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## ABSTRACT

Tuadook Lake map-area lies in the northeastern part of the Appalachian Mountain system in the central part of the Miramichi Highlands physiographic subdivision.

The oldest rocks are Cambro-Ordovician quartzite, phyllite, paragneiss and amphibolite that occupy the core of a large northeasterly-trending anticlinorium, the Miramichi geanticline. These rocks have undergone metamorphism to the amphibolite grade and at least two periods of deformation.

Greenstone, rhyolite, greywacke, slate and conglomerate overlie the metasedimentary rocks conformably. East of the map-area graphitic slate within the assemblage contains Middle or possibly Late Ordovician graptolites.

Cataclastic, commonly foliated to gneissic granitic rocks of Late Ordovician or Early Silurian age cut the metasedimentary rocks and underlie about a third of the map-area, and massive Devonian granitic and gabbroic rocks cut metasedimentary rocks and the Upper Ordovician or Lower Silurian intrusive rocks.

Lower Devonian basaltic, rhyolitic and supposedly cogenetic granitic rocks flank gabbroic and older granitic rocks on the west.

The general structural trend of all rocks within the map-area, except Devonian granitic rocks, is north-northwest athwart the northeasterly Acadian orogenic trend. The most prominent structural feature is the Catamaran fault that strikes easterly across the southern part of the map-area and may have a right lateral strike slip of 4 1/2 miles.



## RESUME

La région du lac Tuadook se trouve dans la partie nord-est de la chaîne des Appalaches, dans le centre de la subdivision physiographique des hautes Terres de Miramichi.

Les roches les plus vieilles sont des quartzites, des phyllites, des paragneiss et des amphibolites du Cambro-Ordovicien qui occupent le coeur d'un grand anticlinorium orienté au nord-est, le géanticlinal Miramichi. Ces roches ont été métamorphisées jusqu'au stage de l'amphibolite et ont subi au moins deux périodes de déformation.

Des roches vertes, de la rhyolite, des grauwackes, de l'ardoise, des conglomérats recouvrent en concordance les roches métasédimentaires. À l'est de la région, l'ardoise graphitique à l'intérieur de l'ensemble contient des graptolithes de l'Ordovicien moyen ou probablement de l'Ordovicien supérieur. Des roches granitiques cataclastiques, de communément feuilletées à gneissiques de l'Ordovicien supérieur ou du Silurien inférieur, coupent les roches métasédimentaires et sont sous-jacentes à environ un tiers de la région. Des roches granitiques et gabbroïques massives coupent les roches métasédimentaires et les roches intrusives de l'Ordovicien supérieur ou du Silurien inférieur.

Des roches basaltiques, rhyolitiques et du granite supposément de même origine, du Dévonien inférieur, longent du côté ouest les roches gabbroïques et granitiques plus anciennes.

La structure générale de toutes les roches de la région, sauf les roches granitiques du Dévonien, présente une orientation nord-ouest en travers de la direction orogénique acadienne orientée vers le nord-est.

La caractéristique structurale la plus remarquable est la faille Catamaran qui s'étend vers l'est à travers la partie sud de la région et pourrait avoir une composante horizontale de rejet du côté droit de 4 1/2 milles.

# GEOLOGY OF THE TUADOOK LAKE MAP-AREA, NEW BRUNSWICK (21 J/15)

## INTRODUCTION

Tuadook Lake map-area lies in the centre of a belt of highly deformed older Paleozoic rocks that extend northeasterly across the province from Woodstock to Bathurst. The map-area is 45 miles west-southwest of Newcastle and 55 miles northeast of Woodstock, New Brunswick.

Field work was carried out during the summers of 1968 and 1969, and able assistance was given by Eugene Hsu, Ian McIlreath, Paul Dean and Boyd Cleveland (cook) in 1968 and H. Dean Rogers, Gerald Peddle, David Desjardins and Erwin Hathaway (cook) in 1969. The writer is indebted to employees of the Fraser Companies Limited, Irving Pulp and Paper Limited and New Brunswick Forest Service for assistance and co-operation.

### Accessibility

The Plaster Rock-Renous Highway (109) crosses the area from west to east and several logging roads branch from it. Fraser Companies Limited maintain an all weather road along the south side of Little Southwest Miramichi River in the northeastern part of the map-area and have logging roads in the northwestern part. These roads branch from the highway 10 miles east of, and 2 miles west of the map-area.

An access road branches northward from the highway, a mile east of North Dungarvon River, cuts through the east half of the map-area and joins the Fraser Companies road a mile northeast of Holmes Lake near the abandoned Renous airstrip. Irving Pulp and Paper Limited maintain a gate-controlled road that branches southward from the highway 3 miles west of Moose Lake and cuts through the southwestern part of the area to Clearwater Brook at the south boundary, and continues southwestward 26 miles to Deersdale on the Juniper-Napadogan Highway (107). A privately owned logging road branches southward from Highway 109 a mile west of the map-area and extends to McCoy Brook. The streams in the area are small and not navigable by boat or canoe.

### Physical Features

The map-area lies in the centre of the Miramichi Highlands of New Brunswick (Weeks, 1957) and has a mature topography of rounded hills and wide shallow valleys. The stream pattern is dendritic, reflecting the granitic and metamorphic terrain. Maximum local relief of 950 feet is in the southwestern part of the area, but generally relief is less than 500 feet. Elevations vary from 750 feet above sea level near Dungarvon River in the southeast corner to 2,150 feet, 2 miles west of Moose Lake in the central part of the west half of the map-area. Some hills near the western boundary of the map-area are 2,000 feet or more high. Most of the streams are small, head within the map-area, and flow southeastward into the Southwest Miramichi River 10 miles south of the map-area. The streams in the northwest corner of the map-area flow northwestward to join Tobique River, a tributary of Saint John River, 13 miles west of the area. There are many small lakes, particularly in the northern half of the map-area, the largest being Tuadook Lake which is 3 miles long, swampy and shallow.

