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MINES AND RESOURCES

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ABSTRACT

The Precambrian rocks of Lac Brûlé and Winokapau Lake map-areas are mainly a sequence of paragneisses and granitic gneisses typical of those found elsewhere throughout the Grenville structural province. Intrusive into these gneisses are several bodies of gabbroic rocks which locally grade into anorthosite. Extensive parts of each map-area are underlain by coarse-grained, massive granitic rocks which are probably intrusive, but as is common elsewhere in the Grenville province, it is difficult to draw a boundary between true intrusive granite and the surrounding gneisses.

The report includes a brief description of a sequence of metamorphosed sedimentary and volcanic rocks which is poorly exposed in the north-central part of Winokapau Lake map-area. These rocks are believed to be a southern extension of the Seal Lake Group of sedimentary and volcanic rocks of probable Proterozoic age. Relatively unmetamorphosed conglomerate, arkose, and slate, apparently much younger than rocks of the Seal Lake Group, outcrop on islands in Lake Michikamau.

As is typical of Grenville rocks, metamorphism appears to follow no regular regional pattern. Metamorphic facies range from the greenschist facies to the granulite facies, with most of the gneisses lying well within the amphibolite facies. Most of the gabbroic rocks fall within the granulite facies.

The structure of the area is undoubtedly the product of several deformations, too complex for detailed study on the present scale of mapping. Foliation dips in the gneisses are invariably steep and locally overturned. Evidence of faulting is everywhere abundant, particularly in the region between Red Wine Mountains and Lake Michikamau, where a series of parallel, northeast-striking faults may represent the position of the Grenville Front in this area. Unfortunately heavy drift and forest cover in this crucial area obscures the southern extension of these faults.

LAC BRÛLÉ AND WINOKAPAU LAKE MAP-AREAS, NEWFOUNDLAND AND QUEBEC

INTRODUCTION

Location and Accessibility

The area forms two contiguous map-areas, Winokapau Lake (13E) on the north and Lac Brûlé (13D) on the south. Situated in southwestern Labrador and eastern Quebec between 52° 00' N and 54° 00' N and 62° 00'W and 64° 00' W, the mapped area is a western extension of the areas mapped in 1965 during the initial phase of Operation Northwest River (Stevenson 1967a, b). Because much of the region is difficult of access, mapping was carried out using a Bell 47G2A helicopter, with detailed traversing being done from a rubber boat along the major rivers and lakes. Adjacent areas on the north and west were previously mapped by Emslie (1964), Roscoe (1952), Eade (1952), and Stevenson (1967c).

The area may readily be reached by float-equipped aircraft operating out of Goose Bay, Labrador; Schefferville, Quebec; or Seven Islands, Quebec. A road, presently under construction between Goose Bay and the Churchill Falls power project, will soon offer access to the central part of the mapped area. Many of the larger lakes are suitable for operation of float-equipped aircraft, but numerous flat, poorly drained areas, some of which are several tens of square miles in extent, are inaccessible except by helicopter or arduous ground traverse. With the exception of Churchill River all but parts of a few of the major rivers are too rapid and/or shallow for canoe travel.

Topography and Drainage

The area forms part of a great plateau which in this region, has a rather uniform elevation some 1,500 feet above sea level. The topography reflects to a considerable degree the character of the underlying bedrock, the flat, poorly drained areas being underlain by rather uniform gneisses and structureless granites, whereas the more rugged areas are generally underlain by basic rocks or highly metamorphosed and contorted gneisses. Elevations range from less than 500 feet above sea level in the valley of Churchill River to almost 2,600 feet above sea level in the extreme northeast corner of the area.

The plateau surface is cut by numerous steep, southeast-trending valleys that were undoubtedly formed in pre-Pleistocene time. During the advance of the ice-sheet, these structurally controlled valleys were gouged out and deepened by the ice and later filled with glacial debris. Upon retreat of the ice, streams occupied these ancient valleys, and as down-cutting by the streams progressed subsequent to uplift of the surface, remnants of drift were left along the valley walls. Such remnants are abundant and well exposed at numerous localities on Churchill River which has down-cut several hundreds of feet to its present level.

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The main watershed roughly parallels Churchill River and lies between 52° 40' N and 53° 00' N. South of this divide, all drainage is south into Gulf of St. Lawrence. Churchill River and its tributaries drain a belt some 70 miles wide through the central part of the area. With the exception of the lowland areas bordering Lake Michikamau and Windbound Lake, the remaining drainage is eastward into Grand Lake and Goose Bay.

Although many of the larger shallow lakes are the result of poor drainage because of lack of relief, others are undoubtedly structurally controlled. Typical of the latter are Hope Lake and Ptarmigan Lake which lie in narrow, steep valleys that dissect the rugged northeast-trending range of hills in the northeast corner of Winokapau Lake map-area. These valleys probably formed by stream erosion and glacial gouging along prominent joints or faults striking slightly north of east. Subsequent damming of the channels by morainal or other glacial material upon retreat of the ice-sheet resulted in the formation of the present deep lakes. Other lakes, such as Long Lake in Lac Brûlé map-area may follow zones of shearing and faulting that trend almost at right angles to the direction of movement of the ice-sheet.

