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DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 72-21

GEOLOGY OF NUELTIN LAKE AND EDEHON LAKE (West half) MAP-AREAS, DISTRICT OF KEEWATIN

K.E. Eade

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(Report. 4 figures and Map 3-1972 and 4-1972)

K.E. Eade

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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ABSTRACT

The map-areas, situated in the southwestern part of the District of Keewatin, lie entirely within the Churchill Structural Province. Glacial drift cover is thick throughout the areas. Metavolcanics, greywacke, argillite or phyllite, amphibolite, paragneiss, granodiorite gneiss, and quartz monzonite to granite, all of probable Archean age, underlie much of the area. Granodiorite gneiss of lower granulite facies occurs in the southern part of Edehon Lake map-area. The Hurwitz Group of Aphebian age, comprising greywacke-conglomerate, greywacke, quartzite, orthoquartzite, argillite, phyllite, dolomite, limestone, gabbro sills, and metamorphosed equivalents, including paragneiss, overlies the Archean rocks. These rocks are in part contiguous to type Hurwitz Group rocks occurring just to the north but they also occur in a number of isolated patches and are considered to be Hurwitz Group on the basis of lithology and stratigraphy. Late Aphebian granite to quartz monzonite plutons intrude Hurwitz Group and Archean rocks. Postorogenic, early Helikian intrusions of fluorite-bearing granite to quartz monzonite comprise the youngest major rock type.

Major structural trends in both Aphebian and older rocks are northeast, except in the southern part of Edehon Lake map-area where trends are east. All the rocks with the exception of the younger plutonic rocks are extensively faulted.

No significant mineralization was discovered.

RÉSUMÉ

La région étudiée, qui est située dans le sud-ouest du district de Keewatin, est complètement à l'intérieur de la province structurale de Churchill. Une épaisse couche de matériaux de transport glaciaire recouvre toute la région. Les couches sous-jacentes sont généralement formées de rouches volcaniques partiellement métamorphisées, de grauwacke, d'argile schisteuse ou de phyllite, d'amphibolite, de paragneiss, de gneiss granodioritiques et de monzonite quartzeux ou granitique, le tout probablement d'âge archéen. Le gneiss granodioritique se présente dans des faciès inférieurs à leptynites dans le secteur sud de la région couverte par la carte du lac Edehon. Sur les roches archéennes repose le groupe aphébien de Hurwitz, qui consiste en grauwacke à conglomérat, en grauwacke, en quartzite, en orthoquartzite, en phyllite, en dolomie, en calcaire, en filons-couches de gabbro et en divers équivalents métamorphisés, dont le paragneiss. Il s'agit de couches partiellement contigues aux roches – type du groupe de Hurwitz que l'on trouve immédiatement au nord, mais elles se présentent également en divers endroits isolés et on les considère comme appartenant au groupe de Hurwitz en raison de leur disposition stratigraphique et de leur nature lithologique. Les roches du groupe de Hurwitz et les couches archéennes présentent des intrusions plutoniennes de granite ou de monzonite quartzeux de la période aphébienne supérieure. Les roches les plus jeunes sont des intrusions de l'Hélikien inférieur de granite à fluorite ou de monzonite à quartz et de formation postérieure à l'orogénèse.

Les structures principales, tant dans les couches aphébiennes que dans les plus anciennes présentent une orientation nord-est, sauf dans le cas de la partie sud de la région du lac Edehon ou les couches sont orientées vers l'est. Toutes les couches, sauf celles formées de roches plutoniennes plus jeunes, présentent une abondance de failles.

L'auteur n'a découvert aucune minéralisation intéressante.

GEOLOGY OF NUELTIN LAKE AND EDEHON LAKE ($W\frac{1}{2}$) MAP-AREAS, DISTRICT OF KEEWATIN

INTRODUCTION

Nueltin Lake and Edehon Lake (west half) map-areas are in the southern part of the District of Keewatin, bordering the Province of Manitoba. The centre of the region is 190 miles northwest of Churchill, Manitoba, 260 miles north-northeast of Lynn Lake, Manitoba, and 155 miles southwest of Eskimo Point, on the Hudson Bay coast. There are no permanent settlements in the areas but some commercial fishing camps operate intermittently on the shores of Nueltin Lake. A small tourist lodge on Nueltin Lake a few miles south of the map-areas is open during the summer months. Lynn Lake and Churchill both have air and rail facilities and air services, available from charter aircraft companies, provides access to the area.

Travel in summer is by float plane, helicopter, or on foot. Small boats and canoes can be used on the larger lakes but with the exception of the Thlewiaza, the rivers are not easily navigable.

Relief may be as much as 325 feet but commonly is less than 100 feet. Pleistocene deposits are extensive throughout the region and rock exposures are generally scarce. From about the middle of Edehon Lake map-area, eastward to Hudson Bay, the region is within the area of postglacial marine overlap, with only rare outcrops projecting through the gently sloping coastal plain.

The Geological Survey mapped this area in 1952 as a part of the geological reconnaissance of southern District of Keewatin (Lord, 1953; Wright, 1967). Lee (1959) described observations on the Pleistocene geology made during this regional study. Aeromagnetic maps covering the region, have been published by the Geological Survey at scales of one inch to one mile and one inch to four miles.

The present work started in 1969 with the assistance of D.S. Pierce, D.P. Smith, R.J. Buchanan, B.D. Calder, and A.J.M. Elliot. The work was completed in 1970 with the assistance of P.L. Broughton, D.H. Waddington, A.W. Lewis, E. Naesgaard, and D.F. VanDine. During the 1969 field season the use of a helicopter for two weeks in the west half of Nueltin Lake map-area provided transportation to otherwise inaccessible localities and in 1970 use of a helicopter for eight weeks facilitated the mapping of the remaining parts of the map-areas. During the summer of 1971, D.W. Flint assisted in the office with compilation of data.

Comments by W.L. Davison, who is familiar with the region, did much to clarify points of uncertainty for which the author is grateful.

GENERAL GEOLOGY

The area is a part of the Churchill Province of the Canadian Shield. The oldest rocks are believed to be metamorphosed volcanic rocks (1), and associated sedimentary rocks (2) which have been metamorphosed to form

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amphibolite (3), paragneiss (4) and some of the granodiorite gneiss (5). All of these rocks, along with most of the granitoid rocks of unit 6, are probably Archean in age. The sediments, metasediments, and associated gabbroic sills, (units 8 to 14) are considered to be Hurwitz Group rocks of Aphebian age. These rocks are intruded by granitic bodies (15) of late Aphebian age. The coarse-grained porphyritic granite to granodiorite (16) is early Helikian (post-Hudsonian orogeny) in age. The youngest rocks in the area are northwest-trending gabbro or diabase dykes (17).

Metavolcanic Rocks (1)

Metavolcanic rocks are present in many places but are most abundant between Fitzpatrick and Tatinnai Lakes, and immediately north of Smith Bay of Nueltin Lake. Meta-andesite to metabasalt is most abundant with some agglomerate, metadiorite to gabbro, quartz latite, and tuff of either andesitic or felsic composition. Pillow structures and, more rarely, flow top breccias are preserved in some places but most of the rocks appear originally to have been massive flow rocks. Pronounced secondary cleavage is pervasive in all rocks of this map-unit.

The meta-andesite to metabasalt is fine grained, dark greyish green to greenish black on both weathered and fresh surfaces, and consists of hornblende, tremolite, chlorite, and altered plagioclase with smaller amounts of epidote, magnetite, biotite, quartz, and sphene. Composition of the plagioclase is difficult to determine due to alteration but where identifiable, it is most commonly andesine and more rarely, labradorite. Small bodies of metadiorite to metagabbro are associated with the flow rocks of similar composition. Lenses of finely bedded (1/8 to 1/4 inch) tuff of andesite composition occur in a few places with the basic volcanic rocks.

Metamorphosed and recrystallized varieties of these rocks are coarser grained and tremolite is replaced by hornblende. Slight alteration of the hornblende to chlorite indicates later retrogressive metamorphism. The metavolcanic rocks in the Tatinnai–Fitzpatrick Lakes region are the least metamorphosed of any of these rocks.

Quartz latite (1a) occurs as unmappable thin flows among the basic volcanics in several localities, but west of Hurwitz Lake a wider band of primarily felsic volcanic rocks has been outlined. Quartz latite is massive and fine grained to very fine grained, white on weathered surfaces, and light green to white on fresh surfaces. It consists of quartz, plagioclase, and minor chlorite, sericite and biotite. Little or no microcline or orthoclase is present. Associated rocks include finely bedded tuff of similar composition, agglomerate consisting of felsic fragments in an andesitic matrix, and flows of andesite.

Two thin bands of finely laminated quartz-magnetite iron-formation (1b) occur with the basic volcanic rocks north of Smith Bay. Anomalies on the aeromagnetic map (Geol. Surv. Can. Map 3167G) suggest the bands may be more extensive than indicated on the geological map. Thin sections of this rock contain approximately 15 to 20 per cent (by volume) magnetite, with quartz and grunerite as the other major constituents.

Greywacke, Greywacke-conglomerate, Argillite, and Phyllite (2)

In the northern part of the region, from Fitzpatrick Lake east to Tatinnai Lake and beyond, rocks of this unit are abundant. Another large area of these rocks is in the south-central part of the region, east and northeast of Trebell Lake, with a smaller area occurring north of Dalpe Lake. These rocks are associated with, and commonly overlie the metavolcanics (1).

The greywacke is massive or thick bedded to thin bedded, medium to fine grained, and grey to greenish grey. Graded bedding is present in many outcrops. Beds of fine-grained argillite, or more commonly, phyllite alternate with the greywacke where it is thin bedded. Scattered pebbles are common in the greywacke and here and there lenses of conglomerate with greywacke matrix are present. The clasts are well rounded, an average of 2 1/2 inches in diameter, but with a maximum diameter of 14 inches. Pink to grey granodiorite to quartz monzonite is most common, particularly among the larger clasts, with barren white quartz pebbles more common in the smaller sizes; less abundant are pebbles of basic metavolcanics and of phyllite or shale. Secondary cleavage is pronounced in these rocks, particularly in the finer grained and more thinly bedded rocks.

The greywacke consists of poorly sorted, subrounded grains of quartz, rock fragments and feldspar – chiefly plagioclase and only minor microcline – in a matrix of fine sericite, chlorite, biotite, quartz, and carbonate grains. The argillite is composed of fine grains of quartz and feldspar in a felt-like mat of sericite, chlorite and biotite shreds.

East from Fitzpatrick Lake to about the west side of Hurwitz Lake, the only obvious sign of metamorphism of the greywacke is the presence of scattered metacrysts of biotite. Farther east, the grade of metamorphism increases and this is reflected by abundantly developed biotite flakes and some hornblende grains. East of Tatinnai Lake the greywacke is completely recrystallized. In the metamorphosed greywacke, there is evidence of retrogressive metamorphism with chlorite alteration of hornblende and biotite.

