UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CRETACEOUS PLUTONIC ROCKS OF ST. LAWRENCE, ISLAND, ALASKA: A PRELIMINARY REPORT.

by

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CRETACEOUS PLUTONIC ROCKS OF ST. LAWRENCE ISLAND, ALASKA; A PRELIMINARY REPORT

By BÉLA CSEJTEY, JR., WILLIAM W. PATTON, JR., and THOMAS P. MILLER
Menlo Park, California

Abstract.--Reconnaissance mapping on St. Lawrence Island, Alaska has revealed seven epizonal granitic plutons of mid-Cretaceous age with a combined outcrop area of about 350 square miles. The plutonic rocks are dominantly quartz monzonite, but include minor amounts of granodiorite, monzonite, syenite, syenodiorite, and alaskite.

The plutons are structurally and petrologically similar to and about the same age as plutons on the Chukotsky Peninsula, U.S.S.R. and in western Alaska. They suggest tectonic continuity between Siberia and Alaska since at least Cretaceous time.

Several mineralized areas containing molybdenum, copper, lead, and zinc sulfides are associated with the plutonic bodies in the western part of the island.

INTRODUCTION

The purpose of this report is to provide a preliminary description of the petrology, age, and regional relations of seven granitic plutons which have been mapped during reconnaissance geologic investigations on St. Lawrence Island, Alaska.

St. Lawrence Island, roughly 2,000 square miles in area, is located in the Bering Sea 130 miles southwest of the Seward Peninsula, mainland Alaska, and 40 miles southeast of the Chukotsky Peninsula, U.S.S.R. (fig. 1). About two-thirds of the island is a tundra-covered

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Figure 1 near here.

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flat wave-cut platform which has been elevated locally as much as 200 feet above sea level. The remainder of the island consists of isolated groups of barren mountains rising sharply 1,000 to 2,000 feet above the wave-cut platform. These mountains, probably former islands, are covered with talus and frost-riven rubble and, with a few exceptions, are cored by granitic plutons. Bedrock exposure are scarce and are confined to coastal sea cliffs, scattered cutbanks along streams, and to a few erosional knobs in the mountainous areas.

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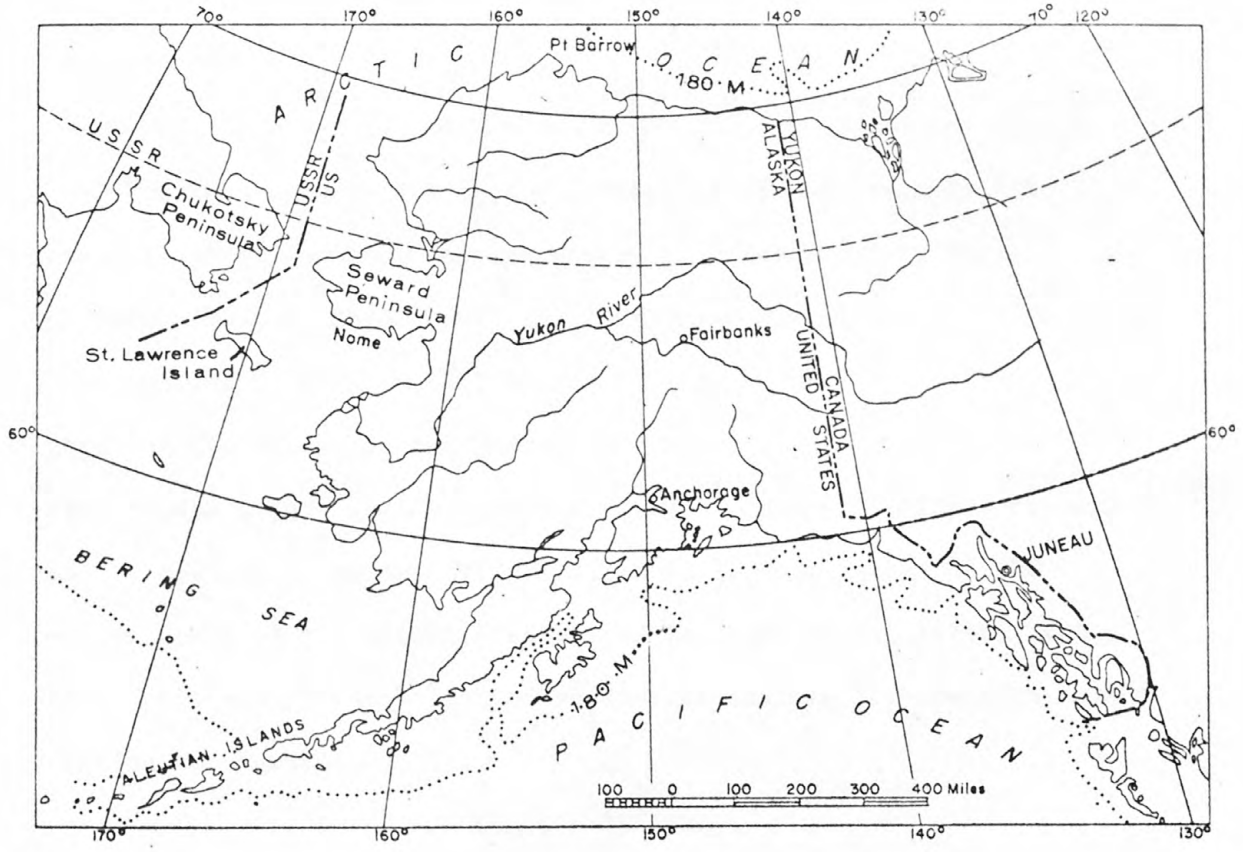

