This document was produced by scanning the original publication.

Ce document est le produit d'une numérisation par balayage de la publication originale.

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 151

PRECAMBRIAN GEOLOGY OF BOOTHIA PENINSULA, SOMERSET ISLAND, AND PRINCE OF WALES ISLAND, DISTRICT OF FRANKLIN

R. G. Blackadar

Price $2.25

1967

PRECAMBRIAN GEOLOGY OF BOOTHIA PENINSULA, SOMERSET ISLAND, AND PRINCE OF WALES ISLAND, DISTRICT OF FRANKLIN

2,000-1966-5525

Chief Scientific Editor
PETER HARKER
Technical Editor
H. M. A. RICE
Editor
F. J. HALPIN
Printed on No. 2 OFFSET ENAMEL
Set in Times Roman with
20th Century captions by
JOHN DEYELL LIMITED
Artwork by CARTOGRAPHIC UNIT, GSC

PLATE I. View west across northern Boothia Peninsula. The prominent rectilinear pattern developed in bedrock due to joints and faults is well displayed. (RCAF T431-L-99)

GEOLOGICAL SURVEY
OF CANADA

BULLETIN 151

PRECAMBRIAN GEOLOGY OF BOOTHIA PENINSULA, SOMERSET ISLAND, AND PRINCE OF WALES ISLAND, DISTRICT OF FRANKLIN

By

R. G. Blackadar

DEPARTMENT OF
ENERGY, MINES AND RESOURCES
CANADA

© Crown Copyrights reserved

Available by mail from the Queen's Printer, Ottawa,
from Geological Survey of Canada,
601 Booth St., Ottawa,
and at the following Canadian Government bookshops:

OTTAWA
Daly Building, corner Mackenzie and Rideau

TORONTO
221 Yonge Street

MONTREAL
Æterna-Vie Building, 1182 St. Catherine St. West

WINNIPEG
Mall Center Bldg., 499 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

A deposit copy of this publication is also available
for reference in public libraries across Canada

Price $2.25 Catalogue No. M42-151

Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1967

PREFACE

This report is one of several publications resulting from a helicopter-supported reconnaissance geological survey carried out in the central Canadian Arctic in 1962.

The conclusions derived from a study of metamorphic rocks from that area are applicable to many parts of the Canadian Shield and the results of *rapid method* chemical analyses given in the text add to the knowledge of the chemical composition of metamorphic terranes.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, March 10, 1965

BULLETIN 151 — Präkambrische Geologie der Halbinsel Boothia, der Somerset-Insel und der Prince-of-Wales-Insel (Franklin-Bezirk).
Von R. G. Blackadar

БЮЛЛЕТЕНЬ 151 — Докембрийская геология полуострова Бутия, острова Соммерсет и острова Принца Уэльского, район Франклина.
Р. Г. Блекадар

CONTENTS

CHAPTER I

PAGE

Introduction 1

Location and accessibility 1

Present investigations and acknowledgments 2

Previous geological investigation and historical summary 3

Physiography 5

Jones-Lancaster Plateaux 5

Boothia-Somerset Upland 5

Boothia-Regent and eastern Victoria Lowlands 8

CHAPTER II

General Geology 9

Aphebian 10

The gneissic complex 10

Structural forms 10

Mafic gneiss 12

Felsic gneiss 17

Granitic rock 21

Granite 21

Quartz diorite 22

Quartz monzonite 23

Ultrabasic rock 25

Helikian 26

Aston Formation 27

Hunting Formation 27

Diabase intrusions 27

Petrography 29

PAGE

CHAPTER III

Structural Geology 32

Introduction 32
Structural elements 32

CHAPTER IV

Metamorphism 37

Facies 37
Age of metamorphism 38
Origin of the gneisses 38

References 44

Appendix A. Tables 19-25,
Mineral associations present in the gneissic rocks 47

Appendix B. Tables 26–38, Chemical analyses 53

Index 61

Illustrations

Map 1219A. Geology, Boothia Peninsula and King William Island ..... *In pocket*
Map 1220A. Geology, Somerset and Prince of Wales Islands ..... *In pocket*

Plate I. View west across northern Boothia Peninsula ..... *Frontispiece*
II. Felsenmeer-covered surface, uplands of Somerset Island 6
III. Upland surface of Somerset Island 7
IV. Valley of Wrottesley River 8
V. Agmatitic gneiss 11
VI. Narrow diabase dykes, south shore, Astronomical Society Islands 28
VII. Sill-like apophyses of diabase intrusive into gneissic complex, northern Boothia Peninsula 28

Figure 1. Structural elements, Boothia Peninsula 34
2. Structural elements, Somerset Island 35
3. Variation of oxide per cent of selected elements plotted against per cent K_2O 42

PRECAMBRIAN GEOLOGY OF BOOTHIA PENINSULA, SOMERSET ISLAND, AND PRINCE OF WALES ISLAND, DISTRICT OF FRANKLIN

Abstract

Boothia Peninsula and western Somerset Island are dominated by the Boothia Arch, a structural and topographic high composed of Precambrian igneous and metamorphic rocks. Relatively flat-lying unfossiliferous sedimentary strata overlie the northernmost exposures of Boothia Arch, and they are in turn overlain by lower Palaeozoic sedimentary rocks.

All pre-Palaeozoic rocks are cut by gabbro dykes and sills. These are most abundant in western Somerset Island.

Potassium-argon age determinations made on biotite indicate an Aphebian (early Proterozoic) age for the latest metamorphism of the gneissic complex.

The results of modal analyses and 82 'rapid method' chemical analyses accompany the descriptions of the gneissic and igneous rocks.

Résumé

La presqu'île de Boothia et la partie ouest de l'île Somerset sont dominées par l'arc de Boothia, qui présente une structure et une topographie élevées, formées de roches ignées et métamorphiques du Précambrien. Des strates non fossilifères à pendage relativement peu prononcé recouvrent au nord les affleurements de l'arc et sont elles-mêmes recouvertes par des roches sédimentaires du Paléozoïque inférieur.

Toutes les roches pré-paléozoïques sont coupées par des dykes et filons-couches de gabbro. Elles se rencontrent surtout dans la partie ouest de l'île Somerset.

Les datations au potassium-argon effectuées sur la biotite indiquent que le dernier métamorphisme du complexe gneissique est d'âge ephébien (Protérozoïque inférieur).

Les résultats des analyses modales et de 82 analyses chimiques selon la «méthode rapide» accompagnent la description des roches gneissiques et ignées.

Chapter 1

INTRODUCTION

This bulletin is one of several final reports resulting from a reconnaissance geological survey carried out in 1962 on Boothia Peninsula and Somerset, Prince of Wales, and King William Islands, all in the central Canadian Arctic.

Except for some general introductory remarks and a brief résumé of the topography of the region, the report is concerned only with Precambrian geology. The Palaeozoic rocks will be the subject of a separate report by R.L. Christie, but in both reports the same set of maps will be used. The Pleistocene and Recent geology of the region will be the subject of a separate report by B.G. Craig.

Preliminary results were presented by Blackadar and Christie (1963) and by Craig (1964). The geological maps accompanying this report and Christie's (*in preparation*) are essentially unchanged from those prepared to accompany the preliminary report by Blackadar and Christie (1963); map-units have been refined, but there is no change in the overall division proposed in the preliminary paper.

More than 100 thin sections were examined during the laboratory study of the rocks of this area, and 82 'rapid method' chemical analyses of certain of these specimens were made in the laboratories of the Geological Survey. Three age determinations were carried out on biotite from gneissic and granitic rocks in the Isotope Geology laboratory.

Location and Accessibility

Prince of Wales, Somerset, and King William Islands comprise the central arctic islands lying as they do between Baffin Island on the east and Victoria Island on the west, and together with Boothia Peninsula and District of Keewatin form the Central Arctic region. Commercially they are at present dependent on service from the western Arctic despite the fact that Spence Bay is equidistant from Frobisher Bay, Churchill, and Yellowknife.

Within the map-area there are only two settlements, Gjoa Haven, a small trading post on southern King William Island, and Spence Bay, on the west side of the Isthmus of Boothia. An outpost of the Roman Catholic mission at Spence Bay is maintained at Thom Bay, on the east coast of Boothia Peninsula. Spence

Bay comprises a Hudson's Bay Company store, nursing station, a Royal Canadian Mounted Police detachment, offices of the Department of Northern Affairs and National Resources, a federal day school, and Anglican and Roman Catholic missions. Prince of Wales and Somerset Islands are at present unoccupied, although from time to time small groups of Eskimo may hunt there for prolonged periods. The Hudson's Bay Company formerly operated a trading post at Fort Ross, in southern Somerset Island. This post, opened in 1937, was closed in 1948 and the staff moved to Spence Bay. The buildings at Fort Ross are in excellent condition and offer emergency shelter. A small trading post was established in 1927 at Port Leopold, in extreme northeastern Somerset Island, but was closed the following year. This building is still standing but offers little shelter.

For the Eskimo too the region covered is a meeting place of East and West. The hunters on Somerset Island may come from Resolute (to the north), Arctic Bay (on northern Baffin Island), or Spence Bay. The Eskimo of Spence Bay are themselves a mixed group, some of whom came originally from southern Baffin Island. These people were settled around the post at Fort Ross about 30 years ago and moved south when Spence Bay was opened.

The intermediate position of the map-area is reflected by the various routes available to reach it. Commercial air services are operated by Pacific Western Airways from Edmonton to Cambridge Bay. Charter services can be arranged from the latter place to points east. Personnel and freight for Operation Prince of Wales were flown by charter service from Churchill. At present (1966) fixed-wing aircraft are based at Resolute on a year-round basis and are available for casual charter.

Heavy freight for the western Arctic is sent by the Mackenzie River route to Tuktoyaktuk, on the Arctic coast, whence it is moved along the coast by small freighters. Because of the long route from the centre of supply and the numerous handlings involved, rates are high and increasing use is being made of air transport for all but the heaviest items.

Present Investigations and Acknowledgments

Field work was carried out in 1962 as part of Operation Prince of Wales, an airborne geological reconnaissance that covered Boothia Peninsula as well as King William, Prince of Wales, and Somerset Islands.

This project was directed by the author, who, together with F. C. Taylor, studied the Precambrian rocks. R. L. Christie, assisted by W. W. Nassichuk, a graduate student, was responsible for the study of the Palaeozoic strata, and B. G. Craig studied the Pleistocene geology. F. C. Wedge served competently as radio operator, and R. A. Baker acted as cook.

Two aircraft were used, a Piper Super Cub contracted from Bradley Air Services and piloted by K. Maclennan, and a Bell 47 G2A helicopter contracted from Spartan Air Services with J. Pridie as pilot and A. Hallam as flight engineer. Non-contract services included a DC-3 flight from Churchill with TransAir Ltd.

and the use of Otter aircraft supplied by Lamb Airways, Pacific Western Airways, and Bradley Air Services.

The season lasted from June 3 to August 25, during which time two base camps were occupied. The first was near Spence Bay settlement, where the survey party was most hospitably received. Especial thanks are extended to Mr. and Mrs. Ralph Knight of the Hudson's Bay Company, Mr. and Mrs. M. Shand, Department of Northern Affairs and National Resources, Ernie Lyall, local resident, and Constable W. Pringle, Royal Canadian Mounted Police.

Field Methods

All fuel for Operation Prince of Wales was sent in 1961 to Spence Bay, the only settlement within the main project area. As a result, the fuel was originally cached at the extreme southern border of the area. The use, however, of the Bell 47 G2A helicopter, which had a more extended range than the models used on earlier air-supported geological projects, meant that only two main base camps were required. One was near Spence Bay and thus required no additional handling of fuel supplies; the second was 200 miles to the north. The latter necessitated the moving of about 2,800 gallons of aviation fuel. It was necessary to locate the camps where both float-equipped and wheel-equipped aircraft could land. This drastically limited the choice, but a long sand spit (part of an extensive esker) 4 miles west of Spence Bay settlement, provided an adequate though dusty site for southern operations. The second camp, 6 miles north of the abandoned post at Fort Ross, Somerset Island, was beside a small lake and offered not only a choice of directions for landing wheel-equipped aircraft but facilities for float aircraft used in camp moves.

A north-south base line was set up to extend from the camp near Spence Bay to northern Somerset Island, and a grid of 31 traverses, spaced at 6-mile intervals, was laid out to cover all Precambrian areas. All traverses, including several check traverses, were made by helicopter. This machine was also used from time to time to fly the Pleistocene and Palaeozoic geologists. Much of their work, however, was accomplished with the Piper Super Cub equipped with low-pressure tires, which was also employed in placing small gas caches for the helicopter.

The first traverses were made on June 16, when snow cover was still extensive. The final traverse was made on August 21, when the weather was deteriorating rapidly and freezing was prevalent.

Previous Geological Investigation and Historical Summary

The surge of interest in Arctic discovery that followed the Napoleonic Wars, beginning with Sir John Ross' expedition of 1818, initiated a new era of exploration, an era in which scientific objectives began to play an increasingly important role. Natural science was a subject with which most naval officers had some acquaintance, and many expedition reports contain scattered references to geology and topography.

Indeed on some expeditions a section of the report, often prepared by the ship's doctor, is devoted to geology.

The first expedition to sight any part of the region covered by this report was that of Sir Edward Parry, who in 1819 had penetrated Lancaster Sound, proving 'Croker Mountains', reportedly sighted by Ross the previous year, to be a myth. The northeastern part of Somerset Island and northern Prince of Wales Island were sighted, but no landings were made.

Parry returned north several times and in 1824 wintered his two ships at Port Bowen, northwestern Baffin Island. The following August, while cruising along the precipitous east coast of Somerset Island, one of his ships was badly pinched in the ice and abandoned. Most of the stores were cached on shore, and their location became a depot used in later years.

Sir John Ross, who had fallen into disfavour after the abortive attempt he made on the Northwest Passage in 1818 by way of Lancaster Sound, was in 1829 sponsored privately by Felix Booth of distillery fame. Using the first steam-powered vessel in the Arctic, Ross coasted south along the east shores of Somerset Island and Boothia Peninsula until beset by ice at Felix Harbour. Extensive scientific work was carried out during the three years spent in southern Boothia Peninsula, the most notable being the location of the North Magnetic Pole by J. C. Ross, nephew of the commander. Geological data gathered during these years are found in Ross (1835).

Ross was forced to abandon his vessel and retreated north by open boat during late August 1832 in the expectation of meeting whalers in Lancaster Sound. He and his men, however, were too late and were obliged to winter at the site of the cache established by Parry at Fury Beach. Not until 1833 did they make contact with the whaling fleet.

The disappearance of Sir John Franklin's expedition, dispatched in 1845 to link the various discoveries made in the search for a Northwest Passage, resulted in a widespread and extensive search all through the Arctic between 1848 and 1859, and it was then that much of the region covered by this report was mapped. The winter of 1848-49 found J. C. Ross in command of two ships at Port Leopold, northeast Somerset Island, and much of the west coast of Somerset Island was explored at that time. Bellot Strait, a final link in the puzzle of the passage, was at last discovered by members of a private expedition sent out in 1851 by Lady Franklin. The fate of Franklin was finally elucidated by Leopold M'Clintock, sent by Lady Franklin after the Admiralty had officially closed the case. He wintered near the western entrance to Bellot Strait (1858-59), and during sledging trips he and Lieutenant Hobson discovered the only written record found to date from Franklin's ill-fated expedition.

After M'Clintock's discovery of the fate of Franklin, interest in polar exploration shifted to attempts to reach the North Pole; little exploration was done in the map-area until early in this century, when Amundsen, in the course of the first successful traverse of the Northwest Passage, wintered at Gjoa Haven. Burwash, an engineer with Canada's Department of the Interior, wintered at the same place in 1925 during his exploratory trip along the continental Arctic coast. With the establishment of the Hudson's Bay Company post at Fort Ross in 1937, travel

throughout the area became more common and the region better known. It was not, however, until after World War II that the completion of a program of trimetrogon air photography permitted the production of reasonably accurate maps.

Physiography

So strongly does the topography of Boothia Peninsula and Somerset Island reflect the underlying bedrock that the various physiographic subdivisions serve as a first-order geological classification.

Three main divisions have been recognized. Northeastern Somerset Island is part of the Jones-Lancaster Plateaux (Fortier, 1957, p. 402). Western Somerset Island and central Boothia Peninsula form the Boothia-Somerset Upland (Fortier, *op. cit.*, p. 401. On Boothia Peninsula the upland area is margined by the Boothia-Regent Lowlands to the east and the Eastern Victoria Lowlands to the west (Fortier, *op. cit.*, p. 404). The plateau and lowland areas are underlain by rocks of Palaeozoic age, whereas the upland area has formed on a crystalline complex of Precambrian rocks.

Jones-Lancaster Plateaux

The eastern two thirds of Somerset Island and northeastern Prince of Wales Island are plateaux of unusually uniform features similar in many respects to other plateau areas within Jones-Lancaster Plateaux region—for example, to Brodeur Peninsula on Baffin Island.

On Somerset Island the surface of the plateau is gently undulating, local relief rarely exceeding a few hundred feet. The plateau surface varies somewhat in elevation but averages between 1,000 and 1,300 feet. Steep sea-cliffs border much of its perimeter, especially on the sides facing Prince Regent Inlet and Lancaster Sound.

Bedrock is poorly exposed and the surface is more often covered with rubble composed of shattered fragments of the underlying sedimentary formations. The high clay content of much of this deposit retains moisture after the melt season, and solifluction features are common.

Rivers in the interior flow in shallow, broad valleys, but near the coast they are deeply entrenched and flow through steep-sided gorges to debouch across a narrow coastal plain, in places absent, into the sea. The plateau is extremely barren, and only here and there are isolated clumps of plants encountered.