The greywacke east of Trebell Lake is recrystallized and metamorphosed with development of biotite and hornblende grains. In some of these rocks, cummingtonite accompanies common green hornblende. The greywacke adjacent to granite – quartz monzonite (15) plutons has undergone contact metamorphism and contains abundant sillimanite and andalusite and minor garnet. In some of the contact metamorphosed greywacke rutile is an abundant accessory mineral. In the extreme eastern part of this belt, in some beds adjacent to the pluton, diopside is abundant, resulting from contact metamorphism of carbonate-rich beds. Narrow bands of paragneiss, too small to show on the map, separate the metasedimentary rocks and the intrusive plutons.

North of Dalpe Lake, greywacke is regionally metamorphosed with some recrystallization and development of biotite and hornblende grains. The original bedding is clearly visible in these rocks in spite of the recrystallization.

Lenses of laminated quartz-amphibole-magnetite iron-formation (2a) are present within the greywacke at several places, on the northeast shore of Tatinnai Lake, about eight miles north of Dalpe Lake, and about nine miles northeast and five miles east-northeast of Trebell Lake. White to light grey, 1/8- to 1/2-inch thick quartz-rich bands alternate with equally thin grey to black bands that are rich in magnetite and amphibole. The rocks are fine to medium grained, the latter being more recrystallized and metamorphosed.

Magnetite content in the available thin sections of these rocks ranges from 15 to 30 per cent. A small area of iron-formation (2a), much recrystallized, occurs within paragneiss (4), just south of Thlewiaza River, in the western part of Edehon Lake map-area.

The iron-formation on the northeast shore of Tatinnai Lake is reflected by a minor anomaly of small length and width on the aeromagnetic map (Geol. Surv. Can. Map 3186G) suggesting that this is a small lens with low magnetite content. On map 3155G, the iron-formation northeast of Trebell Lake results in a moderate anomaly of restricted length. South of the above lens, the iron-formation east of Trebell Lake results in a major anomaly on map 3140G and continuation of the anomaly suggests the iron-formation may extend farther south into the northern part of Baralzon Lake, an extension that is greater than that indicated on the geological map. An extremely high but localized anomaly visible on map 3169G corresponds to the iron-formation north of Dalpe Lake. Iron-formation there is more metamorphosed and recrystallized, and the coarser grain size of the magnetite may account for the resulting anomaly.

Amphibolite, Amphibolite Gneiss, Metagabbro (3)

Metamorphic rocks of this unit contain at least 50 per cent hornblende or altered hornblende, with plagioclase (labradorite to andesine) the other major constituent. They grade into basic metavolcanic rocks (1) and also into rocks equivalent to hornblende granodiorite gneiss (5a). The rocks are typically dark green to greenish black, medium to fine grained, and some of their mineral grains have a preferred orientation. Although normally massive, compositional layering is evident in some of the rocks and secondary cleavage is present in some places.

Small reddish brown garnets are a common accessory mineral in the amphibolite on both the east and west sides of Nueltin Lake, near Smith Bay. In one of the amphibolite bands southeast of Tatinnai Lake the rock contains as much as 12 per cent quartz in a few places, but this is atypical of the normal amphibolite.

Retrogressive metamorphism of a regional type has affected some of the amphibolite, for example east and southeast of Tatinnai Lake. In this rock tremolite has replaced hornblende. The amphibolite east of Sealhole Lake, adjacent to the granite (16) pluton is strongly sheared and tremolitized, an effect considered to be related to the intrusion of the granite.

In this unit (3), a few rocks possess a subophitic texture rather than the typical granular texture of the amphibolites; in these, minor remnants of augite are common. These rocks are considered to be metagabbros. The small area of unit 3, just east of Baralzon Lake is metagabbro and should possibly be included in unit 11a, the metamorphosed gabbro of the Hurwitz Group.

Melanocratic gneiss (3a) occurs only in one small area east of the south end of Hearne Bay, Nueltin Lake. This dark coloured, medium-grained, well foliated rock is composed of plagioclase, biotite and hornblende with some quartz and tremolite and minor hypersthene. The tremolite is secondary after hypersthene. Concordant and discordant bands and stringers of pink granite-pegmatite that cut the rock constitute approximately 10 per cent of the rock mass.

Chlorite schist (3b) occurs in a thin band of limited extent southeast of Sealhole Lake. The rock is dark green, fine to medium grained, and consists of chlorite and altered plagioclase with some tremolite. Chlorite grains oriented parallel to closely spaced cleavage planes account in part for a prominent schistosity.

Two small areas of metamorphosed ultrabasic rock (3c) have been outlined, one five miles north of Dalpe Lake, occurring within metagreywacke (2) and the other seven miles northeast of Dalpe Lake, within amphibolite (3). At the former locality the rock is medium to coarse grained, dark green to greyish green, poorly foliated and consists for the most part of actinolite, with magnetite, chlorite, diopside, and augite remnants. The other ultrabasic body, occurring in amphibolite, consists of diopside, antigorite, anthophyllite, magnetite, actinolite and remnants of olivine. On aeromagnetic maps both occurrences of ultrabasic rock are reflected by significant anomalies.

A few narrow bands of metamorphosed ultrabasic rock occur within the amphibolite band approximately six miles east of the south end of Tatinnai Lake but they are too small to be shown on the map at the scale of mapping.

Much of the amphibolite is probably derived from basic metavolcanic rocks equivalent to unit 1 and the metagabbro is derived from gabbro equivalent to that in unit 1 or possibly from basic dykes and sills older than those of unit 7. The amphibolite with higher than normal quartz content could be derived from tuff that is in part felsic. Some amphibolite could represent metamorphosed calcareous sediments but the rarity of calcareous beds among rocks of unit 2 in these map-areas and the absence of features consistent with derivation from the more calcareous Hurwitz Group rocks, make such an origin unlikely.

Paragneiss, Paraschist, Meta-arkose, and Granulitic Paragneiss (4)

Paragneiss, with minor paraschist (4) is abundant in the northern half of Edehon Lake map-area and the western half of Nueltin Lake map-area. The grey, medium-grained paragneiss is typically well banded, in bands 1/2 inch to 4 inches thick. Banding is probably a relict of bedding. Pegmatitic to medium-grained granite is present in the paragneiss as stringers parallel to the banding or as dykes and crosscutting masses of irregular shape. Variable amounts of quartz, plagioclase (usually oligoclase) and biotite are normally the main constituents, with the addition of common green hornblende in some of the paragneiss in Edehon Lake map-area. Chlorite alteration on the margins of some biotite and hornblende grains indicates slight alteration. Porphyroblasts of feldspar are common, and garnet metacrysts occur in some rocks of this unit. Cordierite is present here and there but is not an essential mineral in the paragneiss. Apatite is an accessory mineral in nearly all of the rocks. Biotite-rich paraschist, present as bands or lenses in the paragneiss, is a minor part of the unit.

In paragneiss adjacent to amphibolite (3) southeast of Tatinnai Lake and in the paragneiss six miles northeast of the north end of Edehon Lake, dark coloured bands contain up to 10 per cent grunerite.

Meta-arkose bands, rich in plagioclase, occur within the paragneiss, particularly in the belt 6 miles southwest of and parallel to Edehon Lake. Quartz-rich paragneiss is uncommon although just north of Smith Bay, Nueltin Lake, the paragneiss underlying quartzite (9) has some bands containing up to 80 per cent quartz.

Paragneiss adjacent to plutons of granite to quartz monzonite (15) has undergone some contact metamorphism. Close to the plutons much microcline, some in the form of large porphyroblasts, is present in the paragneiss and is probably the result of metasomatism. Cordierite or andalusite, the latter partly altered to sillimanite, are commonly present and abundant fine tourmaline needles are also typical of these rocks. In the paragneiss between the two porphyritic granite (16) plutons on the west side of Nueltin Lake, sillimanite and fine grains of green spinel are present.

The rocks of unit 4 are in the amphibolite facies of regional metamorphism and locally have been affected by contact metamorphism as well.

The paragneiss of unit 4 is derived for the most part from rocks equivalent to the greywacke-argillite assemblage of unit 2. Grunerite-bearing paragneiss is derived from more iron-rich rocks of the type associated with iron-formation (2a). In paragneiss just north of Thlewiaza River, close to the eastern boundary of the mapped part of Edehon Lake map-area, some diopside-rich layers are derived from carbonate-rich rocks. Some of this paragneiss may belong to unit 14, i.e., may be derived from the Hurwitz Group sedimentary rocks which are carbonate-rich. Within the map-areas, the rocks of unit 2 that are preserved rarely contain carbonate-rich bands.

North of Smith Bay, paragneiss (4), which on the geological map separates granodiorite gneiss (5) and undifferentiated Hurwitz Group (13), is of uncertain origin. Outcrops are scarce, hence data are lacking. It is most probable that the paragneiss is derived from rocks equivalent to those of unit 2 and that it grades into granodiorite gneiss (5) on the west and is in fault contact on the east with undifferentiated Hurwitz Group (13). However, there is a possibility that this band of paragneiss is unit 14, i.e., it may be derived from Hurwitz Group rocks, which in turn implies a gradational contact on the east with unit 13 and a faulted contact on the west with granodiorite gneiss (5). Absence of calc-silicate bands in the outcrops found suggests the paragneiss is not derived from Hurwitz Group rocks.

Meta-arkose (4a) occurs in one band trending east to northeast in the southwest corner of Nueltin Lake map-area. It continues westward into the adjoining Ennadai Lake map-area (Eade, 1971). The medium-grained grey rock is in beds 1 to 3 inches thick and consists of 40 to 60 per cent quartz, 30 to 40 per cent plagioclase and minor biotite, diopside or tremolite-actinolite. Although recrystallized, the outlines of some of the original rounded grains are visible in thin sections. Strong secondary cleavage is present here and there. Abundant pink quartz-feldspar pegmatite or coarse-grained granite stringers, probably related to the nearby granite (16) pluton, cut the meta-arkose.

Hypersthene-bearing paragneiss (4b) is present in the southwest quarter of Nueltin Lake map-area, between Laderoute Lake and Nueltin Lake and on the northwest side of DeBartok Lake. A longer band of these rocks, trending east-west, occurs in the southern part of Edehon Lake map-area. Banding is also typical of the hypersthene-bearing paragneiss although it is less prominent than in paragneiss (4). The weathered surface is typically rusty brown and the fresh surface grey to dark greenish grey. Quartz, plagioclase and biotite are major constituents, typically accompanied by hypersthene. Hornblende, garnet, and sillimanite are less common. The plagioclase in the granulitic paragneiss commonly has a greenish colour and a greasy lustre. In thin sections, the biotite of these rocks is a distinctive "foxy red" colour. Abundant stringers and irregular masses of pegmatite or granite cutting the granulitic paragneiss compose as much as 20 per cent of the rock in Edehon Lake map-area but in Nueltin Lake map-area much less pegmatite and little or no granite is present. Mineral assemblages of the gneiss are characteristic of the hornblende-granulite subfacies, that is, the lower part of the granulite facies of metamorphism.

