Historically Active Volcanoes

Catalog of Active Volcanoes of the World (CAVW)

Name and Location

Name:	Mount Wrangell volcano
Synonyms:	Wrangell volcano
Type:	Shield with summit caldera
Location:	West end of Wrangell Mountains, 80 km east of Glennallen in south-central Alaska
Latitude, longitude:	62°00′N, 144°01′W
Elevation:	4317 m
USGS 1:250,000 quadrangle:	Gulkana, Nabesna, Valdez, McCarthy
CAVW Number:	1105-02

Form and structure

Mt. Wrangell is a large andesitic shield volcano with a volume of about 900 km^3 (Nye, 1983) (fig. 6). Its top is capped by a 4 by 6 km, ice-filled summit caldera whose depth may exceed 1 km (Benson and Motyka, 1979). The caldera is apparently of non-explosive origin (Richter and others, 1984) formed in response to the withdrawal of magma from high-level reservoirs beneath the summit area. Three small (<1 km in diameter) post-caldera craters, all geothermally active, occur along the west and north margin of the caldera. Mt. Zanetti (3965 m) a large (450 m high) steep-sided, relatively undissected cinder-spatter cone occurs high on the northwest flank of the shield and may be the source of some lava flows. Lavas on the southwest flank have flowed as much as 58 km from their source despite being phenocryst-rich andesite, a mobility attributed to a very high eruption rate (Nye, 1983).

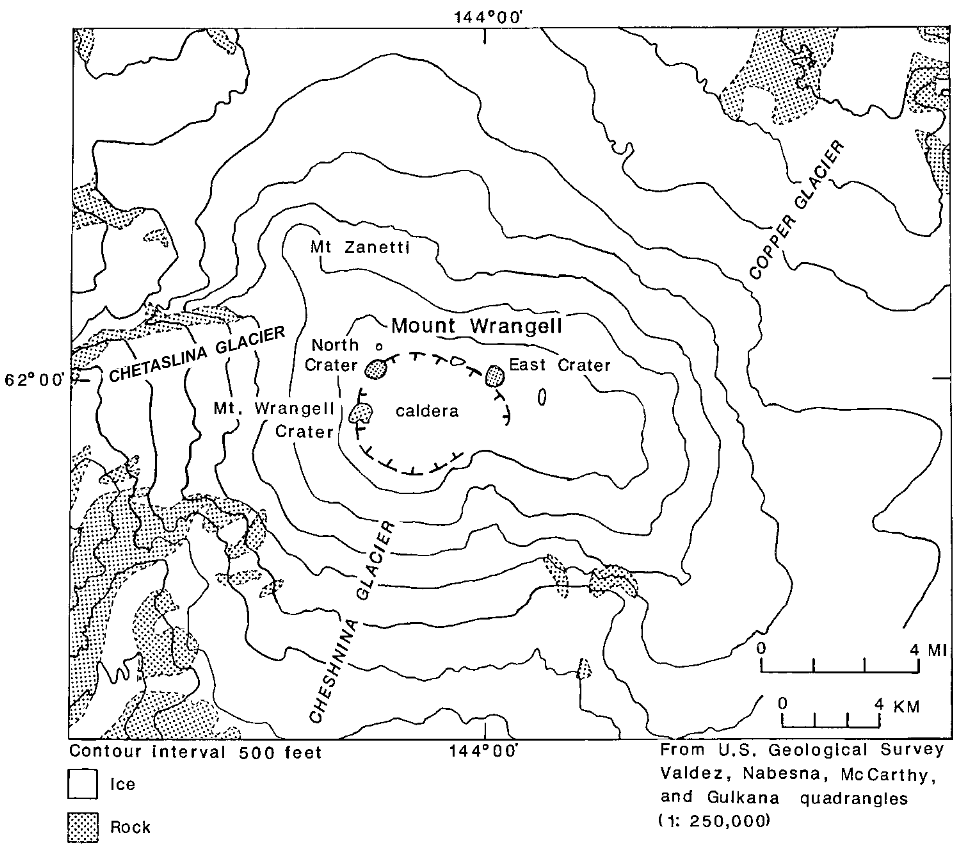

Figure 6. Topographic map of Mount Wrangell showing location of caldera and post-caldera fumarolic vents.

Volcanic activity

Mt. Wrangell is the only historically active volcano in the extensive Wrangell volcanic field of Miocene to Holocene age. Richter and others (1995) list three reports (1784, 1884-85, and 1900) of eruptive activity but at least the first two of these are suspect. Historical activity, which has been limited to fumaroles and minor phreatic eruptions in the summit craters, apparently waxes and wanes in response to changes in the summit heat flux. In addition, some evidence suggests that increases in the heat flux and concomitant increases in fumarolic and phreatic activity have followed major earthquakes in south-central Alaska (Benson and Motyka, 1979). Photographs of the ash-covered summit of Mt. Wrangell that appear in the reports of Mendenhall and Schrader (1903) and Mendenhall (1905) may reflect an increase in activity following the September 3, 1899 Yakutat earthquake. Although major eruptions and lava flows have been reported on Wrangell in the past, none have ever been confirmed (Mendenhall, 1905; Benson and Motyka, 1979; Richter and others, 1995).

Composition

Wrangell lavas range from basalt to dacite (52 to 66 percent SiO_2) in composition (Nye, 1983) and exhibit medium-K calcalkaline affinities (figs. 6A, B,). Predominant lavas are porphyritic 2-pyroxene andesites (57 to 61 percent SiO_2).

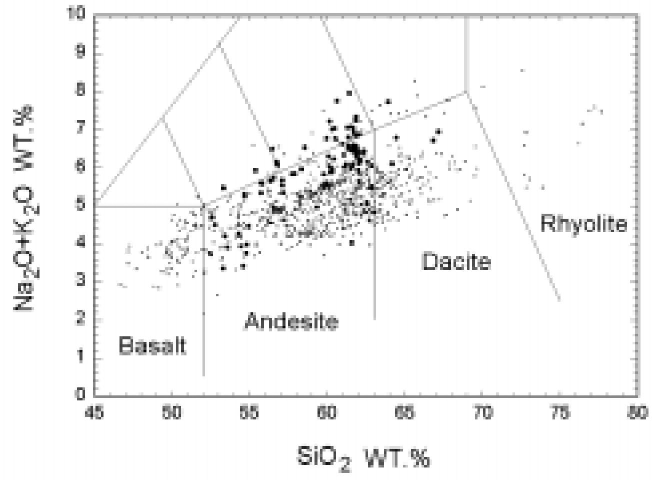

Figure 6A. Total alkalies-silica diagram of Wrangell volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

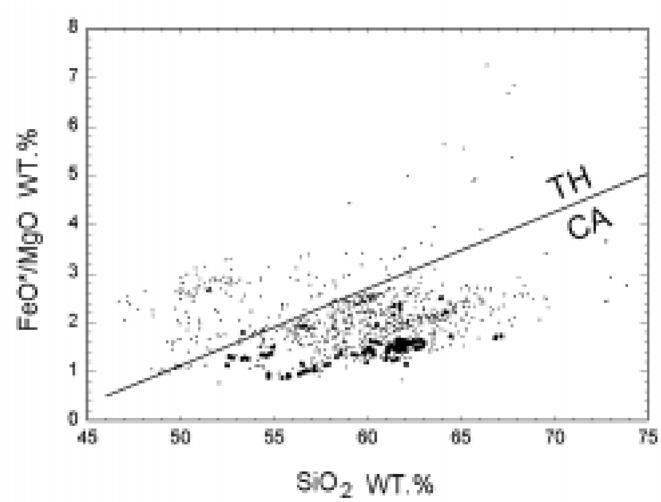

Figure 6B. FeO/MgO-silica diagram of Wrangell volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

NAME AND LOCATION

NAME:	MOUNT SPURR
SYNONYMS:	SPURR VOLCANO
TYPE:	STRATOVOLCANO AND EXPLOSION CALDERA
NAME OF SATELLITIC VENT:	CRATER PEAK
LOCATION:	ON THE EAST FLANK OF THE ALEUTIAN RANGE, 130 KM WEST OF ANCHORAGE.
LATITUDE, LONGITUDE:	61°18′N, 152°15′W
ELEVATION:	3374 M, CRATER PEAK 2309 M
USGS 1:250,000 QUADRANGLE:	TYONEK
CAVW NUMBER:	1103-04

Form and structure

Mount Spurr is a Quaternary stratovolcano located near the northeastern end of the Aleutian volcanic arc (fig. 7). It is the easternmost historically active volcano in the Aleutian arc and is the highest of several snow- and ice-covered peaks that appear to define a large, dissected stratovolcano (Juhle and Coulter, 1955).

Capps (1929) suggested that a summit caldera, largely buried by ice, is associated with Mount Spurr. Later, Juhle and Coulter (1955) disagreed with the caldera interpretation suggesting that the peaks around Mount Spurr only coincidentally resemble the rim of a large subsidence structure. Most recent studies, however, suggest that ancestral Mt. Spurr, constructed during late Pleistocene time (Turner and Nye, 1986), was partially destroyed by a major Bezymianny-type eruption possibly as late as early Holocene time (Riehle, 1985; Nye and Turner, 1990). The eruption produced a voluminous volcanic debris avalanche and subsequent pyroclastic flows that resulted in the formation of a 5- to 6-km-diameter explosion caldera (fig. 7). The volcanic debris avalanche contains blocks as much as 100 m in diameter and traveled a minimum of 25 km. The overlying pyroclastic flows are partially welded and are composed chiefly of high silica andesite. Present Mt. Spurr is the highest of several post-caldera, centrally located, ice-carved cones or domes.

The youngest volcanic feature at Mount Spurr is a satellitic cone, Crater Peak, located in the breach in the caldera about 3.2 km south of Mount Spurr (fig. 7). Crater Peak has a summit crater that is itself slightly breached along the south rim; the north wall of the crater exposes the truncated remains of an older dome or lava lake. Crater Peak has been the source of all Late Holocene eruptive activity at Mt. Spurr (Riehle, 1985). Before the 1992 eruption, a small crater lake occupied the bottom of the crater.

