RECONNAISSANCE GEOLOGY OF THE MOUNT EDGECUMBE VOLCANIC FIELD, KRUZOF ISLAND, SOUTHEASTERN ALASKA

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Abstract.—The postglacial Mount Edgecumbe volcanic field contains at least 14 rock units ranging in composition from olivine-augite basalt to augite-bearing quartz latite. Mesozoic graywacke and slate and Tertiary granitic intrusions underlie the gently dipping basalt which forms the base of the pile. Andesite and basaltic andesite overlie the basalt near Mount Edgecumbe and, in turn, they are probably overlain by the dacitic rocks which make up the composite cone of Mount Edgecumbe proper and by dacite flows and cinder cones on its southwest flank. Mount Edgecumbe and a nearby remnant of a similar cone are cut by latite domes. The remnant is now the site of a caldera 1.6 kilometers in diameter and 240 meters deep. Widespread dacite(?) lapilli and ash probably resulted from explosive eruptions during the formation of the composite cones. Nine chemical analyses define a smooth compositional trend that correlates with the relative age of the map units. The magma series is calc-alkaline and has a close relationship to the high-alumina basalt series.

Mount Edgecumbe is an inactive volcano 26 kilometers west of Sitka, Alaska (figs. 1, 2, and 3). The mountain is part of a Pleistocene and Holocene volcanic field that covers about 260 square kilometers on the southern end of Kruzof Island. The field consists of gently dipping flows, composite cones, and air-fall ash and lapilli. Augite basalt seems to be the most common rock type; olivine basalt, basaltic andesite, hypersthene dacite, and quartz latite are also present.

With the exception of Quaternary(?) vents on Lisianski Inlet, Chichagof Island (Rossman, 1959, p. 186), there are no known Holocene volcanic areas within 240 km of Mount Edgecumbe (Brew, Loney, and Muffler, 1966). The scattered vents of interior British Columbia are 240 to 320 km away (Little, 1962); those of southern southeastern Alaska are 320 km distant; and the volcanic seamounts of the Gulf of Alaska, a few of which could be Holocene, are also at least 320 km away. The volcanic field is far distant from those in the Aleutian Islands (Coats, 1950) and the Wrangell Mountains (fig. 1).

The Mount Edgecumbe volcanic field is closer to the continental margin (as defined by the 100-fathom contour) than are the volcanoes of the interior conterminous United States, Canada, and Alaska, and is even closer than most Aleutian volcanoes (fig. 1). Thus the Mount Edgecumbe field may provide an informational link between the continental volcanoes and the volcanic seamounts of the Gulf of Alaska (Engel and Engel, 1963).

Unsubstantiated (and probably inaccurate) accounts of volcanic activity at Mount Edgecumbe within historic time have been summarized by Becker (1898, p. 13). Two radiocarbon dates provide evidence about the absolute age of the major eruptions of Mount Edgecumbe. One date, from peat underlying an ash layer near Juneau, suggests that large-scale ash and lapilli eruptions from Mount Edgecumbe occurred about 9000 Before Present (Heusser, 1960, p. 97, 184). This date is in good agreement with one of 8750±300 B. P. for rooted wood at the base of a peat layer that overlies the Mount Edgecumbe ash at Sitka (R. W. Lemke, U.S. Geological Survey, oral commun., 1966).

The Mount Edgecumbe volcanic field has been visited by few geologists. William Libbey, Jr., a geographer, visited the field in 1884 (Libbey, 1886, p. 283–286), and H. F. Reid climbed Mount Edgecumbe in 1892 (Gushing, 1897). F. E. Wright, of the U.S. Geological Survey, climbed the volcano in 1904 and studied some of the rocks but never published his results. Adolph Knopf, also of the Geological Survey, visited the east side of the field briefly in 1910 (Knopf, 1912, p. 14) and described a specimen of the most common flow rock. Berg and Hinckley (1963, p. 014–015) mapped the northeast corner of the field and described the major features briefly.

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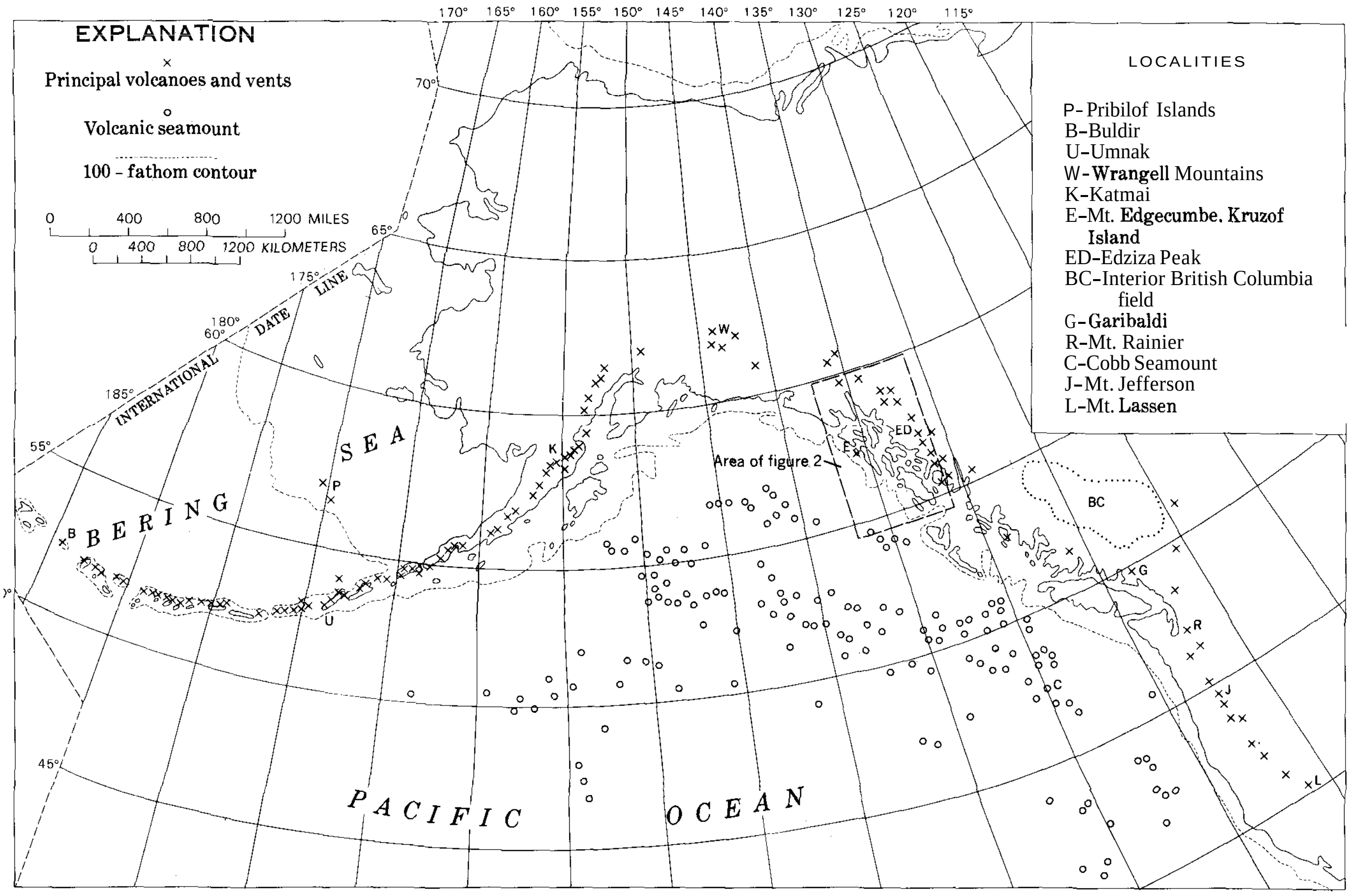


FIGURE 1.—Map of northeastern Pacific region, showing location of some Plio-Pleistocene, Pleistocene, and Holocene volcanoes (x), volcanic seamounts (o), 100-fathom contour (short dashes), and outline of figure 2.

The present study is based on reconnaissance mapping of the shoreline in August 1961 by R. A. Loney and D. A. Brew, with some additional data provided by H. C. Berg and J. S. Pomeroy, and on reconnaissance mapping of the shoreline and island interior in June and August 1962 by D. A. Brew and L. J. P. Muffler. A preliminary photogeologic map of the island was compiled by J. S. Pomeroy and combined with field data by L. J. P. Muffler in 1962. Preliminary petrographic examinations by H. C. Berg in 1961 were used in the preparation of a preliminary map covering the area (Loney and others, 1963). The petrographic studies were completed by D. A. Brew. Some preliminary results of our studies were reported by Brew, Muffler, and Loney (1966).

