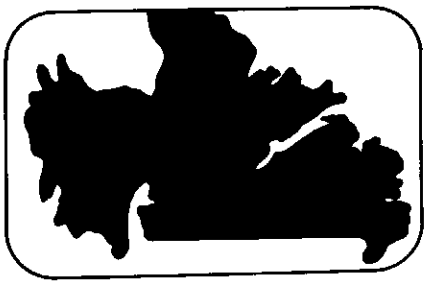

An Outline of the Geology of Labrador

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Summary
Labrador forms the eastern portion of the Precambrian Canadian Shield. It is divisible into four geologic provinces, each characterized by different orogenic history. Superior Province, in Western Labrador, and Nain Province, along the eastern and northern coast, represent parts of Archean orogenic belts. Both consist primarily of high grade metamorphic rocks, which in Nain Province are overlain locally by less deformed Proterozoic sedimentary and volcanic assemblages. Churchill Province trends northward across central Labrador, between the two older orogens. It is composed of a western belt of relatively little deformed sedimentary and volcanic rocks, and an eastern zone of high grade metamorphic rocks, both of which were last deformed in the Early Proterozoic Hudsonian orogeny. Grenville Province trends east-northeast across sothern Labrador. It is composed largely of quartzo-feldspathic gneisses, last deformed in the Grenvillian orogeny of the Middle Proterozoic. The metamorphic rocks of Grenville, Nain and Churchill Provinces are intruded by large anorthosite-adamellite plutons, emplaced during the Middle Proterozoic.

Exploration in Labrador has been concentrated in two areas: the Labrador Trough, in the western part of Churchill Province, and the "Central Mineral Belt" of Labrador, which extends eastward across the southern parts of Churchill and Nain Provinces. Mining in the Labrador portion of the Trough accounts for about half of Canada's iron ore production. Uranium, copper, beryllium and molybdenum occurrences are being investigated in the central mineral belt.

Introduction

The Labrador section of the province of Newfoundland and Labrador forms the eastern part of the Canadian Shield. It is composed essentially of intrusive and high grade metamorphic rocks, overlain in several areas by less deformed sedimentary and volcanic sequences. This Precambrian assemblage is followed in the extreme southeast by Paleozoic sedimentary units forming the western edge of the Appalachian geosyncline.

Any discussion of Labrador geology must make extensive use of the time – stratigraphic classification devised for the Canadian Shield by Stockwell (1973). This classification (Table I) is erected around a framework of Precambrian orogenies and intrusive events identified by isotopic age studies.

General Geology

Introduction. The Canadian Shield has been divided into seven provinces by Stockwell (1961, 1964) on the basis of structural criteria; the division is largely supported by radiometric age determinations. Labrador includes the entire Nain structural province, as redefined by Taylor (1971), and parts of the Superior, Churchill and Grenville provinces (Fig. 1).

Superior Province. Superior Province in Labrador is characterized by east-west structural trends and by Archean age determinations. The province is underlain by granitic and granodioritic gneisses and granulites (the Ashuanipi Complex), intruded by pyroxene-bearing silicic plutons. Its boundary with Churchill Province to the east is marked by an unconformity.

Nain Province. Nain Province, as defined by Taylor (1971) is characterized by north-trending structures and Archean ages, except in the extreme southeast, where the basement gneisses, together with overlying metasedimentary and metavolcanic rocks, have been affected by a later orogeny and give ages of c. 1420 m.y. This southern area, in which east-trending structures and Aphebian ages predominate, has been set aside by Taylor (1971) as Makkovik sub-province (Fig. 1).

Table I
Precambrian time-classification for the Canadian Shield (after Stockwell, 1973).

