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# GEOLOGY OF THE KESKARRAH BAY AREA, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

J.B. Henderson

1998

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To Hewitt
who lead the way
with best regards
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**Cover illustration**

Unconformity between an Archean Yellowknife Supergroup volcanic and granite clast conglomerate of the Keskarrah Group and the Augustus Granite. The Augustus Granite, a high-level intrusion containing 3.2 Ga zircon xenocrysts, is considered to be synchronous with the 2.67 Ga mafic volcanic rocks that mantle it and associated iron-formation-bearing greywacke-mudstone turbidites, all of which are unconformably overlain by facies of the Keskarrah Group.

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# PREFACE

Archean volcanic and sedimentary rocks of the Slave Province in the northwestern Canadian Shield are an important host of gold and base-metal deposits. This bulletin is on the geology of an area in the west-central Slave Province where the supracrustal rock record is unusually complete. It provides a description and interpretation of the evolution of polydeformed and variably metamorphosed sedimentary and volcanic rocks and of the rocks that intrude them. Part of the area is underlain by structurally deeper rocks, including gneiss that predates the supracrustal rocks. It will be of interest to those concerned with stratigraphic, structural, and metamorphic relationships, either in this area or more province wide. As such, it contributes to understanding the geological framework of this economically significant part of the Canadian Shield.

M.D. Everell
Assistant Deputy Minister
Earth Sciences Sector

# PRÉFACE

Les roches volcaniques et sédimentaires archéennes de la Province des Esclaves, dans le nord-ouest du Bouclier canadien, constituent l'encaissant principal des gisements d'or et de métaux communs. Le présent bulletin est consacré à la géologie d'une région située dans le centre ouest de la Province des Esclaves où la géologie des roches supracrustales est remarquablement complète. Les données recueillies fournissent une description et une interprétation de l'évolution des roches volcaniques et sédimentaires polydéformées et variablement métamorphisées et des roches qui les recoupent. Une partie de cette région comprend des roches de niveau structural plus profond, dont des gneiss plus anciens que les roches supracrustales. Ces informations intéresseront les personnes qui étudient les relations stratigraphiques, structurales et métamorphiques à l'échelle soit de cette région, soit de la province. Cet article contribuera donc à mieux faire comprendre le cadre géologique de cette partie du Bouclier canadien d'une grande valeur économique.

M.D. Everell
Sous-ministre adjoint
Secteur des sciences de la Terre

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# GEOLOGY OF THE KESKARRAH BAY AREA, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES


## Abstract

*The Archean rocks of the area divide naturally into two domains representing contrasting structural levels, separated by a major ductile shear zone. The western domain consists mainly of granitoid rocks with large enclaves of complex orthogneisses representing the oldest rocks in the area. The eastern domain is dominated by Yellowknife Supergroup supracrustal rocks. A thick basal sequence of pillowed and massive mafic volcanic rocks with minor, intermediate volcanic units mantles a high-level synvolcanic granite. Greywacke-mudstone turbidites of largely granitoid provenance, containing varied proportions of iron carbonate-, oxide-, and silicate-dominated iron-formation, conformably overlie the mafic volcanic rocks. A small volcanic centre of felsic to intermediate composition within the turbidites is considered contemporaneous with them. Unconformably overlying most of these rocks is a package of conglomerate, shallow-water sandstone, and turbidites representing a fan delta complex formed in response to early movement on what was to become the major ductile shear zone that separates the two domains. An extended record of deformation includes events recorded in the orthogneisses that predate deposition of the Yellowknife Supergroup, a folding event involving the older members of the Yellowknife Supergroup, and a subsequent polyphase deformational history involving all parts of the Yellowknife Supergroup. Three periods of metamorphism include the older, pre-Yellowknife Supergroup evolution of the orthogneisses, the prominent, late Archean, low-pressure series, lower-greenschist to upper-amphibolite metamorphism, and a low-grade Paleoproterozic metamorphism. Economic mineral occurrences include gold associated with iron-formation and minor base-metal showings associated with mafic volcanic rocks.*



## Résumé

*Les roches archéennes de la région se divisent naturellement en deux domaines représentant des niveaux structuraux différents, séparés par une grande zone de cisaillement ductile. Le domaine de l'ouest comprend principalement des roches granitoïdes accompagnées de grandes enclaves d'orthogneiss complexes correspondant aux roches les plus anciennes de la région. Le domaine de l'est est dominé par les roches supracrustales du Supergroupe de Yellowknife. Une épaisse séquence basale de roches volcaniques mafiques massives et en coussins et d'unités volcaniques intermédiaires de moindre importance recouvre un granite synvolcanique de niveau élevé. Des turbidites à grauwacke-mudstone, en grande partie d'origine granitoïde, renferment des unités de formation de fer à faciès carbonaté, oxydé et silicaté en proportions diverses et reposent en concordance sur des roches volcaniques mafiques. Un petit centre volcanique de composition felsique à intermédiaire dans les turbidites semblerait être contemporain de ces dernières. La plupart de ces roches sont recouvertes en discordance par un ensemble de conglomérats, de grès d'eau peu profonde et de turbidites représentant un complexe de cônes de déjection formé à la suite d'un mouvement précoce le long de ce qui est devenu la grande zone de cisaillement ductile séparant les deux domaines. Une longue histoire de déformation comprend des événements ayant touché les orthogneiss qui sont antérieurs à la mise en place du Supergroupe de Yellowknife, une phase de plissement qui a affecté les membres plus anciens du Supergroupe de Yellowknife, et une déformation polyphasée subséquente qui a touché l'ensemble du Supergroupe de Yellowknife. Trois phases de métamorphisme s'articulent dans la région : la phase la plus ancienne, antérieure à la formation du Supergroupe de Yellowknife, qui a produit les orthogneiss, une phase importante de métamorphisme de basse pression survenue à l'Archéen tardif et allant du faciès inférieur des schistes verts au faciès supérieur des amphibolites, et une phase de métamorphisme faible au Paléoprotérozoïque. Les indices minéraux à valeur commerciale comprennent l'or associé à des formations de fer et de petits indices de métaux communs associés aux roches volcaniques mafiques.*

