Geology of Rat Island Aleutian Islands Alaska

By RICHARD Q. LEWIS, WILLIS H. NELSON, *and* HOWARD A. POWERS

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 work in the field, laboratory, and library were assembled hastily 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 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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INVESTIGATIONS OF ALASKAN VOLCANOES

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ABSTRACT

Rat Island is formed of volcanic rocks, conglomerate, and sandstone that are divided into two stratigraphic units. The older, Rat formation, consists of porphyritic hornblende andesite lava flows and breccias, and conglomerate derived from them. The younger, Gunners Cove formation, contains tuffs and lavas of basalt, sandstone and conglomerate composed largely of basaltic fragments, and some hornblende andesite similar to that of the Rat formation. Marine conglomerate interbedded in the basalts contains a small fauna of middle Tertiary age. The older andesitic rocks, and, to a lesser extent the basaltic rocks, have been chemically altered and pyritized along west-northwest-trending fracture zones. Normal high-angle faults are abundant and strike generally west-northwest or within a few degrees of north; the few dikes, all of basalt, strike north. Zones of altered and mineralized rock seem to trend west-northwest.

The physiographic forms are all those of erosion—marine platforms and cliffs that are greatly to slightly dissected by stream erosion, and are modified by glaciation. An extensive emerged marine platform, slightly dissected and glaciated, rises to an inland altitude of about 180 feet. Much of the sea cliff is not attacked by present wave action, being separated from the active shoreline by emerged boulder beaches and rock benches.

INTRODUCTION

Rat Island is near the center of a segment of the Aleutian Ridge on which also are the islands of Amchitka to the southeast and the southern part of Kiska to the northwest (fig. 79). Rat Island is between lat 51°45′50″ and 51°50′15″ N. and long 178°11′32″ and 178°23′10″ E. About half the island is a partly dissected plateau ranging from 125 to 200 feet in altitude. A strongly dissected highland ridge in the east half of the island rises above the plateau to a maximum altitude of 1,127 feet. The surface is almost completely mantled with tundra-type vegetation.

The island is uninhabited and undeveloped, although the remains of many Aleut dwellings and kitchen midden indicate a former Aleut population.

