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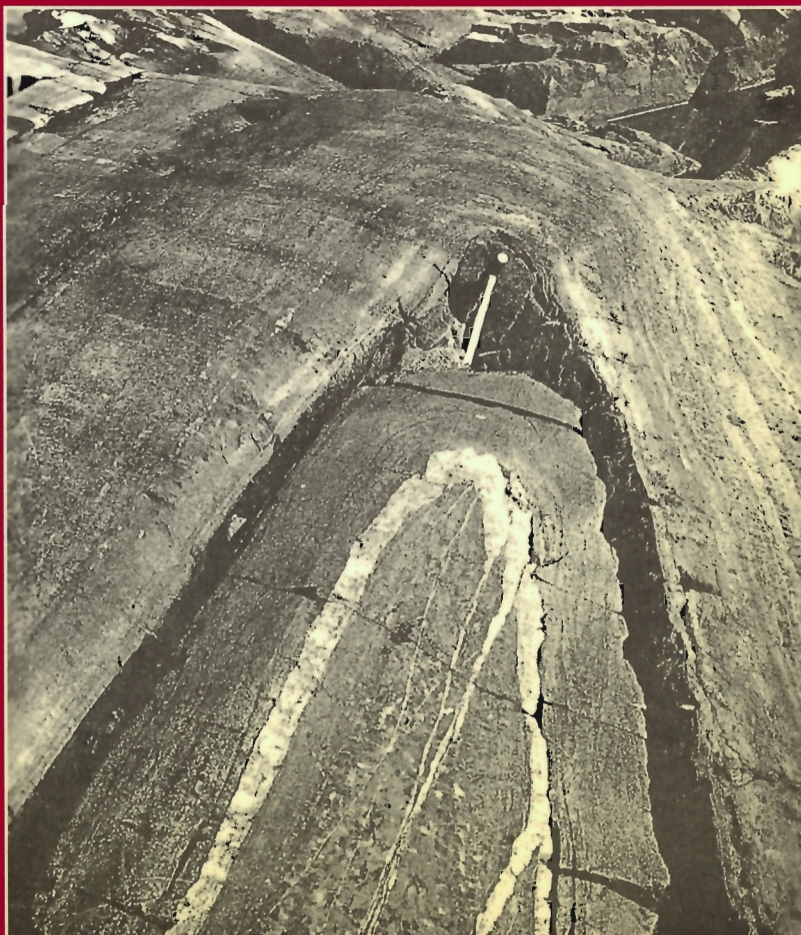
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**GEOLOGICAL SURVEY OF CANADA
MEMOIR 424**

**PRECAMBRIAN GEOLOGY OF THE INDIN LAKE
MAP AREA, DISTRICT OF MACKENZIE,
NORTHWEST TERRITORIES**

R. A. Frith

1993



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Cover

Photograph of second fold (F2) of porphyroblastic
metagreywackes of the Yellowknife Supergroup,
Indin Lake.

Critical reader

Marc St-Onge

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Preface

This memoir outlines the geology of an area that straddles the western margin of the Slave Structural Province and thus encompasses a small part of Wopmay Orogen. Both structural domains contain Archean granitic basement rocks, an extensive sequence of supracrustal rocks, and intrusive plutonic complexes. In the Slave Province the supracrustal rocks are represented by the volcanics and greywacke-mudstones of the Archean Yellowknife Supergroup, whereas in Wopmay Orogen they are chiefly Proterozoic Snare Group metasediments that range from greywacke-mudstones to dolomite, quartzite and conglomerate. The complex polyphase deformational and metamorphic history of the area, particularly the effects of the Proterozoic deformation that resulted from eastward transport of the Bear plate and its interaction with the Slave craton to the east, are described in detail. Understanding the distribution of the Archean and Proterozoic rock types, depicted on the 1:250 000 scale coloured geological map that accompanies the memoir, will aid further exploration for mineral deposits in the Indin Lake area.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

Préface

Le présent mémoire expose les grandes lignes de la géologie d'une zone qui chevauche la bordure ouest de la province structurale des Esclaves et qui, de ce fait, englobe une petite partie de l'orogène de Wopmay. Ces deux domaines structuraux contiennent des roches de socle granitiques de l'Archéen, une séquence étendue de roches supracrustales et des complexes de roches plutoniques intrusives. Dans la province des Esclaves, les roches supracrustales sont représentées par des roches volcaniques et des pélites et grauweekes du supergroupe archéen de Yellowknife tandis que dans l'orogène de Wopmay, ces roches sont surtout constituées de métasédiments protérozoïques du groupe de Snare variant de pélites et grauweekes à des dolomies, quartzites et conglomérats. La déformation polyphasique et l'évolution métamorphique complexes de cette zone, en particulier les effets de la déformation protérozoïque causée par le transport vers l'est de la plaque de l'Ours et son interaction avec le craton des Esclaves à l'est, est décrite en détail. En connaissant la répartition des différentes roches de l'Archéen et du Protérozoïque figurant sur la carte géologique en couleurs à l'échelle de 1/250 000 qui accompagne le présent mémoire, il sera plus facile de procéder à l'exploration future des gisements minéraux qui se trouvent dans la région du lac Indin.

Elkanah A. Babcock, sous-ministre adjoint,
Commission géologique du Canada

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PRECAMBRIAN GEOLOGY OF THE INDIN LAKE MAP AREA, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

Abstract

Indin Lake map area straddles the boundary between the Slave Structural Province on the southeast and the south-central zones of the Wopmay Orogen on the northwest. Within the Slave, supracrustal rocks form irregular, generally north trending belts made up of metamorphosed basaltic volcanic rocks, and turbiditic greywackes, and mudstones of 2.67 Ga age. Intervening areas are made up of hybrid rocks derived from both basement granitoid (about 2.99 Ga) and supracrustal rocks as well as plutonic rocks of mainly granodiorite or granite composition. An orogeny analogous to the Kenoran (about 2.6 Ga) modified existing structures, metamorphosed rocks to the upper amphibolite facies, and re-equilibrated some isotopic systems.

The boundary between the Slave Structural Province and the Wopmay Orogen in the map area is a normal fault over most of its length. Evidence of penetrative deformation during the Proterozoic Calderian Orogeny is most abundant in the supracrustal rocks of the Coronation Supergroup, but evidence of minor penetrative and brittle deformation is present in Archean rocks as much as 40 km into the Slave craton. The west margin of the Slave Province has been thickened by westward subduction of the Bear plate, which caused regional uplifts of areas underlain by buoyant granitoid rock and downwarps of areas underlain by denser rock.

Within the Wopmay Orogen, Archean cratonic rocks are unconformably overlain by the Proterozoic Coronation Supergroup, which is deformed into tight upright- to eastward-verging folds adjacent to the Slave Province. The style and complexity of deformation and regional metamorphism increase westward, changing from a single set of folding and one recognized phase of greenschist metamorphism to three sets of deformation and regional metamorphism up to the granulite facies. Plutons of megacrystic, rapakivi-textured granite, correlated with the Hepburn Intrusive Suite, intruded metamorphosed and deformed rocks of the Coronation Supergroup. Older rocks of the Wopmay Orogen show isotopic re-equilibration at about 2.3 Ga and again with Proterozoic rocks at about 1.9 Ga.

Résumé

La région cartographique du lac Indin chevauche la limite séparant la province des Esclaves, dans le sud-est, et le centre-sud de l'orogène de Wopmay, dans le nord-ouest. Dans la province des Esclaves, les roches supracrustales forment des zones irrégulières, orientées en général vers le nord et composées de roches volcaniques de nature basaltique et métamorphisée, de grauwackes turbiditiques et de pélites âgés de 2,67 Ga. Les zones intermédiaires sont composées de roches hybrides dérivées de granitoïdes de socle (âgées d'environ 2,99 Ga) et de roches supracrustales ainsi que des roches plutoniques principalement composées de granodiorite ou de granite. Une orogénèse analogue à celle du Kénoréenne (il y a environ 2,6 Ga) a modifié les structures existantes, métamorphisé les roches à un degré équivalent au faciès supérieur des amphibolites et a rééquilibré certains systèmes isotopiques.

La limite séparant la province structurale des Esclaves et l'orogène de Wopmay dans la région en question est une faille normale traversant presque tout le secteur cartographié. Des indices de déformation pénétrative au cours de l'orogénèse protérozoïque du Caldérien se trouvent en abondance dans les roches supracrustales du supergroupe de Coronation, mais on trouve également des indices d'une faible déformation pénétrante et cassante dans des roches archéennes, à plus de 40 km à l'intérieur du craton des Esclaves. La bordure ouest de la province des Esclaves s'est épaissie par suite d'une subduction vers l'ouest de la plaque de l'Ours; cette subduction a causé des soulèvements régionaux de zones reposant sur des roches granitoïdes légères et des affaissements de zones reposant sur des roches plus denses.

Au sein de l'orogène de Wopmay, des roches cratoniques d'âge archéen reposent en discordance sous le supergroupe protérozoïque de Coronation qui, près de la province des Esclaves, est déformé en plis serrés dont l'orientation varie vers l'est de verticale à inclinée. Le style et la complexité de la déformation et du métamorphisme régional s'accroissent vers l'ouest, passant d'une simple série de plis et d'une phase reconnue de métamorphisme des schistes verts à trois séries de déformation et de métamorphisme régional atteignant le faciès des granulites. Des plutons de granite mégacrystallin et à texture rapakivi correspondant à la suite intrusive de Hepburn, roches métamorphosées et déformées intrusives du supergroupe de Coronation. Des roches plus anciennes de l'orogène de Wopmay indiquent qu'une rééquilibration isotopique est survenue à environ 2,3 Ga et, par la suite, dans des roches protérozoïques, à environ 1,9 Ga.

SUMMARY

Since the discovery of gold in the Indin Lake map area in the late 1930s geological interest was directed toward mapping at 4 miles to the inch for regional coverage and at 1 mile to the inch in regions of gold potential. In the 1960s and 1970s mapping concentrated on understanding the tectonic setting of the region. In addition, granitoid areas, which received less attention in early regional work, were remapped. This report and map is a compilation of work up to 1974, but takes into account more recent studies in the Bear Structural Province now referred to as the Wopmay Orogen, to the northwest of the map area.

General Geology — Slave Province. The map area straddles the west margin of the Slave Structural Province and about 25 % of the area lies within the Wopmay Orogen. About one third of the Slave is made up of supracrustal rocks which belong to the Yellowknife Supergroup (2.67 Ga) and the remainder of granitoid rocks which include basement (3.0 Ga) to the Yellowknife, hybrid rocks derived from Yellowknife metasediments, plutonic rocks formed or intruded during and orogeny analogous to the Kenoran (2.59 Ga) and volumetrically minor, pegmatites and Proterozoic diabase dykes.

Basement rocks are gneissic tonalite and granodiorite plutons intruded by gabbro dykes, now amphibolitic, that structurally underlie the lowermost volcanic units to the east of the Yellowknife Supergroup in the northern and southern parts of the area. The basement gneiss has been injected by potassic aplite and pegmatitic dykes and veins during an orogenic episode that closely followed the intrusion of the plutons. The contact with the volcanic rocks is sheared and some displacement along the contact likely occurred. The gabbro dykes that intrude the basement gneiss have been interpreted elsewhere in the Slave as possible feeders to the Yellowknife volcanic rocks.

The Yellowknife volcanics occur in three areas: the Indin Lake basin located in the south-central part of the map area; the Chartrand Lake belt, located along the Slave margin; and the Grenville Lake region, in the north-central part of the area. The volcanic rocks are uniform pillowed basalts for the most part, with less than 10 % made up of more felsic flows, tuffs and breccias. The volcanic belts occur as segments separated by metasedimentary rocks which locally underlie the volcanic strata where they have been folded by east-west compression during the Kenoran. These volcanic strata were probably deposited in a more distal environment, contemporaneous with deposition of turbiditic metasedimentary rocks of the supergroup. Volcanic pebble conglomerate occurs locally between the upper volcanic rocks and the overlying metasediments.

The Yellowknife metasedimentary rocks are turbiditic greywackes and mudstone that were deposited in beds that are most commonly 10 to 40 cm thick, but

SOMMAIRE

Depuis la découverte d'or dans la région cartographique du lac Indin à la fin des années 30, les recherches géologiques ont surtout porté sur la cartographie à l'échelle de 4 milles au pouce de cette région et à l'échelle d'un mille au pouce des zones présentant un potentiel aurifère. Durant les années 60 et 70, les cartes étaient principalement dressées afin de mieux connaître le cadre tectonique de cette région. De plus, on a recartographié des zones de granitoïdes qui avaient suscité très peu d'intérêt au cours des premiers travaux de géologie régionale. Le présent rapport et la carte qui l'accompagne se fondent sur des données recueillies depuis 1974 et sur des études plus récentes portant sur la province structurale de l'Ours, aujourd'hui connue sous le nom d'orogène de Wopmay, dans le nord-ouest de la région cartographique.

Géologie générale — Province des esclaves. La région cartographique chevauche la bordure ouest de la province structurale des Esclaves et environ 25 % de ce secteur se trouve dans l'orogène de Wopmay. Environ un tiers de la province des Esclaves est composé de roches supracrustales faisant partie du supergroupe de Yellowknife (2,67 Ga), et le reste des roches granitoïdes incluant le socle (3,0 Ga) du supergroupe; il s'agit de roches hybrides issues de métasédiments de Yellowknife, de roches plutoniques qui se sont formées ou qui se sont introduites au cours d'une orogénèse analogue à celle du Kénorane (2,59 Ga) et d'un faible volume de pegmatites et de dykes de diabase du Protérozoïque.

Le socle se compose de plutons à tonalite gneissique et à la granodiorite recoupés de dykes de gabbro, maintenant amphibolitiques, qui reposent structuralement sous les unités volcaniques les plus basses situées à l'est du supergroupe de Yellowknife dans les parties nord et sud de la région. Le gneiss du socle a été recoupé par des dykes et des filons d'aplite potassique et de pegmatitique au cours de l'épisode orogénique qui a suivi de près l'intrusion des plutons. Le contact avec les roches volcaniques se trouve dans une zone cisailée et il s'est probablement produit un certain déplacement le long de cette surface de contact. Les dykes de gabbro qui pénètrent dans le gneiss du socle ont été interprétés ailleurs dans la province des Esclaves comme étant la source possible des roches volcaniques de Yellowknife.

On trouve des roches volcaniques de Yellowknife dans trois régions: le bassin du lac Indin, situé dans le centre sud de la région cartographique; la zone du lac Chartrand, située le long de la bordure de la province des Esclaves; et la région du lac Grenville dans le centre-nord de la région. Les roches volcaniques sont des basaltes en coussins uniformes pour la plupart, dont moins de 10 % est composé de coulées, de tufs et de brèches plus felsiques. Les zones volcaniques se présentent comme des segments séparés par des roches métasédimentaires qui reposent par endroits sous les strates volcaniques, là où elles ont été plissées par une compression est-ouest durant le Kénorane. Ces couches volcaniques ont probablement été déposées dans un milieu plus distal, pendant la mise en place de roches métasédimentaires turbiditiques du supergroupe. Par endroits, un conglomérat à galets volcaniques se manifeste entre les roches volcaniques supérieures et les métasédiments sus-jacents.

Les roches métasédimentaires de Yellowknife sont des grauwwacks et des petites turbiditiques qui ont été mise en place en couches dont la plupart mesurent de 10 à 40 cm d'épaisseur mais qui varient par endroits de plusieurs mètres d'épaisseur à

vary locally from several metres thick to several centimetres thick where they have a varved-like appearance. The rocks vary as a result of regional metamorphism. In areas of sub-biotite and biotite grade, bedding is commonly well preserved and primary depositional features such as graded bedding, dewatering structures, and minor slump structures are evident. Where metamorphic grade is higher, biotite and porphyroblasts of cordierite, staurolite, garnet and andalusite/sillimanite become major constituents and are referred to in older reports as “knotted” schist and gneiss. The bulk composition of the metasediments is close to that of granodiorite, but slightly less mafic than the Burwash Formation, from the Yellowknife type-area.

Some more variable rock compositions occur locally, such as at Chartrand Lake and Cotterill Lake, where metasediments are amphibolitic and were likely derived from proximal, basaltic detritus. Other variations occur in conglomerate and paraconglomerate, which may contain flattened granitoid disks, derived from granitoid boulders or pebbles.

Hybrid rocks derived by migmatization and melting of metasedimentary rocks, equivalent to the Yellowknife Supergroup, and/or older granitoid rocks have been mapped in three areas referred to as the Meyer migmatite complex, the Snare Lakes migmatite terrane and the Truce Lake — Drumlin Lake migmatite terrane. Detailed petrographic and age studies of the Meyer migmatite complex showed the rocks to be heterogeneous and granitic in overall composition. They contain abundant muscovite and coarse tourmaline-bearing pegmatite, both of which are incompatible with derivation from a sedimentary source, such as the Yellowknife Supergroup. Furthermore, some compositions are decidedly tonalitic. These observations indicate that other source rocks were present or introduced during development. The extensive areas covered by the Snare Lakes and Truce Lake — Drumlin Lake migmatite terranes are similar, i.e. an abundance of remnant metasedimentary paragneiss as paleosome, but patchy presence of tonalitic gneiss and high potassium granite in pegmatite and aplite veins. Age determinations carried out on the pegmatites indicate they are Archean and were formed between 2.59 and 2.57 Ga.

Plutonic rocks in the area are of granodioritic and granitic composition with some tonalite compositions evident locally. Detailed study of the Basler pluton in the southwest corner of the area showed it is a composite body made up of coalescing lobes that intruded together in a pear-shaped intrusive complex with cross-cutting contacts in places and with gradational contacts with migmatites in others. The Basler pluton consists of biotite, hornblende, plagioclase, microcline, quartz, with or without muscovite, accessory minerals with a coarse to medium grained granitic texture. The Origin plutonic complex has a similar shape, but is more homogeneous and less mafic. Other intrusives in the area are smaller rounded to irregular

plusieurs centimètres, là où elles ont une apparence varvée. La nature des roches varie en fonction du métamorphisme régional. Dans les zones dont le degré de métamorphisme est plus faible ou égal à la biotite, la stratification est généralement bien conservée et les principales caractéristiques de la sédimentation tels que le granoclassement, les structures résultant de l'assèchement et les formes associées aux petits glissements sont discernables. Aux endroits où le degré de métamorphisme est plus élevé, la biotite et les porphyroblastes de cordiérite, de staurolite, de grenat et d'andalusite et sillimanite, deviennent les principales composantes de la roche; dans d'anciens rapports, il était question de schiste et de gneiss «tachetés». La composition globale des métasédiments s'apparente à celle de la granodiorite mais se révèle légèrement moins mafique que la formation de Burwash de la zone type de Yellowknife.

Certaines roches sont par endroits de composition plus variable, notamment aux lacs Chartrand et Cotterill où il s'agit de métasédiments amphibolitiques qui découlent probablement de débris basaltiques proximaux. On trouve d'autres variations de composition dans des conglomérats et paraconglomérats qui contiennent parfois des disques granitoïdes de forme aplatie provenant de blocs ou de galets granitoïdes.

Des roches hybrides résultant de la migmatisation et de la fusion de roches métasédimentaires correspondant au supergroupe de Yellowknife ou de roches granitoïdes plus anciennes, ou les deux, ont été représentées sur carte dans trois zones que l'on a appelées: le complexe migmatitique de Meyer, le terrain migmatitique des lacs Snare et le terrain migmatitique des lacs Truce et Drumlin. Des études pétrographiques et de datation détaillées du complexe migmatitique de Meyer ont révélé qu'il s'agit dans l'ensemble de roches hétérogènes et granitiques. Elles contiennent une quantité abondante de muscovite et de pegmatite grossière à tourmaline dont la présence est incompatible avec une origine sédimentaire correspondant aux roches du supergroupe de Yellowknife. De plus, certaines compositions sont nettement tonalitiques. D'après ces observations, d'autres roches mères auraient été présentes ou introduites au cours de leur formation. Les grandes zones de terrain pegmatitique des lacs Snare et des lacs Truce et Drumlin sont de composition semblable, c'est-à-dire que l'on y trouve en abondance un paragneiss métasédimentaire résiduel qui constitue un paléosome mais aussi, par endroits, des gneiss tonalitiques et des granites à haute teneur en potassium dans des filons de pegmatite et d'aplite. La datation des pegmatites a établi qu'ils sont d'âge archéen et qu'ils se sont formés entre 2,59 et 2,57 Ga.

Les roches plutoniques dans cette zone sont de composition granodioritique et granitique et, par endroits, tonalitique. Une étude détaillée du pluton de Basler dans le coin sud-ouest de la région a révélé qu'il s'agit d'un pluton composite constitué de lobes coalescents qui ont pénétré simultanément un complexe intrusif en forme de poire associé avec des contacts obliques à certains endroits et des contacts de gradation avec les migmatites à d'autres. Le pluton de Basler se compose de biotite, de hornblende, de plagioclase, de microcline, de quartz, avec ou sans muscovite, de minéraux accessoires de texture granitique dont la taille des grains varie de grossière à moyenne. Le complexe plutonique d'Origin est de forme semblable mais présente une nature plus homogène et moins mafique. D'autres roches intrusives dans ce secteur sont plus petites, de forme arrondie à régulière; elles pénètrent dans les complexes migmatitiques ou en font partie. Les

bodies that intrude or make up part of the migmatite complexes. The round bodies are generally granodioritic and similar to granodiorites of the Basler complex, whereas the irregular plutons are uniform coarse grained bodies that contain varying amounts of microcline megacrysts. Some intrusions, such as the Sphynx Lake pluton, between the Origin plutonic complex and the Meyer migmatite complex, contain dioritic locally gneissic margins, suggesting they are slightly older. Conversely granodiorite stocks just east of Indin Lake are riddled with inclusions of Yellowknife metasediments and have textures that suggest they are epizonal.

Diabase dykes of two distinct ages form northwest-trending swarms. The oldest, the 1.9 Ga Indin Diabase, is part of a composite set with north-northeast trending dykes. This swarm is widespread in the Indin basin and more sparsely along the west margin of the Slave Province where they may be the same age as similar oriented dykes in the Yellowknife area. The youngest northwest-trending swarm is the 1.2 Ga Mackenzie Diabase that is related to widespread basic magmatism in the northeastern Canadian Shield. These younger dykes are responsible for superimposing a strong north-northwest-trending linear aeromagnetic pattern of the region.

General Geology — Wopmay Orogen. The Wopmay Orogen comprises Proterozoic metasedimentary rocks of the Snare Group, Archean granitoid basement gneiss and batholithic bodies of the Hepburn Intrusive Suite. The Snare Group in the northern half of the area is made up of flysch-type sediments including subgreywackes, mudstones, quartzites, conglomerate, dolomite and calcsilicate rocks. In the southern half of the area the Snare Group is mostly dolomite, argillaceous dolomite, mudstone, minor quartzite and conglomerate. The Archean basement is autochthonous granitoid gneiss, unconformably overlain by the basal Snare Group in the southern part of the area. In the northern half, the same basement cores gneiss domes. The Hepburn Intrusive Suite, Rodrigues granite intrudes the Snare Group in the northwest as a large homogeneous, biotite-plagioclase-quartz-bearing body with megacrysts of microcline, some with Rapakivi texture.

Structural Geology. Rocks of the Slave Province were deformed by at least three separate events; one pre-Yellowknife Supergroup, the Kenoran, and a Proterozoic event that also deformed rocks in the adjacent Wopmay Orogen. Thermal metamorphism associated with the earliest event led to the local potassic metasomatism of basement tonalite dated by Rb-Sr isochron methods at about 2.94 Ga, which followed intrusion of the basement tonalite at 2.99 Ga. Deformational structures associated with this event were mostly destroyed by Kenoran deformation, but there are some inclusions in metagabbro dykes that contain remnant gneissosity that may pre-date the Kenoran.

roches de forme arrondie sont en général granodioritiques et semblables aux granodiorites du complexe de Basler tandis que les plutons de forme irrégulière sont des roches à grain grossier de forme uniforme qui contiennent des quantités variables de mégacristsaux de microcline. Certaines intrusions, comme le pluton de Sphynx Lake situé entre le complexe plutonique d'Origin et le complexe migmatitique de Meyer, comportent des bordures dioritiques et, par endroits, gneissiques indiquant qu'il s'agit peut-être de roches légèrement plus anciennes. Au contraire, les petits massifs granodioritiques situés juste à l'est du lac Indin sont criblés d'inclusions de métasédiments de Yellowknife et présentent des textures d'apparence épizonale.

Des dykes de diabase de deux âges différents forment des essaims à orientation nord-ouest. Le plus ancien, le diabase d'Indin (1,9 Ga) fait partie d'une série composite de dykes à direction nord-nord-est. Ces dykes sont fort répandus dans le bassin d'Indin mais plus épars le long de la bordure ouest de la province des Esclaves où leur formation remonte peut-être à la même période que celle du dykes de même orientation de la région de Yellowknife. L'essaim le plus récent à direction nord-ouest est le diabase de Mackenzie (1,2 Ga) qui est associé au magmatisme basique étendu observé dans le nord-est du Bouclier canadien. Ces dykes plus récents sont à l'origine de la superposition d'une configuration linéaire de direction nettement nord-nord-ouest dont on a établi l'existence à l'aide des levés aéromagnétiques effectués au-dessus de cette région.

Géologie générale — Orogène de Wopmay. L'orogène de Wopmay présente des roches métasédimentaires du Protérozoïque du groupe de Snare, du gneiss de socle granitoïde d'âge archéen et de massifs batholitiques de la suite intrusive de Hepburn. Le groupe de Snare dans la partie nord de la région est composé de sédiments de type flysch comprenant des grauweekes, des pélites, des quartzites, des conglomérats, des dolomies et des roches à silicates calciques. Dans la partie sud du secteur cartographié, le groupe de Snare se compose surtout de dolomie, de dolomie argileuse, de pélites et de pélites quantités de quartzite et de conglomérat. Le socle archéen est un gneiss granitoïde autochtone, sur lequel repose en discordance le groupe basal de Snare dans la partie sud de la région. Dans la partie nord, le même socle occupe le centre de dômes de gneiss. Le granite de Rodrigues de la suite intrusive de Hepburn recoupe le groupe de Snare dans le nord-ouest du secteur sous la forme d'un gros massif homogène renfermant de la biotite, du plagioclase et du quartz accompagnés de mégacristsaux de microcline dont certains sont de texture rapakivique.

Géologie structurale. Les roches de la province des Esclaves ont été déformées par au moins trois événements distincts: un événement survenu avant la formation du supergroupe de Yellowknife, le Kénoranéen et un événement du Protérozoïque qui a aussi déformé les roches de l'orogène adjacent de Wopmay. Le métamorphisme thermique associé au plus ancien événement est à l'origine du métasomatisme potassique local de la tonalite de socle datée par les méthodes isochrones au Rb-Sr à environ 2,94 Ga, donc après l'intrusion de la tonalite de socle à 2,99 Ga. Les structures de déformation associées à cet événement ont pour la plupart été effacées par la déformation du Kénoranéen mais on trouve certaines inclusions dans des dykes de metagabbro caractérisés par la présence d'une gneissosité résiduelle qui remonte peut-être à une période antérieure au Kénoranéen.

Kenoran deformation is the dominant penetrative deformation in the Slave, and forms a pronounced northwest-to north-trending regional foliation. Two phases of folding produced intersecting axial planar foliations in the lowgrade metasediments, but the two foliations are mostly co-planar in higher grade rocks.

Proterozoic deformation is associated with east-west compression due to eastward-directed thrusting of the Bear plate against the Slave craton. The effect on the Slave Province in the map area was mostly brittle deformation. A northwest-oriented upright cleavage is, however, present in low grade metasediments around Indin Lake associated with folding. Brittle deformation in the region from Truce Lake to the lower reaches of the Snare River (termed the Indin structural basin) took place by northwest oriented left-oblique and north-south gravity faulting that depressed the central parts of the basin. Deformation also occurred in the granitoid regions along the west margin of the Slave Province, but they moved up relative to the Indin basin. Density determinations of the Origin intrusive complex indicate it had many properties of a gneiss dome, with less dense rocks in its centre. The Balser plutonic complex in the southern part of the area was uplifted during the Proterozoic, tilting the unconformity with the Snare Group more than 45° to the west.

Wopmay Orogen is dominated by east-west crustal shortening, allochthonous Proterozoic metasediments having been transported from the west onto Archean basement rock in the central and northern parts of the map area. The presence of a thrust fault at, or near, the boundary between rocks of Wopmay Orogen and the Slave Province is inferred from the high degree of compression observed in the Snare Group, relative to the basement which is comparatively less deformed west of the Slave Province boundary in the southwest corner of the area. Rocks of the Snare Group, cores of Archean gneiss domes and intrusions of the Hepburn Suite were probably transported from the west onto the Slave craton along this thrust. East-west compression of the Snare Group in the eastern part of the orogen, above the inferred thrust, formed an isoclinally folded prism of metasediments, buttressed against the Slave Province. The Slave was subsequently uplifted, relative to Wopmay Orogen, along a gravity fault that may coincide with a high angle thrust.

The Archean granitoid basement west of the Slave boundary contains remnant, infolded Snare Group rocks. Local southeast-directed thrusting is present in this environment, but most of the supracrustal rocks in the southern half of the area are autochthonous. They are dolomite and argillaceous facies rocks with open folds, contrasting with the more sandy compositions and tighter folds of the same group in the central and northern parts of the area.

Five gneiss domes occur in the Emile River area in the west-central part of the area. They rose under the influence of gravity during the peak of regional

La déformation kénoranéenne constitue la principale déformation pénétrative dans la province des Esclaves et a créé une foliation régionale prononcée dont l'orientation se dirige du nord-ouest au nord. Deux phases de plissement ont produit des plis synschisteux qui s'entrecoupent dans les métasédiments à faible degré de métamorphisme mais ces deux foliations sont pratiquement parallèles dans les roches à degré de métamorphisme plus élevé.

La déformation protérozoïque est associée à une compression est-ouest causée par un charriage vers l'est de la plaque de l'Ours contre le craton des Esclaves. Les effets de cette déformation sur la province des Esclaves dans le secteur cartographié se limitent à ceux attribuables à une déformation cassante. On observe, cependant, un clivage vertical orienté vers le nord-ouest attribuable à un plissement dans les métasédiments à faible degré de métamorphisme qui se trouvent autour du lac Indin. La déformation cassante dans la région allant du lac Truce aux tronçons inférieurs de la rivière Snare (appelé bassin structural d'Indin) a été causée par des failles à décrochement senestre orientées vers l'ouest et des failles normales nord-sud qui ont provoqué l'affaissement des parties centrales du bassin. Une déformation s'est aussi produite dans les régions granitoïdes le long de la bordure ouest de la province des Esclaves mais ces dernières ont été soulevées par rapport au bassin Indin. La détermination de la densité du complexe intrusif d'Origin indique qu'il possédait bon nombre des particularités d'un dôme de gneiss renfermant des roches moins denses à son centre. Le complexe plutonique de Balser, dans la partie sud de la région a été soulevé au cours du Protérozoïque, en inclinant de plus de 45° vers l'ouest la surface en discordance avec le groupe de Snare.

L'orogène de Wopmay est principalement caractérisé par un raccourcissement crustal à direction est-ouest, les métasédiments d'âge allochtones protérozoïque de l'ouest ayant été transportés jusqu'au socle archéen des parties centrale et nord de la région cartographique. On conclut qu'une faille de charriage a dû se former à la limite de séparation des roches de l'orogène de Wopmay et de celles de la province des Esclaves, ou près de cette limite, en se basant sur les indices de forte compression observés dans le groupe de Snare, par rapport au socle, lequel est moins déformé à l'ouest de la limite de la province des Esclaves dans le coin sud-ouest du secteur cartographié. Des roches du groupe de Snare, des noyaux de dômes de gneiss de l'Archéen et des intrusions de la suite de Hepburn ont probablement été transportés vers le craton des Esclaves le long de cette faille de charriage en provenance de l'ouest. La compression est-ouest du groupe de Snare dans la partie est de l'orogène, au-dessus de la présumée faille de charriage, a provoqué la formation dans les métasédiments d'un prisme de plis isoclinaux qui s'appuie contre la province des Esclaves. Cette dernière a par la suite été soulevée, par rapport à l'orogène de Wopmay, le long d'une faille normale qui coïnciderait avec un charriage à angle élevé.

Le socle granitoïde de l'Archéen à l'ouest de la limite des Esclaves contient des roches résiduelles repliées du groupe de Snare. Il y a eu un charriage local à direction sud-est dans cette zone mais la plupart des roches supracrustales de la partie sud du secteur cartographié sont autochtones. Il s'agit de dolomies et de roches à faciès argileux dont les plis ouverts contrastent avec les plis plus fermés des roches de composition plus sableuse du même groupe qui se trouvent dans les parties centrale et nord de ce secteur.

metamorphism associated with Wopmay orogenesis. Like the overlying Snare Group, the granitoid core gneiss and possibly Archean Yellowknife metasediments were transported from the west along basal thrusts.

Metamorphism. The Slave Province was metamorphosed by at least three distinctly separate events: a pre-Yellowknife event at about 3.0 Ga, during the Kenoran at about 2.59 Ga, and during the event(s) that formed the Wopmay Orogen about 1.9 Ga. Evidence of 2.94 Ga thermal metamorphism comes from Rb-Sr isotopic data, which overprint tonalite rocks that are at least 2.99 Ga and possibly older.

The Kenoran Orogeny resulted in regional metamorphism that ranges in grade from sub-biotite to upper amphibolite facies. The distribution of isograds in much of the western margin of the Slave Province is related not only to Kenoran events, but also to Proterozoic events when thermal metamorphism, due to crustal thickening, triggered less dense areas of rocks, such as the migmatite and plutonic complexes along the province margin to be uplifted. Denser regions, such as the supracrustal rocks of the Indin structural basin were downwarped. The vertical displacements of both supracrustal and granitoid regions were accompanied by brittle northwest-southeast oriented left-oblique strike-slip faulting. Some almost contemporaneous undulatory folding, with axes also oriented northwest-southeast, occurred in the supracrustal rocks.

Isograds in the Snare Group in the west-central part of the area prograde from sub-biotite greenschist facies near the Slave boundary toward granulite facies granitoid basement. Metamorphism was contemporaneous with, or occurred slightly prior to east-west compression, as foliated metamorphic minerals are axial planar, suggesting that metamorphism and deformation developed during a single, Proterozoic event that affected both basement and overlying metasediments.

Economic Geology. Gold discovered in 1938 in the Indin Lake region encouraged exploration in the Indin structural basin during the early 1940s. Small scale underground work was carried out on three properties, but no significant production materialized. Two of the underground workings occur along a major Archean shear zone, the other is in an extensive fractured synvolcanic felsic sill that has been further explored (1974) by Cominco. This deposit is reputed to contain as much as 9 million metric tons of low grade potential gold ore (2.33 g/t). Recent drilling by Echo Bay Mines (1985-87) has concentrated on quartz-veined rocks near the interface between the volcanics and overlying metasediments, in the Lex Lake area. The transition from volcanic to sedimentary deposition, combined with a low regional grade of metamorphism along a major Archean shear is a favourable locus for gold exploration in the region.

Cinq dômes de gneiss se manifestent dans la zone de la rivière Emile dans la partie centre-ouest de la région. Ils se sont formés par gravité à l'apogée de l'épisode de métamorphisme régional survenu pendant l'orogénèse de Wopmay. Tout comme les roches du groupe de Snare sus-jacent, les gneiss granitoïdes centraux et peut-être les métasédiments archéens de Yellowknife ont été transportés le long de failles de charriage basales en provenance de l'ouest.

Métamorphisme. La province des Esclaves a été métamorphisée lors de trois événements distincts: un événement antérieur au Yellowknife à environ 3,0 Ga, pendant le Kénoranéen, à environ 2,59 Ga, et pendant l'événement ou les événements qui ont participé à la formation de l'orogène de Wopmay à environ 1,9 Ga. Un métamorphisme thermique se serait produit vers 2,94 Ga comme le révèlent des données isotopiques au Rb-Sr; il a laissé des traces sur des roches à tonalite d'au moins 2,99 Ga.

L'orogénèse du Kénoranéen s'est traduite par un métamorphisme régional dont le degré varie du sous-faciès inférieur des biotites au faciès supérieur des amphibolites. La répartition des isogrades dans la plus grande partie de la bordure ouest de la province des Esclaves est associée non seulement à des événements kénoranéens mais également à des événements protérozoïques, époque à laquelle un métamorphisme thermique, résultant d'un épaississement de la croûte, a provoqué le soulèvement de zones moins denses de roches comme les complexes migmatitiques et plutoniques situés en bordure de la limite de la province. Des zones de roches plus denses telles que les roches supracrustales du bassin structural d'Indin se sont affaissées. Le déplacement vertical de zones supracrustales et granitoïdes a été accompagné de la formation de failles à décrochement senestre de nature cassante et d'orientation nord-ouest-sud-est. Dans les roches supracrustales, on remarque la formation, presque en même temps, de plis onduleux dont l'accuse lui aussi une orientation nord-ouest-sud-est.

