Reconnaissance Geology of Some Western Aleutian Islands, Alaska

By ROBERT R. COATS

INVESTIGATIONS OF ALASKAN VOLCANOES

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PREFACE

In October 1945 the War Department (now Department of the Army) requested the Geological Survey to undertake a program of volcano investigations in the Aleutian Islands–Alaska Peninsula area. The first field studies, under general direction of G. D. Robinson, were begun as soon as weather permitted in the spring of 1946. The results of the first year's field, laboratory, and library work were assembled as two administrative reports. Part of the data was published in 1950 in Geological Survey Bulletin 974–B, Volcanic activity in the Aleutian arc, by Robert R. Coats. The remainder of the data has been revised for publication in Bulletin 1028.

The geologic and geophysical investigations covered by this report were reconnaissance. The factual information presented is believed to be accurate, but many of the tentative interpretations and conclusions will be modified as the investigations continue and knowledge grows.

The investigations of 1946 were supported almost entirely by the Military Intelligence Division of the Office, Chief of Engineers, U. S. Army. The Geological Survey is indebted to the Office, Chief of Engineers, for its early recognition of the value of geologic studies in the Aleutian region, which made this report possible, and for its continuing support.

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ABSTRACT

The general features of the western Aleutian Islands, from Kasatochi to Attu, were studied in 1946 in connection with investigations of northern Adak Island, northern Kanaga Island, and other Aleutian islands.

The geology of the western Aleutian Islands is complex. Its deducible history begins in the Paleozoic(?) era, when a land made up of metamorphic rocks, intruded by granite, occupied the region. Successive additions of basaltic volcanic rocks and sediments of volcanic derivation were made during Paleozoic(?) and early Tertiary time, producing a highlands south of the present islands from about the longitude of western Tanaga Island to that of eastern Amchitka Island. Submergence of most of the land resulted in the carving of wide wave-cut benches that later emerged from the water. In late Tertiary time, glaciers accumulated in the highland and moved northward over the uplifted benches.

In very late Tertiary and in Quaternary time many basaltic shield volcanoes and composite cones were built on the wave-cut and locally glaciated remnants of the older volcanoes. The new volcanoes were alined on a great arc along the northern margin of the present belt of islands. The eruptions that produced many of these volcanoes began at a time when sea level was higher, relative to the land, than it is now; marine sediments were deposited offshore and are now exposed above sea level. A period of downfaulting followed, and most of the ancient highlands in the southern part of the belt disappeared beneath the Pacific Ocean. Many of the islands were again beveled by marine erosion. Later, the islands reemerged in about their present positions. In Quaternary time, new glaciers developed in the higher parts of the islands, except on the very active volcanoes and on some isolated peaks. Some of the volcanoes became extinct before and during the most recent period of glaciation, but many are still active.

Mild volcanic activity, such as eruptions of ash, can be expected to occur frequently in the northern part of the island belt; violent activity can be expected to occur infrequently.

INTRODUCTION

In the summer of 1946 several of the Aleutian islands west of Atka Island were mapped geologically. In addition to areas mapped in detail on Adak and Kanaga Islands, a number of the islands from Great Sitkin to eastern Attu were examined briefly on the ground, and others from Kasatochi westward were studied from the air. The purpose of this reconnaissance investigation was to choose areas for later, more detailed work, and to acquire general knowledge of the

place of the western Aleutian Islands in the volcanic history of the Aleutian arc.

In order to present a more nearly complete picture, this report summarizes not only the reconnaissance investigations made from Tanaga Island to Attu Island, but also the more detailed work done on Adak and Kanaga Islands. The map accompanying this report (pl. 17) is therefore generalized, even in the areas that have been covered by more detailed maps. The geologic units used in the mapping and description are also broad and generalized.

This report is based almost entirely on field work done during the summer of 1946 by Robert R. Coats, assisted during most of the season by Will F. Thompson, Jr. Eighteen days were spent on Tanaga Island, 4 days on Gareloi Island, half a day each on Ogliuga, Attu, and Amatignak Islands, 4 days on Amchitka Island, and 2 days each on Shemya and Great Sitkin Islands, in addition to time spent on Adak and Kanaga Islands. The Semichi Islands, Buldir Island, and parts of Attu, Kiska, Rat, Amchitka, and the Delarof Islands were observed from the air. Most of the islands from Adak to Amchitka were also observed from shipboard. Aerial photographs of many of the islands, taken by both the U. S. Navy and U. S. Army, materially aided the study.

Acknowledgment is made of the cooperation of officers and men of the Army and Navy, especially Lt. Col. R. E. Ware, post engineer, Adak; Lt. Col. C. E. Johnson, port commander, Adak; Commander S. O. Cole, chief staff officer, Adak Sector; Lt. Col. Leonard Cox, acting post commander, Shemya; Lt. Col. Ivan Cunningham, post engineer, Shemya; and Lt. John Rogers, Attu.

