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CATALOG OF THE HISTORICALLY ACTIVE VOLCANOES OF ALASKA

by
T.P. Miller [1], R.G. McGimsey [1], D.H. Richter [1],
J.R. Riehle [1], C.J. Nye [2], M.E. Yount [1],
and J.A. Dumoulin [1]

[1]U.S. Geological Survey
Anchorage, AK 99508
[2]Alaska Divison of
Geological and Geophysical Surveys
Fairbanks, AK 99709

Open File Report 98-582
1998

Done in cooperation with the
International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI)
and the Catalog of Active Volcanoes of the World (CAVW) Project

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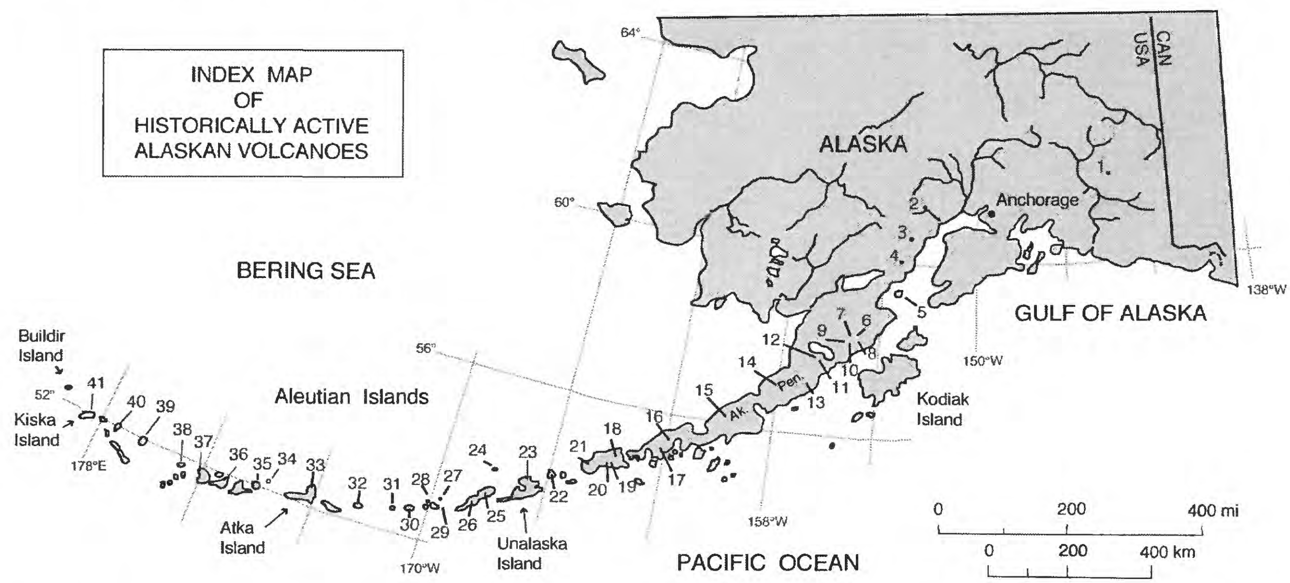
CATALOG OF THE HISTORICALLY ACTIVE VOLCANOES OF ALASKA

Introduction

Alaska hosts within its borders over 80 major volcanic centers that have erupted during Holocene time (<10,000 years). At least 29 of these volcanic centers (table 1) had historical eruptions and 12 additional volcanic centers may have had historical eruptions. Historical in Alaska generally means the period since 1760 when explorers, travelers, and inhabitants kept written records. These 41 volcanic centers have been the source for >265 eruptions reported from Alaska volcanoes.

With the exception of Wrangell volcano, all the centers are in, or near, the Aleutian volcanic arc, which extends 2500 km from Hayes volcano 145 km west of Anchorage in the Alaska-Aleutian Range to Buldir Island in the western Aleutian Islands (fig. 1). The volcanic arc, a subduction-related feature associated with underthrusting of the Pacific plate beneath the North American plate is divided between oceanic island arc and continental margin segments, the boundary occurring at about 165° W longitude (fig. 1). An additional 7 volcanic centers in the Aleutian arc (table 2; fig. 1A) have active fumarole fields but no reported historical eruptions.



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

Figure 1. Index map of historically active Alaskan volcanoes.

This report discusses the location, physiography and structure, eruptive history, and geology of those volcanoes in Alaska that have experienced one or more eruptions that have been recorded in the written history (i.e., in historical time). It is part of the group of catalogs entitled Catalogue of Active Volcanoes of the World published beginning in 1951 under the auspices of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI). A knowledge of the information contained in such catalogs aids in understanding the type and scale of activity that might be expected during a particular eruption, the hazards the eruption may pose, and even the prediction of eruptions. The catalog will thus be of value not only to the inhabitants of Alaska but to government agencies concerned with emergency response, air traffic operations, and weather, as well as to industry and scientists. The combination of the hazard posed by volcanic ash to jet aircraft and the heavy use of international air routes located parallel to, and on either side of, the Aleutian volcanic arc means that even remote volcanoes in Alaska now pose significant hazards to life and property.

Although this report is concerned with historical eruptions from Alaskan volcanoes, other volcanoes in

Alaska have erupted in the past 10,000 years and might therefore be expected to erupt again. Several Holocene volcanic centers in the Aleutian arc have no reported historical activity. Elsewhere in Alaska the Bering Sea basalt fields cover large areas of the Yukon Delta, Seward Peninsula, and several of the islands of the Bering Sea. Holocene centers also occur in the Wrangell Mountains and in isolated occurrences in the interior and southeastern Alaska. Eruptions from these centers have occurred within the past several hundred years but none were transcribed in the written record. Moodie and others (1992), however, report oral traditions among the Northern Athapaskan Indians of the southwestern Yukon Territory that may record the second and younger deposition of the White River Ash circa A.D. 720. This lobe of the White River Ash was deposited during the paroxysmal eruption of Churchill volcano in the Wrangell Mountains of east-central Alaska (McGimsey and others, 1992; Richter and others, 1995).

Acknowledgments: Tom Simkin reviewed this report and has been a tireless supporter of the project. Jean Sobolik (UAFGI) did an extraordinary job in the electronic preparation of the report and Ann Vanderpool ably provided electronic drafting of illustrations. Bob Decker provided strong encouragement at the beginning and end of the project.

Previous work

The first catalog of volcanic eruptions in Alaska was published in the 1840's by the Russian missionary I. Veniaminov. This was soon followed by a comprehensive chronology presented by C. Grewingk in 1848. The first modern listing of active volcanoes in Alaska was published by Robert R. Coats in 1950 who considered 36 volcanoes in the Aleutian arc to have been active since 1760. His careful researching of early documents, many of which are in Russian or are otherwise difficult to obtain, has provided most of the information for eruptions reported before 1949. Simkin and others (1981) produced their classic Volcanoes of the World, a world-wide directory, gazetteer, and chronology of volcanism during the past 10,000 years that listed historical Alaskan eruptions through 1980. This work was extended through 1985 by the Global Volcanism 1975-1985 report by McClelland and others (1989) who summarized the first decade of reports from the Smithsonian Institution's Scientific Event Alert Network (SEAN). Information from these two sources was combined in a second edition of Volcanoes of the World published in 1994. For ease in identification of volcanoes, the Catalog of Active Volcanoes of the World (CAVW) number for each volcano is listed in this report. Volcanoes of North America, a compilation edited by Wood and Kienle (1990), briefly discusses all volcanoes in North America younger than 5 million years.

Methodology

Information on historical volcanic eruptions was taken from the aforementioned previous compendiums plus material from the Smithsonian Institution's Scientific Event Alert Network and Bulletin of Volcanic Eruptions, other published accounts, and the files of the Alaska Volcano Observatory. Information on the geology, composition, form, and structure of the described volcanic centers was taken from the most current literature or from ongoing studies by the authors.

For the purposes of this catalog, an active volcano is defined as one which has experienced a volcanic eruption, other than low level ejection of solely steam and gas, in historical time. A volcanic eruption is defined (Bates and Jackson, 1987, p. 222) as the "ejection of volcanic materials (lava, pyroclasts, and volcanic gases) onto the Earth's surface...". Although this definition seems clear enough, confusion can arise with the volcanic gases part of the definition. At least 40 Alaskan volcanoes are venting steam and other gases continuously from fumarolic fields and often these steam and vapor plumes, which are often quite vigorous, are reported as eruptions. To consider such activity an eruption removes the value of a catalog such as this. Therefore, while large chiefly phreatic events such as recorded from Great Sitkin in 1974 are included herein, the continuous venting at other volcanoes, such as that seen at Mageik volcano in Katmai National Park, is not taken as *a priori* evidence of a historical eruption. Mt. Dutton and Iliamna volcanoes have been included because of recent strong seismic swarms.

The historical record extending from 1760 into this century is spotty. Most of Alaska, and the Aleutian Islands in particular, is remote and sparsely populated; only about one quarter of the historically active volcanoes are within view of permanent inhabitants and these views are frequently obscured by clouds. Early reports of volcanic activity largely resulted from the chance passing of explorers and traders and many eruptions undoubtedly went unnoticed, even during the past century. Uncertainty as to what volcano is actually erupting also arises when eruptions were, or are, witnessed from a great distance.

Moreover, eyewitness accounts must be closely scrutinized to determine whether observers truly witnessed an eruption. Eruptive activity has been erroneously reported because of a variety of physical phenomena such as condensation induced by atmospheric conditions, rock exposed by snowmelt, and dust raised by strong winds and landslides. For example, ash is often reported falling on the southwest end of Kodiak Island and in Shelikof Strait, particularly in the fall of the year. Aerial inspections have failed to locate any evidence of an eruption on the mainland; instead, the "eruptions" appear to result from strong north winds blowing pumice off the unvegetated pyroclastic flow sheets in the Valley of 10,000 Smokes in Katmai National Park. The reporting of steam and condensate plumes from fumarolic vents as "smoke" (i.e., an eruption) is a vexing problem even today since, under the proper meteorological conditions, such plumes can expand to heights of a few thousand feet in minutes resulting in erroneous eruption reports. Iliamna volcano in Cook Inlet is especially subject to such phenomena and several reports of eruptions from the volcano are received at the Alaska Volcano Observatory each year.

We have therefore chosen to view old reports restricted to "smoke" or "active" with a somewhat jaundiced eye. If this is the only report of activity from a volcano (as for Amak Island in the Bering Sea) or other collaborating information is lacking, we have generally deleted the eruption (and in some cases the volcano) from our listing. An additional problem arises as to when one eruption ends and another begins since it is not unusual for individual eruptions to have a quiescent hiatus of weeks to months. Generally, if the period of repose can be determined to be more than 3-4 months, we have considered the eruptions to be separate.

Rock names used in this report follow the recommended IUGS chemical classification of volcanic rocks (LeBas and others, 1986) which is based on silica (SiO_2) and total alkali (Na_2O+K_2O) content. The use of rock names from original sources that had no supporting chemical data are followed by a citation of the source. No chemical analyses of volcanic rocks are included in the description of the individual volcanoes. However, plots of Na_2O+K_2O vs. SiO_2 and FeO*/MgO vs. SiO_2 for over 600 analyses of Aleutian arc volcanic rocks (most of these analyses are from a data base compiled by C.J. Nye, Alaska Division of Geological and Geophysical Surveys) have been calculated for the arc as a whole and for the oceanic and continental segments separately and are presented in figs. 2A, 2B, 2C, 3A, 3B, and 3C.

The FeO*/MgO plots distinguish between tholeiitic and calc-alkaline magma series rocks (Miyashiro, 1974). The eastern continental part of the arc (all volcanoes east of and including Westdahl volcano, fig. 1) shows a predominance of calc-alkaline over tholeiitic compositions, a reflection of the almost complete dominance of calc-alkaline rocks in the eastern third of the arc (Miller and Richter, 1994). The western oceanic part shows a more equal distribution of the two suites.

In addition, for each volcano where major-element chemistry is available, analyses are plotted on Na_2O+K_2O vs. SiO_2 and FeO*/MgO vs. SiO_2 diagrams and compared with analyses from the total data base for that segment of the arc (continental or oceanic) in which the volcano occurs.

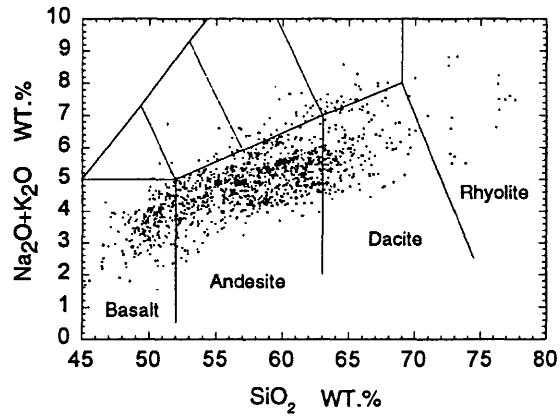


Figure 2A. Figure 2A. Total alkalies-silica (TAS) diagram of Aleutian arc volcanic rocks. Discriminant lines and field names shown are those recommended by the IUGS (Le Bas and others, 1986) and apply to all subsequent TAS diagrams in this catalog.

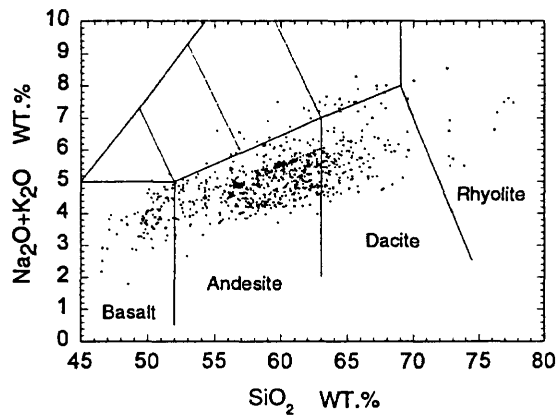


Figure 2B. Total alkalies-silica (TAS) diagram of volcanic rocks from continental margin part of Aleutian volcanic arc.

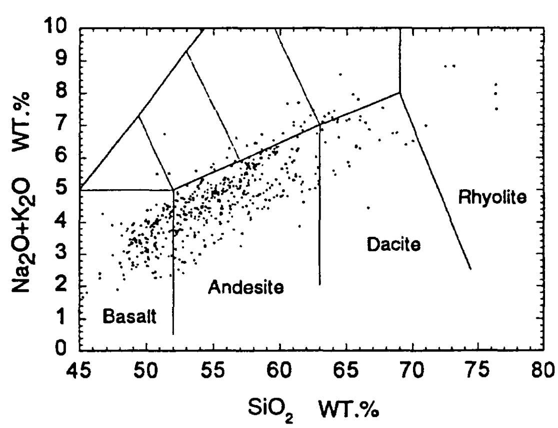


Figure 2C. Total alkalies-silica (TAS) diagram of volcanic rocks from oceanic island-arc part of Aleutian volcanic arc.

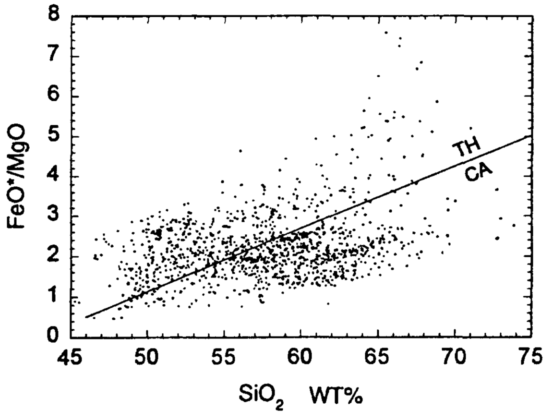


Figure 3A. FeO/MgO-silica diagram of volcanic rocks from entire Aleutian arc.*

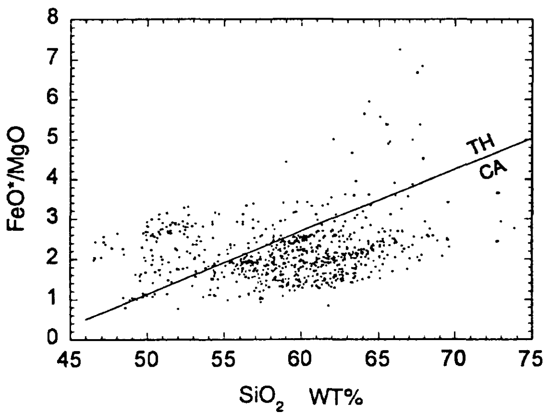


Figure 3B. FeO/MgO-silica diagram of volcanic rocks from continental margin part of Aleutian arc.*

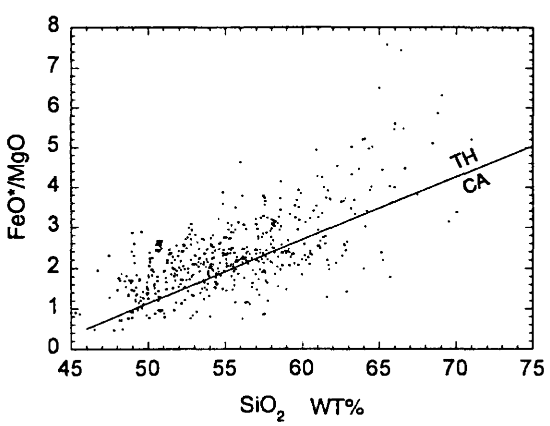


Figure 3C. FeO/MgO-silica diagram of volcanic rocks from oceanic island arc part of Aleutian arc.*

SiO_2 frequency distribution plots (figs. 4A, 4B, 4C) are also calculated for the volcanic arc as a whole and for the two segments. The eastern, or continental margin, part of the arc shows a crudely bell-shaped distribution curve centered around a composition of 60 to 61% SiO_2. The western, or oceanic, island arc shows a broader, more mafic distribution centered approximately around 54 to 55% SiO_2.

Geographic names and synonyms are taken from Coats (1950), Orth (1967), and U.S. Geological Survey quadrangle maps. In the Aleutian Islands, a distinction is made between the name of the volcano and the name of the island only if more than one volcano on the island has been active.

Summary of historical volcanic activity

Forty-one volcanic centers are listed in this catalog. Of these, 29 undoubtedly had historical eruptions and 10 may have had eruptions. Mount Dutton, experienced severe volcano-seismic crises in 1984 and 1988 that resulted from the near-surface movement of magma yet did not yield an eruption. Iliamna volcano experienced similar unrest in 1996. All the volcanoes except Mount Wrangell, a possibly active volcano, are in the Aleutian volcanic arc.

Most reports of eruptive activity date from 1760 on although a few vague reports of eruptions exist between 1700 and 1760 (Grewingk, 1850). At least 265 historical eruptions have occurred at 29 Alaskan volcanoes and another 45 are possible since 1760 giving a frequency rate of 1.1-1.3 eruptions per year. Since many eruptions early in this period surely went unreported, this is a minimum figure.

The problem of estimating eruption frequency through an analysis of the historical record is well-illustrated in Fig. 5A where the number of eruptions per decade in the Aleutian Arc is plotted for the past 200 years. Reported eruptions show a general increase beginning in the 1870-1880 decade and continuing to the 1920-1930 decade where the rate of increase levels off. This increase is assumed to represent expanded travel to this remote area and advances in rapid communication (i.e., newspapers and more recently radio) of eruptive events; interestingly enough, the decades including World Wars I and II show significant decreases. The sharp increase in the 1980-1990 decade has been followed by a return (estimated in part—see caption of Fig. 5) to pre-1980 levels.

A more meaningful eruption frequency estimate can perhaps be calculated over the 50 year period 1945 (the end of World War II) through 1994, a time that marked the

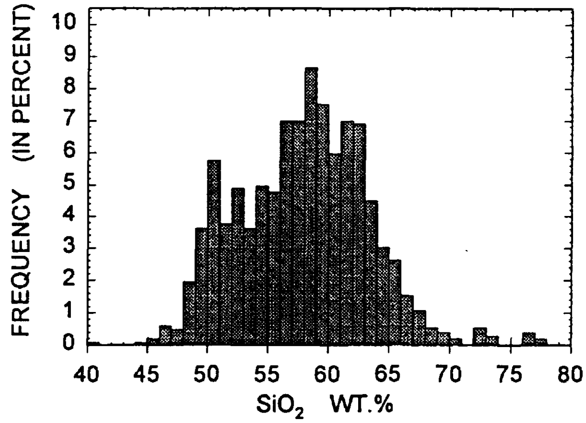


Figure 4A Silica distribution diagram for entire Aleutian arc.

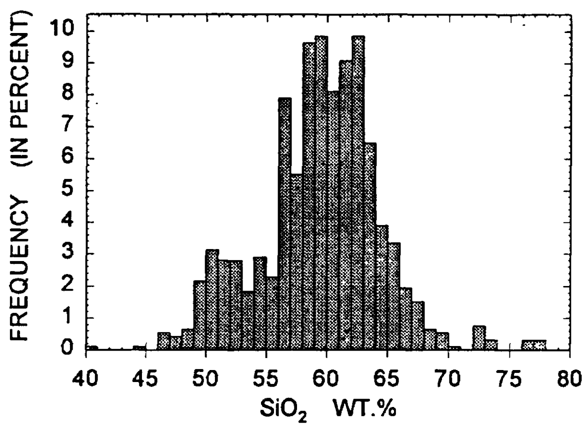


Figure 4B. Silica distribution diagram for continental margin part of Aleutian arc.

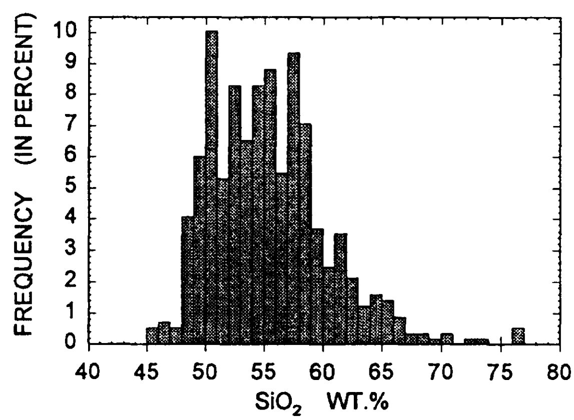


Figure 4C. Silica distribution diagram for oceanic island-arc part of Aleutian arc.

beginning of widespread air travel and other commerce in this remote part of the world. During this 50 year interval, 90 eruptions have been reported from 23 volcanoes for a frequency of about 2 (1.8) eruptions per year.

Although these are estimates of the number of separate eruptions per year, many individual eruptive episodes are spread over weeks and even months. In any one year, therefore, it is not unusual for 3 or 4 Alaskan volcanoes to have experienced eruptive activity.

The number of separate eruptions from individual historically active centers ranges from 1 to 39 and over 60% of the 265 eruptions have come from only 7 volcanoes (Veniaminof, Pavlof, Shishaldin, Akutan, Makushin, Okmok, and Bogoslof Island). These frequently active volcanoes occur along (or, in the case of Bogoslof, behind) a 640 km of the arc in an area where movement between the North American and Pacific plates is most nearly orthogonal. Most of these volcanoes are also marked by long-lived but sporadic strombolian and vulcanian eruptive activity resulting in some difficulty in defining individual eruptions.

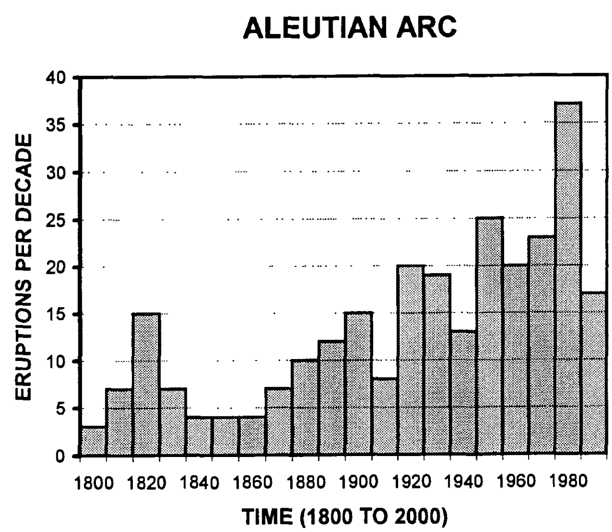


Figure 5. A plot of the number of eruptions reported per decade for the period 1800-2000 for the Aleutian Arc; the 1990-2000 number is estimated by doubling the number of eruptions from 1990-1995.

Historically Active Volcanoes

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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 km³ (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).

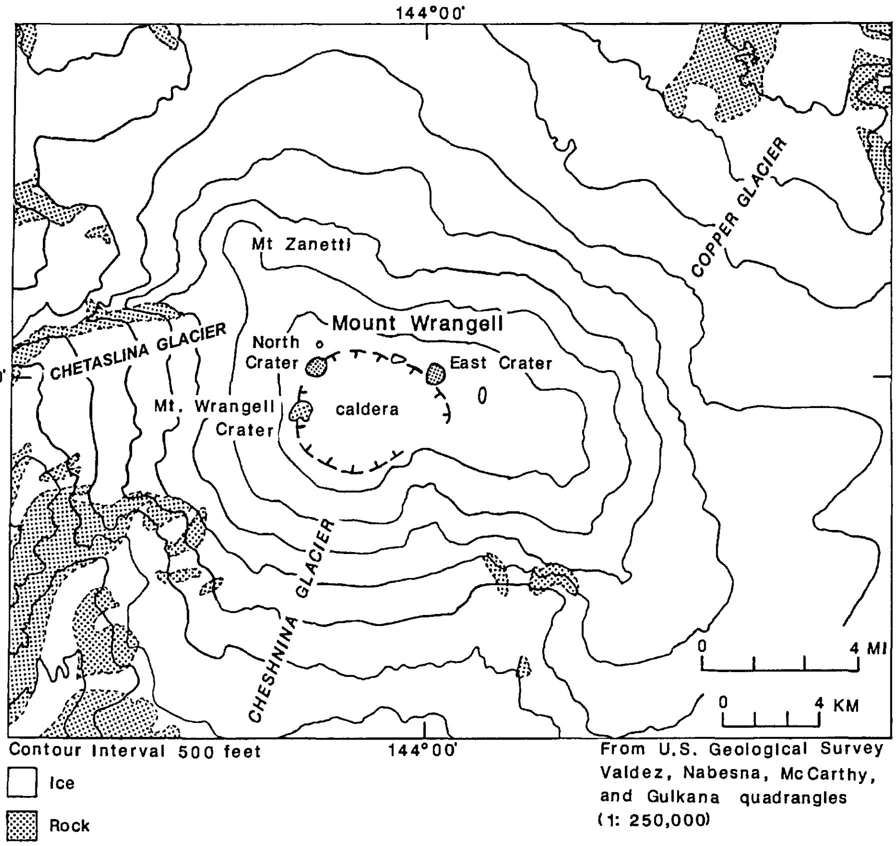


Figure 6. Topographic map of Mount Wrangell showing location of caldera and post-caldera fumarolic vents.

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).

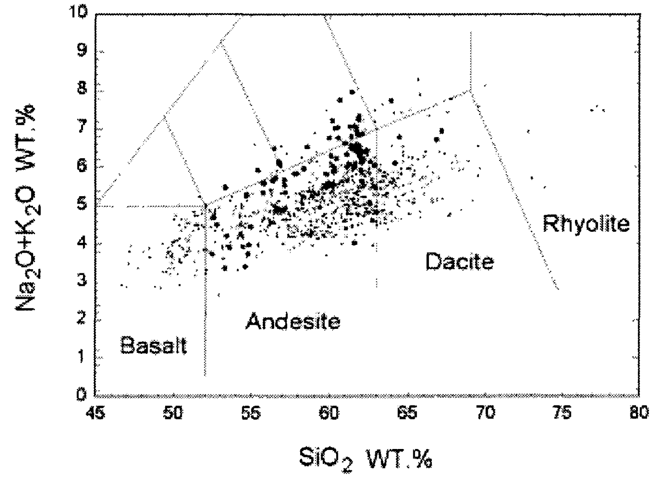


Figure 6A. Total alkalies-silica diagram of Wrangell volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

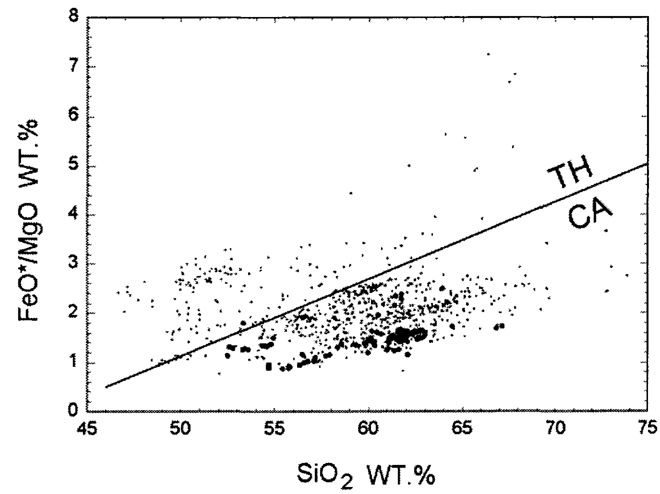


Figure 6B. FeO/MgO-silica diagram of Wrangell volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

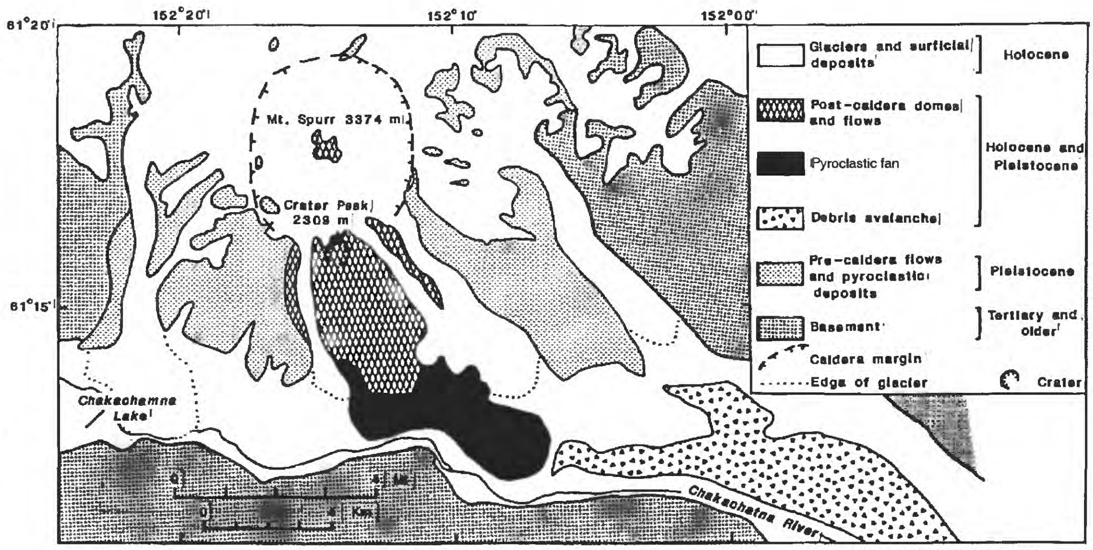
Name and Location

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.



Modified after Nye, 1987, 1990

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

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.

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°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).

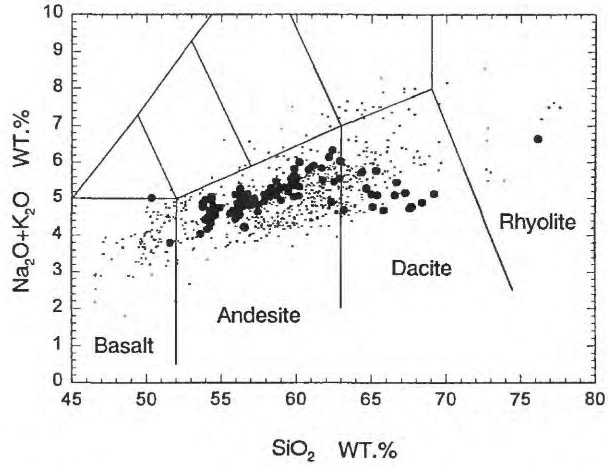


Figure 8. Total alkalies-silica diagram of Spurr volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

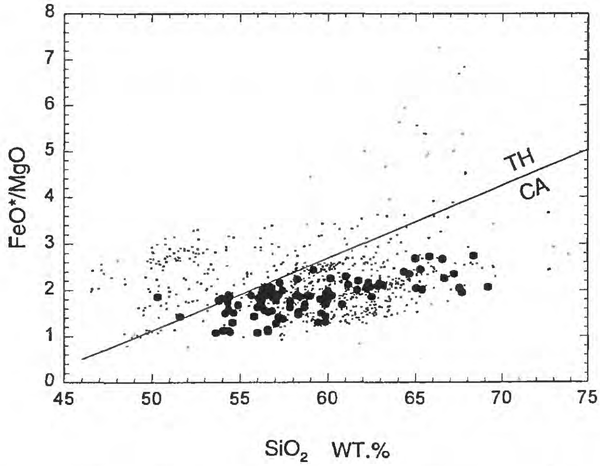


Figure 9. FeO/MgO-silica diagram of Spurr volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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.

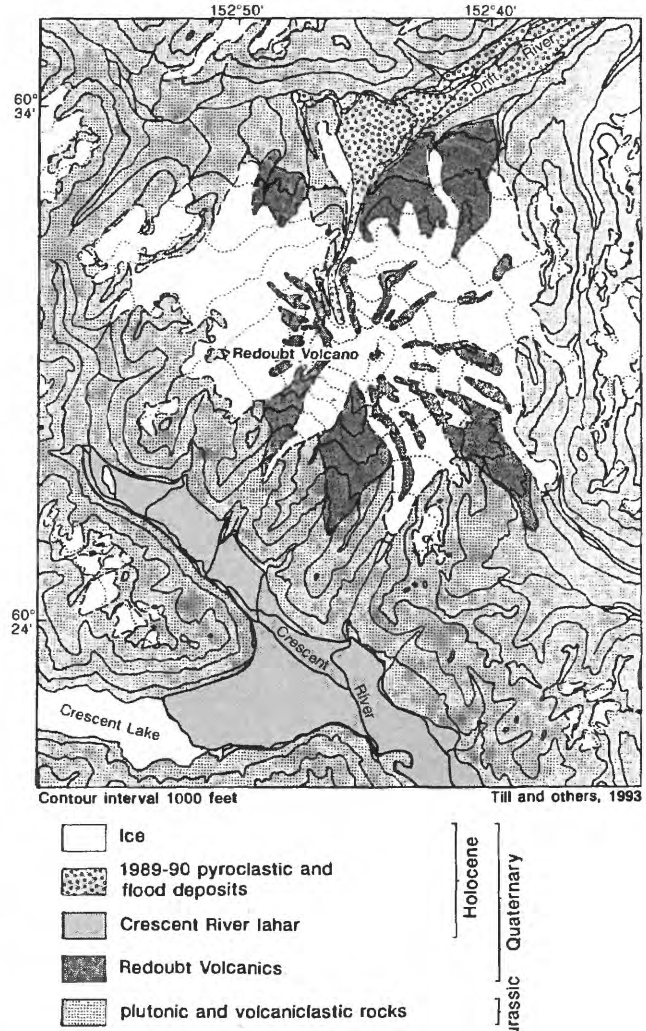


Figure 10. Generalized geologic map of Redoubt volcano; modified from Till and others, 1993.

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.

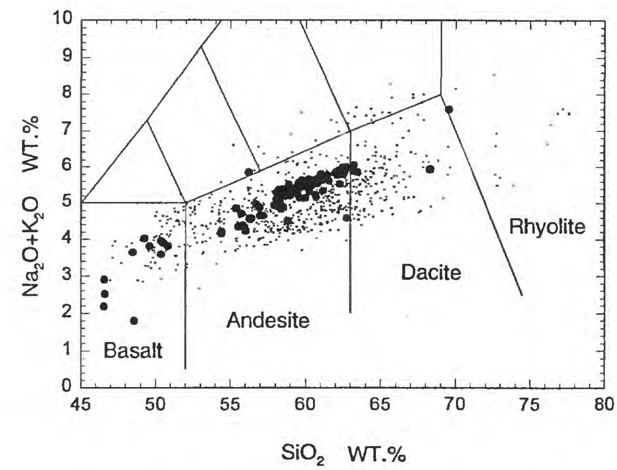


Figure 11. Total alkalies-silica diagram of Redoubt volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2. Samples with 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

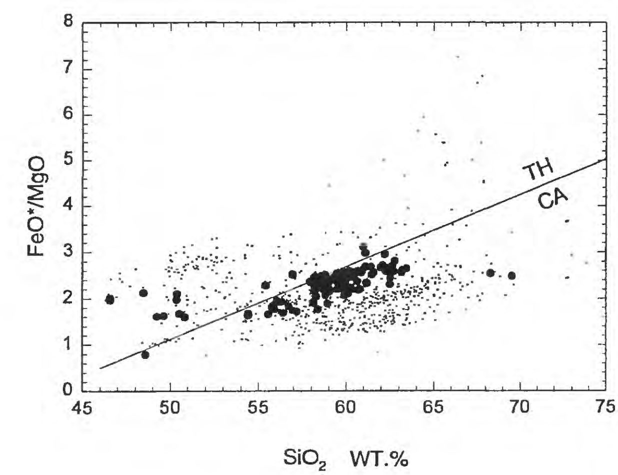


Figure 12. FeO/MgO-silica diagram of Redoubt volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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).

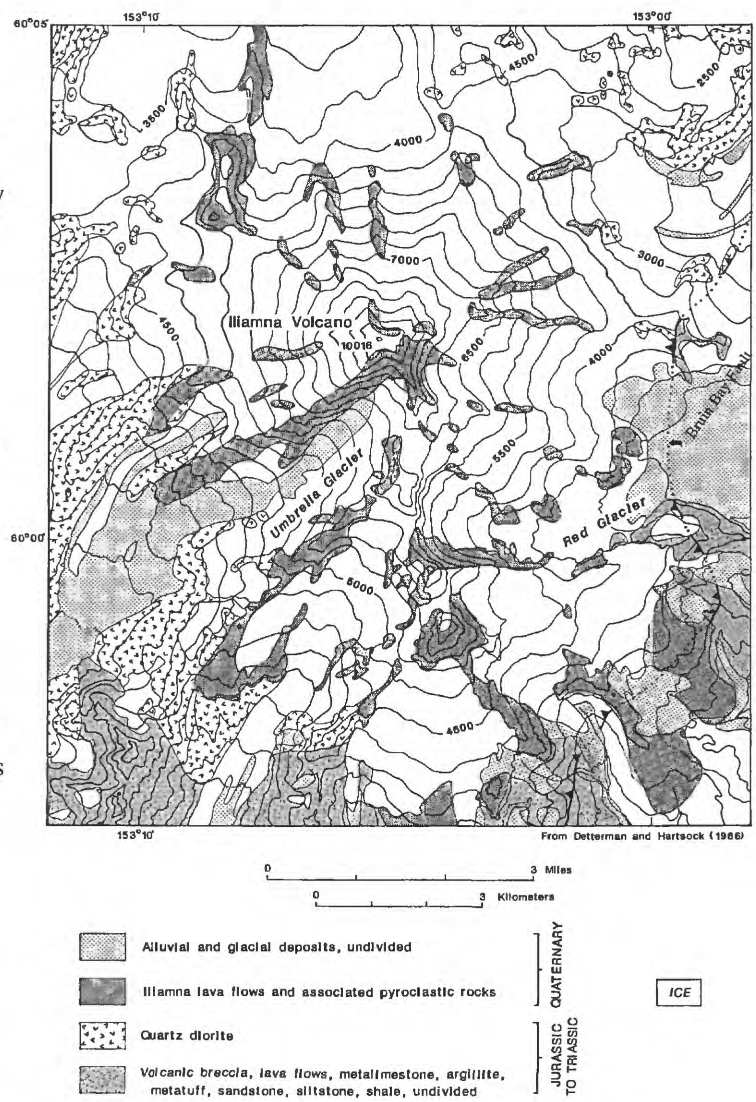


Figure 13. Generalized geologic map of Iliamna volcano; modified from Detterman and Hartsock (1966).