Eon	Era	Sub-Era	Event	Age of Boundary (m.y.) (Rb-Sr scale, 1.47 constant)
Proterozoic	Hadrynian		Grenvillian Orogeny	Ca 1010
	Helikian	Neohelikian	Elsonian Event	Ca 1400
		Paleohelikian	Hudsonian Orogeny	Ca 1750
	Aphebian		Kenoran Orogeny	Ca 2540
Archean				

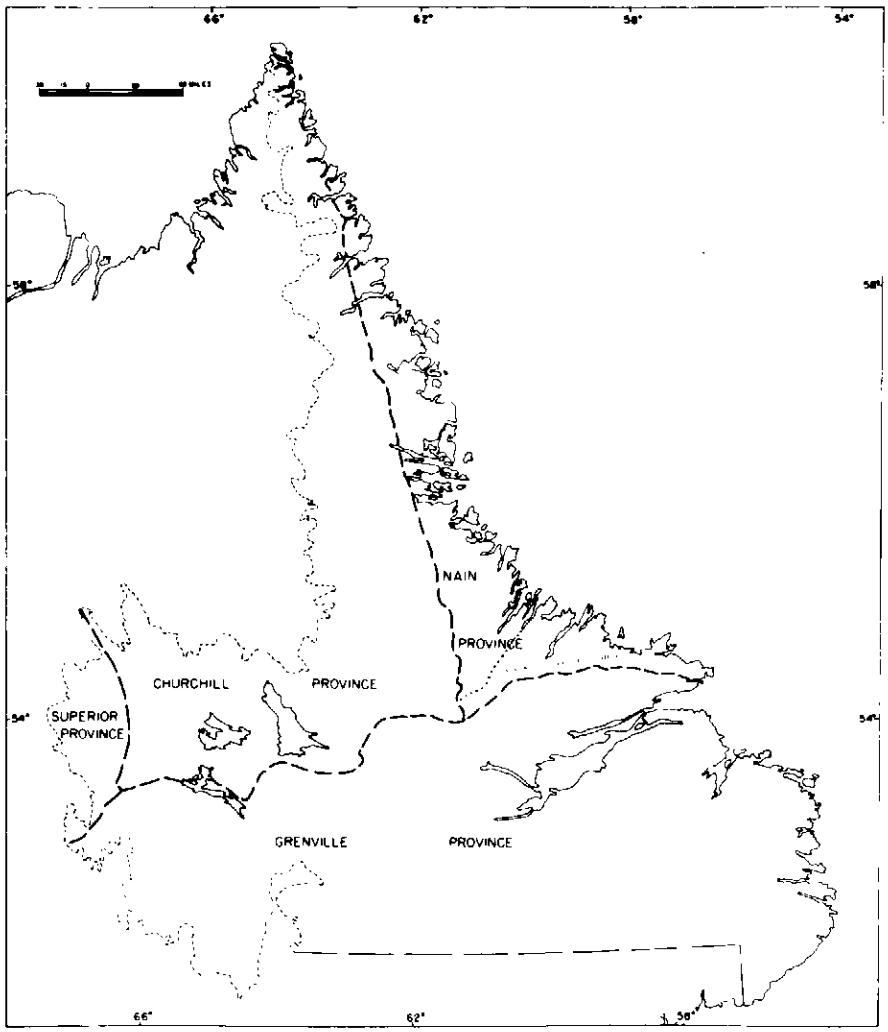


Figure 1
Geological provinces of Labrador (modified after Stockwell et al., *1970; Taylor, 1971).*

The Archean rocks of Nain Province extend from Trout Trap Fiord in the north of the Kaipokok Bay area in the south (Fig. 2). The complex north of Nain is marked by a great diversity of rock types, but leucocratic, migmatitic gneisses of the granulite or upper amphibolite facies predominate. Amphibolites, paragneisses and small ultrabasic intrusions also occur.

