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Preliminary Geologic Investigations of Western St. Lawrence Island, Alaska

By

William W. Patton, Jr., and Béla Csejtey, Jr

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Abstract

Reconnaissance geologic mapping indicates that western St. Lawrence Island is underlain by a wide variety of volcanic, plutonic, and sedimentary rocks ranging in age from mid-Paleozoic to late Cenozoic. The oldest rocks are dolomite and limestone of Devonian and Mississippian age which crop out in the northeastern part of the Putgut Plateau. These carbonates are succeeded by a poorly exposed sequence of mudstone, black chert, and shale which is in part Triassic in age but may include rocks as old as Mississippian and as young as Cretaceous. Overlying the mudstone is a widespread unit of andesitic and latitic flows and volcaniclastic rocks of Cretaceous age. Small patches of early Tertiary felsic flows occur on the Putgut Plateau, and terrigenous coal-bearing deposits of mid-Tertiary age crop out around Niyrakpak Lagoon. Late Tertiary(?) and Quaternary basalt flows of the Kookooligit Mountains sequence form the eastern margin of the mapped area and occur in small patches along the southeast flank of the Poovoot Range. Gabbro and diabase intrusives of probable Permian age are exposed along a narrow belt extending northwestward from Poowooiliak Point, and quartz monzonite intrusives of Cretaceous age underlie about one third of the mapped area in two large plutons, the Sevuokuk and Taphook.

Geochemical sampling indicates that disseminated molybdenite is widespread in the Sevuokuk pluton. A small low-grade porphyry copper deposit was found in a satellitic stock of quartz monzonite in the Poovoot Mountains and five separate deposits of lead-zinc-silver sulfides were noted along a belt extending northeasterly across the island from Southwest Cape.

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Introduction

Reconnaissance geologic mapping of western St. Lawrence Island is part of a long-range program to investigate the mineral resources of the Bering Sea shelf. The purpose of these investigations is not only to assess the mineral potential of the island itself but also to provide basic geologic information needed in the interpretation of offshore geophysical data. In addition, the geology of St. Lawrence Island is of special interest because it furnishes a critical tie-point for regional correlations between Alaska and northeastern Siberia.

St. Lawrence Island, with a total land area of about 2,000 square miles, is located in the northern Bering Sea 130 miles west of mainland Alaska and 40 miles southeast of the Chukotsky Peninsula, U.S.S.R. This report covers about 600 square miles on the western part of the island (fig. 1).

Figure 1 near here

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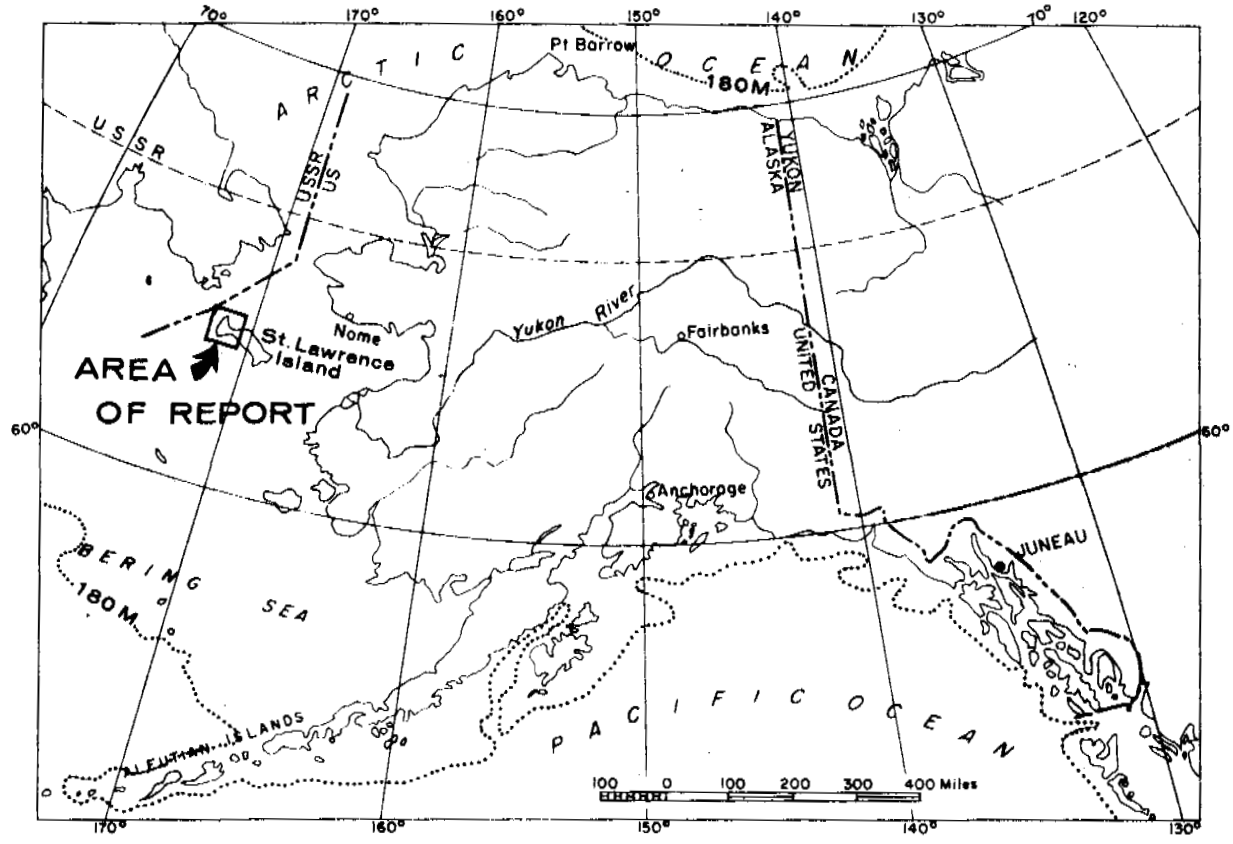