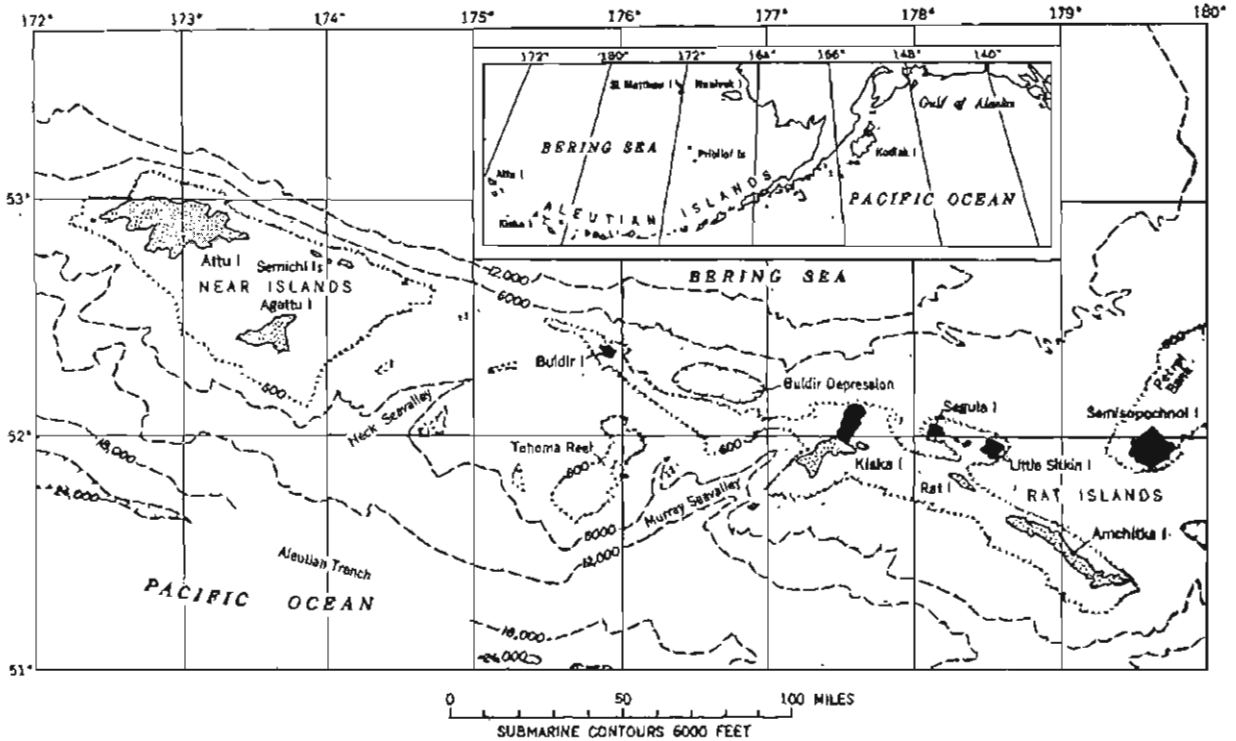

FIGURE 79.—Location of the Aleutian Islands, Alaska, and of Rat Island on the western Aleutian Ridge. Stratovolcanoes of late Cenozoic age shown solid, islands shaped by erosion shown in stipple pattern, form of the western Aleutian Ridge shown by submarine contour.

The climate is typical of the western Aleutians. Rain, fog, and overcast predominate during the summer; strong winds, heavy snow, and violent storms are common in the winter. The marine influence tempers the climate; the summers are cool and the winters seldom have temperatures as low as 0° F. Snow and ice accumulate only on the higher slopes and prolonged freezes are rare.

This report is based on about 3 days of fieldwork in August 1951, by a U.S. Geological Survey party made up of Dennis P. Cox, Joseph P. Dobell, Richard Q. Lewis, Willis H. Nelson, Howard A. Powers, and Edward C. Stover, Jr. The party was supported logistically by the U.S. Geological Survey MS *Eider*, Carl Vevelstad, captain.

PHYSIOGRAPHY

The island is about 6 miles long and 2 miles wide. About half of the island is a partly dissected terrace ranging from 125 to 200 feet in altitude. One small isolated knob near the west end of the island rises above the terrace to an altitude of 404 feet. A strongly dissected ridge rises above the bench in the east half of the island to a maximum altitude of 1,127 feet. The crest of the western part of the ridge is narrow and sinuous, and the east end is a broad summit of low relief.

Locally the higher slopes show physiographic features typical of glaciated areas—cirque-shaped valley heads, smoothed rock knobs, and undrained rock depressions. These features are not noticeable on the lower slopes or on the partly dissected terrace; however, the absence of any moraines indicates that ice must have covered the entire island.

Shoreline features such as wave-cut benches 6 to 8 feet above sea level and at mean sea level, pebble and boulder benches caused by present wave activity, and slightly higher and turf-covered sea cliffs resemble those of Amchitka Island (Powers and others, 1960).

Rat Island is on the midpart of that segment of the Aleutian Ridge which includes Amchitka and southern Kiska Islands (fig. 79). Some features of the submarine physiography around Rat Island resemble those around each of the other two islands. A wide bench at a depth of about 300 feet is southwest, and perhaps northwest of the island. To the northeast, this bench is missing and is replaced, at that depth, by a steep slope which resembles both the slope into Murray Seavalley (Gibson and Nichols, 1953) west of southern Kiska Island and the slope north of the east end of Amchitka Island. A second, more steeply sloping bench terminates shoreward in submerged cliffs and more rugged topography. This bench is well formed at a depth of about 165 feet along the south, but poorly formed along the north side of the island (pl. 70). A third bench, between the 50-foot submarine

contour and the present shoreline, is more than half a mile wide around the island except in a very few places.

GEOLOGY

Volcanic rocks of subaerial and submarine emplacement make up Rat Island. The rocks are mapped as two formations, one limited to the southeastern part of the island and probably older, and the other is in the northwestern two-thirds of the island. The rocks in the southeast area, here named the Rat formation, are lava flows and breccias of porphyritic hornblende andesite and conglomerate derived from them. The rocks forming the larger northwest area, here called the Gunners Cove formation, from the small embayment of that name on the north side of the island, are tuffs and lava flows of basaltic composition, and sandstone and conglomerate made up largely of basaltic material, but including some hornblende andesite possibly from the Rat formation.

The rocks of the Rat formation are lithologically similar to parts of the Amchitka formation; those of the Gunners Cove formation are similar in lithology and type of occurrence to the Banjo Point of Amchitka Island (Powers and others, 1960). The same fossil pecten has been collected from the Gunners Cove and the Banjo Point rocks.