## SUMMARY

The Keskarrah Bay area is located in the west-central Slave Province, at the western margin of an extensive area of Archean supracrustal rocks that can be traced through to the eastern margin of the province. The area comprises two domains with highly contrasting structural levels, separated by a major, north-trending, ductile shear zone.

In the west, the area consists of massive to foliated granitoid rocks and gneisses with a northeasterly trend that becomes parallel to the boundary shear zone as that shear zone is approached. The complex orthogneisses are thought to be largely older than the supracrustal rocks to the east, whereas the more abundant foliated to massive granitoid rocks are considered to largely postdate them. This domain is thought to represent a deeper, mid-crustal environment that contrasts strongly with the locally low-grade, supracrustal-dominated domain to the east. Also present are high-grade metasedimentary gneisses, the only unit to provide a possible linkage to the supracrustal rocks to the east.

The eastern domain is dominated by northerly trending, variably metamorphosed, supracrustal rocks of the Archean Yellowknife Supergroup. Also present are several major bodies of the Augustus Granite, whose age and relationship to the Yellowknife Supergroup are controversial. Minor pegmatites and granite intrude the Yellowknife Supergroup rocks in the easternmost part of the area. The Yellowknife Supergroup has been broken down into three group-rank units and a series of formation-scale units. The volcanic units of the domain are part of the Point Lake Group and include Peltier Formation mafic volcanic rocks, Samandré Formation intermediate volcanic rocks, Beauparlant Formation felsic volcanic rocks, and several smaller, unnamed units. The Perrault Lithodeme, a mafic tectonite at the western margin of the domain, is also considered part of the group. The Cogead Group consists of the two major greywacke-mudstone units that dominate the domain. The Contwoyto Formation contains abundant iron-formation, whereas the Itchen Formation does not contain iron-formation. The Keskarrah Group unconformably overlies the rocks of the Point Lake and Cogead groups as well as the Augustus Granite. It consists of three unnamed formation-scale units that include conglomerates, shallow-water sandstones, and turbidites.

The oldest rocks in the area are the orthogneisses of the western granitoid and granitoid gneiss domain. A small area of orthogneiss is also associated with the Augustus Granite in the eastern supracrustal domain. In the western domain the gneiss occurs as large enclaves

## SOMMAIRE

La région de la baie de Keskarrah est située dans le centre ouest de la Province des Esclaves, à la limite ouest d'une région très étendue renfermant des roches supracrustales de l'Archéen que l'on peut retracer jusqu'à la marge est de la province. Cette région comprend deux domaines comportant des niveaux structuraux extrêmement différents, séparés par une vaste zone de cisaillement ductile à orientation nord.

La partie ouest de la région comprend des roches granitoïdes et des gneiss massifs à foliés, à orientation nord-est, qui deviennent parallèles à la zone de cisaillement limitrophe au fur et à mesure que l'on s'approche de cette dernière. Les orthogneiss complexes sont vraisemblablement en grande partie plus anciens que les roches supracrustales se rencontrant à l'est, alors que les roches granitoïdes foliées à massives, plus abondantes, en seraient en grande partie plus récentes. Ce domaine représenterait un milieu médio-crustal plus profond qui contraste fortement avec le domaine à l'est où prédominent des roches supracrustales par endroits faiblement métamorphisées. Sont aussi présents des gneiss fortement métamorphisés, d'origine sédimentaire, la seule unité qui constituerait un lien avec les roches supracrustales à l'est.

Des roches supracrustales variablement métamorphisées, à orientation nord, du supergroupe archéen de Yellowknife, prédominent dans le domaine de l'est. Plusieurs gros massifs du Granite d'Augustus sont également présents; leur âge et leur lien avec le Supergroupe de Yellowknife sont controversés. Des pegmatites et granites en petites quantités recoupent les roches du Supergroupe de Yellowknife dans l'extrême est de la région. Le Supergroupe de Yellowknife a été divisé en trois unités du rang du groupe et en une série d'unité du rang de la formation. Les unités volcaniques du domaine font partie du Groupe de Point Lake et comprennent les roches volcaniques mafiques de la Formation de Peltier, les roches volcaniques intermédiaires de la Formation de Samandré, les roches volcaniques felsiques de la Formation de Beauparlant et plusieurs unités innommées plus petites. On estime que le Lithodème de Perrault, tectonite mafique se rencontrant à la bordure ouest du domaine, fait aussi partie de ce groupe. Le Groupe de Cogead se compose des deux grandes unités de mudstone-grauwacke qui prédominent dans le domaine. La Formation de Contwoyto renferme d'abondantes unités de formation de fer, mais la Formation d'Itchen n'en contient pas. Le Groupe de Keskarrah repose en discordance sur les roches des groupes de Point Lake et de Cogead et sur le Granite d'Augustus. Il comprend trois unités innommées, dont l'échelle est celle d'une formation, qui contiennent des conglomérats, des grès d'eau peu profonde et des turbidites.