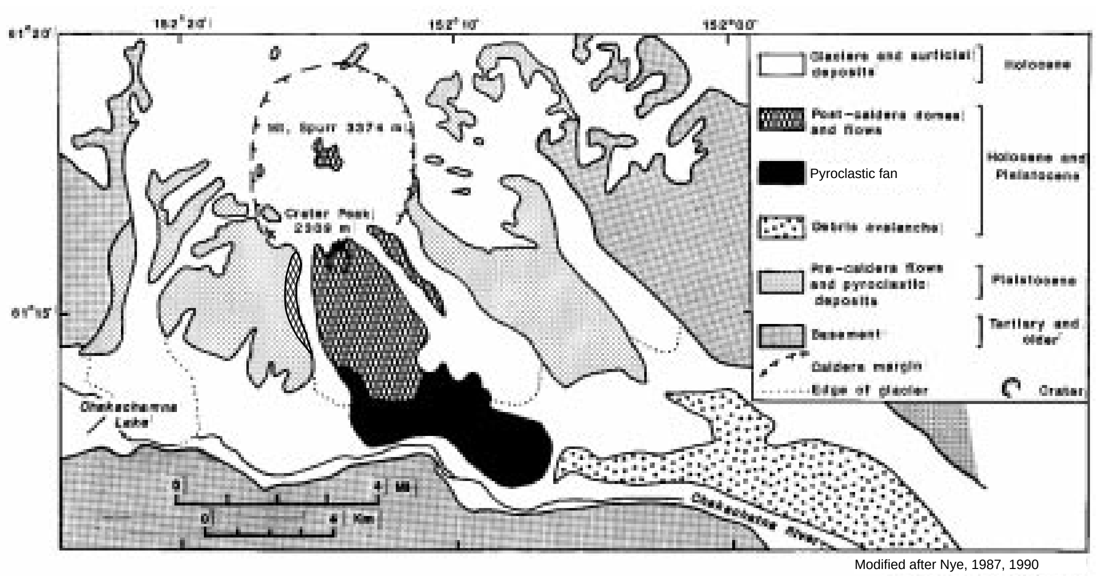

Figure 7. Generalized geologic map of the Mount Spurr volcanic center; modified from Nye (1987).

Volcanic activity

July, 9 - July 10, 1953 and
June 27 - September 17, 1992

Mt. Spurr has only two historical eruptions, although Riehle (1985) identified 35 Holocene tephra layers in the Cook Inlet area that he attributed to Mt. Spurr. Activity before 1953 consisted of occasional vapor emissions from the summit of Mt. Spurr; Crater Peak was ice-filled and had no fumaroles.

The first historical eruption of Mt. Spurr occurred on July 9, 1953, when the Crater Peak vent, in two main eruptive pulses on two succeeding days, produced a tephra blanket about 4 mm thick at Anchorage and detectable up to 350 km to the east (Wilcox, 1959). Ash in the initial eruptive pulse rose to 20 km. Lahars swept down valleys heading on the south flank of Crater Peak, resulting in a dam on the Chakachatna River (fig. 7) which raised the level of Chakachamna Lake at least 3 m (Juhle and Coulter, 1955). Activity was short-lived and essentially confined to the two days.

Activity between 1953 and 1992 consisted of small fumarolic emissions from the inner walls of Crater Peak crater. A warm (56^{o}C) crater lake about 45 m in diameter formed sometime between the 1953 eruption and 1970. Infrequent aerial observations of the Mt. Spurr summit itself during this interval showed only minor vapor emissions and yellow discoloration of the snow around a small vent area near the summit.

The most recent eruption at the Mt. Spurr center began on June 27, 1992 with the first of three explosive events that occurred over a three month period (Alaska Volcano Observatory, 1993; Eichelberger and others, 1995). A slow but steady increase in seismicity beneath and around the center began 10 months before the eruption. By early June, bursts of shallow tremor were occurring at Crater Peak and the small crater lake was showing dramatic changes including increased SO_2/Cl ratios, a change in color from turquoise to gray, and vigorous upwelling. Tremor burst duration increased significantly on June 24 and continuous tremor began midday on June 26 (Alaska Volcano Observatory, 1993). An abrupt increase in tremor amplitude at 0705 on June 27 indicated onset of the first eruptive pulse. The volcano was hidden by clouds which prevented direct observation. During the 4 hour event, small pyroclastic flows mixed with snow swept down the south flank of the cone, and an ash plume rose to an estimated height of 14.5 km, based on C-band radar (Rose and others, 1995); pilot reports suggest a plume height of 15-18 km. Southerly winds carried tephra to the north over the sparsely populated Alaska Range. About 2 mm of ash fell in Denali National Park 260 km downwind and ashfall was observed as far north as Manly Hot Springs, 420 km downwind. Tephra volume was about 44 x 10^6 m^3 and consisted mostly of juvenile andesite (Alaska Volcano Observatory, 1993). Seismicity decreased to pre-August 1991 levels by July 8 and remained low during July to mid-August.

The second eruptive phase of 1992 began on the afternoon of August 18 preceded by only a short tremor burst. C-band radar data indicates the ash plume rose to about 14 km (Rose and others, 1995) (pilots estimated the plume height at about 18 km) and small pyroclastic flows again descended the east and southeast flanks of Crater Peak. The eruption lasted 3.5 hours and produced about 52 x 10^6 m^3 of ash. Westerly winds carried the tephra eastward over Anchorage, across the Chugach Mountains and northern half of Prince William Sound, and southeastward toward Yakutat. Up to 3 mm of sand-sized ash fell in Anchorage and coastal communities 1200 km downwind reported dustings of fine ash (Neal and others, 1995). Anchorage International Airport was closed for 20 hours because of the ashfall.

Following the August 18 event, seismicity remained elevated but no precursory activity occurred until the late hours of September 16 when a 3-hour-long increase in tremor culminated in an 11-minute-long eruptive event. An hour and a half later, a much larger eruptive phase began that lasted 3.5 hours (Alaska Volcano Observatory, 1993). Pyroclastic flows swept down the south, east, and east-northeast flanks of Crater Peak (Miller and others, 1995). The flows entrained snow and other surface debris, developing into lahars, of which at least one temporarily dammed the Chakachatna River (Meyer and Trabant, 1995). A narrow field of ballistics, ejected near the end of the eruption, extends at least 10 km east from the vent (Waitt and others, 1995). Southwesterly winds carried the ash cloud across upper Cook Inlet, narrowly missing Anchorage, up the Matanuska Valley and across eastern Alaska. At least 1 mm of ash fell in Glenallen, 350 km east, and a very light dusting was reported at Burwash Landing, Yukon Territory, 700 km east. Photographs taken from the Space Shuttle several days later show the thin but undispersed ash cloud over western Quebec, Canada. Bulk tephra volume was about 56 x 10^6 m^3.

After the September 16-17 eruption, seismicity remained high through December with intense earthquake swarms occurring October 2-6, November 9-10, and December 21-27. The seismic energy release of the November 9-10 swarm was the greatest of the entire 1992 eruptive period and this activity is regarded as a “failed eruption” (Power and others, 1995). Seismicity gradually declined through the first half of 1993 to near-background levels.

Composition

Lava flows comprising the main portion of the pre-caldera stratovolcano are porphyritic andesite (58%-60% SiO_2; Nye and Turner, 1990; figs. 8 and 9) containing 30% to 50% phenocrysts of chiefly plagioclase, and subordinate clino- and orthopyroxene. Textures are either pilotaxitic or hyalopilitic; some samples display a strongly developed glomero-porphyritic texture. Inclusions of fine-grained, equigranular gabbro (?) or diorite (?), although not exceeding about 5% of any sample, occur in nearly all samples. Some samples contain rare subhedral, heavily oxidized hornblende. Pumice from the early Holocene (?) pyroclastic flows is high-silica andesite or low-silica dacite (60%-63% SiO_2; Nye and Turner, 1990).

Juvenile material from all three eruptions in 1992 are essentially the same composition (figs. 8, 9)—calcalkaline andesite with 56.7% SiO_2 (Nye and others, 1995)—and comprise porphyritic hornblende-bearing andesite with brown, microlite-rich andesitic groundmass glass (Alaska Volcano Observatory, 1993). A variety of metamorphic xenoliths were incorporated in deposits including gneiss clasts, partly remelted and highly inflated garnet-plagioclase-wollastonite skarn, and plagioclase-quartz-glass rock (Alaska Volcano Observatory, 1993).

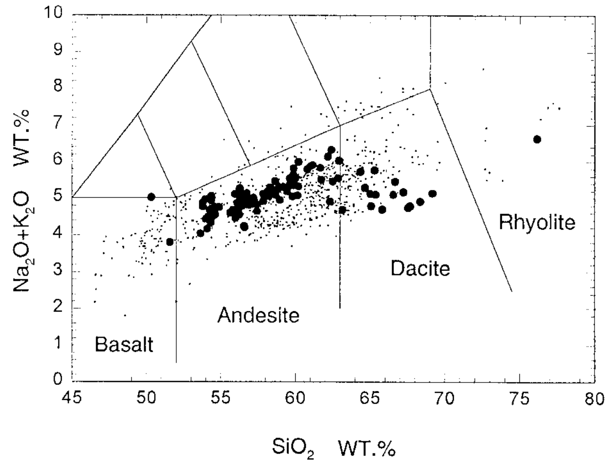

Figure 8. Total alkalies-silica diagram of Spurr volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

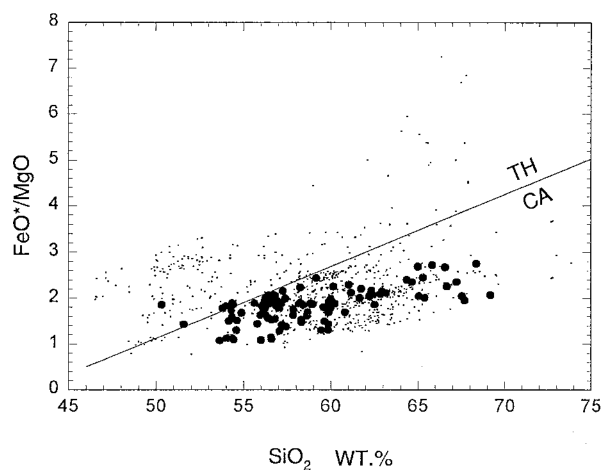

Figure 9. FeO/MgO-silica diagram of Spurr volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

NAME AND LOCATION

NAME: REDOUBT VOLCANO
SYNONYMS: NONE
TYPE: STRATOVOLCANO
LOCATION: 170 KM SOUTHWEST OF ANCHORAGE, ALASKA IN THE ALASKA-ALEUTIAN RANGE
LATITUDE, LONGITUDE: 60°28′N, 152°45′W
ELEVATION: 3108 M
USGS 1:250,000 QUADRANGLE: KENAI
CAVW NUMBER: 1103-03

Form and structure

Redoubt Volcano is a steep-sided cone about 10 km in diameter at its base and with a volume of 30-35 km^3. The volcano is composed of intercalated pyroclastic deposits and lava flows and rests on Mesozoic granitic rocks of the Alaska-Aleutian Range batholith (Till and others, 1993; 1994). It has been moderately dissected by the action of numerous alpine glaciers. A 1.8-km-wide, ice-filled summit crater is breached on the north side by a northward-flowing glacier, informally known as the Drift Glacier, which spreads into a piedmont lobe in the upper Drift River Valley. The most recently active vent is located on the north side of the crater at the head of the Drift glacier. Holocene lahar deposits in the Crescent River and Drift River valleys (fig. 10) extend downstream as far as Cook Inlet.