Les isogrades dans le groupe de Snare (centre-ouest de la région à l'étude) passent progressivement du sous-faciès des biotites du faciès des schistes verts, près de la limite de la province des Esclaves, à un faciès des granulites dans un socle granitoïdes. Le métamorphisme a eu lieu en même temps ou juste avant l'épisode de compression est-ouest, tel qu'en témoigne la présence de minéraux métamorphiques feuilletés de plan axial, phénomène qui semble indiquer que le métamorphisme et la déformation ont eu lieu pendant un seul événement protérozoïque qui aurait affecté à la fois le socle et les métasédiments sus-jacents.

Géologie économique. La découverte d'or en 1938 dans la région du lac Indi a stimulé l'exploration dans le bassin structural d'Indin au cours du début des années 40. Des travaux souterrains à petite échelle ont été réalisés dans trois propriétés mais sans production importante à signaler. Deux des chantiers souterrains étaient situés le long d'une importante zone de cisaillement d'âge archéen et le troisième se trouvait dans un filon-couche felsique très fissuré d'origine synvolcanique que la Cominco a par la suite exploré (1974). Ce gisement contiendrait plus de 9 millions de tonnes métalliques de minerai à faible teneur en or (2,33 g/t). La société Echo Bay Mines a récemment effectué des sondages (1985-1987) dans des roches à filons de quartz situées près de l'interface des roches volcaniques et des métasédiments sus-jacents dans la région du lac Lex. La transition de roches volcaniques à roches sédimentaires,

Base metal exploration and airborne geophysical surveys were carried out in the 1970s in the Spider Lake area, in the and 1980s along the southeast margin of Indin Lake. Some commercially interesting assays were encountered, but no significant tonnages have been reported so far.

combinée à un faible degré de métamorphisme régional le long d'une importante zone de cisaillement d'âge archéen, contribue à faire de cette région un milieu favorable à l'exploration aurifère.

Durant les années 70, on a effectué des travaux d'exploration et des levés géophysiques aériens des métaux de base dans la zone du lac Spider et, durant les années 80, le long de la bordure sud-est du lac Indin. Des analyses de minerais présentant un intérêt commercial ont été réalisées mais aucun tonnage important n'a été signalé jusqu'à maintenant.

INTRODUCTION

The Indin Lake map area (86 B) was mapped during the summers of 1972, 1973, and half of the summer of 1974. The work was partly a compilation of former 1 inch to 1 mile (1:63 360) maps that cover about 25 % of the area. Important localities were revisited and most granitoid areas were remapped. The interpretation of the geology of the area benefited from Rb-Sr whole-rock (Rosaline Frith, 1974), U-Pb zircon, and K-Ar geochronological studies, geochemical whole-rock analyses, and detailed structural studies.

The first geological studies in the map area were carried out in 1938 when gold was discovered near Indin Lake. Systematic reconnaissance mapping at a scale of 1 inch to 4 miles (1:253 440) was initiated by the Geological Survey of Canada in 1939, with C.S. Lord and J. Tuzo Wilson mapping the west half of Indin Lake map area (Lord, 1942). The east half was mapped by Y.O. Fortier in 1948 (Fortier, 1949). One mile to the inch maps were made of potential gold-producing areas within the volcanic and sedimentary rocks in the Chalco Lake (Stanton et al., 1954), Ranji Lake (Tremblay et al., 1947), and Ghost Lake areas (Wright, 1954). Regional studies, carried out as part of the helicopter reconnaissance geological mapping of the northwest Canadian Shield, included the Indin Lake map area (Fraser, 1960, 1964). Other 1 inch to 1 mile studies of the Slave Structural Province boundary were carried out in the east half of Arseno Lake map area (McGlynn and Ross, 1963), the west half of Mesa Lake map area (Ross, 1966), the east part of Mattberry Lake map area (Smith, 1966b), and the Basler Lake area along the southern margin of Mattberry Lake map area (McGlynn and Ross, 1963). The Brownwater Lake area was mapped at a scale of 1:50 000 during a six-week period during 1974 by R. Leatherbarrow and the author. Some unpublished detailed maps around mineral prospects in the area, available from the Resident Geologist's Office in Yellowknife, were used in the compilation. Preliminary reports on the geology of the map area by the author include Frith (1973), Frith et al., (1974), and Frith and Leatherbarrow (1975).

General character of the area

The terrain around Indin Lake is moderately rugged and forested, with local relief up to 60 m. West of Rodrigues Lake vertical faultbounded cliffs provide strong relief, and a fault

scarp separates a granitic plateau area in the western part of the map area from a northerly trending mountainous terrain with steep valley and ridge topography. North of Spider Lake and around the Snare Lake, terrain is relatively flat, with local relief generally less than 30 m.

The height of land between northward drainage along the Coppermine River system and southward drainage down the Emile River system into Great Slave Lake passes through Grenville Lake in the north-central part of the map area. Rivers in the map area are fast flowing, rocky, and generally unnavigable.

Glacial deposits consist of eskers kames, deltas, and sand plains, most of which have been modified by subsequent water action. Felsenmeer is common in flatter terrain that is underlain by granitoid rocks. The west slopes of hills are generally covered with bouldery till, and lowlands are immature, swampy, and generally devoid of outcrop. A glaciofluvial blanket of variable thickness covers the east half of the map area, and north of Truce Lake this blanket is relatively thick and bedrock is exposed only where resistant rocks, such as dykes and volcanic rocks, stand out in relief.

Pleistocene ice moved from east to west across the map area, modified locally by the north-south trending topography. Directions of ice advance are shown by boulder trains, and stoss slopes on the eastern ends of drumlins and roches moutonnées. Some ice fanning may have taken place, as indicated by deviations in local glacial striae. Most glaciofluvial deposits are of local derivation, with individual deposits showing a strong correlation to local bedrock (Sklash, 1973).

Frost action has produced polygonal ground beneath shallow lakes and under swampy ground. Evidence of frost thrusting is most common in flat swampy ground and in rocks that have a well developed fissility. Frost thrust blocks are common, and blocks weighing many tons have moved up and locally out of the surrounding bedrock. The largest blocks are from granitic rocks and the smallest from cross-fractured slates. Thrusting took place by expansion during warming phases (Yardley, 1951). Trapped water is super-cooled to as low as -22°C (Bridgeman, 1915) and then expands with the increase of temperature.

The break-up of ice in Indin Lake took place early in June in 1973 and 1974 and in large lakes near the northern

margin of the map area a few weeks later. Summer air temperatures in the region rarely exceed 30°C and winter temperatures have been reported as low as -40°C (Yardley, 1951). The 5°C, mean annual isotherm and the southern boundary of continuous permafrost (Jenness, 1949) passes 160 km to the south of the map area.

The treeline extends roughly from the southeast corner of the map area northwest to Truce Lake, thence west through Origin Lake and north from Mesa Lake. Vegetation north of the line contains patches of stunted, black spruce, arctic willow, and other low ground cover, whereas south and west of it, areas are forested mostly with white and black spruce, white birch, and locally abundant poplar, jack-pine, and tamarack. Some of the white spruce have diameters as large as 60 cm but most are 15 cm or less. The north-south trending topography along the western side of the map area provides protection from prevailing north-westerly winds, which give rise to forested west-facing slopes.

Wildlife was plentiful in the area during the summers of 1972, 1973, and 1974. In 1972, several thousand caribou migrated southward in early August near the east end of Mesa Lake. Moose lived in the forested areas and along the treeline. Black bears were numerous, and barrenland grizzly bears were seen infrequently near Mesa and Grenville lakes. Small game included Arctic hare, spruce grouse, ptarmigan, and several species of water-fowl. Bald eagles were observed frequently in the Brownwater Lake area, and both common and Arctic loons were seen. Lake trout, pike, and greyling were common, and Lord (1942) has reported the presence of northern sucker, yellow pickerel, and ling.

The map area contains no year-round settlements, but on the north shore of Snare Lake, during the trapping seasons of 1972-1975, a number of people from Rae, Great Slave Lake, inhabited a small village consisting of about 10 log cabins and a regional game management station.

Acknowledgments

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GENERAL GEOLOGY SLAVE STRUCTURAL PROVINCE

The map area straddles the Slave Structural Province boundary, as defined by Stockwell (1964). East of this boundary, bedrock is mainly Archean in age (Fig. 1), but Proterozoic intrusive stocks, dykes, and pegmatites comprise about 2 % of the area.

Archean

Archean rocks in the Slave Province part of the map area include; basement complex rocks, plutonic rocks, and supracrustal rocks of the Yellowknife Supergroup, as shown in the Table of Formations (Table 1). The basement complex consists of hybrid rocks, formed in part by the metasomatism and/or migmatization of older granitoid rocks.

Basement complex

The basement rocks in Indin Lake map area were recognized initially near Grenville Lake by their stratigraphic position beneath the volcanic rocks in that area and by their relatively low grade of regional metamorphism (Frith et al., 1974). The basement tonalite resembles tonalite gneiss found elsewhere in the Canadian Shield (Baragar and McGlynn, 1976). Laboratory dating (Frith et al., 1974, 1986) showed the basement rocks to be older than the supracrustal rocks of the region. Regional mapping in this study outlined other areas of basement rocks within the map area near Cotterill Lake and along Snare Lake (Fig. 2).

Grenville Lake area

Basement rocks in the Grenville Lake area are of heterogeneous composition and characterized by grey- to light-buff granitoid gneiss cut by east-northeast-trending dykes of gabbro or amphibolite. Patchy areas of undeformed muscovite-bearing pegmatite occur within the complex. The granitoid gneiss is cut by pink aplitic veins and minor irregularly bounded, uniform, medium grained granite. The granite contains minor biotite and, in places, muscovite-bearing pegmatitic dykes, veins, and irregular segregations. Altogether the younger granitoid rocks make up about 25 % of the basement rocks in this area. The rocks have been almost ubiquitously metasomatized or migmatized by the addition of potassium, which appears to have come from aplite veins and migrated into the gneiss several metres. Cobaltinitrite-staining techniques were used to trace potassium emanating from the leucosome veins, which permeated the host rock and changed its composition from tonalite to granite or granodiorite. The staining shows high concentrations of K-rich minerals near the veins, which diminish over 0.5 m. Since aplite veins commonly criss-cross every 1 m or less, the resulting rock is mostly metasomatized. In locally restricted areas the rock is grey, medium grained, and of tonalitic or trondhjemitic composition, which was probably the composition of the rock before the introduction of the potassium. Areas of least metasomatized basement gneiss (unit **Ab**) are indicated in Figure 2.

The basement rocks are bounded on the south and west by Yellowknife Supergroup basalt, with tops away from them (Fig. 1). The contact between these two rock types is deformed, but no kinematic indicators were found. The rocks on both sides of the contact are locally mylonitized or sheared. These shear planes intersect an earlier biotite fabric to give shallow, easterly plunging lineations. The shearing diminishes away from the volcanic rocks, but was observed as much as a kilometre north of the contact. Only

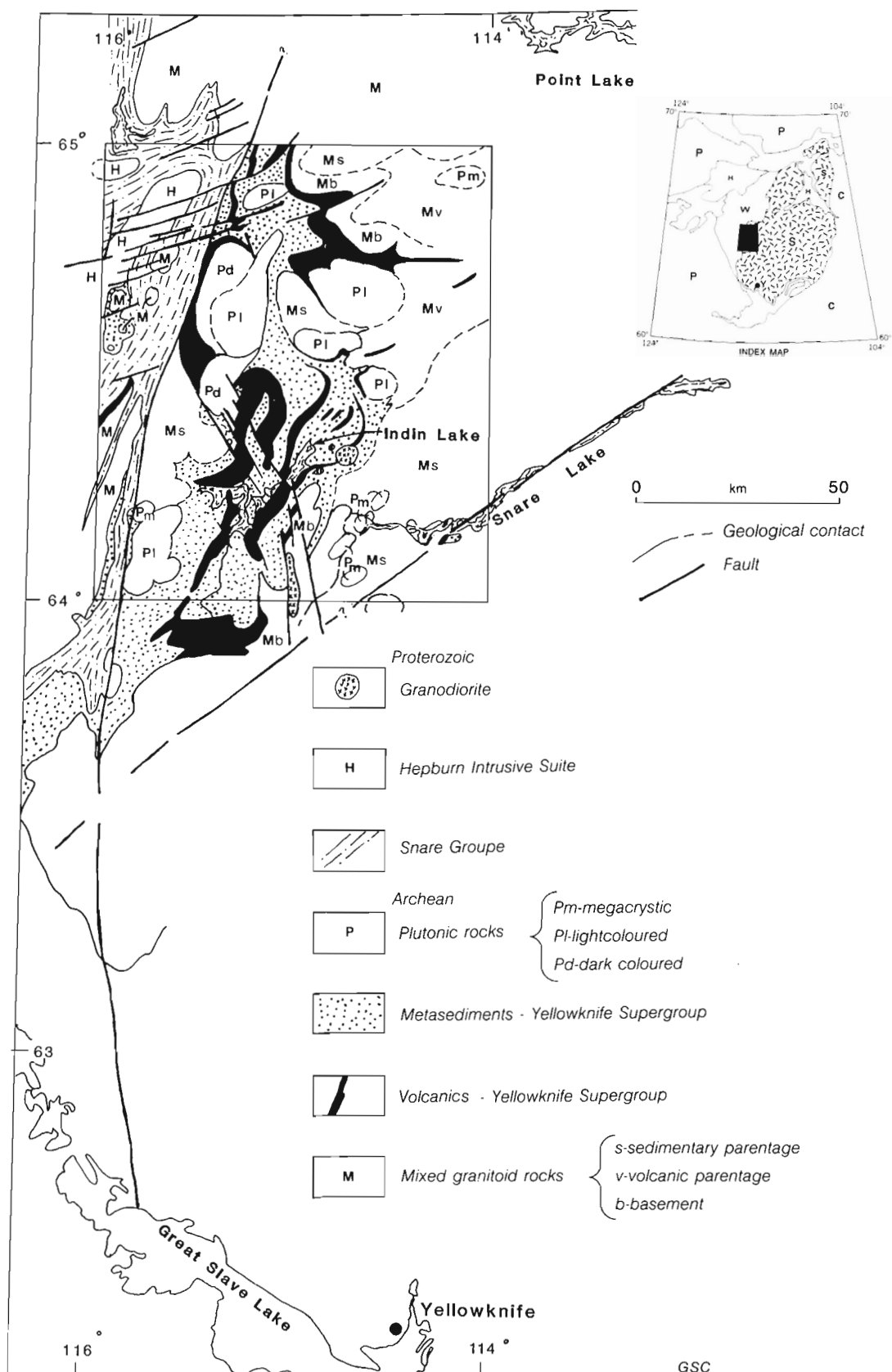


Figure 1 Geological sketch map showing the principal rock types and the tectonic and geographic setting of Indin Lake map area.

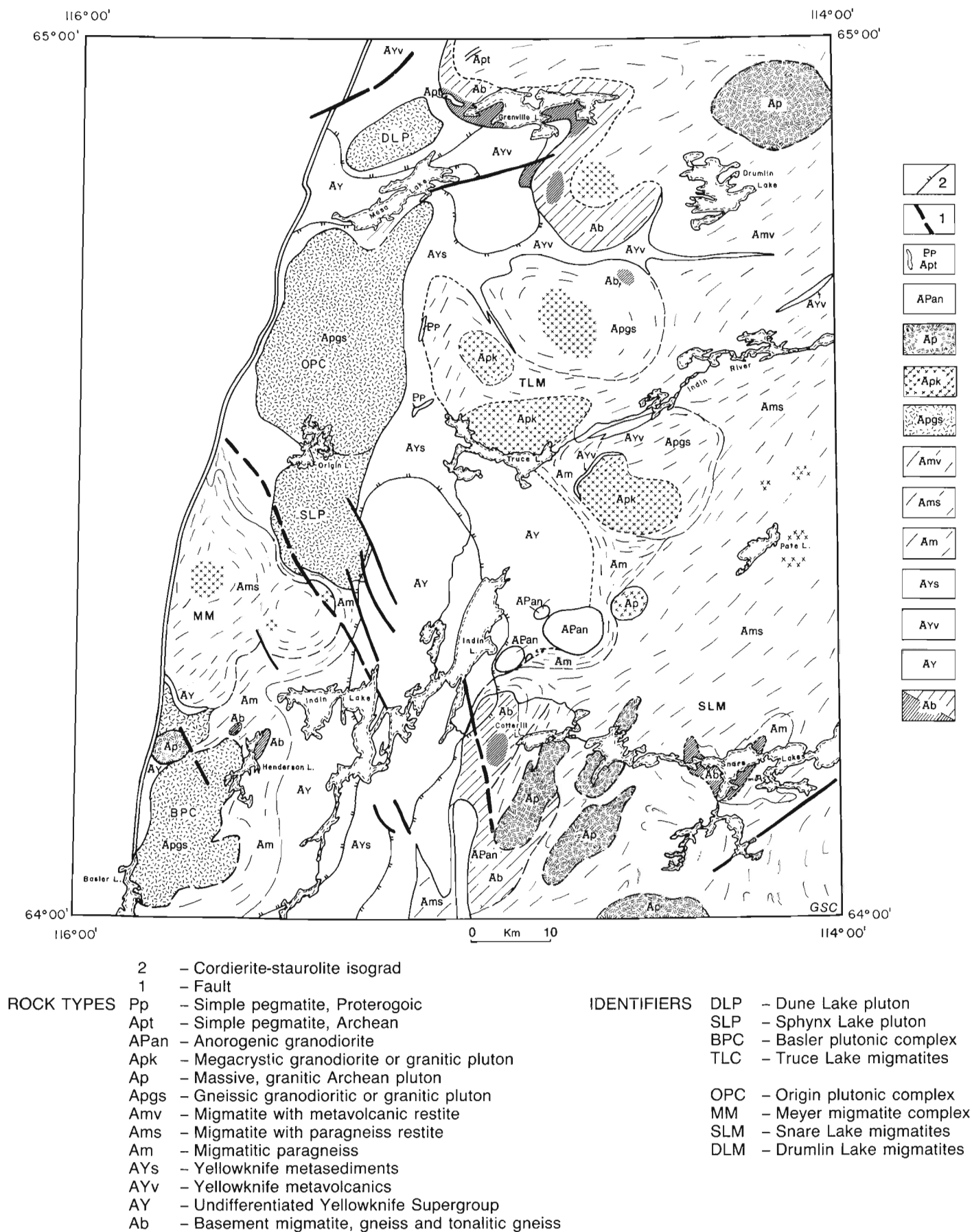


Figure 2 Geological sketch map showing the distribution of the granitoid rocks in Indin Lake map area.

Table 1. Table of formations

Age(Ga)			Formations	Unit symbols	Relationships	Lithology ¹
P R O T E R O Z O I C A M B R I A N	P R O T E R O Z O I C	1.89	Hepburn Batholith	Pp	intrusive	pegmatite, aplite
		1.89		Pd	intrusive	diabase and gabbro sills
		1.89		PH	intrusive into Archean and Snare Group	granite and granodiorite
		1.9		PS	unconformably overlies Archean basement rocks and is locally thrust to the east and south-east	siltstone, argillite dolomite, quartzite, conglomerate, muddy dolomite, sandstone, arkose
	A R C H E A N	2.5+	Basement gneiss	Ag	derived from Archean	migmatite, gneiss hornblende gneiss granitoid gneiss.
					(Wopmay/Slave boundary)	
		1.9	Indin Diabase	Pd	intrusive into YKS/YKV	diabase, gabbro
		1.9	muscovite peg.	Apt	intrusive into YKS	pegmatite, aplite
		2.57	granitoid plutons	Ap	intrusive into YKS/YKV	megacrystic granite, granodiorite
					intrusive into YKS/YKV	granite, granodiorite tonalite
		2.57	hybrid granitoids	Am	intrusive derived partly from YKS	migmatite, gneiss quartz monzonite, granodiorite
		2.67	Yellowknife S.G. metasediments volcanics	AYs AYv	conformable with YKV uncertain	greywacke, mudstone basalt, andesite, and dacite
		2.99	basement complex	Ab		tonalite, granodiorite, amphibolite

YKS = Yellowknife Supergroup metasediments;
YKV = Yellowknife Supergroup metavolcanics
¹Rocks are classified according to Streckeisen (1976).

a few scattered outcrops of paragneiss migmatite are present to the north and east, so that the nature of the contacts with these rocks is unknown.

Metagabbro dykes, possible feeders to the adjacent volcanic rocks, intruded the basement gneiss in a east-northeast direction. They are amphibolitic at the margins and have a foliation that is common to the east-west regional direction. The dykes on the major promontory of Grenville Lake have all been retrograded, but ophitic textures are preserved near their centres.

Cotterill Lake area

The basement rocks in the Cotterill Lake area are more migmatitic than those at Grenville Lake, and the few amphibolite dykes present are more deformed and granitized, but otherwise the principal rock types are similar to those at Grenville Lake. Some of the basement rocks are veined by potassic aplites, others contain porphyroblasts of potassium

feldspar. Deformation has produced a vertical to steeply inclined foliation that is oriented parallel to the volcanic-granitoid contact. In the Cotterill Lake peninsular region and on nearby islands, a fine- to medium-grained, biotite-hornblende paragneiss (Unit **AYg**) is in contact with the basement gneiss. This paragneiss is similar to mafic paragneiss in the Chartrand Lake area and was probably derived from a mafic volcanic source (McGlynn and Ross, 1963). It has been mapped as part of the Yellowknife Supergroup metasediments. The basement rocks are intruded by megacrystic granodiorite, which also intrudes migmatitic rock in the Snare Lake area to the east.

The Cotterill Lake basement rocks are generally highly deformed (Fig. 3, 4). Locally, however, rocks are more massive and are less contaminated by externally derived granitoid pegmatite and aplite. The largest area of basement gneiss in the Cotterill Lake region occurs in an oval-shaped body near the outlet of the Snare River into Indin Lake, and is characterized by an anomalously high aeromagnetic pattern (GSC Map 7202 G).

The contact between the Cotterill Lake basement rocks and metavolcanic rocks near Indin Lake area is relatively sharp, with rocks on both sides being highly foliated and sheared. Hornblende gneiss within the basement complex is stretched and folded. Porphyroblasts of potash-feldspar are locally deformed into augen structures (Fig. 4). The hornblende gneiss is locally interlayered with biotite granite gneiss, and across strike the rocks are heterogeneous and locally mylonitized. The metamorphic grade of the adjacent Yellowknife metasediments near the outlet to the Snare Lake suggests that part of the basement gneiss is below the regional cordierite-staurolite isograd.

Other occurrences of basement rocks

Possible basement rocks occur within the Origin plutonic complex southwest of Mesa Lake and near Origin Lake. Basement now migmatized, may have been uplifted with the complex during Proterozoic isostatic adjustment (Unit Amb).



Figure 3 Basement tonalite gneiss east of Cotterill Lake deformed by a northeast trending fold set (parallel to the hammer handle) which may be analogous to F1, making the east-west fabric pre D1.



Figure 4 Basement tonalite gneiss located east of Cotterill Lake in contact with foliated hornblende gneiss derived from a metagabbro dyke. Note the stretched augen and veins in the metagabbro and the older fabric in the basement inclusion.

The marginal rocks of the Origin plutonic complex in the Origin Lake area are made up of dioritic, tonalitic, and granodioritic gneiss and are fractured and intruded by younger, less deformed, medium-equigranular granite dykes. These granite dykes show intrusive relationships with the surrounding volcanic rocks, but the tonalitic gneiss does not, so that its relationship with the volcanic rocks is uncertain. Chemical analyses of the more gneissic tonalitic rocks indicate they are similar to those in the Grenville Lake and Cotterill Lake areas (compare Tables 2 and 5).

A smaller isolated area of basement tonalite gneiss occurs northeast of the Basler plutonic and metamorphic complex in the southwest part of the map area (Unit Amb). Smith (1966a) thought this gneiss was the oldest rock around Mattberry Lake. The area is made up of hybrid rocks consisting mostly of tonalite and quartz diorite, with secondary, more alkalic, deformed rock. Discontinuous banding at the margins of the tonalite grades into a more massive structure toward the centre of the tonalite body.

An irregular-shaped body of basement tonalite and granodiorite gneiss occurs along the eastern part of the

Table 2. Chemical analyses (in weight per cent) of basement granitoids from the Grenville Lake and Cotterill Lake areas.

	Sample No.						
	1	2	3	4	5	6	7
SiO ₂	75.20	70.50	69.40	73.50	70.70	62.10	66.40
TiO ₂	0.05	0.21	0.38	0.13	0.28	1.02	0.52
Al ₂ O ₃	15.00	15.60	16.80	15.30	15.00	16.80	14.80
FeO	0.20	1.30	1.80	0.40	2.40	4.10	1.70
Fe ₂ O ₃	0.40	0.50	0.60	0.60	1.50	2.40	2.00
MnO	0.02	0.03	0.05	0.02	0.06	0.08	0.08
MgO	0.40	0.53	1.38	0.33	0.64	1.93	2.00
CaO	2.55	2.04	2.57	3.09	3.03	4.61	3.14
Na ₂ O	5.50	5.00	5.30	4.90	4.80	4.20	5.40
K ₂ O	0.69	2.57	1.59	0.99	0.94	1.83	2.36
P ₂ O ₅	0.03	0.10	0.12	0.05	0.09	0.33	0.15
S	0.01	0.00	0.02	0.00	0.00	0.01	0.01
CO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.05	98.38	100.01	99.31	99.44	99.41	98.56
K/Rb	2.9	11.9	7.3	3.2		38.0	49.0
Cr*	<1000	<1000	3400	<1000	nf	nf	1900
Zr	nf	600	500	200	nf	2400	5000
Sr	1600	3300	2900	1100	5600	2200	4900
Rb	1000	900	900	1300	nf	200	200
Zn	nf	100	600	200	nf	500	900
Ni	nf	200	100	100	nf	100	200
Ba	700	10000	4100	920	7100	3200	7400
Y*	<2000	nf	<2000	<2000	nf	3600	4000

NOTES

FeO was determined by conventional methods, all others were by XRF or as noted below.

nf = not found; * = determined by emission spectrometry.

Samples 1-3 = Grenville Lake tonalites, samples 4-7 = Cotterill Lake tonalites.

Snare Lake complex. The gneiss is heterogeneous in composition, and like the Cotterill Lake occurrences, it is characterized by a high aeromagnetic anomaly (GSC map 7202G), perhaps reflecting a greater abundance of ferromagnesian minerals in these rocks. Amphibolite composed of coarse grained hornblende with 10 to 20 % plagioclase occurs in an outcrop-deficient area southeast of the basement gneiss, but its extent is not known. It may be derived from metagabbro dykes similar to those near Grenville Lake.

Geochemistry of the basement gneiss and related rocks

Whole-rock chemical analyses of the various rocks from the basement complexes at Grenville and Cotterill lakes are given in Tables 2 and 3. Analyses of granitoid rocks (Table 2) show a considerable variation in K_2O content, ranging from 0.69 to 2.57 %, in contrast to the Na_2O and Al_2O_3 contents, which show a smaller variation. This variation was observed in the field as pink patches within grey gneissic terrane where Kfeldspar has replaced plagioclase. The analyses have been converted to give Barth mesonorms (Barth, 1962), and the appropriate mineral proportions have been plotted on a Streckeisen diagram (Fig. 5).

Table 3. Chemical analyses (in weight per cent) of Archean gabbro and diabase dykes from the Grenville Lake and Hewitt Lake areas.

	Sample No.	
	1	2
SiO ₂	48.3	61.7
TiO ₂	0.96	1.08
Al ₂ O ₃	16.5	15.7
FeO	8.9	5.8
Fe ₂ O ₃	2.0	0.6
MnO	0.2	0.08
MgO	8.07	2.64
CaO	10.8	3.93
Na ₂ O	2.4	3.2
K ₂ O	0.45	2.79
P ₂ O ₅	0.09	0.25
S	0.03	0.03
CO ₂	0.0	nd
Total	98.7	97.85
Cr*	4100	3300
Zr	nd	1400
Sr	1200	2500
Rb	nd	1200
Zn	800	1000
Ni	1400	400
Ba	900	4600
Y*	2100	2800
Co*	500	3300

NOTES
FeO was determined by conventional methods, all others were by XRF or as noted below.
nd = not detected;
* = determined by emission spectrometry.
1 Grenville Lake gabbro
2 Hewitt Lake diabase

Trace element analyses of basement whole-rock samples support the field observations that these rocks have undergone K-metasomatism. The K/Rb ratio in the more leucocratic rocks (e.g. samples 2 and 4 in Table 2) is markedly lower than it is in the five analyzed specimens. This decrease may have resulted from the production of K and Rb by partial melting of the lower crust, where biotite (a mineral with low K/Rb ratio) is preferentially melted. The fluids would then have accumulated at higher levels as leucosome and enriched the bulk composition of the permeated rocks in potassium and rubidium with low K/Rb ratio (Fig. 6).

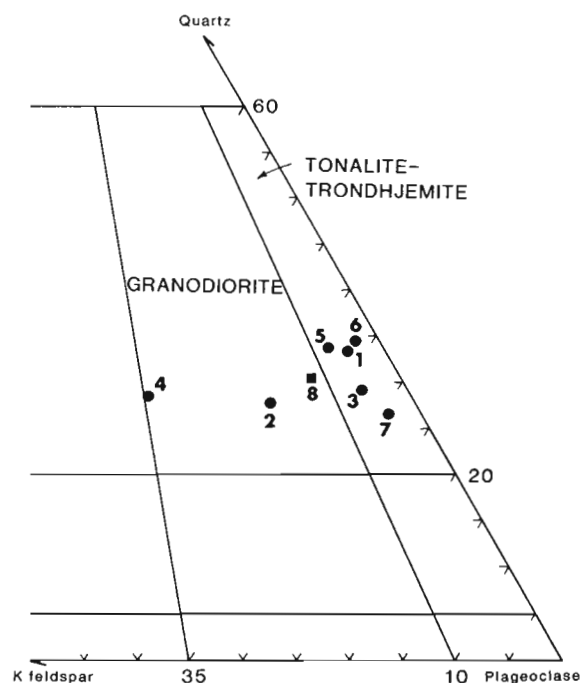


Figure 5 Mesonormal plots for basement gneiss in the Grenville Lake and Cotterill Lake areas. The square symbol (# 8) is the average. The numbers refer to analyses in Table 2.

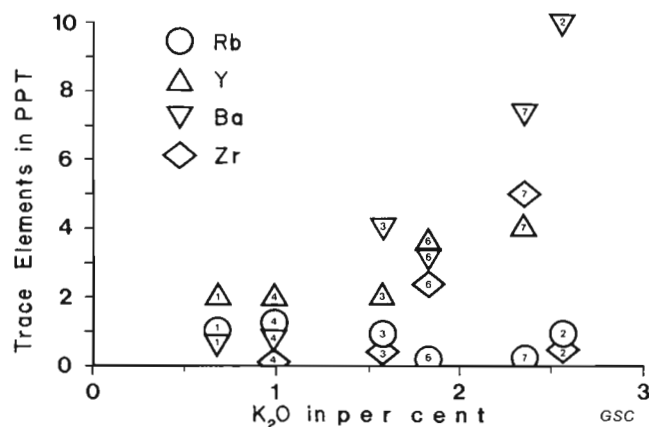
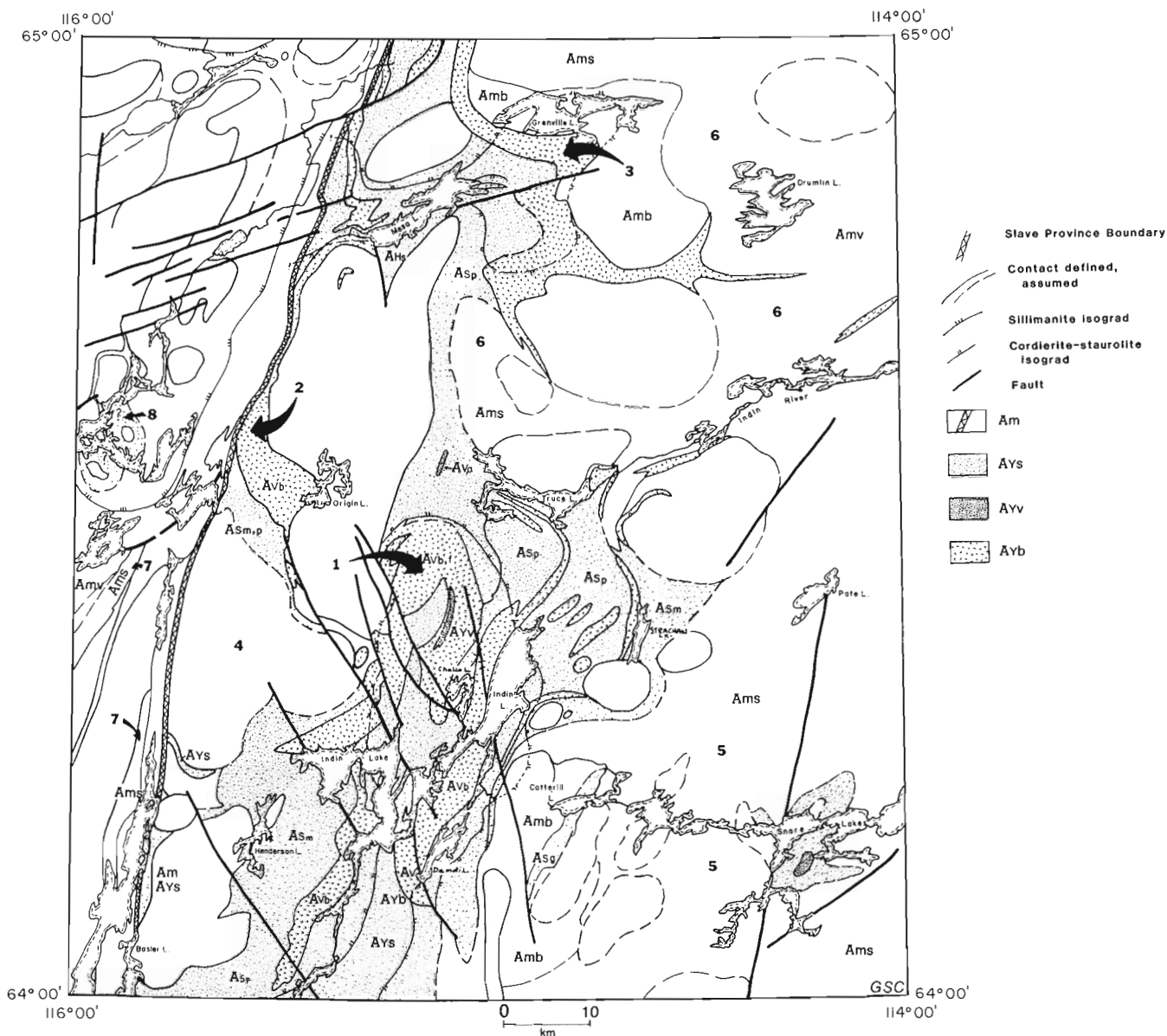


Figure 6 Trace element vs. K_2O distribution in the basement gneiss of the Grenville Lake and Cotterill Lake areas. (PPT = parts per thousand). The numbers refer to analyses in Table 2.



- 1 — Indin Lake volcanic belt
- 2 — Chartrand Lake volcanic belt
- 3 — Grenville lake volcanic belt
- 4 — Meyer migmatite complex
- 5 — Snare Lakes migmatite terrane
- 6 — Truce Lake — Drumlin Lake migmatite terrane
- 7 — Mattberry Lake anticlinorium — migmatite and gneiss.
- 8 — Emile River gneiss and migmatite terrane

Am — Migmatite with paleosome of metasediment (s); volcanics (v); basement granitoids (b).
 Ays — Yellowknife Supergroup metaediments; porphyroblastic (p); volcanogenic (g); migmatitic (m).
 AYv — Hypabyssal rocks associated with Yellowknife Supergroup volcanics
 AYb — Yellowknife Supergroup pillow basalts; felsic flows and pyroclastics (f)

Figure 7. Distribution of volcanic and sedimentary rocks in Indin Lake map area.

Age of the basement granitoid gneiss

Initial Rb-Sr whole-rock isochrons of remnant granitoid gneiss in the Archean basement gneiss in the map area indicate an age of 2939 ± 51 Ma (Frith et al., 1974). This value however, dates the time of regional metasomatism, as deduced from field relationships. More recent U-Pb geochronological studies of zircons have shown that the intrusive age of the gneiss is slightly older, at $2989 \pm 6/-5$ Ma (Frith et al., 1986).

Yellowknife Supergroup metavolcanic rocks

Most of the volcanic belts in the map area (Fig. 7) have been mapped at 1:63 360 scale, resulting in a good understanding of lithological relationships and petrography. The age of the Yellowknife Supergroup has been determined by Frith and Loveridge (1982) on the basis of U-Pb zircon determinations to be 2669 ± 15 Ma from volcanic and detrital sources as well as synvolcanic plutons from a variety of locations within the Slave Structural Province. The volcanic rocks of the map area are similar in appearance and lithology to those in the Yellowknife area, and are probably also similar in composition (as depicted by Baragar, 1966).

The following descriptions of the Indin Lake and Chartrand Lake volcanic belts include information from earlier

reports by Stanton (1947), Stanton et al. (1954), Tremblay (1948), Fortier (1949), Wright (1950), Yardley (1951), McGlynn and Ross (1963), and Ross (1966). The Grenville Lake belt is described herein for the first time.