Les roches les plus anciennes de la région sont les orthogneiss du domaine des roches et gneiss granitoïdes à l'ouest. Une petite zone d'orthogneiss est également associée au Granite d'Augustus dans le domaine des roches supracrustales à l'est. Dans le domaine de l'ouest, les gneiss se

within the granitoid rocks; these enclaves decrease abruptly in size and number westward, away from the boundary shear zone. The orthogneisses consist of complexly deformed units ranging in composition from diorite to granite and include phases of the younger granitoid rocks as well as amphibolitic units of undetermined origin. Some of the earlier fold generations in these rocks are difficult to correlate with those in the supracrustal domain to the east. These rocks are not well dated, but preliminary data suggest the presence of phases ranging in age from about 3.2 to 2.8 Ga, significantly older than the Yellowknife Supergroup rocks present in the area. Also present in the domain, but with undefined relationship to the orthogneisses, are paragneisses consisting of migmatitic metasedimentary rocks that may well represent the high-grade equivalents of the Contwoyto and/or Itchen formations to the east.

présentent sous la forme de grandes enclaves dans des roches granitoïdes; la taille et le nombre de ces enclaves décroissent brusquement vers l'ouest, au fur et à mesure que l'on s'éloigne de la zone de cisaillement limitrophe. Les orthogneiss comportent des unités ayant subi une déformation complexe et dont la composition va des diorites aux granites. Ils contiennent des phases de roches granitoïdes plus récentes et des unités amphibolitiques d'origine indéterminée. Il est difficile d'établir une corrélation entre certaines générations de plis plus anciennes remarquées dans ces roches et celles s'exhibant dans le domaine des roches supracrustales à l'est. L'âge de ces roches n'a pas été déterminé avec précision, quoique des données provisoires semblent indiquer la présence de phases dont l'âge s'échelonnerait entre environ 3,2 et 2,8 Ga, ce qui est donc sensiblement plus ancien que les roches du Supergroupe de Yellowknife observées dans la région. On a également noté la présence de paragneiss, mais leur relation avec les orthogneiss n'est pas définie. Ces paragneiss sont des roches métasédimentaires migmatitiques qui pourraient être l'équivalent, mais plus fortement métamorphisé, des roches de la Formation de Contwoyto, de la Formation d'Itchen ou des deux, trouvées à l'est.

The Augustus Granite is the major granitoid unit in the eastern supracrustal domain. Its relationship to the volcanic rocks that mantle it is equivocal. Zircons recovered from the granite have been dated at about 3.22 to 3.15 Ga, which at face value would suggest that the granite is older than the Yellowknife Supergroup in the area and apparently older than most, if not all, phases of the previously discussed orthogneisses. This would make it a strong candidate for basement to the Yellowknife Supergroup. A magnificently preserved unconformity, locally with a weathered horizon, is found between the Augustus Granite and the conglomerates of the Keskarrah Group, the youngest member of the Yellowknife Supergroup. Contacts between other members of the Yellowknife Supergroup, primarily the Peltier Formation mafic volcanic rocks, are more equivocal as they are invariably sheared. The granite itself is a texturally and compositionally zoned body in which original igneous textures are well preserved. The highest levels of the granite that are approximately concordant to the supracrustal units consist of hypersolvus granite, which suggests emplacement within 1 km of the surface. Elsewhere in the Slave Province, similar granitoid bodies are mantled by Yellowknife Supergroup mafic volcanic rocks and have either similar textures suggestive of high-level emplacement or ages suggesting synchroneity with volcanism. Since the uranium content of the Augustus Granite zircons is very low and, as such, anomalous compared to other granitic intrusions of the Slave

Le Granite d'Augustus constitue la principale unité granitoïde du domaine des roches supracrustales de l'est. Sa relation avec les roches volcaniques sus-jacentes n'est pas évidente. Des datations effectuées sur des zircons extraits du granite donnent des âges s'échelonnant approximativement de 3,22 à 3,15 Ga, ce qui indiquerait, à première vue, que le granite serait antérieur au Supergroupe de Yellowknife présent dans la région et apparemment plus ancien aussi que la plupart ou la totalité des phases des orthogneiss dont il est fait mention ci-dessus. Ce sont là des arguments probants laissant supposer que ce granite formerait le socle du Supergroupe de Yellowknife. Il existe une discordance remarquablement bien conservée, accompagnée par endroits d'un horizon altéré, entre le Granite d'Augustus et les conglomérats du Groupe de Keskarrah, qui est le membre le plus récent du Supergroupe de Yellowknife. Les contacts entre d'autres membres du Supergroupe de Yellowknife, principalement les roches volcaniques mafiques de la Formation de Peltier, sont beaucoup moins évidents, car ils sont invariablement cisaillés. Le granite se présente en un massif à texture et de composition zonées dans lequel des textures ignées primaires sont biens conservées. Les niveaux supérieurs du granite qui sont à peu près en concordance avec les unités supracrustales sont des granites hypersolvus, ce qui laisse supposer qu'ils se sont mis en place à 1 km ou moins de la surface. Ailleurs dans la Province des Esclaves, des massifs granitoïdes similaires sont recouverts par des roches volcaniques mafiques du Supergroupe de Yellowknife; ils montrent soit des textures similaires, traduisant une mise en place à un niveau élevé, soit des âges similaires, laissant

