THE PETROLOGY OF SOME SYENITES AND GRANITES IN LABRADOR

BY

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INTRODUCTION

General Statement and Acknowledgements.

During the summer of 1949, the Geological Survey of Canada carried out a reconnaissance survey of the east coast of Labrador between Hamilton Inlet and Hopedale. Dr. E. H. Kranck, Professor of Petrology, McGill University, was the leader of this party. Dr. Kranck had previously examined the rocks of the coastal region in 1937, as a member of the Finland-Labrador Expedition, and in 1939 as leader of a second expedition from Finland.

The purpose of these surveys was to collect information on the geology of the Labrador Coast in an effort to contribute to the solution of the problems of correlation between the Pre-Cambrian rocks of North America with those of Northern Europe. The Labrador Coast was chosen for this study because it is that part of North America situated nearest North Europe and Greenland.

One of the most interesting areas encountered during the course of these studies was that part of the coast between Cape Harrison and Kingitok. Most of this region is underlain by a granite gneiss. However, remnants of sedimentary quartzites and conglomerates outcrop at several localities. Of particular interest were two igneous rock types definitely known to be intrusive into the gneisses and sediments as representing the youngest plutonic rocks of the region. The first, a coarse grained pink granite, has been called "Strawberry Granite" because of its excellent exposures at Cape Strawberry; and the second is composed of a group of syenites which make up the outer fringe of islands opposite the mainland.

The subject of this thesis is a petrographic study of these granites and syenites.

The writer wishes to acknowledge his indebtedness to Dr. E. H. Kranck, who placed at his disposal a suite of rock specimens collected by him during his examination of the region, and who also, in his supervision of the work, offered many valuable suggestions and much helpful advice. He also wishes to express his appreciation to Mr. George Riley who, as a member of the geological party in 1949, was able to supply much helpful information about the general geology of the region and the field relationships between the rocks.

Location.

The rocks of this thesis are located in the area which lies north of Hamilton Inlet (Lat. 54° 15'; Long. 58° 15') on the east coast of Labrador from Cape Harrison northwest to Kingitok Island and Kayaksuatilik Island (Lat. 55° 25'; Long. 60°).

A map of the area accompanies this thesis.

The area may be reached during the summer months by boat. The coastal steamship service of the Canadian National Railway makes stops between St. John's, Newfoundland and Hopedale. Further charter service is available to Nain.

PREVIOUS WORK.

Investigations of a reconnaissance nature have been made along the Labrador Coast from time to time, but few of these have had the study of the bedrock geology as its sole aim. The first accurate descriptions of a geologic nature were made by Packard (15) in 1891.

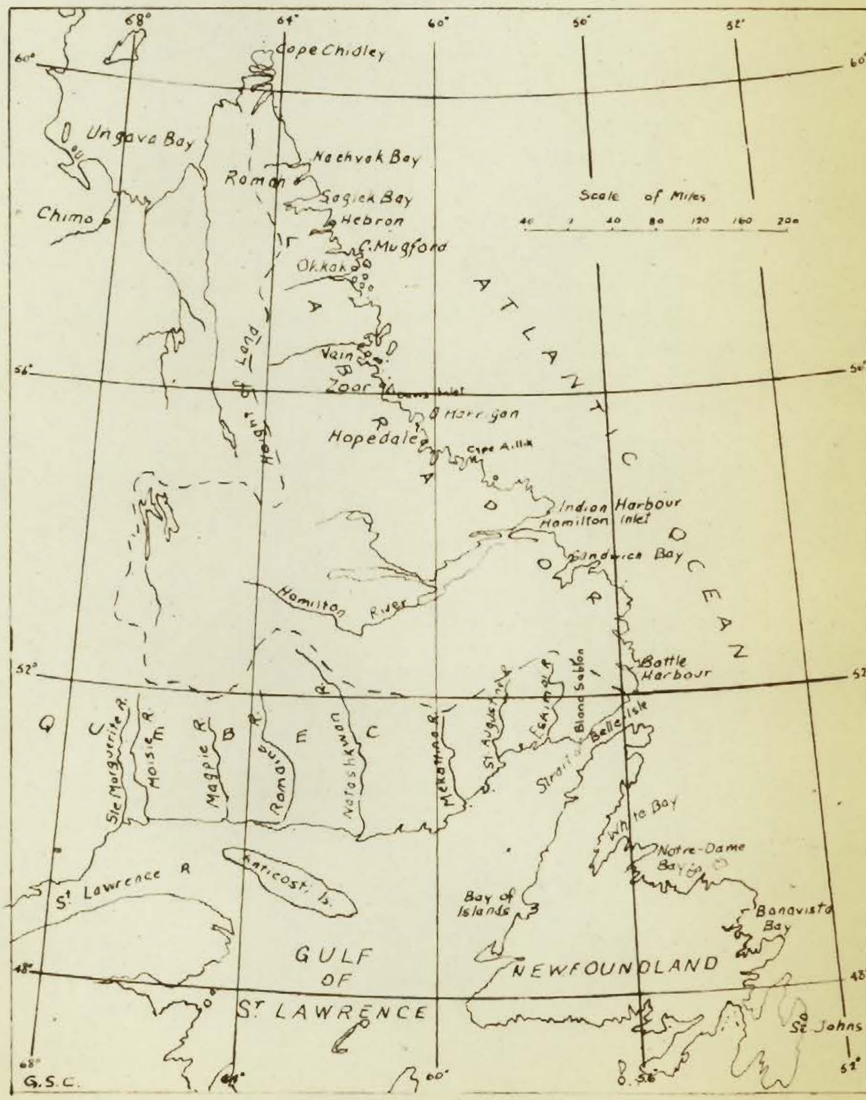
Daly (7) in 1900, as a member of the Brown-Harvard Expedition, made a journey along the coast, but studied only the main features of the bedrock geology and the glacial geology. He made the first descriptions of the sediments of Cape Aillik.

The most recent investigations of the coastal regions were made by the Finland-Labrador Expedition in 1937 under the leadership of Professor Tanner (17). On this trip Dr. Tanner studied the post glacial geology, while Dr. E. H. Kranck (14) examined the bedrock of the coastal region between Battle Harbour and Nain. In 1939 Dr. Kranck, as leader of a second expedition from Finland, studied this same area. Following Kranck's second trip, G. V. Douglas in 1946 made a reconnaissance survey from Blanc Sablon on the Strait of Belle Isle to Cape Chidley. This expedition was to report on the occurrence and extent of any economic minerals which might be discovered along the coastal region. Finally in 1949, under the leadership of Dr. Kranck, the Geological Survey of Canada financed an expedition which examined that part of the coast between Hamilton Inlet and Hopedale. The results of Kranck's last two expeditions and that of the Douglas expedition have not as yet been published.

Although these investigations were not confined to that part of the coast where the rocks of this thesis are exposed, stops were made at various points in the map area to examine the bedrock.

The general geographic relations of the Labrador Coast are indicated in Figure 1.

FIGURE 1



Map showing the main geographic locations along the Labrador Coast.

PHYSIOGRAPHY

The area from Cape Harrison to Hopedale is open and forms a typical "skärgård" coast, which strongly resembles the Scandinavian coasts of the Baltic Sea. It is characterized by innumerable fairly low barren islands and groups of islands. The coast itself is highly indented with several large fiords running about north - south. The inner portions of these fiords are covered with dense forests. The mountains near the coast exceed 2,000 feet in height. They gradually decrease in height from north to south.

DESCRIPTIVE GEOLOGY

Table of Formations

PRE-CAMBRIAN	Younger Acidic and Basic Dykes (undifferentiated)
	Strawberry Granite Makkovik Bay Granite (not shown on map) Syenite Gabbro
	Amphibolite Dykes
	Intrusive Contact
	Granite Gneiss and Migmatite
	Aillik Series: quartzite, quartzite gneiss, conglomerate.

General Statement.

Due to the nature of the investigations which have been carried out to date along the Labrador Coast, a complete description of all the rock types has not been made.

The area in which the granites and syenites occur is shown on the map which accompanies this thesis. Many islands in the region have not, as yet, been investigated. For this reason they have not been coloured.

This region, from Cape Harrison northwest to Kayaksuatilik Island

and Kingitok Island, shows a greater variety of rock types than do the areas to the north and south.

All the consolidated rocks of the area are of Pre-Cambrian age. Granite gneiss and migmatite occupy more than one-half of the area and sediments slightly less than one-quarter. The intrusive rocks occupy the remainder of the region.

