Geology of Segula, Davidof and Khvostof Islands Alaska

By **W. H. NELSON**

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 field studies were made during the years 1946–1954. The results of the first year's field, laboratory, and library work were hastily assembled as two administrative reports, and most of these data have been revised for publication in Geological Survey Bulletin 1028. Part of the early work was published in 1950 in Bulletin 974–B, "Volcanic Activity in the Aleutian Arc," and in 1951 in Bulletin 989–A, "Geology of Buildir Island, Aleutian Islands, Alaska," both by Robert R. Coats. Unpublished results of the early work and all of the later studies are being incorporated as parts of Bulletin 1028. The geological investigations covered by this report were reconnaissance.

The investigations of 1946 were supported almost entirely by the Military Intelligence Division of the Office, Chief of Engineers, U. S. Army. From 1947 until 1955 the Departments of the Army, Navy, and Air Force joined to furnish financial and logistic assistance.

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GEOLOGY OF SEGULA, DAVIDOF, AND KHVOSTOF ISLANDS, ALASKA

By W. H. NELSON

ABSTRACT

Segula, Davidof, and Khvostof are volcanic islands that rise from an extensive submarine platform about 350 feet below sea level. The formation of this platform by erosion is the oldest geologic event recorded here. The subsequent history is largely a record of eruptions of andesitic lava and pyroclastic material which formed Segula Volcano and a hypothetical volcanic mountain immediately north of Davidof Island. A catastrophic eruption, perhaps during late Tertiary time, destroyed this mountain, formed the caldera north of Davidof Island and left Davidof and Khvostof Islands as remnants. The most recently erupted lava and pyroclastic materials on Segula Island are young enough to have been virtually untouched by erosion. Deposits of reworked volcanic debris underlie small areas of these islands.

INTRODUCTION

Segula, Davidof, and Khvostof Islands are part of the Rat Islands, near the center of the western half of the Aleutian Islands chain (fig. 48), and lie between 51°57′ and 52°03′ north latitude and 178°04′ and 178°31′ east longitude.

Reconnaissance, upon which this report is based, was done during 3 days in August 1951. Landings on Segula Island and Davidof Island were supplemented by observations from shipboard. Richard Q. Lewis, Dennis P. Cox, and Edward C. Stoever participated in the fieldwork.

GEOGRAPHY

TOPOGRAPHY

SEGULA ISLAND

Segula Island is formed by a single conical mountain 3,800 feet high and about 4 miles in diameter. The slopes curve relatively smoothly from the summit to sea level. A cinder cone forms the highest point on the island. It covers part of the rim of a poorly defined crater, about one-half mile across, on the south; younger lava flows have poured over and partly obscured the crater on the north.

