GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MEMOIR 339

FORT GEORGE RIVER AND KANIAPISKAU RIVER (WEST HALF) MAP-AREAS, NEW QUEBEC

K. E. Eade

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By
K. E. Eade

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PREFACE

This memoir reports the results of a helicopter-supported reconnaissance survey of a large region in southwest New Quebec.

Most of the area was found to be underlain by Archaean granites, gneisses, and schists. The abundance of gneisses of the granulite facies in the eastern part is of particular interest.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, January 23, 1963

MEMOIR 339: Kartenblatt Fort George River und Kaniapiskau River, westliche Hälfte (Neuquebec). Von K. E. Eade

Diese Abhandlung berichtet über die Ergebnisse einer mit Helikopter durchgeführten Untersuchung eines umfrangreichen Gebietes im Südwesten von Neuquebec, das grösstenteils aus archäischen Graniten, Gneisen und Schiefern besteht.

МЕМУАР 339: К. Э. Ид. Листы. Река Форт Джордж и р. Канниапискау (зап. половина), Новый Квебек.

Этот мемуар посвящен результатам исследования огромного района на юго-востоке Нового Квебека с помощью вертолёта. Большая часть этой территории подстилается архейскими гранитами, гнейсами и шистами.

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Abstract

This report is based on the results of reconnaissance geological mapping carried out by means of helicopters. The area is largely underlain by rocks of Archaean age, granites, gneisses, and schists, with some smaller masses of metamorphosed volcanic and sedimentary rocks. Scattered occurrences of Proterozoic cover rocks are also present: Manitounuk Group on Hudson Bay coast, Kaniapiskau Supergroup of the Labrador 'trough', the Otish Mountains Group, and the hitherto unknown Sakami Formation.

In the western and central parts of the region the Archaean rocks are almost wholly of the amphibolite facies of metamorphism, but in the eastern region large areas of granulite facies rocks are present.

Folds trend east in the western part of the map-area, gradually changing to east-northeast in the eastern part. In the east, superimposed northwest-trending folding complicates the structural pattern; faults are widespread throughout the map-area. It is suggested that a major zone of disruption, extending from James Bay almost to the Labrador 'trough', accounts for preservation of most remnants of Sakami Formation rocks in down-dropped blocks.

In two localities development work has been carried out on quartz-magnetite iron-formation occurring with basic volcanic rocks. Sulphide minerals, chiefly pyrite with some chalcopyrite, were observed in the basic volcanic rocks in a number of places. Sphalerite-galena occurrences in some beds of limestone of the Manitounuk Group had been explored prior to the present survey.

Résumé

Cette étude est fondée sur des travaux de cartographie géologique de reconnaissance effectués à l'aide d'hélicoptères. Le sous-sol de la région se compose en grande partie de roches de l'Archéen, soit des granites, des gneiss et des schistes, associés à des masses plus petites de roches volcaniques et sédimentaires métamorphisées. On trouve aussi par endroits des venues de roches protérozoïques à la surface comme celles appartenant au groupe Manitounuk sur la côte de la baie d'Hudson, le sur-groupe Kaniapiskau dans la fosse du Labrador, le groupe des monts Otish et la formation Sakami, inconnue jusqu'ici.

Les roches archéennes dans le centre et l'ouest de la région présentent presque toutes un métamorphisme à faciès d'amphibolite, mais dans la région de l'Est, on trouve de grandes étendues de roches à faciès de granulite.

Dans la partie ouest de la carte, les plis sont orientés en direction est, changeant graduellement vers l'est-nord-est, dans la partie est. A l'est, des plissements superposés à direction nord-ouest compliquent la structure. Les failles sont nombreuses partout dans la région. On croit que grâce à une importante zone de rupture, qui s'étend de la baie James jusqu'aux abords de la fosse du Labrador, on a pu retrouver une grande partie des restes de roches du Protérozoïque dans des blocs affaissés.

En deux endroits, on a effectué des travaux de mise en valeur d'une formation ferrifère à quartz et à magnétite, associée à des roches volcaniques basiques. On a trouvé en certains endroits dans les roches volcaniques basiques des minéraux sulfureux et surtout de la pyrite avec un peu de chalcopyrite. Avant la présente étude, on avait exploré des venues de galène à sphalérite dans des couches de calcaire du groupe Manitounuk.

Chapter I

INTRODUCTION

The Fort George River and Kaniapiskau River (west half) map-areas in the southern part of New Quebec Territory, Province of Quebec, cover about 110,000 square miles of the Labrador-Ungava Peninsula, lying between latitudes 52 and 56 degrees and extending eastward from the James Bay-Hudson Bay coast to longitude 68 degrees. Preliminary investigation was carried out in 1956 and helicopter-supported systematic reconnaissance mapping was done in 1957, 1958, and 1959. The writer was in charge of field work in 1957 and 1959 and W. W. Heywood in 1958. The extreme southeast corner of the area (NTS 23C) was mapped in 1961 by the helicopter-supported party supervised by I. M. Stevenson. In addition to the writer, mapping was carried out by W. W. Heywood in 1957, 1958; S. E. Brett in 1958; K. L. Currie in 1958; I. M. Stevenson in 1959; and S. H. Kranck in 1959. Efficient assistance in the field was given by K. McConnell in 1956; R. E. Hay, H. C. Palmer, H. F. Morrison in 1957; D. E. Johnston in 1958; P. L. Reynolds and R. B. Roden in 1959. Radio communications were maintained most satisfactorily by A. Craig in 1957, B. A. McGee in 1958, J. L. Blanchard, C. J. Orton, and G. W. Roland in 1959. Investigation of the surficial geology in parts of the area was carried out by H. A. Lee in 1957 and by O. L. Hughes in 1959. The geology of the surficial deposits is described in separate publications (Lee, 1959a, 1959b, 1960; Hughes, 1962).[1]

The accompanying map incorporates the work of Shaw (1942) in the southwest corner (NTS 33C and D) and of Jackson (1960) in the Belcher Islands; these areas are not described in this report.

Previous Work

Bell (1879) described the geology of the Hudson Bay coast, including the first record of the Proterozoic rocks along the coast. The geological reconnaissance carried out by A. P. Low (1887, 1895) on some of the major rivers in the area—Eastmain, Fort George, Great Whale and Kaniapiskau and some of their tributaries—is outstanding and, prior to the present mapping, provided the only knowledge of much of the interior. Low's reports give not only full accounts of the observed geology but also much other factual information on the region. He (1900) also carried out further investigations on the coasts of James Bay and Hudson Bay.

The geology of this coastal area is further described by Kranck (1951), and a brief description of some of the offshore islands is included in a report by Young

[1] Names and/or dates in parentheses are those of *References* cited at end of this report.

(1921). In the southwest part of the Fort George River map-area, Shaw (1942, 1943) did reconnaissance mapping; only a part of his area was re-mapped.

Two detailed descriptions of small areas in the Proterozoic rocks fringing Hudson Bay are contained in reports by Harwood (1949) and Parks (1949), the field work being done while the authors were employed by Gulf Lead Mines Ltd. A study of a limited area on Fort George River in the central part of the area is contained in a thesis by Grenier (1948), the field work being carried out while he was employed by Mistassini Exploration Company.

Geological information pertaining to the Otish Mountains[1] area has been published by Bergeron (1957), based on field work done by Kennco Explorations Ltd. in this region.

Access

The map-area can be divided into three zones for purposes of access—western, central, and eastern—without definite boundaries other than distances from outside bases. The western or coastal zone is served from posts along the Hudson Bay-James Bay coasts, Great Whale River post, Fort George, and Eastmain. These posts in turn are supplied from railhead at Moosonee, Ontario, at the south end of James Bay, either by ship during the open-water shipping season or by aircraft based at Moosonee throughout the year except at break-up and freeze-up. Semi-scheduled and chartered flights with single-engined aircraft are operated from Moosonee by Austin Airways Limited. Normally all aircraft flying out of Moosonee are single-engined, ski- or float-equipped, although during the winter a landing strip on frozen muskeg has been used by larger, ski-wheel-equipped transport aircraft. Float-equipped aircraft can land at any of the posts along the coast although at times winds and tides make landing hazardous. The Hudson's Bay Company operates regular ship service from Moosonee to posts on the coast during the summer and it is possible to have supplies moved in by this means. Great Whale River has two landing strips capable of taking large wheeled aircraft the year round, and scheduled air service (Nordair Limited) from Montreal, through Val d'Or, to Great Whale River is maintained. Both passengers and freight are carried on this service. For large-scale shipments, Great Whale River is served by ship directly from Montreal, through Hudson Strait.

The central zone is served from Chibougamau, Quebec, at the end of the rail line and highway. Although it is about 150 miles south of the south boundary of the map-area, it is still the nearest entry point for the central zone. Chibougamau has regular railway and highway facilities and a scheduled airline service. Single-engined ski- or float-equipped aircraft for charter are based there the year round (Fecteau Air Services Limited). Aircraft is the only practical means of reaching the map-area from Chibougamau, although it is possible to do so by canoe. This central zone is the part of the map-area most remote from outside bases.

The eastern zone is served by Schefferville, Quebec, the northern terminus of the Quebec, North Shore and Labrador Railroad. In addition to the railway passenger

[1]Since preparation of this manuscript the Geographic Board of Quebec has approved the name Monts Marie-Victorin for this feature.

and freight service, Schefferville has good scheduled passenger and freight air service from Montreal through Quebec City, Mont Joli, and Sept-Iles. Single-engined float- or ski-equipped aircraft for charter are not regularly based at Schefferville but arrangements can be made for such service.

Recently the southeast corner of the map-area has been made accessible from Gagnon, Quebec, about 20 miles south of the south boundary, by the construction of a railroad from Port Cartier, on the north shore of the Gulf of St. Lawrence to Gagnon.

Within the map-area, the only practical means of transportation is by float- or ski-equipped, fixed-wing aircraft, or by helicopter. Although many large rivers drain the map-area, few are practical as canoe routes because of numerous rapids and falls. Low, who travelled the major rivers, recorded the difficulties of canoe travel. During the present work canoes were used for transport in restricted areas only.

Population

The population is very small and settlements are few. Fort George, on the James Bay coast, has a Hudson's Bay Company post, Department of National Health and Welfare Nursing Station, Anglican Mission and school, and a Roman Catholic Mission and school. The Anglican Mission was established in 1852. In addition to the permanent Indian population, a larger group of Indians spend the summers at Fort George and trap in the inland area during the winter, travelling as much as 200 miles into the interior. Both the Anglican and Roman Catholic schools are boarding schools with students attending from other localities as well as from the settlement. Many of the Indians from this area, even the older generations, are able to speak English. A subsidiary post of the Hudson's Bay Company store at Fort George is operated during the winter at Kanaaupscow, about 100 miles to the east. This is for the convenience of the trapping families working in the interior and is supplied entirely by aircraft. As the working population at Fort George is larger than trapping can properly support, local labour is readily available.

The settlement at Great Whale River has a Hudson's Bay Company post, a Northern Service officer, RCMP detachment, Nursing Station, Department of Transport meteorological and radiosonde station, and an Anglican Mission and four-room school. The school serves only the local population. Both Eskimos and Indians live and trade in this settlement, one of the few communities where they are in contact. During the winter, the Eskimos trap and hunt seal along the coast north from the settlement, and the Indians trap in the interior. Great Whale River is a sectional control point for the Mid-Canada Line. The landing strips there were originally constructed for use by the Line. At present the base, several miles from the original settlement, has a small RCAF detachment, a group of Marconi Company service employees, a group of catering service employees, and a commercial helicopter group responsible for distribution of supplies and transportation on this section of the Line. A guest house near the air strip provides meals and accommodation for transients. Commercial telegrams may be sent out through the Department of Transport station, and mail service is frequent.

Few local Indians and Eskimos are now employed by the Mid-Canada Line, although many worked during construction. Some local labour is available at the settlement. The Mid-Canada Line extends eastward from Great Whale River approximately along latitude 55 degrees and has regularly spaced stations, the locations of which are given in Department of Transport Air Navigation orders (1957). These stations are unmanned most of the time but radio beacons from them can be turned on by prior request as an air navigation aid.

About 35 miles southeast of Great Whale River, at the property of Great Whale Iron Mines Limited, work has been carried out during the past several summers, and a few temporary buildings have been erected. The only permanent post in the interior of the map-area is the Department of Transport meteorological and radiosonde station of Nitchequon, on Nichicun Lake in the southeastern part of the area. Radio facilities are available there.

Throughout most of the interior region, signs of trapping are observable. The trappers, accompanied normally by their families, make their way inland each autumn and come out again in the spring, generally travelling by canoe although recently more and more are using chartered aircraft. From the James Bay-Hudson Bay coast they go inland, following the river routes; from the Chibougamau-Lake Mistassinni region they enter the southeast part of the map-area to trap; and from Schefferville and the old Fort Mackenzie post to the north they trap in the northeastern part.

Method of Mapping

In 1956, the writer with one assistant carried out a broad reconnaissance of the area to determine its suitability for helicopter work and to study supply problems. The geology of certain limited areas was examined, chiefly as an aid to later airphoto interpretation. During each of the subsequent three field seasons (1957, 1958, 1959), one Bell helicopter (Model 47 G1) and one fixed-wing aircraft (De Havilland Beaver) were attached to the party. The helicopter, carrying one geologist, was used to fly a regular pattern of traverse lines so that practically the entire area has been covered by observations on a spacing of about 6 miles. The fixed-wing aircraft was used for transporting supplies to the field from the various outside supply points, for moving camp, placing gas caches for the helicopter traverses, and moving ground parties.

Along the helicopter traverse lines the geology was observed from the air and at numerous landing points. Where the complexity of the geology or lack of information from the air traverses warranted, limited areas were studied by ground parties. The method of work used during the first year, essentially the same as that used the following two years, is described in Chapter III of "Helicopter Operations of the Geological Survey of Canada" (Officers of the Geological Survey of Canada, 1959) and in another briefer paper (Eade, 1958).

The airphotos of the region were studied prior to actual field work, during the course of the field work as the field information accumulated, and after completion of the field work, during the compilation of the geological maps.

Preliminary results of each year's work, based almost entirely on the field observations, have been published (Eade, *et al.*, 1957, 1959; Heywood, *et al.*, 1958). Although this is the final report on the area and all laboratory and field evidence available have been considered, it must be emphasized that the work itself is a preliminary reconnaissance of the regional geology, based for the most part on observations along lines 6 miles apart, with interpretation and interpolation between observations. This has necessitated the grouping of rock types into broad units which by more detailed mapping can be broken down into smaller units and sub-units, as shown by recently published reports and maps (Eakins, 1961; Sabourin, 1961; Hashimoto, 1962).

Physiography

Drainage

The western two thirds of the map-area is drained by rivers flowing into James Bay and Hudson Bay. The most prominent of these rivers are Eastmain; Fort George or La Grande, with its large tributaries Sakami and Kanaaupscow; Great Whale; and Little Whale. The southeast corner is drained by rivers flowing into the Gulf of St. Lawrence, namely the headwaters of Temiscamie, Peribonca, aux Outardes, and Mouchalagane Rivers. The northeast part is drained by rivers flowing north into Ungava Bay, the main river being the Kaniapiskau and its tributaries. The divide between the Gulf of St. Lawrence and the Hudson Bay-James Bay drainage is well delineated, but the other watersheds are not pronounced. In particular, the divide separating north- and west-flowing waters is difficult to determine, as abundant glacial drift in this locality results in a very disorganized drainage. Large, shallow lakes, filled with islands and with two or more outlets are a result. Lac Bienville and Lac Naococane are good examples of such lakes.

Topography

The land rises gently from James Bay and Hudson Bay inland, except in the coastal area from about 30 miles south of Great Whale River to the north boundary of the map-area, where it rises more steeply into locally rugged hills. These are formed of massive granite dissected by prominent joint lineaments. The narrow fringe of younger Proterozoic rocks on this part of the coast results in pronounced east-facing scarps. Most of the interior landmass stands 1,200 to 1,400 feet above sea-level with here and there hills somewhat higher. In general, areas underlain by massive granite stand higher than those underlain by granite-gneiss. In the eastern part of the area where much of the bedrock is pyroxene-bearing granodiorite, rounded hills separated by deep valleys result in a locally rugged topography. Rocks of the Kaniapiskau Supergroup present in the extreme northeast corner of the map-area form a lowland except where gabbro intrusions weather into locally rugged hills.

The Otish Mountains, underlain by rocks of the Otish Mountains Group, are the most prominent hills in the map-area, rising to 3,700 feet above sea-level and standing about 1,500 feet above the surrounding terrain. The strata dip gently southward, resulting in north-facing scarps, the most prominent of which are formed by resistant gabbro sills. Deep northeast-trending valleys are the surface expression of faults affecting the Otish Mountains Group rocks.

Hare (1959) divided all the Labrador-Ungava peninsula into physiographic divisions by studying airphotos of this vast area. These divisions are the result of broad generalizations and cannot readily be recognized within this map-area. The small-scale, local topography throughout much of the area is controlled by glacial features, eskers, drumlinoid ridges, washboard moraine, pitted outwash, and kames. Descriptions of these surficial deposits are given elsewhere (Lee, 1959a; Hughes, 1964).

A local topographic feature of some interest lies athwart the northern boundary of the map-area. It is the circular outline of each of the two parts of Clearwater Lake (56°00′N, 74°10′W). Some detailed geological work was done on the circular island group in the north lake, just north of the map-area, in 1959 by Kranck (1962), who suggested that the circular structure is due to a collapse caldera. Beals, *et al.* (1960) suggested that these two circular lake basins may have been formed by the impact of twin meteorites.

Wildlife

Throughout much of the interior fur-bearing animals are relatively abundant despite intensive trapping. The following animals or recent signs of them were observed: beaver, muskrat, otter, mink, lynx, red fox, marten, weasel or ermine, wolverine, red squirrel, lemming, rabbit, porcupine, black bear, and woodland caribou. Beaver are confined to the southern, well wooded part of the area and in much of this region have only become re-established through strict conservation measures that are still enforced. Muskrat are abundant only in the southern part. Marten were not observed, but in a few places recent tracks were seen of this shy animal. Lemmings are abundant only in the northern, semi-barren part, whereas porcupine favour the heavy coniferous forest in the extreme south. Black bear are nowhere abundant but range throughout the whole region. Woodland caribou are confined to the eastern quarter of the map-area, more particularly the southern part of that quarter where about forty-five animals were observed in 1959.

No record was kept of the birds seen but it was noted that in many parts of the region small birds are surprisingly scarce probably due to the lack of cover resulting from the large burnt-over areas. There are some published references on bird life in the map-area. Harper (1958) lists some observations made in the extreme eastern part of the area although most of his observations are from farther east near Schefferville. Manning and Macpherson (1952) made a number of observations on bird life along the part of the Hudson Bay-James Bay coast within the area; their report also contains a good bibliography of earlier published reports. Savile (1950) lists some birds seen in the immediate vicinity of Great Whale River settlement.

Fish are abundant in the lakes and rivers, pike, sucker, lake trout, speckled trout, and whitefish in particular. In some of the Eastmain River drainage walleyed pike or dore also occur. Sturgeon are taken by the Indians from some of the lakes and rivers, and on Sakami Lake a small fishery for sturgeon has been started by some of the Fort George Indians. The fish are kept alive in traps after being netted until an aircraft is available to take them to Moosonee. Greyling were observed in a very few of the lakes.

During preliminary work in 1956, a small 18-inch garter snake was observed on Opinaca River (latitude 52°45′), which, in this region, must be close to the northern limit for this reptile.

Timber

The tree cover over the area ranges from heavy coniferous forest with scattered groves of deciduous trees in the south, to the semi-barren areas with scattered and stunted spruce in the northern part of the area, on the highest parts of the Otish Mountains, and close to the coast of Hudson Bay. The western and central parts of the map-area have suffered much from forest fires, in places fires so intense that all organic matter has been burnt out of the soil which now seems incapable of supporting second growth.

Black spruce is the most abundant conifer, probably comprising 90 to 95 per cent of the forest cover, and seems to thrive on both the dry hills and swampy areas. It forms the dense forests of the south, and is present in the barrens of the north in stunted and often grotesque forms. White spruce is far less abundant and is relatively rare more than 150 miles from the coast. Balsam fir grows throughout the area, from the south to the semi-barrens, but is nowhere abundant. It generally is found close to the shores of lakes and rivers. Small amounts of larch or tamarack occur throughout, almost always in swampy or boggy places. Jackpine grows in sandy areas as far north as Great Whale River but does not extend to the semi-barrens. Poplar or aspen is relatively scarce over much of the region although in some burnt-over areas in the central and western parts, it appears as second growth. It is not found north of Great Whale River. On the south side of hills in the part of the area on the southeast, underlain by pyroxene-bearing granodiorite, poplar may grow to considerable size. White birch is more abundant than poplar, and it too favours burnt-over areas and the protection of gullies and southern exposures. Mountain ash are rare, but in the extreme southeast corner some, as much as 10 feet high, were observed.

Tree cover and vegetation are discussed by Hare (1959), who subdivided the whole peninsula into boreal forest zones. Detailed information on both fauna and flora is included in the report of Low (1895).

Climate

The effect of local weather on an aircraft-supported operation is very marked. In addition to the normal effects of weather on flying, the particular nature of this work introduces further factors. A steady rain, for instance, prevents helicopter mapping as air observations are nearly impossible. Winds of more than 20 miles an hour make helicopter landings in confined spaces difficult, and when adverse, enormously increase gasoline consumption preventing the completion of traverses planned. Considerable differences in the length of time lost due to bad weather were noted in each of the three years of the operation.

In the southern part of the area the break-up of ice in the lakes and rivers, sufficient to permit the use of float-equipped fixed-winged aircraft, takes place normally the first week of June, but in the northern part it may be the fourth week of June. Only during 1957 was work attempted before break-up. In that year field work was started at Great Whale River at the beginning of May but recurring snowfalls during the month made aerial observations difficult and so much time was lost that the results did not warrant the increased cost of the early start. Experience during the three years indicated that it is advisable to suspend field work on September 10 or earlier.

Temperatures during the summer vary widely; during July 1957 the minimum at Great Whale River was 34°F and the maximum 82°F. During 24 hours it was found that the temperature might change by 40 degrees. Precipitation is not great, but a steady fine rain lasting two or three days is not uncommon, thoroughly soaking everything and making living conditions uncomfortable. Fog is most prevalent along the Hudson Bay coast and for about 40 miles inland. It may move in very rapidly from the Bay and is a definite flying hazard.

Detailed weather records for Great Whale River, Fort George, Nitchequon, and Knob Lake (Schefferville) just to the east of the map-area, are published by Department of Transport, Meteorological Branch, in the *Monthly Record of Meteorological Observations in Canada*.

Acknowledgments

Besides the geologists and assistants previously mentioned, the aircrews associated with the work, supplied by Canadian Helicopters Limited (1957 and 1958), Autair Helicopters Limited (1959), Laurentian Air Services (1957 and 1959), and Wheeler Air Lines (1958), were essential members of the field parties. Department of Transport personnel at the Great Whale River and Nitchequon stations cooperated fully at all times in maintaining radio communications with outside points and in supplying weather information.

Mr. Robert Scott, Hudson's Bay Company post manager at Fort George, assisted the parties on many occasions by handling supplies and providing radio communication. The use of base and radio facilities of Fecteau Air Services at Cache Lake (Chibougamau) was much appreciated. The personnel of the Department of Health and Welfare Nursing Station at Fort George were of great assistance to the party in 1957. Without the help of the many officials concerned with the Mid-Canada Line, particularly in 1956 and 1957, field work would have been greatly retarded. These included personnel of the Bell Telephone Company of Canada, the Marconi Company, and of the Royal Canadian Air Force.

Officials of Great Whale Iron Mines Limited and of Duncan Range Iron Mines Limited, in particular Mr. Walter Maybank and Mr. J. C. Honsberger respectively, kindly provided detailed information on their properties. Kennco Explorations (Canada) Limited provided information on the Otish Mountains area and the Richmond Gulf area just to the north of the map-area.

Many individuals at the various starting points and supply bases rendered numerous favours.

Chapter II

GENERAL GEOLOGY

All consolidated rocks in the map-area are of Precambrian age, for the most part Archaean but with some small areas of Proterozoic. The oldest rocks, present in isolated bands, consist of an undivided assemblage of andesite, dacite, rhyolite, pyroclastic, and minor ultrabasic rocks; and conglomerate, greywacke, impure quartzite, and quartzite. All are more or less metamorphosed and granitized to rocks ranging from partly granitized sediments and volcanic rocks, sedimentary schist and gneiss with interlayered pegmatite and granite, banded gneisses, migmatite, granitic gneisses, to massive granite. Some late, intrusive granite cuts the above-mentioned rocks but in minor amounts. In the eastern part of the area, pyroxene-biotite granodiorite and gneiss represents a higher metamorphic facies than the schist-gneiss-granite terrains elsewhere in the map-area. Minor bodies of basic and ultrabasic rock are scattered throughout the area, some relatively young and intruding the gneiss-granite terrain and some older and concordant with the gneisses.