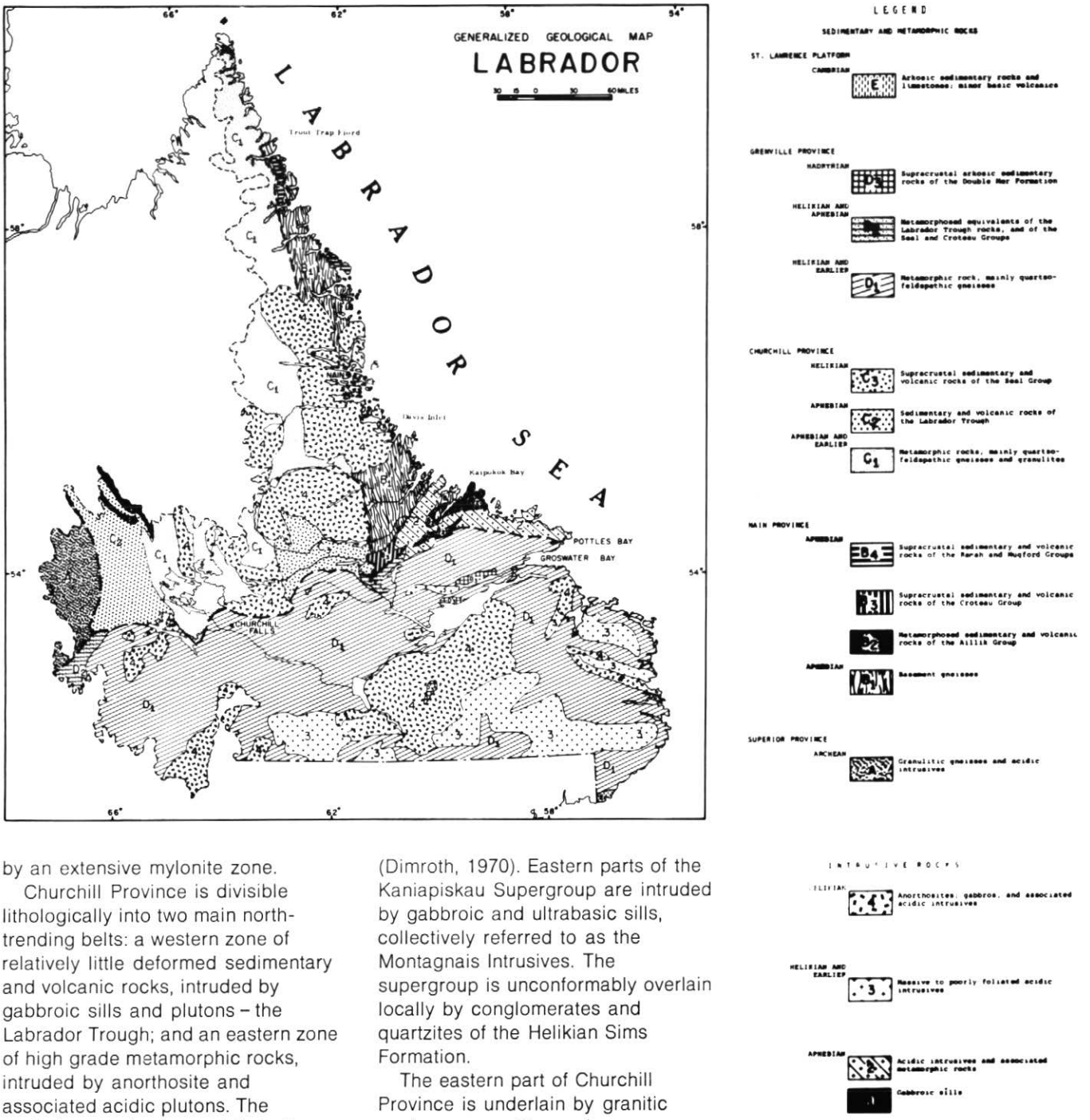
The continuity of the Archean complex is interrupted by the Nain anorthosite-adamellite pluton, but isolated patches of Archean gneisses occur within the plutonic terrain, and serve to connect the northern part of the complex with its continuation south of the intrusives. The coastal rocks of the complex south of Davis Inlet have been referred to the Hopedale Gneiss (Daly, 1902). The sequence here is very similar to that north of Nain, although the metamorphic grade is slightly lower (Wheeler, 1960). Metavolcanic sequences occur within the Hopedale gneiss in the Ugjoktok Bay area (Jesseau and Collerson, 1974).

The Archean gneisses of Nain Province are overlain locally north of Nain by the supracrustal Ramah and Mugford Groups. The Ramah Group is a relatively undeformed sequence of quartzites, sandstones, and euxinic shales of probable Aphebian age (Knight, 1974). The Mugford Group consists of tholeiitic flows and pyroclastics, overlying sedimentary rocks lithologically similar to those of the Ramah Group. K/Ar dating indicates that the Mugford volcanics are at least 1490 m.y. old, and Rb-Sr studies suggest that they may be as old as 2300 m.y. (Barton, 1974).