Pleistocene Geology

The entire area has been extensively glaciated and contains a wide variety of glacial deposits including drift ridges, sand dunes, eskers, drumlins, outwash plains, terraces, morainal material, and lacustrine sediments. Glacial striae and drift ridges indicate that the last major ice-movement was in a southeast direction. The most abundant drift is a thick boulder till, but extensive areas are sand covered, particularly in and adjacent to several of the major river valleys. Although the tops of the higher hills are generally bare of drift, sufficient evidence in the form of glacial grooving and striae remains to indicate that the ice rode over the highest hills in the area.

The region was apparently subjected to a long-continued period of glaciation by an ice-sheet of considerable thickness that moved in a southeast direction. Although the ice may have made repeated advances over the area, all evidence of glaciation other than the last has been obliterated. Great thicknesses of rock have obviously been removed from several of the southeast-trending valleys where the scouring and plucking action of the advancing ice would be concentrated. Extensive drift plains, characterized by swarms of drumlinoid till ridges, cover perhaps two-thirds of the area. Individual drumlins may be several hundreds of feet long, up to 300 feet wide, and from 25 to 100 feet high. The long axes of the drumlins trend southeast, with the stoss ends facing west, and clearly indicate that the direction of advance of the last ice-sheet was from northwest to southeast. Locally the drumlinoid ridges disappear and the topography is characterized by monotonously flat areas of ablation moraine which is invariably covered by muskeg or stunted swamp growth. Eskers are also characteristic of the moraine-covered areas. It would thus appear that after the main thickness of the ice had disappeared from areas of maximum relief, the thin sheets of stagnant ice which remained gradually melted, depositing the eskers and ablation moraine.

GENERAL GEOLOGY

Marble (1)

White, coarsely crystalline marble (1) is exposed along and west of Churchill River near the outlet of Lake Winokapau. Because of difficulty of access, the marble was examined at only two localities but additional outcrops are undoubtedly present. Low (1895) described 'white limestone' on the north bank of Churchill River near the outlet of Lake Winokapau in a band one foot to four feet thick, but no limestone was definitely identified north of the river during the present mapping. Several outcrops presumed to be white marble were observed from the air in the contorted, heavily bush-covered terrain immediately southwest of the mapped outcrops in Winokapau Lake map-area, but no landings could be made. An outcrop of white, laminated rock some two miles east of Churchill River in Lac Brûlé map-area is also probably marble.

Where examined, the rather poorly exposed marble occurs in thin, discontinuous beds rarely more than a few feet thick, interstratified with the sillimanite-rich gneisses of unit 2. In the exposure closest to Churchill River, a small dyke of fine-grained, dark gabbro cuts the irregularly bedded marble at a sharp angle to the bedding. Sparkling white on a fresh surface, the marble weathers to a dull dark grey. The marble and adjacent gneisses are strongly foliated, and in places migmatitic. The marble appears to overlie conformably a 12-inch thick band of mylonitized, biotite-rich amphibolite which in turn overlies laminated, migmatitic gneiss (2) with no apparent structural break.

The marbles are coarsely crystalline with a pronounced sugary texture, and contain abundant silica-rich layers that impart a distinct foliated appearance. Some are crystalline limestones but varied reaction to acid indicates that others may locally approach dolomite in composition. Individual layers containing but little silica form coarse-grained, pure, white marble.

Microscopically, the marbles consist mainly of calcite, olivine (forsterite) and quartz. The forsterite is serpentinized,the alteration appearing along fractures in the individual crystals. Talc and diopside are present in variable amounts. Yellow-brown discoloration in the rock is believed to be due to the serpentinization of olivine crystals.

The crystalline limestones are interbedded with layers of gneiss which probably represented impure, sandy beds in the original calcareous deposit. Locally, the limy layers contain fragments of these gneisses aligned in roughly parallel bands which appear to be floating in the crystalline limestone. The manner in which the limestone appears to have flowed around these fragments is indicative of the great plasticity of limestone relative to that of the adjacent gneisses when subjected to intense pressure. Great compressive forces with attendant folding, twisting, and shearing movements must have broken the associated gneisses into angular fragments around which the limestone flowed. If cataclastic movement in the limestone did take place, all such evidence has apparently been destroyed by recrystallization.

Feldspar-Quartz-Biotite-Sillimanite Gneiss (2)

Grey-brown, sillimanite-rich, highly deformed gneisses (2) form a distinct rock unit that underlies almost one-quarter of the area. These gneisses, readily recognized by their peculiar colour and migmatitic texture, were undoubtedly formed from aluminous sedimentary rocks. In addition to their more intense deformations, they are markedly more resistant to erosion than the adjacent gneisses of unit 3 and as a result form conspicuous rugged upland areas which are several hundreds of feet higher than areas underlain by unit 3. North of Churchill River the sillimanite gneisses outcrop in a belt some 20 miles wide extending from Winokapau Lake northeast for approximately 35 miles where it merges with the Red Wine Mountain [1] massif of basic rocks. South of Winokapau Lake the gneisses are well exposed in an easterly trending belt some 35 miles wide. The reason for the intense structural deformation and high metamorphic grade of the sillimanite-rich gneisses is not definitely known but they may represent old, deep-seated gneisses that were originally formed from sediments older than those which formed the gneisses of unit 3, and as such are the product of multiple orogenies. Also, it is perhaps significant that the sillimanite-bearing gneisses have been subjected to much lit-par-lit injection, migmatitic phases being common throughout the entire unit, with abundant pegmatitic material occurring both across and along the foliation.