Outcrops are scarce. The best exposures are in road-cuts along the Plaster Rock-Renous Highway. Most of the remaining outcrops are on the sides and tops of hills and along the valleys of the most deeply incised streams such as Dungarvon River, and Clearwater and Rocky brooks.

### Glaciation

The map-area was glaciated during the Pleistocene. Glacial striae and drumlinoid forms indicate that the ice moved southeastward across the area.

A thin mantle of glacial till covers the hills and is thicker on the sides of hills and in the valleys. Boulder till is up to 20 feet thick along the highway near Dungarvon River. The valleys contain postglacial sand and gravel deposits which along Little Southwest Miramichi River are 15 feet or more thick. Eskers are present along upper Tuadook and Northwest Branch Little Southwest Miramichi rivers, and Mains and Lake brooks and

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a few small kame deposits occur along the Plaster Rock-Renous Highway west of Dungarvon River.

## GENERAL GEOLOGY

The map-area is underlain mainly by cataclastic, foliated, Upper Ordovician or Lower Silurian granitic rocks (3) and metamorphosed Cambrian-Ordovician sedimentary rocks (1). The western part of the area is underlain by a north-northwesterly trending body of Devonian gabbro (5) flanked on the west by Lower Devonian granophyric granite and volcanic rocks (4). Massive Devonian granitic rocks (6) cut the metasediments, older granite and gabbro as large bodies in the northeast and southeast parts, but also as smaller bodies in other parts of the area.

### Cambrian and/or Lower Ordovician (1)

The oldest rocks in the map-area are tightly folded metasediments. They underlie about 35 per cent of the east half of the map-area and about 15 per cent of the west half and are the southwestward extension of similar rocks in McKendrick Lake (Anderson, 1970a), Big Bald Mountain (Anderson, 1970b) and Sevogle (Dawson, 1961) map-areas and extend southward into the Hayesville (Poole, 1963) map-area. These rocks are best exposed and most accessible in road-cuts along the Plaster Rock-Renous Highway. They range in metamorphic grade from lower greenschist (quartzite and phyllite) in the east to amphibolite (biotite-quartz-plagioclase paragneiss and schist and amphibolite) in the west. Much of the paragneiss contains cordierite and some contains sillimanite, staurolite or andalusite. The metasedimentary rocks are commonly cut by sills and dykes of cataclastic granite (3) and in a few places by dykes and sills of gabbro (5) and granite (6).

Because the base is not exposed, the exposures are scarce, and the structure is complicated, the thickness is not known, but it probably is several thousand feet. Dips are steep and strikes are variable, but the general trend is north to northwest. Commonly the metasediments contain minute crystals of magnetite that produce magnetic anomalies which reflect the trend of the strata (Geol. Surv. Can. aeromagnetic map 144G).

The metasediments have been subdivided into three sub-units based on metamorphic grade and lithology. Sub-unit 1a contains quartzite, phyllite and hornfels, sub-unit 1b mainly paragneiss, and sub-unit 1c mainly amphibolite. Sub-unit 1a occurs mainly in the eastern part of the map-area surrounding the South Renous River quartz monzonite stock (6a). It also is present as an inclusion in the stock, and as a thin lens in the northwest part of the map-area 1 1/2 miles west of Gulquac Lake where it flanks granophyric granite (4c). The lens of sub-unit 1a was observed within a small area on a hillside where it is composed of contorted, thin-bedded quartzite and hornfels. It is intruded on the east by pink, leucocratic, granophyric granite (sub-unit 4c) and occurs as inclusions in the granite. Although the western contact was not seen, the quartzite and hornfels appear to be overlain unconformably by basalt and cherty volcanogenic sediments (unit 4a). Sub-unit 1a is relatively well exposed along the eastern part of the highway.

Sub-unit 1a is composed of interbedded, very fine grained light grey quartzite (metasiltstone), greenish grey phyllite, and adjacent to the quartz monzonite stock (3a), hornfels. Commonly these rocks are finely laminated, but in places they form beds a few inches thick. Generally phyllite is highly crenulated. Grain gradation was noted in many of the outcrops of these rocks and top determinations were made there. Commonly phyllite contains minute disseminated crystals of magnetite and some of the quartzite contains feldspar. Hornfels is grey mottled with brown and is composed of very fine grained quartz, biotite, sericite and chlorite.

Sub-unit 1b contains paragneiss and schist and minor amphibolite and quartzite and occurs as a rim along the west side of sub-unit 1a with a westward salient near the south boundary of the map-area, as a triangular-shaped roof pendant near the centre of the area, as four or more inclusions in the older granitic rocks (3b), as a northwest-trending pod-shaped area flanking the older granite (3b) on the west, and as two or more inclusions in the gabbroic body (5) in the west part of the map-area. Good exposures of these rocks are present in road-cuts along the highway.

