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DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 69-51

PRECAMBRIAN GEOLOGY, KAMINAK LAKE MAP-AREA, DISTRICT OF KEEWATIN

A. Davidson

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A. Davidson

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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CONTENTS

	Page
Abstract	v
Introduction	1
General Geology	2
Region A	5
Kaminak Group	5
Plutonic rocks	9
Pre-Hurwitz diabase	10
Hurwitz Group	11
Lamprophyre dykes	12
Post-Hurwitz diabase	12
Region B	12
Kaminak Group	12
Plutonic rocks	14
Pre-Hurwitz diabase	14
MacKenzie Lake metasediments	15
Granite, migmatite	15
Lamprophyre dykes	15
Region C	16
Gneissic equivalents of the Kaminak Group and the MacKenzie Lake metasediments	16
Gneissic equivalents of the pre-Hurwitz plutonic rocks	18
Pre-Hurwitz diabase	18
Migmatite complex	18
Map-units	19
Post-Hurwitz diabase	19
Structure	19
Metamorphism	21
Age Relations	23
Field relations	23
Radiometric ages	23
Economic Geology	25
References	26

Table I	Outline of differences between Regions A, B, and C of Figure 1	4
II	Table of formations for Region A	5
III	Table of formations for Region B	13
IV	Radiometric age determinations in the Kaminak Lake map-area	24

Illustrations

Map 1285A	Kaminak map-area	(in pocket)
Figure 1	Subdivision of map-area on basis of lithology, structure and metamorphism	3
2	Pillow structure in greenstone at Quartzite Lake	6

CONTENTS (cont'd)

Page

Figure 3 Weathered surface of felsic volcanic breccia southwest of Quartzite Lake 6
4 Mesoscopic flow folds in layered gneiss east of Townsend Lake 17
5 Agmatitic appearance of outcrop of unit 7, twelve miles northwest of Duffy Lake 17
6 Effect of Hudsonian metamorphism on pre-Hurwitz diabase dykes 21

ABSTRACT

Kaminak Lake map-area lies in the barren grounds of northern Canada west of Hudson Bay. This report is the result of a combination of helicopter and ground-mapping carried out in 1966 and 1967. Old metamorphosed volcanic and sedimentary rocks, the Kaminak Group, and a series of intrusive plutons, all of which are probably Archean, are well preserved in the southern half of the map-area. They are cut by diabase dykes and in turn overlain by sedimentary and volcanic rocks of the Hurwitz Group. To the northwest the older rocks are overlain by the MacKenzie Lake metasediments, of uncertain relation to the Hurwitz Group, and the whole succession is deformed and metamorphosed to amphibolite facies of low pressure type. The northern part of the map-area is a region of gneiss and migmatite formed from the Kaminak Group, plutonic rocks, and MacKenzie Lake metasediments, with introduction of some new granitic material. Metamorphism in remnants of pelitic rocks suggest medium pressure amphibolite facies. In the transition zone the older rocks can be traced into their gneissic and migmatitic equivalents to the north. Metamorphism of the pre-Hurwitz diabase dykes serves to outline the approximate southern extent of later Hudsonian metamorphism.

Numerous gossans occur within the metavolcanic rocks of the Kaminak Group. A few have been explored by drilling and trenching. Most are derived from disseminated pyrite and pyrrhotite, but chalcopyrite and sphalerite are present in places.

PRECAMBRIAN GEOLOGY, KAMINAK LAKE MAP-AREA, DISTRICT OF KEEWATIN

INTRODUCTION

Kaminak Lake map-area encompasses 4,400 square miles between 94 and 96 degrees west and 62 and 63 degrees north. Its centre is 95 miles west-southwest of Rankin Inlet, Northwest Territories, and 260 miles north-northwest of Churchill, Manitoba. Access is best gained by light aircraft equipped with ski-wheels or floats. In summer it is also possible to reach the map-area by portable boat from Hudson Bay via Ferguson River.

The map-area lies entirely within the barren grounds. Mean land elevation ranges from about 150 feet along the southeast boundary to about 500 feet near the centre of the northern boundary. Local relief rarely exceeds 200 feet, except in a few places between Carr and Kaminak lakes where rocky hills rise more than 300 feet. The northern half of the area is mainly drift covered, except around Kaminuriak Lake. In contrast, the southern half has much exposed bedrock, except west of Savage Lake and parts of the region southeast of Kaminak Lake.

The physiography and Pleistocene geology of southern District of Keewatin have been described and discussed by Lee (1959). In brief, the map-area lies east of the Keewatin ice divide, and glacial features such as drumlinoid ridges and crag-and-tail structures indicate the latest ice movement to have been southeasterly. Except for the highest ground in the west and northwest parts, the landforms have been modified by late Pleistocene marine submergence.

The first geological observations made in the map-area were made by Tyrrell (1898) during a canoe expedition down Ferguson River in 1896. He reported the occurrence of white quartzite and of "massive green trap" (ibid., pp. 143-145) in the vicinity of Quartzite Lake. Kidd (1930) used the same river for access to the area by canoe from Hudson Bay, and mapped the geology along the shores of Helika, Munro, Snug, and Quartzite lakes, and the northern part of Kaminak Lake. His findings are incorporated in a report on the geology of Maguse River and part of Ferguson River Basin by Weeks (1933). In 1952 the Geological Survey of Canada undertook its first geological reconnaissance using helicopters, Operation Keewatin, in southern District of Keewatin (Lord, 1953a, b). Most of the Kaminak Lake map-area was

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Author's address: Geological Survey of Canada,
601 Booth Street,
Ottawa 4, Canada.

covered by this operation, and the remainder was examined during Operation Baker in 1954 (Wright, 1955). The geology of the whole region is summarized by Wright (1967). Results of helicopter geological mapping on a more detailed scale of an area that includes the southern half of the Kaminak Lake map-area by Giant Yellowknife Mines Limited (Brown, 1964) have not been published to date. Aeromagnetic maps are available for the whole map-area.

Following geological reconnaissance supported by light float-plane in 1966 of the terrane underlain by greenstones southwest of Rankin Inlet, float plane and helicopter supported geological mapping was undertaken in 1967 in the adjoining Tavani (55K) and Kaminak Lake (55L) map-areas, for publication at a scale of four miles to one inch (Heywood, 1968, in preparation; Davidson, 1967, 1968a). These two areas were mapped at the same time by different parties operating from separate base camps, but sharing two aircraft, a Bell 47G2A and a Cessna 180. In addition, a third, mobile party of two men studied the Aphebian Hurwitz Group in both map-areas (Bell, 1968a, b).

Thirteen helicopter traverses were made in the Kaminak Lake map-area. The helicopter was used principally for mapping areas of difficult access or of poor rock exposure. Traverses on foot or by boat were made throughout the region of good rock exposure between Carr Lake in the west and Snug and Southern lakes in the east. Base field camp was established by means of helicopter on June 18, after the snow had left the ground but before break-up of lake ice. The float-plane was first used on July 14, by which time the ice had gone from all but the largest lakes. Geological mapping was completed by August 24.

The present field studies provide more detailed information about the geology of part of the area covered by Operations Keewatin and Baker (Wright, 1967), especially with regard to the age relations between the various rock types. Able assistance in the field was given by N.R. Newson, S.L. Putter, and J.L. Lebel. The helicopter was provided by Autair Helicopter Services Limited and piloted by G. Doneys. Lamb Airways Limited supplied the Cessna 180 in both 1966 and 1967.

GENERAL GEOLOGY

For the sake of clarity, the map-area is divided into three regions, A, B, and C, on the bases of differences in lithology, structure, and metamorphism (Fig. 1). In Region A, a deformed assemblage of stratiform rocks, the Kaminak Group, predominantly volcanic in origin but locally with minor greywacke and iron-formation, is intruded by a variety of plutonic rocks ranging in composition from gabbro to granite. Northerly trending diabase dykes cut all these rocks, but are themselves older than the sedimentary and volcanic rocks of the Hurwitz Group that occupy a fault-bounded trough extending from Happotiyik Lake to Carr Lake.