Macroscopically, the most outstanding characteristics of the sillimanite gneiss are its peculiar grey-brown colour and laminated structure. Only rarely are the tiny prisms of sillimanite visible, but fresh surfaces of the gneiss have a distinct hackly feel because of their presence. Microscopic examination shows the gneiss to consist mainly of orthoclase, microcline, plagioclase, quartz, biotite, hornblende, sillimanite, and garnet. The relative proportions of the minerals vary greatly, but sillimanite rarely makes up more than 15 per cent of the rock. Garnet may be absent from some sections and sillimanite from others, but either garnet or sillimanite are invariably present. The alkali feldspar is mainly microcline, microcline-microperthite, or a mixture of orthoclase and microcline. The former usually has a well-defined quadrille structure and string-like perthitic intergrowth is common. Plagioclase (An_{30} - An_{40}) with myrmekitic texture and zoned crystals is, in places, intergrown with the alkali feldspars. Quartz forms elongated, sutured grains or rod-shaped forms and is invariably strained. Sillimanite occurs in needles, laths, or prisms rarely more than 1 mm long, with the long axes of the individual crystals aligned in the plane of foliation. Evidence of retrograde metamorphism, in the form of yellowish discoloration along the margins and in cross-fractures was noted in a few individual sillimanite crystals. Garnets, where present, occur as porphyroblasts slightly elongated in the plane of foliation. Where fractured, the garnets were seen to be altered to mica in some sections. The biotite, yellow to dark brown, occurs as pods and fibrous laths laced with sillimanite. Accessory minerals, which include magnetite, apatite, spinel, rutile, cordierite and rarely zircon, seldom make up more than 5 per cent of the rock.

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[1] "Red Wine Mountains" as used in this report is a locally used term which has been submitted to but not yet approved by the Canadian Permanent Committee on Geographical Names.

As previously mentioned, the schistosity of the sillimanite gneisses has rendered them particularly susceptible to lit-par-lit injection. Microscopically the pegmatitic material is seen to consist mainly of microcline-microperthite, with minor myrmekitic albite and quartz. It is not known whether the pegmatites result from metamorphism or injection, but the transgressive nature of the stringers would appear to favour the latter. In addition, the pegmatites are much less metamorphosed than the host rock, indicating that they were emplaced later than or at least near the closing phase of the metamorphism.

Quartz-Biotite-Feldspar Gneiss (3)

In marked contrast to, but probably gradational into the laminated, migmatitic gneisses of unit 2 is a heterogeneous assemblage of gneisses (3) composed mainly of orthoclase, plagioclase, quartz, biotite, amphibole, garnet, and locally minor sillimanite. The various gneisses in this unit differ widely compositionally, structurally and texturally, but lack of outcrop and suitable horizon markers make separation of the various types impossible on the present scale of mapping. They may be readily distinguished, however, from the gneisses of unit 2 by their lower degree of metamorphism and higher content of black, flaky biotite. Also, because of their susceptibility to erosion, the gneisses of unit 3 characteristically underlie areas of subdued relief. Although intense recrystallization has imparted a uniform appearance to many of these rocks, thereby obscuring their original character, sufficient evidence of primary structures such as relict bedding, crossbedding, graded bedding, etc. remain to indicate that most of these gneisses are of sedimentary origin. The presence of numerous garnetiferous and aluminous layers, together with bands of resistant, little metamorphosed quartzite also suggest that most are paragneisses. Pegmatitic and aplitic material is common in these rocks but are less prevalent than in unit 2. Included with the gneisses of unit 3 are numerous stock-like bodies of unfoliated granite too small to be shown on the maps accompanying this report. These intrusive granites are probably closely related to the pegmatitic and aplitic material that intrudes the older gneisses (2) and may be part of unit 4.

The most common types of gneisses in unit 3 are: pink, garnetiferous quartz - biotite - feldspar gneiss; biotite-hornblende gneiss; grey, quartz - feldspar - biotite gneiss; and garnetiferous biotite - sillimanite gneiss. Although these various gneisses are in sharp contrast with each other, their boundaries are gradational. Texturally, some exposures of these rocks exhibit well defined foliation; others are coarse grained and characterized by augen structure. Locally, narrow bands of amphibolite, too discontinuous to serve as useful horizon markers, occur as concordant layers in the gneisses. Other discordant, angular amphibolite fragments and masses may represent portions of ancient metamorphosed gabbroic dykes. Garnetiferous zones have a random distribution in the gneisses and are useless as an aid in structural study.

All gneisses of unit 3 are cut indiscriminately by veins and sill-like masses of pegmatitic material, as well as by veinlets of aplite. Many of the pegmatite veins are tightly folded with associated pinch-and-swell structures, and because of its lenticular nature only rarely can an individual pegmatitic body be traced for an appreciable distance. A significant feature of the pegmatites is the similarity of their mineral composition to that of the enclosing gneiss. All pegmatites examined consisted almost entirely of K-feldspar, quartz, and biotite/muscovite. Those pegmatites cutting amphibolitic phases of the gneisses are commonly rich in magnetite and garnet, whereas those cutting the less mafic gneisses have biotite as their principal ferromagnesian mineral. It would seem probable therefore that at least some of the pegmatites were developed in situ with the gneisses and are a product of metamorphism. It may also be that some of the pegmatitic material is closely related to the granitic rocks of unit 4.