GEOGRAPHY

LOCATION AND SIZE OF AREA

The area discussed herein includes that part of the Aleutian chain from Kasatochi Island westward to Attu Island, and is referred to as the western Aleutian Islands (fig. 6). It extends from longitude 175°30′ W. to 173° E., and from latitude 51°15′ N. to slightly more than 53° N. The length of this part of the chain is about 500 statute miles, and the greatest width, which is in the vicinity of Semisopochnoi Island, is about 50 miles. The largest islands are Adak, 284 square miles, and Attu, 318.

The areas of the 10 largest of the western Aleutian Islands (west of Atka Island) are given in the table on page 86. The measurements were made by Harold Drewes, using a planimeter on maps of a scale of 1:250,000.

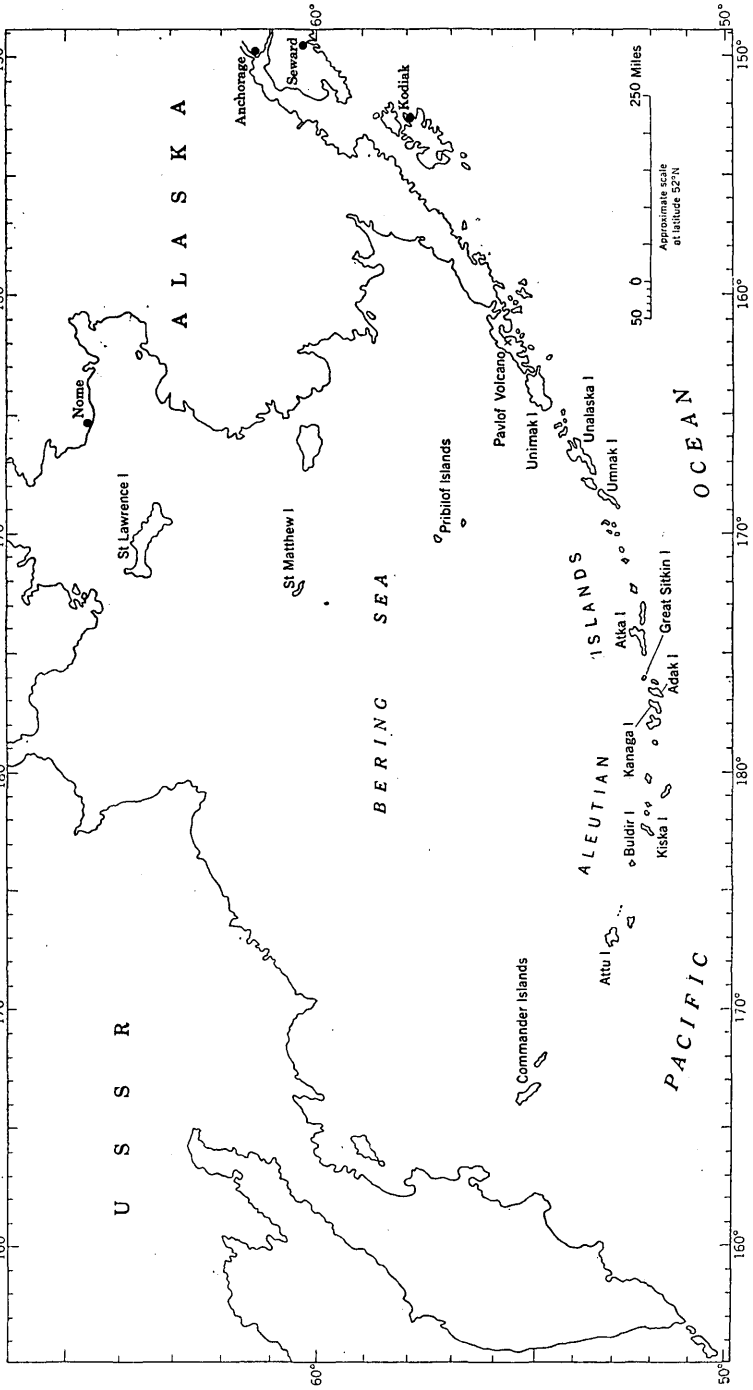

FIGURE 6.—Map of the Alaska Peninsula and Aleutian Islands.