Granodiorite Gneiss (5)

Biotite granodiorite gneiss is abundant in Nueltin Lake map-area, particularly in the central and southern parts, but is of limited extent in Edehon Lake map-area. These grey to pinkish grey rocks are medium grained, and well foliated with concentrations of biotite in alternating bands. Texture of the rocks is characteristically granular but in some places it is interlocking. Quartz, oligoclase and biotite in variable concentrations are the main constituents. Hornblende, in addition to biotite, is present from place to place but there is no significant pattern to the distribution of the mineral. Microcline occurs in small amounts in practically all of these rocks but close to contacts with some plutons or bands of quartz monzonite (6) microcline content increases, foliation is less evident and the composition becomes quartz monzonite. Garnet, epidote, or muscovite are present here and there in the granodiorite gneiss and magnetite, apatite, zircon and sphene are accessory minerals. Slight alteration of biotite to chlorite and plagioclase to clinozoisite and epidote is common. Scattered mafic-rich schlieren or xenoliths of amphibolite or biotite-rich gneiss occur in the granodiorite gneiss. Rocks of this unit are in the staurolite-almandine subfacies of the almandine-amphibolite facies of metamorphism (Turner and Verhoogen, 1960). The additional microcline present, close to contacts with quartz monzonite (6), results from metasomatism associated with the plutons.

Granodiorite gneiss near contacts with plutons of porphyritic granite (16) contain more microcline than is normal, due to metasomatism, considerable sericite, and close to the contact shearing of the gneiss is typical. Granodiorite gneiss on the island in Nueltin Lake just north of the entrance to Smith Bay contains in addition to microcline and sericite, abundant sphene and scattered fluorite grains. Glacial drift and water cover all the area near the island outcrop but aeromagnetic maps of this locality suggest that the granodiorite gneiss is marginal to a small circular pluton with a pronounced aeromagnetic expression, possibly fluorite-bearing granite (16).

Direct evidence of the origin of the grey biotite granodiorite gneiss is lacking but the composition of some xenoliths and the prominent banding suggest many of these rocks are derived from quartzofeldspathic and pelitic sedimentary rocks through metamorphism and metasomatism. Some of the rocks, with vague banding could be orthogneisses.

Contact zones of granodiorite gneiss (5) with massive granodiorite to quartz monzonite (6) are of two types: one, a gradual transition from foliated gneisses to massive rock and the other an intrusive contact with massive, acidic granodiorite cutting the gneiss and inclusions and bands of the gneiss occurring within the massive granodiorite.

Hornblende-biotite granodiorite gneiss (5a) is outlined on the map only in one area, north of Smith Bay, Nueltin Lake. The rock is dark grey to greenish grey and contains abundant inclusions and schlieren of amphibolite or metagabbro. Foliation takes the form of discontinuous streaks and inclusions of mafic material, unlike the banded granodiorite gneiss of unit 5b. Hornblende constitutes between 12 and 20 per cent of the rock and biotite is less abundant. The contacts of the gneiss with metavolcanic rocks (1) and amphibolite (3) are transitional and the gneiss appears to be derived from assimilation or metasomatism of basic rocks by acidic material.

Banded gneiss of granodiorite composition (5b) occurs on the east side of Nueltin Lake just north of the mouth of Hearne Bay and in two small areas in Edehon Lake map-area, one southwest of Edehon Lake, and the other east of Tatinnai Lake and south of the Tha-anne River. Pronounced compositional banding is typical of the gneiss with light grey to white felsic bands and dark grey to black mafic-rich bands. Bands range in width from 1/2 inch to 36 inches but average around 8 inches. Quartz, plagioclase and biotite, in various proportions, are the main constituents with minor hornblende, garnet, or cordierite in places. The lighter bands may contain as much as 60 per cent feldspar but this is unusual. The banded gneiss in some localities is very similar to and in gradational contact with paragneiss (4), and the pronounced banding may be relict bedding. Elsewhere, the texture of the banded gneiss and vague contacts of the bands suggest that metamorphic differentiation and metasomatism may have been responsible for the banding.

Pyroxene-bearing granodiorite gneiss (5c) is present in a large area in the southern part of Edehon Lake map-area and in several small areas in Nueltin Lake map-area. Foliation ranges from a pronounced banding in some places to a vaguely foliated almost massive appearance elsewhere. The rock is medium grained, dark grey to greenish grey on fresh surfaces and is commonly rusty brown on weathered surfaces although some of the more massive rocks are white on weathered surfaces. Quartz, plagioclase (oligoclase to andesine), biotite hypersthene, and hornblende are the essential constituents although hornblende is not always present. Microcline is a minor constituent and apatite and magnetite are accessory minerals. In Edehon Lake map-area the rocks are marked by alteration of hypersthene to hornblende and biotite to chlorite. Pegmatite and granite (15) in stringers and irregular masses cut the pyroxene-bearing gneiss in Edehon Lake map-area and comprise as much as 25 per cent of the outcrop in some places. In Nueltin Lake map-area only minor pegmatite stringers cut the gneiss and alteration of the gneiss is slight.

In Nueltin Lake map-area, the contact of pyroxene-bearing gneiss (5c) with granodiorite gneiss (5) is gradational, as hypersthene and the typical greenish colour of plagioclase disappears.

Except for its higher grade of metamorphism the pyroxene-bearing gneiss is considered to be equivalent to other gneisses of unit 5.

A small area of gneiss ranging in composition from diorite to granodiorite (5d) north of Sealhole Lake in Nueltin Lake map-area is more basic in composition than is the normal granodiorite gneiss. It is well lineated but poorly foliated, is medium grained, and is dark grey on fresh surfaces and grey or rusty brown on weathered surfaces. Plagioclase, hornblende, pyroxene and quartz are essential constituents but quartz content is variable from place to place. In one specimen examined in thin section both augite and hypersthene are present. The relationships of this gneiss with normal granodiorite gneiss (5) and with pyroxene-bearing gneiss (5c) are not known.

Quartz Monzonite to Granite with Minor Granodiorite (6)

Rocks of this unit are distributed throughout much of Nueltin Lake map-area but are confined to the northern part of Edehon Lake map-area. Some rocks included in this unit may belong in unit 15 which is similar in composition and whose rocks have many similar characteristics. Quartz monzonite to granite (6) is typically massive but here and there vague foliation due to alignment of mafic minerals is present. In the northern part of Edehon Lake map-area and the adjoining part of Nueltin Lake map-area, south and southeast of Hurwitz Lake, pinkish grey biotite quartz monzonite constitutes most of this unit with granodiorite composition in a few places. Hornblende and epidote are scattered throughout these rocks. Commonly a minor amount of sericite or muscovite is present in the quartz monzonite, and chlorite alteration of the biotite is prevalent.

The large pluton in the central and southern part of Nueltin Lake map-area ranges in composition from quartz monzonite to granite. This pink rock has fresh biotite as an essential constituent and hornblende is rarely present. In smaller plutons of this unit in Nueltin Lake map-area quartz monzonite is the usual composition, with variation to granodiorite in some places.

Most plutons of quartz monzonite to granite have sharp contacts with adjacent rocks and only slight mixing and assimilation. Several smaller concordant bodies, such as those north of Smith Bay, have gradational contacts with granodiorite gneiss (5) and there is much mixing. Similarly, the small mass of granodiorite to quartz monzonite (6) cutting greywacke (2) west of Hurwitz Lake, contains abundant partially assimilated inclusions of greywacke.

Foliated quartz monzonite to granodiorite (6a) occurs in three general areas of Nueltin Lake map-area. In the northeast corner of the area pink quartz monzonite, varying to granodiorite in composition, has a vague foliation due to alignment of the biotite. Commonly the rock is acidic and some muscovite or sericite accompanies the biotite. In the southwest part of Nueltin Lake map-area the large area of unit 6a consists of pinkish grey foliated granodiorite ranging to quartz monzonite, and containing some bands of granodiorite gneiss (5). A prominent subhorizontal sheeting or jointing is characteristic of these rocks. The alignment of scattered gneiss inclusions and of biotite flakes accounts for the foliation in the rocks. Biotite is more abundant than in the previously described rocks (6a), in the northeast corner of Nueltin Lake map-area, and scattered hornblende grains are also present.

Along the southern boundary, in the central part of Nueltin Lake map-area, the pinkish grey foliated biotite-hornblende quartz monzonite (6a) typically contains abundant white or pink feldspar phenocrysts.

Quartz monzonite to granodiorite containing abundant inclusions or bands (6b) is outlined only in Nueltin Lake map-area – in the northwest corner, in the southeast quarter, and in two small areas, one north of Dalpe Lake and the other on the west side of the lake. Inclusions of granodiorite gneiss are abundant and in the Dalpe Lake areas inclusions of metagabbro or amphibolite occur also. Greyish pink quartz monzonite is the common matrix in these mixed rocks. At their margins, the inclusions and bands are partially assimilated by the quartz monzonite.

Granodiorite containing bands and inclusions of amphibolite (6c) occurs south of Hurwitz Lake. The rocks are similar to (6b) except that all the inclusions are basic rocks.

Quartz diorite to granodiorite (6d), between the north end of Nueltin Lake and Sealhole Lake, is a medium grained dark grey to greenish grey rock that is massive nearly everywhere. Plagioclase (andesine to oligoclase) comprises 60 to 70 per cent of the rock, with minor microcline and up to 20 per cent quartz. Biotite is the usual mafic mineral with hornblende accompanying it in a few places. Close to the granite (16) pluton, the quartz diorite to granodiorite contains abundant epidote and the biotite is almost completely altered to chlorite.

Metagabbro Dykes (7)

North to northeast trending metagabbro dykes (7) are rare in the two map-areas. In Nueltin Lake map-area, short segments of these dykes cut granodiorite gneiss (5) in the southwest corner, and foliated granodiorite (6a) on the east side of Smith Bay and in the northwest corner of the area. East of Tatinnai Lake, in Edehon Lake map-area, dykes cut granodiorite (6), banded gneiss (5b) and amphibolite (3). The longest observed dyke has been traced for six miles. Dykes range in width from 75 to 110 feet. The rocks consist of plagioclase (andesine to labradorite composition), hornblende and biotite, with accessory apatite and magnetite. The original diabasic texture has been modified by recrystallization but relict diabase texture is preserved in a few places. Some dykes are porphyritic and contain phenocrysts of altered feldspar up to 1/2 inch long. Presence of these dykes is not reflected by a recognizable pattern on aeromagnetic maps.