The paragneiss is commonly a grey, medium- to fine-grained, vaguely layered, foliated rock composed of about 25 per cent quartz, 25 per cent andesine, 15 per cent biotite, 10 per cent each of muscovite and chlorite, 15 per cent cordierite and 2 to 5 per cent magnetite. Some contains up to 20 per cent hornblende and grades into hornblende gneiss and/or amphibolite, notably on the highway north of Moose Lake. With increase in mica and decrease in feldspar content these rocks grade into schist and with increase in feldspar and quartz content they grade into distinctly layered gneiss. Some gneiss is finely laminated and some of this type is intensely contorted as along the highway at the junction with the road north to Renous airstrip. Some gneisses have pink layers or lenses of up to 20 per cent potash feldspar (perthite) and some paragneiss in the west half of the map-area contains up to 5 per cent sillimanite, commonly enclosed in cordierite, while others south of the highway contain up to 10 per cent garnet.

Sub-unit 1c contains amphibolite, hornblende (-diopside) gneiss, minor paragneiss, schist and quartzite and occurs as lens-shaped bodies mainly

within the paragneiss (1b) chiefly within the large body in the west half of the map-area, but also in paragneiss along Dungarvon River and Rocky Brook and within the large gabbroic body (5) in the west half of the map-area. The best exposures of amphibolite and hornblende gneiss are present in road-cuts along the highway west of Moose Lake.

Amphibolite is grey, fine to medium grained, laminated to massive, commonly has a "pepper and salt" appearance on weathered surfaces, and is composed of about 20 to 50 per cent andesine, 50 to 80 per cent hornblende and up to 5 per cent magnetite. Hornblende (-diopside) gneiss is grey to greenish grey, fine to medium grained, laminated and contains up to 30 per cent quartz, 30 per cent diopside and 10 per cent biotite and about 30 per cent andesine, 20 to 50 per cent hornblende and up to 5 per cent magnetite. Layers rich in hornblende are dark grey to black and are up to an inch thick; layers and lenses rich in feldspar and quartz are light grey to white and commonly less than 1/4 inch thick; and layers and lenses of diopside are light green and also commonly less than 1/4 inch thick.

The amphibolite and hornblende (-diopside) gneiss appear to have been derived from limy sedimentary rocks because commonly they are thinly laminated, grade into and are interlayered with paragneiss as on the highway near the west end of Moose Lake. Furthermore at this locality 1- to 2-inch "beds" of fine-grained, thinly laminated hornblende-diopside gneiss are boudinaged and engulfed in medium-grained massive "pepper and salt" amphibolite suggesting that the gneiss was a relatively competent silty limestone bed within a purer, more massive limestone that flowed around the boudinaged silty beds prior to, or during the early stages of metamorphism. The only place that definite volcanic material was found within the Cambro-Ordovician rocks is along the highway 1/2 to 1 mile west of Clearwater Brook where gabbro, diabase and granitic dykes cut amphibolite (1c). The basaltic material is believed to be a fine-grained equivalent of the gabbro and diabase (5).

The age of unit 1 is not known but has been given a Cambrian-Ordovician age in adjoining areas to the east (Anderson, 1970a) and south (Poole, 1963) because it appears to underlie Middle Ordovician rocks which are less intensely metamorphosed. Contact relations with unit 2 rocks have not been observed.

## Ordovician (2)

Greenstone and rhyolitic rocks outcrop within an area of less than 2 square miles in the southeast corner of the map-area. The exposures examined are present along or near wood roads. These rocks are correlated with similar ones that are intercalated with grey greywacke, slate, and conglomerate that are well exposed along South Renous River 1 to 3 miles east of the map-area (Anderson, 1970a) and south of the map-area (Poole, 1963). Graphitic slates in this assemblage contain graptolites of Middle Ordovician and possibly Late Ordovician age (Poole, 1963). The thickness, structure and contact relationships with other units within the map-area are not known, but to the southwest (Poole, 1963) these rocks appear to overlie the metasedimentary rocks conformably.

The greenstone is a green weathering, dark grey, aphanitic to fine-grained, massive, basaltic to diabasic textured rock commonly composed of albite, actinolite, chlorite and minor ilmenite and magnetite. Some of the less altered varieties contain andesine in place of albite and some relict clinopyroxene. The rhyolitic rocks are buff weathering, grey agglomerates and tuffs that are intercalated with greenstone in the northeastern part of the area underlain by unit 2. In the adjoining map-areas to the east (Anderson, 1970a) and south (Poole, 1963) where exposures are better, greenstone sills are plentiful in this unit.

## Upper Ordovician or Lower Silurian (3)

There are at least two ages of granitic rocks in the map-area: an older cataclastic type (3) and a younger massive type (6). A third variety has been included with rocks of Early Devonian age (4) because it is closely associated with Lower Devonian rhyolitic rocks (4b) and commonly is microgranophyric. These "granites" (4) are similar to granitic rocks of unit 3 particularly those of subunit 3c that occur along Clearwater Brook, and are in close spatial relationship with unit 4c rocks, suggesting that unit 3 rocks may be Early Devonian in age.

Five samples were collected along the Renous-Plaster Rock Highway and analyzed to determine the age of metamorphism of the metamorphic rocks (1) and the age of intrusion of the igneous rocks (3 and 6) (Skinner, 1972a). Muscovite-biotite quartz schist (1b) 5 miles west of the east boundary of the map-area is cut by pink, foliated, cataclastic muscovite-biotite granite sills a few inches thick, believed to represent the older granite (3a). The K-Ar date of muscovite in the schist gave 379 $\pm$ 16 million years and biotite gave 376 $\pm$ 16 million years. The K-Ar date on muscovite of the granite sill gave 386 $\pm$ 16 million years. Hornblende from amphibolite (unit 1c) from 1 mile west of the Clearwater Brook bridge gave a K-Ar date of 376 $\pm$ 18 million years; and muscovite from pink, massive, porphyritic muscovite-biotite quartz monzonite of unit 6c, 2.3 miles west of the Renous airstrip road, gave a K-Ar date of 382 $\pm$ 16 million years.