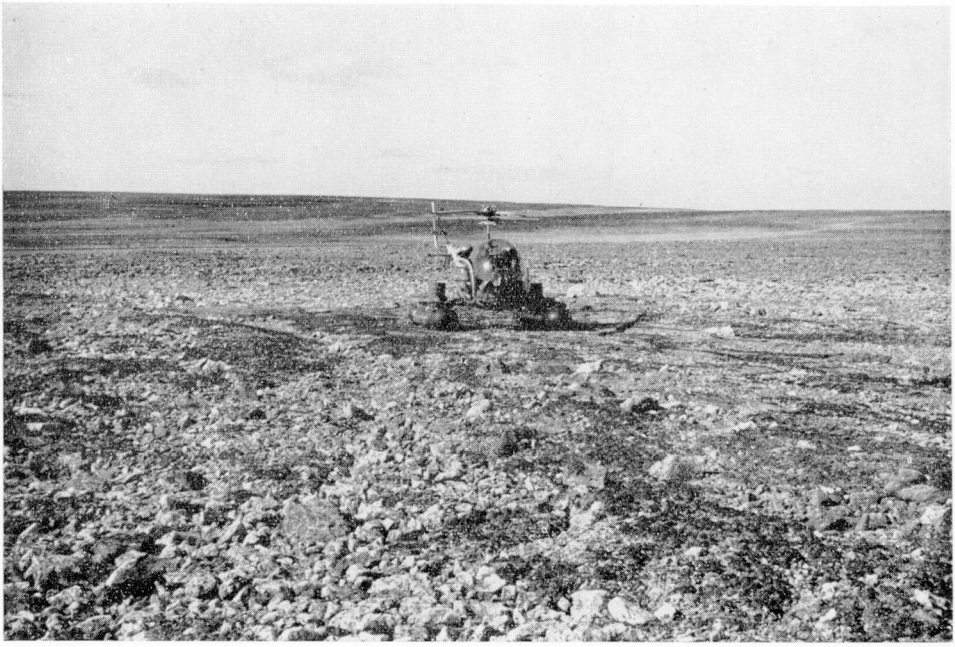
Boothia-Somerset Upland

The spine of Precambrian crystalline rocks extending north through Boothia Peninsula and western Somerset Island from the continental Precambrian Shield consists of diverse though predominantly rugged topography.

On Somerset Island the western part of this upland, which faces Peel Sound, is characterized by rounded hills and extensive outcrops. Maximum elevation exceeds 1,400 feet, and much of the surface is above 1,000 feet. Rivers and lakes occupy deeply incised valleys that appear to be structurally controlled. The most remarkable

of these are east-west trending valleys such as Fitz Roy Inlet, Macgregor Laird Lake, Bellot Strait (on Somerset Island), and others on Boothia Peninsula. These features are at right angles to the dominant northerly strike of the bedrock, with the result that the country is divided into large, more or less rectangular, blocks (*see* Pl. I, *Frontispiece*).

North of Stanwell-Fletcher Lake and inland from Peel Sound, the upland is almost devoid of outcrops. Shattered bedrock (felsenmeer) covers the surface, and only here and there can actual bedrock be found (*see* Pl. II). So slight, however,



RGB 2-14-62

PLATE II. Felsenmeer-covered surface of uplands of Somerset Island.

has been the movement since the formation of the felsenmeer that bedrock features are faithfully reproduced in it. An anastomosing network of basic dykes can be traced from areas of good outcrops into and through this zone of shattered bedrock, and the prevailing northerly trend of the schists and the gneisses that comprise the crystalline complex is reproduced in the felsenmeer.

On Boothia Peninsula, as on Somerset Island, the seaward margins of the upland contain by far the most extensive bedrock exposures (*see* Pl. III). The northern part of the peninsula is a southward continuation of the dissected terrain characterized by prominent east-west valleys. Similar rugged, rounded hills, which, however, lack the pronounced rectilinear pattern, are found on the Tasmania Islands, which

are west of Wrottesley Inlet, and along the entire east coast south from Cape Palmerston.

The central upland area contains a higher proportion of drift, and extensive stretches are covered by boulder fields in places so rough that even helicopter landings are difficult. This region is drained by large rivers, some of which have extensive sand and gravel deposits in their valleys. Headward erosion of many streams is an active process, and cases of incipient stream capture were observed.

FCT 4-1-62

PLATE III

Upland surface of Somerset Island illustrating the deep canyons, prevalence of good rock exposures near the coast, and the rubbly surface characteristic of inland areas. Looking west towards Peel Sound (August 1962).

In the southwestern part of the central upland area drift effectively masks the bedrock, and no clear physiographic break separates those areas to the west underlain by Palaeozoic rocks from the crystalline complex.

Two lowland areas are included within the Boothia-Somerset Upland. The first is the valley of Wrottesley River, northwestern Boothia Peninsula. This valley, margined by steep cliffs of gneiss, is probably structurally controlled (*see* Pl. IV). Thick drift fills the valley and only in the lower reaches does the occasional knob of bedrock project through this cover. The entire valley is bespotted with small lakes through which Wrottesley River placidly meanders northward to the sea.

A second lowland area is the lozenge-shaped plain in southern Boothia Peninsula extending 40 miles north from Spence Bay. Within this lowland are Lakes Jekyll, Hansteen, Kangikjuke, Angmaluktok, Middle, and Krusenstern, the largest bodies of water on the peninsula. Features characteristic of other regions of Boothia Peninsula are intermingled on this plain; low Palaeozoic limestone scarplands, extensive drift covered areas, and crystalline rock surfaces are all present.

FCT 3-5-62

PLATE IV

Valley of Wrottesley River, looking north. Scarp is about 1,000 feet high.

More typical upland topography is found southwest and southeast of the plain. North of Josephine Bay and west of Lord Mayor Bay, high, rounded hills of crystalline rock predominate.

Boothia-Regent and Eastern Victoria Lowlands

A narrow lowland, rarely more than 15 miles wide, extends south for about 70 miles from Brentford Bay on northwest Boothia Peninsula. This feature, formed on Palaeozoic sedimentary strata, is broken by low, southwest-facing scarps. Many small lakes and ponds stud the surface and drainage is poor. To the southwest this lowland abuts against the crystalline rocks of the upland.

The west coast of Boothia Peninsula is similar. There the belt of Palaeozoic sedimentary rocks is about 25 miles wide and extends south for about 125 miles from Weld Harbour to Josephine Bay.

Southwestern Prince of Wales Island forms part of Eastern Victoria Lowlands. It is a region of low relief wherein drift cover is almost continuous. The physiography of this area is due almost entirely to glacial landforms.

Chapter II

GENERAL GEOLOGY

The older Precambrian rocks of Boothia-Somerset area are typical of vast stretches of the Canadian Shield. Banded gneisses and more homogeneous granitic gneisses predominate. Although these rocks are most variable in detail, they are monotonous in bulk; and on a reconnaissance scale, where traverse lines were usually 6 miles apart, little regional variation could be found. Involved fold structures, common in some Shield areas, are rare, and consistent strike directions with variable dips are characteristic of extensive areas.

A broad division into mafic and felsic gneisses and granitic rocks was made in the field by the author. Such a division indicates the predominant aspect of the terrain, but the geology is by no means as simple as these groupings suggest. The mafic gneisses (map-unit 1) are the most diverse, and included within the unit are such varied rocks as banded and *lit-par-lit* gneisses, migmatite, amphibolite, and pyroxene-rich and biotite-rich gneisses. Narrow bands of crystalline limestone (map-unit 1e), most too small to map, are interbedded with these rocks in the vicinity of Bellot Strait. Quartz and feldspar-rich components may be abundant in map-unit 1, as in banded and *lit-par-lit* gneisses and migmatite; or such components may be relatively absent, as in pyroxene gneiss or biotite gneiss. The intricate interplay of mafic and felsic components is best displayed on wave-washed surfaces, particularly in coastal areas.

Large patches of the older Precambrian terrain are light coloured on weathered surfaces and comprise an assemblage of quartz-microcline gneisses (map-unit 2). Mafic constituents include pyroxene, biotite, and hornblende. Many specimens, even the most felsic, contain garnet. This assemblage (map-unit 2) may contain bands and schlieren of mafic rocks similar in every respect to the rocks of map-unit 1. These are too small to map on a reconnaissance scale.

In addition to the two preponderant rock constituents just described, certain parts of Boothia-Somerset region contain outcrops of granite (map-unit 3). These rocks, particularly abundant in southern Boothia Peninsula, lack the prominent foliation of map-units 1 and 2. Their contact with map-units 1 and 2 is commonly gradational, suggesting either that the granitic masses were emplaced at a time when all parts of the area were in a plastic state or that these bodies are not of igneous origin but merely represent areas of maximum metamorphism and metasomatic activity.

A few small patches of ultrabasic rocks (map-unit 4) outcrop in northern Boothia Peninsula and on eastern Prince of Wales Island.

Sedimentary rocks of probable Helikian (Middle Proterozoic) age outcrop on northern Somerset Island and on Prescott Island. Two formations are recognized: the lower, the Aston Formation (map-unit 5), comprising quartzitic sandstone; and the upper, the Hunting Formation (map-unit 6), being predominantly dolomite with minor quartzite.

Dykes and sills of diabasic gabbro cut all Precambrian formations. These intrusions are most abundant on Somerset Island.

In summary, the main development in the geological evolution of the Boothia-Somerset map-areas was the metamorphism, under relatively high pressure and temperature, of ancient sedimentary and possibly volcanic rocks, which resulted in the predominant gneissic complex. Accompanying this activity was the development of granitic masses, either the result of true igneous emplacement or, more likely, a product of metasomatism. Late in this metamorphic period veins of quartz and innumerable small dykes and sills of quartz-feldspar pegmatite were emplaced. Many, although they display intrusive relations, appear to have their material origin in the metamorphism of the original rocks. Few are of more than local extent. An angular unconformity separates the gneissic complex from gently inclined Helikian sedimentary strata. A series of basic sills and dykes intrudes all Precambrian rocks. By analogy with similar rocks on Baffin Island, these are considered to be of Neohelikian age.

Aphebian

The Gneissic Complex

Structural Forms

In the mafic gneisses and, to a lesser degree, in the felsic gneisses, layer or stromatic structure is the most prevalent form. The country rock appears interbedded with a newly formed leucocratic component. 'Banded gneiss' or '*lit-par-lit* gneiss' is the field term applied to such rocks. The layering in these rocks has been controlled by the parallel structure of the country rock. The origin of such a structure is at present controversial; the leucocratic component may be injected or, on the other hand, may result from dominantly chemical effects such as metamorphic differentiation.

Less common are migmatite structures. Mehnert (1962), in a classification of migmatites, includes several types recognized in Boothia-Somerset area, although, as will be obvious from this report, the structures in this area are less complex than those of many classical gneissic terranes.

Agmatitic structure, wherein fragments of country rock are embedded in a leucocratic component, was encountered. The margins of the melanocratic (mafic component) are sharp, showing little assimilation by the quartz-feldspar rock, and could apparently be fitted together again in the manner of a jigsaw puzzle. Little or no rotation of the melanocratic phase has occurred (*see* Pl. V).

FCT 2-12-62

PLATE V

Agmatitic gneiss, Astronomical Society Islands.

Vein structures, in which the melanocratic phase is transected by innumerable diversely oriented veins of leucocratic rock, are present in places, as are augen structures in which blastic feldspars are developed within a predominantly mafic matrix.

Within areas of felsic gneisses (map-unit 2), structures produced by more intense or more prolonged metamorphism can be recognized. In addition to banded structures, which in map-unit 2 contain a preponderance of leucocratic components, schlieren and nebulitic structures are common. In the former the melanocratic component, the original country rock, has been disarticulated. No longer is there any possibility, as in the agmatites, of recognizing once adjacent parts. The relics of country rock now have the form of indistinct, wispy masses that appear to swirl through the predominant felsic phase. Such a structure seems to result from a combination of high temperature and accompanying high plasticity. The former permitted some assimilation of the mafic material by the leucocratic phase, and the latter resulted in a more or less thorough mixing.

Nebulitic structures result when metamorphism is carried one step further. In them the country rock, the mafic component, has all but disappeared as a discrete entity and its place is marked only by patches of slightly darker rock, a local concentration of minerals such as biotite, chlorite, or hornblende.

The final stage of such metamorphism will produce a massive, homogeneous structure, which may resemble a truly igneous leucocratic rock. Perhaps the granitic

rocks of map-unit 3 owe their origin to such a process, but, as will be seen in the descriptive section "Granitic Rocks", no unequivocal evidence in this connection was obtained from field studies.

Mafic Gneiss (map-unit 1)

Gneissic rocks rich in minerals such as pyroxene, hornblende, and biotite are most abundant in the western part of Boothia Peninsula. Although a few extensive outcrop areas are found in the east, the mafic rocks there are more commonly confined to narrow bands within the felsic gneisses. On Somerset Island mafic rocks are more evenly distributed and are interbedded with felsic gneisses and granitic rocks.

The following section was measured from east to west on the north side of Levesque Harbour, northern Boothia Peninsula. Dips there are generally steep, the average being 70 degrees; indeed some beds are nearly vertical.

Lithology

Unit		Thickness (feet)	Height above base (feet)
23	pinkish biotite-quartz-feldspar gneiss; contorted beds; boudins of quartz-feldspar pegmatite	66	3,165
22	gabbro dyke	75	3,099
21	reddish granitic gneiss; minor biotite-rich bands	255	3,024
20	grey, quartz-plagioclase-microcline gneiss	635	2,769
19	gabbro dyke	73	2,134
18	quartz-plagioclase-microcline gneiss	118	2,061
17	biotite-chlorite gneiss	7	1,943
16	quartz-plagioclase-microcline gneiss	115	1,936
15	reddish granitic gneiss	47	1,821
14	grey, quartz-feldspar-biotite gneiss	19	1,774
13	banded gneiss; quartz-feldspar bands 1′-5′ thick and biotite-pyroxene bands up to 2′ thick	132	1,755
12	pink granitic gneiss; eyes of milky quartz	73	1,623
11	banded pyroxene gneiss and quartz-feldspar granitic gneiss; a few rusty bands	55	1,550
10	garnet-hypersthene-quartz-feldspar gneiss; porphyroblasts of poikilitic garnet	24	1,495
9	rusty garnet-graphite-biotite-quartz-feldspar schist	87	1,471
8	granitic gneiss; minor biotite-rich bands	24	1,384
7	finely bedded garnet-biotite-quartz-feldspar gneiss and quartz-feldspar gneiss. Some rusty bands	87	1,360
6	biotite-quartz-feldspar gneiss	390	1,273
5	similar to 6 but many sills of quartz-feldspar parallel with gneissosity	275	883
4	dark, biotite-feldspar gneiss	7	608
3	dark, biotite-rich gneiss	219	601
2	drift-covered interval	100	382
1	greenish biotite gneiss; some rusty bands rich in pyrite and graphite	282	282
	drift below		

The variable thickness and wide diversity of the units comprising map-unit 1 at this point are obvious from this section. There the complex has a somewhat greater preponderance of felsic material than at many other exposures and thus is not wholly typical. The section nevertheless serves to illustrate and emphasize the difficulties inherent in grouping the gneissic rocks into a few broad divisions suitable for reconnaissance mapping. Even the divisions of the above foregoing section could, in some instances, be further refined to better describe certain features.

Lithology

Three principal rock types are included in map-unit 1—rusty biotite-graphite-garnet gneiss (1f), diopside gneiss (1b), and biotite gneiss (1d). Amphibolite bands (1g) and schlieren form a small proportion of the rocks in map-unit 1, as do hypersthene-rich rocks (1c). Cordierite-sillimanite gneisses (1a) are rare.

Diopside gneiss (map-unit 1b). Diopside is abundant in many mafic gneisses and is commonly associated with biotite and hornblende but, surprisingly, never with hypersthene. These rocks have no unique mode of occurrence but are found in banded gneisses, *lit-par-lit* gneisses, and migmatites, with no apparent regional pattern.

The data in Table 1 are typical of these rocks.

Table 1. ***Mineral Composition*** **Table 2.** ***Chemical Composition*** *(recalculated to 100%)*

Diopside Gneiss

Mineral	Volume (1)	% (2)
Quartz	3.0	4.0
Plagioclase	46.5	40.6
Diopside	12.0	17.0
Hornblende	24.0	34.3
Biotite	13.0	4.0
Magnetite	1.0	—

Oxide	Weight (1)	% (2)
SiO_2	52.9	50.4
Al_2O_3	17.3	15.5
Fe_2O_3	0.9	0.1
FeO	6.9	10.0
CaO	11.2	12.5
MgO	5.8	7.0
Na_2O	2.9	3.1
K_2O	1.1	0.7
TiO_2	0.74	0.52
MnO	0.16	0.17

(1) BE 62-48, (2) BE 62-65.

Biotite gneiss (map-unit 1d). Biotite-rich rocks are common in the mafic succession, and the presence of this mineral is often the cause of the well-developed foliation characteristic of large parts of the map-area. Hornblende is commonly present with biotite, and a fine-grained to medium-grained texture prevails in most specimens. In outcrops these rocks have a mode of occurrence similar to that of the other members of map-unit 1. Veins of more felsic rocks are commonly interlayered,

and in thin section fine veinlets of quartz-feldspar rock can be seen to penetrate the mafic-rich matrix. Such veinlets do not have sharp contacts and appear rather to have worked through the original rock. A few biotite or hornblende crystals in the centre of a veinlet surrounded by quartzo-feldspathic rock substantiate this observation.

Table 3. *Mineral Composition* — Table 4. *Chemical Composition* *(recalculated to 100%)*

Biotite Gneiss

Mineral	Volume % (1)	(2)	(3)	Oxide	Weight % (2)	(3)
Quartz	22.3	14.3	8.6	SiO_2	53.6	53.8
Plagioclase	47.6	45.3	61.6	Al_2O_3	21.3	21.0
K-feldspar	—	1.3	—	Fe_2O_3	2.7	3.2
Hornblende	—	12.0	12.3	FeO	6.1	4.8
Biotite	21.6	25.6	13.3	CaO	7.3	6.6
Garnet	8.3	—	—	MgO	1.0	3.0
Apatite	—	0.3	0.6	Na_2O	4.2	5.4
Magnetite	—	1.0	3.3	K_2O	2.5	3.1
				TiO_2	1.0	0.94
				MnO	0.16	0.13

(1) BE 62-36, (2) BE 62-34, (3) BE 62-37.

Crystalline limestone (map-unit 1e). Narrow, discontinuous bands of crystalline limestone are found in an area of rusty schists and gneisses on both sides of Bellot Strait. Most are thin and too small to be shown on the accompanying maps; but some are more than 400 feet thick and are indicated either by outcrop pattern or by spot figures.

The limestone is coarsely crystalline and weathers yellowish grey. Some bands are siliceous, and irregularly shaped cherty layers may form more than half the rock. Greenish diopside is a common constituent, as are phlogopite, graphite, and biotite. Other bands have been serpentinized and contain dark green mica.