Figure 1. Index map of Alaska showing location of St. Lawrence Island.

Previous information on the geology of St. Lawrence Island consists of exploratory surveys along the coast (Dawson, 1894; Emerson, 1904, p. 38-42; Collier, 1906), and unpublished reconnaissance map compiled by E. H. Muller (Dutro and Payne, 1957), a preliminary paper on the Paleozoic and Mesozoic sedimentary rocks of the eastern part of the island (Patton and Dutro, 1969), two preliminary reports on the results of reconnaissance geologic investigations of the western part of the island (Patton and Csejtey, 1970a, 1970b), and a short preliminary report on the geology of eastern St. Lawrence Island (Patton and Csejtey, 1971).

GEOLOGIC SETTING

The St. Lawrence plutons range in size from 1 to 100 square miles with a total outcrop area of about 350 square miles (fig. 2).

Figure 2 near here.

However, they undoubtedly extend beneath surrounding surficial deposits and the Bering Sea and are probably larger than the above figures indicate.

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The plutons intrude rocks of Paleozoic age which are dominantly carbonates and andesitic volcanics of Early Cretaceous(?) age as well as lesser amounts of mudstone, graywacke, chert, gabbro, and diabase (fig. 2). The andesites are mapped with post-plutonic latites and quartz latites of Late Cretaceous to Early Tertiary age because both volcanic suites have numerous varieties, are finely crystalline and strongly altered. The lithology, age, and correlation of these rocks have been discussed previously by Patton and Dutro (1969), and by Patton and Csejtey (1970a and 1971).

Post-plutonic rocks include a few small areas of poorly consolidated mid-Tertiary coal-bearing sediments (not shown on fig. 2); Quaternary olivine basalts, mostly in the centrally located Kookooligit Mountains; and extensive unconsolidated surficial deposits.

All observable intrusive contacts are sharp, steep, and apparently discordant.

The plutons appear to truncate steeply dipping beds and several faults in the country rocks, suggesting emplacement into an already folded and faulted terrane. The post-plutonic latites and quartz latites were subsequently folded and faulted in Late Cretaceous and Tertiary time.

Thermal metamorphic effects extend as much as a mile into the country rocks. However, the width of the metamorphosed zone in the volcanic rocks is difficult to recognize because most of the volcanics have been propylitically altered. Near the intrusive contacts and locally extending out for some tens of feet, the rocks are altered to hornblende hornfels (Fyfe and others, 1958). The carbonate rocks are characterized by a mineral assemblage of garnet-vesuvianite-diopside-quartz-calcite-biotite. The andesitic volcanic rocks are characterized by an assemblage of plagioclase-hornblende-quartz-biotite. Farther away, the volcanic rocks are mostly albite-epidote hornfels; the carbonates are ~~coarse- to~~ medium-grained marble.