Region B is underlain by a similar succession, but here the Kaminak Group appears to contain a greater proportion of metasediments, chiefly of greywacke-type with some iron-formation. These rocks are intruded by a variety of plutonic rocks similar to those of Region A, and both are also cut by dykes of diabase, now metamorphosed to amphibolite. In addition, an assemblage of metasediments, including quartzite, arkose, conglomerate, and quartz-mica schist, referred to here as the MacKenzie Lake

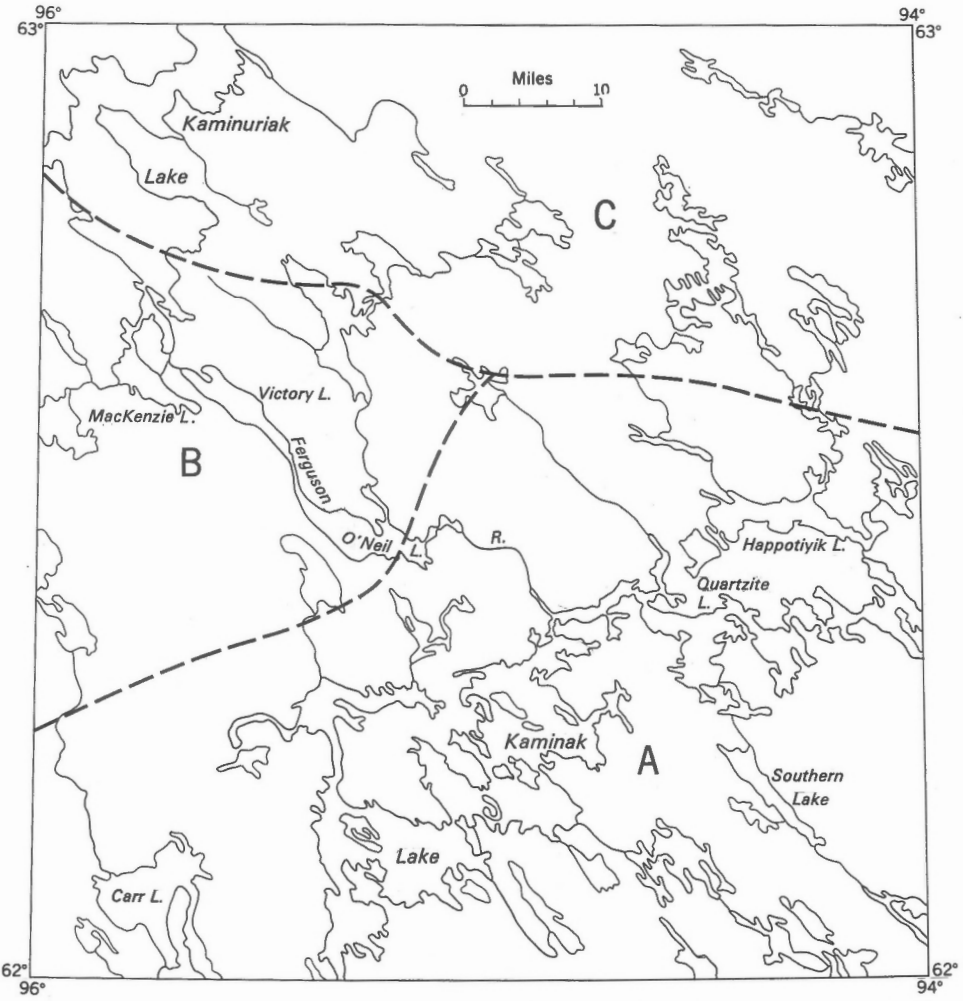

Figure 1. Subdivision of map-area on basis of lithology, structure and metamorphism (see Table I). GSC

metasediments, may be younger than the Kaminak Group; their relationship to the Hurwitz Group is not known. The MacKenzie Lake metasediments are involved in the formation of migmatite with younger granite near the western boundary of the map-area.

Region C is underlain by a complex of gneiss and migmatite. In places near the southern part of this region, remnants of all previously mentioned rock-units, with the exception of the Hurwitz Group, can be recognized. Late granite occurs throughout this region as dykes and sheets within the gneisses and as the matrix of migmatite.

The main differences between Regions A, B, and C are summarized in Table I. Each region is described separately in this report.

TABLE I

Outline of Differences Between Regions A, B, and C of Figure 1

	Region A	Region B	Region C
Lithology	Mainly metavolcanic rocks cut by variety of igneous plutons, overlain by Hurwitz Group	Mainly metasediments cut by granitic plutons	Gneisses and migmatites. New granite restricted to dykes and sheets
Structure	Steeply dipping and plunging structures, strike chiefly west or northwest except around plutons. Northeast-trending folds with shallow undulating axes in Hurwitz Group trough	Dominant northeast strike. Northwest trend of Region A folded about northeast axial planes with steep axes; northeast-trending folds with shallow axes in sediments	Northeasterly striking folds in gneisses, with gentle southwest plunge; flow folds and domal structures in migmatites
Metamorphism	Low grade (greenschist) with local amphibolite grade near and between plutons; grade increases near boundaries of Regions B and C	Medium grade (amphibolite); cordierite knotted schists are developed from the greywackes. Increases towards Region C	Medium to high grade; some pelitic gneisses carry kyanite and/or sillimanite. Old plutonic rocks recrystallized to fine- to medium-grained orthogneisses
Pre-Hurwitz diabase dykes	Trend northerly, variable; not metamorphosed in south, grade increases to north and northwest	Trend northeasterly; metamorphosed to lower amphibolite grade	Few remnants recognized, commonly boudinaged, now garnet amphibolites

Region A

TABLE II

Table of Formations for Region A

Age	Formation	Lithology	
Helikian or younger			Diabase, quartz diabase dykes
Early Helikian			Porphyritic biotite lamprophyre dykes
	Intrusive contact		
Aphebian	Hurwitz Group	Ahd	Massive or pillowed andesite flows, tuff, chert; associated mafic sills and dykes
		Ahc	Laminated siltstone, slate, greywacke; minor stromatolitic dolomite
		Ahb	Orthoquartzite
		Aha	Conglomerate, greywacke, impure quartzite
	Unconformity		
			Porphyritic plagioclase diabase
	Intrusive contact		
Archean			Gabbro, diorite, tonalite, adamellite; migmatite and gneiss derived from older rocks; alkali syenite
	Intrusive contact		
	Kaminak Group	As	Conglomerate, slate, greywacke, minor iron-formation
		Af	Intermediate to felsic flows, tuff, breccia
		Am	Massive or pillowed greenstone, minor tuff, breccia; associated mafic sills and dykes

Kaminak Group (units Am, Af, Av, As, Avs, Afs)

The extensive belt of greenstones and allied rocks that outcrops from between Rankin Inlet and Dawson Inlet on the coast of Hudson Bay west-southwestwards more or less continuously to west of the Henik Lakes, and thence sporadically to the vicinity of Ennadai Lake (Lord, 1953a; Wright, 1967), passes through the southern half of the Kaminak Lake map-area. Within the map-area, these rocks are represented by three main lithologies,

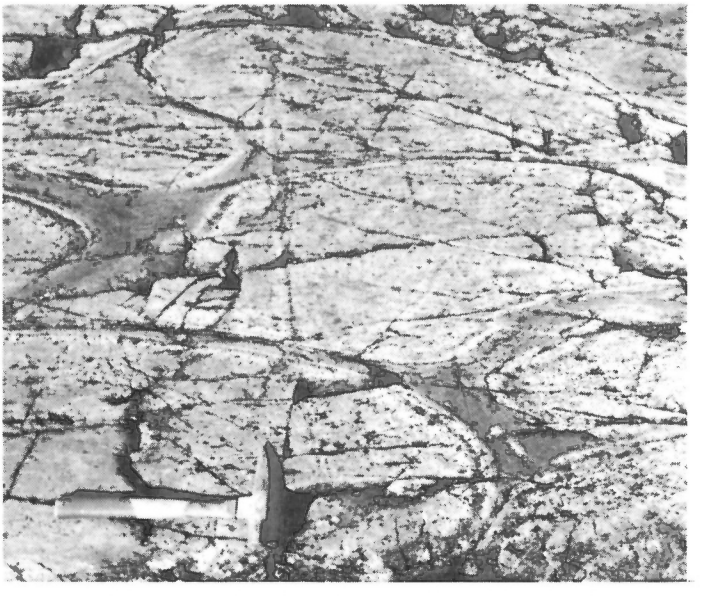

Figure 2. Pillow structure in greenstone (Am) at Quartzite Lake. (G.S.C. 133961)

Figure 3. Weathered surface of felsic volcanic breccia (Af) southwest of Quartzite Lake. (G.S.C. 133976)

namely (1) mafic to intermediate flows and breccias, loosely referred to as greenstones; (2) intermediate to felsic flows, tuffs, and breccias; (3) greywacke-type sediments, locally with iron-formation. Previously unnamed, this assemblage is here named the Kaminak Group. Because the inherently variable nature of the assemblage from place to place precludes precise correlation of any one chosen type section with sections in other parts of the area, the Kaminak Group is defined on the basis of a composite section obtained in the area between Kaminak, Quartzite, and Southern lakes.