The carbonate rocks are interbanded with enclosing mafic and felsic gneisses, and this supports the concept of a sedimentary origin for much of the gneissic complex.

Rusty biotite schists and gneisses (map-unit 1f). From the air, many parts of northern Boothia Peninsula and southern Somerset Island present a rusty, streaky appearance that at first sight would seem to offer possibilities to the prospector. On closer examination, however, these superficially exciting gossan zones prove to be devoid of any significant metallic minerals and are seen to result from weathering of garnet-graphite-biotite-quartz-feldspar schists and gneisses. Unaltered pyrite was detected in a few places; presumably this mineral was widely disseminated in the original rock and its alteration has resulted in the present widespread occurrence of hydrous iron oxides.

Rusty schists and gneisses vary considerably in composition and form. Many are more felsic than their inclusion in map-unit 1 would indicate. These rocks, however, are so closely associated with more mafic rocks that mapping separately is difficult. Garnet may be so abundant that a distinctly spotted appearance is imparted to the outcrop; elsewhere it may be totally absent. Some hypersthene is present in a few of these rocks, but more often biotite and hornblende are the principal mafic minerals.

Table 5 gives the results of modal analyses of a typical sample (BE 62-63) of mafic rock from a rusty band in southern Somerset Island.

Table 5. *Mineral Composition of Rusty Gneiss*

	Volume %
Quartz	0.6
Plagioclase	42.0
Pyroxene	5.0
Hornblende	48.3
Biotite	2.3
Magnetite	1.7

Amphibolite (map-unit 1g). Hornblende-rich mafic gneiss is not abundant, but here and there bands of amphibolite up to 100 feet thick are included in the succession. More often such rocks merely form schlieren in migmatite terranes. Amphibolites tend to weather deeply and black hornblende-rich sand is commonly found on surfaces underlain by such rocks. Many have a sill-like habit and may be relics of gabbro sills intrusive into the premetamorphic terrane.

The analysis (BE 62-15) given in Table 6 is typical of the amphibolitic rocks.

Table 6. *Chemical Composition of Amphibolite*
(recalculated to 100%)

Oxide	Weight %
SiO_2	48.5
Al_2O_3	14.1
Fe_2O_3	1.1
FeO	11.2
CaO	12.7
MgO	7.8
Na_2O	1.9
K_2O	1.0
TiO_2	1.5
MnO	0.23

Mineralogy

Several distinct mineral associations are obvious from the thin-section examination of the rocks of map-unit 1, but none appears to have regional significance. They seem, rather, to reflect local compositional variations. Tables 19-25, Appendix A, illustrate some of these associations.

The principal associations are:

1) cordierite-sillimanite-garnet-biotite-microcline-quartz-plagioclase
2) hypersthene-biotite-quartz-plagioclase
3) hypersthene-biotite-microcline-quartz-plagioclase
4) hypersthene-biotite-microcline-garnet-quartz-plagioclase
5) diopside-biotite-microcline-quartz-plagioclase
6) diopside-hornblende-plagioclase
7) biotite-hornblende-garnet-microcline-quartz-plagioclase.

These associations are significant mainly as indicators of metamorphic facies, a subject considered in Chapter IV.

The following mineral descriptions are applicable to map-unit 1 as a whole and not to any specific group within it.

Cordierite is present in only four of the forty thin sections studied. Where fresh, it may be polysynthetically twinned but more often is extensively altered to antigorite and chlorite. Sericitization has developed inward, but even where a high degree of sericitization obtains, pleochroic haloes may be preserved.

Sillimanite is present in two thin sections examined. Commonly associated with biotite, it may also form in fine grains completely enclosed by potash feldspar.

Potash feldspar is present in most sections examined but rarely exceeds 25 per cent of the mineral content, in contrast to rocks from map-unit 2, which may contain more than 50 per cent of K-feldspar. Most commonly it is interstitial, but in one section interstitial potash feldspar seems to have been followed by the development of larger crystals. Here and there myrmekite has grown near the margin between plagioclase and potash feldspar. Some crystals show perthitic structures, the most commonly developed being flame, bleb, and string perthite. Potash feldspar in the form of antiperthite is found within plagioclase in numerous sections.

Plagioclase is present in most sections examined. In some, extensive alteration to sericite has taken place, but more commonly grains are unaltered and exhibit well-developed twinning. Compositions range from An_{25} to An_{60}, the average composition of twenty sections being An_{37}.

Quartz grains are usually clear, although in a few sections plagioclase and zircon inclusions were seen. This mineral constitutes the fine-grained matrix of many mafic gneisses, but it may also be porphyroblastic. In many sections variable extinction within a grain indicates straining.

Hypersthene grains are equigranular. Pleochroism may be highly developed with strong shades of green and red predominating. A few sections show extensive alteration: a central core of unaltered pyroxene is surrounded by antigorite and a rim of sericite. Such alteration suggests a post-metamorphic origin during the last stages of a potassic metasomatism.

Diopside. Many thin sections contain equidimensional grains of a colourless to pale green or pink pyroxene, which on an optical basis is considered to be diopsidic augite or diopside. Garnet is absent from all examined sections containing diopside.

Biotite. Minor amounts of biotite are present in most of the rocks of map-unit 1. Some is an alteration of pyroxene, but more commonly the biotite appears to be an original constituent of the rock. Occasionally apatite or magnetite is closely associated with biotite. The mineral is highly pleochroic, with colours varying from dark reddish brown to pale yellow and dark brown to yellowish green. Biotite is altered to chlorite.

Garnet. Pinkish garnet is randomly distributed throughout the rocks of map-unit 1, commonly in the form of crystal aggregates. Some garnets contain inclusions such as quartz or sillimanite, but more often they are free from such inclusions. Inclusions, where present, may be very abundant, imparting a sieve-like texture.

Accessories. Zircon, apatite, and sphene are the principal accessory minerals. Some of the zircon is zoned.

Felsic Gneisses (map-unit 2)

The gneissic rocks of Boothia Peninsula and Somerset Island are essentially a banded complex of biotite-pyroxene-hornblende-quartz-feldspar gneiss (map-unit 1), and feldspar and quartz-feldspar gneiss (map-unit 2). The separation of the two is in many places arbitrary, but elsewhere one or the other predominates and readily mappable outcrop areas exist.

Rocks of map-unit 2 are preponderant in the eastern half of Boothia Peninsula north of Thom Bay. Within this area mafic gneisses are rare. In western Boothia Peninsula map-units 1 and 2 are interbanded, although east of Tasmania Islands rocks of map-unit 2 form most of the outcrops. The interbanding of the two types is common on Somerset Island, but felsic gneisses seem to be the more abundant, as they are in eastern Prince of Wales Island.

The contacts between mafic and felsic bands are generally sharp. In many places the felsic material appears intrusive into the mafic rocks, but elsewhere the abrupt change from one type to the other suggests contemporaneity of origin.

Lithology

Quartz, plagioclase, and potash feldspar are the principal constituents, but biotite, diopside, hypersthene, hornblende, and garnet may be present, and a few sections examined contained cordierite and sillimanite.

Textures range from granoblastic to pegmatitic, the former being preponderant. Certain distinctive mineral associations exist but do not appear to be parts of widespread features; at the reconnaissance scale on which this mapping was carried out, such groupings cannot be shown on the accompanying maps.

Quartzitic rocks (2a) are extremely rare in the gneissic complex of Boothia-Somerset region, and almost all rocks in map-unit 2 contain some plagioclase. Many may be of arkosic origin, but rocks derived from relatively pure sandstone appear to be absent.

Rusty bands (2b) are locally abundant in the succession. In contrast to the rusty gneisses of map-unit 1 (1f), these rocks contain little graphite or pyrite. The rusty colour is due rather to the alteration of biotite-rich bands in the predominantly felsic complex.

Here and there amphibolite (2c) is included in the felsic gneisses. Most commonly it forms agmatitic or schlieren structures within the rocks of map-unit 2, but in a few instances coherent masses of amphibolite, some several hundreds of feet long and tens of feet thick, are present. The designation 2c is used on the map to indicate areas where amphibolite–schlieren are abundant constituents of the quartzo-feldspathic gneisses.

In Table 7 the results of six micrometric analyses of the predominant aspects of the felsic gneisses are given; the equivalent chemical data follow in Table 8.

Table 7. ***Mineral Composition*** **Table 8.** ***Chemical Composition*** *(recalculated to 100%)*

Felsic Gneisses

Mineral	Volume %					
	(1)	(2)	(3)	(4)	(5)	(6)
Quartz	38.7	39.3	22.2	—	38.4	24.6
Plagioclase	5.0	35.0	45.5	57.0	35.6	19.3
Microcline	—	7.3	8.0	—	15.7	53.4
Hypersthene	25.7	—	8.4	39.6	—	—
Biotite	—	13.5	4.1	1.0	10.0	—
Garnet	23.9	5.0	10.0	—	—	—
Magnetite	5.9	—	1.5	2.3	—	0.7
Chlorite	—	—	—	—	—	2.0
Apatite	0.6	—	—	—	0.3	—
% An	—	38	—	64	38	—

Oxide	Weight %		
	(2)	(3)	(6)
SiO_2	67.3	61.5	67.8
Al_2O_3	19.4	18.4	15.9
Fe_2O_3	0.1	1.0	2.8
FeO	1.9	6.1	2.1
CaO	4.2	5.8	1.3
MgO	0.6	0.5	0.5
Na_2O	4.0	4.6	2.8
K_2O	2.0	1.0	6.2
TiO_2	0.42	1.0	0.45
MnO	0.01	0.1	0.03

(1) BE 62-96, (2) BE 62-29, (3) BE 62-107, (4) BE 62-67, (5) BE 62-25, (6) BE 62-38.
NOTE: No chemical analyses are available for numbers 1, 4 and 5 of Table 7.

Tables 31a and 32a in Appendix B contain the results of 24 chemical analyses of felsic gneiss. The wide variation from 0.25 to 2.29 that exists in the K_2O/Na_2O ratio is remarkable. Most, but not all, rocks in which the ratio exceeds 1.0 contain perthitic intergrowths. All contain microcline. On the other hand, rocks in which the

ratio is low may include large porphyroblasts of microcline and a few exhibit antiperthite. The volume per cent of these constituents is, however, usually small. Specimen BE 62-86, Table 31, contains 1.2 per cent K_2O, yet in thin section only antiperthite is visible as the source for this oxide. The rock contains no biotite and no porphyroblasts of microcline.

At the reconnaissance scale on which mapping was carried out, no regular variation could be detected between those localities characterized by a high K_2O/Na_2O ratio and those in which the ratio was low; the distribution appears random. Some of the rocks richest in K_2O appear to be of igneous origin in contrast to those more obviously derived by metasomatic activity, but again no generalizations can be made.

In many respects the rocks of map-unit 2 resemble granulites from classic Precambrian terranes, such as Finland. Mineral associations such as quartz-microcline-garnet-(plagioclase), quartz-microcline-hypersthene-(plagioclase-garnet), and plagioclase-hypersthene-(diopside-quartz-microcline), all characteristic of granulites, are commonly encountered in map-unit 2. Especially in the eastern part of Boothia Peninsula, where banded gneisses are less common, there are large masses of relatively homogeneous granular gneiss in which the only structure is indistinct gneissosity derived from the alignment of quartz, microcline, and pyroxene.

The rocks of map-unit 2 are remarkably aluminous. Riley (1960, p. 17) quoted three chemical analyses for 'charnockites' from eastern Baffin Island, rocks similar in occurrence and mineralogy to those in map-unit 2. The Baffin Island rocks contain as much as 8 per cent pyroxene, the remainder being about equally divided between quartz, plagioclase, and microcline. The average Al_2O_3 content is 14.5 whereas for similar rocks from Boothia-Somerset map-area it is 15.9 (Table 31, quartz-feldspar gneiss) and 18.3 (Table 32, garnet-quartz-feldspar gneiss). For K_2O/Na_2O, on the other hand, the ratio is much greater, being 2.2 for the Boothia-Somerset rocks whereas for the garnet-quartz-feldspar gneisses of Boothia-Somerset it is 0.87 and for quartz-feldspar gneisses from the same area it is 0.96.

In mineral composition the pyroxene-amphibole granodiorite gneiss described by Riley (*op. cit.*, pp. 44-47) is also similar to certain aspects represented in map-unit 2. In this rock, pyroxene may be present in amounts up to 5 per cent and amphibole and biotite in amounts up to 10 per cent, and the remainder may be divided more or less equally amongst quartz, plagioclase, and microcline. The analyses given by Riley (*op. cit.*, p. 45) indicate an Al_2O_3 content of about 13.5 per cent and a K_2O/Na_2O ratio of 1.3. These values again contrast markedly with those for map-unit 2.

It is surprising, considering the relatively high Al_2O_3 content of many of the rocks in this map-unit, that sillimanite and cordierite were not more commonly recognized during the field examination of Boothia-Somerset map-areas.

Mineralogy

Plagioclase. Most of the rocks of map-unit 2 examined microscopically contain andesine with a composition varying from An_{33} to An_{43}, the average of 16 determinations being An_{37}. These compositions class the rocks as quartz diorite. Myrmekite

commonly forms near the boundary between plagioclase and potash feldspar, and in a few sections studied antiperthite has been widely developed. A few specimens contain a plagioclase with an anorthite content exceeding 50; these rocks are therefore classed as quartz gabbro. None of the quartz gabbro contains potash feldspar; thus, they contrast with the quartz diorites, almost all of which contain some K-feldspar. The plagioclase composition of two specimens of felsic gneiss is less than An_{30}, and these two rocks are therefore granodiorites. Both contain K-feldspar, and myrmekite is developed near the plagioclase-potash feldspar boundary.

Quartz is present in nearly all specimens of rocks from this map-unit. In some it forms not only large aggregates but also small, discrete, interstitial grains. Many quartz grains show shadowy extinction, possibly indicative of strain, especially as they are commonly associated with fractured plagioclase crystals. Quartz forms up to 40 per cent of the total mineral content of some of the felsic gneisses.

Potash feldspar. All specimens of granodiorite and quartz diorite in map-unit 2 contain some K-feldspar, although this mineral is not present in the quartz gabbro members of the unit. Perthitic structures are common, mainly bleb perthite, but in one section examined flame perthite was seen, apparently encroaching inward from grain boundaries, and in another well-developed string perthite was observed. About half of the sections examined showed well-developed microcline twinning. Potash feldspar usually forms the largest mineral grains present in the thin section and may form as much as 55 per cent of the rock.

Pyroxene was determined in more than half the thin sections examined from this map-unit. Hypersthene in amounts up to nearly 40 per cent occurs in about one third of the sections. Diopside is less common. Hypersthene is pleochroic with pale to strong green to pink colours predominating.

Biotite is present in more than half the rocks examined. It is usually pleochroic, varying from pale yellow to reddish brown. In places it is altered to chlorite, and elsewhere it is commonly surrounded by specks of magnetite.

Hornblende usually appears to be an alteration of pyroxene, although some of it may be primary. Pleochroism varies from pale yellow-green, pale green-dark olive-green, to pale yellow-brown.

Garnet is found in about one third of all specimens collected from rocks of map-unit 2. Its distribution throughout the map-area is random, and no significant pattern appears when the occurrences are plotted. Many garnet crystals are full of small quartz crystals; others contain feldspar and biotite. In colour, the garnet tends towards shades of pink, although a few rock specimens contain a more reddish garnet. Most crystals are euhedral.

Cordierite. Two specimens of felsic gneiss contain cordierite and, like the distribution of garnet, it appears random. No cordierite, however, was found in specimens north of 71°N. A specimen from near Stanley River, north of Thom Bay, is very rich in this mineral. The cordierite shows numerous pleochroic haloes and is well twinned.

Sillimanite is commonly associated, and a reaction rim of spinel has developed where the two minerals are in contact.

A similar association prevails near the north end of Krusenstern Lake. There cordierite forms with knots of garnet, although the minerals may occur separately. The cordierite shows polysynthetic twinning, and a myrmekitic intergrowth is common when biotite is associated. Sillimanite in this rock is most commonly associated with garnet.

Granitic Rock (map-unit 3)

The term 'granitic' is applied to a group of rocks that outcrop throughout the map-area. These rocks vary in composition from quartz diorite to granite, the largest proportion being quartz monzonite. Field relations indicate that here and there the rocks are intrusive into older sedimentary strata, but more often they grade imperceptibly into quartzo-feldspathic gneisses of map-unit 2 and there is a strong suggestion that at least part of the unit is of metamorphic origin.

Rocks of map-unit 3 are most abundant in southern Boothia Peninsula between Josephine and Thom Bays but are found throughout the map-area as irregular-shaped masses within the felsic and mafic gneisses.

Three principal types were recognized in the course of a thin section examination of these rocks. They are granite, quartz diorite, and quartz monzonite and are described briefly in the following pages. The distribution of these types appears erratic, at least on the scale of mapping carried out, and all are grouped together in map-unit 3. On the accompanying maps, spot locations are given for each type.

GRANITE (map-unit 3a)

Field Relations

The largest exposure of granite is between Josephine and Spence Bays in the southwestern part of the map-area. This body appears intrusive into the gneissic complex, the contact zone being characterized by migmatite possibly derived in part from the granite. A K-Ar age of 1,660 m.y. (No. 834) was determined for a specimen from this granitic mass in the Isotope Geology laboratories of the Geological Survey. As this age is similar to two others from map-unit 1, it appears to reflect only the age of the most recent metamorphism.

No other uniformly granitic masses were mapped in Boothia-Somerset area, but here and there an increase in the amount of K-feldspar in quartz monzonites gives rise to local outcrops of granite.

Lithology

The granite northwest of Spence Bay is predominantly porphyritic. Large pink phenocrysts of potash feldspar lie in a fine-grained quartz-feldspar-biotite matrix. Biotite is commonly distorted and appears to flow around the phenocrysts.

In thin section, perthite is visible, usually in the form of fine string perthite.

A micrometric analysis gave the following result.