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, 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.

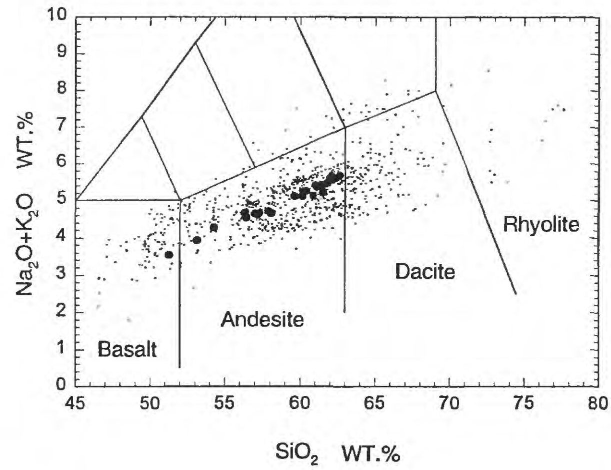


Figure 14. Total alkalies-silica diagram of Iliamna volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

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.

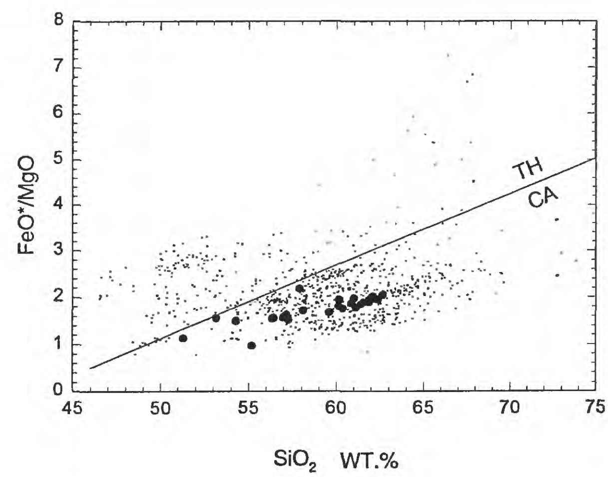


Figure 15. FeO/MgO-silica diagram of Iliamna volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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

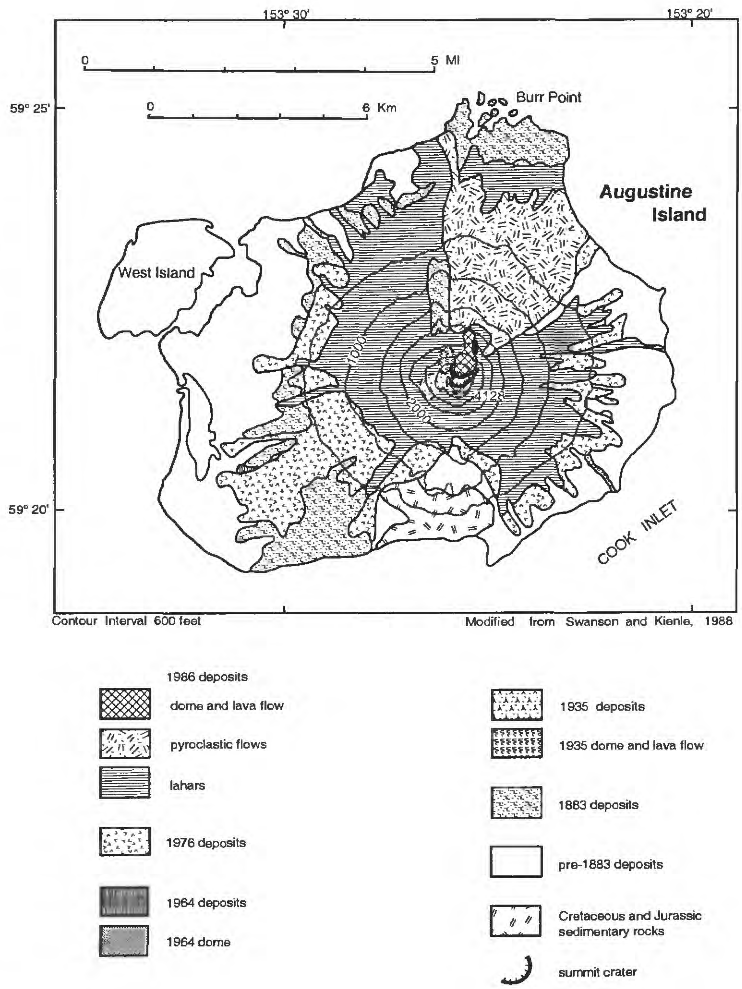


Figure 16. Generalized geologic map of Augustine volcano; modified from Swanson and Kienle (1988).

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.

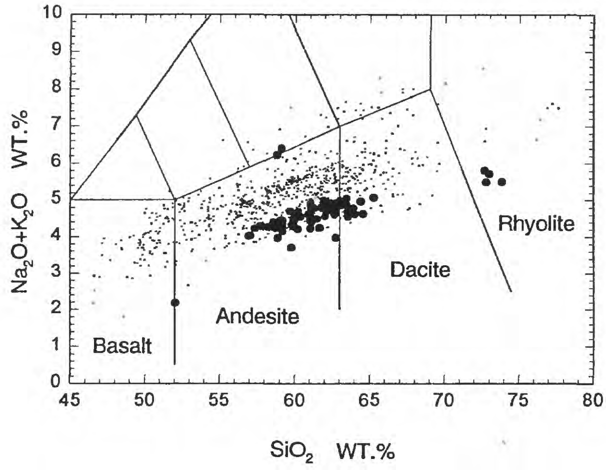


Figure 17. Total alkalies-silica diagram of Augustine volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2. The rhyolites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

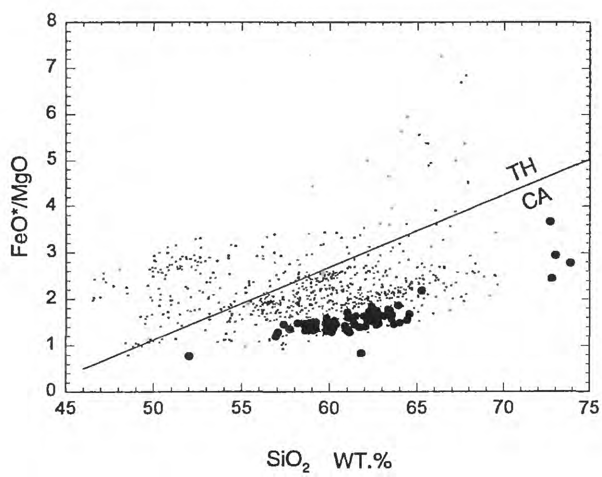


Figure 18. FeO/MgO-silica diagram of Augustine volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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.

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, 1983). 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.

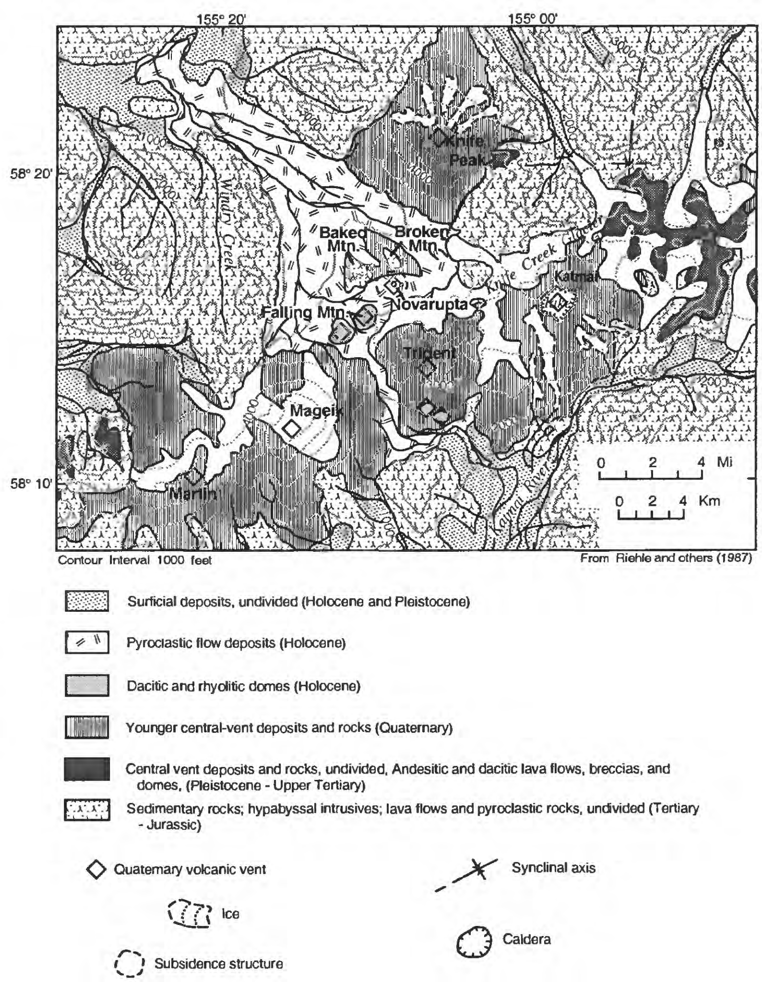


Figure 19. Generalized geologic map of Katmai, Mageik, Martin Mountain, Trident, Knife Peak (Griggs) and Novarupta volcanoes after Riehle and Detterman (1993).

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.

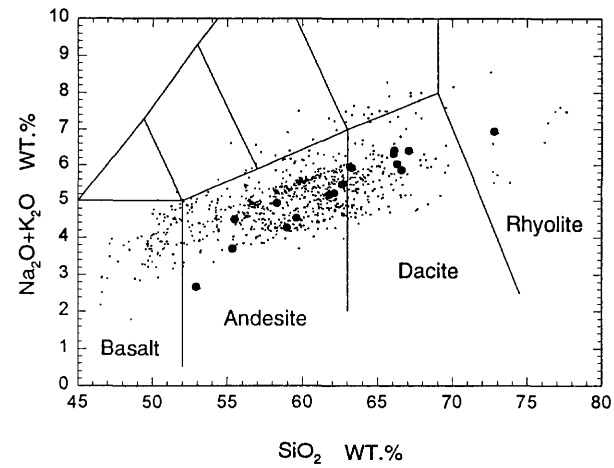


Figure 20. Total alkalies-silica diagram of Katmai volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

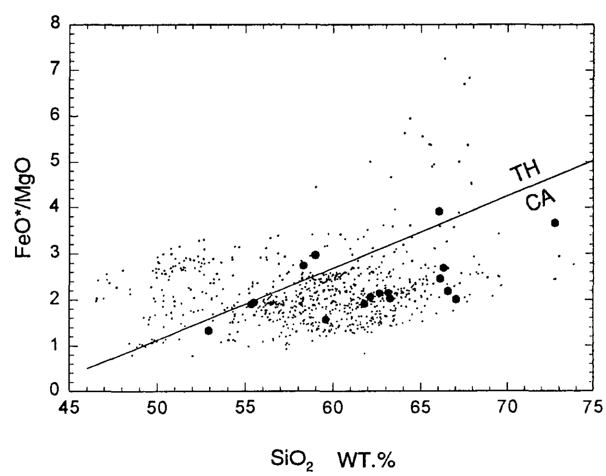


Figure 21. FeO/MgO-silica diagram of Katmai volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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).

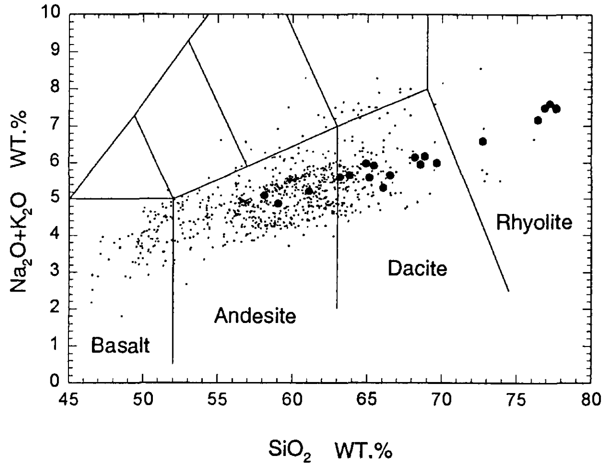


Figure 22. Total alkalies-silica diagram of Novarupta volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

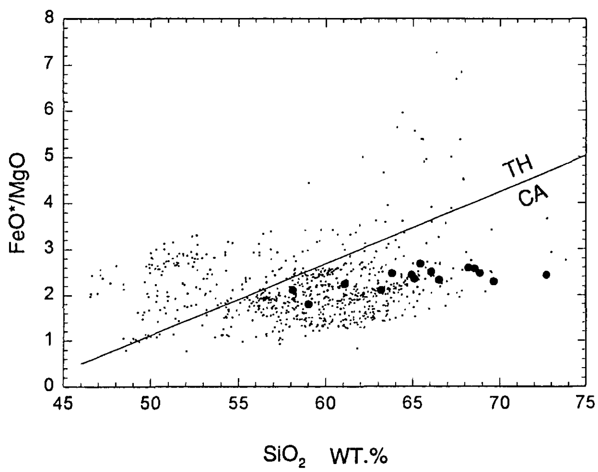


Figure 23. FeO/MgO-silica diagram of Novarupta volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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 1953 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).

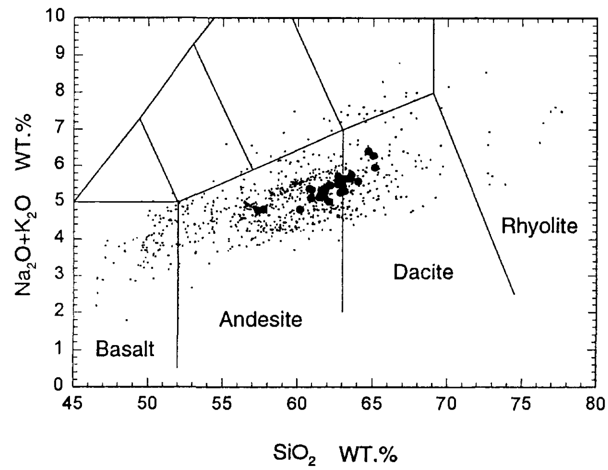


Figure 24. Total alkalies-silica diagram of Trident volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

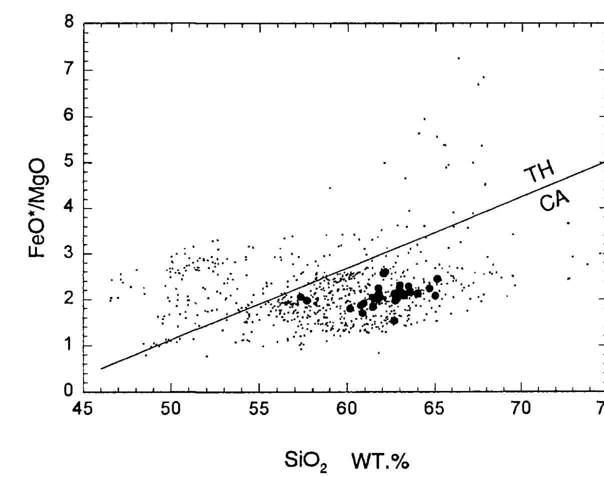


Figure 25. FeO/MgO-silica diagram of Trident volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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 1929 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).

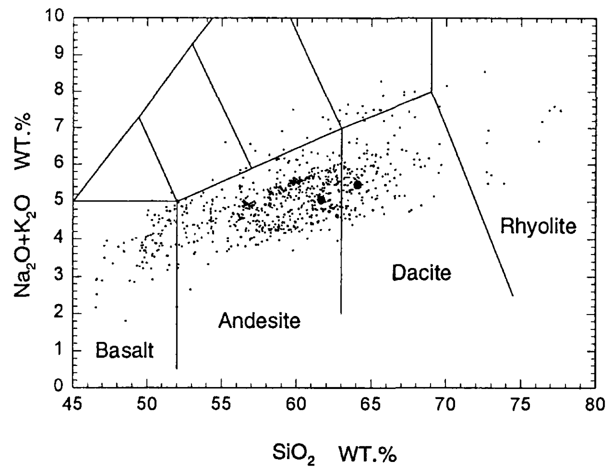


Figure 26. Total alkalies-silica diagram of Mt. Martin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

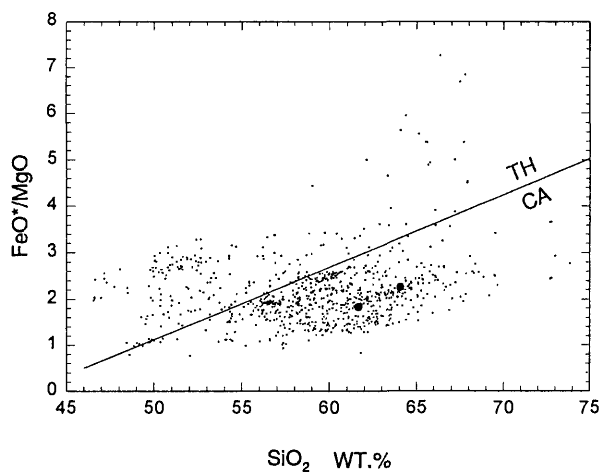


Figure 27. FeO/MgO-silica diagram of Mt. Martin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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.

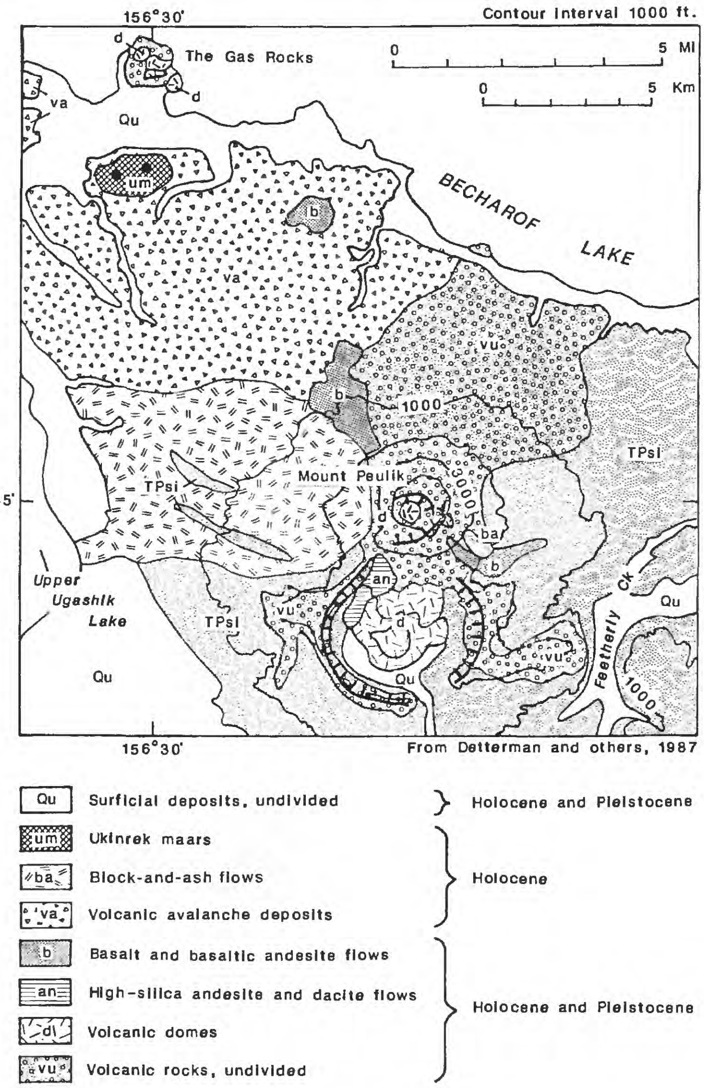


Figure 28. Generalized geologic map of the Ugashik-Mount Peulik volcanic center after Detterman and others (1987).

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.

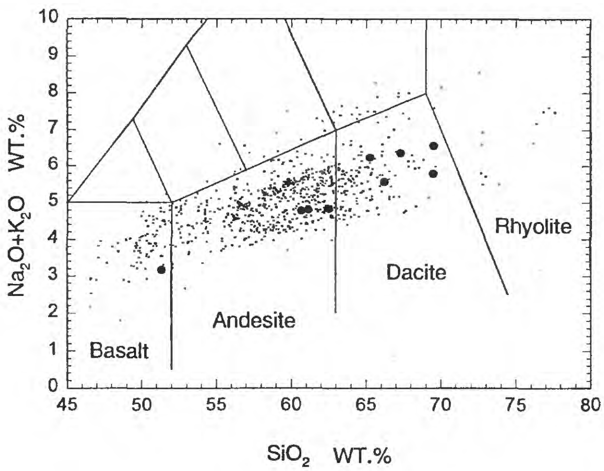


Figure 29. Total alkalies-silica diagram of Peulik volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

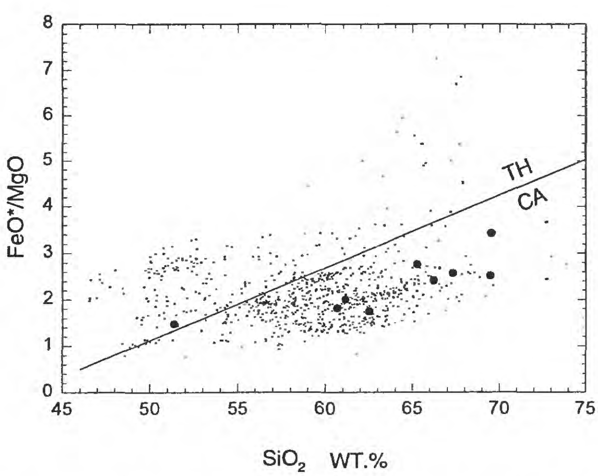


Figure 30. FeO/MgO-silica diagram of Peulik volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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).

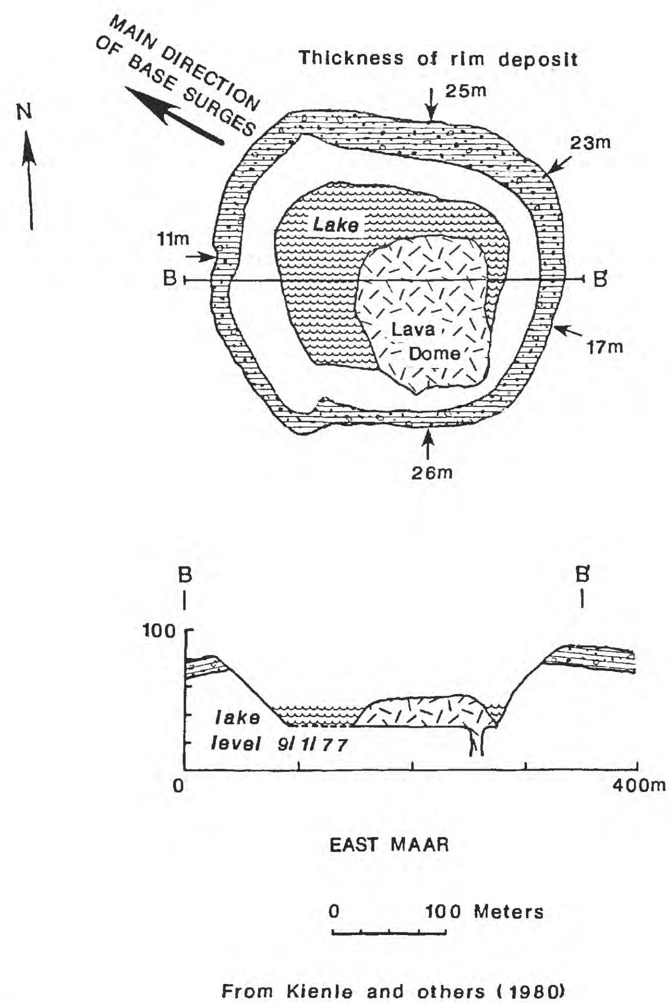


Figure 31. Generalized map and cross-section of the eastern of the Ukinrek Maars from Kienle and others (1980).

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).

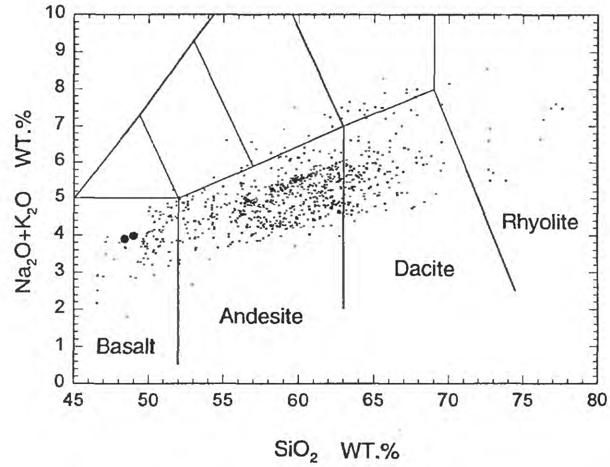


Figure 32. Total alkalies-silica diagram of Ukinrek Maars volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

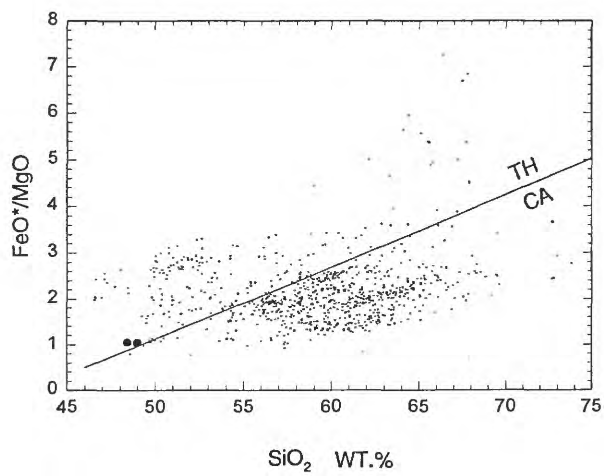


Figure 33. FeO/MgO-silica diagram of Ukinrek Maars volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).s.

Name and Location

Name:	Chiginagak volcano
Synonyms:	Mount Chiginagak
Type:	Stratovolcano
Location:	600 km southwest of Anchorage, on the Alaska Peninsula
Latitude, longitude:	57°08'N, 157°00'W
Elevation:	2135 m
USGS 1:250,000 quadrangle:	Ugashik
CAVW Number:	1102-11

Form and structure

Chiginagak volcano is a symmetric composite cone about 8 km in diameter built on late Tertiary volcanic rocks and Jurassic-Cretaceous sedimentary rocks and located on a southwest trending regional anticline (Detterman and others, 1983). A deep breach on the south flank of the volcano extends to a small summit crater and exposes widespread alteration of interbedded lava flows and breccias near the summit of the volcano. Snow and ice cover much of the uppermost 1000 m of the cone.

Monolithologic breccias (vb) low on the west side of the volcano represent at least two early periods of dome growth and collapse, separated by a period of lava extrusion. The undissected form of the cone is the result of the eruption of andesitic lava flows and pyroclastic rocks (vu) following the emplacement of the youngest breccias. Somewhat younger andesite and dacite flows occur on the west flank and basalt flows (some as young as Holocene) occur on the eastern flank of the volcano. Satellitic dacite (?) domes of Holocene age occur high on the east and west flanks, the most recently active of which is the eastern dome which was the source of thin pyroclastic or epiclastic deposits (ba, fig. 34) that overlie nonglaciated basaltic lava flows.

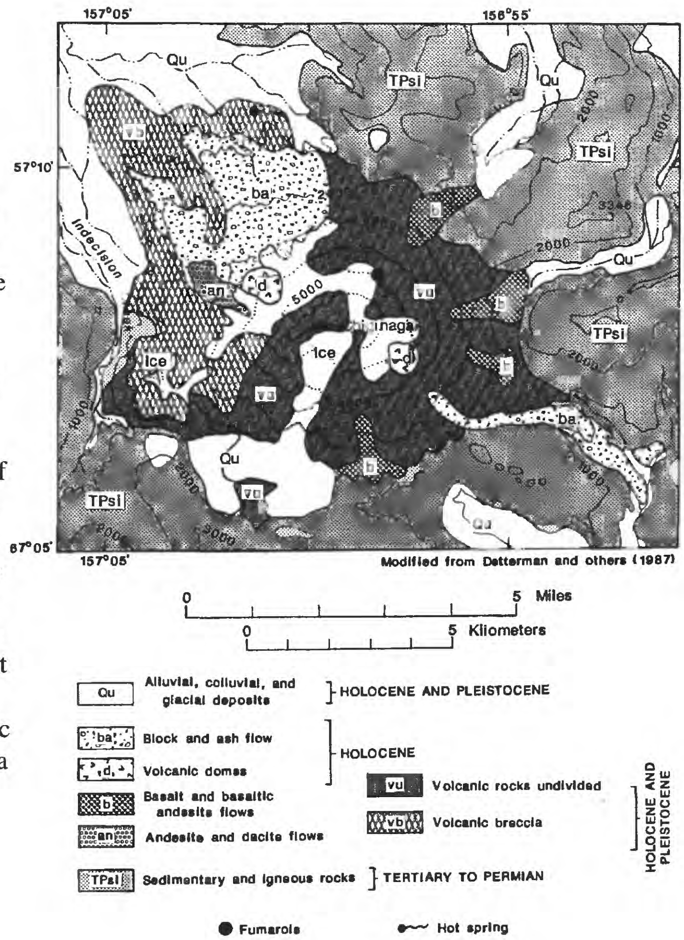


Figure 34. Generalized geologic map of Mt. Chiginagak volcano after Detterman and others (1987).

Volcanic activity

1852 ?
1929 ?
1971 ?

Documentation of any historical eruptions of Chiginagak volcano is sparse. The lack of any undisturbed ash or pumice deposits at or near the ground surface makes the reports of historic activity by this volcano somewhat suspect. Coats (1950) cites reports of smoke from Chiginagak in 1852 and unspecified activity in 1929; the 1929 activity is based on a brief newspaper account of "unusual activity" at Chiginagak and 6 other volcanoes observed by the crew of a ship which probably passed no closer than 25 km to Chiginagak. Mr. Odon Soeth reported observing an ash eruption in July, 1971 from Port Heiden, 100 km southwest of Chiginagak; according to Mr. Soeth, the eruption lasted only 1 evening. Steam and sulfur gases are constantly emitted from a vent high on the north flank of the volcano at about 1,520 m above sea level. Hot springs occur near the base of the volcano on the northwest flank (fig. 34). In late 1997 and 1998, this area of fumarolic activity became enlarged in a vertical direction.

Composition

The oldest recognized deposits of Chiginagak volcano are monolithologic, lithic pyroclastic deposits of dacitic composition. These are overlain by andesitic lava flows, which are overlain by a younger, lithic pyroclastic deposit composed of acid andesite. Two samples of post-glacial lava flows are basaltic.

Chiginagak lava flows generally display a porphyritic texture and contain phenocrysts of plagioclase (30-40%), clinopyroxene and orthopyroxene (15-20%) in approximately equal amounts, and rare, heavily oxidized subhedral hornblende. Silica contents of analyzed, hornblende-bearing samples range from 59% to 64%, waterfree (figs. 35, 36).

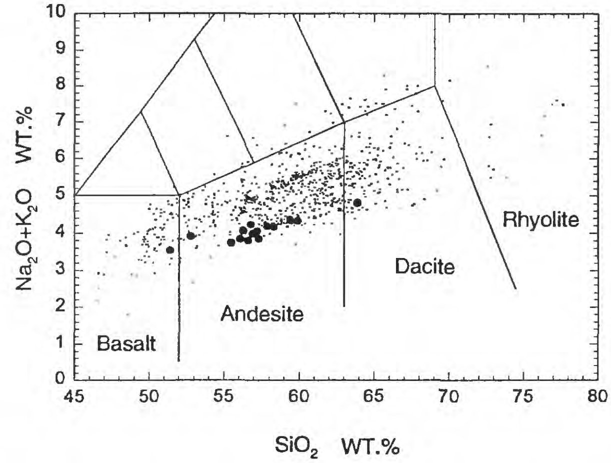


Figure 35. Total alkalies-silica diagram of Chiginagak volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

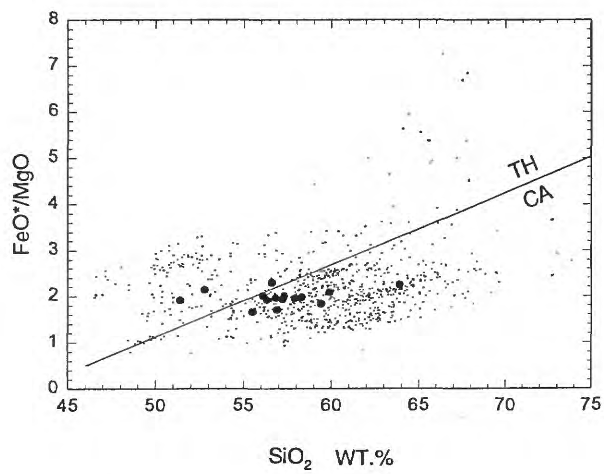


Figure 36. FeO/MgO-silica diagram of Chiginagak volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Aniakchak Caldera
Synonyms:	Aniakchak Crater
Type:	Stratovolcano with summit caldera, intracaldera domes, cones, and vents
Location:	670 km southwest of Anchorage on the Alaska Peninsula
Latitude, longitude:	56°53'N, 158°10 W
Elevation:	Highest point on caldera rim is 1,341 m; Vent Mountain, highest intracaldera cone, is 1,021 m
USGS 1:250,000 quadrangle:	Chignik
CAVW Number:	1102-09

Form and structure

Aniakchak Crater is an ice-free, circular caldera about 10 km in diameter and a maximum of 1 km deep (fig. 37) which was first described by Smith (1925). The pre-caldera cone was built upon a basement of Tertiary sedimentary and volcanic rocks and Jurassic-Cretaceous sedimentary rocks, which are exposed high on the east and south walls of the caldera (Detterman and others, 1981). The elevation of the caldera rim varies from 1,341 m to 610 m. Surprise Lake, a 3.2-km-long lake in the northeast part of the caldera at an elevation of about 335 m is the source of the Aniakchak River, which flows through a breach in the eastern wall of the caldera. Numerous domes, flows, and cones occupy the interior of the caldera (Neal and others, 1992); the largest cone is Vent Mountain, 2.5 km in diameter and rising 430 m above the floor of the caldera. The pre-caldera cone was built on the west side of a basement high. The cone was deeply dissected by numerous glaciers that cut U-shaped valleys into the slopes before the caldera-forming eruption.

Ash flows from the caldera-forming eruption—3430 + 10 yrs B.P. (Miller and Smith, 1987)—reached both the Bering Sea and the Pacific Ocean (Miller and Smith, 1977). They are typically non-welded and fill glacial valleys to a depth of at least 75 m adjacent to the caldera rim. The ash flows were highly mobile, over-running 260-meter-high passes in the Aleutian Range and travelling as far as 50 km from the caldera rim (Miller and Smith, 1977).

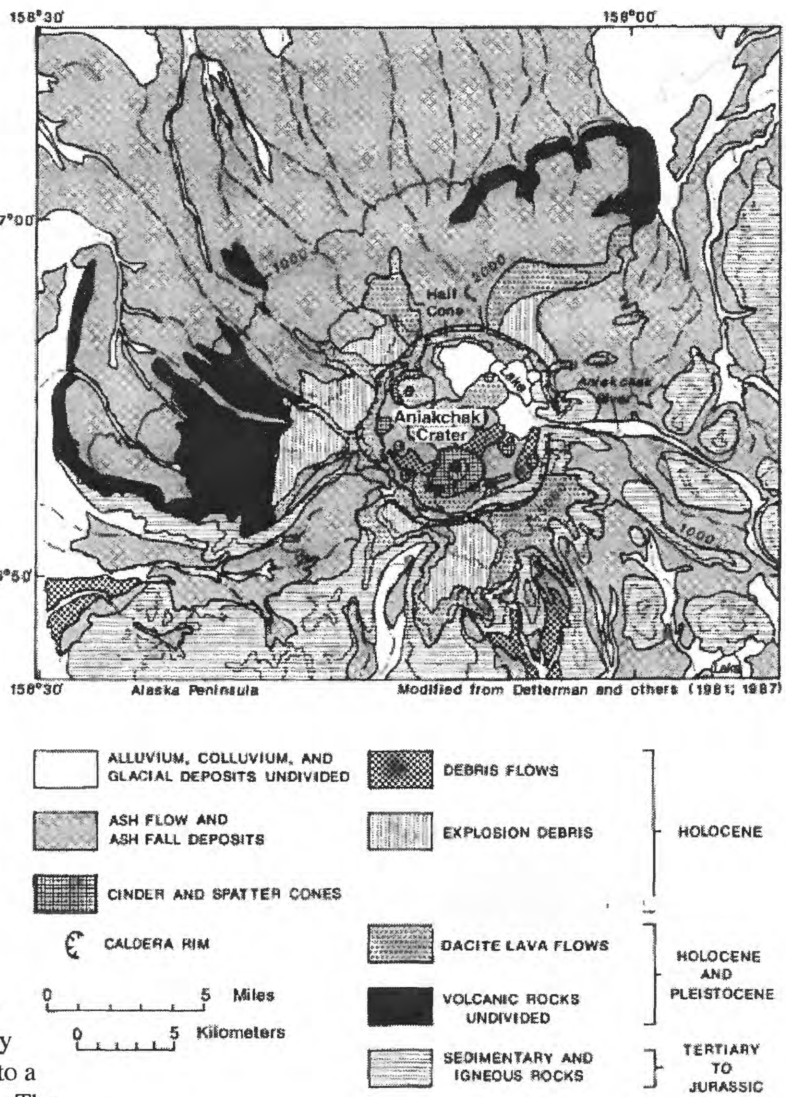


Figure 37. Generalized geologic map of Aniakchak caldera, modified from Detterman and others (1987).

Volcanic activity

1931

The only known historical activity at Aniakchak began at 10:00 a.m. on May 1, 1931 with a series of violent eruptions that lasted until May 11, 1931, another explosion occurring on May 20. No witnesses were at the volcano and the nearest observers were in the villages of Meshik (32 km away) and Chignik (70 km away). The manager of a cannery at Chignik reported that ash fell at a rate of "a pound per hour per square foot" (Jaggar, 1932). About half a centimeter of ash was deposited at Katmai National Monument and on Kodiak Island, and ash fall was reported as much as 480 km away over interior Alaska (Jaggar, 1932). The main source of the 1931 eruption is a low cinder and ash cone about a kilometer in diameter located near the base of the west caldera wall. A dome of blocky coarse-grained dacite was emplaced in the vent, probably in the waning stages of the eruption. At least two other sites along the southern wall and across the south flank of Vent Mountain were active during the 1931 eruption (Neal and others, 1992).