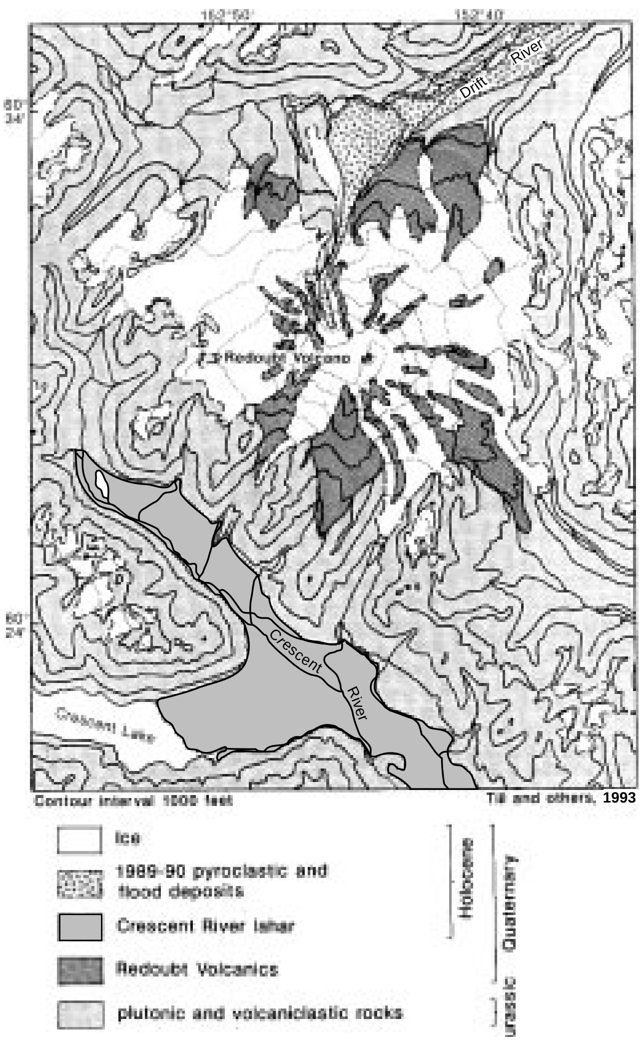

Figure 10. Generalized geologic map of Redoubt volcano; modified from Till and others, 1993.

Volcanic activity

Vapor emissions 1933, 1965, 1967?
Ash-rich explosions 1902, 1966, 1967-68?, 1989-90

Volcanism at Redoubt may have begun as much as 0.88 Ma ago, although the bulk of the cone has been built within the last 200,000 years (Till and others, 1993). Extensive 3500-year-old lahar deposits fill the Crescent River valley and dam Crescent Lake (Riehle and others, 1981). The oldest historical eruption occurred in 1902, when explosions were heard 175 km away and widespread ashfall was reported in the Cook Inlet basin (Martin and Katz, 1912; The Alaskan, Sitka, March 29, 1902). Vapor emissions were reported in May 1933 and January-February 1965. During late January and early February 1966, an explosive eruption produced ash plumes as high as 6100 m; an associated burst of meltwater caused destruction of the glacier draining north from the summit crater and subsequent flooding downstream as far as Cook Inlet (Sturm and others, 1986). A "series of clouds" during January 1967 and five explosions during December 1967 through April 1968 were reported by Wilson and Forbes (1969).

The most recent eruption at Redoubt began with a major phreatomagmatic, vent-clearing explosion at 9:47 am on December 14, 1989 (Brantley, 1990; EOS, 1990; Miller and Chouet, 1994) after less than 24 hours of intense precursory seismicity. Three more ash-rich explosions occurred the following day, December 15, with the last blast generating a pyroclastic flow down the Drift Glacier. The resulting debris flow contained entrained ice blocks as large as 10 m across and crested about 8 m above the river channel near the Drift River Oil Terminal, 35 km downstream (Waitt and others, 1994). A Boeing 747 enroute from Amsterdam that flew into the ash cloud several hours after the eruption experienced complete engine failure and narrowly avoided tragedy when the crew successfully restarted the engines and safely landed in Anchorage (Casadevall, 1994).

These initial explosive events were just the first of 23 major explosive events between December 1989 and April 1990. Following the mid-December explosive phases, the crater vent emitted only minor ash and steam for the next 5-7 days. From December 22 to January 2, 1990, however, a large, over-steepened lava dome grew over the vent. At 5:48 pm on January 2, the first of two powerful explosions destroyed most of the dome and sent ash plumes to over 12 km. Massive block and ash avalanches down the Drift Glacier generated the largest debris flow of the eruption, completely covering the 2-km-wide valley floor and spilling into Cook Inlet. Flood waters entered the oil terminal, as much as 75 cm deep in some buildings, and caused a temporary halt in operations.

Three eruptions occurred in the next two weeks during which time the vent remained open. The January 8 event occurred with no precursory warnings and the resulting ashfall on the Kenai Peninsula disrupted commerce and transportation. Open-vent eruptions on January 11 and 16 resulted in minor debris flows down the Drift River.

After the January 16 eruption, another period of dome growth ensued through mid-February. This dome was smaller than the earlier dome but larger than succeeding domes (Miller, 1994). Early on February 15, the dome was destroyed in an explosive eruption that again sent a large debris flow down the Drift River and blanketed the lower Kenai Peninsula with ash. A pyroclastic flow and surge traveled down the canyon, across the piedmont lobe of Drift Glacier, and swept up the opposite valley wall 700 m topping the ridge (Gardner and others, 1994). Flow down the Drift River was largely diverted into a side drainage that carried flood waters close to oil storage tanks at the downstream oil terminal prompting reinforcement of the containment dikes surrounding the tank farm. A new dome began growing immediately following the eruption.

On February 21, the new, but considerably smaller, dome was destroyed, marking the beginning of a new trend in eruptive behavior. Characteristically, small domes were emplaced and subsequently destroyed explosively or by gravitational collapse, resulting in debris avalanches down the now ice-free canyon leading down to the Drift River valley, and flooding down the Drift River. Ten such eruptions followed from February 24 to April 21 at 4 to 8 day intervals.

Following the April 21 eruption, growth of the present lava dome began and continued through early June. During the next several months, seismic activity declined dramatically and only steam emissions and minor rock falls from the dome were recorded as the eruption came to an end.

The 1989-90 eruption of Redoubt seriously effected the populace, commerce, and oil production and transportation throughout the Cook Inlet region and air traffic as far away as Texas. Total estimated economic costs are $160 million (Tuck and others, 1992), making the eruption of Redoubt the second most costly in U.S. history.

Composition

The oldest deposits of Redoubt Volcano include pyroclastic and hypabyssal rocks of calc-alkaline andesitic to dacitic composition (62-68% SiO_2; figs. 11, 12). Flows and pyroclastic deposits that compose the majority of the present cone range from basalt to andesite (49-62% SiO_2). Most are porphyritic containing phenocrysts of plagioclase, the dominant phase, and variable amounts of olivine, clinopyroxene, orthopyroxene, and hornblende. Juvenile materials from the most recent eruption cycle are all plagioclase-phyric hornblende andesites with SiO_2 ranging from 59.3% to 61.9% (Nye and others, 1994) and are similar to lavas from the 1966 eruption of Redoubt.

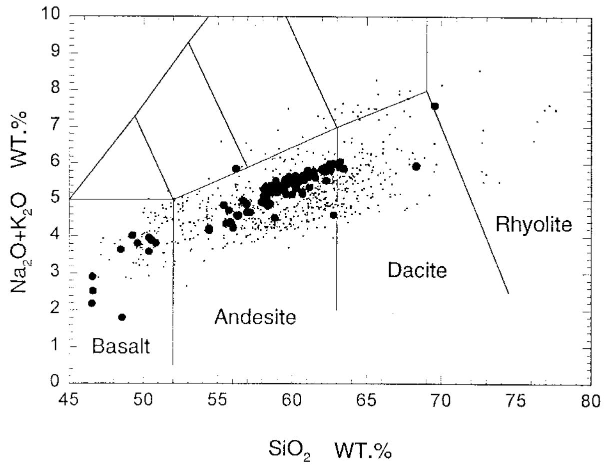

Figure 11. Total alkalies-silica diagram of Redoubt volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2. Samples with <52% SiO_2 are cumulate blocks.

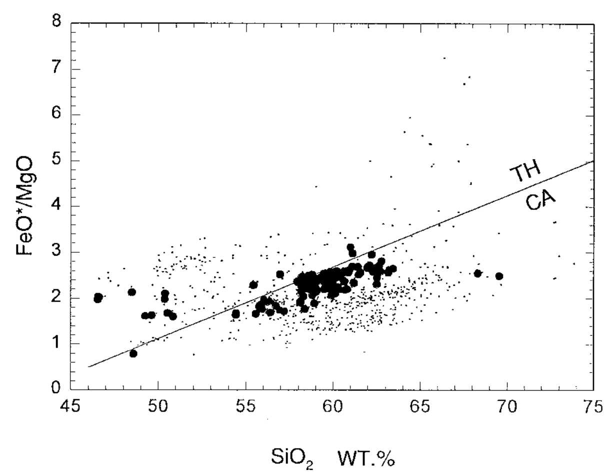

Figure 12. FeO/MgO-silica diagram of Redoubt volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Iliamna Volcano
Synonyms:	None
Type:	Stratovolcano
Location:	225 km southwest of Anchorage, in the Aleutian Range at the north end of the Alaska Peninsula
Latitude, longitude:	60°02′N, 153°04′W
Elevation:	3,053 m
USGS 1:250,000 quadrangle:	Lake Clark
CAVW Number:	1103-02

Form and structure

Iliamna volcano is a broad, deeply dissected and highly altered, roughly cone-shaped mountain at the north end of a 5-km-long ridge trending N10°W (fig. 13). Most of the volcano is covered by perennial snow and ice and numerous glaciers radiate from the summit area. Large avalanche deposits occur on the flanks of the volcano, particularly down the Umbrella Glacier on the southwest side of the volcano.

The volcano is a typical composite stratovolcano composed of interbedded andesite lava flows and pyroclastic rocks. Steep, inaccessible 600-m-high headwalls along the southern and eastern flanks extend nearly to the summit exposing a cross section of the volcanic stratigraphy.

Iliamna is built on a basement of Jurassic granitic rocks of the Aleutian Range batholith (Detterman and Hartsock, 1966) that are juxtaposed against older, Lower Jurassic lava flows and pyroclastic rocks by the Bruin Bay fault, which lies several kilometers east of the summit (fig. 13).