In the petrographic study of the Edgecumbe Volcanic~flat-stage methods were used in examining both thin sections and grain mounts. Precise mafic mineral determinations have not been made, although refractive indices of olivine and clinopyroxene were measured in some specimens. Determinative curves from Troger (1959) were used. Plagioclase compositions were obtained from extinction-angle data and checked in high-dispersion oils, using the method of Emmons and Gates (1948) and the curves of Tsuboi (1923). Modal values were estimated visually from thin sections. The volcanic rocks were classified by means of Peterson's (1961) criteria. In addition, the rock names are modified by prefixing the names of the most important mafic minerals in the specimen. Thus an olivine-bearing augite basalt is a basalt containing more than about 10 percent augite and less than 10 percent olivine in the phenocrystic and groundmass phases taken together. Nine chemical analyses were obtained to verify the compositional classification of critical specimens and to provide a basis for better comparison of this volcanic field with others. Semiquantitative spectrographic analyses for 50 elements were also obtained from these nine specimens (Heropoulos and Mays, 1969).

This brief report cannot do justice to the complicated eruptive and petrogenetic history of the Mount Edgecumbe volcanic field, but it summarizes our present interpretations and hopefully will encourage a detailed study of the area.

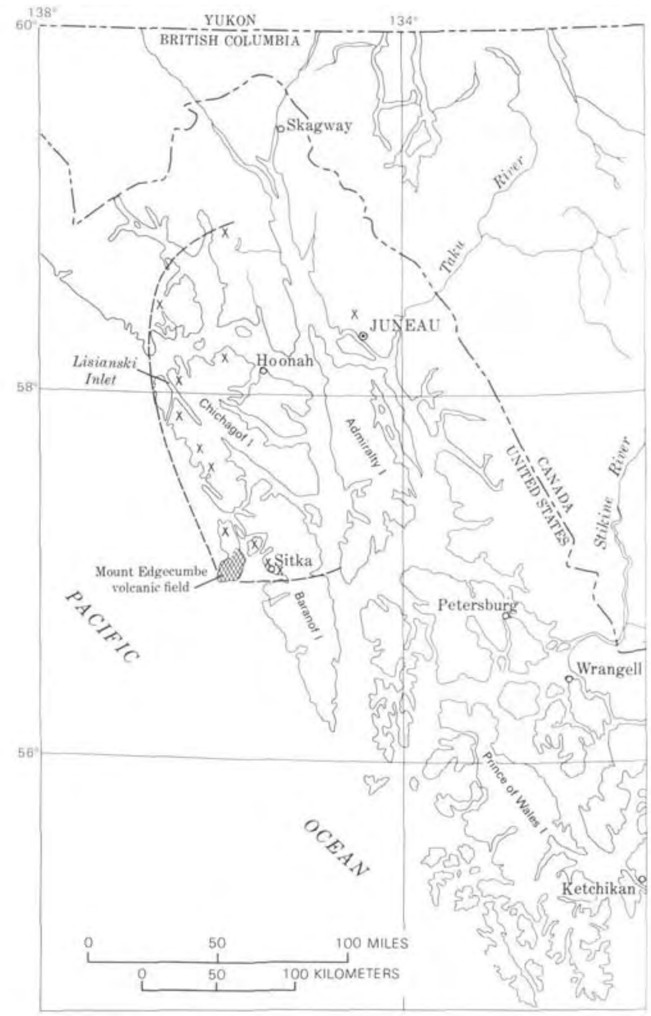


FIGURE 2.—Map of southeastern Alaska, showing location of Mount Edgecumbe volcanic field. Localities where Mount Edgecumbe ash is known to have been deposited are indicated by X. Dashed line is inferred limit of Mount Edgecumbe ash.

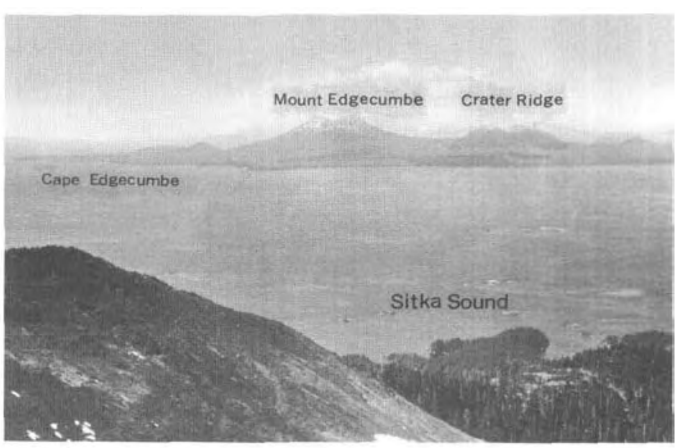


FIGURE 3.—Mount Edgecumbe volcanic field viewed from 29 km southeast across Sitka Sound. Mount Edgecumbeis 976 m high. The part of Kruzof Island shown in the photograph is about **16** km from left to right.

We thank James G. Smith and Donald **A.** Swanson for critically reviewing the manuscript.

STRATIGRAPHY AND PETROGRAPHY

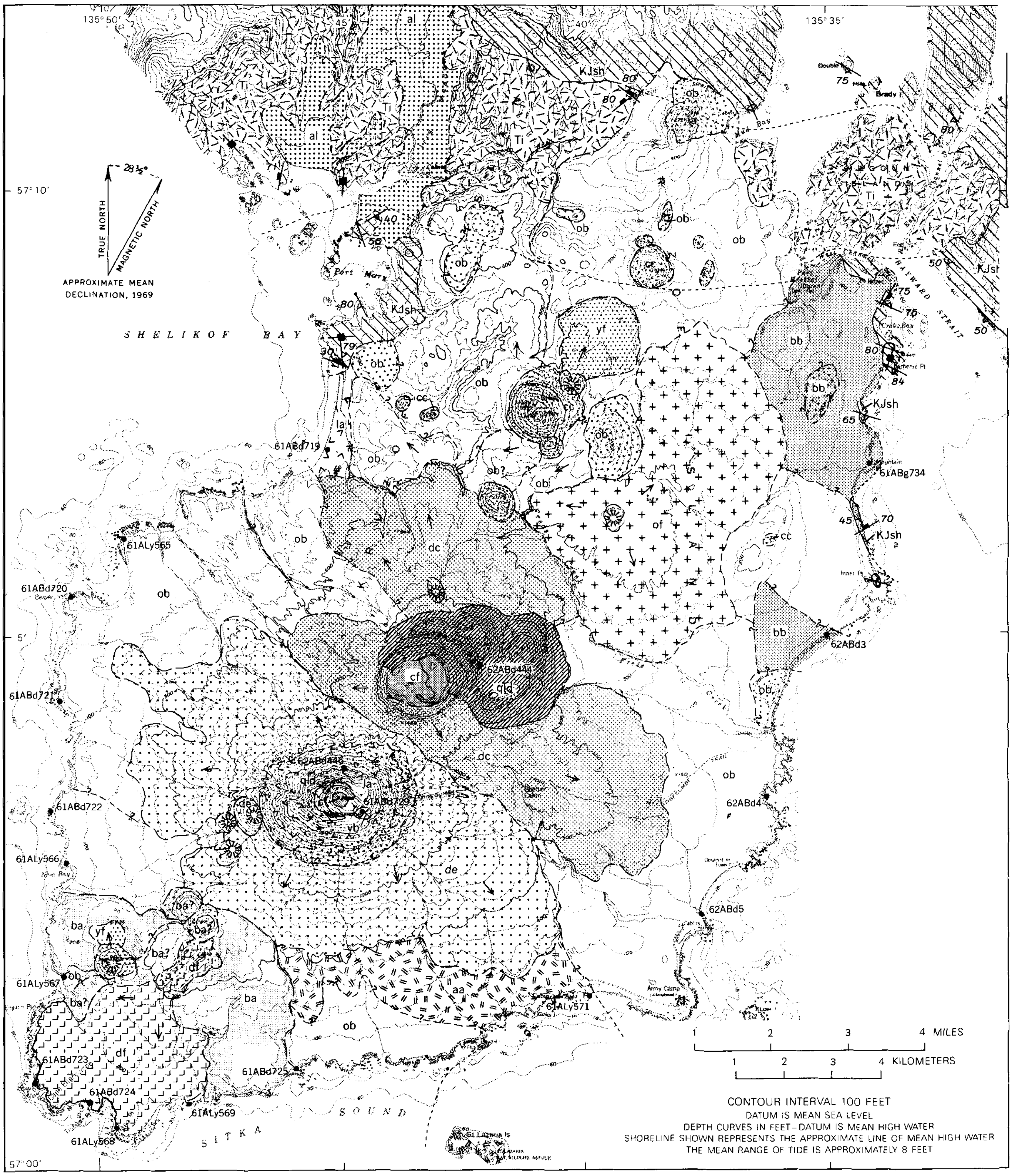
Basement rocks

The volcanic rocks of the Mount Edgecumbe volcanic field were extruded onto a glacially planed surface of Mesozoic graywacke and slate that had been intruded by Tertiary granitic rocks (fig. 4). The graywacke and slate are part of the Sitka Graywacke (Berg and Hinckley, 1963, p. O12–O14; Loney and others, 1963, p. 5; Loney and others, 1964). Unmetamorphosed Sitka Graywacke consists of highly folded thin– to medium-bedded dark-gray graywacke interlayered with dark-gray slate. Although exposed only on the Vitskari Rocks and Vitskari Island (east of Low Island, fig. 4), unmetamorphosed Sitka Graywacke probably underlies the southern third of the volcanic field. The Sitka Graywacke in the northern part of the volcanic field has been thermally metamorphosed to biotite-plagioclase-quartz hornfels and schist, garnet-biotite-plagioclase-quartz hornfels, cordierite-biotite-plagioclase-quartz hornfels, and chlorite-plagioclase-quartz hornfels and schist,. These thermally metamorphosed rocks are well exposed along the east shore of Kruzof Island, where they are locally highly sheared, mostly along north and northwest trends, and range in strike from west-northwest to north. Steeply dipping dikes of porphyritic basalt are exposed where the covering volcanics have been stripped off along the shore by wave erosion. The dikes are 1 to 15 meters wide and trend either about north-south or east-west.