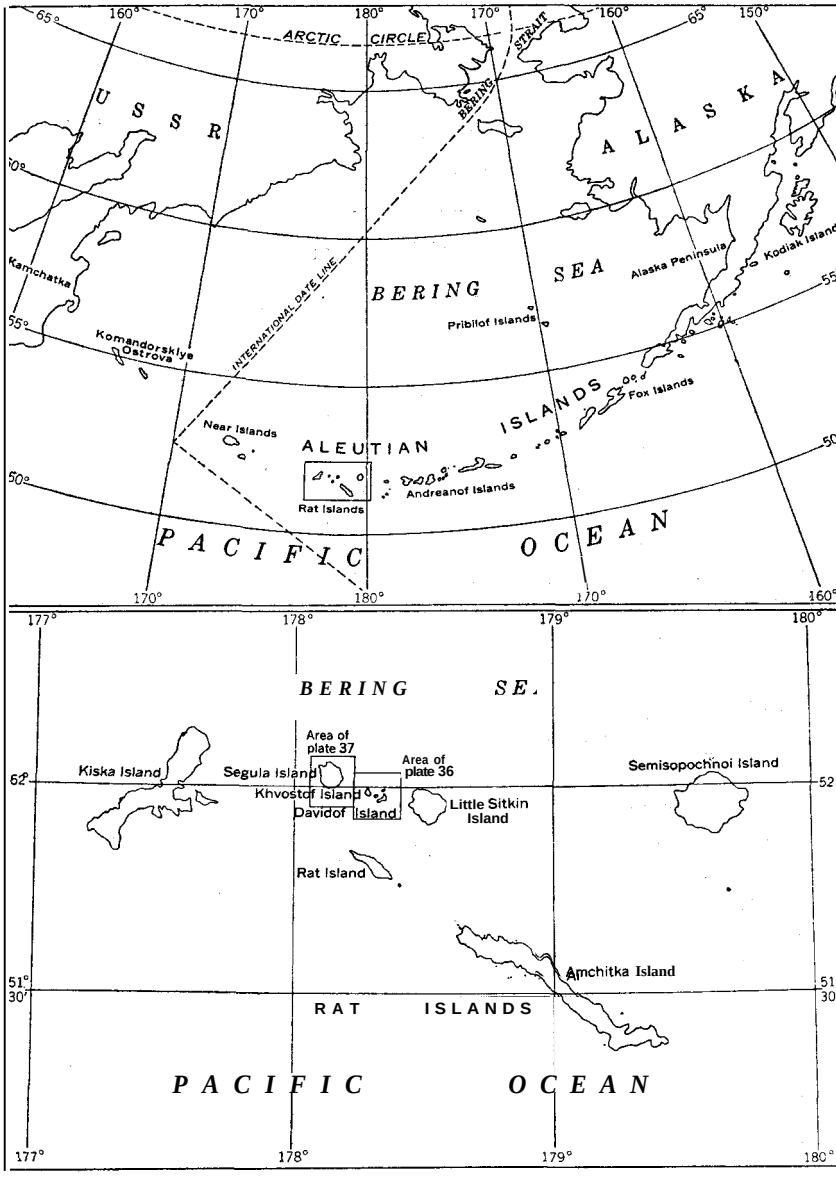


FIGURE 48.—Location of Khvostof, Davldof, and Segula Islands, Alaska.

An extensive lava field covers the northern slope, and a layer of pyroclastic material the southern and eastern slopes. Steep cliffs along much of the western side expose the layered internal structure of the mountain. A deep gully extends from the summit down the south slope of the mountain. A small lava field extends to the coast from its place of origin at a small subsidiary cone and crater about a mile southeast of the summit.

The entrance of a single narrow cove on the north coast of the island is nearly closed by shallow reefs. Landings can be made in favorable weather on narrow beaches around most of the island, but steep sea cliffs almost everywhere back of the beaches make inland access difficult.

Segula has no perennial streams; although the turf blanket is commonly saturated with moisture, the underlying volcanic material is very permeable and allows much of the surface water to seep downward.

KHVOSTOF ISLAND AND DAVIDOF ISLAND

Khvostof has a rudely rectangular outline, and consists of a gently sloping central upland that rises westward to the high point of the island, about 850 feet above sea level. There are several small lakes and streams on the island.

Davidof is very irregular in outline and has a maximum elevation of about 1,050 feet. Most of its surface is steep, and it is completely bounded by very steep sea cliffs. There are no lakes or streams, but small quantities of water probably could be obtained from seepage out of the water-soaked turf blanket.

SUBMARINE TOPOGRAPHY

Davidof and Khvostof Islands are the highest parts of two broad, submerged, coalesced cones that rise from a platform about 350 feet below sea level (pl. 36). Davidof, Pyramid, and Lopy Islands are parts of the rim of a submerged caldera on the eastern cone. Khvostof is the subaerial part of the western cone. About 2 miles south of Khvostof, a flat-topped submarine knob, about 275 feet below sea level, may be another small volcanic cone.

Besides the caldera, several other submarine depressions are shown on plate 36. One, about a mile west of Khvostof Island, is probably surrounded by lava flows. Depressions northeast of Davidof Island are probably of tectonic origin.