Volcanic activity

The only well documented historical volcanic activity at Iliamna is that of numerous, small, solfataric vents at about 2740 m elevation on the eastern flank (fig. 13). Condensate plumes have been observed extending to an estimated 1000 m above the mountain. Although several reports of "smoke" or "steam" rising from the volcano are received each year, aerial inspections invariably reveal that the activity consists of unusually large clouds of condensate related to the summit fumaroles. These reports are particularly common in the spring and fall,

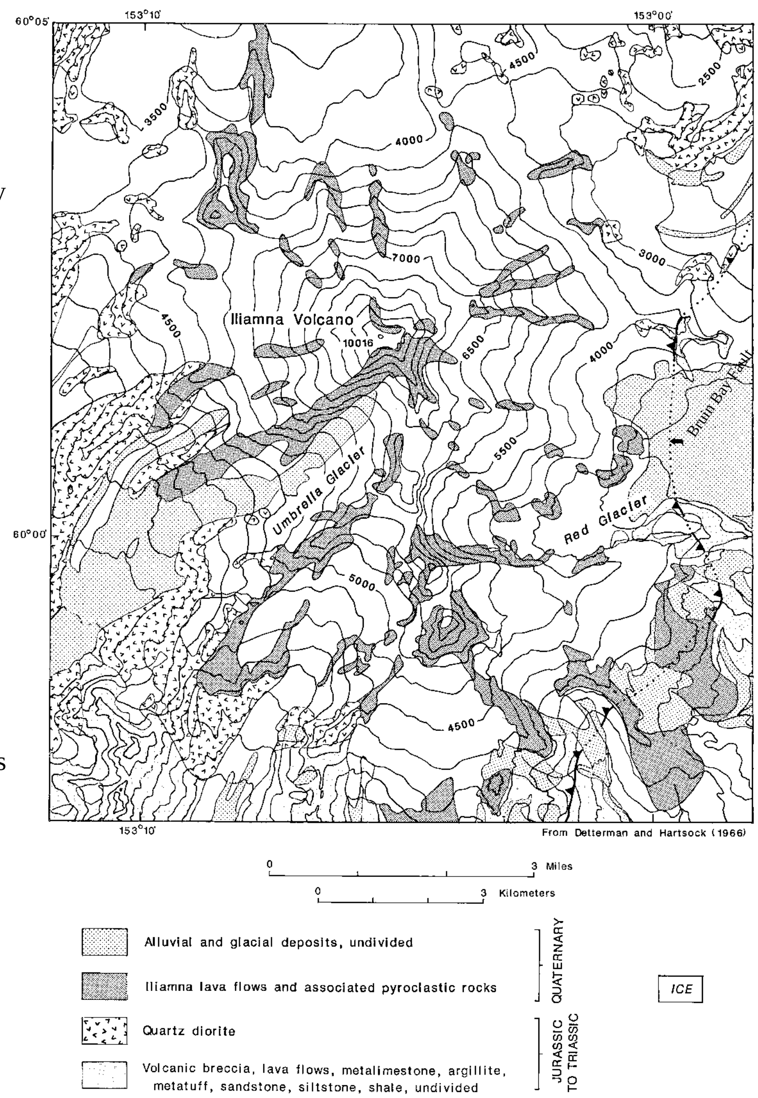

Figure 13. Generalized geologic map of Iliamna volcano; modified from Detterman and Hartsock (1966).

probably because of favorable meteorological conditions (Johnston, 1979), and similar events have undoubtedly been reported as “smoke” in the past. Therefore, although Coats (1950) lists several reports of “smoke”, and an eruption in 1867, documentation is poor and validity of the reports is questionable. Except for the summit fumarolic activity, it is uncertain and perhaps unlikely that Iliamna Volcano has been historically active.

Although no historic (i.e., within the last 200 years) eruptions can be confirmed, recent studies (Begét, 1996) have identified coastal lahars containing juvenile clasts that originated from Iliamna Volcano ~300 ^{14}CyBP and are overlain by 250-year-old trees. These deposits record the most recent eruptive activity from the volcano. However, two strong seismic swarms recorded beneath the volcano in 1996 (Neal and McGimsey, 1997) indicate the volcano remains restless and subject to further eruptions.

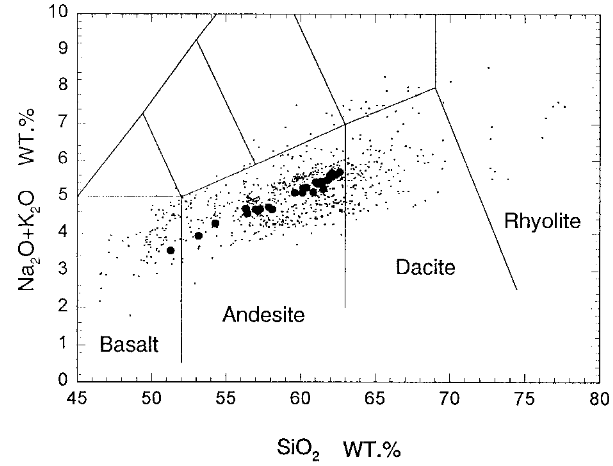

Figure 14. Total alkalies-silica diagram of Iliamna volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

Composition

The volcano is composed of interbedded hypersthene-augite andesite flows and pyroclastic deposits (figs. 14, 15). Most of the flows are light gray and range in thickness from 25 to 120 m. The lava flows contain phenocrysts of plagioclase and subordinate hypersthene and augite in a dense pilotaxitic groundmass composed of randomly oriented microlites with relatively little glass. Sparse olivine occurs in some of the flows but is generally less than one percent of the mode.

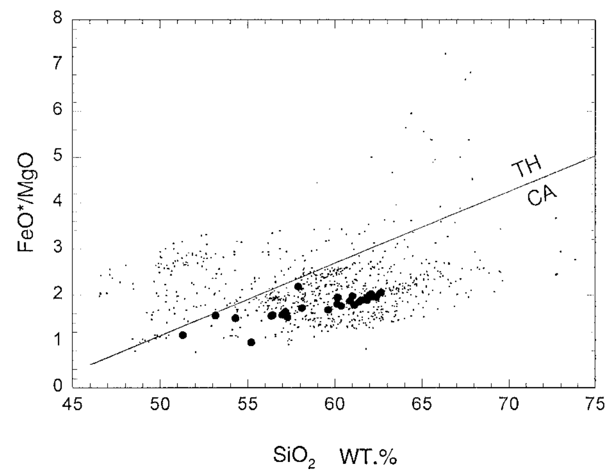

Figure 15. FeO/MgO-silica diagram of Iliamna volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Augustine Volcano
Synonyms:	St. Augustine volcano, Mount St. Augustine
Type:	Central dome cluster
Location:	290 km southwest of Anchorage, on Augustine Island in lower Cook Inlet
Latitude, longitude:	59°23'N, 153°26'W
Elevation:	Approximately 1,260 m
USGS 1:250,000 quadrangle:	Iliamna
CAVW Number:	1103-01

Form and structure

Augustine Island, an 8 by 11 km island in lower Cook Inlet (fig. 16), is composed almost entirely of the deposits of Augustine Volcano. Jurassic and Cretaceous sedimentary strata form a bench on the south side of the island and are overlain by granitoid glacial erratics and volcanic hyaloclastites. The volcano consists of a central dome and lava flow complex, surrounded by pyroclastic debris. The irregular coastline of Augustine Island is due to the repeated catastrophic collapse of the summit dome, forming debris avalanches down the flanks and into Cook Inlet. At least 11 avalanches have occurred in the past 2000 years with an average recurrence interval of about 150-200 years (Begét and Kienle, 1992; Begét, 1986).

Augustine lies within the area of uplift resulting from the 1964 Alaska earthquake; 30-33 cm of uplift was measured on the northwest side of the island (Detterman, 1968). A 25-meter-high, south-facing submarine scarp 3 km south of the island, of similar orientation to joint sets in sedimentary rocks of the Kamishak River area (on the Alaska Peninsula), is almost certainly of tectonic origin.

Volcanic Activity

1812, 1883, 1908?, 1935, 1963-64, 1976, 1986

Augustine Volcano is the most frequently active and the youngest of the Cook Inlet volcanoes. Detterman (1973) considered Augustine to be entirely Quaternary and Johnston (1979) concluded that volcanism at Augustine began during the late Pleistocene Moosehorn glacial advance 19,000-15,500 yBP. Since its discovery by Captain James Cook in 1778, Augustine Volcano has had seven historical eruptions: 1812 (Doroshin, 1870), 1883 (Davidson, 1884; Kienle and others, 1987; Siebert and others 1989), 1908 (Seward Weekly Gateway, March

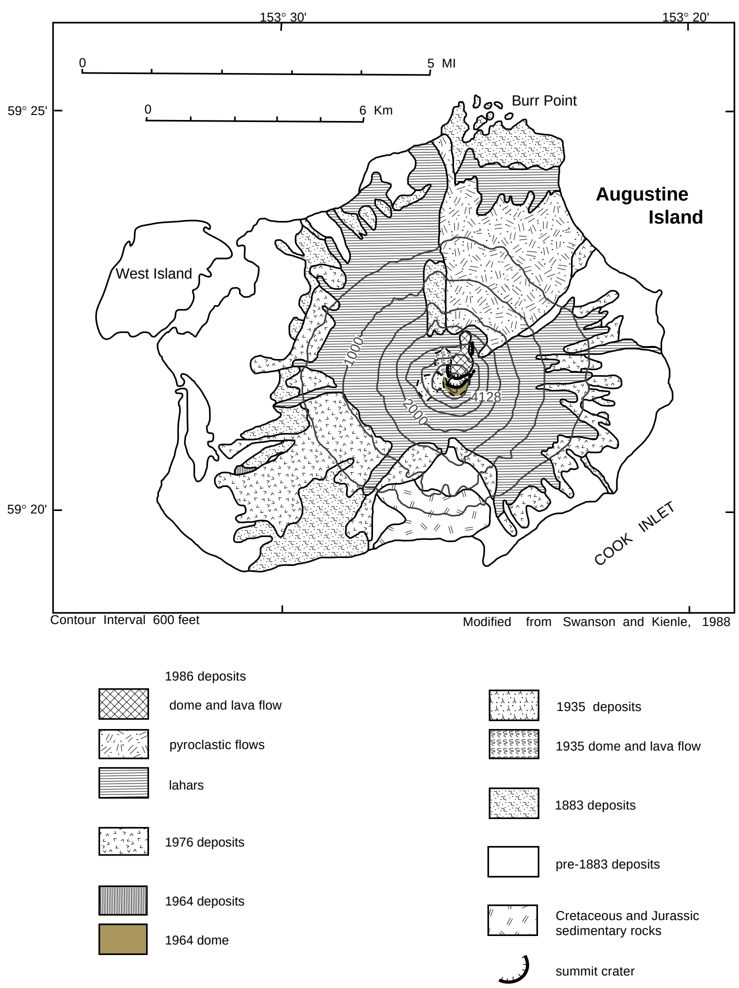

Figure 16. Generalized geologic map of Augustine volcano; modified from Swanson and Kienle (1988).

14, 1908), 1935 (Anchorage Daily Times, April 3, July 13, 1935; Detterman, 1973), 1963-64 (Detterman, 1968), 1976 (Kienle and Shaw, 1979; Kienle and Swanson, 1985; Kamata and others, 1991), and 1986 (Kienle and others, 1986; Yount and others, 1987). The activity in 1908, reported by the captain of a steamer enroute to Seward, was minor and probably did not produce any deposits.

