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.

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 1981 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

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.

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.

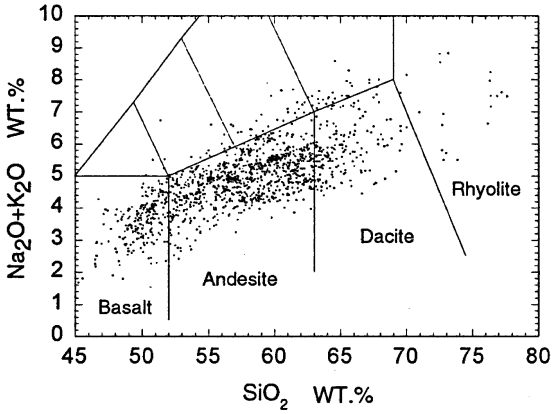

Figure 2A. Figure 2A. Total alkalies-silica (TAS) diagram of Aleutian arc volcanic rocks. Discriminant lines and field names shown are those recommended by the IUGS (Le Bas and others, 1986) and apply to all subsequent TAS diagrams in this catalog.

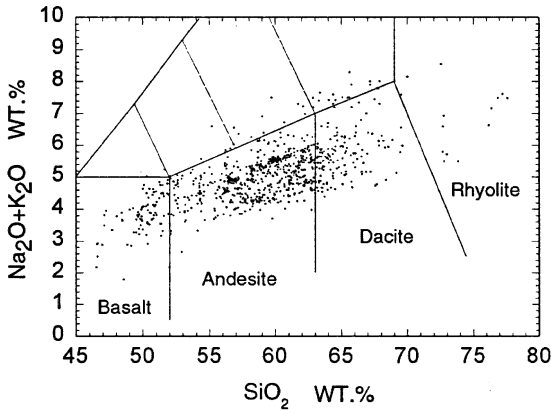

Figure 2B. Total alkalies-silica (TAS) diagram of volcanic rocks from continental margin part of Aleutian volcanic arc.

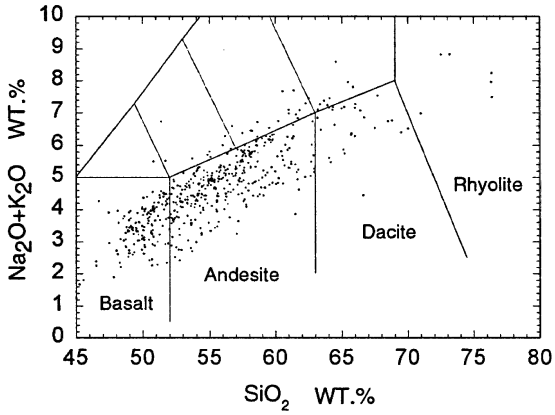

Figure 2C. Total alkalies-silica (TAS) diagram of volcanic rocks from oceanic island-arc part of Aleutian volcanic arc.

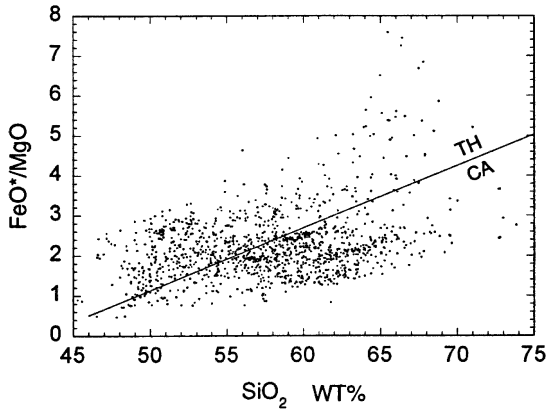

Figure 3A. FeO/MgO-silica diagram of volcanic rocks from entire Aleutian arc.*

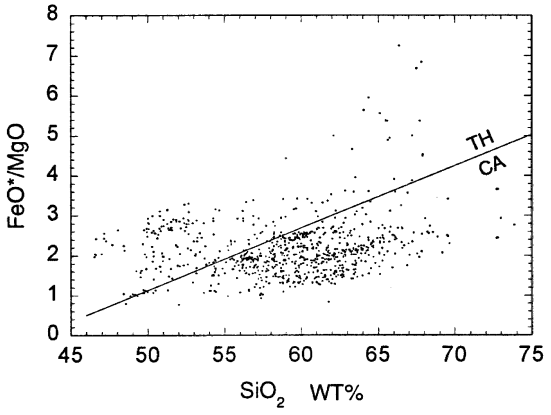

Figure 3B. FeO/MgO-silica diagram of volcanic rocks from continental margin part of Aleutian arc.*

