal Aviation Administration (FAA) and the U.S. Air Force on 18 March 1986, 9 days prior to the eruption, to warn about the possibility of an eruption and the consequences to aircraft operations.

Early on the morning of 27 March 1986, just after the eruption had begun, the U.S. Air Force evacuated planes from Anchorage and kept them away until 30 March. Even though the Anchorage International Airport was never officially closed during the most explosive phase of the eruption, most commercial carriers either canceled or diverted their Anchorage flights between 27 and 29 March.

The following is a summary taken from Aviation Week and Space Technology (1986):

> From March 27 to 29, air carrier service to Anchorage was nearly at a standstill. Subsequently, the wind shifted to a northerly direction carrying the ash away from the Cook Inlet bowl, now affecting the airline traffic between Anchorage and airports at Kodiak and King Salmon. Volcanic ash generally stayed below 15,000 ft (4.5 km) but a stronger eruption on March 31 sent an ash plume up to 30,000 ft (9 km).
>
> Alaska Airlines had its worst day on 28 March, when it canceled 40 out of 68 Anchorage arrivals and departures. Twenty-seven to 29 March, the Anchorage stop of the airline's Seattle-Anchorage-Fairbanks flights, coming and going, were deleted. Western Airlines canceled all of its flights to and from Alaska 27–28 March and flew some flights on 29 March. United Airlines, Northwest Airlines and other international carriers that fly from Europe and Far East Asia over the North Pole canceled service during the worst ash conditions. United canceled 35 flights between 27 and 29 March. Local commuter airplane traffic between Anchorage and the Kenai Peninsula also was largely shut down and the Federal Aviation Agency [sic] (FAA) temporarily shut down its air-route surveillance radar at Kenai for two days. With shifting winds on 31 March 1986, ash was cleared from the air over most of the Cook Inlet basin, and normal air operations resumed.

CONCLUSIONS

A comparison of the eruptions of these volcanoes demonstrates that, as we learn to live with the high activity level of Cook Inlet volcanoes, we improve our ability to cope with the problem of volcanic ash and aviation safety. Air traffic has increased dramatically in Alaska since the eruption of Mt. Spurr in 1953. High-bypass, turbine-powered jet aircraft have replaced larger, propeller-driven passenger planes; both factors increase the risk of danger from encountering airborne volcanic ash. On the other hand, the volcanological community in Alaska has come together since 1953. The 1953 Mt. Spurr eruption caught everyone off-guard, but we were better prepared in 1976 and 1986 for the Augustine eruptions, having instrumented that volcano with radio-telemetered seismographs starting in 1970. In 1986, briefings with the aviation community were held by U.S. Geological Survey volcanologists 9 days prior to the onset of the eruption that paralyzed air traffic in Cook Inlet for 4 days. Significantly, there were no encounters of aircraft, either private or military, with volcanic ash during the most vigorous phase of the 1986 Augustine eruption.

The close cooperation among volcanologists of the U.S. Geological Survey, the Alaska Geological Survey, and the University of Alaska, Fairbanks, that had developed during the 1986 Augustine eruption was formalized in March 1986 with the founding of the Alaska Volcano Observatory. Since then, AVO has instrumented all four Cook Inlet volcanoes with at least four seismometers at each volcano. In addition, remotely controlled slow-scan television cameras have been installed to continuously observe Mt. Spurr and Redoubt Volcano, and we have plans to do the same for Augustine Volcano. Satellite surveillance of the volcanoes and eruptive plumes has become routine at the AVO laboratory in Fairbanks (Dean and others, this volume), and an array of lightning detectors can track electrified plumes in Cook Inlet. Radars and television cameras have been used to track rising eruption columns and their dispersal by wind.

During the two recent eruptions in Cook Inlet at Redoubt Volcano (1989–90) and at Mt. Spurr (1992), AVO went on 24-hour watches for several months. Communication with the carriers and Federal agencies involved with air traffic (Federal Aviation Administration, National Weather Service) were increased and resulted in the production of daily updates on the status of the active volcano and the forecasting of potential plume trajectories every *6* hours (or more often during active phases of ongoing eruptions) (Murray and others, this volume).

In spite of the better level of preparedness in recent years, there was a near fatal encounter of a Boeing 747-400 with an ash plume of Redoubt Volcano on 15 December 1989 (Casadevall, in press). The aviation and volcanology communities in Alaska must jointly strive to avoid any other encounters of this type.

ACKNOWLEDGMENTS

I thank Tina Neal and one anonymous reviewer for their constructive editing of the original draft. This work was supported by the Alaskan Volcano Observatory through U.S. Geological Survey Grant 14-08-0001-0574.

REFERENCES CITED

Aviation Week and Space Technology, 1986, Alaska air traffic disrupted by ash from volcano: v. 124, no. 14, p. 36.

Casadevall, T.J., in press, The 1989–1990 Eruption of Redoubt Volcano, Alaska: Impacts on aircraft operations: Journal of Volcanology and Geothermal Research.

Juhle, W., and Coulter, H.W., 1955, The Mt. Spurr eruption, July 9, 1953: Transactions of the American Geophysical Union, v. 36, p. 188–202.

Kienle, J., 1986, Augustine Volcano: Awake again?: Eos, Transactions of the American Geophysical Union, v. 67, p. 172–173.

Kienle, J., Davies, J.N., Miller, T.P., and Yount, M.E., 1986, The 1986 eruption of Augustine Volcano: Public safety response by Alaskan volcanologists: Eos, Transactions of the American Geophysical Union, v. 67, p. 580–582.

Kienle, J., and Shaw, G.E., 1979, Plume dynamics, thermal energy, and long distance transport of Vulcanian eruption clouds from Augustine Volcano, Alaska: Journal of Volcanology and Geothermal Resources, v. 6, p. 139–164.

Kienle, J., and Swanson, S.E., 1985, Volcanic hazards from future eruptions of Augustine Volcano, Alaska: University of Alaska Geophysical Institute, Report UAG R-275, 122 p.

Swanson, S.E., and Kienle, J., 1988, The 1986 eruption of Mt. St. Augustine: Field test of a hazard evaluation: Journal of Geophysical Research, v. 93, p. 4500–4520.

U.S. Air Force, 1955, History of the Alaskan Air Command, Part 2, natural phenomenon, Mt. Spurr eruption: Anchorage, Alaska Air Command, Elmendorf Air Force Base, p. 73–80.

———1976, History of the 21st composite wing: Anchorage, Alaska Air Command, Elmendorf Air Force Base, v. 1, 121 p.

Wilcox, R.E., 1959, Some effects of recent volcanic ash falls with especial reference to Alaska: U.S. Geological Survey Bulletin 1028–N, p. 409–476.

Yount, M.E., Miller, T.M., and Gamble, B.M., 1987, The 1986 eruption of Augustine Volcano, Alaska: Hazards and effects: U.S. Geological Survey Circular 998, p. 4–13.