The relative ages of the igneous rocks are not definitely known, but they are younger than the sediments, granite gneiss, and migmatite. There are two main ages of dykes, the first cuts the sediments, gneisses, and migmatites, but are cut by the larger intrusive bodies; and the second cuts all the rocks of the area.

Sedimentary Rocks.

Aillik Series.

The Aillik Series consists of quartzites, quartzite gneisses and conglomerate. They are best exposed along the shores of Cape Aillik and Cape Makkovik, as well as on the south shore of Makkovik Bay. The bedrock around Pomiadluk Point is also composed of these rocks. Other bodies of quartzite and quartzite gneiss outcrop on Double Island and Deus Cape southeast of Pomiadluk Point; and on Long Island and the northeast tip of Kaipokok Bay. Smaller outcrops, some of which are too small to be shown on the map, were found on the islands west of Cape Aillik as well as on Kingitok Island, Dunn Island, and the Adlavik Islands.

The sediments around Aillik Bay have gentle dips and are well layered (Plate 1 Fig. 1). They are composed of fine grained sandstones which have been altered to quartzites, but current and ripple marks have been preserved (Plate 1 Fig. 2). The sediments of Pomiadluk Point, although well preserved, are highly sheared and schistose as are the quartzites of Long Island.

Some of the higher hills on each side of Aillik Bay are capped by a conglomerate. This rock consists of well rounded large boulders of quartzite, granite, granite porphyry and metamorphosed sandstone (Plate 2 Fig. 1). In some places the conglomerate is strongly deformed and granitized (Plate 2 Fig. 2).

The contact between the Aillik Series and the granite gneiss and migmatite is gradational. The quartzites gradually grade into gneisses and granitized rocks. The pebbles of the conglomerate become stretched and sheared until all the characteristics of the conglomerate are destroyed and the rock has the appearance of a granite gneiss.

The sediments of Double Island and Deus Cape consist of quartzite, quartzite gneisses and a small amount of interbedded marly sediments. These rocks have been invaded by granitic solutions which have resulted in a dense pattern of pinkish granitic and aplitic veins. At the same time epidote was formed, so that the rock is coloured in red and green. The contact between the granitic veins and the quartzite is not sharp, except where the sediments have become brecciated, in which case fairly sharp edged angular fragments are found included in the granitic material.

Granite Gneiss and Migmatite.

Over one-half of the area is underlain by granite gneiss and migmatite, mainly of granitic and pegmatitic composition, but with numerous inclusions of mica rich schists and basic intrusive rocks. On the Adlavik Islands, remnants of highly granitized quartzites are abundant as dark grey inclusions in schliery granite, but nowhere do they occupy large areas.

Igneous Rocks.

Amphibolite Dykes.

The oldest rocks which are definitely known to be intrusive (other than the basic inclusions in the migmatites) are a series of dykes which cut the Aillik Series, granite gneiss and migmatite. There are at least three systems of dykes, the oldest being slightly inclined to the bedding. Some of the younger dykes are vertical while others have shallow dips. They have been strongly deformed and altered into amphibolite. The largest dykes are 100 feet wide.

Gabbro.

Several small intrusive bodies, which in hand specimen resemble a gabbro, were found in the area. The largest of these outcrops on a small peninsula west of Manak Island. A second mass is found cutting the granite gneiss on the northwest shore of Kaipokok Bay. Several smaller bodies of gabbro, which intrude the Aillik Series, compose the bedrock of West Turnavik Island and several islands nearby.

Syenite.

Kingitok Island, Dunn Island and the Ragged Islands are composed of coarse grained undeformed rocks of syenite composition. The syenite of Dunn Island and Kingitok Island has intruded sedimentary rocks of the Aillik Series. The rock of the Ragged Islands, as seen in hand specimen, is strongly weathered and has a brown coloured surface. The Dunn Island syenite is a dark grey colour, and is fairly fresh. Seen in thin section, however, it has been altered by hydrothermal solutions.

The rock of Kingitok Island is similar in hand specimen to the syenite of the Ragged Islands, but is more highly weathered than the syenite from Dunn Island. Of nine thin sections examined of this rock, three were of a less altered variety. These possess certain characteristics similar to those of the Dunn Island Syenite. For the most part, however, this rock has been altered by hot aqueous solutions to such an extent that its original composition cannot accurately be determined.

Makkovik Bay Granite.

Small outcrops of this granite were found along the inner shores of Makkovik Bay. These exposures, however, are too small to be shown on the map. The granite is light grey in colour, fine to medium grained and generally almost massive. The contact between this granite and the quartzites of the Aillik Series is a gradual one. The quartzites grade through granite gneiss to a massive grey granite. Its relation to the Strawberry Granite is not known.

Strawberry Granite.

This rock is coarse grained, pinkish coloured, very acidic, and composed of large feldspar crystals and biotite. In its typical phase it shows a very conspicuous sub-horizontal jointing.

This rock type, associated with different contact varieties, extends from Cape Strawberry southeastward over Manak Island, Round Island, Indian Island, Iron Island and Dog Island, to a point five miles west of the mouth of Tishualic Bay. Evidently this granite forms the bedrock of the bottom of the great sheltered basin inside the Adlavik Islands.

Basic contact varieties are common along the mainland coast, possibly formed by the assimilation of sedimentary material. In several places a coarse grained gabbro appears, such as at Stag Bay, forming eruptive breccias with the intruding granite. At the contact the granite is fine grained and often schliery (Manak and Indian Islands). Very good contacts occur on the east shore of Pomiadluk Point, where the coarse granite contains inclusions of a well preserved quartzite schist. Several outcrops of a fine grained pinkish granite, which may correspond to a fine grained facies of the Strawberry Granite, are exposed on the Adlavik Islands.

Younger Acidic and Basic Dykes.

The youngest rocks of the area are composed of a series of dykes of several ages. The youngest are alnoites, pyroxenites and monchiquites. The older dykes grade in composition from granitic through dioritic to lamprophyric and diabasic.

The area around Makkovik Bay and Cape Strawberry is extremely rich in igneous dykes, some of which are nearly horizontal while others have steep dips (Plate 3 Fig. 1). In some of the slightly metamorphosed areas around Aillik more than one-half the volume of the rock is composed of these dykes.

STRAWBERRY GRANITE

General Statement.

This granite is exposed along the coast in an elongated body extending from Cape Strawberry southeastward to a point five miles west of Tishualic Bay. It is believed that the shallow sea between the mainland and the Adlavik Islands is underlain by this rock. Several large masses of the granite occur northwest of Cape Strawberry at Nanuaktok Island, Striped Island, and two unnamed islands near the mainland, four miles southwest of Striped Island. Seen from the sea, it is conspicuous by its brownish-red colour forming high cliffs on Cape Strawberry (Plate 3 Fig. 2).

In hand specimen the granite varies from a bright pink to a light greyish-pink colour and weathers dark red-brown. Typically, its grain size is very large (Plate 4 Fig. 1), but some contact facies are much finer grained. Feldspar crystals three centimeters long were observed in hand specimen. In some sections 50%-60% of the rock is composed of feldspar. Quartz is the next predominant mineral. The granite is very poor in ferromagnesian minerals. Small amounts of mica can be identified in hand specimen, as well as a relatively large proportion of fluorite, and in many places allanite.

Petrography.

In thin section the rock is a coarse grained hypautomorphic inequigranular rock composed of interlocking grains of feldspar and quartz with minor amounts of biotite and muscovite. Fluorite, apatite, allanite, sphene, magnetite, epidote and zircon are the accessory minerals.

The feldspars consist of large equidimensional grains of potash feldspar and stubby lath-like crystals of albite-oligoclase. Mica grains occur as small laths or clusters of laths. Both muscovite and biotite altered to chlorite were identified. The rock is conspicuous due to the large number of accessory minerals of which fluorite, allanite and sphene are the most common. Molybdenite is not rare.

The granite shows, with the exception of a few grains of quartz and feldspar, no evidence of any tectonic deformation. Some quartz crystals have undulating extinction and several plagioclase crystals show curved Albite twinning, indicating some deformation. This deformation, however, probably took place while the granite was still fluid and may be the result of the force of crystallization of these crystals butting against earlier formed crystals.

Mineralogy.

Quartz:

This mineral is xenomorphic and fills the interstices between the feldspar crystals. It often occurs as small granular aggregates, the crystals being one to two millimeters in diameter. It is usually colourless, although a few grains show first order yellow interference colours. Crystals which show undulating extinction give an anomalous biaxial interference figure. The majority of grains, however, have uniform extinction and these are uniaxial positive.