Proterozoic sedimentary and igneous rocks are separated into four units whose relationships are not known. The Manitounuk Group, on the Hudson Bay coast, consists of sandstone, arkosic sandstone, shale, dolomitic limestone, siliceous, cherty or concretionary limestone, and quartzite separated by an unconformity from a lower arkose. The upper part of the sequence is capped by gabbro sills and contains intercalated basalt and tuff layers. The Kaniapiskau Supergroup occurs in the extreme northeast and southeast corners of the map-area. In the northeast it consists of sandstone, argillite, cherty metallic iron-formation, slate, phyllite, dolomite, jasper-hematite iron-formation, and a basal arkose; gabbro bodies intrude the lower part of the sedimentary sequence. In the southeast corner, the metamorphic equivalents of these rocks are present. The Otish Mountains Group has a boulder-conglomerate at the base, with sandstone containing grit and pebble-conglomerate beds above. Above this again is a succession of arkose, arkosic sandstone, and red argillite. Gabbro sills are intercalated throughout the sedimentary section. The Sakami Formation, named in this report, consists of widely distributed outliers of lithologically similar clastic sedimentary rocks. The lower part of the section consists of boulder-conglomerate red arkose with red mudstone and siltstone, and pebble-conglomerate beds. The upper part consists of relatively pure quartz sandstone.

Gabbro dykes, with diabasic texture in part, are considered to be of Proterozoic age. Gabbro of similar composition occurs as sills and intrusive bodies in rocks of the Manitounuk and Otish Mountains Groups and the Kaniapiskau Supergroup. In one place the Sakami Formation is believed to be cut by a gabbro dyke.

Table of Formations

Age	Formation	Description
Quaternary		Clay, sand, gravel, boulder deposits
	Great unconformity	
Proterozoic	Unit 15	Gabbro dykes, diabasic in part
	Intrusive contact	
	Belcher Group (14)	Basalt; agglomerate; tuff; dolomite; limestone; argillite; quartzite; greywacke; black slate; vari-coloured ferruginous 'argillites' (iron-formation); chert; jasper; conglomerate; dykes of diabase and feldspar porphyry. Relationship to 10, 13 unknown
	Manitounuk Group (13)	Gabbro; basalt; tuff; sandstone; arkosic sandstone; shale; dolomitic limestone; siliceous, cherty or concretionary limestone; quartzite
		Unconformity
		Arkose. Relationship to 10, 11, 12, 14 unknown.
	Otish Mountains Group (12)	Gabbro; arkose; arkosic sandstone; argillite; sandstone; grit; pebble- and boulder-conglomerate. Relationship to 10, 11, 13, 14 unknown
	Sakami Formation (11)	Boulder-conglomerate; pebble-conglomerate; mudstone; siltstone; arkose; sandstone. Relationship to 10, 12, 13, 14 unknown
	Kaniapiskau Supergroup (10)	Sandstone; argillite; cherty metallic iron-formation; slate; phyllite; dolomite; jasper-hematite iron-formation; arkose; gabbro. Metamorphosed equivalents: crystalline limestone; chert; quartzite; quartz-specularite-magnetite iron-formation; garnetiferous, graphitic, biotite-muscovite-hornblende gneiss; coronite (meta-gabbro). Relationship to 11 to 14 unknown
	Unconformity	
Archaean	Unit 9	Pyroxenite; peridotite; norite; gabbro; anorthositic gabbro; metamorphosed equivalents
	Intrusive contact, rarely structurally conformable	
	Unit 7	Massive biotite and/or hornblende granite; some granodiorite and quartz monzonite; alaskite; porphyritic in part
	Commonly gradational contact, may be intrusive	

Table of Formations (*conc.*)

Age	Formation	Description
Archaean (con't)	Unit 6	Pyroxene-biotite granodiorite and gneiss
	Gradational or structurally conformable contact	
	Unit 5	Granodiorite and granite gneiss; migmatite; banded gneiss. May include minor metamorphosed Kaniapiskau Supergroup rock in the southeast
	Gradational or structurally conformable contact	
	Unit 4	Pink to white pegmatite and pegmatitic granodiorite; granodiorite
	Structurally conformable contact	
	Unit 3	Sedimentary schist and gneiss with interlayered granite and pegmatitic granite
	Structurally conformable contact	
	Unit 2	Gneiss and schist derived from volcanic and sedimentary rocks with minor granitic material.
	Structurally conformable contact	
	Unit 1	Andesite, dacite, rhyolite, and pyroclastic rocks; greywacke, quartzite, impure quartzite and conglomerate; metamorphosed equivalents; minor serpentinite

Undifferentiated Volcanic and Sedimentary Rocks (Unit 1)

Bands of undifferentiated volcanic and sedimentary rocks and their metamorphic equivalents, containing less than 10 per cent granitic material, occur throughout the map-area but are more common in the south half. Because of the nature and scale of mapping, it is not possible to show volcanic rocks and sediments separately, nor to distinguish between unmetamorphosed and strongly metamorphosed rocks.

The volcanic rocks include andesite, with well-developed pillow structures in some localities, dacite, rhyolite, tuff and their metamorphic equivalents, schists, amphibolites, or greenstone. The sediments include conglomerate, iron-formation, quartzite and meta-greywacke, and paragneiss or schist derived from them, mostly of quartz, plagioclase, biotite composition. Cutting the basic volcanic rocks, particularly bands in the east, are irregular bodies of basic or ultrabasic rocks, fresh or altered, which appear to be younger intrusions. The rocks are like those of the small bodies of unit 9, but where they occur with the volcanic rocks it has not been possible to separate them.

Lithology

Metavolcanic rocks are more abundant than metasedimentary rocks in unit 1. Most of the metavolcanic rocks are basic, equivalent to andesite or basalt in composition; dacite and rhyolite and their compositional equivalents are less abundant. Metamorphic equivalents of pyroclastic rocks are present in some places.

The basic metavolcanic rocks are dark green to black on weathered surfaces and medium to dark green on fresh surfaces. Included are massive, fine-grained rocks without structure, well-pillowed andesite, strongly sheared rocks or schists, and recrystallized medium-grained to coarse-grained basic rocks that are now amphibolites, either massive or gneissic with light and dark minerals segregated into bands. The average composition of these basic rocks is as follows: common green hornblende, 55 to 60 per cent; plagioclase (andesine), 35 to 40 per cent; iron oxide, biotite or quartz, 0 to 5 per cent. Hornblende may be more or less altered to chlorite; in the schists alteration is almost complete. The plagioclase may be cloudy or altered, with the formation of epidote and/or clinozoisite, and secondary white mica. Although many specimens have the composition given above, in others the percentage of minerals may vary considerably and other minerals may be present, thus actinolite may be present instead of hornblende.

The dacites are fine grained, light brown to green on weathered surfaces, and grey to green on fresh surfaces. The composition of a typical grey dacite is, common green hornblende in relatively coarse anhedral to subhedral grains, 45 per cent; plagioclase (oligoclase-andesine) much altered to carbonate and zoisite, 30 per cent; quartz, in very fine anhedral grains, 15 per cent; opaque minerals and secondary carbonate in veinlets and irregular masses, 10 per cent. Rhyolite is rare, but in a few places a very fine grained white, quartz-rich variety occurs with greenstone.

Locally, pillow structure and amygdules are preserved in the basic volcanic rocks. Just south of Corvette Lake, in a small greenstone body, pillows 2 feet long and 4 or 5 inches wide are present with chert in lenticular masses in the greenstone and in the one-inch rim of the pillows. The rock itself is vuggy. In the band of metavolcanic rocks just south of Eastmain River, near latitude 52 degrees, deformed pillows are visible in a fine-grained amygdaloidal andesite. The amygdule is quartz and plagioclase. To the west, in the band of volcanic rocks on Eastmain River at longitude 73°10′, vesicules up to a quarter inch in diameter, some filled with quartz, occur in a more acidic volcanic rock consisting of very fine grained plagioclase, quartz, biotite, and chlorite. In the most easterly band of metavolcanic rocks near Eastmain River, remnants of small pillows 12 to 18 inches long and 6 inches wide, occur in the sheared andesite (Pl. I).

Irregular bodies of ultrabasic rock occur with some of the eastern bands of metavolcanic rocks. The ultrabasic rocks are medium- to fine-grained, dark green to black, and less sheared than the surrounding volcanic rocks. The weathered surface is a distinctive rusty red to brown and rough because of the differential weathering of constituents. These dyke-like or irregular bodies of ultrabasic rock are apparently younger than the volcanic rocks they cut. A thin section of a specimen of ultrabasic rock from the most easterly band near Eastmain River indicates a composition of

PLATE I

Small pillows in andesite near Eastmain River.

Heywood, 8-1-58

enstatite, 35 per cent; actinolite, formed by alteration of the pyroxene, 45 per cent; serpentine, formed by alteration of olivine, 10 per cent; green spinel (pleonaste), 2 per cent; remainder is remnants of olivine, chlorite, and magnetite. Another specimen from the band of rocks near Lac Duhesme consists of 55 per cent serpentine, 35 per cent tremolite, 5 per cent brown opaque secondary minerals, remnants of pyroxene, and a few possible remnants of olivine. A specimen of fresh-appearing, fine- to medium-grained ultrabasic rock from the band of volcanic rocks near Lac Aubert is composed of pyroxene, probably augite, 75 per cent; anthophyllite, 10 per cent; serpentine, 5 per cent; magnetite and pyrite, 10 per cent. The variation in composition of these ultrabasic rocks is apparent from the above.

Finely banded rocks occurring with the volcanic rocks are thought to be metamorphosed tuffs. They are fine to very fine grained, dark grey to green on weathered surfaces and grey on fresh surfaces, and show light coloured bands 1 to 2 mm wide at intervals of 8 to 12 mm. Most of these banded rocks contain more quartz than the adjacent volcanic rocks, as indicated by the following average composition; oligoclase, 45 to 50 per cent; quartz, 25 to 30 per cent; common green hornblende normally much altered to chlorite, 20 per cent; secondary epidote or carbonate, 5 per cent. In most specimens the plagioclase is almost wholly converted to secondary white mica. The dark coloured parts of the banded rocks contain more hornblende, up to 60 per cent in some specimens with 10 to 15 per cent quartz, and the remainder plagioclase.

The metasedimentary rocks included in this unit vary somewhat but the most abundant rock is fine- to medium-grained quartz-plagioclase-biotite schist or gneiss, commonly garnetiferous. Foliation is prominent and may represent relict bedding. Laminae may be fine, a quarter inch or less, but the average thickness is about 2 inches. Muscovite or common green hornblende may be present in place of the biotite or with the biotite. This schist or gneiss may be interbanded with amphibolite gneiss and it is possible that some of the banded amphibolite is of sedimentary origin, derived from marly beds.

In the band of unit 1 south of Eastmain River in the eastern part of the area, fine-grained, finely banded light to dark grey rocks have the composition of an impure quartzite: 65 per cent quartz concentrated in light coloured bands, 25 per cent plagioclase, 7 per cent pyrite and magnetite, and minor white mica and epidote. To the northeast of Sakami Lake, included in this unit are bands of grey to white quartzite, up to 45 feet wide, and several beds of meta-conglomerate. The conglomerate has a dark green, chlorite-rich matrix, strongly sheared, and contains well-rounded pebbles up to 4 inches in diameter of white quartz, pink granite and granite-gneiss, and grey quartzite.

Between Lac Duhesme (lat. 53°33′, long. 71°57′) and Fort George River several kinds of metasedimentary rocks are associated with the metavolcanic rocks. Garnetiferous quartz-plagioclase-biotite gneiss varying to schist is prominent but conglomerate layers are present in the gneiss. The matrix of the conglomerate consists of the gneiss or schist, and scattered through the matrix are deformed and stretched pebbles of white quartz, pink granite, and amphibolite. Grenier (1948) described magnetite-grunerite paragneiss (not observed in the course of the present survey) apparently from this locality as consisting of light coloured bands, a quarter to three quarter inch wide, composed of quartz with dark bands of magnetite, grunerite, and brown tourmaline, the minerals varying in proportion from band to band, with garnet in some dark bands. He also noted a single outcrop of impure quartzite, and he described the relations of the paragneiss with the adjoining gneissic rocks of unit 5 and the accompanying pegmatite. His observations were based on ground work carried out for an exploration company.

The following is a description of two bands of unit 1 that contain mineral occurrences of possible economic interest.

Great Whale River Band

This band of metamorphosed volcanic and sedimentary rocks is about 40 miles southeast of the settlement of Great Whale River. The results of detailed mapping in a restricted area, which includes this band, have recently been published (Sabourin, 1961). The metavolcanic part of the band comprises interbedded basic flows and chlorite schists, with a few minor bands of quartz-feldspar schist. The basic flows are mostly massive and featureless with vague contacts, but a few layers are well pillowed. Tops are generally unrecognizable but it is believed that they are to the east. Typical flows range from fine-grained andesite to dense, very fine grained andesite or basalt. The few porphyritic flows present contain feldspar phenocrysts up to 2.5 mm long. The weathered surface is typically dark green to brown and the fresh surface dark green to greenish grey. Very fine quartz and carbonate stringers are locally abundant; epidote stringers are rare.

Interbedded with the massive volcanic rocks are weakly to strongly schistose chlorite schists containing abundant chlorite, some plagioclase, and occasionally tremolite. They are dark to medium green on both weathered and fresh surfaces. It is possible that the chlorite schist represents tuff beds in the original volcanic sequence. Along the east contact of the volcanic rocks (conveniently called greenstone) with the granite-gneiss, particularly in the northern part of the band, the greenstone is metamorphosed to medium-grained amphibolite, commonly with abundant plagioclase phenocrysts. The volcanic rocks form the east half of the band over the northern two thirds of its length. In addition to this main zone, there is a narrow but continuous band of brecciated greenstone and minor chlorite schist within the metasedimentary rocks. This is believed to be at a different volcanic horizon than the main band of greenstone.

The metasediments consist of micaceous schists, iron-formation, and minor greywacke and impure quartzite. The micaceous schists vary somewhat in composition from quartz-biotite rocks to quartz-plagioclase-sericite-biotite rocks. Garnets are commonly present as fine, pin-head sized grains, but in some bands garnet is abundant as porphyroblasts. The colour of the garnets ranges from pink to dark red. Some of the schists are nodular with dense dark siliceous nodules from a quarter to an inch long, around which the flaky, fine-grained, mica-rich matrix bends. The normal schist is fine-grained, speckled black and white with granular quartz and flaky brownish black biotite. Greywacke is not abundant and grades into the quartz-biotite schist. It is a massive textured, speckled, fine-grained rock, dark grey to grey-green, consisting of various amounts of granular quartz, plagioclase, and biotite with minor chlorite. The impure quartzite consists of quartz with biotite and/or sericite and it grades into the micaceous schists. It is not common.

Near the middle of the sedimentary schist part of this band, quartz-magnetite iron-formation occurs in two distinct layers separated by micaceous schist. For the most part the iron-formation is a simple, uniform, laminated rock consisting of fine- to very fine-grained quartz and magnetite. The magnetite content of the iron-formation is estimated to vary from 30 to 60 per cent with the average about 45 per cent. Near contacts with the schist some iron silicate minerals, probably grunerite, occur with the quartz and magnetite. There is some interfingering of the iron-formation and schist. Each of the two magnetite-bearing layers has a maximum thickness of about 400 feet but pinches out at either end; the total exposed length of the layers is approximately 3 miles. At the south end of the exposure, metamorphism has been more intense, resulting in recrystallization and somewhat coarser grain size and the disappearance of the fine laminations.

About 16 miles east of the main Great Whale River band of unit 1 rocks (lat. 55°02′, long. 76°26′) is a body about a mile across in both directions of iron-formation and schist, similar in many respects to rocks of the main band. It is a complexly folded body of quartz-magnetite iron-formation associated with garnetiferous biotite schist. The quartz and magnetite of the iron-formation have been so recrystallized that the laminae are no longer distinct. The schist too shows the recrystallization by the growth of coarse garnet porphyroblasts. Within the iron-formation, in addition to quartz and magnetite, other minerals may be present—blue-green amphibole, grunerite, or carbonate. Very small amounts of pyrite and pyrrhotite occur locally in narrow bands in the iron-formation.

About 12 miles farther southeast (lat. 54°56½′, long. 76°13′) is another small body of very similar quartz-magnetite iron-formation and garnetiferous biotite schist.

Duncan Lake Band

This band of metavolcanic and metasedimentary rocks extends eastward from Duncan Lake (lat. 53°30′, long. 78°). The metavolcanic rocks consist of basic flows with some interbanded chlorite schists that are probably derived from tuffs. The flows range in composition from andesite to dacite, fine-grained and normally massive, but in some parts pillowed. The andesite is dark green on fresh and weathered surfaces, dacitic types are grey or dark grey on fresh surfaces and grey to brown on weathered surfaces. Intense folding and faulting of these rocks precludes an estimate of the thickness of the section. The volcanic rocks in general appear to underlie the metasediments although there is definitely some interbanding of the two.

The metasediments consist of iron-formation, conglomerate, impure quartzite, cherty greywacke, greywacke, quartz-biotite schist, and quartz-plagioclase-biotite schist. In most respects, the rocks are similar to those found in the Great Whale River band. In the quartz-magnetite iron-formation of the Duncan Lake band the minerals are concentrated in laminae from paper thin to an inch or more thick. Pyrite is disseminated through much of the iron-formation. Near Duncan Lake the schist is strongly sheared and contains much disseminated pyrite so that its weathered surface is distinctively rusty brown.

Within this band, just northeast of Duncan Lake, andesite is present in well-formed pillows 2 to 3 feet long. A thin section of a specimen from this rock had the following approximate composition: common green hornblende, 25 per cent; altered plagioclase (andesine) 10 per cent; epidote, 30 per cent; and chlorite, 35 per cent. The feldspar is strongly altered to clinozoisite. Occurring with the andesite at this locality are light weathering bands of more acidic volcanic rock with an approximate composition of quartz, 40 per cent; plagioclase in very fine grains, 25 per cent; chlorite, 20 per cent; and carbonate 15 per cent. This composition is probably typical of the more silicic phases of the volcanic rocks in this band.

To the east of Duncan Lake, in this band there is considerable shearing and most of the rocks are schistose. Thin sections indicate however that the composition of the volcanic rocks is similar to that described above. Substitution of fibrous actinolite for the hornblende was noted in some specimens examined.

In the Duncan Lake band there has been only a slight introduction of granitic material; some quartz veins are present and minor pegmatite segregations occur close to the contacts with the granite-gneiss.

Summary and Interpretation

Rocks of volcanic and sedimentary origin, occurring together or separately, are grouped together in this unit. Only a very minor amount of granitic material is present, as stringers. Recrystallization of the rocks ranges from negligible to almost complete.

In the volcanic rocks, andesites predominate, with dacite and rhyolite much less abundant. Finely banded tuffs occur with the flow rocks. Pillow structures may be present in the less deformed rocks but in many places the rocks are deformed to schists or recrystallized to amphibolites. Probably 90 per cent of the volcanic rocks has an approximate composition of 60 per cent common green hornblende and 40 per cent andesine plagioclase. Basic and ultrabasic intrusions occur with the volcanic rocks, particularly in the eastern part of the area.

Rocks of recognizable sedimentary origin are less abundant in this unit than the volcanic rocks. Iron-formation is an important member in two localities. Conglomerate, quartzite, impure quartzite, and greywacke are present in limited amounts. Sedimentary schist or paragneiss, normally composed of quartz, plagioclase, and biotite, and commonly garnetiferous, is the most abundant metasedimentary rock. These are essentially the same as the paragneiss and schist in map-unit 3.

The grade of metamorphism of these rocks lies in the epidote-amphibolite facies, although in the eastern exposures there is some indication of a higher grade.

Bands of rock included in this unit are, in effect, large inclusions of older rocks in the granite to granite-gneiss terrain. These remnants are preserved because of greater resistance to metamorphism resulting from compositional characteristics or structural controls. They are remnants of the oldest rocks recognizable in the area.

Metamorphosed Volcanic and Sedimentary Rocks with Granitic Material (Unit 2)

This map-unit consists of metamorphosed volcanic and sedimentary rocks, schist, and gneiss like those of unit 1 but with the addition of 15 to 20 per cent granitic material. It is intermediate or transitional between unit 1, which is more or less free of granitic material, and unit 3 with much interlayered pegmatitic granite or unit 5, granitic gneisses containing remnants of sedimentary and volcanic rocks. As there is almost a complete gradation from unit to unit, the contacts between them are arbitrary. Also included with unit 2 are amphibolites apparently derived from old basic sills, dykes, or flows.

The preservation of the small bodies of rock forming this unit is often due to their composition. Amphibolite, quartzite, and iron-formation are common in these occurrences and all are relatively resistant rock types. The iron-formation is of economic significance in some localities.

Lithology

As the lithology of this unit varies considerably, several bodies will be described, between them exemplifying the main rock types. Just north of Yasinski Lake (lat. 53°15′, long. 77°30′) is a small body of metasedimentary rocks with 15 to 20 per cent granitic material, which consists of sedimentary gneiss composed of quartz, plagioclase, minor microcline, abundant hornblende, and some epidote. In some parts of the gneiss deformed granite pebbles are recognizable, indicating the presence of a meta-conglomerate. The rock is dark grey to green on both fresh and weathered surfaces, and in this locality is strongly sheared, due to the proximity just to the north of a major fault that forms the contact with granitic gneisses. In thin section no evidence of sedimentary texture remains, as recrystallization is complete. The abundance of epidote and amphibole indicates that these rocks belong to the epidote-amphibolite facies of metamorphism. To the east and west the paragneiss passes into granitic gneiss. This small remnant of metasedimentary rocks is probably preserved because of the resistant basic volcanic rocks adjoining it to the south. The original sedimentary rock possibly consisted of greywacke, and conglomerate with greywacke matrix.

At about latitude 53°40′, longitude 76°20′, is a small body of fine-grained, grey, impure quartzite with perhaps 20 per cent of interbanded granitic material. A thin section of the impure quartzite gives the following approximate composition: quartz in fine anhedral grains, 75 per cent; plagioclase, 8 per cent; biotite, 5 per cent; white mica, 7 per cent. The quartzite is well banded, with light and dark bands depending on the presence or absence of biotite. This may represent relict bedding. Concordantly banded with the impure quartzite is pink granite or pegmatite containing some biotite.

Just west of Lac Grande-Pointe (lat. 53°50′, long. 75°40′) are four small bodies of metasedimentary rocks with some granitic material. Associated with the paragneiss are concordant dark green, medium-grained amphibolite bands, probably derived from basic volcanic layers, and quartz-magnetite iron-formation similar to that found with andesites in unit 1. Other metasedimentary rocks interbedded with the well-banded quartz-plagioclase-biotite paragneiss in addition to the iron-formation, include quartzite and impure quartzite. The paragneiss commonly contains abundant epidote. A thin section of the iron-formation richer in magnetite than normal has an approximate composition of quartz, 20 per cent; magnetite, 25 per cent; and grunerite, 55 per cent. Interbanded with the sedimentary rocks are grey granitic bands, forming about 10 per cent of the rock mass and composed of quartz, plagioclase, minor microcline, and biotite. Pink granite in irregular patches or stringers cuts the concordantly banded rocks. It is low in mafic minerals and contains more microcline than the grey granitic bands.

In the northern part of the map-area, between longitude 75°30′ and 73°10′, are bodies of metamorphosed gabbro or diorite, probably segments of a single dyke. The dyke, which trends at N75°W and is from 1,500 to 2,000 feet wide, does not outcrop everywhere along its length but segments are aligned in such a way as to indicate a continuous body. Near the eastern end of the body, it is cut by numerous pink, quartz-feldspar pegmatite stringers and segregations. In places the basic rock is partly assimilated by granitic material. The contact between the dyke rock and the adjoining granite and gneiss was nowhere observed, but in many places close to the contact the granite and gneiss contain abundant inclusions of basic rock similar in composition to the adjacent dyke. The dyke rock ranges in composition from quartz-diorite to gabbro. The quartz-diorite is a dark green, medium- to coarse-grained rock, containing 15 per cent quartz, 40 per cent andesine feldspar, 15 per cent augite pyroxene, 15 per cent skeletal biotite grains, and 15 per cent green hornblende. The more basic varieties contain additional hornblende and pyroxene, and no quartz.

This rock does not resemble in appearance the fresh gabbro dykes of unit 15 and gives the impression of having been metamorphosed. It is definitely older than some of the granite, as it is cut and partly assimilated by granite.

In the southwestern part of the map-area a large area of rocks classed as unit 2 is outlined between latitude 52°05′ and 52°22′, and longitude 75°30′ and 76°. Outcrops are not abundant in this part of the region but those observed consist of gneissose and schistose, dark green to grey amphibolites cut by quartz-feldspar granitic stringers. The basic component, forming about 80 per cent of the mass, was apparently derived from basic extrusive rocks, probably andesite, cut by metamorphosed gabbro sills and dykes. With the metavolcanic rocks are small amounts of finely banded light and dark rocks of either sedimentary or tuffaceous origin. This group of metavolcanic and metasedimentary rocks is considerably more recrystallized than the band of unit 1 just to the south. The abundance of amphibole and epidote in these rocks indicates that they lie in the epidote-amphibolite facies of metamorphism.

Just south of Fort George River, at about longitude 73°45′, is a small body of dark grey to green amphibolite and chlorite schist cut by bands, from inches to tens of feet thick, of coarse-grained to pegmatitic white granite. The granite consists of quartz and feldspar with needles and prisms of common green hornblende. The amphibolite and schist is probably derived from basic volcanic rocks. Some well-banded fissile parts that weather a bright red may be derived from tuff beds. This body may contain more granitic material than is normal in rocks of this unit.