Greenstones and greenschists of one form or another (Am) make up the bulk of the Kaminak Group exposed within Region A. The term greenstone is used here to include all the metamorphosed grey-green to dark green rocks of volcanic origin, varying from basaltic to dacitic, but chiefly of andesitic composition. These rocks are generally darker where metamorphosed to amphibolite grade (Am'), as near the major plutonic masses. Although many outcrop areas of greenstone are relatively massive and nondescript, pillows, flow boundaries, amygdules, phenocrysts, variolites, and fragmental texture are preserved in several places. Pillows are notably well preserved on the northeast side of Southern Lake, between Snug and Quartzite lakes, between Quartzite and Happotiyik lakes, and east of Carr Lake (Fig. 2). Poorly preserved pillows and other structures usually can be observed on clean outcrop surfaces but elsewhere are obscured by lichens. In places, for example north of Southern Lake, the greenstones contain intercalated pyroclastic strata, commonly with light coloured fragments in a darker green matrix. More rarely, quartz-plagioclase crystal tuff forms thin beds between mafic flows. Associated also with the mafic flows are sills, dykes, and irregular bodies of massive, dark greenstone or amphibolite that are probably an intrusive phase of vulcanism. The base of the greenstone assemblage is nowhere recognized; the lowest exposed parts are intruded by plutonic rocks. At least 15,000 feet of uniformly facing greenstones are exposed southeast of Southern Lake, and at least 10,000 feet in the vicinity of Quartzite Lake.

Felsic phases of vulcanism within the Kaminak Group are widespread but of more local development than the greenstones. These rocks comprise unit Af, and are mapped separately southwest of Carr Lake, about 15 miles north of Carr Lake, along the southern map boundary south of Kaminak Lake, on the large peninsula on the north side of Kaminak Lake, north of Munro Lake, and as an especially thick unit between Quartzite and Kaminak lakes. These felsic rocks are generally grey or pinkish grey rather than green, and they weather a variety of colours, including purple, pink, grey, white, yellow, and olive. Coarse pyroclastic breccias and agglomerates abound (Fig. 3), but dense, flinty-textured quartz and quartz-feldspar porphyries are also common, especially near Quartzite Lake and at the north side of Kaminak Lake. South of Quartzite Lake, a thick succession of greenish grey to grey lapilli and bomb tuffs and breccias is intercalated with mafic flows in its lower part. To the north, up-section, these give way to intertonguing lenses of porphyry and white-weathering tuff-breccia, with at least one intercalated pillowed greenstone flow. At the top of this succession, near the southwest shore of the main reach of Quartzite Lake, are local pockets of thin-bedded, fine-grained, graded crystal tuffs, probably water-lain, that in turn give way to the greywacke and conglomerate of the overlying sediments (As). At this locality, the predominantly felsic volcanic unit probably attains a maximum thickness in excess of 20,000 feet, but appears to thin

rapidly to the west and to the northeast, intertonguing with greenstones. A similar succession, neither as thick nor as well exposed, occurs south of Kaminak Lake. Elsewhere the felsic volcanic rocks are apparently enclosed by or interlayered with greenstones. In places, felsic and mafic rocks are so intimately mixed as to be inseparable at the present scale of mapping, and are included as unit Av; more rarely, isolated outcrops of well-bedded greywacke, slate, and conglomerate are present also (Avs), as southwest of Carr Lake and on some of the islands and peninsulas in the northern part of Kaminak Lake.

Three bodies of sedimentary rocks within Region A are extensive enough to be mapped separately (As). These are located at Quartzite Lake, south of Kaminak Lake, and between Kaminak and Savage lakes. On the shores of a small peninsula on the north side of Quartzite Lake, the sedimentary rocks are exposed in a vertical to steeply dipping, north-facing section, and conformably overlie massive, pale grey felsite with small, scattered quartz and plagioclase phenocrysts. From the base, the succession is: 85 feet of thin-bedded siltstones, possibly tuffaceous, the upper 30 feet of which contain thin beds of lean, siliceous iron-formation; about 500 feet of volcanic-pebble conglomerate with very rare granitoid pebbles and a sandy matrix containing clear quartz and milky plagioclase clasts; about 200 feet of greywacke-siltstones in beds 1 inch to 6 inches thick, some of them graded; 160 feet of massive, light grey, coarse-grained greywacke in beds up to 6 feet thick; 215 feet of thin-bedded greywacke, siltstone, and slate, again with some graded beds; at least 580 feet of massively bedded, light grey, coarse-grained greywacke with conspicuous clear quartz and milky plagioclase clasts; 500 feet of covered interval, but with nearby scattered outcrops of similar greywacke with some volcanic-pebble conglomerate; at least 200 feet of thin-bedded to laminated siltstone and slate, in places with innumerable quartz veins and lenses. The last unit is apparently in fault contact with greenstones to the north. Total thickness of the sedimentary unit at Quartzite Lake is 2,440 feet.

The sediments south of Kaminak Lake were not examined in detail, but are known to contain rocks similar to the Quartzite Lake section. Here, however, sedimentary iron-formation is well developed, and in one place a single bed of siliceous hematite-magnetite iron-formation is 40 feet thick. Elsewhere in this area, layers rich in iron oxides alternate with grey-green siltstones in beds a few inches thick. In addition, minor amounts of felsite porphyry and tuff are present locally within the sediments.

The sediments between Kaminak and Savage lakes are poorly exposed. At their northern boundary they are both structurally and stratigraphically above mafic flows, and although they contain a few thin interbeds of quartz-plagioclase crystal tuff, there is no extensive development of felsic volcanic rocks between them and the mafic flows. It is possible that the sediments and greenstones are in fault contact. The sediments for the most part are grey, fine grained, thin-bedded to laminated greywackes, siltstones and slates, in places with well-developed graded bedding. Coarse greywacke, conglomerate, and iron-formation were not observed. If there is no repetition by folding or faulting, this sedimentary unit is at least 10,000 feet thick.

Plutonic Rocks (units 1-4)

The plutonic rocks of Region A (units 1-4) include a large variety of rock types, most of which clearly intrude the Kaminak Group. They are distributed in three main plutonic complexes: (1) from north of Carr Lake, through Kaminak Lake, to south of Southern Lake; (2) north of Kaminak Lake; (3) northeast of Southern Lake. In addition, isolated plutons, generally of one rock type, occur within the Kaminak Group, and are probably satellites of the main complexes. The complexes are made up of several plutons, many of which are compositionally homogeneous, that are separated either by well-defined contacts, by zones of mixed rocks, or by screens of steeply dipping layered gneiss (Avn) and amphibolite (Am') derived from the Kaminak Group. All three complexes contain similar suites of rock-types, and rocks of the satellite plutons can be matched with plutonic components of the complexes.

Unit 1 contains the oldest plutonic rocks and is chiefly composed of hornblende gabbro and diorite. The main bodies of these rocks are located south and southwest of Southern Lake, on islands and peninsulas in the central part of Kaminak Lake, south of Kaminak Lake, and also form a large part of the complex north of Kaminak Lake. These rocks characteristically form areas of smooth, dark, rounded hills with locally rugged, moderately high relief. The most common rock type is massive, medium-grained, mesocratic diorite composed of approximately 55 per cent plagioclase, 35 per cent hornblende, 5 per cent biotite, and 5 per cent quartz. This rock grades into gabbro with as much as 60 per cent hornblende. Most thin sections of these rocks show that they are considerably altered; plagioclase is crowded with a mash of very fine secondary minerals, and blue-green hornblende forms aggregates of ragged grains with biotite. Secondary sphene, epidote, and chlorite are common, and microcline and oligoclase form clear, interstitial grains. Less altered rocks contain partly clouded andesine or labradorite and the hornblende commonly has uralite cores in which relics of pyroxene are preserved. At a few localities south of Southern Lake, fresh, dense, black gabbro containing hypersthene and augite, or hypersthene alone (norite), and with clear, dark labradorite, is seen to have been altered to the common clouded plagioclase-hornblende variety along fractures and joints.

Included in unit 1 is a group of mixed rocks that are best described as mafic inclusion breccias (1a). These heterogeneous rocks contain a variety of dark inclusions in a gabbroic or dioritic matrix. Inclusions range from angular to rounded, well-defined to nebulous, fine- to coarse-grained, crowded to well-spaced, and in size from 1 inch to 15 inches in diameter. All varieties have been observed in a single outcrop. These breccias are commonly, but not invariably, marginal to mafic flows of the Kaminak Group, and the fine-grained, angular inclusions are indistinguishable from the amphibolitic greenstones (Am') of these flows.

The bulk of unit 2 is represented by massive to foliated, relatively homogeneous, leucocratic, grey, biotite-hornblende tonalite and granodiorite. The larger, particularly uniform plutons of this type are located immediately south of Quartzite Lake, on the islands and shores of the southern part of Kaminak Lake, northeast of Carr Lake, and southeast of O'Neil Lake. Many smaller bodies of similar rocks are common within the plutonic complexes. For the most part these rocks are irregularly jointed, and normally form low, smooth hills. The tonalite typically contains about 10 per cent hornblende, 5 per cent biotite, 55 per cent plagioclase, 5 per cent

microcline, and 25 per cent quartz. Granodioritic varieties contain as much as 20 per cent microcline, and in these rocks biotite is more abundant than hornblende. Most of the rocks of unit 2 are altered to some degree; plagioclase is clouded, and epidote and chlorite partly replace hornblende and biotite. Vein migmatites (1a/2, Am'/2) and inclusion breccias (2a) are common in relatively narrow zones at the contacts of some plutons, but the cores of these plutons are generally homogeneous. In places, however, the tonalites have a pronounced foliation and are locally gneissic (2b), notably in the central part of the complex around Kaminak Lake, and are associated with lenses of layered gneiss (Avn) probably derived from the Kaminak Group. The foliated plutonites and the gneisses together form large curved structures within the complex.