Figure 1. Index map showing location of St. Lawrence Island and area of this report.

The western part of St. Lawrence Island is dominated topographically by the Poovoot Range, a group of barren, rubble-covered hills that stretch across the island from near Kongok Bay and Boxer Bay on the southwest coast to Taphook Mountain on the north coast (fig. 2). The

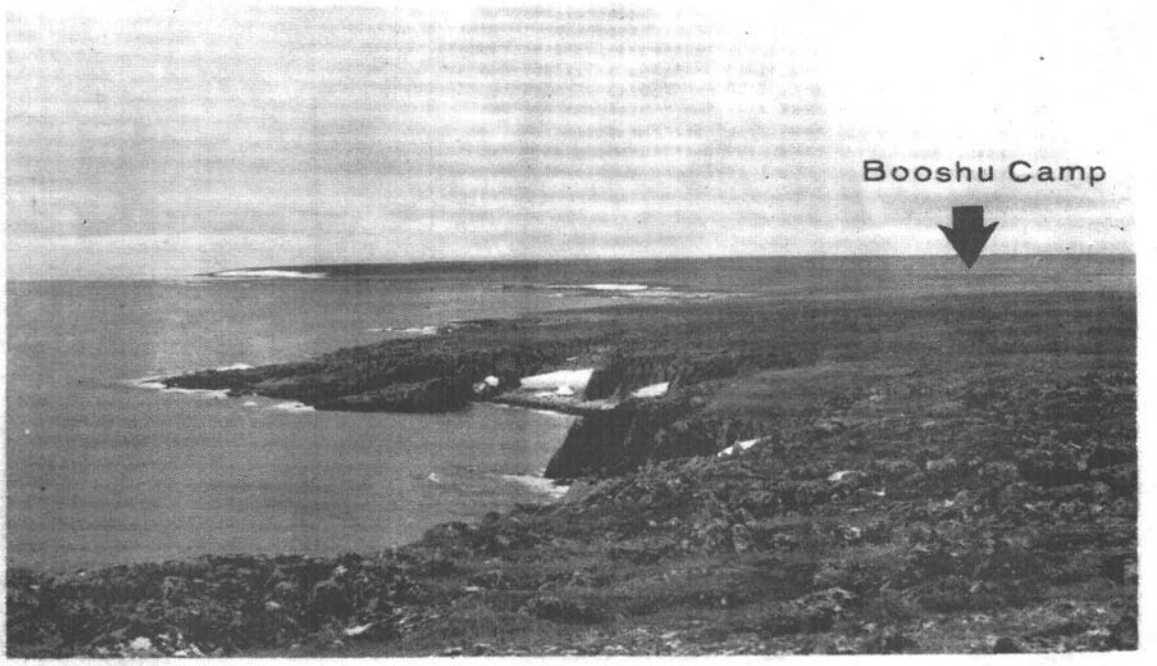
Figure 2 near here

Putgut Plateau, a nearly flat, lake-dotted, tundra-covered surface standing 100 to 200 feet above sea level, flanks the Poovoot Range on the southeast. The west and southwest coasts from Gambell to Poowooiliak Point are marked by rugged cliffed headlands and narrow boulder beaches (fig. 3). The north coast and the south coast east of

Figure 3 near here

Poowooiliak Point are bordered by broad coastal lowlands, tidal lagoons, and barrier beaches.