A belt of metasedimentary and metavolcanic rocks just west of Lac Dalmas (lat. 53°28′, long. 72°) contains 10 to 15 per cent granitic material in the form of white pegmatitic granite. The sedimentary rocks are more abundant than the volcanic rocks and consist of impure quartzite and greywacke that have been moderately metamorphosed. A thin section of a meta-greywacke contains quartz, plagioclase, microcline, biotite, and hornblende, with apatite and zircon as accessories. Banding that is obviously relict bedding is prominent. In some of the impure quartzite beds graded bedding is still visible. At the north end of this metasedimentary belt is a small band of fine- to medium-grained, dark green to black amphibolite derived from basic extrusive or intrusive rocks.

A large area of metasedimentary rocks containing limited amounts of interbanded granitic material is present in the eastern part of the area, centred about latitude 54°, longitude 69°30′. The distinctive characteristic of this body is the high grade of metamorphism as compared with similar rocks to the west. In it garnet is a characteristic mineral and hypersthene pyroxene is rather abundant. These medium- to fine-grained rocks range from brown to dark grey on weathered surfaces and are light grey to dark greenish grey or black on fresh surfaces. Banding, which probably represents relict bedding, is prominent in most of these rocks. Concordant pink or white granite or granite pegmatite stringers or bands occur irregularly throughout the mass. Amphibolites are not abundant and most of the metamorphic rock is obviously metasedimentary. Finely banded, quartz-rich varieties are derived from impure quartzite or sandstone but the more abundant garnet-rich rocks are derived from argillites.

Just east of Otish Mountains (lat. 52°14′, long. 69°59′) a small area of metamorphosed iron-formation is included with rocks of this unit. The weathered surface of the rock is green to black, with a rough, irregular surface and deeply weathered brown patches scattered over it. The fresh rock is grey to bluish green. It is a fine- to medium-grained, magnetite-iron silicate rock consisting of cummingtonite, grunerite, ferrohypersthene, and fayalite with magnetite disseminated among the cummingtonite or grunerite grains. Minor amounts of quartz, plagioclase, and garnet are also present.

Summary and Interpretation

Unit 2 is intermediate between rocks of unit 1 and unit 5 in respect to the amount of granitic material present. In some respects it is like unit 3, but, unlike unit 3, the granitic material is not pegmatitic and it occurs in small isolated patches, not in one large area. Many of the small bodies of unit 2 consist of rocks like quartzite, iron-formation, and amphibolite. Rocks like these are resistant to granitization, which probably accounts for their preservation. Areas of other rocks included in this unit may have been preserved by their structural position.

The amount of granitic material present in rocks of unit 2 varies, but rarely exceeds 20 per cent. However, where contacts are determined by an estimate of the amount of granitic material present, there is naturally considerable latitude.

The metamorphic grade of rocks of unit 2 varies noticeably, the epidote-amphibolite facies being represented in the west and the granulite facies in the east. This is discussed in the section on *Metamorphism*.

Some of the small bodies of unit 2 that contain quartz-magnetite iron-formation may have some economic significance. The magnetite is coarser grained in these metamorphosed and recrystallized rocks than in the original unmetamorphosed rocks and may be easier to beneficiate. This point is discussed in Chapter IV.

Sedimentary Schist and Gneiss with Interlayered Pegmatitic Granite (Unit 3)

In the southwestern and south-central part of the map-area the predominant rocks are sedimentary schists or paragneiss interlayered with coarse-grained to pegmatitic white or pinkish granite. These rocks grade into more even-grained banded gneiss or granite-gneiss (unit 5). In outcrops, the granite being more resistant to erosion is more prominent than the schist or paragneiss. Both mineral composition and texture of the rocks of this unit vary across the wide area of their exposure. The contrast of the dark weathering schist and gneiss with the light coloured granite makes this a distinctive unit in outcrops.

Lithology

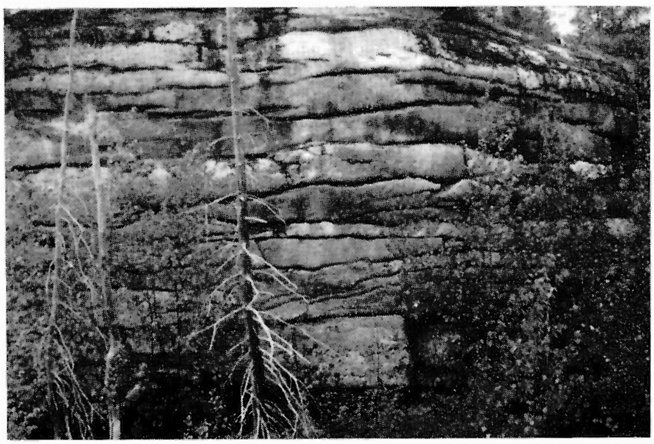
In the southwestern part of the area, just southeast of Sakami Lake, the rock consists of brown weathering, grey, quartz-plagioclase-biotite schist, varying to a less schistose type approaching gneiss. Interlayered with the schist and gneiss is white to pinkish, light coloured, coarse-grained to pegmatitic granite, consisting of quartz, microcline, and plagioclase, and generally containing 5 per cent or less of biotite as the mafic constituent. In a few places coarse hornblende crystals are the dark coloured mineral of the granite phase. The width of the layers varies greatly. In some places the schist is in bands 6 to 12 inches wide with granite layers of about the same width, but elsewhere the schist is in bands up to 150 feet wide with concordant masses of granite 100 feet or more (*see* Pls. II and III). It is difficult to estimate the percentage of each rock type, but in this locality the granite is estimated to form only 25 to 35 per cent of the total rock mass.

In one locality (lat. 53°20′, long. 76°) the quartz-plagioclase-biotite schist contains rounded white quartz inclusions from 1 inch to 2 inches in diameter. These are slightly elongated parallel with the schistosity and appear to be relict quartz pebbles. This schist is believed to have been derived from a conglomerate.

Eade, 1-9-59

PLATE II

Interbanded quartz-plagioclase-biotite schist and pegmatite.



Heywood, 7-1-58

PLATE III

Interlayered quartz-plagioclase-biotite gneiss and coarse-grained granite.

A thin section of a specimen (lat. 53°, long. 76°) of white granite that contains bands of the biotite schist consists of microcline, 45 per cent; plagioclase (oligoclase) 34 per cent; quartz, 20 per cent; less than 1 per cent biotite, and accessory apatite. This is a typical specimen of the coarse-grained granite occurring with the schist. In some places, however, biotite is absent but muscovite and garnet may be present.

A thin section of a specimen of paragneiss of this unit (lat. 53°15′, long. 75°35′) has an approximate composition of quartz, 45 per cent; oligoclase, 35 per cent; biotite, 18 per cent; muscovite, 2 per cent; with small amounts of apatite, magnetite, zircon, and prehnite. There is a preferred orientation of the long direction of mineral grains and a rudimentary separation of minerals into light and dark bands. The prehnite in this section is secondary, occurring as lenticular masses within some of the biotite.

Eastward, the unit becomes more homogeneous, with grey granite-gneiss (unit 5) appearing locally but not in areas large enough to be outlined. Rather than the typical distinct separation into schist and pegmatite, the rocks approach a banded gneiss or granite-gneiss. Near latitude 53°10′, longitude 74°10′, the unit is typically grey quartz-plagioclase-biotite gneiss interlayered with pink, medium- to coarse-grained granite. The biotite gneiss there is garnet-bearing in many places and closely folded. A thin section of the interlayered pink granite has the composition of quartz, 35 per cent; microcline, 35 per cent; oligoclase, 30 per cent; with only scattered biotite flakes, partly altered to chlorite. Just south of this locality the interlayered granite is similar except that garnet is more abundant, perhaps up to 4 per cent of the rock. The garnet is present as small euhedral grains in the granite and as porphyroblasts up to one quarter inch in diameter, in the interlayered gneiss.

Eastward between longitude 73°30′ and 74° bodies of granite-gneiss occur within the unit, as outlined on the map. The contact between the granite-gneiss and the interlayered paragneiss-pegmatitic granite unit is gradational so that contacts on the map are for the most part arbitrary. The interlayered granite in this locality is more medium- than coarse-grained, and the sharp distinction between grain size and colour in the different bands is not so marked as to the west. The composition also may vary, some parts of the gneiss bands containing more quartz. Bodies of amphibolite too small to map, present here and there in the gneiss, are more common in the central part of the unit than they are to the west. These fine- to medium-grained dark green rocks consist of hornblende, biotite, and plagioclase, with minor quartz.

East of about longitude 73°, this unit varies from south to north. In the south it is much the same as in areas to the west, medium- to fine-grained paragneiss or schist with interlayered medium-grained to pegmatitic granite. North of the mass of granite-gneiss that breaks the unit in two, however, the granite interlayered with the paragneiss is all medium-grained and contains more biotite, and the rock generally resembles a banded gneiss. There is little actual difference in composition from north to south, but the granite layers in the north contain less microcline.

In the eastern occurrences of unit 3 there is however a definite change in mineral composition although not in appearance. Brown weathering, grey gneiss with a salt-and-pepper texture on fresh surface is interlayered with pink to white granite with lower mafic content than the gneiss. A thin section of a specimen of the gneiss from latitude 52°45′, longitude 71°50′ has the composition of quartz, 30 per cent; plagioclase, 40 per cent; biotite, 15 per cent; hornblende, 3 per cent; and hypersthene, 12 per cent. Other thin sections contain pyroxene, no hornblende, and relatively abundant apatite. Some specimens however contain no pyroxene, but are like the rocks farther west. The presence of pyroxene in the eastern exposures of this unit indicates a rising grade of metamorphism in that direction.

Summary and Interpretation

Typically the rock of this unit consists of brown weathering, grey paragneiss or schist interlayered with medium- to coarse-grained granite with little mafic material. The rocks grade into banded gneiss and more homogeneous granite-gneiss, small areas of which may be included within the unit. The paragneiss or schist consists of quartz, oligoclase, and biotite, commonly with garnet porphyroblasts and magnetite and apatite as accessories. Hornblende is present but in limited amounts and hypersthene occurs in the extreme eastern part of the unit as outlined. The pink or white granite component normally contains less than 5 per cent biotite. Quartz, microcline, and oligoclase are the major constituents, muscovite or common green hornblende and in some places fine, euhedral garnet crystals may be present.

The granite occurs in the paragneiss or schist in various ways, as concordant bands from half an inch to several hundred feet thick, as concordant pods or lenses, or as irregular segregations or stringers either concordant or, less commonly, cross-cutting. Occasional dark green amphibolite lenses are present in the unit.

The composition and relict banding of the gneiss and schist phases, as well as rare presence of some conglomerate, indicate the sedimentary origin of the original material. Metamorphism of different grades, from epidote-amphibolite facies to granulite facies, has affected the original sedimentary material. The granite phase of the unit is apparently the result of synkinematic granitization accompanying the metamorphism.

Pink to White Granodiorite and Pegmatitic Granodiorite (Unit 4)

Plutons of pink to white granodiorite and pegmatitic granodiorite, all of which occur in or next to the interlayered paragneiss and granite (unit 3), are apparently segregations of a similar type of granitic rock as that interlayered with the paragneiss. Typically, the bodies are homogeneous granodiorite throughout but rarely up to 10 per cent paragneiss or schist may be included.

Coarse grain size and low mafic mineral content are characteristics of this granodiorite, although in some of the larger bodies, medium-grained varieties may predominate over the pegmatitic type. Colour ranges from pink to white or less commonly grey. Only the larger, more prominent bodies have been shown on the map and some smaller masses are included with unit 3.

Lithology

The small body of granodiorite on the east side of Sakami Lake is a white, medium- to coarse-grained rock of very variable grain size. Feldspar crystals up to 12 inches long and distinctive graphic intergrowths of quartz and feldspar are characteristic of the pegmatitic type. Quartz, microcline, and oligoclase compose 95 per cent or more of the rock. Biotite and muscovite are both present and locally small garnet crystals are relatively abundant. In this body the microcline content does not exceed 15 per cent.

About 20 miles east of the above-described body is a slightly larger mass that ranges in character from a white, coarse-grained or pegmatitic rock to a grey, medium-grained rock that may have a pink weathered surface. A thin section of a specimen of the latter shows a uniform granitic texture and an approximate composition of anhedral quartz, 40 per cent; well twinned plagioclase (An_{25}), 45 per cent; microcline, anhedral and in part replacing plagioclase, more than 10 per cent; and biotite less than 5 per cent.

The largest area of granodiorite mapped as unit 4, north of Eastmain River at latitude 76°, varies somewhat in character and should perhaps be included with unit 7 rather than with unit 4. It has the typical low mafic mineral content and pink to white or grey colour of unit 4 but the higher proportion of medium-grained rock is more like unit 7. Biotite is the normal dark mineral and rarely exceeds 8 per cent. In places muscovite occurs with the biotite and in others hornblende is the mafic constituent. A thin section of a specimen of granodiorite from near the east edge of the mass has an approximate composition of quartz, 25 per cent; oligoclase, 55 per cent; microcline, 15 per cent; biotite, in part altered to penninite, 5 per cent; and scattered muscovite and secondary epidote grains. In some parts of the mass, alignment of dark minerals, particularly hornblende, has produced a rude foliation. Near the margins of the mass, dark inclusions of biotite-plagioclase rock are present but nowhere exceed 10 per cent of the rock mass.

Just to the east of the occurrence described above is a smaller elongate body of white or grey, medium- to coarse-grained granodiorite. This rock is normally massive but locally hornblende-plagioclase inclusions give it a gneissic character. A specimen of the gneissic variety from latitude 52°12′, longitude 74°20′ has a composition of quartz, 35 per cent; plagioclase, 40 per cent; microcline, 10 per cent; hornblende, 7 per cent; biotite, largely altered to penninite, 8 per cent; and scattered accessory minerals, apatite, titanite, and magnetite. The relatively high percentage of dark minerals is undoubtedly due to the abundance of inclusions.

Summary and Interpretation

The pink to white granodiorite varies from medium- to coarse-grained or pegmatitic and is typically light coloured. Quartz and plagioclase are present in approximately equal amounts and microcline is much less abundant. Biotite and hornblende—the former more common—together comprise less than 10 per cent of the rock. Muscovite may accompany the biotite, and epidote may also be an essential constituent. Garnets are present in some localities, particularly where schist inclusions occur.

Normally massive, the rock may be gneissic with aligned dark coloured inclusions or schlieren.

The plutons are everywhere in contact with rocks of unit 3, and the granite layers in the paragneiss are physically very similar to the granodiorite of unit 4. Indeed, plutons of unit 4 are simply large segregations of the granitic material containing less microcline and without much included schist or paragneiss. There is no apparent structural relation for the distribution of the plutons, and they have apparently developed by local, large scale segregation of granitic material resulting from synkinematic granitization, essentially the same process as produced the granitic interlayers in unit 3.

Granitic Gneiss, Banded Gneiss, and Migmatite (Unit 5)

This unit comprises foliated granitic rocks that vary in appearance. Most are granodiorites that range from quartz diorite to quartz monzonite and granite. Biotite is the most abundant mafic mineral with common green hornblende less abundant. In isolated localities other mafic minerals such as pyroxene, anthophyllite, or grunerite may be characteristic.

Typically, the rocks are medium grey on both fresh and weathered surfaces, but rocks of different appearance are widespread. Pink is common, particularly in the granitic gneiss. In the banded gneiss and migmatite, dark grey to black bands alternate with light grey or white bands; in the grey granitic gneiss, a salt-and-pepper appearance is typical with dark minerals speckled through a light groundmass. Rocks of this unit grade from well-foliated banded gneisses and migmatites through poorly foliated granitic gneiss to massive granitic rocks.

Unit 5 underlies more of the map-area than does any other unit. This unit could probably be subdivided into at least two units (granitic gneiss and banded gneiss) by more detailed mapping, but not on the scale of the present study. Within it the types of gneiss are transitional from one to another and, indeed, the unit as a whole is gradational to other units, the massive granites on the one hand and the metamorphosed sedimentary and volcanic rocks (units 2 and 3) on the other.

In the southeast corner of the area (NTS 23C, mapped by I. M. Stevenson in 1961), unit 5 probably includes minor amounts of metamorphosed sedimentary rocks of the Kaniapiskau Supergroup (unit 10). There part of the sedimentary section below the iron-formation now consists of a heterogeneous complex of biotite and hornblende gneisses, indistinguishable from the other gneisses of unit 5. These might be separated by detailed structural and stratigraphic studies.

Just to the northeast of the above-mentioned locality, along the west border of the Labrador 'trough', the mixture of granite, granodiorite, and gneisses has been called the "Ashuanipi complex" by various company geologists (Harrison, 1952). Except for the work of Baragar (1962), no systematic mapping has been done but it appears that much of the area is underlain by pyroxene-bearing granodiorite like that of unit 6, with lesser amounts of rocks like those of units 5 and 7. In the Cambrian Lake (west half) area (Fahrig, 1956) the gneisses and granites lying west of the

PLATE IV

Well-banded sedimentary gneiss, near Cape Jones. Light coloured, granitic gneiss in small amounts, but in continuous layers.

Eade, 2-8-56

Labrador 'trough' are called the Pre-Kaniapiskau Group and include rocks similar to those of units 5 and 7. In the present report, neither name, Ashuanipi complex nor Pre-Kaniapiskau Group, is considered appropriate.

Lithology

The great number of rock types that constitute this unit and the infinite variety of ways in which they are combined make it impractical to describe the lithology in more than broad, general terms. Practically all forms of gneissic rocks are present—migmatite, agmatite, veined gneiss, banded gneiss, hybrid gneiss, and so on, but it is impossible in reconnaissance mapping to indicate the extent or importance of each. An attempt is made below to describe some representative gneisses but even typical hand specimens are difficult to secure as no two specimens are quite alike.

The well-banded gneisses of sedimentary origin, the paragneisses, are like those of units 2 and 3. The width of the bands varies from a fraction of an inch to several feet. In general, these rocks are grey with a dark grey mafic-rich component and a light grey or white granitic component consisting essentially of quartz and feldspar. The percentage of each component varies greatly and this in part distinguishes this unit from unit 2. However, in isolated localities within areas of unit 5, granitic material may be very scarce in the banded gneiss. The bands in these rocks may be regular and straight or in places plastically deformed, with pinching and swelling, and intricate folding (Pl. IV). The dark part of the banded gneiss is normally fine to medium grained but the granitic part ranges from medium grained to pegmatitic. The pegmatitic bands are easily distinguished from later, cross-cutting pegmatite dykes or segregations, as most of the latter contain far more potassic feldspar and are pink.

The so-called vein gneiss (Pl. V) differs in appearance from the banded gneiss or paragneiss, as the light material in the vein gneiss is in discontinuous layers. The vein gneiss is grey on fresh surfaces, commonly with a salt-and-pepper appearance of dark mafic grains against white quartz and feldspar. Weathered surfaces are grey to brown,

PLATE V

Typical vein gneiss. Light material in discontinuous layers.

Eade, 2-5-56

the latter normally of gneiss with abundant biotite. The dark bands in the vein gneiss are medium grained, but the light coloured granitic layers are medium grained to pegmatitic or occasionally fine grained and aplitic. The foliation is marked, as it is in the banded gneisses, but in the vein gneiss the layers are commonly elongated and pinched during plastic deformation. The layers or lenses, both light and dark, range from a few inches to many feet long but normally are from 6 inches to 3 feet.

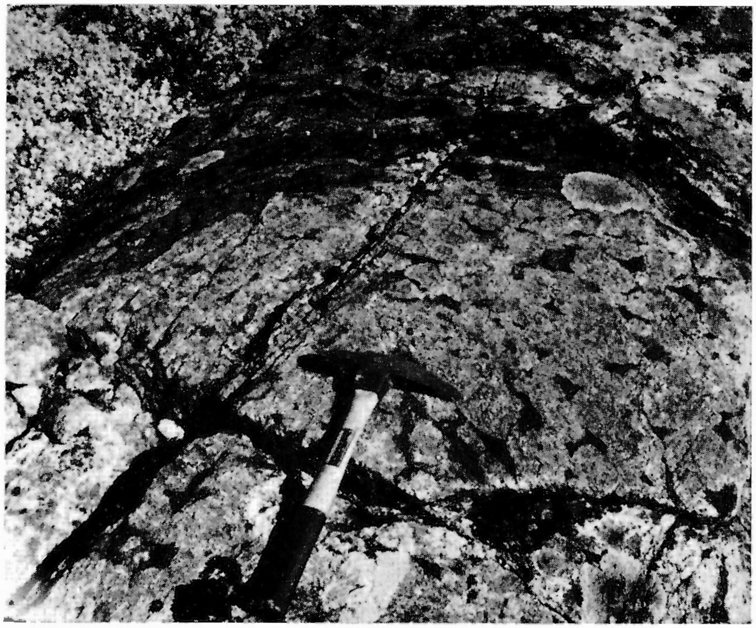


PLATE VI

Typical small mafic inclusions in gneiss.

Eade, 3-1-59

The granitic gneiss is the most homogeneous component of this unit. It is transitional between the more complex varieties of gneiss and the massive granitic rocks. The granitic gneiss possesses a definite foliation, due to the alignment of the long directions of dark mineral and of inclusions and schlieren. It is generally grey, less commonly pink and practically everywhere medium grained. The granitic gneiss is more uniform in appearance than the other gneisses, as there is no pronounced segregation of dark and light minerals, although the numerous dark coloured inclusions introduce a measure of heterogeneity.

The shape, size, and abundance of mafic inclusions in the granitic gneisses cover wide ranges. Practically all the gneisses contain some inclusions although in some outcrops they may be sparse. In many granitic gneisses there is an inclusion every 10 feet or less and in some gneisses—agmatites—inclusions form 75 per cent of the whole. The shape of inclusions varies from sheared elongate lenses to angular blocks. The contacts with the groundmass may be sharp and clean, as they normally are if the inclusion is angular, or indefinite and gradational resulting from the partial assimilation of the inclusion. In size, inclusions range from a fraction of an inch (Pl. VI) to tens of feet. The larger inclusions generally form brecciated basic bands that are partly assimilated (Pl. VII).

On a regional scale the gneisses of this unit have a remarkably consistent mineral composition. The average composition of the grey gneiss is quartz, 40 per cent; plagioclase, 50 per cent; biotite, 10 per cent. Apatite and opaque iron oxides are the most abundant accessory minerals with zircon and titanite less common. Myrmekitic quartz intergrowths may be present, particularly if the rock contains some microcline. The plagioclase, which ranges from fresh to badly altered, is normally oligoclase (An_{20} to An_{30}), although in some specimens it may be andesine (An_{30} to An_{36}), particularly in the hornblende-rich gneisses. Plagioclase in gneisses that contain pyroxene consistently range from An_{26} to An_{28}. Secondary white mica is the most common alteration product of the plagioclase but zoisite and epidote also form. The

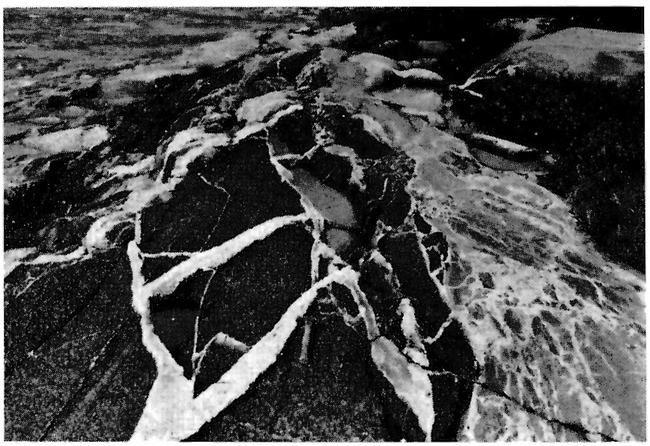


PLATE VII

Brecciated basic band in gneiss, large brecciated inclusions.

Eade, 3-1-56

biotite is normally brown to greenish brown differing from the red-brown biotite characteristic of unit 6. Normally fresh, it may be partly altered to chlorite. Microcline is commonly absent or a minor constituent in the grey gneisses. It may appear as fine anti-perthitic intergrowths in the plagioclase, but some may form as fine stringers cutting the plagioclase or, less abundantly, as discrete grains.

The overall composition of the banded gneisses is the same as that of the grey gneiss, but biotite, which forms about 35 per cent of the dark bands, is absent in light bands with 65 per cent plagioclase, quartz forming the remainder.

In the granitic gneiss and gneissic granites, which grade into massive granite, the rock is normally pink and contains much microcline. The approximate average composition for this rock is quartz, 25 per cent; plagioclase, 35 per cent; microcline, 25 per cent; biotite and/or hornblende, 15 per cent. The microcline shows the typical plaid twinning and may form large euhedral grains as well as stringers and veinlets that cut the plagioclase. The microcline always shows evidence of forming late and cutting and absorbing the plagioclase. In these rocks, myrmekitic quartz intergrowths are abundant.

In some of the grey quartz-plagioclase-biotite gneiss 1 to 3 per cent hornblende may be present as well as biotite. However, hornblende is most common in the more homogeneous types of pink granitic gneiss in which microcline is also more abundant. Possibly some relationship exists between the presence of hornblende and of microcline. Considering the unit as a whole, hornblende is far less abundant than biotite. Some hornblende gneisses are present in limited amounts apparently derived from amphibolites. They contain 25 to 50 per cent hornblende, with plagioclase the other major constituent and quartz normally less than 15 per cent.

Epidote is present in many rocks of this unit, for the most part in small amounts although in some specimens it may form 10 per cent of the whole. Most of it is an alteration product of plagioclase, but in some thin sections scattered grains are seen that appear to be primary.