Indin volcanic belt

The irregular-shaped Indin Lake belt is divided for descriptive purposes into three segments (Fig. 7). The northern segment extends from Hewitt Lake toward Spider Lake, where it curves toward Chalco Lake in an Archean structure called the Spider Lake synclinorium. The eastern segment lies east of Chalco Lake and thins toward the north and east, becoming interstratified and folded with metasedimentary rocks toward Pate Lake, with an off-shoot extending from south of Chalco Lake to Ranji Lake, where it is disjointed by a series of left-lateral faults. The southern segment parallels the west bank of the lower Snare River.

The Indin Lake belt comprises three principal groups of volcanic rocks: (1) basic volcanic rocks consisting mostly of pillow basalt with minor andesite; (2) felsic volcanic rocks consisting of dacitic flows and pyroclastic rocks; and (3) porphyritic sill rocks of mafic and felsic composition.

(1) Pillowed basalts — The bulk of the mafic volcanic rocks which make up the Indin Lake belt have been for the most part regionally metamorphosed to greenschist and upper amphibolite facies. The rocks were further affected by two or more penetrative phases of deformation. Where pillows are not overly deformed their dimensions are about 1:2:3 (Fig. 8).

The mafic volcanic rocks are commonly interbedded with minor felsic tuffs and breccias, the proportion of which increases toward the tops of these successions. The distribution of minor rock types cannot be shown on Map1662A because of the scale of mapping, but a small area near Spider Lake mapped in detail showed that basaltic and andesitic breccias are commonly interlayered with felsic pyroclastic rocks as well as pillowed flows. This detailed study showed a coarse type of bedding that reflects an original deposition now trending in an east to west direction.

The west limb of the north segment of Indin Lake belt consists mainly of recrystallized gneissose or schistose hornblende-bearing rocks that are dark green to grey-green or buff. These rocks are commonly colour banded, alternating greenish brown with buff; fresh surfaces are shades of green and black. These colour alternations are well developed northwest of Grenville Lake. Some flows are amygdaloidal, with calcite infillings. Narrow intercalations of tuff, flow breccia, and dacite are common.

The contact between the basic volcanic rocks and the Sphinx Lake pluton is sharp and well defined, with a few xenoliths present in the intrusion. Basic flows near this contact have been recrystallized to a granular, gneissic rock made up of black hornblende and waxy green plagioclase. Basic sills, whose colour and texture resemble closely those of the enclosing rocks, constitute 5 % or less of these basic flows.



Figure 8 Relatively undeformed pillow basalt near Indin Lake.

(2) *Felsic volcanic rocks* — The Indin Lake volcanic belt includes tuff, lapilli tuff, breccia, and minor porphyry, all of which are interbedded with more mafic volcanic rocks. These felsic volcanic rocks are most common near the base of the Yellowknife Supergroup metasedimentary rocks. Large areas of these rocks are found between Spanner and Indin lakes, and between Cranston and Schwerdt lakes, they cover the full width of the belt. They generally weather grey-green to rusty white. Shear zones and fractures are commonly filled with buff-brown carbonate. In thin section the rocks are recrystallized to a matte of fine quartz, plagioclase, and mica, with minor sericite, hornblende, carbonate, and fine grained opaque minerals.

Tuffaceous rocks are fine grained, light coloured, and banded in shades of buff, grey, and green. They are probably the most voluminous of the felsic rocks and are similar to the felsic interlayers found within the basic volcanic rocks. The tuffs generally have a dacitic composition but are locally as mafic as andesite. However, the original composition has been contaminated by carbonate introduced along fractures, which may accentuate or even cause the fine banding noted locally.

Felsic flows of dacitic composition locally contain quartz phenocrysts or more rarely, feldspar phenocrysts. These rocks are massive and flinty in outcrop and fractured in places. Several ovoid masses are present that may open to sub-surface domes.



Figure 9 Little deformed felsic volcanic flow-breccia from an area south of Spider Lake.

Volcanic breccia is locally interbedded with other volcanic rocks in the Indin Lake belt and commonly occurs as lens-like bodies that grade laterally and vertically into tuffs and lapilli tuffs. Like other felsic volcanics in the map area, the breccia occurs in the uppermost part of the volcanic pile. It contains angular to subrounded fragments in a tuffaceous matrix that is generally of the same mineral composition. The proportion of fragments larger than lapilli size varies and may constitute as much as 50 % of the rock. The fragments are more resistant to weathering and commonly stand out from the matrix as lighter coloured rock. On fresh surfaces, the matrix is greenish and reveals a schistose texture that appears devoid of fragments. Carbonatization associated with shearing has obliterated many primary depositional features.

Flow-breccia was observed in a few localities in the Spider Lake area (Fig. 9). It differs from the pyroclastic breccia by the presence of a meta-igneous matrix and a flow-like orientation of clasts. The fragments are lens-shaped and commonly tapered.

Conglomerates occur locally along the interface between volcanic and sedimentary units. A spectacular example of this phenomenon is exposed along the east margin of a volcanic finger extending from islands near the centre of Indin Lake (Fig. 10). The conglomerates are close packed and made up entirely of pebbles and cobbles of felsic volcanic rocks that are flattened along the principal foliation direction.



Figure 10 Stretched pebbles of felsic volcanic origin from a conglomerate along the eastern margin of the southern segment of the Indin Lake volcanic belt.

(3) *Porphyritic sill rocks* — Porphyritic sill rocks of both basic and felsic composition are present in the Indin belt. The dioritic or gabbroic bodies west of Baton Lake are massive, containing hornblende and plagioclase and locally small blue quartz phenocrysts. The finer grained phases resemble fine grained andesite flows. Large gabbroic plugs in the Ranji Lake area may have been feeders to mafic flows at higher stratigraphic levels. Minor porphyry dykes and sills present in the Indin belt were possibly feeders to felsic volcanic eruptions, as they are within and near the felsic flows and pyroclastic rocks found along the northwest margin of the Damoti Lake segment.

An albitic sill intruded into and near the flank of mafic sills near Baton Lake is a medium grained, grey-white to pink weathering rock composed of albite, quartz, and minor chlorite, biotite, hornblende, and pyrrhotite. Small blue quartz phenocrysts are found in places. The sill is highly fractured and is locally auriferous (see section on Economic Geology). The fractures containing gold are related to late Archean, regional deformation and low-grade metamorphism.

Between 115°30'W, 64°15'N Damoti lakes, the west and east segments are probably two north-south trending limbs of a synclinal structure. The intervening area contains isoclinally folded, younger metasedimentary turbiditic greywackes and mudstones. Between Chalco Lake and Strachan Lake, felsic volcanic rocks occur below the metasedimentary contact. The segment thins eastward, like the more northerly part of the belt. The easternmost volcanic rocks are in upright, vertical, deformed contact with similarly deformed rocks of the Cotterill Lake basement complex. The volcanics have been altered to a hornblende gneiss, but vestiges of extremely attenuated pillows are locally evident. The southern part of the east segment is banded from stretching of pillow structures and recrystallization, and the rocks contain some secondary biotite. The south end of this segment is faulted against hybrid granitoid rocks.

The felsic rocks, consisting of tuffs, lapilli tuffs, and breccias, are less deformed than the mafic rocks, and fragmentary textures are mostly preserved. Small felsic plugs intrude both felsic volcanic rocks and the overlying metasedimentary greywackes. If these were feeders for the younger felsic volcanic rocks, then the sedimentation was locally contemporaneous.

The west segment volcanic rocks are metamorphosed above the cordierite-andalusite isograd, altering the rocks to chlorite-, epidote-, and hornblende-bearing gneiss. Along the western margin of the west segment, the basic volcanic rocks have been completely recrystallized to hornblende-plagioclase gneiss. The metasediments between the western margin of the segment and the Basler Lake plutonic complex have been tightly folded and progressively metamorphosed toward the west, where they become migmatitic.

Chartrand Lake volcanic belt

The volcanic rocks that extend from north of Chartrand Lake to the northern boundary of the map area comprise the

Chartrand Lake belt, bounded to the west over much of its length by the boundary fault that separates the Slave Structural Province from the Wopmay Orogen. This part of the belt thins toward the north and becomes interlayered with metasedimentary rocks of the Yellowknife Supergroup. Elsewhere, stratigraphic relationships suggest the Archean volcanic and metasedimentary rocks are unconformably overlain by Proterozoic metasediments of the Snare Group (Mattberry Lake area). Bedding in the volcanic rocks along the wider parts of the belt, between Grizzly Lake and Origin Lake, has been thinned by east-west compression. In the Mesa Lake area, however the metasedimentary rocks and the interlayered volcanic rocks were folded together in two stages of Archean deformation. During the Proterozoic, these rocks were folded and metamorphosed again, along with the unconformably overlying Snare Group.

The southern part of the Chartrand Lake volcanic belt is more than 6 km wide, and top determinations across it suggest a homoclinal succession with the base against the Origin Lake plutonic complex and the top in conformable contact with paraconglomerate and hornblende gneiss, which are in turn overlain by Yellowknife Supergroup metasedimentary rocks. The volcanic belt has been modified by three buoyant, granitoid bodies: the Origin plutonic complex to the northeast; the Sphinx Lake pluton in the southeast; and the Meyer migmatite complex to the southwest. These bodies have left the stacked, inclined stratigraphic succession more or less intact. The southeastern part of the belt is highly deformed at the margins, but toward the centre, the basalts are little deformed and primary textures, such as pillow structures and amygdulites, are well preserved.

McGlynn and Ross (1963) described the Chartrand Lake volcanic rocks as mostly dark green, fine grained, and foliated, with bluegreen hornblende, local actinolite and plagioclase, with or without small amounts of quartz, sphene, sulphide minerals, epidote, chlorite or biotite. As in other volcanic rocks of the map area, the amphibole minerals are secondary, and platy minerals are oriented parallel to the regional foliation. The foliation has been modified by Proterozoic uplift of the Origin Lake granitoid complex. Plagioclase is commonly crushed and elongated, and pillows are stretched along steep to vertical lines, parallel to the foliation.

Within the volcanic succession are minor tuffaceous bands, small dykes, and irregular masses of felsic porphyry and synvolcanic diorite and gabbro. Banded amphibolites are present along parts of the eastern margin of the belt. The westernmost lavas have been sheared into a zone, up to 150 m wide, of chlorite-carbonate schist. Paraconglomerates overlying the lavas are highly deformed, their volcanic and granitoid cobbles flattened into elongated discs.

Rocks of the Chartrand Lake belt near Mesa Lake have been described petrographically by Ross (1966) as banded hornblende rock with lenses of vestigial pillow lava. Most are dark black to dark green, fine, even grained, massive to foliated rocks. The banded rocks contain an alternation from hornblende-rich laminae to quartzofeldspathic-rich laminae, which like the more southern banded gneiss, were

probably derived from stretched-out pillow structures. The persistent strike of some leucocratic bands suggests that the original rocks may have been more felsic and tuffaceous in this part of the belt.

Grenville Lake volcanic belt

Volcanic rocks of the Grenville Lake belt are generally similar to those of the Chartrand Lake belt, and are almost entirely pillowed basalt and andesite. Felsic rocks are less abundant. West and south of Grenville Lake, the basalt and andesite overlie the basement granitoid gneiss and are in turn overlain conformably by metasediments of the Yellowknife Supergroup.

Regional metamorphism of the volcanic rocks along the south shore of Grenville Lake is of greenschist grade, but the tonalite basement gneiss and volcanic rocks are highly deformed at the interface. This has destroyed any primary structures and relationships between the two rock types. However, in the centre of the belt preserved pillow-like structures suggest that the belt faces away from the older basement rocks. The least deformed volcanic rocks are commonly fractured and impregnated with carbonate and quartz veins, which further mask or destroy primary depositional structures.



Figure 11 Typical graded bedding in sub-biotite-grade greywacke-mudstone turbidites of the Yellowknife Supergroup near Damoti Lake.

Gneissose metagabbro dykes cut the basement complex in the Grenville Lake area and trend in an east-northeast direction. These rocks have been mapped in this report as part of the basement gneiss, but they are probably feeders to the overlying basic volcanic rocks, like some dykes in the Point Lake area (Stockwell, 1933).

Yellowknife Supergroup metasedimentary rocks

The extent of the Yellowknife metasedimentary rocks, and rocks derived from them, is outlined in Fig. 7. They are best preserved in areas where regional metamorphism is lowest, as on the low temperature side of the cordierite-staurolite isograd (e.g. Damoti Lake, Indin Lake structural basin, Fig. 11).

The metasediments are relatively uniformly compositioned greywackes and mudstones, having a bulk composition near that of granodiorite. These rocks have been highly susceptible to thermal metamorphism and deformation, the latter being polyphase, the former having resulted in the formation of schist, gneiss, porphyroblastic schist, porphyroblastic gneiss, and migmatite (e.g. Fig. 12).

Where the rocks are migmatitic, the leucosome may vary from a few per cent to as much as 95 per cent of the rock.



Figure 12 Migmatitic paragneiss derived from Yellowknife Supergroup rocks found near the west end of Indin Lake. Most porphyroblasts of cordierite and staurolite have been retrograded, but sillimanite and garnet are commonly present.

Where the leucosome exceeds 50 %, the rocks have been mapped as migmatites. Primary sedimentary features are commonly discernible, even where highly metamorphosed. In this report the metasedimentary rocks have been divided into two mappable units, based on the presence or absence of porphyroblasts, denoted by the cordierite-staurolite isograd.

Greywackes and mudstones (unit AYs)

Metagreywacke and metamudstones that are only slightly metamorphosed are referred to in this report as greywackes. They commonly occur in graded beds, 20 to 30 cm thick, with sandy tops and darker more argillaceous bottoms (Fig. 11). They are well bedded and were likely deposited as turbidites, for they display most of the features common to the Bouma cycle (Henderson, 1970).

The coarser greywackes are sandy textured, grey to greenish grey, and are composed of quartz and plagioclase, in a finer grained matrix of secondary chlorite, sericite, and biotite. Lithic fragments are difficult to recognize in thin section, but where identified are invariably of volcanic origin. Southwest of Origin Lake, paraconglomerates near the base of the overlying sedimentary successions contain plutonic granitoid clasts as well as felsic and basic volcanics, indicating granitoid as well as volcanic provenance.

The finer grained more argillaceous rocks tend to be slate-like, even in areas of low-grade metamorphism. Chlorite, sericite, and other phyllic minerals impart a sheen and a marked fissility. In thin section, the minute grain size of the mineral and lithic constituents makes identification difficult. From secondary minerals, it is concluded that the matrix minerals are in approximately the same proportion as the framework minerals. Near volcanic contacts, the greywackes are commonly finer grained and locally contain carbonaceous mudstones.

Primary depositional features within the metasediments are most noticeable in areas of low-grade metamorphism. Graded bedding is the most notable sedimentary depositional feature (Fig. 11), but cross bedding, ripple marks, and de-watering structures are also present, though less commonly observed.

Southeast of Damoti Lake metasedimentary rocks of the Yellowknife Supergroup lie adjacent to and in contact with the basement complex of migmatitic tonalite and tonalite gneiss. The rocks on both sides of the contact are sheared over a width of 100 m away from and parallel to the contact, but the nature of the shear zone is unknown, owing to a lack of kinematic indicators.

Contacts between Yellowknife Supergroup metasedimentary and volcanic rocks are conformable where observed. The volcanic rocks are commonly more felsic than basic, which contrasts with the composition of the belts as a whole. The contacts also reflect changing depositional conditions, as indicated by the occurrence of close-packed conglomerates (beach or river?) and carbonaceous mudstones (slow rates of deposition associated with anaerobic bacteria in tranquil depositional basins).

Contacts with plutonic rocks are intrusive, but contact effects, such as chilled and baked margins were not observed, except in a few places where plutonic rocks have cut across sub-amphibolite facies metasedimentary rocks. This is similar to what was observed in other parts of the Slave Structural Province, where contact-aureole porphyroblasts occur only in rocks of greenschist facies. The aureoles predate regional metamorphism and are commonly deformed by later stages of regional Archean deformation (Hill and Frith, 1982). The general lack of similar marginal effects in the Indin Lake map area reflects the higher grades of regional metamorphism of host metasediments prior to intrusion.

Paraconglomerates and conglomerates (unit AYc, AYcp)

Yellowknife Supergroup paraconglomerates in the Arseno Lake area have been described by McGlynn and Ross (1963). There the clasts consist mostly of angular to rounded metavolcanic rocks, but locally granodiorite or quartz-diorite clasts are evident. Other clasts are made up of quartz and fragments of greywacke. The clasts range from 2 to 30 cm in diameter and are embedded like dropstones in a matrix of hornblende, quartz, and plagioclase, presumably of volcanoclastic origin, with the hornblende making up as much as 50 % of the volume. Other minerals include chlorite, biotite, epidote, and minor sulphides. The pebbles are usually stretched and flattened along the principal northwest-striking lineation and foliation directions.

Conglomerates composed entirely of volcanic detritus occur between basalts and metasediments in the western part of Indin Lake (Fig. 10). Close-packed cobbles have been stretched about 2:1. Cobble size and texture suggest shallow water deposition. Other less voluminous conglomerates occur along the Indin River inlet to Indin Lake, where felsic and mafic volcanic pebbles make up about 15 % of the rock, the rest being a matrix of hornblende gneiss, possibly derived from reworked basaltic pebbles.

Hornblende gneiss (unit AYq)

Hornblende gneiss of uncertain origin is present above paraconglomerates in the Chartrand Lake area, interstratified with porphyroblastic metasedimentary rocks. All of these rocks are folded along with the overlying turbiditic metasedimentary rocks. The hornblende gneiss is compositionally similar to the underlying metamorphosed basic volcanics. However, though mineralogically similar (both consist mainly of hornblende and plagioclase), the gneiss is persistently banded into dark and lighter mineral constituents (like the hornblende paragneiss in the Chartrand Lake area), which preserve sedimentary textures (McGlynn and Ross, 1963) that suggest the rock may have been a volcanogenic sediment.

Hornblende-biotite rocks of even more enigmatic origin occur in the Cotterill Lake region where they form a poorly defined area between basement rocks and a plutonic megacrystic granodiorite. The rocks are compositionally similar to the hornblende gneiss northwest and southeast of Chartrand Lake with which they have been mapped, but

gneiss and schist are present containing hornblende, biotite, plagioclase, and quartz, with biotite making up to 30 % of the rock. Pink alaskite and aplite form variably sized veins, which locally transform the enigmatic hornblende-biotite rock into a banded or schlieren migmatite. Toward its western margin the gneiss is fine grained and equigranular and of quartz dioritic composition. Some outcrops are rusty coloured. Foliation is steep to vertical, but is irregular and locally contorted by right-lateral displacements. The rock is only in contact with migmatite. The rocks may be metamorphosed and deformed basaltic paragneiss.

Porphyroblastic gneiss and schist (unit AYp)

Porphyroblastic gneiss and schist found in those parts of the map area that lie on the high-temperature side of the cordierite-staurolite isograd shown in Figure 12 are discussed in more detail in the section on structure and metamorphism,

Chemistry

The chemistry of the Yellowknife Supergroup metasediments is complicated by heterogeneity due to graded bedding. Whole-rock chemical analyses have been carried out on samples of the Burwash Formation from the Yellowknife area (Jenner et al., 1981) and of the Beechey Lake Group from the northeastern part of the Slave Structural Province (Frith, 1987). Table 4 presents whole-rock geochemical analyses of Yellowknife Supergroup metasedimentary rocks from a single outcrop from an island in the north arm of Indin Lake. All three samples sites were channel-sampled to provide average compositions. The results are plotted and fitted with error envelopes to show a single standard deviation (Fig. 13). In this figure the plots of the Indin Lake data are intermediate between those of the Beechey Lake and Yellowknife sample data, suggesting that the source of the Beechey Lake rocks was comparable to but slightly more felsic than that of the Indin Lake metasedimentary rocks, whereas the source of the Yellowknife area rocks was comparable to but slightly more mafic.

Hybrid granitoids

Hybrid granitoids in the map area include migmatites(*) derived from the Yellowknife Supergroup, granodioritic gneiss of uncertain origin, minor pegmatite, and anatectic granite and granodiorite. Contacts with metasedimentary rocks are mostly gradational and parallel the host foliation. These granitoid rocks are divided for mapping convenience into the following three bodies: Meyer migmatite terrane, Snare Lake migmatite terrane, and Truce Lake-Drumlin Lake granitoid terranes (Fig. 1).

(*) In this report migmatites are defined as heterogeneous hybrid granitoid rocks in which the leucosome portion exceeds 50 %. Areas mapped as migmatite may contain rocks with less leucosome but because of mapping scale are not always delineated.

Table 4. Whole-rock analyses (in weight per cent) of Yellowknife greywackes and mudstones from channel samples obtained by diamond drilling from a single outcrop located on an island in the northeast arm of Indin Lake, located near the cordierite-staurolite isograd.

	Sample No.						
	1	2	3	4	5	6	7
SiO ₂	69.90	69.00	64.70	60.10	71.60	67.10	67.07
TiO ₂	0.54	0.60	0.69	0.74	0.55	0.62	0.62
Al ₂ O ₃	13.10	14.30	16.30	18.50	14.50	15.00	15.28
FeO	3.00	2.30	4.30	5.30	3.10	4.20	3.70
Fe ₂ O ₃	0.80	2.30	1.00	0.70	0.50	0.90	1.03
MnO	0.06	0.04	0.05	0.06	0.03	0.05	0.05
MgO	2.12	2.40	2.87	3.34	1.95	2.80	2.58
CaO	1.34	0.73	0.71	0.61	0.41	1.00	0.80
Na ₂ O	3.00	3.40	4.10	3.10	3.80	3.00	3.40
K ₂ O	1.85	2.15	1.88	2.90	1.93	2.01	2.12
P ₂ O ₅	0.12	0.12	0.11	0.11	0.09	0.10	0.11
Cr ₂ O ₃	0.06	0.05	0.06	0.06	0.07	0.05	0.06
H ₂ O Total	1.90	2.30	3.10	3.40	2.10	2.80	2.60
CO ₂	1.60	0.60	0.30	0.40	0.10	0.50	0.58
Total	99.39	100.29	100.17	99.32	100.73	100.13	100.63
Ba	0.030	0.044	0.030	0.050	0.032	0.036	0.037
Sr	0.022	0.018	0.021	0.020	0.019	0.018	0.020
Rb	0.004	0.014	0.004	0.006	0.003	0.004	0.005
Zr	0.005	0.007	0.003	0.002	0.004	0.002	0.004
Zn	0.003	0.006	0.008	0.011	0.004	0.008	0.007
Ni	0.007	0.008	0.010	0.009	0.007	0.007	0.008
S	0.100	0.140	0.130	0.070	0.080	0.070	0.098

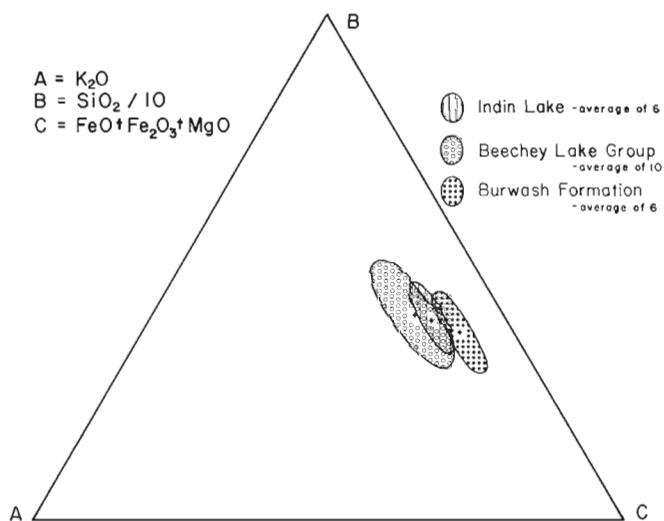


Figure 13 K₂O — SiO₂/10 — (FeO + Fe₂O₃ + MgO) plot for average whole-rock analyses of Yellowknife Supergroup metasedimentary rock samples (with one standard deviation error envelopes) from Indin Lake map area, the Beechey Lake Group (from the northeastern part of the Slave Province), and the Burwash Formation (from the southern Slave Province) (data from Frith, in press, and Jenner et al, 1981).

The migmatites are typically of granodioritic bulk composition, although in some areas they are distinctly more granitic or dioritic. Several varieties were recognized: schlieren types (Fig. 14, 15), banded types (Fig. 16), and breccia or agmatitic types (Fig. 17). Schlieren migmatite locally grades into Yellowknife Supergroup paragneiss and was probably derived from it, whereas the banded and agmatitic types are most closely associated with paleosome derived from metavolcanic rocks. Migmatites of the area commonly occur as prograde metamorphic products, on the higher temperature side of migmatitic paragneiss (Fig. 12). These products in turn are metamorphosed beyond porphyroblastic gneiss and schist. The boundary between migmatitic rocks and true migmatites is mostly an arbitrary line, except where intrusive rocks such as those of the Basler plutonic complex cut across the foliation.

(1) Meyer migmatite terrane (unit Am)

The rocks of unit are characterized by an overall heterogeneity both on the outcrop scale and generally on hand-specimen scale. The major rock types include: migmatite derived from sedimentary paragneiss, biotite gneiss, pegmatite, and plutonic rocks of variable composition. They cover an extensive area to the east of the Indin Basin, between the Basler plutonic complex to the south and Chartrand Lake to the north. The terrane is separated from the

Sphinx Lake pluton by a septum of gneiss and nodular schist. The terrane to the west is in fault contact with rocks of the Wopmay Orogen.

Considerable work has been carried out in various parts of the Meyer migmatite terrane (Stanton, 1948; Stanton et al., 1954; Yardley, 1951; Frith et al., 1977), but the best studied area may be the southern part, which Smith (1966a) referred to as the Eau Claire pluton.

Smith (1966a) carried out a systematic sampling of the whole of the southern part of the terrane, including a detailed 24 sample grid over a 120 m² area, to determine the compositional variation of the migmatite. The location of the grids and a Strekeisen diagram of the modal analyses are shown in Figure 18. The data indicate a range in composition from tonalite through granodiorite to granite, with the bulk of the rocks being granodioritic. Smith found tonalitic compositions similar to those of the basement granitoid rocks, which he included as part of the presently termed Meyer migmatite terrane.

In the southern part Smith (1966a) recognized two types of migmatite. The most widespread type is characterized by pegmatite and aplite veins in a fine- to medium-grained intermix of granite, gneiss, or schist. A second type is a younger migmatite similar to the first, but containing abundant coarse grained granite, which cuts across the finer



Figure 14 Schlieren-type migmatite evidently derived from rocks equivalent to the Yellowknife Supergroup meta-sediment.

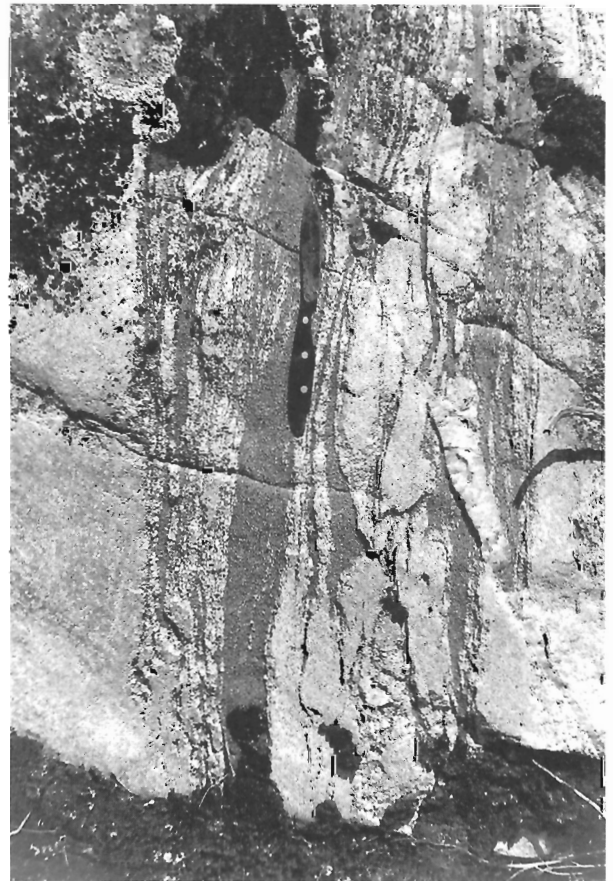


Figure 15 Schlieren-type migmatite of uncertain origin, with a high proportion of leucosome found in regions of granitoid gneiss.

grained type. Typically the migmatites are layered and/or foliated, and the first type is commonly folded on both outcrop and hand-specimen scale.

Megacrysts of unoriented K-feldspar were observed in some of the the Meyer migmatites and in late cross-cutting leucosome veins. The migmatites and gneiss usually contain sodic plagioclase, biotite, and quartz, but muscovite is rare. Potash-feldspar and tourmaline are associated with the leucosome phase of migmatites.

Northwest of Hewitt Lake the Meyer migmatite terrane is surrounded by nodular schists that contain numerous pegmatites, most commonly oriented parallel to the foliation. The contact between these nodular schists and the terrane is gradational, and the location of the contact on the map is somewhat arbitrarily drawn. The biotite in the nodular schist becomes coarser grained toward the contact with the terrane, and porphyroblasts become retrograded and less evident. The transition to migmatite terrane is characterized by the presence of muscovite in the coarser leucosome. The migmatite is deformed and the paleosome has a 'digested' appearance. Garnet is present locally.



Figure 16 Banded migmatite in an area south of Drumlin Lake. The paleosome is probably derived from in situ basic volcanic rocks, but the leucosome, composed mostly of plagioclase and quartz, was from an extraneous source.



Figure 17 Breccia migmatite from south of Drumlin Lake, intruded by granitoid leucosome. Note the reaction rim around the clasts and the fabric within the clast that pre-dates migmatization.

Coarse, homogeneous, pegmatitic granite occurs within the migmatite terrane in places and locally contains books of muscovite up to a few centimetres thick. This granite weathers to pinkish white or white. The granitoid rocks are more distinctly granitic in composition near the contact with the metasediments, which contrasts with the more granodioritic border-phase gneiss in the southern part of the terrane (Fig. 18). Several small areas of massive, coarse grained granite are found within the Meyer migmatite terrane. In addition several areas containing coarse muscovite-bearing granite occur northwest of Hewitt Lake, the largest of which is found around 'Fetus' Lake (Fig. 18).

Pegmatite dykes make up 10% or more of the terrane and consist of coarse microcline, oligoclase, quartz, large muscovite books, and in places biotite. Fine needles and aggregates of black tourmaline are commonly present.

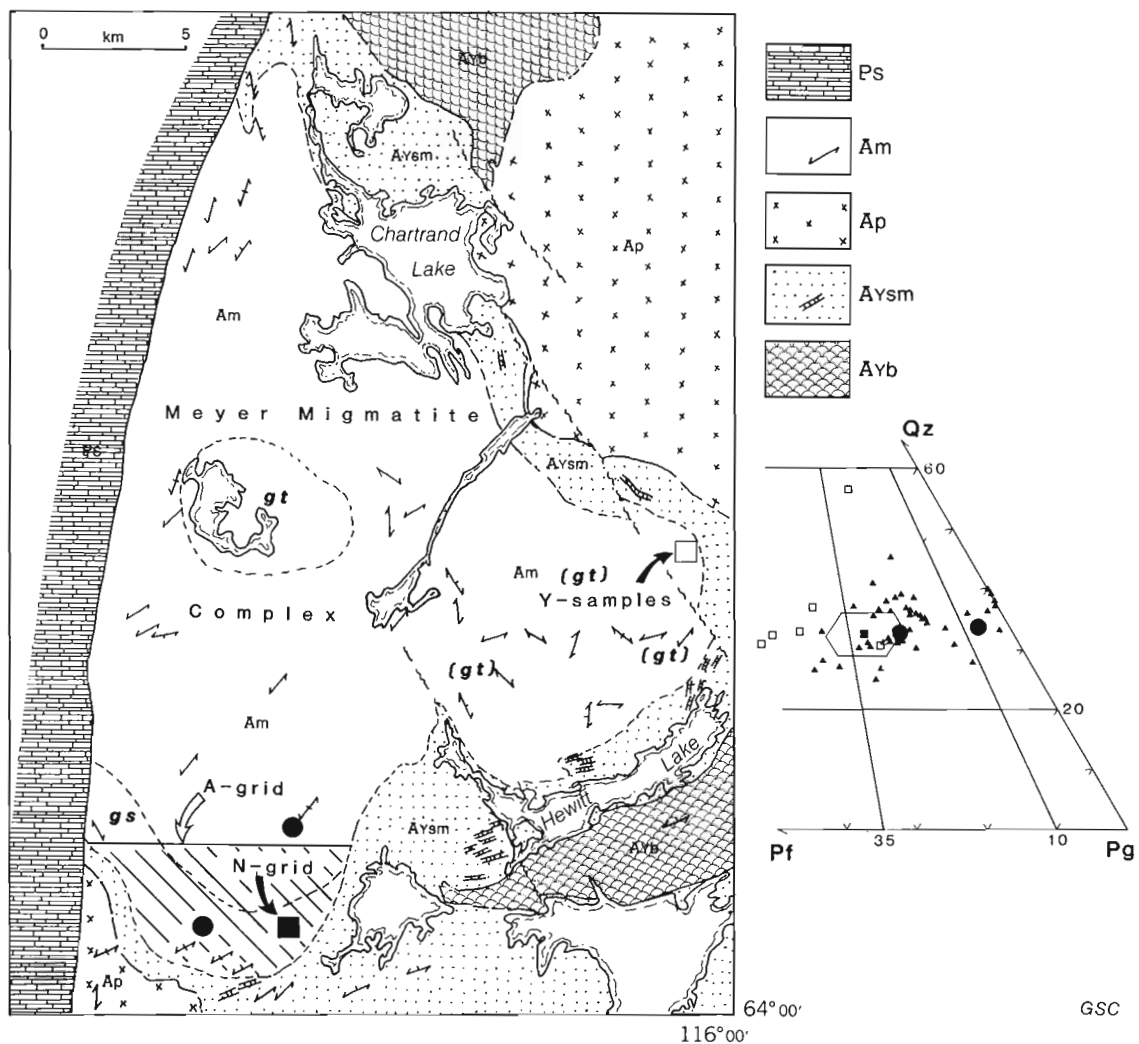
Studies elsewhere in the Slave Structural Province show that metasediments of the Yellowknife Supergroup are granodioritic to tonalitic, within a narrow compositional range (Fig. 13). Rocks melted from such a protolith should be of similar composition. However, this is not always the case in the Indin Lake map area, where granites are in general too potassic to be batch melted from Yellowknife metasediments. Modal analyses from the margin of the Meyer migmatite terrane are less granitic than analyses from some of the more central muscovite-bearing parts of the terrane (Fig. 18), suggesting that large cation additions from an extraneous source were mixed to batch melts of paragneiss. One possible source is from the mantle during anatexis (Collerson and Fryer, 1978). Recent studies discount partial melting as a viable magma-forming process (Wyllie, 1984).

Age of the Meyer migmatite terrane

The coarse anatectic granite at 'Fetus' lake and near the eastern part of the Meyer migmatite terrane were dated by Rb-Sr whole-rock isochron at 2473 ± 101 Ma (Frith et al., 1977). The isochron had an initial $\text{Sr}^{87}/^{86}\text{Sr}$ value of 0.711 ± 0.002 , which along with the gradational contact, is in keeping with an anatectic origin for the more coarse grained, massive parts of the terrane. The age is younger than the more accurately dated 2596 ± 3 Ma age obtained for synorogenic monazite from the Grenville Lake area basement gneiss, which dates the thermal peak in the region.

(2) Snare Lake migmatite terrane

This terrane is characterized by over-all heterogeneity, with schlieren migmatites and wispy rust-stained gneiss and schist of granodiorite and granite composition predominating (Fig. 14, 15). Pink, fine- to medium-grained granite with only a few per cent mafic minerals is common in layers or zones. The composition of the migmatite is largely controlled by the proportion of biotite, which is in turn controlled by the mix of leucosome to paleosome. The gneiss locally has skeletal remnants referred to as 'ghost' gneiss, derived from the almost complete digestion or granitization of parashist. In a few places the rocks contain garnet, particularly near migmatitic paragneiss contacts where the proportion of biotite is greatest.



- Ps – Proterozoic Snare Group, Wopmay Orogen
- Am – Meyer migmatite complex, made up of granodiorite, tonalite gneiss and migmatite (gs) and local muscovite granite (gt).
- Ap – Plutonic granodiorite; Sphinx Lake pluton to the northeast and the Basler pluton to the southwest.
- AYsm – Yellowknife Supergroup migmatitic paragneiss with local concentrations of pegmatite (ladder symbol).
- AYb – Yellowknife Supergroup volcanic rocks of the Chartrand Lake belt (north) and Indin Lake belt (southeast).
- gs – gneissic texture;
- gt – granitic composition (present locally)

Figure 18 The Meyer migmatite complex and normative compositions showing locations for:

- ▲ A-grid 48 grid samples of gneissic granodiorite (Smith, 1966a);
- N-grid average of 24 samples with a one sigma distribution envelope (Smith, 1966a);
- Y-samples 6 samples 10-180 m from the metasedimentary contact;
- whole-rock analyses.