Table 9. *Mineral Composition of Granite*

Mineral	Volume %
Quartz	36.0
Biotite	12.4
Plagioclase	4.6
Microcline	45.0
Chlorite	0.8
Magnetite	trace
Apatite	1.2
Zircon	trace

QUARTZ DIORITE (map-unit 3b)

Field Relations

Quartz diorite most commonly occurs as part of map-unit 2, but in places in southern Boothia Peninsula it forms part of certain granite outcrops. These rocks appear gradational into the more potash feldspar-rich quartz monzonites. Here and there inclusions of more mafic rock types are encountered. These commonly have somewhat rounded margins, possibly owing to partial remelting during the emplacement of the quartz diorite. The inclusions vary greatly in size, but most are only a few tens of feet in greatest dimension.

Lithology

The quartz diorites are medium grained, massive to weakly foliated, light grey to pinkish. Myrmekite is commonly present in interstices between grains of plagioclase and quartz. The quartz frequently exhibits a mosaic texture. Plagioclase is usually highly altered, mainly to white mica. Potassic feldspar is randomly distributed through these rocks, and both perthite and antiperthite may be present. Small amounts of both hypersthene and diopside are found in the quartz diorites.

Table 10. *Mineral Composition* Table 11. *Chemical Composition* (*recalculated to 100%*)

Quartz Diorite

Mineral	Volume %			Oxide	Weight %		
	(1)	(2)	(3)		(1)	(2)	(3)
Quartz	21.5	27.0	35.0	SiO_2	63.9	58.6	71.4
Plagioclase	51.0[1]	42.0	40.5	Al_2O_3	16.8	20.3	16.3
K-feldspar	13.0	12.0	16.5	Fe_2O_3	1.5	0.1	0.3
Pyroxene	—	11.0	1.0	FeO	2.4	5.9	1.0
Biotite	—	7.0	—	CaO	1.4	5.7	0.7
Magnetite	1.0	1.0	—	MgO	3.9	3.5	0.8
Apatite	1.5	—	—	Na_2O	3.9	3.5	3.4
Zircon	trace	—	—	K_2O	5.1	1.3	5.6
Chlorite	12.0	—	—	TiO_2	0.94	0.92	0.28
Hornblende	—	—	7.0	MnO	0.05	0.08	0.01

[1]Mainly sericite
(1) TA 62-10, (2) TA 62-14, (3) TA 62-32.

QUARTZ MONZONITE (map-unit 3c)

Field Relations

By far the largest group of granitic-textured rocks in the map-area is that containing an abundance of potash feldspar. Quartz is also relatively abundant in these rocks, and most may thus be classified as quartz monzonite. Except for their massive appearance, these rocks are indistinguishable from the quartz monzonites that make up the bulk of map-unit 2. The massive quartz monzonites are medium to fine grained, greyish to reddish, and usually equigranular, although phenocrysts of feldspar and, less commonly, quartz occur.

Lithology

Quartz, potash feldspar, and plagioclase are the principal constituents of the quartz monzonite rocks. Biotite, hornblende, and clinopyroxene may be present in small and varying amounts. Epidote group minerals, mainly zoisite, are present as alterations of feldspar.

Quartz. Clear to smoky quartz predominates. It has a varied habit, and in some specimens large aggregates of sharply margined quartz crystals are found, whereas in others the mineral is interstitial to perthite, and in still other rocks it is found as small subrounded crystals. Some quartz aggregates show strain extinction, and others appear to have been intensely crushed.

Plagioclase. Compositions varying from An_{26} to An_{38} were encountered. The plagioclase thus varies from oligoclase to andesine. Myrmekitic intergrowth is common in most of the sections examined and is usually most highly developed near the contact between plagioclase and potash feldspar grains. In a few sections an albitic rim separates plagioclase and potash feldspar grains. Plagioclase is in general more highly altered than potash feldspar in these rocks, sericite or minerals of the epidote group being the most common products.

Potash feldspar is the most abundant constituent of the quartz monzonites and commonly exceeds 50 per cent of the rock. Twinning is present in some grains, giving rise to the typical 'hatched' appearance of microcline.

In many sections examined perthitic intergrowths are abundant. Bleb perthite is the usual form, but string perthites were also seen. Perthite and microcline crystals are commonly large and may impart a porphyritic appearance to the hand specimen.

Mafic minerals. Biotite, hornblende, and clinopyroxene are the principal mafic minerals. Biotite is pleochroic in shades of yellow to reddish brown. In several sections the biotite appears to be primary and to predate the formation of quartz and alkali-feldspar. Alteration of biotite to chlorite has taken place in some sections, but biotite is more often fresh and unaltered.

Hornblende is pleochroic in shades of yellow-green to green. It is usually an alteration of pyroxene, but some may be primary.

Diopside, present in some of the sections examined, forms discrete aggregates

and is usually less than 5 per cent of the mineral content of the rock. The diopside is mainly unaltered, but in places partial alteration to biotite has taken place.

Accessories. Small amounts of apatite and magnetite are seen in some sections of quartz monzonite but never in excess of 2 per cent.

Micrometric analyses of five thin sections gave the results shown in Tables 12, 13 and 14.

Table 12. ***Mineral Composition***

Mineral	Volume %				
	(1)	(2)	(3)	(4)	(5)
Quartz	24.2	41.0	21.0	26.7	34.0
Plagioclase	15.7	0.5	26.5	8.2	12.5
% An	38	—	—	26	26
K-feldspar	55.0	57.5	34.0	46.0	48.5
Pyroxene	3.0	1.5	—	13.7	—
Biotite	1.5	—	18.0	3.5	4.7
Magnetite	0.5	—	0.5	1.2	0.3
Apatite	—	—	—	0.5	—

Table 13. ***Chemical Composition*** *(recalculated to 100%)*

Quartz Monzonite

Oxide	Weight %			
	(2)	(3)	(4)	(5)
SiO_2	74.1	64.9	64.0	71.1
Al_2O_3	15.5	18.2	17.8	16.5
Fe_2O_3	0.1	0.8	1.2	0.1
FeO	1.0	2.9	3.2	1.8
CaO	1.0	2.0	4.3	1.3
MgO	0.5	0.5	0.5	0.5
Na_2O	3.0	3.0	5.0	2.3
K_2O	4.6	7.0	3.3	6.0
TiO_2	0.1	0.65	0.69	0.32
MnO	0.02	0.02	0.06	0.01

(1) TA 62-16, (2) TA 62-17, (3) TA 62-55, (4) TA 62-65, (5) BE 62-2.

Certain significant oxide ratios are presented in Table 14.

Table 14. ***Selected Oxide Ratios***

	K_2O/Na_2O	MgO/CaO	Al_2O_3/Na_2O	K_2O/CaO
Granite[1]	1.18	0.44	1.51	2.06
Granodiorite[1]	0.71	0.43	1.46	0.62
Quartz diorite[1]	0.62	0.52	1.49	0.39
Granite[2]	1.28	0.31	1.49	3.06
Quartz diorite[2]	1.35	0.99	1.68	1.54
Quartz monzonite[2]	1.48	0.38	1.45	2.42

[1]From Barth, T. F. W., Theoretical Petrology, 1st ed., 1952, p. 69
[2]From this study

Although the ratios for typical granite and for granite from Boothia-Somerset map-area are similar, there is a marked deviation from typical quartz diorite. The quartz diorites of the map-area are much richer in K_2O and MgO. A possible cause of this enrichment may be metamorphic differentiation, an aspect discussed in greater detail on page 41.

Ultrabasic Rock (map-unit 4)

Several small masses of ultrabasic rock outcrop in northern Boothia Peninsula and occur on the east coast of Prince of Wales Island. These rocks are deeply weathered, and colours of moderate yellow-green to moderate yellowish brown predominate on the weathered surface. Gossan is widespread, and the outcrops are easily spotted from the air. Moderate yellow-green veinlets and irregular patches of serpentine are also widespread. North of Amituryouak Lake, pyrrhotite is associated with these rocks. There the gossan is several hundred feet in diameter, but little unaltered ore mineral is exposed at or near the surface. The Amituryouak locality was the only place metallic minerals could be seen in outcrops. This apparent absence is due possibly to the deeply weathered nature of the outcrops.

Two and a half miles northwest of the north end of Nudlukta Lake, thin bands of serpentinized rock are included in the succession of banded gneisses. They are of irregular shape in contrast to more sill-like masses of pyroxene-hornblende gneiss associated with them. A thin section of the serpentinized rocks shows that more than half the rock is composed of serpentine. Within the mass of fibrous serpentine are small grains of olivine, veined and partly replaced by serpentine. The serpentine is also filled with disseminated magnetite with which a green spinel (pleonaste?) is intergrown. The remainder of the rock is composed of pyroxene and large grains of colourless amphibole. Green spinel and colourless amphibole are also constituents of some of the associated hypersthene gneisses.

Serpentinization has been so extensive in many of the ultrabasic rocks that micrometric analyses proved extremely difficult to make. Two chemical analyses were made, however, and are presented in Table 15. The high FeO, MgO, and CaO content of these rocks and virtual absence of K_2O and Na_2O contrast markedly even with the mafic gneisses of map-unit 1.

Table 15. ***Chemical Composition of Ultrabasic Rocks***
(recalculated to 100%)

Oxide	Weight %	
	(1)	(2)
SiO_2	46.9	46.5
Al_2O_3	21.4	20.6
Fe_2O_3	1.5	0.2
FeO	5.2	10.6
CaO	11.3	10.6
MgO	10.6	8.8
Na_2O	1.3	1.1
K_2O	1.4	0.1
TiO_2	0.18	1.1
MnO	0.11	0.19

(1) BE 62-56, (2) BE 62-59.

These rocks are remarkably aluminous. Poldervaart (1955, pp. 134-136) quoted 70 water-free chemical analyses representative of all types of igneous, sedimentary, and metamorphic rocks. None, except metamorphic rocks derived from slates, approaches within two percentage points of the Al_2O_3 content of specimens from map-unit 4. Rocks having a high alumina content are obviously not derived from peridotites but could conceivably have originated from olivine gabbro. The CaO, MgO, and low SiO_2 contents of the rocks represented in Table 15 are consistent with such a source. The abundance of Al_2O_3, however, remains unexplained.

Helikian

Unfossiliferous sedimentary strata, presumed to be Proterozoic, outcrop south and southeast of Aston Bay, northwest Somerset Island. These rocks were first recognized and mapped during Operation Franklin, 1955 (Fortier, *et al.*, 1963), at which time two formations were recognized—the Aston Formation, an assemblage of sandstone and quartzitic sandstone, and the Hunting Formation, an assemblage of carbonate rocks. Both are intruded by sills and dykes of gabbro. The similarity between these rocks and presumed late Precambrian successions elsewhere in the Canadian Arctic was the basis for assigning an Upper Proterozoic age to the Somerset Island succession. The sequence in northern Somerset Island is similar in certain respects to that in northwestern Baffin Island (Lemon and Blackadar, 1963), where a quartzitic succession is overlain by a varied sequence of carbonate and clastic rocks, both groups being cut by gabbro dykes. Age determinations made on two specimens of intrusive rocks collected near Arctic Bay (Blackadar, 1965) gave ages of 914 and 1,140 m.y., which suggests that the intruded rocks are not younger than Neohelikian—to follow the nomenclature proposed by Stockwell (1964, p. 8). Until more definite information is available, it is reasonable to assign a similar age to the succession in northwestern Somerset Island, as field relations are similar.

Snow covered much of the ground at the time personnel of Operation Franklin mapped the Somerset Island exposures, and the Aston Formation as originally mapped was extended too far west owing to confusion between the quartzitic bands in the Hunting Formation and the quartzite of the Aston Formation.

Felsenmeer covers much of the area underlain by the Aston Formation and the surrounding gneisses, and this fact, in addition to the similarity in surface appearance of the formation and gneisses, which is due in part to lichen growth, makes it difficult to separate them either in the course of air observation or during airphoto interpretation. Similarly, it is extremely difficult to separate the many gabbro sills from the intruded Aston Formation. For these reasons contacts are generalized on the accompanying maps, and only the larger intrusions (map-unit 7) are shown.

Owing to operational difficulties, detailed stratigraphic studies in the Aston Bay area during Operation Prince of Wales were not possible, but a one-day helicopter traverse was carried out. Observations made at that time permit a revision in the outcrop pattern of the Aston Formation and the recognition of a new member at the base of the Hunting Formation.

In 1964 the Department of Geology of the University of Ottawa initiated a

study of the geology, meteorology, natural history, and archaeology of parts of Somerset Island (Dineley, 1965; Tuke, *et al.*, 1966). A wide variety of stromatolitic and sedimentary structures was found in Hunting Formation, and magnetometer traverses across the Helikian–Palaeozoic contact near Cape Granite showed little or no evidence of an angular discordance between the Hunting Formation and the Palaeozoic strata.

Aston Formation (map-unit 5)

(Blackadar, R. G., in Fortier, et al., 1963, p. 146)

The Aston Formation was originally described as a succession of light to dark grey, yellow, and red quartzites containing minor amounts of interbedded siltstone, black and red shale, and pebble-conglomerate. The thickness, including that of basic intrusive rock, was reported to be from 3,900 feet to more than 7,000 feet.

In 1962, crossbedded structures with tops up were noted and the unconformable nature of the contact between the gneissic rocks and the Aston Formation was proven. Pebbles in the conglomerate are usually milky quartz and may exceed 1 inch in diameter.

The Aston Formation is overlain conformably by the Hunting Formation.

Hunting Formation (map-unit 6)

(Blackadar, R. G., in Fortier, et al., 1963, p. 146)

The Hunting Formation outcrops on the south side of Aston Bay between Cape Granite and a mile east of Hunting River. At the type locality, measured along Hunting River, this unfossiliferous formation is at least 2,250 feet thick and comprises light grey to yellow dolomite and minor amounts of interbedded shale and conglomerate.

A banded unit comprising moderate orange-pink and light grey dolomite (map-unit 6a) is present near the base of the formation although not recognized at the extreme eastern and western limits of the outcrop area. The thickness of individual bands varies but averages about 100 feet. The total thickness of the banded unit may exceed 2,000 feet.

Quartzitic members appear more abundant in the Hunting Formation than they were previously thought to be. Many are medium grey, possibly because of argillaceous material.

The Hunting Formation overlies the Aston Formation conformably. The upper contact of the formation has not been observed.

Diabase Intrusions (map-unit 7)

Sills and dykes of diabase and gabbro intrude the Precambrian strata in all parts of the map-area (*see* Pl. VI) but are particularly abundant in northern Somerset Island, where they form a network of diversely oriented, narrow, steeply dipping dykes. The varying orientation of these dykes appears to be related to fracture patterns developed in the Boothia Arch. Some can be traced upwards of 10 miles but others are discontinuous, appearing and disappearing along the same fracture zone.

PLATE VI

Narrow diabase dykes, south shore, Astronomical Society Islands.

FCT 2-7-62

Still others are arranged *en échelon* and occupy parallel fractures. Hardly any exceeds more than a few tens of feet in width.

Near Bellot Strait a few thin sills of gabbro are included in the steeply dipping, north-trending gneissic complex, and a few dykes are also present (*see* Pl. VII).

RGB 3-4-62

PLATE VII. Sill-like apophyses of diabase intrusive into gneissic complex, Levesque Harbour, northern Boothia Peninsula.

Within Boothia-Somerset map-area only two dykes can be traced for tens of miles, in contrast to northern Baffin Island, to the east, where similar intrusions form a belt 15 miles wide and traceable for more than 100 miles. These two occur on Boothia Peninsula. They are several hundreds of feet wide, and one extends more than 70 miles northwest from north of Thom Bay. Here and there are smaller dykes, some closely paralleling the two larger ones, others lying perpendicular to them.

Where basic intrusions have been injected into unmetamorphosed sedimentary rocks, their characteristic form is sills rather than dykes. The type section of the Aston Formation contains, in all, more than 1,400 feet of gabbro, one sill exceeding 600 feet in thickness. Differentiation that has occurred in the larger of these sills has resulted in 'red-rock' and segregations of quartz.

Within the crystalline complex, some diabase dykes and sills appear older than the main series. These rocks are commonly foliated parallel with the foliation of the gneisses and are usually more highly altered than the rocks of the main series. In places, these 'old diabases' are cut by granite. Some could be traced for at least 1,000 feet and are several hundreds of feet wide. In general, they are more highly altered than the 'younger series' and are not easily confused with them. They are mapped with unit 1.

Petrography

The diabase dykes are remarkably similar in mineral composition. Plagioclase and pyroxene are the principal minerals present, the latter sometimes being altered to hornblende or biotite. Quartz is relatively scarce, in contrast to similar intrusions on Baffin Island (Lemon and Blackadar, 1963). Magnetite and apatite are ubiquitous but never abundant. Olivine was recognized from only one locality, north of Thom Bay near the southern limit of the largest dyke in the map-area.

Plagioclase. Twinned, lath-like crystals of plagioclase intergrown with pyroxene impart the characteristic diabasic texture to the dyke rocks. In some sections examined, extensive alteration to sericite or saussurite has taken place, but most rocks are more or less unaltered. Zoned crystals are present in a few sections. Usually it is the largest crystal that shows the greatest development of zoning. A composition of An_{62} was determined from the central part of a well-zoned crystal from a dyke north of Stanwell-Fletcher Lake, Somerset Island. Compositions for unzoned, lath-like crystals fall within the andesine range.

Pyroxene. Augite is the principal pyroxene in these rocks, although some contain diopside. Hypersthene was recognized in a few thin sections. Some pyroxene crystals are zoned and others show exsolution lamellae of a second pyroxene along twin planes. Pigeonite appears in many sections as a second pyroxene, but the relative proportions of the two pyroxenes were not determined.

Retrograde metamorphism has resulted in the formation of hornblende, biotite, and chlorite. In some sections alteration is incipient, but in others only the crystal outline serves to establish the former presence of pyroxene.

Quartz and micropegmatite are generally interstitial and are insignificant in the total composition of the rock rarely exceeding 5 per cent.

Where the intrusive rocks are in the form of sills, especially where strata of the Aston and Hunting Formations have been intruded, there has been some differentiation. The centres of such sills are richer in quartz and micropegmatite and tend to be coarser grained than the margins. Hydrothermal alteration has been especially active under these conditions, and much of the plagioclase and pyroxene is completely altered. In outcrops such rocks weather readily and the surface is commonly a sandy rubble.

Data in Table 16 are illustrative of the composition of the basic dykes.