PLUTONIC ROCKS

Petrography and petrology

The plutonic rocks of St. Lawrence Island are chiefly quartz monzonite but include granodiorite, monzonite, syenite, alaskite, and some olivine-bearing syenodiorite. The classification of plutonic rocks used in this report, based on the normalized modes of felsic components, is shown in figure 3. Textural variations range from

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Figure 3 near here.

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coarse to fine grained, from granitic to porphyritic and seriate. All the plutonic rocks are massive and non-foliated. Hybrid rocks rich in mafic minerals and of irregular texture occur in minor amounts near the margins of some plutons.

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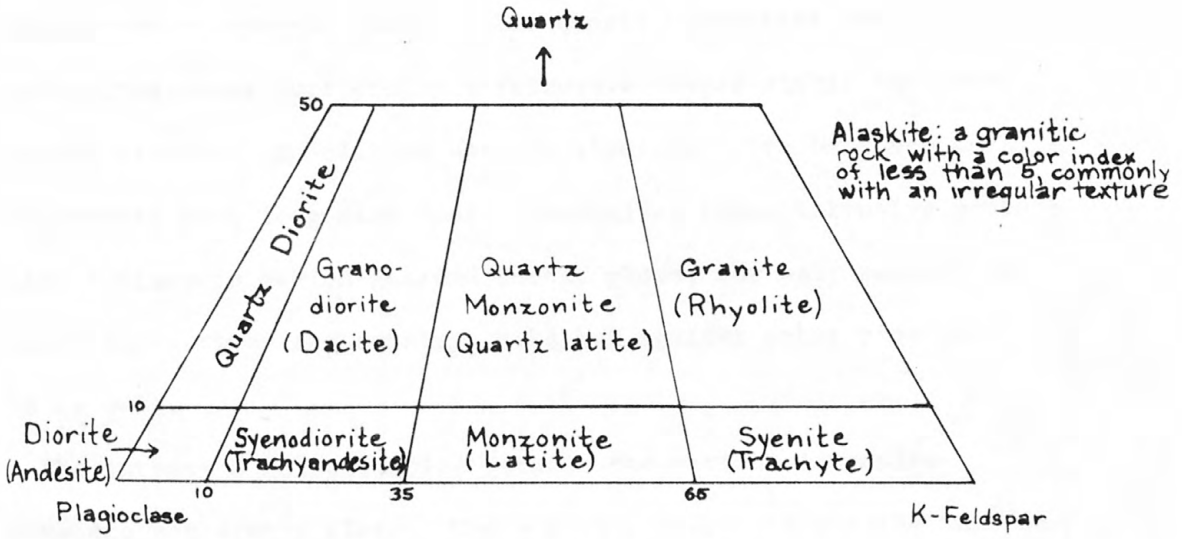

Figure 3. Igneous rock nomenclature used in this report. Aphanitic varieties shown in parentheses.