It was hoped that the K-Ar dates from the schist, amphibolite and cataclastic granite would yield pre-Devonian ages thus indicating an Upper Ordovician or Lower Silurian metamorphic history.

The Middle Devonian ages obtained indicate that the schist, amphibolite and granite sills were metamorphosed and/or were raised by crustal upwarp of the Miramichi geanticline during the Acadian Orogeny and retention of radiogenic argon began from that time. The supposed Middle Devonian age of the massive quartz monzonite was supported.

Upper Ordovician or Lower Silurian granitic rocks (3) underlie about a third of the map-area (130 square miles) mainly in a northwest-trending belt through the centre of the map-area that is about 13 miles wide at the north boundary and narrows southward. A stock of these rocks lies at the east boundary, two smaller bodies are in contact with or within a large gabbro body in the west part of the area, and a belt a mile or so wide lies mainly along the western half of the south boundary.

The older granitic rocks (3) are commonly pink, cataclastic, foliated or gneissic, the foliation and gneissosity commonly paralleling the foliation, gneissosity or bedding in the Cambro-Ordovician metasedimentary rocks (1). Cataclastic granitic sills are common in Cambro-Ordovician metasedimentary rocks (1) and the latter are common as inclusions in the old granitic rocks (3). The parallelism and close relationship of these rocks suggests a metasomatic origin for the older granitic rocks.

Granitic rocks (3) commonly contain 20 to 30 per cent perthite and microcline (in places as phenocrysts), 20 to 50 per cent zoned and altered oligoclase, 20 to 40 per cent strained quartz, 5 per cent minute flakes of biotite partly altered to chlorite, and in places up to 5 per cent hornblende partly altered to chlorite. The feldspars and quartz are generally fractured and the biotite bent.

The South Renous River stock (3a), near the east boundary of the map-area, is composed of pink and grey, commonly porphyritic, cataclastic, foliated biotite quartz monzonite, minor granodiorite and quartz diorite. Rapakivi texture is present in porphyritic quartz monzonite along South Renous River near the east boundary, where pink perthite phenocrysts up to 2 inches across are mantled by oligoclase about 1/4-inch thick. The southern part of the stock contains an inclusion, or roof pendant of thinly laminated quartzite, phyllite and hornfels (unit 1a) about 1 mile long and 1/3-mile wide.

Variety characterizes the main body of older granitic rocks (3b). In the south half of the map-area along Lake Brook, near the southern boundary, these rocks are pinkish grey granodiorite gneisses that contain lenses of amphibolite; along Rocky Brook they are pink leucocratic quartz monzonite gneisses; along South Dungarvon River they are pink quartz monzonite gneisses and augen gneisses; along the highway they are pink, foliated quartz monzonites; and north of Indian Lake they are pink, foliated and gneissic granites.

In the north half of the map-area the older granitic rocks (3b) east of Island Lake are mainly pink, foliated biotite quartz monzonite and granite with some gneissic and augen gneissic varieties all cut by pink, massive leucocratic aplitic granite. Reddish orange, fine-grained quartz-feldspar porphyry similar to unit 4c cuts unit 3b rocks about 1 3/4 miles northwest of the west end of Tuadook Lake. West of Island Lake unit 3b rocks are mainly pink quartz monzonite augen gneiss with mylonitized equivalents along the western contact. Along the south shore of Trousers Lake the rocks are grey, cataclastic biotite granodiorite.

The older granite along the south boundary of the map-area is cut by the Catamaran fault and is more cataclastic than most especially near the fault where it is mylonitized. Commonly it is pink, fine-grained, gneissic, chloritic granite or quartz monzonite; some is pink, coarse-grained, sheared augen gneiss as on the north shore of the unnamed lake on Lake Brook, or is grey, sheared, biotite augen gneiss as at the west boundary 1 1/2 miles north of the south boundary, and another is very fine-grained to aphanitic, cream coloured, thinly laminated mylonite or a light grey, brecciated, rhyolitic-looking rock as along Rocky Brook 2 miles south-southwest of Twin Lakes. Greenish grey, sericitic and chloritic, crushed granite occurs along Catamaran fault a mile east of the Irving Pulp and Paper Limited Road, on Rocky Brook and in the northernmost outcrops near the west boundary of the map-area.

The granitic stock (3c) near the west boundary of the map-area along and near Clearwater Brook is mainly pink, medium-grained, cataclastic, microgranophyric, biotite quartz monzonite that is well exposed along the highway. Along Little Northeast Clearwater Brook this body is composed of grey, medium-grained, cataclastic, biotite granodiorite similar to the rock present in the smaller stock of unit 3c along the highway within the large gabbro body (5).

## Lower Devonian (4)

Volcanic and associated granitic rocks underlie a northerly trending belt of about 40 square miles along the western side of the map-area and extend several miles westward into the Plaster Rock map-area (Skinner, 1971). Minor siltstone and shale are interbedded with the volcanic rocks. Brachiopods from Falls Brook, 2 1/4 miles west of the map-area and 2 miles south of the north boundary, identified by A.J. Boucot (pers. comm., 1972) include Coelospira, Spinoplasia and Anoplia, and suggest an early Devonian age. Associated trilobites identified by W.T. Dean of the Geological Survey of Canada (pers. comm., 1972) include an indeterminate calymenid pygidium, a fragment of an indeterminate homalonotid thorax, Dalmanites

and Otarion. All these are known also from Silurian strata and do not offer any conclusive evidence of a Devonian age.