Makkovik sub-province is underlain largely by the Aphebian Aillik Group, and by a variety of intrusive rocks associated with the Hudsonian orogeny. The Aillik Group, which has an estimated thickness of 25,000 feet, consists predominantly of quartzo-feldspathic rocks with lesser amounts of conglomerate, argillite, limestone, basic volcanics, paragneiss and iron formation (Gandhi *et al.*, 1969; Stevenson, 1970). The quartzo-feldspathic rocks, although partly of metasedimentary origin, are largely silicic volcanics (Clarke, 1971). The group unconformably overlies the Archean Hopedale Gneiss along its northern boundary, but the unconformity is obscured because the Hopedale Gneiss was deformed with the Aillik in post-Kenoran orogenies; along its southern boundary, the Aillik Group grades into gneisses across the Grenville Front. The group is followed to the west by the Croteau Group of subaerial calc-alkaline volcanics and minor sedimentary rocks. Relationships between the Aillik and the Croteau are obscure, but isotopic dating suggests they are roughly equivalent in age.

The Archean gneisses of Nain Province are intruded by large plutons of anorthosite and adamellite, most of which lie along the Nain-Churchill boundary. The anorthosite intrusions are about 1400 m.y. old, while the adamellite bodies are slightly younger. The rocks of Makkovik sub-province are intruded by a variety of silicic plutons, and by the Adlavik Gabbro. The Michael Gabbro, a swarm of south dipping sheets, occurring near the Grenville Front, is included either in Makkovik subprovince or in the Grenville Province, depending upon where one places the Front.

Churchill Province. Churchill Province in Labrador has a north to northwest structural grain and a predominance of Aphebian age determinations; it was apparently last deformed in the Hudsonian orogeny. Its eastern boundary is obscured in the central portions by anorthosite intrusions, but it is marked in the north



by an extensive mylonite zone.

Churchill Province is divisible lithologically into two main north-trending belts: a western zone of relatively little deformed sedimentary and volcanic rocks, intruded by gabbroic sills and plutons – the Labrador Trough; and an eastern zone of high grade metamorphic rocks, intruded by anorthosite and associated acidic plutons. The gneissic complex is overlain in the extreme southeast by supracrustal formations of the Seal Lake Group (Fig. 2).

The strata of the Labrador Trough (the Kaniapiskau Supergroup) are Aphebian in age. They comprise three cycles of deposition, each cycle beginning with quartzites, carbonates and iron precipitates, and culminating with deposition of slate and greywacke in western sections, and of basaltic volcanics in the east (Dimroth, 1970). Eastern parts of the Kaniapiskau Supergroup are intruded by gabbroic and ultrabasic sills, collectively referred to as the Montagnais Intrusives. The supergroup is unconformably overlain locally by conglomerates and quartzites of the Helikian Sims Formation.

The eastern part of Churchill Province is underlain by granitic gneisses, granulites and paragneisses, with an extensive zone of mylonitized gneisses along the Nain-Churchill boundary. These high grade metamorphic rocks, for the most part, yield Hudsonian K/Ar ages; both Aphebian and updated Archean material is probably present. The gneisses are intruded by large anorthosite-adamellite plutons and both gneisses and intrusives are overlain locally by continental red-beds of the Siamarnekh Formation

and its equivalents. Mistastin Lake, in the east-central part of Churchill Province, is the site of a meteorite impact crater of Tertiary age (Marchand and Crocket, 1974).

The gneisses and intrusives of eastern Churchill Province are overlain in the extreme southeast by supracrustal rocks which are undeformed in northern exposures but are affected by Grenville folding in the south. This sequence comprises the Seal Lake and Letitia Groups. The Seal Lake Group consists of some 28,000 feet of plateau basalts, quartzites and shales, intruded by thick diabase sills (Barager, 1974). The group has been dated at 1250 m.y. The Letitia Group outcrops in a thin belt between the Seal Lake sedimentary and volcanic rocks and the gneisses of Grenville Province. It consists mainly of quartz feldspar porphyries, lithologically similar to those of the Croteau Group, and has generally been considered to be Aphebian in age. The Letitia Group is intruded by small pre-Grenvillian alkaline plutons (Curtis *et al.*, 1974).