Bedrock exposures on western St. Lawrence Island are limited to sea cliffs and a few scattered cutbanks along locally incised streams. Interior parts of the island below 400 feet elevation are almost completely blanketed by tundra vegetation and above that elevation by frost-riven rock rubble. No trees or shrubs more than a few feet high grow anywhere on the island.



A. Exposures of quartz monzonite in cliffs along west coast of St. Lawrence Island.

B. Wave-cut surface of jointed quartz monzonite near Booshu Camp. Quartz monzonite contains stringers and sparsely disseminated small grains of molybdenite.

Figure 3

St. Lawrence Island has no all-weather roads or trails. During the summer months overland transportation is limited to tracked or other type vehicles capable of travelling over water-saturated tundra. The lagoons and the larger lakes are suitable for float-plane landings after spring breakup, which generally occurs in mid-June. Coastal areas can be reached by small boat from Gambell during periods of favorable surf and wind conditions. Gambell, the only settlement on western St. Lawrence Island, is served by scheduled airline from Nome.

Geologic mapping and geochemical studies of western St. Lawrence Island were carried out on foot and by small tracked vehicle and float plane during the summers of 1968 and 1969. Approximately 250 stream-sediment and rock samples were collected and analyzed by semiquantitative spectrographic and atomic-absorption methods. The authors were assisted in the field by V. A. Frizzell, M. B. Estlund, and A. F. White, geological assistants, and by W. T. Booshu and J. K. Patton, camp hands.

Previous reports of the geology of St. Lawrence are confined to early-day exploratory surveys along the coast (Dawson, 1894; Emerson, 1904, p. 38-42; Collier, 1906), an archeological investigation by O. T. Geist and F. G. Rainey (1936), and an unpublished geological reconnaissance map compiled by E. H. Muller (Dutro and Payne, 1957).

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Stratigraphy

Layered rocks

Devonian rocks

Dolomite.--The oldest rocks on western St. Lawrence Island are in a sparsely exposed sequence of dolomite on the northeastern part of the Putgut Plateau (fig. 2). Much of the dolomite has been altered to a light-tan and gray, sugary-textured marble by contact with granitic intrusives of the Taphook pluton, but a few scattered exposures of unaltered dolomite occur on small incised drainages along the northern edge of the Plateau. Gray, massive, laminated, locally brecciated, dolomite and dolomitic limestone in the lower part of the sequence grade into sooty-black, thin-bedded, fine-grained dolomite in the upper part.

These rocks are correlated with the dolomite sequence of Devonian age described by Patton and Dutro (1969) on the Seknak River on the eastern part of the island. A Devonian age for these rocks is also suggested by the occurrence of brachiopods of probable Devonian age in rubble of silicified coquina, 4 miles west of Kangee Camp. J. T. Dutro, Jr., who examined this collection reports: "...brachiopod shells, predominantly atrypids (both Atrypa and Spinatrypa); also a few spiriferoids including a possible Kozlowskiellina and a Mucrospirifer? sp. The age is definitely Devonian, no younger than Frasnian on the basis of atrypids. If the Kozlowskiellina is correctly identified, overlapping ranges would suggest an Emsian (late Early Devonian) or possibly early Eifelian (early Middle Devonian) age."

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Mississippian rocks

Limestone and chert.--Next above the Devonian dolomite is an estimated 1,500 feet of gray crinoidal limestone and limestone breccia with abundant black nodular chert. Two narrow bands of these rocks occur in the northeastern part of the Putgut Plateau and scattered bedrock exposures are found on several small incised streams (fig. 2). The limestone contains abundant but poorly preserved fragmental debris of crinoids, corals and brachiopods of probable Mississippian age. Both the fauna and lithology indicate a correlation with the Upper Mississippian strata described in the Ongoveyuk River region on the eastern part of the island (Patton and Dutro, 1969).

Mississippian to Cretaceous rocks

Mudstone, black shale, and chert.--Overlying the Upper Mississippian limestone and chert is a diverse assemblage of rocks including dark pyritiferous mudstone, black shale, thin-bedded dark limestone, bedded chert, graywacke, tuff, and breccia. Scattered talus banks and rubble patches of this rock assemblage were found on the northeastern part of the Putgut Plateau and in a small roof pendant that lies within the Taphook pluton, 8 miles southwest of Taphook Mountain (fig. 2). In addition, a few isolated patches of rubble, too small to be mapped separately on figure 2, are present in the belt of gabbro and diabase of Permian(?) age that trends northwesterly from Poowooiliak Point.