In thin section gneisses of unit 3 are seen to vary from relatively pure metaquartzites to gneisses composed almost entirely of feldspar and biotite. In addition, mineral assemblages range all the way from those of the greenschist facies to those of the granulite facies, with an attendant development of numerous minerals peculiar to each facies. The great majority of the gneisses, however, lie well within the epidote-amphibolite facies of metamorphism, and only the more prominent minerals peculiar to the rocks of this facies will be briefly described.

Plagioclase is the most abundant mineral, commonly forming as much as 60 per cent of the rock. Generally it is oligoclase or andesine (An_{25} - An_{35}) but varieties as sodic as An_{15} and as calcic as An_{45} were identified. The plagioclase is usually grey on both fresh and weathered surfaces but locally it may weather pink. Individual crystals are commonly sericitized and albite twinning with or without pericline twinning is commonly well developed. Normal zoning is present in most sections examined with much of the plagioclase intergrown with potash feldspar to form perthite. Potash feldspar, both monoclinic and triclinic, is common throughout the gneisses but is appreciably less abundant than plagioclase. Much of the K-feldspar is microcline with excellent quadrille structure, commonly intergrown with albite to form perthite.

Quartz is present in variable amounts in all phases of the gneisses. Generally it occurs in clear, slightly rounded, mildly strained interlocking grains that locally may be intensely fractured. Biotite in variable amounts is also present in practically all gneisses of this unit, typically in the form of brown, ragged, pleochroic plates lying in layers along the plane of foliation. In some specimens biotite is altered to chlorite and locally replaces sillimanite. Green and brown hornblende, strongly pleochroic, is associated with biotite in most sections examined. Fibrous aggregates or small euhedral crystals of sillimanite may be present in the garnet-bearing gneisses but rarely in appreciable amounts. Garnet, of the almandite variety, is a major constituent of many of the gneisses of unit 3. Individual garnets may appear as euhedral crystals up to one-half inch in diameter scattered throughout the rock, but in most finely layered gneisses, they occur as tiny crystals in a matrix of biotite with minor sillimanite.

Accessory minerals normally present include pyrite, apatite, zircon, rutile, tourmaline, and titaniferous magnetite. Secondary alteration products such as chlorite, calcite, epidote, and sericite are almost universally present in variable amounts.

Granite and Related Rocks of Probable Intrusive Origin (4)

Coarse, pink biotite granite (4), locally gradational into quartz monzonite and other closely related rocks, underlies about one-quarter of Lac Brûlé map-area, but is much less common in Winokapau Lake map-area. Exposures are generally small and widely scattered because of the heavy drift and an accurate estimate of the amount of granite present cannot be made. The granites tend to underlie areas of slight relief and many small, stock-like intrusives, too small to be mapped on the present scale, have undoubtedly been included with unit 3.

Typically, the granitic rocks (4) are coarse grained and massive, but in a single outcrop the rock may vary from medium grained to coarsely porphyritic over a few feet. Angular fragments of the adjacent paragneisses (2, 3), apparently preserved as roof pendants in the intrusive granites, may possibly indicate extensive masses of the latter underlying the gneisses at shallow depth. The granites are cut by numerous pegmatite and aplite dykes, composed mainly of microcline, plagioclase, quartz, biotite, and muscovite, which are undoubtedly closely related to the granite and may be end members of the same melt. This pegmatitic material cuts both the granite and adjacent gneisses indiscriminately, and as is common elsewhere in the Grenville province it is difficult to draw a boundary between true intrusive granitic rock and the adjacent gneisses. Crosscutting contacts between the granite (4) and adjacent gneisses (2, 3) are only rarely exposed and even though the granites are massive in outcrop a faint foliation parallel to that of the surrounding gneisses can usually be recognized from the air. Although the granites and related rocks (4) are, for the most part, believed to be intrusive, future detailed mapping may prove some of these granitic rocks to be gneisses of sedimentary origin that have been granitized. There is no evidence that the granites have provided heat for the metamorphism of the gneisses which they intrude; on the contrary, mineral assemblages indicative of the greenschist facies very commonly occur in gneisses adjacent to the granite.

Microscopically, the granite is seen to consist of anhedral grains of microcline (40-60 per cent) with prominent quadrille texture, and generally string, braid, and patch composite perthite showing both exsolution and replacement. Plagioclase (An_{20} - An_{30}) is next in order of abundance, with weakly zoned, saussuritized crystals commonly rimmed with microcline. Quartz, in white, opalescent, mildly strained, anhedral crystals may form up to 20 per cent of the rock. Biotite and hornblende, the former laced with chlorite and the latter intergrown with biotite, are the chief mafic minerals, but rarely do they compose more than 10 per cent of the whole. Accessory minerals include magnetite, sphene, apatite, and chlorite. The petrography of the angular inclusions in the granite identifies them as fragments of gneiss from units 2 and 3.

Intermediate to basic Gneisses (5)

An undivided assemblage of intermediate to basic gneisses (5), markedly different in appearance from the gneisses of units 2 and 3 outcrops on either side of Red Wine Mountains. South of the mountains, these gneisses (5) consist mainly of hornblende, biotite, plagioclase, and variable amounts of quartz with abundant accessory garnets. The contact between the basic rocks of the Red Wine Mountain Complex (6) and the gneisses of unit 5 was not observed there but the former are probably intrusive, whereas the contact between units 5 and 3 is believed to be gradational. South of Red Wine Mountains, the intermediate gneisses (5) are extremely garnetiferous, the garnets occurring in narrow bands which, because of their resistance to weathering, impart a laminated appearance to the exposed surface of the rock. Although these garnetiferous gneisses are well foliated they are rarely migmatitic. In composition, they are very similar to the gneisses of unit 3 but contain a much higher percentage of garnets. It is probable that most of the gneisses of unit 5 south of Red Wine Mountains are merely altered equivalents of the gneisses of unit 3, metamorphosed by intrusion of the basic rocks of the Red Wine Mountain Complex (6).