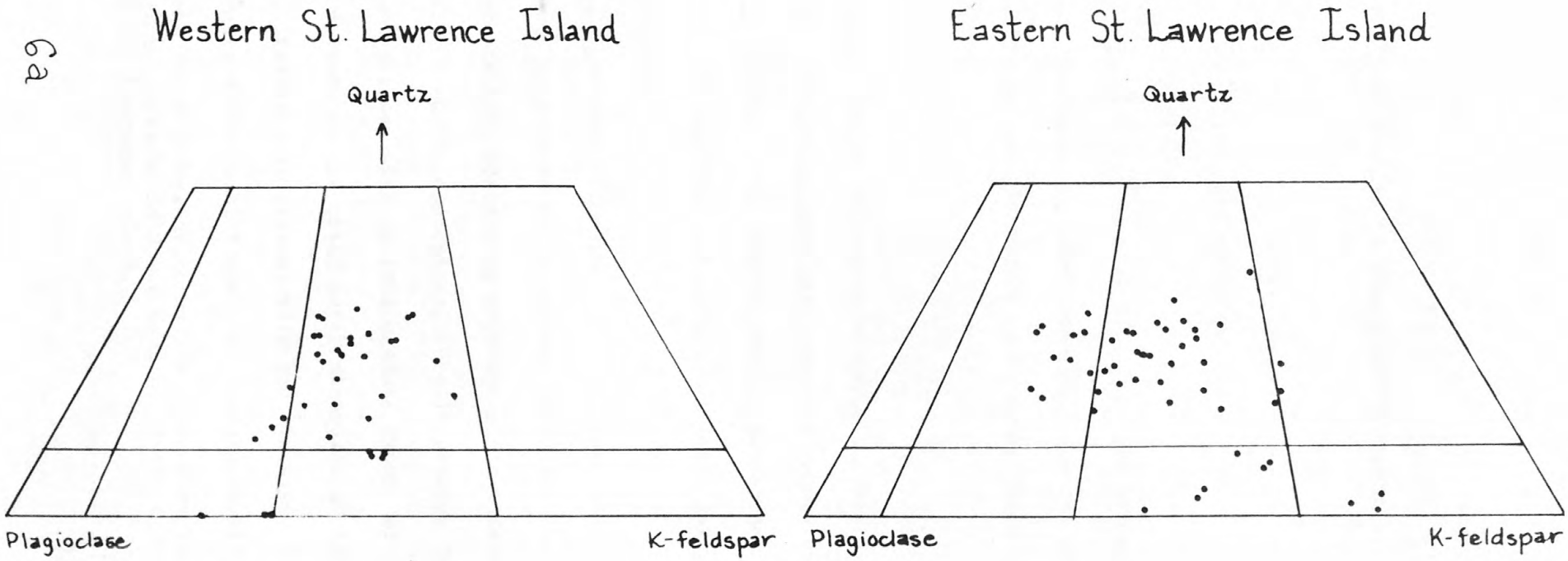

Figure 4. Summarized plots of plutonic rock modes from western and eastern St. Lawrence Island, Alaska. See table 1 for plots of individual plutons.

The petrography of the plutons is summarized in table 1. The

TABLE 1 NEAR HERE.

intrusive members of each pluton are listed in order of decreasing relative age, known or postulated. The geologic map of the Iwoonut, Sevuokuk, and Taphook plutons is shown on figure 5, and of the Myghapowit, Soomaghat, Kialegak, and Kinipaghulghat plutons on figure 6. Field mapping of the various intrusive members was based on the

Figures 5 and 6 near here.

"characteristic features" listed at bottom of table 1. Rocks of the Iwoonut, Sevuokuk, and Taphook plutons have been previously described by Patton and Csejtey (1970a). The olivine monzonite of that report is herein reclassified, on the basis of additional modal data, as an olivine-bearing syenodiorite.

The St. Lawrence plutonic rocks fall more or less into three major categories: (1) monzonites and syenites, including the olivine-bearing syenodiorite, containing abundant mafic minerals but little or no quartz; (2) quartz monzonites, locally grading into monzonites and granodiorites, with an intermediate amount of quartz and with hornblende as the chief mafic mineral; and (3) quartz monzonites, locally grading into granodiorite and alaskite, which have a high quartz content and low color index with biotite as the chief mafic mineral. These three groups of rocks are thought to represent the three major magmas, emplaced in a succession, of the mid-Cretaceous plutonic episode of St. Lawrence Island.

Dike rocks and xenoliths

All the plutons contain a large number of dikes and small plugs of a variety of late-stage rocks; namely, aplite and alaskite, lamprophyre, hypabyssal felsic porphyries, and a few thin veins of hydrothermal quartz. The age of these dike rocks relative to each other is not known and only the larger bodies have been mapped (figs. 5 and 6).

The aplites are fine grained and frequently grade into medium- to coarse-grained, irregular textured alaskite, occasionally with miarolitic cavities. The aplitic rocks rarely grade into coarse-grained pegmatitic nests of K-feldspar, quartz, and muscovite. These rocks occur in thin dikes and in small intrusive bodies as much as 1 square mile in area. Whereas aplites are common in all the plutons, they rarely extend into the surrounding country rocks.