Grenville Province. Grenville Province trends east-northeast across southern Labrador, truncating the other three provinces. It is marked by irregular and curved structural trends, and by late Neohelikian isotopic ages. Its northern boundary, the Grenville Front, is marked in places by extensive faulting and mylonitization, in other places by a change in metamorphic grade.

High grade metamorphic rocks underlie most of Grenville Province. Distinctive representatives of the Kaniapiskau Supergroup – iron formation, marble, quartzite – can be recognized within the gneisses at the southern end of the Labrador Trough, and some of the metasediments and metavolcanics in the northeastern part of the province probably represent metamorphosed equivalents of the Seal Lake and Croteau Groups. The remaining gneisses probably represent, in large part, Archean material updated in the Grenvillian orogeny.

The gneisses are intruded by large anorthosite-adamellite plutons, similar to those in Churchill and Nain Provinces. Both gneisses and intrusives are overlain by essentially undeformed continental redbeds of the Double Mer Formation and its equivalents. Cambrian sedimentary and volcanic rocks, platform deposits of the Appalachian geosyncline, overlie the Grenville gneisses in the Strait of Belle Isle area.

Economic Geology

Introduction. Mineral exploration in Labrador, after an initial rapid reconnaissance of large areas in the 1940s and early 1950s, has tended to concentrate largely in two areas: the Labrador Trough, and the "Central Mineral Belt", which stretches eastward from Michikamau Lake to the coast near Makkovik. Work in the Labrador Trough has resulted in the discovery and development of one of the largest iron ranges of the world. Uranium, copper, molybdenum and beryllium discoveries have been investigated in the Central Mineral Belt. Outside of these two regions, little work has been done.

Labrador Trough. Cherty iron formation, outcropping along the western part of the Labrador Trough, extends from Ungava Bay to the Grenville Front, and its metamorphosed equivalents are recognized south of the front as far as Pletibi Lake, giving a total outcrop length of over 700 miles. The iron formation forms the host rock for deposits of high-grade, direct-shipping ores in the Knob Lake area, where several open pit mining operations have been in production since 1954. Lower grade, beneficiating ore is being mined south of the Grenville Front, in the Wabush Lake area. These operations in recent years have accounted for more than 80 per cent of the total value of mineral production in Newfoundland.

Copper-nickel mineralization is widespread along the eastern side of the Labrador Trough. Most prospects consist of pyrrhotite and pyrite, with minor chalcopyrite, sphalerite and galena, occurring as fine grained disseminations and small massive bodies in the sedimentary rocks of the Kaniapiskau Supergroup. The mineralization appears to be physically and genetically related to mafic and ultramafic sills which intrude the Kaniapiskau Supergroup.

Central Mineral Belt. The Central Mineral Belt is composed of the Seal Lake, Letitia, Croteau and Aillik Groups. These rocks contain concentrations of copper, beryllium, uranium and molybdenum.

Copper occurrences were first observed in the Seal Lake Group in 1946. Mineralization consists of native copper, chalcopyrite, chalcocite and bornite, in shear zones and veins, with quartz and calcite as the main gangue minerals. Most of the occurrences are closely associated with basic flows or diabase sills, either lying within the igneous rocks, or in sedimentary beds close to the contacts.

The beryllium deposits are located in schistose acidic volcanic rocks of the Letitia Group. Beryllium occurs as barylite and eudidymite, in shear zones and disseminations associated with small intrusions of soda-rich syenite. Mineralogy is complex, and many rare and a few new minerals have been reported (Nickel, 1963).

Significant uranium concentrations are known in the Aillik Group, in the eastern part of the Central Mineral Belt. Uranium occurs as pitchblende and uraninite in a wide variety of deposits in granites and pegmatites, as disseminations in quartzites, as veins and disseminations in argillites and tuffaceous units, in shear zones and faults, and in granulites (Ruzicka, 1971).

Molybdenum mineralization has been known in the Aillik Group since 1953. The principal occurrences consist of molybdenite in mylonitized quartzites, and in narrow veins of quartz and pegmatite associated with quartz monzonite.