The 1883 eruption appears to have been the most violent historical eruption of Augustine, and is thought to have generated a tsunami with wave heights of 7.5 to 9 m at English Bay on the Kenai Peninsula 80 km east of the island (Davidson, 1884). The tsunami has been attributed to a debris avalanche from the north side of the volcano into Cook Inlet (Kienle and others, 1987; Siebert and others, 1989).

The most recent eruption, which began on March 27, 1986, after more than five weeks of increased seismic activity and continued through August 1986 (Smithsonian Institution, 1987), is probably typical of most Augustine eruptions. A nearly continuous ash-rich plume rose 3,000 to 4,600 m; periodic explosive bursts reached altitudes of 12,200 m (Yount and others, 1987). Numerous pyroclastic flows were generated in the early stages of the eruption and moved down the north flank. Several large flows reached the north shore 5 km away and entered the sea. Much of the snowpack on the upper flanks melted producing lahars (fig. 16). As the eruption evolved, generation of pyroclastic flows diminished and dome building began. A short lava flow also issued down a steep gully on the north flank.

Military and commercial air traffic was disrupted in upper Cook Inlet during the first week of the eruption when airborne ash was moving northward. Light ashfall occurred over most of the Cook Inlet area, and ash was detected as far north as the Brooks Range several days into the eruption (Yount and others, 1987).

Eruptions of Augustine typically consist of multiple phases spanning several months. During each phase, explosive ash eruptions are often accompanied by mudflows and pyroclastic flows. Usually the first phase is the most violently explosive; successive phases often include extrusion of lava, enlarging the central dome and lava flow complex.

Composition

Augustine volcanic rocks are of calc-alkaline andesite and dacite composition (figs. 17, 18) but of the low-K, rather than medium-K variety. Phenocryst phases include plagioclase (the dominant phase), orthopyroxene, clinopyroxene, hornblende, and rare olivine. Much of the lava is rich in glass and highly vesicular.

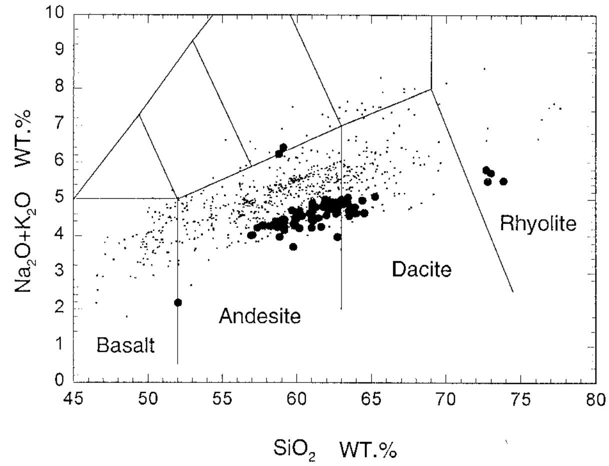

Figure 17. Total alkalies-silica diagram of Augustine volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2. The rhyolites are individual pumice lapilli.

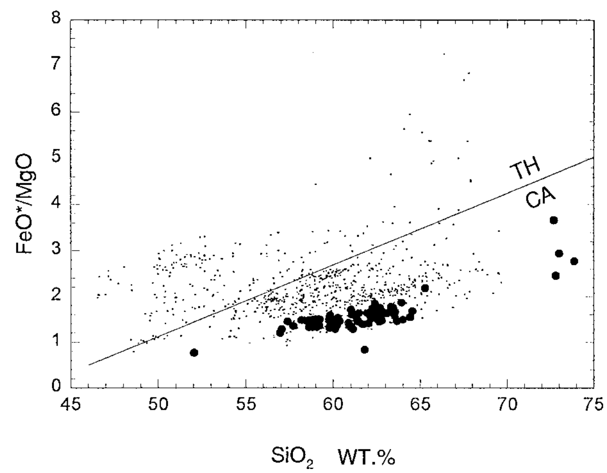

Figure 18. FeO/MgO-silica diagram of Augustine volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Mt. Katmai, Katmai Caldera
Synonyms:	Katmai volcano
Type:	Stratovolcano with central caldera
Location:	Katmai National Park, 440 km southwest of Anchorage, on the Alaska Peninsula
Latitude, longitude:	58° 16′N, 154° 59′W
Elevation:	2047 m
USGS 1:250,000 quadrangle:	Mt. Katmai
CAVW Number:	1102-17

Form and structure

Katmai volcano is a large stratovolcano about 10 km in diameter with a central lake-filled caldera whose rim is about 4.2 by 2.5 km in area (fig. 19). The caldera rim has a maximum elevation of 2047 m and in 1975 the lake surface was at an elevation of about 1236 m. The estimated elevation of the caldera floor is about 995 m.

The volcano is one of five stratavolcanoes near the Novarupta dome, source of the voluminous pyroclastic flows erupted in 1912 (Hildreth, 1983). It consists chiefly of lava flows, pyroclastic rocks, and non-welded to agglutinated air fall (Fenner, 1920; Hildreth, l983). The Quaternary volcanic rocks at Katmai and adjacent cones are less than 1500 m thick (Hildreth, 1983). Much of the volcano is mantled by snow and ice and several valley glaciers radiate out from the flanks and three glaciers originating from the upper caldera walls descend into the crater to the lake (Motyka and Benson, 1975).

Katmai volcano is built on the sedimentary rocks of the Naknek Formation of Late Jurassic age, which are exposed just west of the caldera rim at an elevation of about 1520 m, as well as north and southeast of the crater (Curtis, 1968; Riehle and others, 1987).

Volcanic activity

June 6-8, 1912

Little is known about the historical activity of Katmai volcano before the great 1912 eruption. Early Coast and Geodetic Survey maps suggest a pre-caldera summit elevation of about 2286 m and local villagers reported in 1898 that one of the volcanoes in the general area “smoked” occasionally.

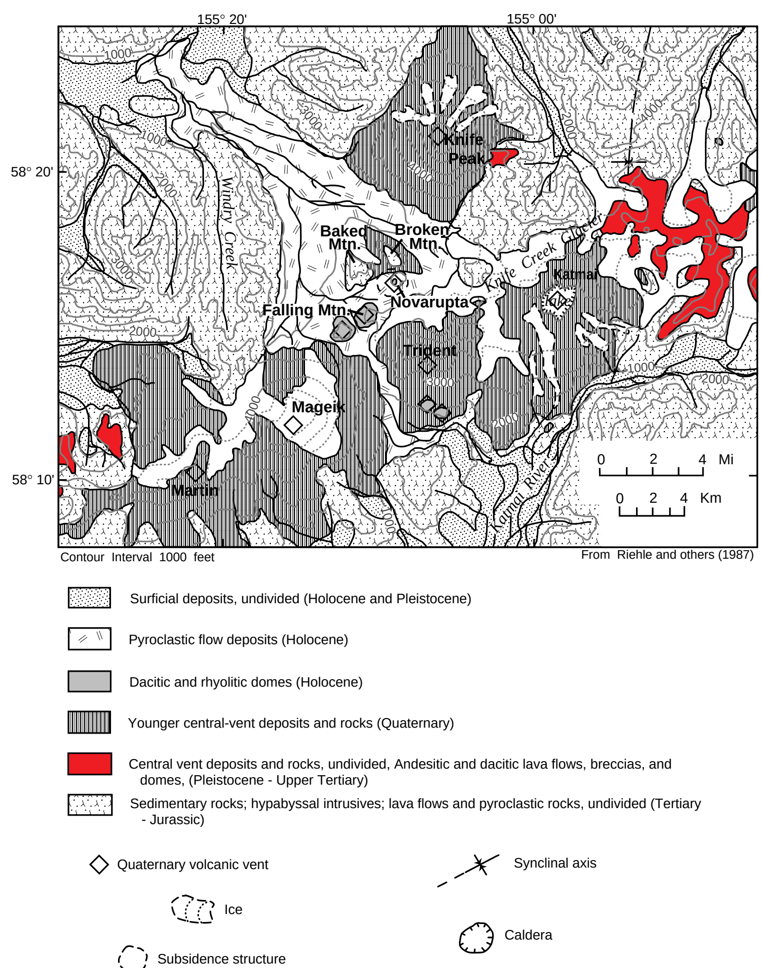

Figure 19. Generalized geologic map of Katmai, Mageik, Martin Mountain, Trident, Knife Peak (Griggs) and Novarupta volcanoes after Riehle and Detterman (1993).

In June of 1912, the most spectacular Alaskan eruption in recorded history and the largest eruption in the world in the twentieth century resulted in the formation of a small summit caldera at Katmai volcano. The 60-hour-long eruption actually took place at a vent about 10 km to the west of Mt. Katmai (now marked by Novarupta dome) from which an estimated 30-35 km^3 of ash flows and tephra were ejected (Hildreth, 1983; Fierstein and Hildreth, 1992) rather than at Mt. Katmai itself. Based on geochemical and structural relationships, Hildreth (1987) suggests that magma drained from beneath Katmai Volcano to Novarupta via the plumbing system beneath Trident Volcano (fig. 19). The withdrawal of magma beneath Katmai resulted in the collapse of the summit area, forming the caldera (Curtis, 1968; Hildreth, 1991). Following the subsidence, a small dacitic lava cone was emplaced on the floor of the caldera; this is the only juvenile material erupted from Katmai caldera during the historical eruption. In 1919, a lake covered a large part of the caldera floor, but by 1923 the lake was gone and numerous fumaroles, mud pots, and a large mud geyser were active (Fenner, 1930). Approximately 12-15 km^3 of magma was vented during the 1912 eruption producing about 35 km^3 of tephra. An estimated 11-15 km^3 of ash flow tuff traveled 20 km northwest covering an area of about 120 km^2 in what subsequently came to be known as the Valley of Ten Thousand Smokes. Maximum thickness of the ashflow is estimated to be about 250 m (Hildreth, 1983). Light ash fall was reported as far away as the Puget Sound region (2400 km). Extremely fine ash blown into the stratosphere remained in suspension as aerosols for months and caused spectacular red sunsets in many parts of the world.

Composition

Katmai volcano is composed of rocks ranging in composition from low-silica and low-potassium andesite to dacite but two-pyroxene andesite (figs. 20, 21) is the most common rock type (Fenner, 1926). The andesite is commonly porphyritic with plagioclase and pyroxene phenocrysts in an aphanitic groundmass of plagioclase, hypersthene, augite, magnetite, and glass. Biotite and quartz are absent, and hornblende is rare.