Although no eruptions had been reported before 1931, Hubbard (1931) reported and photographed numerous fumaroles in the Half Cone region of the caldera (fig. 37). In 1973, temperatures of 80°C were measured at a depth of 15 cm in loose volcanic rubble adjacent to the small cinder cone in the northwest part of the caldera 1.5 km northeast of the vent of the 1931 eruption. Springs near the north-west end of Surprise Lake had a temperature of 25°C in July, 1993. Although Hubbard (1931) concluded that the crater of Vent Mountain was still hot in 1930 based on the red color of the flows inside the crater, no activity was noticed by scientists who made a helicopter landing inside the crater in 1973; the red color was merely the result of oxidation of scoriaceous flows.

Composition

The pre-caldera volcano, which have been mapped and sampled only in reconnaissance, consist mainly of basaltic andesite, two-pyroxene andesite, and dacite (figs. 38, 39). Phenocrysts of plagioclase, orthopyroxene, clinopyroxene, and less commonly olivine occur in a glassy groundmass of plagioclase and pyroxene microlites and magnetite euhedra.

The ash flows of the caldera-forming eruption range in composition from andesite to dacite with the SiO_2 content as high as 67.9%. Many ash flow outcrops are compositionally zoned with darker andesitic flows overlying lighter colored dacitic ash flows.

The intracaldera volcanic rocks are predominantly glassy pyroxene dacite having SiO_2 contents ranging from 64.0 to 66.5%.

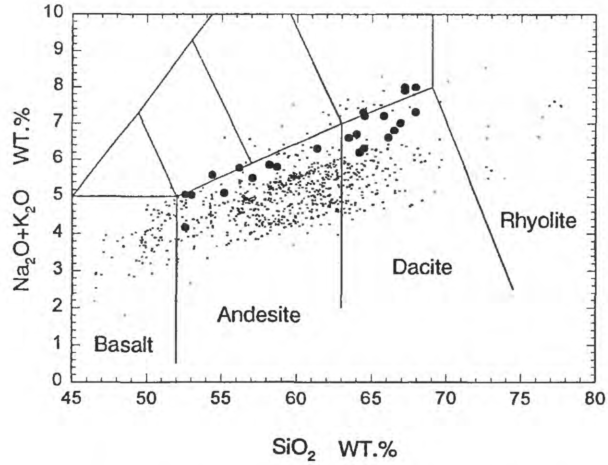


Figure 38. Total alkalies-silica diagram of Aniakchak volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

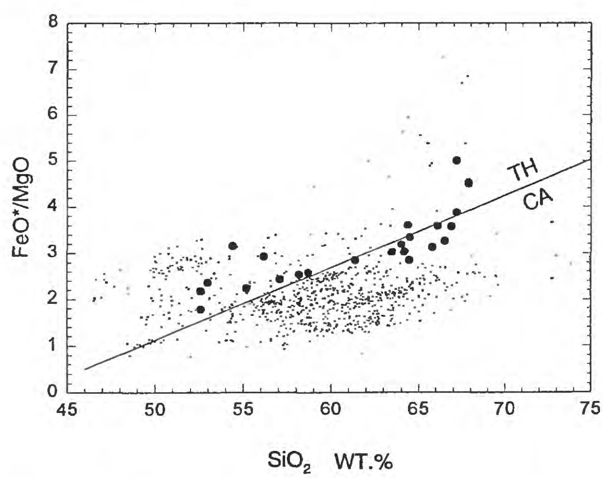


Figure 39. FeO/MgO-silica diagram of Aniakchak volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

NAME AND LOCATION

NAME:	MOUNT VENIAMINOF
SYNONYM:	VENIAMINOF CRATER
TYPE:	STRATOVOLCANO WITH A SUMMIT CALDERA
LOCATION:	ABOUT 760 KM SOUTHWEST OF ANCHORAGE ON THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	56°10'N, 159°23'W
ELEVATION:	THE HIGHEST POINT ON THE CALDERA RIM IS 2507 M ABOVE SEA LEVEL
USGS 1:250,000 QUADRANGLE:	CHIGNIK
CAVW NUMBER:	1102-07

Form and structure

Mount Veniaminof is a broad conical mountain, 35 km wide at the base, truncated by a spectacular steep-walled summit caldera 8x11 km in diameter (fig. 40). The caldera is filled by an ice field that ranges in elevation from approximately 1750 to 2000 m; ice obscures the south rim of the caldera and covers 220 km^2 of the south flank of the volcano. Alpine glaciers descend from the caldera through gaps on the west and north sides of the rim and other alpine glaciers occupy valleys on the north-, east-, and west-facing slopes of the mountain. In the western part of the caldera, an active intracaldera cone with a small summit crater has an elevation of 2156 m, approximately 330 m above the surrounding ice field. The rim of a larger but more subdued intracaldera cone protrudes just above the ice surface in the northern part of the caldera (not shown on fig. 40); based on limited exposure and physiographic features, it may have a summit crater as much as 2.5 km in diameter.

Andesitic and dacitic ash-flow tuffs from the caldera-forming eruption occur in many of the valleys on the north slope of the volcano and are found as far away as 50 km from the caldera rim on both the Bering Sea and Pacific Ocean coasts.

A northwest-trending belt of post-caldera cinder and scoria cones, including the two intracaldera cones, extends from near the Bering Sea coast approximately 55 km across the main volcanic edifice and the Aleutian Range divide, well down the Pacific slope (Detterman and others, 1981).

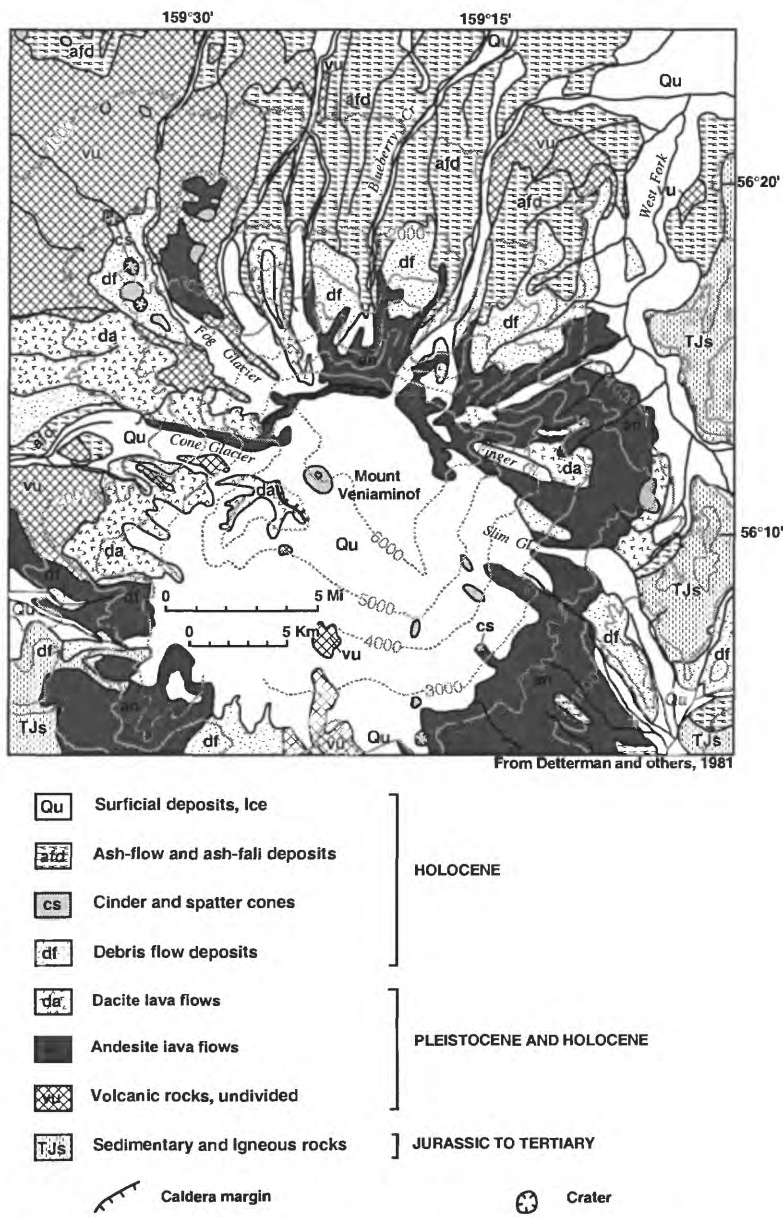


Figure 40. Generalized geologic map of Mount Veniaminof volcanic center modified from Detterman and others (1981).

Volcanic activity

1830-40?
August 4, 1838
1852
1874
1892
1930
May 23 - June 26, 1939
November 1939
March 28, 1944
March - May 1956
June 2, 1983 - April 1984
1993-1995

Mount Veniaminof's summit caldera formed 3700 years B.P., sending ash flows 50 km toward the Bering Sea and into bays and estuaries on the Pacific coast (Miller and Smith, 1987). Historical reports of activity at Mount Veniaminof are often sketchy and second-hand. Father Veniaminof, after whom the volcano is named, reported "smoking" from 1830 to 1840 (Grewingk, 1850). Doroshin (1870) reported an ash eruption in 1838 and "smoking" in 1852. Dall (1918) saw intermittent steam and black "smoke" puffs erupted during the summer of 1874. A violent ash eruption in 1892 was recorded by Davidson (1892) and Becker (1898). Hubbard (1931) saw ash explosions from the western intracaldera cone in 1930. On May 23, 1939, a series of explosions began that lasted until at least June 26, 1939; a U.S. Coast Guard cutter offshore reported an ash cloud to 6,100 m with 450 m high "flames". Ash from the eruption reportedly reached an average depth of 2-5 cm over a 84-km radius; most residents of Perryville, 35 km south and directly downslope of the volcano, were evacuated. (Perryville was established in 1912 by relocation of the former residents of the village of Katmai.) A mild ash eruption occurred on March 28, 1944 (Coats, 1950). Activity beginning in March 1956 culminated with ash explosions on May 19 and 23, 1956 which sent ash-rich eruption columns to approximately 6,100 m according to airline pilot reports.

A moderate Strombolian eruption with accompanying lava flows began June 2, 1983 and lasted to mid-April 1984, with a hiatus from mid-August to early October. Lava flows from the summit crater of the western intracaldera cone and adjacent subglacial activity melted ~0.15 km^3 of the caldera ice field, forming a 0.9x2 km water-filled ice pit approximately 120 m deep (Yount and others, 1985; Yount and Miller, 1987). The ice pit subsequently was partially filled by an estimated 0.04 km^3 of lava.

After a 9-year hiatus, a Strombolian eruption of ash and steam began on July 30, 1993 from the central cinder cone (Smithsonian Institution, 1993). An overflight on May 9, 1994 by Alaska Volcano Observatory personnel revealed a new oval-shaped lava field formed on the southeast flank of the main intracaldera cone between 1925 m and 1770 m elevation. The lava field extends about 1000 m in a north-south direction and about 800 m in an east-west direction and appears to have been chiefly fed from vents in the northern part of the lava field. Lava volume is estimated at 30-50 x 106 m^3. Intermittent emissions of ash and steam were observed and pilots reported a new steam vent in the icefield adjacent to the active cone, possibly resulting from a subglacial lava flow. Residents of nearby Perryville reported a fiery nighttime scene in September, 1994, as incandescent material was ejected an estimated 300 m above the vent. Pilot reports and satellite imagery indicate sporadic activity continued well into 1995.

Composition

The pre-caldera volcano consists predominantly of andesitic and basaltic andesite lava flows (figs. 41, 42) with intercalated pyroclastic rocks; dacitic lava flows are minor. The ash flows of the caldera-forming eruption range in composition from andesite to dacite. Scoria collected inside the caldera and thought to be related to the active cone is basaltic andesite.

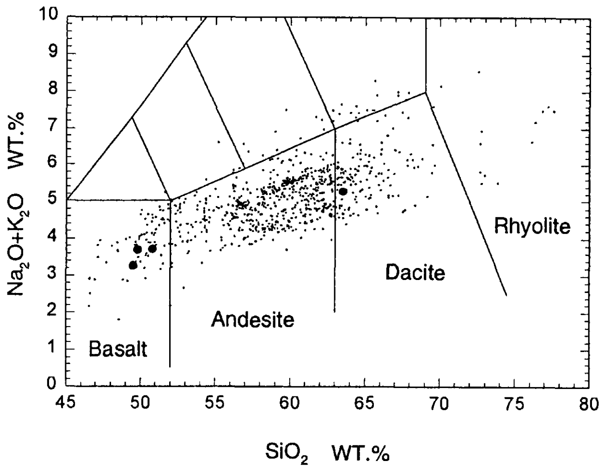


Figure 41. Total alkalies-silica diagram of Veniaminof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

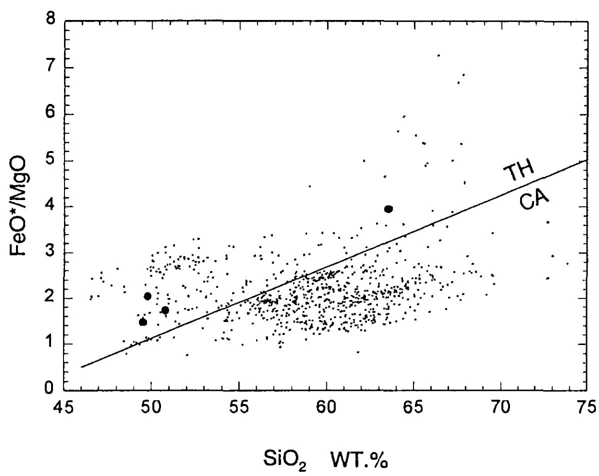


Figure 42. FeO/MgO-silica diagram of Veniaminof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Pavlof Volcano
Synonyms:	None
Type:	Stratovolcano
Location:	Near southwest end of Alaska Peninsula, 60 km northeast of Cold Bay
Latitude, longitude:	55°25'N, 161°54'W
Elevation:	2518 m
USGS 1:250,000 quadrangle:	Port Moller
CAVW Number:	1102-03

Form and structure

Pavlof Volcano is a largely snow-covered, cone-shaped mountain with a high ridge extending to the southwest towards the rim of Emmons Lake Caldera (fig. 43). The volcano is approximately 7 km in diameter and has active vents on the north and east sides close to the summit (McNutt and others, 1991). It is situated high on the northeastern flank of Emmons Lake caldera along a northeast-trending alignment of vents that includes Pavlof Sister, and several intracaldera cones (Kennedy and Waldron, 1955). The stratovolcano is relatively undissected and is mostly Holocene in age. Pavlof lies within the Shumagin seismic gap (Davies and others, 1981).

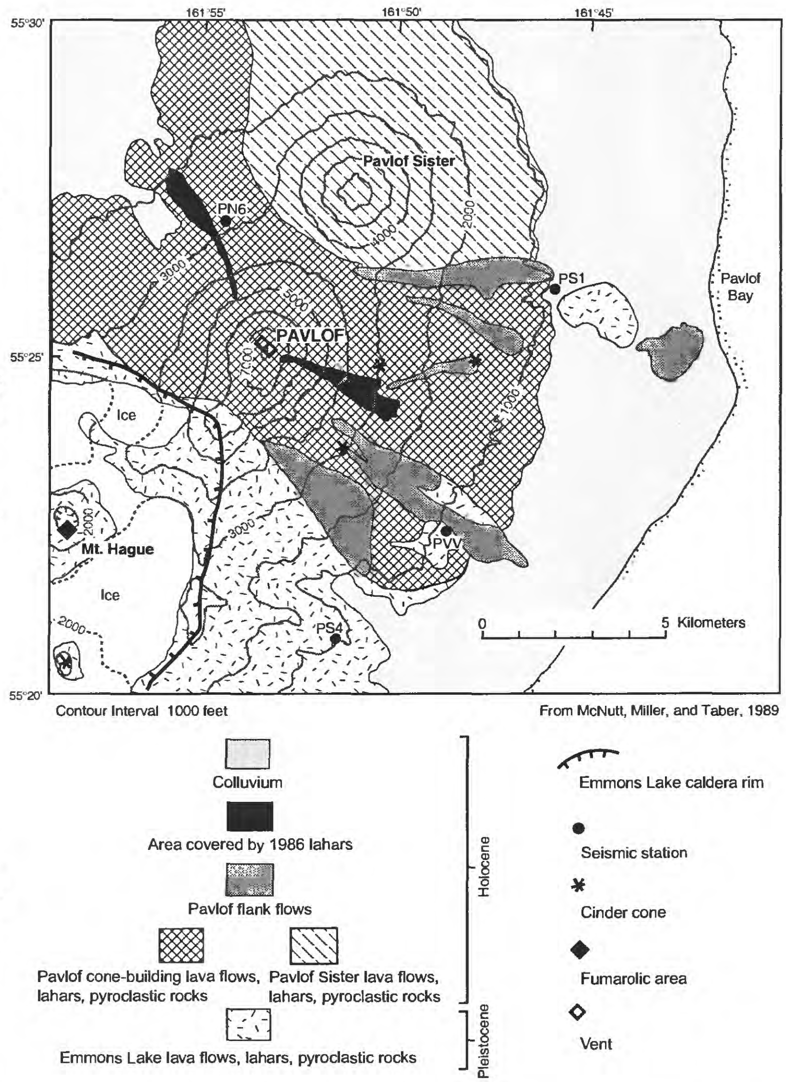


Figure 43. Generalized geologic map of Pavlof volcano from McNutt and others (1989).

Volcanic activity

1790	1906	1942	1974
1825	1910-1911	1945	1975
1838	1914	1947	1980
1844	1917	1948	1981
1846	1922	1950	1983
1852?	1923	1951	April 1986-
1866	1924	1953	August 1988
1880	1929	1958	Sept. 1996-
1886	1931	1962	Jan. 1997
1892	1936	1966	
1894	1937	1973	

Pavlof Volcano is the most active volcano in the Aleutian volcanic arc with almost 40 relatively well-documented eruptions dating back to 1790 (Newhall and Dzurisin, 1988; Smithsonian Institution, 1976-1988; McNutt, 1987; Coats, 1950; Jaggar, 1932). It is so consistently active that a question sometimes arises as to what constitutes a separate eruption. Some Pavlof eruptions have been short-lived (1-2 days duration) and similar eruptions in the past may have occurred unnoticed in the sparsely populated region.

Pavlof eruptions are typically strombolian to vulcanian in character and consist of rhythmic ejection of incandescent bombs and ash to heights of 200-300 m above the summit (McNutt and others, 1991); spatter-fed lava flows emanate from the summit vents on occasion. Short-lived volatile-rich vulcanian ash columns reaching to heights of 10 km or more have been noted, usually at the beginning of an eruption. McNutt (1987) found a correlation between seismic activity and type of eruption. Strong volcanic tremor accompanied major strombolian magmatic eruptions, whereas episodes of explosion quakes, with little to no volcanic tremor, were diagnostic of minor phreatomagmatic events.

The largest historical eruption of Pavlof occurred on December 6-7, 1911 at the end of a five year period of activity. A fissure vent opened along the north flank, large blocks were ejected, and lava flows issued from the fissure (McNutt, 1987).

A recent vigorous eruptive period began mid-April, 1986 and continued through August, 1988 (Smithsonian Institution, 1986-88; McNutt and others, 1991). Frequent steam and ash emission, explosions, and strong tremors accompanied summit lava fountaining that fed several agglutinate lava flows, which in turn produced a number of both hot and cold, ˇextensive mudflows. During the early course of the eruption, the eruptive vent shifted from the north to the east side of the summit.

The most recent eruptive episode at Pavlof Volcano began about September 11, 1996 and continued into early 1997 (Neal and McGimsey, 1997). The eruptive activity was strombolian in character and similar to most Pavlof eruptions. Intermittent explosive activity and lava fountaining were recorded from two closely-spaced vents high on the northwest summit of the volcano. Incandescent spatter, spatter-fed flows, and small lahars moved down the northwest flank of the volcano for the next four months melting a narrow channel through snow and ice. Occasional elongate plumes that rose to a maximum of 10 km above sea level (generally less than 6 kilometers) and extended up to several hundred kilometers downwind were detected on satellite images and reported by pilots. These clouds consisted chiefly of vapor and gas with minor amounts of ash. Light ash fall was reported on several occasions from nearby communities.

Composition

Pavlof Volcano is composed of basaltic andesite lava flows (figs. 44, 45) and pyroclastic rocks that overlap similar rocks from nearby Little Pavlof. The flows are moderately phyric with about 25% phenocrysts, mostly plagioclase with minor olivine and clinopyroxene. The agglutinate flows of 1987 are of similar andesitic composition.

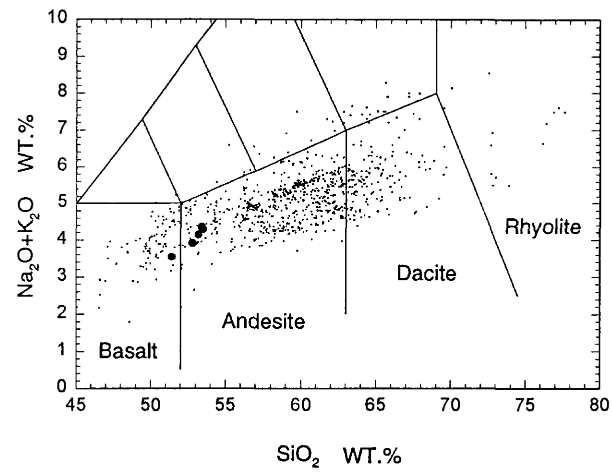


Figure 44. Total alkalies-silica diagram of Pavlof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

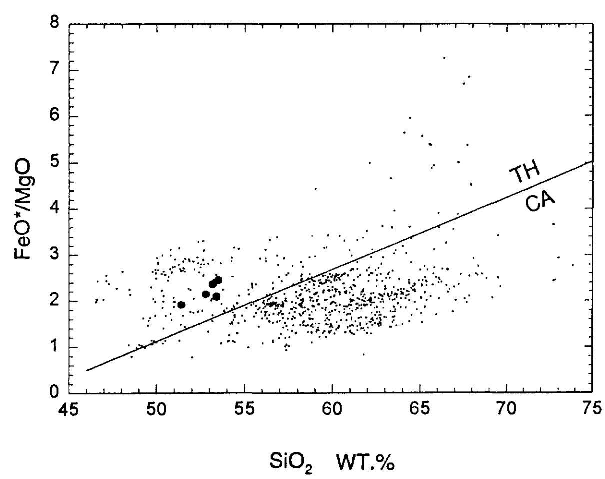


Figure 45. FeO/MgO-silica diagram of Pavlof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

NAME AND LOCATION

NAME:	MOUNT DUTTON VOLCANO
SYNONYMS:	NONE
TYPE:	STRATOVOLCANO WITH SUMMIT DOME COMPLEX
LOCATION:	SOUTHWEST TIP OF ALASKA PENINSULA 30 KM EAST OF COLD BAY
LATITUDE, LONGITUDE:	55°11'N, 162°16'W
ELEVATION:	1473 M
USGS 1:250,000 QUADRANGLE:	COLD BAY
CAVW NUMBER:	1102-011

Form and Structure

Mount Dutton is a small snow-and ice-covered calc-alkaline volcanic center with an approximate diameter of 5 km (not including the isolated large intra-canyon lava flow 5 km southwest of the summit) and an estimated volume of 7-15 km³ (fig. 46).The volcano is built on an east-sloping basement of hydrothermally altered Tertiary volcanic rocks (Kennedy and Waldron, 1955).

The volcano consists of a central multiple dome complex (Davies and others, 1988) in which successive domes shouldered aside earlier domes and the enclosing cone-building volcanic rocks. Some hydrothermal alteration occurs along vertical contacts between adjacent domes. The dome-building activity and associated collapse has caused extensive destruction of cone-building lava flows and, to a lesser extent the domes themselves. This has resulted in the massive, thick-bedded debris flows 100-200 m thick that surround and mantle the central dome complex.

A headwall scarp about 300 m high and dipping to the northwest about 45° forms the west side of the summit. Debris avalanches from this and lower areas moved down either side of the east-west oriented range crest. The resulting avalanche deposits include blocks up to 5 m in diameter and are characterized by hummocky topography and small closed depressions. The avalanche deposits cover a total area of about 11.4 km² and have an estimated volume of about 0.17 km³.

Only slightly dissected debris flows and pyroclastic flows occur on the east flank of the volcano. Two flank-domes occur 3.5 km north-northeast of the summit of Mount Dutton at an elevation of 520 m.

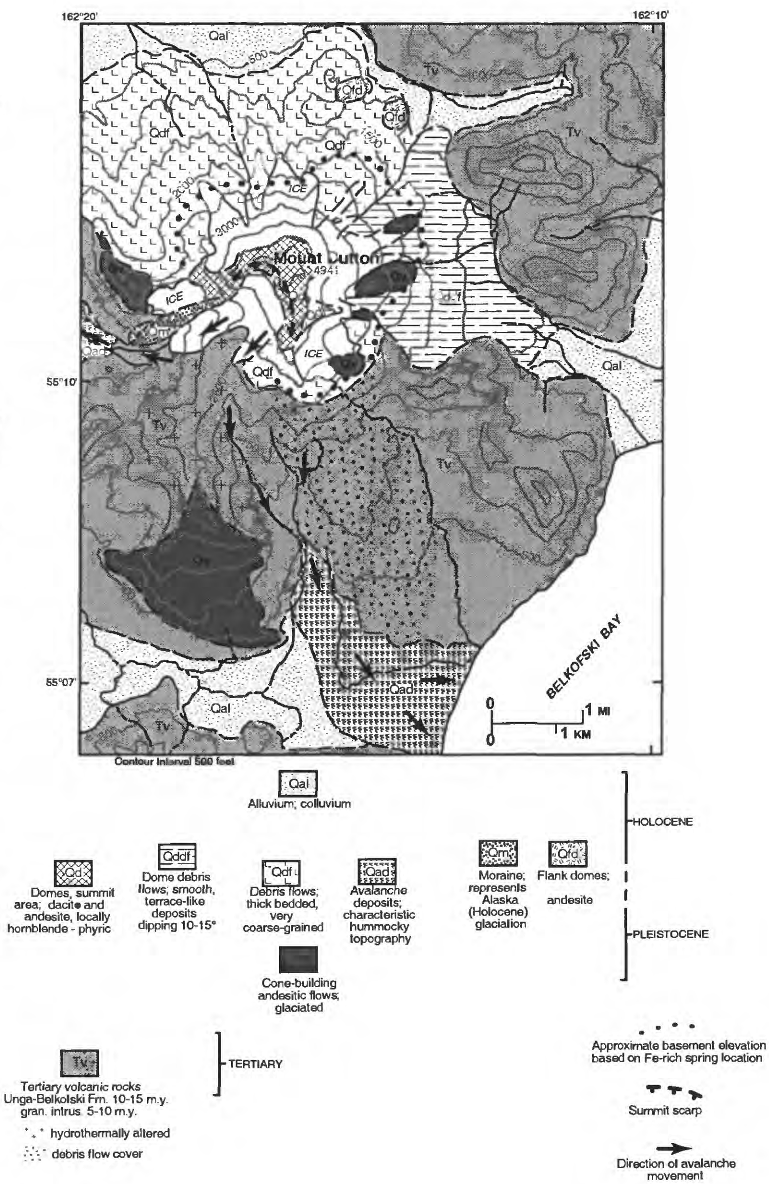


Figure 46. Geologic map of Mount Dutton volcano; mapped by T.P. Miller, C.A. Neal, and M.E., Yount.

These non-glaciated flank domes are assumed to represent Holocene eruptions. Most, if not all, of the avalanche and debris flows that mantle the volcano's flanks are also Holocene in age.

Volcanic activity

Although historical eruptions have not been reported from Mount Dutton, recent seismic activity suggests near-surface magma movement which could be precursory to eruption. A swarm of shallow earthquakes during July and August, 1988, beneath Mount Dutton (Smithsonian Institution, 1988) sparked a volcano-seismic crisis. The activity was concentrated in three episodic sub-swarms with the largest event ML=4.0; many of these events were felt sharply at nearby communities, particularly King Cove, causing much concern. The distribution of epicenters forms a roughly linear zone which extends in a southeast direction about 10 km from the western shoulder of the volcano. The trend of the epicentral zone is parallel to the direction of maximum horizontal compression resulting from subduction of the Pacific plate and includes a prominent zone of hydrothermal alteration of the country rock. These similarities suggest that the seismic activity results from fracturing of the country rock as a dike is emplaced beneath Mount Dutton.

Composition

Mapping and sampling of the volcano has been preliminary only but the volcano appears to consist chiefly of calcalkaline feldspar-phyric andesite and subordinate dacite (fig. 47, 48) with SiO_2 ranging from 55 to 63 percent.

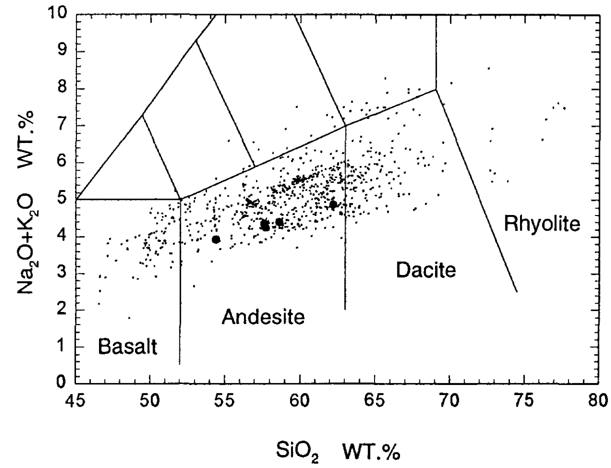


Figure 47. Total alkalies-silica diagram of Dutton volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

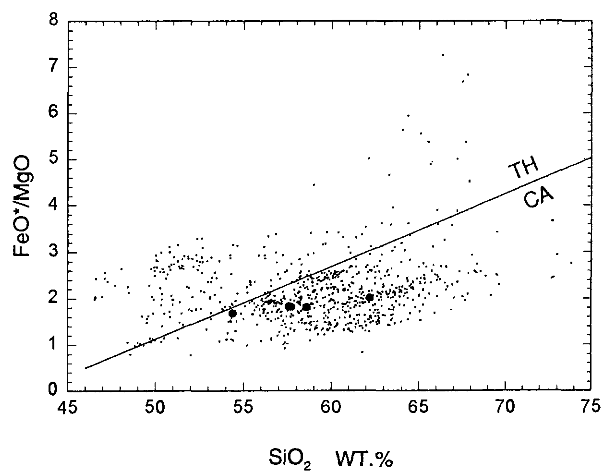


Figure 48. FeO/MgO-silica diagram of Dutton volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Isanotski volcano
Synonyms:	Isanotski Peaks
Type:	Stratovolcano
Location:	Unimak Island, eastern Aleutian Islands, about 80 km west of Cold Bay, Alaska
Latitude, longitude:	54°45'N, 163°44'W
Elevation:	2446 m
USGS 1:250,000 quadrangle:	False Pass
CAVW Number:	1101-37

Form and structure

Isanotski volcano, located near the eastern end of Unimak Island, is a dissected, snow- and ice-covered stratovolcano with a basal diameter of about 10 km (fig. 49). It is much more deeply eroded than neighboring Shishaldin volcano and lies between Shishaldin and Roundtop along a roughly east-west alignment.

Volcanic activity

1795	1830
1825	1845

Coats (1950) lists activity of Isanotski volcano as occurring in 1795, 1825, 1830, and 1845; these eruptions are poorly documented and some or all may have occurred at neighboring Shishaldin volcano. For example, during an eruption of March 25, 1825, which is presumably that listed by Coats, "a low ridge on the northeast end of Ounimak [Unimak] opened in five places..." (Petroff, 1884, p. 91); this description does not fit a central eruption of Isanotski volcano, although the proximity of the observer(s) is not known. Owing to an extreme degree of erosional dissection, historical eruptions of Isanotski must be regarded as uncertain without further evidence; it is possible that historical fumarolic activity has served as the basis for reported activity.

Composition

Isanotski Volcano has not been mapped geologically and no description of its geology or composition is available.

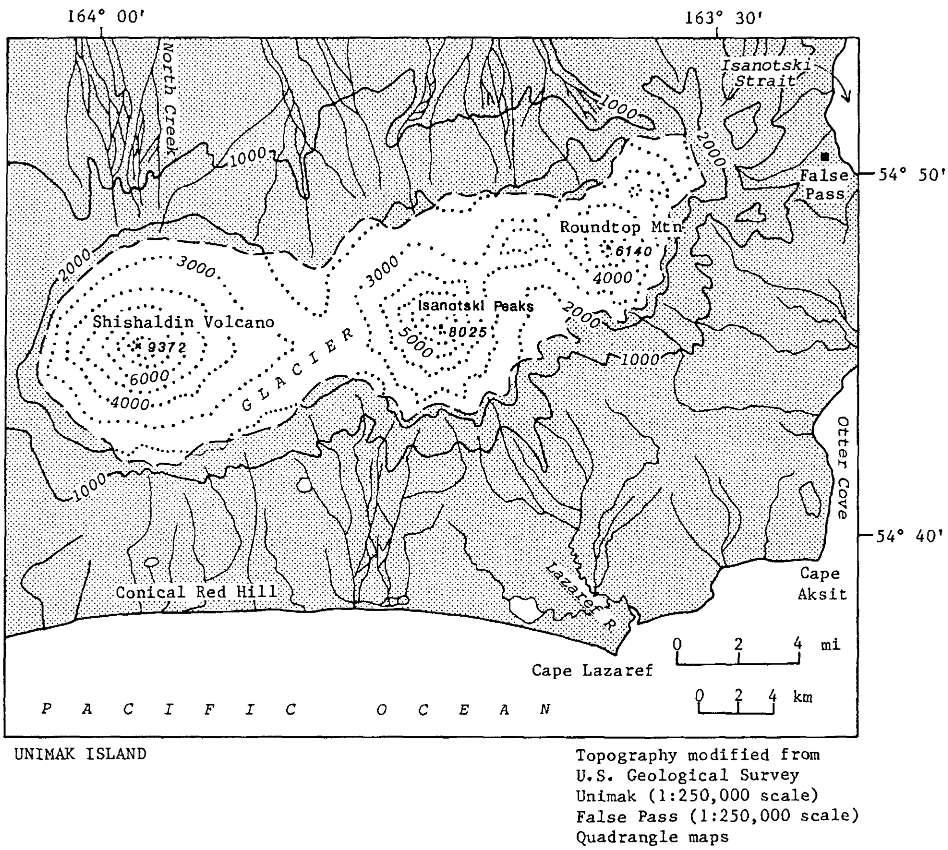


Figure 49. Topographic map of Isanotski Peaks and Shishaldin volcanoes.

page 41 follows

NAME AND LOCATION

NAME:	SHISHALDIN VOLCANO
SYNONYMS:	NONE
TYPE:	STRATOVOLCANO
LOCATION:	UNIMAK ISLAND, EASTERN ALEUTIAN ISLANDS, ABOUT 90 KM SOUTHWEST OF COLD BAY, ALASKA
LATITUDE, LONGITUDE:	54°45'N, 163°58'W
ELEVATION:	2857 M
USGS 1:250,000 QUADRANGLE:	FALSE PASS
CAVW NUMBER:	1101-36

Form and structure

Shishaldin Volcano, located near the center of Unimak Island, is a spectacular symmetrical cone about 16 km in diameter at the base. The mountain, which rises to a summit 2857 m above sea level (fig. 49), is the highest peak in the Aleutian Islands and has a small summit crater from which a steady cloud of steam is emitted. The upper 2000 m is almost entirely covered by perennial snow and ice. It is flanked to the northwest by 24 monogenetic parasitic cones (Fournelle, 1988). The Shishaldin cone is less than 10,000 years old and is constructed on a glacially eroded remnant of an ancestral somma and shield (Fournelle, 1988), which in turn are underlain by volcaniclastic rocks of probable late Tertiary age (McLean and others, 1978). Fournelle (1988) suggests that the basement may consist, at least in part, of plutonic rocks.

Volcanic activity

1775-78	1927-28
1790	May-June 1929
1824-25	Feb-May, 1932
1827-1830	Aug, 1946-Jan 1947
1838	1948
1845 (1842?)	July, 1955
1865	Dec 28, 1963
1880-81	Jan 28, 1967
1883	Sept 13 (-Oct?), 1975
1897-1899	Apr-May, 1976
1901	Feb 8, 1978
1912	Feb 1979
1922	March 1986-Feb 1987
1925	December 1995-May 1996

Shishaldin, one of the most active volcanoes in the Aleutian volcanic arc, is situated near that part of the arc where the maximum rate of subduction occurs. At least 27 eruptions have been reported since 1775 with the latest occurring in 1995-1996 (Neal and McGimsey, 1997) (Jaggar, 1932; Coats, 1950; Wentworth, 1951; Anchorage Daily News, July 14, 1955; Anchorage Times, October 10, 1975, September 26, 1975, January 25, 1976; Smithsonian Institution, 1978, 1979, 1986, 1987). Most, if not all, of the reported activity is strombolian ash and steam eruptions.

Major explosive eruptions occurred in 1830 (Coats, 1950) and 1932 (Jaggar, 1932), and eight historical eruptions have produced lava flows (Smithsonian Institution, 1986). Steam and minor ash emission began in March 1986 and continued intermittently through mid-February, 1987.

A poorly documented short-lived eruption of steam and ash, perhaps as high as 10 km, occurred on December 23, 1995 (Neal and McGimsey, 1997).

see next page

Composition

Shishaldin Volcano has been mapped geologically at a reconnaissance level by Finch (1934) and Fournelle (1988) made a detailed study of the petrology of the volcano. According to Fournelle, the volcano is tholeiitic in character and predominantly basaltic (figs. 50, 51) with only a few compositions >53% SiO_2 but with elevated TiO_2. Three main varieties are present: high magnesian basalt with ~20% olivine and diopsidic clinopyroxene; porphyritic high alumina basalt with 30-45% plagioclase, <5% olivine, and rare clinopyroxene, and aphyric FeTi basalt with <20 % plagioclase and rare olivine. Recent lava flows are mostly high alumina, titanium-enriched basalt and high magnesium basalt (Fournelle, 1988). Older lava flows, possibly associated with the somma on the western flank are high magnesium basalt, dacite-rhyodacite, high alumina-titanium basalt and minor andesite (Fournelle, 1988). Salmon-colored pumice (64% SiO_2) containing minor plagioclase and clino- and orthopyroxene occurs as recent tephra and in rare flowage deposits.