Hurwitz Group (8-14)

The sedimentary rocks (8, 9, 10, 12), gabbro sills (11), undivided argillite, gabbro and dolomite (13) and the metamorphosed equivalents including paragneiss and paraschist (14), are considered to be part of the Hurwitz Group. Rocks of these units occurring between Sealhole Lake and Hurwitz Lake are contiguous to or in part continuous with type Hurwitz Group rocks in Kognak River map-area (Eade, 1964, 1966) and along with those present near the head of Smith Bay, Nueltin Lake and in the northwest corner of Nueltin Lake map-area, were previously (Lord, 1953; Wright, 1955, 1967) mapped as Hurwitz Group. The many scattered occurrences of rocks included in the Hurwitz Group on the present map were not considered to be Hurwitz Group on the basis of the earlier reconnaissance mapping (Lord, 1953; Wright, 1955, 1967). The more detailed data on lithology and stratigraphic associations now available indicate a correlation with the Hurwitz Group.

Greywacke-conglomerate, Greywacke, Protoquartzite (8)

The basal unit of the Hurwitz Group, present in some places only, consists of a varied succession of greywacke-conglomerate, greywacke and protoquartzite. North and west of Fitzpatrick Lake it unconformably overlies metavolcanics (1) or greywacke (2). It occurs in discontinuous layers, however, for in the same locality quartzite (9) overlies the older rocks and unit 8 is absent.

The medium-grained, grey, thin to thick bedded greywacke consists of subangular to subrounded, poorly sorted, clastic grains of quartz, rock fragments and some feldspar in an abundant matrix composed of sericite, opaques and fine quartz grains. Rounded pebbles up to 3 inches in diameter, most commonly of granodiorite, granodiorite gneiss and white quartz, are scattered throughout or form rare small lenses of conglomerate.

At two localities in Edehon Lake map-area, one 6 miles and the other 22 miles southwest of Edehon Lake, rocks occur that are considered to be equivalent to this unit. At the former locality the unit is more arkosic than the previously described type and is also more noticeably metamorphosed with development of biotite metacrysts in the matrix. It contains pebbles and cobbles of granodiorite and white quartz and, as in the northern area, orthoquartzite overlies it conformably. In the occurrence 22 miles southwest of Edehon Lake, the rock is lithologically similar to the northern occurrences, although slightly metamorphosed. The rocks unconformably overlie greywacke (2) but no overlying units are preserved, i.e., units 9-13.

Secondary cleavage is present in rocks of unit 8 between Fitzpatrick and Hurwitz Lakes but it is not as pronounced as it is in the adjacent greywacke of unit 2. The lack of argillite bands, less prominent cleavage, and regional discordance of the rocks of unit 8 distinguish them from the adjacent and lithologically similar rocks of unit 2.

Quartzite, Orthoquartzite (9)

White to light grey quartzite or orthoquartzite is glassy, fine, or medium grained and is composed of at least 85 per cent quartz. Scattered feldspar grains and sericite matrix, with rare biotite and magnetite, are other constituents. In outcrop, it is almost impossible to distinguish orthoquartzite from quartzite. Although in places it is thin bedded (3/4 to 1 1/2 inches) most of the rock is thick bedded to massive. Ripple-marks are present in some of the thin-bedded quartzite. The original clastic texture of the rock is in most places almost completely obscured by recrystallization or by crushing of the grains accompanying the secondary cleavage. The orthoquartzite on the south side of Smith Bay is completely brecciated and recemented by secondary quartz. In many outcrops of these rocks it is difficult to determine bedding planes if ripple-marked surfaces cannot be found.

Six miles southwest of Edehon Lake, rocks included in this unit contain minor tremolite and scattered grains of diopside and carbonate. This is the only locality where calc-silicate or carbonate minerals occur in the quartzite.

Five miles north of Fitzpatrick Lake measurements on ripple-mark orientation, after corrections for structural dislocation, show a northeast trend of the ripple crests and asymmetry of the ripples indicates transport from the southeast to the northwest. This was the only locality in the map-areas where a sufficient number of ripple-marks were found to warrant measurement. Crossbedding was not observed anywhere in these rocks.

Within the quartzite sequence east of Fitzpatrick Lake there is a thin greywacke member (9a) that is not present elsewhere. The greywacke is medium grained with scattered pebbles and cobbles up to 14 inches in diameter but normally between 2 and 4 inches. Granodiorite and pure white quartz or quartzite clasts are most abundant but some are fine-grained chloritized basic rock. The greywacke consists of poorly rounded and poorly sorted grains of quartz, rock fragments, chlorite, and minor feldspar in a fine matrix of sericite, chlorite, and quartz. Some biotite metacrysts are present. Below the greywacke member is a 10-foot section of orthoquartzite in beds 2 to 10 inches thick interlayered with thinner bedded fine-grained argillite. The argillite is composed of subangular to subrounded grains of quartz and rock fragments, the latter mostly quartzite but some of chloritized basic rock, all in a matrix of fine sericite. The greywacke to pebbly greywacke (9a) is a lens of limited extent within the quartzite.

Argillite and Phyllite (10)

Argillite and phyllite, with intercalated limy beds, minor shale, siltstone, and greywacke overlie the quartzite (9). On the accompanying geological maps these rocks are for the most part included in an undivided unit (13) but in a few places they are separated. The rocks are fine grained and finely bedded, grey to dark grey in colour and consist of quartz, sericite and chlorite with varying amounts of carbonate. Scattered feldspar grains are present and magnetite is an abundant accessory mineral. Thin beds of limestone or dolomite are interbedded with the argillite. Secondary cleavage in the fine-grained argillaceous rocks distinguishes the phyllites. In a few places beds of medium-grained greywacke or very fine grained siltstone occur with the argillite.

On the north shore of Windy River, near where it flows into Smith Bay, beds ranging in thickness from 3 to 10 inches, and containing 20 to 25 per cent magnetite are interlayered with greywacke. Quartz is the major constituent of these rocks, with minor carbonate and epidote and some biotite. Such magnetite-bearing beds are not common in this unit.

At the south end of Sealhole Lake in addition to the argillite and phyllite with interbedded limestone, some black to green slate and siltstones are present in the lower part of the unit. In Kognak River area to the north (Eade, 1966), slate, shale and siltstone, overlying the orthoquartzite constitute a mappable rock unit but in this area they have only been found around Sealhole Lake, and are included in the undivided Hurwitz Group (unit 13).

North of Hearne Bay, a small area of rocks is included in unit 10 because of the lithology – finely bedded fine-grained argillite or phyllite with interbedded dolomite. These rocks appear to be preserved in a downdropped fault block. The designation of these rocks as unit 10 is based solely on lithology as no rock types accompany them comparable with other units of the Hurwitz Group.

Gabbro Sills (11)

Gabbro (11) and metagabbro (11a) sills occur within the rocks of unit 10 in many places in Nueltin Lake map-area and at one place in Edehon Lake area. The sills are discontinuous, at least in outcrop, and it is unlikely they represent segments of a single gabbro sill. The dark green to black gabbro is medium grained but near the margins is fine grained. Hornblende, much altered to chlorite, and plagioclase (andesine to labradorite), partly altered to epidote and clinozoisite, are the major constituents with minor magnetite, biotite, and quartz. Uralitization of the pyroxene is typical of these rocks. The metagabbro (11a) is recrystallized to a granular texture; it contains more biotite, and the metacrysts of hornblende contain inclusions of feldspar, magnetite, biotite and quartz.

Neither the gabbro nor metagabbro of this unit results in anomalies or distinctive patterns on the aeromagnetic maps.

Dolomite and Limestone with Interbedded Argillite or Phyllite (12)

Carbonate rocks with some argillaceous interbeds conformably overlie unit 10, as in the type section of the Hurwitz Group in Kognak River map-area (Eade, 1964, 1966), at the south end of Sealhole Lake and at the head of Smith Bay (both localities in Nueltin Lake map-area). At Sealhole Lake the rocks are dominantly thin- to thick-bedded dolomite with only minor limestone and thin argillite interbeds. There is little evidence of metamorphism. In the vicinity of Smith Bay and Windy River, dolomite and limestone are equally abundant, with some argillite to phyllite interbeds. The presence of minor diopside and tremolite-actinolite indicates slight metamorphism of the rocks.

On the islands at the head of Smith Bay quartz-magnetite beds are interbedded with dolomite (12a). Up to 20 per cent magnetite occurs in some beds with abundant quartz, and some biotite, carbonate and epidote. These magnetite-bearing beds result in anomalies that are readily recognizable on the aeromagnetic maps.

In the Hurwitz Group rocks that occur in the central and southern parts of Nueltin Lake map-area no mappable carbonate units were found. Carbonate rocks or their metamorphosed equivalents are present in quantity but they are more interbedded with argillaceous beds than is the case in unit 12, and are included in undivided Hurwitz Group (13). It is possible that the only rocks preserved or occurring in outcrop are equivalent to those near the transitional contact of units 10 and 12 or it is possible that mixed carbonate and argillaceous rocks in the southern part of the basin of deposition of Hurwitz Group rocks, may be stratigraphical equivalents of the thick carbonate beds of the northern part of the basin.

Undivided Hurwitz Group (13)

In most parts of the two map-areas, units 10-12 of the Hurwitz Group rocks are not separable in mapping. As suggested above, it is possible that the characteristics of units 10 and 12 change southward and that no predominantly carbonate unit was deposited there.

Metamorphism has affected most of the Hurwitz Group rocks in the central and southern parts of the map-areas and the rocks are included in unit 13a, the metamorphosed undivided rocks. An exception are the rocks about 20 miles east of McAleese Lake, which are placed in unit 13; even there some of the rocks are metamorphosed, and could be placed in unit 13a. In the metamorphosed rocks, although bedding is prominent, recrystallization of minerals is pervasive. In the argillaceous rocks biotite metacrysts are prominent, hornblende is present in some, and where metamorphism has attained a higher grade, one or more of the minerals cordierite, andalusite and sillimanite may be present. Carbonate beds are converted to coarsely crystalline limestone or a mixture of diopside, actinolite, and carbonate. In places, rocks of unit 13a become paragneiss to paraschist with interbedded calc-silicate layers.

It is difficult to determine how much of the metamorphism that affected the rocks of the Hurwitz Group is regional metamorphism and how much is contact metamorphism associated with plutons of granite to quartz monzonite (15). It is probable that there was considerable regional metamorphism prior to intrusion of the plutons. In thin sections from a number of specimens of rocks in this unit fine needles of tourmaline, suggestive of contact metamorphism, are distributed across the boundaries of grains of the metamorphic minerals.

Paragneiss, Paraschist, with Calc-silicate Bands (14)

The distinction between paragneiss and paraschist derived from Hurwitz Group rocks, unit 14, and paragneiss with some paraschist derived from Archean greywacke and argillite, (unit 4), is a major problem. If quartzite (9), which is not greatly altered in appearance by metamorphism, is present, then stratigraphic position of the paragneiss relative to the quartzite provides a key. If unit 9 is absent or its relations to the paragneiss obscure, then definition of the paragneiss is difficult. As unit 2 contains few or no carbonate beds in these map-areas, and as Hurwitz Group units 10, 12, and 13 do, then if otherwise indeterminate paragneiss contains calc-silicate bands it is assumed to be metamorphosed Hurwitz Group (14).