The intrusions which thermally metamorphosed the Sitka Graywacke in Tertiary time (Loney and others, 1967) consist of light-gray medium-grained biotite granodiorite, biotite adamellite, and biotite granite (Loney and others, 1963, table 1) and probably underlie a third of the volcanic pile. The presence of granodiorite clasts among the ejecta at the summit of Mount Edgecumbe and as boulders in streams draining from wholly volcanic areas south of Shelikof Bay indicates that the magma conduits in those areas are at least partly within the intrusive rock.

Edgecumbe Volcanics

The volcanic rocks of southern Kruzof Island, named the Edgecumbe Volcanics by Berg and Hinckley (1963, p. O14–O15), are unglaciated and rest uncomformably on a low-relief glaciated surface that truncates all rocks older than the volcanic rocks. The volcanic rocks are overlain by alluvial deposits north and east of Shelikof Bay (fig. 4).



Base from U.S. Geological Survey
Sitka A-5 and A-6 1951

Geology by D. A. Brew, R. A. Loney, L. J. P. Muffler,
H. C. Berg, J. S. Pomeroy, and D. W. Hinckley, 1960–62

FIGURE 4.—Reconnaissance geologic map of the Mount Edgecumbe volcanic field, Kruzof Island, southeastern Alaska.

EXPLANATION

Holocene

al — Alluvium

yf — Younger unsampled flows and associated cinder cones

cc — Young unsampled cinder cones

Pleistocene and Holocene / Late Wisconsin / Edgecumbe Volcanics

cf — Caldera fill and crater subsidence deposits

vb — Vent breccia

la — Lapilli and ash
Probably mantles all older units

of — Older unsampled flows and associated cinder cones

qld — Quartz latite domes

df — Dacite flows and associated cinder cones

Dacite
Dacite of Mount Edgecumbe cone and associated cinder cones

dc — Possible dacite
Possible dacite of Crater Ridge and associated cinder cone

ba — Basaltic andesite
Basaltic andesite north and east of Cape Edgerumbe

aa — Andesite
Porphyritic hypersthene andesite of St. Lazaria Islands

bb — Basalt and breccia
Dense olivine basalt and associated breccia of Mountain Point

ob — Oldest basalt flows
Vesicular porphyritic olivine bearing basalt

QUATERNARY

UNCONFORMITY

Eocene

Ti — Intrusive rocks
Biotite granodiorite, adamellite, and granite

TERTIARY

Upper Jurassic and Lower Cretaceous

KJsh — Hornfels and schist
Biotite-garnet and biotite-cordierite hornfels and schist derived from Sitka Graywacke

JURASSIC AND CRETACEOUS

?
Contact
Long-dashed where approximately located; short-dashed where indefinite or inferred; queried where hypothetical; dotted where concealed. Used both within and between map units

55 Inclined — 80 Overturned — Vertical
Strike and dip of beds
Dot indicates top of beds known from sedimentary structures

65 Inclined — Vertical
Strike and dip of foliation in layered rocks

71 Inclined — Vertical
Strike and dip of joint or joint set

Direction of lava flow as inferred from pressure ridges, tunnels, and (or) general configuration

Cinder cone and (or) eruptive vent

•61ABd720
Location and number of thin-sectioned specimen of Edgecumbe Volcanics

FIGURE 4.— (CON.)

The Edgecumbe Volcanics contains flows, minor intercalated breccias, cinder cones, and steep-sided domes. The volcanic field is dominated by one large composite volcanic cone, Mount Edgecumbe, and also contains a collapsed composite cone, Crater Ridge, and several smaller cinder cones, all of which stand above a broad base made up of many thin flows. Both composite cones and all but the youngest lava flows appear to be mantled by unconsolidated lapilli and ash.

The major vents are alined in a narrow 24-km-long belt that trends N. 30° E. Some of the youngest activity appears to have been concentrated near the southwestern tip of the island, but the overall eruptive sequence indicates no systematic change of active vent locations.

We have subdivided the Edgecumbe Volcanics into 14 units (table 1; figs. 4 and 5); their stratigraphy and petrography are treated separately below.

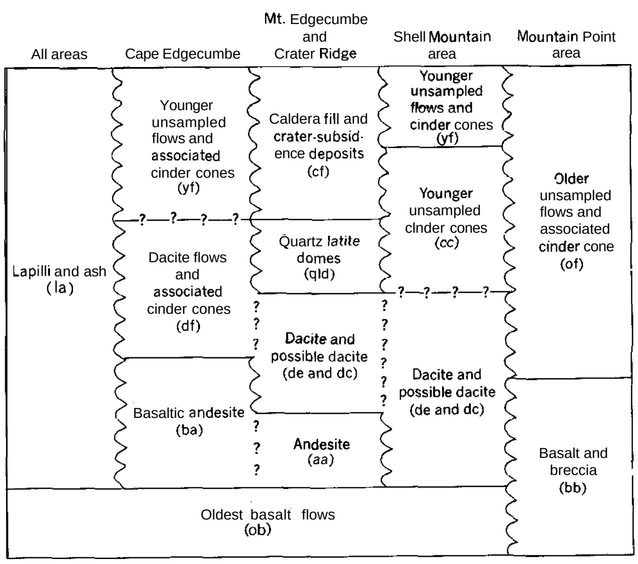


FIGURE 5.—Correlation chart showing reconnaissance subdivision of Edgecumbe Volcanics. Vertical position in chart shows probable place in eruptive sequence. Solid lines indicate stratigraphic relation known. Queried solid lines indicate stratigraphic position inferred. Wavy vertical lines separate geographic groups of units whose mutual relations are not known. Queries along vertical lines indicate possible correlation between units in adjacent columns. Lowercase letters in parentheses are map symbols used on figure 4. Vent breccia (vb of fig. 4) not shown on chart because of uncertainty of its age relation to crater fill and crater subsidence deposits.

Oldest basalt flows.—Most of the broad platform that underlies the spectacular composite cones of southern Kruzof Island consists of medium-gray vesicular porphyroaphanitic olivine-bearing augite basalt flows (fig. 4). These flows are characterized by 10–30 percent vesicles, 5 40 percent plagioclase phenocrysts, and scattered olivine phenocrysts 0.5–1 millimeter in diameter. Individual flows range from 0.5 m to a few meters in thickness and commonly have chilled bottoms and highly vesicular oxidized pahoehoe tops. Other features include (1) well-developed polygonal columns 0.3–1.2 m across and (2) abundant pressure domes and ridges up to a few hundred meters in maximum dimension and as much as 2 m high. The flanks of these domes and ridges have dips as steep as 50°.

Other'rock types have been locally included in the "oldest basalt flows" unit (fig. 4). Interlayered breccia and medium- to dark-gray slightly vesicular basalt occur about 1 mile northeast of Beaver Point on the west coast of the island. Both the basalt flow and the fragments in the breccia are slightly porphyritic olivine-bearing augite basalt. The breccia fragments range from 2 centimeters to 1 meter in maximum dimension, and some bomblike fragments were noted. A sequence of pahoehoe flows with minor breccia layers has also been included in the map unit north of Neva Bay. These flows are composed of light- to medium-gray porphyritic to microporphyritic vesicular olivine-augite basalt. The flows contrast with those typical of the "oldest basalt flows" unit because of their slightly greater olivine content, poorer columnar jointing, thinness (average 30–50 cm), and relatively small (3-m diameter) domes. The breccia interlayers are 2–6 m thick and consist of angular to subangular fragments, 1 cm to 1 m in diameter, of flow-rock lithic type in a soft fine-grained tuff matrix.

Another group of flows included in the "oldest basalt flows" unit occurs along the shore due south of Mount Edgecumbe. These flows are light- to medium-gray, coarsely vesicular, microporphyritic augite-bearing olivine basalt. They are further characterized by polygonal columns 0.5–1 m in diameter, small domes, and rare pahoehoe tops; single flows are probably a few meters thick.

Petrographic characteristics of thin-sectioned specimens from the "oldest basalt flows" are given in table 1. These flows are typified texturally by vesicularity, abundant phenocrysts, and intergranular groundmass textures. The low amount of olivine phenocrysts and the consistent olivine and plagioclase compositions (table 1) are important. A consistent range of clinopyroxene compositions was not obtained from the optical data, and the mineral is therefore reported simply as augite, although most is probably diopsidic augite and some is subcalcic augite.

Fine grain size made it difficult to determine compositions and proportions of groundmass olivine and clinopyroxene and to determine the presence or absence of reaction relations around olivine phenocrysts.