Contacts with the Yellowknife Supergroup metasedimentary rocks are gradational, similar to those of the Meyer migmatite terrane. In the area east of Strachan Lake and south to the Snare River, the paragneiss is migmatitic, but remnant bedding is locally preserved; nevertheless actual contacts there are vague and have been mapped somewhat arbitrarily. The rocks of this terrane are mostly devoid of porphyroblasts. However, sillimanite (and more rarely retrograded cordierite) porphyroblasts are locally evident within the paleosome. The leucosome commonly cuts across the foliation or layering (Fig. 36) and is locally folded.

(3) Truce Lake — Drumlin Lake migmatite terrane (Unit Am)

This migmatite terrane is bounded on the west by rocks of the Yellowknife Supergroup, both metasedimentary and metavolcanic, and is of unknown extent to the north and east. The boundary between this terrane and the Snare Lake terrane is not defined, and extends roughly along a line between Strachan Lake and Pate Lake. The terrane is intruded by numerous plutons in the Truce Lake area, and the intervening migmatites and biotite gneiss are probably related genetically to metasedimentary paragneiss. Rocks south, north, and west of Drumlin Lake are overlain by heterogeneous gneiss, which is commonly highly contorted and which contains amphibolitic paleosome that may be derived from volcanic rocks (Fig. 16, 17). The terrane probably grades into the Grenville Lake basement complex, but the nature of this gradation is unknown because of poor rock exposure. This area is of dioritic to granodioritic composition and contrasts in overall colour index with migmatites found elsewhere. The close association of the migmatite with basement gneiss and the presence of fine grained amphibolite suggest that volcanic rocks form keel-like remnants within basement areas that are stretched and thinned in vertical orientations. Near its northern boundary the map unit is underlain by migmatitic rocks derived from rocks similar to the Yellowknife metasedimentary rocks.

The gneiss and migmatite southwest of Whitewolf Lake locally contains porphyroblasts of K-feldspar. The oval body southwest of Whitewolf Lake is more massive than the surrounding migmatites and contains abundant K-feldspar porphyroblasts or megacrysts. The contact between this body and the surrounding rocks was not evident, but judging from the varying content of K-feldspar porphyroblasts in the surrounding migmatite, it is probably gradational. This pluton has been grouped with the megacrystic granodiorite plutons common to the Cotterill Lake area.

Volcanic selvages within the unit consist of hornblende gneiss, which shows rare relict pillow structures. The selvages are widespread within the terrane, but only the larger ones are shown on the map as easterly to northeasterly trending, doubly terminated bands. They are particularly evident along the northern margin of the Whitewolf Lake area and in the region between Drumlin Lake and Indin River. The rocks are similar to the thinner parts of the Grenville volcanic belt and are undoubtedly of similar origin.

Fortier (1949) noted that fine grained dioritic rocks within the migmatites south of Drumlin Lake (which he thought were derived from basic volcanic rocks) were more

heterogeneous than paleosome derived from paragneiss of metasedimentary origin. This is possibly due to the more refractory nature of the volcanic paleosome. Leucosome is coarse grained, white to grey rather than buff to pink, and consists of quartz and feldspar, which were probably not derived from materials *in situ*, but rather from an outside leucocratic-rich source. The origin of this source is highly speculative, but its trondhjemitic-tonalitic composition and its association with nearby granitoid basement complex rocks suggest it was derived from basement tonalites and possibly mixed with mantle-derived out-fluxing of lithophile cations during orogeny. The leucosome veins were intruded during or slightly after regional deformation, as many are deformed.

Plutonic rocks (unit Ap)

Plutonic rocks of the Indin Lake map area are characterized by granitic or granodioritic composition, modal biotite, few inclusions, and generally well defined contact relationships. The Origin intrusive complex and the Basler Lake pluton were studied in more detail than other intrusive rocks in the area (particularly those in the east half of the map area which were only mapped at reconnaissance scale).

Plutons in the map area generally post date the peak of Kenoran deformation, but most have an internal intrusive fabric parallel to the country rock contact, a fabric that formed during emplacement. Some plutons have little or no fabric, are commonly coarse grained, and have megacrysts of K-feldspar and gradational boundaries with migmatites. Others are polyphased and have both gneissic borders and massive internal parts. There are also plutons that were probably intruded prior to the peak of the Kenoran Orogeny, as they are retrograded and deformed. Some are possibly synvolcanic.

Origin plutonic complex

The Origin plutonic complex is polyphased (Fig. 1, 2). It is a gneissic tonalite or granodiorite along the west margin and possibly older than the Chartrand Lake volcanic rocks which border it to the east. These gneissic tonalite or mafic granodiorite rocks grade eastward into massive granite near the centre of the plutonic complex. The marginal phase is similar to the marginal phase of the Sphinx Lake pluton.

The northern lobe of the complex is bounded to the west, northwest, and southwest by an outward-facing homoclinal volcanic belt, by a narrow belt of metasedimentary rock to the east, and by the Sphinx Lake pluton to the south. The northern part of the Origin plutonic complex has many of the characteristics of an asymmetrical gneiss dome: (1) the rocks are more than 7 % denser along the west margin than they are at the core of the complex (Fig. 19); the central phase is oval and probably represents the lowest structural level; and (3) the marginal rocks are commonly sheared, and the core-rock mineral lineations steepen to the east from 25 to 45 degrees. Upward movement may have occurred during Proterozoic time, at the same time as the downwarping of the Indin Lake Structural Basin (see Structural Geology section).

The rocks that make up the marginal phase in the western and southwestern corner of the northern lobe of the complex include: granodiorite, tonalite, and quartz diorite that is cut by alaskitic and aplitic veins of at least three generations. Salmon-pink microcline and pistachio-green epidote are common as late-forming minerals. The composition of the host granitoid rock changes from quartz diorite through granodiorite to granite near the centre of the complex. The

southern margin is in fault contact with the Sphinx Lake pluton, possibly because of uplift of the more buoyant Origin complex.

The northern margin is structurally and lithologically complex, containing areas of migmatite derived from metasedimentary rocks and possibly from basement gneiss. Much of the complex southwest of Mesa Lake has been intruded by diabase dykes oriented in a north-northwest direction. The complex is in fault contact with the migmatites south of Mesa Lake, and there are numerous north-northeast trending quartzfeldspar-muscovite-tourmaline pegmatites. The host rocks consist of both massive and heterogeneous rocks, including migmatitic gneiss and schlieren migmatite, all derived from paragneiss. Some pink and grey migmatites occur just east of a fault zone that separates the volcanic rocks from the complex. They are similar in appearance to the tonalite basement gneiss found in the Grenville Lake area, suggesting that the marginal parts of the complex may have dragged basement gneiss from deeper levels.

The eastern margin of the northern lobe of the Origin plutonic complex is almost devoid of ferromagnesian minerals and is made up, for the most part, of pink to white granite or quartz-monzonite. The complex in this region is intruded by numerous aplite and alaskite veins, which locally constitute up to 25 % of outcrop areas. As elsewhere within the complex, epidote is common.

The central part of the northern lobe is similar to the eastern margin, but is less deformed and less retrograded. Many outcrops are devoid of mafic minerals, except for a little epidote.

Age of the Origin plutonic complex

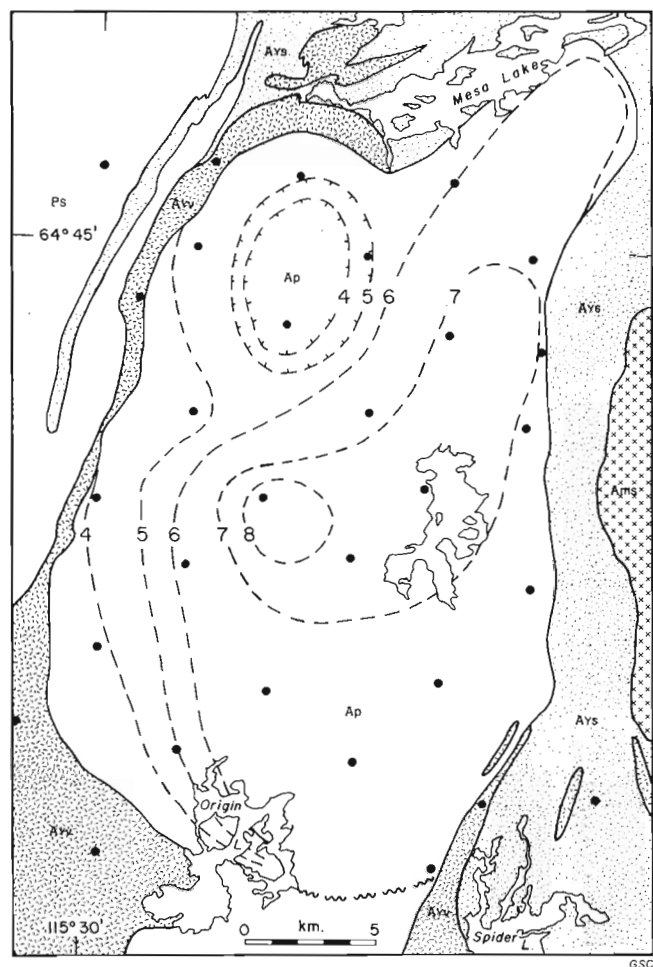
The Origin plutonic complex was dated by Rb-Sr whole-rock techniques, which yielded an isochron age of 2506 ± 186 Ma and an initial ratio of 0.701 (Frith et al., 1977). Although the age was interpreted as an age of magmatism, more recent dating of rocks in the area (Frith et al., 1986) suggests that thermal metamorphism in the region peaked at 2596 Ma.

Sphinx Lake pluton

This pluton (unit SLP in Fig. 2) is an irregular-shaped body, rounded to the southwest and west, where it is in contact with metamorphosed volcanic rocks and greywackes. Along its southern and eastern margin, it is in contact with similar volcanic rocks and greywacke, but they have been faulted by a series of left-lateral oblique-slip off-sets, giving the eastern margin an irregular outline.

The pluton is dominantly quartz monzonite and silica-poor granite, with lesser amounts of granodiorite, quartz monzodiorite, and quartz diorite. More plagioclase-rich facies are found mainly near the margins of the body.

The Sphinx Lake pluton intruded volcanic and sedimentary rocks of the Yellowknife Supergroup, but there is little evidence of contact metamorphism. The contact is sharp and characterized by a general lack of inclusions. According to



- | | | | | |
|-----|-----|----|----|-----|
| AYv | AYs | Ps | Ap | Ams |
| AYv | AYs | Ps | Ap | Ams |
| AYv | AYs | Ps | Ap | Ams |
| AYv | AYs | Ps | Ap | Ams |
| AYv | AYs | Ps | Ap | Ams |
- AYv – Yellowknife Supergroup volcanic rocks
AYs – Yellowknife Supergroup metasediments
Ps – Snare Group metasediments
Ap – Origin plutonic complex
Ams – Migmatite derived from Yellowknife Supergroup metasediments

Figure 19 Density contour map of the Origin plutonic complex, with a zero datum of 2.8 g/cm³ for Yellowknife metasedimentary rocks. Stations are indicated by dots, and the density contours are given as a negative percent difference from the datum. Volcanic rocks are 5-10% denser and Snare Group metasediments are about the same density as the datum

Yardley (1951), the margins of the pluton are pink or red, generally massive, medium to coarse grained, and contain up to 30 % mafic minerals. The weathered surface is commonly grey to light tan, with a chalky pink cast. Most of the marginal rocks have a quartz diorite composition and a gneissosity that parallels the contacts. Mafic minerals, mainly retrograde chlorite and biotite, typically make up 12 % of the rock. In thin-section, epidote, sericite, zoisite, and leucoxene replace plagioclase. Potash-feldspar is fresh and unaltered, suggesting that alteration predated the growth of the K-feldspar. Yardley (1951) proposed that potassic metasomatism replaced plagioclase by microcline, releasing CaO to form secondary zoisite and epidote.

At the margins of the Sphynx Lake pluton, cataclastic movement produced broken grains, bent feldspar twins, veinlets, and small fractures, all of which are aligned parallel to the margin. Deformation occurred either during late-magmatic emplacement or during the Proterozoic (as suggested in the section on Structural Geology), when vertical movements were triggered by events taking place in the Wopmay Orogen. The northwest-trending sinistral strikeslip or oblique-slip faulting of the eastern margin of the pluton took place during the Calderian Orogeny.

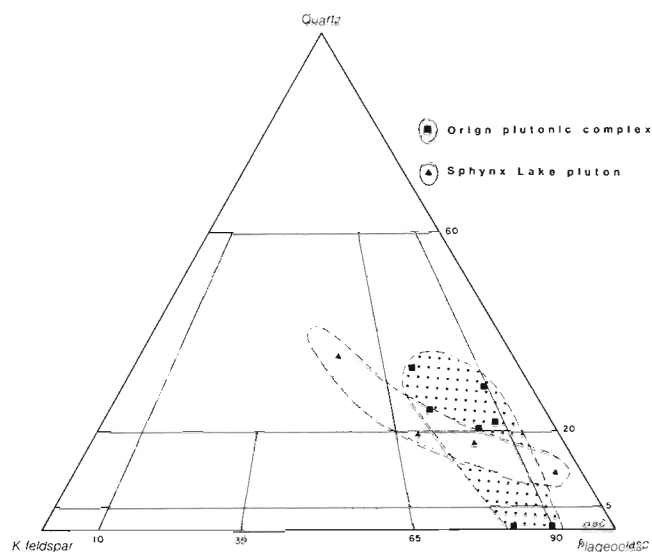


Figure 20 A Streckeisen diagram of the Origin plutonic complex and the Sphynx Lake pluton showing the range of composition from quartz diorite near the margins, through quartz monzonite and granodiorite to granite. Refer to Table 5 for data.

Table 5. Whole-rock analyses (in weight per cent) from the Origin plutonic complex and Sphynx Lake pluton.

Sample No.											
	1	2	3	4	5	6	7	8	9	10	11
SiO ₂	73.00	66.40	71.50	65.20	64.30	68.30	71.20	66.60	64.60	74.30	56.90
TiO ₂	0.10	0.52	0.18	0.09	0.11	0.37	0.38	0.54	0.57	0.12	0.85
Al ₂ O ₃	14.10	14.80	15.40	19.90	19.10	15.10	14.20	15.60	15.00	14.20	16.30
FeO	0.70	1.70	0.80	0.30	0.00	2.00	1.70	3.00	2.50	0.10	4.20
Fe ₂ O ₃	0.30	2.00	0.40	0.40	0.80	0.60	0.80	0.10	1.50	0.20	2.30
MnO	0.02	0.08	0.02	0.09	0.11	0.37	0.38	0.07	0.08	0.02	0.13
MgO	0.36	2.00	0.45	0.49	0.67	1.19	0.73	2.04	3.19	0.58	4.97
CaO	1.37	3.14	1.88	0.26	0.19	3.36	2.19	2.44	2.74	0.56	5.45
Na ₂ O	5.50	5.40	6.50	8.90	10.70	4.50	3.90	4.40	5.30	3.40	4.80
K ₂ O	3.56	2.36	2.46	3.91	2.93	2.06	3.44	4.93	3.87	5.15	3.18
P ₂ O ₅	0.06	0.15	0.06	0.04	0.06	0.10	0.09	0.21	0.24	0.09	0.28
Cr ₂ O ₃	0.03	0.01	0.02	0.02	0.02	0.04	0.04	0.04	0.04	0.02	0.05
H ₂ O T	0.40	1.00	0.40	0.40	0.60	1.10	0.90	0.70	1.20	0.70	1.30
Total	99.50	99.56	100.07	100.00	99.59	99.09	99.95	100.67	100.83	99.44	100.71
Ba	0.080	0.047	0.100	0.075	0.064	0.078	0.071	0.070	0.090	0.042	0.081
Sr	0.041	0.063	0.058	0.018	0.013	0.032	0.021	0.054	0.041	0.009	0.075
Rb	0.021	0.006	0.012	0.007	0.013	0.003	0.010	0.013	0.019	0.019	0.013
Zr	0.000	0.003	0.000	0.000	0.000	0.006	0.009	0.023	0.009	0.000	0.015
Zn	0.000	0.003	0.000	0.000	0.000	0.004	0.005	0.003	0.006	0.001	0.008
Ni	0.001	0.002	0.001	0.000	0.001	0.002	0.001	0.003	0.006	0.001	0.007
S	0.020	0.010	0.030	0.000	0.020	0.020	0.000	0.000	0.040	0.000	0.030
NOTES 1 = (T411-1) Origin L. 2 = (T319-1) 3 = (T405-1) 4 = (T305-1) 5 = (T305-2) 6 = (T307-2) 7 = (T407-2) 8 = (T593) Sphynx L. 9 = (T596) 10 = (T580) 11 = (T584)											

Chemistry of the Origin plutonic complex and the Sphynx Lake pluton

Eleven whole-rock analyses were carried out on samples from the Origin plutonic complex and from the Sphynx Lake pluton, the results of which are listed in Table 5. The major rock-forming minerals calculated from Barth (1962) mesonorms have been plotted together in Figure 20.

These analyses suggest that the bulk of the Sphynx Lake pluton is more mafic than the bulk of the Origin plutonic complex. Samples representative of the various phases of the Sphynx Lake body vary from quartz diorite through quartz-monzonite to granite. The Origin intrusive complex, on the other hand, contains marginally more quartz and is compositionally a granodiorite and tonalite.

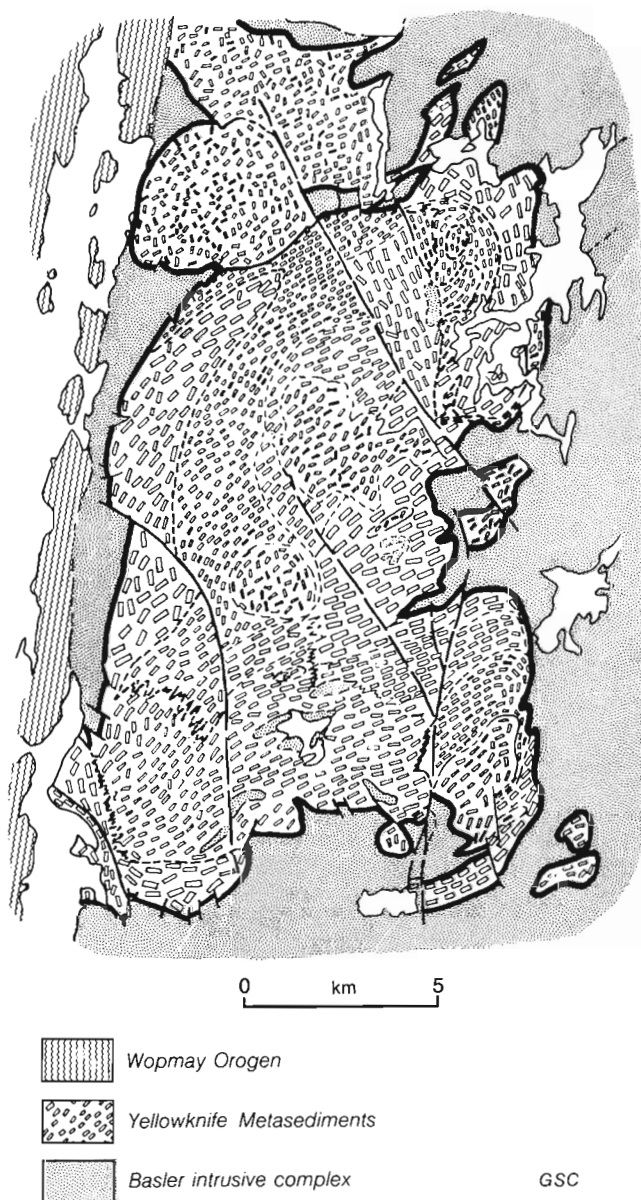


Figure 21 A map of the Basler intrusive complex showing the distribution and degree of gneissosity (or lack of it) and relative grain size within the complex (adapted from Smith, 1966a)

Basler plutonic complex

The Basler pluton is an orogenic pluton that intruded Yellowknife Supergroup metasedimentary rocks in the southwestern part of the map area. It is bounded on the south and east by migmatite and by paragneiss that becomes progressively less metamorphosed eastward (down to greenschist facies near the axis of the Indin structural basin). To the west, the pluton is bounded by porphyroblastic paragneiss, and both the pluton and the host paragneiss are unconformably overlain by basal rocks of the Proterozoic Snare Group (Lord, 1942). To the north, the pluton grades into migmatite and granitoid gneiss of the Meyer migmatite terrane. The pluton has a penetrative deformation that formed during emplacement, because foliated inclusions are oriented in the same plane as the host metasedimentary rocks. The two are probably contemporaneous.

The following account is digested from Smith (1966a) and from the author's subsequent geochronological studies and re-mapping of part of the east margins of the Basler pluton.

The Basler pluton is a polyphased intrusion of varying lithologies and textures (Fig. 21). Most rocks exhibit preferred orientation of platy minerals in a eastnortheast direction. The pluton was faulted and uplifted during Proterozoic time, a feature common to the less dense granitoid rocks along the western margin of the Slave Structural Province boundary. The pluton was intruded by diabase dykes, which are probably related in age to the Indin Diabase swarm. Coarse pegmatite is locally present at the margins of the pluton and is also present within the host metasedimentary rocks and migmatites. It is presumed to have been derived from an extraneous, possibly anatectic source.

The rocks are mainly biotite granites (with or without muscovite) and biotite granodiorites. In the eastern part of the pluton they are comparatively fine grained, potassium-poor granodiorite and granite that locally intercalate with the adjacent migmatite-paragneiss. In outcrop, the rocks are medium to coarse grained and mostly grey, but with some red and pink colouration.

Some contacts are faults. Contacts on the western margin were not observed, but textural contrast between the pluton and host rock suggest they are sharp. Toward the centre of the pluton the textures are more massive and individual intrusive phases are more bulbous than sheet-like in form. Some cross-cutting relationships are present, and the younger facies are commonly more massive, suggesting local resurgence. For example, the circular-shaped body of biotite granodiorite near the centre of the plutonic complex cuts across other more foliated intrusive phases.

The degree of foliation is generally related to the proximity of marginal host rocks and to the relative age of plutonic phases. Contact aureoles were not observed, except along the margin of the Matberry granite, the round north-eastern lobe of the Basler plutonic complex.

Textures vary systematically within individual intrusive phases and throughout the pluton as a whole. Foliation is best developed in the more basic phases, and the grain size is generally coarser near the margins than the centre. The

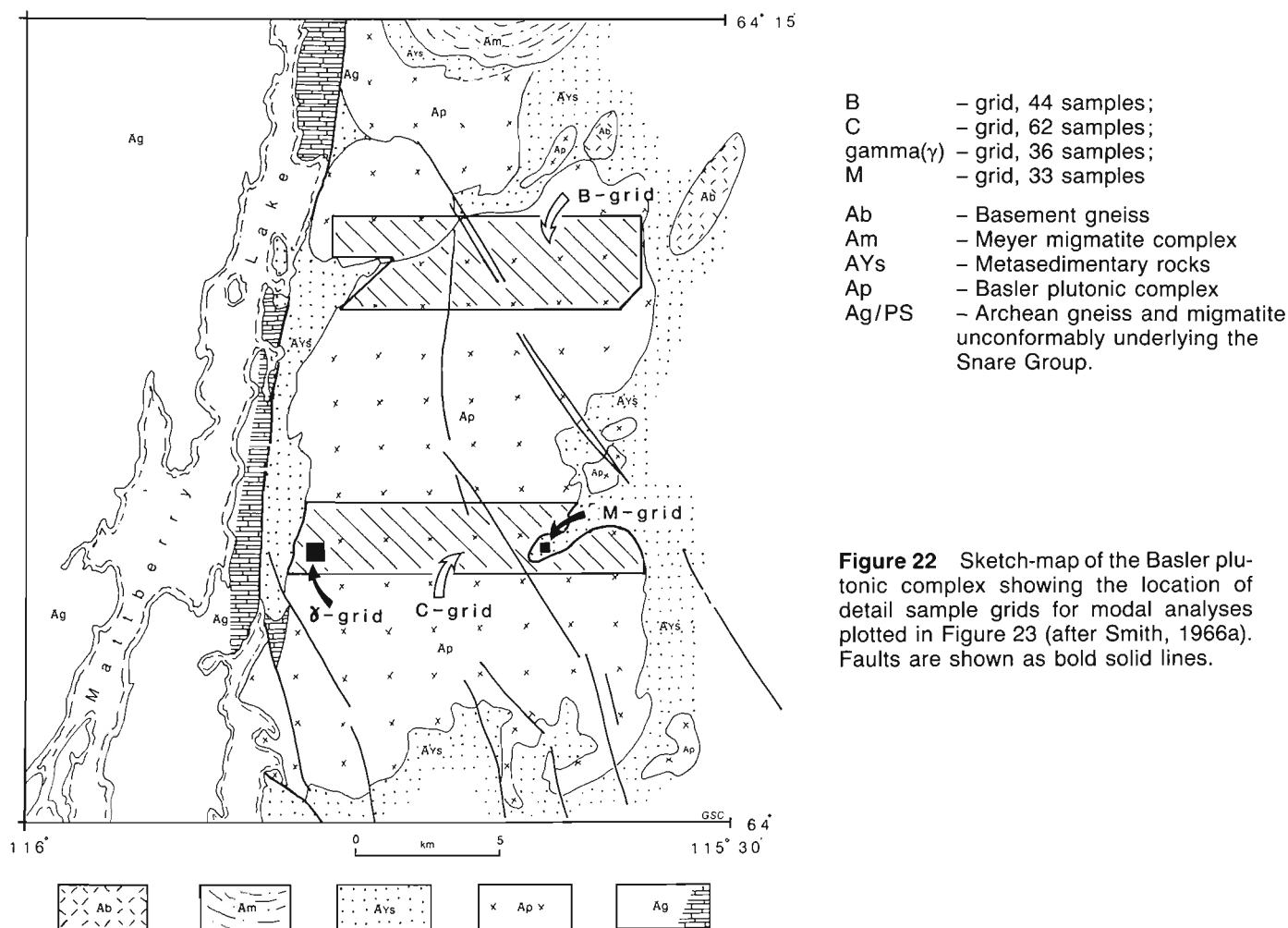
eastern margin of the intrusion is medium to coarse grained and contains xenoliths of metasediment oriented in the same direction as the regional fabric. Xenoliths are rare on the western margin and the host rocks are more massive, coarser grained, and have less compositional variation.

Composition of the Basler pluton — Modal analyses carried out on whole-rock specimens from grids from the pluton as a whole and from detailed grids (Fig. 22, 23) illustrate the range of composition of the suite specimens. Average compositions determined from the data show that the bulk of the samples analyzed are of granite or granodiorite composition.

Age of the Basler pluton — A Rb-Sr whole-rock isochron age of 2517 ± 106 Ma was obtained for a suite of five specimens from the Basler pluton, the Meyer migmatite terrane, and the Mattberry Lake granodiorite (McGlynn, 1972). The data are derived from three different intrusive phases, possibly of differing ages. The co-linearity suggests a metamorphic re-equilibration that approximates the age of intrusion of the rocks. The age is somewhat less than more recent age determinations, which place the peak of thermal metamorphism in the region at 2596 Ma (Frith et al., 1986).

Other plutonic rocks (units Apgd, Apgt, APan) — Other more massive and homogeneous plutons are found northeast and south of Truce Lake. These intrusions are composed mostly of granodiorite (unit Apgd) and granite (unit Apgt), with biotite and chlorite as the principal mafic minerals. The rocks are plutonic, judging from their more homogeneous composition and texture, and have few inclusions. The Truce Lake pluton (on the north shore of that lake) is a of freshlooking, medium- to fine-grained and usually equigranular rock, which cuts across the regional trend of foliation. The large massive pluton between Truce Lake and Drumlin Lake is similar to the Truce Lake pluton, but contains some tonalitic gneissic rock toward its northeastern margin. The contact relationships between these plutons and the migmatitic and gneissic granitoids that surround them are unknown, but from the lack of compositional contrast with the host rocks they are presumed to be gradational.

Dune Lake Pluton — The Dune Lake pluton (DLP in Fig. 2) intrudes Yellowknife Supergroup metasediments and volcanic rock in the region north of Mesa Lake. The pluton is a faintly gneissic, mostly leucocratic granite and granodiorite body, which has metamorphosed the Yellowknife metasediments at the contact. The field relationships and lithology are consistent with other intrusive bodies of



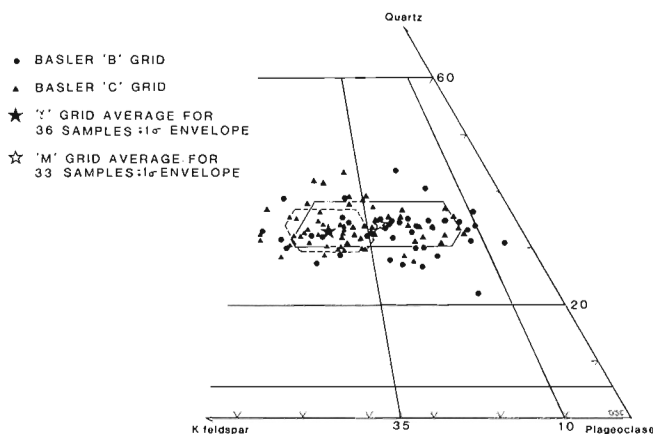


Figure 23 Streckeisen diagram for rocks of the Basler plutonic complex and the east-adjacent migmatitic metasediments of the Yellowknife Supergroup. Grid locations are shown in Figure 22 (Smith 1966a).

Archean age in the map area. Rb-Sr whole-rock age techniques gave a value of 2204 Ma with a high initial $\text{Sr}^{87}/\text{Sr}^{86}$ intercept of 0.720 (Frith et al., 1977). The Dune Lake pluton isotopic data were interpreted as a rejuvenated «age», derived from an Archean, probably syntectonic pluton. The intrusion is on line with other Archean bodies within the Wopmay Orogen in the map area, that form the cores of gneissic diapirs.

Megacrystic plutons (unit Apk)

K-feldspar, megacrystic granodiorite and granite form irregular and oval-shaped plutons in the Cotterill Lake-Snare Lakes area, a 10 km wide oval pluton in the Whitewolf Lake area, and a small stock (the Mattberry Lake granodiorite) near the north end of Mattberry Lake.

(1) Cotterill Lake-Snare Lakes area — The rocks are coarse grained, granoblastic granodiorites or granites, with 2–4 cm long K-feldspar megacrysts, which make up between 5 and 40 % of the rock. The rocks are pink to light buff on the fresh surface. The groundmass is coarse grained, equigranular, and uniform in mineral proportions. Biotite is the most abundant mafic mineral, comprising 5 to 10 % of the rock. It occurs mainly as randomly oriented grains, but is locally oriented parallel to the regional gneissosity and not necessarily to the margins of the host rocks.

The megacrysts are commonly zoned and twinned on the Carlsbad law, implying a late magmatic paragenesis similar to that of comparable plutons elsewhere in the Slave Structural Province (Hill and Frith, 1982). The megacrysts are locally augened, suggesting the pluton was intruded during or slightly after major regional deformation (see the following sections on Structure and Metamorphism). Textural and stratigraphic relationships suggest that magmatism and regional metamorphism were contemporaneous.

The megacrystic plutons intruded the basement complex of tonalite gneiss and migmatites in the Cotterill Lake area.

Contacts were not observed, but within the complex small areas of metasedimentary rock are present that contain *in situ* K-feldspar porphyroblasts that probably formed at the same time as the leucosome in the migmatite.

Age of the Cotterill Lake megacrystic granites — The age of the Cotterill Lake megacrystic granites was determined at 2532 ± 126 Ma by Rb-Sr whole-rock techniques (Frith, 1980). This age is younger than the culmination of regional metamorphism, dated at 2596 ± 5 Ma from monazite from the Grenville Lake basement gneiss (3.0 Ga) and 2580 ± 50 Ma from Pb-Pb whole-rock isochron techniques from granitoid gneiss in the nearby Ghost Lake area granitoid gneiss (Robertson and Folinsbee, 1974).

(2) Mattberry Lake granodiorite — The Mattberry Lake granodiorite is considered to be part of the Basler Lake pluton, but in appearance closely resembles other megacrystic granodiorites and granites in the map area, so is discussed in the present section. It is a medium- to coarse-grained roughly circular stock made up of plagioclase, quartz, biotite, and megacrysts of microcline (up to 25 % of the rock). The microcline megacrysts commonly contain inclusions and display Rapakivi-like textures (Smith, 1966a). The stock is texturally homogeneous and equigranular and has sharp cross-cutting relationships to the surrounding host rocks, but does not contain marginal xenoliths. The contacts are locally hornfelsed.

The Mattberry Lake granodiorite is similar to the Basler Lake plutonic rocks and is probably of comparable Archean age. The granodiorite was used to construct one point on the Rb-Sr age of the Basler Lake pluton (McGlynn, 1972), but the point by itself is ambiguous. However, similar rock types west of the Slave Structural Province boundary have Rb-Sr whole-rock isochron ages of approximately 2.2 Ga, the same age as the K-Ar age for the Mattberry Lake granodiorite.

Biotite granodiorite (unit APan) — In the area from Strachan Lake to Daran Lake, granodiorite stocks from 300 m to 15 km long have intruded basement rocks and the supracrustal rocks of the Yellowknife Supergroup (Fig. 24). The stocks are riddled with foliated xenoliths of biotite schist or hornblende gneiss, both derived from the Yellowknife supracrustal host rocks. The granodiorite is generally medium grained, light to dark grey, and contains 20 to 50 % mafic minerals. Its composition is highly variable, and the mafic-mineral content increases with the proportion of xenoliths present. The margins of the stocks are gneissic, and the foliation is steep and oriented parallel to the margins. In outcrops at the south end of the northeast arm of Indin Lake, the granodiorite is fractured in a 010° azimuth direction.

The more homogeneous, xenolith-free varieties are medium grained, equigranular, and made up of stubby plagioclase, K-feldspar, quartz, biotite, and hornblende. Deuteric alteration of plagioclase and mafic minerals to saussurite and chlorite is common.

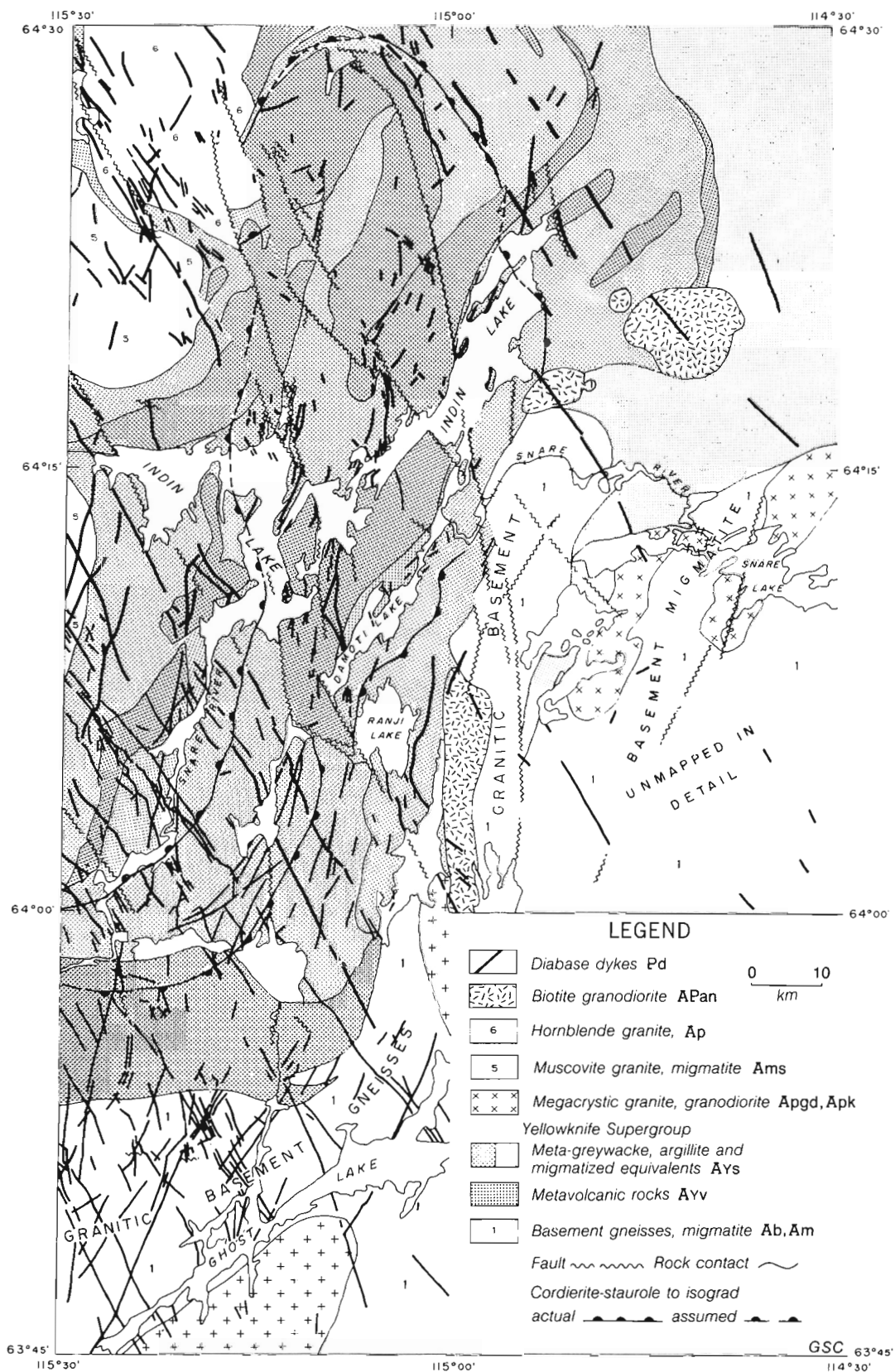


Figure 24 Map showing distribution and orientation of diabase dykes in the Indin Lake and Ghost Lake areas. The cordierite-staurolite isograd is indicated. (From an unpublished paleomagnetic study by R.A. Frith and K. L. Buchan, 1985).