Province, the zircons may well be xenocrystic. The Augustus Granite could then be a synvolcanic intrusion. This is the preferred interpretation in this report.

supposer qu'ils sont contemporains du volcanisme. Puisque la teneur en uranium des zircons du Granite d'Augustus est très faible et donc anormale par rapport à d'autres intrusions granitiques de la Province des Esclaves, il est fort probable que les zircons soient des xénocristaux. Le Granite d'Augustus serait alors une intrusion synvolcanique. C'est l'interprétation que nous avons retenue dans le présent rapport.

The Peltier Formation, a mafic volcanic sequence that is the largest member of the Point Lake Group, occurs at the western margin of the supracrustal domain. Although folded and disrupted by faults, the northerly trending volcanic unit in large part mantles the Augustus Granite. Because of structural complications, the thickness of the Peltier Formation is unknown although it appears to reach a maximum in the west. In the eastern part of the area, the Augustus Granite is unconformably overlain by younger Keskarrah Group conglomerates so that it is difficult to know whether the Peltier Formation originally thinned and had limited extent to the east beyond the area. The formation is similar to many mafic volcanic sequences in the Slave Province in that it consists mainly of pillowed and massive flows with some mafic sills that are considered to be contemporaneous with volcanism. Minor mafic breccias and volcaniclastic units are also present, as are rare occurrences of volcanic rocks of intermediate composition. Black shale units occur locally, particularly near the conformable contact with the overlying Contwoyto Formation greywacke-mudstone turbidites.

La Formation de Peltier, séquence volcanique mafique qui constitue le membre le plus vaste du Groupe de Point Lake, se rencontre à la bordure ouest du domaine des roches supracrustales. Bien qu'elle soit plissée et disloquée par des failles, l'unité volcanique, à orientation nord, recouvre en grande partie le Granite d'Augustus. En raison de complexités structurales, on ne peut déterminer l'épaisseur de la Formation de Peltier qui semble être maximale dans la partie ouest de la région. Dans la partie est de la région, le Granite d'Augustus est recouvert en discordance par les conglomérats plus récents du Groupe de Keskarrah. Il est donc difficile de déterminer si la Formation de Peltier s'est originellement amincie et si elle était d'étendue restreinte à l'est, au-delà de la région étudiée. Cette formation est semblable aux nombreuses séquences volcaniques mafiques se trouvant dans la Province des Esclaves, c'est-à-dire qu'elle se compose principalement de coulées massives et en coussins et de quelques sills mafiques qui seraient contemporains du volcanisme. Elle comprend aussi des brèches mafiques et des unités volcanoclastiques de moindre importance, ainsi que de rares roches volcaniques de composition intermédiaire. Des unités de shale noir se rencontrent localement, en particulier au voisinage du contact concordant avec les turbidites à mudstone-grauwacke sus-jacentes de la Formation de Contwoyto.

The Perrault Lithodeme is a tectonite that is part of the domain-bounding shear zone. It consists largely of a finely compositionally layered amphibolite defined by varied proportions of actinolite or actinolitic hornblende and plagioclase. It is considered to be derived from the Peltier Formation. Associated with it are sills to lenses of coarser grained, variably deformed mafic bodies ranging in composition from ultramafic through gabbroic to leucogabbroic. Similar intrusions occur in the immediately adjacent Contwoyto Formation where the Perrault Lithodeme is thin, as well as in the nearby granitoid rocks to the west.

Le Lithodème de Perrault est une tectonite qui fait partie de la zone de cisaillement limitrophe. Il comporte principalement une amphibolite à différenciation pétrographique fine, définie par des proportions variées d'actinote ou de hornblende actinolitique et de plagioclase. Il serait dérivé de la Formation de Peltier. Lui sont associés des sills et des lentilles de massifs mafiques à grain grossier, déformés à divers degrés, dont la composition va d'ultramafique à gabbroïque et jusqu'à leucograbbroïque. Des intrusions semblables se rencontrent dans la Formation de Contwoyto immédiatement adjacente, à l'endroit où le Lithodème de Perrault est peu épais, ainsi que dans les roches granitoïdes avoisinantes à l'ouest.

A small, intermediate to felsic volcanic centre in the centre of the map area is surrounded by Contwoyto Formation greywacke-mudstone turbidites. It consists mainly of the Beauparlant Formation, a leucocratic, chiefly massive rhyolite with less common volcaniclastic breccia to lapillistone facies. The associated Samandré Formation is largely volcaniclastic, more intermediate in composition, and more heterogeneous. A discontinuous unit of carbonate rock occurs at the contact between the volcanic centre and the adjacent Contwoyto Formation. Thin units of similar volcanic

Un petit centre volcanique de composition intermédiaire à felsique, situé au milieu de la région cartographique, est entouré par des turbidites à mudstone-grauwacke de la Formation de Contwoyto. Il se compose principalement de la Formation de Beauparlant, une rhyolite leucocrate principalement massive avec des faciès moins fréquents de brèches volcanoclastiques et de lapillistones. La Formation de Samandré associée est en grande partie volcanoclastique, sa composition est plus intermédiaire et elle est plus hétérogène. Une unité discontinue de roches carbonatées se rencontre au contact entre le centre volcanique et la Formation de Contwoyto adjacente. De rocks occur within the nearby Contwoyto Formation. The Contwoyto Formation northeast and east of the centre contains turbidites of volcanogenic origin, suggesting that the centre was contemporaneous with sedimentation. The volcanic centre is a small example of several centres of this type that are found at several localities throughout the Slave Province.