Irregular dikes of lamprophyre, a few inches to a few feet in width, are common in the northern half of the Sevuokuk pluton. The lamprophyre is dark gray and porphyritic, with dark hornblende phenocrysts as much as 3 mm long in a finely crystalline, lamprophyric textured matrix of brown hornblende, plagioclase, and minor augite.

The felsic porphyries common in every pluton occur as irregular hypabyssal bodies up to 2 square miles in area and intrude both the plutonic and the country rocks. The porphyries range from latite to quartz latite in composition and contain large phenocrysts of corroded quartz and subhedral K-feldspar in a medium- to light-gray aphanitic groundmass. Miarolitic cavities are common. Most of the porphyries are altered to an aggregate of quartz, sericite, kaolin , and pyrite, with minor amounts of chlorite and epidote. These hypabyssal felsic porphyries are probably the source of the latite and quartz latite volcanics of Late Cretaceous to Early Tertiary age.

Xenoliths are common in the coarse- and medium-grained rocks. Most xenoliths are rounded and equant, a few inches to about 1 foot long, with fairly sharp boundaries; all have been reconstituted to a fine- to medium-grained, hornblende-rich hornfels. Several apparent roof pendants of recrystallized Paleozoic limestone, a few tens of feet in dimension, occur in the Soomaghat and Kinipaghulghat plutons.

Structural features

All the plutons appear to be jointed, but few joint measurements could be obtained because of scarcity of bedrock exposures. Two sets of vertical joints striking northeast and northwest are conspicuous in every coastline exposure of the Sevuokuk pluton.

One of the most characteristic features of the St. Lawrence plutons is that they are devoid of obvious regional foliation and lineation. Only in the Soomaghat and Sevuokuk plutons where flow alinement of orthoclase phenocrysts occur were any obvious but localized structural features observed. Because most rock specimens were collected as float, no attempt was made to find preferred orientation by petrofabric measurements with thin sections.

Depth and method of pluton emplacement

The structure and the petrography of the plutons suggest the plutons were emplaced at relatively shallow depths in the earth's crust. The St. Lawrence plutons are epizonal, according to the usage of Buddington (1959), on the basis of the following features: sharp and discordant contacts with the regionally unmetamorphosed country rocks, presence of chilled border facies, presence of xenoliths and apparent roof pendants, lack of regional foliation and lineation, association with compositionally similar hypabyssal volcanic intrusives which commonly contain miarolitic cavities.

Emplacement of the plutons was accomplished by successive injections of apparently consanguineous magmas of diverse composition. The method of magma emplacement is not known. There is no evidence that the intrusions deformed the country rocks.

Mineralization

Several small mineralized areas of molybdenum, copper, lead, and zinc sulfides occur in and around the granitic plutons in the western part of the island. They have been described previously by Patton and Csejtey (1970a, 1970b) and are only briefly mentioned here.

Molybdenite is widely disseminated in the Sevuokuk pluton. A small mineralized satellitic stock of biotite quartz monzonite, containing low-grade porphyry copper and minor molybdenite, is located approximately 8 miles east-southeast of Booshu Camp (fig. 5). Five small occurrences of lead-zinc-silver sulfides were found along a northeast-trending belt south and east of the Taphook pluton.

Similar mineralized areas have not been found in the eastern part of the island (Patton and Csejtey, 1971). However, detectable amounts of tin were found in stream-sediment samples from streams draining the Soomaghat and Kinipaghulghat plutons. The source of the tin is unknown and only 2 of 15 representative rock samples of the two plutons contain detectable amounts of tin.

Age

Available stratigraphic evidence suggest a probably Cretaceous age for the St. Lawrence plutons. The latest datable country rocks are of Triassic age, according to fossil evidence (Patton and Csejtey, 1970a). The age of the youngest intruded rocks, the andesitic volcanics, is imperfectly known, but similar andesitic volcanic rocks in west-central Alaska have been dated as Early Cretaceous (Patton and Miller, 1966; Patton, 1967). The basal portion of the oldest post-plutonic rocks, a sequence of latitic and quartz latitic volcanics, yields a Late Cretaceous K-Ar age of 88.7 $\pm$ 3 m.y. (Patton and Csejtey, 1970a).