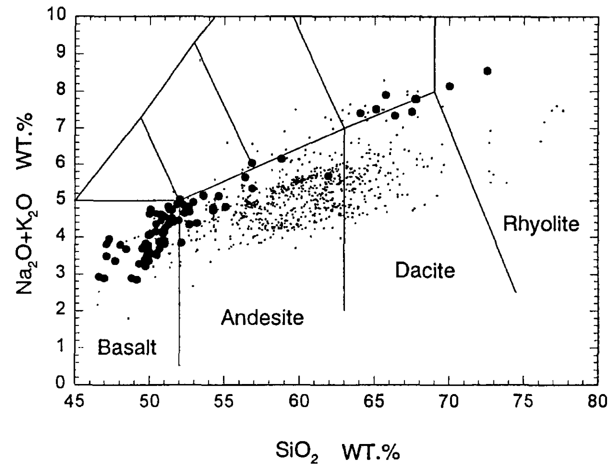


Figure 50. Total alkalies-silica diagram of Shishaldin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

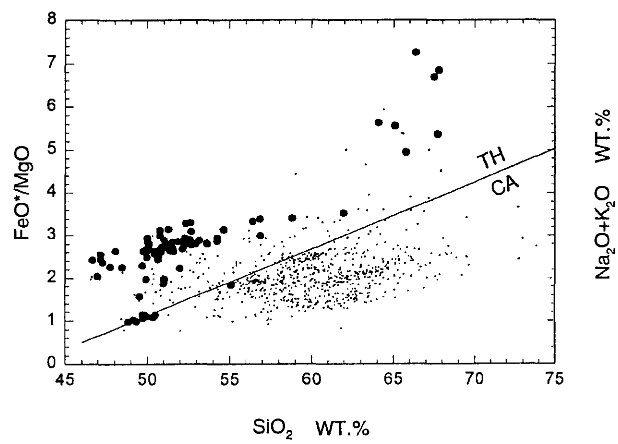


Figure 51. FeO/MgO-silica diagram of Shishaldin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974). The two rhyolites have very high FeO/MgO because of their very low MgO contents, and plot off the scale of this diagram.*

Name and Location

Name:	Fisher Caldera
Synonyms:	None
Type:	Caldera with post-caldera domes, lava and pyroclastic flows
Location:	Unimak Island in the eastern Aleutian arc about 70 km southwest of the tip of the Alaska Peninsula
Latitude, longitude:	54°39'N, 164°26'W
Elevation:	1112 m maximum (caldera rim); 183 m (caldera lake)
USGS 1:250,000 quadrangle:	Unimak
CAVW Number:	1101-35

Form and structure

Fisher caldera is 11 km wide by 18 km long, and has a maximum internal relief of 929 m. It is one of at least three volcanoes on Unimak Island that have been active in historical time.

The caldera is remarkable in size—one of the largest calderas in the Aleutian arc—and for the mobility of the ash flows that resulted from the caldera-forming eruption about 9100 years ago (Miller and Smith, 1977; 1987). The ash flows reached the Pacific Ocean 8 km to the southeast, and swept part way up the slopes of stratovolcanoes to the east and southwest (fig. 52). To the north, ash flows crossed 15 km of lowland to reach the Tugamak Range, surmounted drainage divides as much as 400 m above the lowland surface in the range, and continued northward an additional 8 km to the Bering Sea coastline. Miller and Smith (1977) inferred that the ash flows had unusually high velocities to cross such topographic barriers and suggested that the high velocities resulted by ash fall-back from a high eruption column.

Fisher caldera was the location of a large andesitic stratovolcano that was largely destroyed during caldera formation. Very little study has been done on the caldera itself. Post-caldera activity of Fisher caldera appears to consist of dome emplacement and eruption of lava flows and associated pyroclastic material, some of which may be historical in age (Miller and Smith, 1977).

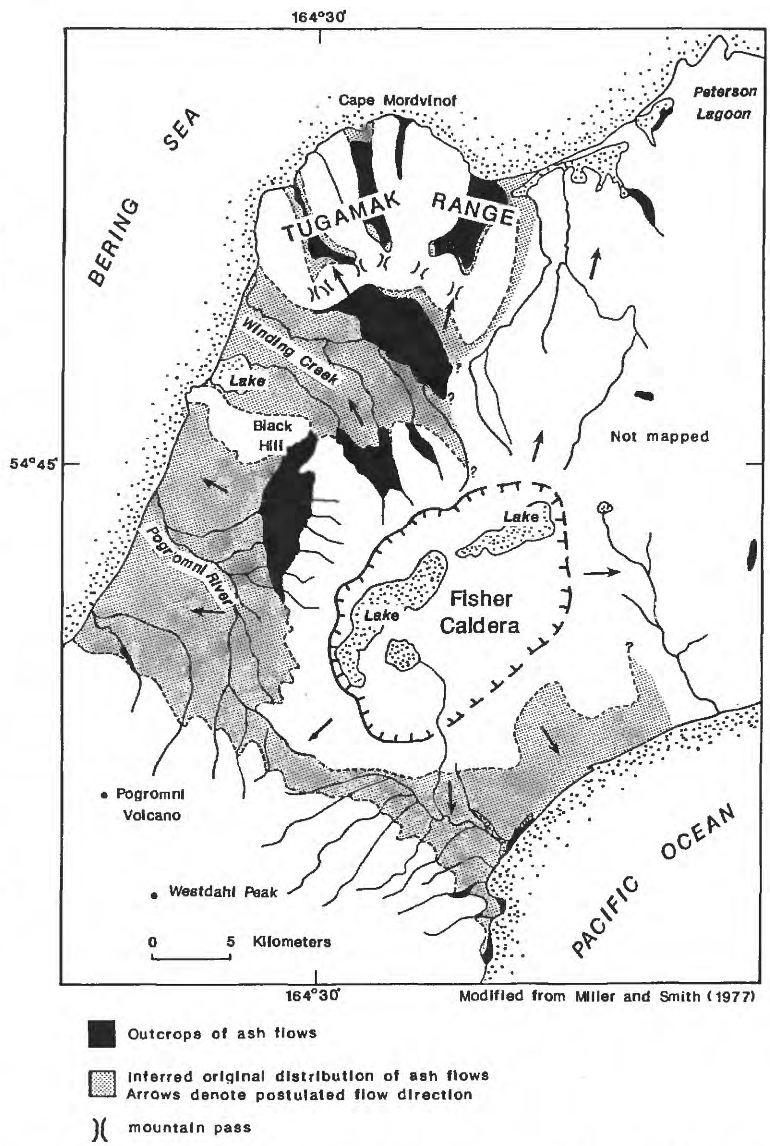


Figure 52. Generalized geologic map of Fisher caldera and vicinity after Miller and Smith (1977).

Volcanic activity

1795? 1830?
1826?

Veniaminov (1840, p. 19) described the activity of a volcano on the southwest side of Unimak Island, which is most likely that of Fisher caldera: "the low peak in the interior of Unimak Island, near its south end, burned until the upheaval of the southwest range [Westdahl], in 1795, then was extinguished. On October 11, 1826, with a dull noise, it burst, emitting strong flames and a large quantity of ash. In August 1830, the summit of this peak exploded again, but without any other special phenomena.".

Active fumaroles occur in the central part of the caldera (Newhall and Dzurisin, 1988).

Composition

Juvenile pumice and scoria produced during the caldera-forming eruption ranged (figs. 53, 54) from basaltic andesite (52.5% SiO_2) to dacite (65.4% SiO_2) (Miller and Smith, 1977). Fournelle (1990) reported that pre-caldera volcanic rocks consist of aphyric andesitic (61% SiO_2) pyroclastic rocks and lavas and some high Al plagioclase basalt. Post-caldera rocks include low Al porphyritic basalt.

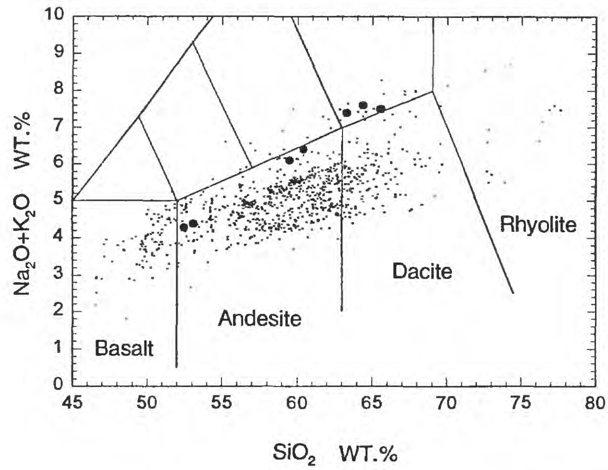


Figure 53. Total alkalies-silica diagram of Fisher volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

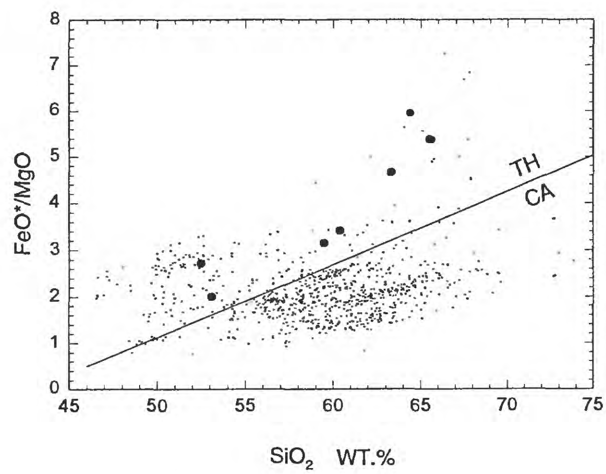


Figure 54. FeO/MgO-silica diagram of Fisher volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

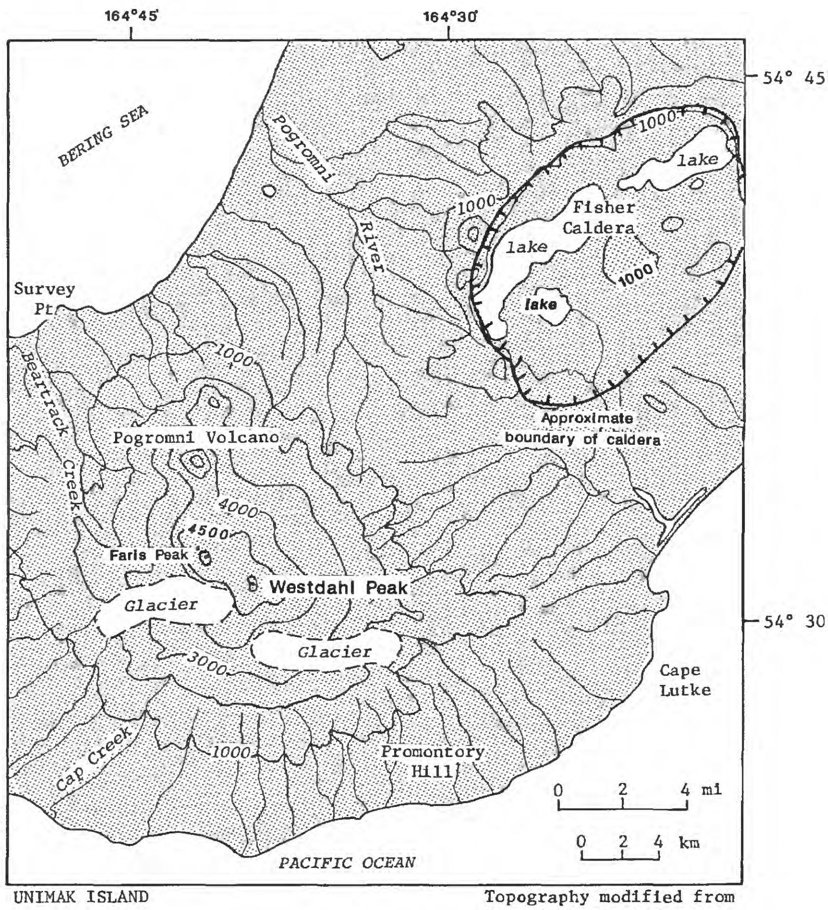
Name:	Westdahl volcano
Synonyms:	Westdahl Peak
Type:	Uncertain; possibly a pyroclastic cone on a truncated ancestral stratovolcano or shield
Location:	Unimak Island, in the eastern Aleutian arc about 85 km southwest of the tip of the Alaska Peninsula
Latitude, longitude:	54°31'N, 164°39'W
Elevation:	1560 m
USGS 1:250,000 quadrangle:	Unimak
CAVW Number:	1101-34

Form and structure

Westdahl Peak, including nearby Faris Peak and Pogromni volcano, is located on a gently sloping plateau (mean elevation 1220 m) that may represent the surface of a truncated ancestral cone (fig. 55). Westdahl Peak is about 18 km in diameter at the base.

The size of the postulated ancestral cone is about 19 x 30 km at sea level, making it one of the largest volcanoes in the Aleutian Islands be it a stratovolcano or a shield. The entire ancestral cone has been extensively dissected by erosion, with the northeast-facing slopes steeper and of greater relief than the other slopes.

Based on the degree of erosional dissection, most of the postulated stratovolcano must have formed before early post-glacial time. Pogromni Volcano is moderately dissected and has broad valleys that have probably been glacially eroded. Such glacial erosion could have occurred during neoglaciation beginning about 3000 years ago (Black, 1974, Table 1), although one or two thousand years seem inadequate to account for the degree of dissection. Pogromni volcano was probably active by latest Pleistocene time, which implies that truncation of the ancestral stratovolcano must have occurred earlier.



Topography modified from U.S. Geological Survey Unimak (1:250,000 scale) Quadrangle map

Figure 55. Topographic map of Westdahl and Fisher caldera volcanoes.

Volcanic activity

1795	1964
1796	Feb. 3-9, 1978
1820	Feb 8-9, 1979
1827-30	Nov. 29, 1991 - mid. Jan. 1992

Veniaminov (1840, p. 18) described an eruption in 1795 on the southwest end of Unimak Island, which most likely occurred at Westdahl. Coats (1950) attributed four eruptions in the late eighteenth century and early nineteenth century to Pogromni volcano. Based on recent observations from aircraft, however, Pogromni does not appear to have been active in historical time. The eruptions should probably be assigned to Westdahl. Known eruptions of Westdahl occurred in 1964 (Anchorage Times, March 11, 1964) and 1978 (Anchorage Times, Feb. 9, 1978). The 1978 event lasted about six days (Feb. 3-9); ash fell on a ship 1000 km southeast of the volcano, and a mudflow extended down the flank of the volcano to the sea (Smithsonian Institution, 1978).

An apparent 8-km-high, 50-km-wide eruption cloud from Westdahl was observed on satellite imagery on February 8-9, 1979. However, no activity was reported from the U.S. Coast Guard station at Cape Sarichef, less than 25 km from Westdahl (Smithsonian Institution, 1979).

On November 29, 1991, pilots reported the beginning of a fissure eruption through the ice at Westdahl resulting in a lava flow approximately 3 km wide, 5-10 m thick, and about 7 km long extending down the northeast flank. Debris flows reached the sea 18 km from the vent. Dramatic lava fountaining and phreatic activity produced ash plumes that rose to 7 km altitude, prompting FAA to divert air traffic. Most of the ash was narrowly confined and remained at lower altitudes, dissipating harmlessly over the Bering Sea, however, light ashfalls occurred on Unimak Island including the village of False Pass, located 90 km northeast of the vent. The activity declined in mid-December and had ceased by mid-January, 1992 (Smithsonian Institution, 1991; 1992; McGimsey, 1995).

Composition

The volcano has not been mapped and little petrologic information is available. A few unpushed chemical analyses from USGS files indicate a range from basalt to dacite and tholeiitic character.

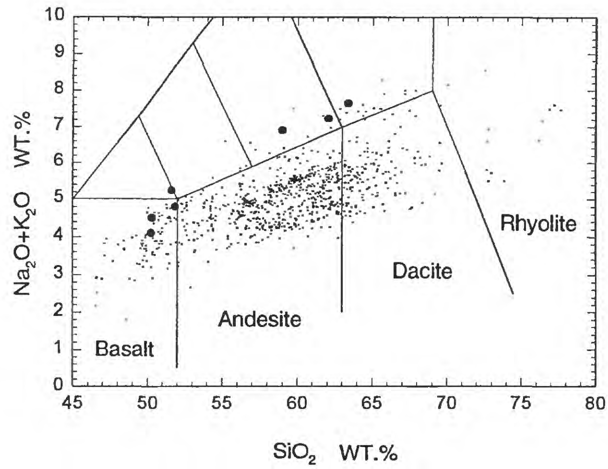


Figure 56. Total alkalies-silica diagram of Westdahl volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

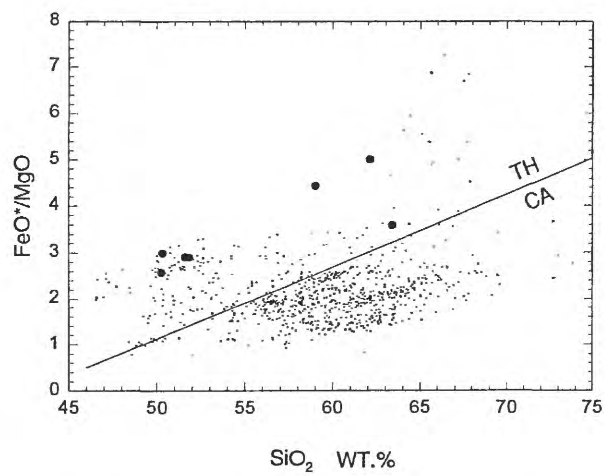


Figure 57. FeO/MgO-silica diagram of Westdahl volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of continental affinity (those located east of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Akutan volcano
Synonyms:	Akutan Peak
Type:	Stratovolcano with caldera
Location:	West central Akutan Island, largest of the Krenitzin group, in the eastern part of the Aleutian Islands and about 185 km southwest of the tip of the Alaska Peninsula
Latitude, longitude:	54°08'N, 165°58'W
Elevation:	1303 m
USGS 1:250,000 quadrangle:	Unimak
CAVW Number:	1101-32

Form and structure

Akutan volcano is a composite stratovolcano with a circular summit caldera about 2 km across and 60 to 365 m deep (Byers and Barth, 1953; Romick and others, 1990; Motyka and others, 1981) (fig. 58 A, B) and an active intracaldera cinder cone. The caldera rim reaches a maximum altitude of 1303 m at Akutan Peak, the remnant of a pre-caldera cone now filled with a lava plug. The caldera is breached to the north. Caldera subsidence accompanied or followed eruptions from a series of rim vents. The vestige of a larger caldera, of probable late Pleistocene age and at least in part older than the cone of Akutan Peak, extends 1.5 km southwest of Akutan Peak and is terminated to the north by the younger caldera. Small glaciers fill the older crater and lie within the southwest and southeast margins of the younger caldera.

The active intracaldera cinder cone is over 200 m high, about 1 km in diameter, and located in the north-east quarter of the caldera. Three small sulfur-lined craters occupy its summit and several fumarole zones are present along its south and southwest flank (Byers and Barth, 1953). A crescent-shaped lake along the inner southwest rim of the caldera and a hot and slightly acidic lake along the northern caldera wall were noted by Byers and Barth in 1948 but Motyka and others (1981) speculate that these lakes may have been obliterated by more recent activity. Both lakes drained to the north through a gap in the caldera wall.

The lava flows and pyroclastic deposits of Akutan volcano are no older than Pleistocene as Romick and others (1990) report ages of 1.1±0.1 to 1.8±0.8 Ma for the oldest of these rocks. The caldera-forming eruption occurred about 5,200 yBP (Reeder, 1983) and was the source of small volume andesitic pyroclastic-flow

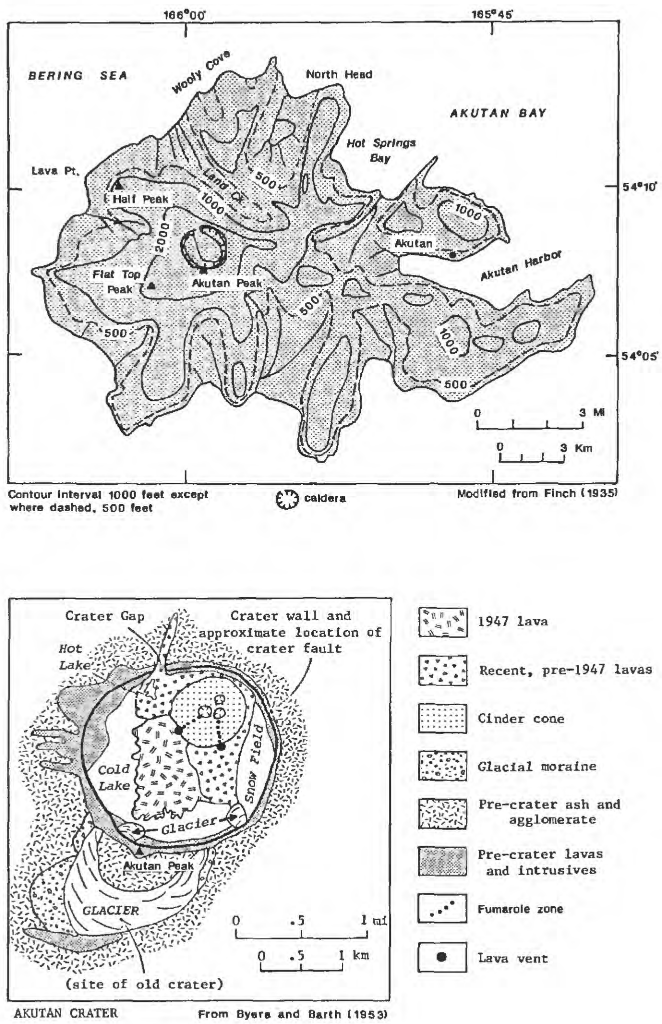


Figure 58. Topographic map of Akutan island (A) and geologic map of Akutan volcano (B) after Byers and Barth (1953).

deposits in valleys on the north, south, and east sides of the volcano (Miller and Smith, 1987; Romick and others, 1990). Young basaltic lava flows, some of which were erupted in 1929, cover the caldera floor south and north of the cinder cone and extend several hundred m downslope through the crater rim gap. Flows extruded in 1947 blanket the central portion of the northwest end of the island at Lava Point, where about 4 km^2 of jagged aa basalt occurs adjacent to several cinder cones. The entire island is mantled by an ash layer that thickens toward Akutan Peak; landslide and mud flow deposits have concentrated this ejecta in the valleys north and northeast of the caldera and a maximum fill depth of 7 m occurs at Wooly Cove (Finch, 1935).

Active hot springs occur northeast of the caldera at the head of Hot Springs Bay valley and along the shore of Hot Springs Bay; Byers and Barth (1953) and Motyka and others (1990) recorded temperatures between 67 and 84°C and a pH range of 6.6 to 7. Surface waters of the hot caldera lake were 50°C with a pH of 5.0 and steam issuing from fumaroles along the cinder cone base averaged 96°C (Finch, 1935).

Volcanic activity

1790	1892	Apr 29-Aug ? 1948
1828	1896	Oct., 1951
1838	1907	1953
1845	1908	March-May, 1973
March, 1848	1911	Feb. 11, 1974
1852	1912	Oct. 15, 1976-May, 1977
1865	1928	Sept.-Oct., 1978
1867	Dec (May?) 1929	July 8, 1980
1883	May-Aug 1931	Jan. - March, 1987
1887	Dec., 1946- Jan., 1947	June, 1987
		March - April, 1988
		March - May, 1992

Akutan is one of the most active volcanoes in the Aleutian arc. At least 27 separate episodes of volcanism have been noted since 1790 and it is likely that additional events have gone unrecorded due to the remoteness and sparse population of the island. Moreover, Akutan frequently produces low-level eruptive activity including steam and ash emission.

Few details are available concerning early Akutan volcanism (Finch, 1935; Byers and Barth, 1953; Simkin and Siebert, 1994). Vigorous activity was reported along the northwest flank of the main cone in 1852; a pyroclastic eruption in 1911 deposited ash as far east as Akutan village, 13 km from the volcano summit. Some of the flows at Lava Point may have formed in the late 1920's when C. Anderson, captain of the mail steamer Starr, observed smoke near Lava Point, which may have issued from a large cinder cone at the base of Half Peak. Much of the Lava Point lava field, however, may have originated before 1870.

Other twentieth century events within Akutan caldera are better documented. In 1929, lava was observed flowing through the breach in the north caldera rim and extending about 0.7 km down the northeast flank. A mudflow produced at the front of this lava tongue flowed into valleys to the north and northwest. "Dark smoke" was noted above the caldera cinder cone in 1931.

Lava extrusion resumed in early 1947 from a vent near the base of the caldera cone. Navy vessels evacuated 75 island residents on January 5th, but the flow was confined to the center of the caldera. Three earthquakes preceded a major eruption on April 29, 1948, which covered Akutan village with measurable deposits of ash (Alaska Sportsman, 1949). Activity continued full scale until mid-May, and in August of that year, clouds of ash-laden gas and incandescent fragments up to 1 m in diameter were still being ejected at intervals of 1 to 5 hours from the summit cone . Dark-grey cauliflower-shaped clouds rose 1.6 km above the cone and explosions were heard at Akutan village. Ash eruptions continued to be reported until 1953.

More ash eruptions occurred in 1973 and 1974; in May, 1977, clouds of light brown ash were ejected about every 15 minutes, with intervening periods of steam emission. Activity was renewed in late September, 1978; airline pilots observed incandescent fragments, some "as big as a car", ejected 100 m above the summit, and a lava flow along on the slopes of the main cone. This flow may have gone through the north breach of the caldera rim. Minor ash and steam were observed in 1980.

Emission of steam and ash were reported from January through early March, 1987. Following a lull in activity between March and early June, the eruption resumed in late June; a 300-m-high steam plume, ash blackened snow, and an orange glow at the summit were observed. Further activity was reported in March, 1988 when small ash eruptions began from the summit cinder cone and continued intermittently through July, 1988. During this eruption cycle, ashfall and strong sulfur fumes were reported on several occasions at Akutan village, 12.5 km east of the volcano.

From August 1988 to February 1989, only steam emissions were reported. During February and March 1989, ash and steam emissions resumed from the summit tephra cone. Akutan village reported a light dusting of ash on March 16. Activity then subsided until September 1990 when a brief period of intermittent emission of small ash and steam plumes occurred. A two-month period of intermittent steam and ash emission began again in September 1991. The most recent eruptive activity from

Akutan was during March through May 1992 and possibly into 1993 when localized steam and ash emissions with plumes rising up to 4600 m were reported. The mild sporadic Strombolian eruptive activity of the early 1990's suggest that a magma column may have been in the central vent conduit for much of this time.

An intense earthquake swarm began beneath Akutan volcano in the eastern Aleutian Islands on March 10, 1996 causing apprehension in the nearby village of Akutan that an eruption might be eminent. About 7:30 PM (AST) on March 10, residents of Akutan reported feeling almost "continuous" earthquake activity, punctuated by frequent strong shocks. This earthquake swarm continued through most of March 11 before beginning to subside about 5:00 PM (AST). At the peak of the swarm, earthquakes were being felt every few minutes and over 40 events/hour were recorded on Dutton volcano stations 300 km to the east.

Seismic activity continued to decline through March 12 with felt events reported at the rate of about 1 per hour. This decreased level of activity continued until about 5:00 PM (AST), March 13, when another intense earthquake swarm began. Felt earthquakes were occurring at the rate of about 1 per minute, similar to the rate reported on Monday, March 11 and ~ 30 events/hour were recorded at Dutton. This second earthquake swarm continued until about 7:30 PM March 14 when it began to decline.

Although most of the earthquakes were small, at least 3 had magnitudes between 5.0 and 5.3. The strongest earthquakes were felt in Dutch Harbor some 50 km to the west. Some damage was reported including cracks in walls, objects falling off shelves, and cracked plumbing.

The seismicity continued to decline over the next week although still remaining at relatively high levels. Recorded earthquakes declined from over 800 a day on Thursday and Friday, March 14-15, to about 60 per day by March 22.

Almost all of these earthquakes are volcanic-tectonic (VT) or tectonic events and were chiefly located on the northeast flank and east of the volcano with the suggestion (?) of a NW-SE trend over the known thermal areas.

The frequency, size, and duration of the seismic activity suggests magma movement beneath the volcano.

Composition

Relatively little information has been published on the composition of modern Akutan volcano; the report of Byers and Barth (1953) covered only the products of the 1946-1948 eruptions. Romick (1982) recognized two petrologic groups: olivine-clinopyroxene basalt from the western part of the island, and clinopyroxene-orthopyroxene andesites exposed elsewhere on the island. Romick et al (1990) did a more detailed study of the composition of ancestral volcanic rocks and included two analyses of lava from the modern Akutan cone and one from the sea level lava field (Lava Point) at the west end of the island. The samples are porphyritic 2-pyroxene andesite (55.-57.8% SiO_2) in the case of Lava Point and plagioclase-augite-olivine andesite in the cone lavas.

Lava extruded in January of 1947 and a block ejected in August of 1948 are both porphyritic basalts containing about 30% plagioclase phenocrysts (An^{47}-An^{70}), minor augite and sparse hypersthene, olivine and magnetite grains in a complexly intergrown groundmass of calcic andesine, pyroxene, ilmenite and magnetite (Byers and Barth, 1953).

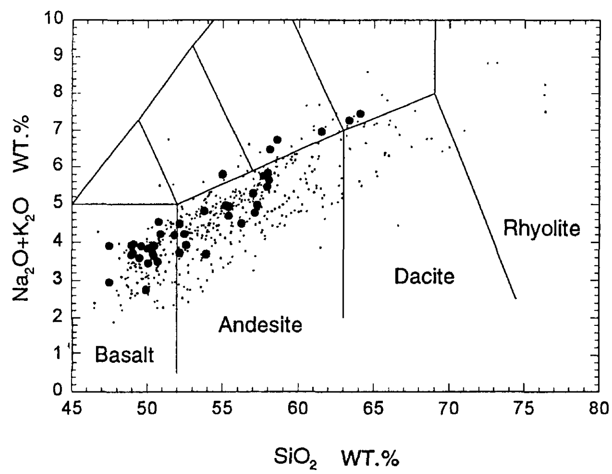


Figure 59. Total alkalies-silica diagram of Akutan volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

continued

Pyroclasts up to 3 mm in diameter were also produced during the 1947 and 1948 eruptions and deposited as tephra. Scoriaceous fragments composed of plagioclase and augite phenocrysts in a matrix of light brown glass constitute most of this material (Byers and Barth, 1953, p. 391).

Pre-1932 flows were examined by Finch within the caldera and at Lava Point; all were considered "normal basalts" (Finch, 1935, p. 159).

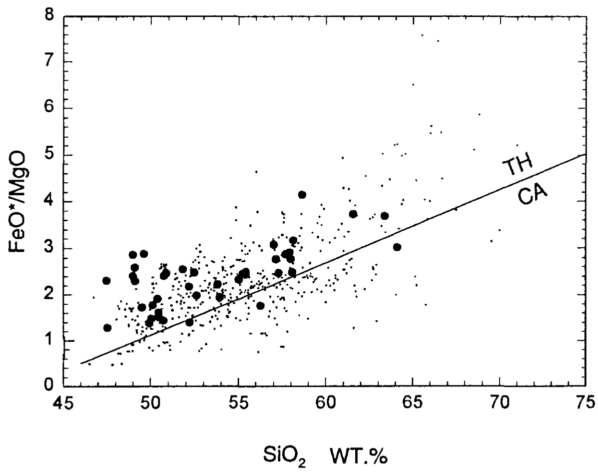


Figure 60. FeO/MgO-silica diagram of Akutan volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

NAME AND LOCATION

NAME:	MAKUSHIN VOLCANO
SYNONYMS:	NONE
TYPE:	STRATOVOLCANO WITH CALDERA AND PARASITIC CONE
LOCATION:	UNALASKA ISLAND, ABOUT 250 KM SOUTH-SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	53°53'N, 166°56'W
ELEVATION:	1800 M
USGS 1:250,000 QUADRANGLE:	UNALASKA
CAVW NUMBER:	1101-31

Form and structure

Makushin volcano is a broad, truncated stratovolcano, 1800 m high and 16 km in basal diameter, which occupies most of the triangular northwest extension of Unalaska Island (fig. 61). A breached summit caldera, about 3 km across, contains a small cinder cone, eroded remnants of other cones, and several fumaroles. The volcano is capped by an icefield of about 40 km^2; subsidiary glaciers descend the larger flanking valleys to elevations as low as 305 m.

Makushin volcano was constructed during two periods of volcanism separated by an interval of pronounced erosion (Drewes and others, 1961). Bedrock is exposed as high as 975 m on the southeast flank of the volcano. The first episode began in Pliocene or early Pleistocene time (the oldest known age of lavas is 0.93 Ma [Nye, 1990]) and produced extensive flows and subordinate pyroclastic deposits of basaltic and andesitic composition (fig. 61), which enlarged the island by several kilometers along the northwest coast. Radial dips of flows suggest that Makushin Volcano itself was the principal vent area. The older flows are extensively glaciated, which implies a minimum age of late Pleistocene. The summit of Makushin subsequently collapsed, forming a caldera. Andesitic pyroclastic-flow and debris flow deposits occur in glaciated valleys on the north and south sides of the volcano indicating a Holocene age for the caldera-forming eruption Miller and Smith, 1987). Reeder (1983) reported a ^{14}C age determination of 7950 ± 90 ybp on organic soil directly beneath the pyroclastic flow deposits and Nye and others (1984) report a limiting ^{14}C age of 4280 ± 280 ybp on organic material in a debris flow.

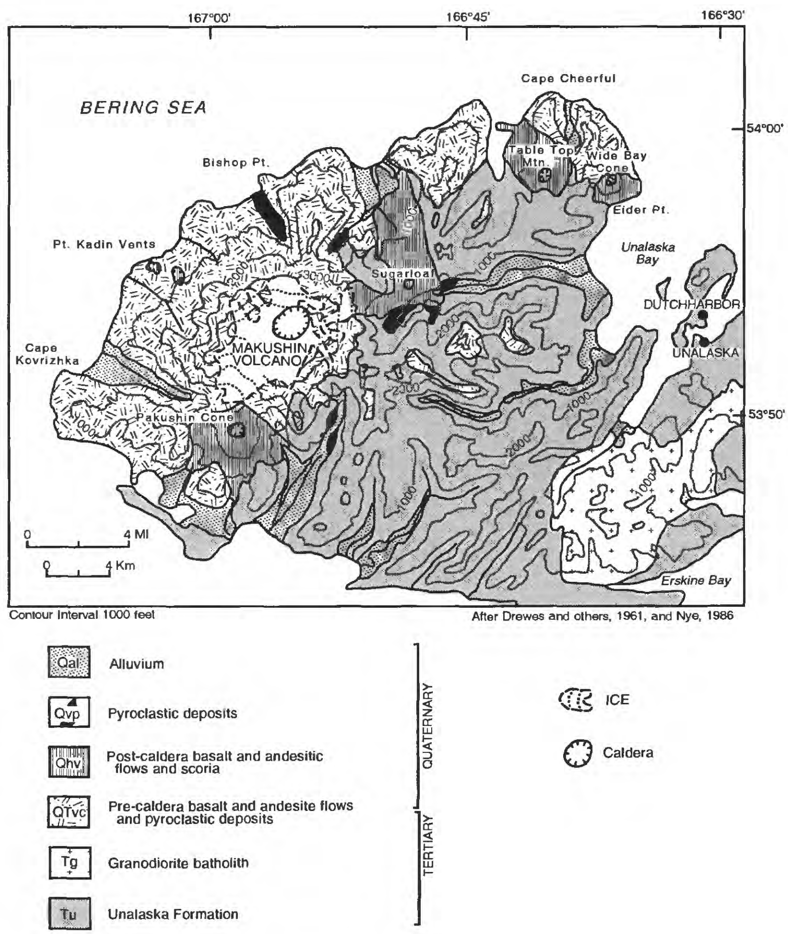


Figure 61. Generalized geologic map of Makushin volcano after Drewes and others (1961) and Nye (1986).

Several monogenetic satellitic vents composed of basaltic and andesitic lava flows, ash, and scoria cones occur within the summit caldera. These vents also form smaller cones on Makushin's flanks and surrounding area. Most of these vents have been slightly glaciated but blanket late Pleistocene topography indicating a latest Pleistocene or early Holocene age. Pakushin cone, a multiple-cratered composite cone, lies 8 km southwest of Makushin Volcano. Tabletop Mountain, the eroded remains of a pyroclastic cone encircled by flows originating from small flank vents, is 20 km northeast. Wide Bay cone, a small symmetric cone with an oval summit crater, occupies the northwest edge of Unalaska Bay, and Sugarloaf cone, built of steeply dipping, crudely bedded pyroclastics, is situated 14 km to the southwest. The Point Kadin vents, 10 small cones and explosion craters aligned along a rift zone trending N 75° W from the summit caldera, lie just south of an ash-flow deposit which fills a valley extending north from the volcano to the coast. The deposit is relatively undissected and may correlate with a blanket of airfall ash and cinders that covers part of the icefield on the volcano's northern flank. Based on geomorphic analysis, Arce (1983) infers that the sequence of Holocene events to have been as follows: construction of Sugarloaf cone, activity at Tabletop Mountain, construction of Makushin cone, and lastly, construction of the Wide Bay cone and activity on the Pt. Kadin vents.

Arce (1983) concludes that at least 15 tephra layers of Holocene age are recognizable on northern Unalaska Island; however, he assigns some to satellite vents of Makushin Volcano and others to more distant sources, so the exact number of deposits attributable to Makushin Volcano is uncertain.

Volcanic activity

1768-1779	1845	Dec. 1926
1790 (1792)?	1865	Oct. 1938
1802	1867	Dec. 20, 1951
1818	1883	1952
June, 1826	1907	1980
1827-38	1912	

Makushin Volcano has been reported active since its discovery in 1763 by Russians under the command of Korovin, but no major eruptions have occurred since 1826 (see Coats, 1950, Table 2). Powers (1958) lists an ash eruption in 1951 and smoke in 1952. Drewes and others (1961) conducted field studies of Unalaska Island in 1953-1954; during this period, vigorous solfataric activity was noted in and adjacent to Makushin's summit caldera. Several fumaroles bordering the main vent emit a mixture of water vapor, H_2S and SO_2; temperatures as high as 154°C have been recorded and the heat of the escaping gases keeps the center of the caldera free from ice. A minor explosive eruption from a small vent on the south flank may have occurred in the spring or early summer of 1980 (Smithsonian Institution, 1980).

Two smaller regions having superheated fumarole activity occur in northwestern Unalaska Island. One is 4.8 km southeast of Makushin's summit vent, and the other is 3.2 km to the south. Hot springs are found at these sites, as well as near Summer Bay, 32 km east of Makushin.

Composition

The Pleistocene lavas are dominantly basalt and basaltic andesite (figs. 62, 63) but include some andesite and dacite (Nye, 1990, Drewes and others, 1961). Early Holocene lavas have a wide compositional range and are generally more silicic than the Pleistocene lavas. Late Holocene lavas mark a return to more mafic compositions.

Older flows are 3 to 15 m thick. Flow breccias and thin ash beds are the main pyroclastic deposits. Thicker, massive pyroclastic deposits occur locally. Flow rocks are commonly porphyritic with felted or fluidal groundmass textures. Phenocrysts include plagioclase (most commonly labradorite), augite, hypersthene, and rare olivine. Accessories include opaques, apatite, zircon, and very rare amphibole and cristobalite. A few small hypabyssal bodies of basaltic, andesitic, and dacitic compositions intrude the older Makushin volcanics.