The Contwoyto Formation and the lithologically similar Itchen Formation are part of the Cogead Group. The Contwoyto Formation is the dominant supracrustal unit in the area. It consists of thinly interlayered metamudstone, metasiltstone, and less common metagreywacke in thin, parallel-sided, laterally continuous, graded beds with sedimentary structures typical of turbidity-current deposits. Its defining feature is the presence of iron-formation. It is variably metamorphosed from sub-biotite greenschist to sillimanite-bearing amphibolite facies. It conformably overlies mafic volcanic rocks of the Peltier Formation and is probably contemporaneous with the small felsic to intermediate volcanic centre, which it surrounds. It is unconformably overlain by conglomerates of the Keskarrah Group and may be conformably overlain by or possibly interfinger with the Itchen Formation, a similar turbidite unit that occurs to the east. The Contwoyto Formation is intruded by mafic sills near the domain-bounding ductile shear zone to the west, and by pegmatite and minor granite in the higher grade rocks to the east.

The sandstones and siltstones of the Contwoyto Formation are composed mainly of anhedral, polycrystalline quartz, granitoid clasts, a variety of fine-grained lithic clasts, and less abundant fresh to highly altered plagioclase in an abundant matrix. An extensive, partly weathered, largely granitoid source is indicated. Northeast and east of the felsic to intermediate volcanic centre, the Contwoyto Formation is dominated by quartz- and feldspar-poor sedimentary rocks of volcaniclastic origin.

Iron-formation, in varied proportions and types, occurs throughout most of the Contwoyto Formation. The types present in the area include carbonate iron-formation consisting largely of siderite, oxide (magnetite) iron-formation, and silicate iron-formation composed mainly of grunerite. The various types are found in a series of northerly trending, overlapping zones that are on the order of several kilometres wide. The mineral zoning is a complex response to primary, diagenetic, and metamorphic conditions. The iron-formation occurs in metre-scale units that locally reach several tens of metres in thickness and that consist of thinly interlayered or laminated iron-mineral-dominated layers and lesser silica-dominated layers.

minces unités de roches volcaniques similaires se rencontrent au sein de la Formation de Contwoyto avoisinante. Au nord-est et à l'est du centre volcanique, la Formation de Contwoyto contient des turbidites volcanogéniques, ce qui signifierait que le centre volcanique est contemporain de la sédimentation. Ce centre en est un parmi plusieurs autres de même type que l'on trouve à plusieurs endroits dans la Province des Esclaves.

La Formation de Contwoyto et la Formation d'Itchen qui lui est lithologiquement similaire font partie du Groupe de Cogead. La Formation de Contwoyto est l'unité supracrustale prédominante dans la région. Elle est formée de mudstone, de siltstone et de grauwacke moins abondant métamorphisés, finement interstratifiés, dans de minces lits granoclassés, parallèles et latéralement continus, accompagnés de structures sédimentaires caractéristiques des dépôts de courants de turbidité. La présence de formation de fer constitue sa caractéristique déterminante. Elle est variablement métamorphisée, allant du sous-faciès inférieur aux schistes verts à biotite jusqu'au faciès des amphibolites à sillimanite. Elle repose en concordance sur des roches volcaniques mafiques de la Formation de Peltier et est probablement contemporaine du petit centre volcanique de composition felsique à intermédiaire qu'elle entoure. Elle est recouverte en discordance par des conglomérats du Groupe de Keskarrah et est peut-être surmontée en concordance ou imbriquée par la Formation d'Itchen, unité turbiditique semblable qui se rencontre à l'est. La Formation de Contwoyto est recoupée par des sills mafiques près de la zone de cisaillement ductile limitrophe à l'ouest et par des pegmatites et un peu de granite dans les roches de métamorphisme plus intense à l'est.

Les grès et siltstones de la Formation de Contwoyto sont composés principalement de quartz polycristallin anédrique, de clastes granitoïdes, d'une variété de clastes lithiques à grain fin et, en moindre abondance, de plagioclases non altérés à intensément altérés dans une matrice abondante. Ils proviendraient d'une source en grande partie granitoïde, partiellement altérée et de grande étendue. Au nord-est et à l'est du centre volcanique de composition felsique à intermédiaire, la Formation de Contwoyto est dominée par des roches sédimentaires pauvres en quartz et en feldspath volcanoclastique.