Rocks of unit 14 are derived from those equivalent to unit 13 and where the two are in contact, as in the extreme eastern part of the mapped portion of Edehon Lake map-area, the contact is gradational. The paragneiss to paraschist is medium grained to fine grained, banded or bedded, and consists of quartz-plagioclase-biotite or quartz-plagioclase-hornblende. Interlayered are bands of diopside-hornblende-quartz-plagioclase, with the diopside commonly partially altered to tremolite-actinolite. Garnets occur only here and there in these rocks.

In the western part of Nueltin Lake map-area, near the head of Smith Bay, small areas of unit 14 occur infolded with quartzite (9). On the west side of Smith Bay well banded quartz-plagioclase-biotite-garnet paragneiss is interbanded with quartz-plagioclase-diopside-hornblende gneiss. On the east side of Smith Bay banding is less evident and the rock consists of quartz-plagioclase-biotite-sericite layered gneiss to granodiorite gneiss. At the latter locality some microcline appears to have been introduced.

An area of paragneiss at the south border of the Nueltin Lake map-area, in the southeast quarter, is considered to be equivalent to Hurwitz Group rocks although no quartzite is present. In part, the rocks are well stratified with quartz-plagioclase-hornblende gneiss alternating with diopside-quartz-hornblende gneiss. Elsewhere, massive to poorly banded hornblende-plagioclase-quartz rock (i.e., quartz-bearing amphibolite) is typical. All of these rocks are derived from interbedded argillite and carbonate and massive argillaceous carbonate rocks.

In the central-western part of Edehon Lake map-area, on the Thlewiaza River, a small area of paragneiss (14) is surrounded by older paragneiss (4). No quartzite is present but the rocks designated as unit 14 contain abundant calc-silicate bands.

The band of paragneiss (14) across the boundary of Nueltin Lake and Edehon Lake map-areas at 60°30'N is bounded on the west by a fault separating it from the metamorphosed undivided Hurwitz Group rocks (13a). To the south, quartzite (9) separates the paragneiss and younger intrusive granite to quartz monzonite (15) and (15b) and the paragneiss is cut by small bodies of granite pegmatite (15c). Both regional metamorphism and contact metamorphism associated with the younger granite have affected the paragneiss. In some places in the paragneiss and associated calc-silicate bands, abundant tourmaline related to the contact metamorphism, is present. Limestone is completely converted to tremolite-actinolite which is cut by veins of asbestiform actinolite and at one locality is as much as 6 inches wide. Scattered flecks of graphite occur in the tremolite-actinolite rock.

Granite, Quartz Monzonite (15)

Pink to red medium-grained felsic granite to quartz monzonite (15) is the most abundant rock type in Edehon Lake map-area but only extends into the extreme eastern part of Nueltin Lake map-area. The low mafic content, commonly less than 5 per cent, is characteristic of the rock and the mafic mineral is nearly everywhere biotite. In the pluton extending into Nueltin Lake map-area just south of 60°30'N, hornblende rather than biotite is present. Accessory magnetite is present nearly everywhere but apatite and zircon are rare accessory minerals. The biotite in these rocks is slightly altered to chlorite, probably a form of deuteric alteration or perhaps a later retrogressive metamorphism. Here and there within the plutons assimilation of inclusions results in higher mafic content and some compositional change. For example, the quartz monzonite west of Baralzon Lake, in the southeast corner of Nueltin Lake map-area, contains hornblende, diopside and minor carbonate as well as biotite at one locality.

White to light grey granodiorite (15a) occurs in a single elongate pluton intruding paragneiss (4) and meta-arkose (4a) in the southwest corner of Nueltin Lake map-area. The rock is massive to slightly foliated, medium- to coarse-grained, normally equigranular but porphyritic in some places, and has a distinctive chalky white weathered surface. Biotite is the normal mafic mineral although accompanied by minor hornblende here and there. Scattered garnets and fine needles of sillimanite are present in the rock, probably the result of assimilation of paragneiss. Tourmaline is an abundant accessory mineral. Near the contacts of the pluton, inclusions of paragneiss and meta-arkose occur in the granodiorite.

Parts of some large plutons of granite to quartz monzonite which contain abundant inclusions and bands of other rock types have been separated as unit 15b. These are zones within the large plutons that probably represent partially assimilated roof pendants, and are more extensive than the narrow mixed zones found along contacts elsewhere. Inclusions of biotite granodiorite gneiss (5) are most abundant but in the southwest corner of Edehon Lake map-area inclusions in unit 15b are recognizable as derivatives of pyroxene-bearing granodiorite gneiss (5c) although they have since undergone retrograde metamorphism to amphibolite facies rocks.

Twelve miles east of Longpre Lake, unit 15b contains remnants and bands of paragneiss and quartzite derived from Hurwitz Group rocks. The quartzite (9) band just south of the rocks of unit 15b is cut by stringers of granite to quartz monzonite, as is the nearby granodiorite (6).

With the exception of quartzite inclusions, the inclusions in unit 15b characteristically contain abundant introduced microcline and some sericite.

Small masses of granite pegmatite (15c) cut paragneiss (14) and greywacke (2) in the eastern part of Nueltin Lake map-area. The pegmatite is white to pink and contains only quartz and feldspar with minor muscovite and black tourmaline.

Granite to Quartz Monzonite (16)

Coarse-grained, porphyritic granite to quartz monzonite (16), informally named the Nueltin Lake Granite by Wright (1967), is present in the western half of Nueltin Lake map-area. Outcrops of these rocks commonly have a very heavy black lichen cover. The red to pink or rarely grey, rock contains microcline phenocrysts up to 2 1/2 inches long with 1 inch being the average size. Two distinctly different types of quartz are always present, clear or white and dark smoky or bluish. Microcline, present as both phenocrysts and in the groundmass, is normally more than two-thirds of the total feldspar content but in parts of some plutons plagioclase constitutes as much as 50 per cent of the total feldspar. Biotite is the typical mafic mineral but hornblende accompanies the mica in some of these rocks. In a single specimen from the pluton east of Nueltin Lake, minor augite occurs with biotite and hornblende. Purple fluorite, in fine to coarse grains, is a characteristic accessory mineral but is absent from the pluton east of Nueltin Lake and rare in the pluton south of Hearne Bay. Apatite, zircon, magnetite, and sphene are common accessory minerals in all these rocks. The descriptions and discussions of Nueltin Lake Granite in the adjoining Ennadai Lake map-area (Eade, 1971) apply to the rocks in this area. Further data and discussion are included in a following section of this report.

Gabbro and Diabase Dykes (17)

Two northwest-trending dykes, one in the northeast corner of Nueltin Lake map-area and the other east of Tatinnai Lake in Edehon Lake map-area, consist of fresh diabase to gabbro and are equivalent to the Mackenzie diabase dykes of Fahrig and Jones (1969). Neither of the dykes is well exposed but their locations and trends are apparent on aeromagnetic maps. Although dykes of this trend have not been found cutting the coarse-grained granite to quartz monzonite, radioisotopic age determinations indicate the dykes are younger. Fahrig and Jones (1969) indicate ages in the range 1100 to 1200 m.y. for these dykes, based on potassium-argon radiosotopic data. A strontium-rubidium isochron on rocks equivalent to unit 16 indicates an age of 1700 ± 16 m.y. (a correction from 1697 m.y., <u>in</u> Eade, 1971).

These dark green to black rocks of gabbroic composition are unmetamorphosed but show effects of slight deuteric alteration. They are medium grained except for the fine-grained contact zones and locally have a diabasic texture.

STRUCTURAL GEOLOGY

Little is known about the oldest structural trends that reflect deformation prior to deposition of Hurwitz Group rocks, as the deformation and intrusions of the younger Hudsonian orogeny mask the older deformation. Foliation and gneissosity, probably coinciding with the trend of original structure in the Archean rocks in much of the map-areas, trend northeast to north-northeast. A similar trend present in the younger rocks implies renewed deformation with the same trend. An exception is in the granulite-facies rocks, of the southern part of Edehon Lake map-area, where foliation trends east to slightly north of east. A suggestion of this same trend is seen in the older rocks along the southern margin of Nueltin Lake map-area.

The Hurwitz Group rocks in the northeast part of Nueltin Lake map-area are folded about northeast-trending axes and west to northwest-trending axes, the same trends that are present in similar rocks in the adjoining Kognak River map-area (Eade, 1964, 1966). Hurwitz Group rocks north of Trebell Lake are probably folded about northeast trending axes although extensive faulting complicates the interpretation.

Northeast-trending fold-axes in the gneisses on the east side of Nueltin Lake are probably the result of Hudsonian deformation although the trend could represent the older Archean deformation.

Fold axes in the small area of Hurwitz Group rocks in the northwest corner of Nueltin Lake map-area trend north. Although this trend could represent a change in the regional trend it is more likely a local deviation due to the large pluton of porphyritic granite (16) just to the east.

The east-northeast trend of Hurwitz Group rocks in the two elongate bands, one east of Dalpe Lake and the other northwest of Trebell Lake, appears to be controlled more by regional faults than by folding. This trend is more easterly than the trend of folding found in other Hurwitz Group rocks.

The oldest major faults in the map-area are probably north-trending, for example the one in the western part of Edehon map-area. These old faults however have undoubtedly been reactivated at later times. Other major faults trend east-northeast and are probably related to the Hudsonian orogeny but later movement on them has displaced the younger granite (16) east of Nueltin Lake. Probable reverse faults, trending eastward and displacing Hurwitz Group rocks west of Hurwitz Lake, are considered to be related to the folding about axes with this same trend. Northwest-trending faults are generally considered to be the youngest faults and they too displace the young granite (16).

Hypotheses on regional tectonism are discussed in a following section.

ECONOMIC GEOLOGY

A large number of pyrite and pyrrhotite occurrences are known, especially in shear zones in metavolcanics (1), greywacke (2) and amphibolite (3). Meta-andesite (1) commonly contains disseminated pyrite but where shear zones cut these rocks there are some concentrated zones of pyrite mineralization that on weathering give broad rusty zones. In the faulted segment of meta-andesite five miles east of the south end of Fitzpatrick Lake small shear zones associated with the nearby fault contain abundant pyrite. Two miles to the east and close to another fault, broad shear zones in the meta-andesite are marked by rusty zones although no pyrite is visible in the deeply weathered rock. At the west end of the small area of meta-andesite north of Hurwitz Lake, close to the east boundary of Nueltin Lake map-area, abundant quartz veins up to one foot wide containing disseminated pyrite cut the metavolcanic rocks. Exploration work was done on this occurrence some years ago as pits have been excavated to expose some of the veins.