Table 16. *Mineral Composition of Diabase Dykes*

Mineral	Volume %								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Quartz	1.1	0.3	0.7	1.7	—	2.3	3.3	2.3	0.3
Plagioclase	37.0	45.7	56.7	58.5	37.3	46.3	56.9	48.3	55.9
Micropegmatite	2.0	—	0.5	4.1	—	—	—	3.9	1.6
Pyroxene	46.3	24.0	34.2	27.5	46.2	17.5	10.6	31.1	38.4
Hornblende	7.0	26.5	2.5	5.7	15.4	12.5	9.8	7.0	—
Biotite	1.3	0.3	0.5	trace	—	2.9	6.9	0.5	1.5
Magnetite	5.1	3.2	2.5	2.4	1.1	8.3	12.5	4.8	2.1
Apatite	trace	trace	trace	trace	trace	trace	trace	trace	trace
Olivine	—	—	2.5	—	—	—	—	—	—

(1) BE 62-61, (2) TA 62-72, (3) TA 62-19, (4) BE 62-39, (5) TA 62-84, (6) TA 62-50, (7) TA 62-49, (8) BE 62-110, (9) BE 62-69.

Table 17. *Chemical Composition of Diabase Dykes*
(recalculated to 100%)

Oxide	Weight %			
	(1)	(4)	(5)	(9)
SiO_2	50.1	51.9	50.2	53.4
Al_2O_3	12.7	18.9	16.9	16.0
Fe_2O_3	2.2	1.8	0.7	0.9
FeO	11.4	7.8	7.7	6.4
CaO	11.8	11.9	13.5	14.3
MgO	6.8	3.3	7.2	5.3
Na_2O	2.6	2.6	2.1	2.0
K_2O	0.1	0.7	0.5	0.3
TiO_2	2.1	0.91	0.91	0.86
MnO	0.25	0.16	0.17	0.17

(1) BE 62-61, (4) BE 62-39, (5) TA 62-84, (9) BE 62-69.

The quartz content of these rocks is surprisingly low. Similar intrusions in northern Baffin Island contain as much as 10 per cent quartz, and the combined

quartz and micropegmatite content may exceed 20 per cent (Lemon and Blackadar, 1963, p. 37). In other respects the mineralogy of these rocks does not differ markedly from that of the northern Baffin Island intrusions.

Barth (1962, p. 191) presents chemical analyses of typical diabases from widely separated localities. A comparison of the data contained in Table 17 with Barth's data shows that the Boothia-Somerset diabase dykes contain less TiO_2, K_2O, and Na_2O and are richer in iron (both Fe_2O_3 and FeO) and CaO. Titanium in gabbroic rocks is commonly contained in titaniferous magnetite. The generally low magnetite content (Table 16) may be the cause of the low TiO_2 content in the Boothia-Somerset diabases.

The relatively high SiO_2 content and the low MgO and (Na_2O+K_2O) contents suggest that the diabasic rocks of the Boothia-Somerset region belong to the tholeiitic magma type rather than to the olivine-basalt magma type.

Chapter III

STRUCTURAL GEOLOGY

Introduction

The Precambrian granitic and gneissic rocks on Boothia Peninsula and Somerset Island form the Boothia Arch, a structural feature that remained active at least into Palaeozoic time. Cambrian and Ordovician strata (Kerr and Christie, 1965) flank the arch. Most are flat-lying to gently dipping, but here and there steep flexures obtain along linear zones, apparently reflecting faulting in the crystalline rocks. That structures on the east and west sides of the arch are not symmetrical indicates that the arch is not the result of simple upward flexing (*op. cit.*). On the east flank of the arch, block faulting in the basement appears to be the cause of numerous faults and rapid undulations in the Palaeozoic strata, whereas on the west flank a zone of vertical and overturned Palaeozoic strata, as well as widespread areas in which basal Palaeozoic beds are absent, are thought to be due to thrust faulting. The effects of block faulting within the crystalline rocks are reflected by several large Palaeozoic outliers on southern Boothia Peninsula a few miles north of Spence Bay and on Somerset Island east and south of Stanwell-Fletcher Lake.

Unfossiliferous, presumably Helikian, sedimentary strata (the Aston and Hunting Formations) flank the northernmost exposures of the Boothia Arch. Numerous small faults mark the contact between the crystalline rocks and the Hunting Formation.

The dominance of north-trending foliation within the crystalline complex, combined with two principal lineament directions, has had a marked effect on topography. On northern Boothia Peninsula and southern Somerset Island the combination of these features imparts a blocky appearance to the land (Pl. I), and the major drainage patterns also reflect the dominance of these structural features.

Structural Elements

Foliation. Compared with many Precambrian gneissic areas, Boothia-Somerset area is structurally simple. The convoluted structures so common in Grenville type terranes are absent, and the area is dominated instead by a north-trending foliation that shows little variation across the entire area. This foliation is most obvious on Somer-

set Island and western Boothia Peninsula, where from the air the beds give the impression of marching rank on parallel rank as far as the eye can see. Most are steeply dipping, and dips in excess of 70 degrees are common. Southeastern Boothia Peninsula is somewhat more diverse, a few major folds being recognized. The axes of most of these trend north, thus conforming to the predominant foliation direction (*see* Figs. 1 and 2).

Foliation in the area derives from orientation of platy minerals such as biotite and is emphasized by the common alternation of felsic and mafic bands in the gneissic complex. Felsic components, especially feldspar, may also form a lineation, thus serving to emphasize the orientation of the strata.

Boudinage. Boudinage structure is well developed in *lit-par-lit* gneiss, in which bands of granitic material pinch and swell along strike. Similarly amphibolite bands show great variation in thickness along strike and may even become disarticulated. In general, however, boudinage structure is not dominant throughout the area.

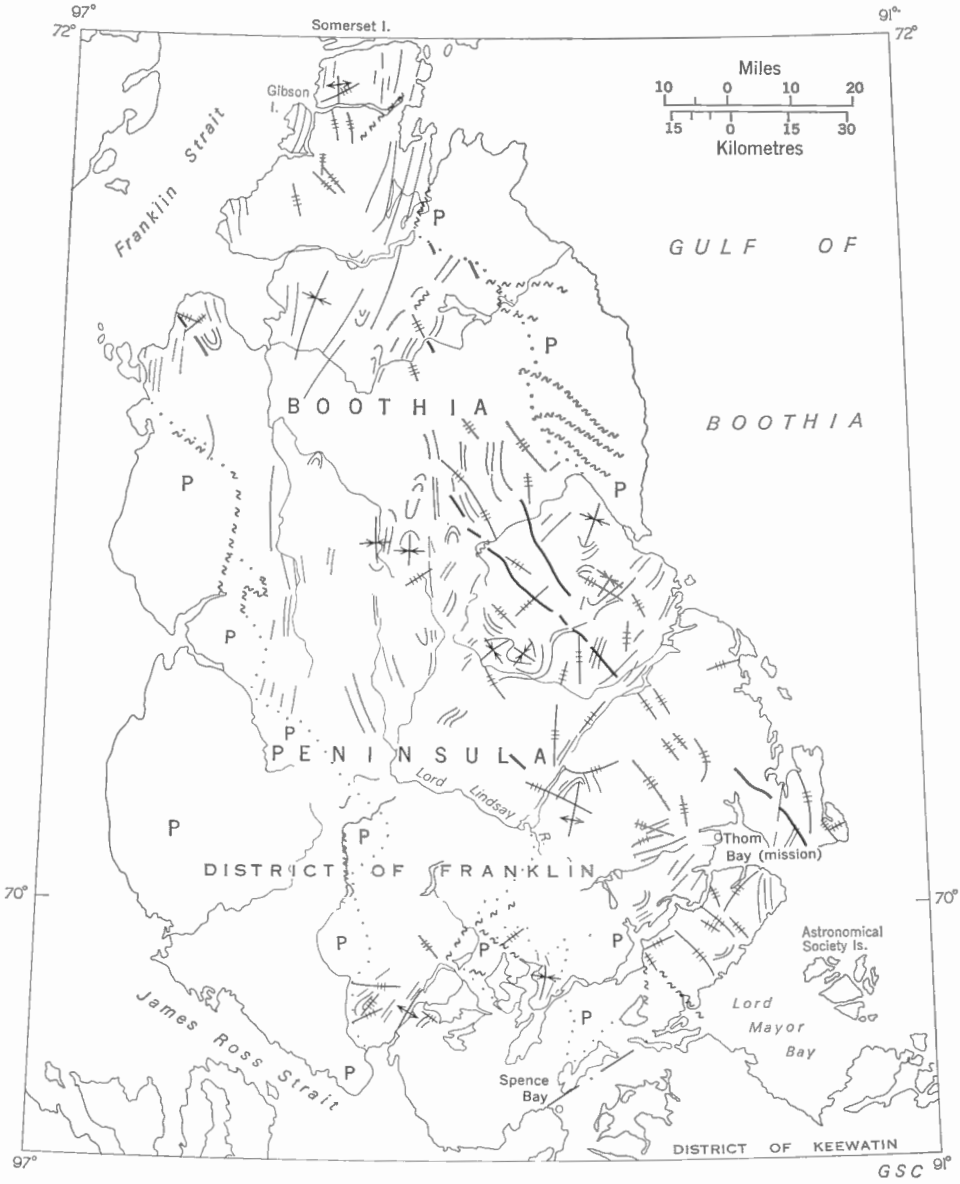
Boudinage structure is an indication of the degree of plastic deformation that has occurred in the rock mass, and its relative absence supports the conclusion derived from the relatively simple foliation pattern, that the Boothia-Somerset gneisses were on the whole not in a highly plastic state during deformation.

Joints. Most of the crystalline rocks are jointed. Because of the reconnaissance nature of the field program, however, and the large area examined, the joints were not systematically studied. The felsic gneisses (map-unit 2) and the granitic rocks (3) are most generally jointed. Usually at least two sets of joints are involved, commonly three. One direction is dominant and closely parallels one of the two principal lineament directions about to be discussed. Little movement seems to have occurred along the joint planes.

Faults and linear features. Figures 1 and 2 clearly show the dominance of two orientations of linear features. The most significant direction appears to be northwest to north-northwest, the direction of most of the diabase dykes and of the widest and most extensive linear features. A large number of features are northeasterly aligned, as are a few small diabase dykes.

Topographically the linear zones are marked by scarps or steep-walled, continuous valleys. A most outstanding example is in the vicinity of Lord Mayor Bay. This bay, in gross detail almost a perfect rectangle, is bounded on the north by the straight, northwesterly trending shores of Astronomical Society Islands (*see* Pl. I). The south shore is a steep, northwest-trending scarp that can be traced northwestward from the bay for at least 40 miles and southeast for the same distance. Movement has occurred along this scarp, some at least post-dating the intrusion of a diabase dyke that outcrops near the southwest corner of the bay. Evidence for this movement is found in slickensides along the margin of the dyke. Elsewhere, mylonite and highly fractured bedrock mark the locus of the lineament.

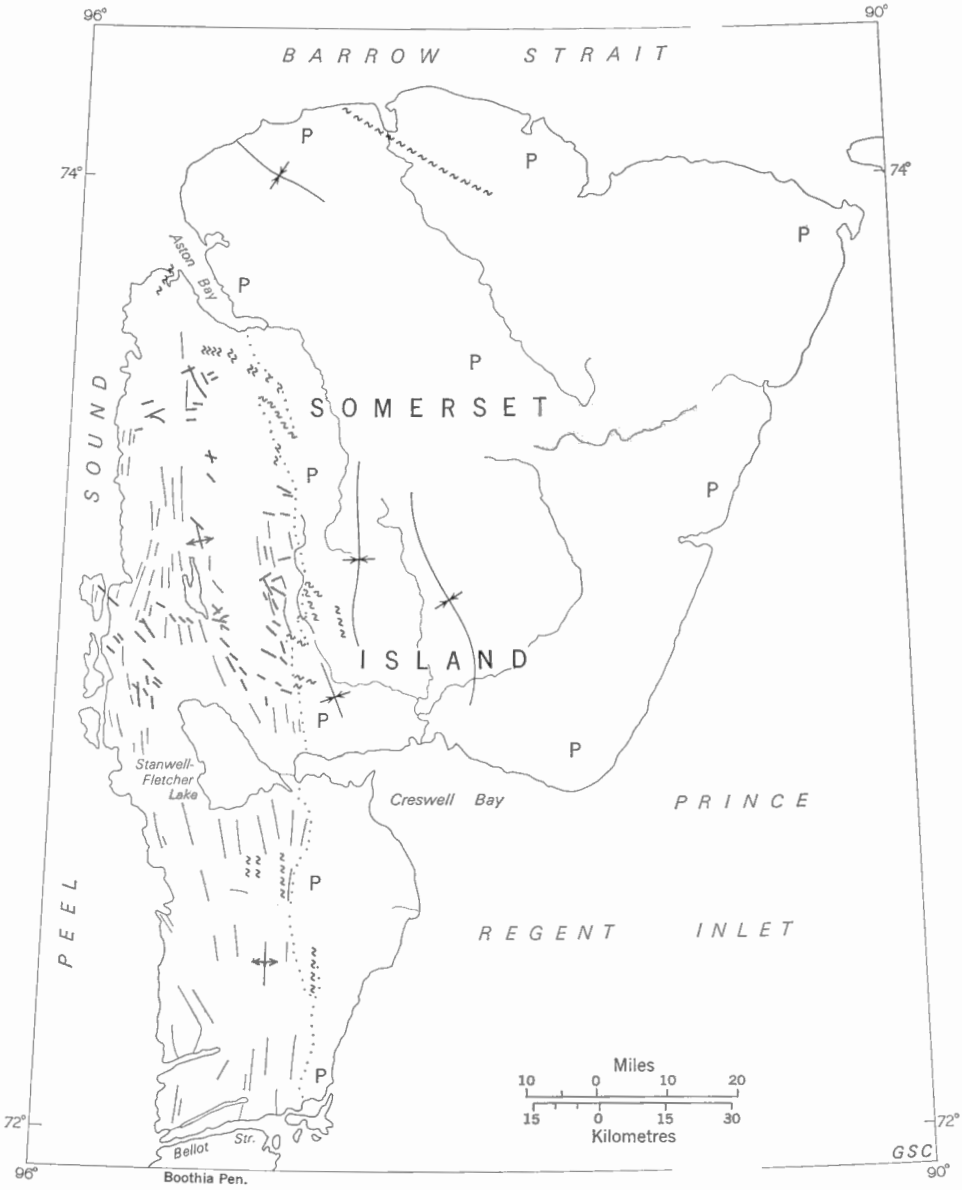
Sanagak Lake and the chain of lakes to the north leading into Agnew River are a good example of a northeast-trending linear feature. Steep cliffs more than 1,000 feet high rise above the lake levels. Several parallel breaks that occur close together



LEGEND

Palaeozoic outcrop	P	*Lineament*	
Diabase dyke		*Fault (assumed)*	
Geological boundary (approximate)		*Anticline*	
Structural trend		*Syncline*	

FIGURE 1. Structural elements, Boothia Peninsula.



LEGEND

Palaeozoic outcrop	P	*Structural trend*	
Diabase dyke		*Fault (assumed)*	
Geological boundary (approximate)		*Anticline*	
		Syncline	

FIGURE 2. Structural elements, Somerset Island.

have been differentially deepened by erosion. Thus the river and lake system has a step-like appearance, which always trends northeast. Garry River and the lakes that constitute its headwaters in southwest Boothia Peninsula appear to be a southward continuation of the 'Sanagak Lineament'. They form a very distinctive feature.

Other prominent features having a northeasterly trend or, in some cases, a more easterly one, are Bellot Strait, Fitz Roy Inlet, Macgregor Laird Lake, which is on Somerset Island, and Pattinson Harbour and Amituryouak Lake, which are in northern Boothia Peninsula.

These two principal structural directions have been dominant throughout the geological history of Boothia-Somerset region. Uplift in the northern part of the Boothia Arch after deposition of the Aston and Hunting Formations caused small northeast-trending faults along the southern contact of the Hunting Formation.

Uplift of the Arch continued throughout much of Palaeozoic times. After deposition of lower Palaeozoic strata, this uplift resulted in the formation of major faults, especially along the east flank of the Arch. There many northwest-trending faults give a serrated contact between crystalline rocks and the Palaeozoic sedimentary strata. Elsewhere block faulting resulted in the downdropping of the Palaeozoic strata now preserved as outliers within the crystalline rocks. Such outliers are found in southern Boothia Peninsula west of Kangikjuke Lake and in southern Somerset Island. In the former locality northwest- and northeast-trending faults are believed to bound the outcrop area; in the latter the fault directions are more northerly.

Folds. The relatively uncomplicated structure of the area has previously been mentioned. The accompanying maps and Figures 1 and 2 show that strike directions are generally uniform, yet there are gentle undulations. Steep dips are common, but in places there is nearly horizontal foliation. Here and there, especially in northern and eastern Boothia Peninsula, there are broad synclines and anticlines. Although a diverse orientation characterizes the axes of these, a northerly to northeasterly trend appears most common.

Chapter IV

METAMORPHISM

Facies

All Precambrian rocks in the area older than the Aston Formation have been metamorphosed and, although there is some variation in the degree of metamorphism, all rocks show features indicative of relatively high grade metamorphism. This general uniformity and the reconnaissance nature of the mapping carried out during Operation Prince of Wales preclude drawing any definite facies boundaries.

Tables 19 to 25 (Appendix A) give typical mineral associations for map-units 1, 2, and 3.

The mineral associations of hypersthene gneiss in Table 19 indicate that this assemblage is of the pyroxene granulite subfacies of the granulite facies (Fyfe, Turner, and Verhoogen, 1958, p. 234) and as such is indicative of high temperature and pressure during metamorphism.

Diopside gneiss of map-unit 1 (Table 21) would also appear to be part of the same subfacies although, according to Fyfe, *et al.* (*op. cit.*), the alkali feldspars in this subfacies are characteristically perthite and the plagioclase is antiperthitic. The almost total absence of perthite in these rocks is seen from Table 21.

The granulite facies as proposed by Eskola was said to be deficient in cordierite, but, Fyfe, *et al.* (*op. cit.*, p. 235) consider that this mineral may occur in their new hornblende granulite subfacies of the granulite facies. Mineral associations of cordierite gneiss as given in Table 21 differ from the expected in that pyroxene is absent. In fact, biotite is the only mafic mineral present. Sillimanite is abundant in three of the cordierite-bearing gneisses and is intimately interlayered with biotite. Sillimanite is more indicative of the pyroxene granulite subfacies than of the hornblende granulite subfacies. It would appear logical, however, to place the cordierite-bearing gneiss in the granulite facies and probably in the hornblende subfacies.