Gas bubbles and inclusions occur scattered irregularly throughout the quartz grains and are thus assumed to be primary. Because of the diminutive size of the gas bubbles, it was not possible to determine whether or not they contained any liquid. Specks of magnetite and flakes of mica occur as inclusions as well as minor amounts of apatite and rutile.

Potash Feldspar:

Potassic feldspar is the dominant mineral of the rock. Two distinct types occur, a twinned variety (microcline) and an untwinned type which may be orthoclase. The microcline shows two sets of polysynthetic twinning almost at right angles to each other, giving the grains a net or gridiron structure. These crystals are usually fresh, equidimensional in form, and up to one centimeter in diameter.

The untwinned variety is more irregular in outline and sometimes slightly altered. It seldom possesses any cleavage, is biaxial positive with an axial angle between 70° and 85°. This large optic angle suggests that some of this untwinned feldspar may be microcline.

Microperthite:

Numerous microcline crystals were found to contain small blebs of plagioclase intergrown with them, forming a microperthite structure (Plate 4 Fig. 2). The composition of the plagioclase is albite-oligoclase. The albite-oligoclase is considerably more altered than the microcline. This alteration has developed sericite with some epidote and zoisite flakes. The Albite twinning of these blebs is orientated parallel to one another and to the long direction of the crystal. These facts suggest that the microperthite was formed by a replacement of albite-oligoclase by microcline, leaving islands, or blebs, of the host mineral in the replacing microcline.

In other cases this orientation does not occur, the albite twinning is not very sharp and the albite crystals are fresher than the microcline. This phenomena is usually found associated with albitization of the feldspars. The perthitic structure of this type is also thought to be due to albitization of microcline and orthoclase.

Plagioclase:

These crystals are subhedral, usually lath-shaped and have a maximum length of three millimeters. Their composition is $Ab_{85}An_{15}$, but ranges between $Ab_{80}An_{20}$ and $Ab_{88}An_{12}$.

Due to a slight alteration (sericitization) of the plagioclase, many of these crystals have a clouded appearance. A few of them have been more highly altered. This alteration has produced small flakes of zoisite. This mineral is colourless in plain light, but shows abnormal blue and yellow interference colours under crossed nicols.

Both the potash and plagioclase feldspar have had a secondary growth of albite added to or replacing the crystals. This alteration, known as albitization, has, in places, replaced the potash feldspar, while in others it has formed a growth of secondary albite to the original plagioclase crystals.

Quartz is also found as an intergrowth with the feldspar, forming a myrmekite.

Mica:

Muscovite and biotite occur as narrow laths scattered irregularly throughout the rock.

The muscovite is usually fresh, while the biotite has been altered to chlorite. Both are optically negative, but the axial angle of muscovite is much higher than that for biotite. Muscovite is slightly pleochroic, whereas the altered biotite is usually strongly so and shows abnormal blue interference colours of chlorite.

These two minerals contain an abundance of small crystals of fluorite as well as small amounts of zircon and magnetite.

Accessories.

Fluorite: This is the most common accessory mineral of the granite. It occurs as small irregular grains included in the mica minerals, the plagioclase feldspar and fills the spaces between quartz and feldspar (Plate 5 Fig. 1).

Fluorite is identified by its negative relief, its index, which is lower than balsam, and by the fact that it is isotropic. It usually occurs as small colourless crystals.

Allanite: Several slides possess clusters of euhedral grains of allanite (Plate 5 Fig. 2). Several grains are coated with epidote. In many cases allanite occurs as inclusions in biotite (Plate 6 Fig. 1). Allanite is a deep brown colour, and is pleochroic in brown and yellow. Some grains have poor extinction, but those with good extinction positions have the extinction angle $c \wedge x = 34°$. The mineral is biaxial negative with a large optic angle.

Sphene: This mineral, like allanite, is found as inclusions in biotite and in contact with the feldspar and quartz. It is always euhedral and possesses good crystal faces against these minerals.

Sphene usually has a faint yellow tinge. Its birefringence and relief are very high. It is biaxial positive with a moderate axial angle.

Epidote: Epidote occurs as a mantle around several allanite crystals and as inclusions in plagioclase. It is colourless in plain light with second order interference colours showing under crossed nicols. In elongate sections it has extinction parallel to 001 cleavage. It is biaxial, negative with a large 2V.

Magnetite: Small amounts of this mineral occur as inclusions in biotite and muscovite.

Apatite: Several grains of this mineral were found as inclusions in quartz, feldspars and micas.

A Rosiwal Analysis of the Strawberry Granite gave the following mineral volume percentages.

MINERAL	SECTION NUMBER														
	534	556	539	C-87	I-81	1	2	3	4	5	6	7	8	9	10	Aver. of Sec. 1-10
Quartz	42.20	30.90	28.92	27.80	22.41	27.82	38.90	33.97	34.56	25.41	31.22	26.82	34.78	34.29	36.13	32.39
Orthoclase	14.20	17.00	16.01	11.12	13.20	6.66	3.32	7.23	2.88	16.23	7.16	5.97	5.29	7.18	7.27	6.91
Microcline	27.00	39.00	37.92	38.44	29.40	50.48	33.48	46.76	49.58	35.23	30.14	49.47	32.76	39.17	43.85	41.12
Plagioclase	14.30	11.10	13.71	21.23	21.30	12.72	12.18	7.41	9.71	21.46	23.51	13.82	19.24	13.28	8.28	14.16
Muscovite Biotite	1.80	1.91	1.90	6.51	7.70	1.78	8.73	3.04	2.85	1.25	6.59	1.89	6.21	4.12	2.76	3.92
Allanite	.11		.21	.21	.32		.68	.21		.26	.45	.40	.52	.72	.02	.40
Fluorite	.21		.13	.07	.28	.21	.21	.82	.30	.04	.01	.68	.62	.81	.74	.56
Magnetite	.04		.10	.02	.01	.32	1.89	.11	.10	.07	.70	.73	.72	.21	.01	.45
Epidote			.03													.03
Sphene		.09	.81					.40	.10			.13		.03	.07	.14
Totals	100.00	100.00	100.00	100.01	100.01	99.99	99.75	99.95	100.07	99.78	99.91	99.81	100.14	99.81	99.16	

Sections 1 to 10, 534, 556 and 539 were taken from Cape Strawberry; I-81 from Indian Island, and C-87 from the west side of a small bay 12 miles south of Striped Island.

A study of the above table gives one the impression that the Strawberry Granite is not mineralogically homogeneous. However, studies of hand specimens and observations made in the field present evidence that the rock is fairly homogeneous. The apparent heterogeneity is in all probability due to the coarse grained character of the granite. The grain size of the principal mineral constituents of this rock is as follows:-

Single quartz crystals, range 1 mm. to 2 mm., average 2 mm.

Quartz aggregates, range 2 mm. to 7 mm., average 4 mm.

Feldspar, range 2 mm. to 8 mm., average 4 mm.

Micas, range 0.2 mm. to 2 mm., average 1 mm.

With a coarse grained rock of this type, a single thin section is not a representative sample of the rock as a whole. However, an average of the Rosiwal Analysis of thin sections 1 to 10, which were taken from a single locality on Strawberry Point, is considered to give a fairly accurate analysis of the mineral volume percentage of this rock.

Sequence of Crystallization.

In considering the order of crystallization the following facts were used to determine which of two minerals crystallized first (a) degree of idiomorphism - well developed crystals being early, (b) minerals which occur as inclusions have solidified before the mineral in which they are included, and (c) minerals which partially: or: completely surround other minerals have formed later than the mineral which they surround.

The order of crystallization, as determined from a study of the thin sections, has been as follows:

(1) Accessories - Allanite, Epidote, Magnetite, Sphene, Fluorite, Zircon.

(2) Biotite and Muscovite.

(3) Albite-Oligoclase.

(4) Potash Feldspar.

(5) Quartz Fluorite.

The earliest formed minerals were allanite, epidote and magnetite. Allanite occurs as inclusions in biotite, hence it crystallized before this mineral. This mineral has also crystallized before sphene as shown by the relative idiomorphism between the two where they occur together. Epidote is considered to have crystallized later than allanite since it forms a mantle around many allanite crystals. Epidote also occurs as inclusions in plagioclase, therefore, it is the earlier of the two. Magnetite is only found as inclusions in biotite and muscovite, but is usually considered to crystallize early.

Sphene occurs as inclusions in biotite and as euhedral crystals in contact with feldspar and quartz. Therefore, it crystallized earlier than these minerals.

Small crystals of zircon occur as inclusions in biotite and have, therefore, formed earlier than this mineral. It was not found associated with allanite, magnetite or sphene.