Four K-Ar age determinations were obtained on three of the St. Lawrence plutons (table 2). Two ages were measured on biotite

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TABLE 2 NEAR HERE.

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from the biotite quartz monzonite of the Sevuokuk pluton, one on biotite from the finer grained portion of the biotite quartz monzonite of the Kialegak pluton, and one on hornblende from the monzonite-syenite member of the Kinipaghulghat pluton.

Three of the four ages are in close agreement, a little over 100 m.y. each, though they represent different members of the intrusive series. An age of 91 m.y. obtained on a sample from a mineralized satellitic stock of the Sevuokuk pluton (Patton and Csejtey, 1970a) probably reflects the effects of the post-plutonic mineralization or it may represent a younger plutonic episode. In any event, the small range of the measured ages suggests that the composite St. Lawrence plutons were emplaced in a relatively short period of geologic time, around 100 m.y. ago.

Regional correlation

Granitic plutons of similar age, composition, and structure occur in adjacent regions of Siberia and mainland Alaska.

Table 2. - Potassium-argon age determinations for granitic rocks of St. Lawrence Island, Alaska

[Argon analyses and age calculations by J.C. Von Essen and J. 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 $K^{40} = 1.19 \times 10^{-4}$]

Pluton & rock type	Map no. (figs. 5 & 6)	Location		Field No.	Mineral	K_2O (percent)	Ar^{40}_{rad} (10^{-10} moles/gr)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
		Lat (N.)	Long (W.)						
Sevuokuk; biotite quartz monzonite	1	63° 45′	171° 40′	66AMm-211	Biotite	4.77, 4.72 (avg. 4.745)	7.606	0.95	106 ± 3
Sevuokuk; biotite quartz monzonite	2	63° 27′	171° 32′	69APa-219e	Biotite	7.94, 8.01 (avg. 7.98)	0.1102	0.87	91.3 ± 3
Kialegak; biotite quartz monzonite	3	62° 59′	169° 35′	70ACy-162	Biotite	8.17	0.1257	0.87	101 ± 3
Kinipaghvlghat Monzonite-Syenite	4	63° 11′	168° 25′	66AMm-245	Hornblende	1.48, 1.47 (avg. 1.475)	2.277	0.90	101.7 ± 3.1

A belt of epizonal granitic plutons has been described from west-central Alaska and from the eastern portion of the Seward Peninsula by Miller (1970a). In the Seward Peninsula the plutons consist of quartz monzonite and lesser amounts of syenite and feldspathoidal rocks and have been assigned to a plutonic episode dated at 108-98 m.y. (Miller, 1970b). In addition, the plutons in the Seward Peninsula trend approximately north-south and appear to be restricted to the boundary areas between the Paleozoic and Precambrian metamorphic and sedimentary rocks of the Seward Peninsula to the west, and the adjacent Mesozoic volcanogenic province to the east (Miller, 1970b).

An examination of figure 2 reveals that on eastern St. Lawrence Island the country rocks are dominantly Paleozoic carbonates and on the western part the country rocks are chiefly Early Cretaceous(?) andesitic volcanic rocks. Thus, on the basis of similar age, composition, and geologic setting, the plutons of St. Lawrence Island appear to be a continuation of the 100 m.y.-old plutonic belt of the eastern Seward Peninsula.

A broad belt of granitic plutons extends from the Siberian mainland into the Chukotsky Peninsula, U.S.S.R. (Shilo, 1965). The plutons are epizonal and composite, range in composition from quartz monzonite and granite to undersaturated syenite, and the bulk of them are reportedly 80 to 100 m.y. old. In the southern half of the Chukotsky Peninsula the country rocks are mostly Mesozoic andesitic volcanics, whereas on the northern half they consist mainly of Precambrian to Mesozoic metamorphic and sedimentary rocks (Drabkin, 1970).