Quartz-rich bands occur in the gneiss in some places, particularly in the western third of the map-area. These bands were apparently derived from quartzite or impure quartzite beds in an original sedimentary sequence and have proven to be less susceptible to the processes of granitization. Specimens from such bands show 80 to 85 per cent quartz, 10 to 15 per cent plagioclase, scattered biotite or muscovite flakes, and rarely garnet grains. Such bands are rare considering the great extent of the unit.

Rocks of unit 5 in contact with the pyroxene-bearing rocks of unit 6 commonly contain some pyroxene, although in other respects there is no similarity. Hypersthene is the normal pyroxene and may constitute as much as 10 per cent of the rock. In other respects, the pyroxene gneiss resembles the common grey gneiss, pyroxene taking the place of some of the biotite. Microcline is not abundant, generally less than 5 per cent. In a very few specimens common green hornblende occurs with the pyroxene and biotite.

The pyroxene gneiss represents a higher metamorphic facies than other members of unit 5. Garnet is always present, although garnet also occurs widely in other varieties of gneiss, particularly the banded gneiss. Indeed, selected specimens of banded gneiss contain as much as 30 per cent garnet. However, in the pyroxene gneiss much of the garnet is in well-developed euhedral grains, whereas in the banded gneisses it is normally poikilitic with inclusions of biotite and quartz.

In some gneiss of this unit near units 1 and 2, grunerite is an abundant constituent, as much as 30 per cent being found in one specimen. This iron-rich amphibole is not a normal constituent of the gneisses and is apparently only present in those gneisses derived from iron-formation in the original sedimentary and volcanic sequence.

Of the large number of thin sections examined, only one contained andalusite and sillimanite. These metamorphic minerals are apparently an extremely rare constituent of this unit.

The inclusions in the gneisses are similar in composition to the amphibolites in unit 2. They consist of about equal amounts of common green hornblende and oligoclase-andesine feldspar. Less commonly, biotite is a major constituent being present in equal amounts with hornblende and plagioclase and with minor quartz. Rare inclusions consist of 75 per cent biotite and the remainder quartz. In some places in the western third of the map-area, inclusions of iron-formation are abundant in the gneiss. They consist of up to 30 per cent magnetite, the remainder being quartz and hypersthene or grunerite. These inclusions retain the fine banding characteristic of the iron-formation of unit 1. In the eastern part of the area, some of the pyroxene-bearing gneisses included with this unit contain ultrabasic inclusions, composed of pale green amphibole, probably cummingtonite, hypersthene, and some olivine. Such inclusions are not so common as they are in parts of unit 6.

Throughout the gneiss unit porphyroblasts of feldspar occur, although nowhere so widespread as to form a distinctive subunit. Most are plagioclase although some in the granitic gneiss are microcline. Augen gneiss is found sparingly throughout the area, the augen consisting of microcline or plagioclase grains that have been crushed and elongated.

Summary and Interpretation

Unit 5 is composed of a wide variety of foliated rocks, from well-banded and vein gneisses to more homogeneous granitic gneiss. Most of the rocks are granodiorites, although true granite, quartz monzonites, and quartz diorites are also present. Biotite is the most abundant mafic mineral, the next being hornblende and, in restricted areas, pyroxene. Most of these rocks are medium grained and shades of grey, although most granites are pink.

The abundance of biotite and the presence of some hornblende and epidote indicate that the rocks are for the most part in the epidote-amphibolite facies of metamorphism. In the western part of the area, near Burton Lake, is an area of pyroxene-bearing gneiss of unit 6. Some of the gneisses of unit 5 around this body contain abundant pyroxene and garnet, indicating that they approach or are in the granulite facies. Similarly but on a much larger scale, in the eastern part of the map-area close to large areas of unit 6, the presence of pyroxene and garnet in gneisses of unit 5 indicate it is in the granulite facies of metamorphism.

The gneisses of unit 5 represent a stage of metasomatism intermediate between massive granitic rocks (unit 7) and the gneisses of units 2 and 3. Most of the gneisses and granitic rocks of this unit are thought to have resulted from the granitization of sedimentary and volcanic rocks, with some intrusive rocks, without passing through a magmatic stage although there has undoubtedly been entry and exit of material. Migmatite of various types, consisting of igneous or igneous-appearing parts and metamorphic parts, are abundant. In some of the granitic gneisses in which the metamorphic parts are much less abundant or even absent, there is evidence of potassium metasomatism, resulting in the late development of microcline feldspar. Evidence of potassium metasomatism is however not as striking in these gneissic rocks as in the massive granitic rocks (unit 7).

Rocks most resistant to change, such as basic rocks and to a lesser degree quartzite and iron-formation, constitute most of the abundant remnants or inclusions in the gneisses. Between areas of unit 5 gneisses and less metamorphosed unit 3 rocks, it is common to find a belt of rocks of unit 1 which consists largely of basic volcanic rocks. It is interesting to speculate on the possibility that these belts have been a barrier to the processes of metasomatism or granitization.

There appears to be a very definite relationship between the areal distribution of the gneisses and the structural geology; this is discussed under *Structural Geology*.

East of the map-area, bordering the Labrador 'trough', gneisses similar to those of this unit, included in the Ashuanipi complex by company geologists (Harrison, 1952), are stated to be much like the gneisses of the Grenville Series in southeastern Ontario and southern Quebec. In the type areas of the Grenville Series, crystalline limestone or calc-silicate beds and quartzites are prominent. In the gneisses of unit 5 and probably in those bordering the Labrador 'trough', neither calc-silicate nor quartzite inclusions appear. It is possible of course that the amphibolite inclusions are derived from metamorphosed limestones but on the whole it is felt that these gneisses are unlike those of the Grenville Series.

Pyroxene-Bearing Granodiorite and Gneiss (Unit 6)

Rocks of unit 6 are characterized by yellowish green plagioclase with a greasy lustre, which gives a dark appearance to the rock mass. In some parts of the unit, the quartz is conspicuous because of its blue colour. Biotite is abundant, which accounts for the typical rusty brown weathered surface of much of the rock. Hypersthene is a characteristic constituent but it is not present everywhere. Potassium-bearing feldspar is not abundant and most of the rock is a granodiorite. Included in this unit are massive granitic textured rocks, with or without inclusions, to well-foliated or banded gneisses and even paragneiss.

The contacts with rocks of units 5 and 7 are normally well defined but in places there is considerable mixing of rocks of units 6 and 7 across the zone of contact. In places rocks of unit 6 are intruded by pink granite similar to that included in unit 7.

Most rocks of unit 6 have much in common with the charnockite suite of many authors, and, except that it serves no useful purpose in this report, could be so designated.

Lithology

The rocks of unit 6, which show only a rude foliation due to the alignment of basic inclusions and schlieren, have a relatively constant composition of approximately, plagioclase An_{28} to An_{30}, 55 per cent; quartz, 20 to 30 per cent; biotite, 10 per cent; pyroxene, 5 to 15 per cent. Magnetite and apatite are common accessory minerals. The plagioclase may contain fine perthitic intergrowths of potassic feldspar, but microcline or orthoclase are not normally present as discrete grains. The pyroxene is most commonly monoclinic, probably augite, but in some specimens it is orthorhombic. The biotite is a very typical red-brown in all these rocks, and is only slightly altered to chlorite. The composition of the plagioclase is remarkably constant in all the sections examined, which were from widely separated localities. Apatite is an ever present accessory mineral, and in some specimens may form as much as 1 per cent of the rock.

Rocks of unit 6 are medium grained with a granitic texture. The distinctive greenish, greasy-lustred plagioclase gives the rock its typical dark cast; the quartz which may be blue to black adds to its dark coloration. The weathered surface is typically rusty brown due to the weathering of the abundant biotite.

Most of the massive rocks contain some inclusions or schlieren of dark, more basic material, rich in biotite and with more pyroxene than the surrounding groundmass. The inclusions vary from rounded to blocky bodies up to 3 feet across with sharp contacts, or elongated schlieren with more gradational contacts.

The massive rocks pass imperceptibly into foliated rocks as increasingly abundant aligned inclusions pass into well-developed dark bands. There is not much difference in the overall composition although in thin sections of gneissic specimens, hypersthene is a prominent mineral and augite only sparingly present. Some specimens from the gneisses contain common green hornblende formed at the expense of the pyroxene. Garnet, an accessory mineral only in the massive rocks, is abundant in the gneisses. Some specimens contain potassic feldspar as fine intergrowths in plagioclase, and a few contain microcline in grains, but these never form more than 5 per cent of the rock. In both massive and foliated varieties, apatite and magnetite are abundant accessories.

There is a gradual change in the appearance of the foliated rocks from the dark variety with greasy-lustred feldspar to a somewhat lighter grey gneiss, interlayered with dark bands. The composition of the lighter coloured bands differs from that of the dark bands only in a lower mafic minerals content and in plagioclase feldspars being slightly more albitic, An_{24} to An_{26} as compared to An_{28} to An_{30}. The gneiss of the light grey bands is very similar to the pyroxene-bearing gneiss of unit 5 and on a regional scale is probably transitional into it.

The rocks described above are from the eastern quarter of the map-area. Other pyroxene-bearing rocks lie in the northwestern part, and there no massive types were observed. The weathered surfaces are dark grey to rusty brown and the rocks are typical dark coloration on fresh surfaces. The plagioclase is greenish with a greasy lustre, typical of all these rocks. Either orthopyroxene or clinopyroxene (hypersthene or augite) may be present. In a few specimens, diallage rather than augite is the monoclinic pyroxene. The pyroxenes are altered to common green hornblende and, less commonly, to actinolite. The composition of these rocks is similar to that of those in the east except that microcline is slightly more abundant and occurs in discrete grains as well as in fine intergrowths in the plagioclase. In this western body the boundaries are less well defined and the dark-coloured gneisses of unit 6 grade into the light grey gneisses of unit 5.

Summary and Interpretation

The pyroxene-bearing granodiorite and granodioritic gneisses are characterized by a rusty brown weathered surface and a dark fresh surface and by greenish, greasy-lustred plagioclase. Hypersthene and augite are the usual pyroxenes although diallage has been noted. On the basis of limited observations, it is suggested that orthopyroxene is more abundant in the foliated rocks and the clinopyroxene in the massive types. The pyroxene grains may be almost completely rimmed by common green hornblende or, rarely, by actinolite. These amphiboles are indicative of retrograde metamorphism. Garnet is a common accessory mineral and may be an essential constituent in some of the foliated rocks. Biotite is everywhere abundant. Potassic feldspar is rare.

The composition of the plagioclase is remarkably consistent over the wide area of these rocks. The range is from An_{26} to An_{32}, most lying between An_{28} and An_{30}. In thin section these feldspars appear comparatively fresh and unaltered and no reason is apparent for the greenish colour or greasy lustre. This colour and lustre are characteristic features of such rocks on a world-wide scale. The colour of the quartz, blue to black, is another feature that is found in many parts of the world in similar rocks. It should be noted that in occasional specimens of this unit of typical appearance pyroxene was absent.

The pyroxene-bearing rocks represent a higher grade of metamorphism—the granulite facies—than is common in most of the other rock units. This is discussed in the section *Metamorphism*.

Massive Pink and Grey Granite (Unit 7)

This unit includes massive rocks of granitic composition and in part porphyritic. They probably represent rocks of more than a single type and origin. The unit includes minor amounts of foliated gneissic granite of the kind described in unit 5, for the contacts between massive and foliated granitic rocks are normally gradational. Typically, the rocks are pink, medium grained, equigranular, biotite-bearing granites but there is much variation from this norm and grey or white granites are present in places. The rocks may be coarse grained to pegmatitic, although this is unusual. Porphyritic texture is a common feature. Hornblende rather than biotite may be the essential mafic mineral. For the most part, the rocks are granites but range from granodiorite and quartz diorite through quartz monzonite. Although the granitic rocks of this unit are far more homogeneous than are the related gneisses of unit 5, inclusions and schlieren are still relatively abundant.

The most common rock is a massive granite that grades imperceptibly from the granitoid gneisses (unit 5) by the gradual disappearance of foliation. Grey granites are most common in these transition zones and schlieren and inclusions are abundant. A completely different granite, included in this unit because it cannot be separated on the present scale of mapping, is a late, light pink variety, characterized by a low mafic content (generally less than 5 per cent dark minerals) that cuts both the gneisses of unit 5 and some of the massive granite of unit 7. No large bodies of this late granite were encountered. Few bodies are more than a couple of miles across and most are dykes or stringers of irregular shape. This late granite is found throughout the area but nowhere in sufficient abundance to permit mapping separately.

Within areas of unit 7 are bodies of homogeneous salmon-pink granite, commonly porphyritic, that appear to be younger and to intrude the massive granite that grades into the granitoid gneisses. Several irregular bodies of this porphyritic granite were noted. The salmon-pink granite appears to be older than the light pink granite and to be intruded by it.

Thus the massive granite (unit 7) includes at least three distinct varieties of granitoid rocks, from oldest to youngest as follows:

(1) Grey to pink granite with inclusions and schlieren that grades into granitoid gneisses. This may be porphyritic and forms about 90 per cent of unit 7.

(2) Salmon-pink granite, normally porphyritic with fewer inclusions than type (1).

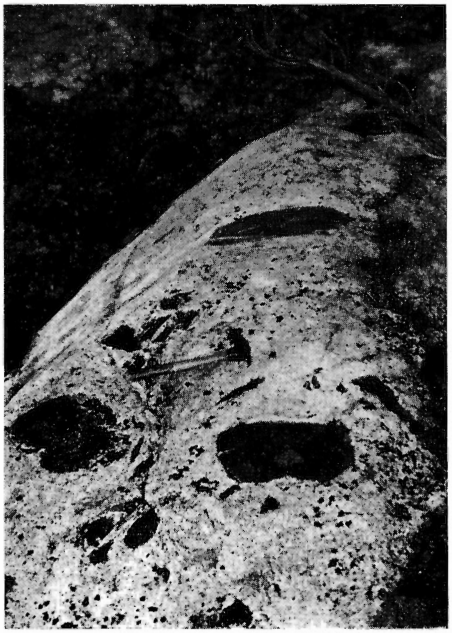
(3) Light pink, medium-grained to aplitic granite, very low in mafic minerals. This occurs most commonly in small dyke-like bodies.

Undoubtedly more detailed mapping would permit subdivision of these granites into several more units.

Lithology

The composition of the granitic rocks of variety (1) varies from granodiorite with about 25 per cent quartz, 50 per cent oligoclase, 15 per cent microcline, and 10 per cent biotite, to true granite with 30 per cent quartz, 30 per cent oligoclase, 30 per cent microcline, and 10 per cent biotite. The character of the potassic feldspar is of interest, for in practically every thin section examined there is evidence that the microcline formed late. It almost always has typical plaid twinning, embays and cuts the plagioclase, and large grains may contain small inclusions of badly altered plagioclase. Small veinlets of microperthite cut the plagioclase or may be interstitial to the plagioclase and moulded around it. Myrmekite is very common between the two feldspars. In some thin sections, the plagioclase, normally oligoclase, is turbid due to sericitization but develops clear and slightly more sodic (albite) rims where adjacent to microcline. The alteration of the plagioclase grains, which are subhedral and equidimensional or subrectangular, varies but, in general, is more extensive where there is most microcline. Sericite is the most abundant secondary product but epidote and fine zoisite are also common.

Biotite is the typical dark mineral of the granites but common green hornblende may accompany the biotite or in some rocks be the only mafic mineral present. Apatite and opaque iron oxides, probably magnetite, are almost always present as accessory minerals, with zircon less common and sphene an occasional accessory.



Eade, 2-3-56

PLATE VIII

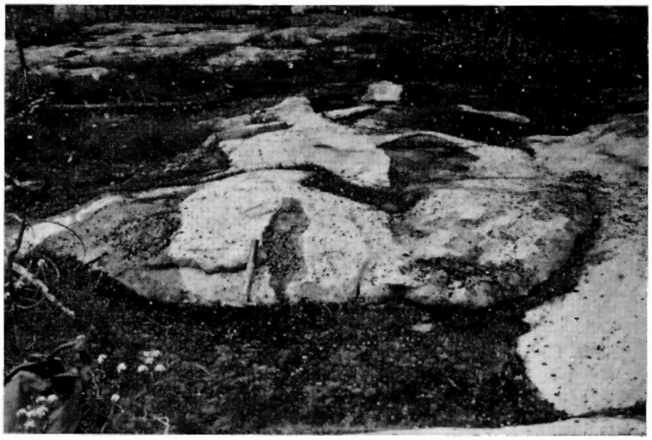
Typical mafic inclusions in massive granite of unit 7, variety 1.

Epidote is present in many of the sections of granite examined, probably forming as a secondary alteration of the plagioclase although in some specimens it is in large euhedral grains that appear to be primary constituents. Chlorite, resulting from alteration of biotite or hornblende, is present in many sections and in some has completely replaced biotite. Muscovite or white mica is not abundant and in many specimens appears to be of secondary origin.

Pyroxene, either augite or more rarely hypersthene, has been noted in a few places, generally but not always near large bodies of the pyroxene-bearing rocks of unit 6.

The inclusions in the grey to pink granite (Pl. VIII) are similar in composition to those in the gneisses of unit 5. Most are amphibolite, consisting of common green hornblende and andesine plagioclase. Biotite may be present but hornblende is the characteristic mineral.

The pink to salmon coloured, normally porphyritic granite (variety 2) is practically a true granite in composition. Either biotite or hornblende or both are the mafic constituents, but rarely constitute more than 10 per cent of the rock. The plagioclase, oligoclase to albite in composition, forms from 25 to 30 per cent of the rock, quartz about 25 per cent, and microcline feldspar from 30 to 35 per cent. The large pink phenocrysts are microcline. Inclusions are rare or absent but scattered dark, hornblende-rich schlieren may be present. The plagioclase of typical specimens of this granite is moderately altered to sericite and/or epidote but the microcline is fresh. In thin section this granite has a more homogeneous appearance than the granite of variety (1) with much less evidence of feldspar intergrowths.



Heywood, 10-2-58

PLATE IX

Granite-gneiss inclusions in intrusive pink granite (variety 3).

The youngest pink granite (variety 3) that forms small dykes and irregular intrusive bodies cutting earlier granites and gneisses, is characterized by its low mafic mineral content, rarely more than 5 per cent of the rock, and normally about 1 or 2 per cent. The rock has an approximate composition of 25 to 30 per cent quartz, 35 per cent microcline, 30 to 35 per cent albite to oligoclase, and scattered flakes of biotite or muscovite or rarely scattered hornblende grains. The biotite may be completely altered to chlorite. Normally the rock is medium grained, but it may be fine grained with granitic or aplitic texture. It is rarely porphyritic and is in sharp contact with other rocks, with little evidence of assimilation. It may contain some inclusions of the rocks it cuts and these only show slight rounding and assimilation (Pl. IX). This intrusive pink granite is distinguished in the field by its low mafic content and its cross-cutting relations.

Summary and Interpretation

Within unit 7, which includes granodiorites and quartz monzonites as well as true granite, three broad types have been recognized, although in a reconnaissance of this nature it has not been possible to map them separately. Most abundant and also the earliest to form is a grey to pink granite that grades into the gneisses of unit 5. The granites, like the gneisses, are regarded as synkinematic, with a similar origin, but the granite apparently developed at a lower level in the crust. This resulted in a greater metasomatic effect with more introduced potassium and consequently more microcline and a more homogeneous end product. There is some indication that soda metasomatism also took place locally, resulting in clear albitic rims around some of the plagioclase grains.

Next to develop was a salmon-pink granite, normally porphyritic or porphyroblastic, with few inclusions and only scattered schlieren. This is believed to be a late kinematic granite. In places it seems to be intrusive but other parts of the same body grade into the earlier grey to pink granite. Potassium metasomatism is even more marked and complete in this granite with euhedral grains of microcline a common feature and few feldspar intergrowths. The scarcity of inclusions and schlieren seem to indicate more complete assimilation of inclusions. The prevalent salmon-pink colour of this rock is due to the higher percentage of microcline.

Youngest is a pink intrusive granite, low in mafic minerals, considered to be post-kinematic. The lack of mafic minerals is typical of many such granites and its sharp intrusive contacts indicate that it is late in the orogenic-granitization sequence.

Undifferentiated Granite, Granitic Gneiss, Paragneiss, and Schist (Unit 8)

This unit is confined to the southwest corner (NTS 33 C and D) of the map-area, which was mapped by Shaw (1942) and not examined during the present work. Unit 8 consists of a heterogeneous assemblage of rocks like those of units 2, 3, 4, 5, and 7.

Basic and Ultrabasic Intrusions (Unit 9)

Small basic and ultrabasic intrusive bodies, scattered sparsely and irregularly throughout the map-area, constitute a very small but possibly economically important part of the rock sequence. They are resistant to erosion and many form topographic prominences. Bodies of various ages are probably present, for some are fresh whereas others are somewhat altered. Other ultrabasic rocks that occur intimately mixed with the volcanic rocks of unit 1 have been described with that unit as it was not possible to map them separately.

Although practically all bodies of unit 9 are so small that they can hardly be shown on a map of this scale, they have been shown wherever possible because of their possible economic significance. Furthermore, if aeromagnetic mapping is carried out in this region, the location of even small bodies of these rocks may aid in the interpretation of results.

Lithology

In the gneisses of unit 5, underlying the large island in Burton Lake (lat. 54°45′, long. 78°15′), is a band of schist of ultrabasic composition. The band is not less than 90 feet wide, probably much wider, and is apparently concordant with the gneisses in which it occurs. It is a schistose, greenish black rock, fine to medium grained and slightly porphyritic, with large dark phenocrysts of altered pyroxene. The rock is composed chiefly of enstatite altered to tremolite and serpentine, serpentine being more abundant. Scattered flakes of brown biotite, partly altered to chlorite, are present, a few flakes of colourless white mica, possibly of secondary origin and a few remnants of olivine in the serpentine. This band must be considered as a relatively old ultrabasic rock, occurring as it does concordantly with the gneisses, and having undergone metamorphism and tectonic deformation.

Just south of the Great Whale River band of unit 1 rocks around latitude 54°58′, longitude 76°54′, is a small dyke-like body or plug of ultrabasic rock. It is a massive, medium-grained, greenish black rock of high specific gravity, slightly porphyritic in part. A thin section of a specimen from this body has an approximate composition of hypersthene, 55 per cent; olivine, 15 per cent; augite, 5 per cent; iron oxides, 5 per cent; actinolite, 20 per cent; serpentine, minor. The olivine grains, with abundant fine iron oxide grains through and around them, are surrounded by the hypersthene, which is a strongly pleochroic type. The monoclinic pyroxene, believed to be augite, is slightly pleochroic and apparently formed later than the hypersthene. The hypersthene is considerably altered to bladed actinolite and a few fine stringers of secondary serpentine cut the rock. Although the presence of actinolite indicates some alteration of the rock, in general it looks fresh.

A small area of fresh ultrabasic rock, centred around latitude 52°46′, longitude 75°57′, is composed of several small related bodies rather than a single body. This mass is greenish grey to black on fresh surfaces and rusty brown on weathered surfaces; it is massive, hard with a high specific gravity, and is fine to medium grained. It seems to have been emplaced by a series of intrusions, for within the mass are fine-grained contacts of later intrusions against earlier rocks of exactly the same composition, the younger enclosing fragments of the older. Thus the bodies must have been intruded over a period of time long enough for the older intrusion to have chilled contacts against the country rock and then to cool enough to chill the margin of the subsequent intrusion. The rock is composed of approximately 75 per cent fresh monoclinic pyroxene, probably augite, 20 per cent olivine, 3 per cent opaque iron oxide, and 2 per cent serpentine in small stringers through the rock. This rock is a peridotite and is fresher than most of the ultrabasic rocks seen in the map-area.

Just northwest of the Otish Mountains, at about latitude 52°02′, longitude 72°00′, is a gabbro mass in the granitic gneisses of unit 5. This mass may be related to the gabbro sills included with the Otish Mountains Group unit 12, as they are rather similar in character. It shows some flow-banding. The gabbro is coarse grained, greenish grey to black on fresh surfaces, and dark grey to brown on weathered surfaces. Some plagioclase phenocrysts are scattered through the rock. Cutting the coarse-grained gabbro are small dyeklets of fine-grained ultrabasic rock, probably pyroxenite. A thin section of the gabbro has an approximate composition of, slightly pleochroic augite, 60 per cent; enstatite, 20 per cent; labradorite, 20 per cent; and minor opaque iron oxides and green hornblende alteration of the pyroxenes. The gabbro is remarkably fresh.

A small isolated body of anorthositic gabbro is present at latitude 52°02′, longitude 70°00′, in the southeast part of the map-area. It is a homogeneous rock, although some indistinct banding is visible in places and forms a topographic prominence. It is medium-grained, grey with black flecks on fresh surfaces, and spotted black on white on weathered surfaces. A thin section of a specimen shows that labradorite feldspar constitutes about 80 per cent of the rock, the remainder being common green hornblende that may be secondary after pyroxene. This body of anorthositic gabbro is probably genetically related to the large mass of anorthosite some 30 miles to the southwest, just west of Pletipi Lake. Information on this anorthosite body was made available by Kennco Explorations (Canada) Limited in a private report (1954). The position of the anorthositic gabbro body in the map-area may have given a clue to the position of the "Grenville Front", and is discussed further in the section on *Metamorphism*.

Just north of Otish Mountains, in an area of few outcrops, is a small ridge of ultrabasic rock at about latitude 52°34′, longitude 70°23′. The rock is dense, dark grey-green and porphyritic, and is composed almost entirely of orthopyroxene, with minor opaque iron oxide. Oval to circular grains of pyroxene up to half an inch in diameter, are set in a medium-grained groundmass of the same mineral. The large phenocrysts are more resistant to weathering and protrude on the weathered surface.