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Island	Square miles	Island	Square miles	Island	Square miles
Attu	317.8	Amchitka	114.1	Agattu	77.5
Adak	284.1	Kiska	109.8	Great Sitkin	61.6
Tanaga	184.8	Semisopochnoi	78.3	Kagalaska	45.4
Kanaga	134.6				

TERRAIN TYPES

Great topographic diversity exists among the western Aleutian Islands as a result of numerous differences in their geologic histories. Broadly, the islands are of two terrain types—low-lying islands and mountainous islands. The low-lying islands are wave-cut platforms whose surfaces are nearly featureless. The relief of the mountainous islands is constructional, because of volcanism, or destructional, because of dissection of an upland surface, or a combination of the two. The topography of many areas of each terrain type has been modified by glaciation. Both terrain types are present on some of the larger islands.

LOW-LYING ISLANDS

The elevated wave-cut platforms that constitute the low-lying islands and parts of some of the mountainous islands are of three types. The platforms that emerged most recently retain the initial surface form, practically unmodified by fluvial erosion. Some of these surfaces are covered by thin layers of boulder gravel, perhaps of glacial derivation, that were reworked by marine abrasion before the emergence of the platforms. The second type of platform emerged earlier, and the topography has been modified to a greater extent by subaerial erosion; distinctions may be made within this group on the basis of the relative age. The third type of platform has been eroded by ice sheets, formed by the confluence of valley glaciers that originated in nearby highlands, since the latest emergence of the island.

The platforms that emerged most recently retain the almost featureless surfaces produced by marine abrasion, and are either horizontal or are gently tilted. A few streams head near the crenulated margins of the platforms, which they breach and descend in short, steep canyons. The steep margins of the platforms are fringed at their bottoms by narrow boulder beaches. A few large, round or elliptical lakes are present on the platform surfaces. Islands of this type include Ogliuga, Ilak (pl. 18 *A*), Skagul, Kavalga, and Unalga in the Delarof Islands, and Shemya and Oubeloi in the Semichi Islands.

The second type of platform emerged earlier than the first and has a more mature topography. Several successive marine benches are commonly present, and the surface of the highest one generally forms the principal interstream divide. The bench surfaces are poorly drained and many have lakes of different size and irregular shape.

Stream valleys are longer and drainage patterns better developed than on the platforms that emerged most recently. Drainage patterns are poorly adjusted to bedrock structure. An example of this type of physiography is eastern Amchitka Island, where glacial boulders occur beneath marine gravel at altitudes of more than 100 feet (pl. 18*B*).

On the oldest platforms the interstream divides are narrow, and lakes are few, large, and of simple outline, except where the encroachment of vegetation has made them irregular. Narrow alluvial plains are present along the larger streams. With increasing altitude the ancient sea cliffs between successive levels of marine abrasion have progressively more gentle slopes. The wave-cut platforms of southwestern Kanaga Island and southern Tanaga Island are of this type.

Wave-cut platforms on several islands were glaciated during the Pleistocene epoch. The effect of glaciation has been to emphasize the bedrock structure. Streams and chains of lakes lie along fault zones and weak beds, preferentially excavated by glacial erosion. The topography in general is minutely irregular or hummocky, and numerous bedrock knobs, small depressions, ponds, and lakes are present. Glacial erosion has generally beveled off the abrupt shoulders between uplands and sea cliffs. In places cliffs have been cut in the slopes by postglacial marine erosion, but these cliffs are generally low. The platform of Ulak Island is of this type as is that of the extreme southwestern part of Adak Island and the adjacent part of Kanaga Island. The sources of the eroding glaciers were the highlands of Amatignak and Adak Islands, respectively.

MOUNTAINOUS ISLANDS

Two types of mountainous or hilly islands have been distinguished. The relief of one type, herein referred to as an oldland, is destructional, being due to differences in the resistance of the rocks to erosion, although uplift of the entire landmass was probably an accessory factor in producing the topography. The relief of the other type is constructional, owing its height to upbuilding by volcanic activity.

The oldland islands of the Aleutian chain comprise three groups: those that have been dissected by normal subaerial erosion but not by glaciers, those that formerly had small glaciers near the higher summits, and those that were extensively glaciated. The highlands of Alaid Island seem not to have been glaciated. A few relatively small glaciers were present in the highlands of western Amchitka Island. Islands extensively covered by glaciers include Attu, Kiska, Agattu (Sharp, 1946), Amatignak, Adak, and the southern Andreanof Islands east of Adak. These islands are characterized by knife-edge ridges at high altitudes, glacially striated and rounded ridges at lower altitudes, numerous rock-basin lakes, flat-floored passes, and wide, U-shaped valleys.

The highlands built by volcanic activity include those that have been dissected by streams and glaciers, and those, either lower in altitude or of relatively recent construction, that have undergone little or no dissection and still retain their original conelike forms. The volcanic cones on Tanaga Island, except the high triple peak of Tanaga Volcano, have been dissected by glaciation; and all but small remnants of the southern flanks of the lower peaks along the eastern part of the north coast have been removed by vigorous marine erosion. The two volcanoes on Adak Island—Mount Moffett and Mount Adagdak—have been somewhat dissected by subaerial erosion, and by marine truncation on the sides exposed to the sea; Mount Moffett has been locally glaciated. The low cone on Bobrof Island has been deeply dissected and large parts have been removed by marine erosion.