Unit 3 is composed of massive, homogeneous, medium- to coarse-grained, leucocratic, pink biotite adamellite, commonly with megacrysts of microcline. It forms a well-defined pluton northwest of Southern Lake, two very poorly exposed plutons southeast of Kaminak Lake, several small plutons west of Kaminak Lake, and an apparently isolated pluton east of Happotiyik Lake. Well-developed jointing has resulted in the formation of blocky felsenmeer above plutons of this type, in contrast to unit 2. Typically the adamellite contains subequal proportions of microcline, oligoclase, and quartz, with very minor amounts of biotite; secondary muscovite, chlorite, and epidote are common in places. Small quartz-microcline pegmatites are found locally within and around the plutons, especially north of Southern Lake where they contain very minor amounts of muscovite, garnet, and purple fluorite. Dykes and apophyses of unit 3 have been observed to cut most phases of units 1 and 2. Isolated bodies of vein migmatite in mafic flows of the Kaminak Group (Am'/3) occur between Snug and Quartzite lakes and north of Happotiyik Lake and are probably above unexposed plutons.

Unit 4 is represented by one small pluton of alkali syenite and related rocks on the northeast side of Kaminak Lake (Davidson, 1968b). Coarse-grained syenite, nepheline syenite, melanite ijolite and melteigite, and a variety of altered equivalents of these rocks, form the bulk of this poorly exposed pluton. Syenite dykes cut the tonalite pluton to the east. Age relations to unit 3 are not known.

Pre-Hurwitz Diabase

Throughout Region A, both the Kaminak Group and all the plutonic rocks so far described are cut by numerous diabase dykes, most of which are between 25 and 200 feet thick. The dominant trend of these dykes is slightly east of north, except on the islands and peninsulas in the east-central part of Kaminak Lake where the trend swings to northwesterly. Most dykes are medium grained in their central parts and have fine-grained, chilled margins. They normally carry scattered, large, tabular phenocrysts of plagioclase, usually less than 2 inches across but in places as much as 6 inches across. In some dykes the phenocrysts are arranged in zones parallel to the dyke margins. In a few dykes the phenocrysts are so crowded as to form the bulk of the rock. Some dykes are sinuous, but most are relatively straight. Faults displace the dykes, generally with dextral sense and locally by as much as one-half mile. Very few dykes can be traced continuously for more than 5 miles. In the central-southern and southeastern part of Region A the

dykes are either fresh or are deuterically altered. Their increasing alteration by metamorphism to the north and northwest is the subject of a later section.

Mafic sills within the Hurwitz Group appear similar in some respects to the diabase of the dykes, except that they are entirely nonporphyritic. None of the porphyritic diabase dykes is known to cut rocks of the Hurwitz Group; in several places the dykes are truncated at the Hurwitz contact, although this contact is usually inferred to be faulted.

Hurwitz Group (units Aha, Ahb, Ahc, Ahd)

Extending from Happotiyik Lake to the north side of Carr Lake is a down-faulted, synclinal trough of sedimentary and volcanic rocks 60 miles long and between 1 1/2 and 3 miles wide. These rocks are correlated by Bell (1968a, b) with the Hurwitz Group in the Henik Lakes area to the southwest (Eade, 1964, 1966), on the basis of lithologic succession. Polymictic conglomerate with pebbles, cobbles, and boulders of granitoid rocks and greenstone, and some pebbles of quartz, jasper, quartzite, and slate, in a quartzofeldspathic sandy to silty matrix (Hurwitz A of Bell, 1968b) forms the basal unit of the Hurwitz Group, and is well exposed north of Carr Lake. This unit is overlain by varicoloured micaceous siltstone that locally contains sandy and pebbly beds (Hurwitz B of Bell). These two units together (Aha) are perhaps as much as 1,000 feet thick north of Carr Lake, but thin rapidly to the northeast and are not exposed in the northeastern half of the belt.

Unit Ahb (Hurwitz C and D of Bell) contains the white, extremely pure orthoquartzite, so characteristic of the Hurwitz Group, that forms prominent white ridges and hills along the length of the belt. The lower part (Hurwitz C) is composed of pink, white, and grey, medium- to coarse-grained, rarely pebbly, slightly feldspathic quartzite that contains scattered grains of bright red jasper, and forms thick beds that are locally cross-stratified. This unit is about 900 feet thick north of Carr Lake, but thins northeastwards to about 20 feet at Quartzite Lake. The upper part (Hurwitz D) contains thin-bedded, ripple-marked, white and pink orthoquartzite and is about 800 feet thick throughout the belt.

The next unit (Ahc; Hurwitz E of Bell) is recessive and very rarely exposed. Scattered areas of frost-heaved flags and chips of grey, green, and purple slate, siltstone, and calcareous greywacke, commonly showing fine graded bedding transected by slaty cleavage, are the nearest thing to outcrop in most places. In four places at Quartzite Lake, outcrops of pink, aphanitic dolomite, in part cherty and stromatolitic, occur within this unit.

Unit Ahd (Hurwitz F of Bell) forms a range of dark, rugged hills in the central part of the Hurwitz trough. It is composed mainly of massive or sheared, fine-grained greenstone. Sheared lapilli tuff and pillowed lava with black chert nodules between pillows are intercalated with layers of featureless greenstone in the vicinity of Quartzite Lake. The lower part of the unit contains massive sills of medium-grained greenstone. The lowest sill south of the west arm of Quartzite Lake lies above about 600 feet of unit Ahc, and is itself about 700 feet thick. To the northeast, this sill becomes thinner and gradually cuts down through the section until it is a narrow dyke within the quartzite of unit Ahb. On the north side of the west arm, the lowest sill is apparently at the interface between units Ahb and Ahc. Thin layers of graded

greywacke, siltstone, and slate, similar to unit Ahc, are commonly found between the flows and sills of unit Ahd. Thin sections of this greywacke reveal that many of the clasts are of fine-grained volcanic rock, and some clasts have the irregular shape of deformed shards; thus some of the greywackes are in fact tuffaceous. The flows, therefore, were extruded at the same time as sediment deposition, and the sills were probably intruded into the lower part of this succession contemporaneously or at a slightly later time.

Bedding in the lowest units of the Hurwitz Group generally conforms to the contact with the bordering rocks. In most places the contact is covered, but where exposed it is usually the locus of severe shearing parallel to the contact. Hurwitz strata in most places dip steeply away from these contacts, but locally are overturned. Where adjacent to layered rocks of the Kaminak Group, there is usually a pronounced angular discordance in attitude. In all probability, then, the Hurwitz Group was deposited on the older rocks with pronounced angular unconformity, since modified by shearing.

Lamprophyre Dykes

East-southeast-trending dykes of dark grey lamprophyre, rarely more than 10 feet thick, are present here and there throughout Region A, and cut all the rocks so far described. At four localities they cut folded strata of the Hurwitz Group and are not themselves deformed. The lamprophyre is medium- to fine-grained and usually contains coarse phenocrysts of biotite. The groundmass of this rock is largely composed of K-feldspar, with some biotite, quartz, and pale blue-green actinolite-like amphibole, and accessory sphene and apatite. One 8-foot dyke east of Carr Lake contains well-rounded inclusions of granitic and gneissic rocks up to 9 inches in diameter.

Post-Hurwitz Diabase

Northwest-trending, fresh to deuterically altered diabase cuts rocks of the Hurwitz Group between Happotiyik and Quartzite lakes. It extends as a series of dykes *en echelon* throughout the Kaminak Lake map-area. It has not been observed to cut across lamprophyre dykes. Dykes of the same swarm cut the Dubawnt Group to the north (Wright, 1967).

Region B

Kaminak Group (units Am', Af', Av', As', Avs')

A narrow band of amphibolitic greenstones near the northeast shore of O'Neil Lake connects greenstones of the Kaminak Group southwest of O'Neil Lake with a large area predominantly underlain by amphibole schists (Am', Av') north of the same lake; here too are minor amounts of felsite and quartzofeldspathic schist probably derived from felsic flows and tuffs. Similar rocks occur in the vicinity of Townsend Lake, west of which are outcrops of amphibolite containing structures reminiscent of flattened pillows. The associated band of quartzofeldspathic schist (Af') contains rocks with light

TABLE III

Table of Formations for Region B

Age	Formation	Lithology
Early Helikian		Porphyritic biotite lamprophyre dykes
	Contact not observed	
Aphebian		Granite, migmatite
	Intrusive to gradational contact	
Aphebian?	MacKenzie Lake metasediments	Granite- and quartz-pebble conglomerate, meta-arkose, impure quartzite, white orthoquartzite, micaceous schist
	Contact not observed	
Aphebian		Porphyritic plagioclase meta-diabase
	Intrusive contact	
Archean		Metamorphosed gabbro, diorite, tonalite, adamellite; migmatite and gneiss; in part considerably sheared and recrystallized
	Intrusive contact	
	Kaminak Group?	As' Metagreywacke, quartz-biotite-plagioclase schist, in places with cordierite, garnet, andalusite, or staurolite porphyroblasts; thin-bedded iron-formation, amphibolite
	Kaminak Group	Af' Quartzofeldspathic schist, in places with biotite and amphibole
		Am' Hornblende schist, amphibolite

coloured lenses in an amphibole-bearing matrix that probably represent metamorphosed felsic breccias. The band of amphibolite (Am') enclosed by metagreywacke (As') southwest of Victory Lake is almost certainly of volcanic origin, but the layered amphibolite and hornblende schist (Av') west and southwest of MacKenzie Lake were not seen to contain relics of primary volcanic structures by which they could be identified.