Des formations de fer, en proportions et de types variés, se rencontrent dans la presque totalité de la Formation de Contwoyto. Les types observés dans la région sont une formation de fer à faciès carbonaté composée principalement de sidérite, une formation de fer à faciès oxydé (magnétite) et une formation de fer à faciès silicaté composée principalement de grunérite. Ces divers types de formation de fer se trouvent dans une série de zones chevauchées, à orientation nord, qui ont plusieurs kilomètres de large. La zonation des minéraux est le résultat complexe de conditions primaires, diagénétiques et métamorphiques. Les unités de formation de fer sont de dimension métrique et, par endroits, elles peuvent atteindre plusieurs dizaines de mètres d'épaisseur. Elles comprennent des couches finement interstratifiées ou laminées où prédomi-

A given iron-formation unit consists of one dominant iron-formation type, although the other types are commonly present in much lower proportions, particularly at lower metamorphic grades. Silicate iron-formation locally contains sulphide minerals that in some cases are anomalously rich in gold. The iron-formation is thought to be the product of volcanogenic hydrothermal processes and were deposited by a series of density currents that in large part overwhelmed the background argillaceous sedimentation while iron-rich chemical sedimentation was taking place. Occasionally, siliciclastic material was also deposited from turbidity currents active during chemical sedimentation.

The second turbidite unit, the Itchen Formation, is found east of the Contwoyto Formation. It has been metamorphosed to amphibolite grade. It differs from the Contwoyto Formation in that it lacks iron-formation, is typically thicker bedded and coarser grained, and some of its coarser metagreywacke beds contain carbonate concretions.

The Keskarrah Group, consisting of three distinct facies with as yet undefined stratigraphic relationships, unconformably overlies the older members of the Yellowknife Supergroup as well as the Augustus Granite. Preliminary detrital zircon age determinations suggest a probable maximum age of sedimentation of about 2.60 Ga, or about 60 million years after the older members of the Yellowknife Supergroup in the area. The Keskarrah Group is everywhere metamorphosed to greenschist grade, the same grade as the rocks it unconformably overlies.

Conglomerates form the most abundant facies and consist of thick units of mainly granite and mafic volcanic clasts derived chiefly from the Augustus Granite and presumably the Peltier Formation respectively. Granitoid gneiss clasts are found in western exposures and volcanic clasts of felsic and intermediate composition occur locally. Locally, the conglomerates contain thin units to lenses of coarse-grained, crossbedded sandstone with a composition similar to that of the conglomerates. A quartz-rich, crossbedded sandstone facies is associated with the conglomerates, mainly in the west. It typically forms parallel-sided, 10 to 20 cm thick units commonly separated by thin mudstone layers to partings. In rare cases, the crossbedding sets are metre scale. A shallow-water, lower shoreface environment has been suggested for this facies. The sandstone is composed mainly of angular, commonly finely polycrystalline quartz, abundant lithic clasts of various types, and minor, commonly altered, plagioclase. As with the

nent des minéraux de fer et des couches de silice moins abondantes. Une unité de formation de fer déterminée se compose d'un type de formation de fer dominant, quoique les autres types soient généralement présents dans des proportions beaucoup plus faibles, en particulier à des degrés de métamorphisme faibles. La formation de fer à faciès silicaté renferme par endroits des minéraux sulfurés dont les teneurs en or sont parfois anormalement élevées. Les formations de fer seraient le produit de processus hydrothermaux volcanogéniques; elles ont été déposées par des courants de densité qui ont en grande partie submergé la sédimentation argileuse environnante pendant que se poursuivait la sédimentation chimique de matériaux riches en fer. Par endroits, des matériaux silicoclastiques ont également été déposés par des courants de turbidité pendant que se poursuivait la sédimentation chimique.

La seconde unité de turbidite, la Formation d'Itchen, se trouve à l'est de la Formation de Contwoyto. Elle a été métamorphisée au faciès des amphibolites et diffère de la Formation de Contwoyto en ce qu'elle ne renferme pas de formation de fer, que ses lits sont généralement plus épais et ses grains plus grossiers et que certains de ses lits de métagrauwacke à grain plus grossier renferment des concrétions carbonatées.

Le Groupe de Keskarrah, qui s'articule en trois faciès distincts dont les relations stratigraphiques restent à définir, repose en discordance sur les membres plus anciens du Supergroupe de Yellowknife et sur le Granite d'Augustus. Une datation provisoire sur du zircon détritique indiquerait que l'âge maximal probable de la sédimentation serait d'environ 2,60 Ga, soit approximativement 60 millions d'années après la mise en place des membres plus anciens du Supergroupe de Yellowknife présents dans cette région. Le Groupe de Keskarrah est partout métamorphisé au faciès des schistes verts, soit le même degré de métamorphisme que les roches sur lesquelles il repose en discordance.

Les conglomérats constituent le faciès le plus abondant; ils comprennent des unités épaisses composées essentiellement de clastes de granite, dérivés essentiellement du Granite d'Augustus, et de fragments de roches volcaniques mafiques, dérivées vraisemblablment de la Formation de Peltier. Des clastes de gneiss granitoïde se rencontrent dans des affleurements à l'ouest; localement, on trouve aussi des clastes de roches volcaniques felsiques à intermédiaires. Par endroits, les conglomérats renferment de minces unités allant jusqu'à des lentilles de grès à grain grossier à stratification entrecroisée, de composition semblable à celle des conglomérats. Un faciès de grès riche en quartz, à stratification entrecroisée, est associé aux conglomérats, principalement à l'ouest. Il forme généralement des unités parallèles les unes aux autres, de 10 à 20 cm d'épaisseur, séparées fréquemment par de fines couches ou des lamines de mudstone. Dans de rares cas, les faisceaux à stratification entrecroisée sont de l'ordre du mètre. Ce faciès se serait accumulé sur une avant-plage inférieure, en eau peu profonde. Le grès se compose surtout de quartz anguleux et conglomerate, a mixed granitoid and volcanic provenance is indicated. The third facies is a turbidite that occurs in the southeastern part of the area, where it conformably overlies the conglomerate facies in that area and consists mainly of thick-bedded, coarse-grained greywackes, thus contrasting strongly with the nearby Contwoyto Formation, although the clast composition is similar.