Several significant petrographic features common to all specimens are not shown in table 1 and are therefore noted here. Plagioclase phenocrysts commonly are progressively zoned over a range of 30 percent An from core to rim with conspicuous oscillatory zoning near the rims. Their composition in tabla 1 is representative of the "outer core" and is practically an average for the phenocryst. In some of the specimens, the phenocryst outlines are irregular owing to reaction with the groundmass material after crystallization or with the magma.

Another striking feature of some of these basalts is the presence of glomeroporphyritic clots of plagioclase and mafic crystals as large as 1 cm in diameter.

Minerals derived from olivine after crystallization are described in table 1 simply as an orange-brown or red-brown secondary mineral. Probably this late product is "bowlingite" or "iddingsite." Chlorophaeite present in a few specimens is included with the glass in table 1.

Three samples (61ABd720, 61ABd725b, and 61ALy-566) of the "oldest flows" were analyzed chemically (columns 2, 3, and 4, table 2).

Basalt and breccia.—A lithologically distinct unit consisting of volcanic breccia overlain by dense massive lava flows is exposed in two areas along the east shore of Kruzof Island. Between Port Krestof and Mountain Point the unit rests uncomformably on hornfels derived from the Sitka Graymacke. South of Inner Point the unit has bean interpreted from photogeologic evidence to rest on the "oldest basalt flows," but the evidence is poor. The stretch of shore separating the northern and southern exposures is made up of hornfels overlain by "oldest basalt flows."

The relations of the "basalt and breccia" unit to the other rock units in the volcanic field are not clear from the available reconnaissance data. The unit is considered younger than the "oldest basalt flows" (fig. 5) and probably older than the "older unsamplecl flows," but could antedate or be coeval with the "oldest basalt flows" unit.

The lower part of the "basalt and breccia" unit is volcanic breccia consisting of bomblike or pillowlike fragments of vitrophyre and dense nonvesicular slightly porphyritic olivine basalt as much as 75 cm in maximum dimension in a poorly sorted matrix of irregularly shaped breccia fragments and tuff. The breccia is variable in thickness and locally contains fragments that appear to be weathered fine-grained graywacke; this latter feature suggests that subaerially weathered debris was incorporated in the breccia during movement. The "basalt and breccia" unit may have been erupted, at least in part, from a dissected cone about 2.4 km northwest of Mountain Point.

Flows of olivine basalt compositionally similar to the large fragments in the breccia overlie the breccia. The flows are subhorizontally layered, massive, dense, fine grained, and generally nonvesicular. In places erosional remnants of the flows rise above the breccia and superficially resemble dikes.

The augite-bearing olivine and olivine-augite basalts are characterized by the absence or near absence of vesicles and phenocrysts (table 1). The available petrographic data suggest that this unit may contain a variety of rock types and, perhaps, compositions. One sample (61ABg734d) from the "basalt and breccia" unit was analyzed chemically (column 1, table 2).

Andesite.—A distinctive unit of subhorizontal andesite flows is well exposed along the shore near Lava and Goloi Islands and on St. Lazaria Islands (fig. 4). These flows probably came from near Mount Edgecumbe. The andesitic composition suggests affinity with rocks of Mount Edgecumbe rather than with the "oldest basalt flows," which the andesites are interpreted to overlie and which they resemble in outcrop.

The unit consists of nonvesicular, highly porphyritic, dark-gray olivine-bearing hypersthene andesite or basaltic andesite flows a few meters thick. The andesites have excellently developed joint columns about 30 cm in diameter that are oriented perpendicular to flow surfaces. The andesite flows are also characterized by abundant domes as much as 15 m across and a few meters high, and the columns appear to radiate from many centers beneath the domes. Locally the flanks of the domes dip as steeply as 40°.

Petrographic features of the andesite (table 1) include the following: abundant broken plagioclase phenocrysts and microphenocrysts that are partly replaced by an epidotelike mineral, synneusis-twinned plagioclase phenocrysts, glomeroporphyritic clots of plagioclase and locally corroded pigeonitic augite, hypersthene apparently intergrown with clinopyroxene and plagioclase, and rare quartz xenocrysts.

One sample (61Ly571) of this andesite unit was analyzed chemically (column 6, table 2). Comparison of the analysis with Nockolds' (1954) averages suggests that the rock is best called an andesite.

Basaltic *andesite.*—Low on the southwest flank of Mount Edgecumbe are rocks mapped separately (fig. 4) as basaltic andesite. The flows probably originated from now slightly dissected cinder cones at elevations between 700 and 1,200 feet and spread over the southwestern part of Kruzof Island. They rest on the "oldest basalt flows" unit on the south side of the island and between Engano Point and Neva Bay on the west side

TABLE 1.—*Petrographic characteristics of thin-section specimens from*

[Specimen locations shown on figure 4. Asterisk (*) indicates chemically analyzed specimen. Abbreviations—General: Comp., composition; Tr., trace; V, very. Mineral: m, medium;

Specimen No.	Rock name	Texture: General (percent): Vesicles	Texture: General (percent): Phenocrysts	Texture: Specific: Whole rock	Texture: Specific: Groundmass	Average phenocryst size (mm): Plagioclase	Average phenocryst size (mm): Olivine	Average phenocryst size (mm): Pyroxene	Composition (percent): Plagioclase: Phenocrysts: Total	Composition (percent): Plagioclase: Phenocrysts: An content	Composition (percent): Plagioclase: Groundmass: Total	Composition (percent): Plagioclase: Groundmass: An content	Composition (percent): Olivine: Phenocrysts: Total	Composition (percent): Olivine: Phenocrysts: Fa content
OLDEST BASALT FLOWS (ob)														
Typical flows														
61ABd720*	Vesicular porphyritic olivine-bearing augite basalt.	≈25	42	Porphyro-aphanitic.	Intergranular	1×3	0.6	....	30	50–60	46	50–55	8	5–10
61ABd721b	do	≈15	25	do	Intergranular to micro-ophitic.	1×5	1X1.7	....	22	57	52	57	3	12–15
62ABd5	do	≈30–40	40	do	Intergranular	1×3	0.6	....	36	61	30	48	5	15–25
62ABd4	Vesicular porphyritic augite-olivine basalt.	=35	28	do	do	0.8X3.6	0.5	....	26	62	35	64	3	15–20
Leas typical breccia fragment														
61ALy565a	Vesicular porphyritic olivine-bearing augite basalt.	=10	10	Porphyro-aphanitic.	Intergranular to felty.	1×3	2	....	6	60	47	60	3	20–23
Other flows														
61ABd722a*	Vesicular porphyritic olivine-augite basalt.	≈20	22	Porphyro-aphanitic.	Intergranular and intersertal.	0.5×1	0.8	....	12	70	15	64	10	15
61ALy566*	Vesicular microporphyritic augite-olivine basalt.	=10	....	Microporphyro-aphanitic.	Felty intergranular to intersertal.	....	....	....	5	48	55	51	3	15
61ABd725b*	Vesicular microporphyritic olivine basalt.	=15	....	do	Intergranular to intersertal.	....	....	....	2	60	56	48	3	10–15
BASALT AND BRECCIA (bb)														
61ABg734a*	Olivine-pigeonitic augite basalt.	....	....	Aphanitic	Microophitic to intersertal.	....	....	....	....	....	53	59	....	....
62ABd3	Slightly vesicular porphyritic olivine basalt.	≈5	7	Vitrophyric	Hyalopilitic	....	0.7–3.0	....	....	....	47	56	7	10–15
ANDESITE (aa)														
61ALy571*	Porphyritic hypersthene basaltic(?) andesite.[1]	....	40	Vitrophyric	Hyalopilitic	0.75	0.2–0.6	0.2–0.6	30	65	20	46	2	10–20
BASALTIC ANDESITE (ba)														
61ALy567a*	Porphyritic olivine-bearing pigeonite basaltic andesite.[1]	....	20	Porphyro-aphanitic.	Felty intersertal.	0.5×1	1	0.5	15	58	38	50	4	15–25
61ALy567b	Porphyritic hypersthene-bearing olivine basalt or basaltic andesite.	<2	25	do	Felty intergranular.	2	0.7	0.6	18	60	49	54	5	10
61ALy569a	Slightly vesicular porphyritic olivine-bearing pigeonite basalt or basaltic andesite.	≈5	15	do	Felty intersertal.	0.4×0.8	0.9	?	9	52	50	52	3	0–5
61ALy569c	Slightly vesicular porphyritic olivine-bearing pigeonite basaltic andesite.	<5	20	do	Felty intersertal to pilotaxitic.	0.6×1	0.6	0.6	16	53	20	48?	4	15
61ABd725c	Slightly vesicular porphyritic olivine-bearing pigeonite?-augite basaltic andesite.	10	20	do	Felty intersertal.	0.8	0.3	1.5	15	55	50	47–55	1	15

See footnotes at end of table.

the Edgecumbe Volcanics, Kruzof Island, soulheastern Alaska

Pg, subcalcic augite; Di, diopside; Hy, hypersthene; Au, augite; Mg, magnetite; Il, ilmenite; Hm, hematite. Color: or, orange; br, brown; gn, green; gy, gray; dk, dark; lt, light]