Basaltic rocks (unit 4a) appear to be at the base of the Lower Devonian sequences in the northern and southern parts of the belt. These rocks underlie hilly areas in the northwest corner of the map-area north and south of Ogilvie Lake, and a northwest-trending belt in the south, mainly between McCoy Brook and Pond Brook.

The basaltic rocks are commonly greenish grey, aphanitic to fine-grained, massive, blocky-breaking basalt and greenstone. Some are amygdaloidal, but no pillows were observed in them. A few are medium- to coarse-grained, diabasic and gabbroic varieties and may be related dykes and sills. Buff-weathering quartz-feldspar porphyry flows or sills, and cherty volcanogenic sediments are intercalated with basalt in the southern part of the northern basaltic area, and quartz-feldspar porphyry is intercalated with basalt along McCoy Brook in the southern area. Dark grey, fine-grained greywacke occurs with basalt north of Ogilvie Lake.

Acidic volcanic rocks (4b) flank basaltic rocks (4a) and related granitic rocks (4c) on the west. The relationships to one another are not definitely known, but the acidic volcanic rocks are thought to be cogenetic with the granitic rocks and appear to overlie the basaltic rocks. The stratigraphic relationship is based on westward facing tops in intercalated graded greywacke beds along Lake Branch Gulquac River 1/4 mile west of the map-area. The best exposures of these rocks are along the Plaster Rock-Renous Highway.

The acidic volcanic rock unit (4b) consists mainly of red, brown and grey, commonly finely porphyritic quartz latite and rhyolite interlayered with reddish orange, brown and pink quartz-feldspar porphyry and minor grey shale, argillite, siltstone, greywacke and greenish grey basalt. Some of the acidic volcanic rocks are fragmental tuffs and agglomerates. The phenocrysts are mainly albite and quartz, but some are perthite. Some of the latite and rhyolite is microgranophyric and consists of flows or sills. A few exposures are laminated, contain shards and are almost certainly tuffs. A good example of laminated quartz latite tuff is in the most easterly outcrop of unit 4b along the highway 3/4 mile east of Gulquac River. It has 1-inch grey laminations with light red and green borders and lies between pink feldspar porphyry on the ea t and argillite on the west. A similar rock occurs about 1/3 mile west of that exposure. Light greenish grey, vaguely laminated, shard-filled tuff is intercalated between pink quartz porphyry on the east and brown mudstone on the west, 1/2 mile west of Gulquac River. Thinly laminated acidic volcanic rocks are common to the west in the Plaster Rock map-area (Skinner, 1971).

Granitic rocks (4c) spatially related to acidic volcanic rocks (4b) underlie a northerly trending belt about 12 miles long and 1/2 mile wide north of the highway and up to 2 miles wide south of the highway. These rocks flank rhyolitic rocks (4b) and the northern area of basaltic rocks (4a) on the east being separated from the latter by a narrow lens of Cambro-Ordovician quartzites (1a). The eastern contact of granitic rocks (4c) is mainly with granitic rocks (3c) south of the highway and, with gabbroic rocks (5) north of the highway. Along the highway 1.4 miles east of Gulquac River, pale red, massive, fine-grained feldspar porphyry of unit 4c is in fault contact with a sheared diabasic gabbro dyke, that cuts pink, cataclastic micrographic quartz monzonite of unit 3c.

Granitic rocks of unit 4c consist of four main types that commonly have a microgranophyric texture and have similar compositions and appearance. The most prominent type is reddish orange, medium-grained, massive, microgranophyric, leucocratic granite which is present along the highway 1.1 miles east of Gulquac River, up to 1 1/4 miles north of the latter outcrop and in the west and central parts of the unit 4c area south of the highway. Red feldspar porphyry and quartz-feldspar porphyry are commonly associated with it.

The next most common type of granitic rock assigned to unit 4c is a light brown to pink, fine- to medium-grained, chloritic hornblende-biotite quartz monzonite that almost always has a microgranophyric texture. It occurs mainly in the northern and southeastern parts of the area south of the highway. Some of these rocks outcrop about 1 1/2 miles north of the highway.

The third most abundant variety of unit 4c rocks is an orange pink, fine-grained, massive, leucocratic granophyre sparsely speckled with chloritic biotite. This rock occurs mainly in the northern part of the area of unit 4c west and northwest of Gulquac Lake.

The fourth type is a brown to red, massive quartz-feldspar porphyry in which hornblende and/or biotite is commonly altered to chlorite.

Feldspar porphyry and porphyritic quartz latite are widely distributed throughout unit 4c rocks. The feldspar phenocrysts are plagioclase (albite to andesine) and perthite, and the groundmass is commonly microspherulitic and microgranophyric.

## Devonian (5, 6)

Devonian intrusive rocks include two main types: gabbroic (5) and granitic (6). The gabbroic rocks occur mainly as a large north-northwesterly trending lens-shaped body 16 miles long and up to 4 miles wide in the west half of the map-area, lying mainly between granitic rocks (3c) and (4c) and basaltic rocks (3a) in the west and metasedimentary rocks (1b) and (1c) in the east. There

are some inclusions of metamorphic rocks (1b) and granitic rocks (3c) along and near the highway and the body has been intruded by two granitic stocks (6d) in the south. Granitic dykes cut the body along the Irving Pulp and Paper Limited Road west of upper Fairley Brook.