Fluorite grains fill the interstices between quartz and feldspar crystals. This mineral also occurs as inclusions in biotite and plagioclase feldspar. This suggests that it started to crystallize before the mica and continued to crystallize after the feldspar and quartz had formed.

That biotite and muscovite crystallized before the plagioclase feldspar, potash feldspar and quartz is shown by the relative idiomorphism between these minerals where they occur together. The mica always possesses good crystal faces against both the feldspars and the quartz grains.

Plagioclase feldspar occurs as lath-shaped crystals having good crystal boundaries against both the potash feldspar and quartz. Often potash feldspar is seen to enclose or partially surround crystals of plagioclase. Thus this mineral has crystallized earlier than the potash feldspar and quartz.

There is a slight difference in age between the twinned and untwinned feldspar. The untwinned variety shows, in some cases, a slight alteration, whereas the twinned microcline feldspar is fresh. Secondly, the untwinned variety is sometimes partially surrounded by microcline. This suggests that the microcline variety formed slightly later than the untwinned type.

Where quartz and potash feldspar are in contact, the age relationships are difficult to work out. Quartz is definitely later than the feldspar, as it fills the interstices between feldspar grains. It is possible, however, since neither the quartz nor the feldspar possess good crystal faces, that both crystallized simultaneously for a short period during the final stages of crystallization of the feldspar. Quartz then continued to crystallize, filling the interstices between these minerals.

DUNN ISLAND SYENITE

General Statement.

This rock is found on Dunn Island four miles northeast of Cape Strawberry. It differs slightly from the syenite from Kingitok in colour, composition and degree of alteration. In its most typical form it is a medium grained, slightly porphyrytic rock, light grey in colour which weathers to a dull dark grey. The phenocrysts are large feldspar crystals which are embedded in a matrix of feldspar and mafics (Plate 6 Fig. 2).

Petrography.

Microscopically the texture of this rock is hypautomorphic - haphazard - granular. Its mineral composition in order of abundance is microcline, plagioclase, orthoclase, biotite, hornblende and pyroxene. The quartz content is higher than that in the Kingitok Syenite. Accessory minerals are magnetite, apatite and sphene. Mineralogically this syenite corresponds to a Nordmankite (Plate 7 Fig. 1).

The rock is very fresh with the exception of the plagioclase crystals, which show some alteration to sericite.

A particularly distinctive feature of this rock is the high amount of microcline and plagioclase intergrown together, forming microperthite.

A study of these microperthite textures establishes a two cycle development. In the first cycle the plagioclase has been replaced by microcline having small orientated patches of plagioclase in a crystal of microcline. Early replacement shows up as irregular bands and veinlets of microcline cutting the plagioclase (Plate 7 Fig. 2). The microcline is easily identified by its polysynthetic twinning in two directions, nearly at right angles, giving the crystal a gridiron or net structure.

The centre of the plagioclase crystals is usually attacked first. Some crystals show almost complete replacement of the centre part with just the ends and islands of plagioclase remaining in a microcline crystal.

The second stage results in the formation of exsolution microperthite. This type of microperthite is distinguished from the replacement type by the orientation of the cleavage and albite twinning of the exsolved blebs. In the replacement microperthite, the cleavage and albite twin lamellae of the plagioclase blebs are orientated parallel to each other and to their direction in the original crystal, whereas in the exsolution type there is no such orientation.

Mineralogy.

Feldspar:

Microcline is the dominant feldspar in this rock. It occurs as equidimensional grains and as the guest mineral replacing plagioclase. It is easily distinguished by its twinning which is polysynthetic in two directions almost at right angles to each other. Orthoclase is distinguished from microcline by its lack of twinning and its moderate axial angle. It occurs as irregular grains possessing no crystal boundaries. The largest grains of microcline are 8 mm. in diameter.

The plagioclase was determined to be albite-oligoclase.

In its typical form it is lath-shaped, stubby and polysynthetically twinned after the Albite Law. Some albite is found as small anhedral grains filling the interstices between other crystals, suggesting a second crystallization of feldspar.

Biotite:

This mineral occurs as small unaltered lath-like crystals which are often seen in a fan-shaped arrangement surrounding a crystal of magnetite (Plate 8 Fig. 1). In other places plates of mica were found. The radial biotite is non-pleochroic, whereas the other is pleochroic in green and brown. It commonly contains inclusions of magnetite. It has parallel extinction to the 001 cleavage and is biaxial negative with a small 2V.

Amphibole:

Common green hornblende is the dominant amphibole in this rock. It is pleochroic in light brown and green. The extinction angle is $Z \wedge c = 15°$. It is biaxial negative with an axial angle of 85°. The dispersion is moderate to weak $r < v$. The hornblende occurs as automorphic lath-shaped crystals, commonly associated with biotite, which also occurs intergrown along the cleavage planes of the amphibole. A second amphibole, riebeckite, occurs in small amounts. This mineral forms minute subhedral prismatic crystals associated with the hornblende. It is strongly pleochroic in deep and light blue. The crystals are length fast and the maximum extinction angle in elongated crystals is $X \wedge c = 3°$.

Pyroxene:

The typical pyroxene of this rock is colourless diopside. It occurs as short stubby prismatic crystals. The maximum extinction angle in sections cut almost parallel to the C-axis is 42°. It is optically positive with a 2V of 60°. The dispersion is $r < v$, weak.

Aegerine-augite occurs in small amounts usually associated with secondary hornblende (uralite), which forms a corroded border around the pyroxene crystals. Under plain light, it is strongly pleochroic in light and dark green. The aegerine-augite is biaxial positive with a large 2V. The extinction angle is $C \wedge Z = -62°$.

Both contain magnetite as an inclusion along the cleavage planes forming a poor schiller structure.

Accessories.

Quartz: This mineral fills the interstices between the biotite and feldspar crystals. It is xenomorphic, uniaxial and positive. In several grains of feldspar, quartz was found to form a myrmekitic intergrowth.

Apatite occurs as small six sided elongated prismatic crystals. It is most abundant as inclusions in biotite.

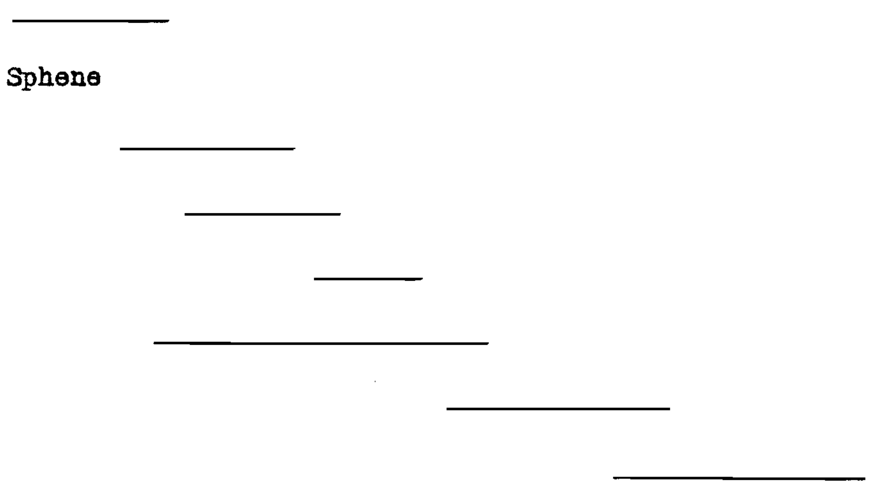
Magnetite is the most common accessory mineral and occurs associated with biotite and hornblende as inclusions. It forms cubic-shaped crystals or aggregates of small irregular crystals. It also occurs as needle-like crystals along cleavages in pyroxene.

Sphene is present in only small amounts, as minute wedged-shaped crystals included in biotite.

Sequence of Crystallization.

From a study of the thin sections the order of crystallization of this rock is given below.

Mineral	Early	Late
(1) Accessories		
Apatite, Magnetite, Sphene		
(2) Pyroxene		
(3) Hornblende		
(4) Biotite		
(5) Plagioclase		
(6) Potash Feldspar		
(7) Quartz		



Apatite is found as inclusions in biotite and, therefore, has crystallized earlier than this mineral. Although it was not found included in the other mafic constituents it is commonly assumed to have been one of the first minerals to crystallize.

Magnetite occurs as inclusions in biotite and often has biotite laths radiating outward from it. Since it occurs as an inclusion, this is evidence that it is earlier than the biotite, probably, in some cases, forming a nucleus around which the biotite crystallized. Secondly, magnetite is found as inclusions in pyroxene and is, therefore, older than this mineral.