Massive fine- to medium-grained gabbro, light bluish grey on weathered surfaces, greenish grey to black on fresh surfaces, forms a high ridge at latitude 52°25′, longitude 70°03′. The rock weathers deeply to a dark gravel-like material. The approximate composition of the rock is, labradorite, 55 per cent; hypersthene, 25 per cent; biotite, 15 per cent; and diopside, 5 per cent. The pyroxene is in medium-sized grains surrounded by fine-grained, yellowish plagioclase.

In the vicinity of latitude 54°31′, longitude 71°16′, a small body of gabbro similar to that just described is characterized by the same deep weathering.

Summary and Interpretation

Small isolated bodies of basic and ultrabasic rocks occur sparingly throughout the area. They may be gabbro, norite, peridotite, pyroxenite, or anorthositic gabbro. Strongly metamorphosed types, interbanded with gneisses of unit 5, are included in this unit as well as fresh types that intrude the same gneiss unit. One body of gabbro included here may be related to the gabbro sills of the Otish Mountain Group unit 12. Some of the small ultrabasic bodies may be related in origin to ultrabasic rocks included with the basic volcanic rocks of unit 1.

Except for a little pyrite and magnetite, no mineralization was observed associated with these rocks.

Kaniapiskau Supergroup (Unit 10)

The Kaniapiskau Supergroup comprises all the so-called Labrador 'trough' rocks and the name is used in the sense defined by Duffell and Frarey (1964). The unit includes the relatively unmetamorphosed rocks in the extreme northeast corner and the strongly metamorphosed rocks in the southeast corner (NTS 23 C) mapped by Stevenson, who compiled all the information given here on this part of the map-area. The rocks of this group were not studied in detail and many of the rock types are largely obscured by the heavy cover of glacial drift. Furthermore, in the northeast corner the tree cover is heavier than that of adjacent areas underlain by granitic rocks, so that helicopter landings could not always be made where desired. Structural deformation of the rocks further complicates study of their stratigraphy. It is impossible to correlate formations in the northeast part of the map-area with those in the southeast.

In map-areas adjacent to the northeast corner, rocks of this group are described in more detail by Roscoe (1957) and Baragar (1962). Rocks like those in the southeast corner are described in detail by Duffell (1959) from the adjoining Mount Wright area.

Lithology

The basal beds of the relatively unmetamorphosed rocks in the northeast consist of buff, pink, or maroon arkose, the maroon colour due to finely disseminated hematite. The rocks are medium to coarse grained and range from compact to poorly indurated. In one place the arkose passes upward into jasper-hematite iron-formation, which consists of alternating layers or lenses from a fraction of an inch to 5 inches thick of jasper and red iron oxides, and grey or white chert. In some places the iron oxide is weathered out leaving an extremely pitted weathered surface. Overlying these lower reddish beds of arkose and, in part, iron-formation is a sequence of grey to black shale and argillite. Outcrops are poor but fragments are abundant in the covering soil. This arkose, iron-formation, shale, argillite series of beds is regarded as the basal formation in this area.

Overlying the basal formation is massive buff and well-laminated grey dolomite. Grey to black chert lenses and fragments are abundant in the massive dolomite and stromatolithic structures may be present. The dolomite varies from very fine grained, massive varieties to sandy textured, darker varieties or to siliceous beds containing abundant quartz grains.

The dolomite formation is overlain by a sequence of argillites, slates, and phyllites, with some dolomite interbeds. The argillites and phyllites are generally grey to greenish grey. In the upper part black, carbonaceous slate, commonly containing pyrite concretions, is abundant. Massive grey to dark grey dolomite interbeds were noted at various levels. In the western exposures of these sedimentary rocks the dolomite formation and overlying argillaceous formation are much thinner than they are to the east.

Above the argillaceous formation is cherty-metallic iron-formation, so called because of its metallic appearance. This consists of magnetite disseminated in chert and is similar to the Sokoman iron-formation of the Knob Lake area (Harrison, 1952). The iron-formation is resistant to erosion and outcrops more prominently than most other formations. In a small area in the extreme north a thin sequence of dark grey argillite or slate with some sandstone interbeds overlies the iron-formation.

Greyish green to black gabbro is found only in the extreme northeast corner of the map-area and occurs only in fault contact with the sedimentary rocks. It is a massive, medium- to coarse-grained rock, apparently intrusive rather than extrusive, judging by the grain size. There is no indication within the map-area as to the relative ages of the gabbro and the sedimentary formations, but Roscoe (1957) placed the basic intrusive and extrusive rocks low in the sedimentary sequence in the adjoining map-area to the north.

There is insufficient evidence on which to estimate the thickness of the various formations.

In the southeast corner of the map-area (NTS 23 C), the lowest beds recognized as part of the metamorphosed Kaniapiskau Supergroup are of crystalline limestone and quartzite. Biotite-hornblende-muscovite migmatite gneiss below the limestone and quartzite are included in unit 5, although in this locality they are probably, in part at least, the metamorphosed equivalents of lower Kaniapiskau Supergroup rocks. Both quartzite and limestone are discontinuous and appear only locally below the iron-formation. The quartzite is a white, massive to poorly bedded orthoquartzite, commonly with layers of muscovite along the bedding planes. The limestone is a coarse-grained, bedded, dark weathering dolomitic limestone, commonly altered to tremolite and/or diopside.

Three varieties of metamorphosed iron-formation were recognized, although they could not be separated on the scale on which mapping was done. These are the (1) quartz-specularite, (2) quartz-magnetite, and (3) quartz-silicate. Varieties (1) and (2), and (2) and (3) are gradational into each other. The quartz-specularite iron-formation, which is the most important economically, is composed almost entirely of quartz and specularite, together with a small amount of finely disseminated magnetite. Diopside, actinolite, and calcite are accessory minerals. The rock may be massive, or foliated with alternating quartz and specularite layers. The quartz-magnetite variety is mostly transitional into the quartz-specularite, with quartz and specularite freely intermingled. The quartz-silicate iron-formation is more complex. It is a medium-grained, banded granular rock with a rust coloured weathered surface. Minerals present may be quartz, grunerite, augite, hypersthene, magnetite, calcite, and dolomite. Because of complex folding, the thickness of the iron-formation layers varies but rarely exceeds 200 feet.

Overlying the iron-formation is a garnetiferous, rusty weathering paragneiss containing graphitic layers. This is commonly migmatized and grades locally into massive grey to pink porphyritic granite. Except perhaps for the extreme abundance of garnet, this gneiss is indistinguishable from the gneisses of unit 5 and has been mapped as unit 10e solely on the basis of its stratigraphic position overlying the iron-formation.

Metamorphosed gabbroic rocks, which were probably intrusive into the sedimentary rocks, are tentatively classed as coronites. These garnet-rich amphibolites, containing up to 20 per cent garnet, are dark coloured, fine-grained, generally massive rocks that locally are well foliated. Subophitic texture may be distinguished microscopically in most of the rock. Individual primary olivine crystals have developed coronas of amphibole, garnet, orthopyroxene, and spinel, thereby imparting a distinctive mottled appearance to the rock. Blue quartz crystals, as much as an inch long, are also a distinctive feature. It is impossible to determine whether these rocks were originally extrusive or intrusive.

Summary

The Kaniapiskau Supergroup in this area consists of relatively unmetamorphosed rocks in the northeast and highly metamorphosed rocks in the southeast. In the northeast, a basal arkose, with some jasper-hematite iron-formation and argillite, is overlain by a thick dolomite formation. The dolomite in turn is overlain by argillaceous rocks, argillite, slate, and phyllite with some dolomite interbeds. The next higher formation in the sequence is cherty metallic iron-formation, with a limited amount of dark grey argillite overlying the iron-formation. Intrusive gabbro in this locality has only been observed in fault contact with the sedimentary rocks.

In the southeast, the iron-formation, consisting of three varieties: quartz-specularite, quartz-magnetite, and quartz-iron silicate, is the important marker bed. Orthoquartzite or crystalline limestone occur discontinuously below the iron-formation. Gneisses below the iron-formation are included with gneisses of unit 5. Gneisses overlying the iron-formation are garnet-rich and graphitic but otherwise are indistinguishable from the gneisses of unit 5. Amphibolite with a distinctive coronite texture is a characteristic member of the metamorphosed Kaniapiskau Supergroup in this area.

Reports on more detailed mapping in adjacent map-areas deal with the rocks of this group in more comprehensive fashion than is possible on the basis of this reconnaissance survey.

Sakami Formation (Unit 11)

Isolated patches of clastic sedimentary rocks are scattered over a wide area but in two main belts. The southern belt extends from Fort George River east of Lac Tilly westward past Lac Tilly to Sakami River, a distance of about 160 miles. The two northern localities, about 120 miles north of the Fort George River belt, are near Lac Gayot and some 50 miles west of it near Little Whale River.

The lithology in the various isolated occurrences is remarkably consistent. The formation can be divided into an upper and a lower part, the lower part consists of red beds, boulder-conglomerate, arkose, mudstone, and siltstone, and the upper primarily of clean quartz sandstone. The beds are gently dipping to horizontal; steep dips are present only near faults. All the occurrences appear to be bounded by faults and the rocks have been preserved in down-dropped fault blocks.

For lack of evidence to the contrary, these flat-lying, unmetamorphosed rocks are assumed to be of Proterozoic age. Previous to the present survey, they were unknown, and for ease of reference the name Sakami Formation is proposed, after Sakami Lake, one of the largest in the map-area, which lies just south of the largest occurrence of these rocks. The relations of this unit to the other Proterozoic sedimentary rocks are unknown.

Lithology

Fort George River Occurrence

Just north of Fort George River, at approximately latitude 53°58′, longitude 73°22′, is a belt of clastic sedimentary rocks some 21 miles long and a maximum of 3 miles wide. These rocks trend east-northeast and unconformably overlie paragneiss, granite-gneiss, and granite of the older complex. In many places however the two are in fault contact.

The lowest observed part of the sequence, which is apparently not the basal beds, is a complex of red beds some 850 feet thick. These beds are characterized by a brick-red colour throughout and consist of interbedded arkose, arkosic conglomerate, and minor red siltstone in 1- to 2-inch bands or lenses. Cobbles in the conglomerate are all granite or white vein quartz. Graded bedding is a common feature and mud-cracks are common in the siltstone or mudstone. Scattered through much of the arkose are rock fragments up to 3 mm across. In the mudstones, scattered quartz pebbles up to three quarter inch diameter are found. The distinctive red colour is due to finely disseminated iron oxide present throughout this part of the sequence.

Outcrops of the overlying beds are scarce but there appears to be about 200 feet of pink to red sandstone and then a further 60 feet of red, medium-grained, quartz-rich sandstone grading into a pale greenish sandstone. Overlying the sandstone is about 200 feet of boulder-conglomerate; the lower 100 feet has a distinctive yellow sandy matrix. Boulders vary from 2 inches to 1 foot in diameter and are chiefly of pink granite, but some of quartzite, iron-formation, and amphibolite are also present. The conglomerate with yellow sandy matrix grades into a similar conglomerate with a red, arkosic matrix. In the upper part of the conglomerate lenses of buff to brown sandstone as much as 2 feet thick occur. Overlying the conglomerate is a thick sequence of sandstone beds, forming at least 300 feet of section. The lower beds are mauve, coarse-grained sandstone, totalling some 30 feet thick; these pass into orange to red sandstones with a few thin interbeds of red mudstone.

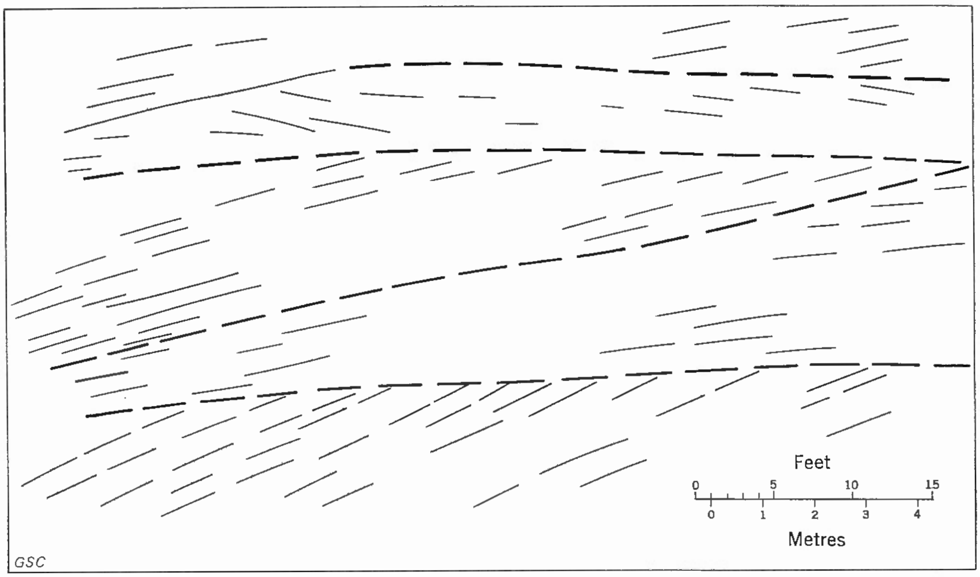


FIGURE 1. Sketch from photograph of large-scale crossbedding in upper sandstone of Sakami Formation, near Fort George River.

The north and south sides of the belt are apparently bounded by faults trending approximately N60°E and a similar trending fault cuts the belt thus repeating the section. North of the fault within the belt, the strata are mainly of the upper sandstone and south of this fault mainly of the lower beds. The beds generally dip southeast, mostly at less than 30 degrees except close to the faults. The strike of beds is northeast to east-northeast. Large scale crossbedding is present in the upper sandstone beds in several localities.

The lower red beds of the section, containing mud-cracks and graded bedding, represent continental basin deposition, as do those at Lac Tilly. The upper more homogeneous quartz-rich sandstones appear however to have been deposited in an epicontinental environment.

Section I—Sakami Formation, Fort George River Section

	Thickness (feet)	Height above base (feet)
Erosion surface		
Sandstone, orange to brick-red, medium grained; minor interbeds of red mudstone	250	1,600
Sandstone, mauve, coarse grained	30	1,350
Conglomerate, lower 100 feet yellow sandy matrix, upper 100 feet red arkosic matrix; lenses of buff sandstone 2 feet thick in upper part; cobbles from 2 inches to 1 foot in diameter, chiefly of pink granite but some of quartzite, iron-formation, and amphibolite	200	1,320
Sandstone, reddish, grading into pale green, medium-grained and quartz rich	60	1,120
Sandstone, reddish, poor outcrops	200	1,060
Arkose, arkosic conglomerate, mudstone, and siltstone; a variable sequence of red beds	860	860
Base not exposed		

Lac Tilly Occurrence

On the west side of Lac Tilly (lat. 53°55′, long. 74°02′) a thick sequence of clastic sedimentary rocks overlies granite, granite-gneiss, and amphibolite, in part unconformably and in part in fault contact with them. It forms a north-trending belt 4 miles long and 2 miles wide.

The basal beds are composed of interbedded yellow-green and red shales, conglomerates, siltstone, arkose, and quartzite. Small unconformities occur here and there within the section and at least one unconformity persists throughout most of the occurrence. The conglomerates are as much as 650 feet thick, thickest in the southern part of the occurrence. Most of the section is composed of well-sorted, massive to thin-bedded quartzite, varicoloured but predominantly in shades of pink and grey.

The beds strike north and dip from 7 to 43 degrees east. Folds, in the form of broad open flexures, have easterly plunging axes. East-west linear valleys form both the north and south boundaries, and it is apparent that these valleys are the loci of steeply dipping faults. In the south valley, the rocks on each side are strongly sheared and brecciated. Minor east-trending, steep-dipping faults also occur within the sedimentary sequence.

Section II—Sakami Formation, Lac Tilly, North Section

	Thickness (feet)	Height above base (feet)
Erosion surface		
Sandstone, banded pale orange, medium-grained and grey or white, coarse-grained; 2-foot beds, excellent bedding plane parting; light buff sandstone near base; outcrops almost continuously	1,520	1,880
Sandstone, pebbly, buff to grey, medium-grained; abundant round white quartz pebbles, ¼ inch in diameter	10	360
Sandstone, banded pale grey and purple, medium-grained	136	350
Sandstone, arkosic, buff to red, medium-grained; minor interbeds of red siltstone	34	214
Covered, probably underlain by thin-bedded shale or siltstone	180	180

Section III—Sakami Formation, Lac Tilly, Central Section

	Thickness (feet)	Height above base (feet)
Erosion surface		
Sandstone, pink, medium-grained, and white, coarse-grained; beds 1 foot to 2 feet thick, some with graded bedding	1,200	1,640
Sandstone, porous, quartz-rich, purple, medium-grained; may contain minor magnetite	11	440
Sandstone, banded orange and white, ¼-inch bands; quartz grains very well rounded	160	429
Sandstone, red, arkosic, banded with white, quartz-rich, in 1-inch bands; finely laminated in ⅛-inch beds; grains angular to subrounded	63	269
Siltstone, red, very fine grained; minor grey siltstone interbeds ¼ inch thick	10	206
Sandstone, buff, medium-grained	12	196
Siltstone, red to purple, very fine grained; contains irregular grey patches and some specularite; minor arkosic sandstone interbeds	19	184
Shale, yellow-green, locally reddish, thin bedded; grades upward into red silty shales or siltstone; in some places 10 feet of conglomeratic arkose at base; thickness varies from 80 feet to 250 feet, with 165 feet an average	165	165

Section IV—Sakami Formation, Lac Tilly, South Section

	Thickness (feet)	Height above base (feet)
Erosion surface		
Sandstone, white and bright orange, interbedded in 1-inch beds; grades locally into reddish arkosic sandstone	30	1,640
Sandstone, brilliant brick-red, medium-grained; quartz stained with red iron oxide is the chief component	45	1,610
Sandstone, quartz-rich, white, medium-grained	25	1,565
Sandstone, purple to pale purple, medium-grained; very well bedded in 1-inch beds	60	1,540
Sandstone, conglomeratic, pale purple; 2-inch pebbles of orange sandstone	10	1,480
Disconformity, sandstone weathered and beds bevelled		1,470
Sandstone, interbedded pale orange and grey; grey sandstone is coarse-grained and occurs as lenses in the orange	950	1,470
Sandstone, pure quartz, pale buff, medium-grained	60	520
Covered, probably underlain by pink arkosic sandstone	306	460
Shale, green to grey, fine-grained; weathers olive; interbedded conglomerate in 1-foot beds, with abundant rounded vein-quartz pebbles, minor lean iron-formation and meta-andesite pebbles	24	154
Covered, but abundant boulders of conglomerate, with coarse yellow-green sandy matrix and pebbles of meta-volcanics, lean iron-formation, granite, and granite-gneiss; average diameter of pebbles is 2 inches; pebbles form 80 per cent of rock	130	130

Sakami River Occurrence

On the north side of Sakami River (lat. 53°32′, long. 76°35′) is a belt of clastic sedimentary rocks trending east-northeast which is some 28 miles long and at most 5 miles wide. In part, these rocks unconformably overlie granite-gneiss (unit 5) and metavolcanic rocks (unit 1), and, in part, they are in fault contact with granite-gneiss.

No detailed section of the sedimentary rocks was determined but in general in ascending order the section is as follows: basal beds, 200+ feet of coarse conglomerate boulders and cobbles of granite and granitic gneisses in red arkosic matrix; red to pink arkose and arkosic sandstone with occasional interbeds of red siltstone; pink to grey or white pure quartz sandstone, beds 8 to 10 feet thick, all grains about 1 mm in size, no apparent grain gradation, estimated 70 per cent of the quartz is in grains and 30 per cent is matrix, occasionally some red quartz sandstone beds that contain fine disseminated hematite; uppermost beds, pink or orange and white banded quartz sandstone. The upper sandstone beds are at least 550 feet thick and probably considerably more. At several localities in the upper sandstone part of the section, large scale crossbedding is a prominent feature.

Just east of the large occurrence described above along Fort George River are three small patches of these rocks. At the westernmost patch there is an estimated 1,700 feet of sedimentary rocks, with an average dip of 20 degrees. The section is, in general, similar to that of the main occurrence, but at one place the basal beds, rather than being a conglomerate, consist of an angular breccia containing abundant fragments of iron-formation (quartz-magnetite). The faults that bound these three small areas of sedimentary rocks are part of the same fault system that bounds the larger area to the west.

Little Whale River Occurrence

On either side of Little Whale River, at about latitude 55°50′, longitude 72°32′, a belt of sedimentary rocks about 9 miles long and a maximum of 6 miles wide trends east-northeast. In some places the sedimentary rocks unconformably overlie granite (unit 7), but for the most part the two are in fault contact. Outcrops are scattered and the belt is cut by faults so that the sequence of beds is uncertain. There appears, however, to be two distinct groups of beds, a lower red bed group and an upper orange quartz sandstone group. In general, the sequence from bottom to top seems to be as follows: about 100 feet of coarse red boulder-conglomerate, with boulders up to 10 inches in diameter, commonly of pink granite like that outcropping nearby and pebbles of white vein quartz. This conglomerate was observed in one place to grade into the underlying granite through a regolith zone. Upwards, the conglomerate grades into a 500-foot pebbly and bouldery arkosic sandstone unit with scattered thin, red argillite beds. Bedding is mostly from 8 to 10 inches thick. Overlying this unit is approximately 300 feet of brick-red gritty mudstone, with grit-sized particles of quartz and more rarely feldspar, and with quartz and granite pebbles up to 2 inches in diameter scattered through it. The red mudstone has some interbeds of gritty, red, arkose and sandstone, angular quartz grains giving the gritty texture. In one locality some thin, uniformly banded pale olive mudstone is interbedded with red mudstone. Overlying the red mudstone unit is some 500 feet of coarse red boulder conglomerate and red sandstone. Boulders and pebbles form 90 per cent of the conglomerate and consist of pink granite and white vein quartz. The sandstone above the conglomerate is brick-red and shows much crossbedding. Above this unit there is believed to be at least 2,000 feet of orange or apricot coloured quartz sandstone and banded orange and white sandstone, the bands being about ¼ inch thick.

The sedimentary rocks are considerably disturbed by faulting but some of the steep dips appear to be due to deposition on an irregular erosion surface at a high initial angle. In general, all dips are south, mostly at 40 degrees or less if not tectonically disturbed. The southern boundary of the belt is an east-northeast-trending fault, separating the belt from the granite. This is marked by a steep north-facing scarp of granite. On the north, too, there is evidence that the granite-sedimentary rock contact is a fault. Small north-northwest-trending subsidiary faults cross the belt. A major east-northeast-trending fault is believed to traverse the belt longitudinally roughly along the present course of Little Whale River. The succession is interrupted along this fault, the upper orange and white sandstones being prominent north of the fault and the lower red beds south of it. Minor warps in the bedding have been noted but they are probably related to the faulting.

Some boulders of the upper orange sandstone are cut by narrow (⅛ inch) quartz veins but no such veins were observed in outcrops.

Some speculation as to the mode of origin of this sequence of beds seems justified. The thick, lower red bed section with its abundant conglomerate would appear to have formed under conditions of deposition prevailing in a continental basin, possibly of rather limited size. In places the conglomerates appear to be of torrential origin. However, the upper sandstone (almost pure quartz in composition, with its distinct colour) would appear to be a foreland type of deposit, that is epicontinental deposition in a widespread sea.

Section V—Sakami Formation at Little Whale River

	Thickness (feet)	Height above base (feet)
Erosion surface		
Sandstone, apricot, orange, banded white and orange, crossbedded; almost pure quartz in composition	2,000	3,400
Break in deposition of unknown magnitude		1,400
Coarse boulder-conglomerate, pebbles and boulders of pink granite and white vein quartz in red sandy matrix; minor brick-red to red crossbedded sandstone	500	1,400
Mudstone, brick-red, gritty, grit particles of quartz and feldspar; contains sandy layers and erratic quartz and granite pebbles up to 2 inches diameter; some red arkose beds; in one locality some thin uniformly banded pale olive mudstone and thin (½ inch) bands of red mudstone	300	900
Sandstone, pebbly and bouldery, conglomeratic, red, arkosic; thin, shaly beds scattered throughout	500	600
Conglomerate, large granite boulders, some white quartz pebbles, red arkosic matrix; in places grades into underlying granite through a regolith zone	100	100

Lac Gayot Occurrence

Two adjoining blocks of younger sedimentary rocks occur about 16 miles north and northeast of Lac Gayot, between approximately latitude 55°53′ and 56°, and longitude 70°10′ and 71°. These blocks are separated by a fault trending N65°E, but are lithologically alike. Faults trending N65°E and N60°W form the only observed contacts of these rocks with the underlying granite and granite gneiss.

The lowest observed beds consist of red arkose or arkosic sandstone with interbeds of deep red argillite or mudstone. Some 150 feet of vertical section of this arkosic sequence is exposed. These beds are overlain by buff, grey, white, or pink sandstone or orthoquartzite. The lower part of the sandstone sequence is in general not well indurated but upwards the rock is compact to glassy. The upper part of the section contains a few quartz-pebble conglomerate lenses with well-rounded white quartz pebbles up to $1\frac{1}{2}$ inches in diameter and averaging 1 inch or slightly less. There is estimated to be a minimum of 1,500 feet of sandstone and quartzite exposed and the section may be considerably thicker. Bedding is well developed, generally in beds 2 to 3 inches thick. The rock where examined is strongly jointed parallel with the bedding, on a 3- to 4-foot spacing, and this jointing produces a very characteristic outcrop pattern.