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The stratigraphic relationships of the various rock types included in this assemblage are uncertain owing to structural complexities and poor exposures, and the age of most of the strata cannot be fixed more closely than Mississippian to Cretaceous. Some black shale-chert-limestone beds, however, appear to correlate with Middle and Upper Triassic strata described by Patton and Dutro (1969) on the eastern part of the island. Fragmentary flat clams of probable Triassic age were found in a contact metamorphosed sequence of these beds, 6 miles southwest of Taphook Mountain.

Cretaceous rocks

Andesitic and latitic volcanic and hypabyssal intrusive rocks.--Andesitic and latitic volcanic and hypabyssal intrusive rocks underlie more than 120 square miles of western St. Lawrence Island. They occur mainly in two broad belts: one just east of the Sevuokuk pluton and the other along the southern part of the Putgut Plateau (fig. 2). These volcanic rocks are best exposed in steep but largely inaccessible sea cliffs in the vicinity of Boxer Bay. Inland exposures consist of patches of frost-riven rubble, sparse erosional knobs, and a few stream cutbanks, chiefly along the southern edge of the Putgut Plateau.

The rocks of this unit include a wide variety of flows, hypabyssal intrusives and volcaniclastic rocks. The flows and intrusives range in composition from andesites to latites, but basalts, quartz latites and rhyolites are locally present. The volcaniclastic rocks include andesitic and latitic lithic and crystal tuffs, breccias, and volcanic conglomerates and graywackes. Adjacent to the monzonite plutons the volcanic rocks have been altered to hornblende hornfels and albite-epidote hornfels. All of the volcanic rocks are devitrified and more or less altered to a greenish gray aggregate of chlorite, epidote, sericite, clay minerals, calcite, and pyrite.

The volcanic rocks are assigned a Cretaceous age based upon a potassium-argon age determination of 88.7 $\pm$ 3 m.y. from a crystal tuff near Poowooiliak Point (table 1). Although this age determination

TABLE 1 NEAR HERE

dates the sampled rocks as Late Cretaceous (Geol. Soc. of London, 1964), some of the volcanic rocks included in this assemblage clearly cannot be younger than Early Cretaceous as they are intruded and altered by mid-Cretaceous (106 $\pm$ 3 m.y.) quartz monzonite of the Sevuokuk pluton.

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Table 1.--Potassium-argon data for biotite from andesitic crystal tuff near Poowooiliak Point. (Sample no. 69 APa-187b)

[Argon analyses and age calculation by J. C. Von Essen; potassium analyses by L. B. Schlocker. Decay constants for K^{40}: $\lambda_e = 0.585 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.72 \times 10^{-10}$ year^{-1}. Atomic abundance of $K^{40} = 1.19 \times 10^{-4}$]

K_2O(percent)	Ar^{40}_{rad} (10^{-10} moles per gr)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
5.96) 5.98) 5.97	8.009	0.76	88.7±3

Tertiary rocks

Felsic volcanic and hypabyssal intrusive rocks.--Rocks of this assemblage were encountered at the eastern edge of the Putgut Plateau near VABM Glass and in a small area along the beach about 2 miles north of Poowooiliak Point (fig. 2). Near VABM Glass the rocks are typically light-gray to drab-colored, unaltered trachyte flows composed of large phenocrysts of twinned sanidine and reddish-brown hornblende in a fine-grained trachytic matrix. Float of lignite, presumably from interbedded coaly layers, was found along a small drainage that flows northward from VABM Glass. The rocks north of Poowooiliak Point include light-gray, fine- to medium-grained, massive, quartz latite crystal tuffs, and a small hypabyssal intrusive of light-gray, fine-grained rhyolite. Thin seams and disseminated particles of carbonaceous material occur in the fine-grained tuffs.

The trachyte flows at VABM Glass are assigned a Paleocene age based upon a potassium-argon determination of 62.8 $\pm$ 1.9 m.y. and 60.5 $\pm$ 1.8 m.y. on the mineral pair, sanidine and hornblende (table 2).

TABLE 2 NEAR HERE

The rocks north of Poowooiliak Point have not been isotopically dated but their general lithologic character and apparent stratigraphic position above the andesitic and latitic volcanic rocks of Cretaceous age suggest that they too are probably early Tertiary in age.