Six miles northeast of Dalpe Lake, amphibolite (3), probably derived from metavolcanics (1), is cut by shear zones parallel to the large north-south fault just to the west. These shear zones contain abundant pyrite mineralization.

Within the band of amphibolite (3), adjacent to granite (16), four miles west of the north end of Sealhole Lake, abundant disseminated pyrite and small veinlets of pyrite occur in the amphibolite. At this locality no outcrop is present but large angular blocks are probably frost-heaved from nearby, drift covered outcrop.

Disseminated pyrite is a typical feature of the greywacke (2) in the northeast corner of Nueltin Lake map-area. In places the pyrite is more concentrated and on weathering, rusty surfaces characterize the outcrops. Shear zones cutting the greywacke contain abundant pyrite in some places. Approximately eight miles northeast of Fitzpatrick Lake, at 60°52'30"N, 98°24'30"W, small shear zones in greywacke contain abundant pyrite and the highly fractured outcrop is heavily stained with rust.

In greywacke (2) just north of Baralzon Lake, in the southeast corner of Nueltin Lake map-area, certain beds of greywacke contain abundant disseminated pyrite. In the same general region, six miles northeast of the north end of Trebell Lake, extremely sheared greywacke (2) contains pyrite bands or stringers parallel to the cleavage. The surfaces of the outcrops have large rusty areas marking the pyrite-bearing zones.

On the island in the southwest part of Tatinnai Lake, sheared greywacke (2) close to the contact with meta-andesite (1), contains much disseminated pyrite and some magnetite which has resulted in a prominent rusty zone on the outcrop surface. On the northeast shore of Tatinnai Lake, quartz-magnetite iron-formation (2a) contains some disseminated pyrite.

On the south side of the Thlewiaza River, south of Longpre Lake, in Edehon Lake map-area, some beds of paragneiss adjacent to metamorphosed iron-formation (2a), contain abundant disseminated pyrrhotite and some pyrite. The rock is a sheared carbonate-bearing metagreywacke. Some nearby beds of amphibolite, probably derived from carbonate-rich sedimentary rocks, contain disseminated pyrite. About four miles east of Longpre Lake, at 60°39'N, 97°27'30"W, quartz-rich metagreywacke beds in the paragneiss (4) contain disseminated magnetite and minor pyrite which result in highly rusted zones on the outcrop surface.

In the scattered occurrences of Hurwitz Group rocks in the central and southern parts of the map-areas, some beds contain disseminated sulphide minerals, chiefly pyrite. In the metamorphosed undivided Hurwitz Group rocks (13a) three miles north of Trebell Lake, at 60°14'30"N, 98°12'W, certain beds carry disseminated pyrite and small shears associated with the nearby fault contain pyrite concentrations. Five miles to the northwest, in the less metamorphosed Hurwitz Group rocks, fine grained to very fine grained argillite or siltstone beds contain abundant disseminated pyrite. Six miles west of Trebell Lake, at 60°16'N, 98°25'W, quartzose metagreywacke (13a) beds contain some pyrite. Approximately 1 1/2 miles east of the south end of Downer Lake, at 60°34'45"N, 96°52'30"W, disseminated pyrite with minor specks of chalcopyrite, occurs in metagreywacke (13a) that is stratigraphically just below an orthoquartzite band.

Some beds in the paragneiss (14) south of the mouth of Windy River, adjacent to granite (16), contain abundant disseminated pyrite.

Molybdenite is present in a few small scattered patches in granite (15) at 60°29'N, 96°51'W, near the eastern margin of the area mapped in Edehon Lake map-area.

Scintillometer (Rank, type ND148) readings on the quartzite (9), greywacke, conglomerate and protoquartzite (8) and greywacke and greywacke-conglomerate (2) gave only background values (5 to 8 μR/hour). Readings on granite to quartz monzonite (15) ranged from 15 to 45, with an average of 24 μR/hour. Coarse-grained granite (16) gave variable readings; the pluton east of Nueltin Lake gave values ranging from 13 to 22 with an average of 17 μR/hour; the pluton on the northwest side of Nueltin Lake gave values ranging from 19 to 45 with an average of 31 μR/hour; the mass west of Nueltin Lake gave an average of 50 μR/hour and in the southeast lobe of the pluton where values are higher, a reading of 95 μR/hour was obtained at one place.

In summary, none of the observed mineral occurrences is considered to be of economic significance. Some of the shear zones in metavolcanic (1) rocks containing pyrite mineralization may merit investigation for possible gold mineralization or economic sulphide mineralization. The presence of sulphides in parts of the Hurwitz Group suggests the possibility that chalcopyrite might be found in some of these beds. It seems unlikely that disseminated molybdenite is present in the granite (15) in any quantity as it was seen only in one place. The possibility of finding economic concentrations of radioactive minerals in the map-areas seems remote.

DISCUSSION

Orogeny and Tectonism

Some hypotheses can be advanced concerning the tectonic events and orogenies that have affected the rocks in the Nueltin Lake–Edehon Lake map-areas and surrounding areas, based on the available geological mapping and published aeromagnetic maps. In the map-areas to the south, Munroe Lake and Nejanilini Lake (Davison, 1963, 1968), structural trends are more nearly east as compared to the general northeast trend in the southern District of Keewatin. These trends are also apparent on aeromagnetic maps. It is suggested that an approximate boundary between the east and the northeast trend extends east to west across the northern margin of Munroe Lake map-area, from 2 to 8 miles south of Nueltin Lake map-area. This boundary of structural discontinuity extends approximately 12 miles into Nejanilini Lake map-area but then is offset northward into Edehon Lake map-area by a major north-south fault as shown on Figure 1. The boundary separating the two trends is transitional and probably represents an ancient suture or join between two cratonic blocks, which has been annealed with some mixing during later orogenies.

The north-south fault which offsets the suture is ancient but has been subject to periodic reactivation. The major movement, with the east side rising relative to the west, was of large magnitude, sufficient to raise deeper crustal levels to the surface for granulite-facies rocks are now exposed over much of the eastern block, in Nejanilini Lake map-area. However, the reconnaissance gravity map (Gravity Map Series, No. 75, Seal River, Gibb and McConnell, 1969) does not suggest this abundance of granulite-facies rocks in the eastern block. Some small areas of granulite-facies rocks are present west of the fault but they are relatively minor. The apparent offset of the suture, with the movement northward on the uplifted eastern block, suggests the suture may be north dipping, unless there has been considerable translational movement on the fault.

The movements postulated above probably took place in Archean time and erosion had exposed the granulite-facies rocks prior to the deposition of Aphebian sedimentary rocks. It is suggested that the slightly to moderately metamorphosed sedimentary rocks overlying the granulite-facies rocks in Nejanilini Lake map-area are at least in part equivalent to the rocks of the Hurwitz Group.

The Hudsonian orogeny, with its deformation and igneous intrusions, has obscured some of the relationships. In the southern part of Edehon Lake map-area, major granite intrusions obscure both the suture and the major north trending fault. The granulite-facies rocks are intruded and partially assimilated by the younger granite and the intrusions have also resulted in widespread retrogressive metamorphism of the granulite-facies rocks.

Granite plutons are present on both sides of the fault but are more abundant to the east as shown on Figure 1. East of the fault in Edehon Lake map-area, the two large areas of granite are separated by an east-west trending band or pendant of metamorphosed and partially assimilated Archean and Aphebian sedimentary rocks. At the margins of the plutons the amount of mixing and assimilation of country rock is variable, in some places there are extensive zones of mixed rock (15b), but elsewhere only a narrow contact zone is present. In the latter case, it seems likely the contact of the pluton is steeply dipping, but where the zone is broad, the contact is gently dipping.

The Hudsonian plutons extend northward to approximately 60°50'N but farther north the effects of the orogeny are much less apparent. In Kognak River map-area to the north, igneous rocks associated with the Hudsonian orogeny are relatively rare. There is therefore a rapid decrease in intensity of igneous activity associated with the Hudsonian orogeny from south to north in Edehon and Nueltin Lakes map-areas.

Metamorphism in this region can only be defined in a broad manner. West of Henik Lakes, in Kognak River map-area Archean volcanic and sedimentary rocks are chiefly referable to greenschist metamorphic facies, and this area of low-grade metamorphism extends into the northeast part of Nueltin Lake map-area. To the east, west and south, Archean metamorphism increased to amphibolite facies and here and there in the southern part of Nueltin Lake map-area it reaches the lower part of the granulite facies. The effects of metamorphism accompanying the Hudsonian orogeny, as observed in the Hurwitz Group rocks, is mild in the northern part of the region, around Henik Lakes and in the northeastern part of Nueltin Lake map-area. In the eastern part of Ennadai Lake map-area, metamorphic grade increases from north to south but no similar increase affects the sedimentary rocks in the western part of that area. The intensity of Hudsonian metamorphism increases somewhat from north to south in Nueltin Lake map-area but shows a marked increase eastward into Edehon Lake map-area.

It seems likely that most of the granodiorite-gneiss in the region resulted from metamorphism and metasomatism associated with an Archean orogeny and that the Hudsonian orogeny, although it locally results in some paragneiss, is more notable for the igneous intrusions.

The Nueltin Lake granite (16) does not occur east of approximately the middle of Nueltin Lake map-area. As discussed in a previous report (Eade, 1971), the regional distribution of plutons of this granite may be related to the intersection of regional structural trends. However, the lack of distinctness between what may be Archean structural trends and those trends related to Hudsonian deformation weakens this theory. Archean and Aphebian structural trends, where they can be distinguished with some certainty, are plotted on Figure 1, as well as the plutons of Nueltin Lake granite.

Nueltin Lake Granite

K.E. Eade and D.W. Flint

During 1971, D.W. Flint studied thin sections and stained slabs of specimens from plutons of the granite from both Ennadai Lake and Nueltin Lake map-areas. Some spectrographic analyses of specimens and X-ray determinations of minerals were done in the laboratories of the Geological Survey of Canada. The work of Calder (1970) provided additional information about the pluton on the northwest side of Nueltin Lake.

In the previous report (Eade, 1971) this post-kinematic granite was classified as Aphebian. In the present report it is placed in the Helikian because the plutons transect and are younger than structures associated with the Hudsonian orogeny, which by definition (Stockwell, 1964) marks the end of the Aphebian.

Field Relations

The granite intrudes both Archean and Aphebian rocks, the latter including Hurwitz Group sedimentary rocks and quartz monzonite plutons of the Hudsonian orogeny. For the most part, the intrusions have not resulted in strong disturbance of the country rock although there has been some faulting and warping of the adjacent rocks. The border phase of the granite is equigranular and medium grained. A few inclusions of country rock occur in the granite near the margins but they are relatively rare.