Other Areas. Outside of the Labrador Trough and the Central Mineral Belt, exploration has been limited. The remainder of Labrador is, for the most part, underlain by high grade metamorphic rocks, and large intrusive bodies whose potential has been considered low in comparison with that of the supracrustal sequences. Recent discoveries in some of the anorthosite-adamellite complexes suggest that this assessment should be revised.

References

Barager, W. R. A., 1974, The Seal Lake and Croteau volcanic rocks of Labrador: *in* Author's Abstracts, Geol. Assoc. Can. – Min. Assoc. Can., Ann. Meeting, 1974, p. 5.

Barton, J. M. Jr., 1974, The Mugford Group volcanics, Labrador: age, geochemistry and tectonic setting: *in* Author s Abstracts, Geol. Assoc. Can. – Min. Assoc. Can., Ann. Meeting, 1974, p. 6-7.

Clarke, A. M. S., 1971, Structure and lithology of a part of the Ailiik Series, Labrador: Geol. Assoc. Can., Proc., v. 24, p. 107-117.

Curtis, L. W., J. G. Gittins and K. L. Currie, 1974, A metamorphosed agpaitic complex from central Labrador: *in* Author's Abstracts, Geol. Assoc. Can. – Min. Assoc. Can., Ann. Meeting, 1974, p. 23.

Daly, R. A., 1902, The geology of the northeast coast of Labrador: Harvard Univ. Mus. Comp. Zool., Bull., v. 38, geol. ser. v. 5, p. 205-270.

Dimroth, E., 1970, Evolution of the Labrador geosyncline: Bull. Geol. Soc. Amer., v. 81, p. 2717-2742.

Gandhi, S. S., R. L. Grasty and R. A. F. Grieve, 1969, The geology and geochronology of the Makkovik Bay area, Labrador: Can. Jour. Earth Sci., v. 6, p. 1019-1035.

Jesseau, C. W. and K. D. Collerson, 1974, Geological relationships and evolution of a Precambrian meta-volcanic sequence, Nain Province, Labrador: *in* Author's Abstracts, Geol. Assoc. Can. – Min. Assoc. Can., Ann. Meeting, 1974, p. 45.

Knight, I., 1974, The Ramah Group – Mugford Group – Snyder Group – a correlation in Labrador and a possible link between the Labrador Trough and Western Greenland: *in* Author's Abstracts, Geol. Assoc. Can. – Min. Assoc. Can., Ann. Meeting, 1974, p. 50.

Marchand, M., and J. H. Crocket, 1974, The Mistastin Lake pluton and meteorite crater, northern Labrador: *in* Author's Abstracts, Geol. Assoc. Can. – Min. Assoc. Can., Ann. Meeting, 1974, p. 58.

Nickel, E. H., 1963, Eudidymite from Seal Lake, Labrador: Can. Mineral, v. 7, p. 643-649.

Ruzicka, V., 1971, Geological comparison between east European and Canadian uranium deposits: Geol. Surv. Can. Paper 70-48.

Stevenson, I. M., 1970, Rigolet and Groswater Bay map-areas, Newfoundland: Geol. Surv. Can. Paper 69-48.

Stockwell, C. H., 1961, Structural provinces, orogenies, and time classification of rocks of the Canadian Precambrian Shield: Geol. Surv. Can. Paper 61-17, p. 108-127.

Stockwell, C. H., 1964, Fourth report on structural provinces, orogenies and time classification of rocks of the Canadian Precambrian Shield: Geol. Surv. Can. Paper 64-17, Part II, p. 1-21.

Stockwell, C. H., 1973, Revised Precambrian time scale for the Canadian Shield: Geol. Surv. Can. Paper 72-52.

Taylor, F. C., 1971, A revision of Precambrian structural provinces in northeastern Quebec and northern Labrador: Can. Jour. Earth Sci., v. 8, p. 579-584.

Wheeler, E. P. II, 1960, Anorthosite adamellite complex of Nain, Labrador: Geol. Soc. Am. Bull., v. 71, p. 1755-1762.

MS received, May 31, 1974.