The metasediments (As') of Region B, now mainly biotite-bearing schists, were derived from thin-bedded greywackes similar to those of the Kaminak Group in Region A southeast of Savage Lake. Unlike the metasediments at Quartzite Lake, these rocks are not associated with felsic volcanic rocks, and conglomerate was not observed. Small amphibolite nodules in some metagreywackes are probably derived from calcareous concretions, and suggest that interbedded amphibole-rich layers are similarly derived from calcareous greywackes. Thin-bedded siliceous magnetite iron-formation is interbedded with light grey siliceous siltstones and amphibolitic

rocks southeast of Victory Lake, and gives rise to a large magnetic anomaly (Geol. Surv. Can., Map 7297G, 1966). A similar anomaly at the south end of Townsend Lake suggests that the metasediments underlie much of this drift-covered area as well. In the northwestern part of the area underlain by unit As', light coloured meta-arkose and quartzose semipelite are interbedded with the more usual dark grey metagreywacke and pelitic schist.

This metasedimentary unit is everywhere metamorphosed to at least lower amphibolite grade. Cordierite-andalusite, staurolite-andalusite, and garnet-staurolite-andalusite assemblages are present in the pelitic schists; kyanite was not observed.

Plutonic Rocks (units 1-3)

Two plutonic complexes, one extending westwards from O'Neil Lake and the other west of Townsend Lake, contain mildly to strongly altered equivalents of units 1, 2, and 3 of Region A. Alteration is most pronounced in the metamorphosed gabbros, diorites, and mafic inclusion breccias (1, 1a), well-foliated and recrystallized examples of which are found around O'Neil Lake. The original mafic minerals are replaced by aggregates of biotite, blue-green hornblende, and epidote; plagioclase is considerably epidotized. Metadiorite (1) and metatonalite (2) between Townsend and MacKenzie lakes are similarly altered; in most rocks original quartz grains are reduced to lenticles of interlocking grains.

The granitic rocks of unit 3 southwest of O'Neil and Savage lakes and around Victory Lake appear similar to their counterparts in Region A. Megacrysts of K-feldspar remain, but the rocks commonly have a blastogranitic texture, especially noticeable in thin sections. Quartz and biotite are in part recrystallized, but plagioclase, although epidotized, appears to retain its original form. At MacKenzie Lake and west of the north end of Townsend Lake these rocks are recrystallized to a fine-grained quartz-feldspar-biotite aggregate, in places with ragged relics of K-feldspar megacrysts.

As in Region A, unit 3 is the latest plutonic phase. The metadiorite breccia northwest of Savage Lake is cut by numerous apophyses and dykes of granitic rock, forming a vein migmatite (1a/3).

Pre-Hurwitz Diabase

Northeast-trending dykes of metadiabase are remarkably well-preserved within all rock units so far described, especially in the granitoid rocks around Savage Lake. Blastoporphyritic texture is given these rocks by relict plagioclase phenocrysts, now mostly rounded aggregates of fine-grained oligoclase or andesine, in a fine- to medium-grained groundmass of plagioclase and blue-green hornblende with some biotite and minor quartz, epidote, and sphene. The dykes still retain fine-grained marginal zones, but recrystallization has destroyed all traces of an original ophitic texture.

MacKenzie Lake Metasediments (A'q)

A belt of metamorphosed conglomerate, orthoquartzite, impure quartzite, and arkose in steeply dipping beds extends southwestwards from the northwest end of Victory Lake (unit A'q). These rocks are referred to as the MacKenzie Lake metasediments by Bell (1968b). Their contact with granitic rocks to the northwest is sheared, and there is no evidence that these granitic rocks have intruded the metasediments. The southeastern contact of these rocks with unit As' is not exposed; it is possible that some of the more quartzofeldspathic metasediments mapped as As' in fact belong to the MacKenzie Lake metasedimentary succession. Northwest of this belt, quartzofeldspathic schists, in places with much muscovite, are probably more highly deformed and metamorphosed equivalents of the MacKenzie Lake metasediments. Metadiabase was not observed to have cut these rocks.

The most abundant conglomerate contains well-rounded pebbles, cobbles, and boulders of granitoid rocks and quartzite set in a schistose quartz-feldspar-biotite matrix, in places with muscovite. This conglomerate is similar to the conglomerate (Aha) at the base of the Hurwitz Group north of Carr Lake in Region A. White orthoquartzites at MacKenzie Lake and those of the Hurwitz Group (Ahb) are also similar, except that the former lack sedimentary structures. Interbedded with the conglomerate and quartzite near MacKenzie Lake are impure quartzite, quartz-pebble and quartz-iron-formation- pebble conglomerate, meta-arkose, and micaceous schist. These rocks do not occur in a stratigraphic order that suggests correlation with the Hurwitz Group. Despite this, it is possible that the MacKenzie Lake metasediments are a correlative facies of the lower part of the Hurwitz Group; on the other hand they may be entirely unrelated.

Granite, Migmatite (5, 5a)

Ten miles southwest of MacKenzie Lake, near the western map-boundary, are outcrops of a granite pluton (5) that postdates the MacKenzie Lake metasediments. At its northern edge, meta-arkose and conglomerate are involved in the formation of migmatite (5a) with this granite, and it is very difficult to distinguish recrystallized arkose from granite. Pegmatite dykes cut metaconglomerate one mile northeast of this pluton. On its eastern side the pluton is composed of massive, fresh, homogeneous, equigranular, medium- to coarse-grained, pale pink leucogranite. Although not exposed, its contact trends across the strike of bedding in nearby metagreywackes and cordierite-andalusite knotted schists. It is possible that granite of unit 5 is included within bodies assigned to unit 3 along the western map-boundary to the north and south of this pluton.

Lamprophyre Dykes

Narrow dykes of biotite lamprophyre, identical in all respects with those of Region A, are abundant west and southwest of O'Neil Lake, and are known to cut metadiabase dykes. They have not been observed to have cut the MacKenzie Lake metasediments or the granite of unit 5. At 62°29 1/2'N and 95°43'W, a small body of hornblende-biotite quartz syenite, less than

one-half mile in diameter, appears to be related to a swarm of lamprophyre dykes. At 62°24'N and 95°29'W, an isolated outcrop of hornblende-biotite-perthite porphyry may be of similar kindred.

Region C

North of a line that extends west-northwesterly from the eastern map-boundary at 62°35'N to the southern part of Kaminuriak Lake (Fig. 1), the rocks of Regions A and B are converted to a variety of gneisses and migmatites. More accurately, this line represents a zone a few miles wide across which known rock units of the southern regions become increasingly less recognizable.

Gneissic Equivalents of the Kaminak Group and the MacKenzie Lake Metasediments (Amn, Avn, Asn, A'qn, 6)

The Kaminak Group can be traced across the southern boundary zone of Region C in the area north of Happotiyik Lake, where three prominent outcrop ridges of amphibolitic greenstone and greenschist (Av') grade along strike to the northeast into regularly layered amphibolite gneiss and hornblende-plagioclase gneiss, in places with garnet. In the easternmost ridge, garnetiferous paragneiss adjacent to amphibolite gneiss contains layers of quartz-magnetite iron-formation. North of the northwesternmost ridge lies a tract of metasedimentary schist and gneiss (Asn) within which are isolated thin bands of white, glassy quartzite; associated pelitic schists contain staurolite, garnet, and kyanite. These rocks may be equivalents of the metasediments southwest of Victory Lake, including derivatives of both the metagreywackes (As') and the MacKenzie Lake metasediments (A'q). To the north and northeast of these metasediments, regularly layered hornblendic gneiss interlayered with quartzofeldspathic gneiss (6) are possible derivatives of the Kaminak Group. Many outcrops of these gneisses display mesoscopic flow-folding (Fig. 4).