Some structural adjustments accompanied by faulting have affected the plutons and surrounding rocks as the intrusions cooled but such movements are minor considering the overall area of the plutons. At the contact at the north end of the pluton west of Nueltin Lake, along Windy River, the medium-grained border phase of the granite is brecciated and re-cemented by a stockwork of barren white quartz.

In the country rock surrounding some of the plutons of granite there occur minor stringers or veinlets, of pink, medium-grained to aplitic felsic granite that are considered to be associated with the plutons. They are most common in the biotite granodiorite gneiss (5) west of Nueltin Lake but even there they are much too small and rare to map separately.

Mineralogy

Alkali feldspars: Alkali feldspar is the major modal constituent of the Nueltin Lake granite. In hand specimens the phenocrysts of microcline-perthite, up to 6 cm long, have well developed crystal structure and faces. Under the microscope, the phenocrysts are normally tartan-twinned microcline with exsolved bead or interlocking albite but some are not twinned and could possibly be orthoclase. Rarely, the twinned microcline contains some small patches of untwinned, inhomogeneous feldspar, which is not perthite and may be orthoclase. It is suggested that these are remnants of an incomplete transition from orthoclase to microcline. In a very few specimens, coexisting with abundant grains of unzoned homogeneous alkali feldspar, there are occasional grains of alkali feldspar rimmed with plagioclase. The cores are microcline-perthite (~5 mm x 25 mm) rimmed with calcic oligoclase (An_{25}).

Alkali feldspars poikilitically enclose quartz, biotite, zoned plagioclase and apatite, with quartz by far the most common. The composition of inclusions of zoned, euhedral plagioclase laths ranges from An_{30} to An_{12}. The composition of the laths may have changed from that at crystallization because of increasing Ab molecules from the exsolution of the perthite.

Composition of the perthites is limited in range with albite forming 15 to 25 per cent of the crystals and the remainder, neglecting incomplete exsolution, microcline.

Plagioclase feldspars: Plagioclase feldspar grains are euhedral, albite twinned, and compared to the alkali feldspar phenocrysts, small, with a maximum length of 20 mm. Composition ranges from An_{25-35} with a well defined average of An_{30}. In a few specimens anhedral, zoned, untwinned grains of albite to sodic oligoclase occur interstitially to quartz and alkali feldspar. Euhedral plagioclase grains in the same specimens with the interstitial albite are zoned from a calcic oligoclase (An_{25}) core to a sodic oligoclase (An_{16}) rim.

Quartz: In hand specimens two distinct types are present but the difference between the clear and smoky quartz is not apparent in thin section nor does the grain size or habit differ. No large bubble trains, colloidal dispersions or microcrystalline inclusions are visible in thin section. Possible causes of the colouring are radiation damage, aluminium content or minute inclusions of rutile.

Biotite and hornblende: Biotite is the typical mafic mineral of the granite and is always present. Although in some specimens biotite is included within alkali feldspar phenocrysts, normally it occurs in clots interstitial to the phenocrysts and associated with quartz, apatite and zircon. Zircon and apatite commonly occur as inclusions in the biotite. Variations in pleochroism or colour of the biotite are absent suggesting that the composition is constant.

Green hornblende occurs irregularly in the granite, commonly intergrown with biotite in mafic clots. However within one specimen in addition to the intergrown clots, individual clots of hornblende and biotite also occur. The pleochroism indicates the hornblende is iron-rich, probably hastingsite or ferrohastingsite. The FeO:MgO ratio in three analyzed samples of granite ranges from 6.3 to 8.5, corresponding to ferrohastingsite hornblende or an iron-rich biotite. The study of the thin sections offers no evidence as to whether or not both biotite and hornblende are primary minerals or if one has been derived from the other.

Apatite: Euhedral hexagonal crystals of apatite occur included in biotite, hornblende, and alkali feldspar grains but it is concentrated in the interstices surrounding clots of mafic minerals along with quartz and fluorite. Compositionally, it is fluroapatite and probably contains rare-earth elements replacing some of the calcium. The chemical analyses suggest that although sufficient rare-earth elements are present to form monazite, calcium was available in sufficient quantity to form apatite rich in rare-earth elements. In some specimens, light pleochroic haloes occur in the biotite surrounding apatite.

Fluorite: Purple fluorite occurs ubiquitously in the granites with the exception of the pluton east of Nueltin Lake. It occurs in anhedral grains always associated with the mafic clots and apatite.

Zircon: Accessory zircon occurs only in euhedral crystals enclosed in biotite. Noteworthy is the great variation in grain size, from fine to extremely coarse in a few specimens.

Bastnäsite and allanite (?): A brown earthy mineral occurs in euhedral crystals within biotite of the granite. In thin section the mineral has a relief greater than biotite. It is isotropic and has no visible cleavage, zoning or twinning. X-ray examination of the mineral in the laboratory of the Geological Survey results in a very weak pattern for bastnäsite, $CeCO_3F$, a common alteration product of rare-earth minerals. The host mineral is metamict and is probably one of allanite (orthite), cerite, or chevkinite, all common accessories in alkalic granites. The metamictization suggests the primary mineral was most probably a Th-U-bearing allanite.

Magnetite: Opaque iron oxide in anhedral grains, apparently magnetite for the most part, is a common accessory mineral in the granite, associated with the clots of mafic minerals.

Epidote: Fine- to coarse-grained epidote, probably secondary, is associated with the mafic clots and opaque minerals. It is an iron-rich epidote and grains sometimes show a zonal structure. The formation of the epidote seems to have been accompanied by development of fine expansion cracks in the surrounding quartz and feldspar grains, implying that those minerals were completely crystallized prior to development of the epidote.

Modal Analysis

The determination of modes using a point-counting method is not entirely satisfactory for this coarse-grained porphyritic rock. It is estimated that for most specimens of Nueltin Lake granite a surface smaller than 12 square inches (3" x 4") is not sufficiently homogeneous to be representative. The percentage of phenocrysts of microcline-perthite can be accurately determined on large, stained, cut slabs using a grid but the proportions of quartz, plagioclase, and mafics are open to error because of the counting interval. However the modal proportion of the finer grained components can be accurately determined in large thin sections. Best results are obtained using the combination of large stained slabs and thin sections. The proportion of alkali feldspar phenocrysts to all other components is determined from the slab and the proportion of fine grained constituents to each other is determined from the thin section (excluding the phenocrysts from the count).

In the interpretation of stained alkalic feldspars caution is required. It is possible for rocks of the same chemical composition to have different alkali feldspar/plagioclase ratios based on the point count analysis depending on whether the Ab molecule is concentrated in perthite or in solid solution in the plagioclase.

Results of modal analysis on thirty-two specimens of Nueltin Lake granite are shown in Figure 2. These data are also plotted on a quartz-alkali feldspar-plagioclase ternary diagram, Figure 3 for two of the plutons. No marked trends or distinctions between plutons are evident from the ternary plot. The variance within bodies is approximately the same as the variation of all the specimens as a group.

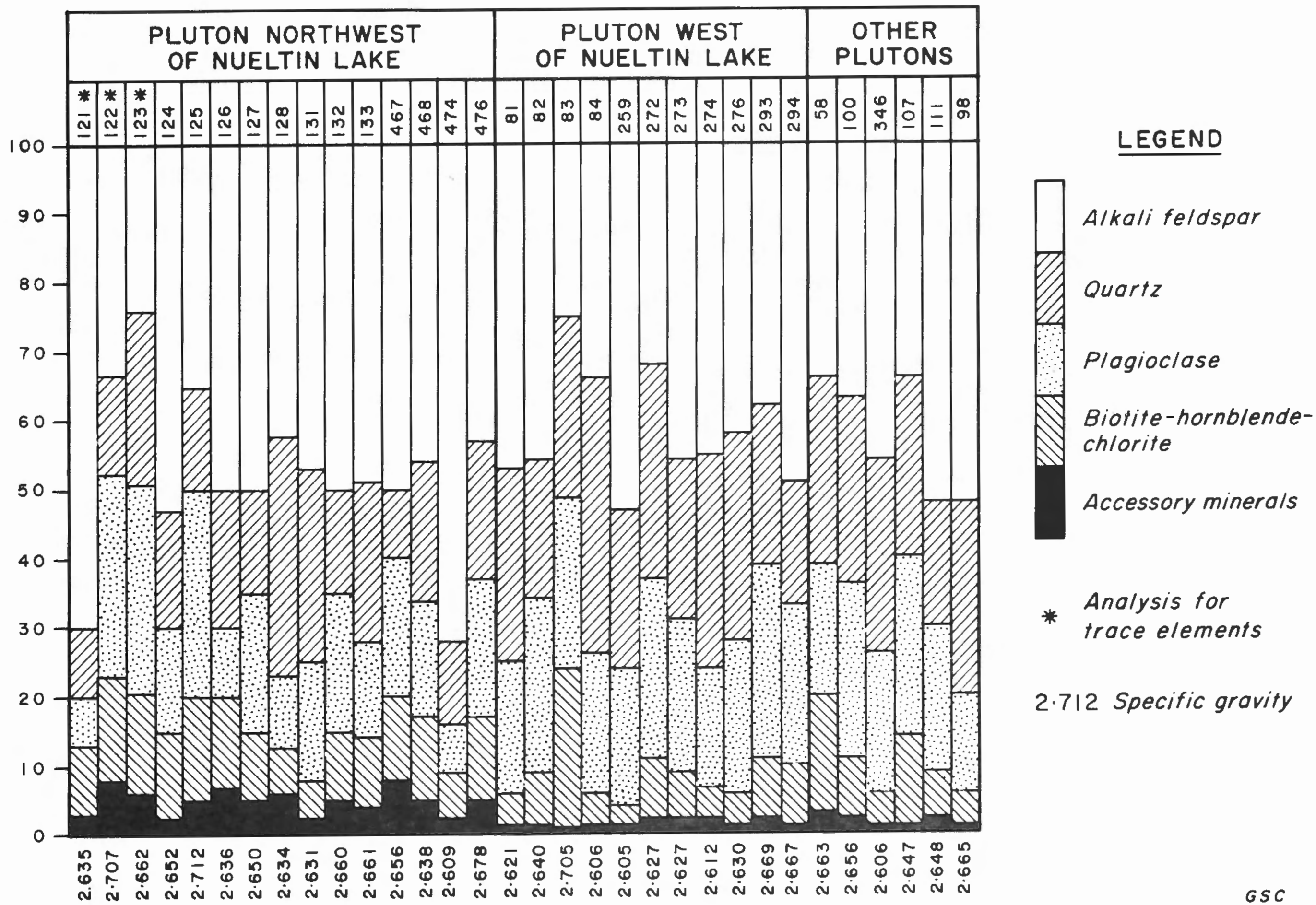


Figure 2. Modal analysis, thirty-two specimens of Nueltin Lake granite.

The average for specimens from the pluton on the northwest side of Nueltin Lake contains less modal quartz and plagioclase than does the average for the pluton just to the south. The average for the former is a granite and for the latter a quartz monzonite. The differences between the plutons is not significant however since the variance within each body is large.