North of Red Wine Mountains, the gneisses (5) are generally more basic, outcropping mainly as dark, thinly layered amphibolites with numerous rusty layers due to weathering of biotite. Some of these basic gneisses are undoubtedly metamorphosed arkosic and pelitic sediments; others, particularly those exhibiting little or no foliation, probably represent altered gabbroic rocks with very little quartz. Interbedded with these gneisses are a few thin layers of highly metamorphosed, grey-green volcanic rocks that probably originated as basaltic tuffs. These latter rocks are interbedded on outcrop scale with 1- to 2-foot thick beds of thinly laminated, light grey quartzite, rich in biotite. All rocks in this area are cut by boudinaged sills and large, irregular patches of pink granitic material, probably closely related to the granite of unit 9. The structural trend of the gneisses (5) in this region is southwest, but unfortunately the southern extension of the exposures is covered by thick drift which effectively obscures the contact between the gneisses and the granitic rocks of unit 9. The latter rocks are, however, probably younger than and intrusive into the gneisses (5).

Basic and Ultrabasic Rocks, undivided (6)

A well exposed, heterogeneous assemblage of basic and ultrabasic rocks (6), consisting mainly of anorthosite, anorthositic-gabbro, gabbro, and quartz gabbro outcrops in Lake Winokapau map-area and forms a rugged, northeast-trending range of high hills known locally as Red Wine Mountains (Lee, 1953). With the exception of some small patches of anorthosite, all of these rocks are coarsely layered with faint banding parallel to the strike of the mountains, i.e. about N 40° E true. Included with the more basic rock types are various gneisses of dioritic composition, some of which are well foliated.

With the exception of some of the anorthosites (6a), the gabbroic rocks (6b) are rarely coarse grained and invariably contain a high content of hypersthene. In fact, most of these rocks are norites, in which the proportion of orthopyroxene far exceeds that of clinopyroxene. Typically, the norites of Red Wine Mountains are greyish green on fresh surface and weather dull grey.

Hypersthene-bearing anorthosite and gabbro outcrop in Lac Brûlé map-area, west and north of Long Lake and east of Lac Brûlé. Although the relative ages of these rocks and those of Red Wine Mountains have not definitely been established, the rocks are remarkably similar in composition and appearance and are therefore included in the same unit (6).

Scattered at random throughout both map-areas are isolated bodies of hypersthene-bearing gabbro and diorite which, because of their resistant nature, generally form prominent hills above the adjacent gneisses (2, 3) which they intrude. Their age relationship to the other rocks is not known, but because of similarity in appearance and composition they have been included with the rocks of unit 6.

Unlike anorthosite in Goose Bay map-area (Stevenson, 1967a) unit 6a is commonly fine grained and contains abundant hypersthene. Two distinct types of anorthosite were recognized: (1) a fine- to medium-grained, sugary-textured type, composed entirely of brownish green labradorite completely lacking in labradorescence and (2) a medium- to coarse-grained type composed of labradorescent, purple plagioclase (An_{55} - An_{60}) and a variable amount of hypersthene with which a few grains of ilmenite are associated.

Included with the gabbro (6b) is a wide variety of rocks including anorthositic gabbro, norite, and quartz gabbro. These rocks are all closely related to each other and are gradational. All rocks in this unit consist of variable amounts of basic plagioclase, hypersthene, diallage, olivine, hornblende, biotite, quartz and accessories. The lighter coloured rock types, such as some of the foliated norites, are invariably characterized by calcic plagioclase and a low silica content.

The typical gabbros consist of well twinned, roughly equidimensional plagioclase (An_{50} - An_{60}) crystals with slight visible zoning. Inclusions of tiny plates of ilmenite and sericite commonly impart a brownish appearance to many of the feldspar crystals. Augite, containing exsolved lamellae of hypersthene, is a common constituent along with much brilliantly pleochroic hypersthene in subhedral, elongated prisms which, in the leucocratic norites, are interstitial between the plagioclase crystals. Olivine, though not abundant, appears as scattered crystals in some of the more basic gabbroic rocks. Green hornblende associated with biotite may be present but is not common. Quartz is present in the form of clear crystal grains and also as intergrowths with alkali feldspar, but the quartz seldom forms more than 10 per cent of the rock. Accessories include apatite, titaniferous magnetite, and minor pyrite.

Throughout much of the Red Wine Mountain Complex, particularly in those areas underlain by leucocratic norite, the rocks have been unaffected by shearing. Generally the texture is hypidiomorphic, granoblastic, and granular, but locally cataclasis is apparent and the original gabbroic texture of the rocks has been obliterated, resulting in a granular, hypersthene-plagioclase-quartz gneiss. Many gabbros in the vicinity of Long Lake are so intensely sheared that they form typical mylonites and cataclasites.