Table 2.--Potassium-argon data for sanidine and hornblende from trachyte near VABM Glass. (Sample no. 66 APa-242)

[Argon analyses and age calculations by J. C. Von Essen and Joan Engels; potassium analyses by L. B. Schlocker. Decay constants for K^{40}: $\lambda_e = 0.585 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.72 \times 10^{-10}$ year^{-1}. Atomic abundance of $K^{40} = 1.19 \times 10^{-4}$]

Mineral	K_2O(percent)		Ar^{40}_{rad} (10^{-10} moles per gr)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
Sanidine	6.24 6.25	6.245	5.894	0.92	62.8±1.9
Hornblende	0.955 0.990	0.972	0.8837	0.52	60.5±1.8

Sandstone, coal, and tuffs.--Terrigenous coal-bearing deposits of Tertiary age are exposed in bluffs along the west shore of Niyrakpak Lagoon and in scattered cutbanks on the lower Aghnuk River (fig. 2). These deposits are composed of poorly consolidated calcareous sandstone, grit, and conglomerate, carbonaceous mudstone, ashy tuff, and volcanic breccia. Lignitic coal occurs in seams as much as 2 feet thick. Exposures of these deposits are badly slumped so that little can be determined about their thickness and structure. Plant fossils from the Niyrakpak Lagoon exposures, originally were assigned an Eocene age by Chaney (1930), but now are regarded as Oligocene by J. A. Wolfe, (oral commun., 1968).

Tertiary(?) and Quaternary rocks

Basalt.--Nearly flat-lying basalt flows of Late Cenozoic age form the main mass of the Kookooligit Mountains and are exposed along the eastern edge of the mapped area. Small patches of these basalts also occur on the northwestern part of the Putgut Plateau and cap upland surfaces between Boxer Bay and the Ökok River (fig. 2). The bulk of the flows are composed of fresh, medium- to dark-gray, vesicular, olivine basalt containing large rounded crystals of strained olivine in a fine-grained, intergranular matrix of labradorite, augite (probably titanaugite), olivine, and magnetite. Some vesicles are filled with zeolites. Pyroclastics including tuff breccias and lithic tuffs together with some flows are present at the base of the Kookooligit Mountain sequence. Clasts in these tuffs consist of a dark-gray to black, fresh, fine-grained to cryptocrystalline basalt, and range in diameter from less than 1 inch to as much as 10 inches. Olivine is lacking and only a few clasts are vesicular. Matrix of the tuffs is cryptocrystalline, probably glass in part, and is partially altered to chlorites and possibly chlorophaeite.

The fresh, unaltered character of some of the flows and volcanic cones in the Kookooligit Mountains suggest that the latest extrusion took place not more than a few thousand years ago and probably most, if not all, of the olivine basalt flows are of Quaternary age. The basal pyroclastic rocks, however, may be as old as late Tertiary.

Quaternary deposits

Surficial deposits.--Unconsolidated deposits of gravel, sand, silt, and peat underlie the coastal lowlands and are exposed in scattered bluffs along the seashore and around the lagoons. Terrace gravels as much as 100 feet thick crop out in bluffs near Kangee Camp and on the lagoons that fringe the north edge of the Putgut Plateau.

About 30 feet of deformed marine silt and sand overlain by scattered patches of glacial drift containing striated boulders are reported by D. S. McCulloch (oral commun., 1970) on a spit at the east end of Niyrakpak Lagoon. The source of the drift is uncertain but two possibilities are suggested: 1) it was derived from a small Pleistocene cirque glacier on nearby Taphook Mountain, or 2) it was deposited by a vast ice sheet which covered the Bering Strait region and large parts of western Seward Peninsula during Pleistocene (Sainsbury, 1967). Morainal deposits (not mapped on figure 2) also were found in two places near Kongok Bay, but these are clearly related to small Pleistocene cirques on the northwest flank of the Poovoot Range.

Intrusive rocks

Permian(?) rocks

Gabbro, diabase, and siliceous mudstone.--This map unit underlies about 40 square miles primarily along a belt that trends northwestward across the island from Poowooiliak Point (fig. 2). Isolated patches of rubble were also found on the southern and eastern parts of the Putgut Plateau. Outcrops of the gabbro, diabase, and mudstone can be seen in accessible sea cliffs along the coast near the mouth of the Okok River and in cutbanks along the lower course of the Okok River.

The bulk of this unit is composed of dark-greenish-gray, rusty weathering, massive gabbro and diabase. Siliceous mudstone with some finely laminated tuffs occur in isolated outcrops within the main belt of gabbro and diabase but the contact relationships of these rocks to the gabbro and diabase are uncertain.