On the east shore of Mandreville Lake, a narrow band of layered amphibolite (Am') is structurally overlain by quartzofeldspathic metasediments within which a few layers of conglomerate are preserved. Flattened granitoid pebbles are recognizable, and thin plates or rods of quartz probably represent quartz or quartzite pebbles. These rocks grade to the northeast into quartzose gneisses (A'qn). Farther northeast, at Duffy Lake, similar quartzose gneisses again structurally overlie hornblende gneiss and layered amphibolite (Amn). Still farther to the northeast, near the northern map-boundary, amphibolite gneiss (6), locally containing garnet and diopside, borders a small outcrop area of sedimentary gneiss (A'qn), including impure, glassy quartzite and micaceous gneiss containing garnet and sillimanite.

East of the south part of Kaminuriak Lake, unit 6 is predominantly straight-layered, fine- to medium-grained, dark hornblendic gneiss and quartz-feldspar-biotite gneiss, in places with granitoid gneiss layers and irregular or cross-cutting granitoid veins.

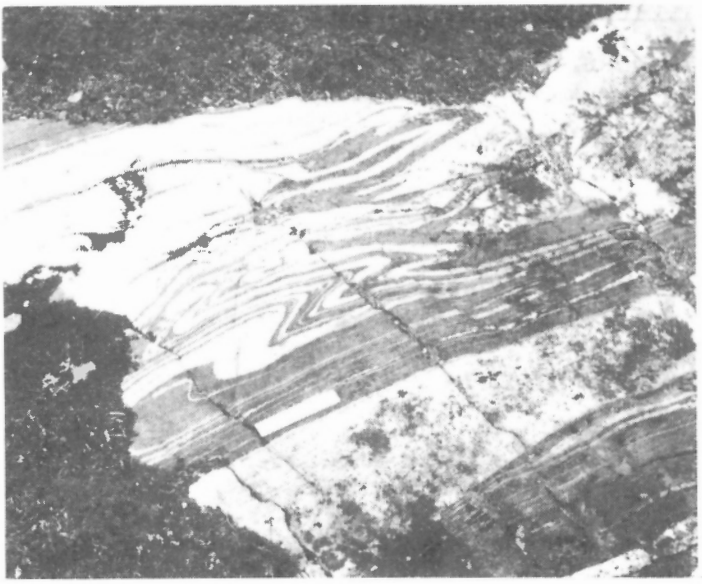

Figure 4. Mesoscopic flow folds in layered gneiss (unit 6) east of Townsend Lake; scale is 6 inches long. (G.S.C. 133964)

Figure 5. Agmatitic appearance of outcrop of unit 7, twelve miles northwest of Duffy Lake. Flat-lying dark gneiss is pervaded by granitoid filaments and dykes. (G.S.C. 133966)

Gneissic Equivalents of the Pre-Hurwitz Plutonic Rocks (1', 2', 3')

Within Region C are large masses of relatively homogeneous granitoid rocks (2', 3'), varying from place to place from subfoliated or lineated to vaguely or irregularly gneissic. Most of these rocks are fine grained and have a sugary texture. Northwest of Happotiyik Lake, a pluton of tonalite and granodiorite (2) with blastogranitic texture grades into fine-grained, sugary orthogneiss (2') across the boundary zone between Regions A and C. Similarly, blastogranitic adamellite (3) west of the north half of Townsend Lake grades to the northeast into pink, fine-grained, lineate orthogneiss (3') of the same composition. Similar bodies of orthogneiss are present in the very poorly exposed central and eastern parts of Region C. A body of medium-grained, homogeneous hornblende diorite orthogneiss (1') on the east side of Kaminuriak Lake is in marked contrast to the surrounding gneiss and migmatite.

Boundaries between layered gneiss (6) and the orthogneisses (2', 3') are well defined in some places; elsewhere they are gradational in the sense that homogeneous orthogneiss passes with increasing amounts of included foreign material from nebulitic and schlieren gneiss, through gneisses containing tabular lenses of dark layered gneiss, into layered gneisses *per se*.

Pre-Hurwitz Diabase

As the boundary zone of Region C is approached from the south, the pre-Hurwitz diabase dykes of Region A become increasingly metamorphosed and dislocated by shearing and small faults; in addition, their trend becomes more northeasterly. Small patches of amphibolite with streaky lenses of fine-grained plagioclase are present in the orthogneisses in the eastern part of Region C, and may represent relics of these dykes. Northeast of Townsend and Mandreville lakes, within unit 6, are several well-preserved relics of these dykes, now metamorphosed to schistose amphibolite, in places with minor garnet. The original plagioclase phenocrysts are represented locally by elongated and subrounded augen of recrystallized plagioclase, but in most places these have been reduced to thin streaks.

Migmatite Complex (7, 8)

Most of the northern part of Region C is underlain by swirly and irregularly layered migmatitic gneisses (7) in which numerous small structures are suggestive of mobilization and flowage. In general, biotite-rich layers and streaks are contorted, and amphibole-rich layers are severed into blocks and plates separated by leucocratic filaments and irregular granitoid dykes. Seen from the air, some outcrops where the foliation is subhorizontal have the appearance of agmatite (Fig. 5). However, in the sides of such outcrops, and where the foliation is steep, these rocks appear to have fairly regular, warped layering with leucocratic layers that pinch and swell and are continuous with irregular cross-cutting dykes. In addition, a massive, fresh-appearing, pink granitic phase has invaded these rocks both as parallel and cross-cutting tabular bodies, forming a large-scale stockwork. Units 7 and 8 are separated on the basis that the new granitic phase is the

dominant rock in bodies of unit 8. However, as these bodies occur in areas where the migmatitic gneisses are flat lying, they may be fortuitously exposed, relatively thin, sill-like masses of new granite within the gneisses. The new granitic phase, although locally aplitic, is mostly medium-grained and equigranular. In composition it is biotite adamellite or granite, and in texture it closely resembles the granite of unit 5.

Map-units 9 and 10

Ten miles due south of Duffy Lake, a prominent hill is formed of dense, medium-grained, black pyroxenite (9) whose relations to the surrounding rocks are not known. This rock contains both ortho- and clinopyroxene euhedra in a groundmass of less than 10 per cent labradorite. The pyroxenes are in part replaced by olive-green hornblende, colourless acicular amphibole, and biotite.

Just south of the west arm of Kaminuriak Lake, a large outcrop exposes part of a body of massive, medium-grained, dark green rock (10) composed predominantly of green augite and hornblende, with some biotite, enclosed in large poikilitic crystals of both microcline and oligoclase. This peculiar rock intrudes the surrounding migmatitic gneisses (7).

Post-Hurwitz Diabase

The same group of *en echelon* diabase dykes that cuts the Hurwitz Group and older rocks in Region A continues throughout Region C, and is therefore entirely post-orogenic. Lamprophyre dykes were not observed in Region C.

STRUCTURE

South and east of the Hurwitz belt, the dominant trend of primary layering in the Kaminak Group is east or southeast. Dips are normally steep, and in places, such as along the northeast side of Southern Lake, thick sequences of flows are overturned. Major folds are all but impossible to delineate on account of lack of stratigraphic control, refolding in the neighbourhood of the plutonic rocks, and severe dislocation by numerous faults. However, the widespread northerly facing attitudes from Southern Lake, through Quartzite Lake, and along the northern part of Kaminak Lake suggest that the plutonic complex about Kaminak Lake occupies a major anticlinal region. To the north, southerly facing attitudes likewise suggest that a complementary major syncline extends westwards from Helika Lake through the northern part of Kaminak Lake. Lack of stratigraphic symmetry about this synclinal axial zone is probably due chiefly to faulting, but may also be in large part a function of the natural discontinuity and localization of the strata that make up the volcanic pile; in felsic volcanic rocks particularly, locally thick sequences may dwindle to nothing within a very few miles.

It is only along this postulated synclinal region, and also in the extreme southeast and southwest parts of the map-area, that primary structures such as pillows, breccia fragments, and conglomerate pebbles are

relatively nondeformed. Within, between, and bordering the plutonic complexes, flattening of these features is accompanied by parallel metamorphic mineral foliation. Refolding in response to emplacement of the plutonic rocks probably accounts for the variety in attitude around the complexes. The curved bands of gneissic rocks within the Kaminak Lake complex may well be tightly appressed equivalents of folds like the syncline south of Kaminak Lake.

North and west of the Hurwitz belt, towards Regions B and C, rocks of the Kaminak Group are notably more schistose, and the dominant trend of both primary and secondary foliations swings northeasterly. Compositional layering in these rocks north of O'Neil Lake is thrown into closely spaced folds with pronounced, steep, northeast-trending axial plane cleavage. Bedding in the metagreywackes (As') and in the MacKenzie Lake metasediments (A'q) southwest of Victory Lake trends consistently northeast, and fold axes plunge variably to the northeast and southwest.

The plutonic rocks in the southern part of the map-area become increasingly deformed to the north. In the whole region on the north side of the Hurwitz belt, most of the plutonic rocks are closely fractured and laced with numerous small faults and sheared zones. Severe penetrative shearing has locally reduced the tonalites and diorites north of Carr Lake and east of O'Neil Lake to flaser gneiss and mylonite. The pre-Hurwitz diabase dykes are also affected by this deformation, being offset by the faults and in places sheared along their contacts.