Poorly exposed outcrops of ultrabasic rocks including peridotite, pyroxenite, and hornblendite (6c) were encountered at various localities. They generally appear as small, dyke-like intrusives cutting the gneisses of units 2, 3. North and south of Lake Winokapau, near the eastern end of the lake, several deeply weathered outcrops of peridotite intrude the gneisses of unit 2 and the granite of unit 4 indiscriminately, and it is thought that these intrusive ultrabasics may be related to the rocks of Red Wine Mountain Complex. The intensely altered peridotites are readily recognized from the air by their distinctive brown weathering. Compositionally, they consist of serpentinized olivine crystals (30 - 50 per cent) in a matrix of altered amphibole (tremolite), muscovite, chlorite and antigorite.

The rocks of unit 6 are cut by numerous veins of pegmatite and aplite, as well as by diabase dykes.

Mainly Quartzite, Sandstone, Arkose, Tuff (?) (7)

Impure, highly altered sandstone, arkose, and perhaps reworked tuff are poorly exposed in the area east of and adjacent to Lake Michikamau. This region is covered by dense bush, and, because of the thick drift, exposures are limited to a few lakeshores, stream valleys, and the crests of some of the higher hills.

Rocks in this unit (7) grade from relatively pure quartzite through sandstone and arkose to subgreywacke. All have been metamorphosed and intruded by granitic material. Detrital crystal fragments in the sediments are for the most part subrounded grains of quartz and feldspar, with variable amounts of interstitial green and brown chlorite, and some mica. Glauconite is a common constituent, occurring as rounded grains or tiny flakes between the sand grains. A few specimens contain glass shards indicative of a tuffaceous origin for at least some of the sandstones.

All examined outcrops and corresponding thin sections of the rocks of unit 7 displayed evidence of alteration by the intrusion of granitic material, presumably that of unit 9. Almost invariably, microscopic examination revealed a highly cataclastic mortar texture in which plagioclase and quartz grains are broken and crushed suggesting severe tectonic stresses. Resulting fracture faces are lined with green chlorite and epidote, which impart a distinct yellow-green tinge to most outcrops.

Where exposed, the contact between the granitic rocks (9) and metasedimentary rocks (7) is gradational, with the latter grading gradually from a light grey, fine-grained metasedimentary rock into a greenish, medium- to coarse-grained granite or syenite containing pink feldspar phenocrysts $< \frac{1}{2}$ inch long in a dark green groundmass. Rocks underlying the high hill between Michikamau and Windbound Lakes are representative of the gradational facies.

Because of poor exposure, the relationships between the rocks of unit 7 and those of unit 8 could not be established. On the basis of lithological and petrological similarities, however, the rocks of both units have been tentatively included in the Seal Lake Group (Roscoe, 1952; Fahrig, 1959).

Gabbroic, Sedimentary, and Volcanic Rocks, undivided (8)

A heterogeneous assemblage of gabbroic sills and volcanic flow rocks, in which are included a few discontinuous layers of massive, white or reddish quartzite, outcrops east of Windbound Lake in Winokapau Lake map-area. (These rocks are similar in many respects to those described by Fahrig (1959) as belonging to the Seal Lake Group, and are a southern extension of those mapped by Roscoe (1952) in the adjacent area to the north). In Winokapau Lake map-area the contact between unit 8 and unit 5 is probably a thrust fault, with the latter unit thrust over the former. The crucial contact area is heavily drift-covered, but several prominent northeast-striking lineaments reflected in the drift and readily apparent on air photographs are undoubtedly faults. The few outcrops exposed in the vicinity of these faults are intensely sheared, brecciated, and locally mylonitized.

Gabbroic sills, some with distinct ophitic texture, form the major part of the rock sequence of unit 8. Typically, these gabbros are composed of labradorite, clinopyroxene, hypersthene, minor olivine and quartz. In some of the coarser phases of the rocks, a rough banding is faintly visible due to parallelism of feldspar and pyroxene crystals, but in outcrop the gabbros are generally massive. Individual flows are several hundreds of feet thick and the constituent crystals become progressively larger toward the central parts of the flows. Included with the sills are small bodies of massive gabbro whose age relationship to the other rocks in the unit is in doubt.

The white quartzite (8a) consists of rounded, well sorted grains of quartz and minor feldspar cemented by quartz. Compositionally, much of the quartzite is an arkose in which about equal amounts of quartz and feldspar grains are present in a matrix of feldspar, amphibole, quartz, and comminuted rock fragments of diverse origin. Where individual mineral crystals have been coated by hematite much of the quartzite has a reddish tinge. Some quartzite outcrops show crossbedding with the beds steeply overturned to the northwest. The granitized and otherwise altered rocks of unit 7 are probably derived from the sedimentary rocks of unit 8.

The volcanic rocks (8b) are dark, greyish green, basaltic, amygdaloidal flows composed mainly of labradorite crystals in a matrix of pyroxene (augite, pigeonite, hypersthene). Where the rocks are amygdaloidal, the vesicles are filled with carbonate, epidote, amphibole, chlorite, and serpentine. Although not common, olivine may be a constituent. Many of the flow rocks have been intensely sheared and deformed to the point where the original texture has been completely destroyed and the rock is now a chlorite-epidote-carbonate schist.

The rocks of unit 8 are similar in many respects to those described by Fahrig (1959), and are a southern extension of those mapped by Roscoe (1952). Accordingly, they have tentatively been assigned to the Seal Lake Group.