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Thin section study shows the gabbro and diabase to be composed of augite, plagioclase (chiefly sodic labradorite), hornblende, opaque minerals, potash feldspar, and quartz with accessory apatite and zircon. Texture is intergranular in the diabases grading into subophitic. Hornblende occurs in reaction rims around augite; potash feldspar and quartz are interstitial, and form graphic intergrowths. Point counts on six stained rock slabs (600-900 counts/slab) indicate the following modal composition ranges in volume percent: plagioclase---30 to 48; mafic minerals---43 to 54, magnetite and subordinate ilmenite and chalcopyrite---3 to 14, potash feldspar---1 to 6, quartz---0 to 5, and pyrite---<1 to 2. All feldspars are more or less altered to sericite, clay minerals, and calcite; and mafic minerals to chlorites, biotite, and magnetite.

This unit is assigned a tentative Permian age based on a potassium-argon age determination of 238 $\pm$ 7 m.y. (table 3) from gabbro

TABLE 3 NEAR HERE

collected in an isolated exposure north of the Mamagnak Mountains.

Table 3.--Potassium-argon data for hornblende from gabbro north of Mamagnak Mountains. (Sample no. 69 APa-229a)

[Argon analyses and age calculation by J. C. Von Essen; potassium analyses by L. B. Schlocker. Decay constants for K^{40}: $\lambda e = 0.585 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.72 \times 10^{-10}$ year^{-1}. Atomic abundance of $K^{40} = 1.19 \times 10^{-4}$.]

K_2O(percent)	Ar^{40}_{rad} (10^{-10} moles per gr)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
0.890) 0.895) 0.892	3.348	0.87	238±7

Cretaceous rocks

Quartz monzonite.--Quartz monzonite underlies about 150 square miles of western St. Lawrence Island in two large intrusive bodies: the Sevuokuk pluton along the western coast, and the Taphook pluton in the north-central part of the mapped area (fig. 2). The Sevuokuk pluton is excellently exposed in nearly continuous wave-cut cliffs along the western coast from Gambell to Boxer Bay (fig. 3).

The quartz monzonite is light brownish gray to light gray, medium to coarse grained, and commonly porphyritic. A fine-grained dark-brownish-gray border phase occurs along the contact. Aplite dikes and xenoliths of mafic hornfels are locally abundant. Two sets of vertical joints striking NE and NW are conspicuous in every coastline exposure.

Point counts on five stained rock slabs (1,000 counts/slab) from the Sevuokuk and Taphook plutons give the following modal ranges in volume percent: plagioclase (calcic oligoclase to sodic andesine)---35 to 43, potash feldspar---26 to 40, quartz---10 to 27, biotite---4 to 8, hornblende---0 to 5, accessory minerals (opaque and nonopaque)---0.6 to 1.

Both the Sevuokuk and Taphook plutons are discordant and are characterized by lack of linear and planar structures. No essential lithologic differences were noted between the two plutons and it seems likely that they are comagmatic and possibly coextensive at depth. Both plutons are assigned a Cretaceous age based on a potassium-argon determination of 106 $\pm$ 3 m.y. on biotite from a sample near Gambell (table 4).

TABLE 4 NEAR HERE

Table 4.--Potassium-argon data for biotite from quartz monzonite east of Gambell. (Sample no. 66 AMm-211).

[Argon analyses and age calculation by J. C. Von Essen and Joan Engels; potassium analyses by L. B. Schlocker. Decay constants for K^{40}: $\lambda_e = 0.585 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.72 \times 10^{-10}$ year^{-1}. Atomic abundance of $K^{40} = 1.19 \times 10^{-4}$.]

K_2O(percent)	Ar^{40}_{rad} (10^{-10} moles per gr)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
4.77) 4.72) 4.745	7.606	0.95	106±3

Olivine monzonite.--The only occurrence of this rock on western St. Lawrence Island is a small stock, less than 1 square mile in area, along the eastern shore of Boxer Bay. Massive sea cliff exposures of the stock fringe the coastline but are accessible on foot in only a few places.

The olivine monzonite is a medium- to dark-greenish-gray, coarse- to medium-grained, massive, structureless rock with a granitic texture. In hand specimen, crystals of twinned plagioclase, as long as 15 mm, dark-greenish-gray pyroxene, and flakes of reddish-brown biotite are readily discernible. Point counts on 4 thin sections (2,000 counts/section) and one rock slab (1,000 counts) indicate the following modal composition ranges in volume percent: plagioclase---53 to 64, K-feldspar---22 to 29, augite---4 to 10, biotite---3 to 7, olivine---1 to 3, magnetite---1 to 3, and apatite---about 1. Most of the plagioclase is sodic labradorite. Olivine forms small anhedral crystals, partly altered to biotite and magnetite, and occurs poikilitically enclosed in feldspars.