The cone on Gareloi Island (pl. 19) has been only slightly dissected, even though it supports two glaciers. The large island of Semisopochnoi consists of a great postglacial caldera and several young, undissected volcanic cones. The symmetrical cones on Segula and Kiska and Buldir Islands have not been deeply glaciated or dissected by streams.

VEGETATION

The low-lying areas of the western Aleutian Islands support a dense growth of grass and moss during the late summer. Narcissus, anemone, and lupine are abundant, and dense stands of wild rye occur near beaches. Heath plants associated with a very thick, spongy carpet of moss and lichens are common on poorly drained ridgetops. A species of prostrate willow grows on some exposed slopes. The principal plant associations have been described by Collins, Clark, and Walker (1945, p. 64–68).

GEOLOGY

Eight geologic units have been distinguished in the western Aleutian Islands. Six of these have been mapped, and their distribution is shown on plate 17. The units and their distribution are discussed below, but no attempt is made to describe separately the geology of each island.

GRANITIC AND METAMORPHIC ROCK

Some smoothly rounded boulders in gravel beds on the wavecut platform of western Tanaga Island and on Ogliuga Island appear to be derived from the oldest rocks in the western Aleutians. The contrast between these boulders and the rough angular boulders derived from the exposed bedrock of these islands is marked. The rounded boulders are of several rock types, including hornfels,

hornblende gneiss, slate, schist, granulite, granodiorite, and several varieties of granite, including biotite granite and hornblende granite.

The bedrock source of the boulders was not seen and may not be exposed. Therefore, the relative ages of the granitic and metamorphic rocks composing the boulders could not be definitely determined. The granitic rocks are believed to be younger, however, because most of them lack directional textures, indicating that they have not been metamorphosed, although some are slightly gneissic. The boulders may represent rocks of many ages and more than one interval of erosion. The boulders of metamorphic rock have undergone more thorough recrystallization than is known in any rocks now exposed in the western Aleutians, suggesting that the parent rocks are older than the Finger Bay volcanics (p. 89), and that they may be of Paleozoic age. The presence of crystalline rocks clearly of continental type indicates that a large land mass must have existed in the vicinity in Mesozoic or Paleozoic time.

GRANITE(?)

The U. S. Coast and Geodetic Survey (1944, p. 120), reports that Ilak Island is composed of granite. [In the summer of 1952 landings were made on the island and the rock was found to be a light-colored granular rock, resembling the quartz diorite that forms intrusions in many of the islands.]

BASALTIC ROCKS, ARGILLITE, AND GRAYWACKE

A sequence of dark-green to black basalt flows and basaltic tuff, gray hard argillite, and gray-green coarse graywacke, containing small lenses of brown chert and brown limestone, was seen on Attu and Shemya Islands. The rocks on Attu, described by Capps (1934, p. 151), evidently are part of this sequence. Most of the rocks have been intensely sheared and fractured.

The age of the rocks is not known. They have been found in contact only with early Tertiary volcanic rocks which intrude them. Because of their greater degree of shearing and deformation, they are tentatively considered older than the Finger Bay volcanics and the graywacke and graywacke breccia sequence of Amatignak Island (see below).

FINGER BAY VOLCANICS

A sequence of black, dark-gray, purplish-gray, greenish-gray, and grayish yellow green volcanic rocks crops out along the north shore of Finger Bay on Adak Island and has been named Finger Bay volcanics. These rocks, which underlie most of Adak Island, consist of basaltic flows, tuff-breccia, agglomerate, and tuff, intruded by large masses of gabbro and small masses of rhyolite. The volcanic rocks

and many of the intrusive masses included with them have been greatly deformed and hydrothermally altered. Similar rocks are present on southeastern Great Sitkin Island, and they probably compose most of the Andreanof Islands east of Adak. The rocks have been studied on Great Sitkin and Adak Islands and are discussed by Simons and Mathewson (1955) and Coats (1956a).

The deformed and altered Finger Bay volcanics were correlated, on lithologic grounds, with volcanic rocks of Mesozoic age on the Alaska Peninsula (Simons and Mathewson, 1955). Because a late Paleozoic plant has been identified in the Finger Bay volcanics exposed in an isolated outcrop on Adak Island, these rocks are now regarded as Paleozoic(?) in age (Coats, 1956a).