Although sphene does not occur in contact with any mineral except biotite, in which it occurs as inclusions, it is usually considered to have crystallized early.

Pyroxene is usually found as automorphic crystals, which, when in contact with mica, has well developed crystal form against the biotite. It is definitely earlier than hornblende, as several crystals of pyroxene show reaction rings with hornblende completely surrounding them. Biotite crystallized earlier than plagioclase, as seen by the relative idiomorphism of the two minerals. In every case, where these two are in contact, the biotite has better developed crystal form than the plagioclase. Plagioclase always shows good crystal boundaries against the potash feldspar and quartz and, therefore, crystallized earlier than these minerals.

Where quartz and potash feldspar are in contact, it is sometimes difficult to determine which of these two minerals crystallized first. However, in several instances, the quartz fills the interstices between the potash and plagioclase feldspar suggesting that, in the final stages at least, quartz was the later mineral to solidify.

Rosiwal Analysis: The mineral composition in terms of volume percent was calculated from the sections and appears in the table below.

MINERAL	SECTION NUMBER		
	568	567	196
Microcline	47.59	39.10	39.40
Plagioclase	23.62	18.25	28.62
Microperthite	9.38	8.78	5.84
Orthoclase	7.56	14.02	11.68
Biotite	7.34	7.10	4.06
Hornblende	1.32	3.15	5.00
Pyroxene	1.02	1.01	1.96
Quartz	3.14	4.65	3.65
Accessories	Tr.	Tr.	Tr.

KINGITOK SYENITE

General Statement.

The Kingitok Syenite is a coarse grained dark coloured rock characterized by strong weathering. Certain specimens of this rock resemble a coarse grained gabbro. The amount and colour of the feldspars usually governs the colour of the rock. Specimens which are composed almost entirely of feldspar are light pink in colour, while others, having a large proportion of mafic minerals and darker coloured feldspars, are a dull dark grey in colour (Plate 8 Fig. 2).

The feldspar crystals are lath-shaped and have a maximum length of one and one-half centimeters. The mafic component seldom is seen possessing good crystal outlines, but occurs as blotches surrounded by small lath-shaped feldspar crystals.

Nearly all the specimens are cut by minute stringers which contain a high content of iron oxides. This iron oxide can be seen along the cleavages of the larger feldspar crystals.

All specimens are strongly weathered. This has produced a misty appearance to the more mafic varieties and has clouded or dulled the feldspars in the specimens poor in mafic minerals.

This rock may belong to the same family as the Dunn Island Syenite. The two are separated here for descriptive purposes because of the much more intense alteration which has affected the Kingitok variety.

Petrography.

Microscopically the texture is coarse grained - allotriomorphic - granular. The principal constituents are: coarse perthitic microcline and antiperthitic plagioclase, green pyroxene (aegerine-augite) with slight pleochroism, biotite, and a large proportion of a complex made up chiefly of a blue amphibole, iron oxides, sericite, chlorite, zoisite and sometimes calcite and quartz. Accessory minerals are apatite and sphene.

The feldspars are long lath-shaped crystals composed of an intergrowth of microcline and albite. Two main varieties of microperthite can be distinguished, a lense structure and a gridiron structure in which the albite component occurs as a network of small veinlets crossing each other at almost right angles. A third microperthite texture occurs less commonly and is composed of blebs of microcline in a host of plagioclase. The potash component of the microperthite usually exceeds the albite component, but in some crystals the plagioclase is as abundant as the microcline.

Although the feldspar crystals are lath-shaped in form, their boundaries are highly sutured due to a secondary alteration which has produced a growth of albite to many of the crystals. This albitization has also replaced the original crystals along the contact between two feldspar crystals in such a manner that the boundaries between them are interfingered (Plate 9 Figs. 1 and 2).

The mafic component of this rock was originally a green pyroxene - aegerine-augite. However, this mineral has been altered to a secondary blue amphibole, iron oxides, sericite, chlorite, zoisite, calcite and quartz. In most sections this complex possesses no crystal outlines, but fills the interstices of the feldspar crystals.

Nine thin sections of this rock were examined. In three of these, the rock is less altered. The minerals contained in these sections, as well as their texture and alteration, are similar to the thin sections examined of the Dunn Island Syenite.

Mineralogy.

Feldspar:

Both plagioclase and potash feldspar occur in this rock. The plagioclase was determined to be albite-oligoclase, $Ab_{88}An_{12}$, in composition. It occurs as lath-shaped crystals, some having a length of two millimeters. These crystals have been moderately altered, which produced a clouded effect under plain light. The alteration has produced a large amount of sericite as well as flakes of zoisite and epidote.

The potash feldspar is always intergrown with the plagioclase, forming a microperthite texture. The microcline is identified by polysynthetic twinning in two directions at right angles to each other. In this intergrowth, the potash feldspar (microcline) is invariably slightly altered to sericite, while the albite component is always fresh. These microperthite crystals, which are lath-shaped, have their crystal boundaries interfingered with each other as well as with the non-perthitic grains of albite.

A third feldspar seen under the microscope looks like a plagioclase which has lost some of its albite twinning, but has not reached a stage whereby it could be called microperthite. Determination of the indices of refraction of this type by the immersion method, established that its composition is that of albite and not microcline.

Pyroxene:

The principal mafic component of this rock is a slightly pleochroic greenish pyroxene. The maximum extinction angle in longtitudinal section is 60° and in this case the extinction direction nearest the C-axis is the slower ray ($Z \wedge C = 60°$). It is biaxially negative with a moderate axial angle. Grains of this mineral average .5 mm. in diameter.

The pyroxene, where it is not altered, occurs as subhedral short prismatic crystals, which show good crystal faces against the feldspar crystals. However, in most of the slides the pyroxene has been broken down into a complex of blue amphibole, iron oxides (hematite and magnetite), sericite, chlorite, zoisite, calcite and quartz. The latter two minerals only occur in small amounts. These minerals occur as an opaque mass which now fills the interstices between the feldspar crystals, long tongues often projecting between the boundaries of two crystals from the main mass of the complex (Plate 10 Fig. 1).

The most characteristic mineral of this complex is a blue amphibole. This mineral occurs as short subhedral prismatic crystals (.2 mm. long) which are almost fibrous. It is found associated with the altered pyroxene along cleavage planes in the feldspar and in the several magnetite veinlets which cut this rock (Plate 10 Fig. 2). It possesses an intense blue colour which is strongly pleochroic, is length slow and has a high relief. The maximum extinction angle in elongate sections is 3°. These optical properties correspond to riebeckite.

Hematite occurs as a red opaque mass usually associated with magnetite grains, sericite and chlorite. The amount of sericite is larger than the chlorite and occurs as greyish minute flakes and scales intergrown with blue chlorite. Zoisite is found only in small amounts, usually as a coating restricted to areas of the complex. Calcite, likewise, is found in small amounts in the complex, but is more abundant as patches in the feldspars. It also occurs as granular aggregates filling the spaces between the feldspar crystals and the complex. Quartz occurs only in minute amounts and is most common in the veinlets that cut this rock.

Biotite:

Only a small amount of this mineral was found in the thin sections. It occurs as small lath-shaped crystals up to .1 mm. in length, and exhibits good basal cleavage. Undoubtedly, some of the complex is the result of a breakdown of biotite.

It is biaxial negative with a very small 2V. The colour is quite dark brown, indicating a high iron content.

Accessories.

Apatite: Minor amounts of this mineral occur as small rounded prismatic crystals included in the ferromagnesian minerals.

Sphene: Several wedged-shaped crystals of sphene were found in the less altered variety of this syenite. The crystals are usually small and well developed.

Calcite: Most calcite seems to be a secondary mineral formed from the alteration of the feldspars and pyroxene. In one slide, however, an aggregate of calcite crystals is seen to fill the space between two feldspar crystals and the pyroxene complex. Associated with the calcite are well developed magnetite crystals. The calcite is colourless, but clouded in thin section and has high interference colours under crossed nicols. The cleavage is not prominent. The crystals are too small to obtain any interference figure.

Alteration.

The alteration of the Dunn Island Syenite has been complex. Four stages of alteration can be worked out from examination of the thin sections. The rock in its present form consists of the following mineral constituents:-

1 - Highly sericitized lath-shaped albite.

2 - Lath-shaped microperthite crystals composed of slightly altered microcline and very fresh albite.

3 - A slightly pleochroic green pyroxene, which has been, in some cases, completely altered to a complex of blue amphibole, iron oxides, sericite, chlorite and zoisite.