Granite, Quartz Monzonite, Granodiorite, Quartz Diorite, Syenite (9)

A band, some 15 miles wide, of massive to faintly foliated, coarse-grained, locally porphyritic granite and related rock-types outcrops along the south shore of Lake Michikamau and extends eastward to the vicinity of Red Wine Mountains. Typically, these rocks consist of phenocrysts of pink feldspar in a greenish matrix of plagioclase, microcline, quartz, hornblende and biotite, and locally they may vary from structureless, coarse-grained granite through granodiorite to a fine-grained syenitic rock containing little or no visible quartz. The most striking and distinctive characteristic of the rocks of this unit is the abundance of epidote readily visible in outcrop, in marked contrast to the granitic rocks of unit 4 which contain little or no epidote. Relative ages of the rocks of unit 9 and those of other units are not known definitely, but if the epidotization and alteration of the sedimentary rocks of unit 7 are related to the emplacement of the granitic rocks (9), then the latter are younger.

Microscopically, the various rock types in unit 9 are seen to be connected with virtually continuous gradations in texture, the variations in rock type depending mainly upon the quartz content and relative percentage of potash feldspar to total feldspar. In most thin-sections examined, the plagioclase is in the oligoclase-andesine range (An_{20} - An_{35}), with the more calcic plagioclase occurring in the quartz diorite and granodiorite. Typically, oligoclase is more abundant in the granites, but locally albite is present due to albitization of the original rock. A few rounded grains of quartz are generally present in the rims of the plagioclase crystals. Microcline perthite is common in the granite, with perthitic blebs constituting a major proportion of many of the grains. Both orthoclase and microcline crystals are present in several sections examined, and some of the larger grains contain inclusions of plagioclase, ferromagnesian minerals, and magnetite. Anhedral quartz crystals, some mildly strained and with abundant liquid inclusions, occur in variable amounts in all rocks of this unit. Dark green, pleochroic hornblende and brown biotite are the most common ferromagnesian minerals in the granites, with pyroxene becoming progressively more abundant as the rocks become more calcic. Muscovite, either an alteration product of plagioclase or formed from inclusions of aluminous material, is present in a few sections but is not abundant.

Epidote and chlorite are present in practically all rock types in this unit. Epidote occurs both as an alteration product of plagioclase and ferromagnesian minerals and also as a deuteric mineral. Accessory minerals include apatite, magnetite, zircon, rutile, and sphene.

Diabase Dykes (10)

Abundant diabase dykes (10), most with ophitic texture and chilled margins, cut the rocks of units 1-9 indiscriminately. Although numerous, only rarely do the individual dykes exceed a few tens of feet in thickness and hence few appear on the accompanying maps. Diabase dykes were not observed cutting the rocks of unit 11 and therefore probably pre-date the latter.

Conglomerate, Arkose, Siltstone (11)

Gently dipping, dull red conglomerate, arkose, and siltstone (11) outcrop on the south shore of Lake Michikamau and form several islands in the lake. The conglomerate is composed mainly of subrounded boulders, cobbles, and pebbles of granite in a matrix of arkose and siltstone consisting of quartz, ferric iron oxide, and calcite. Feldspars in the arkoses and siltstones are fresh with few broken or bent lamellae. All rocks in this unit are cut by veins of white quartz.

In general, these rocks have gentle dips and are but little disturbed. Locally, however, shearing and folding have occurred and the beds are vertical or overturned. Evidence of such tectonic activity is exposed in an outcrop on the south shore of Lake Michikamau at 63° 58'W, where the red conglomerates and arkoses are steeply dipping and contorted. The rocks of this unit are but slightly metamorphosed relative to all other rock units in the map-areas, and are therefore probably of Proterozoic age.

METAMORPHISM

All rocks in the area have been metamorphosed to varying degrees, ranging from the greenschist facies of some of the slightly altered sedimentary rocks of unit 7, 8, and 11 to the granulite facies of many of the gabbroic rocks of unit 6 where the mineral combination labradorite-hypersthene-hornblende is commonly encountered. A particularly interesting texture, typical of the granulite facies, is displayed in the anorthosite (6a) exposed at 63° 33'W, at the extreme southern limit of Lac Brûlé map-area. In these rocks, orbicules up to 3 inches in diameter composed of green fibrous pyroxenes enclosed by radially arranged reaction rims of fine-grained pyroxenes and amphiboles are well exposed over an appreciable area.

By far the greater proportion of rocks in the area fall in the albite-epidote-amphibolite and the amphibolite facies of metamorphism, typical of medium- and high-grade regional metamorphism common everywhere to rocks of the Grenville province. Locally, various subfacies have developed, dependent upon the mineral assemblages present and the variables of temperature, pressure, and shearing stress peculiar to that immediate environment. The presence of sillimanite in the gneisses of unit 2 is indicative of the sillimanite-almandine subfacies for the rocks of that unit; abundant chlorite and actinolitic hornblende in the granitic rocks of unit 9 place the latter rocks in the lower part of the albite-epidote-amphibolite facies. The majority of the gneisses and granitic rocks of units 3 and 4 lie in the amphibolite facies of metamorphism.

The intense plastic deformation of most of the gneissic rocks in the area, particularly those of unit 2, suggest that these rocks were once deeply buried. There does not, however, appear to be any connection between the intensity of deformation and the metamorphic grade of the rocks concerned. It is more probable that both the degree of metamorphism and the mineral composition of the rocks were controlled mainly by the availability of volatile and fluid materials during metamorphism.