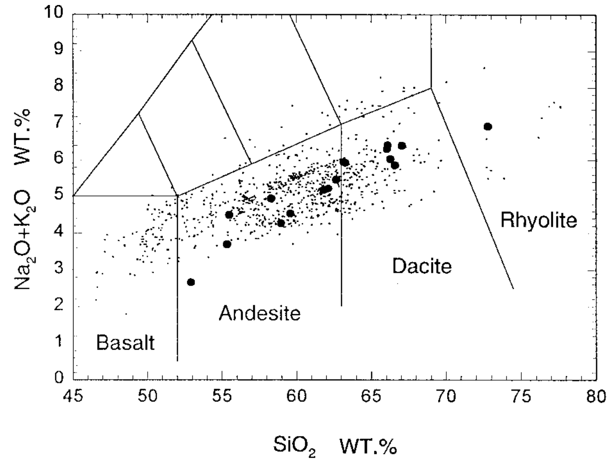

Figure 20. Total alkalies-silica diagram of Katmai volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

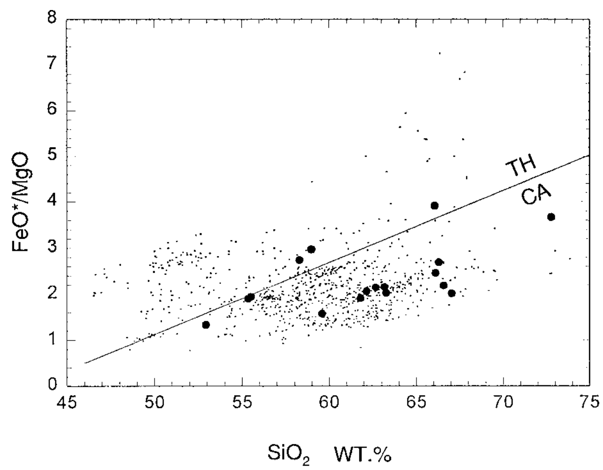

Figure 21. FeO/MgO-silica diagram of Katmai volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Novarupta
Synonyms:	None
Type:	Plinian pyroclastic vent with plug dome
Location:	Valley of Ten Thousand Smokes, Katmai National Park, Alaska Peninsula
Latitude, longitude:	58°16′N, 155°09′W
Elevation:	841 m
USGS 1:250,000 quadrangle:	Mt. Katmai
CAVW Number:	1102-18

Form and structure

The Novarupta dome is about 400 m in diameter and 65 m high at its center (Curtis, 1968) (fig. 19), and is surrounded by a 2-km-wide, funnel-shaped structure (Hildreth, 1983; Goodliffe and others, 1991). The surface of the dome is completely fractured into chaotic blocks and crumble breccia. The dome is a plug-like feature emplaced within a low ejecta ring. Prominent scarps along the flanks of Baked, Falling, and Broken Mountains surrounding the Novarupta depression indicate considerable subsidence occurred following the 1912 eruption. Nearby stratovolcanoes (including Trident and Katmai) form a volcanic front trending N65°E; Novarupta lies about 4 km behind the front. Linear fractures normal to the front extend between Novarupta and Trident (Hildreth, 1987).

Volcanic activity

June 6-9, 1912

The eruption of 1912, largest twentieth century eruption in the world, produced the largest historic ash flow sheet (see frontspiece) deposited entirely on land (Hildreth, 1983). Eruptive activity started early in the afternoon of June 6, 1912 with the violent eruption of rhyolitic pumice and ash beginning about 1:00 p.m. Emplacement of the rhyolitic ash flow began concurrent with the plinian eruption and was followed continuously by fallout and ash flows zoned from rhyolite to andesite that lasted for about 20 hours (Fierstein and Hildreth, 1992). Approximately 12 km^3 of magma was vented during the 1912 eruption producing about 30 km^3 of tephra. An estimated 11 km^3 of ash flow tuff traveled as far as 20 km northwest covering an area of about 120 km^2 in what subsequently came to be known as the Valley of Ten Thousand Smokes. Maximum thickness of the ashflow is estimated to be about 250 m (Curtis, 1968). About 17 km^3 of airfall tephra was carried preferentially east and southeast but light ash fall was reported as far away as the Puget Sound region (2400 km). Extremely fine ash blown into the stratosphere remained in suspension as aerosol for months and caused spectacular red sunsets in many parts of the world.

Voluminous rhyolitic eruptions are typically followed by collapse of the vent and formation of a caldera. However, local complex magma reservoirs and plumbing systems resulted in the summit collapse at Katmai, 10 km to the east, in response to magma transfer towards Novarupta, possibly via Trident (Hildreth, 1983, 1987, 1991).

Following the pyroclastic eruption, the dome was emplaced near the center of the vent region. Fumarolic activity in the vent area has subsequently decreased and no other eruptions have been reported.

Composition

Three distinct magmas (rhyolite, dacite, and andesite) were mechanically and complexly intermingled during the 1912 eruption producing mixed deposits with a range of bulk composition. The main ash flow is compositionally zoned with the earliest part nearly all rhyolite and the later half progressively more dacitic and andesitic (Hildreth, 1983). The plug dome is rhyolite, contaminated with a minor amount of interbanded dacite and andesite lava. The bulk SiO_2 content is 77% for the rhyolite, 66-64.5% for the dacite, and 61.5-58.5% for the andesite (figs. 22, 23). Rhyolite ejecta is phenocryst-poor, in contrast to the andesite and dacite ejecta, which contain many 30-45% phenocrysts. Phenocryst minerals are quartz (rhyolite only), augite (all except rhyolite), plagioclase, orthopyroxene, titanomagnetite, ilmenite, apatite, pyrrhotite, and rare olivine (andesite only) (Hildreth, 1983).

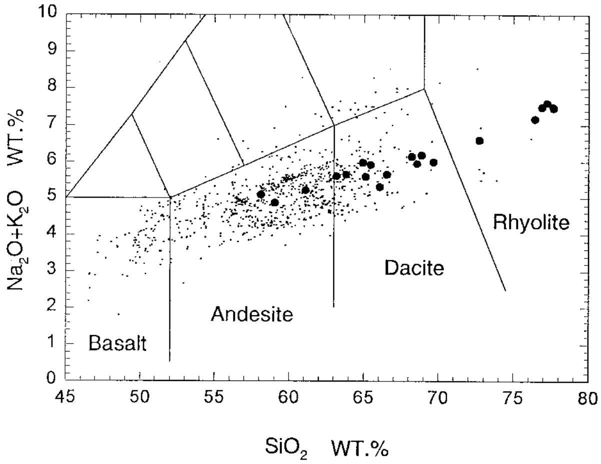

Figure 22. Total alkalies-silica diagram of Novarupta volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

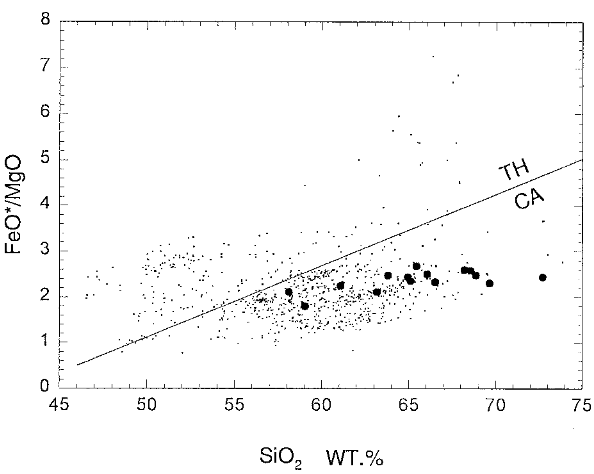

Figure 23. FeO/MgO-silica diagram of Novarupta volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Trident Complex
Synonyms:	Trident volcano
Type:	Cluster of three stratovolcanoes and several domes
Location:	Katmai National Park, Alaska Peninsula
Latitude, longitude:	58°14'N, 155°07'W
Elevation:	1097 m (elevation of 1953 dome)
USGS 1:250,000 quadrangle:	Mt. Katmai
CAVW Number:	1102-16

Form and structure

Trident is an eroded volcanic complex consisting of three stratovolcanoes and numerous domes, as high as 1864 m in elevation, along a northeast-southwest oriented volcanic front (fig. 19) on the Alaska Peninsula (Hildreth, 1987). A new fragmental cone was built beginning in l953 at an altitude of 1097 m in an amphitheater on the southwest flank of the southwest peak.

Volcanic activity

1953-1974

There is no evidence of recent eruptive activity at the several older summits of Trident, nor have there been any reports of historical activity, except fumarolic activity on the east side. However, a satellite cone formed February 15, 1953 on the southwest flank of Trident following an explosive eruption that sent ash to an altitude of over 9 km (Snyder, 1954; Ray, 1967). A succession of blocky lava flows were erupted in 1953, 1957, 1958, and 1959-1960 from the new vent. Ash eruptions, some to altitudes over 12 km, also occurred (Ray, 1967). By 1960 the fragmental cone had grown nearly 260 m high, and the sequence of viscous flows, up to 300 m thick and covering an area of 5 km^2 south of the volcano, had been extruded (Snyder, 1954; Decker, 1963). Phreatic explosions and plug emplacements within the small crater of the cone continued until 1974. In the 1980's and 1990's, steam and/or vapor continued to rise from the central vent area of the new cone as well as from numerous sulfurous fumaroles on the near-vent portion of the blocky lava flows.

Composition

Trident lavas are andesitic to dacitic (figs. 24, 25) in composition (Ray, 1967; Kosco, 1981). The dominant phenocrysts are zoned plagioclase, hypersthene, clinopyroxene, titanomagnetite, and rimmed olivine. The five flows erupted from the new vent during 1953-1960 are olivine-bearing, two pyroxene, high-silica andesite (Ray, 1967).