The highest and largest magnetic anomaly in the map-area (Geol. Surv. Can. aeromagnetic map 144G), is underlain by gabbro about a mile south-southeast of Gulquac Lake. The anomaly trends northerly into a northwesterly trending belt of paragneiss (1b) indicating that the gabbro underlies the paragneiss at a shallow depth. Another high anomaly underlies paragneiss (1b) along Clearwater Brook southwest of where the brook crosses the highway; this suggests that the gabbro is close to the surface there also.

Gabbroic rocks (5) occur as dykes tens of feet wide cutting metamorphic rocks (1b) and (1c) along the highway west of the Irving Pulp and Paper Limited Road, along Dungarvon River, and along upper North Renous River. Gabbroic rocks (5) of uncertain form cut quartzite and phyllite (1a) northeast of North Renous Lake and older granitic rocks (3b) along North Dungarvon River and on the highway 1.4 miles east of Gulquac River. Probable gabbroic stocks cut older granite (3b) near South Dungarvon River and paragneiss (1b) along Rocky Brook.

Gabbroic rocks (5) include gabbro, diabase, diorite, quartz gabbro and one known outcrop of serpentinite (5a). Gabbroic rocks of the large body are commonly greenish grey, medium grained, massive, ophitic and contain fresh labradorite, altered pyroxene and/or hornblende and up to 5 per cent magnetite. Some of these rocks are fine grained like basalt or greenstone. Olivine gabbro is present west of Gulquac Lake and diorite occurs west of the south end of Gulquac Lake and 2 miles south of it, and along Clearwater Brook north of the smaller of the two quartz monzonite stocks (6d). Quartz gabbro outcrops along the highway on the east side of the body. The gabbro is mylonitized at the contact with granitic rocks (3c) along the highway 1.7 miles east of Gulquac River and highly fractured along Little Northeast Clearwater Brook and along Clearwater Brook.

Two small stocks or large dykes of gabbro occur in the southern part of the east half of the map-area. One is exposed 1 1/4 miles northwest of the junction of North Dungarvon River and South Dungarvon River. The gabbro is greenish grey, coarse grained, ophitic, fractured, and contains labradorite and hornblende partly altered to actinolite and chlorite. The other stock occurs on Rocky Brook 1/2 mile north of Catamaran fault. This gabbro is greenish grey, medium grained, massive and contains fresh labradorite and augite partly altered to tremolite. Three altered gabbroic dykes outcrop along the highway. One, with a diabasic texture, is 25 feet wide and occurs 0.4 mile southeast of Clearwater Brook. Another is rusty, magnetic, in places laminated, and noritic, at least 50 feet wide, and occurs 0.5 mile west of Clearwater Brook. Both of these dykes cut amphibolite (1c). The third, a hornblende gabbro, at least 120 feet thick, cuts older granite (3c) 1.4 miles east of Gulquac River. Two outcrops of massive altered hornblende gabbro occur on and east of Dungarvon River where the dyke (?) cuts paragneiss (1b) and amphibolite (1c). One or more gabbro dykes occur on North Dungarvon River 1.2 miles north of the highway. The southern outcrops are greenish grey, sheared to schistose plagioclase-hornblende-biotite-chlorite rocks. The next outcrop 225 feet north appears to be an easterly trending dyke, 20 to 25 feet wide, of greenish grey, medium-grained, massive, ophitic rock composed of plagioclase, hornblende, biotite and magnetite.

A serpentine dyke (5a) cuts amphibolite schist (1c) on the south side of the road about 1/2 mile north of the west end of Mud Lake in the northwest part of the map-area. The outcrop has been trenched, but the size of the dyke is not known. The serpentinite is olive green, sheared, and contains about 5 per cent magnetite.

The age of the gabbroic rocks is uncertain. They postdate the deformation and metamorphism of units 1 and 3, and are therefore younger than Late Ordovician-Early Silurian. They themselves have been deformed and are cut by stocks and related dykes of Devonian granite (6d) along and west of the Irving Pulp and Paper Limited Road in the southern part of the map-area. Thus, it appears that the gabbros are Early Devonian in age, and may be the intrusive equivalent of Lower Devonian basaltic rocks (4a), a suggestion also made by F.D. Anderson (1968) for similar rocks in the Woodstock, Millville and Coldstream map-areas 18 miles to the south-southwest.

The Devonian granitic rocks (6) occur as parts of stocks in the northeast and southeast parts of the map-area and as smaller bodies mainly within older granitic rocks (3b) and within gabbro (5). The largest area underlain by Devonian granitic rocks of type 6a is in the northeast part of the map-area along and north of the Little Southwest Miramichi River and around Tuadook Lake. This body extends 2 miles eastward into McKendrick Lake map-area (Anderson, 1970a) and an unknown distance northward into a large area of undifferentiated granitic rocks in the Tobique map-area (Anderson, 1962). It cuts Cambro-Ordovician metamorphic rocks (1b) discordantly in the south and concordantly in the west. It also cuts Ordovician-Silurian granitic rocks (3b) in the west. Granitic rocks (6a) in the western part of the body around Tuadook Lake and northward are mainly pinkish grey, medium grained, massive, biotite quartz monzonite, and minor pink leucocratic granite, pink biotite quartz monzonite, and grey hornblende quartz diorite. In the central part of

the body pink and grey, massive, in places porphyritic, biotite quartz monzonite are common, and in the northeast corner unit 6a rocks are pinkish grey, massive, in part porphyritic, biotite quartz monzonite and grey, fine- to medium-grained, massive hornblende-biotite quartz diorite and biotite granodiorite.