FOLDING

The structure of the area is undoubtedly the product of several deformations, resulting in an extremely complex fold pattern too complicated for detailed study on the present scale of mapping. Major fold structures can only rarely be identified because of thick drift and poor exposures, but foliation dips in the gneisses generally exceed 50 degrees and are locally steeply inclined. Foliation trends are visible on some air photographs, particularly in those areas with rugged relief, but the axial planes of the folds cannot be located accurately and hence do not show on the accompanying maps.

North of Churchill River the dominant strike of the foliation in the gneisses is northeast parallel to the trend of Red Wine Mountains. The same strike is reflected in the gneisses of unit 2 in Lac Brûlé map-area, becoming northwest to west in the vicinity of Long Lake and south of Little Mecatina River. A prominent arcuate topographic depression of unknown origin, convex toward the north and extending in an east-west direction across the southwest corner of Lake Winokapau map-area, follows the strike of the foliation in that region, and is undoubtedly controlled by some deep-seated orogenic movement. Drag-folds, ubiquitous in the gneisses of unit 2, were rarely recognized in the rocks of other units. In general, the sillimanite-rich gneisses (2) are more intensely folded on a regional scale than the other rocks, and one would suspect that the former are perhaps of greater age and hence have been subjected to more intense and additional deformations.

FAULTING

The entire area has been extensively faulted but most of the criteria commonly used to determine the actual displacement along individual faults are obscured by drift. Prominent topographic lineaments readily identified on air photographs as depressions in the drift, are in many places undoubtedly faults. The generally drift-filled valleys obscure critical features; where exposed, the valley walls have been gouged and eroded and all evidence of faulting removed. Microscopic examination, however, indicates that rocks adjacent to many of the major lineaments are mylonitized and brecciated, and in some cases intensely chloritized, epidotized and injected by tiny veinlets of quartz, calcite and feldspar. Where such evidence of faulting was recognized the lineaments are assumed to be faults.

South of Lake Winokapau and extending into Lac Brûlé map-area the gneisses of unit 2 are cut by a system of prominent fractures which, because of insufficient evidence, could not be definitely classified as either faults or joints. Two prominent sets of fractures are present, a north-trending set and an east-trending set. Some of these lineaments are undoubtedly joints, but minor shearing and slickensides exposed along some of the fracture walls are indicative of faulting.

The nature and position of the Grenville Front in Lake Winokapau map-area have not been definitely established. The crucial area between Red Wine Mountains and Michikamau Lake through which the front is presumed to pass is thickly drift-covered and rock exposures limited. A series of northeast-trending topographic lineaments between 62° 25'W and 63° 00'W are believed to represent a series of parallel faults, but with the exception of a few exposures close to the north limit of the map-area, all rocks along the walls of the lineaments are obscured. Where exposed, rocks adjacent to the lineaments are brecciated, sheared, and mylonitized. Granitic rocks (9) adjacent to Michikamau Lake are generally massive but are almost invariably intensely chloritized and epidotized. West of Windbound Lake the sedimentary rocks (7) are highly brecciated and cataclastic. The Grenville Front in Winokapau Lake map-area is probably represented by a broad, northeast-trending zone of cataclasis and shearing in which the rocks immediately west of Red Wine Mountains have been thrust northwest along a series of northeast-trending faults.

MINERALIZATION

No mineralization of economic importance was recognized, but much of the area has not been systematically prospected because of difficulty of access and thick drift. Aeromagnetic maps, which would be an invaluable aid in prospecting, are lacking for most of the area.

Magnetite, ilmenite, pyrite, pyrrhotite, and chalcopyrite were the most common minerals encountered, but no showing examined was of economic value. Magnetite and ilmenite commonly occur as segregations in the gabbro and anorthosite; as disseminations in the gneisses; and as components of the beach sands in many of the lakes. Titaniferous magnetite outcrops in a zone some 10 miles long by 2 miles wide north of Wilson Lake in Winokapau Lake map-area. There the mineralization consists of tightly folded lenses and pods of hematite, magnetite, and ilmenite mixed with amphibole. Individual lenses, ranging from 2 to 10 inches in width are concordant with the foliation of the gneisses (2) and commonly pinch out gradationally along strike. Contacts between the iron-rich rock and the host gneisses are typically irregular with finger-like protrusions of the former in the latter. Because of their resistance to erosion, these mineralized layers tend to outcrop as elevated ridges in the gneisses. Although much of the magnetite-hematite is coarsely granular, some outcrops have a distinct layered structure. The presence of the rather rare mineral sapphirine ($Mg_5Al_{12}Si_2O_{27}$) in these rocks is of particular scientific interest (Meng, 1967).

A prominent south-striking, discontinuous zone some 500 feet wide with a rusty, gossan-like appearance can be traced for about 3 miles from the south shore of Wilson Lake. The structure of the gneisses (2) through which the zone passes is extremely complicated and the location of the mineralized zone is undoubtedly structurally controlled. The mineralization, which is confined to the rusted zone, consists mainly of oxidized pyrite associated with numerous white quartz veins. A few pods and lenses of magnetite-ilmenite, similar to those north of Wilson Lake, also occur in the rusted zone.

Minor amounts of chalcocite are present in some of the pegmatites, along with pyrrhotite and pyrite. Pyrite is present in practically all basic and ultrabasic rocks including diabase dykes. Numerous small showings of pyrite with minor traces of pyrrhotite and chalcopyrite occur at random throughout the gneisses (2, 3), and are generally associated with granitic intrusives.

Gravel and sand suitable for road building and construction are present in abundant quantities throughout both map-areas.

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