A study of the thin sections has shown the following sequence of alteration to have taken place.

1 - Alteration of the primary albite crystals.

2 - Replacement of some of these crystals by potash rich solutions, forming microcline which retained the original lath-shaped outline.

3 - Alteration of microcline.

4 - Albitization which has (a) replaced much of the microcline, forming microperthite, (b) replaced some of the non-perthitic altered albite along the boundaries, so that they are now highly interfingered.

This alteration was probably a continuous operation, the hydrothermal solution first being rich in potash and finally rich in soda.

Primary microcline usually occurs as anhedral equidimensional grains which show crystal boundaries only against quartz, since it is considered to crystallize late in the cooling history of the magma. Rarely does it occur as lath-shaped crystals where the rock contains both plagioclase and potash feldspar. The fact that the microcline occurs in lath-shaped crystals with fresh albite, indicates that this mineral is secondary. If the microcline formed as exsolution from the original albite component, it should be as highly altered, if not more so, than the original albite, since it is more susceptible to hydrothermal alteration. The high percentage of microcline in the perthitic crystals indicates a greater proportion of potash than could normally be held in solution by the albite. Thus, it seems that the microcline is secondary and most probably replaced the original albite.

The albite component of the perthitic feldspar is completely unaltered, whereas the non-perthitic albite has been highly sericitized. This is definite evidence for a secondary origin of the fresh albite. This albite is also later than the microcline for it too is slightly altered. In some sections the albite component of the perthite is equal to and sometimes greater than the microcline component. If the albite were due to exsolution, this large amount of albite would not be formed. Thus, the fresh albite was produced by a later stage in the alteration of the syenite.

During the complex alteration of the feldspar crystals, the hydrothermal solutions also attacked the mafic component of the rock. This attack resulted, in some cases, in the complete breakdown of the pyroxene to a complex of iron oxides, sericite, chlorite and zoisite. The formation of a soda rich amphibole (riebeckite) from the pyroxene strengthens the hypothesis that the solutions were rich in sodium.

RELATIONSHIP OF THE SYENITES TO THE GRANITE

Field Relationships.

The character of these rocks, as seen in the field, suggests that they may be related genetically. The granite of Cape Strawberry forms an elongated body extending southeastward from Cape Strawberry to a point five miles west of Tishualic Bay. The most northerly point where this rock is found is at Nanuaktok Island, 18 miles northwest of Cape Aillik. In the field, there is no evidence that the granite has suffered any tectonic deformation.

The syenites of this section of the coast lie in close proximity to the main granite mass. These rocks are also undeformed. The syenite from Dunn Island is situated nearest to the Strawberry Granite, the distance between them being 4 miles. Kingitok Island is somewhat farther away, being located 11 miles from the nearest known outcrop of granite.

The remainder of the rocks of the coastal section are granite gneisses, quartzite gneisses, and quartzites which show at least traces of shearing. Similarly, to the north and south of this region the rocks all show some evidence of deformation.

Thus the association of two undeformed bodies of igneous rock in close proximity to one another, intruding rocks which have suffered tectonic deformation, strongly suggests that these two bodies are genetically related.

Unfortunately, no contacts between the granite and syenite were observed in the field. Therefore, their relative ages are, as yet, unknown. From his studies of this region, Kranck (14) believes that the syenite is slightly older than the granite, but that it belongs to the same sequence of intrusion. It is possible, of course, that the syenite is the same age as the granite.

Petrographic Relationships.

A microscopic study of the Dunn Island Syenite and the Strawberry Granite presents further evidence that these igneous rocks may have a genetic relation. Due to the intense alteration of the Kingitok Syenite, it was not possible to make an accurate determination of its mineral composition. However, certain features of the rock are similar to those of the Dunn Island Syenite. Both are coarse grained and the mineral assemblage of the less altered Kingitok Syenite is similar to that of the Dunn Island Syenite. Since only three thin sections of this variety were available for study, the suggestion that these two rocks are equivalents is, at best, only a tentative one. The Dunn Island Syenite and the Strawberry Granite are very coarse grained, the granite containing slightly larger crystals than the syenite. These rocks are fairly homogeneous and the textural characteristics are those which would be expected of rocks which have crystallized from a melt. Neither rock type shows any evidence of tectonic deformation such as granulation, cataclastic structure, or zones of mashed crystals common to igneous bodies which have suffered deformation produced by orogenetic movements. The mineral assemblage has uniform extinction under crossed nicols, showing no evidence of straining.

The alteration of the rocks has been produced by similar aqueous solutions, which has formed a microperthite. This alteration has been more intense in the syenite bodies, especially in the Kingitok Syenite, as shown by the almost complete breakdown of the mafic mineral constituents of this rock.

Mineralogically the syenite is richer in mafic minerals and plagioclase, while the granite has a higher percent of quartz. This difference in mineralogy is shown below in Table 1. Columns two and three give the average mineral composition as volume percent determined by Rosiwal Analysis.

TABLE 1

Mineral	Straw. Granite	Dunn Is. Syenite
Quartz	32.39	3.80
Potash Feldspar	48.03	62.80
Plagioclase	14.16	23.50
Pyroxene		1.30
Hornblende		3.20
Biotite	3.92	5.70
Accessory	1.68	.90

Examination of the above table shows that the granite contains more quartz and accessory minerals, while the syenite contains a higher percentage of potash feldspar, plagioclase, pyroxene, hornblende, and biotite.

In Table 11, below, column A lists the results of a chemical analysis made by Dr. N. Sahlbom. Columns B and C give the calculated chemical composition of the Dunn Island Syenite and the Strawberry Granite in terms of oxides. This analysis was computed by calculating the weight percent of each mineral from the volume percent in terms of 100%. The chemical composition of each mineral in terms of oxides was then determined. For purposes of comparison, the total content of each oxide has been tabulated.

In the Rosiwal Analysis of the Strawberry Granite and the Dunn Island Syenite the quartz content of these rocks is 32.39% and 3.80%, respectively (see Table 1, Page 39). In order to make a comparison between the rocks, the quartz content of the Strawberry Granite was made equal to that of the Dunn Island Syenite and the mineral volume percent in terms of 100% determined. The chemical composition in terms of oxides was then computed as for columns B and C. The results of this calculation are tabulated in column D.

TABLE 11

OXIDE	Dunn Island Syenite		Strawberry Granite	
	A	B	C	D
SiO_2	60.62	63.43	73.76	65.46
TiO_2	1.05	Tr.	.85	.27
Al_2O_3	16.07	18.54	12.46	18.40
Fe_2O_3	1.45	.87	.68	.99
FeO	5.73	1.06	.43	.54
MnO	.22	Tr.		
MgO	.49	2.18	1.11	1.62
CaO	2.66	1.29	.49	.71
Na_2O	6.10	2.29	1.46	2.22
K_2O	5.13	10.80	8.28	12.20
P_2O_5	.34	Tr.	Tr.	Tr.
$H_2O + 105°$	.36			
	100.22	100.46	99.58	102.50
$H_2O - 105°$	.20		.06	.09

A: Analysis by Dr. N. Sahlbom.

B: Calculated from Rosiwal Volume Analysis.

C: " " " " "

D: Calculated from Rosiwal Volume Analysis using an amount of quartz equal to the quartz content of the Dunn Island Syenite.

Since the syenite from Kingitok Island has been highly altered by hydrothermal solutions, no chemical composition of this rock was determined. Such a chemical composition would be inaccurate due to the complexity of the alteration and would not give the true chemical composition of the original rock.

Columns A, B and D in the above table show the following chemical relationship between the granite and syenite. The Strawberry Granite contains more SiO_2, Al_2O_3, and K_2O, but is lower in Fe_2O_3, FeO, CaO, and Na_2O than the syenite. MgO occurs in approximately equal amounts.

If the granite is younger than the syenite, then this chemical relationship may be partially explained by differentiation of early crystallized ferromagnesian minerals and feldspar, followed by segregation of these minerals into small pockets before the excess SiO_2 of the magma crystallized as free quartz. This differentiation might be explained by Bowen's fractional crystallization scheme (5).

However, if these igneous bodies are the same age, it is possible that some portions of the magma were contaminated by material which would combine with the excess SiO_2, leaving portions of the magma lacking in free quartz.

Summarizing, the following facts strongly suggest a common origin for these intrusive bodies, (a) their field association, (b) undeformed character in an area which has suffered tectonic deformation, (c) igneous characteristics, (d) texture.

ORIGIN OF SYENITE AND GRANITE

General Statement.