Shallow-plunging, northeast-trending folds within the Hurwitz belt are reflected in the adjacent older rocks by steep shearing parallel to the belt. Bedding in the Hurwitz Group along the faulted margins of the belt is generally steep and in places overturned, but in the central part it dips moderately about closely spaced folds with steep axial planes. Slaty cleavage in the greywackes and mudstones of unit Ahc and fracture cleavage in the dolomites of the same unit are well developed and in most places are steeply inclined to bedding. The apparent lack of continuity in the distribution of the older rocks on either side of the Hurwitz belt suggests considerable dislocation in the underlying basement.

Region C is characterized by a predominant northeast structural grain. The layered gneisses are folded about shallow southwest-plunging axes, collinear with which a penetrative mineral alignment in both layered gneisses and orthogneisses is commonly developed. To the north and northwest, especially in the migmatites (7), the folds appear to open out, and the layering is gently warped about shallow southwest or subhorizontal axes. Small-scale domal structures are common in the migmatites, and in the northeast corner of the map-area the dominant lineation reverses plunge through horizontal to shallow northeast.

Region A contains numerous faults and shear zones of many orientations, commonly accompanied by hydrous alteration. Faults trending between northeast and southeast are seen to have dextrally offset the pre-Hurwitz diabase dykes. The latest recognized fault set trends southeast and transects the Hurwitz belt. Similarly oriented faults cut the northern contact of the MacKenzie Lake metasediments at Victory Lake. Faults are rarely recognized in Regions B and C; although partly explained by poor rock exposure, it is possible that the numerous faults in Region A are an expression in brittle rocks at higher structural level of the same tectonic forces that were relieved by more penetrative deformation in the northern regions.

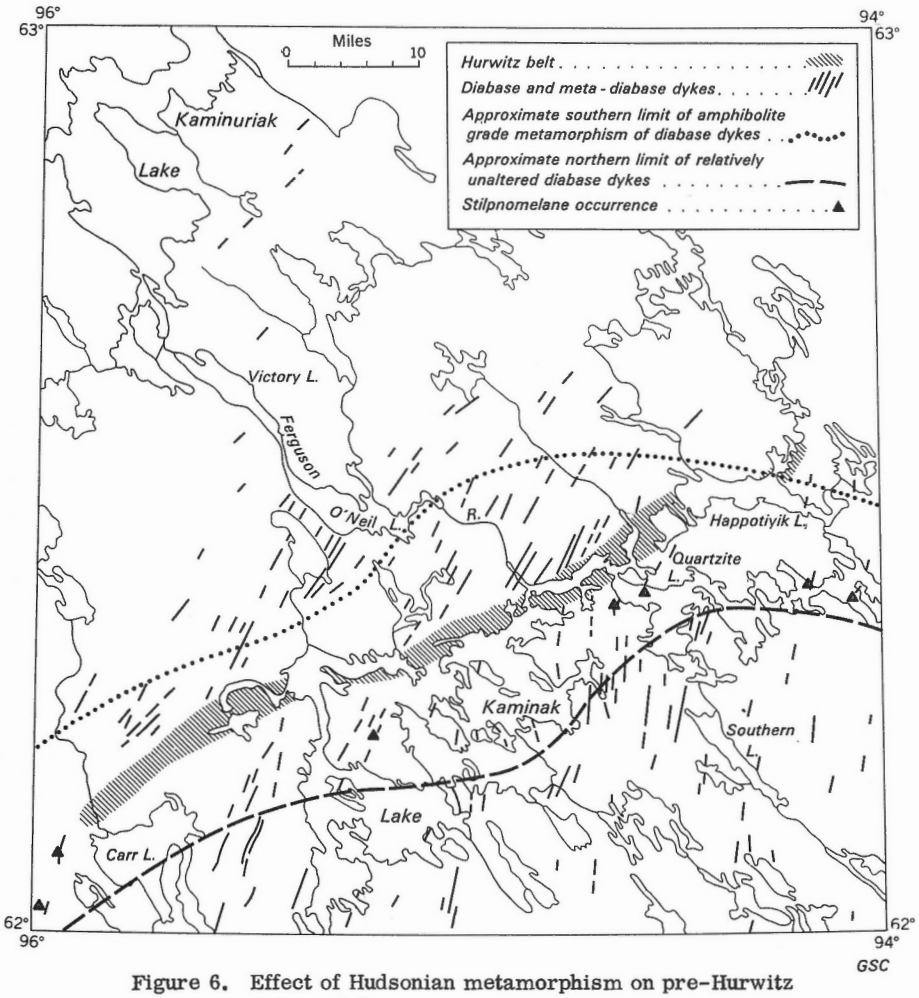

Figure 6. Effect of Hudsonian metamorphism on pre-Hurwitz diabase dykes.

METAMORPHISM

Two major periods of metamorphism have affected the rocks of the Kaminak Group. Metamorphism of the pre-Hurwitz diabase dykes, intruded between these two periods, serves to outline the southern extent of the later metamorphism. Figure 6 illustrates the distribution of metamorphism of the pre-Hurwitz diabases. South of the dashed line on this figure, the dykes are either fresh or deuterically altered with development of uralite, biotite, and chlorite around pyroxenes, and epidote in plagioclase phenocrysts. North of the dotted line, the dykes are amphibolites composed of andesine and poikilitic or acicular blue-green hornblende, with minor orange-brown biotite, epidote, sphene, and quartz; all traces of original ophitic texture are destroyed, but relics of plagioclase phenocrysts are preserved. In the southern part of the area between the dashed and dotted lines, the diabase

is dull greenish grey and contains metamorphic chlorite, epidote, calcite, sphene, rare golden brown stilpnomelane (identified by X-ray powder diffraction methods), and incipient greenish biotite. Ophitic texture and relics of original pyroxene are preserved. Plagioclase phenocrysts are crowded with small epidote metacrysts. In the northern part, north of the Hurwitz belt, pale blue-green amphibole appears in the metamorphic assemblages, biotite is better crystallized and assumes a greenish brown colour, pyroxene relics and stilpnomelane are absent, and ophitic texture is commonly masked by new mineral growth.

Mafic volcanic rocks and associated sills and dykes (Ahd) within the Hurwitz Group contain the same secondary mineral assemblages as the pre-Hurwitz diabases adjacent to the belt. Some of the Hurwitz slates (Ahc) contain tiny metacrysts of biotite. The Hurwitz Group, therefore, appears to have been affected by the later regional metamorphic event. The lamprophyre dykes, however, are apparently not metamorphosed.

Within the area of nonmetamorphosed pre-Hurwitz diabase, metamorphism in the Kaminak Group is an effect of the earlier orogenic event, and appears to be related to emplacement of the plutonic rocks. The lowest grade Kaminak rocks are the farthest removed from plutonic complexes, and lie in a belt parallel with the postulated major synclinal region that extends from Helika Lake to the northwest part of Kaminak Lake; low grade rocks also occur in the extreme southwest and southeast parts of the map-area. Low greenschist grade metamorphism is suggested by chlorite-epidote-albite-calcite assemblages in mafic flows and quartz-albite-muscovite-calcite assemblages, with minor chlorite and epidote, in the felsic rocks and sediments, and also by the absence of biotite and the rarity of actinolite. Towards the Kaminak Lake plutonic complex, and in the mafic flows around Southern Lake, metamorphic grade passes through the greenschist facies to lower amphibolite facies close to plutonic contacts. Normally the mafic flow rocks are metamorphosed to dense amphibolites composed of andesine and blue-green hornblende; garnet is present in some relict pillow selvages. Country rocks adjacent to gabbro south of Southern Lake are locally recrystallized to coarse assemblages containing gedrite, garnet, biotite, labradorite, and rare cordierite. Screens within the Kaminak Lake complex are also metamorphosed to amphibolite grade. Middle to upper greenschist grade is reached in the core of the syncline south of Kaminak Lake, where biotite, epidote, chlorite, actinolite, and garnet are present in the metasediments.

Metamorphism is of amphibolite grade throughout Regions B and C, and is regional in nature. Pelitic rocks, however, indicate that different metamorphic pressure conditions prevailed in the two regions. In Region B, aluminous rocks of unit As' contain assemblages with cordierite and andalusite; these rocks are found many miles from either older (1, 2, 3) or younger (5) plutonic rocks, and are therefore interpreted as the result of regional low-pressure metamorphism. Micaceous pelitic schists in Region C north of Happotiyik Lake contain kyanite, staurolite, and garnet, and are of higher pressure origin. In the northeast part of Region C, pelitic gneisses contain sillimanite, and amphibolitic gneisses locally contain pale green diopsidic augite.