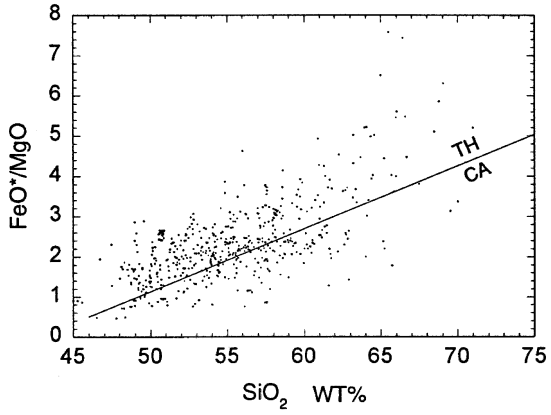

Figure 3C. FeO/MgO-silica diagram of volcanic rocks from oceanic island arc part of Aleutian arc.*

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

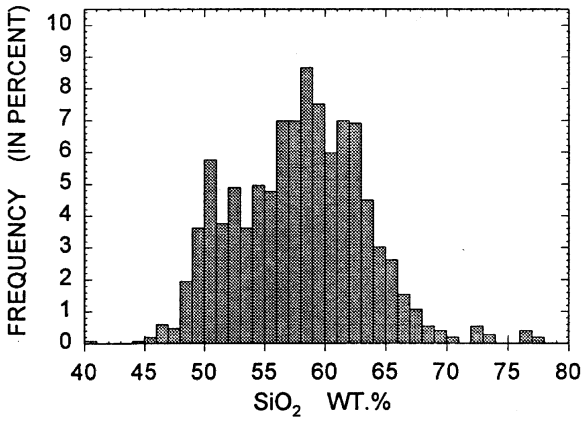

Figure 4A Silica distribution diagram for entire Aleutian arc.

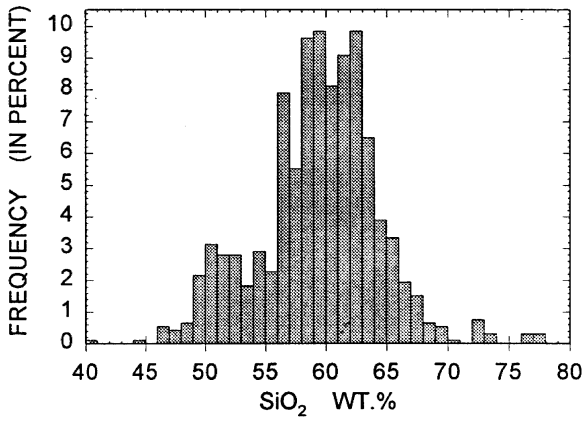

Figure 4B. Silica distribution diagram for continental margin part of Aleutian arc.

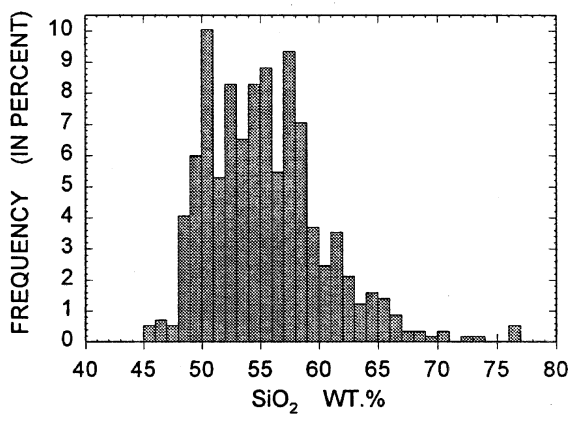

Figure 4C. Silica distribution diagram for oceanic island-arc part of Aleutian arc.

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.

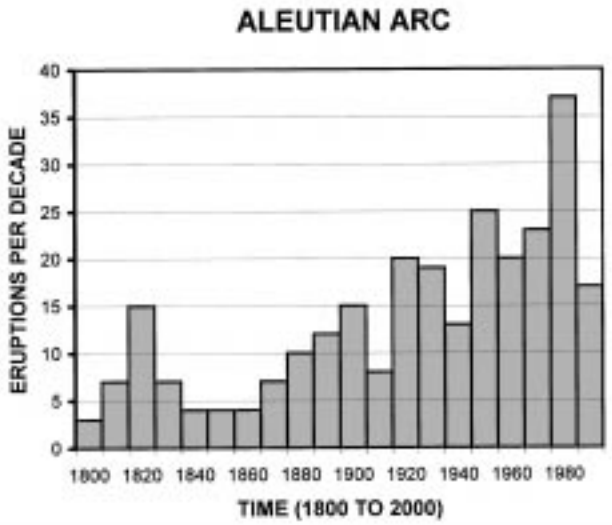

Figure 5. A plot of the number of eruptions reported per decade for the period 1800-2000 for the Aleutian Arc; the 1990-2000 number is estimated by doubling the number of eruptions from 1990-1995.

TABLE OF CONTENTS