RAT FORMATION

The Rat formation contains only andesitic rock and conglomerate derived from it. The most abundant andesite is porphyritic and has many conspicuous phenocrysts of zoned plagioclase and elongate prisms of hornblende. The rock occurs as thick, columnar-jointed lava flows and massive flow breccia. It is the only constituent of the pebbles and cobbles of a few layers of conglomerate within the formation. Phenocrysts make up about a third of the rock: zoned labradorite-andesine crystals as large as 1 cm are abundant but not conspicuous because they are unaltered, and prisms of green hornblende from 1 to 5 mm long are conspicuous but less abundant (from 10 to 15 percent). There are also a few phenocrysts of augitic clinopyroxene and apatite. The groundmass is dominantly stubby crystals of sodic plagioclase in intergranular texture, containing a very small amount of interstitial cryptocrystalline material having a low index of refraction. Commonly the rock is altered so that the plagioclase crystals appear a chalky gray to white, and the groundmass is speckled gray and greenish gray. At the head of the cove about 2½ miles southeast of Gunners Cove, the rock is intensely altered and pyrite is abundant. One specimen of slightly altered material was collected for analysis

from the small isolated area of the Rat formation a mile north of Gunners Cove, though even here most outcrops are red from oxidized iron. The sample is from a thick flow that dips about 20° N. judging from the inclination of well-developed columns. The results of the analysis are given below:

Analysis of porphyritic hornblende andesite from the north coast of Rat Island at lat N. 51°49'15", long E. 178°18'41", laboratory No. 54-444, Denver rock analysis laboratory, U.S. Geological Survey

Analysis				Norm	
Chemical (analyst, L. Kehl)		Spectrographic (analyst, P. R. Barnett)			
SiO_2	57.81	B	<0.001	Q	13.9
Al_2O_3	18.34	Ba	.04	or	6.1
Fe_2O_3	3.80	Co	.002	ab	30.4
FeO	1.80	Cr	.004	an	30.7
MgO	3.81	Cu	.005	wo	.2
CaO	6.49	Ga	.001	en	9.5
Na_2O	3.61	Li	.001	mt	4.6
K_2O	1.02	Ni	.002	il	.9
H_2O-	1.17	Rb	.001	hm	.6
H_2O+	1.21	Sc	.002	ap	.3
TiO_2	.52	Sr	.07	H_2O	2.4
CO_2	.01	V	.02		
P_2O_5	.15	Y	.004	Symbol "II. 4". "3. 4"	
F	.02	Yb	.0002		
MnO	.12	Zr	.006		
	99.88				
Less O	.01				
	99.87				

Less abundant in the Rat formation is an andesite containing many amphibole phenocrysts, a few biotite phenocrysts, and no augite crystals. The amphibole in this rock is also a hornblende, in yellow, green, and brownish green, but the colors are fainter than in the hornblende of the more common rock. The texture and other constituents are similar in both rocks.

No fossils were found in rocks of the Rat formation, and the contact with the Gunners Cove formation is not exposed. The trace of the contact trends north-south across the high crest of the island and is probably a high-angle normal fault. The small area of Rat formation north of Gunners Cove is probably a window through overlying

beds of the Gunners Cove formation (pl. 70). Some cobbles of porphyritic andesite similar to the rocks of the Rat formation are in the conglomerate of the Gunners Cove formation; it is inferred that the Rat formation is older than the Gunners Cove formation, and probably is of Tertiary or older age.

GUNNERS COVE FORMATION

The Gunners Cove formation includes, in approximate order of decreasing abundance, tuffaceous conglomerate and sandstone, crystal-vitric basaltic tuff, and thin flows of basaltic lava. These rocks make up two-thirds of the island; they are exposed from sea level to an altitude of about 1,050 feet. Beds dip from 5° to 35° in diverse directions. Because structural details were not determined, no estimate of total thickness can be made.

The sandstone and conglomerate is made of moderate- to well-rounded fragments, mostly of basalt but some of porphyritic hornblende andesite, in a matrix containing less well-rounded fragments of basaltic glass and commonly fragments of marine shells. Many of the beds were deposited in the littoral zone, and one cobble deposit now exposed on the north shore of Gunners Cove is especially rich in fragments of barnacles, echinoids, crinoids, and pectens.