GRAYWACKE AND GRAYWACKE BRECCIA

Beds of grayish-green graywacke and graywacke breccia, containing subordinate mudstone, were seen on Amatignak Island. They are exposed in sea cliffs along a small bay on the northeast side of the island, and between the bay and the highest point of the island. The rocks are composed of fragments of chloritized, albitized, and epidotized basalt. The rocks are well bedded and well indurated. They are intruded by sills of medium-grained granophyric, partly uralitized gabbro, as much as several hundred feet thick.

The relative age of this rock sequence has not been definitely determined, as its contact with another sequence has not been seen. All fragments appear to be those of basaltic rocks; no metamorphic or granitic fragments are present. The sequence could be the sedimentary equivalent of the Finger Bay volcanics, or it might be regarded as consisting of material derived from Finger Bay volcanics that were eroded and deposited in shallow water. Sediments that are somewhat similar to these, except that they contain a great proportion of chert, occur on Agattu Island (Sharp, 1946, p. 193–194).

EARLY TERTIARY BASALTIC ROCKS

Volcanic rocks of probable early Tertiary age have been examined on Tanaga, Ogliuga, Amchitka, and Shemya Islands. Rock types include basalt and hornblende basalt tuff, tuffaceous agglomerate, tuff-breccia, agglomeratic tuff, flows, and dikes. Many of the fragments in the tuff-breccia are large, some as much as 7 feet in length. The flows are generally thin and in places are interbedded with scoria. On eastern Amchitka Island these volcanic rocks are intruded by a stock of quartz diorite.

The early Tertiary volcanic rocks include five masses of andesite porphyry near Zeto Point on the east coast of northern Adak Island (Coats, 1956a), and a similar mass of hornblende andesite porphyry on Shemya Island.

Evidence for age determination is inconclusive. Because the rocks are much less altered than the Finger Bay volcanics, are but slightly deformed—the greatest measured secondary dips being only 10° to 15°—and have been glaciated, they are believed to be of Tertiary age. They have been beveled during one or more stages of wave cutting, and are therefore assigned an early Tertiary age to distinguish them from other glaciated volcanic rocks that have not been similarly beveled and that are assigned a late Tertiary or Quaternary age.

LATE TERTIARY AND QUATERNARY BASALTIC ROCKS

The northern parts of Great Sitkin, Adak, Kanaga, and Kiska Islands, and most of Kasatochi, Bobrof, Gareloi, Semisopochnoi, Little Sitkin, Segula, and Buldir Islands are composed of practically undissected volcanoes. All the volcanoes seem to be stratovolcanoes (composite cones) made up of interbedded basaltic and andesitic pyroclastic rocks and lava flows, and of mudflows and volcanic sedimentary rocks on their lower slopes. The oldest of these rocks appear to rest unconformably upon a plane of marine abrasion that bevels the early Tertiary volcanic rocks. Assuming the period of marine erosion to be middle Tertiary, the extrusion of these rocks is believed to have begun during the late Tertiary and to have continued intermittently to the present.

On many of the islands, the oldest rocks of this sequence are well-bedded volcanic sandstone and conglomerate, interbedded with or grading laterally into tuff-breccia and overlain by thick flows of basalt that retain low initial outward dips. Around Kanaga and Tanaga Volcanoes and on northern and western Semisopochnoi Island, the low-dipping flows and pyroclastic rocks form the radial ridges and arcuate rims of large calderas. Within these calderas, single or multiple composite cones have been built. The cones are made up of lava and scoria whose initial dips are as much as 30°. The extrusion of black to dark-gray vesicular-to-compact lava has been occasionally interrupted by the explosive ejection of much fine basaltic and andesitic lapilli and ash, and smaller quantities of pumice.

A blanket of fine ash covers large areas on Kanaga, Tanaga, Ogliuga, and other islands at least as far west as Amchitka. The thickness of this blanket varies considerably, depending on the length of time since the land surface was last scoured by sea or glaciers, the distance from active volcanoes, the direction of prevailing winds, and the rate of removal of the ash after it was deposited. The maximum thickness is more than 5½ feet on Adak Island, more than 7½ feet on northern Kanaga Island, and more than 19 feet on northern Tanaga Island. The ash on each island probably accumulated to its present depth over a period of several thousand years and as a result of the eruptions

of various volcanoes. The ash on Ogliuga Island is about 5½ feet deep, but its freshness suggests that almost all of it may have been erupted recently, perhaps by Mount Gareloi.