The combination of abundant, thick units of coarse conglomerates and associated shallow-water sandstones in the west and deeper water turbidites in the east suggests that the Keskarrah Group represents a fan-delta complex with a presumed high-relief source to the west. The relief may have been formed by early movements along the major ductile shear zone system that separates the two principal domains of the map area.

Granitoid rocks that postdate all or most of the Yellowknife Supergroup are a minor component of the eastern domain and a major one of the western domain. In the eastern domain, pegmatites, small two-mica granite plugs, and one small pluton intrude the higher grade rocks of the Itchen and Contwoyto formations. In the western domain, the previously mentioned granitoid gneisses form large enclaves contained in what are presumed to be mainly post-Yellowknife Supergroup granitoid rocks. These granitoid rocks range in composition from granite to tonalite, and several ages are indicated on the basis of crosscutting relationships. Dykes and veins from these intrusions intrude the gneisses and are found locally within the deformed volcanic rocks in the boundary ductile shear zone as tectonically disrupted dykes and veins. Most have a northeasterly trending foliation that increases in intensity and becomes more northerly as the boundary shear zone is approached.

Two sets of diabase dykes are known to exist in the area. The oldest Paleoproterozoic set trends east. No original igneous mafic minerals have been preserved and the dykes now contain actinolite, suggesting low-grade Paleoproterozoic metamorphism. They are possibly correlative with the similarly trending Mackay diabase dykes of the central and eastern Slave Province, which have a preliminary U-Pb age of 2.21 Ga. The younger dyke set is the north-northwesterly trending, 1.27 Ga Mackenzie diabase.

généralement finement polycristallin, de clastes lithiques abondants et, accessoirement, de plagioclases fréquemment altérés. Comme pour les conglomérats, il serait dérivé de roches granitoïdes et de roches volcaniques. Le troisième faciès est une turbidite qui se rencontre dans le sud-est de la région; il repose en discordance sur un faciès conglomératique. Il se compose principalement de lits épais de grauwacke à grain grossier et, par conséquent, il est très différent de celui de la Formation de Contwoyto avoisinante, bien que la composition des clastes soit semblable.

La combinaison d'unités abondantes et épaisses de conglomérats à grain grossier et de grès associées d'eau peu profonde dans l'ouest et de turbidites d'eau plus profonde dans l'est laisse supposer que le Groupe de Keskarrah correspond à un complexe de cônes de déjection qui aurait eu une source à relief marqué à l'ouest. Ce relief se serait formé lors de mouvements précoces survenus le long du grand réseau de zones de cisaillement ductile qui sépare les deux principaux domaines de la région cartographique.

Des roches granitoïdes postérieures à l'ensemble ou presque du Supergroupe de Yellowknife constituent une composante mineure du domaine de l'est et une composante majeure du domaine de l'ouest. Dans le domaine de l'est, des pegmatites, de petits culots volcaniques de granite à deux micas et un petit pluton recoupent les roches plus fortement métamorphisées des formations d'Itchen et de Contwoyto. Dans le domaine de l'ouest, les gneiss granitoïdes mentionnés précédemment forment de grandes enclaves au sein de ce qui semblerait être principalement des roches granitoïdes plus récentes que le Supergroupe de Yellowknife. Ces roches granitoïdes ont une composition allant du granite à la tonalite et leurs âges varient vraisemblablement, à en juger par les liens qui existent entre les intrusions. Des dykes et des filons de ces intrusions recoupent les gneiss et se rencontrent par endroits sous la forme de dykes et de filons tectoniquement disloqués dans les roches volcaniques déformées de la zone de cisaillement ductile limitrophe. La plupart d'entre eux montrent une foliation à orientation nord-est qui devient plus marquée et s'oriente davantage vers le nord au fur et à mesure que l'on s'approche de la zone de cisaillement limitrophe.

On a noté la présence de deux essaims de dykes de diabase dans la région. L'essaim paléoprotérozoïque le plus ancien essaim a une orientation est. Aucun minéral mafique igné originel n'y a été conservé; les dykes renferment maintenant de l'actinote, ce qui laisse supposer qu'ils auraient été le siège d'un faible métamorphisme au Paléoprotérozoïque. Ils sont probablement en corrélation avec les dykes de diabase de Mackay, à orientation similaire, qui se rencontrent dans le centre et l'est de la Province des Esclaves et dont l'âge provisoirement déterminé sur U-Pb est de 2,21 Ga. L'essaim de dykes plus récent est la diabase de Mackenzie, à orientation nord-nord-ouest, dont l'âge a été établi à 1,27 Ga.

The only post-Archean supracrustal rocks in the area are a small outcrop area of dolostone that is possibly correlative with the Rocknest Formation of the Epworth Group, which outcrops a few kilometres northwest of the area.

The area was glaciated during the Quaternary, with ice flow generally to the west. The ice withdrew about 9000 years ago. The unconsolidated Quaternary sediments are dominated by till with minor glaciofluvial, glaciolacustrine, alluvial, and organic deposits.