CLIMATE

The Rat Islands have a cool, wet, windy, marine climate, as does the entire Aleutian region. Temperatures recorded at Amchitka from February 1943 through April 1949 (Arctic Weather Central, 1950)

ranged between 65°F and 15°F and averaged 39°F. August, the warmest month, had a mean temperature of 48°F, and January, the coldest, a mean temperature of 31°F. The annual precipitation averaged 34.6 inches and included 70.6 inches of snow. Precipitation during August, the wettest month, averaged 4.32 inches, and during February, the driest month, 2.76 inches. Snow can be expected from October through May, the greatest amount falling in February, when snowfall averages 15.5 inches. Snow accumulates only at higher elevations because winter temperatures close to sea level allow the snow to melt. Fog and cloud are nearly always to be reckoned with.

The Rat Islands are in the path of major storms that frequently bring winds in excess of 100 miles per hour. Winds exceeding 75 mph occur on all the islands from 2 to 15 times a year, and winds exceeding 32 mph occur about 80 times a year. Over 90 percent of the strong winds arrive during the 6-month period, October through March. The maximum wind velocity recorded at Amchitka is 115 mph. Average wind velocities range between 31 mph in December and 19 mph in June.

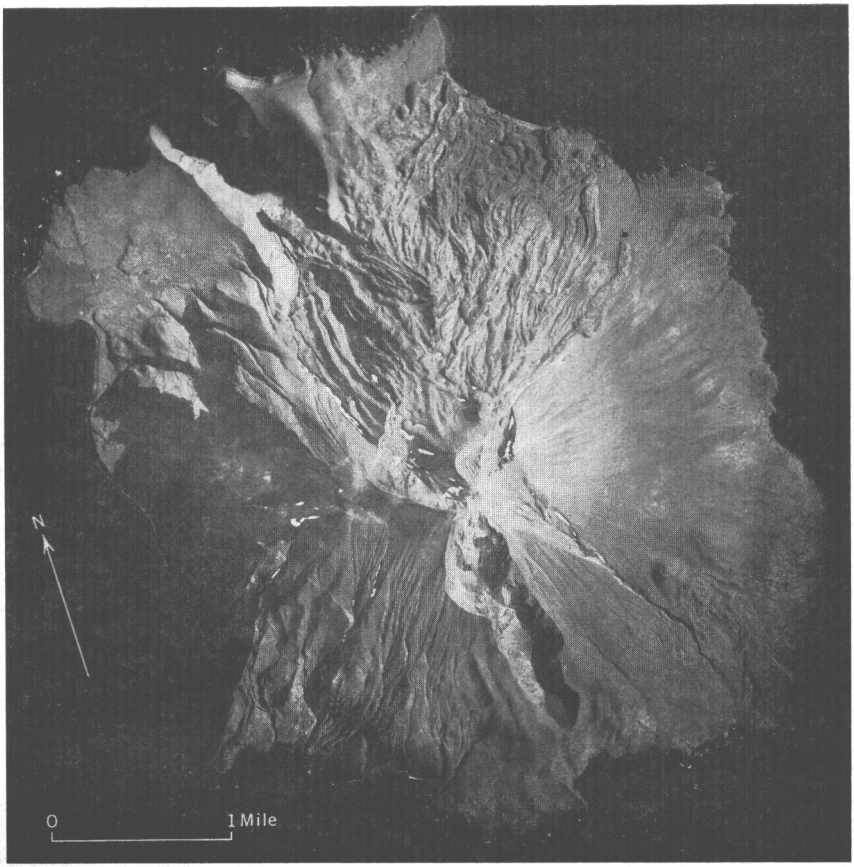
VEGETATION

Stable slopes below about 1,500 feet are covered with a deep, water-soaked carpet of lush vegetation underlain by a thick mat of peaty plant remains. No trees or shrubs grow in these islands. The vegetation is chiefly composed of moss, lichens, and plants of the heath family. Grasses and sedges abound, especially along the beaches, where thick stands of wild rye or strand wheat attain heights of 4 or 5 feet. Fungi, liverworts, horsetails, clubmosses, ferns and a wide variety of herbaceous flowering plants add to the variety of the vegetation. Prominent among the flowering plants are the white-flowered narcissus anemone, lupines, and several species of orchids. Luxuriant growths of marine algae or seaweed are abundant along the shores and on rocky reefs between high tide and about 240 feet below sea level.