TERTIARY AND QUATERNARY SEDIMENTARY ROCKS

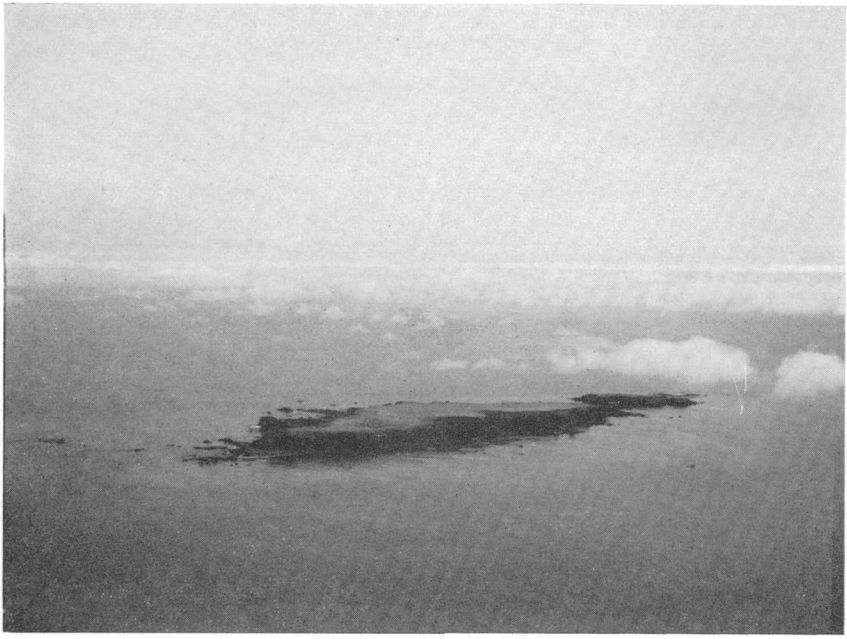
Tertiary and Quaternary sedimentary rocks occur on most of the islands in minor quantity. The outcrop areas are too small to be conveniently indicated on plate 17.

The only fossiliferous Tertiary or Quaternary sedimentary rocks recognized are exposed in small areas on Adak Island near the base of the east side of Mount Adagdak, and on Amchitka Island at the head of a small bay 2.6 miles west of East Cape. Other areas have been mentioned by Dall (1896). The rocks consist of poorly consolidated fossiliferous sandstone and conglomerate. The precise age of the fossils is not known, but they are Tertiary in aspect. On Adak Island these rocks overlie beds of boulder conglomerate. On Amchitka Island, west of the head of Constantine Harbor, a sequence of regularly interbedded, unfossiliferous, yellow-gray, poorly consolidated sandstone and siltstone, about 60 feet thick, is exposed in borrow pits. The sandstone and siltstone are overlain by till and unconformably underlain by early Tertiary volcanic rocks.

On Adak Island, glacial drift forms a tattered mantle covering much of the northern part of the island. It consists chiefly of ground moraine, but includes subordinate amounts of lateral moraine and fluvioglacial deposits. Glacial deposits are less conspicuous on other islands; small deposits were observed on Tanaga, Amatignak, Amchitka (pl. 18*B*), and Attu Islands. On Amchitka Island, on the north shore of Constantine Harbor, three successive layers of till and interbedded fluvioglacial sediments are exposed.

Wave-cut terraces, covered by a thin veneer of marine boulder gravel, are present at several places along the shores of the higher islands. On northern Adak Island are remnants of three terraces, the highest about 100 feet above sea level. Most of southern Tanaga Island is mantled by marine gravel, resting on a wave-cut platform. On Ogliuga Island coarse boulder gravel veneers a wave-cut platform and is overlain by coarse volcanic cinders. Unconsolidated sand and gravel as much as 10 feet thick rests on a similar wave-cut platform on Shemya Island. Small beaches are present on most of the islands; most of the material composing them ranges in size from that of cobbles to that of boulders.

Streams emptying into bays protected by bay-mouth bars have built deltas, a few tens or hundreds of acres in extent. Most of the delta sediments are reworked pyroclastic or glacial material. Similar



A, ILAK ISLAND FROM THE NORTHEAST.

A remnant of a marine abrasion platform, uplifted and tilted to the west. Photograph by U. S. Navy.

B, ANGULAR GRANITIC BOULDERS ON AMCHITKA ISLAND.

Origin, probably glacial. Overlain by marine gravels.

GARELOI ISLAND FROM THE SOUTHWEST.
A relatively simple cone of basalt and basaltic pyroclastic rocks. Photograph by U. S. Navy.

material forms small patches of alluvium along some of the streams, particularly where streams empty into glacial lakes.

On Adak Island, a few acres are occupied by sand dunes on both sides of the entrance to Clam Lagoon. Dune areas are also present on Tanaga Island. The maximum height of the dunes is about 100 feet. All appear to have been stabilized, except those from which the cover of vegetation has been recently removed. On Ogliuga Island, isolated hillocks, rising a few feet above the featureless plain of volcanic ash, are apparently composed of wind-blown ash.

STRUCTURE

Knowledge of the structure of the western Aleutian Islands is incomplete because of the absence of information about many of the islands, concealment of many critical areas beneath the sea, lack of fossils that indicate the age of the rocks, and lack of key horizons that reveal structural details.