In discussing the origin of these rocks two facts must be kept in mind. Studies of the coastal section of Labrador have been of a reconnaissance nature only. These observations collected valuable information concerning the wider aspects of the geological history of the area. However, detailed investigations of certain critical areas would undoubtedly uncover more facts which would be helpful in solving many of the problems of the coast.

Secondly, the author has not had the opportunity of studying these rocks personally, and is, therefore, at a greater disadvantage than those people who have been able to make personal observations in the field.

No attempt will be made here to prove any one origin for these rocks. The author will review the main theories on the origin of syenites and granites, and will then suggest one which, in the light of present investigations, seems the most favourable.

The Origin of Syenite.

Rocks of syenite composition are relatively rare in nature. Two main theories are involved in their origin, (1) contamination of a granitic magma by material which will "soak up" silica, (2) formation of a syenite by differentiation from a basaltic magma by fractional crystallization as suggested by Bowen (5).

The first theory is based on the widespread field occurrences of small stocks and bosses, as well as marginal facies of syenite composition associated with larger intrusions of granite or foyaite. Thus F. F. Grout (12) has mapped six such syenite bodies in the immediate vicinity of the Vermilion Granite. Similarly, syenite forms a marginal facies about a foyaite intrusion such as in the Haliburton-Bancroft district of Ontario (1).

Diorite, monzonite and syenite are found in many calci-alkalic sequences and represent successive intrustions derived from a crystallizing mafic magma, which, in many regions, have been modified by syntexis at one stage or another in its crystallization history. Special processes of differentiation, such as transfer by volatiles, have been called upon to explain the features observed in some areas. Other syenites have been explained as accumulations of floated crystals, which, in some cases, have been modified by flow or filter pressing.

The general opinion of most petrologists, is that no independent magma of syenitic composition exists in the lithosphere, but that syenite rocks are contaminated parts of a granitic magma or are differentiates of a basaltic magma. R. A. Daly (9) has shown that of 234 districts in the world known to contain alkaline rocks, 163 are associated with carbonate rocks. Thus, a large proportion of syenite rocks are the result of the interaction between the molten magma and a host rock containing large amounts of carbonate bearing minerals.

The Origin of Granite.

The origin of granite has been one of the most discussed problems of petrology and, at the present time, no uniform opinion has been formulated for its origin. As in the case of syenites, there are two main theories for the origin of granite - (1) crystallization from a magma, (2) granitization, that is, fusion and recrystallization or replacement of former sedimentary rocks.

That granite has been produced by both these methods is impossible to doubt if one examines the field occurrence of rocks of granitic composition. The question in debate at the present time is the relative importance of these two methods of origin.

There is little agreement about how a granite magma originates, even among those petrologists who favour the origin of granite by crystallization from a magma. Several methods have been suggested, (a) large scale fusion of portions of the sial, (b) syntexis or melting of siliceous xenoliths on a large scale by a mafic magma, (c) fractional crystallization of a mafic magma.

The first theory is based on the density stratification of the outer portion of the earth. R. A. Daly (8) postulates that the lower portion or basaltic substratum is capable of melting large portions of the overlying sialic layer, forming a granitic magma. Special physical chemical conditions, such as downwarping, friction, radio-activity, and upward migration of hot tenuous gases, have been called upon to produce the heat necessary to melt large portions of cool rock.

Syntexis of siliceous material undoubtedly increases the amount of granite associated with ferromagnesian rich rocks. The amount of granitic liquid produced by fractional crystallization is increased in direct proportion to the amount of incorporated siliceous material.

The theory that a granitic magma is derived from fractional crystallization of a mafic magma is widely accepted. Compelling evidence is found in the field association of these granite bodies associated with basic intrusives. Thus, the granitic portion of thick sills of Pigeon Point are considered to be differentiates of a diabase magma (13).

ORIGIN OF THE SYENITES AND GRANITE OF LABRADOR

From a study of the Strawberry Granite, the Dunn Island Syenite, and the Kingitok Syenite, evidence has been presented which suggests that these rocks have the characteristics of igneous intrusives which have crystallized from a magma. Kranck (14) has suggested that the syenite and the granite belong to the same sequence of intrusion. The coarse even grained texture of these rocks, their undeformed character and geographic location add weight to this argument. Studies of the Strawberry Granite and the Dunn Island Syenite in the field and under the microscope show that these rocks are homogeneous, a characteristic common to intrusive rocks. Since the area occupied by the Strawberry Granite is so much larger than that occupied by the syenites, it seems conceivable that they crystallized from a magma of granitic composition.

In order to understand the genesis of the granitic magma, a consideration of the association of the Strawberry Granite with the altered quartzites, gneisses and related granite bodies (Makkovik Bay Granite) is of particular interest. There is a gradual change in the Makkovik Bay area from quartzites, through gneisses, to a light coloured, almost massive granite. It is believed that these granite bodies are the result of the granitization of the older bedrock - in this case quartzite and associated conglomerate (Kranck 14).

A recent study of the Makkovik Bay Granite, the granite gneisses, and the quartzites by Mr. George Riley revealed that their chemical composition approximates very closely to that of the Strawberry Granite.

This suggests (a) that the Makkovik Bay Granite may be a fine grained facies of the Strawberry Granite; (b) since the Makkovik Bay Granite is believed to be the result of the fusion of portions of the sediments, and since its chemical composition is similar to that of the Strawberry Granite, the origin of the magma from which the Strawberry Granite crystallized may be related to the granitization, and anatexis, of the Aillik sedimentary series.

The total thickness of these rocks is unknown, but it is thought that a large part of the granite gneiss and migmatite of the area were originally quartzites. The present well preserved quartzites may represent the upper part of this series.

It is quite conceivable, therefore, that during the deformation of the Aillik Series to form gneisses and migmatites, a large part of the lower portion of this series, and perhaps part of the sialic layer, became molten. This molten magma would be expected to have a composition fairly close to that of the sediments.

This melting could be produced in two ways, (a) downwarping of the sediments sufficient enough to raise the isogeotherms to melt the lower portion of these rocks, (b) by the interaction of the basic substratum with the sialic and sedimentary layer.

The granite magma then intruded into the Aillik sedimentary series late or after a period of deformation. Evidence in the region supports the hypothesis of a period of deformation during or before the intrusion of the granite.

Several petrographic facts support this hypothesis. The granite is coarse grained, which suggests slow crystallization, probably from a molten mass. It is definitely intrusive into the Aillik Series, as shown by the crosscutting relationship of the granite to the sediments. The coarse grained texture of this rock can be explained by slow cooling following intrusion in the late stages or after a period of mountain building. That the magma was intruded late in the deformation history of the area is shown by the undeformed character of its mineral constituents. The mineral composition suggests a low temperature of crystallization, probably at a shallow depth.

Later erosion of this area has exposed the lower portions of the mountains and exposed also this granite.

The origin of the Dunn Island Syenite is a more difficult problem, for its relative age to the granite is unknown. It is definitely younger than the quartzites since it is intrusive into them. It is undeformed and, therefore, was intruded late or following the deformation of the Aillik Series, (possibly during the same sequence of intrusion of the Strawberry Granite).

Since no rock, such as limestone, has been observed in the area, it is doubtful whether the syenite formed by contamination of a granitic magma.

The Strawberry Granite contains a high amount of accessory minerals such as fluorite, allanite and epidote. The perthitic texture of the feldspars has been produced by albitization and replacement of the plagioclase feldspar. These facts suggest that the granite magma contained a high percentage of volatiles.

According to Bowen's fractional crystallization scheme, the earliest formed minerals, (that is, those which crystallize at a high temperature) are the pyroxenes, the amphiboles, and plagioclase feldspar. These minerals are composed of those oxides which are dominant in the syenite. It is possible, therefore, that the granite magma was rich in volatile constituents, and that these solutions were instrumental in segregating the early formed crystals before quartz began to crystallize. That is, the syenite may be a differentiate of the granite magma brought about by the action of volatile solutions contained in the magma. This suggested origin for the Dunn Island Syenite can only be a tentative one, since the relation of this rock to the Strawberry Granite is not definitely known.

Due to the intense alteration of the Kingitok Syenite, its original mineralogical composition could not be determined. Certain less altered sections of the rock resemble the syenite from Dunn Island. It is conceivable, therefore, that these two rock types may be related. The coarse grained texture of the Kingitok Syenite, and its undeformed character argue in favour for this relation. If further work can present proof of this relationship, then this syenite may have had an origin similar to that of the Dunn Island Syenite.