Composition (percent)																
Olivine		Clinopyroxene				Orthopyroxene				Opaque minerals		Glass		Secondary minerals		Remarks
Groundmass		Phenocrysts		Groundmass		Phenocrysts		Groundmass								
Total	Fa content	Total	Comp.	Total	Comp.	Total	Comp.	Total	Comp.	Total	Type	Total	Description	Total	Description	
OLDEST BASALT FLOWS (ob)																
Typical Bows																
1	12	4	Pg?	9	Pg?					1	Mg?	1		Tr.	Or br	
2	12–15	15	Ti rich.							3	Mg, Il?	3	Murky.	Tr.	do	Probable reaction around olivine.
3	15–25	5	Di?	15	Di?					5	Mg?			2	do	
15	5–15			16						5	do	Tr.?		1	do	No reaction around olivine.
Less typical breccia fragment																
1	23	1	Di?	25	Au					10	Mg?	5	Devitrified.			Possible reaction around olivine.
Other flows																
Tr.	15			27	Di?					20	Mg?	10		Tr.	Red br	No reaction around olivine.
12	15–20			12	do					7	do	6	Dk br, murky.	Tr.	Gn, or-br.	Olivine has magnetite+ clinopyroxene rims; microphenocryst composition is given.
24	10–15			5	Pg?					3	do	6	do			Possible reaction around olivine; microphenocryst composition is given.
BASALT AND BRECCIA (bb)																
17	10–15			20	Pg			1	Hy	5	Mg	4	Br, gn, devitrified.	1	Gn chlorite?	
10	10–15			4	Au							32	V dk br			No reaction around olivine.
ANDESITE (aa)																
		2?	Pg?			6	Hy	5	Hy?	15	Mg?	18	Dk	2	Murky.	10 percent plagioclase microphenocrysts included with phenocrysts; 5 percent hypersthene microphenocrysts included with groundmass; one quartz phenocryst noted.
BASALTIC ANDESITE (ba)																
		1	Pg?	25	Pg					2	Mg?	15	Br, gy, murky.			livine has clinopy rims; excellent flo alinement around phenocrysts.
4?		1	Au	15	Au	1	Hy	?			do	3	M br			Olivine has clinopyroxene rims; proportion of orthopyroxene may be > given; one exotic sphene grain noted.
1?		3	Pg?	20	Pg					8	do	15	Lt m br.	1	Chlorophaeite.	Possibly two generations of plagioclase phenocrysts; olivine has clinopyroxene+ magnetite rims; 5 percent "late alkalies" in groundmass.
1?		4	Pg?	43	Pg?					8	do	8	M br			Plagioclase and olivine phenocrysts reacting with groundmass.
		4	Pg	10	Au					10	do	10	Dk br			Plagioclase, olivine, and pigeonite phenocrysts reacting with groundmass.

TABLE 1.—*Petrographic characteristics of thin-section specimens from*

[Specimen locations shown on figure 4. Asterisk (*) indicates chemically analyzed specimen. Abbreviations—General: Comp., composition; Tr., trace; V, very. Mineral: m, medium;

Specimen No.	Rock name	Texture: General (percent): Vesicles	Texture: General (percent): Phenocrysts	Texture: Specific: Wholerock	Texture: Specific: Groundmass	Average phenocryst size (mm): Plagioclase	Average phenocryst size (mm): Olivine	Average phenocryst size (mm): Pyroxene	Composition (percent): Plagioclase: Phenocrysts: Total	Plagioclase: Phenocrysts: An content	Plagioclase: Groundmass: Total	Plagioclase: Groundmass: An content	Olivine: Phenocrysts: Total	Olivine: Phenocrysts: Fa content
DACITE (dc)														
62ABd446*	Slightly vesicular porphyritic augite andesite(?) [2]	≈8	25	Porphyro-aphanitic.	Hyalopilitic	0.2	------	0.4	17	55	43	43	------	------
DACITE FLOWS (df)														
61ABd723a	Lineated porphyritic pyroxene andesite or trachyandesite.	------	5	Porphyro-aphanitic.	Pilotaxitic	1	------	------	[3] 3	64	40	43	------	------
61ABd723d*	Porphyritic augite-hypersthene andesite or trachyandesite. [2]	------	7	do	do	------	------	------	[5] 4	78	40	35	------	------
61ABd724c	Vesicular porphyritic hypersthene-augite andesite?	20	4	do	Hyalopilitic	0.5×1	------	------	3	46	[8] 55	47	------	------
61ALy568	Porphyritic hypersthene-augite andesite or trachyandesite.	------	8	do	Pilotaxitic	0.3×0.8	------	0.3×0.5	[9] 5	53	23	33	------	------
QUARTZ LATITE DOMES (qld)														
62ABd444*	Banded porphyritic augite-bearing andesite or trachyandesite. [10]	≈2	5	Vitrophyric	Felty hyalopilitic.	0.5×1	------	0.3×1	4	46?	40	37	------	------
VENT BRECCIA (vb)														
61ALy729b	Vesicular porphyritic augite-bearing andesite? or trachyandesite?	15	25	Porphyro-aphanitic.	Intersertal to intergranular.	------	------	------	[11] 10	50	35	35-39	------	------
LAPILLI AND ASH (la)														
61ABd719-1	Pyroxene- and plagioclase-bearing pumice.	40	5	Holohyaline	------	0.3×1	------	------	5	------	------	------	------	------
61ABd719-2	Hypersthene- and plagioclase-bearing pumice.	50	4	do	------	------	------	------	2	33	------	------	------	------

[1] Andesite on basis of chemical analysis.
[2] Dacite on basis of chemical analysis.
[3] Twenty percent microphenocrysts of An_{42} and An_{55} (two generations).
[4] Two percent augite microphenocrysts also.
[5] Ten percent microphenocrysts f An_{53} and An_{38} also.
[6] One percent augite microphen ry: lso.

the Edgecumbe Volcanics, Kruzof Island, southeastern Alaska—Continued

Pg, subcalcic augite; Di, diopside; Hy, hypersthene; Au, augite; Mg, magnetite; Il, ilmenite; Hm, hematite. Color: or, orange; br, brown; gn, green; gy, gray; dk, dark; lt, light]

Composition (percent)																		Remarks
Olivine		Clinopyroxene				Orthopyroxene				Opaque minerals		Glass		Secondary minerals				
Groundmass		Phenocrysts		Groundmass		Phenocrysts		Groundmass										
Total	Fa content	Total	Comp.	Total	Comp.	Total	Comp.	Total	Comp.	Total	Type	Total	Description	Total	Description			
DACITE (de)																		
----	----	7	Au	10	Au	17	----	----	----	7	Mg?	15	Devitrified?	----	----			Proportion of orthopyroxene may be greater than given.
DACITE FLOWS (df)																		
----	----	[4] 2	An	12	Au	2	Hy	----	----	15	Mg?	6	Gy br	----	----			
----	----	[6] 1	Au	28	Au	72	Hy	----	----	8	do	5	Murky	----	----			
----	----	----	----	10	7	1	Hy	----	----	6	do	25	Br, murky.	----	----			
----	----	1	Au	15	Au	2	Hy	----	----	12	do	12	Lt-m-br	----	----			Hypersthene has narrow reaction rim with groundmass; most mafic phenocrysts in glomeroporphyritic clots.
QUARTZ LATITE DOMES (qld)																		
----	----	Tr.	Au	----	----	----	----	----	----	10	Mg?, Il?	45	Devitrified.	4	Hm			1 percent of opaques are phenocrysts.
VENT BRECCIA (vb)																		
----	----	5	Pg?	15	Au	10	Hy	----	----	10	Mg?	5	Gy br	----	----			Plagioclase phenocrysts broken and reacted; hypersthene phenocrysts have reaction rim with groundmass.
LAPILLI AND ASH (la)																		
----	----	7	----	----	----	----	----	----	----	2	Mg?	93	Colorless	----	----			
----	----	----	----	----	----	2	Hy	----	----	----	----	94	Lt br	----	----			2 percent lithic fragments (also dark-brown vesicular glass with plagioclase phenocrysts).

[7] One percent hypersthene microphenocrysts also.
[8] Actually microphenocrysts.
[9] Thirty percent microphenocrysts of An_{60}? also.
[10] Quartz latite on basis of chemical analysis.
[11] Ten percent microphenocrysts of An_{50} also.

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and are overlain by the "dacite flow and associated cinder cone" unit and some of the "younger unsampled flows." The relation to the "andesite" unit, which the basaltic andesite also contacts, is unclear.

The rocks of this unit are porphyroaphanitic olivine-bearing pigeonite basaltic andesites (table 1). They are nonvesicular to slightly (10 percent) vesicular and commonly contain 15–20 percent phenocrysts (mostly plagioclase) that are 1–2 mm long. Some vitrophyres and breccias are interbedded with the usual flow rocks. In general the unit is characterized by dense light- to medium-gray cliff-forming flows.

The andesites are notable for well-developed felty textures and reaction relations betwen phenocrysts and the groundmass. The flow-alined plagioclase laths of the groundmass neatly surround the phenocrysts, which have been rotated into the flow planes together with flattened and collapsed vesicles.