As now conceived, the structural history of the western Aleutians begins with an oldland, made up of metamorphic rocks intruded by granite. The structural trends in this oldland cannot be inferred, but the younger graywacke of Amatignak Island and, locally, the Finger Bay volcanics on Adak Island have fold axes that trend northward. Locally, the Finger Bay volcanics and the early Tertiary rocks have been folded along axes trending eastward. All the rocks formed before late Tertiary time are cut by faults that trend roughly parallel to the trend of the Aleutian arc. The late Tertiary and Quaternary volcanoes are evidently related to a fault or fracture zone extending the length of the Aleutian arc. Too little is known about the distribution of the early Tertiary and older rocks to permit a statement of their relation to the present arc; it is inferred that the Aleutian Islands were established in about their present form and distribution late in Tertiary time.

PRE-TERTIARY

The sequence of older basaltic volcanic rocks, argillite, and graywacke of Attu and Shemya Islands is intensely sheared and faulted. Determining the age of the faults is difficult because no rocks of definitely known age are involved. In a quarry 2½ miles north of the Attu airbase, many faults are exposed which strike N. 10°–30° W., and dip 65°–68° SW. It is not known whether the faults were formed earlier than a vertical fault that trends west-northwestward and cuts early Tertiary rocks on Shemya Island, or were produced simultaneously as complementary shears.

The attitudes of the Finger Bay volcanics are diverse. On the southern shore of Adak Island, rocks that from the boat were judged

to be part of the Finger Bay volcanics occur as a great open syncline trending westward; the dips on the flanks of this fold approach 20°. Comparable open folding and trends are suggested by the low dips in the series of Finger Bay volcanics between Andrew and Clam Lagoons, on Adak Island. Farther south, between Kuluk Bay and Shagak Bay, and between Finger Bay and Sweeper Cove, steeper dips and northward trending folds are present. This discordance in trends on Adak Island may be due to the presence of two unconformable sequences in the rocks mapped as Finger Bay volcanics.

Many faults, which appear to be steeply dipping normal faults, occur in the Finger Bay volcanics on Adak Island. The predominant trends of these faults range from N. 60° E. to N. 60° W. and from N. 20° E. to N. 10° W., but faults of intermediate trend are present, and some faults curve through a wide range of trends. Their age is not definitely determinable. They do not appear to cut any of the Tertiary rocks of the island, but they cut gabbro, which intrudes the Finger Bay volcanics and is probably the youngest pre-Tertiary rock.

Beds of graywacke and graywacke breccia on Amatignak Island have been tilted and now trend about N. 8° W., and dip 30° E. These beds and the gabbro sills that intrude them have been faulted; the faults, apparently reverse faults, trend N. 35°–50° E. and dip 50°–70° SE. The age of these faults is uncertain, as no younger Tertiary sedimentary or volcanic rocks appear to have been cut by them.

TERTIARY AND QUATERNARY

In addition to the cones built of Tertiary and Quaternary volcanic rocks, Tertiary and Quaternary structures of tectonic origin occur on some western Aleutian Islands.

Early Tertiary volcanic rocks on Amchitka Island, and the sedimentary rocks associated with them, are gently folded or tilted. The beds trend westward and dip from 10°–27° S.

Layers of Pleistocene glacial till on Amchitka Island are cut by normal faults, ranging in trend from N. 80° E. to N. 45° E. Some of these faults outline downfaulted blocks in which the younger sediments are preserved; one such block forms Constantine Harbor, the floor of which has been dropped about 130 feet on its north side.

Some of the numerous faults cutting the basaltic volcanic rocks, argillite, and graywacke sequence on Shemya and Attu Islands seem to be related to a fault which cuts early Tertiary volcanic rocks on Shemya Island. This fault, exposed on the north shore of Shemya Island a few hundred feet from the eastern end, cuts a tuffaceous basaltic conglomerate, evidently part of the early Tertiary volcanic rocks. The fault is vertical and strikes N. 60° W. A mylonitized zone is developed along it. Faults on Attu Island that are possibly re-

lated to this fault trend N. 85° W. and dip from 50° S. to vertical. The trend of the fault striations is northeast, and the south sides of the fault appear to have moved up and eastward relative to the north sides.

The youngest faults found are those on the flanks of Mount Adagdak on Adak Island. They are probably Recent in age, and they appear to be normal, the downthrown side being toward the mountain summit. They were probably caused by subsidence which occurred when magma was withdrawn from beneath Mount Adagdak.