Younger volcanics are cinder cones, volcanic mud flows, and lava flows that retain much of their primary morphology. Porphyritic, felted or fluidal textures are dominant in flow rocks, and vugs and vesicles are common. Flow thickness are similar to those of the older volcanics. Phenocrysts include sodic bytownite or labradorite, augite, olivine, and in some samples hypersthene.

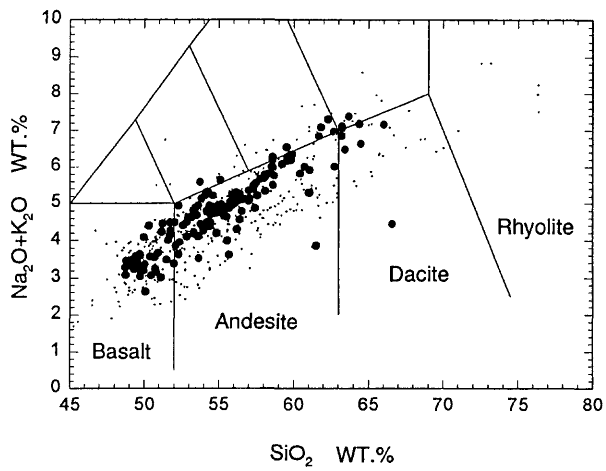


Figure 62. Total alkalies-silica diagram of Makushin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

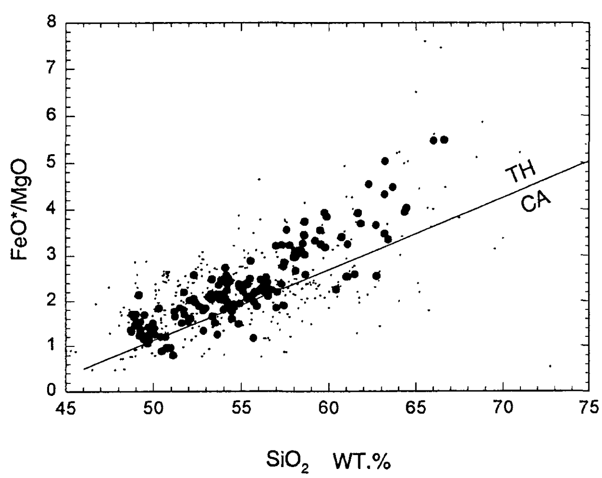


Figure 63. FeO/MgO-silica diagram of Makushin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

NAME AND LOCATION

NAME:	BOGOSLOF VOLCANO
SYNONYMS:	BOGOSLOF ISLAND
TYPE:	STRATOVOLCANO
LOCATION:	BOGOSLOF ISLAND, 43 KM NORTH OF UMNAK ISLAND AND ABOUT 312 KM WEST-SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	53°56'N, 168°02'W
ELEVATION:	101 M (U.S. COAST AND GEODETIC SURVEY, 1947); 150 M (HARBIN, 1994)
USGS 1:250,000 QUADRANGLE:	UMNAK
CAVW NUMBER:	1101-30

Form and structure

Bogoslof Island is the largest of a cluster of small, low lying islands that comprise the emergent summit of a large submarine stratovolcano that rises more than 1500 m above the Bering Sea floor (Byers, 1959, plate 39). The volcano appears to be a back-arc feature as it occurs well behind the volcanic front of the main Aleutian arc. The island has undergone dramatic changes in size and shape during historical time, an evolution that has been unusually well observed and recorded for such an isolated volcano.

The island is presently shaped like an irregular isosceles triangle about 2.0 km long and 0.75 km wide covering an area of 0.75 km^2 (fig. 64). Castle Rock, a steep, twin-spired pinnacle along the southwest side of the island is the eroded remnant of a dome extruded in 1796. Vent agglomerate produced during the explosive phase of that eruption lies in fault contact with the dome material and is best exposed in the southeast part of the sea cliff below Castle Rock.

A blanket of basaltic agglomerate and ash is plastered against the steep north and east flanks of Castle Rock and extends north and east as a broad terrace. This material is interpreted by Byers (1959) to have been deposited primarily during the 1926 eruption but may also be from earlier Bogoslof eruptions. The tephra layer, along with a basaltic dome extruded in early 1927, comprises most of the area of the island, which is steadily being reduced by marine erosion. The 1927 dome is a rounded knob more than 40 m high and 305 m in diameter on the northwest coast, and fronts an arcuate salt water lagoon to the east. Cobble-boulder beaches fringe the island's north and southeast shores and a sand beach extends along the eastern margin.

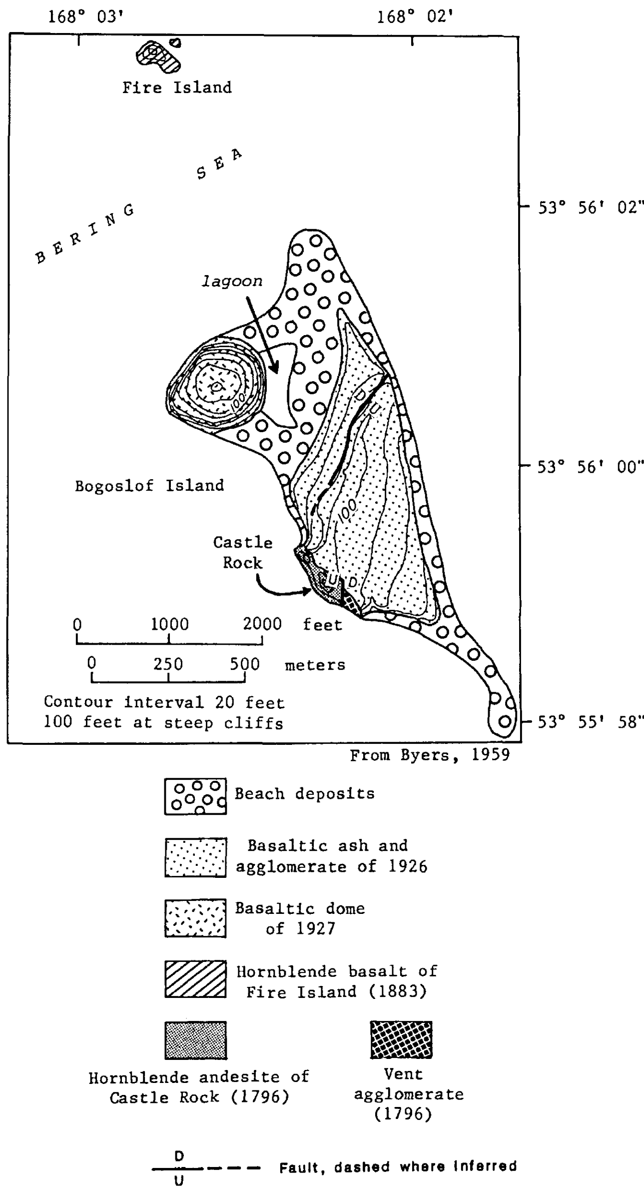


Figure 64. Generalized geologic map of Bogoslof island modified from Byers, (1959).

About 610 m northwest of Bogoslof lies Fire Island, a tiny flat-topped stack resembling a lighthouse. The island is the remnant of a dome extruded in 1883. Domes produced during other episodes of Bogoslof volcanism have been completely destroyed through subsequent explosive eruption and marine erosion.

Volcanic activity

May 1796-1804	Jan. 1907-
Sept. 19 1806-1823	Sept. 1909-1910
Sept. 27, 1883 (1882?) - 1895	July 1926-1931 (?)
March 1, 1906-Jan. 1907 (?)	Sept. 1951
	July 1992

A small rocky prominence, called Ship Island or Ship Rock, was observed in 1768 by Russian explorers at the approximate site of Bogoslof Island; it disappeared through marine erosion by the end of the 19th century and little is known concerning its composition and origin (Byers, 1959). An explosive eruption of debris in 1796, followed by extrusion of viscous lava, built a second island by 1804, about 0.6 km south of Ship Rock. The second island was known successively as Ioann Bogoslof, Old Bogoslof and Castle Rock. The vent agglomerate and hornblende andesite of Castle Rock, exposed on the southwest end of modern Bogoslof Island, represent early and late products, respectively, of this eruption (Byers, 1959). Russian-American Company personnel on Umnak Island reported three days of earthquakes and brilliant flames during the creation of the Ioann Bogoslof, and almost eight years elapsed before it had cooled sufficiently to permit first-hand examination (Henning and others, 1976). In 1806, lava flowed from the summit north into the sea creating new land and increasing the summit altitude. This increase in size and altitude appears to have ended in 1823, when the dome had a pyramidal form at least 110 m high (Byers, 1959).

In 1882, Unalaska residents noticed steam rising from the ocean about 2 km north of Ship Rock (Byers, 1959). On September 17, 1883, a volcanic dome was first observed at this site, and one month later a violent eruption deposited ash on the village of Unalaska, 96 km to the east. The new island was called Grewingk or New Bogoslof; its erosional remnant is now designated Fire Island. In 1884, the cone (presumably the dome was destroyed) had a diameter of about 1 km, a craggy profile, and pinnacles that reached an altitude of about 150 m (Byers, 1959). In May of that year, officers of the Revenue Marine steamer Corwin examined the Bogoslof group. They found Ship Rock, Old Bogoslof and New Bogoslof connected into a single land mass by bars of volcanic debris and sand-boulder beaches. Second Lieutenant J.C. Cantwell observed 15 separate vents on the upper third of New Bogoslof cone issuing jets of steam with great force and regularity; thick sulfur deposits surrounded most of the vents, and the temperature in a crack near the summit was estimated to exceed 260°C. Great quantities of fine ash coated the slopes, but little coarse ejecta or flow lava was encountered (Henning and others, 1976). In 1895, New Bogoslof was still steaming vigorously, and was a flat-topped structure about 90 m high, separated by several hundred meters of open water from Old Bogoslof. By 1897 New Bogoslof had cooled (Byers, 1959).

In 1906, a dome bearing a broken spire at its summit appeared midway between Old and New Bogoslof. This structure, called Metcalf Cone, exploded in late 1906 or early 1907, destroying its southern extent, but soon thereafter another dome emerged, joining Metcalf Cone and Old Bogoslof (Byers, 1959). This dome, McCulloch Peak, was subsequently obliterated in a violent explosion on September 1, 1907 that showered Unalaska village with 0.5 cm of ash and mantled the remaining Bogoslof islands with debris. Yet another conical islet, Tahoma Peak, was formed during the winter of 1909-1910 in the bay created by the destruction of McCulloch Peak. Explosions in September of 1910 produced a deep crater at its summit (Byers, 1959); this was apparently the first documented crater in a Bogoslof dome (Jaggar, 1930).

By 1922 the last vestiges of Metcalf Cone and Tahoma Peak had been removed through continued explosions, collapse, and marine erosion (Byers, 1959). New Bogoslof (now called Fire Island by the U.S. Coast and Geodetic Survey) was reduced to a small islet, and Old Bogoslof (Castle Rock) to two rocky horns. Renewed submarine explosions between the two islands in 1926 produced another conical dome by early 1927. A tephra ring, located about 3 m above high tide, surrounded the new dome and connected it to Fire Island and Castle Rock, thus forming a single elongate island. By July, 1927, the circular dome was 60 m high and 300 m across and was circled by a shallow lagoon of warm water. On October 31, 1931, the dome was still incandescent, and floating pumice was observed south of the island (Byers, 1959, p. 361). By 1935 an open water strait again separated Fire Island from the larger southern island; the southern island was then officially called Bogoslof and comprised Castle Rock, the pyroclastics produced in 1926, and the dome formed in 1927. A possible submarine eruption or landslide occurred in September, 1951 when a vessel traversed 3 km of "muddy water" adjacent to Bogoslof; no further volcanism has been reported (Byers, 1959).

The most recent activity occurred in July 1992 when steam and ash plumes were reported rising up to 8 km above the main island (Smithsonian Institution, 1992). U.S. Coast Guard observations and photography on July 24 confirmed that a new 100-m-high lava dome had been

continued

constructed on the north tip of the island adjacent to the remnant 1927 lava dome. Harbin (1994) reports this dome to be about 150 m high, 150 m x 275 m in diameter, and composed of hornblende basaltic andesite. Eruptive activity had subsided by late July, 1992; several active fumaroles with temperatures as high as 165° were found on the dome in 1994 (Harbin, 1994).

Composition

Considerable detailed petrographic information is available for many phases of Bogoslof's eruptive history. Vent agglomerate of the 1796 eruption contains abundant angular fragments of limonite-stained hornblende-bearing andesitic porphyry (figs. 65, 66) in a grayish matrix of ash (Byers, 1959). The porphyry fragments resemble the eroded remnant of the 1796 lava dome of Castle Rock (Byers, 1959; Arculus and others, 1977).

The 1883 Fire Island dome is composed of nepheline-normative hornblende basalt (Arculus and others, 1977). Ash that fell at Unalaska village during the 1883 eruption has a slightly higher silica content than that of the lava flows (Byers, 1959).

Basaltic ash and agglomerate produced in 1926 comprise almost 3 m of section at the north end of Bogoslof Island. A sample examined by Arculus and others (1977) contains about 10% hornblende phenocrysts, zoned plagioclase (bytownite to andesine), calcic augite, and scattered xenoliths of hornblende gabbro. Lava samples from fragments in the agglomerate and from the 1927 dome consists of hornblende phenocrysts and inconspicuous phenocrysts of plagioclase and clinopyroxene; the groundmass of both rock types is microlitic plagioclase, clinopyroxene, opaque oxides and glass (Byers, 1959). The dome lava differs from the tephra in that it has more altered amphiboles and additional groundmass phase of anorthoclase(?). As pointed out by Byers (1961), Bogoslof lava flows erupted from 1796 to 1927 are progressively less siliceous.

No petrographic information is available for the constituents of Ship Rock, Metcalf Cone, McCulloch Peak or Tahoma Peak.

Bogoslof lava flows are more alkalic and more SiO_2-undersaturated than lava flows on adjacent Umnak Island (Byers, 1961, p. 104-105). Amphibole-bearing basalts are rare in island arcs, and the absence of olivine and abundance of amphibole in basalts is unusual (Arculus and others, 1977). Based mainly on isotopic ratios, Arculus and others (1977) suggest that the Bogoslof eruptions of 1796 and 1926-27, though separated by geologically very short time intervals, were associated with genetically separate magmas and are not directly related by simple fractional crystallization.

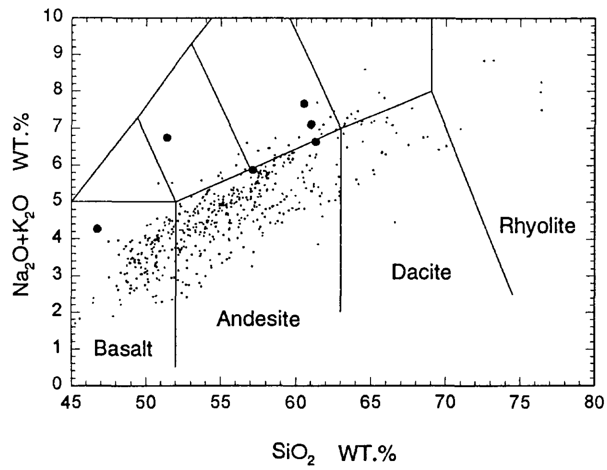


Figure 65. Total alkalies-silica diagram of Bogoslof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

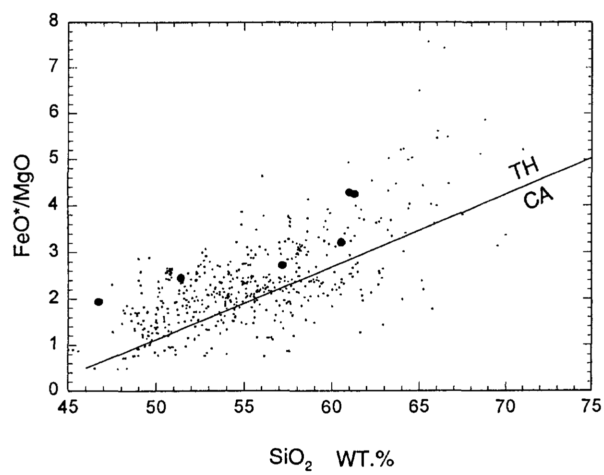


Figure 66. FeO/MgO-silica diagram of Bogoslof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Okmok volcano
Synonyms:	Okmok Caldera
Type:	Central shield complex with nested caldera
Location:	Umnak Island, in the eastern Aleutian Islands about 340 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	53°24'N, 168°10'W
Elevation:	1073 m
USGS 1:250,000 quadrangle:	Umnak
CAVW Number:	1102-29

Form and structure

Okmok Volcano occupies most of northeastern Umnak Island (fig. 67). The volcano, built on a base of Tertiary volcanic rocks, consists of three rock series: older flows and pyroclastic beds of a pre-caldera shield complex; pyroclastic deposits of two major caldera-forming eruptions; and a post-caldera field of small cones and lava flows that includes historically active vents within the caldera (Byers, 1959).

Construction of the pre-caldera volcano began in late Tertiary or early Quaternary time. Two whole-rock K-Ar analyses of a sample of basaltic lava are 1.7 ± .2 and 2.1 ± .2 m.y. (Bingham and Stone, 1973). Basaltic flows and pyroclastics compose most of the older rocks (unit Qbm, fig. 67); flows are more voluminous than pyroclastic deposits (see Byers, 1959, plate 41). Vent agglomerate is exposed in the walls of the younger caldera and tuffs and tuff-breccias occur further down the flanks. Flows and pyroclastic beds dip radially from the caldera at less than 5° in most sectors, except for local steepening and reversal of dips at former vents. Such radial dips suggest that the older complex was a central volcano with parasitic vents. Domes and plugs of andesitic and rhyolitic composition and basaltic lava flows (Byers, 1959, p. 312) mark minor vents that were active

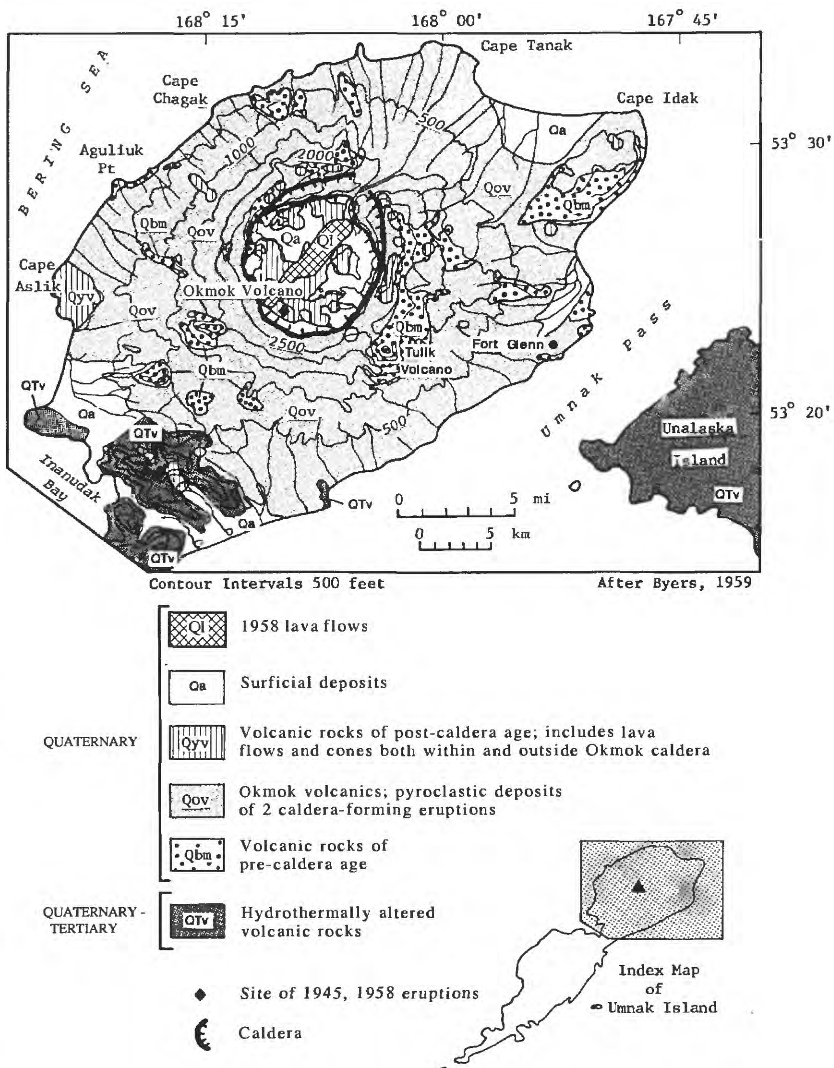


Figure 67. Generalized geologic map of Okmok caldera and vicinity after Byers (1959).

before caldera formation; these rocks are only slightly modified by erosion and are presumably early post-glacial in age.

Catastrophic pyroclastic eruptions resulted in the formation of 2 overlapping calderas (Byers, 1959, p. 274). The deposits, referred to as the Okmok Volcanics (Byers, 1959, p. 314), are mainly thick, non-sorted agglomerate at the caldera rim overlain by ash-flow tuffs, and airfall ash and pumice that cover the flanks of the volcano to the shoreline (unit Qov, fig. 58). Two arcuate ridges located about 1.5 km north and east of the main topographic basin are the remnants of the older caldera, which formed about 8200 years ago (Black, 1975). The topographic basin of the younger caldera is about 9.5 km in diameter; the maximum elevation of the rim is about 1070 m and the mean elevation of the floor, exclusive of areas underlain by post-caldera volcanic rocks, is about 370 m. The occurrence of 2 major ash-flow sheets, separated by a basalt flow and an erosional unconformity, supports the two caldera-forming eruptions (Miller and Smith, 1975). Miller and Smith (1987) have reported a maximum ^{14}C age of 2400 ± 200 yr for the second and younger caldera-forming eruption.

Numerous small flows, plugs, and cinder cones on the flanks of Okmok Volcano are interbedded with or overlie the upper parts of the Okmok Volcanics (unit Qyv, fig. 58). Within the caldera, the oldest post-caldera deposits are brecciated pillow lavas and pyroclastic rocks that were deposited in a caldera lake. The lake attained a maximum depth of about 150 m and the upper surface reached an elevation of about 475 m, at which point it overtopped the low point of the caldera rim. A small shallow lake located near the outlet of the caldera is all that remains today. Three dissected tuff cones may have been produced by eruptions beneath the former caldera lake. Other cinder cones occur atop pillow lavas; such cones apparently breached the surface of the former lake. Cinder cones and associated lava flows that are younger than the caldera lake are identified by structures and textures characteristic of subaerial eruption. The documented eruption of 1945 occurred at a cinder cone near the southwest caldera wall (Byers, 1959; Robinson, 1948); this cone may have been the site of all historical activity of Okmok volcano. Hot springs and fumaroles occur both within Okmok caldera and at Hot Springs Cove, 20 km to the southwest.

Volcanic activity

1805	June 1943
Mar 1, 1817	June-Dec., 1945
1824-30	Aug., 1958
1878	Oct., 1960
1899	March 24, 1981
March 21-May 13,1931	July 8, 1983
1936	Nov. 1986-Feb. 1988
1938	Feb. 11, 1997-April 1, 1997

Several major eruptions and a number of minor events have occurred in Okmok caldera in historic time. Many of these episodes were originally ascribed to Tulik Volcano, 3 km southeast of Okmok but this deeply glaciated peak almost certainly has not erupted in the last 200 years (Coats, 1950). Early records of eruptive activity at Okmok are sketchy. Several vents on the caldera floor have probably been involved. Major explosive eruptions occurred in 1817 and 1899 (Coats, 1950); the former deposited large quantities of coarse ejecta to the north along Cape Tanak and buried the Aleut village situated there (see Dall, 1870). Petroff (1884, citing Grewingk, 1850) refers to a "flow of ashes" during the 1817 eruption. Formation of a new crater accompanied by earthquakes and a tsunami reportedly occurred in 1878 (Hantke, 1951). Less violent activity over the past 200 years probably produced lava flows (Byers, 1959) such as during eruptions in the 1820's, 1931, 1938, and 1945.

The course of the 1945 eruption is well documented (Robinson, 1948; Wilcox, 1959). On June 1, a sharp earthquake was felt at Fort Glenn army base, 16 km east of Okmok. The caldera itself was hidden by persistent low clouds until June 4, when pilots reported black ash rising to 3000 m near the southern rim. Observations on June 10 revealed ash and lava bombs up to 1 m long being ejected from a small cinder cone near the southwest edge of the caldera floor. A lava tongue 12 m thick issued from the cone's base at a rate of 0.15 m/s. This flow followed a circular path, undermining a large ice mass in the southern part of the caldera; it eventually extended about 6.5 km during a month of intermittent activity. Air-borne ash was carried southeast and deposited on the ice of the caldera floor to a depth of 1 m; several centimeters of ash collected on and immediately outside the caldera rim, and light traces were observed as far as 14.5 km from the active vent.

By late July, lava effusion had ceased and the eruption column was comprised principally of steam containing only minor amounts of ash. A brief resurgence of activity in December produced light ash fall and a small lava flow northeast of the cone; temperatures up to 1100°C were measured in this flow soon after its eruption. Although plans were made to evacuate Fort Glenn in early June, such action proved unnecessary. Ash fall at the military base was negligible and caused no significant damage to machinery or facilities; lava was confined within the caldera. The cone increased 30 m in height and developed a broad central crater during the 1945 event.

Eruptions including lava fountaining were reported in 1958 and 1960 (Anchorage Daily News, August 16 and 19, 1958; Anchorage Times, August 15, 1958; October 17, 1960).

A commercial pilot observed an eruption on March 24, 1981 from the cone of the 1945 eruption. The ash and steam plume rose to about 5500 m altitude and drifted to the northwest (Bulletin of Volcanic Eruptions, 1987).

On July 8, 1983 a small ash eruption was observed by a local pilot and on satellite imagery (Newhall and Dzurisin, 1988). A commercial pilot also reported a steam and ash plume above a cinder cone (probably the 1945 cone) in the southwestern part of the caldera on November 18, 1986. Another small ash eruption occurred from the same cone on January 5, 1987 about 13 hours after a shallow, magnitude 6.6 (Ms) earthquake struck 130 km south of Okmok. A small pyroclastic flow was produced on the southeast flank of the cone and ash emission from the cone continued intermittently from January 1987 to February 1988 (Smithsonian Institution, 1983, 1986, 1987, 1988).

The most recent eruption at Okmok began on or about February 11, 1997 when a steam and possible ash plume was reported by pilots. An eruption from Cone A (Byers, 1959), located on the caldera floor near the south rim (fig. 67) and last active in 1945, was verified by additional pilot reports and satellite imagery. By February 13, the intracaldera cone was in a state of moderate strombolian eruption with a dark ash plume rising from the caldera and a lava flow extending from the cone. The eruption produced lava fountains, multiple spatter-fed and effusive lava flows that nearly crossed the caldera floor. Frequent explosive events sent ash to 16,000 ft ASL and at least once to a reported 30,000 ft ASL during the first two months of the eruption. Satellite imagery and reports from pilots and ground observers indicate that the main phase of the eruption continued sporadically through early April although steam emissions and occasional minor ash bursts continued for several more months. The exact end of eruptive activity is uncertain because of the remote location and poor weather frequently obscuring visibility.

Composition

Flows of the pre-caldera volcano are mainly basalts; some smaller flows are more silicic (figs, 68, 69). The basalt is both aphyric and porphyritic. Phenocrysts include olivine, augite, and plagioclase, with or without opaque phases. Byers (1959; 1961) and Nye and Reid (1986) present analyses of pre-caldera basalts, with a range of SiO_2 content from 46.3% to 52.3%. Rhyolite, in the form of alternating bands of dense black obsidian and light grey felsite, occurs as an inferred dome in a radial fracture near the 8200 yr caldera rim. The rhyolite is presumably younger than most pre-caldera basaltic rocks, and is covered by Okmok volcanics. The youngest pre-caldera rocks are a sequence of aphyric basaltic flows, exposed only in the north wall of the caldera, with a total exposed thickness of 150 m.

Four analyses of the Okmok volcanics range from 54.4% to 65.5% SiO_2 (Byers, 1959). Two samples from the lower, agglomeratic part of the Okmok volcanics are distinctly lower in silica content (54.4% and 57.4%) than are two samples from the upper, pyroclastic-rich portion (63.8% and 67.6%).

Post-caldera volcanic rocks within Okmok Caldera are mainly of basaltic composition.

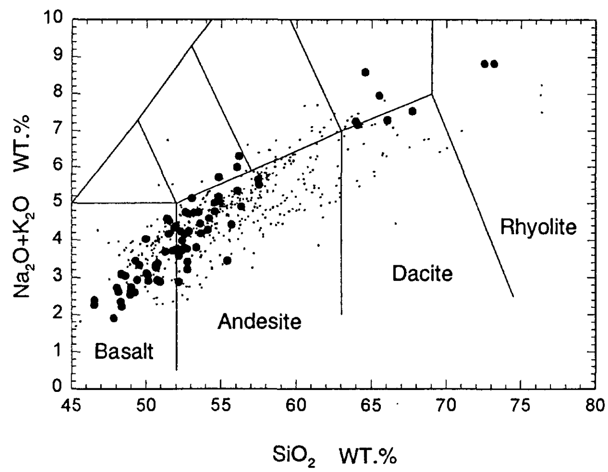


Figure 68. Total alkalies-silica diagram of Okmok volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

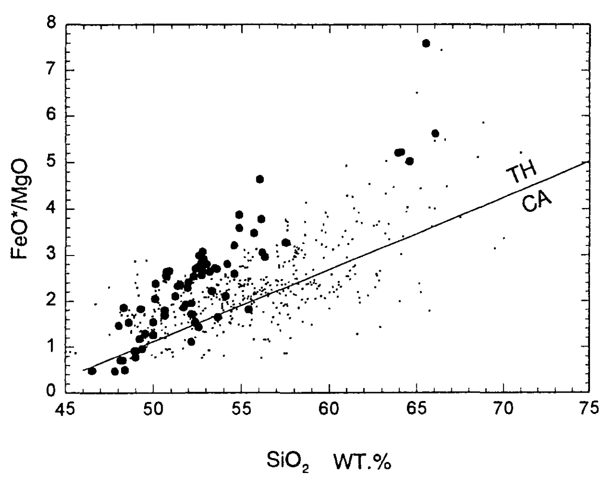


Figure 69. FeO/MgO-silica diagram of Okmok volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

page 61 follows

Name and Location

NAME:	VSEVIDOF VOLCANO
SYNONYMS:	MOUNT VSEVIDOF
TYPE:	STRATOVOLCANO
LOCATION:	UMNAK ISLAND, WESTERNMOST OF THE FOX ISLAND GROUP N THE EASTERN ALEUTIAN ISLANDS, ABOUT 388 KM WEST SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	53°08'N, 168°41'W
ELEVATION:	2149 M
USGS 1:250,000 QUADRANGLE:	UMNAK
CAVW NUMBER:	1101-27

Form and structure

Mount Vsevidof is a symmetrical stratovolcano near the southwest end of Umnak Island. It is about 10 km wide at the base (fig. 70) and steepens from 15° at 300 m altitude to about 30° near the summit. A circular crater, 1.2 km in diameter, occupies the summit. Glacial ice fills the crater and extends down the north and east flanks of the cone; some of these glacial tongues have incised narrow canyons up to 120 m deep.

A chain of small cinder cones (unit Qc, fig. 70) below altitude 1220 m parallels a rift on the western flank (Byers, 1959). Young flows of andesite and dacite (unit Qvf, fig. 70) were extruded from this rift and from other vents on north and south flanks of the cone. Pyroclastic deposits, apparently products of a culminating summit eruption, attain a thickness of more than 30 m at the crater but thin downslope.

The oldest Vsevidof flows (unit Qvba, fig.70) are overlain by till of the last major glaciation, but the bulk of the cone is believed to be of post-glacial, i.e., Holocene, age. The cone is locally underlain by hypersthene-andesite lava flows and pyroclastic rocks of the more deeply eroded Mount Recheshnoi. Lava flows from both Recheshnoi and Vsevidof unconformably overlie a basement of probable early to middle Tertiary age including plutonic rocks (unit Tdp, fig. 70) and altered sedimentary and metamorphic rocks.

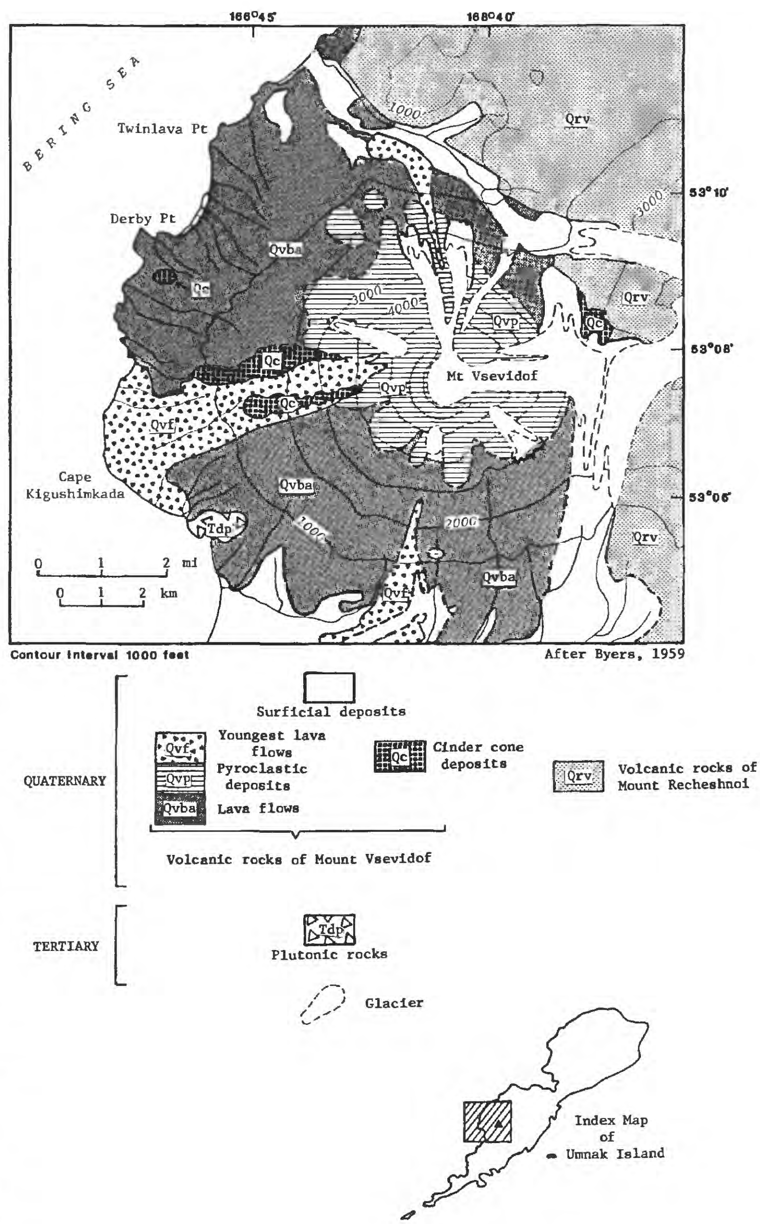


Figure 70. Generalized geologic map of Mount Vsevidof volcano after Byers (1959).

Volcanic activity

1784
May 30, 1790
1817
1830
1878
1880
March 11-12, 1957?

Several episodes of minor volcanism have been attributed to Vsevidof during historical time (see Byers, 1959; Coats, 1950, Becker, 1898). "Smoke" was reported above the cone in 1784, 1790, and 1880. Activity was noted on the southwest end of Umnak Island in 1830 (Petroff, 1884, citing Grewingk, 1850). The uppermost pyroclastic beds may have formed during one of these early eruptions (Byers, 1959, p. 305). Recorded activity in 1878 may have been from a radial fissure eruption on the west flank; this event may have produced the youngest dacite flow, which extends west-southwest to Cape Kigushimkada (Byers, 1959). Another phreatic eruption, possibly from the west rift, occurred in March, 1957 (Byers, 1959, p. 305, citing article in Anchorage Times of March 12, 1957). Earthquakes were felt throughout southeast Umnak, and residents of Nikolski, the island's main village 24 km southwest of Vsevidof, reportedly observed discharges of steam and volcanic ash. However, in a subsequent article (Anchorage Times, March 15, 1957) a pilot reportedly observed no evidence of a volcanic eruption.

Composition

Mount Vesvidof rocks are thoeliitic in character and composed (figs. 71, 72) of an older sequence of basaltic and andesitic lava flows, an intermediate sequence of dacitic pumice and andesitic scoria, and a younger series of more silicic flows of which one may have been erupted during historical time (Byers, 1961, p. 97). The older flows contain scarce phenocrysts (total 2 to 3%) of zoned plagioclase, euhedral olivine and augite in a groundmass of subparallel plagioclase microlites (Byers, 1959, p. 306).

The younger more silicic flows contain up to 5% (by volume) more phenocrysts than the older lava flows (Byers, 1959). Phenocrysts consist of hypersthene augite and plagioclase and the groundmass tends to have more orthoclase than that of the older flows.

Two distinct pyroclastic beds of the intermediate series may have formed in a culminating summit eruption that occurred no more than several thousand years ago (Byers, 1959). The lowermost is a welded, greyish-orange dacitic pumice bed; the lower bed grades upwards into a layer of irregularly banded andesitic scoria with minor clots of black andesitic glass. Both the pumice and scoria beds contain 10 to 15% accessory blocks of andesite and diorite.