Thus, the geology and the geographic location of the St. Lawrence plutons strongly suggest a tectonic continuity, at least since the middle of the Cretaceous, across the Bering Sea shelf between the Chukotsky Peninsula and western Alaska.

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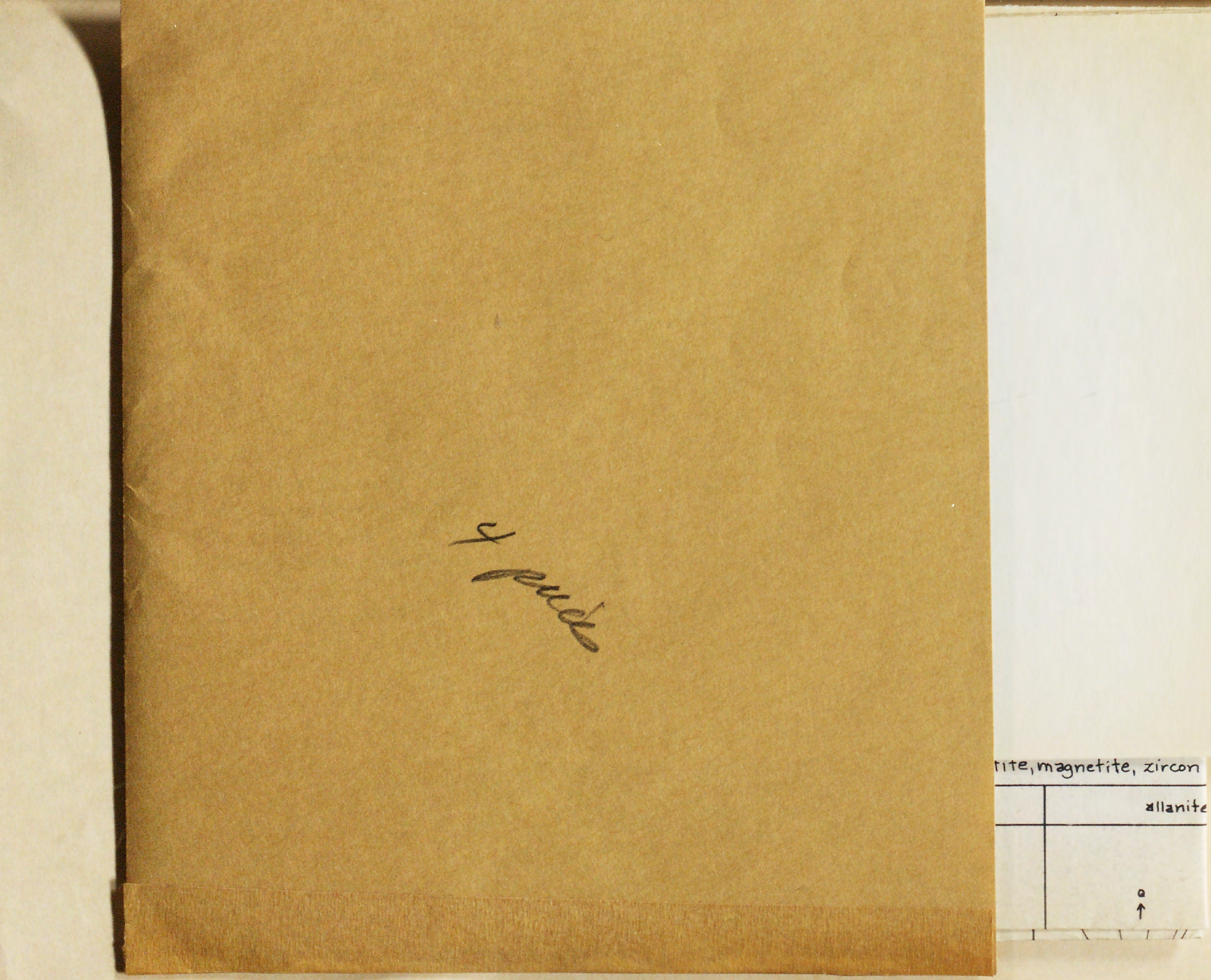
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