The rocks contain igneous textures that suggest the pluton was epizonal and anorogenic. The Strachan Lake stock and the elongate granodiorite near the south-centre of the map area have been intruded by diabase dykes that have no aeromagnetic expression, and are presumed to be part of the northeast set of Indin Lake dykes estimated to be 1.9 Ga in age (see below). The intrusion also pre-dates D₃, because the northwest-oriented upright cleavage, noted mostly in the Yellowknife Supergroup metasediments, is locally present near the margins of the Strachan pluton.

Age of the Strachan Lake stock — The Strachan Lake stock was imprecisely dated at 1887 ± 179 Ma by Rb-Sr whole-rock isochron techniques (Frith et al., 1977) and at 1925 Ma by K-Ar biotite techniques, but a K-Ar age determination of hornblende from one of the inclusions in the stock was 2540 Ma (Frith, 1978b), suggesting that the pluton is late Archean in age.

Pegmatites

Simple pegmatites of granite composition are common along the contact between granitoid areas and the rocks of the Yellowknife Supergroup. They occur in the Grenville Lake basement complex, along the east margin of the sedimentary rocks east of the Origin plutonic complex and Daran Lake, in the contact zone between the Basler pluton and Meyer migmatite terrane, and along the margin between the Truce Lake complex and the metasedimentary rock to the west. The pegmatites are generally undeformed and either oriented parallel to the regional gneissosity or having a bulbous shape that cuts across regional structures.

The pegmatites commonly contain quartz, plagioclase, perthitic microcline, and muscovite, with minor amounts of biotite, epidote, and black tourmaline. Grain size is highly variable. The pegmatite near Grenville Lake contains books of muscovite several centimetres thick and microcline measuring up to 15 cm long. Pegmatites south of Mesa Lake contain tourmaline crystals measuring 2 by 10 cm.

Simple pegmatites consisting mostly of feldspar and quartz are also abundant in migmatite terranes. They are unzoned and have a granite or granodiorite composition. This type is usually concordant with the foliation of the country rock and was most likely genetically associated with the development of the regional migmatites with which they were mapped.

Crudely zoned, beryl-bearing pegmatites have been reported from the Ranji Lake area and east of Indin Lake by Fortier (1949), who remarked that these pegmatites closely resembled those of the Yellowknife-Beaulieu River area, which subsequently were described by Hutchinson (1955).

Age of the pegmatites

Rb-Sr whole-rock dating of muscovite from pegmatites in the Grenville Lake area has given a preliminary age of 2573 ± 39 (Otto Van Breeman, personal communication, 1985). These pegmatites cut basement gneiss and the Grenville

Lake volcanic rocks of the region. Similar pegmatites are found in regional migmatites and within the metasedimentary rocks of the Yellowknife Supergroup and are probably associated with the close of the Kenoran Orogeny.

Proterozoic

Diabase Dykes

The distribution and strike of diabase dyke swarms in the Slave Structural Province have been reviewed by McGlynn and Henderson, (1972) and their paleomagnetism by McGlynn and Irving (1975). The intrusions consist mostly of diabase with lesser volumes of gabbro, which occur as sills and stocks. Dykes of the Indin and Mackenzie swarms trend in the same direction, but since there are few prominent aeromagnetic anomalies, a feature commonly associated with the Mackenzie Diabase, there are probably few dykes of that dyke swarm and age in the Indin Lake map area, compared with dykes of the Indin Diabase. Some dykes matching those described as the Mackenzie Diabase dykes or their equivalents found elsewhere in the Slave Structural Province (Leech, 1966) are present in the Indin Lake area (Table 5 in Eade, 1948), but they have not been shown on the accompanying map. Some older diabase dykes within the basement gneiss complexes have been tentatively linked to Yellowknife volcanism. These are described in the section on basement complex rocks in a preceding section.

Indin Diabase

The Indin Diabase consists of a swarm of diabase and gabbro dykes that is most dense between Spider Lake, in the north, and Ghost Lake in the south of the map area (Fig. 24). The dykes range in width from a maximum of 100 m (in the Ranji Lake area) down to a few centimetres where dykes pinch out or splay. They are of two principal compositions: one, which contains olivine and weathers down topographically, and the other, which contains no olivine and resists erosion so that it is topographically embossed. The following descriptions are of samples from the Indin structural basin and are based on the descriptions and modal analyses (Table 5) of Eade (1948).

Northwest-trending diabase dykes — These constitute about 90 % of the dykes in the area (Fig. 24). The dykes are most commonly 30 to 40 m wide, as much as 20 km long and are tapered near the ends. Apophyses occur, but are of limited extent. Chilled margins of 15 cm width are common. The dykes weather to a brown or rusty, but fresh surfaces are dark green to grey with white feldspar. Microscopically, plagioclase is present as ophitic equidimensional or elongated grains 1 to 2.5 mm long; compositionally it is 50 to 60 % anorthite. The plagioclase is variably altered to sericite, zoisite, and epidote. Augite is the only pyroxene present and occurs as colourless to light brown intragranular grains 1-2 cm wide. It may be ringed by secondary actinolite, which occurs as discrete, irregular shaped olive-green to blue grains, which in turn are altered to chlorite at their margins. Minor minerals include euhedral magnetite and pyrite, and minute biotite locally altered to chlorite.

Olivine in the more basic dykes occurs as 1 mm wide grains that may be overgrown by pyroxene. Round pseudomorphs of matted serpentine after olivine are present, commonly with exsolved magnetite. Plagioclase in the olivine-bearing dykes is more anorthite-rich, and opaques are more abundant.

The quartz-bearing diabase dykes that make up part of the northwest-trending swarm are more sodic and contain euhedral pyroxenes, which are altered partly to actinolite and chlorite. Biotite is present in small quantities.

The north-northeast-trending dykes — These commonly cut the northwest-trending dykes. They are 20 to 30 m wide and in the northeast arm of Indin Lake occur as chain-like islands. The dykes are brown on weathered surfaces and in places plagioclase phenocrysts emboss the surface. On fresh surfaces most are black to dark grey and have glassy unaltered plagioclase and some pyroxene. Some of the north-northeast-trending dykes are olivine bearing. Both olivine and pyroxene are altered to serpentine and actinolite.

Age of the Indin Diabase — McGlynn and Irving (1975) determined from paleomagnetic studies that the northwest- and north-northeast-trending dyke sets were conjugate. However, the paleomagnetic properties of the dykes (W.H. Fahrig and K.L. Buchan, personal communication, 1985) suggest that the rocks have been retrograded and that more than one swarm of preMackenzie dykes may be present in the area. Early K-Ar age determinations of Indin Diabase whole-rocks in the Indin Lake map-area range between 1155 and 1965 Ma (Wanless, 1970). Leech (1966) considered these dates too young and assigned them a «preferred age» of 2000 Ma. Rb-Sr whole-rock and mineral age determinations using an assumed initial ratio, yielded dates of 2023 and 2049 Ma (Gates and Hurley, 1973). The Indin Diabase dykes are possibly equivalent to gabbro sills in the Wopmay Orogen. The magnitude of the northwest-trending dyke swarm suggests that these dykes may be deeper equivalents of the gabbro sills that intrude the Snare Group rocks in the Arseno Lake and Lac Castor regions of the map-area, which suggests that their age is between 1.89 and 1.88 Ma (Hoffman and Bowring, 1984).

Mackenzie Diabase

The scale of field mapping in this study was not sufficiently detailed for all of the northwest-trending diabase dykes to be plotted on the geological map accompanying this report. However, two sets of northwest-trending dykes were recognized on the basis of cross-cutting relationships and the degree of alteration. The Mackenzie Diabase swarm cut earlier northwest- and north-northeast-trending dykes. The Mackenzie dykes are commonly associated with an anomalously high aeromagnetic signature, in contrast to the low magnetic signature of the northwest-trending Indin Diabase. They are more sporadic in distribution and individual dykes are rarely more than 10 m wide. Mackenzie Diabase weathers brown, with waxy white plagioclase phenocrysts up to 1 cm in diameter. The plagioclase is saussuritized, and zoisite, epidote, and sericite are present (see modal analysis 6, Table 6).

Table 6. Modal analyses (in volume per cent) of diabase dykes from the Indin structural basin (after Eade, 1948).

	Sample No.					
	1	2	3	4	5	6
Plagioclase	30-48	47-60	52-60	44-49	47	43
Pyroxene	7-28	22-33	25-34	1-3	33	6
Amphibole	30-38	6-8	2-16	39-45	11	44
Opasques	5-7	1-10	4-7	5-8	4	2
Olivine	*	2-11	*	*	5	*
Epidote	*	*	*	1-2	*	5
Apatite	*	*	*	1-2	*	*

* = not observed
1 = Northwest dykes containing plagioclase and pyroxene.
2 = Northwest dykes containing plagioclase, pyroxene and olivine.
3 = Northwest dykes containing plagioclase, pyroxene and quartz.
4 = North-northeast dykes containing plagioclase and pyroxene.
5 = Northwest dykes with waxy white plagioclase cut 1-4.
6 = Northwest dykes with plagioclase phenocrysts and pyroxene (possibly equivalent to the Mackenzie Diabase).

GENERAL GEOLOGY — WOPMAY OROGEN

Wopmay Orogen, which lies to the east of the Slave Structural Province, has been divided into five north-south-trending tectonic zones, which extend westward from Takijuk Lake (at the west margin of the Slave Province 100 km north of Indin Lake map area) to the unconformity with the Paleozoic beds near Great Bear Lake (Hoffman, 1984). Two of these tectonic zones, the Asiatic fold-thrust belt and Hepburn metamorphic-plutonic belt, extend from the type area near Hepburn Lake into Indin Lake map area. The supracrustal rocks of these two zones form a continental sedimentary prism (Coronation Supergroup), which has been thrust to the east by westward subduction of the Slave plate (Hoffman, 1984). The prism was shortened, thickened, and transported to the east along sole faults during the Calderian Orogeny (St-Onge et al., 1984; Tirrul, 1983). The sedimentary prism was intruded by the peraluminous Hepburn Intrusive Suite (1.89 Ga) before the close of the orogeny (Hoffman, 1984), and much of the suite is allochthonous. Gabbroic sills intruded the Coronation Supergroup in the Arseno Lake and Lac Castor regions prior to the folding of these supergroup rocks.

In Indin Lake map area, Coronation Supergroup consists entirely of the Snare Group, which is probably equivalent to the Akaitcho Group and/or possibly the Epworth Group north of the map area (Hoffman, 1984).

Archean rocks within the Wopmay Orogen in the map area are similar in type to those in the Slave Structural Province, but have been deformed by the Calderian Orogeny. The rocks include granite and granodiorite gneiss, amphibolite rocks derived from basaltic pillow lavas, and migmatitic and gneissic rocks derived from rocks equivalent to turbidite greywacke-mudstones of the 'Yellowknife Supergroup'. In the southern part of the map area, the basement rocks occur

along the core of an anticlinorium. Contacts between the basement and the overlying Snare Group rocks are steep, and the supracrustal rocks are present as narrow (but extensive along strike) infolds, which suggests that the basement was folded with the overlying Proterozoic rocks. Near the boundary of the Slave Structural Province the cover rocks are more tightly folded and locally thrust to the southeast. Farther north, basement rocks in the cores of gneiss domes are little deformed, despite high-grade regional metamorphism of the basement. Relationships suggest that east-west compression was taken up mostly in the overlying supracrustal rocks, but both basement and supracrustal rocks are probably allochthonous.

Archean basement granitoid rocks

Granitoid rocks in the cores of the Emile River gneiss domes (unit Ag)

The granitoid rocks are similar in appearance, colour, and composition to those farther east in the Slave Structural Province (unit Ap, APan). The gneiss domes are mantled by para-migmatite (unit Am) or paragneiss of Archean and/or Proterozoic age, and both granitoid and mantle rocks have been metamorphosed to granulite facies.

The southern gneiss dome is cored with medium-equigranular pink-to-grey granodiorite or granite with 5-15% biotite. The biotite provides a planar fabric best developed near the contacts with the mantle gneiss. Near the centre of the dome the rocks are surprisingly massive and cut by pods of coarse grained alaskite and metagabbro or metadiabase dykes. The gneiss is cut by a 50 m-wide northwest-trending amphibolite dyke, which was probably derived from Archean diabase or gabbro.

The western gneiss dome is structurally and lithologically heterogeneous. The rock is a buff-coloured, equigranular granodiorite, containing hornblende and biotite, and is cut by leucocratic pegmatite and veins of aplite and alaskite. The gneissosity and the leucosome veins are contorted. Locally, the rocks are banded, and these banded facies too are folded in contorted patterns. Near the margins, the gneissosity parallels the contacts. Along the western margin of this gneiss dome mullion structures dip 70 degrees to the west. The eastern margin is sheared, and deformation has obliterated any unconformable relationship that may have been present. Some thin sections of the core gneiss show the presence of retrograded orthopyroxene.

The central gneiss dome is oval in outline and has a well developed concentric foliation. Its western margin is sheared, whereas its eastern margin and the adjacent mantle gneiss are migmatized by coarse grained, white quartz feldspar leucosome. Quartz pebble conglomerate is present along part of the northern margin of the structure. The core gneiss is a medium grained, equigranular granodiorite, composed of biotite, quartz, and feldspar; the granodiorite is cut by 2-10% pegmatite and vein aplite, which are locally folded. Lineations near the northern, western, and eastern margins plunge consistently west-to-north between 30 and 40 degrees. The eastern margin is bordered by mixed gneiss and migmatite. Host rocks along the southern margin of the gneiss dome are locally calcsilicate bearing, and purple quartzite was noted in one locality.

The northern gneiss dome is similar in lithology and contact relations to the central gneiss dome, but its different shape suggests that the dome may have formed by compressive, as well as gravitational deformation (see further discussion in the section on «Structural Geology»).

Two small outliers of basement granitoid gneiss are exposed south of a right-lateral fault between the Rodrigues granodiorite and the south end of the northern gneiss dome. They are irregular in shape and bordered locally by dolomite and/or calc-silicate rocks. The rocks are gneissic, and their foliation is irregular but strikes in a generally northerly direction. The rocks are similar to the western gneiss dome, but no orthopyroxene was noted.

Two small problematic areas of granite gneiss occur in the northwestern part of the map-area, one between Rodrigues Lake and El Capitan Hill and the other between Mesa Lake and El Capitan Hill. These have been described by Ross (1966) as Proterozoic intrusions of white, foliated, even, fine grained granite, commonly containing tourmaline and/or country-rock inclusions. However, Rb-Sr whole-rock age determinations of the body north of Mesa Lake gave an age of 2204 Ma, which was interpreted as a rejuvenated Archean date (Frith et al., 1977) similar to other rejuvenated Archean rocks (Yellowknife metasediments) along the Slave Structural Province boundary. The age of these granitoids has been assigned to the Archean.

Migmatite and gneiss — Mattberry anticlinorium (units Ams, Amv)

Gneiss and migmatite that make up the core of the Mattberry anticlinorium consist partly of paragneiss derived from rocks similar to those of the Yellowknife Supergroup (*). More homogeneous granitoid gneiss, augen granite gneiss, and migmatite are also present, derived from Archean granitoid rocks that have been significantly changed by Proterozoic metamorphism and deformation.

Hornblende gneiss (unit Amv)

Hornblende gneiss occurs in long northerly trending windows in anticlinorial structures in the area between Castor and Norris lakes. Most of the rocks are sheared, and their origin is not apparent from outcrop or hand specimen evidence. However, they occur below unconformities, overlain by quartz-pebble conglomerates which in the Mattberry Lake area overlie rocks of the 'Yellowknife Supergroup' metasediments. The hornblende gneiss (or amphibolite) is therefore considered to be lithologically and stratigraphically equivalent to 'Yellowknife' Supergroup volcanics.

Contacts between the hornblende gneiss and calc-silicate-bearing dolomite of Proterozoic age are locally sheared, and their nature is unknown. West of Mirror lake,

(*) Henderson (1970), in his definition, restricted the distribution of the Yellowknife Supergroup to the Slave Structural Province. In this study equivalent rocks within the Wopmay Orogen are similarly termed but are expressed in single quotation marks.

hornblende gneiss is in contact with megacrystic, commonly augened granite gneiss (unit Agk). Frith et al. (1972) considered the augen gneiss west of Mattberry Lake to be deformed Archean granitoid rock, as it unconformably underlay Snare Group conglomerates. Furthermore, the massive megacrystic rocks west of Mirror Lake preserve Rb-Sr isotopic values that suggested an age in excess of 2.2 Ga. The deformed and migmatized 'Yellowknife' Supergroup metasediments in the same region gave a Rb-Sr whole-rock isochron age of 2210 ± 245 Ma (Frith et al., 1977), which is older than the basal units of the Coronation Supergroup.

The hornblende gneiss of the Mattberry Lake anticlinorium is associated with gneiss and migmatite of suspected Archean age. The hornblende gneiss is usually banded to massive, fine to medium grained, and has a well developed sub-vertical foliation, which strikes northerly. The hornblende gneiss may be interlayered with biotite schist and coarsegrained, white feldspar pegmatite. The biotite schist may be a reactant between the hornblende gneiss and the pegmatite. Anthophyllite was recognized in a few hand specimens, but generally the rocks are made up entirely of hornblende and plagioclase. The grain size may be reduced by shearing, and some exposures of the hornblende gneiss are distinctly mylonitic.

'Yellowknife Supergroup' metasedimentary rocks

The inter-domal paragneiss that makes up most of the rocks in and around the Emile River gneiss domes is thought to be of Archean age (locality 8 on Fig. 7). They are similar in overall appearance to the metamorphosed Snare Group arkoses. Their distribution and contact relationships are not well defined and they have been mapped as one unit (PSr). The rocks commonly attain granulite-facies metamorphic grade. Imprecise Rb-Sr whole-rock age determinations indicate their age to be about 2.1 Ga (Nielsen, 1977). They are spatially associated with Archean granitoid rocks in the southern dome area (Frith et al., 1977), where both have been metamorphosed to the same grade of regional metamorphism. Throughout the gneiss dome area, Proterozoic conglomerates and minor calc-silicate rocks have been folded along with the paragneiss.

'Yellowknife Supergroup' rocks occur west of Mattberry Lake where they have been deformed and migmatized during the Proterozoic (Frith, 1978a). Sedimentary structures such as turbiditic graded bedding can still be recognized in these rocks, despite isoclinal folding and high-grade thermal metamorphism. The rocks locally make up megaboudinage blocks within aplitic leucosome areas. Rb-Sr whole-rock studies indicate their age to be at least 2.2 Ga (Frith et al., 1977). The rocks unconformably underlie Snare Group conglomerates on islands in the northern part of Mattberry Lake.

Granitoid augen gneiss (unit Agk), biotite gneiss, and migmatite (unit Ams)

The most abundant rock types in the Mattberry Lake anticlinorium are granitoid augen gneiss, biotite gneiss, and

migmatites of granitic to granodioritic composition. The augen gneiss is mostly granitic, buff to pink on both weathered and fresh surfaces, and made up of potash feldspar augen megacrysts in a matrix of quartz, plagioclase, and biotite. Less commonly muscovite, ilmenite, magnetite, epidote, pyrite, and garnet are present. The degree of K-feldspar flattening ranges from undeformed equidimensional flasered K-feldspar megacrysts to highly flasered aggregates that exceed 5:1 in length-to-width ratio. The more deformed gneiss contains ribbons of quartz. Generally the degree of flattening is greater eastward toward the Slave Structural Province boundary, for the gneiss grades into a massive granitoid rock type within 8 km of that boundary.

West of Norris Lake the granitoid gneiss is less megacrystic, is more granodioritic in composition, and is cut by abundant aplitic and alaskitic pegmatite and migmatitic leucosome. Biotite schlieren are common, suggesting an association with Archean migmatites derived from metasedimentary paragneiss.

The augen gneiss west of Mattberry Lake unconformably underlies basal Proterozoic conglomerates (Frith et al., 1977) and grades into more massive (on the outcrop scale) megacrystic granite and granodiorite, which are compositionally and texturally similar to Archean granites and granodiorites that make up parts of the Basler plutonic complex east of Mattberry and Cotterill lakes. However, the gneiss lacks cross-cutting relationships with the Snare Group and has therefore been mapped as Archean metasediments.

Paragneiss and migmatite of uncertain age

The rust-coloured paragneiss in and around the Emile River gneiss domes consist of biotite gneiss, schist, and migmatite, with an overall granodioritic composition, which according to Nielsen (1977) may be derived from rocks equivalent to the Yellowknife Supergroup metasediments. The paragneiss has been metamorphosed to the granulite facies, similar to the Archean, orthopyroxene-bearing, gneiss dome cores and granitoid rocks in the Ghost Lake area (Robertson and Folinsbee, 1974) of the Slave Structural Province. A Rb-Sr study of samples of the paragneiss around the Emile River gneiss domes suggests that parts of the granulite-facies terrane are older than 2.11 Ga and hence can be considered basement to the 1.9 Ga basal Coronation Supergroup (Hoffman and Bowering, 1984). However, even though there is ample evidence of Archean granulite metamorphism, the geochronological data are imprecise and cannot be used to date the age of the metamorphism in the Emile River region. Furthermore the rocks grade from a granulite-facies 'hot-spot' in rocks of uncertain age to greenschist-facies rocks that are as young or younger than the basal Snare Group. Also, it may be argued that all of the exposed rocks near the gneiss domes are allochthonous, including even the gneiss domes, as the basement gneiss elsewhere in the Wopmay Orogen was possibly of lower temperature than the allochthonous overlying thrust prism (St-Onge et al., 1984).

Proterozoic rocks

Coronation Supergroup

Initial mapping of the region resulted in the assignment of all Proterozoic supracrustal rocks to the Snare Group (Lord, 1942). According to Lord (1942) this group extended from the boundary of what is now the Slave Structural Province, westward beyond the Wopmay fault, north to the boundary of the Indin Lake map-area, and south to Marion Lake, near Great Slave Lake. Fraser (1964, 1960), McGlynn and Henderson, (1970, 1972), and McGlynn (1977) subsequently correlated the Snare Group with the Epworth Group. More recent work has reduced the area previously included within the Snare Group, and various parts have been correlated with either the Akaitcho, Epworth, or Labine groups (Hildebrand, 1981; Hoffman et al., 1971; Hoffman, 1978). In this report, all Proterozoic sedimentary rocks in the map area have been assigned to the Snare Group, a reconnaissance stratigraphic subdivision of the Coronation Supergroup (Hoffman, 1981).

The Proterozoic sedimentary basins around the Slave craton are similar in many respects. The Epworth Group was found to be stratigraphically equivalent to parts of the Goulburn Group (Fraser and Tremblay, 1969) and to parts of the Great Slave Supergroup (Hoffman, 1973). Hoffman (1981) has recently placed the Epworth Group in the Coronation Supergroup along with the Akaitcho and Recluse groups.

The Snare Group adjacent to the boundary of the Slave Structural Province shares many of the characteristics common to rocks of the Goulburn Group and the Epworth Group found farther north, such as: they lie unconformably on Archean basement; they are floored by quartzite or conglomerate; they are overlain by argillites, siltstones, and arkosic sandstone; the rocks are all interstratified with less voluminous quartzite and dolomite; and all have been intruded by gabbro sills and dykes, which have been deformed with the sedimentary rocks. The stratigraphically older Akaitcho Group occurs along the northwest margin of the map area (M.R. St-Onge, personal communication, 1986) and its sedimentary units may be extrapolated into the map area, but the volcanic rocks that characterize the group to the north are absent, except as rare clasts within conglomerates of the group. No demarcation between the Epworth-like rocks and the Akaitcho-like rocks was feasible, rather all were included within the Snare Group. The sillimanite isograd separates one type from the other, but this criterion for distinguishing the two types is artificial, and the rocks on each side of the isograd may have originally been similar.

Snare Group

The Snare Group consists mostly of argillites, siltstones, and sandstones interlayered with dolomite and quartzites, all of which were intruded by gabbro sills (now amphibolite). The detrital rocks are commonly limey and contain calc-silicate minerals. Thin-bedded, quartz-pebble conglomerate and quartzite may occur at or near the base of the Snare

Group, where they unconformably overlie the Archean craton, most notably in the Mattberry Lake area. The stratigraphic thickness of the Snare Group is unknown, but its folded thickness may be significant, as can be deduced from aeromagnetic maps of the area, which present anomalously low values over the upright fold zone north of Arseno Lake (G.S.C. Map. 2918G).

The supracrustal rocks grade from simply folded greenschist facies at the boundary of the Slave Structural Province to complexly folded and highly metamorphosed rocks westward. The transition occurs at the sillimanite isograd, which separates porphyroblastic rock types of dominantly amphibolite facies from greenschist-facies rocks. Metamorphism also increases in grade north-northeast from Arseno Lake so that the sillimanite isograd approaches the Slave craton rocks in the Capitan Hill region.

High-grade regional metamorphism precludes distinction between Snare Group and 'Yellowknife Supergroup' metasediments where lithologies are similar. Some rock types, such as quartz-pebble conglomerates and orthoquartzites have no equivalents in the Slave Structural Province, and such rocks are assumed to be Proterozoic and part of the Snare Group. Similar correlations for dolomitic rocks are more ambiguous, because dolomitic rocks also occur (though with rarity) in the Slave Structural Province. Nevertheless these dolomitic rocks in the Wopmay Orogen have been included within the Snare Group as they are associated temporally with the conglomerates and orthoquartzites. The high-grade rocks have been mapped separately, but much of the area outlined by this map unit on the geological map accompanying this report may be derived in part from Snare Group arkoses.

Conglomerates and orthoquartzites (unit PSc, PSg)

The conglomerate and sandstone in the Emile River area (Fig. 25, 26) are made of well washed cobbles, which range in size from 20 cm in diameter to grit-sized particles (Fig. 25, 26) and are composed predominantly of vein and aggregate quartz with lesser clasts of quartzite, granite, aplite, rhyolite, and amphibolite. The matrix is mostly quartz with some K-feldspar, biotite, and muscovite. Some sandy beds have a carbonate matrix. Cobbles are commonly stretched as much as 10:1. In the Acasta River area, conglomerate beds are as much as 100 m thick and locally contain granitoid clasts that make up to 20 % of the rock. Some of the clasts are tonalitic.

Bedding traces of the thicker conglomerate beds are faint, but where they can be determined, beds 1-2 m thick are not uncommon. The overlying beds are generally rusty biotite gneiss, but in places banded iron formation is present (north of Acasta River).

Conglomerate and orthoquartzite near the Slave craton serve as marker beds to outline a tight isoclinal style of folding that extends from the area west of Mesa lake southward to Norris Lake. The rocks are interstratified with siltstones, sandstones, and limey clastic rocks, but unlike their equivalents to the west are relatively thin. This is not a tectonic thinning, however, because many of the clasts are not as compressed as those around the gneiss domes.

From Norris Lake southward to Mattberry Lake, conglomerate occurs mainly along the basal unconformity where it fills depressions in the Archean basement (Frith et al., 1977). There are some reasons to suggest that most of this region is autochthonous, except for minor southeast-directed thrusts mapped in the Mattberry Lake area (Smith, 1966a). (This is discussed in more detail in the section on Synthesis)

Orthoquartzite occurs as basal units 1- to 4-m thick in troughlike remnants in the Mattberry Lake anticlinorium. It is massive and bluish grey and is made up almost entirely of fine- to medium-grained quartz. Because of its resistance to weathering the orthoquartzite stands out topographically.

Arkosic sandstones

The metamorphosed Snare Group in the map area is made up mostly of rusty coloured, medium- to coarse-grained, bedded gneiss and schist made up primarily of biotite, quartz, plagioclase, and K-feldspar (Fig, 27). Commonly included in small amounts (depending on metamorphic grade) are andalusite, sillimanite, cordierite, staurolite and/or garnet. Relict bedding is defined by variations in the proportion of leucocratic minerals.

The metasedimentary rocks in the Emile River area are tightly folded and thinned by tranposition along fold limbs,

but in tectonic shadow zones they appear well bedded and similar in many respects to the Yellowknife Supergroup metasediments with which they are easily misidentified. The rocks around the Emile River gneiss domes and adjacent to the Rodrigues granodiorite have been deformed by two penetrative sets of folding, followed by gneiss doming and strike-slip faulting.

The cordierite-, sillimanite- and garnet-bearing gneiss is common in the high-grade zones and near the contact with granitoid rocks. Some of the mantling gneiss is distinctly migmatitic. Layered migmatite with discontinuous banding is also found near the margins of the Rodrigues granodiorite. Some of the arkosic sandstones have been metamorphosed to the granulite facies and the quartz grains in them have polygonal granular outlines in thin section. Retrograde metamorphism has locally produced secondary muscovite.

Minor calc-silicate rock occurs along the southwestern margin of the central gneiss dome and around the margins of the small basement masses that lie east of the Rodrigues granodiorite. The distribution of the dolomite-bearing rocks suggests they formed thin, basal, sheetlike strata that may have extended intermittently over much of the area now underlain by younger Proterozoic rocks.



Figure 25 Snare Group conglomerate from the 'Clearwater' Lake area. Pebbles are made up mostly of quartz in a matrix of arkose, but with clasts of granitoid rock, volcanic rock and jasper noted locally.



Figure 26 A thick, resistant bed of conglomerate showing interlayers of grit, 'Clearwater' Lake area.



Figure 27 Folded sillimanite grade, rusty sub-greuwacke of the Snare Group from the Brownwater Lake area.

Dolomite and Calisalicate work (units PSd, PScs)

This unit consists of dolomite, argillaceous dolomite (unit PSd) and carbonate-bearing siltstone and argillite (unit PScs). Metamorphism has recrystallized these rocks and obliterated most of their primary structures, and deformation has locally obscured bedding thicknesses, except in the Norris Lake area, where deformation is less pronounced, and beds up to 100 m thick occur, with individual beds measuring 3–40 cm. The dolomite is dark to medium grey and fine grained. Layers of shale, siltstone, and sandy argillite comprise about 10 % of the rock.

Dolomite is also interstratified with other units of the Snare Group. Limey arkose and argillite beds 10 to 20-m wide are folded in tight isoclines in the Arseno Lake area, whereas dolomite occurs in the cores of synclines. Dolomite is more abundant toward the top of the sedimentary succession where it thins toward the Slave craton. From regional tectonics evidence (Hoffman, 1984) it is postulated that compression from the west folded the rocks and possibly thrust them along a decollement surface, where they abut against the Slave craton. Antigorite is locally present against slickenside surfaces at the contact, but kinematic indicators showing eastward thrusting were not observed.

Gabbro Sills (unit Pd)

Diabase, gabbro, and diorite occur as sills or sub-parallel dykes within the Snare Group. They have been folded with rocks of the Snare Group, so they predate deformation and postdate sedimentation of that group, which took place between 1.89 and 1.88 Ga (Hoffman and Bowring, 1984). This suggests that the dykes and sills followed closely on Snare Group deposition.

Elongated bodies of diabase, gabbro, or diorite intruded the Proterozoic rocks in the Grand and Little Crapeau Lakes area and northwest of Robesca Lake to the Wopmay River (Lord, 1942). These intrusions are from a few metres to several kilometres wide and of uncertain thickness. They are commonly below the volcanic flows of the Akaitcho Group in the more northerly parts of the Wopmay Orogen (Easton, 1981, 1982). Lord (1942) suggested a genetic relationship between the flows and the sills that cut the Snare Group. A further correlation is proposed between these and the northwest-trending Indin Diabase. Metamorphism at about 1960 Ma has locally changed the basic rocks to hornblende- and plagioclase-bearing metamorphic rocks.

Hepburn Intrusive Suite

The principal intrusion of the Hepburn Intrusive Suite in the map area is the Rodrigues pluton, a large granitic to granodioritic body that underlies a plateau area from Brownwater Lake to the Acasta River. This pluton has intruded rocks of the Coronation Supergroup, both in Indin Lake map area and north of it as far as Coronation Gulf (St-Onge et al., 1984). It is bounded on the east by steep, commonly sheared contacts with the Snare Group and is cut by several east-northeast-trending dextral strike-slip faults. Other small intrusions of similar lithology occur southwest of Brownwater Lake, along the Acasta River, and near the

Slave Structural Province boundary near the upper reaches of the Emile River. The core of the anticlinorium that stretches from the north end of Norris and Castor lakes to Mattberry Lake is made up of augened granitoid gneiss whose composition and overall appearance are similar to those of the Rodrigues pluton, but relationships suggests it is older.

The pluton is predominantly granite, but granodiorite and quartz diorite facies are also present. Typically, the granite is a homogeneous, coarse grained rock, with unoriented to slightly oriented 2- to 6-cm long megacrysts of microcline. The matrix is grey to buffbrown, equigranular, and made up of grey to smokey quartz, biotite, and plagioclase. Some of the megacrysts are Rapakivi textured. Individual, more heterogeneous plutons of quartz diorite composition have intruded the Snare Group between the Acasta River and Exmouth Lake. These plutons contain fewer megacrysts (or none at all) and locally exhibit a layered migmatitic appearance.

The contacts between the Rodrigues pluton and the metamorphosed Snare Group are intrusive, as apophyses of aplite emanating from the pluton penetrate the host rocks. However, the contacts are commonly sheared. In places, elongated quartz clasts (which may have been derived from conglomerate) occur at the contact, plunging steeply away from the pluton.

Flow orientation is suggested by the alignment of megacrysts. However, at some contacts megacrysts of microcline occur in the host paragneiss, implying they formed *in situ*. Rapakivi textures and megacryst zoning suggest there were at least two stages of megacryst growth.

Host paragneiss occurs as inclusions locally in the intrusive suite. Rounded xenoliths of medium grained, equigranular diorite and quartz diorite are found near the margins of the pluton, suggesting some digestion of host rock (Fig. 28). Assimilation probably took place near the contacts of the pluton. The host paragneiss commonly contains garnet porphyroblasts. Nearby plutonic phases are locally garnet-bearing, possibly due to assimilation of all of the metasediment except for the refractory garnet (Fig. 29).



Figure 28 Margin of the Rodrigues granite showing inclusions of amphibolite and cross-cutting veins of aplite.



Figure 29 Margin of the Rodrigues granite showing post intrusive garnets (dark round spots) in the host gneiss of the (Snare Group or possibly metamorphosed equivalents of the Yellowknife Supergroup greywackes) and in the granite itself (from west of Brownwater Lake).

Pegmatites (unit Pp)

Pegmatites are common in Snare Group rocks of amphibolite- and granulite-facies grade, where they cut across or run parallel to the foliation. Pegmatites commonly stand out as white coarse rocks and consist of white plagioclase, K-feldspar, and quartz. Less commonly, pegmatites contain muscovite, biotite, tourmaline needles, and rose quartz.

Age of the pegmatite

Rb-Sr isotope analyses of rock samples from pegmatite along the southeastern margin of the Brownwater Lake gneiss dome yielded an approximate age of 1.8 Ga (Frith et al., 1977). However, this age is somewhat too young, as there is no reason to believe that the pegmatites are not syn- to late-tectonic and comparable to the Hepburn Intrusive Suite (Van Schmus and Bowring, 1980), which has been dated at 1.89 Ga.

STRUCTURAL GEOLOGY

Slave Structural Province

The rocks in the Slave Structural Province were deformed during three separate events associated with: (1) Archean, preYellowknife Supergroup magmatism and possible regional metamorphism/metasomatism; (2) deformation related to the Archean "Kenoran" Orogeny; (3) deformation related to Proterozoic tectonic events.

Pre-Yellowknife Supergroup events

Geochronological studies of the basement granitoid rocks have shown that plutons of tonalite were intruded about 2989 ± 6 Ma (Frith et al., 1986). This intrusive event and earlier magmatism have been recorded elsewhere in the Slave Structural Province (Krogh and Gibbons, 1978; Scharer and Allegre, 1982; Nikic et al., 1980). In the Grenville Lake area plutonism was accompanied or followed

shortly after by metasomatism of potassium- and rubidium-bearing fluids channeled along fissures now filled with aplitic dyke rocks (Frith et al., 1974).

The basement granitoids were penetratively deformed during the Kenoran Orogeny (Stockwell, 1964). Similarly deformed were the Yellowknife Supergroup supracrustal rocks and amphibolite dykes, which cut the basement gneiss and are presumed to be feeders to the Yellowknife volcanic rocks.

Textures associated with the 2.9 Ga thermal and metasomatic event were mostly obliterated by later more penetrative deformation during synvolcanic deformation and subsequent Kenoran orogenesis. Deformation produced a steep planar fabric in the amphibolite dykes that cut the basement. In the Cotterill Lake area, similar amphibolite dykes contain inclusions of basement gneiss, inclusions which contain a fabric that may pre-date the Kenoran event (Fig.3).