GEOLOGY

GENERAL FEATURES

Segula Volcano and the caldera north of Davidof Island are two of a row of volcanoes that extends eastward from Kiska Volcano at least to Semisopochnoi Island, and possibly as far as the Andreanof Islands (fig. 48), and that probably marks an extended zone of weakness in the ocean floor. Segula Island is essentially a single composite volcano composed of many superimposed and interbedded layers of lava and pyroclastic rocks all dipping radially outward from the



SEGULA ISLAND

Aerial view. Photograph by Air Force Photographic and Charting Service (MATS), United States Air Force.

center of the island (pls. 37 and 38). Davidof, Khvostof, Pyramid and Lopy Islands are made up of interbedded lava and pyroclastic deposits in every way similar to the rocks of Segula Island.

There is no fossil evidence on which to assign an age to these rocks. It is inferred that the Segula Volcano is of late Quaternary age from the absence of any evidence of glaciation and the small amount of destruction of the volcanic cone by marine erosion. The rocks of Khvostof and Davidof are somewhat older than the youngest lava flows on Segula, but probably are about the same age as the main body of Segula.

The submerged caldera north of Davidof and the linear topographic feature that crosses Segula Island in a north-northwesterward direction are structural features formed by volcanism. Except for these, there has been little structural disruption and most of the rocks probably have their original depositional attitudes.

COMPOSITE VOLCANIC MATERIAL

Interbedded lava and pyroclastic material can be seen wherever erosion has exposed thick sections, especially in the sea cliffs that bound all the islands and in the riftlike gully on the south side of Segula Volcano. The lavas accumulated as many small, lenticular tongues and sheets from a few to about 100 feet thick. The pyroclastic layers are comparable in thickness to the lava flows but individual units cover much wider areas.

SURFACE PYROCLASTIC LAYERS

A pyroclastic mantle, lithologically similar to the older pyroclastic deposits, forms constructional surfaces on much of Segula Island, and possibly Davidof and Khvostof Islands. On Segula the pyroclastic mantle is largely covered at lower elevations by vegetation, but light-gray pyroclastic debris at least 150 feet thick is well exposed at Gray Point on the east side of Davidof Island. The ash mantle subdues or obscures older topography, and can be recognized by its relatively smooth surface on aerial photographs, even though much of it is covered by vegetation.

The pyroclastic fragments range in size from fine sand to large blocks of lava several feet across, but fragments between one-eighth inch and 2 or 3 inches predominate. The fragments vary from pumiceous and scoriaceous to massive andesite and glass, and may be red, brown, gray, tan, or black. The ejecta of individual eruptions usually abound in fragments of one color and, less consistently, of one texture, at any particular point of observation.

SURFACE LAVA FLOWS

UNA——ED FLOWS

Recent lava flows analogous to the older lavas cover about one quarter of the surface of Segula Island. On the north slope of Segula Volcano, lava apparently issued from several openings within the summit crater and from a fissure that extends northward for about one third of a mile from a place 3,200 feet due north of the summit. This field of lava is formed of many separate flow tongues. Smaller lava flows that reach the sea along the southeast shore of Segula Island issued from vents in two small coalesced subsidiary cones about 1,200 feet above sea level. At Chugul Point two recent flows lie beneath a thin cover of volcanic ash. Parts of Davidof and Khvostof appear to have constructional topography although none of the volcanic material there is recent enough to be free of some vegetation.

Many of the flows are covered by vegetation, but can be identified on the aerial photographs by their lobate form, natural dikes or levees, and flow-ribbed surfaces.

Basal parts of many flows consist of brick-red breccia. The flows are generally dark gray, glassy or fine-grained, compact or dikytaxitic. Phenocrysts of feldspar, pyroxene, and olivine are common, The unaltered, relatively young lava flows are petrographically similar. Seven specimens from Segula Island and one from Davidof Island were studied petrographically and two were chemically analyzed. All are porphyritic and feldspathic. Phenocrysts of bytownite, clinopyroxene (augite), olivine, and in some specimens, orthopyroxene, are in a groundmass of labradorite, pyroxene, olivine, magnetite, and cryptocrystalline material. Maximum refractive indices of bytownite phenocrysts are between 1.576 and 1.578. Labradorite phenocrysts in a specimen from Segula Island were found to have $n\mathrm{Z}=1.564$.