The phenocrysts occur singly or in glomeroporphyritic clots and show clear evidence of reaction with the groundmass material. Plagioclase phenocrysts are commonly sieved with small crystals of mafic minerals and have corroded outer margins. Olivine and subcalcic augite phenocrysts have thin selvages of augite with or without magnetite granules. Flat-stage optical data suggest the presence of both subcalcic and calcic augite as phenocrysts and groundmass minerals in most of the basaltic andesites, as in many other rocks from the Mount Edgecumbe volcanic field.

One basaltic andesite (61ALy567a) was analyzed chemically (column 5, table 2), and comparison of its analysis and norm with Nockolds' (1954) average andesite suggests that the rock is an andesite, although the mode shows basaltic affinities.

FIGURE 6.—Aerial view of Mount Edgecumbe from the southeast. Light-colored lapilli and ash on upper unforested flanks are underlain by outward-dipping lava and tuff layers. Photograph by U.S. Navy.

Dacite and possible *dacite.*—The composite cone of Mount Edgecumbe consists of alternating meter-thick dncite flows and airfall tuff layers here called the "dacite" unit. The deposits around the former vent at Crater Ridge are probably similar and are here referred to the "possible dacite" unit. The "possible dncite" is known only from aerial observation and from a few thin sections of specimens collected at unspecified localities by F. E. Wright in 1904; the available field and petrographic evidence supports their temporal and compositional similarity to the deposits of Mount Edgecumbe.

The Mount Edgecumbe dacite flows and airfall tuff deposits are well exposed on the rim of the summit crater (figs. 4 and 6), where they dip outward from a point close to the northwest part of the rim. Many individual lava and tuff units are present; in general, the purplish-gray-weathering airfall tuff layers predominate over the medium-gray-weathering flows. The lava flows are slightly vesicular, porphyritic augite dacites and hypersthene-augite dacites characterized by well-developed flow features, including vesicle trains, and by oxidized flow tops.

The alternating lava flow and tuff layers are mantled on the outer slopes, and locally within the summit crater, by the distinctive yellow and orange "lapilli and ash" unit; they are intruded by a small quartz latite(?) dome on the northwest rim near the apex of the projected layers. The sides of the summit crater are obscured by rubble and talus in many places (fig. 8).

Some petrographic features of a typical dacite from Mount Edgecumbe cone are summarized in table 1. Other notable features include broken phenocrysts of zoned plagioclase that show blotchy alteration to a claylike mineral. Optical properties suggest that both orthopyroxene and clinopyroxene (augite and subcalcic nugite) are present.

The rock Iooks like an andesite, on the basis of color, hyalopilitic groundmass texture, and general contrast with the basalts. However, a chemically analyzed sample (62ABd446; column 7, table 2) is a dacite by comparison with Nockolds' (1954) averages.

Quartz latite domes.—The dacitic lava flows and tuff layers of Mount Edgecumbe and Crater Ridge were intruded by two viscous steep-sided quartz latite domes.

The largest of these masses covers about 6.5 sq km on Crater Ridge (fig. 7) and the hills directly east of the ridge. It consists of locally vesicular or amygdaloidal, gray- and reddish-brown-weathering aphanitic, augite-bearing quartz latite. The detailed internal structure of this vertically flo -layered dome is not known, but it is probably a composite of at least three contiguous masses which rose more or less synchronously. The

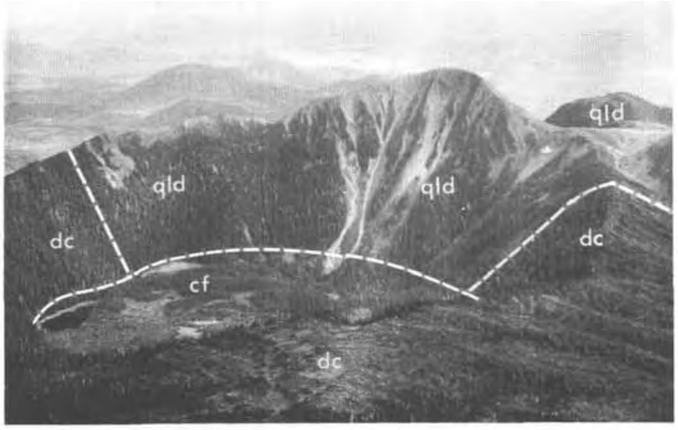

FIGURE 7.—Crater Ridge and Crater Ridge caldera viewed from Mount Edgecumbe, Kruzof Island, southeastern Alaska. The quartz latite dome (qld) makes up all but the left-hand part of Crater Ridge. Possible dacite unit (dc) and caldera fill unit (cf) shown also. Shell Mountain and other cinder cones are visible in the distance beyond the ridge.

FIGURE 8.—Aerial view of summit crater of Mount Edgecumbe, Kruzof Island, southeastern Alaska, from the southeast. The crater is filled largely by colluvium derived from the dacite and tuff layers which form the cone. "Lapilli and ash" unit (la) at left and right overlies "dacite" unit (de), which is intruded by quartz latite(?) (qld) at right center. Possible vent breccia (vb) is exposed in a small area. Photograph by U.S. Navy.

domal complex probably was about 0.65 sq km larger before collapse of the Crater Ridge caldera.

A second quartz latite dome forms a gray-weathering outcrop about 300 m in diameter on the west-northwest rim of Mount Edgecumbe (fig. 8). It clearly truncates the radially dipping tuff and lava-flow deposits of the composite cone. The attitudes of these deposits suggest, that their vent was close to, and may be plugged by, the dome.

The quartz Iatite contains only a few percent of plagioclase and other phenocrysts in a felty groundmass (table 1). The material surrounding the alinecl plagioclase laths of the groundmass is anisotropic, probably devitrified glass. The banding in the quartz latite is caused by streaks and irregular splotches of hematite and, to a lesser extent, opaque minerals more or less parallel to the flow alinement in the groundmass.

Comparison of a chemical analysis (table 2, column 9) and norm with those of the average dellenite (quartz latite), rhyodacite, and rhyolite obsidian of Nockolds (1954) suggests that the rock is a quartz latite or a rhyodacite.

Dacite flows and associated cinder toner.-The "basaltic andesite" unit on the southwestern tip of Kruzof Island is overlain by about 13 sq km of cliff-forming dacite flows, which crop out continuously from near Engano Point to beyond Sitka Point. The exposures are best visited at low tide because the surf breaks against the sea cliffs at all other times.

The lower part of the unit includes medium-dark-gray and grayish-brown, strikingly layered flows; its upper part is made up of dense reddish-gray flows and minor breccia and tuff. Some of the dense flows and breccias were deposited on an irregular (erosional?) surface cut across the layered flows.

All four rock specimens studied in thin section contain a few percent of corroded plagioclase phenocrysts, and accompanying phenocrysts of augite and hypersthene have narrow reaction zones. Perhaps the most striking microscopic feature of these rocks is the presence of abundant microphenocrysts intermediate in size (and, for plagioclase, intermediate in composition) between phenocrysts and groundmass minerals. The microphenocrysts are generally well alined in a felty texture, and groundmass plagioclase laths are also well alined in some specimens.

The specimens studied were classified as nonvesicular porphyroaphanitic hypersthene-bearing augite andesites or trachyandesites on the basis of their microscopic features (table 1), but comparision (table 2, column 8) with Nockolds' (1954) average suggests a dacitic composition.

Older unsampled flows and associated cinder cone.—About 20 sq km of gentle terrain southeast and east of Shell Mountain was mapped photogeologically as "older unsampled flows and associated cinder cone?' (fig. 4). The unit has a shieldlike form and appears to have been erupted from near a partly dissected cinder cone. The unit is interpreted to rest on the "oldest, basalt flows" and "basalt and breccia" units, and it may be constrained on the southwest by "possible dacite" flows which emanated from Crater Ridge.

Caldera fill and crater subsidence deposits.—The deposits partly filling the caldera at Crater Ridge and the summit crater of Mount Edgecumbe are poorly known. The Mount Edgecumbe crater appears to be filled mostly by colluvium derived from the crater walls (fig. 7). The debris in Crater Ridge caldera was described by F. E. Wright (unpub. notes, 1904) as a jumble of great angular blocks of lava, and the mound near the north wall of the caldera was described as consisting of blocks of slightly scoriaceous lava 0.9–9.0 m in diameter. Wright described the caldera floor as swampy in places and noted that the shallow lake on the west side bubbled locally at irregular intervals. The bubbles are of nonflammable gas according to Wright and are definitely not marsh gas.

The caldera of Crater Ridge in particular is worth further study. As shown on figure 4, it is 1.6 km in diameter at the rim, 1.1 km in average diameter at the floor, and about 240 m deep. The volume is calculated to be 1.4 cubic kilometers. Truncation of the quartz latite dome by the caldera suggests that it formed by collapse, but conclusive evidence is lacking. Figure 5 and the explanation of figure 4 reflect the inexact dating of the caldera formation. Our reconnaissance data do not provide the age relation between the "lapilli and ash" unit and the formation of the caldera.