The beds normally dip at 30 degrees or less, except near the boundary faults. In the eastern part of the exposure the rocks are gently warped into a broad open syncline and anticline, the axis trending at N45°E and plunging gently southwest. In addition to the bounding normal faults there is some evidence of other parallel normal faults trending N65°E as well as some bedding plane faults. The latter may repeat some of the beds and give a false impression of the thickness of the section.

The sequence of beds in this occurrence is similar to that at Lac Tilly and Little Whale River; a lower arkosic group of red beds overlain by a succession of sandstones or orthoquartzites.

Although the faults at the Little Whale River occurrence are parallel with those at the Lac Gayot occurrence, they do not apparently project into one another. It is suggested that, rather than being a single fault or narrow fault zone, they are in a broad zone consisting of a number of parallel faults and that this zone extends northeastward into the Cambrian Lake (west half) map-area. This would account for the depression and consequent embayment in the Labrador Trough rocks described by Fahrig (1957), and suggest a tectonic origin for this transverse depression.

Summary and Interpretation

The occurrences of the clastic sedimentary rocks of this newly named unit although scattered are lithologically remarkably similar. The lower part of the formation includes typical continental beds, torrential conglomerate, mud-cracked siltstones, and abundant arkose. This part of the sequence probably consists of material transported no great distance and deposited rapidly in continental basins of limited size. It is unlikely that the known occurrences represent all the rocks originally deposited, although basins in which they formed must have been small at all times.

The position of these basins may have been determined by tectonic depressions outlined by the ancestors of the faults that account for the present preservation of the rocks.

The relatively pure quartz sandstone that typifies the upper part of the formation probably represents a completely different environment of deposition—the foreland or epicontinental facies. If these sandstones do represent a foreland facies, one would expect the sandstone to have been deposited over a far wider area and on a larger scale than the underlying continental beds. If this was so, only the small remnants described above remain.

The relative ages of this formation and of the Kaniapiskau Supergroup are unknown. The Sakami Formation rocks near Lac Gayot were probably deposited in the same tectonic depression as the arkose at the base of the Kaniapiskau Supergroup in the embayment of the Labrador Trough in Cambrian Lake map-area (Fahrig, 1956, 1957) mentioned above. The basal arkoses are indeed remarkably similar in character. Nonetheless, even if they were deposited in the same tectonic basin, there is no evidence that it was at the same time. If, however, the two basal arkoses are contemporaneous, then the Sakami Formation is older than much of the Kaniapiskau Supergroup.

Otish Mountains Group (Unit 12)

The Otish Mountains Group consists of gently dipping sedimentary strata with interlayered basic sills, the whole dipping southward and forming irregularly dissected cliffs and steep north-facing slopes. The group was named by Bergeron (1957) but little has so far been published about these rocks other than Bergeron's original description, which is based on work by Kennco Explorations, Limited.

The Otish Mountains form an east-northeast-trending belt some 40 miles long and 10 miles wide, just north of latitude 52° and between longitude 70°10′ and 71°30′, and are underlain by rocks of the Otish Mountains Group. The highest elevation is 3,700 feet above sea-level, and the average about 3,200 feet. Local relief varies from 300 to 800 feet.

According to Rousseau (1959, p. 467), "Otish" means "small mountain" in the local Montagnais Indian dialect. Rousseau's paper gives some history of the discovery of these hills.

Lithology

The lower part of the Otish Mountains Group consists of a thick series of buff, grey to white, and pink, medium- to fine-grained sandstone and arkosic sandstone. Interbedded with these but in lesser amounts are some coarser grained grit beds and lenses of pebble-conglomerate. At one place a basal conglomerate was observed, made up of rounded boulders of granite and granite-gneiss tightly packed in a small amount of grey sandy matrix. The sandstone and arkosic sandstone vary in composition from an almost pure quartz sandstone, an orthoquartzite, to true arkose containing about 35 per cent feldspar. The most common variety is a rock with 15 to 20 per cent feldspar and the remainder quartz grains. Grains are rounded to subrounded and have an average diameter of about 0.3 mm. The degree of sorting of grains within beds varies considerably; in some specimens all the grains are about the same size whereas in others the size varies widely and some grains may be as much as 2 mm in diameter. The grains are best sorted in the quartz-rich beds. The pink colour of some beds seems to be due to finely disseminated hematite dust. Silica cement forms the matrix in most specimens, although shreds of white mica are also present in a few. Scattered grains of black opaque minerals, probably magnetite, were the only accessory minerals observed.

The upper part of the Otish Mountains Group is characterized by the red to purplish red colour of the beds. Arkose and arkosic sandstone form the greater part of the sequence although quartz constitutes as much as 90 per cent of some beds.

White mica in fine shreds is almost everywhere present and also fine argillaceous material. Interbedded with the red arkosic sandstone are thin beds of fine-grained, red argillite. This same red argillaceous material is normally the matrix in the arkose although in some specimens carbonate and silica form the matrix. The arkose is a medium-grained, well-indurated rock with angular to subrounded grains, poorly sorted as to size. Many of the grains appear to be long and thin rather than equidimensional.

Other than some blue or green sandstone beds in the lower part of the group, distinctive marker beds are lacking. It is estimated that the lower part of the Otish Mountains Group is 3,500 feet thick, if the boulder-conglomerate at the base of the exposed section is the base of the group; this conglomerate was not actually observed in contact with the underlying granite-gneiss. The upper part, the red beds, is conformable with the lower. Some 1,200 feet of beds is preserved, but an unknown amount has been removed by erosion.

Bedding is well developed throughout the section except in the pink orthoquartzite near the top of the lower part of the group. Crossbedding was noted at a few places in the sequence.

Sills and dykes of gabbro intrude the sedimentary rocks of the Otish Mountains Group. Sills are the more abundant, particularly in the upper part of the sequence. On weathered surfaces the gabbro is normally dark grey and on fresh surfaces, greenish black. It is fine grained near the margins but medium grained and, in part, ophitic near the centre. The sills have well-developed columnar jointing, which is displayed best on the north-facing cliffs. The resistant basic rocks in many places cap the sedimentary sequence.

The rocks vary from gabbro to olivine gabbro and consist of plagioclase (labradorite), augite pyroxene with well-marked parting (diallage), minor iron oxide, and olivine as either an essential constituent or an accessory. In some specimens the olivine is almost completely altered to serpentine containing small stringers of fine-grained iron oxide. Biotite is very rare. The variation in composition is in response to differentiation within the sills, for all specimens that have olivine as an essential constituent are from the base of a sill. Suites of specimens taken from bottom to top of sills show a decrease in olivine content upward. Iron oxide also seems to be concentrated at the lower levels, for in some specimens from near the bottom of a sill magnetite is an essential constituent.

The maximum observed thickness of any one sill is approximately 300 feet. Most of the sills appear to be slightly discordant over a considerable length but concordant locally. Few gabbro dykes are more than 100 feet wide and most are much narrower. The gabbro intrusions have had remarkably little metamorphic effect on the adjoining sedimentary rocks. To a distance of 1 foot to 2 feet from the contact some white sandstone is reddened, apparently due to introduction of hematite, but other than that no metamorphism is apparent. Although the sills occur only within the sedimentary sequence, dykes, apparently related in origin, cut both the sedimentary rocks and the adjoining Archaean granite and granite-gneiss (units 5 and 7).

The north contact of the Otish Mountains Group with underlying granite-gneiss is apparently unconformable although it was nowhere observed. On the southeast side, however, the contact is a fault. Four parallel faults trending N60°E cut both the sedimentary rocks and the underlying older rocks, and remnants of Otish Mountains Group rocks occur as outliers along some of the faults, apparently as small down-dropped slices. The bedding of the sedimentary rocks dips gently for the most part, 3° to 10°SE in the north steepening southward to 20 or 25 degrees. Near the faults, where the sedimentary rocks may be much sheared and brecciated, dips are much steeper.

The grade of metamorphism is low and seems to be limited to the formation of white mica in some of the argillaceous rocks. There is no evidence of recrystallization in the sandstone or orthoquartzite.

Summary and Interpretation

The relations of the Otish Mountains Group with the Kaniapiskau Supergroup and the Sakami Formation are unknown. Lithologically the lower part of the Otish Mountains Group is similar to the upper part of the Sakami Formation, and it is possible that these sandstones are part of a widespread foreland deposit. The sandstones also resemble the Sims Formation (Fahrig, 1960), which unconformably overlies rocks of the Kaniapiskau Supergroup some 50 miles northeast of Otish Mountains, in Shabogamo Lake map-area.

Southwest of Otish Mountains, just northeast of the north end of Lake Mistassini, is a succession of late Precambrian rocks that has been described by Neilson (1951) and Chown (1960, 1961). The lowest unit of these rocks, named the Papaskwasati Formation, has definite lithologic affinities to the Otish Mountains Group. It consists of well-bedded, little metamorphosed sandstone and orthoquartzite, with pebble-conglomerate lenses in the lower part of the section. Present are some arkosic beds containing considerable amounts of pink feldspar. Believed to overlie the Papaskwasati beds conformably, although no contact has been observed, is the Cheno River Formation, the lowermost beds of which consist of arkose and arkosic conglomerate, greywacke, and greywacke conglomerate. Dips of the beds are gentle. It is possible that the Papaskwasati Formation can be correlated with the lower part of the Otish Mountains Group, both consisting of sandstone and orthoquartzite, and that the basal Cheno River beds can be correlated with the arkosic facies of the upper part of the Otish Mountains Group. On published geological maps the two groups of rocks are separated by a minimum of 52 miles.

In the area just south of Otish Mountains, adjoining this map-area, Hashimoto (1960) recognized sandstone and arkosic sandstone, with minor pebble-conglomerate and purple mudstone, that are a part of the Otish Mountains Group. South of these rocks, where the glacial drift is thick, Berard (1960) saw nothing that seemed equivalent, so that it is impossible to correlate directly the Otish Mountains Group with the Papaskwasati Group.

Manitounuk Group (Unit 13)

Proterozoic sedimentary and basic igneous rocks occur along the Hudson Bay coast from Long Island, just off Cape Jones (Pointe Louis XIV) at the northeast corner of James Bay, northeast to the north boundary of the map-area, and on to beyond Richmond Gulf. Along the mainland south of the head of Manitounuk Sound, only remnants of the younger rocks are found but northward, the mainland strip of these rocks widens from about 3 miles to some 20 miles near Little Whale River. These rocks, particularly those close to the coast, have already been examined in some detail (Bell, 1877; Low, 1900; Young, 1921; Parks, 1949; Harwood, 1949) and the present study added only a few additional details, such as the extent inland and the like. The following discussion is therefore based largely on earlier work, published and unpublished.

On a regional scale these rocks can be assigned to two groups separated by an unconformity, but considerable confusion has attended the naming of these units. The earliest published name, applied to the undivided succession by Bell (p. 11C, 1877-78), is Manitounuck Group, after Manitounuck Sound (the spelling of this name has since been changed to Manitounuk). Low (p. 55J, 1889) continued the use of the name Manitounuk Group but in a later report (p. 80D, 1900) used the name Manitounuk Series, which he apparently restricted to the extreme upper part of the sedimentary sequence that lies beneath the diabase capping on the Manitounuk Islands. These islands extend south from the head of Manitounuk Sound.

Leith (1910) proposed the name Nastapoka Group for the upper group of rocks and Richmond Group for the group underlying the unconformity. Young (p. 16E, 1921) in general accepted these names but suggested that, as a part of the Ordovician has long been known as the Richmond Group, this Precambrian Formation be called the Richmond Gulf Group. Parks (1949), Harwood (1949), and Bergeron (p. 109, 1957) followed Leith's terminology. Woodcock (1960), however, has in part followed the modification of Young (1921), using the terms Nastapoka Group and Richmond Gulf Formation.

The map embodying the preliminary results of the present survey (Eade, Heywood, and Lee, 1957) used the term Manitounuk Group for all the igneous and sedimentary rocks both above and below the unconformity. It is proposed to retain this term and to divide the group into upper and lower units, equivalent respectively to Leith's Nastapoka and Richmond Groups.

Lithology

Briefly the lower unit consists of a coarse arkose, commonly ferruginous, grading upward into sandstone and argillite, with interbedded basic igneous rocks, probably both extrusive and intrusive. The upper unit is cherty limestone and dolomite in the lower part, overlain by quartzites or quartz sandstones. The upper part of these clastic rocks grade laterally into iron-formation. Basic sills, flows, and pyroclastic rocks compose the upper part of the sequence.

The arkose forms the bulk of the lower unit, although in places in the upper part of the sequence red argillite interbeds are present and elsewhere beds of grey or buff sandstone replace the arkose. The main mass of arkose may be red, buff, or green, the red coloration being due to the ferruginous character of some beds. Crossbedding of a torrential type is present in many places. Much of the rock is in such thick beds that bedding may not be recognizable in outcrops. In the lowest exposures, close to the unconformable contact with the underlying granite (unit 7), the arkose comprises reconstituted granite or regolith that is difficult to distinguish from the underlying Archaean rocks. Generally, on most weathered surfaces, however, occasional small rounded quartz pebbles can be found and the mineral grains can be seen to be slightly rounded. The green arkose owes its colour to the presence of plentiful shreds of biotite or amphibole, altered to chlorite. This rock resembles a diorite and is probably derived primarily from basic rocks. The thickness of the lower unit of the Manitounuk Group in this area seems to vary greatly over short distances, and it is apparent that these sedimentary rocks were deposited on an extremely irregular surface or on one that was subjected to tectonic movements during deposition, or possibly both. The thickest section measured is about 375 feet.

Basic igneous rocks occur with the arkose of the lower unit. In part these are gabbro sills and in part, in the eastern exposures of the map-area, fine-grained basalt, probably volcanic flows, that seem to be interbedded with the sedimentary rocks. Possibly these flows are correlatives of the Pachi Group of Woodcock (1960).

The general trend of the lower unit seems to be northwest, with dips to the southwest from 20 to 50 degrees. The southernmost exposures of the arkose are bounded by a west-trending fault and it seems likely that these rocks are also cut by faults trending from N70°E to east and by smaller faults trending approximately N10°E. The granite near the arkose of this lower unit is crossed by mylonite zones that suggest abundant faulting at this locality.

In the area just to the north, bordering Richmond Gulf, Woodcock (1960) mentioned two units, separated by an unconformity, within the arkose sequence, with the Pachi Group volcanic rocks below the unconformity. No field evidence of such an unconformity within the lower unit was found during this reconnaissance survey, although study of the air photos (No. A13520-140) suggests that one may exist.

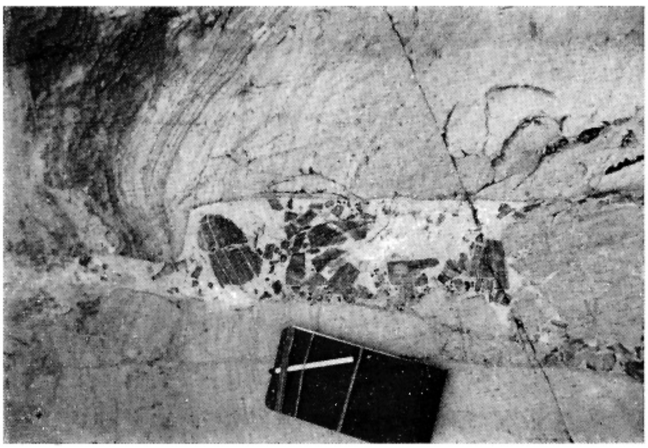


PLATE X

Dolomite (Manitounuk Group) in joint in gneiss, near Cape Jones.

Heywood, 2-3-57

A definite angular unconformity however separates the upper unit of the Manitounuk Group from the lower, although in only a few places within the map-area are the two seen close together. Just south of the mouth of Little Whale River are contiguous exposures of the two units and the angular discordance is obvious. In some places to the north, in the region of Richmond Gulf, there are indications that the two units are separated by a fault. Thus, although normally the contact is an angular unconformity, it is also possible that in places it may be a fault. The upper unit extends much farther south along the Hudson Bay coast than the lower unit and, where the lower beds are missing, the upper unit overlies the granite (unit 7) unconformably. In some places, as around Cape Jones, the upper beds have practically all been removed by erosion, and dolomite occurring in joint fractures in the gneisses of unit 5 is the only remaining evidence of the former presence of the sedimentary rocks (Pl. X). In general, the erosion surface on which the upper Manitounuk beds were deposited seems to have been of low relief.

The upper unit shows considerable variation laterally both in thickness of the beds and in lithology. This is obvious from a study of Sections VI, VII, VIII, and IX. The lower beds of the upper unit consist of siliceous dolomitic limestone, with a few thin sandstone interbeds and in many places abundant black shaly partings. These beds pass upward into brecciated cherty limestone, which in a few places carries a little galena and sphalerite. The brecciated member is overlain by a thick sequence of limestone and dolomite beds, in part cherty, showing oölitic structure and more rarely concretionary structures. These beds may be thin or comparatively thick and in one, sphalerite and galena are sufficiently abundant to be of economic interest. Thin argillite beds are present in parts of the section and some of the limestone is slightly siliceous. Sandy beds, arkosic sandstone, and quartzite, with less abundant shale or argillite interbeds conformably overlie the carbonate beds. These sandy beds show considerable lateral variation, and within this part of the section iron-formation appears in a few places, either as quartz-hematite or iron-carbonate type, especially on Long Island and on some of the Manitounuk Islands. Some of the sandy beds show ripple-marks and crossbedding (Pl. XI), but minor structures are not abundant.

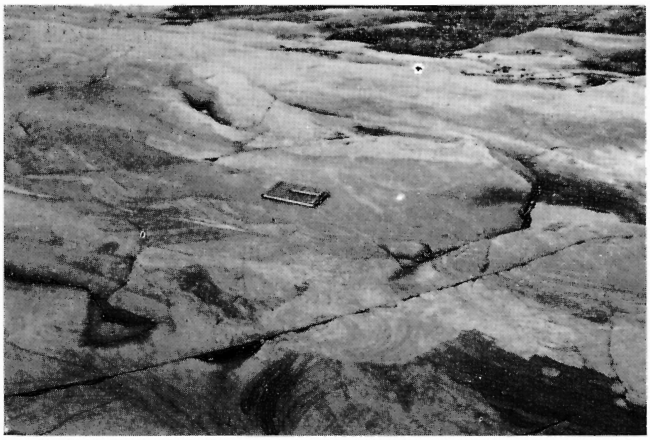


PLATE XI

Crossbedded sandstone, upper unit of Manitounuk Group, Long Island.

Heywood, 2-2-57

Overlying the sedimentary rocks are a series of basic flows, a thick basic sill, and some associated thin beds of pyroclastic rocks. Detailed information on these igneous rocks is given by Parks (1949), much of it derived from the study of diamond-drill cores through the sequence. The basic rocks in many places cap the sedimentary rocks and normally the top of the section is an erosion surface. The only exception is about 3 miles south of the mouth of Little Whale River, where, according to Parks (1949), a thin ripple-marked quartzite bed overlies the basic rocks. There the section of basic rocks is assumed to be complete, none having been removed by erosion. It consists of three main flows and a sill together with three thin interbedded pyroclastic members. The flows vary in thickness from 50 to 125 feet but have the following general features in common: upper 5 to 10 feet of each flow show flow breccias, amygdules occur in the upper 15 to 20 feet, the flows are fine grained at the top and bottom but somewhat coarser in the central parts, amygdules are present occasionally at the lower margin of the flows, and the flows show columnar jointing where they outcrop as scarps. The thin pyroclastic beds, generally 2 to 3 feet thick, consist of fine-grained, angular fragments of quartz and feldspar in a very fine grained matrix, the rock exhibiting a rude banding. The sill in many places has a diabasic texture, contains abundant feldspar phenocrysts in the upper two thirds, and has fine-grained margins and a medium-grained central part. The quartzite or sandstone underlying the sill is baked for a short distance next to the contact.

Section VI—Manitounuk Group, south side of Little Whale River, 2 miles inland from coast (from Low, p. 72D, 1900)

	Thickness (feet)	Height above base (feet)
Erosion surface		
Upper Unit		
Gabbro or diabase, dark green	150	1,137
Sandstone, dark grey, flaggy	33	987
Sandstone, light pink and grey	10	954
Sandstone, dark grey, carbonaceous with shaly limestone and black shale; upper 6 feet mostly shale with a few thin limestone bands	30	944
Sandstone, light grey, thin partings of arenaceous limestone	45	914
Limestone, light buff weathering, light blue, siliceous, with many partings of light blue chert; upper 20 feet flaggy	94	869
Limestone, light coloured, cherty, weathering buff; full of cavities lined with quartz containing some pyrite, galena, and sphalerite	30	775
Limestone, compact, light blue cherty	160	745
Concealed	50	585
Sandstone, light grey, containing blocks of chert	140	535
Chert conglomerate	10	395
Dolomite, light blue, cherty, weathering buff with patches of dark blue chert	210	385
Unconformity		175
Lower Unit		
Arkose, dark red, coarse-grained, composed chiefly of red feldspar, decomposed hornblende, and quartz in pebbles	175	175

Section VII—Manitounuk Group, 3 miles southwest of the mouth of Little Whale River (from Parks, 1949)

	Thickness (feet)	Height above base (feet)
Erosion surface		
Upper Unit		
Quartzite, greenish black, fine-grained, ripple-marked	1	764
Basalt flow; upper 12 feet vesicular and brecciated; upper 20 feet contains chlorite, carbonate, and agate-filled amygdules; fine-grained near top and bottom, coarser grained in central part	124	763
Tuff, greenish, banded	2	639
Basalt flow; upper 6 feet is flow breccia with greenish black amygdaloidal and vesicular fragments in fine-grained, purple-green matrix; fine-grained near top and bottom, coarser and porphyritic in central part	51	637
Basalt flow; brecciated and amygdaloidal in top third of flow; upper and lower parts fine-grained, coarser grained and mottled in central part	57	586
Tuff, fine-grained, red to green	7	529
Tuff, black weathering, grey, carbonated	2	522
Porphyritic diabase sill	106	520
Sandstone, thin-bedded, dark grey, arkosic, with black and green shaly partings; baked for 10 feet below sill	75	414
Limestone, buff weathering, siliceous, dolomitic; thin-bedded, black, shaly partings, and thin sandstone interbeds	120	339
Limestone, brecciated, cherty; contains minor galena and sphalerite	5	219
Limestone, buff weathering, siliceous, with oölitic structure; thin basal green mudstone member	10	214
Limestone, massive, cherty, weathers yellow to white, contains stylolites	54	204
Limestone, greyish brown weathering, cherty, concretionary; contains a galena-sphalerite-bearing bed	70	150
Limestone, grey weathering, cherty, probably concretionary	80	80
Rest of section not studied		

Summary and Interpretation

The lower unit of the Manitounuk Group consists of red or green, thick-bedded arkose, with some sandstone and red argillite in the upper part. A regolith, rather than a conglomerate, appears to form the basal beds. Gabbro sills and some basic volcanic rocks intrude or are interbedded with the sedimentary section. The thickness of this arkose unit varies greatly, suggesting deposition in local basins of limited extent.

The upper unit consists of about 450 feet of concretionary limestone and cherty dolomite in the lowest part, overlain by a maximum of 960 feet of sandstone and quartzite with minor argillite and some iron-formation, overlain in turn by approximately 350 feet of basic flows, sills, and pyroclastic rocks.

The basic sill in the upper unit is probably related in origin to the basic flows; the sills in the lower unit may also be related, but this is not so certain. Indeed it seems more likely that the latter are related to the flows in the lower unit and that there were in fact two periods of igneous activity.

Conditions during the deposition of the two units differed considerably. The lower unit was deposited in a continental environment in basins probably of tectonic origin, and sediments were transported a short distance only. Probably this was a tectonically active zone, with much block faulting which continued during deposition of the entire unit, resulting in considerable differences in thickness of beds from place to place. The prevalence of crossbeds suggests this type of basin deposit. The regolith preserved in places on the underlying granite surface indicates that a long period of erosion preceded the deposition of the sedimentary rocks. The upper unit seems, in part at least, to have been deposited on a clean erosion surface and in a marine shelf environment. The lateral variation in beds and some of the rock types present suggest an open lagoon type of environment for part of the sequence. There is no evidence of tectonic activity, and it is suggested that the break between deposition of the two units was long enough for the lower one to undergo considerable erosion and for the surface on which the upper unit was deposited to become reasonably level and stable.

The relations of the Manitounuk Group to the Otish Mountains Group, the Sakami Formation, and the Kaniapiskau Supergroup are completely unknown. Rocks of the upper unit of the Manitounuk Group have been tentatively correlated with the sedimentary rocks of the Belcher Islands (Young, Leith, etc.), and it seems likely that the areas underlain by the Manitounuk Group, the Nastapoka Islands and the Belcher Islands, were parts of a single great basin of deposition.