Table 19 gives the mineral associations of biotite gneiss, the most widespread group of rocks in map-unit 1. These data indicate a similarity to the staurolite-quartz subfacies of the almandine-amphibolite facies and thus indicate temperatures approaching those of the granulite facies. The presence of hornblende and biotite indicates high water pressure.

That two facies characterize the rock of map-unit 1 is not surprising. Both result

from high pressure and temperatures probably in excess of 700°C and differ mainly in the presence or absence of hydrous silicates.

The felsic gneisses (2) include similar facies. The most abundant rock type is quartz-feldspar gneiss that has mineral associations typical of those given in Table 22. The rather widespread occurrence of small amounts of pyroxene and amphibole in these rocks suggests that they fall into the hornblende granulite subfacies, although the quartz-feldspathic assemblages of this subfacies are still rather imperfectly described and little distinction is made between these rocks and similar associations in the almandine-amphibolite facies.

Cordierite-sillimanite quartzo-feldspathic rocks are extremely rare in map-unit 2. Where present, however, they indicate the sillimanite-almandine subfacies of the almandine-amphibolite facies.

From the preceding it will be apparent that the predominant rock types in the area all attained about the same degree of metamorphism and that it was relatively high.

The granitic rocks of map-unit 3 also appear to have been subjected to the same regional metamorphism as affected units 1 and 2. The mineral associations, listed in Table 25, are characteristic of the granulite facies.

Age of Metamorphism

Three K-Ar age determinations have been made of the gneisses and granitic rocks of Boothia-Somerset region in the laboratories of the Geological Survey.

The first of these (K-Ar No. 832) was determined on orange-brown biotite from a narrow band of biotite gneiss within felsic gneiss on Boothia Peninsula (71°18′N,95°55′W). It gave an age of 1,635 m.y.

The second (K-Ar No. 833) was also determined on orange-brown biotite from biotite gneiss (1d). This specimen is from southern Somerset Island (72°38′N, 95°50′W) and gave an age of 1,670 m.y.

The third determination (K-Ar No. 834), already quoted in the description of map-unit 3, was made on brown biotite from a specimen of granite from southern Boothia Peninsula and gave an age of 1,660 m.y.

It is apparent that all these ages reflect the same period of metamorphism, Aphebian in age and substantiate the northward extension of the Churchill structural province (Stockwell, 1961).

Origin of the Gneisses

Despite the prevalence of migmatite, *lit-par-lit* gneisses, and other structural forms—features indicative of partial mobility in some components of the gneisses—the writer considers that most rocks now included in the gneissic groups are of sedimentary or volcanic origin.

Large-scale, clearly intrusive contacts are rarely seen even in the large bodies of relatively massive, unfoliated granitic rock (map-unit 3) in south and southeast

Boothia Peninsula. These rocks can be traced with no apparent break into the extensive area of leucocratic gneisses of eastern Boothia Peninsula.

Although the alternation of leucocratic and melanocratic layers in some gneisses may reflect original variations in composition, as does, for example, the alternation of beds of arkose with more shaly layers, many of the gneissic structures are probably the result of 'injection' of the leucocratic phase. The absence of any truly intrusive granite in the map-area suggests to the writer that this 'injected' material originated from the melting of quartz-feldspar-rich sedimentary rocks and not from some large igneous mass.

Evidence for the non-igneous origin of much of the gneissic complex is widespread. The presence of bands of crystalline limestone interbedded with the gneisses near Bellot Strait suggests a sedimentary origin for both the enclosing gneisses and the carbonate bands. Similarly many of the leucocratic gneisses contain abundant plagioclase and quartz, and some still exhibit gradation between coarse- and fine-grained layers. Such rocks may be metamorphosed arkose. Many melanocratic gneisses may be derived by metamorphism of argillaceous sedimentary rocks, but others are obviously of volcanic or igneous origin. Basic sills and dykes predating the Hudsonian period of metamorphism were recognized throughout the region. In many, the diabasic texture is still visible although the original minerals have been extensively altered—plagioclase to sericite and saussurite, and ferromagnesian minerals to chlorite and uralite.

Amphibolite bands, present in both map-units 1 and 2, may locally form up to 20 per cent of the rock. They may be derived from marly or calcareous sedimentary rocks, basic or ultrabasic intrusive rocks, or volcanic rocks. In Boothia-Somerset map-area no relic textural features were found that could establish their original nature.

Rusty schist and gneisses (1f), particularly widespread in northern Boothia Peninsula and southern Somerset Island, are thought to represent layers of pelitic sedimentary rocks that were more highly sheared during folding because of their original bedded structure. Metasomatism connected with the development of the innumerable pegmatite dykelets that transect these rocks may have effected the alteration of biotite to sericite, muscovite, alkali feldspar, and quartz. The 'Fe' freed by these processes formed the pyrite and magnetite so characteristic of the rusty gneisses, and these minerals in turn have in places been replaced by iron oxides and hydroxides which give rise to the extensive gossan zones seen in parts of the region.

Even stronger evidence for a sedimentary origin for rusty schists and gneisses is graphite, a common constituent of these rocks. It is difficult to explain its presence if the rusty rocks are other than sediment-derived.

All pre-Aston Formation rocks reflect widespread metasomatism, a process that presumably took place late during the principal metamorphism or even followed it. This was potash metasomatism, and many thin sections disclose its effects. Potash feldspar may form discrete grains intergranular to quartz and plagioclase, or it may all but replace the original feldspar. Perthites are widespread. Some appear to be true

exsolution features, but most, by their irregular habit, indicate a replacement origin. Antiperthite is not uncommon (*see* Tables 19-25); by many petrographers this structure is thought to be primarily replacement in origin.

The most obvious metasomatic effects are the ubiquitous veins and dykelets of microcline-quartz. These cut randomly across outcrops, vary from a few inches to hundreds of feet in length, and may be sheet-like or rod-like in habit. Few have the continuity indicative of a common source. Rather, they appear to have formed in situ and are presumed to have been derived from the schists and gneisses in which they are now found.

A similar process operated in areas of *lit-par-lit* gneiss and migmatite. Bands of felsic gneiss with large porphyroblasts of microcline are an obvious result.

The field evidence presented is strongly suggestive of a sedimentary origin for much of the gneissic complex, and possible source rocks have been suggested.

Table 18, with data drawn from Appendix B and the literature, compares chemical analyses of the Boothia-Somerset gneisses with chemical analyses of classic gneissic areas and with possible sedimentary source rocks. The 'rapid method' of chemical analysis used in the preparation of the analyses accompanying this report is less precise than the time-consuming methods used in standard rock analyses, and the consequent difference in precision must be kept in mind when results derived by the different methods are compared. The accuracy of the method is discussed in greater detail in the introduction to Appendix B.

Table 18. *Chemical Analyses of Gneissic and Sedimentary Rocks*

Oxide	Weight %						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SiO_2	52.0	61.6	64.5	64.4	70.9	69.7	58.1
Al_2O_3	17.4	19.3	17.5	16.3	12.2	13.5	15.4
Fe_2O_3	2.1	0.7	1.5	1.9	1.3	0.7	4.0
FeO	7.28	4.7	3.9	4.4	4.1	3.1	2.5
CaO	11.0	5.3	4.6	5.7	1.6	1.9	3.1
MgO	4.0	1.3	1.4	2.2	2.3	2.0	2.4
Na_2O	3.4	4.0	3.5	3.5	3.7	4.2	1.3
K_2O	1.6	2.3	2.6	0.6	2.9	1.7	3.2
TiO_2	0.9	0.8	0.7	0.6	0.3	0.4	0.7
MnO	0.2	0.1	0.1	0.1	0.04	0.01	—
H_2O	—	—	—	—	—	2.3	5.0
CO_2	—	—	—	—	—	—	2.6
SO_3	—	—	—	—	—	—	0.6

(1) Diopside-quartz-feldspar gneiss (1b) Table 27
(2) Hypersthene-quartz-feldspar gneiss (1c) Table 28
(3) Biotite-quartz-feldspar gneiss (1d) Table 29
(4) Isortoq gneiss, Ramberg (1948)
(5) Quartz-biotite gneiss, Grenville series, Engel and Engel (1953, p. 1039)
(6) Average of three greywackes, Engel and Engel (1953, p. 1039)
(7) Average shale, Engel and Engel (1953, p. 1039)

Many gneissic complexes, those in map-unit 1 included, exhibit evidence of addition of substances, although there may be some segregation of substances. If the original sedimentary source rocks are shales or shaly sandstones, the K_2O/Na_2O ratio should exceed 2.0 (*see* Table 18, col. 7), yet in all cases the ratio is less than 1.0 in the gneissic rocks of map-unit 1. In other sedimentary rocks the ratio should be equally high: for sandstone K_2O/Na_2O should approximate 2.9 and for a mixed shale-sandstone-limestone this ratio should be about 2.5 (*see* Pettijohn, 1957, p. 106). The explanation seems to be that such rocks are formed under weathering conditions that permit the leaching of soda and its removal before deposition. Greywacke, on the other hand, is a clastic rock deposited soon after formation. Both sorting and weathering are incomplete. Leaching is relatively restricted, and the resultant rock is much richer in soda than in potash. A comparison of column 6, Table 18, with the preceding five columns illustrates the similarities in alkali content. Greywacke is characteristic of geosynclinal deposits and is commonly associated with volcanic rocks. Field evidence indicates that some of the melanocratic gneisses may be metavolcanic rocks, although no unequivocal evidence was seen.

The field observations and the chemical data discussed in the preceding paragraph suggest that the melanocratic gneissic rocks (map-unit 1) may represent a metamorphosed succession of greywackes and minor volcanic rocks.

The leucocratic gneisses (map-unit 2) exhibit a less consistent pattern in the ratio of K_2O/Na_2O. Data in Table 31 indicate that this ratio varies from 0.25 to 2.29. Those specimens in which the K_2O/Na_2O ratio is high contain perthite and microcline and commonly show a myrmekitic intergrowth. Petrographic evidence indicates that potash has been added to these rocks, and the spotty distribution of potash is indicative of the nature of this addition.

Several authorities (e.g., Ramberg, 1948, and Engel and Engel, 1958) have pointed out that when metamorphism takes place under granulite facies conditions, there is a tendency for the stable association to approach a quartz diorite in composition rather than a granite or a granodiorite. Certain elements are thought to be expelled and to migrate to places where lower metamorphic conditions prevail. Predominant amongst these elements are Si, K, Na, O; H_2O is also squeezed out. Such a process would leave a rock more mafic than its source rock. The trend of this 'metamorphic differentiation' is illustrated in Figure 3.

For all but cordierite-sillimanite gneiss (1a) the trend is regular.

Banding so well developed over wide stretches of the gneissic complex may reflect actual sedimentary layering. It is difficult, however, to visualize processes of sedimentation that would result in the rapid alternation of beds rich in Mg, Ca, and Fe, with those in which Si, Na, and K predominate. It seems more probable that there has been some differentiation that has accentuated possible original lithological variations. If such a process operated, it becomes increasingly difficult to speculate on the primary composition of the source rocks of the gneissic complex.

Speculation on the origin of granitic and gneissic rocks by metamorphic processes is filled with difficulties, for, as F. Grout wisely observed, "the first and almost insurmountable difficulty in proving that an igneous-looking rock resulted from the

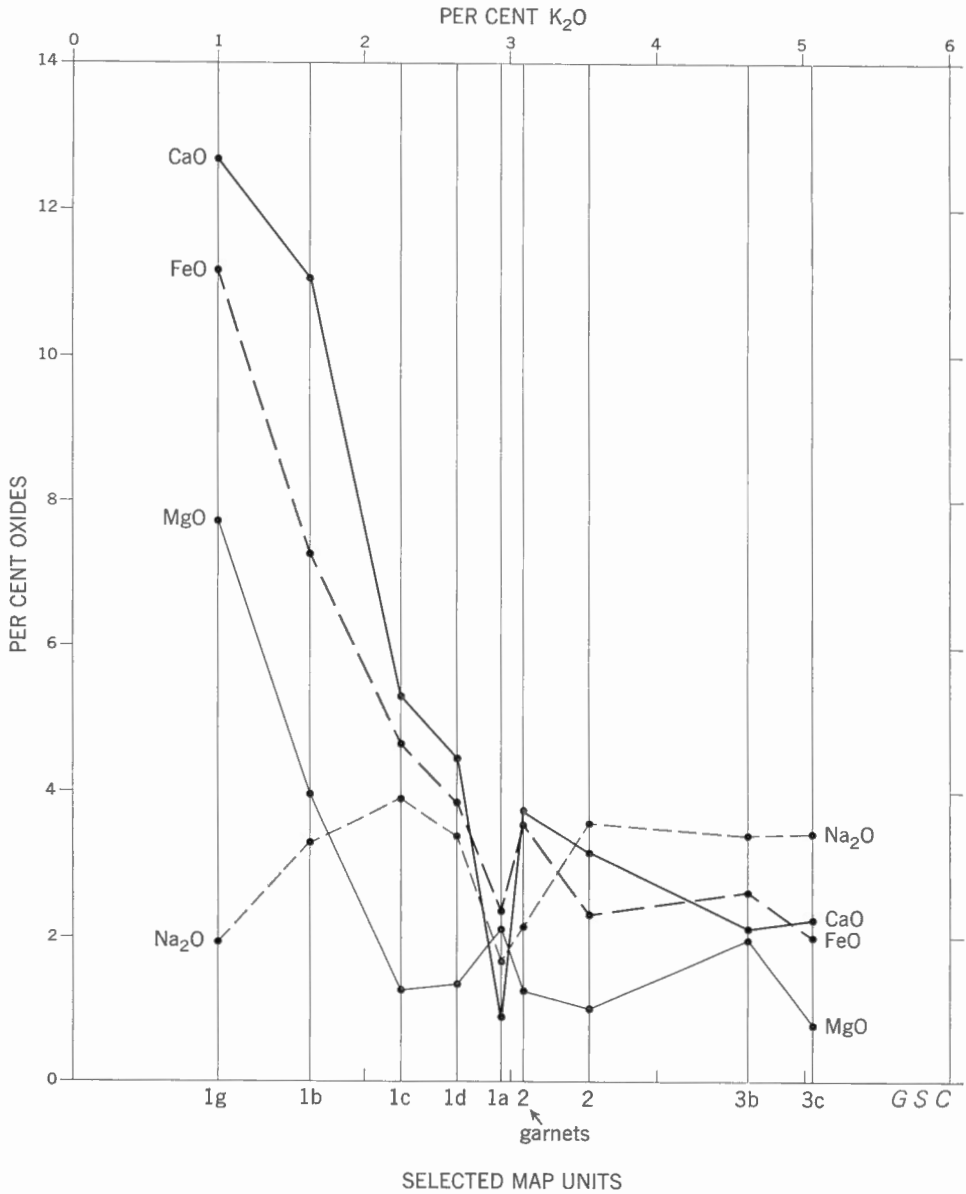


FIGURE 3. Variation of oxide per cent of selected elements plotted against per cent K_2O.

metasomatism of one that was not previously igneous-looking is that the more successful the process is the more completely it destroys the evidence of the process by which it was formed". The writer nevertheless considers that the chemical and other data presented in the preceding pages indicate that many of the gneisses of Boothia-Somerset region, even the most granitic looking, are metamorphosed sedimentary and volcanic rocks. Partial melting of this succession and injection of the mobile fraction into less plastic material took place under high temperature and pressure and was followed by potash metasomatism.

REFERENCES

Barth, T. F. W.
1952: Theoretical igneous petrology, 1st ed.; New York, John Wiley & Sons.
1962: Theoretical igneous petrology, 2nd ed.; New York, John Wiley & Sons.

Blackadar, R. G.
1965: Geological reconnaissance of the Precambrian of northwest Baffin Island, Northwest Territories; *Geol. Surv. Can.*, Paper 64-42.

Blackadar, R. G., and Christie, R. L.
1963: Geological reconnaissance, Boothia Peninsula and Somerset, King William and Prince of Wales Islands, District of Franklin; *Geol. Surv. Can.*, Paper 63-19.

Craig, B. G.
1964: Surficial geology of Boothia Peninsula, King William Island, Somerset Island and Prince of Wales Island, District of Franklin; *Geol. Surv. Can.*, Paper 63-44.

Dineley, D. L.
1965: Notes on the scientific results of the University of Ottawa expedition to Somerset Island, 1964; *Arctic*, vol 18, No. 1, pp. 55-57.

Engel, A. E. J., and Engel, C. G.
1953: Grenville series in the northwest Adirondack Mountains, New York; *Bull. Geol. Soc. Amer.*, vol. 64, pp. 1013-1097.
1958: Progressive metamorphism and granitization of the major paragneiss, northwest Adirondack Mountains, New York; *Bull. Geol. Soc. Amer.*, vol. 69, pp. 1369-1414.

Fortier, Y. O.
1957: The Arctic Archipelago, *in* Geology and economic minerals of Canada; *Geol. Surv. Can.*, Econ. Geol. Ser. No. 1 (4th ed., C. H. Stockwell, ed.).

Fortier, Y. O., *et al.*
1963: Geology of the north-central part of the Arctic Archipelago, Northwest Territories; *Geol. Surv. Can.*, Mem. 320.

Fyfe, W. S., Turner, F. J., and Verhoogen, J.
1958: Metamorphic reactions and metamorphic facies; *Geol. Soc. Amer.*, Mem. 73.

Kerr, J. W., and Christie, R. L.
1965: Tectonic history of Boothia uplift and Cornwallis Fold Belt, Arctic Canada; *Bull. Am. Assoc. Petrol. Geol.*, vol. 49, pp. 905-926.

Lemon, R. R. H., and Blackadar, R. G.
1963: Admiralty Inlet area, Baffin Island, District of Franklin; *Geol. Surv. Can.*, Mem. 328.

Mehnert, K. R.
1962: Zur Systematik der Migmatite; *Kristalinikum* 1, Prague, pp. 95-110.

Pettijohn, F. J.
1957: Sedimentary rocks, 2nd ed.; New York, Harper and Brothers.

Poldervaart, A.
1955: Chemistry of the earth's crust, *in* "Crust of the earth"; *Geol. Soc. Amer.*, Special Paper 62.