GEOLOGIC HISTORY

The earliest event that can be inferred in the geologic history of the western Aleutian Islands is the deposition, perhaps in Paleozoic time, of sedimentary and volcanic rocks in the vicinity of what are now Tanaga, Ogliuga, and Adak Islands. These rocks were deformed and metamorphosed, then intruded by granite. After a long interval of erosion, volcanism was resumed in Mesozoic(?) time. Stratovolcanoes were built on Shemya and Attu and perhaps on other islands. Around the margins of these volcanoes, marine deposits of argillite and graywacke were made between intervals of extrusive activity. Graywacke and graywacke breccia were deposited in quiet water on what is now Amatignak Island, probably either at the same time or slightly after the Finger Bay volcanics were extruded.

The Finger Bay volcanics and the older rocks were compressed, in part by forces acting nearly normal to the present trend of the chain, and extensively faulted. Deformation was accompanied by hydrothermal alteration. Gabbro intruded the rocks, and some of the intrusive masses were faulted and hydrothermally altered along with their host rocks. After a period of deformation and erosion, basaltic and andesitic volcanic rocks were erupted in early Tertiary time to form new sequences on the dissected foundation of older volcanic and intrusive rocks.

The early Tertiary volcanoes were beveled by marine erosion at a time when sea level was as much as 150 feet higher, relative to the land, than it is at present. It is not known whether this difference indicates that the level of the sea was actually higher or that a later upward movement of the land occurred. The terraces produced by this marine beveling are not of uniform height, and some are tilted.

Volcanic activity was resumed in late Tertiary time. The new vents were, in general, north of the Mesozoic and early Tertiary vents. The early flows from some of the late Tertiary vents rest upon sediments that apparently accumulated under marine conditions, suggesting that when the building of the late Tertiary cones began the level of the sea was again relatively higher than at present; fluctuations of

relative sea level apparently occurred several times during later Tertiary time. Fine-grained marine sediments, locally fossiliferous, which accumulated during periods when sea level was relatively high, are now exposed.

During a period of relatively low sea level, perhaps in early Pleistocene, glaciers advanced northward from a highland, presumably developed on the older volcanic, metamorphic, and intrusive rocks. This highland is inferred to have lain south of the present islands and to have extended from about the longitude of western Tanaga Island to that of eastern Amchitka Island. Glaciers moved northward across the emergent platforms, then retreated. Subsequent submergence permitted waves to work the glacial tills on Ogliuga, Tanaga, and perhaps other islands. The disappearance of most of the highland is thought to be due chiefly to downfaulting below sea level.

In Quaternary time, glaciers born in the highlands of many of the present islands greatly modified the topography of the upper mountain slopes before retreating. Narrow marine terraces, now covered with thin layers of boulders, were cut during one or more interglacial stages. Since the most recent glaciation, the rocks on some islands have been cut by steep-dipping faults of small displacement. Several cones, such as Mount Moffett and Mount Adagadak on Adak Island, became inactive before or during the last interval of glaciation, but volcanoes on most of the islands from Kasatochi to Buldir have been active since then.

FUTURE VOLCANIC ACTIVITY

Many of the western Aleutian Islands have active volcanoes. The volcanic cones on other islands are deeply eroded, and early renewal of activity is unlikely. Volcanoes believed or known to be active include those of Kasatochi, Great Sitkin, Kanaga, Tanaga, Gareloi, Semisopochnoi, Little Sitkin, Segula, and Kiska Islands. Inactive volcanoes include that on Bobrof Island, Mount Adagak and Mount Moffett on Adak Island, and the mountains of eastern Tanaga Island. Recorded activity-years[1] for Kiska, Little Sitkin, Semisopochnoi, Gareloi, Tanaga, Kanaga, and Great Sitkin Islands total 30 during the 185 years since 1760. None of the recorded eruptions can be classed as major. Many other eruptions have undoubtedly occurred but have not been recorded. On the basis of the fragmentary records, a mild eruption can be expected, on the average, once every 6 years in the western Aleutian Islands.

One great caldera-forming eruption has occurred on these islands in postglacial time, but such an eruption, analogous to the one that

[1] Activity-year is defined herein as a calendar year during which one volcano is active. For example, if three volcanoes are active during a single calendar year, then three activity-years are recorded.

created Okmok Caldera on Umnak Island, could occur on any of the active volcanic islands. Caldera-forming eruptions are least to be expected on the islands on which calderas have already been formed—Kanaga, Tanaga, and Semisopochnoi. No evidence has been found suggesting that such violent activity is in prospect for the near future, except possibly at Great Sitkin Island (Simons and Mathewson, 1955, p. 40–41).

In general, the zone of greatest volcanic activity has moved northward in the western Aleutian Islands. The most recently active and the least eroded volcanoes are on the northern parts of the large islands or on the more northerly small islands. Activity in the near future can be expected to be limited to the northern part of the western Aleutian arc.

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