«Kenoran» deformation

Deposition of the Yellowknife Supergroup took place at 2669 ± 15 Ma (Frith and Loveridge, 1982). The thermal peak of the Kenoran Orogeny took place at 2596 Ma, as determined by U-Pb dating techniques on monazite (Frith et al., 1986). Deformation associated with the orogeny took place in two stages, D_1 and D_2 , which were probably part of a single continuous phase of deformation that gave rise to east-northeast- structures, followed by north-northwest-trending structures.

D_1 structures(*)

The presence of large-scale isoclinal structures within supracrustal rocks may be deduced from top determinations, bedding foliation relationships, and the presence of rare F_1 fold hinges in metasedimentary rocks (Fig. 30). Around Indin Lake, F_1 folds and their associated fabric are best recognized where F_1 and F_2 can be distinguished in the regions of low-grade regional metamorphism. West of the Indin Lake basin, schistosity is defined by chlorite or biotite in the metasediments and by actinolite, chlorite, and hornblende in the volcanic flows and pyroclastics rocks. More argillaceous greywackes and mudstones became slaty, and pillow structures in volcanic rocks were flattened and elongated sub-vertically by D_1 .

Planar fabric in metasedimentary rocks of the Yellowknife Supergroup consistently dips away from granitoid bodies but commonly dips toward volcanic belts. The southern part of the Ranji Lake area contains metasediments with F_1 fold axes and related planar fabrics that are oriented in westerly directions. Volcanic rocks south of Spider Lake and near Grenville Lake have bedding and foliation planes that parallel volcanic margins.

(*) Structural terminology used in this memoir is as follow:

D_n = deformation phase, S_0 = bedding,
 S_n = foliation phase F_n = fold phase

... where n = a sequential phase.

D₁ folds with east- and northeast-trending axes were refolded by more northerly D₂ folds in the Float Lake area (Tremblay, 1948). This style of folding interference was observed within areas of low-grade regional metamorphism and where folding was not controlled by more competent volcanic rocks. Elsewhere, D₁ folds were commonly further compressed during the period of D₂ deformation so that their axes are essentially co-linear.

Areas of high-grade regional metamorphism, such as the gneissic terrane south and east of Basler Lake pluton, contain leucosome segregations that developed parallel to S₁ and were subsequently folded into tight isoclines by D₂. North of Indin Lake, volcanic and sedimentary rocks were folded into an anticlinorium. The morphology of these folds and the occurrence of thin volcanic bands sandwiched between metasedimentary rocks (east of the northeastern arm of Indin Lake) suggest that sedimentary rocks underlie the volcanic rocks that thin toward the east from Chalco Lake to Strachan Lake. These F₁-fold traces curve from north-northeast to north to northwest (south of Truce Lake) aligned by northwest-trending, Proterozoic D₃ folds with associated open folding.

North of Chalco Lake, volcanic rocks face eastward and are overlain by carbon-bearing metasediments. The overlying rocks were deformed in three distinct phases. D₁ and D₂ formed co-planar to nearly co-planar isoclinal folds with near-vertical axial-planes and foliations, which are cut by a sub-vertical northwest-trending cleavage (S₃).

The Cotterill Lake basement gneiss contains an easterly trending foliation, locally accentuated by leucocratic and mafic mineral segregations. This gneissosity is cut by a north-northeast-trending gneissosity, which parallels the volcanic margin rocks and the D₁-D₂ folds within the Indin

Lake basin. If these north-northeast-trending folds and gneissosity are coeval, then the basement gneissosity is older.

In the Mesa Lake area two-phase Archean deformation of the Yellowknife Supergroup is not easily recognized (Ross, 1966) because of co-axial deformation. However, on the northeast shore of Mesa Lake, an S₁ gneissosity parallels easterly trending beds and is in turn cut by a north-northeast-trending S₂ crenulation cleavage.

Volcanic rocks were not generally folded by D₁, but were thinned, as seen in the stretching out of pillows in sub-vertical orientations. However, two generations of folding have been preserved where sedimentary rocks are inter-layered with relatively thin tongues of volcanic rock. Detailed mapping south of Spider Lake shows volcanic bedding traces snaking from east to west, even though the volcanic belt itself is oriented parallel to the north-northeast-trending, D₂ folding direction. The enclosing metasedimentary rocks have deformed readily, and their foliation is dominated by D₂ structures. In volcanic rocks, foliation parallels bedding and F₁ structures. D₂ structures in volcanic rocks are only evident where limbs of folds have been drawn into co-planar directions and S₁ is essentially parallel to S₂.

D₂ structures

The dominant deformation in the Yellowknife Supergroup was an east-west compression that gave rise to a steep foliation within the volcanic rocks and ubiquitous northerly trending isoclinal folding in the metasedimentary rocks. The folding of the metasedimentary rocks was probably controlled by a buttressing effect of volcanic rocks, on the one hand, and penecontemporaneous emplacement of granitoid domes and plutons on the other. The sedimentary rocks were far more readily deformed than either the volcanic rocks or the granitoid rocks (which have shapes that suggest they intruded and pushed out the surrounding host rocks in a manner similar in concept to the Ramsay balloon (Ramsay, 1967)). Where the volcanic rocks trend northerly, D₂ structures generally parallel D₁ structures and are further flattened.

D₂ structures are found in the central part of the Indin structural basin. Slaty cleavage is common in the mudstones and earlier isoclines were subjected to a second isoclinal folding (Fig. 30).

Cleavage associated with D₂ locally cuts across cordierite porphyroblasts developed in areas of high-grade regional metamorphism, suggesting that deformation accompanied the close of thermal metamorphism. Locally, porphyroblasts are aligned parallel to S₂ (Fig. 31), and cordierite, sillimanite, a second phase of andalusite, and biotite grew during the D₂ deformation period (Frith, 1978a). Segregation veining is most commonly folded during D₂.

Smith (1966a) has shown that the Basler pluton was intruded during the second phase of regional deformation, as segregation veining developed during D₁ is folded into tight isoclines along the southern margin of the pluton. Similarly, along the pluton's eastern margin, S₁ fabric is folded

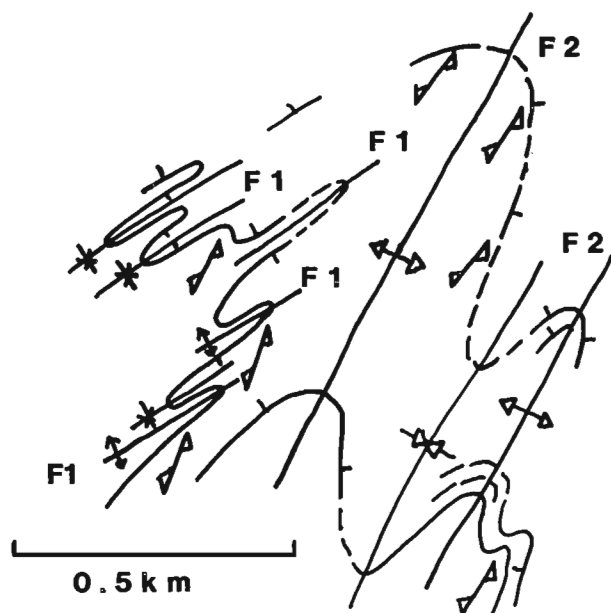


Figure 30 Interference patterns between F₁ and F₂ folds in vertically dipping greywackes and mudstones, near Float Lake. Structural symbols are the same as on map in the pocket (after Frith et al., 1974).

along northerly trending axes, preserving a well developed S_2 schistosity or gneissosity in the metasedimentary rocks. Development of porphyroblasts of garnet and sillimanite, which formed in the thermal aureole during the late stages of Basler plutonism, outlasted the D_2 deformation. Garnet overgrew cordierite remnants as well as their pressure shadows in the metamorphosed gneiss (Smith, 1966a). Fabric formed during D_2 has conformable counterparts within the pluton, as some of this fabric is attributed to syn-kinematic emplacement of partly solidified magma.

Most of the preferred orientation in the Basler pluton trends northeasterly, which contrasts with the S_2 north-northeast direction observed in the central Indin structural basin, where D_2 orientation was partly controlled by the northerly trend of the basin structure. Outside of the Indin structural basin, S_1 and S_2 structures are not readily distinguished, but from folded S_1 segregations they are approximately co-planar. Structures within the Indin structural basin may have been rotated during Proterozoic brittle deformation of the basin, as described below.

Linear fabric formed by the intersection of S_1 and S_2 foliations is generally steep (60 degrees and vertical). Pillows and clasts in volcanic rocks and pebbles in volcanic conglomerates are consistently stretched into similar orientations.

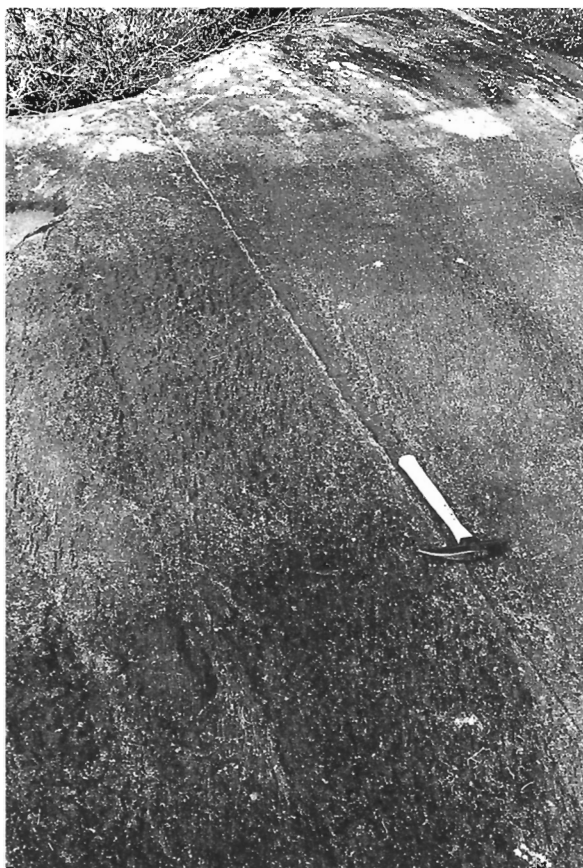


Figure 31 Andalusite porphyroblasts near the cordierite staurolite isograd, Indin Lake, showing a preferred orientation along the S_2 cleavage direction. S_1 is developed parallel to bedding (hammer handle).

Proterozoic deformation

D_3 structures

Penetrative upright cleavage in the marginal parts of the Strachan Lake stock, the metasedimentary rocks nearby, and in some of the thinner volcanic strata, provide evidence for a third phase of deformation (D_3). The cleavage planes trend northwesterly (Fig. 32) and are locally defined by chlorite. Evidence of warping along axes parallel to this cleavage is present south of Truce lake and northwest of Strachan Lake (Fig. 33). Both warping, folding, and cleavage are probably related to the main phase of deformation in the Wopmay Orogen, dated at 1.88 Ga (the same age as the Hepburn Intrusive Suite, which intruded folded rocks of the Akaitcho and Epworth groups).

Faulting possibly related to D_3 Deformation of autochthonous Archean basement in the Wopmay Orogen (Mattberry Lake area) converted Snare Group quartz pebbles in conglomerate into vertical to steeply oriented disks. Within the Slave Structural Province this same deformation probably took place under relatively low temperature conditions,



Figure 32 Third phase cleavage (S_3) in metasedimentary rocks from a shore line area on the north arm of Indin Lake.



Figure 33 Third-phase folding (F_3) of metasedimentary rocks of the Yellowknife Supergroup with an upright axial plane that strikes in a northwest direction, southwest of Strachan lake.

causing brittle deformation, so that the rocks in the Indin structural basin were deformed by faulting. The rocks in this basin are denser than the granitoid rocks on the east and west sides of it and were depressed or down-faulted at the same time as the northwest faulting occurred. The distribution and orientation of the faults were controlled in part by the shape of the Indin structural basin and possibly associated north-south basin- and granitoid-bounding faults. The brittle deformation also displaced the adjacent basement rocks on each side of the basin, the supracrustal rocks, the anorogenic Strachan Lake stock and associated stocks and the shear zone separating the volcanic rocks along the basin's eastern margin from the basement granitoids. Lineations in the volcanic rocks along this shear zone indicate that the granitoid rocks to the east moved up relative to the basin rocks, but the amount of vertical displacement is not known. A small intrusion, correlated with the Strachan Lake stock located on a peninsula at the southern end of the northeast arm of Indin Lake, shows evidence of north-south shearing, which was probably associated with the downwarping of the structural basin.

Evidence of north-south shearing is found along the eastern margin of the Basler pluton. The overall shape of the Indin structural basin and the distribution of the basement rocks on each side of it together suggest that the shearing may have re-activated an older zone of structural weakness such as the margins of a rift zone or graben. Granitoid rocks east of the Indin structural basin were also faulted, but the faults peter out and are deflected into the older foliation directions of the basement due, perhaps, to the greater strength of the basement rocks.

Evidence of a reverse fault has been observed in subsurface drill cores from the Lex Lake region (P. Sargeant, personal correspondence, 1985). The fault trends north-northeast and dips westerly, suggesting that it was the result of east-west compression. The fault is older than the northwest left-lateral set, but cuts S_2 .

Age of the fault(s) The rocks of the Indin structural basin have been cut by left-oblique faults. These faults approximate the trends of the 1.84 Ga northwest oriented faults in the Wopmay Orogen (Hoffman, 1984), where they have been reported as conjugate with dextral strike-slip faults cutting Proterozoic and Archean rocks in the northwestern part of Indin Lake map area. These faults are the same as similarly oriented faults that cut every zone of the Wopmay Orogen. However, the northwest-trending faults in the Slave Structural Province are not known to cut the unconformity between Coronation Supergroup and Slave Province basement rocks, either in the Indin Lake map area, or to the south where similar left-lateral faults cut the rocks of the Yellowknife Bay area (J.B. Henderson, personal communication, 1985) and do not extend into any units of the Great Slave Supergroup in the east arm of Great Slave Lake (P.F. Hoffman, personal communication, 1985).

These northwest-trending faults are probably older than and unrelated to the northwest-trending folds, but were probably associated with the depression of the Indin structural basin.

K-Ar whole-rock age determinations of the Yellowknife Supergroup metasediments gave anomalously high 'ages' because of the presence of excess argon. This was interpreted as an effect of Proterozoic downwarping of the basin. Whole-rock isochron studies of these rock samples (a method used to overcome the presence of excess argon) gave an age of 2.5 Ga, dating the age of the regional metamorphism. However, the same samples gave the age of Proterozoic thermal metamorphism at 2.0 Ga (Frith, 1978).

D₄ Structures

The widespread conjugate faults of the Wopmay Orogen accommodated east-west compression by north-south extension. There was a preponderance of dextral slip over sinistral slip, which Hoffman (1984) suggested was due to clockwise rotation of the Coronation Supergroup, relative to the Slave Structural Province. Within the Indin Lake map area, the same explanation may be used for the rightlateral strike-slip fault that affects the Coronation Supergroup, the Hepburn Intrusive Suite, the western margin of the Slave Structural Province, and the Archean rocks east of that margin.

Tectonic interpretation of the Indin structural basin

Archean deformation

The Indin structural basin is filled mostly by supracrustal rocks of the Yellowknife Supergroup. It is a rectangular-shaped structure, bounded on the west by plutonic and migmatitic complexes and to the east, north, and south by migmatites derived, in part, from preYellowknife basement rocks, and by migmatites and gneiss derived, in part, from Yellowknife metasediments. Reconstruction of the basin by 'un-faulting' the northwest-trending faults suggests that the granitoid regions were uplifted relative to the basin, which is made up of denser volcanic and sedimentary rocks.

Textures in the supracrustal rocks indicate that most volcanic and sedimentary deposition was sub-aqueous, but the local presence of cobbles of granitoid and volcanic provenance in conglomerates near the interface between volcanic and sedimentary deposits suggests that emergent land was locally present during both volcanism and sedimentation.

Bedding (S_0) and early foliation (S_1) directions indicate east-northeast striking structures, such as F_1 folds near the centre of the belt. Similar directions are preserved in the adjacent Basler pluton and the enclosing migmatite east of Strachan Lake, but the structures and fabrics in those two bodies were developed during D_2 deformation and are presently co-planar with those of D_1 .

The change in orientation from an east-northeast direction for D_1 structures to a north-northeast direction for D_2 structures is most evident in the Indin structural basin, where supracrustal accumulation was thickest. The orientation of the D_2 structures and their foliations was partly controlled by the north-south re-orientation of the basin

structure by left-lateral northwest-trending faults. Relatively straight basin boundaries are marked by pre-northwest faults. East-northeast-trending volcanic rocks were similarly reoriented and dominate the outcrop pattern within the basin.

Most of the volcanic rocks in the western half of the area between Spider Lake and Strachan Lake trend north-northeast. East of the north arm of Indin Lake, however, volcanic rocks folded with the metasediments suggest that the volcanic rocks were thinner there than elsewhere and that metasediments locally underlie the volcanic rocks, as they do in the Mesa Lake area (Ross, 1966). Metasediments are in contact with the basement granitoid rocks in the Cotterill Lake area. If these metasediments are similar to the basal Yellowknife Supergroup metasediments referred to in previous sections, then they may overly the basement gneiss in this region, where they form thin distal parts of a prism-shaped wedge that thickens to the west.

Proterozoic deformation

The last stage of deformation took place in response to the Calderian Orogeny, an easterly directed compression of the Coronation Supergroup and the underlying Slave craton. The effect on the craton was not as pronounced as the effect on the cover rocks, as the bulk of the rocks of the Slave craton were rheologically competent granitoids. An exception to this generalization, however, was the Indin structural basin, whose supracrustal rocks were folded along axes that trend to the northwest. They were subsequently deformed by brittle deformation and then faulted. The bulk of the strain in the Indin Lake structural basin was taken up by the north-south extension along northwest-striking oblique strike-slip faults. Similarly oriented faults and a north-south extension took place in some of the granitoid regions, but the vertical component led to uplift rather than depression in these regions.

Boundary of the Slave Structural Province

Previous studies of the boundary of the Slave Structural Province were carried out by Ross and McGlynn (1965). Their work confirmed the observation of Lord (1942) that the Snare Group unconformably overlies Archean metasedimentary rocks similar to those of the Slave Structural Province. The underlying and unconformably overlying rocks were deformed by structures related to Aphebian deformation (the Calderian Orogeny in the map area), and according to Stockwell's (1964) definition of the various structural provinces, lie within the Bear Structural Province (here referred to as the Wopmay Orogen). The actual boundary in the Indin Lake map area runs from the south margin on Basler and Mattberry lakes, through Norris and Arseno lakes to near Mesa Lake, and is a normal fault. North-northeast of Mesa Lake the Slave craton has been uplifted to higher structural levels and the boundary fault is no longer evident, so the boundary follows the Archean-Proterozoic basal unconformity.

A structural province boundary, as defined by Stockwell (1964), denotes a change from one dominant structural trend

to another. The 'overprinting' by younger deformation is transitional up to where younger penetrative structures become dominant. The boundary in the Indin Lake map area is well defined using this concept, because a gravity fault, denoted by steeply plunging slickensides on the fault trace, separate deformed, possibly allochthonous, Proterozoic rocks in the western part of the map area from Archean rocks in the eastern part, which, at the present level of erosion, have poorly developed Proterozoic fabric. In the Mattberry Lake area steep southeast-directed thrust faults were recognized by Smith (1966a), but these probably pre-dated the normal faulting. North of Emile River, near El Capitan Hill, the recognition of Archean versus Proterozoic structures is ambiguous and the structural boundary is best defined along the trace of the Proterozoic-Archean unconformable contact. North of the map area a décollement was recognized between allochthonous Coronation Supergroup and basement rocks, and this structure probably extends north of the Indin Lake map area (M.R. St-Onge, personal communication, 1985).

Southwest-facing Yellowknife Supergroup volcanic and sedimentary rocks near Chartrand Lake were affected by three phases of penetrative deformation: the first and second by the 'Kenoran' Orogeny, and the third during the period of Proterozoic deformation. Early isoclinal folding of sedimentary rocks was accompanied by mineral recrystallization and stretching along planes that now strike north to northwest and dip at or near the vertical. Stretched volcanic pebbles in autochthonous overlying Archean paraconglomerate indicate a 50 to 75 % compression. Pebbles from the Snare Group conglomerate to the west (although possibly allochthonous) have been compressed only 20 to 30 %.

The boundary fault at Arseno Lake is gently curved, and its southward extension passes along the east side of Mattberry Lake. The carbonates and sandstones west of the fault are little metamorphosed and folded into open concentric folds (Ross and McGlynn, 1965). The unconformity in the Mattberry Lake area has been tilted from what is presumed to have been nearly horizontal to about 60 degrees west. The boundary fault in this area is a single plane, but on the east side of the Slave Structural Province it consists of composite movement planes of dominantly left-lateral strike-slip, similar to faults of the Indin structural basin, caused by east-west compression that was taken up by strike-slip fault movement. Nowhere are the northwest-trending faults known to cut the boundary fault. The uplift of unconformable surfaces along the western margin of Basler pluton also suggests some vertical component, which like the Indin Lake structural basin, indicates a clockwise rotation of the Slave Structural Province and a complimentary sinistral strike-slip movement along the boundary fault. The fault is probably not very deep, for there is little or no fluctuation of aeromagnetic patterns across it. If the faulting was related to brittle deformation of the Indin structural basin, it is probable that the vertical movement took place during the D₃ deformation period.

Metamorphic grade generally increases from south to north in rocks of the Snare Group. Slickenside minerals along the face of the boundary fault indicate that greenschist conditions prevailed during deformation. The fault face near

Arseno Lake contains rosettes of chlorite developed from dolomitic siltstone. Folding of the Snare Group changes from a concentric style, in the Mattberry Lake area, to a tightly folded style in the Dune Lake area (Ross and McGlynn, 1965). This change in style may be attributed to depth caused by north-south undulatory Tree River folding (Hoffman et al., 1983, 1984), as described below.

Archean supracrustal rocks in the Slave Structural Province boundary area near Mesa Lake were folded during Proterozoic deformation as well as during the earlier Archean deformation (Ross, 1966). This Proterozoic deformation took place under amphibolite facies conditions, as indicated by the mineral assemblages in the rocks of the Snare Group. The folds are similar and have upright to inclined axial planes. Shallow north-plunging folds at Arseno Lake reverse their plunge near Mesa Lake, perhaps because of the uplift of granitoid regions to the north associated with Tree River folding, a series of broad flexures of the basement and cover oriented on east-northeast-trending axes (M.R. St-Onge et al., 1984).

Wopmay Orogen

The Wopmay Orogen in the Indin Lake map area may be divided into several structural domains, each characterized by a different style and complexity of folding. A convenient dividing line between two of these domains is the andalusite-to-sillimanite isograd, which separates an upright to easterly verging fold region adjacent to the margin of the Slave Structural Province (where evidence of single axial planar deformation is present) from the northern gneiss dome and plutonic region, characterized by uplift of basement granitoid rocks and intrusion of the Hepburn Intrusive Suite. To the north of the map area uplifts are more regional (Hoffman and Pelletier, 1982), and part of the cover and the Hepburn Intrusive Suite are allochthonous, derived from the west by shallow overthrusting (St-Onge et al., 1984). If similar conditions prevailed in the Indin Lake map area, the most probable allochthonous rocks would be the Snare Group and associated rocks north of Norris Lake.

The Snare Group was deformed by two or more sets of folds, except near the boundary of the Slave Structural Province. The first was produced by isoclinal folding accompanied by penetrative axial planar foliation; the second set refolded earlier folds and was contemporaneous with the uplift of large areas including the Mattberry Lake anticlinorium, the northern gneiss dome, and the Rodrigues granite (Hepburn Batholith). A third set, parallel to the second set is locally present. All sets are probably part of a continuous phase of deformation, similar to that observed in the Wopmay Orogen to the north, where intrusion of the Hepburn Intrusive Suite is considered syntectonic (Hoffman, 1984). Dextral strike-slip faulting marked the close of tectonism in the area, which was dominated by east-west compression caused by converging plate margins.

South of Arseno Lake, similar eastward-directed thrusting may have taken place, but no evidence of movements of any magnitude was observed. West of Norris and Mattberry lakes (Mattberry Lake anticlinorium) the cover rocks are thin and were deformed during the Wopmay Orogeny,

along with the basement rocks. Proterozoic deformation and metamorphism overprinted the unconformably underlying Archean rocks and structures to the same degree as in the Proterozoic rocks.

Archean Deformation

Archean structures and primary depositional features in the Yellowknife Supergroup are commonly re-oriented, flattened, thinned and stretched by Proterozoic deformation. In the Slave Structural Province near Mesa Lake, Proterozoic fold planes are parallel or subparallel to Archean fold planes (Ross, 1966), so that angular discordance between the Snare Group and Yellowknife Supergroup is slight or absent. Similarly, Proterozoic deformation of Archean basement rocks in the Norris and Mattberry lake areas has superimposed a steep foliation, which is oriented parallel to the Slave Structural Province boundary. Archean planar features evident in migmatites derived from rocks equivalent to the Yellowknife Supergroup have been folded and leucosome layers boudinaged (Frith, 1978a).

Proterozoic Deformation

Folded rocks adjacent to the Slave Structural Province boundary

The Snare Group along the west margin of the Slave Structural Province from Mesa Lake to Mattberry Lake is folded from south to north in a concentric to similar style (Ross and McGlynn, 1965). Within the zone of similar folds, a single axial planar foliation is evident, even though earlier structures are evident in the region (Ross, 1966).

The folding style is outlined on the ground by quartzite marker beds (see Fig 36). The fold axes and axial planar foliations strike north-northeast and the foliations dip steeply to the west. Since the folds are oriented parallel to the boundary of the Slave Structural Province, it is probable that it buttressed eastward-directed compression. Fold axes plunge gently to the north from Mattberry Lake to Mesa Lake and southerly from that point north.

Interdomal paragneiss structures

The paragneiss in the inter-domal areas and the southern Emile River gneiss domes were studied in detail by Leatherbarrow (1975) and by Frith and Leatherbarrow (1975). The observations, analyses, and conclusions outlined below are digested from their work.

Stretched quartz pebbles enable F_1 folds to be distinguished from F_2 folds, as the pebble elongation directions vary on different parts of F_2 fold limbs. F_2 deformation folded major F_1 axial planes as well as their foliations. F_2 fold axes tend to wrap around the Emile River gneiss domes, and F_2 fold axes plunge both north and south as a result of gneiss-dome uplift. F_2 fold vergence changes northward around the southern lake dome, suggesting that the F_1 fold axes pass through the horizontal. Curved axial planes, as well as several microscopic superimposed folds, describe type-three interference patterns (Ramsay, 1967). A third set of folds (F_3) gently warped F_1 and F_2 structures, but has no

penetrative foliation. Hinge lines trend north and south and the F_3 folding may have been related to the uplift of the Emile River gneiss domes.

Much of the paragneiss in and around the Emile River gneiss domes is deformed by F_1 and F_2 fold sets. The second set of folds, although variable, generally has axes that trend in a northerly direction, similar in orientation to the foliation parallel to the isoclinal folding observed in the Snare Group adjacent to the Slave Structural Province boundary near Arseno Lake. The foliation in this region is mostly single-phase but has been designated S_2 . Bedding (S_0) and the initial isoclinal folding and its axial planar foliation (S_1) are mostly parallel, except at fold hinges, where S_1 cuts across S_0 . Where F_1 and F_2 folds are co-planar, further closing of fold limbs and renewed bedding compression took place (doubly transformed beds).

Mica and sillimanite are present along the same S_2 planes, suggesting they were contemporaneous with the peak of regional metamorphism. In regions of higher-grade metamorphism, e.g. south of Brownwater Lake, Snare Group sub-greywackes have been stretched along major fold limbs as seen by the presence of tension-gashes and boudinaged quartz veins (Fig. 34). However, most commonly F_2 folds are associated with a dominant penetrative fabric which commonly parallels bedding or is at close angles to it (Fig. 35).

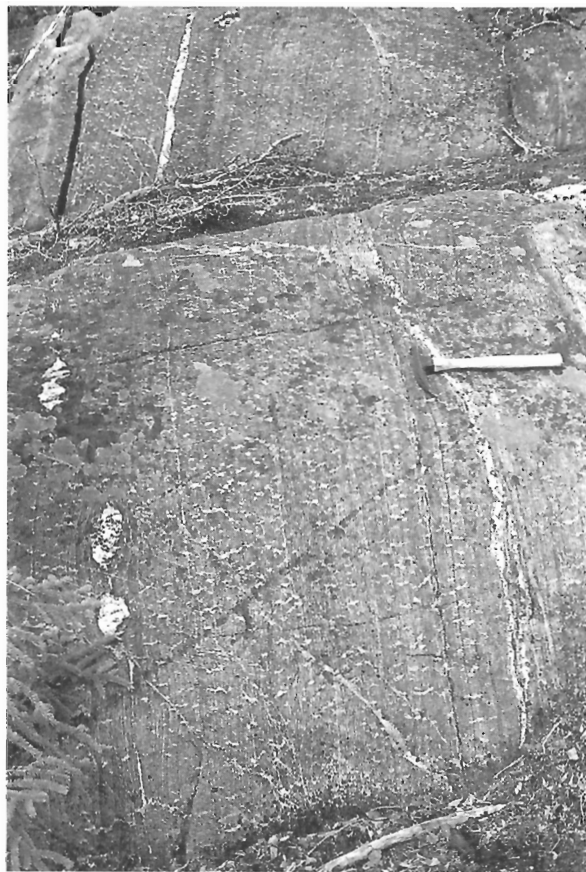


Figure 34 Boudinaged quartz veins and tension gashes due to extension parallel to S_2 foliation, from Snare Group south of Brownwater Lake.

In the southern gneiss dome, F_2 folds are tight to isoclinal, with inclined axial planes that tend to drape over the gneiss dome. In the interdomal regions the fold axes are upright and in cross-section axial planes fan out toward the domal areas.

Quartz pebble beds are present as intraformational markers within the schistose part of the Snare Group, which would otherwise be a monotonous sequence of similar rusty-coloured biotite granite paragneiss. The conglomerate outlines the folding style of both F_1 and F_2 , and the analysis of elongated pebbles allows a measure of the fold geometry.

The southern gneiss dome (Fig. 36) is almost completely surrounded by marker beds of quartz pebble conglomerate, which describe a large loop in outcrop pattern, suggesting an almost continuous sheet of conglomerate. The fold-style outlined by the conglomerate is typical of F_1 , which varies between cylindrical and isoclinal.

Three types of D_1 linear features are present; minor fold axes, mineral lineations, and pebble elongations. Where all three are present they are more or less parallel, indicating that deformation was intense enough to rotate quartz pebbles into positions approaching the orientation of non-material lines, such as minor fold axes. Lineations plunge about 40° southwestward, but local reversals of plunge due to second-phase folding also occur.



Figure 35 Foliation cutting across remnant bedding of Snare Group sub-greywackes, Brownwater Lake.

Gneiss dome structures

Six centri-clinal gneiss domes ranging in width from 2 to 10 km, make up the Emile River gneiss dome suite. The domes are ovoid to irregular in shape, and three of them are arrayed in a row parallel to the Slave Structural Province boundary. The cores of the Emile River gneiss domes are made up of granodiorite, tonalite, and granite pegmatite of Archean age (Frith et al., 1977). The northernmost dome is emplaced into paragneiss, derived either from the Snare Group or possibly re-worked Archean metasedimentary rocks. The contacts are generally sharp and most are conformable with host bedding and foliations. The western dome has a variable gneissosity, but near the margins the core gneissosity is concentric and is developed parallel to the metasedimentary host rocks. The granitoid gneiss contains more biotite near its contact than in its central parts. The granitoid core gneiss locally contains 'xenoliths' of amphibolite, which may have been derived from dismembered diabase dykes and other rocks that are similar to the host paragneiss. The xenoliths are generally elongated parallel to the gneissosity. No xenoliths of granitoid gneiss

were observed within the mantling paragneiss. From the age, structural relationships, and density determinations carried out on the core and mantling paragneiss (Leatherbarrow, 1975) the Emile River gneiss domes have been classified as mantled gneiss domes, after the scheme proposed by Salop (1971).

Model mantled gneiss domes (Ramberg, 1967) may have discordant contacts between the core and cover rocks, and the latter may be overturned at or near the contact. The Emile River gneiss domes do not show any obvious discordant relationships, but evidence of local shearing was observed. In places (such as in the central dome, shown in Fig. 36) the host rocks are derived from marbles, like ones in the lower part of the Snare Group in the map area. This suggests that these strata were dragged up with the rising core gneiss, possibly detached from the basal succession. Mantling gneiss, according to Ramberg (1967), is commonly migmatized near the core-mantle contact, and this feature is well developed in the Emile River gneiss domes. The leucosome in migmatites along the southeastern contact of the southern dome has been dated by Rb-Sr whole-rock

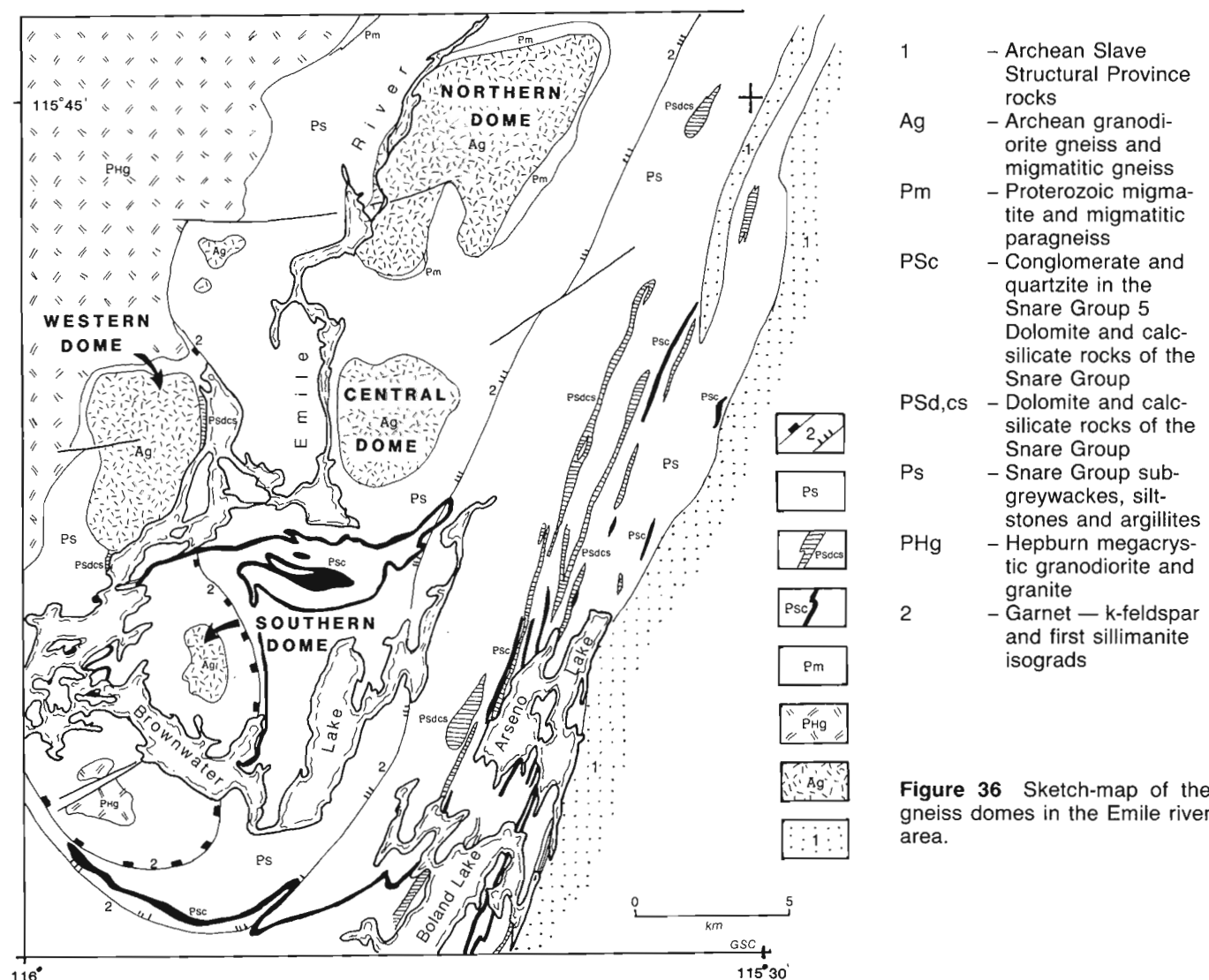


Figure 36 Sketch-map of the gneiss domes in the Emile river area.

methods at 1808 ± 43 Ma (Frith et al., 1977). The isochron has a high initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio, which suggests that the leucosome formed in situ. Since the mobile phase was folded by the F_2 deformation, the thermal peak associated with migmatization probably took place prior to F_2 deformation.

Leatherbarrow's (1975) study of the Emile River gneiss domes indicates they rose under the influence of gravity, but he suggested that the doming was also controlled by rheological changes because of regional metamorphism of the host rock and by F_1 and F_2 interference folding.