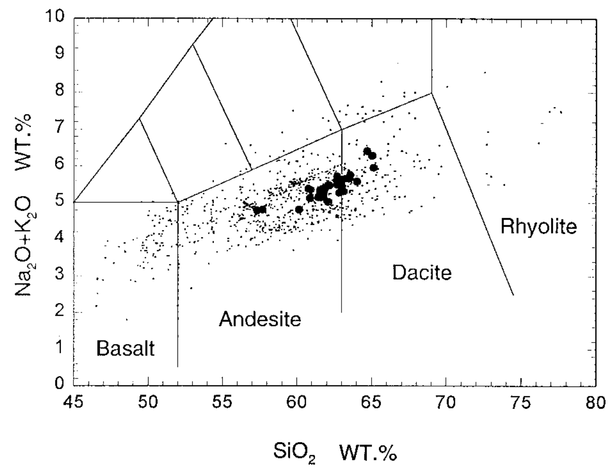

Figure 24. Total alkalies-silica diagram of Trident volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

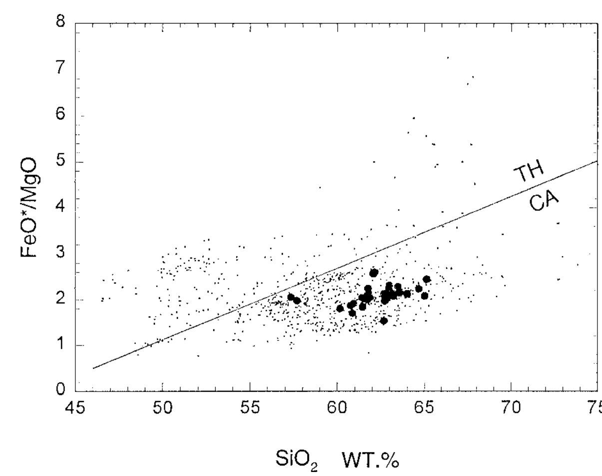

Figure 25. FeO/MgO-silica diagram of Trident volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Mount Mageik
Synonyms:	None
Type:	Composite volcano
Location:	Katmai National Park, 450 km SW of Anchorage
Latitude, longitude:	58°11'N, 155°14'W
Elevation:	about 2165 m
USGS 1:250,000 quadrangle:	Mt. Katmai
CAVW Number:	1102-15

Form and structure

Mount Mageik is a broad cone-shaped volcano that rests on a basement of Jurassic sedimentary rocks at the northeast end of a 12-km-long basement ridge shared by neighboring Mount Martin (fig. 19). The summit area, which is largely ice-covered, consists of a central high peak (elevation 2165 m) and three smaller topographic highs, each a separate vent-cone. A small (< 1 km in diameter) phreatic crater on the northeast side of the central peak contains a crater lake and supports vigorous fumarolic activity accompanied by sulfur deposition. The slopes of the volcano are moderately dissected by glacial ice, except the young lava flows of the east side. Two small debris avalanches, including the Mageik landslide—one of which occurred during the 1912 Katmai eruption (Griggs, 1922) originated from areas high and low on the south flank. The 1912 avalanche, containing boulders as big as 3 to 5 m, travelled 6 km down the broad valley of Martin Creek, south and east of Mount Mageik.

Volcanic activity

1927?
1929?
1936?
1946?

Coats (1950) attributed 4 possible eruptions to Mount Mageik: in August 1927, in December 1929, in July 1936, and in 1946. The 1927 report is based on a Seattle newspaper's account of a report by a ship's captain who was sailing off the Alaskan Peninsula when Mageik supposedly erupted (Jaggar, 1927). The account mentions the ship was engulfed in ash and that fist-size pumice lumps were floating in the water. But the only pumice mantling Mount Mageik itself, is that of 1912 from Novarupta. Hildreth (1983) doubted the validity of the report and concluded that "...there are no credible reports of historical eruptions in the Katmai group except at Novarupta in 1912 and at Trident in 1953-1968..." Fumaroles from the summit crater are the only documented, historical emissions of Mount Mageik, although several lava flows on the volcano's east flanks are certainly post-glacial. The l929 and 1936 reports may have been based on a very brief reference to "unusual activity" of Mount Mageik and other volcanoes in a newspaper account, and from reports of a ship's crew; the crew probably was no closer than 25 km to the volcano.

Composition

Sampled lava flows from Mount Mageik are all andesite or high-silica andesite containing 56 to 65 percent SiO_2 (M.E. Yount, D.E. Kosco unpublished data; Hildreth, 1987).

Name and Location

Name:	Mount Martin
Synonyms:	None
Type:	Stratovolcano and lava-flow field
Location:	About 450 km southwest of Anchorage, in the Katmai group of volcanoes
Latitude, longitude:	58°10′N, 155°21′W
Elevation:	1860 m
USGS 1:250,000 quadrangle:	Mt. Katmai
CAVW Number:	1102-14

Form and Structure

Mount Martin is located near the center of a high (>1400 m) ridge of altered basement rocks that extends more than 12 km, west-southwest from Mount Mageik (fig. 19) (Riehle and others, 1987). A crater, approximately 300 m in diameter and breached on its southeast side, occurs high on the east side of the summit cone. The crater is the site of intense fumarolic activity and steam emission, and contains an ephemeral crater lake. The summit cone and the voluminous lava-flow field, which fill the upper valley of Angle Creek northwest of the volcano, which are of Holocene age. This flow-field, which erupted from a vent low on the north flank of the summit cone, covers approximately 31 km^2 and has volume in excess of 5 km^3. Martin's extent has previously been overestimated because the young volcano lies adjacent to the glaciated remnants of a mid-Pleistocene andesitic edifice (Alagogshan volcano).

Volcanic Activity

1913-1919?
1927, May 18?
1951, July 22
1953, February
1953 and 1954, summers?

Mount Martin, venting a prominent steam plume, was first photographed in 1913 but erroneously called Mt. Katmai (Griggs, 1922). In 1915, Griggs (1922) recognized that the mountain was an unknown, fumarolically active volcano west of Mount Mageik and named it in honor of George C. Martin, who was the first to visit and describe the Katmai area following the 1912 eruption.

Numerous reports of activity from Mount Martin are contained in the literature. Sapper (1927) reported strong “smoke” clouds from Mount Martin during the period 1913-1919; Griggs (1922), who explored the area during that time, mentioned only steam. Jaggar (1927) saw Mount Martin steaming on May 18, 1927 from a boat in Shelikof Strait. Muller, Juhle, and Coulter (1954) assumed that “ashfall at Kukak Bay on July 22, 1951, and the eruptions reported as occurring…in February, 1953” probably came from Mount Martin rather than Mount Mageik, apparently based on the relative volume of steam emissions observed from both during July 1953.

However, all reports of eruption or ash emission are probably spurious, reflecting only the persistent and conspicuous steam plume. Steam emission is normally vigorous and continuous from the summit vent of Mount Martin with plumes occasionally rising 600 m above the vent and extending downwind for 20 km.

see next page

Composition

Information on the composition of Mount Martin is meager but it appears to consist chiefly of andesite and low-silica dacite lava flows (figs. 26, 27). The voluminous Holocene lava flow in Angle Creek is a high-silica andesite containing 62.5 percent SiO_2 (M. E. Yount).

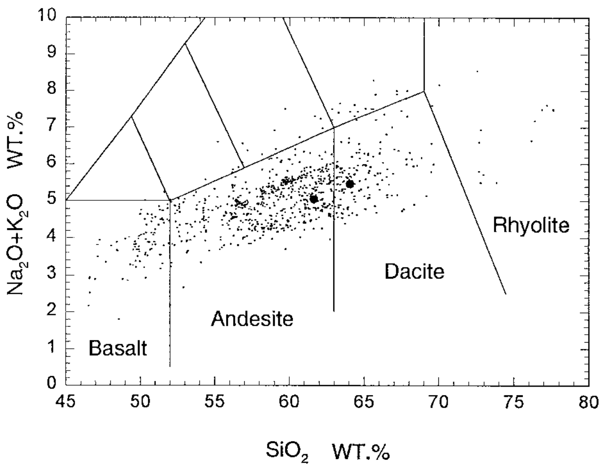

Figure 26. Total alkalies-silica diagram of Mt. Martin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

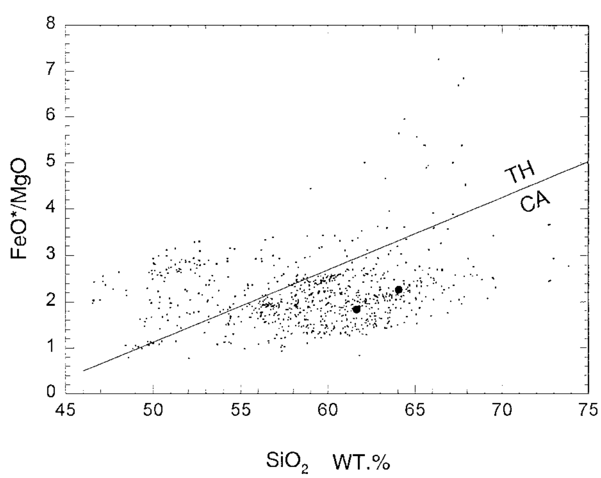

Figure 27. FeO/MgO-silica diagram of Mt. Martin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Mount Peulik volcano
Synonyms:	None
Type:	Stratovolcano with summit and flank domes
Location: Alaska Peninsula;	540 km southwest of Anchorage
Latitude, longitude:	57°45′N, 156°21′W
Elevation:	1474 m
USGS 1:250,000 quadrangle:	Ugashik
CAVW Number:	1102-13A

Form and Structure

Mount Peulik volcano, a small truncated stratovolcano with a basal diameter of about 10 km, is located just north of the main axis of the Aleutian Range near Becharof Lake on the Alaska Peninsula (fig. 28). The volcano lies west of the axis of a northeast-striking syncline (Detterman and others, 1987) and is built upon Jurassic sedimentary rocks. The volcano partially overlaps the north flank of Ugashik caldera, a small circular structure about 5 km in diameter and of probable Late Pleistocene age. A summit crater, about 1.5 km in diameter, has been breached on the west side and is occupied by a dome about 0.5 km in diameter. This dome, and possibly earlier predecessors, were the source of a thick deposit of block-and-ash flows that underlie about 40 km^2 of the western flank of the volcano. A smaller dome occurs on the east flank at an elevation of 1200 m and was the source of a small block-and-ash flow. Avalanche deposits representing an earlier sector collapse (Miller, in press) underlie an area of 75 km^2 northwest of the volcano. Flows from flank eruptions of Peulik cover about 8 km^2 north of the volcano extending as far as Becharof Lake.

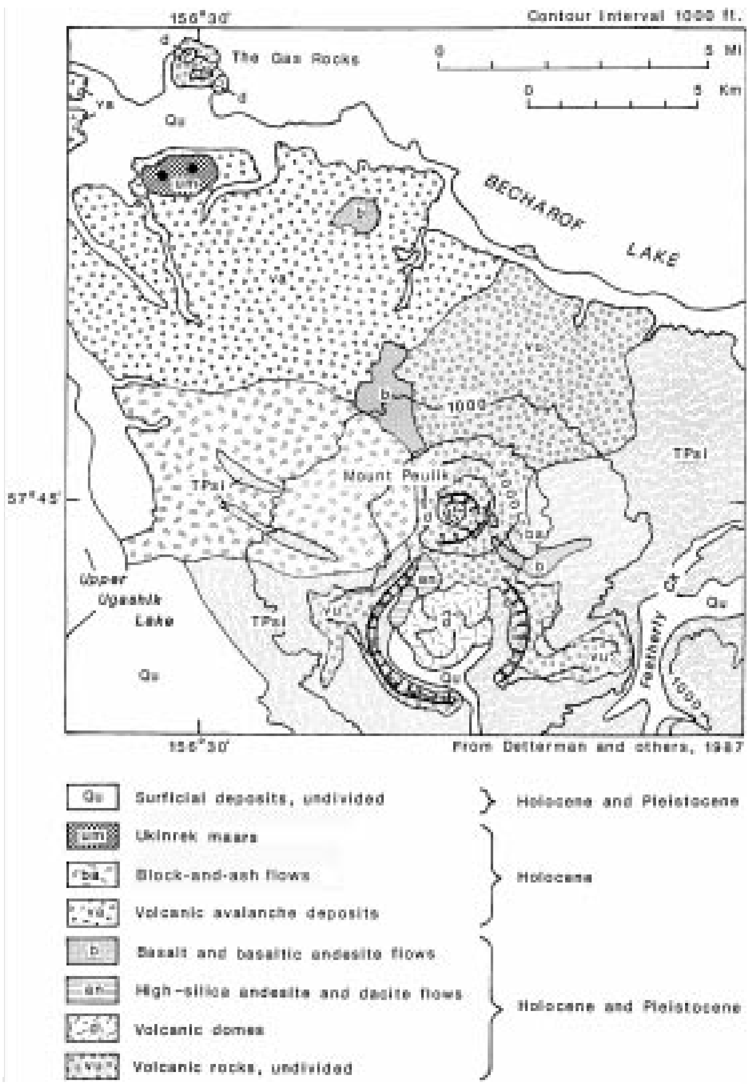

Figure 28. Generalized geologic map of the Ugashik-Mount Peulik volcanic center after Detterman and others (1987).