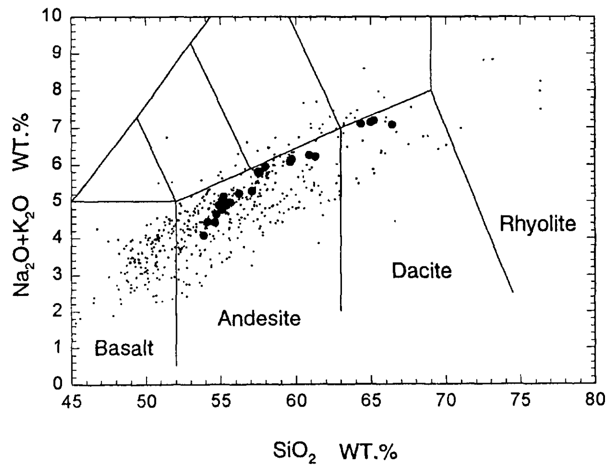


Figure 71. Total alkalies-silica diagram of Vsevidof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

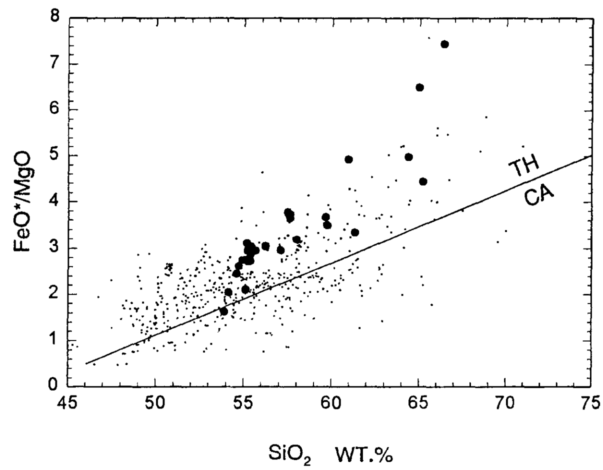


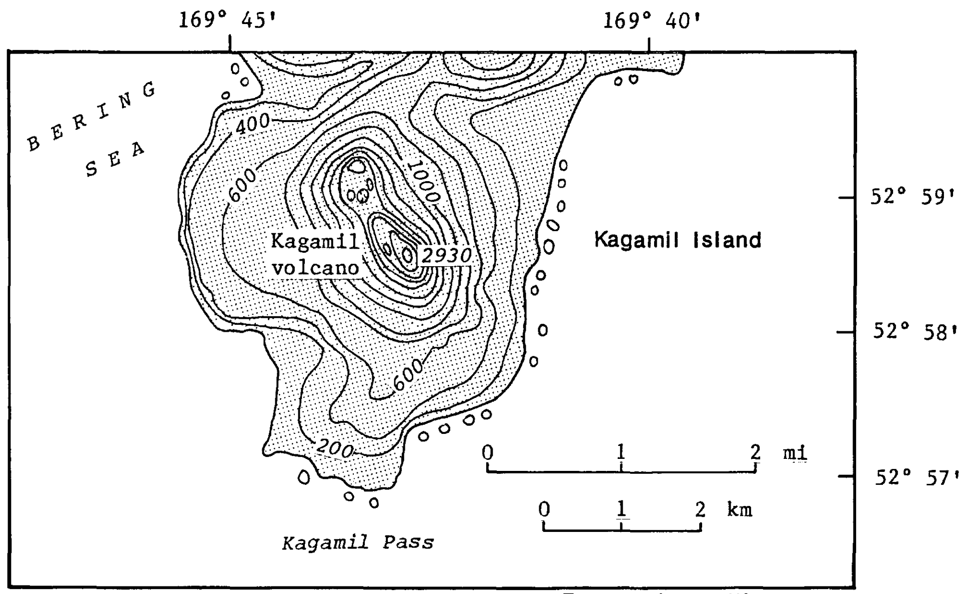
Figure 72. FeO/MgO-silica diagram of Vsevidof volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Kagamil volcano
Synonyms:	Kagamil Island
Type:	Stratovolcano
Location:	Kagamil Island, northeasternmost of the Islands of the Four Mountains group; 467 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	52°58'N, 169°43'W
Elevation:	893 m
USGS 1:250,000 quadrangle:	Samalga Island
CAVW Number:	1101-26

Form and structure

Kagamil volcano occupies most of the southern half of Kagamil Island, 55 km west of Umnak Island in the eastern Aleutian arc. The volcano consists of two cones and has an oval shape, 3.5 by 2 km in basal dimensions, with the long axis trending northwest-southeast (fig. 73). The larger cone at the southeastern end of the volcano has an elevation of 893 m; the cone at the northwestern end is about 610m high and appears to have two small summit craters. Hot springs and fumaroles occur near the southeastern shore of the island (Sekora, 1973).



Contour interval 200 feet

Topography modified from U.S. Geological Survey Samalga Island Quadrangle map (1 : 250,000 scale)

Figure 73. Topographic map of Kagamil volcano.

Both cones appear to be virtually undissected by erosion, indicating a post-glacial age. The cones rise from a more gently sloping surface with mean elevation of about 200 m.

Volcanic activity

December, 1929

Historical reports of volcanism of the island are meager. Veniaminov (1840) stated that Kagamil "formerly" flamed and smoked and solfataric activity was reported in the 1800's on Kagamil Island (Waring, 1965). Coats (1950) mentioned only a single period of activity—in December, 1929—but gives little information on the eruptive pattern or products of this event. Murie (1959) noted that "noisy steam jets issued from a rocky bluff and rumblings could be heard under the boulder beach" during a biological reconnaissance of Kagamil conducted in 1937.

Composition

No information is available concerning the composition of Kagamil Volcano. Presumably it consists of intercalated lava flows and pyroclastics of basaltic and/or andesitic composition like other cones in the eastern Aleutian arc.

page 65 follows

Name and location

Name:	Cleveland volcano
Synonyms:	Mt. Cleveland
Type:	Stratovolcano
Location:	Chuginadak Island, east central part of Aleutian arc in the Islands of the Four Mountains, 490 km west of the tip of the Alaskan Peninsula.
Latitude, longitude:	52o49'N, 169o57'W
Elevation:	1730 m
USGS 1:250,000 quadrangle:	Samalga Island
CAVW Number:	1101-24

Form and structure

Mt. Cleveland is a stratovolcano that comprises the entire western half of Chuginadak Island, 40 km west of Umnak (fig. 74). Distinctively conical and symmetrical in form, Cleveland is about 8.5 km in diameter and is joined to the rugged, though lower, eastern half of the island by a low, narrow strip of land (fig. 74). Sekora (1973, p. 36) reports that this strip is dotted with "lava flow, cinder and ash patches, and conical hills."

Although it is the tallest member of the Four Mountains group, Mt. Cleveland is reported to lose snow more rapidly than neighboring peaks presumably from anomalous heat generation (Sekora, 1973, p. 27). Hot springs were noted at the base of a volcano on Chuginagak Island in the 1800's (Waring, 1965).

Like many other Aleutian volcanoes, the lower flanks of Mt. Cleveland up to about the 300 m elevation are more irregular and dissected than the upper flanks. The cones on the eastern half of Chuginadak Island are dissected by broad valleys presumably eroded in part by glaciers; in contrast, the upper cone of Mt. Cleveland is virtually undissected.

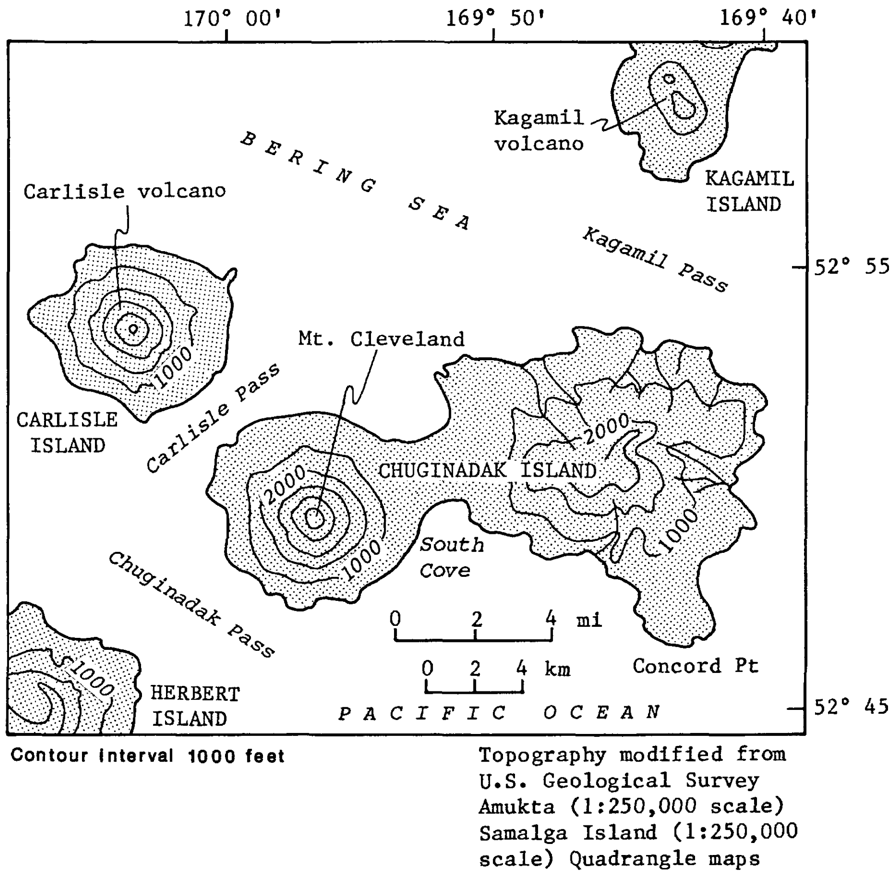


Figure 74. Topographic map of Mt. Cleveland and other volcanoes of the Islands of the Four Mountains.

Volcanic activity

1893
1897
1929(?)
Jan., 1932
1938
June 10-12, 1944
Nov. - Dec., 1951(?)
1975(?)
April 28 - July, 1986
June - August, 1987
May 25, 1994

The Islands of the Four Mountains area are remote and uninhabited; consequently, information exists on only three—1932, 1944, and 1953—of the eight reported episodes of eruptive activity before 1982 (Coats, 1950; Powers, 1958; Simkin and others, 1981; Smithsonian Institution, 1986, no. 12). It is possible that several late 18th and 19th century eruptions attributed to Carlisle Volcano should in fact be ascribed to Cleveland (Coats, 1950).

The 1932 eruption, which began in January and proceeded for an indeterminate length of time, was explosive in nature.

The 1944 eruption was characterized by two days of Vulcanian explosive activity from the central crater, which produced lava flows as well as tephra (Simkin and others, 1981). Severe earthquakes were felt throughout the episode. Clouds of steam and ash rose to 6000 m and lava flows extended 5 km from the central crater. Boulders "as big as automobiles" were ejected across the island and for a considerable distance into the surrounding ocean (Alaskan Sportsman, 1944; Freiday, 1945). This eruption of Mt. Cleveland has the infamous distinction of having resulted in the only reported historical fatality attributable to volcanic activity in Alaska. A small detachment of the Eleventh Army Air Force was stationed on Chuginadak Island and one soldier who apparently advanced too close to the active vent during a reconnaissance investigation was killed (Smithsonian Institution, 1985); the soldier was possibly killed by a mudslide (Lowney, 1946). Army personnel and equipment were evacuated from the island and the outpost was abandoned for the duration of the war (Anchorage Daily Times, June 26, 1944; Robinson, 1948).

On June 25, 1953, a military observer reported dark ash on the snow around the vent of Mt. Cleveland (report on file at Geophysical Institution, University of Alaska, Fairbanks).

An increase in commercial air and sea traffic subsequent to 1980 has resulted in more frequent reports of activity on Mt. Cleveland. Fairly continuous fumarolic activity has occurred since 1982 (Smithsonian Institution, 1985). In May through July of 1986 minor ash, steam, and incandescent zones in the summit crater were reported (Smithsonian Institution, 1986, nos. 4, 6).

Activity during June - August of 1987 included ash and steam emission, minor lava flows, and a short interval of active lava fountaining from the summit crater vent; an incandescent feature was observed in the summit crater. On August 28, 1987, a large eruption of Mt. Cleveland was recorded by remote sensing and satellite imagery. A sustained rumbling was audible to a ground party on Kagamil Island, 25 km to the northeast, however, overcast conditions prevented direct observation. An approximate 10-km-high plume, elongated in a west-northwest direction, was recognized on satellite images (Smithsonian Institution, no. 6, 1987; no. 7, 1987; no. 8, 1987). Pilot reports received by the Alaska Volcano Observatory indicate that on May 25, 1994, an explosive event sent a short-lived ash plume to ~10.5 km altitude.

Composition

No information is available.

NAME AND LOCATION

NAME:	CARLISLE VOLCANO
SYNONYMS:	CARLISLE ISLAND
TYPE:	STRATOVOLCANO
LOCATION:	CARLISLE ISLAND, IN THE ISLANDS OF THE FOUR MOUNTAINS GROUP; ABOUT 491 KM WEST-SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	52°54'N, 170°03'W
ELEVATION:	1620 M
USGS 1:250,000 QUADRANGLE:	AMUKTA
CAVW NUMBER:	1101-23

Form and structure

Carlisle Island consists of a single symmetric cone, 1524 m high and 6.5 km in diameter at sea level (fig. 74); its steep upper slopes are generally snow-covered year round. Little is known about Carlisle volcano's structure and composition. The topography suggests that the lower slopes of Carlisle are slightly more irregular in form and more dissected by erosion than are the uppermost slopes. According to Sekora (1973), the western margin of the island consists of a small plateau at an elevation of 50 m, suggesting that the Carlisle stratovolcano is constructed on an emergent marine terrace.

Volcanic activity

1774
1828
1838
Nov. 1987

Carlisle was reported "active" in 1774 and 1828, and "smoke" was noted above the island in 1838 (Coats, 1950). However, documentation of these episodes is poor. Various names were applied to Carlisle on early hydrographic charts, including Uliaga, Kigalgain and variants thereof; it was also sometimes referred to along with the western half of Chuginadak Island, as Tanak-Angunak. It is thus possible that some of the activity ascribed to Carlisle should be attributed to Uliaga or Mount Cleveland (Coats, 1950). Petroff (1884, citing Grewingk, 1850) lists activity at "Chegulakh" (53° 08'N, 169° 24'W) and "Ouliagan" (52°53'N, 169°40'W) for the period 1700-1710. Coordinates for "Chegulakh" plot near modern Kagamil volcano, whereas "Ouliagan" could actually be Carlisle Volcano or Mount Cleveland. A separate listing is given for "Taunakh-Angunakh", which is either Mount Cleveland on Chuginadak Island or Carlisle Volcano. However, a separate listing is also given for Kagamil and there is some question as to whether "Chegulakh" actually refers to Kagamil. Furthermore, other entries for activity in "the Four Peaks islands" are given for 1796-1800. Any of the activity during 1700-1710, 1774, 1796-1800, 1828, and 1838 could refer to Carlisle Volcano as well as to Mount Cleveland or even Kagamil Volcano.

The most recent activity occurred during mid to late 1987. Steam was reported emerging from the summit of Carlisle on August 28, and on November 16, two pilots observed a plume of steam and some ash rising to 2500 m altitude and streaming 30 km east-northeast from the summit of a volcano they tentatively identified as Carlisle; however, the eruption could possibly have been from Mt. Cleveland, 10 km to the southeast, which had also recently been active (Smithsonian Institution, 1987.

Composition

Carlisle Island has not been mapped. The volcano is assumed to consist of interbedded basaltic and/or andesitic lava flows and pyroclastics.

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Name and Location

Name:	Yunaska volcanic complex
Synonyms:	Yunaska Island
Type:	Shield volcano with caldera and associated stratovolcanoes, cinder cones and lava field
Location:	Yunaska Island, in the Islands of the Four Mountains group; about 540 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	52°38'N, 170°38'W
Elevation:	550 m
USGS 1:250,000 quadrangle:	Amukta
CAVW Number:	1101-21

Form and structure

Yunaska Island lies near the west end of the Islands of the Four Mountains group and is flanked by Chagulak and Amukta Islands on the west and the remainder of the group on the east. Yunaska Island is roughly oval in form and about 23 km long. It consists of two volcanic centers separated by a flat valley with moderately sloping walls (fig.75). The western volcano, 950 m high, is the eroded remnant of a series of four overlapping stratocones (Nicolaysen and others, 1992); a group of cinder cones and fissure flows extends from the west end of the stratocone complex. This western volcano has presumably not been active in historical time.

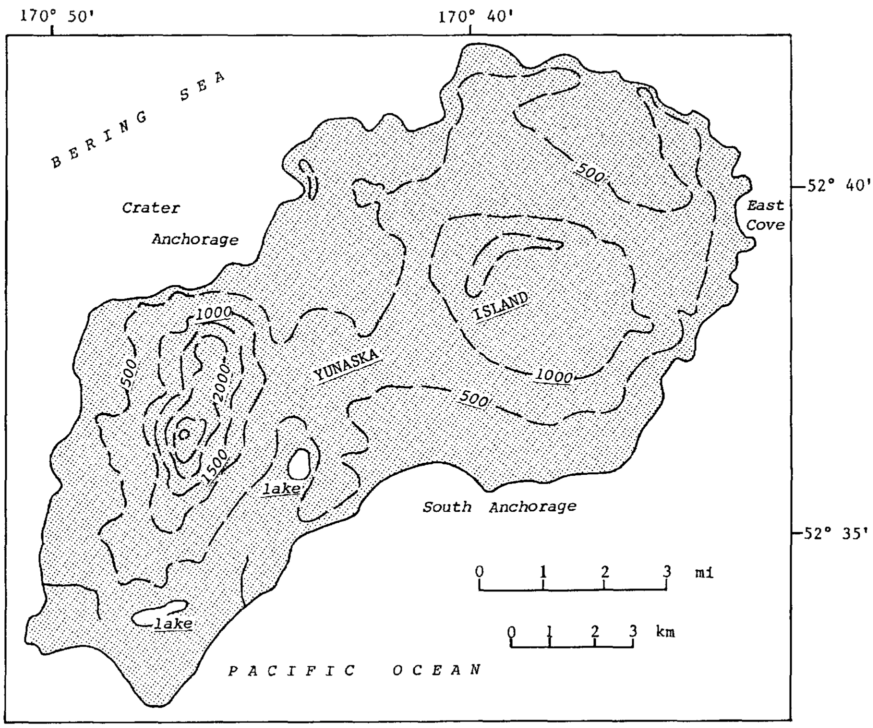


Figure 75. Topographic map of Yunaska volcano.

The eastern volcanic center, to which all recent Yunaska volcanism has been attributed, has been described by Nicolaysen and others (1992) and Lamb and others (1992) in preliminary reports as a large shield volcano topped by two overlapping calderas. No age has been reported for caldera formation but the fresh morphology of the younger caldera and the non-glaciated nature of the associated pyroclastic rocks suggests it at least is Holocene in age. The older of the two calderas (caldera CI, Lamb and others, 1992) has a diameter of 10-13 km, the younger (caldera CII) about 3 km. Low ridges and peaks along the northern and eastern shores of the island define the postulated caldera (see physiographic descriptions in Sekora, 1973). Sinuous ridges and small cones, craters, and lava flows of the active field occur both within and outside caldera II. The most prominent flow extends 1.5 km south from the southwestern lip of caldera II but does not reach the sea. A second area of relatively young lava flows lies north of the caldera, and a smaller flow is situated on the east flank.

Known cones and inferred lava vents outside the caldera are located within 1 km of the rim. Within the caldera is a 500 m cone that has its own small summit crater. Low relief on the eastern part of Yunaska Island implies that either the pre-caldera volcano had a shield-like form, or that a former cone has been subsequently destroyed. No hot springs or active fumaroles are known to exist on the island.

Volcanic activity

1817	1929?
1824	Nov. 3-4, 1937
1830	

Several episodes of minor volcanism and two violent events have been attributed to Yunaska Island in historical times. Smoke was reported in 1817 and possibly in 1929 (Powers, 1958), and a minor ash emission was observed in 1830. A major explosive eruption took place in 1824 (see Coats, 1950). The ship Boxer reported a "violent volcanic eruption" with "flames" originating from near the center of the island in early November of 1937 (Anchorage Times, November 4, 1937).

Composition

Like other members of the Four Mountains group, Yunaska Island has not been geologically mapped. Nicolaysen and others (1994) report in an abstract that the pre-caldera rocks include plagioclase + olivine basalt and andesite flows ranging in composition from 51-55% SiO_2. Cross-cutting dikes and post-caldera rocks include andesite to dacite compositions (56.4-64.5% SiO_2).

Name and Location

Name:	Amukta volcano
Synonyms:	Amukta Island
Type:	Stratovolcano
Location:	Amukta Island, westernmost of the Islands of the Four Mountains group; about 585 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	52°30'N, 171°15'W
Elevation:	1066 m
USGS 1:250,000 quadrangle:	Amukta
CAVW Number:	1101-19

Form and structure

The undissected stratovolcano of Amukta volcano composes most of nearly circular, 7.7-km-wide Amukta Island (fig. 76). The cone, about 5.8 km in basal diameter and topped by a 0.4 km wide summit crater, appears on synthetic-aperature radar imagery to be built upon a 300+ meter high, east-west trending arcuate ridge. Extensions of that ridge on the southwest and east sides of the island indicate an older caldera approximately 6 km in diameter and open to the sea on the south side. No hot springs or fumaroles have been reported from Amukta. Sekora (1973, p. 29) reports the presence of a cinder cone near the northeastern shore of the island.

Volcanic activity

1770?	July 12, 1984
1786-1791	Aug., Sept. 1987
1876	July, Sept. 1996
February, 1963	

Well documented reports of historical Amukta volcanism are sparse; activity was noted from 1786 to 1791, and again in 1876 (Coats, 1950). Petroff (1884, citing Grewingk, 1850) lists activity at Amukhton in 1770, presumably the same volcano; conversely, Dall (1870, citing Grewingk, 1850) describes a cessation of activity at Amukta in 1770.

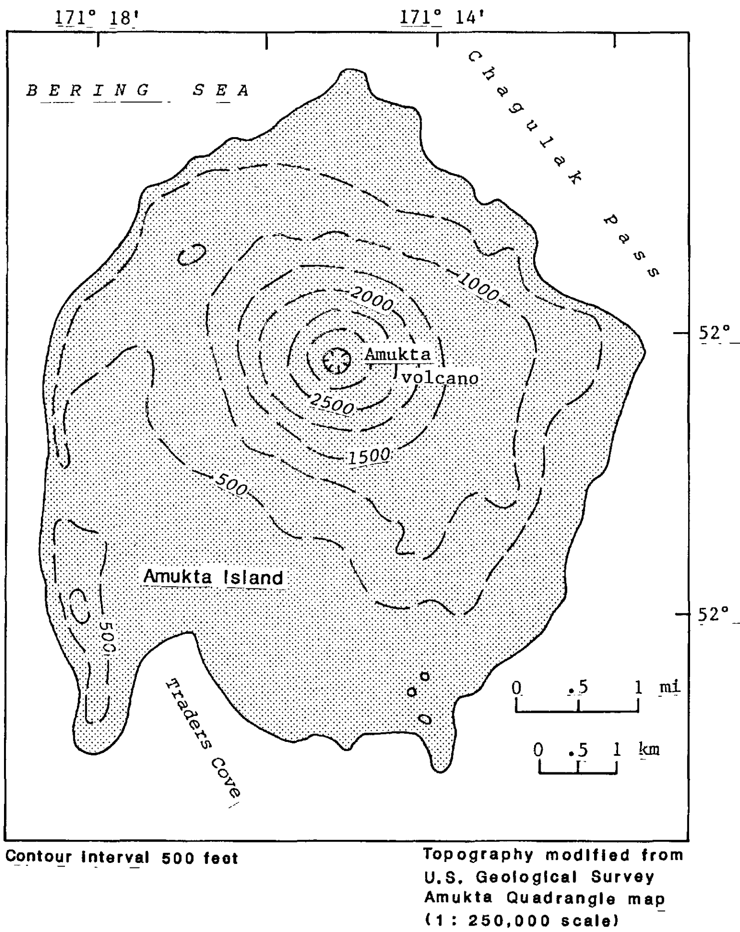


Figure 76. Topographic map of Amukta volcano.

On February 13, 1963 an eruption occurred involving the central crater and one or more parasitic vents; both ash and lava were produced (Anchorage Times, February 11, 1963; Decker, 1967). Persistent low clouds obscured the exact source of the lava, but the flow was seen to extend from the west side of the cone southwest into the sea at Traders Cove (Bulletin of Volcanic Eruptions, 1963).

In early July 1996, a passing ship reported a 1-km high plume of "ash and smoke" (Neal and McGimsey, 1997). On August 28 Mt. Cleveland, 100 km to the northeast, was also active and winds were blowing towards Amukta. In late August and early September, 1987, a commercial pilot observed a 10.5-kilometer-high eruption plume rising through cloud cover near Amukta Island. On September 4, another pilot observed a small dark ash plume issuing from the summit of Amukta (Smithsonian Institution, 1987). On Sept. 18, yet another pilot reported a 300m-high ash plume.

Composition

No geologic map or rock descriptions are available for Amukta volcano.

Name and Location

Name:	Seguam volcano
Synonyms:	Pyre Peak
Type:	Stratovolcano within caldera(?)
Location:	Seguam Island is in the central Aleutian arc, 645 km west-southwest of the tip of the Alaskan Peninsula
Latitude, longitude:	52°19'N, 172°31'W
Elevation:	1054 m
USGS 1:250,000 quadrangle:	Seguam
CAVW Number:	1101-18

Form and structure

Seguam Island consists of the remnants of two late Quaternary calderas. Holocene volcanic cones occur in both of the calderas and a third Holocene cone lies at the east end of the island. Pyre Peak, commonly referred to as Sequam volcano (fig. 77), highest of the young cones, dominates the western half of the island and occupies the center of the western caldera (Singer and others, 1992) that is defined by remnants of a semi-circular ridge about 3 km in original diameter and about 700 m high. A Holocene basalt field surrounds Pyre Peak (Singer and others, 1992) extending down to shoreline. This general area has been the site of most if not all historical volcanic activity. Late Quaternary lavas and pyroclastic rocks ranging in age from 1.1 Ma to 0.03 Ma underlie the basalt. The two Holocene cones to the east are surrounded by andesite and dacite lava flows with well preserved constructional features (Singer and others, 1992).

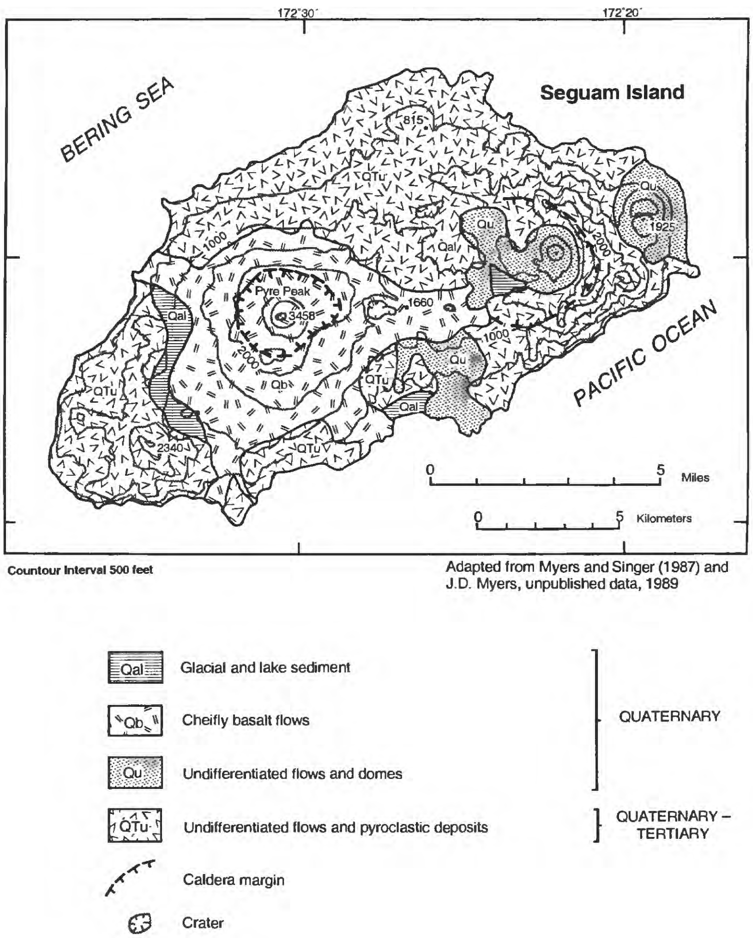


Figure 77. Geologic map of Sequam Island modified from Myers and Singer (1987) and J.D. Myers, unpublished data, 1989.

Volcanic activity

1786-1790	1901 ?
1827	1927
December 1891	March 6, 1977
Spring, 1892	December 27, 1992
	July 31-August 19, 1993

Several episodes of volcanism have been attributed to Seguam Island in the past 200 years, and it is likely that other events have gone unrecorded due to the remoteness and inclement weather of the region. The earliest documented activity is 1786-90 (Grewingk, 1850, cited in Petroff, 1884). "Smoke" was reported in 1827, and in

December of 1891 a minor eruption was reported (Coats, 1950). The most vigorous of the early eruptions took place in the spring of 1892; it produced detonations heard at the village of Atka, 120 km to the west, and two large cauliflower-shaped jets of ash (Jaggar, 1927; Coats, 1950).

In early March, 1977 the crew of the U.S. Coast Guard Cutter Mellon reported eruptive activity. Eight lava fountains, up to 90 m high, were noted along a radial rift about 1 km long and about 2.5 km southwest of the summit. At least two tongues of lava were extruded. The larger flow, 1 km wide, extended 2.5 km to the southwest; the smaller, 0.5 km wide, extended 1 km south. Neither tongue entered the sea. Pyroclastic material was also produced during the event. Dense clouds containing black ash and incandescent fragments were emitted from one or both of the vents effusing lava, and a coating of fine ash was visible on the surrounding snow. By March 8th, lava extrusion and fountaining had apparently ceased, but a considerable amount of steam, possibly containing some ash, was still being discharged. (Anchorage Times, March 8, 1977; Smithsonian Institution, 1977).

In late December 1992, U.S. Coast Guard pilots reported an ash cloud up to 1200 m above Pyre Peak, the site of the 1977 eruptive activity. Intermittent, localized bursts of ash rising 100-200 m were observed several days later, and the activity apparently subsided soon after (Smithsonian Institution, 1992). Explosive ash eruptions along with a lava flow were reported by Coast Guard observers from July 31, 1993 through August 19, 1993; ash clouds were reported to altitudes of 3,500 m at times during this interval.

Composition

Holocene post-Pyre Peak caldera lava flows, which were erupted from the vents along the caldera wall and from the central intracaldera cone, are highly porphyritic basalt (figs. 78, 79) in contrast to intracaldera dacite and rhyodacite in the eastern caldera (Myers and Singer, 1987). These young lavas overlie a sequence of Plio-Pleistocene andesitic flows and pyroclastic deposits that comprise the bulk of Seguam Island.

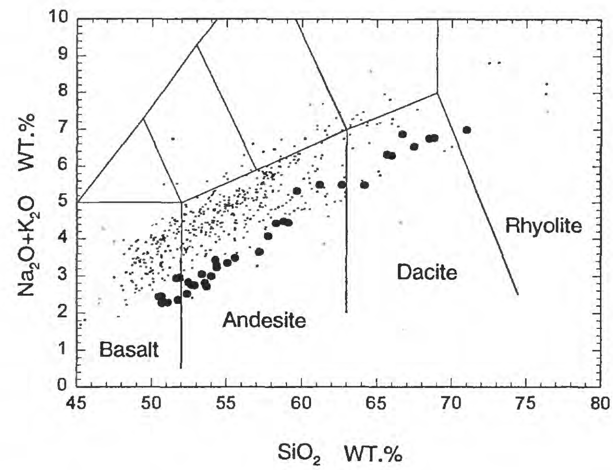


Figure 78. Total alkalies-silica diagram for Sequam volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and fieldnames (LeBas and others, 1986) are explained in Figure 2.

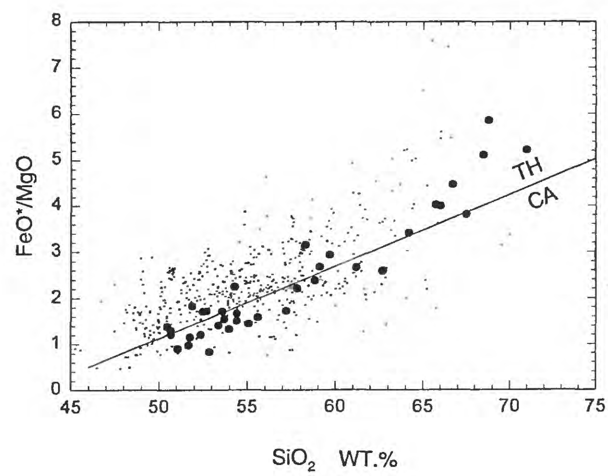


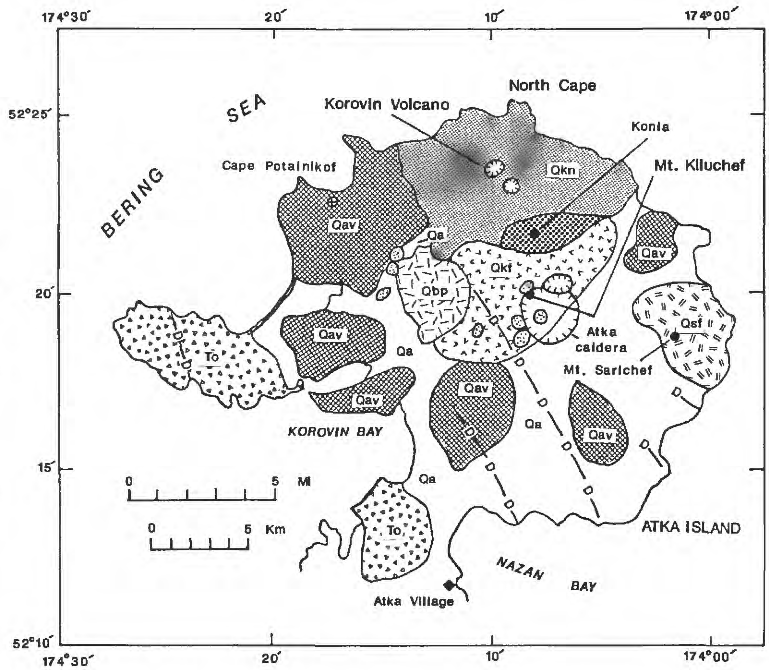
Figure 79. FeO/MgO-silica diagram of Sequam volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiic versus calc-alkaline discriminant line from Miyashiro (1974).*

NAME AND LOCATION

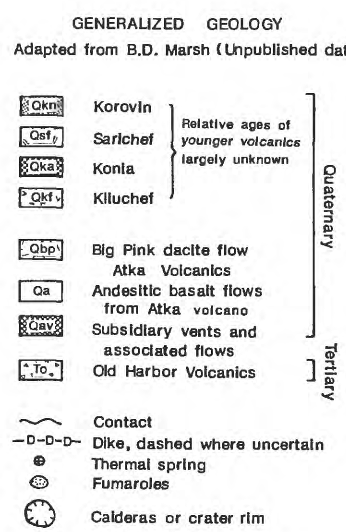
NAME:	KOROVIN VOLCANO
SYNONYMS:	NONE
TYPE:	STRATOVOLCANO
LOCATION:	ATKA ISLAND, IN THE CENTRAL ALEUTIAN ARC ABOUT 760 KM WEST-SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	52°23'N, 174°09'W
ELEVATION:	1533 M
USGS 1:250,000 QUADRANGLE:	ATKA
CAVW NUMBER:	1101-16

Form and structure

The active volcanic front runs through northern Atka Island which has been geologically mapped on a reconnaissance scale by Marsh (1990) who described the overall structure of the volcanic center as that of a broad central shield upon which a large stratocone (Atka volcano) had been built. This cone was destroyed during caldera formation about 300,000 to 500,000 years ago. Korovin, neighboring Kliuchef, and probably Konia (fig. 80) are products of the latest stage of volcanic activity on the island, which began perhaps about 100,000 years ago based on the degree of dissection (B. Marsh, written commun., 1982).



Korovin volcano is a stratovolcano, 1533 m high and almost 7 km in basal diameter, having two summit vents 0.6 km apart (fig. 80). The northwestern summit vent is a symmetric cone with a small crater. The southeastern summit vent is on the remnant of a cone with a steep-walled crater, about 1 km wide at the rim and at least several hundred meters deep. Intercalated lava flows and pyroclastic rocks comprise the upper part of the crater wall, but the bottom one hundred meters or so are nearly vertical and apparently consist entirely of lava flows. A turquoise green lake fills the lower part of the crater; the color suggests the occurrence of solfataric activity (Sekora, 1973).



The west side of Sarichef and east flank of Konia are extensively dissected; Konia has a relatively fresh cinder cone on its west flank. Sarichef is most likely a satellite

Figure 80. Generalized geologic map of the north end of Atka island including Korovin and Mt. Kliuchef volcanoes; adapted from B.D. Marsh (unpublished data).

vent of the earlier Atka volcano as is Kliuchef which is located on the northern rim of the Atka caldera. Korovin and Kliuchef are virtually undissected and are thus apparently of post-glacial age. Hot springs and fumaroles occur on the south and west flanks of Mt. Kliuchef and near the head of a glacial valley 6 km southwest of Korovin Volcano (Motyka and others, 1993).

Volcanic activity

1812 (Kliuchef) ?	1951?	May 23, 1986
1829-30	1953-54?	March 18, 1987
1844	1973	
1907?	1976?	

Minor volcanic activity has characterized northern Atka Island during historical time (Coats, 1950). One episode of activity—in 1812—has been attributed to Sarichef by Grewingk (1850), although it probably was associated with either Korovin or Kliuchef. Of the four vents on Mt. Kliuchef, the most northeasterly one appears to be the youngest and may be the source for the eruption of 1812 attributed to Sarichef (B. Marsh, written commum., 1982). Dall (1870, citing Grewingk, 1850) listed violent eruptions and earthquakes for the 1812 activity. Other eruptions have possibly gone unreported due to the endemic poor visibility and sparse population of the region.

Korovin has produced "smoke" and localized ash fall several times in the last 200 years. In 1907 "dense clouds of vapor" enveloped the summit of Korovin (Eakle, 1908) and a light coat of "fresh volcanic cinder" was observed on snowfields near Mt. Kliuchef (Jaggar, 1927, p. 24). Powers (1958) reported smoke in 1951 and various times in 1953 and 1954 (reports on file at Geophysical Institute, University of Alaska, Fairbanks). In 1973, Atka villagers in a boat near North Cape reported a 10 m wide lava flow extending half way down the northern flank of Korovin volcano from a fissure vent located near the northern summit (Reeder, 1988). "Smoke" emission was observed in 1976 at Korovin from Atka village, located 20 km to the south (Arctic Environmental Information and Data Center, 1978).

Steam emission was observed in early May, 1986, and on May 23rd a 600 m steam plume containing some ash reportedly occurred soon after a 7.7 magnitude earthquake struck about 100 km to the southwest (Smithsonian Institution, 1986).

The most recent eruptive activity at Korovin was observed on satellite imagery taken March 18, 1987. Three plumes, each 95 km long, were drifting east-northeast from the summit of Korovin and several vents 5-6 km to the south (Kliuchef). Later that day, a >3000-meter-high ash plume was observed drifting southward from the summit of Korovin (Smithsonian Institution, 1987).

Composition

Marsh (1990) reports that more than 90% of the lava flows on Atka Island are basalt, having an average silica content of about 50%. He also noted a slight tendency towards more silicic compositions in the very latest stages of activity for each volcano; Korovin and Kliuchef are composed mainly of basalt but have late dacite flows.

Phenocrysts in the basalts are plagioclase (An_{80-90}), olivine (Fo_{70}), titanomagnetite (Usp_{45}), and clinopyroxene in the more advanced stages of crystallization (B. Marsh, written commun., 1982). Orthopyroxene replaces olivine in the more silicic rocks and trace biotite was reported from the summit dacite dome of Kliuchef.

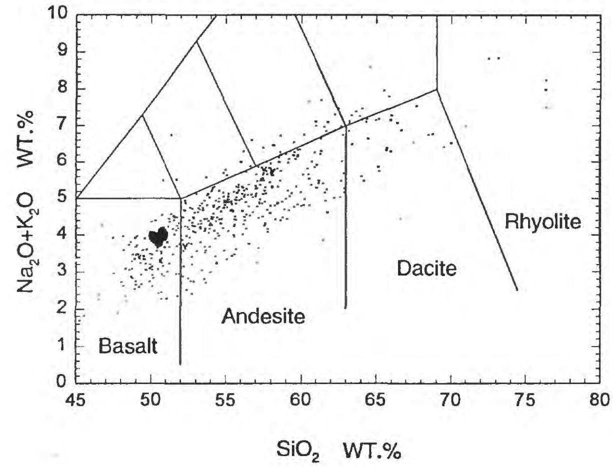


Figure 81. Total alkalies-silica diagram for Korovin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and fieldnames (LeBas and others, 1986) are explained in Figure 2.