The crinoid and the pectens were identified in 1954 by F. Stearns MacNeil of the U.S. Geological Survey who reports:

> The crinoid, *Isocrinus* aff. *I. oregonensis* (Moore and Vokes) and the pectens, *Chlamys* aff. *C. washburnei* Arnold, are considered to be of probable middle Tertiary age (Oligocene or early Miocene). These two species are associated in rocks in the sea cliff north of the mouth of the Yachats River, Oregon, which have been assigned variously to the Pliocene (Arnold), Middle Miocene? (Weaver), and to the early Oligocene (Vokes, written communication 1954). According to Parke D. Snavely (oral communication 1959) the locality near Yachats is equivalent to some part of the Keasey formation.

Basaltic lava occurs as thin flows, some with pillow structure and some with poorly formed columnar jointing, in thick crudely bedded partly glassy scoria intruded by irregular-shaped bodies, and in swarms of thin dikes. One complex of scoria, irregular intrusive material and thin flows, probably a local vent deposit, forms the headland of the north shore of Gunners Cove, and a second similar complex forms a promontory on the Pacific coast due west of Gunners Cove. The basalt is porphyritic to microporphyritic containing phenocrysts of augite and olivine, and a few phenocrysts of calcic plagioclase. The groundmass ranges from glassy to fine intergranular in texture, and is composed of euhedral to subhedral crystals of plagioclase and clinopyroxene.

STRUCTURE

The only obvious structures on Rat Island are high-angle normal faults. Two directions of faults seem dominant, one strikes about N. 60° W., parallel with the alinement of the Aleutian Ridge, and the other, nearly at right angles, strikes approximately north. Several high-angle faults appear in sea-cliff exposures and others have been inferred from linear elements of the topography.

One fault near the west end of the island is nearly vertical, strikes N. 10° E., and has about 50 feet of displacement. This fault is nearly parallel to the north-trending contact between the Rat and the Gunners Cove formations south of Gunners Cove. This contact is exposed as a fault in the sea cliff at Gunners Cove. The high-angle contact observable on the ridge crest south of Gunners Cove suggests that the fault is continuous across the island to the south coast.

A shear zone representative of the faults striking N. 60° W. is exposed in the west shore cliff of the small cove 2½ miles southeast of Gunners Cove. The fault dips about 70° NE. Many linear elements to the topography and the apparent fault scarps in the submarine topography suggest the existence of many additional faults in the area.

Fieldwork was inadequate to determine the presence of any significant folds or structures in the rocks.

GEOLOGIC HISTORY

The first geologic event recorded on Rat Island is the eruption of porphyritic andesite lava flows and flow breccias, probably subaerial. Land areas probably were small, as marine conglomerate derived from these lava flows are locally interbedded with them. The age of this activity is known only to be before the emplacement of the Rat formation.

The rocks were faulted and chemically altered, and some pyrite was introduced along the fracture zones. By analogy with the history of Amchitka Island, this occurred perhaps in more than one episode.

Erosion of these rocks preceded and accompanied middle Tertiary volcanic activity during which rocks of basaltic composition were erupted. Much of this activity was submarine, but locally shoals and many small islands were formed. Regional subsidence during this time is inferred from accumulation of these shoal deposits to thicknesses of several hundred feet in a region including the Rat, Amchitka, and southern Kiska Islands.

Before the last major glaciation, the island was uplifted, perhaps in more than one episode, and the topography shaped by both sub-

aerial and marine erosion. Possibly the ridge crest at an altitude of 350 to 400 feet and almost certainly the terrace at about 180 feet, are wave-cut platforms. The 180-foot terrace [1] may be a platform cut at the sea level of the last interglacial sea.

The broad bench submerged about 300 feet [1] may be the wave-cut bench of a low sea level during a glacial maximum. A shallower bench that terminates in an inferred shoreline at a depth of 165 feet [1] may be related to the last glaciation.

After the last glaciation, a shoreline was formed whose cliffs are beyond present wave attack and whose boulder beaches were the site of many Aleut dwellings.

Six to eight feet below these boulder beaches are the tops of the storm beaches, which result from present wave activity.

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Powers, H. A., Coats, Robert R., Nelson, Willis H., 1960, Geology and submarine physiography of Amchitka Island, Alaska: U.S. Geol. Surv. Bull. 1028P, p. 521–554.

[1] These figures of altitude and depth cannot be used to measure eustatic shift of sea level because they have been affected by unmeasured amounts of fault movement.