Ramberg, H.
1948: On the petrogenesis of the gneiss complexes between Sukkertoppen and Christianshaab, West-Greenland; *Medd. fra Dansk Geol. Forening*, vol. 11, No. 3, pp. 312-327.

Riley, G. C.
1960: Petrology of the gneisses of Cumberland Sound, Baffin Island, Northwest Territories; *Geol. Surv. Can.*, Bull. 61.

Ross, Sir John
1835: Narrative of a second voyage, vol. 2, app., pt. 2, pp. 101-106; London, A. W. Webster.

Stockwell, C. H.
1961: Structural provinces, orogenies and time classification of rocks of the Precambrian Shield; *in* Age determinations by the Geological Survey of Canada, Report 2, compiled by J. A. Lowden; *Geol. Surv. Can.*, Paper 61-17.
1964: Fourth report on structural provinces, orogenies, and time classification of rocks of the Canadian Precambrian Shield; *in* Age determinations and geological studies; *Geol. Surv. Can.*, Paper 64-17 (pt. 2).

Tuke, M. F., Dineley, D. L., and Rust, B. R.
1966: The basal sedimentary rocks in Somerset Island, N.W.T.; *Can. J. Earth Sciences*, vol. 3, No. 5, pp. 697-711.

APPENDIX A

MINERAL ASSOCIATIONS

Tables 19-25

Table 19. *Biotite Gneiss (map-unit 1d)*

	1	2	3	4	5	6
Quartz	X	X	X	X	X	X
Plagioclase	X	X	X	X	X	X
% An	30	33	34	32		
Microcline			X	X	X	X
Perthite	X					
Hornblende				X		X
Biotite	X	X	X	X		X
Garnet	X	X				
Magnetite			X	X	X	X
Chlorite					X	
Apatite				X		X

Table 20. *Hypersthene Gneiss (map-unit 1c)*

	1	2	3	4	5	6	7	8	9
Quartz	X	X	X	X	X		X	X	X
Plagioclase	X	X	X	X	X	X	X	X	X
% An	33	37	41	29	25	37	40	36	
Microcline	X	X	X	X	X	X	X	X	
Perthite									
Antiperthite			X				X		
Hypersthene	X	X	X	X	X	X	X	X	X
Diopside									
Hornblende						X			X
Biotite	X	X	X	X	X	X	X		
Garnet	X	X	X	X					
Magnetite			X	X			X	X	X
Apatite				X					
Zircon	X	X	X		X				

Table 21

	Cordierite Gneiss (map-unit 1a)					*Diopside Gneiss (map-unit 1b)*					
	1	2	3	4	5	1	2	3	4	5	6
Plagioclase	X	X	X	X	X	X	X	X			X
Quartz	X	X	X	X	X	X	X	X	X	X	X
% An				36		38	37	38	50	27	43
Microcline	X	X	X	X		X	X	X	X	X	X
Perthite	X	X	X		X					X	
Cordierite	X	X	X	X	X						
Sillimanite	X	X	X								
Diopside						X	X	X	X	X	X
Hornblende						X	X	X	X		X
Biotite	X	X	X	X		X	X	X	X	X	X
Garnet		X	X	X							
Magnetite									X	X	X
Apatite						X	X				
Sphene										X	

Table 22. *Quartz-Feldspar Gneiss (map-unit 2)*

	1	2	3	4	5	6	7	8
Quartz		X		X	X	X	X	
Plagioclase	X	X	X	X	X	X	X	X
% An	70	40		34	50	30	36	64
Microcline	X	X		X		X	X	
Perthite				X				
Hypersthene					X			X
Diopside	X	X	X				X	
Hornblende	X	X	X	X	X			
Biotite		X			X	X	X	X
Magnetite				X	X			
Apatite		X		X			X	

	9	10	11	12	13	14	15	16
Quartz		X	X	X	X	X	X	X
Plagioclase	X	X	X	X	X	X	X	X
% An	43		34	38	33	37		24
Microcline		X	X	X	X	X	X	X
Perthite			X	X		X	X	X
Hypersthene	X	X		X	X			
Biotite	X		X	X	X	X		X
Magnetite	X	X	X		X			X
Chlorite						X	X	X
Apatite	X			X				
Zircon				X				

Table 23. *Garnet-Quartz-Feldspar Gneiss (map-unit 2)*

	1	2	3	4	5	6	7
Quartz	X	X	X	X	X	X	X
Plagioclase	X	X	X	X	X	X	X
% An		42	38	33	37	43	
Microcline	X		X	X	X	X	X
Perthite			X	X			
Antiperthite				X			
Hypersthene	X			X		X	X
Biotite	X	X	X	X	X	X	
Garnet	X	X	X	X	X	X	X
Magnetite					X	X	
Apatite				X		X	X

Table 24. *Cordierite Gneiss (map-unit 2)*

	1	2	3
Quartz	X	X	
Plagioclase	X	X	X
% An	33		
Microcline	X		X
Perthite	X		
Antiperthite	X		
Cordierite	X	X	X
Sillimanite	X	X	
Hypersthene			X
Biotite	X	X	X
Garnet	X	X	X
Zircon			X
Spinel		X	

Table 25. *Granitic Rocks (map-unit 3)*

	Quartz Monzonite (3c)						*Quartz Diorite (3b)*		
	1	2	3	4	5	6	1	2	3
Quartz	x	x	x	x	x		x	x	x
Plagioclase	x		x	x	x	x	x	x	x
% An	26		26	34				37	
Microcline	x		x	x	x	x	x	x	x
Perthite	x	x	x	x		x			x
Hypersthene								x	
Diopside	x	x		x					x
Hornblende				x					x
Biotite	x		x		x	x		x	
Magnetite				x		x	x	x	
Chlorite				x			x		
Apatite							x	x	
Zircon					x		x	x	

APPENDIX B

CHEMICAL ANALYSES

(Data recalculated to 100% appears in brackets)

Tables 26-38

The data in the following tables are the results of *rapid method* chemical analyses carried out in the laboratories of the Geological Survey. This method offers relatively rapid determinations, but the accuracy does not compare with that of the standard, or classical, chemical analysis. For this reason these data are not used to determine modes and norms but rather to indicate trends within the various lithological units.

This type of analysis combines the use of X-ray fluorescence spectroscopy and chemical methods and is designed to get results with a large number of samples in a relatively short time.

As many as thirteen constituents may be determined, and on the basis of a single analysis the final summation is considered satisfactory if it falls between 97.5 and 102.5 per cent.

The probable error for each oxide in an individual determination is as follows:

(a) Determined simultaneously by X-ray fluorescent spectroscopy (%)

SiO_2 (30-75%)	1.2
Al_2O_3 (up to 20)	0.7
Total Fe as Fe_2O_3 (up to 15)	0.5
CaO (up to 40)	0.3
MgO (up to 40)	1.0
K_2O (up to 5)	0.1
MnO (up to 1)	0.02

(b) Determined separately by chemical methods (%)

FeO (up to 15%)	0.2
Na_2O (up to 10)	0.15
P_2O_5 (up to 1)	0.04
CO_2	0.1
H_2O (total)	0.1

For the purpose of this study the oxides H_2O, CO_2, and P_2O_5 were not determined because they are not probable constituents of relatively high grade metamorphic rocks similar to those in the map-area.

In the following tables oxides are given in weight per cent. The data have been recalculated to 100 per cent (shown in brackets) to facilitate comparison with published data, but such recalculation masks possible errors in the analyses. For this reason the original data are also presented.

Table 26. *Cordierite-Sillimanite-Quartz-Feldspar Gneiss (map-unit 1a)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
BE 62-1	57.9 (58.5)[1]	27.2 (27.5)	0.8 (0.8)	4.6 (4.7)	0.5 (0.5)	3.9 (3.9)	0.8 (0.8)	1.9 (1.9)	1.3 (1.3)	0.03 (0.01)
BE 62-11	74.2 (77.1)	13.0 (13.5)	0.1 (0.1)	2.0 (2.0)	0.3 (0.3)	2.0 (2.0)	0.9 (0.9)	3.5 (3.6)	0.42 (0.42)	0.01 (0.01)
BE 62-66	70.4 (73.8)	14.0 (14.6)	0.4 (0.4)	0.5 (0.5)	2.0 (2.0)	0.6 (0.6)	3.4 (3.6)	3.3 (3.4)	1.0 (1.0)	0.01 (0.01)

[1]Figures in parentheses recalculated to 100%

Table 27. *Diopside-Quartz-Feldspar Gneiss (map-unit 1b)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-27	57.8 (58.4)	18.8 (19.0)	2.2 (2.2)	4.5 (4.5)	6.4 (6.5)	2.2 (2.2)	4.1 (4.1)	2.2 (2.2)	0.67 (0.67)	0.13 (0.13)
TA 62-38	46.7 (48.5)	19.0 (19.7)	3.8 (3.9)	6.5 (6.7)	11.0 (11.4)	2.9 (3.0)	4.0 (4.1)	1.0 (1.0)	1.4 (1.4)	0.21 (0.21)
TA 62-41	47.8 (51.2)	19.8 (21.2)	2.4 (2.6)	6.5 (7.0)	10.1 (10.8)	0.6 (0.6)	3.7 (3.9)	1.3 (1.4)	1.0 (1.0)	0.16 (0.16)
TA 62-89	55.5 (59.1)	15.8 (16.8)	1.5 (1.6)	3.7 (3.9)	7.9 (8.4)	1.3 (1.3)	3.7 (3.9)	3.8 (4.0)	0.65 (0.65)	0.06 (0.06)
TA 62-90	54.3 (56.7)	16.8 (17.6)	1.7 (1.8)	3.2 (3.3)	8.3 (8.7)	2.4 (2.5)	4.6 (4.8)	3.6 (3.8)	0.71 (0.71)	0.08 (0.08)
BE 62-35	41.6 (43.4)	16.1 (16.8)	1.4 (1.5)	12.1 (12.6)	14.6 (15.2)	7.2 (7.5)	1.1 (1.1)	0.2 (0.2)	1.3 (1.3)	0.17 (0.17)
BE 62-47	44.8 (49.7)	12.8 (14.2)	0.9 (1.0)	5.6 (6.2)	13.6 (15.1)	9.2 (10.2)	1.1 (1.2)	1.7 (1.9)	0.31 (0.31)	0.15 (0.15)
BE 62-50	49.4 (52.2)	17.4 (18.4)	4.2 (4.4)	6.8 (7.2)	7.2 (7.6)	2.6 (2.7)	4.6 (4.9)	0.8 (0.8)	1.5 (1.6)	0.19 (0.19)
BE 62-65	49.2 (50.4)	15.1 (15.5)	0.1 (0.1)	9.8 (10.0)	12.2 (12.5)	6.8 (7.0)	3.0 (3.1)	0.7 (0.7)	0.52 (0.52)	0.17 (0.17)
BE 62-88	47.7 (50.5)	13.8 (14.6)	2.0 (2.1)	10.8 (11.4)	13.3 (14.1)	3.0 (3.2)	2.3 (2.4)	0.2 (0.2)	1.2 (1.2)	0.21 (0.21,

[1]Figures in parentheses recalculated to 100%

Table 28. *Hypersthene-Quartz-Feldspar Gneiss (map-unit 1a)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
BE 62-27	59.7 (61.1)	17.4 (17.8)	1.7 (1.7)	5.1 (5.2)	4.7 (4.8)	1.4 (1.4)	4.7 (4.8)	1.6 (1.6)	1.3 (1.3)	0.19 (0.19)
BR 62-41	61.8 (64.0)	18.6 (19.3)	0.7 (0.7)	3.4 (3.5)	4.6 (4.8)	0.5 (0.5)	3.2 (3.3)	3.2 (3.3)	0.54 (0.54)	0.02 (0.02)
BE 62-62	59.0 (62.3)	18.2 (19.2)	0.5 (0.5)	3.5 (3.7)	5.2 (5.5)	1.7 (1.8)	4.5 (4.7)	1.6 (1.7)	0.48 (0.48)	0.06 (0.06)
BE 62-68	66.1 (73.2)	12.6 (13.9)	0.2 (0.2)	3.6 (4.0)	2.4 (2.7)	1.4 (1.5)	3.3 (3.7)	0.3 (0.3)	0.35 (0.35)	0.10 (0.10)
TA 62-9	46.4 (48.8)	19.7 (20.7)	1.2 (1.3)	9.1 (9.6)	8.5 (8.9)	2.8 (2.9)	4.2 (4.4)	1.6 (1.7)	1.4 (1.5)	0.19 (0.20)
TA 62-33	63.1 (63.6)	20.8 (21.0)	0.3 (0.3)	2.4 (2.4)	4.6 (4.6)	0.6 (0.6)	3.5 (3.5)	3.2 (3.2)	0.63 (0.63)	0.03 (0.03)
TA 62-35	62.8 (64.7)	18.6 (19.2)	0.1 (0.1)	3.3 (3.4)	2.8 (2.8)	0.8 (0.8)	3.9 (4.0)	4.2 (4.3)	0.56 (0.58)	0.05 (0.05)
TA 62-37	64.2 (66.3)	19.0 (19.6)	0.1 (0.1)	2.3 (2.4)	4.1 (4.2)	0.5 (0.5)	3.1 (3.2)	3.3 (3.4)	0.46 (0.47)	0.02 (0.02)
TA 62-91	53.3 (55.9)	20.5 (21.4)	1.1 (1.1)	6.4 (6.7)	6.9 (7.2)	0.5 (0.5)	4.4 (4.5)	1.6 (1.6)	0.90 (0.94)	0.13 (0.13)
TA 62-93	55.3 (56.7)	20.0 (20.4)	1.0 (1.0)	6.0 (6.1)	6.8 (7.0)	2.2 (2.2)	3.9 (4.0)	1.4 (1.4)	1.1 (1.1)	0.13 (0.13)

[1]Figures in parentheses recalculated to 100%

Table 29. *Biotite-Quartz-Feldspar Gneiss (map-unit 1d)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-21	61.7 (62.8)	18.8 (19.2)	0.1 (0.1)	4.8 (4.9)	4.3 (4.4)	2.0 (2.0)	2.7 (2.7)	2.8 (2.9)	0.88 (0.88)	0.05 (0.05)
BE 62-33	65.0 (69.6)	16.4 (17.5)	0.1 (0.1)	1.6 (1.7)	3.2 (3.4)	0.5 (0.5)	3.5 (3.7)	3.0 (3.2)	0.28 (0.28)	0.01 (0.01)
BE 62-34	51.5 (53.6)	20.5 (21.3)	2.6 (2.7)	5.9 (6.1)	7.0 (7.3)	1.0 (1.0)	4.0 (4.2)	2.4 (2.5)	1.0 (1.00)	0.16 (0.16)
BE 62-37	50.3 (52.7)	19.7 (20.6)	3.0 (3.1)	4.5 (4.7)	6.2 (6.5)	2.8 (3.0)	5.0 (5.3)	2.9 (3.1)	0.88 (0.94)	0.13 (0.13)
BE 62-97	81.2 (82.7)	8.5 (8.9)	1.5 (1.5)	2.0 (2.1)	1.2 (1.2)	0.4 (0.4)	1.4 (1.4)	1.5 (1.5)	0.39 (0.40)	0.03 (0.03)

[1]Figures in parentheses recalculated to 100%

Table 30. *Amphibolite (map-unit 1g)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
BE 62-15	44.2 (48.5)	12.9 (14.1)	1.0 (1.1)	10.2 (11.2)	11.6 (12.7)	7.1 (7.8)	1.7 (1.9)	0.9 (1.0)	1.4 (1.5)	0.23 (0.23)

[1]Figures in parentheses recalculated to 100%

Table 31. *Quartz-Feldspar Gneiss (map-unit 2)*

(variable amounts of microcline; no garnet)

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-4	70.3 (70.8)	15.7 (15.8)	0.1 (0.1)	1.7 (1.7)	2.6 (2.6)	0.5 (0.5)	3.3 (3.3)	4.8 (4.8)	0.32 (0.32)	0.01 (0.01)
TA 62-42	62.2 (63.0)	18.4 (18.7)	0.1 (0.1)	4.1 (4.2)	4.9 (5.0)	2.9 (2.9)	4.3 (4.4)	1.1 (1.1)	0.55 (0.56)	0.09 (0.09)
TA 62-44	73.5 (73.0)	15.4 (15.3)	0.1 (0.1)	0.6 (0.6)	1.4 (1.4)	0.5 (0.5)	2.7 (2.7)	6.3 (6.2)	0.15 (0.15)	0.01 (0.01)
TA 62-48	48.0 (49.9)	17.8 (18.5)	1.5 (1.6)	9.3 (9.7)	9.3 (9.7)	5.2 (5.4)	2.1 (2.2)	1.4 (1.4)	1.30 (1.30)	0.17 (0.17)
BE 62-14	59.9 (60.6)	17.3 (17.5)	1.0 (1.0)	4.7 (4.8)	5.6 (5.7)	2.3 (2.3)	3.7 (3.7)	3.5 (3.5)	0.75 (0.76)	0.06 (0.06)
BE 62-17	52.9 (57.6)	17.9 (19.5)	1.5 (1.6)	4.6 (5.0)	7.1 (7.7)	0.4 (0.5)	4.8 (5.2)	1.7 (1.9)	0.77 (0.84)	0.12 (0.12)
BE 62-38	65.3 (67.8)	15.3 (15.9)	2.7 (2.8)	2.0 (2.1)	1.3 (1.3)	0.5 (0.5)	2.7 (2.8)	6.0 (6.2)	0.43 (0.45)	0.03 (0.03)
BE 62-42	68.3 (75.0)	14.8 (16.2)	0.1 (0.1)	1.0 (1.1)	0.5 (0.5)	0.5 (0.5)	2.8 (3.1)	2.9 (3.2)	0.19 (0.20)	0.01 (0.01)
BE 62-43	66.5 (72.0)	14.0 (15.2)	0.1 (0.1)	1.7 (1.8)	2.2 (2.4)	0.5 (0.5)	4.3 (4.7)	2.7 (2.9)	0.30 (0.31)	0.05 (0.05)
BE 62-45	68.4 (73.6)	13.5 (14.5)	0.1 (0.1)	1.5 (1.6)	0.9 (1.0)	0.3 (0.3)	2.7 (2.9)	5.1 (5.5)	0.38 (0.41)	0.02 (0.02)
BE 62-49	71.4 (75.9)	13.2 (14.0)	0.8 (0.9)	0.1 (0.1)	1.0 (1.1)	0.5 (0.5)	2.2 (2.3)	4.7 (5.0)	0.07 (0.07)	0.01 (0.01)
BE 62-52	73.2 (74.6)	12.6 (12.8)	0.1 (0.1)	1.7 (1.7)	1.0 (1.0)	1.0 (1.0)	4.2 (4.3)	4.2 (4.3)	0.05 (0.05)	0.02 (0.02)
BE 62-53	72.3 (74.8)	12.3 (12.7)	2.4 (2.5)	0.5 (0.5)	2.8 (2.9)	1.0 (1.0)	2.8 (2.9)	2.5 (2.6)	0.12 (0.12)	0.01 (0.01)
BE 62-55	63.8 (67.0)	15.2 (15.9)	1.8 (1.9)	1.8 (1.9)	3.2 (3.4)	0.5 (0.5)	3.6 (3.8)	4.6 (4.8)	0.66 (0.69)	0.03 (0.03)
BE 62-70	68.1 (71.7)	15.9 (16.7)	0.1 (0.1)	0.5 (0.5)	3.1 (3.3)	0.5 (0.5)	4.4 (4.6)	2.0 (2.1)	0.32 (0.34)	0.01 (0.01)
BE 62-86	65.0 (66.4)	16.2 (16.5)	1.0 (1.0)	3.8 (3.9)	4.9 (5.0)	0.5 (0.5)	4.6 (4.7)	1.2 (1.2)	0.65 (0.66)	0.07 (0.07)
BE 62-87	71.5 (71.7)	14.8 (14.8)	1.0 (1.0)	0.8 (0.8)	1.2 (1.2)	0.9 (0.9)	4.0 (4.0)	5.3 (5.3)	0.25 (0.25)	0.01 (0.01)
BE 62-91	71.1 (70.6)	15.8 (15.7)	1.3 (1.3)	0.8 (0.8)	3.4 (3.4)	1.2 (1.2)	5.0 (5.0)	1.9 (1.9)	0.12 (0.12)	0.01 (0.01)