The next largest area of Devonian granitic rocks of unit 6a occurs around and southeast of Island Lake. The limits of this body are not well defined, but it appears to be more or less conformable to Cambro-Ordovician metasedimentary rocks (1b) on the west and to cut Ordovician-Silurian cataclastic granitic rocks (3b) on the east. These rocks are best exposed around Island Lake and are mainly pink to grey, medium-grained, massive, biotite quartz monzonite, granodiorite and quartz diorite.

Smaller bodies of Devonian granitic rocks of type 6a cut Ordovician-Silurian granitic rocks (3b): pinkish grey biotite granodiorite, about 2 miles south of Island Lake; grey biotite granodiorite 4 miles east of Island Lake; and pink quartz monzonite north of Gulquac Lake. Devonian granitic rocks (6a) cut metasedimentary rocks (1b) and granitic rocks (3b): grey biotite granodiorite 2 3/4 miles east, and 3 miles southeast of Island Lake. The boundaries of these bodies are poorly defined.

The second largest area of Devonian granitic rocks, this of type 6b, in the map-area is in the southeast, south of the Catamaran fault. The major part of this body (32 square miles) occurs in the Hayesville map-area (Poole, 1963) where it cuts pre-Silurian rocks discordantly. Within the Tuadook Lake map-area these rocks are mainly moderate reddish orange, medium- to coarse-grained, massive, leucocratic quartz monzonite and granite. The quartz is light grey (smoky) and occurs as phenocrysts to 1/2 inch across. At the eastern border pink and grey biotite quartz monzonite is present, commonly cut by pink aplite dykes.

A basic phase of Devonian granitic rocks (6c) occurs along and north of Dungarvon River, mainly north of the highway. This body cuts Cambro-Ordovician metasedimentary rocks (1b) more or less discordantly on the west and Ordovician-Silurian granitic rocks (3b) on the east. These rocks (6c) are mainly grey, fine- to medium-grained, massive, biotite (-hornblende) quartz diorite and granodiorite, but pink, medium-grained biotite quartz monzonite and granite are also present. A K-Ar date on muscovite from pink, semiporphyritic biotite-muscovite quartz monzonite along the highway about 1/3 mile south of the North Dungarvon River bridge yielded an Early Devonian age of 382 ± 16 million years.

Two small, poorly defined stocks of Devonian granitic rocks (6d) cut the southern part of the large Devonian gabbro body (5). The western stock underlies a 1,550-foot-high hill and is composed of pinkish grey, medium-grained, massive biotite granodiorite and the eastern, larger one, is composed of grey to pinkish grey, fine-grained, massive hornblende-biotite quartz monzonite. Some of these rocks are microgranophyric. Granitic dykes, apparently apophyses from the eastern stock, cut gabbro (5) along the Irving Pulp and Paper Limited Road north of the stock and on Clearwater Brook north of the southwest part of the stock.

## STRUCTURE

Pre-Silurian rocks occupy the core of the large northeasterly trending Miramichi anticlinorium, which extends from 20 miles south-southwest of Woodstock, northeasterly to Bathurst, a total distance of 160 miles, with a maximum width of 45 miles about 12 miles northeast of the Tuadook Lake map-area (Poole et al., 1970, p. 257). The north boundaries of the Tuadook Lake and eastward-adjoining McKendrick Lake map-areas span the total width of the anticlinorium at this latitude (47°00').

### Folds

Details of the structure of the strata in the Tuadook Lake map-area are not known, primarily because of: poor exposure of bedrock, lack of distinctive horizon markers, obliteration of primary structures by metamorphism, and the complexity of the structures. The pre-Silurian rocks seem to have been isoclinally folded and later refolded one or more times. The trends in these rocks are mainly north-northwesterly but some are northeasterly to easterly as around the northern and southern parts of the South Renous River stock (3a) and west along the highway to 4 1/2 miles west of Moose Lake. In the McKendrick Lake map-area to the east, the trends in the western part of the map-area are northwesterly and in the eastern part they are northeasterly. These trends are also evident on the aeromagnetic maps of these map-areas (Geol. Surv. Can. aeromagnetic maps 144G and 123G). Proceeding northeasterly along the Miramichi anticlinorium northwest- and northeast-trending structures are characteristic of each map-area from Tuadook Lake to the Bathurst-Newcastle district (Skinner, in press). It seems probable that they are the result of two episodes of folding, the Taconic and Acadian.

The detailed structure of the Lower Devonian volcanic rocks is not known, but the trends are west-northwesterly in the south, and north to northwesterly in the north.

## Faults

The most prominent fault in the map-area is the Catamaran fault, which cuts easterly across the southern part of the map-area, extends northeastward into and across the McKendrick Lake map-area (Anderson, 1970a) and southwestward into the Juniper map-area (Skinner, 1972b). The fault is expressed as a pronounced topographic lineament observable on air photographs, particularly in the central and eastern parts of its length across the Tuadook Lake and McKendrick Lake map-areas. In the central part of the Tuadook Lake map-area, along Rocky Brook and up to a few miles west of the brook where the fault cuts mainly old granitic rocks (3b), the lineament is a steep-walled valley two to three hundred feet deep. The fault is also indicated in the east half of the Tuadook Lake map-area on aeromagnetic map 144G by a change in intensity and texture of magnetic anomalies north and south of the fault. The fault is marked by a sharp aeromagnetic gradient separating a rugged plateau area underlain by metasediments (1b) and older granite (3b) to the north from a smooth plains area underlain by Devonian granite (6b) to the south.