Most of the plagioclase phenocrysts have normal zoning. Small poikilitic inclusions of mafic minerals and amorphous material are common, generally in only one part of the phenocryst, either the core or one of the zones. All the specimens contain phenocrysts of monoclinic pyroxene. In one specimen the monoclinic pyroxene has a 2V of 54° and a $n\mathrm{Z}$ of about 1.695, indicating that this pyroxene is augite. The phenocrysts are euhedral to subhedral, usually twinned, and range from 0.2 to 1.5 millimeters long. They make up about 5 to 15 percent of the volume of the rock.

In four of the specimens some of the orthohombic pyroxene phenocrysts are rimmed by monoclinic pyroxene, although many are not.

Analyses of porphyritic feldspathic lavas of Segula volcano

[Chemical analyses by L. Kehl; spectrographic analyses by P. R. Barnett, June 1954]

	Surface flow of 2*-pyroxene andesite* [1]	*Older flow of olivine-bearing basalt* [2]
Chemical analyses:		
SiO_2	62.64	51.21
Al_2O_3	16.22	18.91
Fe_2O_3	2.29	2.70
FeO	4.33	6.21
MgO	1.72	5.81
CaO	4.62	11.24
Na_2O	4.86	2.57
K_2O	1.86	.66
H_2O-	.02	.00
H_2O+	.00	.00
TiO_2	.88	.60
CO_2	.01	.01
P_2O_5	.34	.14
F	.04	.01
MnO	.18	.17
BaO	.04	.02
Total	100.05	100.26
less O	.02	.00
	100.03	100.26
Spectographic analyses:		
B	0.005	0.0
Ba	.06	.03
Co	.001	.004
Cr	.0003	.008
Cu	.003	.02
Ga	.001	.0009
Li	.001	.0002
Ni	.0	.003
Rb	.008	.0
Sc	.002	.004
Sr	.04	.08
V	.008	.03
Y	.008	.006
Yb	.0005	.0004
Zr	.02	.005
Norm:		
q	14.58	1.32
or	11.12	3.89
ab	40.87	21.48
an	16.96	38.09
wo	1.28	16.82
fs	4.88	8.32
en	4.30	14.50
mt	3.25	3.94
il	1.67	1.22
ap	1.01	.34
C. I. P. W. classification	II.(45)(2)3.4 andose	II(III).5.4 hessase
Rittmann classification	dacite	labradorite-andesite

[1] 52°02'25" N. lat., 178°07'23" E. long.
[2] 52°02'41" N. lat., 178°07'04" E. long.

These phenocrysts are euhedral to subhedral, range from 0.2 to 1.5 mm in length, and make up a small percentage of the rock.

Olivine phenocrysts were seen in six of the specimens studied. They are anhedral, vary from 0.5 by 2 mm in length, and make up 1 to 5 percent of the rock volume.

The groundmass of the lava is composed of plagioclase, pyroxene, magnetite, cryptocrystalline material, and olivine in some flows. The plagioclase commonly forms fine lathlike crystals, with maximum extinction angles of from 28° to 32°, indicating compositions of about An_{55}. Most of these plagioclase crystals have narrow normally zoned rims. The other groundmass minerals occur as small euhedral grains.

ALTERED VOLCANIC ROCKS

Much of the rock on Lopy Island and on the north end of Davidof Island has been intensely altered to bright yellow, orange, and brown, probably by hydrothermal solutions. The most highly altered rock is mapped on plate 36. In a specimen from an altered flow on Davidof Island the only minerals that retain their original appearance are the plagioclase phenocrysts; the mafic phenocrysts have all been altered to chlorite, or chlorite and magnetite, and the groundmass to chlorite cryptocrystalline quartz, and magnetite. The quartz, which now makes up 10 to 15 percent of the rock volume, was probably introduced during the alteration.

SEDIMENTARY DEPOSITS ON SEGULA ISLAND

Deposits composed of more or less reworked volcanic debris underlie small areas on Segula Island.