Section VIII—Manitounuk Group, central part of Castle Island, Manitounuk Sound (from Low, p. 78D, 1900)

	Thickness (feet)	Height above base (feet)
Erosion surface		
Upper Unit		
Diabase, dark green, fine-grained	225	1,111
Slate and greywacke, very dark, fine-grained; baked light green for 15 feet from contact with diabase	36	886
Limestone, rusty weathering, arenaceous, with sandstone partings; contains some iron carbonate	52	850
Sandstone, light blue and pink, fine-grained	93	798
Sandstone, light pink	40	705
Concealed	25	665
Sandstone, light blue and pink	18	640
Limestone, dark, shaly	3	622
Sandstone, light blue and pink	15	619
Limestone, dark grey, siliceous; contains transparent quartz grains	33	604
Sandstone, light pink	31	571
Sandstone, very fine grained, light pink, with partings of shaly limestone	23	540
Sandstone, very fine grained, dark	6	517
Sandstone, grey, with partings of shaly limestone	18	511
Concealed	30	493
Quartzite, light grey and bluish, with patches and pebbles of limestone, ripple-marked	443	463
Concealed to sea-level	20	20
Underlying the above section and outcropping on the east side of Manitounuk Sound is at least 400 feet of light grey to bluish dolomite and limestone, many beds cherty and some concretionary.		

Section IX—Manitounuk Group, north end of Long Island
(*from* Young, p. 16E, 1921)

	Thickness (feet)	Height above base (feet)
Erosion surface		
Upper Unit		
Iron-formation	340	550
Quartzite, with sandstone and some shaly beds	60	210
Limestone and dolomite	150	150
Low (p. 79D, 1900) found on Long Island 203 feet of limestone and dolomite, and that the iron-formation is overlain by 50 feet of diabase.		

Belcher Group (Unit 14)

The Belcher Group underlies Belcher Islands, only a small part of which lie in the map-area. It has been studied by Jackson (1960) and the reader is referred to his report for discussion of these rocks.

Gabbro Dykes (Unit 15)

Gabbro dyke rocks, commonly with a diabasic texture, occur throughout the map-area in limited amounts. It is suggested these are the youngest rocks present in the map-area, but there is no direct evidence to that effect. Basic dykes cut all Archaean rocks, but have not been observed to cut all the so-called Proterozoic sedimentary rocks. Between Sakami and Fort George Rivers, sedimentary rocks of the Sakami Formation (11) are apparently cut by a gabbro dyke (Brummer, pers. com.) and the Kaniapiskau Supergroup (10), the Otish Mountains Group (12), and the Manitounuk Group (13) are all intruded by basic sills of composition similar to that of the dykes. Moreover, the sills in the Otish Mountains Group lie not far from dykes.

In the western and central thirds of the region, the dykes are more abundant in the south half than in the north half, seeming to favour areas underlain by rocks of unit 3. In the eastern third however they have a more general distribution and favour no particular rock-units. Moreover, the trends of the dykes there vary much more than those of the dykes in the western two thirds.

None of the dykes outcrops continuously for more than a few miles and all have therefore been mapped as small segments. In some places it is obvious that several segments are parts of a single dyke, and in one such case the dyke is at least 40 miles long. The width of these bodies ranges from dykelets of a foot or less to a maximum of approximately 300 feet. Dykes less than 50 feet wide are not shown on the map; all dip vertically or near vertical.

Lithology

The gabbro dykes are dark green to black and have a typical brown to rusty red weathered surface. Most are medium grained, the texture varying from granitic to diabasic. Contacts with adjoining rocks are clear and sharp, and the dykes have fine-grained chilled borders up to 3 inches wide, the chilled rock being splintery and black. The country rocks normally show no metamorphic effects bordering the dykes except, in some places, granite or granitic gneiss may be reddened for as much as 15 feet from the contact. The dykes show a very typical jointing normal to their trend and from the air this jointing is a prominent, readily recognizable characteristic.

The composition of these dyke rocks is remarkably uniform, generally, 45 to 50 per cent labradorite, commonly in euhedral grains; 45 per cent monoclinic pyroxene, generally non-pleochroic and probably augite; 5 per cent opaque metallic minerals, chiefly magnetite with some pyrite; minor dark brown biotite and generally a little interstitial micrographic quartz. In some specimens the metallic minerals and micrographic quartz constitute as much as 15 per cent of the rock. Generally the dyke rocks are fresh, but there may be minor alteration of some minerals, pyroxene to common green hornblende or chlorite or both, plagioclase to secondary white mica, fine zoisite, or epidote.

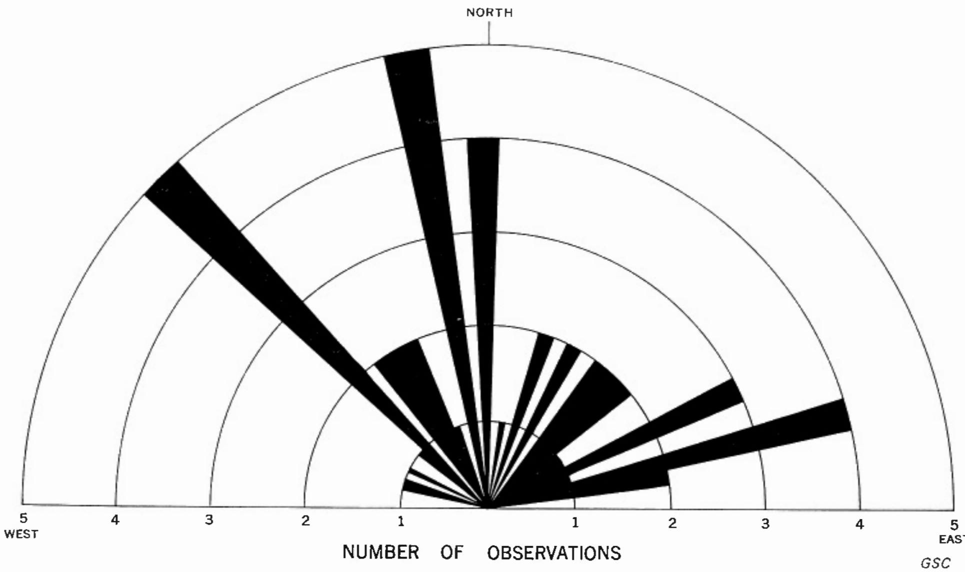


FIGURE 2. Trends of gabbro dykes, note three directions of preferred orientation.

Summary and Interpretation

Fresh gabbro dykes of uniform composition are present throughout the area. They are nowhere abundant but are most frequent in the less granitized rocks of unit 3 in the central and western parts of the map-area. The distinct red-brown weathered surface and strong jointing normal to trend are typical, easily recognized features of these rocks.

There is no direct evidence that all the dykes are of about the same age, although their similarity in so many respects suggests this. Some appear to be related to gabbro sills intruding Proterozoic sedimentary rocks, in particular around the Otish Mountains.

Field observations suggest there is some preferred orientation of the dykes (*see* Fig. 2) and that it changes from east to west across the map-area. In the west north to N10°W is the common trend, in the central region N75°E and N30°W are the prominent directions, and in the east, although there is some variation, N45°E and N45°W are important trends with N30°E, N65°E, and N80°E less common. The stresses that produced the tension fractures along which the dykes are emplaced cannot be determined, but they may bear some relation to the earlier stresses responsible for the regional folding in the Archaean bedrock. The complicated fold pattern in the eastern part of the area, discussed later, may be reflected in the varying trends of dykes in that region, and the change in trends of dykes from west to east may reflect a similar change in trend of fold axes. Solution of this problem must await more detailed information.

Absolute Age Determinations

Absolute ages have been determined in the laboratories of the Geological Survey of Canada on biotite and muscovite from specimens collected within the map-area. This has been done as a part of a comprehensive program of age determinations on rocks of the Canadian Shield (Lowdon, 1960, 1961). Determinations pertinent to this map-area are given in Table I.

Table I

Absolute Age Determinations

GSC Specimen No.	Location	Map-Unit No.	Age, M.Y.
59-58	55°05′N, 76°50′W	1	2,625
59-59	55°05′N, 76°50′W	1	2,555
59-60	54°54′N, 72°45′W	5	2,510
59-61	53°33′N, 72°30′W	2	2,530
59-62	52°11′N, 72°14′W	3	2,055
59-63	55°00′N, 67°50′W	6 (equivalent)	2,365
60-119	54°38′N, 75°57′W	5	2,395
60-120	53°21′N, 76°03′W	3	2,450
61-171	52°50′N, 69°57′W	6	2,485
61-164	52°13′N, 68°52′W	10e	910
61-165	52°13′N, 68°52′W	10e	900
63-152	52°23′N, 70°47′W	12	1,465

Determination GSC 59-63 is from outside the map-area but on a specimen of rocks certainly equivalent to those of map-unit 6.

In this range of ages, the limits to be applied to the calculated values are $\pm$ 125 m.y. (Lowdon, p. 2, 1960). Thus, with the exception of GSC 59-62, all specimens of the Archaean rocks fall within a single range, approximately 2,450 to 2,550 m.y., or an average of 2,500 m.y.

Data are as yet too limited to draw detailed conclusions, but it seems clear that the last metamorphism to affect rock units 1 to 6 was about 2,500 m.y. ago or during the Kenoran orogeny (Stockwell *in* Lowdon, 1961, p. 112) and that the rocks affected are therefore Archaean. The age obtained for the metamorphism of the Kaniapiskau Supergroup falls within that assigned to the Grenville orogeny, and the rocks affected are therefore not younger than middle Proterozoic.

The age determination for GSC 59-62 is significantly later than any of the rest of the gneisses. The specimen was taken some 40 to 50 miles northwest of the Grenville front and perhaps the effects of the Grenville metamorphism may have penetrated that far with a resultant loss of some argon. More dates from the vicinity might determine whether this is a general date for rocks there or a sporadic occurrence.

It is interesting to note that the ages determined for unit 6, while both within the range of the Kenoran orogeny, are somewhat on the late side. These are both from specimens of the granulite facies and further samples may show that the difference in age is significant and the metamorphism producing the granulite facies is slightly later than the metamorphism affecting the rocks farther west or that the increased grade of metamorphism caused some loss of argon.

The absolute age determined on a whole rock specimen of a gabbro sill in the Otish Mountains Group, unit 12, gives 1,465 m.y. This is believed to be the approximate age of intrusion of the gabbro and gives a minimum age for the sedimentary rocks of the unit.

Metamorphism

On a regional basis, two distinct grades of metamorphism are recognized, the granulite facies and the amphibolite facies. The granulite facies is represented by rocks of unit 6, the pyroxene-bearing granodiorite and gneisses and some of the sedimentary gneiss and schist of unit 2 that contains pyroxene. The common mineral assemblage—quartz, plagioclase, microcline, biotite, and hornblende, with the microcline rare or absent in some rocks—is stable within the amphibolite facies. This mineral assemblage is common to several rock-units; massive granite (7), granodiorite gneiss, migmatite, and banded gneiss (5), the sedimentary schist and gneiss with interlayered pegmatite or granite, and bodies of the same granite (3 and 4), the metamorphosed sedimentary and volcanic rocks (1), and those with minor granitic material (2). The development of epidote and chlorite in some of these rocks, together with some secondary white mica in the plagioclase, suggests that some retrograde metamorphism has taken place at temperature-pressure conditions consistent with the epidote-amphibolite facies of metamorphism. Similar relations are noted in the regions to the north of this map-area (Kretz, 1960).

In the southeast corner of the map-area, in the zone of Grenville metamorphism, the gneisses are also in the epidote-amphibolite facies of metamorphism. Absolute age determinations indicate that the ages of metamorphism differ greatly although the metamorphic facies is the same.

In the western three quarters of the map-area, which is for the most part within the amphibolite facies, are some areas of higher grade metamorphism. The largest of these is the area of pyroxene-bearing gneiss (unit 6) just south of Burton Lake. In other smaller areas that are not shown on the map, pyroxene-bearing rocks are present and, in one locality, sillimanite-bearing gneiss. These are apparently small local areas where the grade of metamorphism was higher than that of the general amphibolite facies.

It has been stated that the pyroxene-bearing granodiorite and gneiss (unit 6) is representative of the granulite facies of metamorphism although biotite is a major constituent. The biotite is a red-brown type readily distinguishable in thin section by its colour from the biotite in the rocks of the amphibolite facies. Normally, biotite-rich rocks are not included in the granulite facies but in these rocks, the absence or scarcity of microcline is significant. It is suggested that these rocks belong to the lowest temperature part of the granulite facies of metamorphism.

Within the rocks characteristic of the amphibolite facies, textures range from schists, through foliated gneisses, to massive granitic rocks. Thus, although conditions of temperature and pressure may have been the same throughout, the degree of recrystallization or remobilization of the constituent elements apparently varied. The bulk composition of the original sedimentary and volcanic sequence, from which all Archaean units except unit 6 were mainly derived, was probably much the same. The basic volcanic rocks of units 1 and 2 probably resulted in the abundant basic inclusions in the foliated rocks of unit 5. The source rocks of units 3 and 4 were probably mainly sediments, basic volcanics being rare.

The differences in the textures of the various rock-units may be related to the depth of formation of the rocks, possibly to its effect on the amount of water retained. The degree of remobilization of the original elements, as represented by textures of the present rocks, varies systematically about the map-area. In the northern part are mainly massive granitic rocks (unit 7) that represent almost complete remobilization. Southward are the foliated gneisses of unit 5 in which there has been less mobility of rock elements, and still farther south, separated by a barrier of impermeable basic volcanic rocks, the interlayered schist, gneiss, and pegmatite granite (units 3 and 4) in which mobility was limited to certain elements. It is suggested that from north to south, in the western three quarters of the map-area, there is a gradient in the degree of mobilization, greatest in the north and least in the south.

On a smaller scale, the distribution of massive and foliated rocks is related to structures as discussed in a following section. Massive rocks tend to appear in anticlines and foliated rocks in synclines. It appears therefore that the structure and the mobility of material during metamorphism bears some relationship. Similarly, the small local areas of higher grade metamorphism (granulite facies) within the zone of the amphibolite facies are probably related to local structures.

The bulk of the granulite facies rocks occurs in the eastern quarter of the map-area, and probably developed at greater depth than the rocks of the amphibolite facies. It is interesting to note the position of these rocks, paralleling the Labrador 'trough', and to speculate as to a possible relationship. The granulite facies rocks are obviously of much greater age than are the Kaniapiskau Supergroup rocks of the Labrador 'trough', but in this general zone there may have been tectonic activity over a great period of time. Perhaps the granulite facies rocks formed after sinking to great depth in this zone. Subsequent uplift raised them and was followed by a second period of sinking, this one restricted to the central part of the zone to form the geosyncline in which the Kaniapiskau Supergroup rocks were deposited. Final uplift and deformation resulted in the situation now obtaining.

The Proterozoic rocks show little evidence of metamorphism. There is some development of white mica in the matrix of some of the sedimentary rocks but evidently metamorphism has been slight.

Chapter III

STRUCTURAL GEOLOGY

Folding

Some major folds are indicated on the accompanying geological map, but it must be recognized that from reconnaissance mapping on this scale information on structural geology is scattered and these folds may not be precisely located. However, the information as plotted illustrates in a broad manner the general pattern of the folding in the area. In detail, within limited areas, it has been observed that numerous smaller folds are superimposed on the major folds but that the smaller folds normally follow the regional trend of the folding. Small-scale folding, i.e., drag-folding, has not been shown, as it is doubtful if enough observations were obtained to permit regional interpretation, although they do indicate the regional plunge of the folding. Aerial photographs are of very limited assistance in this region in determining the pattern of the folding.

Pattern of Folding

In the western part of the map-area, the trend of the folding is east with variations both north and south of east. Eastward, there is a gradual change in the trend of the axes to north of east and eventually northeast, with local variations. In a general way, a line representing the trend of folding is an arc trending east in the western part of the map-area and swinging to northeast in the eastern part. The general plunge is eastward. Numerous observations on minor folds support this, but reversal of plunge with resultant dome and basin structures is a common feature. The general character of the folding in much of the area is broad and open. There are, however, exceptions to this in the southwest part of the area underlain by rocks of unit 3 where folding is close and overturning or isoclinal folding common. Fold axes could not be shown in this region, as the information available is too limited.

Just to the west of Sakami Lake, in the area underlain by rocks of units 1, 3, and 5, instead of the normal easterly trend the trend of the folding is northeast. There is no apparent reason for this difference but it may be related to the zone of disruption just to the north, discussed in the section on *Faulting*.

Detailed mapping on the properties of Great Whale Iron Mines Limited (Gregory, 1958; Jones, 1959; Scofield, 1960) provides some detailed structural information on local areas. On the northern part of the Great Whale River band of metamorphosed volcanic and sedimentary rocks, which includes the "A" deposit of Great Whale Iron Mines Limited, the trend of the folding in the belt is approximately N45°W, which is at a considerable angle to the regional trend of folding. The detailed structural picture in this belt is extremely complicated, with tight isoclinal folding and some overturning. The plunge of this local folding is southeast. As part of the regional picture it is suggested that this small-scale folding at N45°W in this remnant of early volcanic and sedimentary rocks is in fact cross-folding, and that it probably lies on the north limb of a major east-plunging anticline. Just to the east, in the "D" deposit of this company (Jones, 1959; Scofield, 1960), detailed mapping shows that the trend of folding is east and the plunge east, which conforms with the regional picture of folding.

The report by Ingham (1958) on the property of Duncan Range Iron Mines Limited indicates that the trend of folding in the limited area studied is in general eastward and the plunge east, in conformity with the regional trend. There is some evidence in the Duncan Lake area that the folding in the belt of metamorphic rocks is overturned and that there is some cross-folding trending slightly west of north.

The cross-folding, in both the Great Whale River and the Duncan Lake areas, is considered to be contemporaneous with the regional deformation.

Information on the structural geology of the eastern part of the map-area is sparse. In part of this area there is good evidence of folding that trends northeast, but in the area underlain by pyroxene-bearing gneisses and granodiorite (unit 6) the structural picture is more confused. In addition to the folding trending northeast, there is some indication of folding trending northwest, more or less parallel with the Labrador 'trough'.

Stevenson found that the rocks in the extreme southeast corner (NTS 23C) have a dominant west trend but locally are very distorted. Where the iron-formation (unit 10d) can be used as a horizon marker, the complicated nature of the folding can be appreciated. He suggests that two distinct periods of folding are probably involved, with deformation about two axes intersecting at a high angle. Much of the evidence of the earlier folding has been removed by the later. Detailed studies by company geologists around the iron ore deposits of Mount Reed show the iron-formation has been folded into a 'W'-shaped outcrop, a form that could result from two directions of folding. In the Mount Wright area just to the east (Duffell, 1959), there is good evidence of folding along two trends but the relations between them are not clear.

No fold axes trending northwest have been shown on Map 1155A, although it seems likely that detailed mapping in the eastern region would reveal such folding.

In the extreme north of the map-area, in one of the small outliers of Sakami Formation (unit 11) around latitude 55°55′, longitude 70°30′, gentle folds trend N35°E and plunge southwest. These are probably unrelated to the previously described and earlier deformations. This gentle warping may be due to disturbance during the faulting that outlines this small area of sedimentary rocks.

Relationship Between Folding and Rock Units

The reconnaissance mapping indicates that, in a general way, there is a relationship between the folding pattern and the areal distribution of massive granite (unit 7) and foliated granitic rocks (unit 5). Massive granitic rocks generally appear along major anticlines and foliated rocks along synclines. This is particularly apparent in the western part of the map-area, for there the contacts between massive and foliated rocks follow a sinuous course, following the noses of the plunging major folds. It is interesting to note that in a general way the pattern of contacts corresponds to the gravity contours in this region as shown on the gravity maps of the Dominion Observatory (Tanner, 1961). It seems possible to relate bodies of foliated rock in the massive granite to the structures. For example, the foliated rock around latitude 55°, longitude 74°15′ is related to a synclinal axis.

The change in character of the folding from broad, open folds in the foliated granitic rocks to closed, isoclinal and overturned folds, characteristic of at least a part of the area underlain by rocks of unit 3, may be in part due to differences in the type of rock involved. In the area where folding is intense, the rocks are typically quartz-plagioclase-biotite schist of unit 3 with some interbanded pegmatitic material. The schist is an incompetent rock so that the isoclinal folding there may result from stresses similar to those that result only in open folding in the granitic rocks. Probably depth of burial at the time of deformation is another factor.

In the eastern part of the area, the granulite facies rocks of unit 6 have apparently undergone deformation that resulted in northeast- and northwest-trending folds. Possibly the northwest trend of folding reflects deformation at a much greater depth than deformation that produced the northeast folding and possibly this great depth changed the rocks to granulites. It was suggested earlier that granulite facies may have developed slightly later than the granitic rocks to the west.

Faulting

Reconnaissance mapping is deficient in providing details on much of the geology, and this is particularly true of faults. Where faults lie along or in younger Proterozoic rocks they are readily recognizable, but where they are in the great areas of Archaean granitic rocks they are difficult to map with any degree of certainty.

In the southwest part of the map-area, in the Otish Mountains region, a zone of faults trends N60°E and cuts rocks of both the Otish Mountains Group (unit 12) and the gneisses of unit 5. These faults parallel the trend of the 'Grenville Front' and in this region may represent the front. This zone of faulting is 16 miles wide, with four faults recognized and probably others that were not observed. The faults appear to be normal and to dip steeply. The sense of the movement on them was not ascertained, but it is suggested that on most of them the northwest side moved downward relative to the southeast side. Gravity observations in this region (Innes, 1957) are not in sufficient detail to assist in interpreting the relations between these faults and the 'Grenville Front'.

The remnants of the Sakami Formation (unit 11), north of Sakami River and in small patches eastward beyond Lac Tilly, are all preserved in small, down-faulted blocks. These faults trend approximately N70°E, and are apparently normal and steeply dipping. Along the contacts of the younger sedimentary rocks with the older Archaean rocks, direct evidence of the faulting may be observed—slickensides and fault gouge or breccia. In many places, however, the fault may follow a topographic depression without outcrops and the nearest outcrops may be only slightly broken. Faults with the same trend and characteristics cut rocks of units 1, 5, and 7 just to the northeast of Duncan Lake, where there appears to be a zone of faulting that trends N70°E. It is some 12 to 16 miles wide with Duncan Lake approximately in the centre, and extends northeast from Duncan Lake to beyond Lac Tilly, some 160 miles to the east. This zone of disruption consists of a series of short *en échelon* faults with some east-trending cross-faults. Direct field evidence along the course of this zone of disruption has been obtained only here and there, as faults in granite are hard to recognize. Furthermore, few lineaments attributable to the zone can be recognized in air photographs. It may, however, extend west as far as James Bay and east beyond Lac Tilly, forming an arcuate zone of disruption of major proportions.

The small remnants of Sakami Formation rocks (unit 11) in the extreme north seem to be similarly bounded by faults. The body around latitude 55°50′, longitude 72°30′ is definitely bounded on the south by a fault, as there is a prominent fault scarp with fault gouge and breccia present. On the north side of this outlier however outcrops are lacking, but it seems probable that there is a fault and that the sedimentary rocks are in a small down-dropped block.

The body around latitude 55°55′, longitude 70°30′ is also probably bounded on all sides by faults, although not all were observed. It is suggested that the system of faults responsible for the preservation of these two remnants of Proterozoic rocks in down-dropped blocks extends northeastward into the Cambrian Lake (west half) area (Fahrig, 1957) and joins faults recognized there that cut rocks of the Kaniapiskau Supergroup on the west side of the Labrador 'trough'. Fahrig (1957, p. 114) suggested that a depression existed there in which Kaniapiskau Supergroup rocks were deposited. Perhaps this depression was of tectonic origin and further movements along the fault system took place after deposition of the sediments.

In the northwest part of the map-area, a near vertical normal fault trending east cuts the Proterozoic rocks of the Manitounuk Group (unit 13) and granite (7). Field evidence of this fault, in the form of breccia and gouge, was observed at several localities and along part of its length the fault has pronounced topographic expression. Just to the north of the present map-area, Woodcock (1960) indicated several faults with the same trend cutting the Proterozoic sedimentary rocks.

Jointing

No systematic study of jointing was attempted. Certain joints that are prominent lineaments on air photographs were examined on the ground, but practically none gave indication of other than very minor slipping. This is particularly true in the massive granite northeast of Great Whale River settlement where many prominent lineaments are visible on the air photographs.

Massive granite (unit 7) is the most noticeably jointed of all the rock types and very rarely is a joint pattern lacking. The foliated granitic rocks of unit 5 are also normally well-jointed, but with good foliation the joints are not so obvious.

Chapter IV

ECONOMIC GEOLOGY

Detailed geological mapping, airborne and ground geophysical work, and diamond drilling have been carried out on the properties of Great Whale Iron Mines, and geological mapping and ground geophysical work have been done on the property of Duncan Range Iron Mines. Exploration and prospecting have been done in the map-area by several companies, but no published records of this work are available and for the most part the results are not known to the writer. Grenier (1948) however based his unpublished thesis on material obtained in the course of exploration work. Since publication of the preliminary results of the present survey (Eade, *et al.*, 1957; Heywood, *et al.*, 1958; Eade, *et al.*, 1959) exploratory work has been carried out on some previously unknown volcanic rock bands (unit 1). Considerable work was done by Gulf Lead Mines Limited on their property in the extreme northwestern part of the area, bordering Hudson Bay. Geological mapping and some diamond drilling were done on a galena-sphalerite occurrence in the limestones of the Manitounuk Group (unit 13), and Parks (1949) and Harwood (1949) based their unpublished theses on material collected during this work.

At scattered localities throughout the area minor sulphide occurrences were noted, chiefly pyrite but also some chalcopyrite. On a reconnaissance mapping project of this type no details on the character of the mineralization could be obtained and only a rapid examination of the localities noted was possible.

During the period July 27, 1955 to January 4, 1961 the Government of the Province of Quebec withdrew from staking all New Quebec Territory, which includes most of the mainland part of the map-area. Exploration licences for specified blocks of ground only were granted during that period.

The following discussion summarizes the available information, published and unpublished, supplemented by whatever field information was available.