The olivine monzonite is thought to be of Cretaceous age and related to the same intrusive event as the nearby Sevuokuk pluton. Both bodies intrude the andesitic and latitic volcanic unit of Cretaceous age.

Structure

Very little structural information is obtainable on western St. Lawrence Island owing to the scarcity of bedrock exposures. The few outcrops available, chiefly along sea cliffs and stream cutbanks, indicate that all pre-Tertiary rocks are intensely deformed and faulted. Gross distribution of the major rock units seems to suggest that regional trends are N. 40-50° E. in the eastern part of the mapped area and N. to N. 25° W. in the western part (fig. 2). Examination of aerial photographs reveals two prominent sets of lineaments, probably faults, trending N. 25-45° E. and N. 25° W.

Mineral occurrences

Molybdenum

The presence of molybdenite near Booshu Camp on the west coast of St. Lawrence Island has been known by the local inhabitants for many years and was reported by Anderson (1947) and by Berg and Cobb (1967). Additional deposits were found during the present investigations and these together with some anomalously high stream sediment sample values indicate that the distribution of molybdenite in and around the Sevuokuk pluton is far more widespread than formerly recognized. In all occurrences, however, the molybdenite is sparsely disseminated and the deposits appear to be low grade.

The previously known deposit near Booshu Camp (Anderson, 1947) is located on a wave-cut shelf of quartz monzonite half a mile south of the outlet of the Moghoweyik River (fig. 3) (localities 1, 2, 3 in fig. 4).

Figure 4 and TABLE 5 near here

The molybdenite occurs as disseminated grains and thin scaly fracture-fillings in the quartz monzonite along with minor amounts of chalcopyrite and pyrite. Sulphide mineralization appears to have been accompanied by addition of small amounts of quartz and partial sericitization of feldspars.

Molybdenite was also found on the north bank of the Moghoweyik River three-quarters of a mile above the mouth (localities 5, 6, 7 in fig. 4). Here thin veinlets of molybdenite occur in highly oxidized pyritiferous quartz monzonite which is cut by aplite dikes and quartz veins. A pan concentrate from the river bed gravels at this locality yielded 70 ppm molybdenum and 5,000 ppm tungsten.

Another deposit was found on the upper Moghoweyik River along the eastern edge of the Sevuokuk pluton (localities 8, 9, 10 in fig. 4). The molybdenite in this deposit is sparsely distributed over a half-mile-wide zone of heavily oxidized limonite-stained, pyritiferous quartz monzonite near the contact with volcanic rocks of Cretaceous age. The molybdenite occurs as scales and thin veinlets along fine fractures in the quartz monzonite and as large euhedral crystals in drusy quartz veins.

Table 5.--Semiquantitative spectrographic analyses of selected grab samples of sulphide-bearing rocks from western St. Lawrence Island.

[Results reported in parts per million in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1. N, not detected; G, greater than value shown; L, detected but below limit of determination. Sample localities shown in figure 4. Analysts: K. J. Curry, C. L. Forn, A. Farley, Jr.]

Sample locality	Field no.	Ag	Cu	Mo	Pb	Zn	Remarks
1	69APa-38c	N	300	150	L	N	Disseminated molybdenite and chalcopyrite in quartz monzonite.
2	-38e	N	10	700	L	L	Molybdenite and vein quartz in altered quartz monzonite.
3	66AMm-239	N	30	1,000	30	N	Molybdenite disseminated in quartz monzonite.
4	69APa-49b	1.5	1,000	15	30	N	Disseminated pyrite and chalcopyrite in quartz monzonite.
5	-51b	1	700	7	L	N	Pyritiferous quartz monzonite.
6	-51d	N	150	500	20	N	Thin veinlet of molybdenite in pyritiferous quartz monzonite.
7	-514	N	15	1,500	10	N	Irregular masses of molybdenite in monzonite.
8	-83b	N	20	500	N	N	Molybdenite and pyrite in drusy quartz vein.
9	-84c	2	150	500	30	N	Pyritiferous and silicified quartz monzonite with veinlets of molybdenite.
10	-84d	1.5	1,000	7	70	N	Pyritiferous quartz monzonite.
11	-212	10	1,500	30	L	L	Pyritiferous altered volcanic rock.
12	-219b	1	3,000	L	70	N	Disseminated malachite, chalcopyrite, pyrite in quartz monzonite porphyry.
13	-202b	N	700	N	N	L	Disseminated magnetite, ilmenite, pyrite, and chalcopyrite in gabbro.
14	-203b	N	700	N	N	L	Disseminated magnetite, ilmenite, pyrite, and chalcopyrite in gabbro.
15	66AMm-227a	1,000	10,000	L	G20,000	G10,000	Galena, sphalerite, chalcopyrite, pyrite in calcite veinlet in gabbro.
16	69ACy-212	1.5	30	N	2,000	N	Galena and pyrite in volcanic rock.
17	-181	L	L	N	15	700	Pyritiferous volcanic rock.
18	68ACy-75b	10	150	N	2,000	3,000	Galena and sphalerite in quartz veins in volcanic rock.
19	69APa-132b	15	15	N	G20,000	200	Galena in contact marble.
20	-132d	70	700	N	G20,000	G10,000	Galena and sphalerite in contact marble.