Specific Gravity

The specific gravities measured on a number of specimens of the granite range from 2.605 to 2.712 with an average value of 2.62. The areal variation of specific gravity within plutons does not suggest S.G. zoning of the plutons although the density of sampling may be inadequate to define such

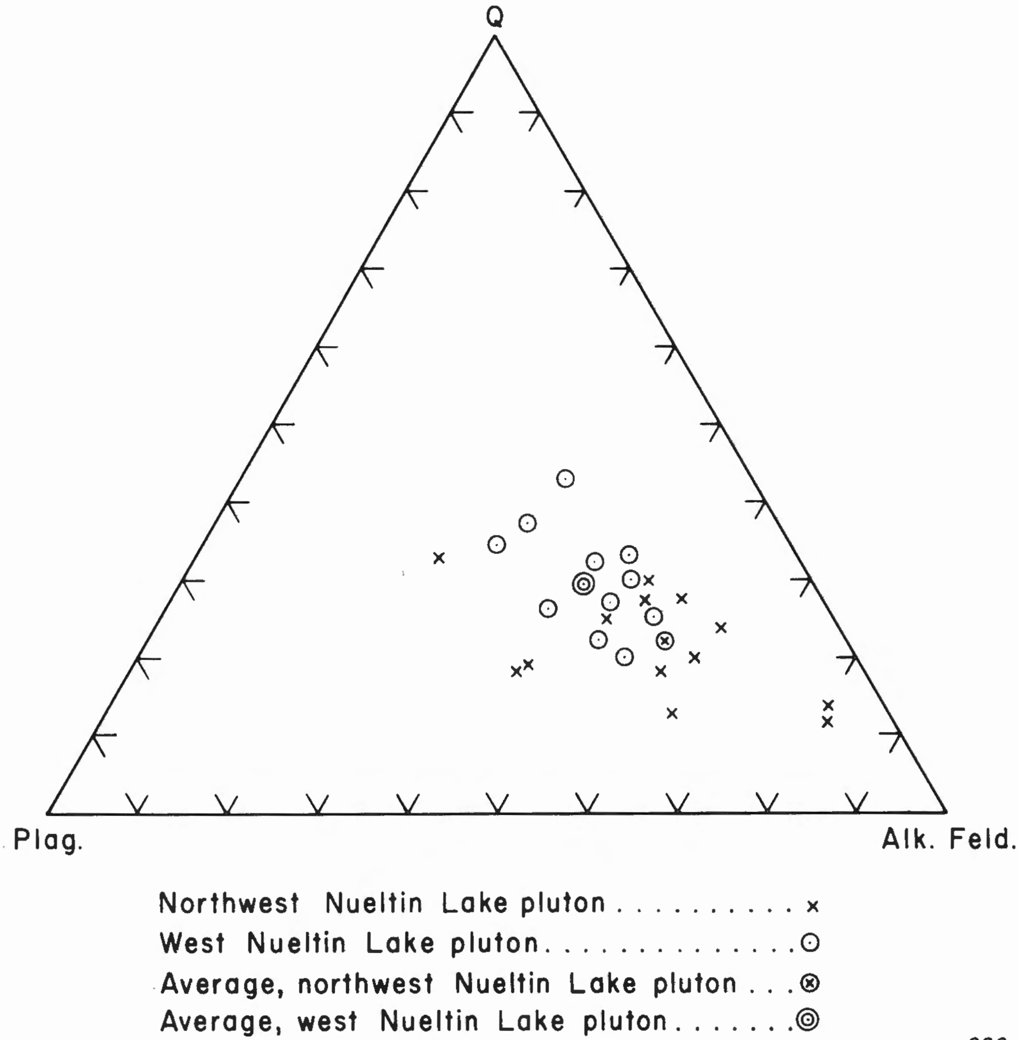


Figure 3. Modal compositions of leucocratic components of two plutons of Nueltin Lake granite.

zones. In the pluton west of Nueltin Lake a possible trend of increasing S.G. from the margins to the core is evident. There is no marked correlation between modal compositions and specific gravity other than high modal mafic content in those rocks with higher specific gravity.

Chemistry

Minor element abundances were determined spectrographically on three specimens from the pluton northwest of Nueltin Lake. The results are listed in Table 1 and it is apparent there is enrichment of the rare-earth elements as compared to normal granite. To compare the rare-earth element content in the Nueltin Lake granites with that of two Precambrian age post-orogenic granites of Finland and a composite of North American shales, on Figure 4 the values have been plotted according to the method of Haskin, et al. (1966), using their data for the Finnish granites and the shale composite. In this method the ppm of rare-earth elements have been normalized to Yb = 1.00, then divided element by element, by the Yb-normalized average for chondritic meteorites. The resulting ratios have been plotted on a logarithimic scale against rare-earth ionic radius. The comparison plot indicates that the rare-earth elements in the Nueltin Lake granites are strongly fractionated towards the cerium-earths and only relatively enriched in the yttrium earths.

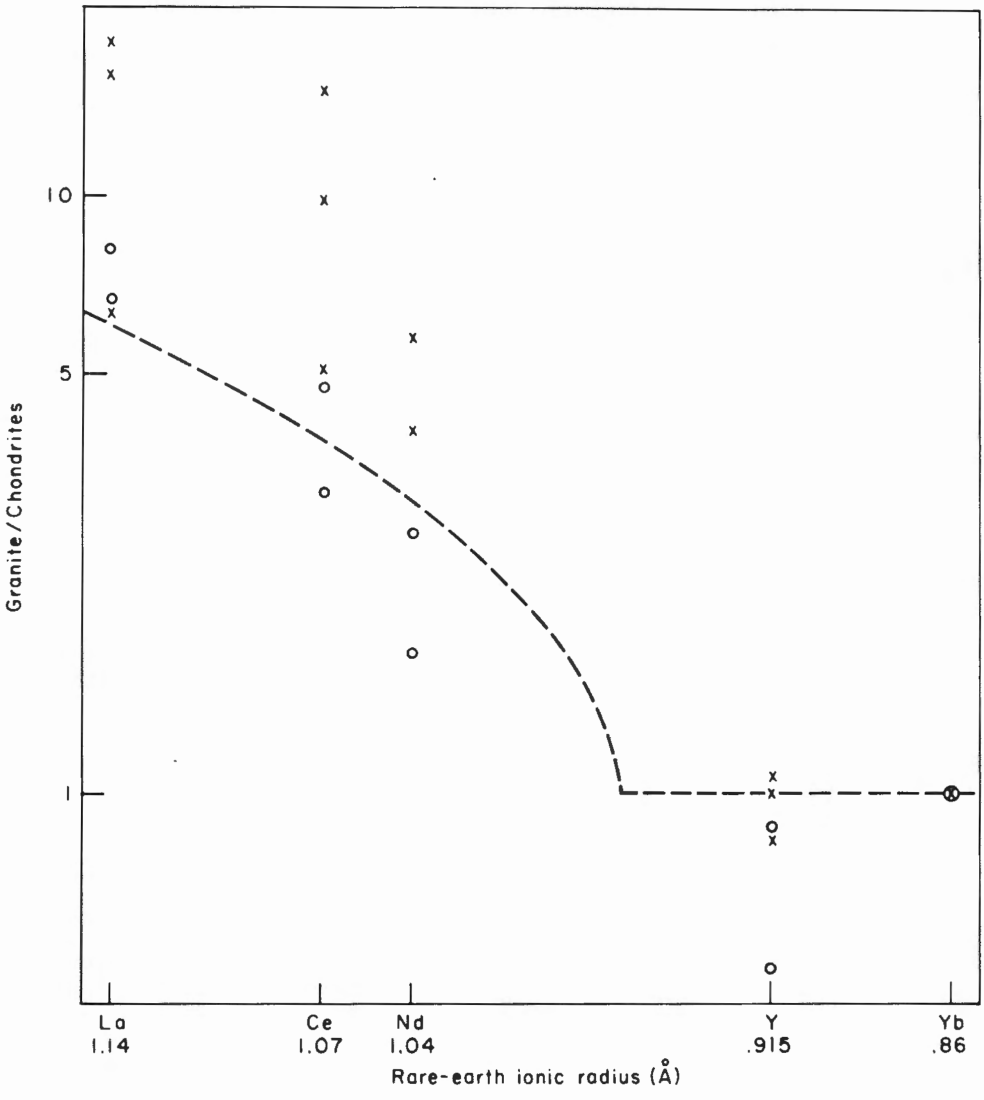
From the data in Table 1, it is apparent the Nueltin Lake granites are not enriched in metals such as Sn, Mo, or Be.

Table 1

Trace element content by spectrographic analyses of three Nueltin Lake granite specimens

Sample No.	121	122	123
Ti %	.26	.26	.15
Mn	.029	.024	.022
Sr	.0078	.011	.0037
Ba	.046	.092	.15
Zr	.083	.057	.086
Ni	.0023	.0018	.0027
Cu	.00096	.00067	.00074
Ce	.063	.050	.038
Y	.014	.0078	.013
Nd	.026	<.020	.021
La	.037	.022	.017
Yb	.0013	.00068	.0015
Sc	.00071	.00059	.00055
Be	.00036	.00058	.00080
Zn ppm	64	66	55
Pb	69	64	60
Sn	4.2	3.6	2.4
Ge	1.7	1.4	1.7
Mo	5.0	1.0	1.5
Tl	2.1	NF	1.2
Ag	.16	.20	.13

NF-not found



Nueltin Lake granites. x
Bodom & Obbnäs granites, Finland (Sahama and Vähätalo, 1941). . . . . o
North American shale composite (Haskin et al, 1966). . . . . ———

GSC

Figure 4. Rare-earth element comparison plot of Nueltin Lake granites, two Precambrian post-orogenic granites from Finland and a North American shale composite. The ppm REE have been normalized to Yb - 1.00, then divided element by element by the Yb-normalized average for chondritic meteorites. The resulting ratios have been plotted on a logarithmic scale against RE ionic radius. This method is that of Haskin et al. (1966).

Petrology

Textural evidence in the Nueltin Lake granite indicates that plagioclase started to crystallize earlier than alkali feldspar and the presence of rapakivi-like texture in some of the rocks suggests crystallization of plagioclase continued in a few places beyond that of alkali feldspar. However, the bulk of the feldspar formed by almost simultaneous crystallization of alkali feldspar and plagioclase, as separate phenocrysts under very steady equilibrium conditions and with a relatively high P_{H_2O}.

The assemblage of hydrous mafic minerals, phosphates, and fluorine-bearing minerals which are uniformly distributed throughout the plutons implies high vapour pressure with no release of the differentiated residual liquid.

The complete equilibrium crystallization implicit in the textures indicates little hope for concentrations of ore minerals in greisen or pegmatites associated with granite since little late stage liquid has escaped.

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