[1]Figures in parentheses recalculated to 100%

Table 32. *Garnet-Quartz-Feldspar Gneiss (map-unit 2)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-28	62.9 (63.0)	19.2 (19.2)	0.8 (0.8)	4.5 (4.5)	3.5 (3.5)	2.0 (2.0)	3.7 (3.7)	2.3 (2.3)	0.88 (0.88)	0.04 (0.04)
BE 62-6	56.3 (57.0)	19.7 (19.9)	0.1 (0.1)	6.9 (7.0)	5.5 (5.6)	4.0 (4.0)	3.3 (3.3)	1.8 (1.8)	1.10 (1.1)	0.09 (0.09)
BE 62-29	63.7 (67.3)	18.4 (19.4)	0.1 (0.1)	1.8 (1.9)	4.0 (4.2)	0.6 (0.6)	3.8 (4.0)	1.9 (2.0)	0.40 (0.42)	0.01 (0.01)
BR 62-31	71.3 (71.5)	16.3 (16.3)	0.9 (0.9)	1.1 (1.1)	1.6 (1.6)	0.5 (0.5)	2.4 (2.4)	5.5 (5.5)	0.05 (0.05)	0.02 (0.02)
BE 62-46	67.9 (69.2)	16.2 (16.5)	0.9 (0.9)	1.0 (1.0)	1.9 (1.9)	0.5 (0.5)	3.4 (3.5)	5.9 (6.0)	0.25 (0.25)	0.02 (0.02)
BE 62-107	58.2 (61.5)	17.4 (18.4)	0.9 (1.0)	5.8 (6.1)	5.5 (5.8)	0.5 (0.5)	4.4 (4.6)	1.0 (1.0)	0.90 (1.00)	0.10 (0.10)

[1]Figures in parentheses recalculated to 100%

Table 33. *Plagioclase Gneiss (map-unit 2)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-11	45.3 (50.4)	17.8 (19.8)	3.6 (4.0)	8.0 (8.9)	5.8 (6.5)	3.3 (3.7)	3.5 (3.9)	0.8 (0.9)	1.5 (1.6)	0.26 (0.26)
TA 62-80	57.4 (60.1)	15.6 (16.4)	1.7 (1.8)	2.4 (2.5)	6.3 (6.6)	2.6 (2.7)	3.6 (3.8)	5.2 (5.5)	0.55 (0.56)	0.05 (0.05)

[1]Figures in parentheses recalculated to 100%

Table 34. *Granite (map-unit 3a)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-100	70.9 (71.6)	15.2 (15.3)	0.9 (0.9)	1.0 (1.0)	1.6 (1.6)	0.5 (0.5)	3.8 (3.9)	4.9 (5.0)	0.24 (0.24)	0.01 (0.01)

[1]Figures in parentheses recalculated to 100%

Table 35. *Quartz Diorite (map-unit 3b)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
BE 62-3	69.2 (71.2)	15.4 (15.8)	0.1 (0.1)	1.4 (1.4)	1.0 (1.0)	0.5 (0.5)	2.9 (3.0)	6.4 (6.6)	0.30 (0.30)	0.01 (0.01)
TA 62-10	62.7 (64.0)	16.5 (16.7)	1.5 (1.5)	2.4 (2.4)	1.4 (1.4)	3.8 (3.9)	3.8 (3.9)	5.0 (5.1)	0.92 (0.94)	0.05 (0.05)
TA 62-14	57.3 (58.6)	19.8 (20.3)	0.1 (0.1)	5.8 (5.9)	5.6 (5.7)	3.4 (3.5)	3.4 (3.5)	1.3 (1.3)	0.90 (0.92)	0.08 (0.08)
TA 62-32	70.3 (71.4)	16.2 (16.5)	0.3 (0.3)	1.0 (1.0)	0.7 (0.7)	0.8 (0.8)	3.3 (3.4)	5.5 (5.6)	0.27 (0.28)	0.01 (0.01)

[1]Figures in parentheses recalculated to 100%

Table 36. *Quartz Monzonite (map-unit 3c)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
TA 62-17	74.0 (74.1)	15.5 (15.5)	0.1 (0.1)	1.0 (1.0)	1.0 (1.0)	0.5 (0.5)	3.0 (3.0)	4.6 (4.6)	0.10 (0.10)	0.02 (0.02)
TA 62-25	71.5 (72.9)	14.5 (14.8)	0.5 (0.5)	0.9 (0.9)	1.0 (1.0)	0.5 (0.5)	2.5 (2.5)	5.5 (5.6)	1.2 (1.2)	0.01 (0.01)
TA 62-55	63.6 (64.9)	17.8 (18.2)	0.8 (0.8)	2.8 (2.9)	2.0 (2.0)	0.5 (0.5)	2.9 (3.0)	6.9 (7.0)	0.64 (0.65)	0.02 (0.02)
TA 62-65	62.0 (64.0)	17.2 (17.8)	1.2 (1.2)	3.1 (3.2)	4.2 (4.3)	0.5 (0.5)	4.8 (5.0)	3.2 (3.3)	0.67 (0.69)	0.06 (0.06)
BE 62-2	70.5 (71.1)	16.4 (16.5)	0.1 (0.1)	1.8 (1.8)	1.3 (1.3)	0.5 (0.5)	2.3 (2.3)	5.9 (6.0)	0.32 (0.32)	0.01 (0.01)
BE 62-16	74.4 (73.7)	13.3 (13.2)	0.8 (0.8)	2.7 (2.7)	0.9 (0.9)	0.5 (0.5)	2.5 (2.5)	5.3 (5.2)	0.48 (0.48)	0.03 (0.03)
BE 62-89	59.4 (62.0)	14.8 (15.4)	2.8 (2.9)	2.3 (2.4)	4.6 (4.8)	1.0 (1.0)	4.3 (4.5)	6.0 (6.3)	0.55 (0.57)	0.08 (0.08)
BE 62-100	65.3 (65.5)	16.0 (16.1)	1.5 (1.5)	1.7 (1.7)	3.4 (3.4)	3.1 (3.1)	5.5 (5.5)	2.7 (2.7)	0.43 (0.43)	0.03 (0.03)

[1]Figures in parentheses recalculated to 100%

Table 37. *Ultrabasic Rocks (map-unit 4)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
BE 62-56	43.2 (46.9)	19.7 (21.4)	1.4 (1.5)	4.8 (5.2)	10.4 (11.3)	9.8 (10.6)	1.2 (1.3)	1.3 (1.4)	0.17 (0.18)	0.10 (0.11)
BE 62-59	45.1 (46.6)	20.0 (20.6)	0.2 (0.2)	10.3 (10.6)	10.3 (10.6)	8.5 (8.8)	1.1 (1.1)	0.1 (0.1)	1.1 (1.1)	0.18 (0.19)

[1]Figures in parentheses recalculated to 100%

Table 38. *Diabase and Gabbro (map-unit 7)*

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO
BE 62-39	50.0 (51.9)	18.2 (18.9)	1.7 (1.8)	7.5 (7.8)	11.5 (11.9)	3.2 (3.3)	2.5 (2.6)	0.7 (0.7)	0.88 (0.91)	0.15 (0.16)
BE 62-61	46.4 (50.1)	11.8 (12.7)	2.0 (2.2)	10.6 (11.4)	10.9 (11.8)	6.3 (6.8)	2.4 (2.6)	0.1 (0.1)	1.9 (2.10)	0.23 (0.25)
BE 62-69	50.2 (53.6)	15.0 (16.1)	0.8 (0.9)	6.4 (6.4)	13.4 (14.3)	5.0 (5.3)	1.9 (2.0)	0.3 (0.3)	0.81 (0.86)	0.16 (0.17)
TA 62-67	47.2 (49.3)	17.5 (18.2)	2.9 (3.0)	8.8 (9.2)	8.8 (9.2)	2.4 (2.5)	3.3 (3.5)	1.5 (1.6)	2.9 (3.0)	0.20 (0.20)
TA 62-83	55.5 (57.6)	14.5 (15.0)	1.1 (1.1)	8.0 (8.3)	7.4 (7.7)	3.1 (3.2)	2.8 (2.9)	1.8 (1.9)	1.9 (2.0)	0.16 (0.17)
TA 62-84	49.0 (50.2)	16.5 (16.9)	0.7 (0.7)	7.6 (7.7)	13.2 (13.5)	7.0 (7.2)	2.0 (2.1)	0.5 (0.5)	0.89 (0.91)	0.17 (0.17)
TA 62-102	47.4 (49.0)	15.0 (15.5)	0.6 (0.6)	10.1 (10.4)	12.8 (13.2)	8.0 (8.3)	1.7 (1.8)	0.1 (0.1)	0.88 (0.91)	0.20 (0.21)

[1]Figures in parentheses recalculated to 100%

INDEX

PAGE

Agmatitic structure 10, 18
Agnew River 33
Air services 2
Amituryouak Lake 36
Amphibolite 15, 18, 33
Amundsen, R. 4
Antiperthite 20, 22, 40
Aston Formation 10, 26, 27
Astronomical Society Islands 33

Bellot Strait 4, 6, 36
Biotite 17
Biotite gneiss 13, 20
Boothia Arch 27, 32, 36
Boothia-Regent Lowlands 8
Boothia-Somerset Upland 5
Boudinage 33

Cordierite 16, 20, 21
Crystalline limestone 14

Diabase 27
Differentiation 29, 30
Diopside 17
Diopside gneiss 13

Eastern Victoria Lowlands 8
Eskimo 2

Faults 33
Felsenmeer 6, 26
Field methods 3
Fitz Roy Inlet 6, 36
Folds 36
Fort Ross 2, 3
Franklin, Sir John, search for 4

Gabbro 27
Garnet 17, 20
Garry River 36
Gjoa Haven, settlement 1, 4
Gneissic complex 10
  felsic gneiss 17
  granitic rock 21
  mafic gneiss 12
Gneisses, origin of 38

PAGE

Granitic rock 21
Granulite 19

Hornblende 20
Hunting Formation 10, 26, 27
Hypersthene 17

Joints 33
Jones-Lancaster Plateaux 5

Linear features 33

Macgregor Laird Lake 6, 36
Mafic gneiss 12
M'Clintock, Leopold 4
Metamorphism, age of 38
Metamorphic differentiation 24, 41
Metamorphic facies 37
  almandine amphibolite facies 38
  granulite facies 37, 38
  hornblende granulite subfacies 38
  pyroxene granulite subfacies 37
  sillimanite almandine subfacies 38
Metasomatism 39
Migmatite structure 10
Myrmekite 22

Nebulitic structure 11

Palaeozoic outliers 36
Parry, Sir Edward 4
Pattinson Harbour 36
Perthite 16, 20, 21, 22, 23, 39
Physiography 5
Plagioclase 23, 29
Port Leopold 2, 4
Potash feldspar 16, 20
Prescott Island 10
Pyroxene 20, 29
Pyrrhotite 25

Quartz 16, 20, 23
Quartz diorite 21, 22
Quartz monzonite 21, 23

Ross, Sir John 3, 4
Rusty schists and gneisses 14, 18

PAGE

Sanagak Lake 33
Schlieren structure 11, 18
Serpentine 25
Sillimanite 16, 21
Slickensides 33
Spence Bay, settlement 1, 3
Stanwell-Fletcher Lake 6
Stromatic structure 10
Structural forms, gneisses 10
Thom Bay, mission 1
Ultrabasic rock 25
Vein structure 11
Wrottesley River 7

BULLETINS

Geological Survey of Canada

Bulletins present the results of detailed scientific studies on geological or related subjects. Some recent titles are listed below:

126 Feldspar and quartz phenocrysts in the Shingle Creek porphyry, British Columbia, *by* H. H. Bostock, 1966 ($2.00)

127 Ordovician Ostracoda from Lake Timiskaming, Ontario, by M. J. Copeland, 1965 ($2.00)

128 Upper Volgian (latest Jurassic) ammonites and buchias of Arctic Canada, *by* J. A. Jeletzky, 1966 ($2.00)

129 Structural evolution and plutonism in Valhalla gneiss complex, British Columbia, *by* J. E. Reesor, 1965 ($3.25)

130 The copper content of Canadian Shield rocks, Red Lake–Lansdowne House area, northwestern Ontario, *by* R. F. Emslie and R. H. C. Holman, 1966 (90 cents)

131 The Permian ammonoids of Arctic Canada, *by* W. W. Nassichuk, W. M. Furnish, and B. F. Glenister, 1965 ($2.00)

132 The Cretaceous Smoky Group, Rocky Mountain Foothills, Alberta and British Columbia, *by* D. F. Stott, 1967 ($3.75)

133 Upper Devonian stromatoporoids from the Redwater Reef Complex, Alberta, *by* J. E. Klovan; Upper Devonian stromatoporoids from southern Northwest Territories and northern Alberta, *by* C. W. Stearn, 1966 ($4.50)

134 Contributions to Canadian palaeontology: Part I Trilobites from Upper Silurian rocks of the Canadian Arctic Archipelago, *Encrinurus (Frammia)* and *Hemiarges*; Part II Ordovician and Silurian tabulate corals *Labyrinthites, Arcturia, Troedssonites, Multisolenia,* and *Boreastor*; Part III A new species of *Hemicystites, by* T. E. Bolton, and G. Winston Sinclair, 1965 ($2.50)

135 Type lithostrotionid corals from the Mississippian of western Canada, *by* E. W. Bamber, 1966 ($1.50)

136 Surficial geology of Dawson, Larsen Creek, and Nash Creek map-areas, Yukon Territory, *by* P. Vernon and O. L. Hughes 1966 ($1.00)

137 A geochemical method of correlation for the Lower Cretaceous strata of Alberta, *by* E. M. Cameron, 1966 ($1.35)

138 Reconnaissance of the surficial geology of northeastern Ellesmere Island, Arctic Archipelago, *by* R. L. Christie, 1967 ($1.65)

139 Groundwater studies in the Assiniboine River drainage basin, *by* Peter Meyboom. Part I, The evaluation of a flow system in south-central Saskatchewan, 1966 ($2.00); Part II, Hydrologic characteristics of phreatophytic vegetation in south-central Saskatchewan, 1967 ($1.65)

140 Silurian brachiopods and gastropods of southern New Brunswick, *by* A. J. Boucot, *et al.*, 1966 ($3.00)

141 Geology and structure of Yellowknife Greenstone Belt, *by* J. F. Henderson and I. C. Brown, 1967 ($2.50)

142 A comprehensive study of the Preissac-Lacorne batholith, Abitibi county, Quebec, *by* K. R. Dawson, 1966 ($2.00)

143 Ferromagnesian silicate minerals in the metamorphosed iron-formation of Wabush Lake and adjacent areas, Newfoundland and Quebec, *by* K. L. Chakraborty, 1966 ($1.00)

144 Groundwater resources of the Coastal Lowland and adjacent islands, Nanoose Bay to Campbell River, east coast, Vancouver Island, *by* E. C. Halstead and A. Treichel, 1966 ($2.00)

145 Part I—Stratigraphy and structure of southeastern Prince Edward Island; Part II—Surficial Geology, *by* Larry Frankel, 1966 ($2.00)

146 The Devonian Cedared and Harrogate Formations in the Beaverfoot, Brisco, and Stanford Ranges, southeast British Columbia, *by* H. R. Belyea and B. S. Norford, 1967 ($2.00)

147 Patterns of groundwater flow in seven discharge areas in Saskatchewan and Manitoba, *by* Peter Meyboom, R. O. van Everdingen, and R. A. Freeze, 1966 ($1.50)

148 Granite and pegmatite studies at Northern Indian Lake, Manitoba, *by* R. Kretz, 1967 ($1.50)

149 Studies of rock-forming micas, *by* J. H. Y. Rimsaite, 1967 ($2.50)

150 Geology of the New Quebec Crater, *by* K. L. Currie, 1966 ($1.00)

151 Precambrian geology of Boothia Peninsula, Somerset Island, and Prince of Wales Island, District of Franklin, *by* R. G. Blackadar, 1967 ($2.25)

152 Lower Cretaceous Bullhead and Fort St. John Groups, between Smoky and Peace Rivers, Central Rocky Mountain Foothills, Alberta and British Columbia, *by* D. F. Stott, 196– ($)

153 Lower and Middle Devonian trilobites of the Canadian Arctic islands, *by* A. R. Ormiston, 196– ($5.50)