Iron Occurrences

Great Whale Iron Mines Limited

Detailed information on this property which consists of three separate concessions centring about a point some 50 miles east-southeast of Great Whale River settlement, has been kindly supplied by the company. The writer examined the largest of these occurrences in the summer of 1956, during the first preliminary reconnaissance of the area. The band of metavolcanic rocks in which the iron-formation occurs was observed on an aircraft flight and a ground traverse in July 1956, when abundant iron-formation outcrops were seen. No report on the occurrence had been published at that time; the first published reference was made the following year after further examination (Eade, *et al.*, 1957).

In the summer of 1957 field staff of Belcher Mining Corporation Limited first investigated the area and in September of that year a Mining Exploration licence was taken out covering some of the deposits. The concession was turned over to a newly formed company, Great Whale Iron Mines Limited, after which an extensive aeromagnetic survey was made. This survey indicated four smaller anomalies, in addition to the outcrops of iron-formation. Examination indicated that two of these were on occurrences of some promise and two further Mining Exploration licences were taken out in 1959 to cover them. The three occurrences of greatest interest are called "A", "D", and "E" by the company and are respectively centred about latitude 55°05′, longitude 76°50′; latitude 55°02′, longitude 76°27′; and latitude 54°56′30″, longitude 76°12′30″. Of these three, the one originally found ('A') is the largest. Detailed geological mapping was carried out on the "A" deposit by Gregory (1958), on the "D" deposit by Jones (1959), and on the "E" deposit by Edmunds (1960). Scofield (1960) summarized the geology of the three deposits and the following is quoted from the abstract of his report.

> The "A" enclave constitutes a fairly large area of some 15 miles in north-south length and up to 5 miles or more in width. Within the area studied it consists of a north-south trending greenstone belt, believed to be anticlinal, flanked on both sides by a schist series which contains the iron formation and ultimately merges into the granitic background through increasingly granitic zones of paragneiss on each side. The principal development of the iron formation lies just west of the greenstone in a series of tight isoclinal folds pitching to the south. The deposit has an overall length in excess of 18,000 feet, with a variable width due to fold duplication ranging from 300 feet to over 3,000 feet, including interleaved schists. The strike of the layered rocks is north-south and the dip is everywhere steep to the east. Two deep drill holes show that the iron formation in the limbs of the folds extends downward on dip for at least 800 feet. Certain zones of quartz-feldspar schists are believed to represent acid sills, as they transgress the strike and dip of the layered rocks at a low angle. The grain size of the magnetite in the iron formation varies. All along the east side of the deposit close to the greenstone anticline, the grain is considerably finer than elsewhere; whereas close to granite and pegmatite at the south end of the deposit, the grain is considerably coarser than average. Amphibolitic silicates are present in some horizons of the iron formation.
>
> The "D" enclave occupies an irregular area about one mile in diameter. It consists of a complex fold of a schist and iron formation sequence. The contact of the rocks within the enclave with the background granite appears to follow the base of the iron formation. The gradation through paragneiss to granite is accomplished over a much narrower zone than is the case at the "A" deposit. The principal feature of the "D" enclave is a central trench marking a major fault which has been injected by a diabase dyke. West of the fault, the iron formation and schist series forms a syncline pitching southeastward. East of the fault, the rocks appear to be overturned and to have been thrown northward and probably downward. The whole structure might be described as an overturned pocket fold of which the bottom of the pocket has been cut off and displaced by a major fault. The iron formation resembles that of the "A" deposit but the grain is considerably coarser.
>
> The "E" enclave has a surface area about a half-mile square. An eastward-dipping iron formation and schist series there is surrounded and underlain by the background granite, with contact relationships somewhat similar to those at "D". However, at "E" the granite cuts across the bedding of the layered rocks and closes in around the hangingwall side so that the enclave appears to represent only one segment of a monoclinal series left as a roof pendant in the granite mass. The iron formation of the "E" deposit has a lower initial iron content than that of the other deposits and contains more silicates. The grain size is slightly coarser than at the "D" deposit.

Figure 3 shows the general location of the three deposits and detailed geological maps of the deposits. These maps are adapted from those of Great Whale Iron Mines Limited and published with their permission. The descriptions quoted above and the maps are based on detailed surface mapping and more than 56,000 feet of diamond drilling.

On chemical analyses and milling tests of bulk samples the company based the information given below.

Table II

Estimated Ore Grades of the Deposits of Great Whale Iron Mines Limited

	"A" Deposit		"D" Deposit		"E" Deposit	
	crude	concentrate	crude	concentrate	crude	concentrate
Combined ferrous and ferric iron	36.7%	66.6%	36.8%	68.2%	24.1%	67.5%
Silica		6.6%		3.5%		4.4%

The company estimate of the dry long tons of concentrate in each of the three orebodies is: "A"—219,756,000; "D"—65,864,000; "E"—97,263,000.

Sources for hydroelectric power are available on Great Whale River not far away. The main factor in developing these deposits in the near future would appear to be the cost of transportation of the concentrates to a market.

Duncan Range Iron Mines Limited

The property of Duncan Range Iron Mines Limited covers a 15-mile band trending northeast from the southeast corner of Duncan Lake (lat. 53°28′, long. 77°58′). This lake is approximately 50 miles southeast of Fort George settlement on James Bay. The following information is from a private report by Ingham (1958), who discussed the property in some detail. A less-detailed report (Ingham, 1960) was published later.

Surface geological mapping, ground magnetometer surveys, and an aeromagnetic survey have been carried out on the property and observations are based on that work. The geophysical work was used to delineate the bands of iron-formation where no outcrops occur. The six main occurrences of iron-formation are designated No. 1 to No. 6 (*see* Fig. 4). Nos. 1 to 4 lie along a general northern belt and Nos. 5 and 6 are parts of a parallel southern belt. The No. 1 and No. 2 occurrences constitute a magnetite-bearing zone traced continuously for 9 miles, but only the parts more than 100 feet wide are considered to be of economic interest. At one point near the south end, No. 1 occurrence is 1,300 feet wide. The dip of most of the bodies is very steep to vertical.

The iron-formation is interbedded with other metasedimentary rocks, including greywacke, cherty greywacke, chert, impure quartzite, and slate. Much of the greywacke and cherty greywacke is metamorphosed to quartz-biotite-plagioclase schist. Basic volcanic rocks are present with the sedimentary rocks, and Ingham stated that

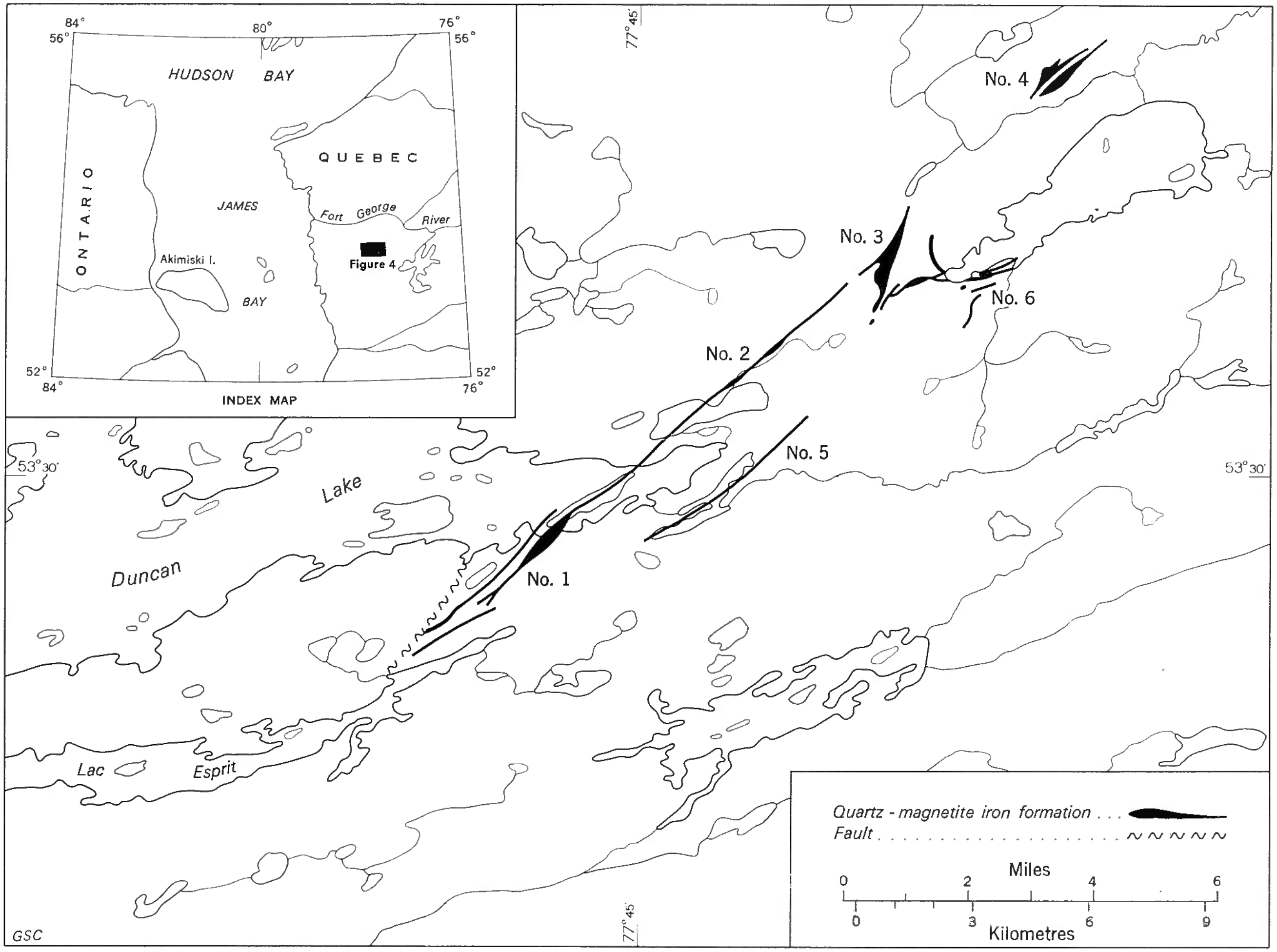


FIGURE 4. Distribution of iron-formation on property of Duncan Range Iron Mines Limited (adapted from company maps, Ingham, 1958).

most of the volcanic rocks underlie the sedimentary rocks, although in the eastern part of the north belt the two are definitely interbedded. The volcanic rocks are chiefly andesite and dacite flows with small bands of tuff. Pillow structure is well developed in some of the flows. In part the volcanic rocks are altered to schistose chloritic rocks and minor amounts of granite, granodiorite, or syenite occur. North-trending diabase dykes cut the bands.

No. 1 occurrence consists of two parallel, overlapping bands, separated by 200 to 400 feet of cherty greywacke containing only a few thin magnetite-rich beds. Chip samples from various parts of this occurrence showed an iron content varying from 26 to 39 per cent. *No. 2* occurrence, which lies along the same band as No. 1, has three sections more than 100 feet wide and is 7,900 feet long. Samples from these sections show an average iron content of approximately 33 per cent. *No. 3* occurrence is a complicated structure, the northern part appears to be the drag-folded and greatly thickened extension of Nos. 1 and 2 and the southern part may be an extension of the southern belt of iron-formation in the form of a cross-fold. The northern part, which has an average width of 500 feet over a length of 7,200 feet, averages about 35 per cent iron content. The southern part has approximately the same iron content but it is narrower. *No. 4* occurrence, the most easterly, is in two parts, apparently opposite limbs of a synclinal structure. They are separated by 100 to 400 feet of greywacke containing only minor magnetite-bearing beds. The northern part is 4,000 feet long and averages 300 feet wide, the southern part is 6,000 feet long and averages 500 feet wide. The iron content varies from 29 to 34 per cent. *No. 5* occurrence, the only body that does not dip steeply, has 5,600 feet that is over 100 feet wide. It averages 33 to 37 per cent iron content. *No. 6* occurrence is considered to be the eastern end of the south belt of iron-formation and is probably an extension of No. 3 body, as they are separated by only a small body of igneous rock. The iron-formation has been intruded and partly absorbed by a syenitic intrusion. The body is considered to be 6,000 feet long with an estimated average width of 800 feet. Samples average about 33 per cent iron.

At the time of writing, no diamond drilling had been carried out on the property and the above estimate, as given in Ingham's report, must be considered as preliminary. The figures for iron content are for the most part based on chip samples.

Lac Grande-Pointe Iron Formation

Just to the west of Lac Grande-Pointe (lat. 53°50′, long. 73°30′) are some small areas of metamorphosed sedimentary and volcanic rocks (unit 2) that contain quartz-magnetite iron-formation. In one of these iron-formation is present over a width of more than 200 feet. Examination of thin sections indicates the presence of sufficient magnetite to give an iron content of 30 to 35 per cent. The iron-formation in these small bodies is somewhat coarser grained than that in the Great Whale and Duncan Lake localities, due to more intense metamorphism.

Magnetite Sands, Fort George River

At four localities along the shore of Fort George River, centred around latitude 53°44′, longitude 75°51′, considerable concentrations of magnetite sand occur. These form beds up to 6 inches deep of almost pure magnetite sand but their extent and total thickness were not determined.

A 260-gram sample of magnetite sand from one locality was submitted for analysis to the Mines Branch, Department of Mines and Technical Surveys (*see* Table III).

Table III

Results of Magnetic Separation, Iron Sands, Fort George River

Product	Weight %	Assay, Fe, %	Distribution, Fe, %
Magn. conc.	53.9	69.60	69.1
Tailing	46.1	36.40	30.9
Head (cal'd)	100.0	54.29	100.0

Analysis of Magnetic Concentrate
(per cent)

Iron, acid soluble	69.60
Manganese	0.10
Titanium	0.51
Phosphorus	0.025
Sulphur	0.010
Insoluble	1.08

Lee (1959a), in discussing the surficial geology of this area, suggested that further investigations might reveal other concentrations of magnetite sand in some of the glacio-fluvial and marine sands.

Magnetite-Iron Silicate Occurrences

Just east of Otish Mountains, at approximately latitude 52°14′, longitude 69°59′, is a single outcrop of metamorphosed iron-formation. Disseminated magnetite is present in the rock with cummingtonite, grunerite, fayalite, and ferrohypersthene.

Grenier (1948) described a magnetite-grunerite paragneiss with minor garnet and brown tourmaline near Fort George River at about longitude 72°15′. This locality was not examined during the present survey and no further information is available.

Iron-Formation Inclusions in Gneisses

In the course of field mapping, inclusions of quartz-magnetite iron-formation from a few inches to several feet in diameter were noted in gneisses of unit 5. Inclusions at the following locations have been indicated on the map:

	Latitude	*Longitude*
(1)	54°54′	77°05′30″
(2)	54°35′	77°05′
(3)	54°04′30″	78°45′30″
(4)	54°00′10″	74°47′30″

None of these was examined in detail and no further information is available. It is, however, improbable that any are of economic interest.

Proterozoic Iron-Formation—Manitounuk Group

Iron-formation has been reported in the upper part of the Manitounuk Group at two places in the map-area. This iron-formation has tentatively been correlated with that of the Belcher Islands (Young, 1921). On Long Island (lat. 54°53′, long. 79°20′), Young (op. cit.) reported 340 feet of iron-formation at the top of the sedimentary section, and near Little Whale River (lat. 55°58′, long. 76°45′) Low (1902) observed 82 feet at the top of the sedimentary section. Neither of these localities was examined during the present survey.

Proterozoic Iron-Formation—Kaniapiskau Supergroup

In the small area underlain by rocks of the Kaniapiskau Supergroup, in the extreme northeast corner of the map-area, both cherty metallic iron-formation and minor jasper-hematite beds are present. The iron in the iron-formation has not been concentrated as it has around Schefferville (Knob Lake), so that at present this iron-formation is not of ore grade. Its regional relationship is well illustrated by Gross (1961). This iron-formation is similar to some of that described by Harrison (1952) from the Knob Lake area but is in very much smaller amounts.

In the Kaniapiskau Supergroup rocks in the southeast corner of the map-area, iron occurrences associated with metamorphosed iron-formation (unit 10d) are of considerable economic interest. The locations and descriptions of these deposits are given by Gross (1961, 1962) and by Waddington (1960).

Sulphide Deposits

Manitounuk Group

Galena and sphalerite are present in limestone beds of the Manitounuk Group in the extreme northwest corner of the map-area. During the present survey no examination was made of these occurrences and the following information is extracted from Parks (1949). His report is based on detailed geological mapping and diamond drilling carried out by Gulf Lead Mines Limited on twenty-five claims about 6 miles south of Little Whale River. The approximate locations of the two areas where work was done are latitude 55°57′40″, longitude 76°43′, and latitude 55°56′10″, longitude 76°49′.

The sulphides occur in concretionary cherty limestone and dolomite that is overlain by thick basaltic flows and sills with some thin interbedded pyroclastic rocks. The volcanic rocks have a maximum thickness of 350 feet and between the flows and the limestone there may be as much as 900 feet of quartzite and sandstone. The maximum thickness of the limestone member is about 430 feet. The sulphides occur at two different horizons within the limestone member. The upper zone, 5 to 10 feet thick, carries small amounts of galena and sphalerite in a limestone containing up to 50 per cent chert. The main mineralized zone, a cherty, concretionary limestone, is from 8 to 80 feet thick and contains the principal galena and sphalerite occurrence. It is commonly marked by a gossan, resulting from the oxidation of abundant pyrite that is also present. The galena and sphalerite, with pyrite and carbonate, occurs as veins, disseminated through the limestone, or as massive lenses in the limestone. Fracturing and vein filling may be so pronounced in some places as to produce a mineralized breccia.

Duncan Lake Band

The belt of metamorphosed sedimentary and volcanic rocks (unit 1) extending eastward from Duncan Lake carries considerable pyrite and some chalcopyrite and galena. Just south of Duncan Lake, around latitude 53°28′20″, longitude 77°48′30″, abundant disseminated pyrite is present in a sheared impure quartzite. Along the fault zone that cuts the northern part of the belt there is extensive gossan and at three points considerable pyrite. At one of these some chalcopyrite was also seen. The three locations are latitude 53°35′30″, longitude 77°33′, pyrite; latitude 53°37′, longitude 77°21′, pyrite; and latitude 53°36′, longitude 77°29′, pyrite and chalcopyrite.

Ingham (1958), in his report to Duncan Range Iron Mines Limited, described occurrences of sulphides on the company's property. Near latitude 53°31′06″, longitude 77°43′30″, a band of sericite schist in the metasedimentary rocks is heavily mineralized with pyrite. In the metasedimentary rocks around latitude 53°28′40″, longitude 77°48′52″, pyrite is widely disseminated, producing outcrops weathered to a reddish brown gossan. A small amount of chalcopyrite was found in these pyritized rocks. A grab sample from a 4-foot gossan zone near latitude 53°29′55″, longitude 77°42′45″, according to Ingham, assayed 1.90 per cent copper. A 60-foot vein of white quartz near latitude 53°35′55″, longitude 77°35′10″, contains inclusions of metasedimentary rocks, some of which are sparsely mineralized with chalcopyrite and galena. Galena is also reported from 500 feet to the south of this point in a 3-inch quartz veinlet cutting meta-greywacke.

Shear zones in the No. 3 iron-formation occurrence (*see* Fig. 4) are heavily impregnated with pyrite. Metavolcanic rocks just to the north of the No. 4 iron-formation occurrence contain much disseminated pyrite and in metavolcanic rocks at the eastern side of the No. 4 body, there is an irregular zone with much pyrite 20 to 40 feet wide and 300 feet long.

In late 1961, published reports (*The Northern Miner*, November 2, 1961, Vol. XLVII, No. 32, pages 1 and 11) appeared of discoveries of massive sulphides on the Duncan Range Iron Mines Limited property, made by Canadian Dyno Mines Limited. The original discovery was on a small peninsula in the east end of "Long Lake", just east of Duncan Lake. The mineralized rock is reported to consist of thickly disseminated to massive sulphides, predominantly chalcopyrite, in an east-trending silicified shear zone. The published statement reported a channel sample across a width of 44 feet as containing 8.1 per cent copper and 1.13 ounces of silver. Diamond drilling of this prospect was started.

Sakami River Band

In the southern belt of metavolcanic rocks at Sakami River a little pyrite is developed. Near latitude 53°29′, longitude 75°35′, pyrite is disseminated in basic metavolcanic rocks. Farther west in the same band, extensive rusty zones, probably due to oxidation of pyrite, and abundant barren quartz veins were noted at latitude 53°30′, longitude 74°13′, and latitude 53°31′40″, longitude 74°11′30″. Just on the contact of this belt at latitude 53°35′, longitude 73°54′, a small quartz vein containing a little molybdenite was observed.

Western Eastmain Band

Disseminated pyrite is present in basic metavolcanic rocks around latitude 52°03′, longitude 75°16′. To the west, in the same band of rocks, Shaw (1942) reported that disseminated pyrite was common and that specks of chalcopyrite were seen at various places. Shaw also stated that gold had been reported from this band, but he did not state the locality.

Eastern Eastmain Band

At two places in this belt, sulphides have been noted. Around latitude 52°18′, longitude 72°44′30″, pyrite and some copper stain are present in acid to intermediate volcanic rocks. This is in a zone up to 20 feet wide and more (probably much more) than 150 feet long, in which there is some massive and much disseminated pyrite. An assay of grab samples from this locality, carried out by the Mines Branch, Department of Mines and Technical Surveys, gave copper 0.03 per cent and gold not detected. West of this point, around latitude 52°16′, longitude 72°06′, pyrite is disseminated freely in the volcanic rocks and some copper stain has been seen.

Wahemen Lake Band

At two localities in the Wahemen Lake band of metamorphosed basic volcanic rocks the effects of mineralization have been noted. Near longitude 71°33′, the greenstone contains abundant disseminated pyrite and the surface of the rock is rusty brown from oxidation of the pyrite. Near latitude 52°39′30″, longitude 71°26′ the andesite to dacite country rock is strongly sheared, and much disseminated pyrite and some secondary quartz are introduced. There too, the rock surface is rusty brown.

Lac Duhesme Band

In the metamorphosed basic volcanic and sedimentary rocks near latitude 53°33′, longitude 72°31′10″, considerable evidence of mineralization is present, particularly along a shear zone about 50 feet wide and at least 600 feet long. Pyrite and arsenopyrite were noted, and possibly some chalcopyrite. A grab sample from this locality assayed at the Mines Branch, Department of Mines and Technical Surveys, gave copper only 0.01 per cent and gold not detected. A short distance to the north, within the same belt of rocks, there is a rusty brown shear zone some 500 feet wide and about 1,000 feet long. Just to the west of this band, around latitude 53°31′10″, longitude 72°06′, disseminated pyrite is abundant in amphibolite of unit 2. To the north, around latitude 53°42′, longitude 72°10′, abundant disseminated pyrite has produced a rusty weathered surface on metasedimentary or metavolcanic rocks, a silicified amphibolite of unit 2.

Lac Aubert Band

The metamorphosed basic volcanic rocks and impure quartzite in this locality contain some pyrite. Around latitude 54°58′30″, longitude 74°44′, quartz stringers containing pyrite cut the country rock. Near latitude 55°02′, longitude 71°24′30″, the rock surface is rusty brown from oxidation of sulphide minerals and the rock itself contains disseminated pyrite with minor chalcopyrite. At latitude 55°04′30″, longitude 71°25′, the greenstone contains much disseminated pyrite and is cut by quartz-epidote stringers.

Rusty Zones

At various places small rusty zones have been indicated on the accompanying map. Near latitude 55°54′, longitude 75°24′, disseminated pyrite in a metamorphosed gabbro dyke (unit 2) results in a rusty rock surface. A small body of ultrabasic rock, probably pyroxenite, at latitude 54°58′, longitude 76°53′ has a distinctive weathered surface that is probably due to the weathering of pyroxene and minor biotite, as no metallic minerals were observed.

At three different localities in the area underlain by pyroxene-bearing gneiss (unit 6) south of Burton Lake, areas of rusty weathering were noted. These are (a) latitude 54°35′45″, longitude 78°15′; (b) latitude 54°24′, longitude 78°48′30″; and (c) latitude 54°16′, longitude 77°58′. This rock normally has a rusty brown weathered surface but at these points the rusty colouring is particularly pronounced. This may be due to weathering of the abundant biotite present as no metallic minerals were observed. At another locality, latitude 54°21′, longitude 79°05′30″, in the same type of rock, disseminated pyrite is present.

Disseminated pyrite was noted in granite-gneiss (unit 5) near latitude 54°58′, longitude 76°44′30″, and a small gossan, possibly due to weathering of magnetite in granite (unit 7) at latitude 54°15′, longitude 75°55′.

Structural Materials

Sand and Gravel

Throughout the area sand and gravel are abundant in the Pleistocene and Recent deposits. Lee (1959a) and Hughes (1964) have shown the location and extent of most of these deposits. Certain of the re-worked glacial deposits, lying within the area of marine submergence (Lee, 1959a, 1960) probably provide the best material, as there are less fines.

Stone

During construction of the Mid-Canada Line a stone crushing plant was in operation near the Great Whale River base. Local rock, granite, and granodiorite (unit 7) were crushed for use as concrete aggregate and as surfacing material for the air strip at Great Whale River. The hard dense character of the rock made crushing difficult and caused extreme wear on the crusher. Commonly chloritized basic inclusions scattered through the rock mass are also undesirable, as they are unsuitable material in aggregate. If crushed rock is again needed the limestone of the Manitounuk should be considered.

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