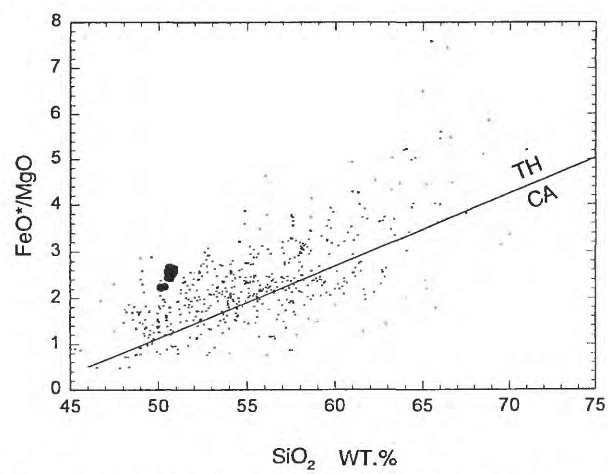


Figure 82. FeO/MgO-silica diagram of Korovin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiic versus calc-alkaline discriminant line from Miyashiro (1974).*

NAME AND LOCATION

NAME:	KASATOCHI VOLCANO
SYNONYMS:	KASATOCHI ISLAND
TYPE:	STRATOVOLCANO
LOCATION:	KASATOCHI ISLAND, IN THE CENTRAL ALEUTIAN ARC, ABOUT 838 KM WEST- SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	52°11'N, 175°30'W
ELEVATION:	314 M
USGS 1:250,000 QUADRANGLE:	ATKA
CAVW NUMBER:	1101-13

Form and structure

Kasatochi Island, like Gareloi, Bogoslof and several other volcanoes in the western Aleutian arc, represents the emergent summit of a predominantly submarine volcano. The island consists of a single, undissected cone with a central lake-filled crater about 0.75 km in diameter (fig. 83). A maximum height of 314 m is on the southern crater rim; elevation of the lake is less than about 60 m. Kay (1990) reports a lava dome on the northwest side of the cone at an elevation of ~150 m.

Coats (1956) refered to Kasatochi as one of a group of little-known volcanoes that appear to be stratovolcanoes composed of basaltic and andesitic flows and pyroclastics. The mean slope of the southern flank (about 18°) is considerably less than the mean slope of the northern flank (about 45°). This asymmetry of form may reflect a predominance of lava flows low on the southern flanks, or, it may be due to a higher rate of erosion by wave action from the north. Bathymetry indicated that Kasatochi is at the northern end of a 15-km-long, 6-km-wide submarine ridge that is normal to the trend of the Andreanof Islands. Water depths along the ridge are less than 90 m; if Kasatochi is constructed entirely on the ridge, the total height of the volcanic pile is only a little more than 400 m.

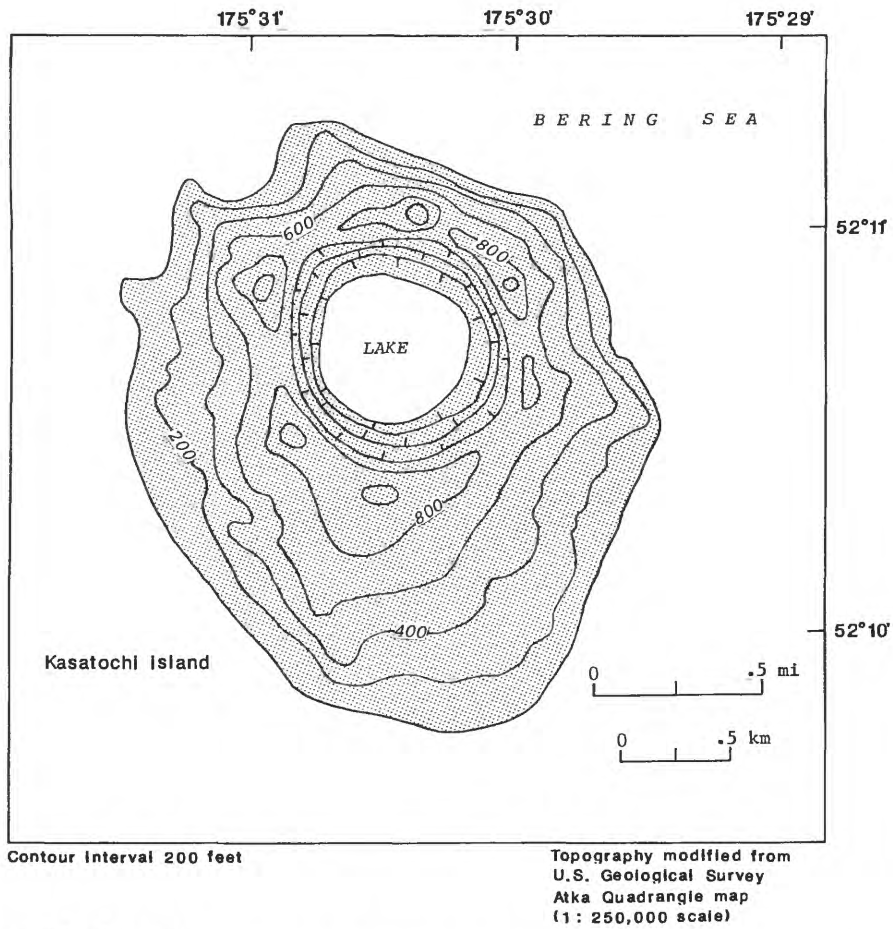


Figure 83. Topographic map of Kasatochi Island volcano.

Volcanic activity

1760?
1827
1828

The recorded history of eruptions at Kasatochi is sparse; the episodes listed above were originally attributed to Koniuji, a small volcanic islet situated 25 km to the east. Koniuji, however, is "deeply eroded" and "does not appear to have been active in Recent time"; the relatively undissected Kasatochi appears a more likely source of historical volcanism (Coats, 1950, Table 2). Little detail is available concerning the historical events: the island was reported "rising" in 1760 (Grewingk, 1850, cited in Petroff, 1884) and "smoke" was noted in 1827 and 1828. In 1899, the crater lake disappeared for a brief period while steam rose from the crater; the lake eventually reappeared (Jaggar, 1927). No activity has been confirmed at Kasatochi in this century.

Composition

There are no geologic maps and little petrologic data available for Kasatochi Island. Kay (1990) states that the lava flows and scoria are olivine basalt and pyroclastic rocks and dome lavas are hornblende andesite and dacite.

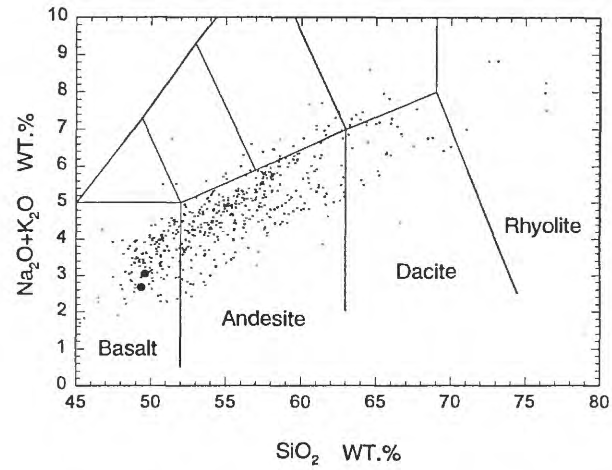


Figure 84. Total alkalies-silica diagram for Kasatoachi volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and fieldnames (LeBas and others, 1986) are explained in Figure 2.

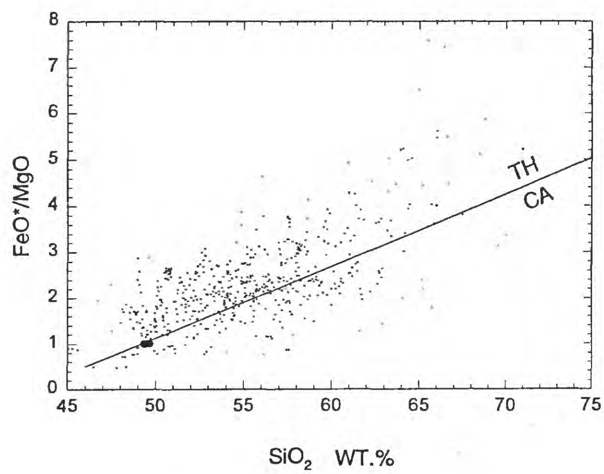


Figure 85. FeO/MgO-silica diagram of Kasatochi volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiic versus calc-alkaline discriminant line from Miyashiro (1974).*

NAME AND LOCATION

NAME:	GREAT SITKIN VOLCANO
SYNONYMS:	GREAT SITKIN ISLAND
TYPE:	STRATOVOLCANO WITH CALDERA AND DOME
LOCATION:	GREAT SITKIN ISLAND, CENTRAL ALEUTIANS, ABOUT 965 KM WEST-SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA
LATITUDE, LONGITUDE:	52°05'N, 176°08'W
ELEVATION:	1740 M
USGS 1:250,000 QUADRANGLE:	ADAK
CAVW NUMBER:	1101-12

Form and structure

Great Sitkin Volcano occupies most of the northern half of Great Sitkin Island, a member of the Andreanof Islands group in the central Aleutian Islands. The volcano is roughly oval-shaped, 8 by 11 km at the base, with the long axis trending east-west (fig. 86). It is a composite structure consisting of the remains of an older, decapitated volcano and a younger parasitic cone that collapsed forming a small caldera (0.8 by 1.2 km) on the west flank (Simons and Mathewson, 1955). The highest point on the island is apparently a remnant of the former central volcano's eastern rim. Most of the constructional surface of the cone has been deeply eroded. A steep-sided, recently emplaced dome (unit Qgd, fig. 86) occupies the center of the caldera at an elevation of 1220 m. The dome is 183 m high, 0.4 km wide, and 0.6 km long with a blocky, flat top. Five small plugs (unit Qa, fig. 86) are intruded into the northwest slope of the cone; three of the plugs are aligned in a northwest direction from the crater, and the remaining two are aligned north-northwest.

Rocks that comprise the main cone are named the Great Sitkin volcanics (unit Tgc, fig. 86), and consist of andesite and basalt lava flows interbedded with tuff beds (Simons and Mathewson, 1955). Lava flows predominate on the upper part of the cone, which has undergone extensive glacial erosion; construction of the cone may have begun in late Tertiary or early Quaternary time and was apparently completed before

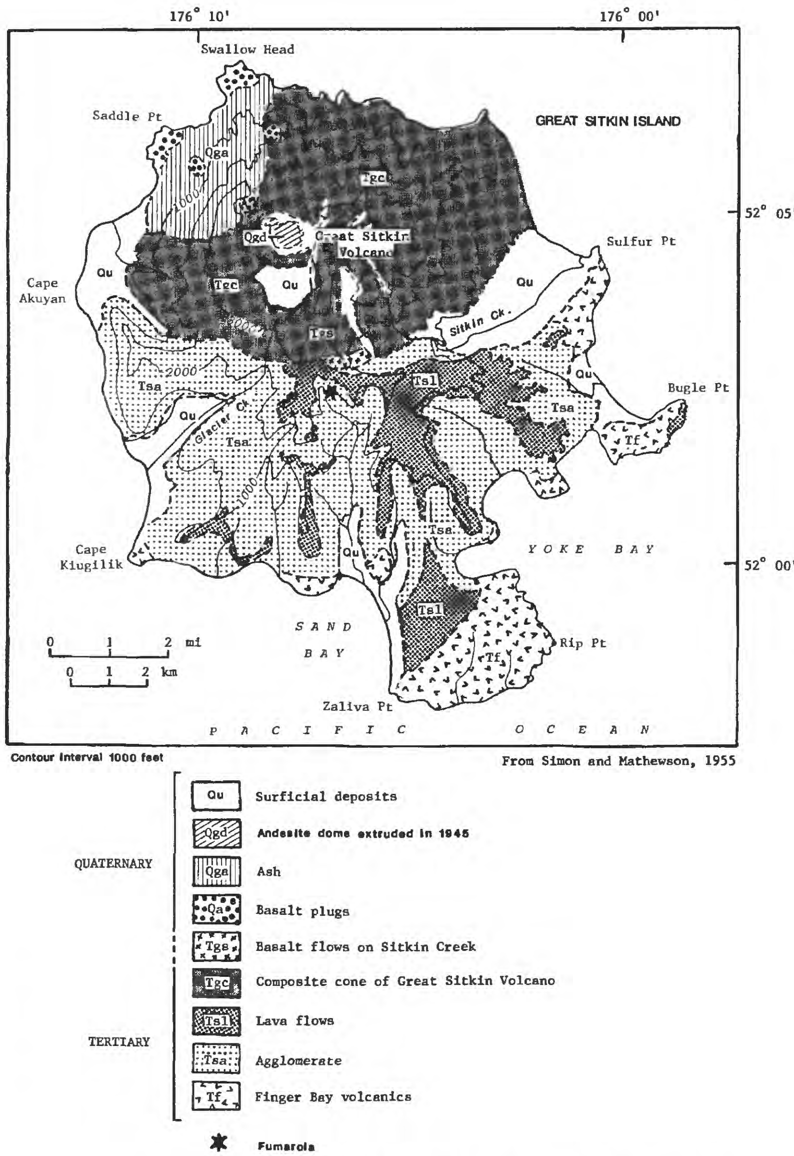


Figure 86. Geologic map of Great Sitkin Island from Simon and Mathewson (1955).

the end of Pleistocene glaciation. Partial destruction of the cone's former peak was followed by a westward shift in eruptive activity. A parasitic cone was built and subsequently destroyed during caldera-forming eruptions of unknown age. Pumice, scoria, and rock fragments from this eruption blanket the island to depths of a few centimeters to more than 6 m. Overlying the pumice deposit on the northwest flank of the main cone is an ash deposit that was apparently erupted from a subsidiary vent located immediately northwest of the crater (Simons and Mathewson, 1955). A glacially truncated, columnar jointed basalt flow occurs low on the south flank of the main cone near the head of Sitkin Creek (unit Tgs, fig. 86). This flow is the product of a flank eruption, the source of which is covered by pumice (Simons and Mathewson, 1955, p. 31).

Great Sitkin volcano is built upon the eroded remnants of a late Tertiary shield volcano, which forms most of the southern half of the island. The undeformed succession, termed the Sand Bay volcanics by Simon and Mathewson (1955), consists of pyroclastic rocks, mainly volcanic breccias, which are overlain by a sequence of andesite and basalt lava flows. The succession crops out in a gently dipping radial pattern suggesting a source near the present cone.

The Sand Bay volcanics unconformably overlie the Finger Bay volcanics, an older, highly altered and deformed sequence of lava flows, breccia, and tuff that form the rugged headlands along the southern and southeastern coasts. By correlation with nearby Adak Island, the Finger Bay volcanics are probably no younger than late Eocene in age, and may be as old as Cretaceous (Scholl and others, 1970).

Volcanic activity

1792	March, 1945
1828-29	Aug. 14, 1946
1904	1949-50 ?
Nov., 1933	19 Feb-Sept., 1974

Several episodes of volcanic activity, most relatively minor, have been reported for Great Sitkin Volcano since its discovery in 1741 during the Bering Expedition. Other eruptions have probably gone undetected as a consequence of the island's remoteness from principal shipping lanes. The major event that produced both the crater and the extensive pumice fall blanketing the island is interpreted by Simons and Mathewson (1955, p. 32, 40) to have taken place within the past several thousand years, and possibly only a few hundred years ago.

In historical times, "smoke" has been reported above Great Sitkin in 1828-29, 1904, 1946, and 1951 (Simons and Mathewson, 1955; Wentworth, 1951, p. 6) and explosive eruptions in 1792, 1933, 1949-50, and 1974 (Anchorage Times, February 21, 1974; the 1974 event may have included some additional dome growth as well as vigorous phreatomagmatic activity. The ash layer on the northwestern slope of the main cone was probably deposited during one of these eruptions as it appeared to Simons and Mathewson (1955) as "at most only a few hundred years old". The most notable recorded activity occurred in March of 1945 when much of the crater dome was apparently extruded (Coats, 1950). A nocturnal glow was visible above Great Sitkin from Adak Island for a period of several weeks. Army aviators observed clouds of steam rising from the crater, and a strong earthquake was felt at Sand Bay during this time. Steam has been observed subsequent to dome emplacement, and on August 14, 1946, a small smoke cloud was observed from Adak Island (Simons and Mathewson, 1955). Powers (1958) reports ash eruptions in 1949-50.

Activity at Great Sitkin during 1946-48 comprised periodic steam emission from the crater and the continued existence of a group of hot springs, mud pots and fumaroles about 4 km south of the crater rim (Byers and Brannock, 1949). The hot springs occur at the site of a possible volcanic vent that predates the rocks of Great Sitkin Volcano.

Composition

Petrographic information for rocks of Great Sitkin volcano is from Simons and Mathewson (1955); Marsh (1976) provides another general account. Lava flows and tuff beds make up the main cone. Flow rocks are mostly black to light grey, medium-grained porphyritic andesite and basalt (figs. 87, 88) displaying little or no flow structure; Marsh (1976) classifies the rocks as andesites and basaltic andesites. Phenocrysts include plagioclase, calcium-rich pyroxene, olivine, and magnetite. Local pyrite impregnation and plagioclase alteration probably indicates former solfataric activity at one site on the southeast flank. Flow rocks at the summit are also altered. The crater dome is a black vitrophyric andesite.

Pumice erupted during caldera formation is buff to light brown-grey. The tephra blanket contains fragments up to 10 cm in diameter. The ejecta contains crystals of plagioclase, pyroxene and amphibole set in a matrix of pale glass; pyroxene crystals are up to 6 mm across. Minor amounts of rock fragments, primarily of two types, are mixed in the pumice blanket. A second minor constituent of the pumice blanket is lithic fragments of coarse-grained cumulative gabbro xenoliths consisting of plagioclase and amphibole grains up to 2 cm across, and accessory olivine, pyroxene and magnetite.

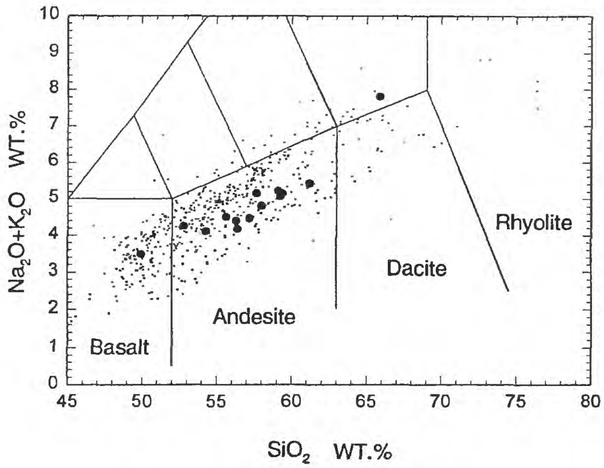


Figure 87. Total alkalies-silica diagram of Great Sitkin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

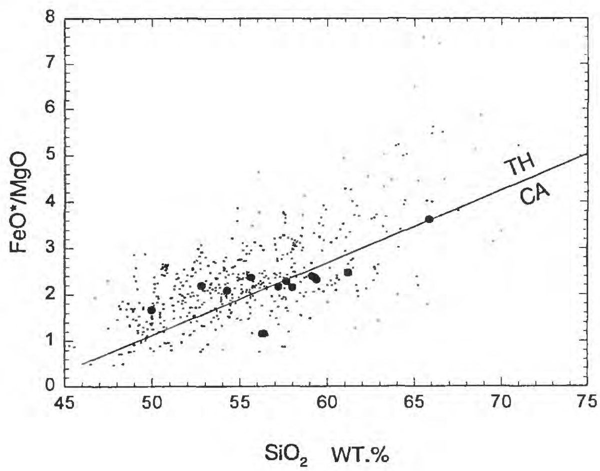


Figure 88. FeO/MgO-silica diagram of Great Sitkin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Kanaga Volcano
Synonyms:	None
Type:	Stratovolcano within caldera
Location:	Kanaga Island, one of the Andreanof group near the center of the Aleutian arc; 965 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	51°55'N, 177°10'W
Elevation:	1307 m
USGS 1:250,000 quadrangle:	Adak
CAVW Number:	1101-11

Form and structure

Kanaga Volcano occupies the northern corner of Kanaga Island, one of the most southerly members of the Aleutian chain. It is a symmetric composite cone 1307 m high and 4.8 km in diameter at sea level (fig. 89), built of interbedded basaltic and andesitic lava flows, scoria layers and pyroclastic rocks. Mudflow deposits and other volcaniclastic rocks occur on the volcano's lower slopes. A circular summit crater, approximately 200 m across and 60 m deep, contains recent deposits of vent agglomerate, and several active fumaroles.

A mantle of volcanic ash and pumice, up to 7 m thick, and containing several soil horizons, blankets the northern half of the island. Most of this deposit was probably erupted from Kanaga Volcano, although some may be derived from explosive eruptions on nearby islands (Coats, 1956a, p.74; Fraser and Barnett, 1959, p. 226). A thin layer of andesitic and basaltic pumice, younger than the ash-and-pumice mantle, coats the volcano's upper slopes, and blocks of dense basalt occur across the island. Fragments of the latter material have produced impact craters up to 4 km from the summit. Four young andesitic flows extend from fissures near the summit of the cone on the south, southwest, and northeast flanks (unit Qkb, fig. 89).

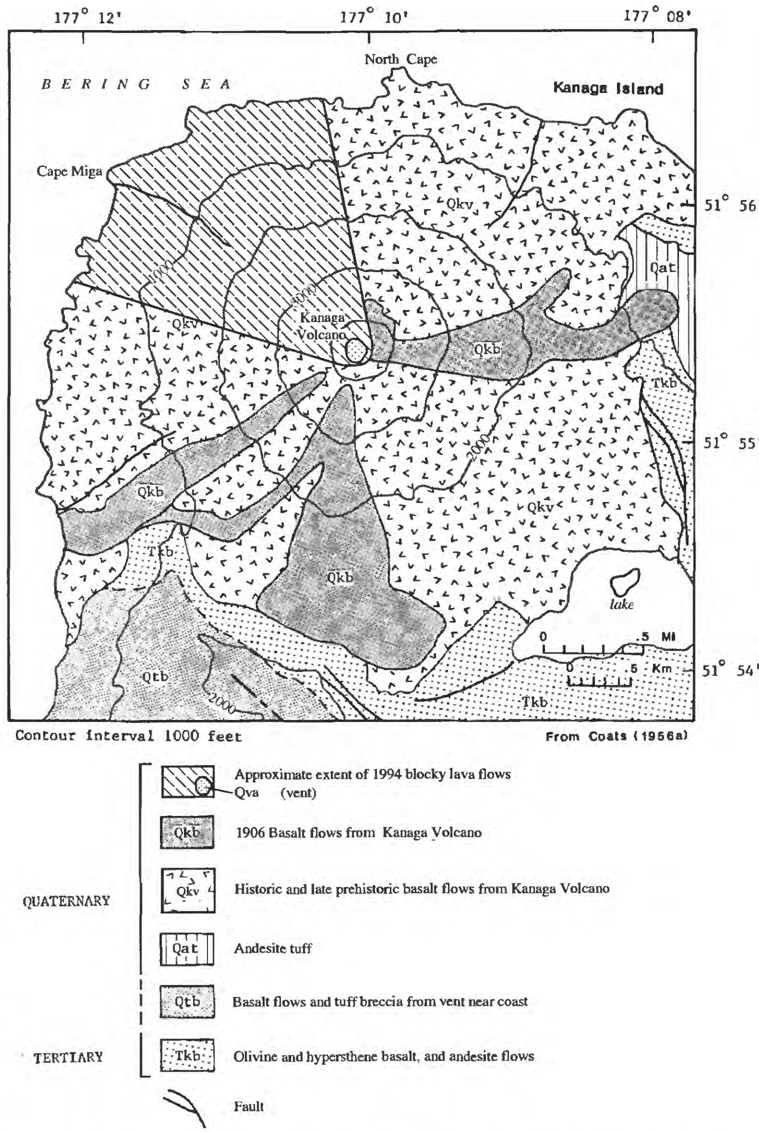


Figure 89. Generalized geologic map of the north end of Kanaga Island after Coats (1956a).

Kanaga Volcano is flanked on the south and east by an arcuate ridge up to 800 m in elevation; a somma lake, 2 km in diameter, is situated between Kanaga Volcano and the southeast corner of the arcuate ridge. The ridge and associated scarp may represent the eroded remnant of a caldera rim. Two observations support the caldera origin of the ridge. First, although dissected, remnants of the ridge are located along 150° of an approximately circular arc and the radially outward dip of the comprising flows indicates a central source near the present summit of Kanaga Volcano. Secondly, a thin (0.6-9 m) but widespread blanket of andesitic crystal-lithic tuff (unit Qat, fig. 89) occurs over northern Kanaga Island south and east of Kanaga Volcano (Coats, 1956a) where relative age and lithologic character suggest that it may be the product of a caldera-forming eruption.

Coats (1950, 1956a, b) suggested the caldera formed through collapse of a Tertiary volcano (Mount Kanaton) near the end of Pleistocene time. However, Miller and Kirianov (1994) suggested periods of caldera formation on Kanaga occurred ~6,000, ~4,500, and ~3,000 yBP based on tephrochronology studies on nearby Adak Island.

Precaldera rocks include flows and pyroclastic rocks and minor intrusive rocks. Coats (1956a), and Fraser and Barnett (1959) have assigned a late Tertiary to Pleistocene age to these older rocks. Apparently several episodes of volcanism preceded construction of modern Kanaga Volcano. Low outward dips imply that most of the older rocks were part of a broad, shield-shaped volcano with a vent area near the site of Kanaga Volcano. There is, however, evidence that at least one composite cone was constructed on the site before formation of the caldera, and of other vent eruptions from the flanks of the ancient volcano (Coats, 1956a).

Evidence of glaciation has not been noted on Kanaga Island, although adjacent islands such as Tanaga display signs of glacial erosion down to sea level.

Volcanic activity

1763?	1827
1768?	1829
1786?	1904?-May, 1906
1790?	1933?
1791	1993-95

Persistent but relatively mild volcanic activity has characterized Kanaga Volcano during the past 200 years. "Smoke" was reported above the island in 1790, 1791, 1827, and 1829; some or all of these accounts may actually refer to steam produced by hot springs on or near the cone (Coats, 1956a). Activity of an unspecified nature was noticed in 1763, 1768, 1786 (Grewingk, 1850, cited in Petroff, 1884), and 1933 (Coats, 1950). The most significant volcanic event observed on Kanaga during the historical period was a series of lava flows erupted in 1906 (Coats, 1956a), and possibly earlier in 1904 (Jaggar, 1927). A trapper living on the island in 1906 experienced several earthquakes and witnessed lava pouring down both east and west sides of the cone. Coats (1956a) interpreted these flows to be the ones now present on the northeast and southwest slopes of Kanaga Volcano. Another flow, slightly older, is perhaps the result of the poorly documented activity in 1904.

The most recent eruption began in mid-1993 and continued intermittently through most of 1995. The eruption was characterized by steam and ash plumes rising to as high as 7.5 km and drifting a few tens of kilometers downwind, lava extrusion within the summit crater, and minor avalanching of incandescent debris down the north flank reaching the sea in some cases (Neal and others, 1995 a, b). Strong sulfur odors were detected on occasion by ground observers in Adak, 33 km to the east.

Solfataric activity on Kanaga Island has been known since the first exploration of the Andreanof group in 1760-1764 (Coats, 1956a). Hot springs located at the foot of the cone were not found by Coats in 1946, but he did observe several conspicuous fumaroles near and in the summit crater. The most spectacular of these produces a vapor cloud that can be seen on a clear day from Adak, 50 km to the east. Several other fumaroles are floored with opaline products of rock disintegration. Fissures emitting a variety of hot gases (including hydrogen sulfide) are sulfur encrusted. The maximum surface temperature measured was 104°C (Coats, 1956a). Fumarolic activity was also reported in 1951 (Wentworth, 1951, p. 6).

Composition

Geologic mapping and petrographic studies of Kanaga Island were conducted in 1946 by R. Coats and in 1952 by G. Fraser and F. Barnett. Kanaga Volcano is composed of interbedded scoria, tuff breccias, and flows; compositions (figs. 90, 91) probably include basalt, andesite, and/or basaltic andesite. In general, both older and more recent lava flows comprise grey to black vesicular flow rocks with glass in the groundmass. Phenocrysts are typically zoned plagioclase (up to 4 mm long), smaller grains of hypersthene and augite, and accessory magnetite and apatite. Some flows contain hornblende, or rarely, olivine.

The two most recent pyroclastic deposits were also studied by Coats (1956a). The first, limited in distribution to the slopes of Kanaga Volcano, consists of two thin pumice layers; the older contains pale gray pumice and the younger contains dark grey pumice. The second deposit comprises ejecta of basalt blocks, some of which were ejected as much as 50 km from the main cone, which contain labradorite and augite phenocrysts with accessory magnetite in a groundmass of equant feldspar grains and pale glass. These tephra deposits predate all but one of the four youngest lava flows.

Rocks of the pre-caldera (shield?) volcano apparently range from basalt to andesite in composition. Crystal-lithic tuff, possibly erupted during a caldera-forming eruption, is high-SiO_2 andesite or dacite in composition.

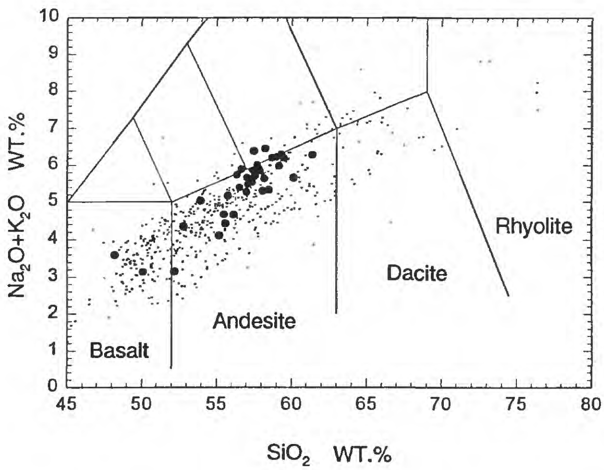


Figure 90. Total alkalies-silica diagram of Kanaga volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

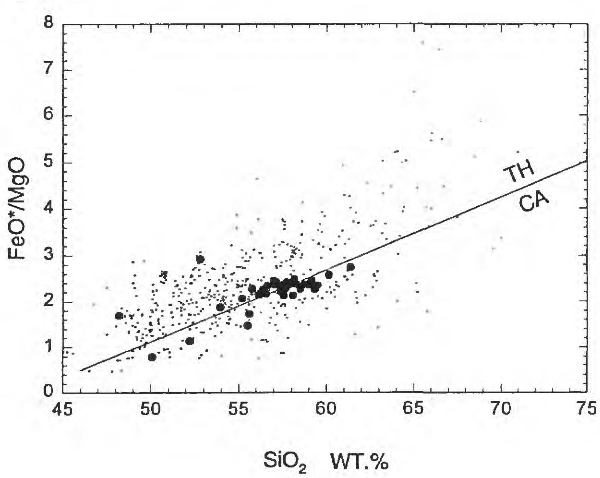


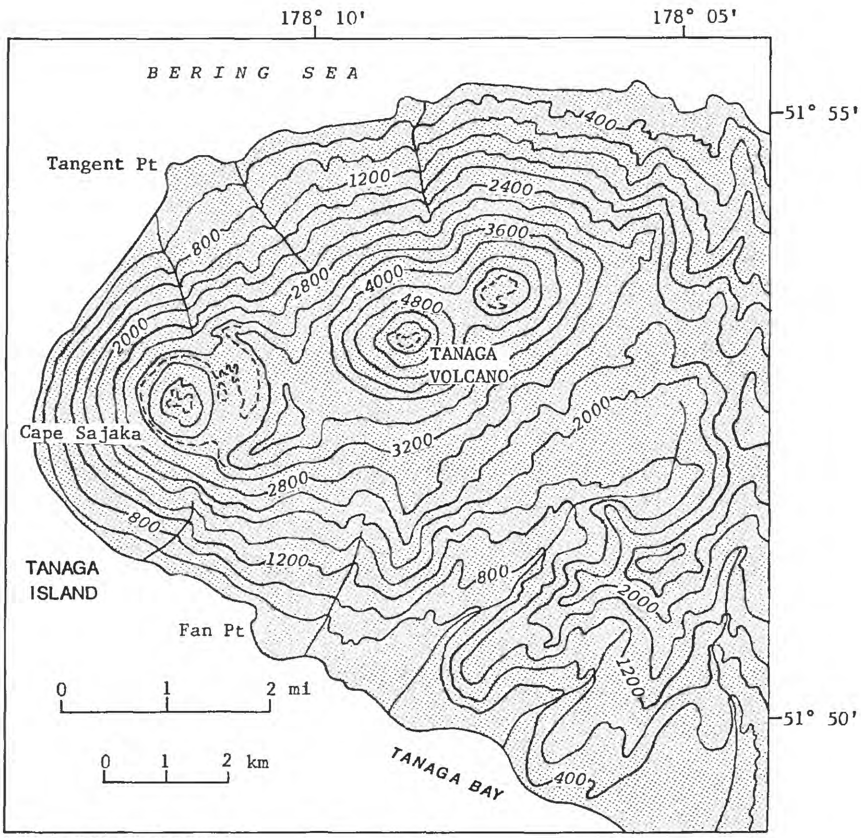
Figure 91. FeO/MgO-silica diagram of Kanaga volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

Name and Location

Name:	Tanaga Volcano
Synonyms:	None
Type:	Stratovolcano with two flanking strato-volcanoes
Location:	Tanaga Island, westernmost of the Andreanof Islands, about 1024 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	51°53'N, 178°08'W
Elevation:	1806 m
USGS 1:250,000 quadrangle:	Gareloi Island
CAVW Number:	1101-08

Form and structure

Tanaga Volcano is the central and highest of three adjacent stratovolcanoes at the northwest end of Tanaga Island (fig. 92). The volcano, mostly undissected by erosion, has an altitude of between 1770 and 1830 m. Interbedded lava flows and pyroclastics of the upper slopes have initial dips as steep as 35°. The three stratovolcanoes lie unconformably on a slightly older series of interbedded lava flows and pyroclastics, which Fraser and Barnett (1959) suggest are of late Tertiary or Pleistocene age. A shield-like form is inferred for this earlier volcanic center based on shallow radial dips. Alternatively, it may be that only the lower flanks of an old stratovolcano have been preserved. Arcuate ridges and scarps border the three modern stratovolcanoes on the east and south, features that may represent the partial rim of a caldera developed in late Pleistocene time (Coats, 1950; 1956).



Contour interval 400 feet
200 feet (dashed areas)

Topography modified from U.S. Geological Survey Gareloi Island Quadrangle map (1: 250,000 scale)

Figure 92. Topographic map of Tanaga volcano.

Tanaga Volcano and the neighboring cones roughly define an east-west trend across northern Tanaga Island. At least four cones adjacent to Tanaga Volcano apparently have been active since the last glaciation. The stratovolcano located 4 km west-southwest of Tanaga Volcano is in an older, breached crater. A blanket of fine ash, as much as 6 m thick covers large areas of Tanaga Island. The ash, stratified and intercalated with thin soil layers, may have accumulated over a period of several thousand years.

The oldest rocks on Tanaga Island comprise a thick sequence of unaltered shallow marine and subaerial lava flows, tuff breccias, and subordinate interbedded sediments. This series, considered to be of late Tertiary or

Quaternary age based on microfossils and mollusks (Fraser and Barnett, 1959; Marlow and others, 1973), constitutes the southern half of the island, and may underlie the northern part as well. Though Tanaga was extensively glaciated during the Pleistocene—morainal material has been recognized in high-altitude cols and cirques throughout the northern portion of the island—only a few small patches of ice remain on the flanks of the dormant easternmost cones.

Volcanic activity

1763-1770?	1829
June 7, 1791	1914

Few details are available concerning historical activity of Tanaga Volcano, and some or all of the events attributed to it may have involved adjacent cones in the northwest part of the island (Coats, 1950). Tanaga was reported active throughout the period 1763-1770. Smoke was noted above the island in 1791 and 1829, and a lava flow was observed in 1914 (Coats, 1950, table 2).

Composition

The lava flows of northern Tanaga Island range in composition from crystal-rich, high-alumina basalt to glassy dacite (Coats and Marsh, 1984). The basalts are characterized by nearly unzoned phenocrysts of plagioclase (An_{80-92}) and olivine (Fo_{65-73}), clinopyroxene ($En_{43}Wo_{44}$) and titanium-magnetite, whereas the andesites and dacites have zoned plagioclase (An_{85-65}), and orthopyroxene (En_{69}) instead of olivine (Coats and Marsh, 1984). Fraser and Barnett (1959, p. 222) present a single chemical analysis of a basalt flow or sill, from the oldest rocks on Tanaga Island, having a SiO_2 content of 51.8%.

Name and Location

Name:	Gareloi volcano
Synonyms:	Mount Gareloi
Type:	Stratovolcano
Location:	Gareloi Island, northernmost of the Delarof group, Andreanof Islands, about 1062 km west-southwest of the tip of the Alaska Peninsula
Latitude, longitude:	51°47'N, 178°48'W
Elevation:	1573 m
USGS 1:250,000 quadrangle:	Gareloi Island
CAVW Number:	1101-07

Form and structure

Mount Gareloi, which makes up most of Gareloi Island, is a stratovolcano 10 km by 8 km in diameter at its base (fig. 93) with two summits, separated by a narrow saddle. Two small glaciers extend northwest and southeast from the saddle. The northern, slightly higher peak is on the southern rim of a crater about 300 m across, which contains several active fumaroles. Thirteen younger craters, from 80 to 1600 m in diameter, are aligned along a south-southeast trending fissure that extends from strandline to the southern summit (fig. 93). These craters formed during a major explosive eruption in 1929 that also produced four blocky lava flows (unit Q1, fig. 93), and a blanket of glassy andesitic tuff that covers an area roughly 2.5 x 5 km on the volcano's southeast flank (Coats, 1959).