SUMMARY AND CONCLUSIONS

Reconnaissance surveys of the east coast of Labrador have collected valuable information concerning the broader aspects of the geological history of the region. Of particular interest is a group of coarse grained granites and syenites which outcrop along that part of the coast lying between Cape Harrison and Kingitok Island. These rocks are intrusive into a series of granite gneisses, quartzite gneisses and quartzites. The bulk of the bedrock of this region is composed of these latter rocks. A detailed petrographic study was made of the granite from Cape Strawberry and the syenites from Dunn Island and Kingitok Island.

Several facts suggest that these two igneous rocks are related genetically - (a) their field occurrence and geographic association, and (b) their textural similarities and undeformed character in a region of deformed sedimentary quartzites and gneisses.

The petrographic study also presents evidence that these rocks crystallized from a molten magma. The chemical similarity between the granite and the quartzites of the Aillik Series suggests that this magma was formed by a melting of part of this series, by either downwarping or by the interaction of the basaltic substratum with the sial and sedimentary formations. No definite origin could be advanced for the syenites of this region, due to a lack of detailed geologic knowledge of the area. It is suggested, however, since these rocks show certain similarities mentioned above, that the syenite is a differentiate of the granite magma produced by the action of volatiles contained in this magma.

Further detailed investigations in this area are required to correlate, (a) the age relationship between these two igneous bodies, (b) the relationship of the Kingitok Syenite to the Dunn Island Syenite. These investigations will undoubtedly present evidence which will support any theory concerning the origin of the Strawberry Granite and the syenites associated with it.

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PLATE 1

Fig. 1 Primary bedding in Aillik quartzite. (Photograph by E. H. Kranck)

Fig. 2 Ripple marks in Aillik quartzite, Aillik. (Photograph by E. H. Kranck)

PLATE 2

Fig. 1 Aillik Conglomerate, Aillik.

(Photograph by E. H. Kranck)

Fig. 2 Strongly deformed and granitized conglomerate, Makkovik. (Photograph by E. H. Kranck)

PLATE 3

Fig. 1 Lamprophyric dykes in quartzite,

Aillik. (Photograph by E. H. Kranck)

Fig. 2 Cliffs of Strawberry Granite at

Strawberry Harbour, Strawberry Point.

(Photograph by E. H. Kranck)

PLATE 4

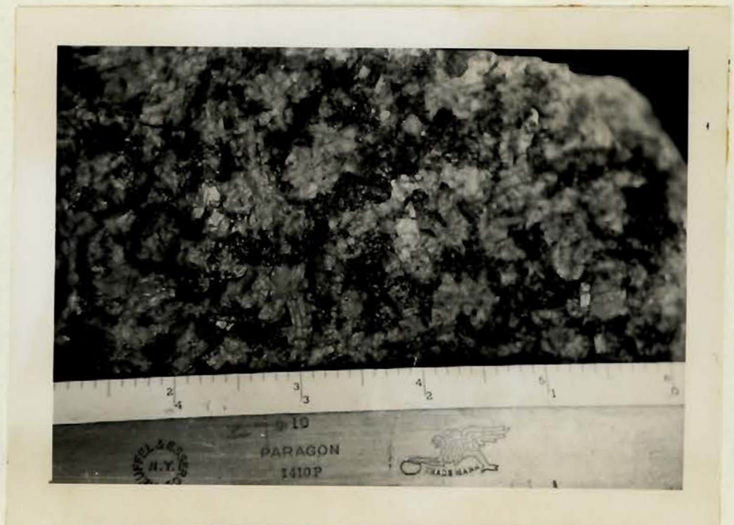

Fig. 1 Hand specimen of Strawberry Granite.

Fig. 2 Photomicrograph showing microperthite in the Strawberry Granite. Crossed nicols X44.

PLATE 5

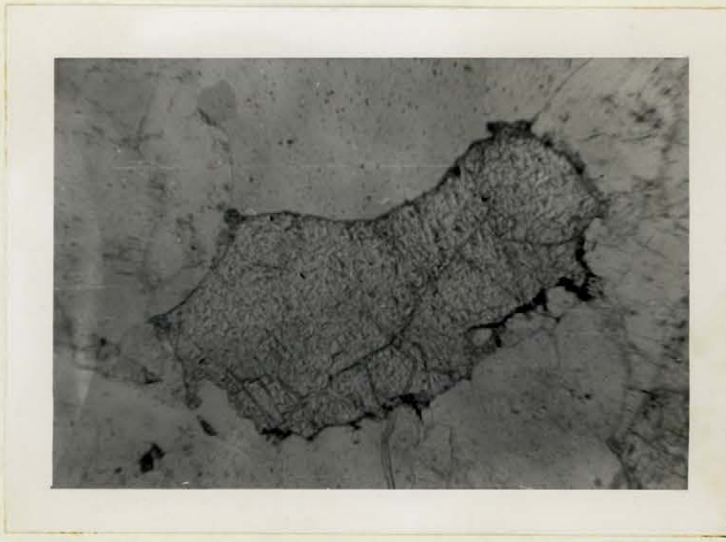

Fig. 1 Photomicrograph illustrating a grain of fluorite in Strawberry Granite. Natural Light X44.

Fig. 2 Photomicrograph of an allanite grain in Strawberry Granite. Natural light X44.

PLATE 6

Fig. 1 Photomicrograph showing a crystal of allanite included in biotite, Strawberry Granite. Crossed nicols X20.

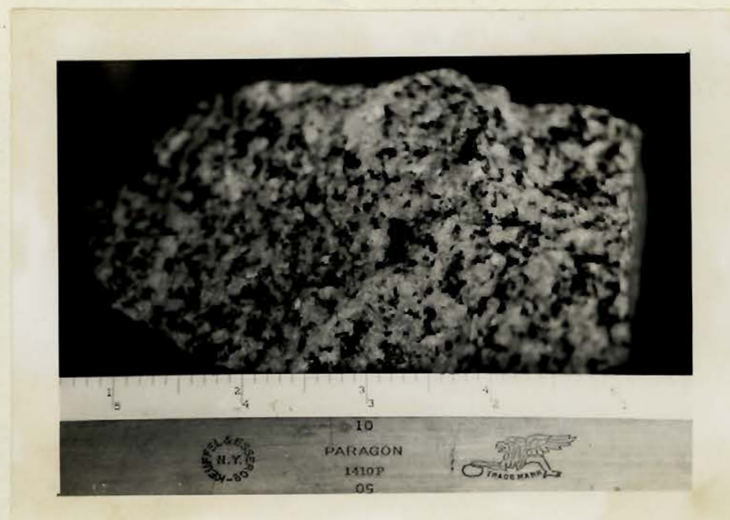

Fig. 2 Hand specimen of Dunn Island Syenite.

PLATE 7

Fig. 1 Photomicrograph of Dunn Island Syenite. Crossed nicols X20.

Fig. 2 Photomicrograph illustrating veinlets and small bands of microcline in plagioclase, Dunn Island Syenite. Crossed nicols X44.

PLATE 8

Fig. 1 Photomicrograph illustrating radial biotite in Dunn Island Syenite. Natural light X20.

Fig. 2 Hand specimen of Kingitok Syenite.

PLATE 9

Fig. 1 Photomicrograph showing sutured contacts in feldspar, Kingitok Syenite. Crossed nicols X20.

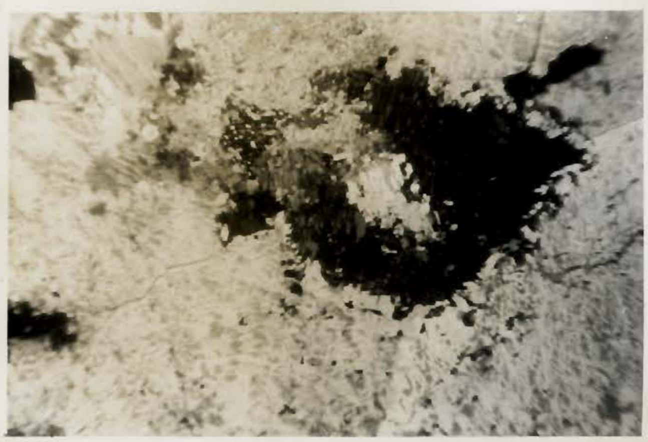

Fig. 2 Photomicrograph showing sutured contacts in feldspar, Kingitok Syenite. Natural light X20.

PLATE 10

Fig. 1 Photomicrograph illustrating the complex in the Kingitok Syenite. Natural light X20.

Fig. 2 Photomicrograph showing a veinlet of magnetite cutting the Kingitok Syenite. Crossed nicols X20.