Vent breccia.—A small area on the southeast rim of Mount Edgecumbe is underlain by glassy volcanic breccia which truncates the layered deposits of the cone (figs. 4 and 8). The breccia is interpreted to fill a vent. It is reddish-brown weathering, contains about 25 percent angular, 0.2–5-cm-long fragments of dacite(?) and vesicular porphyroaphanitic hypersthene-augite dacite in a flow-banded, dark-red and black glassy matrix. About 10 percent of the rock consists of angular voids.

The one specimen studied in thin section (table 1) is a clast in the vent breccia and is somewhat similar to the dacitic rocks from elsewhere on Mount Edgecumbe. It is notable mainly for its high content (10 percent) of hypersthene phenocrysts, the presence of plagioclase microphenocrysts in addition to the groundmass and phenocrystic plagioclase, and the reaction relations around hypersthene and plagioclase phenocrysts.

In addition to the rock fragments, the glassy breccia matrix also encloses scattered small (less than 1 mm) plagioclase phenocrysts of about An,, composition.

Lapilli and ash.—The distribution of the "lapilli and ash" unit shown in figure 4 is misleading because the only outcrop areas shown are the most conspicuous ones noted. Probably almost all the volcanic field and adjacent basement rock areas are or were mantled by this unit; large areas of unknown size inland from the south and east shores of the island are known to have a thick ash blanket.

The lapilli and ash deposits noted during the mapping range from zero to 5–6 m in thickness on the lower parts of the island and may be more than 15 m thick on the higher parts of Mount Edgecumbe (fig. 7).

The lapilli and ash weather reddish orange and yellowish brown at different localities and consist almost entirely of siliceous pumice and (or) scoria with less than 5 percent phenocrysts and lithic fragments. The two specimens studied in thin section (table 1) are very vesicular glassy rocks with minor content of plagioclase and pyroxene crystals and lithic fragments. The refractive index of the glass is about 1.51 to 1.52, indicating a silica content of 65 to 68 percent according to the general curve of Huber and Rinehart (1966). Hence the rocks may be dacites.

Young and younger unsampled cinder cones *and* flows.—The two youngest volcanic units shown on figure 4 are known only from aerial photographs and distant aerial observations. The "young unsampled cinder cones" making up Shell Mountain and nearby smaller cones are distinguished from other, apparently older cones by their undissected forms. As interpreted, all the young cones rest on the "oldest basalt flows" unit and one also apparently overlaps onto the "possible dacite" unit of Crater Ridge.

The "younger unsampled flows and associated cinder cones" were mapped separately because they are undissected and are not covered by thick vegetation, as are all the other volcanic units.

Alluvium

The areas shown on figure 4 as "alluvium" are broad valleys filled with sand and gravel of probable local derivation. These areas were not examined in detail, and it is probable that many are underlain at shallow depths by the "lapilli and ash" unit.

PETROGENESIS

The Mount Edgecumbe volcanic field is nearly ideal for the study of petrogenetic relationships within a single magma series for the following reasons: (1) there is wide variation of rock type, from basalt containing 48 percent SiO_2 to quartz latite containing almost 70 percent SiO_2; (2) the relatively short duration of activity and the clear temporal separation from earlier magmatic activity (that is, the mesozonal intrusions of middle Tertiary time) obviate many interpretive problems that can arise in a complex area such as the Cascade Range (Hopson and others, 1967); (3) the geographic isolation from other Holocene volcanic centers eliminates problems of mixing or contamination with other magma series; and (4) the geomorphic features are varied and well preserved and consequently are useful in establishing stratigraphic succession.

The reconnaissance nature of our fieldwork and the lack of precise determinations of phenocryst and groundmass compositions preclude setting up a detailed petrologic model for the Mount Edgecumbe volcanic field. However, the available data do permit a few tentative conclusions and a comparison with other volcanic series.

The chemical analyses (table 2) define a relatively smooth compositional trend (figs. 9 and 10) that we interpret as reflecting differentiation in a subjacent magma chamber. The trend from basalt to quartz latite also correlates with sequence of eruption, as

TABLE 2.—*Chemical* analyses and CIPW norms of specimens from the *Edgecumbe* Volcanics, *Kruzof* Island, Alaska

[Analyses 1 and 3-7 by P. L. D. Elmore, S. D. Botts, Lowell Artis D Taylor, G. W. Chloe, H. Smith, and J. L. Glenn using rapid-rock techniques (Shapiro and Brannock, 1962) supplemented by atomic absorption. Analyses 2, 8, and 9 by A. C. Bettiga using X-ray spectroscopy for SiO_2, Al_2O_3, CaO (Nos. 8 and 9 only), TiO_2, MnO, and total iron, by L. B. Beatty using wet chemistry for FeO, MgO (No. 2 only), CaO (No. 2 only), Na_2O, K_2O, H_2O+, H_2O-, P_2O_5, and CO_2, and by R. E. Mays using quantitative spectrographic analysis for MgO (Nos. 8 and 9 only)]

Number	1	2	3	4	5	6	7	8	9
Chemical analysis									
SiO_2	48.0	50.0	51.3	52.6	53.8	56.7	59.5	60.4	69.5
Al_2O_3	17.3	17.4	18.1	18.4	18.1	17.7	17.5	16.9	15.2
Fe_2O_3	2.1	2.3	2.0	2.8	1.5	1.0	1.2	1.8	3.2
FeO	6.5	6.2	6.1	5.5	6.1	6.2	4.7	4.9	.33
MgO	9.6	7.1	6.5	5.6	5.2	4.2	3.6	2.6	.42
CaO	11.0	10.8	10.2	9.0	9.1	7.0	6.8	5.5	2.3
Na_2O	2.5	3.4	3.3	3.4	3.8	3.5	4.2	4.8	5.0
K_2O	.13	.20	.25	.47	.40	1.3	.81	1.2	2.1
H_2O-	.77	.12	.10	.12	.04	.08	.09	.05	.25
H_2O+	1.0	.26	.51	.48	.26	.64	.39	.07	.85
TiO_2	.79	1.1	1.1	1.1	.98	1.1	.74	.96	.32
P_2O_5	.13	.30	.34	.35	.39	.40	.32	.37	.10
MnO	.17	.18	.16	.16	.16	.15	.12	.13	.12
CO_2	<.05	<.05	<.05	<.05	<.05	<.05	<.05	.06	<.05
Total	100	99.4	100	100	100	100	100	99.7	99.7
Specific density:									
Powder	2.94	--------	2.91	2.88	2.89	2.78	2.78	--------	--------
Bulk	2.88	--------	2.50	2.60	2.63	2.69	2.48	--------	--------
CIPW norms									
Q	--------	--------	0.1	3.5	2.6	7.9	11.1	11.4	27.2
C	--------	--------	--------	--------	--------	--------	--------	--------	.9
or	0.8	1.2	1.5	2.8	2.4	7.7	4.8	7.1	12.4
ab	21.2	28.8	27.9	28.8	32.2	29.6	35.5	40.6	42.3
an	35.6	31.6	33.8	33.6	31.1	28.7	26.5	21.0	10.4
wo	7.4	8.2	5.9	3.5	4.6	1.3	2.0	1.4	--------
en	11.6	11.0	16.2	13.9	13.0	10.5	9.0	6.5	1.0
fs	4.5	5.0	8.0	6.3	8.6	9.0	6.6	6.2	--------
fo	8.6	4.7	....	....	....	....	....	....	....
fa	3.7	2.3	--------	--------	--------	--------	--------	--------	--------
mt	3.0	3.3	2.9	4.1	2.2	1.5	1.7	2.6	.5
il	1.5	2.1	2.1	2.1	1.9	2.1	1.4	1.8	.6
ap	.3	.7	.8	.8	.9	.9	.8	.9	.2
cc	<.1	<.1	<.1	<.1	<.1	<.1	<.1	.1	<.1
Total	98.3	99.0	99.3	99.5	99.6	99.3	99.5	99.6	98.6
di	14.3	15.9	11.5	6.9	9.1	2.5	4.0	2.9	--------
hy	9.2	8.3	18.6	16.9	17.2	18.2	13.7	11.2	1.0
ol	12.3	7.0	....	....	....	....	....	....	....

1. **61ABg734a.** Olivine-pigeonitic augite basalt from "Basalt and breccia" unit.
2. **61ABd720.** Porphyritic olivine-bearing augite basalt from "Oldest basalt flows" unit.
3. **61ABd725b.** Microporphyritic olivine basalt from "Oldest basalt flows" unit.
4. **61ALy566.** Microporphyritic augite-olivine basalt from "Oldest basalt flows" unit.
5. **61ALy567a.** Porphyritic olivine-bearing pigeonite basaltic andesite from "Basaltic andesite" unit.
6. **61ALy571.** Porphyritic hypersthene basaltic(?) andesite from "Andesite" unit.
7. **62ABd446.** Porphyritic augite dacite from "Dacite and possible dacite" unit.
8. **61ABd723d.** Porphyritic pyroxene dacite from "Dacite flows and associated cinder cones" unit.
9. **62ABd444.** Porphyritic augite-bearing quartz latite from "Quartz latite domes" unit.