Volcanic Activity

1814
1852

Coats (1950) cites only two reports of historical activity that were apparently taken from Doroshin (1870) who stated that “around 1814 its [Peulik] summit collapsed with a rumble, covering the base with enormous boulders”. This report may record an episode of dome destruction. Doroshin reported that in 1852 he saw only “smoke” coming from the south side of the crater. No fumarolic activity was noted when the dome was examined in 1973.

Composition

Mount Peulik volcanic rocks include calcalkaline flows, lava domes, and pyroclastic deposits (figs. 29, 30). Cone-building volcanic rocks are predominantly two pyroxene andesite with minor olivine basalt (Miller, in press); dome rocks and their associated pyroclastic-flow deposits are chiefly hornblende dacite and rhyodacite. Flank eruptions include basalt.

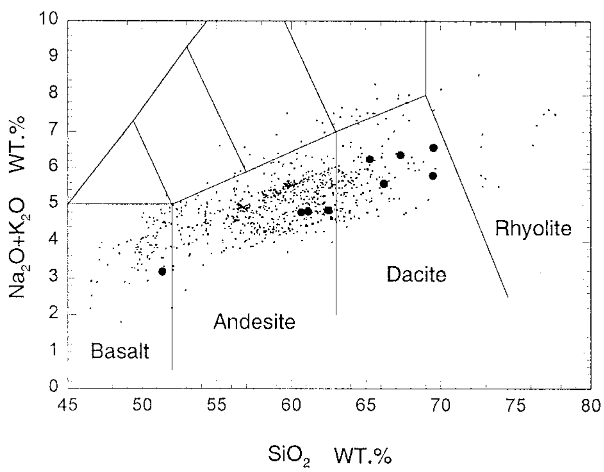

Figure 29. Total alkalies-silica diagram of Peulik volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

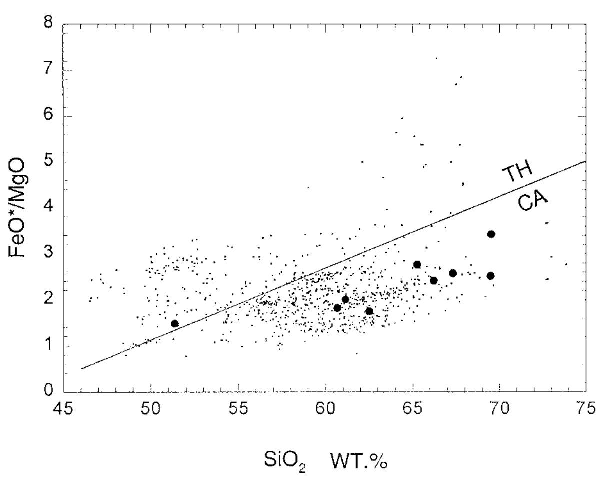

Figure 30. FeO/MgO-silica diagram of Peulik volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name: Ukinrek Maars
Synonyms: None
Type: Maars
Location: about 530 km southwest of Anchorage on Alaska Peninsula
Latitude, longitude: 57° 50′N, 156° 30′W
Elevation: 91 m
USGS 1:250,000 quadrangle: Ugashik
CAVW Number: 1102-13B

Form and structure

Ukinrek Maars are a pair of phreatomagmatic explosion vents that formed on a low (less than 100 m high), 4-km-long, ridge in the Bering Sea Lowland 1.5 km south of Becharof Lake and 12 km northwest of Peulik Volcano (fig. 28 [Peulik Volcano figure]). West Maar, elliptical in shape and up to 170 m in diameter and 35 m deep, formed on the northwest end of the ridge (Kienle and others, 1980). East Maar lies 600 m east of West Maar at a lower elevation. It is circular, up to 300 m in diameter and 70 m deep, and has a 49-m-high central lava dome that is now partly covered by a crater lake. Location of the maars apparently coincides with, and may be controlled by, the intersection of the Bruin Bay fault and regional structures (Kienle and others, 1980; Detterman and others, 1983).

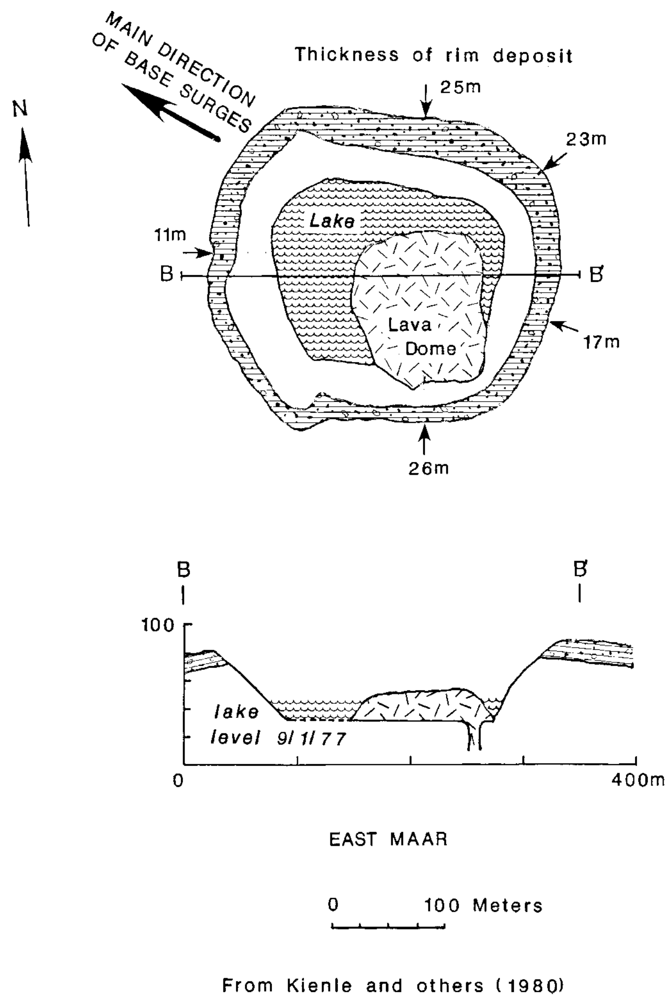

Figure 31. Generalized map and cross-section of the eastern of the Ukinrek Maars from Kienle and others (1980).

Volcanic activity

March 30-April 10, 1977

Ukinrek Maars were created during a 12-day violent eruption that began on March 30, 1977 (Kienle and others, 1980; Smithsonian Institution, 1977). Apparently, magma rose to the surface along deep intersecting structures and encountered ground water stored in a silicic pumice-rich pyroclastic deposit interbedded in glacial till (Self and others, 1980). West Maar formed first, during a period of phreatomagmatic explosions that generated steam and ash plumes to 6500 m. Several days later, activity shifted from West Maar to a new crater (East Maar). During the next several days, strong phreatomagmatic explosions at East Maar spewed ash and steam clouds to 4000 m, initiated moderate base surges, and hurled blocks as far as 600 m. Light ash fall occurred up to 160 km north. Near the end of the eruption, Strombolian fountaining and dome building was observed as the magma degassed and vesiculated. By April 10, all activity had ceased except for steaming from the lava dome as water flowed into the crater from the walls (Kienle and others, 1980).

Composition

Pyroclastic deposits associated with the 1977 eruption include juvenile ash, lapilli and blocks, stratified base surge deposits, and cognate and accidental lithic blocks (Kienle and others, 1980; Self and others, 1980). The rim deposit on East Maar consists of alternating layers of fine to medium grained tephra and black scoria with interspersed coarse lithic fragments. The deposit ranges in thickness from 11 m to 26 m (fig. 31). The juvenile Ukinrek ejecta are dark gray to black porphyritic olivine basalt (figs. 32, 33), which, like the CO_2 that issues from nearby Gas Rocks (fig. 28), is mantle derived (Kienle and others, 1980; Barnes and McCoy, 1979). Cauliflower, spherical, and ribbon bombs are common and vesicularity of the ejecta ranges from scoria to dense lapilli, bombs, and blocks. Olivine is the dominant phenocryst phase; euhedral plagioclase laths (An_{75}) are the most common microphenocrysts (Kienle and others, 1980).

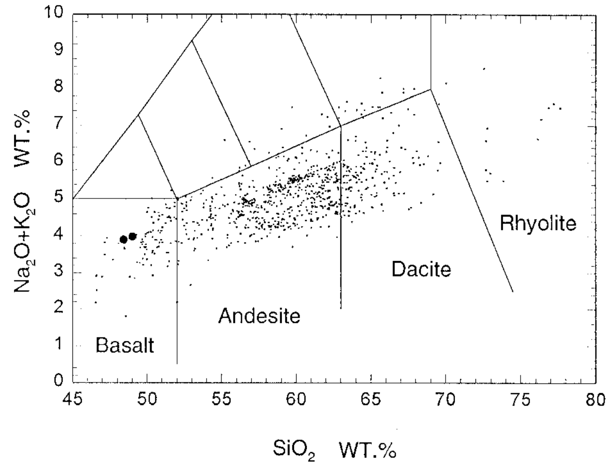

Figure 32. Total alkalies-silica diagram of Ukinrek Maars volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

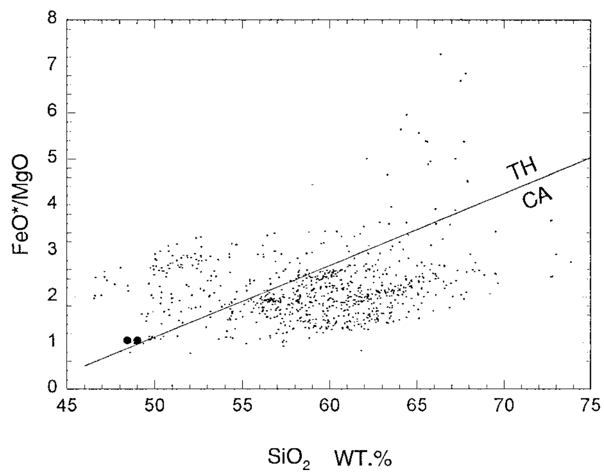

Figure 33. FeO/MgO-silica diagram of Ukinrek Maars volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).s.