Anomalous molybdenum values (15 ppm or greater) were obtained in sediment samples from several streams draining the Sevuokuk pluton and the bordering volcanic rocks (fig. 5). Values as high as 70 ppm were

Figure 5 near here

found on tributaries of the Kookooliktook River which drain a large pyrite gossan and a small mineralized quartz monzonite porphyry stock. Small flecks of molybdenite are visible in the quartz monzonite but none was seen in the pyrite-rich volcanic rock.

Sediment samples with molybdenum values ranging from 15 to 50 ppm were obtained on an eastern tributary of the Boxer River, 2 1/2 miles north of Boxer Bay. The source of the high values is believed to be a nearby pyrite gossan in the volcanic rocks (fig. 4).

A single sediment sample from Kitnepaluk Creek, which drains the Sevuokuk pluton 14 miles south of Gambell, yielded 70 ppm molybdenum (fig. 5).

Copper

Finely disseminated chalcopyrite, malachite, pyrite, and minor molybdenite occur in a small stock of quartz monzonite porphyry in the Poovoot Range near Poovookpuk Mountain (locality 12 in fig. 4). The stock, which is roughly half a mile across, intrudes Cretaceous volcanic rocks. The sulphide mineralization, although spread over a large part of the stock, is sparsely disseminated and low grade. Selected grab samples of the mineralized rock yielded as much as 3,000 ppm copper but composite chip samples randomly collected on foot traverses across the stock contained 700 ppm copper or less. The Cretaceous volcanic rocks are heavily pyritized and extensively oxidized over a broad area in the vicinity of the porphyry stock. No sulphides other than pyrite were identified in the volcanics but a selected grab sample of massive pyritized volcanic rock near the intrusive contact contained 1,500 ppm copper and 10 ppm silver (locality 11 in fig. 4). Stream sediment samples from several small tributaries of the Kookooliktook River that drain the stock and the surrounding altered volcanic rocks gave values as high as 70 ppm molybdenum, 1,500 ppm copper, 500 ppm lead, 700 ppm zinc, and 1.5 ppm silver (figs. 5, 6, 7, 8, 9).

Figures 6, 7, 8, 9 near here

Analyses of several grab samples of gabbro from the Okok River yielded 700 ppm copper (localities 13, 14 in fig. 4). No copper sulphides are visible in hand specimens of the gabbro but polished sections reveal finely disseminated blebs of chalcopyrite.

A small amount of native copper was found in float of a mafic volcanic hornfels 4 1/2 miles northeast of Vngyat Point.

Lead, zinc, and silver

Small sulphide deposits of lead, zinc, and silver were found along a belt trending northeastward from the Okok River on the south coast to near Kangee Camp on the north coast (localities 15 to 20 in fig. 4). None of these deposits appear to be of economic significance but their apparent structural alignment suggests that a careful search for additional deposits along this belt may be warranted.

Locality 15.--Galena, sphalerite, chalcopyrite, and pyrite in a 1- to 2-inch wide calcite vein that cuts fine-grained gabbro. The nearly vertical vein strikes about N. 35° E. and is exposed on a wave-cut bench within the tidal zone.

Locality 16.--Pyrite and a small amount of galena in irregular quartz veins cutting kaolinized, limonite-stained lithic tuff. Well exposed along the beach at the base of a wave-cut cliff.

Locality 17.--Pyrite containing 700 ppm zinc in a silicified fine-grained volcanic rock. Exposed in creek bed.

Locality 18.--Float of galena and sphalerite in quartz vein cutting altered andesitic volcanic rocks.

Locality 19 and 20.--Irregular stringers of galena, sphalerite, and pyrite in marble near contact with Taphook pluton. Exposed in stream bed.

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