Mattberry anticlinorium

This structure extends from Castor Lake south to the edge of the map area and possibly farther south. The bulk of the rocks within it are Archean gneiss, migmatite derived mostly from 'Yellowknife Supergroup' paragneiss, and granitoid rocks similar to those in the Slave Structural Province. The anticlinorium contains several infolded keels of Proterozoic metasedimentary rocks, with locally preserved basal conglomerates resting on an unconformable surface.

Axial planar structures within the anticlinorium near the Slave Structural Province boundary west of Mattberry Lake verge eastward, and locally folds are thrust along planes that dip about 45 degrees to the northwest (Smith, 1966a).

The augen gneiss that makes up the bulk of the granitoid rocks of the anticlinorium is highly augened in its eastern part, but toward the west the augens become less deformed, and near the western map boundary the rocks are megacrystic, massive, and have textures similar to those of the Rodrigues pluton.

METAMORPHISM

Slave Structural Province

The Slave Structural Province has been metamorphosed by at least four separate events: the first affected only pre-Yellowknife Supergroup, granitoid rocks; the second was

associated with the Kenoran Orogeny; the third and fourth were associated with events in the Wopmay Orogen, and their effect is most evident near the structural province boundary.

Pre-Kenoran metamorphism of the basement

Evidence of thermal events in the granitoid basement rocks comes only from isotopic studies. Rb-Sr whole-rock isochron age determinations show an age of 2939 ± 50 Ma (Frith et al., 1977), and U-Pb determinations on zircons give an age of 2989 ± 6 Ma (Frith et al., 1986). The isochron dates a metasomatic event that took place shortly after intrusion and caused the usually Rb-depleted tonalite rocks to become enriched in K and Rb.

Metamorphism of the Yellowknife Supergroup metasediments

Metamorphism of the Yellowknife Supergroup metasedimentary rocks grades from greenschist facies, found mainly in the central parts of the Indin Lake structural basin, to upper amphibolite facies, found adjacent to migmatite complexes and igneous intrusions. Orthopyroxene-bearing granulite-facies rocks have been reported (Robertson and Folinsbee, 1974; Folinsbee, 1940) a few kilometres southeast of the map area.

Isograds have been drawn (on the geological map accompanying this report) between biotite-bearing and non biotite-bearing rocks in the Ranji Lake area (after Tremblay et al., 1953) and between those with cordierite and staurolite and those without. These sub-divisions comply with the metamorphic map of Canada (Fraser and Heywood, 1978) and are essentially the same as those of others in the map area (Tremblay, 1948; Wright, 1954; Frith, 1977), and elsewhere in the Slave Structural Province (Ramsay, 1973). No systematic study of metamorphism in the map area was done, but a detailed study of the metamorphic transition between biotite and cordierite-staurolite grades was carried out near the west arm of Indin Lake (Frith, 1977). Other metamorphic studies were done on porphyroblastic



Figure 37 Porphyroblasts of cordierite and staurolite concentrated near the top of the more argillaceous part of graded bedding, west arm of Indin Lake.

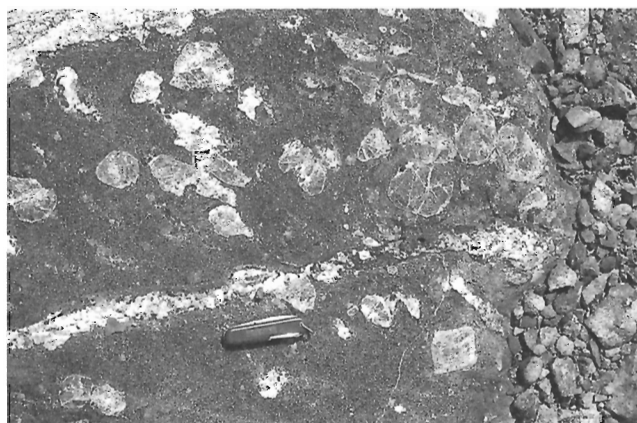


Figure 38 Retrograded cordierite porphyroblasts in argillaceous beds of migmatitic metasedimentary rock, from the Hewitt Lake area.

metasediments near Mesa Lake. The following account is drawn from these studies and from thin-section studies by Tremblay (1948) and Wright (1950) of specimens from the Chalco Lake-Ranji Lake area.

Isograds

The isograds shown on Map 1662A (in pocket) are the same as those for the 1 inch to 1 mile maps of the Chalco to Ghost Lake area, which were based on the visual presence or absence of biotite or porphyroblasts (e.g., cordierite or staurolite). A third zone, outlined for rocks metamorphosed to higher grades, was not incorporated on Map 1662A because of inadequate control outside of those areas mapped in detail.

Mineral assemblages

The least metamorphosed of the Yellowknife Supergroup metasediments invariably contain quartz, biotite, and plagioclase. Porphyroblastic rocks are present where they contained sufficient argillaceous material (Fig. 37). The main minerals forming the porphyroblasts are staurolite, cordierite, garnet, and sillimanite, all of which (with the exception of staurolite) are stable together. Chistalite was observed in the area north of Chalco Lake, where carbonaceous mudstones are present (Tremblay, 1948).

High-grade rocks commonly contain leucosome segregations of quartz and feldspar, some of which may have formed from the alteration of muscovite. Porphyroblasts of cordierite and staurolite are commonly highly retrograded in these rock types (Fig. 38, 39).

Argillaceous rocks that have been subjected to prograde metamorphism commonly contain microscopic biotite, which becomes slaty toward the biotite isograd (Tremblay et al., 1953), where visible 'spots' of biotite become apparent. Andalusite is commonly the next prograde porphyroblast to occur, and it occurs here and there within the biotite zone. The next prograde mineral is commonly cordierite, which occurs near staurolite and sillimanite. Andalusite, cordierite, staurolite, and sillimanite have been observed in the same rock in the Ranji Lake and Mesa Lake areas.

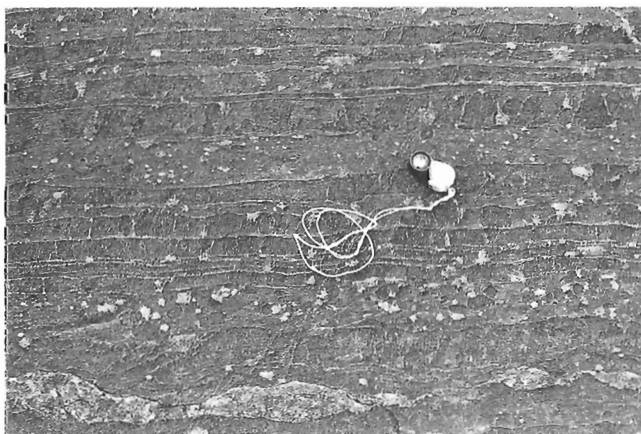
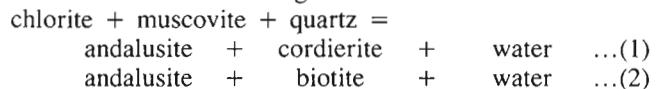


Figure 39 Retrograded cordierite porphyroblasts in Yellowknife Supergroup metasedimentary rocks from the Grenville Lake area.

Garnet is the most widespread porphyroblast because of its wide stability range. It occurs in the biotite zone and as a late-stage mineral in the migmatitic gneiss east of the Basler Lake pluton. It is present in volcanic tuffs, along with actinolite and carbonate. The variety of garnet present is invariably almandine and it is normally unaltered, except at Mesa Lake, near the Slave Structural Province boundary, where retrograde margins were observed in specimens examined in thin-section.

Cordierite is commonly poikiloblastic, incorporating early clastic and metamorphic grains. Elongated quartz parallel to S_1 may be the only evidence of earlier fabric in the nodular schists. The cordierite forms ovoid knots 2-4 cm long, but a small proportion of the knots are as much as 10 cm long. The porphyroblasts weather differentially and the poikiloblastic textures are visible to the naked eye. In some outcrops cordierite overgrows staurolite and garnet, which suggests that it locally developed later than these minerals. Clear gem-quality cordierite was a late-forming mineral in the high-grade regionally metamorphosed rocks of the Ghost Lake area (Folinsbee, 1940). More typically, cordierite is altered to micaceous minerals (pinite?) and chlorite.

Andalusite, like cordierite, is mostly poikilitic, but in places forms blades up to 15 cm in length (Fig. 40). Locally it is chistalitic. Poikilitic varieties may contain quartz and biotite in parallel alignment. Where sillimanite is present as a second polymorph, andalusite occurs as retrograded grains, indicating instability toward higher temperature conditions. Two phases of andalusite have been noted from the west arm of Indin Lake (Frith, 1978a): the first is poikilitic, the second is clear of inclusions. The andalusite may have formed from the following reactions:



Staurolite is less abundant than other porphyroblasts. In thin section it is yellow and euhedral and in the more quartz-feldspathic sediments commonly twinned. Where the grade of regional metamorphism is higher the staurolite has been retrograded to ragged relicts.

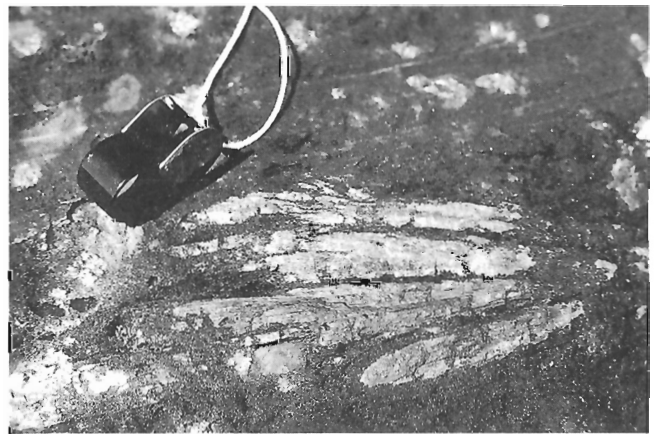


Figure 40 Andalusite porphyroblasts in Yellowknife Supergroup sediments from the north arm of Indin Lake, near the cordierite-staurolite isograd.

Sillimanite occurs as mimetic, aggregate bundles parallel to compositional planes or as aggregated knots, probably after andalusite. Coarse, non-fibrolite varieties are less common and are generally restricted to the areas displaying higher grades of regional metamorphism. More commonly, it is associated with schists containing retrograded cordierite and staurolite. In migmatitic terrane it occurs in rocks of granitic texture and is associated with leucosome segregations, which may also contain tourmaline and mica. Some typical metamorphic mineral assemblages are shown in Table 7.

Contact Metamorphism

Along the eastern margin of Sphynx Lake pluton, basic volcanic contact rocks are fractured, infilled, and partly replaced by zoisite, epidote, and fine mica. Secondary quartz is present as an extraneously derived mineral, as it is not observed in thin-section in the host rock. Near the contact the volcanic rocks have been recrystallized to a dioritic, coarser-grained texture, and along parts of the contact they are schistose.

The central volcanic rocks were observed in thin-section to include epidote, sphene, biotite, zoisite, magnetite, and pyrite. Much of the epidote is in fracture fillings. Two generations of hornblende are present in the volcanic rocks; a younger hornblende fills fractures and, like the epidote, surrounds older hornblende in a needle-like matte reminiscent of augen texture. Biotite and chlorite increase progressively away from the contact, whereas hornblende and epidote decrease. Carbonate is commonly present in these rocks, but is notably absent at the contact. Despite the obvious mineralogical changes in the volcanic rocks near the contact with the Sphynx Lake pluton, pillow structures can still be recognized, indicating regional thermal metamorphism was locally more important than deformation.

Where metasedimentary rocks are in contact with the Sphynx Lake pluton, nodules consisting of pseudomorphs of cordierite are generally absent. They are locally conspicuous 60 m from the contact, but diminish progressively toward it. Similarly, at the contact the metasediments are more massive, coarser grained, and gneissic. Garnets are more common, and modal feldspar increases toward the pluton contact, as does the proportion of leucosome veins.

Stanton (1947) noted that the main period of thermal metamorphism in the Chalco Lake area produced one or more phases of biotite. Andalusite and cordierite are commonly overgrown by a second biotite fabric, and cordierite has been seen (in thin-section) retrograded to pinite, suggesting that regional metamorphism continued after deformation. Even though several phases of the same mineral, such as biotite or andalusite, may be present, it is likely that they formed during one major phase of Archean metamorphism (Thompson, 1978).

Contact rocks along the eastern margin of the Basler pluton are not hornfelsed. Rather, they are similar to other paragneiss in the map area that have been regionally metamorphosed to the upper amphibolite facies. Both contain mica, flasered feldspar, and ribboned quartz developed

during the same phase of deformation. This foliation has been refolded by later deformation associated with plutonic emplacement. On the western margin of the Basler pluton, Smith (1966a) noted that early cordierite and mica in the host metasediment predated emplacement of the pluton. Later increase of temperature and degree of deformation penetratively deformed these early minerals and resulted in recrystallization of quartz and plagioclase. In some localities garnet and sillimanite grew after emplacement. Other porphyroblasts, such as sillimanite, were folded prior to emplacement and re-oriented into D_2 -related lineation directions. Smith (1966a) recognized that thermal overprinting outlasted deformation, resulting in an annealing of cataclastic, pre-emplacement textures in quartz and plagioclase. The post-emplacement quartz and plagioclase is unstrained and similar to the degree of strain within the pluton. The most deformed plutonic rocks have an east-northeast fabric, which parallels the paragneiss gneissosity. This gneissosity becomes north-south oriented along the eastern margin of the Indin Lake map area and is parallel to D_2 structures in the paragneiss.

Wopmay Orogen

The rocks on each side of the boundary between the Slave Structural Province and Wopmay Orogen are commonly similar in appearance and composition, consisting of Snare Group arkose, subgreywackes, argillites, and calc-silicate rocks on the Wopmay side and Yellowknife Supergroup greywacke-siltstones on the Slave side. Each is characterized by Abakuma-type metamorphism, the Slave side by Archean age (2.59 Ga) amphibolite facies and the Wopmay, by Proterozoic age (1.89 Ga) amphibolite facies. Toward the west, the Snare Group becomes more flysch-like and consists mainly of subgreywackes that resemble those of the Yellowknife Supergroup to such a degree that rock distinction can only be made by examining subtle geochemical changes or by inference, where associated rocks are present, such as dolomitic interlayers. The Archean rocks are commonly more complexly deformed than rocks of the Snare Group. The presence of K-feldspar is not diagnostic, as much of the area is on the high-temperature side of the muscovite breakdown to K-feldspar.

Archean metamorphism

Most Archean fabric and textures were obliterated or rendered more complex during the Calderian Orogeny (St-Onge et al., 1984). Yellowknife Supergroup metasedimentary migmatites west of Mattberry Lake were boudinaged by Proterozoic deformation, and remnant porphyroblasts have been retrograded to grades comparable to those of Proterozoic regional metamorphism.

In the Emile River gneiss dome area some of the gneiss around the domes and megacrystic plutons of the Hepburn Intrusive Suite contain spinel, which along with other minerals is attributed to granulite facies metamorphism (Nielsen, 1977). Rocks of the region have Abakuma facies mineral assemblages, which are zoned as follows: biotite — andalusite — cordierite — sillimanite — almandine garnet

These minerals suggest pressures of 2 to 4 kb and temperatures between 350 and 700 °C, but with little or no melting. The crystal chemistry indicates a lack of metamorphic equilibrium. However, a metamorphic grade based on distance from a thermal dome to the almandine — K-feldspar isograd may be used in conjunction with mole percent ghanite in spinel (which equilibrates readily to thermal conditions (Nielsen, 1977)) and allows a metamorphic zonation beyond the almandine — K-feldspar isograd (Fig. 41).

Biotite in the Archean biotite gneiss around the southern dome contrasts with biotite in the biotite gneiss of the Snare Group. Tetrahedral Al⁴ and the Si/Al⁴ ratio increase with metamorphic grade, but there is no systematic change

in the Y-site, as there is for the Snare Group biotites. Cordierite, in contrast to biotite, has increased Al⁴ and Mn and decreased Mg owing to exchange during Calderian metamorphism. Spinel grains in cordierite change from low ghanite with 0.73 % ZnO to 16.53 % ZnO.

Remnant orthopyroxene has been observed in the greenish gneiss that constitutes part of the western gneiss dome (Frith, 1978). This orthopyroxene probably formed during granulite-facies metamorphism under P-T conditions similar to those found in the Ghost Lake area, south of the map area, which came to a close approximately 2580 Ma ago (Robertson and Folinsbee, 1974). The uplift of the granitoid domes into a lower P-T regime gives a retrograded appearance to the granitoid western gneiss, which has been locally hydrated, changing feldspar from green to pink megascopically.

Proterozoic metamorphism

Archean rocks on both sides of the Slave Structural Province boundary give K-Ar and Rb-Sr 'dates' that indicate a thermal event at about 2.2 Ga (Frith, 1978a). Rocks equivalent to metasediments of the Yellowknife Supergroup were re-equilibrated at this time in the region west of Mattberry Lake (Frith et al., 1977) and around the Emile River gneiss domes (Nielsen, 1977). Megacrystic granodiorite derived from remobilized Archean granitoid rocks yielded similar ages (Frith et al., 1977). In the Bigspruce Lake area, 60 km south of the map area, alkaline intrusions with an age of 2150 Ma have been reported (Martineau and Lambert, 1974).

Yellowknife Supergroup metasediments west of Mattberry Lake were boudinaged by the same deformation that folded and tectonically thinned the unconformably overlying Snare Group. Porphyroblasts in some of the rocks have been retrograded, where the regional Proterozoic metamorphism is of lower amphibolite grade.

The nature of this metamorphism is not understood. Indeed it is possible that these 'dates' reflect a mixture of Archean and Proterozoic isotopic systems. High-precision U-Pb dates from zircons in the Wopmay Orogen have placed the Calderian Orogeny at 1885 Ma (Hoffman and Bowring, 1984). Muscovite pegmatite in the Slave Structural Province 10 km from its boundary with the Wopmay Orogen was dated by Rb-Sr muscovite at 2573 ± 39 Ma (O. Van Breeman, personal communication, 1985) suggesting that a ca. 2.2 Ga metamorphic overprint was variable and did not take place everywhere along the boundary. Recent data indicate rift-related, alkaline intrusions along the boundary at Bigspruce Lake, 50 km south of the map area, at 2188 Ma (Cavall and Baadsgaard, 1986).

Calderian metamorphism

Metamorphism in the Wopmay Orogen grades from greenschist facies (where the uppermost dolomites of the Snare Group are in contact with the Slave Structural Province boundary fault near Norris Lake) to upper amphibolite facies (where the Snare Group is in contact with rocks of the Hepburn Intrusive Suite). According to Nielsen (1977),

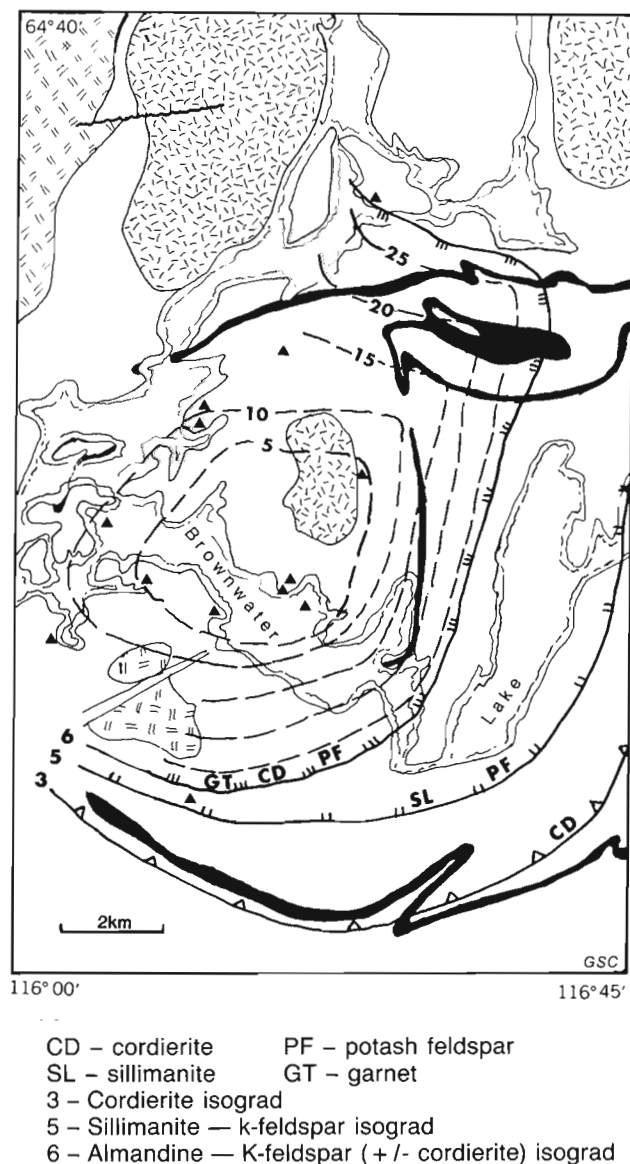


Figure 41 Prograde isograds in the Brownwater Lake region. Water-saturated stable minerals are noted on the hot side of each isograd. The contours are drawn from the ghanite content of spinel minerals (triangles), which prograde toward a granulite facies «hot spot». (Adapted from Nielsen, 1977) Rock types are the same as in Figure 36.

the rocks grade from east to west through: (a) chlorite zone; (b) biotite zone; (c) cordierite — andalusite zone; (d) cordierite — sillimanite zone; and (e) cordierite — almandine — K-feldspar zone (Fig. 41).

Chlorite zone

The chlorite zone is up to 2 km wide and extends from north of Arseno Lake to Norris Lake. Pelites contain chlorite, sericite, quartz, feldspar, and minor ilmenite and pyrite. Grains are commonly in a recrystallized quartzofeldspathic matrix. The upper limit of this zone is defined by the biotite isograd.

Biotite zone

Biotite is present in all rocks of the Snare Group, except for those in the chlorite zone. The upper limit of the zone is defined by the cordierite isograd.

Metapelites are characterized by chlorite and sericite phyllitic minerals, and by quartz and feldspar. Porphyroblasts of biotite with rutile needles cut the cleavage planes; otherwise the mineralogy is similar to that in comparable rocks in the chlorite zone. Graphite was noted in some samples from this zone.

Subgreywackes have the same mineralogy as the metapelites, but have more quartz and feldspar. Biotite is less abundant and plagioclase is more recrystallized toward the cordierite-andalusite zone. Spessartine garnets are present locally.

Cordierite-andalusite zone

Cordierite-andalusite-zone rocks contain poikiloblastic porphyroblasts of cordierite and euhedral andalusite in a matrix of biotite, muscovite (or chlorite), feldspar, and quartz. The rocks are chiefly subgreywackes, which are more massive than similar composition rocks of lower metamorphic grade. The foliation is faint and defined by the sub-parallel alignment of mica. The upper part of the cordierite zone is defined by the presence of garnet in association with cordierite and biotite.

Cordierite-sillimanite zone

The first appearance of sillimanite in Proterozoic gneiss occurs in rocks that are characterized by a rusty appearance. The sillimanite in such localities has replaced andalusite. A second sillimanite is formed with K-feldspar by the breakdown of muscovite and quartz. In general the rock is a rust-coloured gneiss with cordierite porphyroblasts. The sillimanite may occur as bundles of fibrolite or as coarse prismatic grains. The rocks locally form banded migmatites.

Cordierite-almandine-K/feldspar zone

This is the highest metamorphic grade attained by rocks of the Snare Group in the map area. Common minerals in the gneiss of this zone are cordierite, garnet, biotite, quartz, ilmenite, rutile, plagioclase, and sillimanite. Sillimanite occurs within cordierite, but is never found in contact with

garnet. Migmatites are common, generally associated with abundant garnet. Anhedral garnet is locally rimmed with biotite and plagioclase according to the following retrograde reaction:

$\text{garnet} + \text{K-feldspar} + \text{water} = \text{biotite and plagioclase.}$

Nielsen (1977) recognized six isograds in the Arseno Lake — Brownwater Lake area where:

- 1 biotite is produced;
- 2 andalusite is produced;
- 3 cordierite is produced and both muscovite and chlorite are consumed;
- 4 sillimanite is produced and andalusite is consumed;
- 5 sillimanite and K-feldspar are produced and both muscovite and quartz are consumed; and
- 6 almandine and K-feldspar are produced (with or without cordierite) and both biotite and sillimanite are consumed.

To avoid congestion, only isograds 1 and 4 have been drawn in the Wopmay Orogen part of the map area on the Map 1662A (in pocket). The other isograds have been shown in Figures 7 and 41. Isograds 1 and 3 for the Wopmay Orogen are essentially the same as those drawn on the geological map in metasedimentary rocks of the Slave Structural Province.

ECONOMIC GEOLOGY

History of exploration

Gold was discovered at Indin Lake in the summer of 1938 by prospectors of the Territories Exploration Company Limited. Many claims were staked during the winter of 1938-39 and summer of 1939. In early 1941, Frobisher Exploration Company Limited drilled the 'Brown' vein on the property that became North Inca Gold Mines Limited. Interest in the area waned until 1945, when renewed exploration outlined many prospects, which led to underground exploration on three properties. No significant gold production ever materialized. Lord (1942) reported that 83 oz. (2415 g) of fine gold was recovered from the deposit as part of a feasibility study carried out during the winter of 1938-39. Little work was done in the area between 1947 and the 1970s, when exploration for base metals took place.

Freeport Oil Company carried out work at the southern tip of Spider Lake on the Peter claims, the Farkle claims at the northern end of Indin Lake, the JAN claims northeast of Lex Lake, and on the Van claims along the southeast margin of Indin Lake. Airborne EM and aeromagnetic surveys were carried out in 1970, and several targeted areas in felsic to basic volcanic and hypabyssal rocks, metasedimentary graphitic argillite, and greywacke were drilled. Sphalerite and chalcopyrite were noted, and assays of drill core from the VAN claims revealed up to 1 % Cu, 4 % Zn, and 5 oz. (142 g) of Ag, but no significant mineralized intersections were encountered. Au was negligible (J. Boldy, Assessment Reports, Canada Department of Indian and Northern Development).

Other exploration for base metals was carried out on the Jig claims, east of Indin Lake, by Great Plains Development Company in 1971. Ground and EM surveys were carried out but no follow-up work has been reported.

In 1974 Cominco Ltd. drilled 20 holes in the Baton Lake area and in 1984 acquired control of ground in and around the Colomac gold deposit. In the 1940s the property was thought to contain 9 720 000 metric tons of potential ore with gold content averaging 2.33 g/t (Northern Miner, May 30, 1985).

Echo Bay Mines Ltd. and partners announced a gold strike at Lex Lake on the Kim claim group late in 1984. The mineralization occurs mostly in recrystallized pillowed andesite near the interface between volcanic and sedimentary rocks. By 1985, 37 holes had been drilled, and further work was in progress. Preliminary results suggested mineralization over a width of 2 to 30 m along a strike length of about 600 m and grading up to 17 g/t of Au, with common grades of 8 g/t in seven of the better holes. In 1985 a reverse fault was discovered, extending the known reserves to greater depth. The success of Echo Bay Mines increased interest in the area, and in 1985 and 1986 several major and junior companies were actively exploring and acquiring new ground.

Characteristics of the gold deposits

At present there are many known gold occurrences in the map area. The following general description of the gold mineral occurrences is based mostly on unpublished reports by officers of the Geological Survey of Canada from work carried out between 1948 and 1954.

Gold occurs in the free state in grey quartz veins, where it is mostly fine and not readily observed. Where present, it is commonly associated with arsenopyrite and pyrite. Many of the associated veins are carbonate-bearing.

Gold-bearing quartz veins occur individually or as stockworks. In the main zone of the North Inca gold deposit, zones of gold-bearing quartz veins 2-m wide are present, locally thickening to 5 m. Antimony-bearing minerals, common to gold deposits in the Yellowknife area, have not been reported from Indin Lake.

Gold-bearing veins most commonly cut Yellowknife Supergroup rocks and have not been reported cutting diabase, gabbro, or any granitoid rocks, except at the Colomac deposit, where gold occurs in fractures developed in quartz-albite rock that is presumed to be of synvolcanic, hypabyssal origin and related to volcanism. Gold-bearing veins within volcanic strata generally have higher gold contents than those within metasedimentary rocks. The highest-grade veins within the metasedimentary rocks are those closest to the volcanic-sedimentary interface, suggesting that the gold is spatially related to volcanism. Evidence of shearing is common along the interface, but is more common in metasedimentary rocks.

The known gold-bearing deposits around the Leta Arm of Indin Lake are found along one shear zone, which may have localized the gold. These include the Diversified shaft, the North Inca shaft, and the Lexindin deposit. Other deposits in the area are located along fractured or shattered zones associated with northerly trending shears, possibly associated with regional folding of the supracrustal rocks in the Indin structural basin (see Synthesis section). It is noteworthy that few if any of the showings in the area are

associated with the northwest-trending oblique-slip faults. Gold showings are most commonly associated with rocks of greenschist-facies regional metamorphism.

Quartz veins and stringers are widely distributed through the area. In a few places they are grouped and abundant, forming zones up to 4 m wide that extend for up to 100 m along strike. Most veins are lenticular, narrowing and swelling in irregular fashion, commonly pinching out at both ends. The lenses may be up to 2.5 m wide, and some have been measured up to 20 m long. Groups of quartz-veins may occupy sheared rock, whereas large single veins are most commonly associated with bedding and joints. Although most veins parallel the bedding, a few trend northwest, with steep to vertical dips, modified locally by late folding.

In Float Lake, Chalco Lake, and Leta Arm regions most of the auriferous veins appear to have developed along cleavage planes that formed during D₂. The veins have a preferred orientation and are associated with fractures best developed in brittle rock, such as the quartz-albite host rock of the Colomac Deposit east of Steeves Lake. Some gold may also have migrated, not only along S₂ fracture planes or shears, but along volcanic contacts, such as those between inter-flow tuffs and volcanic breccias (Tremblay et al., 1953). The concentration of gold along the interface between the volcanic and sedimentary rocks suggests that it was also a preferred migratory route for gold-bearing solutions.

Auriferous quartz veins are known to cut only rocks of the Yellowknife Supergroup and genetically related synvolcanic dykes and sills. The quartz veins that cut gabbro dykes, granitoid plutons, and migmatites are barren. Since both diabase and gabbro dykes are Proterozoic, it is evident that there were at least two periods of quartz veining. In the Yellowknife area, the gold mineralization was associated with Archean regional metamorphism (Boyle, 1961). The general distribution and apparent age of gold in the showings in the Indin Lake map area are similar to those of the Yellowknife area, and they probably share a common mode of origin.

Quartz in auriferous veins, stringers, and lenses is most commonly white, milky white, and grey. Less common are veins of light grey, bluish or brownish grey, rusty red, and black. In some localities quartz is mottled or fractured, but mostly it is glassy, massive, or sugary. White quartz is vuggy in places. The white or milky variety of quartz locally cuts the grey variety, but more commonly the colour just grades from one to the another. Carbonate is generally present and may make up to 50 % of vein material. It commonly weathers out partly as a buff coloured residue. Tourmaline is locally present. Other minerals identified in the field or under the microscope include; pyrite, marcasite, pyrrhotite, arsenopyrite, chalcopyrite, galena and sphalerite. Arsenopyrite crystals may be several centimetres long.

Mineral Deposits

Only the principal mineral deposits are described here. For a more complete description of the occurrences of gold and other economic minerals in the map area the reader is referred to Mineral Inventory Reports of the Department of Energy, Mines and Resources .

The Diversified Mine

In 1945 Diversified Mining commenced drilling on the company's Arseno group claims. Its gold-bearing quartz veins were thought to contain sufficient gold to mine, and in 1947 the company opened the Inca mine. Initial values of 15 g/t were reported, but the mine did not get past the development stage, even though 44 000 tons of blocked-out ore at a grade of 22 g/t over a 60 m length was reported. A 500 short ton per day mill was planned and construction started, but production never got underway. By 1948 tonnage was shown to be 'medium' and market conditions were described as 'adverse'. As of October 1948, the gold-bearing shear zone was known to extend 88 m over a width of 2.2 m grading 12 g/t gold.

The Colomac Deposit

The gold occurrences in the quartz-albite dyke along the west side of Baton Lake are found on properties formerly owned by Colomac Yellowknife Mines Ltd., Indian Lake Gold Mines Ltd., Dyke Lake Gold Mines Ltd., Hearne Yellowknife Mines Ltd., Indyke Gold Mines Ltd., and Nareco Gold Mines Ltd. None of these companies is now in existence. The area, as of August 1987, is controlled by Neptune Resources.

Gold was first found in 1945 in quartz veinlets in the quartz-albite dyke (Fig. 42). During 1946, 14 300 m of diamond drilling were carried out and an underground adit opened 175 m into the dyke. Exploration drifts, both north and south, totalled about 760 m. About 65 000 metric tons of potential ore per vertical metre were outlined, for a possible total deposit of 9 720 000 metric tons of gold ore. Bulk samples from the adit cuts were assayed at 2.4 g/t of gold and 2.1 g/t of silver. Interestingly the bulk samples showed about 25 % more gold than did the drill-core assays. In 1974 Cominco Ltd. drilled an additional 20 holes over 2 865 m.

Lex Lake deposits

The recently announced gold re-discovery by Echo Bay Mines (Northern Miner, October, 1984) was originally described as the «A-zone» by Stanton (1947) near the presently positioned DDH 84-1. The gold occurs in quartz carbonate veinlets and stringers in recrystallized andesite. The contact between the volcanics and metasediments is not exposed, but lies beneath Lex Lake. Minerals include free gold, pyrrhotite, pyrite, and arsenopyrite (Stanton, 1947). Initial work included about 917 m of diamond drilling, trenching, and assay work. Although the original work showed that the mineralized zone extended over 140 m or more, gold values were considered to be too low for follow-up work. As of May 30, 1985, 37 holes were drilled on the Kim claims, some of which are reported in Table 7.

Other mineralization

Sulphide minerals are common throughout the Yellowknife Supergroup. Rocks near the contact between the volcanic and sedimentary rocks are commonly more mineralized than those elsewhere. Felsic volcanic and porphyry rocks

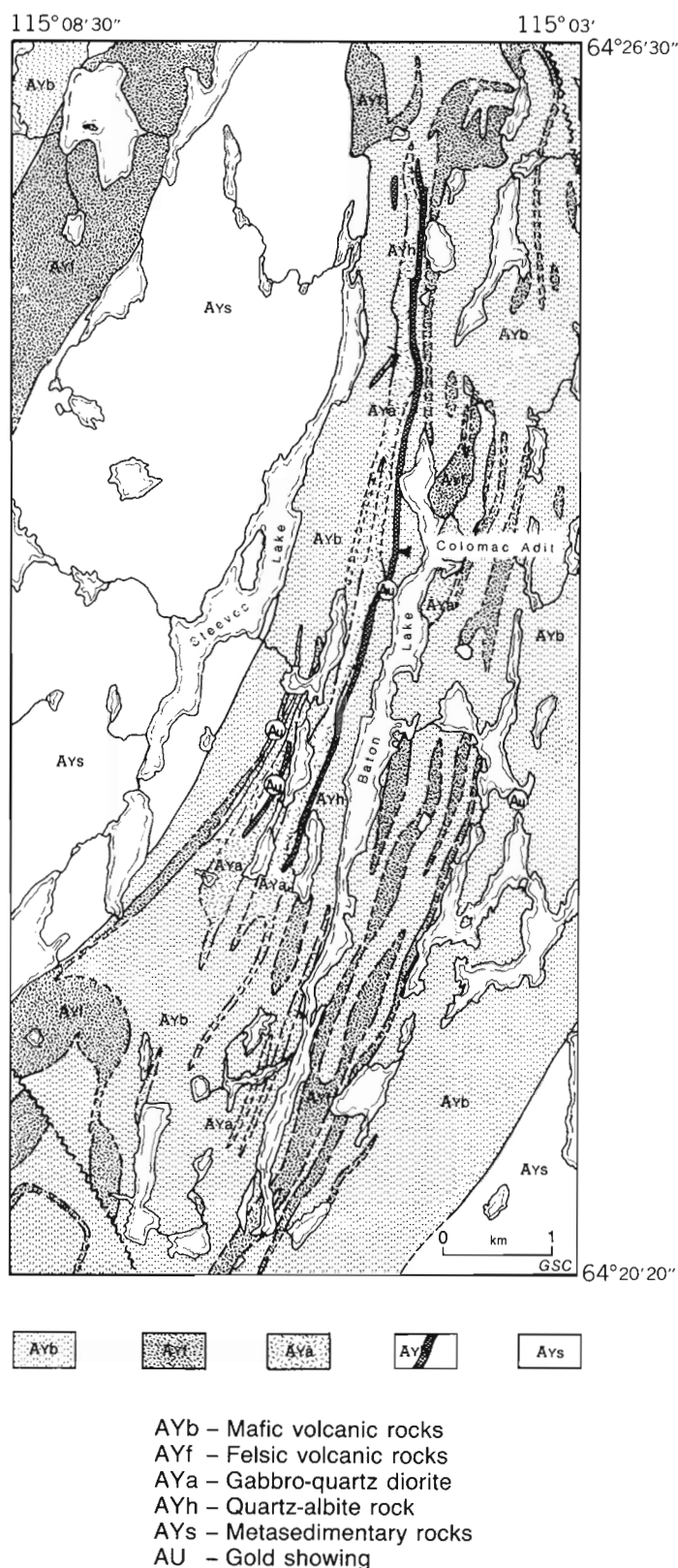


Figure 42 Geological sketch-map of the Baton Lake area showing the relationships of the auriferous quartz-albite sill to the Yellowknife volcanic and metasedimentary rocks of the region.

locally contain as much as 5 % pyrite. Galena, chalcopyrite and shalerite have been reported from the Chalco Lake and Cranston Lake areas (Stanton et al., 1954).