The fault cuts mainly Ordovician-Silurian granitic rocks (3b), but in the east it also cuts Cambro-Ordovician metasedimentary rocks (1) and in part forms the contact between Devonian granite (6b) and Cambro-Ordovician metasediments (1), and in the west lies along the contact between the older granite (3) and Devonian gabbro (5). The only outcrops seen in the Catamaran fault lineament are of older granite (3b) along Rocky Brook, up to 2 miles east and west of the Irving Pulp and Paper Limited Road, and near the west boundary. At these places the granite is mylonitized, and up to 1 1/2 miles from the fault the granite is highly sheared.

Anderson (1972) analyzed fracture patterns in intrusive and metamorphic rocks along 60 miles of the Catamaran fault. The analysis indicated that the faulting was in response to a northwest-southeast trending principal compressive stress similar to that deduced for other faults in the Maritime Provinces. He concluded that the fault is post-Middle Devonian and pre-Carboniferous in age, that the movement was mainly right-lateral strike-slip, and from the apparent displacement of a magnetic anomaly, it appears to have a displacement of 4 1/2 miles. Anderson suggested that the fault may extend eastward under Miramichi Bay into the Gulf of St. Lawrence and southwestward into flanking Siluro-Devonian volcanic and sedimentary rocks about 7 miles north-northwest of Juniper, New Brunswick, giving it a length of 250 miles or more.

At least three faults were noted in the western part of the map-area along the highway within and along the east and west contacts of the quartz monzonite body (3c). The most easterly, 0.2 mile west of a south-flowing branch of Clearwater Brook, is a mylonite zone along the contact between quartz monzonite (3c) and gabbro (5). The exposure, which is about 200 feet north of the highway, is vaguely laminated and looks like greywacke or tuff until examined in thin section. Another fault is indicated about 400 feet farther west where the quartz monzonite is highly sheared and brecciated. A third fault is indicated about 1,000 feet west of the brecciated zone where a gabbro dyke (or dykes) has been sheared and brecciated, and cut by aplitic granite.

## GEOLOGICAL HISTORY

The map-area lies in the core of the Miramichi anticlinorium where the oldest rocks occur and the degree of metamorphism is the highest. The oldest rocks are Cambro-Ordovician thinly laminated quartzites and phyllites, paragneisses and amphibolites. Volcanic rocks are not known to be present; the amphibolites are believed to be derived from shaly limestones. The unmetamorphosed equivalents of these rocks (sandstones, shales and limestones) are typical of a paraplatformal environment. Middle Ordovician basalt, rhyolite, greywacke and slate conformably overlie the Cambro-Ordovician metasedimentary rocks on the southeast indicating rapid subsidence of the area and conversion to a eugeosynclinal environment.

The Cambro-Ordovician rocks in the core area were tightly folded, metamorphosed, intruded by granitic rocks, uplifted and deeply eroded, probably during the Taconian Orogeny (Late Ordovician to Early Silurian). The southeastward flanking Middle Ordovician rocks were not cut by these intrusive rocks and were metamorphosed only to low greenschist grade. The age of the cataclasis of the Upper Ordovician-Lower Silurian granite (3) is uncertain, but probably is Taconian.

During the Late Silurian and Early Devonian the area subsided and was flanked on the west and east by north- to northeast-trending troughs in which basalt, rhyolite and shale were deposited in the west and greywacke and shale in the east. During the Middle Devonian Acadian Orogeny these deposits were folded, slightly metamorphosed and intruded by gabbro and diabase and the pre-Silurian rocks were intruded by gabbro (5) and granite (6).

In the Bathurst-Newcastle area, 15 miles to the northeast, Helmstaedt (1971) found that the Early and Middle Ordovician Tetagouche Group, equivalent to units 1 and 2 of Tuadook Lake map-area, had undergone at least three separate phases of deformation. The first and most penetrative phase produced a regional foliation and tight to isoclinal folds on microscopic to macroscopic scales and was accompanied by the main meta-

morphic recrystallization which increased from chlorite subfacies in the northeast to biotite subfacies in the southwest. The second phase of deformation produced a relatively penetrative crenulation cleavage which is essentially postmetamorphic. The third phase of deformation is expressed by large regional folds. Helmstaedt correlated the first two phases of deformation with the Taconian Orogeny and the third phase with the Acadian Orogeny. However, more recently Helmstaedt and Skinner (in preparation) suggest a late Taconian age for the third phase of deformation. The tectonic history of the Tuadook Lake map-area undoubtedly is the same as that of the Bathurst-Newcastle area, but the metamorphism and probably the deformation were more intense in the Tuadook Lake area.

## ECONOMIC GEOLOGY

No significant mineral occurrences are known within the map-area. Phyllite and quartzite (1a) contain rusty pyritic zones up to 1/2 mile south of the Catamaran fault in the southeast part of the map-area. Another rusty zone was noted in a magnetic, vaguely laminated, noritic gabbro dyke cutting amphibolite (1c) on the highway 1/2 mile west of Clearwater Brook. The gabbro contains considerable magnetite and at least some pyrite and pyrrhotite. A spectrochemical analysis of a sample by the Geological Survey of Canada yielded 10 to 15% iron, 2.5% titanium, 0.097% vanadium, 0.0034% copper and 0.0043% cobalt and less than 0.002% nickel (all values are expected to be accurate to within ± 15% of value reported).

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