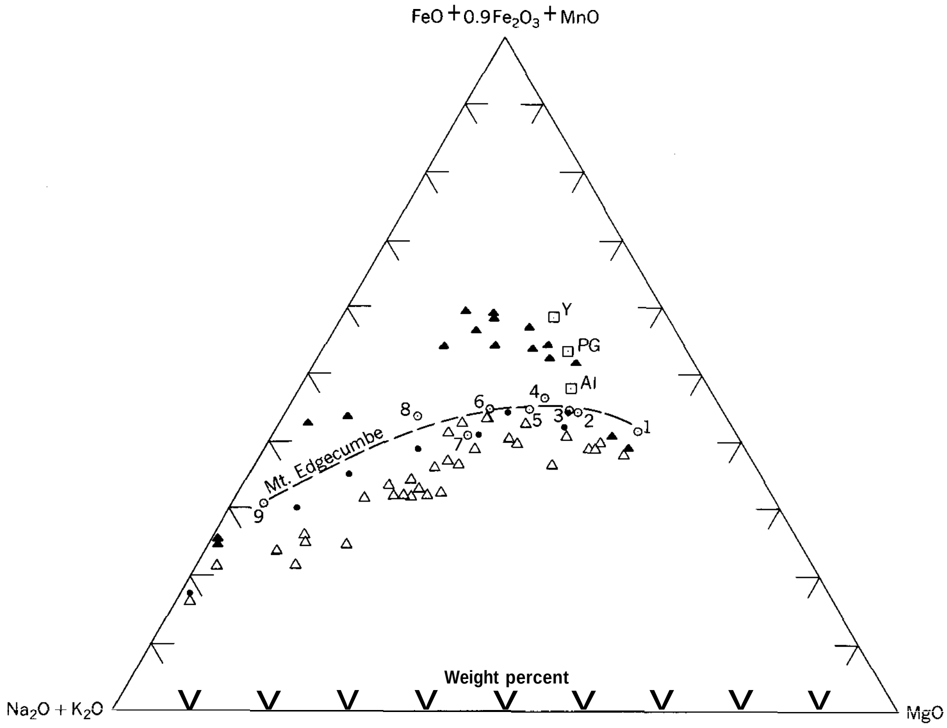

FIGURE 9.—AFM diagram comparing Mount Edgecumbe rocks with selected volcanic rocks from the Pacific coast of North America. Open circles, Mount Edgecumbe (numbers refer to columns of table 2). Closed circles, Mount Jefferson (Greene, 1968). Open triangles, Mount Lassen (Williams, 1932). Closed triangles, aphyric lavas and groundmasses, northeastern Umnak Island, Aleutian Islands, Alaska (Byers, 1961). Open squares, magma types of Waters (1962); Y, Yakima type; PG, Picture Gorge type; Al, high-alumina type from the Oregon Plateaus and Cascade Range.

deduced from the field criteria (fig. 5). The younger rocks are closer to the AF side of the APM diagram (fig. 9) and richer in silica (fig. 10). The apparent exception is No. 1, the basalt lowest in silica and highest in MgO. If the admittedly tentative stratigraphic assignment is correct (p. D7), this sample was extruded later than the "oldest basalt flows" (samples 2, 3, and 4, table 2).

Many of the analyzed specimens from the Mount Edgecumbe field are porphyritic, and, as Bowen (1956) has emphasized, the composition of a porphyritic rock may or may not represent the composition of a liquid, depending on the gain or loss of crystals during crystallization. Smooth variation on diagrams such as figures 9 and 10 is commonly taken to indicate close approximation of the rocks to liquids. Efforts to correct the Mount Edgecumbe chemical data for phenocryst content, by use of data from table 1, scattered the data points and considerably distorted the simple AFM variation of the uncorrected analyses. We therefore conclude that the porphyritic rocks closely approximate a liquid.

The chemical variation displayed by the Mount Edgecumbe series is similar to that displayed by many

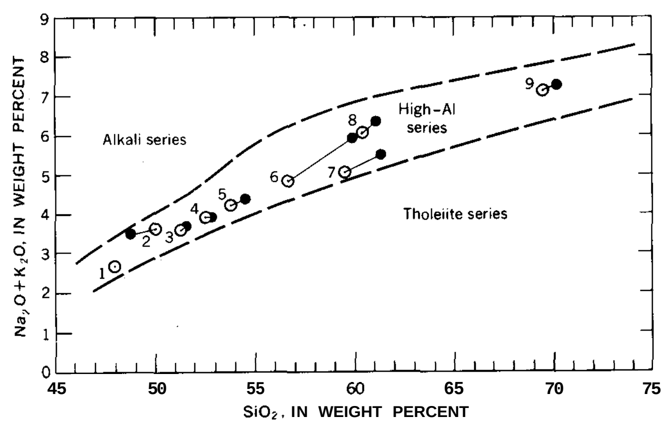

FIGURE 10.—Variation of Na_2O+K_2O with SiO_2 in the Edgecumbe volcanic series. Open circles, Na_2O+K_2O uncorrected for phenocrysts. Closed circles, composition of groundmass as calculated by subtraction of phenocrysts. Dashed lines are boundaries of magma series of Kuno (1965). Numbers refer to columns of table 2.

circum-Pacific volcanic suites (fig. 11). The alkali-lime index of the Mount Edgecumbe series is 60–61, thus falling within the calc-alkalic subdivision of Peacock (1931). This index is lower than that of the calcic High Cascades magma series (61–64), but higher than that of the calc-alkalic Oregon Plateaus series (55–58; LeMasurier, 1968).

The variation curve of the Mount Edgecumbe series in the AFM diagram shows a relative low iron content that is characteristic of calc-alkaline volcanic series (Nockolds and Allen, 1953) (fig. 9). The data suggest that the various calc-alkaline series plotted in figure 9 differ systematically in Fe/Mg+alk ratio, the Lassen series having the smallest ratio and the Umnak series the largest.

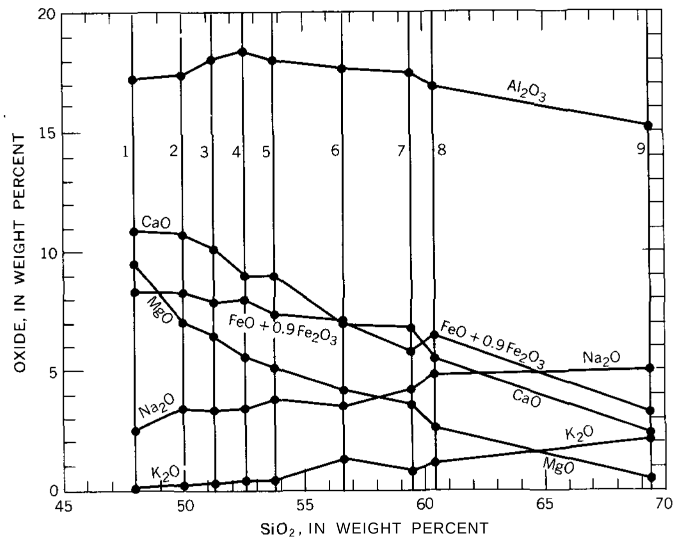

FIGURE 11.—Variation of major oxides with SiO_2 in the Edgecumbe volcanic series. Numbers refer to columns of table 2.

The differences among the series in figure 9 cannot be evaluated simply, for the various series are not comparable as to the manner in which the phenocrysts were treated in the evaluation of the raw analyses. The variation curves for Mount Lassen, Mount Jefferson, and Mount Edgecumbe are probably comparable, because they are for whole rocks, many of which are porphyritic, and have not been corrected for phenocryst content. The Umnak data, on the other hand, are from aphyric lavas or have been corrected for phenocryst content (Byers, 1961). Recalculation of the Mount Edgecumbe data for phenocryst content reduces, but does not eliminate, the difference between the Mount Edgecumbe series and the Umnak series.

Interpretation of the Mount Edgecumbe data in the framework of Kuno (1960, 1965) shows that all the analyses fall within the high-alumina basalt series (fig. 10). Correction for phenocryst content and composition (as above) shifts all the analyses within the high-alumina field. The exception, 61ABd720, is the sample rich in olivine and plagioclase phenocrysts. The basalts of Mount Edgecumbe are also compared in figure 9 with the three basalt types of Waters (1962) from the Columbia Plateau and Cascade Range in Oregon. The Edgecumbe basalts are closer to his high-alumina Cascade basalts than the Yakima and Picture Gorge Basalts of the Columbia Plateau.

The chemical correspondence of the Edgecumbe basalts to high-alumina basalt is compatible with their petrographic characteristics. However, neither the chemical nor the petrographic data indicate definitely whether the Edgecumbe basalts are alkalic basalt or whether they are tholeiite, according to the criteria of Macdonald and Katsura (1964). The "oldest basalt flows" (p. D6–D7) contain sporadic phenocrysts of olivine rimmed by grains of clinopyroxene and magnetite. This apparent reaction relationship, together with the occurrence of at least some subcalcic augite, suggests a tholeiite affinity when one uses the criteria of Macdonald and Katsura. On the other hand, the abundant groundmass olivine suggests an alkalic affinity.

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