Progressive metamorphism of the older plutonic rocks is manifest northwards from Quartzite and Kaminak lakes by an increasing degree of recrystallization, especially of the mafic minerals. In the southern part of Region A, the alteration of pyroxene-bearing gabbros to hornblende diorites

and gabbros with clouded plagioclase probably accompanied the later intrusion of tonalite and adamellite plutons, as these later rocks are still relatively fresh. In the zone of low grade diabase metamorphism (Fig. 6), however, the tonalites and adamellites are altered too, chiefly by development of secondary epidote, chlorite, and sphene from the original mafic minerals, and the incomplete alteration of plagioclase to epidote and muscovite; these altered rocks are usually a lustreless greenish grey colour. Near the northern boundary of Region A, recrystallization is more complete, and in several places was accompanied or preceded by various degrees of cataclasis. The tonalites and adamellites contain bluish or milky quartz grains that thin sections show to be formed of aggregates of small polygonal or interlocking grains. Biotite has recrystallized to irregular aggregates of small flakes. Feldspar grains tend to retain approximately their original size and shape and commonly form indistinct augen throughout the rocks. The rock texture so engendered does not change much beyond this throughout Region B. In Region C, however, even the feldspar grains are comminuted, and the orthogneisses thus developed from the older plutonic rocks generally have a fine-grained granulose or sugary texture with small, aligned grains or clusters of biotite peppered throughout; hornblende, where present, forms larger poikilitic grains. In the northeast part of Region C, plagioclase in some of the orthogneisses is mildly antiperthitic.

AGE RELATIONS

Field Relations

Field work has established beyond doubt the age relations outlined in Tables II and III. Metamorphic and plutonic rocks of probable Archean age in Region A formed the basement for Proterozoic (Aphebian) sedimentary and volcanic rocks, and were relatively little disturbed during subsequent orogeny to the north and northwest. Regions B and C were deformed and metamorphosed after the deposition of the Aphebian rocks, during the Hudsonian Orogeny, and before the deposition of the postorogenic Dubawnt Group to the north (Donaldson, 1967). Age relations between Regions B and C are not certain: possibly Region B represents a higher crustal level of the same orogenic episode that affected Region C, or possibly the tectonism in Regions B and C occurred at different times.

Radiometric Ages

The Churchill Province of the Canadian Shield was the site of extensive and complex tectonism, the Hudsonian Orogeny, in mid-Proterozoic time. This orogeny took place some 750 million years after the Kenoran Orogeny, the last period of major tectonism recorded in the neighbouring Slave and Superior provinces. Volcanic and related intrusive rocks of the Dubawnt Group, which overlies the Hudsonian orogen some 50 miles north of the Kaminak Lake area, are radiometrically dated at about 1,720 million years (Donaldson, 1967). Stockwell (1964), considering age determinations from the whole Churchill Province, gives a mean age of 1,735 million years

for the Hudsonian Orogeny. Hudsonian metamorphism in paragneisses 24 miles north of the Kaminak Lake map-area, and presumed to be within the northern continuation of Region C, has been dated at 1,770 ± 90 million years (Leech, et al., 1963).

A variety of ages have been obtained from the igneous and plutonic rocks south and east of Quartzite Lake. These are listed in Table IV, below.

TABLE IV

Radiometric Age Determinations in the Kaminak Lake Map-area

Geological age	Rock type	Location	Material	K-Ar age (in m.y.)
Post-Hurwitz	Lamprophyre	62°10 1/4'N 94°34'W	biotite	1690 ± 55
Pre-Hurwitz	Diabase (fresh)	62°05 1/4'N 94°55 1/2'W	whole rock	2330 ± 200
	Diabase (altered)	62°20 1/2'N 94°24 1/2'W	whole rock	1690 ± 185
Pre-Hurwitz and pre-diabase	Hornblende gabbro (1)	62°15 1/2'N 94°27'W	hornblende	2585 ± 70
	Hornblende-biotite granodiorite (2)	62°14'N 94°37'W	biotite	2010 ± 50
	Biotite gneiss (Avn)	62°10'N 94°47'W	biotite	1925 ± 100
	Alkali syenite (4)	62°16 1/2'N 94°46'W	biotite	1820 ± 60
	Biotite adamellite (3)	62°13 3/4'N 94°17'W	biotite	1805 ± 55

The lamprophyre dyke dated at 1,690 million years cuts the folded Hurwitz Group and provides a minimum age for deformation of the Hurwitz fold-belt. Its age suggests possible correlation with Dubawnt igneous activity. The older of the two diabase ages was obtained from a particularly fresh dyke southeast of Kaminak Lake; the younger, from a mildly altered dyke of the same swarm between Quartzite and Snug lakes, at about the southern limit of the region in which these dykes are easily recognized as metamorphosed. There is, as yet, no field evidence suggesting more than one period of pre-Hurwitz diabase dyke intrusion, so it is assumed that the younger of the two ages has been updated. The various ages obtained from the pre-diabase plutonic rocks suggests that these are also updated, and, if so, that the Hudsonian Orogeny affected the argon retention properties of biotite farther south than the limit of Hudsonian metamorphism as outlined by the pre-Hurwitz diabase dykes. The hornblende age of 2,585 million years obtained from pre-Hurwitz gabbro is an Archean (Kenoran) age, and hints that the Kaminak Group may be comparable in age to similar volcanic and sedimentary rocks in the Slave and Superior provinces. If this is so, then the broad belt of greenstones and plutonic rocks that extends for about 200 miles west-southwest of Hudson Bay is a remnant of a much older crustal segment preserved in the centre of the Churchill Province, as now defined.

ECONOMIC GEOLOGY

So far as is known, the first prospectors to enter the Kaminak Lake area travelled up Ferguson River in the late 1920s, at about the same time that copper-nickel sulphides were discovered at Rankin Inlet (Dryborough, 1931). Since that time, several major companies have launched exploration programs within the greenstone belt west of Hudson Bay. Wright (1967, pp. 74-82) has summarized the history of mineral exploration in this region, and has described two of the three main mineral showings in the Kaminak Lake map-area. The third showing of interest, at Southern Lake, was explored by drilling in the mid 1950s by Sherritt Gordon Mines Limited. Here, pyrite and nickeliferous pyrrhotite are disseminated in amphibolitic greenstones adjacent to shear zones near the contact of these rocks with mafic plutonic rocks to the southwest. Trenching on a gossan at one place on this contact reveals scattered pockets of pyrrhotite and chalcopyrite mineralization in coarsely recrystallized rocks containing gedrite and garnet.

Giant Yellowknife Mines Limited carried out extensive geological and geophysical reconnaissance in 1959 and 1960, followed up by groundwork at promising showings in 1961, notably on the Dee and the Peter groups of claims (Wright, 1967, pp. 79-80). Drilling and trenching operations have not been carried out within the area since that time. The most recent prospecting has been concentrated on the search for uraniferous conglomerates at the base of the Hurwitz Group and in the MacKenzie Lake metasediments (see Heywood and Roscoe, 1967).

Numerous gossans and rusty zones were noted during geologic mapping in 1967, and are marked on the accompanying map. They are nearly all located within the boundaries of Region A; a few are associated with amphibolites and schists in Region B, but none was observed in the gneisses and migmatites of Region C. Where not too deeply weathered, gossans that were examined were found to have developed from pyrite-pyrrhotite disseminations in greenstones, or from pyrite disseminated in sheared felsic volcanic rocks. Small quartz veins and stringers, in places containing pyrite, are locally associated with these disseminated sulphides. Pyrrhotite, where present, usually gives a weak positive dimethylglyoxime test for nickel. Small amounts of chalcopyrite occur with pyrrhotite and pyrite in several places. Thin quartz veinlets with minor chalcopyrite are present locally in the mafic flows of the Hurwitz Group. Other than on the Dee Group (Wright, 1967, p. 80), sphalerite occurs with chalcopyrite, pyrite, and pyrrhotite near the northwest side of Kaminak Lake, and 5 miles south of the east end of O'Neil Lake. A small outcrop of greywacke on an island in the northeast part of Kaminak Lake is cut by widely spaced fractures that are locally filled with quartz and a little sphalerite. Molybdenite was observed in narrow, discontinuous quartz veins in greenstones near the southwest contact of the adamellite pluton northeast of Southern Lake.

Iron-formation is exposed in association with greywackes and siltstones of the Kaminak Group at three localities: in the syncline south of Kaminak Lake, southwest of Victory Lake, and at the eastern map-boundary northeast of Happotiyik Lake. These occurrences have been described in the previous section on general geology. It is doubtful that these occurrences are either rich enough or close enough to transportation to make ore grade at the present time.

The plutonic rocks are generally devoid of signs of sulphide mineralization, although scattered grains of chalcopyrite and pyrrhotite are not uncommon in the hornblende gabbros of unit 1. Parts of a fault zone cutting gabbro and diorite 5 miles north of where Ferguson River enters Quartzite Lake are mineralized with chalcopyrite.

The poorly exposed pluton of alkali syenite (4) at the northeast side of Kaminak Lake is a potential source of elements such as niobium and the rare-earth metals, but likely minerals such as pyrochlore are not present in the specimens collected during mapping.

The possibilities of finding uraniferous conglomerates in the Hurwitz Group has been discussed by Bell (1968b).

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