Unconsolidated rudely sorted, moderately well bedded volcanic detritus (mostly pyroclastic) at least 500 feet thick crops out around the cove on the north coast. The fragments resemble those elsewhere interbedded with flows and range in size from fine sand to blocks of lava several feet across. Sizes between one-eighth inch and 3 inches predominate. Although the material is unconsolidated it stands in steep slopes where eroded at sea cliffs. The stratigraphic position of this deposit is uncertain, but its poor state of consolidation, as well as the fact that it is composed mostly of pyroclastic material that could have been derived from the volcano above suggests that it is younger than much of the composite cone material.

Large amounts of rock dislodged from the composite volcanic material on the west side of the island form landslide cones along the coast.

Poorly sorted volcanic debris fills a channel at the mouth of the large gully on the south shore.

Wave-rounded boulders mixed with minor amounts of fine gravel form beaches along parts of the coast. The beach at the back of the cove on the north coast is the only one that contains appreciable quantities of sand.

STRUCTURE

SEGULA ISLAND

Evidence of tilting or warping of rocks on Segula Island is lacking, but some topographic features suggest volcanic rifts. The deep gully on the southeast slope of the volcano, the summit crater, and the cove on the north coast form a linear topographic depression that transects the island. A recent flow apparently fills parts of this depression on the north slope of Segula Volcano. Recent constructional land surfaces on either side of the rift do not appear to be displaced, and the cuspate shape of the sides of the gully suggests that a series of explosions or collapses took place at several places along the rift, possibly as a result of the stoping action of molten lavas within or below the cone.

Such volcanic rifts, without displacement, are common in the Aleutian Islands. The summit of Kanaga Volcano is cut by a linear series of depressions associated with active fumaroles; these depressions occur within the crater and on the outer flanks of the cone but the crater rim itself is not broken (Snyder, G. L., oral communication). A curvilinear series of thirteen separate craters and four small lava flows occur on the southeast flank of Gareloi Volcano as a result of an eruption in 1929. (Coats, in preparation, 1956.) Several series of alined explosion craters and small pyroclastic cones occur on the northwest flank of Makushin Volcano (Fraser, G. D. oral communication).

Another possible fissure or rift extends northward from a point 3,200 feet north of the summit of Segula Volcano, and appears to have provided the conduits which feed some of the recent flows. Another fissure or rift is suggested by a topographic high near the source of the recent lava flows on the north flank of Segula Volcano.

DAVIDOF ISLAND AND KHVOSTOF ISLAND

Attitudes of some lava flows and pyroclastic layers on Davidof Island and Khvostof Island are shown on plate 36. The dips are mostly gentle or moderate and generally to the southeast and east.

A large submarine caldera lies between the two islands. A lava flow that forms a dip slope extending southward from the highest point on Davidof Island may have originated from an undiscovered vent near the present crest of the island; its appearance suggests,

however, that it flowed down the slopes of a volcanic mountain that no longer exists. Such a mountain probably was present immediately north of Davidof Island prior to the eruption that formed the caldera there.

The two submarine depressions northeast of Davidof Island are believed to be at least partly due to faulting. Steep interior north rims suggest fault scarps.

GEOLOGIC HISTORY

The oldest recorded geologic event in the Segula, Davidof, Khvostof area was the development of an extensive flat platform, now about 350 feet below sea level; probably the platform was formed by erosion in middle Tertiary time. Subsequently, volcanism built the islands and the submerged knobs and depressions on the submarine platform. One of the later events in the Davidof-Khvostof area was the catastrophic eruption that resulted in the formation of the caldera north of Davidof Island. This eruption probably occurred during later Tertiary time. The caldera, which is northwest of Davidof Island, appears to have been little modified since its formation.

FUTURE VOLCANIC ACTIVITY

Although Segula Volcano and the caldera north of Davidof Island are now quiescent, a major eruption of lava, ash, or both can occur at any time. Segula Volcano has erupted intermittently until recent times as proven by the presence of flows and pyroclastic materials, which can not be more than a few hundreds of years.

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