In the Chalco Lake map area, molybdenite has been reported in pegmatites formed within nodular schists. Black tourmaline is abundant in pegmatites in the western half of Ranji Lake, and beryl has been reported in pegmatites in the eastern half of Ranji Lake at 64°05'N and 115°05'W (Mulligan, 1968).

Hints to gold prospectors

The most common gold-bearing veins are those with grey quartz or quartz-carbonate within volcanic and metasedimentary rock of the Yellowknife Supergroup. They generally also contain some pyrite and arsenopyrite. Quartz veins within the volcanic rocks carry a higher percentage of gold in most cases. Sheared zones and silicified

Table 7. Metamorphic minerals in the Yellowknife Supergroup metasedimentary rocks from 12 thin-sections from the Ranji Lake area (Tremblay, 1948).

QZ	MS	BO	GR	ST	PG	AD	CD	SL	TR
X	X	X			X	X	X		X
X	X	X			X		X		
X	X	X				X			
X		X		X					
X		X		X		X	X		
X		X		X			X		
X		X	X		X				
X		X	X				X		X
X		X	X		X	X		X	
X		X			X	X			
X		X			X				X
X		X							
X		X							

QZ = quartz MS = muscovite BO = biotite
ST = staurolite PG = plagioclase AD = andalusite
SL = sillimanite TR = tourmaline GR = garnet
CD = cordierite

Table 8. Assay results from some of the higher gold content diamond drill hole cores from the Kim claim group, Lex Lake.

Hole	From:	Length	Au Grade (g/t)
84-1	25.30	11.19	7.10
84-2	37.49	12.38	9.49
84-3	56.39	29.81	4.66
85-1	92.29	8.29	7.86
85-9	100.49	5.09	8.73
85-24	51.36	15.03	8.44
including	51.36	1.83	16.88
	54.80	1.65	11.06
	58.06	8.32	8.73
85-29	2.90	25.85	3.20
including	2.90	6.10	6.40
	44.20	8.38	2.91
	44.20	2.72	6.98
	74.49	2.50	8.15

shear zones within metasedimentary rocks near the volcanic-sedimentary contact warrant careful attention, as many gold occurrences have already been found in that locale. Boyle (1961) considered that the gold was related to low-grade regional metamorphism, whereby gold was 'sweated' out of the volcanic and metasedimentary rocks and as a result is more commonly found in rocks of low-grade regional metamorphism where it is localized in quartz veins. Veins in rocks other than the volcanic and metasedimentary rocks of the Yellowknife Supergroup are generally barren.

The northwest-trending faults and associated structures in the Indin Lake structural basin and the dykes that make up the Indin diabase dyke swarm are late geological features and are unlikely to contain appreciable gold, despite the local occurrences of abundant pyrite.

SYNTHESIS

Tectonic events in the map area took place during three orogenic events; an enigmatic pre-Yellowknife Supergroup event, the "Kenoran Orogeny", and the Calderian Orogeny. A summary of the relationships among orogeny, supracrustal deposition, metamorphism, and plutonism is presented in Table 9.

Archean pre-Yellowknife Supergroup tectonism

The oldest rocks in the map area have isotopic values that indicate tectonism about 3.0 Ga. Areas of tonalite gneiss (now granite to granodiorite in composition) found underlying the lowermost volcanic rocks in the Grenville Lake region give U-Pb zircon dates of 2989 ± 5 Ma (Frith et al., 1986), comparable to a Rb-Sr whole-rock isochron from the same area (2939 ± 51 Ma; Frith et al., 1977). The tonalite gneiss has been metasomatized and the Rb-Sr isochron measures when Rb was introduced. Sporadic occurrence of basement tonalite gneiss as paleosome in migmatite terrane in the map area and the widespread occurrence of similar rocks throughout the Slave Structural Province suggest that older basement rocks were widespread and formed the basement on which the volcanic rocks were deposited (McGlynn and Henderson, 1970; Frith and Roscoe, 1980).

Zircons in the tonalite, although of differing shapes and sizes, are concordant and show no overgrowths, suggesting they formed magmatically. Rb-Sr whole rock studies suggest metasomatism followed close behind plutonism.

The extent of the tonalite and granite rocks before volcanism is unknown, but there are several factors that point to widespread distribution. The migmatite terranes (Meyer, Snare migmatite terranes) contain bodies of gneiss similar to the basement tonalite gneiss dated as older than the volcanic rocks. This migmatite-enclosed gneiss (e.g. near Snare Lake and Drumlin Lake) is structurally more complex than other granitoid rocks in the map area and it is reasonable to assume that much of the more granitoid migmatite gneiss and the plutonic rocks within these migmatite areas is derived from basement rock that was re-mobilized during subsequent orogeny. Banded and schlieren-type migmatite results from high-grade regional metamorphism of layered

rocks, but the same process acting upon massive granitoid gneiss would cause batch melting and plutonism, yielding rocks of granodioritic and granitic composition.

Evidence from outside of the map area suggests that basement gneiss once covered much of the area presently underlain by Yellowknife Supergroup supracrustal rocks and younger granitoid rocks:

- (1) The sedimentary rocks of the Slave Structural Province are of granodiorite composition and are too rich in quartz to have been derived from the type of volcanic rocks present in the volcanic belts exposed at the present surface and must have been derived from another quartz-rich provenance (Henderson, 1975; Pettijohn, 1970). Recent work suggests that both felsic volcanic rocks and granitoid rocks were probable sources (see below).
- (2) Readily recognized basement gneiss in the Slave Structural Province is rare. However, in the known widely disseminated occurrences the basement gneiss always structurally underlies the oldest volcanic rocks of the region.
- (3) The oldest flows are of tholeiitic composition, but the younger parts are calc-alkaline, such as in the Yellowknife volcanic belt (Condie and Baragar, 1974). In some belts such as the Hackett River Group greenstone belt, most of the rocks have calc-alkaline compositions. Volcanic rocks of calc-alkaline composition were probably melted from the crust (Frith and Fryer, 1985).
- (4) The age of the basement gneiss varies from place to place, but values older than the Yellowknife Supergroup are now commonplace (Nikic et al., 1980; Frith et al., 1974; Schärer and Allégre, 1982; Krogh and

Table 9. Correlation of supracrustal deposition, deformation, and plutonism within the map area.

Age (Ga)	Supracrustal deposition	Deformation*	Metamorphism	Intrusion	Wopmay Orogen	Slave Structural Province
Proterozoic (1.84)	Geat Bear SG	ENE dextral faulting		I-5	— NW and ENE conjugate faulting, Gt Bear Bath.	— ENE dextral strike-slip faults
Proterozoic (1.9)	Coronation SG	C	M ₃	I-4	— intrusion of Hepburn Intrusive Suite — emplacement of gneiss domes — folding of Coronation S.G. — intrusion of diabase sills — deposition of Cornation S.G.	— northwest left-oblique faulting — depression of Indin S.B. uplift to west — local open folding, NE cleavage in YKS — intrusion of Indin Diabase — intrusion of Strachan granodiorite?
Proterozoic (2.2)	(none)		M ₂	outside the area	— Some Rb-Sr systems reset — Pre-D ₄ in Archean metasedimentary rocks	— Some Rb-Sr, K-Ar isotopic systems reset
Archean (2.58)	Yellowknife metasediments Yellowknife volcanics	K	M ₂	I-3	— plutonic and migmatic rocks present	— anorogenic plutons, anatectites, migmatites — orogenic plutons
(2.67)				I-2	— equivalents to Yellowknife Supergroup are present	— synvolcanic intrusions
Archean (2.9)	?	PK	M ₁	I-1	— pre-Yellowknife granitoids not identified	— K and Rb metasomatism (M ₁) — intrusion of tonalite pluton

*
 PK = Pre-Kenoran — only evident in the fabric of suspected synvolcanic metagabbro dykes.
 K = Orogeny analogous to the Kenoran — 2 sets of folding recognized:
 F₁ — ENE isoclinal folding of Yellowknife Supergroup identified mostly in areas of low-grade regional metamorphism.
 F₂ — NNE isoclinal folding of Yellowknife Supergroup identified mostly in areas of medium- to high-grade regional metamorphism, such as the Indin structural basin. In other areas, D₂ structures are commonly co-planar with those of D₁.
 C = Calderian Orogeny — 3 sets of folding were recognized:
 F₁ — ENE cylindrical to isoclinal folding of Coronation Supergroup rocks (equivalent to brittle NW sinistral faulting of Indin structural basin and margins).
 F₂ — NNE isoclinal folding, re-folds F₁ in regions of high-grade regional Proterozoic metamorphism. This is the only folding recognized in low-grade rocks.
 F₃ — N-S open folding, and crenulation of F₁ and F₂ — restricted occurrences..lm5

Gibbons, 1978; Chamberlain et al., 1984; J. King and S.A. Bowring, personal communication, 1986) with dates ranging from 2.7 to 3.5 Ga. This range of ages is comparable to the range of ages of older rocks found in other Archean terranes, indicating the widespread occurrence of 2.7+ Ga plutonism.

Archean “Kenoran” Orogeny

The Kenoran Orogeny was a major tectonic event, typified in the Superior Structural Province (Stockwell, 1964), but the term has been used in the Slave Structural Province for an analogous, somewhat younger event, (Hill and Frith, 1982). Supracrustal deposition in the Slave Structural Province was similar to that in the Superior Structural Province, but the proportion of metasedimentary rocks far exceeds that found in the Superior Province (McGlynn and Henderson, 1970). This difference may reflect age, levels of erosion, and other factors, but from recent studies of the Slave Province it probably reflects different supracrustal source rocks, the metasedimentary rocks in the Slave Structural Province being derived principally from a felsic volcanic source (Frith and Fryer, 1985).

Supracrustal Deposition

The Yellowknife Supergroup was deposited about 2669 ± 16/-14 Ma ago (Frith and Loveridge, 1982). The supergroup's metasedimentary rocks were eroded from a penecontemporaneous volcanic and granitoid source and some probably older granitoid gneiss (Schärer and Allégre, 1982). Frith and Fryer (1985) concluded, from rare-earth-element and mass-balance studies of the granitoid and volcanic rocks of the northeast part of the Slave Structural Province, that much of the sediment in the Yellowknife Supergroup was probably derived from felsic, pyroclastic rocks and the contribution of granitoid rocks to the sediments that make up the Yellowknife Supergroup need not be excessive. Their conclusion makes the granitoid provenance of the sediments less important than earlier studies (McGlynn and Henderson, 1970). However, the volcanic rocks in many parts of the Slave Structural Province were themselves probably derived from a granitoid source, as discussed further on. Where mafic volcanic rocks predominate over felsic ones, as in the Indin Lake map area, source rocks, whether they be felsic volcanic, or felsic granitoid, were eroded away or had a provenance outside of the map area, such as the intermediate to felsic volcanic rocks of the High Lake area, to the northeast.

The preponderance of turbiditic metasediments in basins underlain partly by volcanic flows and pyroclastic rocks suggests that erosion and deposition were rapid. The presence of volcanic conglomerate at the interface between the volcanic and sedimentary rocks implies high energy wave or stream action and the local emergence of volcanic terrane. The present pattern of volcanic rocks overlain by these conglomerates suggests that the main Indin belt thinned toward the northeast, underlain not by basement gneiss, but by metasediment, as suggested for some of the volcanic flows in the Mesa Lake area (Ross, 1966).

Volcanic flow-lines in the more felsic rocks south of Spider Lake indicate that bedding trends were east-northeast, similar to the orientation of the volcanic belt south of Hewitt Lake. The volcanic rocks were subsequently deformed by north-northeast-trending folds (F_1) and then re-folded by more northerly trending folds (F_2), to give their present configuration, which gives a false impression that volcanic deposition was north-south oriented.

The first phase of “Kenoran” Orogeny involved widespread tholeiitic and intermediate-to-felsic calc-alkaline volcanism, and less voluminous synvolcanic intrusions of gabbro, tonalite, and granodiorite. The age of the more gneissic plutonic rocks of the region, such as the Sphynx Lake pluton, is uncertain, but studies at the margin of the pluton indicate it post-dated the adjacent volcanic rocks. The presence of granitoid cobbles in paraconglomerates of the Grizzly Lake area indicates that plutonic rocks similar to those in the Sphynx Lake pluton were present during their deposition. However, synvolcanic intrusions of similar size have not been recognized in the map-area. Smaller, generally elongated felsic sills and small round mafic plugs are present, but these make up a small part to the total volume of eroded rocks and were probably not a major source of granitoid detritus.

Formation of metamorphic, hybrid, and plutonic rocks

Metamorphic rocks

The distribution of isograds outlines the ‘hot’ and ‘cold’ parts of the map area. The ‘hot’ areas are located above predominantly granitoid regions, such as the plutonic and migmatitic terranes and the ‘cold’ areas are situated where supracrustal rocks are abundant, as in the Indin Lake basin area. Density studies of the Origin plutonic complex demonstrated that the control for the distribution of isograds was at least partly influenced by isostasy. Large areas presently underlain by migmatitic rocks became less dense, by processes similar to those described below, and rose relative to the more dense areas underlain by heavy supracrustal rocks.

The thermal history of the supracrustal rocks in the region may be deduced from geochronological data. The supracrustal rocks were deposited throughout the Slave Structural Province at 2.67 Ga (Frith and Loveridge, 1982), whereas the anorogenic plutonic rocks were intruded in the Indin Lake map area at 2.59 (Frith et al., 1986). Regional metamorphism most commonly pre-dates the intrusion of plutonic rocks, retrograding porphyroblasts developed in the metasedimentary rocks. Since regional metamorphism grades from sub-biotite grades to granulite facies (in the Ghost Lake area, in the south-adjacent map area) the changes in pressure and temperature conditions probably came about by thickening of the crust, followed by increased temperature build up that resulted in the formation of lower crust melts, intrusion and isostatic adjustments whereby plutonic and migmatitic ‘ovals’ (in the sense of Salop, 1971) rose to higher levels. The intrusion of these relatively hotter rocks locally remetamorphosed or retrograded existing metamorphic minerals in a so called ‘second’ phase of orogeny, as outlined below.

Hybrid and plutonic rocks

The second phase of the "Kenoran" Orogeny resulted from crustal thickening and thermal build-up in the crust, with the ensuing production of hybrid rocks, derived from supracrustal rocks and plutonic rocks. Three processes are envisioned which took place alone or concurrently: (1) granitoid rocks in the catazone were melted and intruded into the mesozone; or (2) rocks in the catazone were desiccated, producing alkalis and water and leaving residual granulites; or (3) hybrid rocks were formed at mesozonal levels from catazonal and possibly mantle products.

- (1) Bridgwater and Collerson (1976) suggested that alkalis such as Rb and K may be derived from the mantle during melting, which would provide the parent nuclides that are needed to give «mantle-derived» $^{87}\text{Rb}/^{86}\text{Sr}$ ratios, yet satisfy the constraints that require calc-alkaline magmas to be generated within the crust (Wyllie et al., 1976). This would explain the occurrence of rocks with «mantle» $^{87}\text{Rb}/^{86}\text{Sr}$ ratios.

Partial melting of rocks to produce granitoid plutons is not a viable process, owing to the high viscosity of granitic liquids (Rice, 1981). Batch melting, on the other hand, would produce rocks of the same composition as the source rock. Frith and Fryer (1985) have postulated that melting of granitoid basement gneiss was a probable source of the plutonic rocks in the northeastern part of the Slave Structural Province. They also suggested that single-composition magmas that were formed from batch melting of low-Rb tonalites would, when mixed with mantle-derived alkalis, form a suite of plutonic rocks if differentiated, over the range of compositions from quartz diorite to granodiorite. Rocks more felsic than granodiorite were thought to have formed from the melting of metasediments, similar in composition to those of the Yellowknife Supergroup and mixed with catazone- or mantle-derived alkalis, particularly K. These more potassium- and rubidium-rich rocks have higher initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios than tonalite progenitors, which may explain the higher $^{87}\text{Sr}/^{86}\text{Sr}$ ratios observed from Rb-Sr whole-rock isochron studies of granites in the Indin Lake map area (Frith et al., 1977).

- (2) South of Daran Lake, in the Ghost Lake area, basement gneiss has been metamorphosed to the granulite facies. A Pb-Pb whole-rock isochron from these rocks of 2580 Ma indicates the rocks were metamorphosed at this time, which is consistent with the 2595 Ma age of regional metamorphism ascertained from U-Pb monazite age determinations (Frith et al., 1986).
- (3) Alkalis and water produced in the mantle and catazone during orogeny would accumulate in the mesozone. The introduction of these constituents would affect the mesozonal rocks in different ways. Massive granitoid rocks would be metasomatised *in situ* and have irregular contacts (Cotterill Lake megacrystic granites) or if buoyant, would intrude in viscous spherical shapes (e.g. Whitewolf granite).

Alkalis and water from the catazone and mantle would collect in the leucosome phase of migmatites formed by metamorphic segregation (Kretz, 1977) or partial melting. The migmatites in the map area are commonly

more felsic than the paragneiss that constitutes the likely source rocks of the area, particularly where the paleosome is more closely linked to volcanic rocks than to metasedimentary rocks. The concentration of granitic components in the leucosome reflects liquidus conditions and the vertically oriented, planar channel-ways in migmatites through which mobile constituents migrated. Since leucosome veins are commonly folded or otherwise deformed, it is concluded the migmatites formed during the peak of thermal metamorphism, prior to D_2 .

Hybrid rock types make up the bulk of the granitoid rocks formed in the mesozone, currently exposed at the erosion surface. These include the following:

- (a) Migmatites — from tonalite basement.
- (b) Migmatites — from paragneiss, mostly from metasediments.
- (c) Megacrystic granodiorites — from K-metasomatism of homogeneous tonalite formed in place or intruded into higher levels.
- (d) Granites — from metasomatised and subsequently batch-melted metasedimentary rocks.

Regional thermal metamorphism also changed the rheology of the enclosing rocks, allowing less dense granitoids to rise in core zones where rocks are hottest and wettest. This gives a false impression that plutonic rocks are providing the heat for regional metamorphism. There is no evidence from the plutons of the region that they produced the heat required to metamorphose the country rocks of the region, except where late, still hot plutons were gravitationally emplaced into lower metamorphic-grade country rock. These rocks are always granites with low specific gravity.

Deformation and metamorphism

Pre-Yellowknife deformation features and metamorphic fabrics from basement areas were largely destroyed by "Kenoran" Orogeny overprinting. Archean deformation followed the deposition of the Yellowknife Supergroup. Deformation (D_1) was locally contemporaneous with the peak of thermal metamorphism, as determined from the age of readily equilibrated basement monazite (2596 ± 4 Ma, Frith et al., 1986), whereas the close of thermal metamorphism, measured from the age of crystallization of undeformed pegmatite, took place at 2573 ± 39 Ma (O. Van Breeman, personal communication, 1985). This 23 Ma time-spread between D_1 and D_2 is consistent with the view that the two are broadly contemporaneous (Thompson, 1978).

Although the time of the thermal peak of regional metamorphism probably varied from place to place, close study of contacts showed that the thermal metamorphism outlasted plutonism, except possibly where low-grade regionally metamorphosed rocks were the host rocks (e.g. the northeastern part of the Basler plutonic complex). If there was a second thermal peak as suggested by Frith (1978a), it would also be broadly coeval with deformation and plutonism. Regions of high-grade metamorphism were

probably hotter for longer and the tailing effect on cooling may be reflected in younger K-Ar blocking temperatures determined from rocks of these regions.

The fabric and form present in the Basler plutonic complex implies that it was intruded during the first phase of folding and was uplifted during D_2 and subsequent deformations. Both the basin supracrustal rocks and the plutonic rocks along the boundary of the Slave Structural Province were faulted in patterns that accommodated uplift of the granitoid areas along the boundary and depression of the heavier supracrustal rocks of the Indin structural basin during two events associated with 1.89 Ga tectonic events in the Wopmay Orogen.

Textures within intrusive bodies in the map area show a considerable variation, and rocks such as the marginal phases of the Origin plutonic complex are more gneissic and possibly older than the more massive, central portions. Plutons, such as the massive megacrystic granites of Cotterill Lake, gave a Rb-Sr whole-rock isochron age of 2532 ± 132 Ma, strikingly similar to the 2528 Ma RbSr age of late Kenoran muscovite obtained from metasediments in the Indin structural basin (Frith, 1980; Frith, 1978b).

Penetrative Proterozoic deformation (D_3) is most evident in the Indin structural basin. The age of D_3 may be obtained from regional tectonic patterns. If the age of the northwest-trending cleavage is related to similarly oriented folds in the Calderian Orogeny, then D_3 took place after the emplacement of the Indin Diabase, the age of which may be comparable with the 1.89 Ga age of the sills in the Epworth Group and Snare Group. Chlorite has developed along some of the S_3 cleavage planes, indicating that low-grade regional metamorphism was associated with the development of the cleavage. Many of the mica ages along the boundary of the Slave Structural Province were reset from about 2500 to 1900 Ma. Rocks in the central parts of the Indin structural basin give abnormally high K-Ar whole-rock dates because of excess argon (3120 and 3175 Ma; Frith, 1978a). However, a whole-rock $40\text{Ar}-40\text{K}$ isochron age of 1.89 Ga approximates an age of thermal re-equilibration that is probably associated with the D_3 metamorphism, if not the age of the depression of the basin. Plutonism and diabase-dyke emplacement were broadly contemporaneous.

Indin Structural Basin

The Indin structural basin was formed during the Kenoran Orogeny as described in the preceding section. However, the basin and some of the granitoid terranes along the Slave Structural Province boundary were further affected during the Calderian Orogeny, when isostatic adjustments and brittle deformation took place (discussed further on).

The more northerly trend of F_2 folds, developed during the Kenoran Orogeny within the Indin structural basin, contrasts with S_2 foliation traces found elsewhere in the Indin Lake map area. This S_2 foliation was most likely controlled by the more northerly trend of the Indin structural basin. Deformation along the marginal zones of the basin was more ductile than near its centre.

East-northeast-trending folds (F_1) in the Indin structural basin occur as remnants near the centre of the belt, where regional metamorphism was low (Tremblay et al., 1953). Similar foliation trends are preserved in the Basler pluton and the enclosing migmatites east of Strachan Lake. The change in orientation may have been controlled by deep-seated local structure, such as graben or single fissure faults that fed homoclinal volcanism or by the buttressing effect of the refractory volcanic segments. East-northeast-trending volcanic rocks were deformed into large-scale anticlinorial structures, which dominate the outcrop pattern in the Indin structural basin.

The volcanic rocks in the Indin structural basin were folded into a broad synclinorium with a dominant north-northeast trend. The volcanic rocks from the west margin of the basin are presumed to be thicker than those near the east margin, because east of the north arm of Indin Lake they are folded at decreasing wavelengths along with the overlying and underlying metasediments. Metasediments are in contact and may have overlain basement gneiss in the Cotterill Lake area. In the Mesa Lake area, metasediments underlie volcanic rocks where they were folded with the metasediments (Ross, 1966). These relationships suggest that the volcanic rocks toward Truce Lake and Cotterill Lake were more distal, possibly overlying Archean granitoid basement that has since been uplifted to higher structural levels.

Proterozoic Calderian Orogeny

The Calderian Orogeny culminated with the emplacement of the syntectonic Hepburn Intrusive Suite, an intrusion of peralkaline granite, granodiorite, and diorite of batholithic extent, which intruded metamorphosed and folded supracrustal rocks of the Coronation Supergroup, marking the first collision of the Bear and Slave plates (Hoffman, 1984) at 1.89 Ga (Van Schmus and Bowring, 1980). The Hepburn Intrusive Suite and its host rocks comprise the central zone of the Wopmay Orogen. In many respects the orogeny was similar to the Archean 'Kenoran' Orogeny in the degree of deformation, metamorphism, and plutonism, which has prompted some workers in the region to extrapolate the plate-tectonic interpretation of the geological events of the Wopmay Orogen to the Slave Structural Province (Hoffman, 1986).

The Wopmay Orogen has been interpreted as a classic «Wilson Cycle» (Hoffman, 1980), with deposition, deformation, and intrusion along plate margins, beginning with the development of north-south rifts, which filled with bimodal volcanic rocks and turbiditic sediments (Akaitcho Group). These deposits subsided and were overlain by west-facing continental-margin deposits (Epworth Group). Extension turned to compression and the Slave Plate subducted beneath the Bear Plate, scraping the rift and continental-margin deposits on to the Slave craton. Continued subduction caused magmatism over the Bear Plate and eastward-directed thrusting of supracrustal rocks over the Slave continental crust.

Proterozoic tectonism in the Slave Structural Province

The chronologic relationship of events in the Wopmay Orogen (Hoffman and Bowring, 1984) to Proterozoic events in the Slave Structural Province is summarized below and in Table 10.

The earliest Proterozoic events to take place in the Slave Structural Province are recorded in Rb-Sr whole-rock isotopic systems, which date the time of isotopic re-equilibration of the Dune Lake pluton and the Archean granitoid basement west of Mattberry Lake at 2204 and 2210 Ma respectively. Similar dates have been reported from alkaline intrusions from the Bigspruce Lake area (Martineau and Lambert, 1974). However, even though the data suggest rifting may have started as early as 2.2 Ga, with the intrusion of alkaline intrusions and local regional metamorphism, active deposition of rift-related sediments and volcanic rocks around the Slave craton did not take place until 1.9 Ga, as determined from U-Pb zircon age determinations of volcanic rocks from the Akaitcho Group and from the Wilson Island Group (Bowring et al., 1984).

Volcanic rocks, although typical of Wopmay Orogen rift deposition, were not deposited in the Indin Lake map-area,

which implies a different depositional environment or that rocks mapped as Snare Group, but possibly associated with the Akaitcho Group, have some other correlation.

Proterozoic Deformation of the Indin Structural Basin

The geometry of the northwest-trending, sinistral oblique-slip faults is best explained by a downward movement of the metasedimentary rocks of the basin, since the central low greenschist facies rocks were probably topographically higher than the upper amphibolite facies rocks on either side. The downward movement of the basin may be linked to events in the Wopmay Orogen in the following ways:

- (1) The east-west extension that gave rise to rifting of the western margin of the Slave craton stops at the Wopmay Fault (P.F. Hoffman, personal communication, 1984). However, early rifting was associated with alkaline intrusions such as those at Bigspruce Lake. The Indin Diabase dyke swarm was intruded before east-west compression, and is possibly correlative with sills in the Snare Group. The direction of emplacement of the north northwest set of the Indin Diabase may have been controlled by east-west extension.

Table 10. Time-stratigraphic relationships of events in the Wopmay Orogen compared with events in the Indin Basin

Interval (Ga)	Wopmay Orogen	Indin Lake map area
1.85-1.81	— Collision of the west side of the Bear plate causing pervasive transcurrent faulting throughout the Wopmay Orogen and reactivation of earlier fault structures such as the Bathurst and McDonald Fault systems	— Extensive right-lateral faulting of the Hepburn Intrusive Suite, the Slave Structural Province boundary and Archean rocks within the Slave near the boundary (Mesa Lake area).
1.86-1.85	— Compression and right-lateral en echelon faulting of the Great Bear magmatic arc and intrusion of high-level silica-deficient intrusions.	— Not evident
1.87-1.86	— Development of the Great Bear magmatic arc	— Not evident
1.88-1.87	— Oblique folding of Slave cover rocks by NW — SE compression	— Not evident
1.89-1.88	— Calderian Orogeny — metamorphism	— greenschist to granulite in the Wopmay, greenschist in the Slave
	— intrusion of the Hepburn Intrusive Suite	— intrusion of the Hepburn Intrusive Suite and the emplacement of Archean gneiss domes in Wopmay.
	— eastward thrusting of the sedimentary prism	— Eastward fold vergence — No documented thrusts present, but for minor SE thrusts in southern Slave margin area — Development of NW-SE folds and vertical cleavage in metasedimentary rocks of the Yellowknife S.G. — NW sinistral oblique-slip faulting of Indin S.B.
	— sedimentation into eastward migrating foredeep basin	— Not evident
1.90-1.89	— Intrusion of diabase and gabbro sills	— Intrusion of the Indin Diabase
	— Deposition of the west-facing Epworth Group shelf facies	— Same
2.05-1.90	— Rift valleys formed and filled with the Akaitcho Group	— Same — Possible extension of Indin structural basin

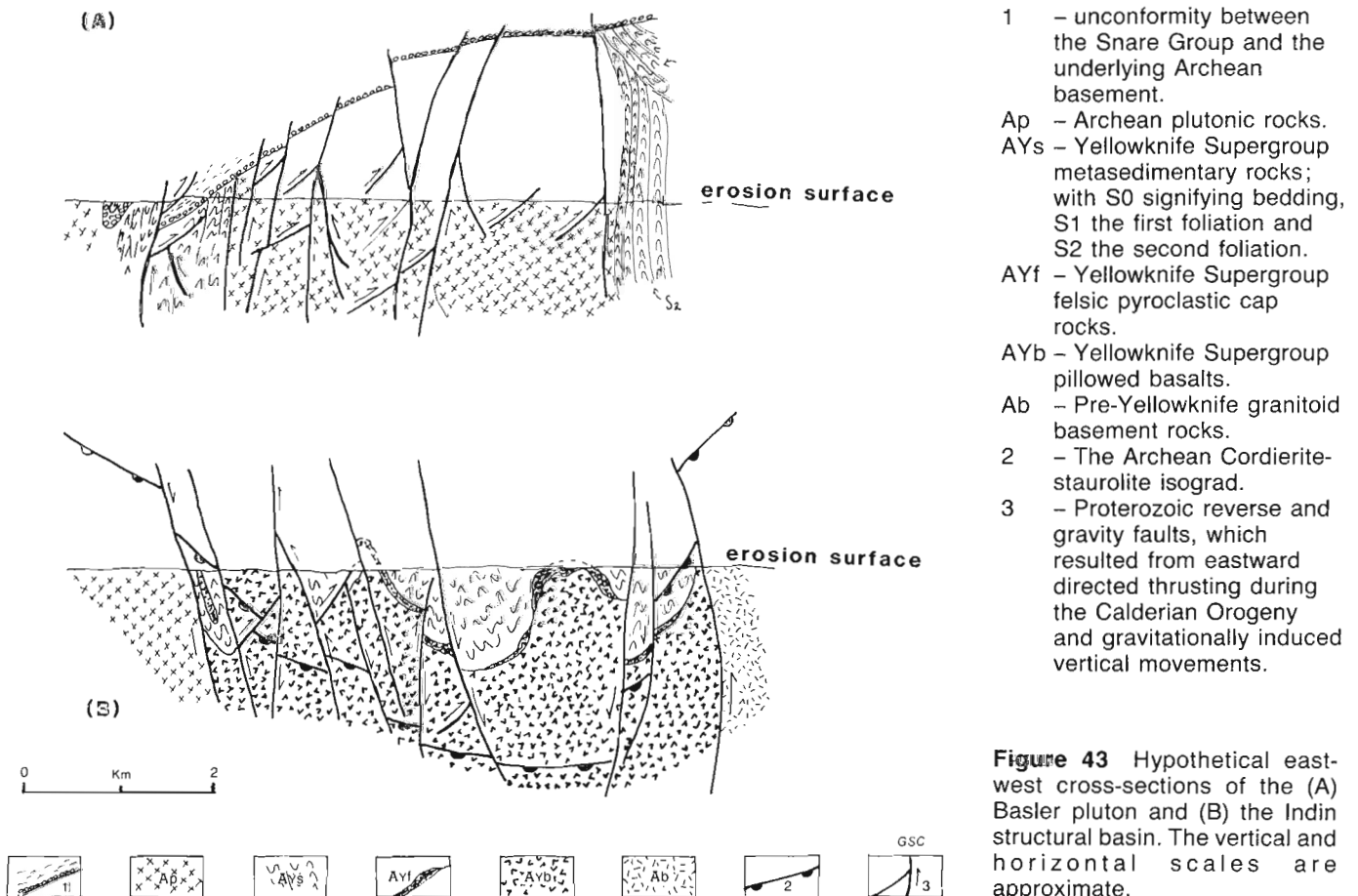
- (2) East-west compression in the Wopmay Orogen gave rise to upright to eastward-verging folds in the cover rocks of the Coronation Supergroup and compression of the underlying basement. Temperatures were cooler in the basement, as isograds in the orogen always prograde away from it. East of the Slave Structural Province boundary, the rocks failed by brittle deformation along fault patterns similar to those exhibited by the uplift of the Basler pluton and the depression of the Indin structural basin (Fig. 43). Vertical extension in both cases was partly controlled by the relative density of rocks in the region affected.
- (3) Eastward-directed thrusting related to pan-Wopmay dextral strike slip faulting (the «second collision» of Hoffman (1984)) caused major dextral off-sets of the north-south-trending Hepburn Intrusive Suite, the Snare Group, the Slave Structural Province boundary, and Archean rocks along the western side of the Slave Province part of the map-area. Northwest-trending faults in the northern internal parts of the Wopmay Orogen were associated with left-lateral strike-slip movement and are considered to have been conjugate with east-northeast dextral, strike-slip faults. These faults are considered to have been formed contemporaneously with similar faults in the Great Bear magmatic arc, where they cut 1.84 Ga plutons (Hoffman and Bowring, 1984).

The northwest-trending faults in the Indin structural basin and near the west boundary of the Slave Structural Province are sub-parallel to those in the central Wopmay Orogen, but nowhere do they cut the Snare Group unconformity in the map area. The same northwest-trending faults in the Yellowknife area offset the Yellowknife greenstone belt, but not the Great Slave Supergroup, implying that in both regions these faults are older than the circum-Slave, Proterozoic rocks, but post-«Kenoran» in age.

- (4) North of the map area Tree River folding (Hoffman et al., 1983) correlated with open east-northeast-undulations of the region probably continued south into the present map-area, so that the area along the northern margin of the map-area, near the Slave Structural Province boundary is a structural high, the Arseno Lake area a low, and the area between Origin and Mattberry Lakes another high. The faulting may also have been correlative with renewed movement on major circum-Slave transcurrent faults, such as the McDonald and Bathurst fault systems (Hoffman, 1984).

Proterozoic Deformation in the Wopmay Orogen

The part of the map area that lies within the Wopmay Orogen was deformed and metamorphosed by the Calderian Orogeny. In some respects this orogeny has produced



different results in the map area than it did in the type region to the north (Hoffman, 1984). Some of the major conclusions concerning the region are as follows:

- (1) Basement rocks include the full range of rock types observed in the Slave Structural Province. Both basement and cover rocks are in place between Norris Lake and the south margin of the map area, except for minor southeast-directed thrusts near the Slave Structural Province margin. Both were metamorphosed to greenschist facies during the Calderian Orogeny. Deformation of the basement rocks was greater than it was in the cover rocks in the southern part of the map area, as the former were deformed during both the Archean and the Proterozoic.
- (2) Basement in the central part of the Wopmay Orogen was metamorphosed to the granulite facies, but the date of the metamorphism is unknown. If it is Archean, as at Ghost Lake (which borders the southeastern margin of the Indin structural basin), then the evidence of a prograde Proterozoic regional metamorphism centred around the basement granitoids is hard to explain. If the metamorphism was Proterozoic, then the regional metamorphism must have involved the basement. This makes an allochthonous relationship for the cover rocks difficult to explain. Alternately, both the basement and the cover rocks may be allochthonous, a hypothesis difficult to prove, but it does explain a common regional metamorphism and a relatively sharp change of structural style in the southern part of the Arseno Lake area.
- (3) If the rocks in the Arseno Lake area west of the Slave Structural Province boundary are mostly allochthonous and the basement is part of an allochthonous wedge, all of the rocks were transported to the east along a decollement surface (or surfaces) that has (or have) not been delineated. Such a fault (or faults) may steepen and merge with the Slave Structural Province boundary fault.
- (4) The emplacement of Archean-cored gneiss domes within an allochthonous wedge took place under the influence of gravity, but locations of such domes were possibly determined by interference fold patterns generated during early deformation (D_1 of Hoffman, 1984). Apart from their non-intrusive mode of emplacement, the gneiss dome cores behaved in similar fashion to the plutons of the Hepburn Intrusive Suite.
- (5) Augen gneiss in the Mattberry anticlinorium is no longer correlated with the Rodrigues pluton of the Hepburn Intrusive Suite (Frith et al., 1974), as the Rodrigues pluton intruded the Snare Group and was probably thrust from the west. Parts of the Mattberry anticlinorium consist of massive porphyritic granites similar to rocks of the Rodrigues pluton, but these rocks are rooted to the basement because they can be traced across strike to augen gneiss deformed during the Calderian Orogeny. This augen gneiss forms the basal part of an unconformity that is overlain by similarly deformed conglomerates of the Snare Group (Frith et al., 1977).

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