The intercalated lava flows and pyroclastic debris that make up Gareloi volcano were produced during two periods of activity separated by an extended interval of quiescence and erosion. Lava flows range from 1 m to more than 6 m in thickness; some flows of the older sequence appear to have originated from flank vents rather than from the summit. Some valleys cut in older rocks are U-shaped, suggesting that the older series is of late Pleistocene age or older. Rocks of the

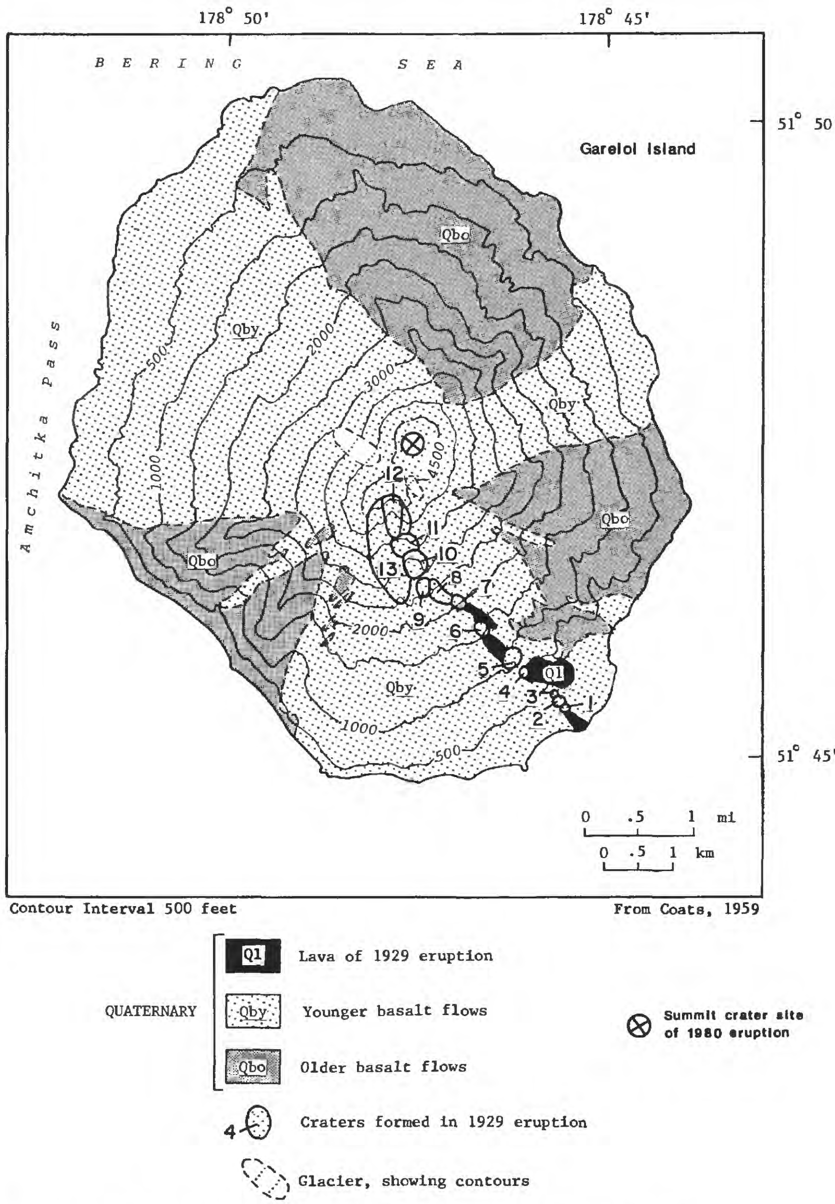


Figure 93. Geologic map of Gareloi Island after Coats (1959).

younger series are relatively undissected; many appear to have been erupted from at or near the summit crater. Craters formed during the 1929 eruptions are probably only partly of phreatic origin; erupted material includes essential, pumiceous glass, and reddened scoria. Lava flows that erupted in 1929 emerged at elevations below 600 m. In 1946, one crater at an elevation of 900 m, contained a small, milky blue-green lake, which suggests that acid fumaroles were still active in the crater at that time (Coats, 1959, p. 253).

Volcanic activity

1760	1922	Jan. 15, 1982
1790-92	1927	Sept. 4, 1987
1828-29	Apr. 1929-30	Aug. 17, 1989
1873	Aug. - Sept. 1980	

Volcanic activity has been frequently reported from Mount Gareloi since its discovery during the Bering Expedition in 1760. "Smoke" or unspecified activity was noted in 1760, 1828 and 1873, and 1927; lava extrusion in 1792; minor explosive eruptions in 1790 and 1791; and major explosive eruptions in 1922 and 1929-30 (Coats, 1950; 1959). The 1929 event is the most violent on record for Gareloi volcano; its course can be reconstructed in some detail from a second-hand report of what was apparently an eyewitness account (Coats, 1959, p. 252) and the findings of Coats' 1946 field examination.

In April of 1929, a phreatic eruption opened an elongate crater 1600 m in maximum diameter just below the southern summit; further explosions produced 12 smaller craters aligned along a south- to southeast-trending fissure. Glassy pumice, lapilli, scoria, and accidental rocks were then ejected from the lower craters, blanketing an area roughly 2.5 by 5 km on the southeast slope. Ash layers up to 2 m thick on Ogliuga Island, located about 16 km southeast, may be attributable at least in part to this eruption (Coats, 1956, p. 92) and several centimeters of pyroclastic debris are known to have fallen on Atka Island (about 300 km eastward) during the event. Extrusion of lava, which formed short steep flows, occurred at four sites along the fissure after the tephra eruptions. Various metallic oxides and halides (including atacamite, paratacamite and hematite) were deposited in several of the lower craters. Activity may have continued into 1930.

Known eruptive activity on Gareloi between 1930 and early 1980 was limited to that of fumaroles (Wentworth, 1951, p. 6) and sulfur dioxide emission at the northern summit, and discharge of odorless steam (maximum temperature 62°C) from small transverse fissures on the southeast flank. In August and September, 1980, eruptions were reported at Gareloi volcano (Anchorage Times, August 16, and September 19, 1980); the nature of eruptive activity is uncertain, but apparently it involved ash and steam (Smithsonian Institution, 1980).

On January 14, 1982, a magnitude 3.2-3.3 earthquake struck the area; the following day, January 15, a 7-9 km eruption cloud was observed on satellite imagery (Smithsonian Institution, 1982).

On September 4, 1987, a commercial pilot observed a narrow flow-like feature on the east flank that extended from the north crater rim at 1500 m altitude down to at least 1100 m, below which it was obscured by clouds. Steam rose 100 m above the flow(?) and the crater was vigorously steaming (Smithsonian Institution, 1987). On August 17, 1989, a grayish black ash cloud was observed from a passing aircraft about 700 m above the volcano's summit (Reeder, 1992).

Composition

The only petrographic information currently available for Gareloi volcano was obtained by Coats during a brief reconnaissance survey in 1946. The older rocks, probably late Pleistocene in age, consist of olivine basalt flows, 1 to 6 m thick, that are commonly holocrystalline and rich in augite; coarse reddened scoria is interbedded with exposures on the northeast flank (Coats, 1959, p. 250). Younger flows consist of olivine basalt; augite and olivine content differ among the flows. Textures range from fine-grained with a few small phenocrysts, to seriate and porphyritic.

Juvenile material erupted in 1929 may be significantly more siliceous than the older basaltic or basaltic andesite rocks. The lava was apparently highly viscous and generally formed blocky, vesicular, or scoriaceous flows, one of which is 75 m wide and 15 m thick. Orthopyroxene, brown hornblende, plagioclase (average composition about An_{48}), and clinopyroxene were observed in lava flows and pyroclastics of the 1929 eruption (Coats, 1959, p. 254-255).

NAME AND LOCATION

NAME:	SEMISOPOCHNOI VOLCANO
SYNONYMS:	MOUNT CERBERUS
TYPE:	INTRACALDERA STRATOCONES
LOCATION:	SEMISOPOCHNOI ISLAND, EASTERNMOST OF THE RAT ISLAND GROUP, ANDREANOF ISLANDS, ABOUT 1168 KM WEST-SOUTHWEST OF THE TIP OF THE ALASKA PENINSULA; THE ISLAND IS LOCATED AT THE JUNCTION OF BOWERS RIDGE AND THE INSULAR ALEUTIAN ARC
LATITUDE, LONGITUDE:	51°56'N, 179°35'E
ELEVATION:	800 M
USGS 1:250,000 QUADRANGLE:	RAT ISLANDS
CAVW NUMBER:	1101-06

Form and structure

Mount Cerberus comprises three young, relatively undissected composite cones (fig. 94), all of nearly equal height (800m) and with basal diameters somewhat more than 3 km (Coats, 1959). The cones all have summit craters and are built principally of andesitic lava flows and pyroclastic rocks. The easternmost crater is the smallest and most irregular in shape of the three; its vent has apparently shifted position slightly during or between past eruptions. Lava flows appear to have originated from flank eruptions below 500 m altitude.

About 1.6 km east of Mount Cerberus is a partially destroyed cone, 260 m above sea level. In the northeast part of the caldera, a small scoria mound (Lakeshore Cone; unit Qbl, fig. 94) was the source of two small lava flows 4 km northeast of Mount Cerberus, and a small scoria and agglutinate mound occurs 1.9 km south of Mount Cerberus.

Lava flows (unit Qbc, fig. 94) on the north flanks of Mount Cerberus appear in general to be younger than those on the south flank. The

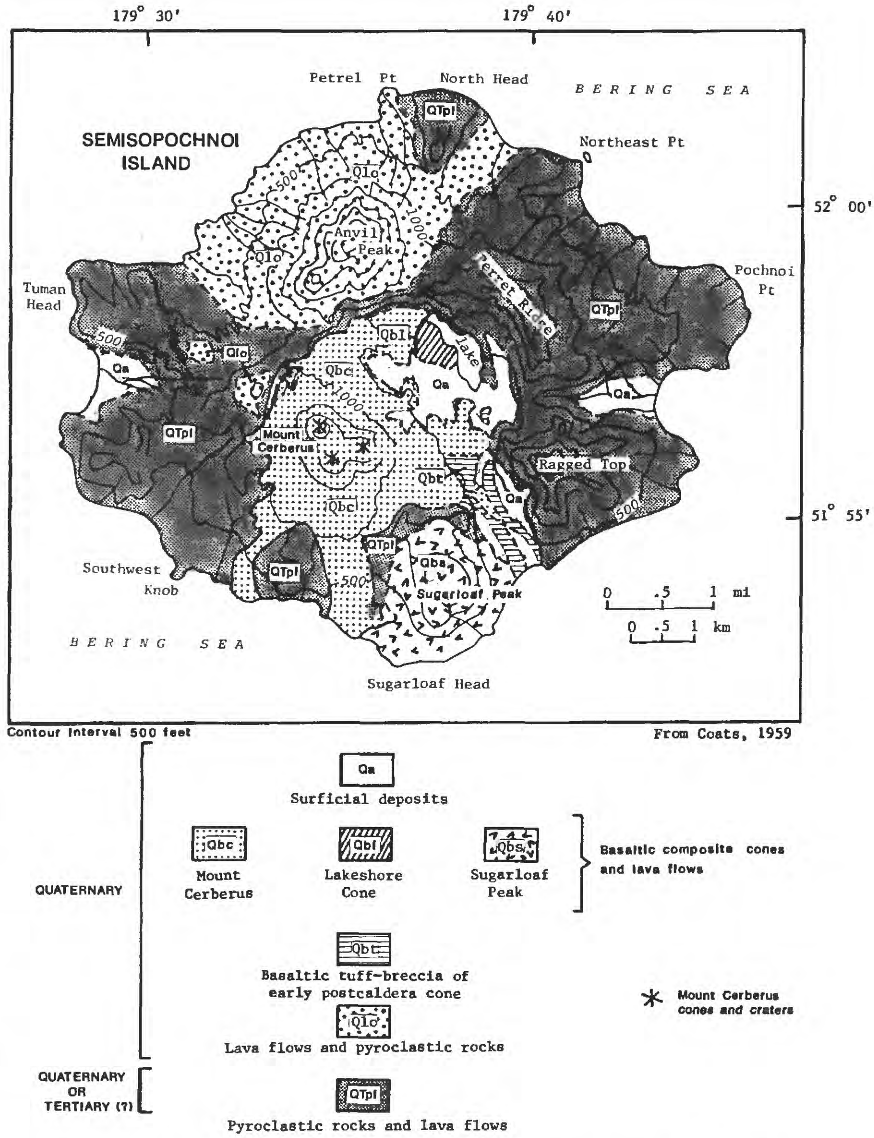


Figure 94. Geologic map of Semisopochnoi Island after Coats (1959).

youngest flow, as distinguished by degree of ash and vegetation cover, extends 600 m from the north base of the west summit and is probably no more than a century old according to Coates (1959). Other individual flows, consisting of single or multiple pulses as defined by sets of lava levees, can be identified. Many older flows, particularly those on the north flanks of Mount Cerberus, have been largely buried beneath loose detrital material washed from the upper reaches of the cone.

A widespread blanket of pre-Cerberus dacitic ash, and younger andesitic or basaltic ash derived from the eruptions of Cerberus and two neighboring cones, covers much of the island. The two neighboring cones—Sugarloaf Peak and Lakeshore—may also have been active in historical time (Coats, 1959). The summit of Sugarloaf Peak, 855 m high, lies about 4.4 km southeast of Mount Cerberus on the south coast of Semisopochnoi Island. Composed chiefly of pyroclastics with intercalcated lava flows up to 2m thick (unit Qbs, fig. 94), it has a double parasitic cone on its south flank from which vapor is sporadically emitted.

The oldest rocks exposed on Semisopochnoi Island are deeply eroded remnants of a late Tertiary-early Pleistocene volcano that had an eruption center or centers somewhere within the central part of the present island. These rocks, termed the Pochnoi Volcanics, crop out northeast and west of Cerberus (unit Qtpl, fig. 94) (Coats, 1959). Remnants of composite cones, perhaps slightly younger than and parasitic to a main volcano, are exposed around the margins of the island (unit Qtp, fig.94). Four other cones, one of which may have contained a lava lake in its summit crater, and associated lava flows (unit Qlo, fig. 94) are distinguishable from the composite cone remnants by being less eroded (Coats, 1959). The aforementioned deposits are glacially eroded, although the youngest of the cones only slightly so. After glaciation, large volumes of dacitic pumice and ash were erupted during formation of an elliptic caldera (8 km in greatest width) and formed pyroclastic-flow deposits on the flanks of the volcano. Deposits of post-caldera, pre-Cerberus eruptions are limited to sparse pyroclastic deposits and thin flows (unit Qbt, fig. 94) which extend from within the caldera out through a breach in the southeast wall. Flows from Cerberus and the smaller Lakeshore Cone have nearly covered the caldera floor; a small arcuate lake, 2.5 km long, lies along the inner northeast rim of the caldera. Nearly all deposits of Mount Cerberus are contained within the southern and western portion of the caldera. Flows have breached the southern caldera wall in two places and extend 2-5 km to the coast.

Volcanic activity

1772	Sugarloaf? 1987
1790	
1792	
1830	
1873?	

Records of volcanism on Semisopochnoi Island are scant; historical eruptions could have involved the small Lakeshore Cone and Sugarloaf cone in addition to Mount Cerberus. However, since at least one of the early reports specified that the activity noted was in the center of the island, and Mount Cerberus is the least eroded of the recent cones, it is believed to have been the source of most recorded events (Coats, 1950; 1959). These events include emissions of smoke in 1772, 1790, 1792 and 1830 and unspecified activity in 1873. In 1947, wisps of steam were observed emerging from the vicinity of a parasitic cone on the south flank of Sugarloaf Peak (Coats, 1959).

None of the historical activity has been correlated with specific lava or pyroclastic deposits on Semisopochnoi. However, a young flow on the lower northeast flank of Mount Cerberus displays vegetation cover comparable to that on a 1906 Kanaga Island flow at slightly higher altitude, and was possibly erupted during the twentieth century (Coats, 1959, p. 502).

The latest reported activity occurred on April 13, 1987 when a plume extending 90 km ENE from Semisopochnoi Island was observed on satellite imagery; the plume extended only 15 km ENE several hours later. On April 24, 1987, a commercial pilot flying about 50 km SE of the Island observed that one of the snow-covered peaks, possibly Sugarloaf, was blackened (Smithsonian Institution, 1987).

Composition

The 1947 field studies of Coats provide the most detailed petrographic information available for Semisopochnoi Island. Mount Cerberus flows comprise primarily grey, porphyritic basalt or andesite (figs. 95, 96) with phenocrysts of plagioclase, augite, hypersthene and, more rarely, olivine. Locally, silicic lava flows of hypocrystalline andesite or dacite are intercalated with these basalts.

Pyroclastic material erupted from Cerberus is generally similar in composition to the lava flows. Fragments are less than 30 cm in diameter. Scoriaceous, dark grey to black essential lapilli constitutes about 5% of these deposits and small fragments of accessory lithic basalt make up most of the rest.

Products of Sugarloaf Cone differ from those of Mount Cerberus in that Sugarloaf specimens lack hypersthene, which occurs in every Mount Cerberus sample studied (Coats, 1959). Since activity at the two cones appears roughly contemporaneous, the cones may tap different magma chambers or different parts of the same chamber. Most of the Sugarloaf rocks are olivine basalts or picritic basalts, that have intergranular textures and phenocrysts of labradorite to bytownite plagioclase, conspicuous green augite, olivine and magnetite.

Lava flows and pyroclastic deposits of Lakeshore Cone were not closely examined by Coats and no petrologic information is available.

Rocks of the volcanic series of Semisopochnoi Island range from basalt to dacite (Coats, 1959; DeLong and others, 1985) with SiO_2 contents of 50.4-65.3% and are thoeliitic in character. A composite sample of ash and pumice associated with caldera formation has a SiO_2 content of 61.02%; other samples of pumice have SiO_2 contents of 60.22% and 60.98%.

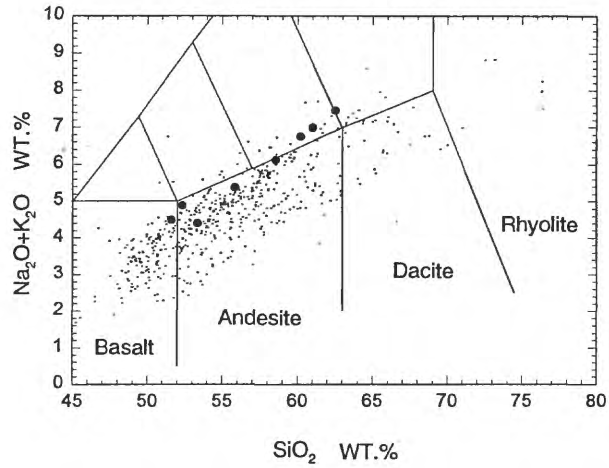


Figure 95. Total alkalies-silica diagram of Semisopochnoi volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

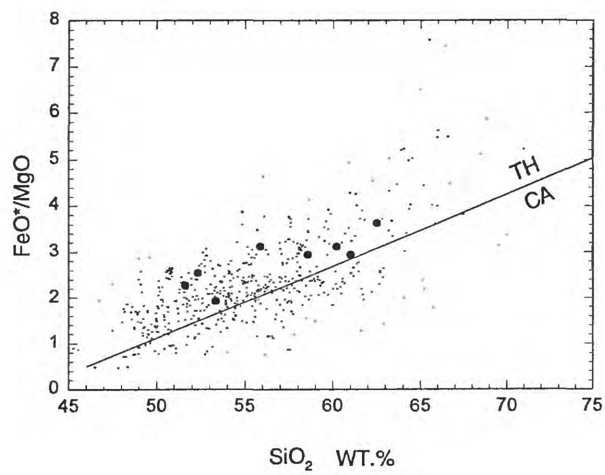


Figure 96. FeO/MgO-silica diagram of Semisopochnoi volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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Name and Location

Name:	Little Sitkin volcano
Synonyms:	Little Sitkin Island
Type:	Stratovolcano within nested calderas
Location:	Little Sitkin Island, in the Rat Island group of the western Aleutian Islands, about 1200 km west-southwest of the tip of the Alaska Peninsula, and 76 km northwest of Constantine Harbor on Amchitka Island
Latitude, longitude:	51°57'N, 178°32'E
Elevation:	1188 m
USGS 1:250,000 quadrangle:	Rat Islands
CAVW Number:	1101-05

Form and structure

The active stratovolcano on Little Sitkin Island occurs within the eroded remnants of a nested double caldera of probable late Pleistocene age. The older caldera (Caldera One, fig. 97) is about 4.8 km in diameter and is centered slightly northeast of the island's midpoint. The caldera formed at the site of a large stratovolcano, the remnants of which are the oldest rocks exposed on the island (unit Qtw, fig. 97; Snyder, 1959).

A second stratovolcano was constructed almost entirely of lava flows (unit Qd, fig. 97) within Caldera One and attained a height of about 900 m. A cataclysmic eruption, possibly in early post-glacial time, resulted in the formation of a second, smaller caldera (Caldera Two, fig. 97) that partly destroyed this cone. Caldera Two is elliptical in outline and measures 2.7 by 4 km; the inferred eastern and southern margins are coincident with those of Caldera One. Field relations suggest that the northern boundary of Caldera Two is a hinge along which a large block, comprising most of the Caldera One stratovolcano, was tilted southward during the caldera-forming eruption. The highest peak on the island is on the post-caldera remnant of the second cone.

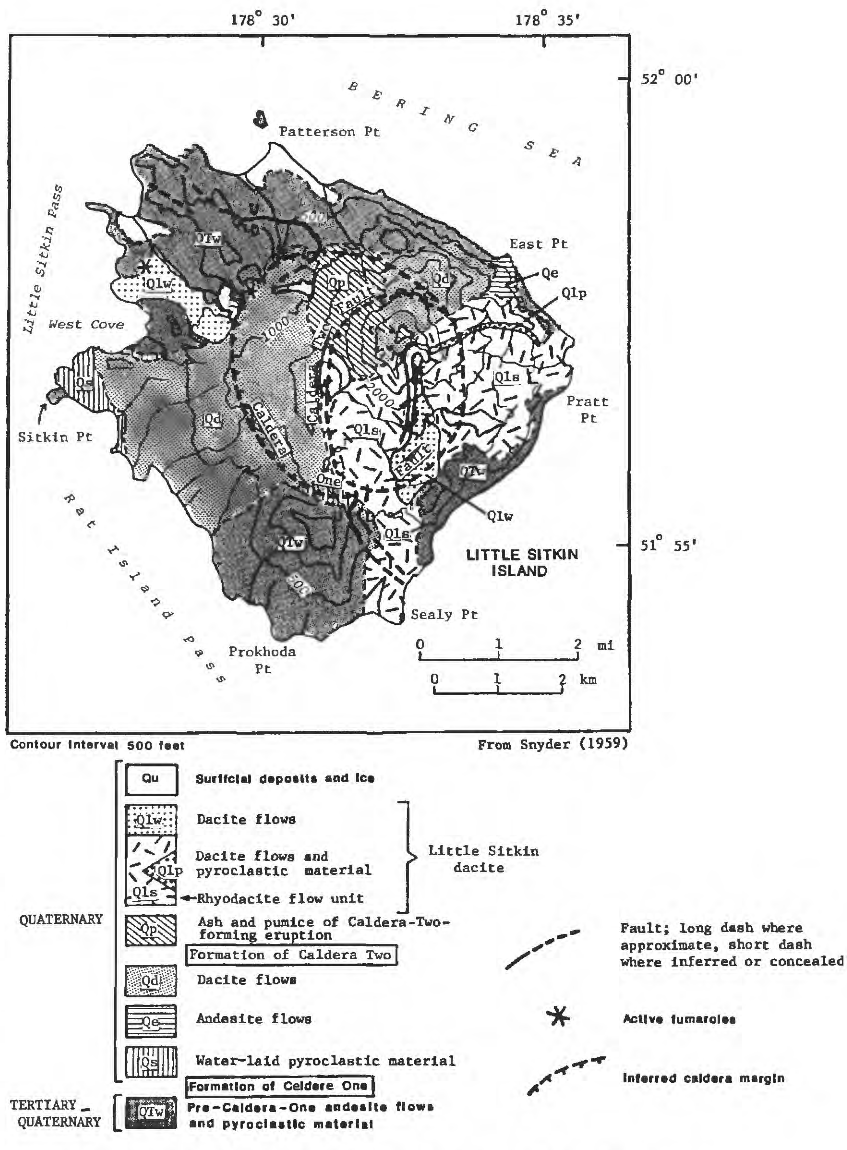

Figure 97. Geologic map of Little Sitkin Island after Snyder (1959).

A deposit of partly welded tuff up to 100 m thick (unit Qp, fig. 97) extends from the remnant cone northwest across the Caldera Two boundary fault, to slightly beyond the inferred location of the Caldera One boundary fault. The deposit is thought to have been emplaced by one or more pyroclastic flows, possibly associated with formation of Caldera Two (Snyder, 1959).

Post-Caldera Two deposits are mainly lava flows (units Qls, Qlp, and Qlw, fig. 97). Two relatively recent aa flows have well developed levees; one originated from the breached central crater of Little Sitkin volcano, and the other from a fissure along the western trace of the Caldera One boundary fault (Snyder, 1959).

Volcanic activity

1776
1828-30
ca. 1900?

Historical records of Little Sitkin volcanism are few and fragmentary. A 1776 eruption involving "flames" (C. Grewingk, cited in Dall, 1870), attributed to Sitignak, probably occurred at Little Sitkin volcano (Coats, 1950). Smoke was reported above the island during 1828-30 (Dall, 1870). Evidence of more recent volcanism is provided by Snyder (1959), who mapped two dacitic flows on the south and west flanks of the crater that appeared no more vegetated at comparable altitudes than andesite flows produced during a well-documented 1906 eruption on Kanaga Island, 60 km to the west. Snyder (1959, p. 183) argues that these extrusions "are not older than" the 1906 Kanaga flows, implying that Little Sitkin has erupted at least once during the 20th century.

Jaggar (1927), states that "Chugul and Little Sitkin are said to be fuming volcanoes"; no further details are given.

Current activity on Little Sitkin Island is limited to solfataric emissions. Three major fumarolic areas in the northwest quarter of the island are aligned parallel to the north-northwest trend of neighboring volcanic centers.

Composition

Petrographic data for Little Sitkin volcano are presented by Snyder (1959). The oldest rocks on Little Sitkin Island are andesitic lava flows, dikes, and pyroclastic deposits, with subordinate amounts of dacitic and basaltic lava flows and pyroclastic deposits (figs. 98, 99) of an ancestral composite cone. Plagioclase phenocrysts in a single sample of basalt range from 45% to 65% An-content and from 45% to 60% in a single sample of andesite (Snyder, 1959, p. 190-191). Augite exceeds or equals orthopyroxene in abundance, and olivine occurs in trace to accessory amounts in both the basalt and andesite.

Petrographic data on the pyroclastic rocks that may have been erupted during formation of Caldera One are limited to inclusions of nonporous and pumiceous dacite. In the inclusions, plagioclase phenocrysts have an average An-content of 45%, quartz is not observed, clinopyroxene and orthopyroxene occur in varying proportions, and olivine and hornblende are present but uncommon.

The lava flows composing the central cone built within Caldera One range in composition from andesite to dacite and are characterized by ubiquitous andesitic xenoliths. Plagioclase phenocrysts in one specimen of andesite range from 26% to 74% in An-content; pleochroic brown hornblende, clinopyroxene, orthopyroxene, and opaque are the other phenocryst phases. The dacite contains plagioclase phenocrysts ranging in An-content from 23% to 55%; orthopyroxene, clinopyroxene, hornblende, opaques, and tridymite are the remaining phenocrysts. Trace amounts of olivine occur in other specimens of both andesite and dacite that lack tridymite.

Tuffs emplaced during formation of Caldera Two are separable into 2 varieties: an upper, light grey to blue-grey, firmly consolidated ash-and-lapilli tuff, and a lower, grey-white to salmon-pink welded tuff; both of these are probably pyroclastic flow deposits. The upper unit contains 1 to 2% angular to subangular blocks of andesite, basalt, and dacite up to 60 cm long. The lower unit contains 5 to 10% rounded to subrounded bombs(?) consisting of black glass with layers, blebs, and stringers of white glass. Plagioclase phenocrysts range in An-content from 43% to 76%, and abundance of clinopyroxene equals or exceeds that of orthopyroxene. Olivine, hornblende, and quartz are not known to occur.

Post-Caldera Two lava flows range in composition from andesite to dacite or rhyolite. Plagioclase phenocrysts in a single sample of andesite range from An_{35} to An_{56}; in 4 samples of dacite, the range is An_{25} to An_{78}. Plagioclase phenocrysts in 2 samples of dacite or rhyolite range from An_{27} to An_{50} and from An_{35} to An_{60}.

One of the young flows that may have erupted in the early 1900's is an andesite or low-silica dacite. Like the older, post-Caldera Two low-silica dacites, this sample contains plagioclase phenocrysts ranging from An_{36} to An_{62}.

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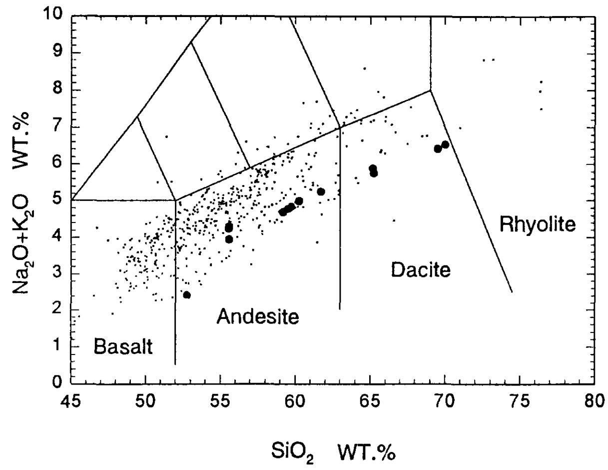


Figure 98. Total alkalies-silica diagram of Little Sitkin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

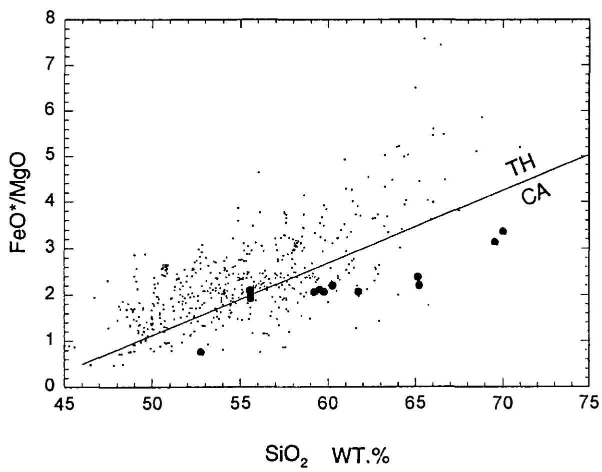


Figure 99. FeO/MgO-silica diagram of Little Sitkin volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

page 97 follows

Name and Location

Name:	Kiska Volcano
Synonyms:	None
Type:	Stratovolcano
Location:	Kiska Island, westernmost of the Rat Island group, in the western Aleutian Islands: 1270 km west-southwest of the tip of the Alaska Peninsula, and about 400 km west of Adak
Latitude, longitude:	52°06'N, 177°36'E
Elevation:	1220 m
USGS 1:250,000 quadrangle:	Kiska
CAVW Number:	1101-02

Form and structure

Kiska Volcano is a stratovolcano, 8.5 by 6.4 km in diameter at its base and 1221 m high, on the northern end of Kiska Island. A slightly elliptical crater, about 0.4 km in diameter and breached on the north, occupies the summit (fig. 100). A parasitic 30-m-high cinder cone, formed in 1962 near sea level, occurs at Sirius Point and an older parasitic cone, now levelled by marine erosion, occurs at sea level 5.6 km southwest of Kiska Volcano.

The southern part of Kiska Island has been glacially eroded, but the volcano shows no evidence of glacial dissection (Coats, 1956). Surface lava flows are thus younger than the last major glaciation. Five of the youngest lava flows (unit Qkr, fig. 100) have been mapped separately by Coats and others (1961) based on geomorphic expression; the flows of block lava have steep fronts as much as 30 m high. Source areas of the flows range from the base of the cone to the summit. The highest flows appear to have emerged from the summit crater through the breached north wall.

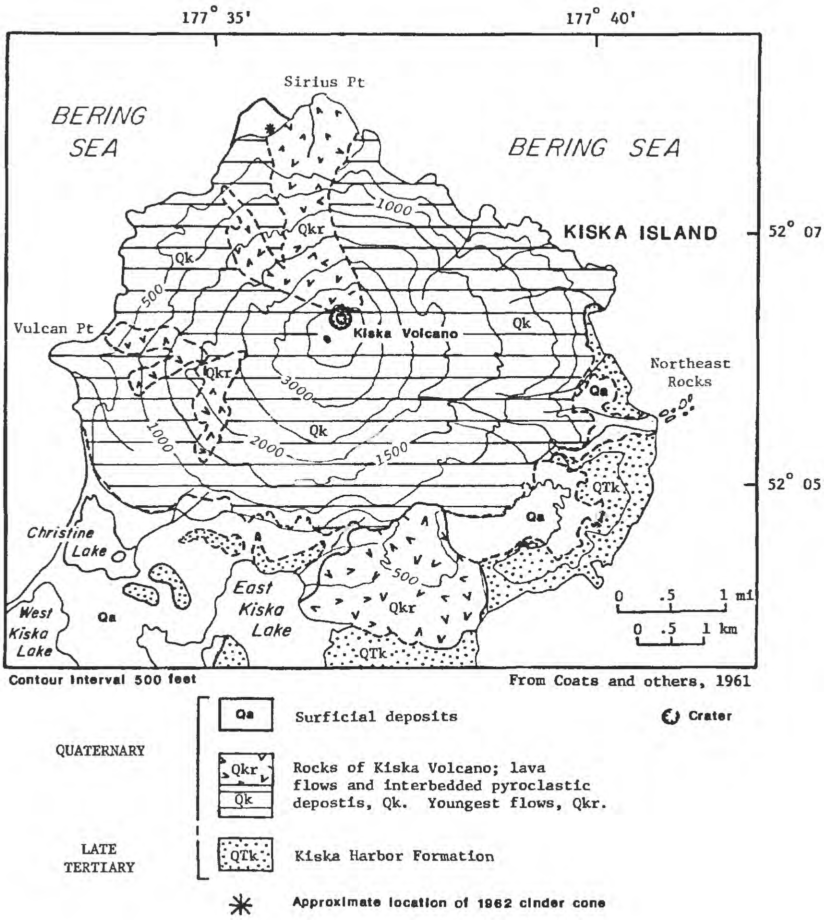


Figure 100. Geologic map of the north end of Kiska Island after Coats and others (1961).

Kiska Volcano is underlain and flanked on the south by the remains of an older composite volcano; a single K-Ar age of 5.5 ± 0.7 m.y. is cited in Marlow and others (1973) for an andesitic lava flow in this older volcano.

Volcanic activity

1907	March 18, 1964
1927	September 11-16, 1969
January 24, 1962	April 15, 1987 ?
	June 1, 1990

Records of activity during early historical time are scanty; crater solfataric emissions were mentioned as early as 1905 and "smoke" was observed over the island in 1907 and possibly in 1927 (Coats, 1950). Coats briefly visited Kiska volcano in 1947 and found no evidence of recent ash flows nor any active fumaroles; the youngest lava flows were more heavily vegetated at any given altitude than counterparts on adjacent islands known to have been erupted in the 20th century. The youngest lava flows before 1962 were probably between 100 and several hundred years old. Coats concluded that any events between 1905 and 1947 were at most solfataric (Coats and others, 1961).

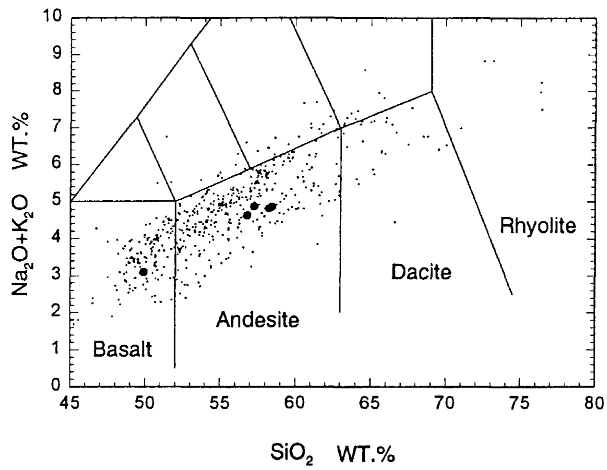
An explosive eruption occurred on January 24, 1962 accompanied by lava extrusion and the construction of a cinder cone about 30 m high at Sirius Point on the north flank of Kiska Volcano, 3 km from the summit of the main cone (Anchorage Daily News, January 30, 1962). A second eruption that produced a lava flow was reported to have occurred March 18, 1964 (Bulletin of Volcanic Eruptions, 1964). Coast and Geodetic Survey personnel recorded renewed activity on Kiska Island in early September, 1969; an ash column was observed rising to 400 m and steam to 4000 m. "Flames" and what appeared to be lava were reportedly visible from Amchitka, 80 km distant. On September 16, strong sulfur odors, air temperatures elevated by 10 to 15°C, and possible evidence of a small lava flow were noted during a military flight over north Kiska Island (Smithsonian Institution, 1969; eyewitness accounts on file at Geophysical Institute, University of Alaska, Fairbanks.)

On April 15, 1987, a narrow, drifting plume located 60 km east of Kiska Island, was observed on satellite imagery and is inferred to have originated at Kiska volcano (Smithsonian Institution, 1987).

Steam and minor ash emission from an upper flank vent on June 1, 1990 was reported by an observer on neighboring Amchitka Island (Anchorage Times, June 3, 1990; Smithsonian Institution, 1990). Although a sizeable steam plume was reported during the next several days, ash emission apparently lasted only several hours.

Composition

Coats and others (1961) provide the only detailed petrographic information available for Kiska Volcano; their work is based on reconnaissance studies carried out in 1947 and 1951. Interbedded lava flows and pyroclastic deposits make up the main cone. Both glass and hornblende are reported to occur in the pyroclastic material. Lava flows range from less than 1 m to more than 30 m thick and are primarily grey, fine-grained porphyritic andesite (figs.101, 102). Some of these rocks contain hypersthene and minor olivine; others are two-pyroxene andesite. Five of the youngest flows examined by Coats and others are medium grey to light brown and consist of augite-hypersthene andesite, locally containing minor olivine, and basalt.



Figuare 101. Total alkalies-silica diagram of Kiska volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Discriminant lines and field names (Le Bas and others, 1986) are explained on Figure 2.

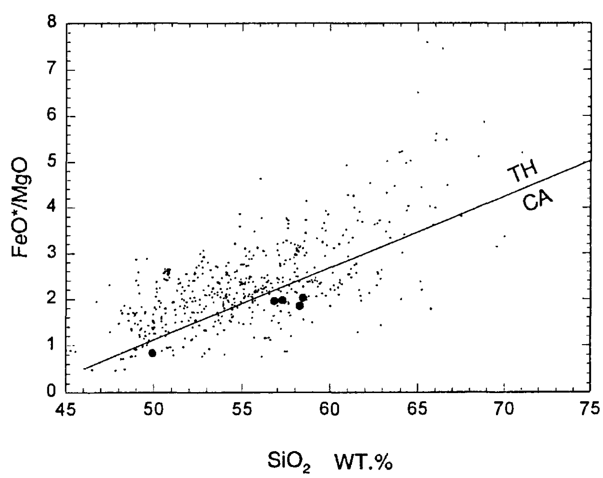


Figure 102. FeO/MgO-silica diagram of Kiska volcanic rocks (solid circles) and other Aleutian arc volcanic rocks (small dots) of oceanic affinity (those located west of 165°W longitude). Tholeiitic versus calc-alkaline discriminant line from Miyashiro (1974).

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