On structural grounds, the area can be divided into three domains that coincide with the western granitoid and granitoid gneiss domain, the eastern supracrustal-dominated domain, and a boundary domain consisting of the ductile shear zone that separates the other two.

The western domain is dominated by northeasterly trending units and foliations that swing parallel with the northerly trending boundary shear zone at its margin. This northeasterly trend is apparent in several regions of the southwestern Slave Province as far south as Yellowknife. Older structural elements are found in the gneissic enclaves in the domain, most of which are difficult to correlate with structures in the eastern supracrustal domain and may well predate the Yellowknife rocks.

The northerly trending, en échelon, ductile shear zones of the boundary domain dip moderately to steeply east and involve rocks of both the western granitoid and eastern supracrustal domains. The shear zone itself is folded into a series of lobate-cuspate buckle folds with wavelengths up to several kilometres and axes oriented at a low clockwise angle to the shear zone, which cannot be traced far into the adjacent structural domains.

The supracrustal rocks of the eastern domain have undergone polyphase deformation. The principal structures are a series of north-trending, steeply westerly verging folds with gently northerly and southerly plunging fold axes and wavelengths of several kilometres. These folds involve both the Point Lake and Cogead groups as well as the rocks of Keskarrah Group that unconformably overlie them. At least one older deformational event involving the older Yellowknife rocks is indicated, as the unconformity below the Keskarrah Group cuts several of the older Yellowknife Supergroup units as well as the Augustus Granite. The limbs of the principal folds contain mesoscopic folds with steep but locally varied plunges. The axial planar foliation of these mesoscopic folds is overgrown by metamorphic porphyroblasts. In the western part of the domain, these folds

Les seules roches supracrustales postarchéennes de la région sont une petite zone affleurante de dolomie qui est peut-être en corrélation avec la Formation de Rocknest du Groupe d'Epworth, laquelle affleure quelques kilomètres au nord-ouest de la région.

La région a été englacée au Quaternaire; les glaces se sont écoulées généralement vers l'ouest et se sont retirées il y a environ 9000 ans. Les sédiments meubles du Quaternaire sont principalement du till avec de petits dépôts de sédiments fluvioglaciaires, glaciolacustres, alluviaux et organiques.

On peut diviser la région en trois domaines structuraux, soit le domaine de l'ouest où prédominent des granitoïdes et des gneiss granitoïdes, le domaine de l'est où prédominent des roches supracrustales et un domaine limitrophe comportant une zone de cisaillement ductile qui sépare les deux premiers domaines.

Le domaine de l'ouest est dominé par des foliations et des unités à orientation nord-est qui deviennent parallèles à la zone de cisaillement limitrophe, orientée vers le nord, à sa marge. Cette orientation nord-est est visible dans plusieurs régions de la partie sud-ouest de la Province des Esclaves aussi loin au sud que Yellowknife. Le domaine de l'ouest comporte des éléments structuraux plus anciens dans les enclaves de gneiss; il est difficile d'établir une corrélation entre la plupart de ces éléments et les structures du domaine des roches supracrustales à l'est; ces éléments pourraient être antérieurs aux roches du Supergroupe de Yellowknife.

Les zones de cisaillement ductiles en échelon, à orientation nord, du domaine limitrophe ont un pendage est modéré à fort et ont touché tant les roches du domaine de l'ouest que celles du domaine de l'est. La zone de cisaillement est plissée en une série de plis de flambement lobés et cuspidés, dont les longueurs d'onde vont jusqu'à plusieurs kilomètres et dont les axes sont orientés selon un angle subhorizontal, dans le sens de l'aiguille d'une montre par rapport à la zone de cisaillement, laquelle n'a pu être retracée très loin dans les domaines structuraux adjacents.

Dans le domaine de l'est, les roches supracrustales ont subi une déformation polyphasée. Les structures principales comprennent un ensemble de plis à orientation nord et à vergence ouest raide, dont les axes plongent doucement vers le nord et le sud et les longueurs d'onde sont plurikilométriques. Ces plis ont déformé les roches des groupes de Point Lake et de Cogead et les roches du Groupe de Keskarrah qui les recouvrent en discordance. Il y a eu au moins un événement de déformation plus ancien qui a touché les roches plus anciennes du Supergroupe de Yellowknife, car la discordance à la base du Groupe de Keskarrah recoupe plusieurs des unités plus anciennes du Supergroupe de Yellowknife de même que le Granite d'Augustus. Les flancs des principaux plis renferment des plis mésoscopiques à plongement raide mais localement varié. Des porphyroblastes métamorphiques se sont formés dans la schistosité de foliation de ces plis mésoscopiques. Dans la partie have an 's' sense of asymmetry and are similar in style, if not in scale, to the lobe and cuspate buckle folds of the boundary domain. The foliations associated with these folds have been modified by two additional deformational phases or events. Finally, in the western part of the domain, there seems to be a large-scale structural depression that is responsible for the inward plunge of the principal fold axes and in which are preserved both the lowest grade rocks within it as well as the stratigraphically highest rocks of the Yellowknife Supergroup at the present erosional level.

Several groups of faults of varied ages, trends, and environments are found throughout the area. The oldest and probably longest lived structure is the boundary ductile shear zone that resulted in the exposure of deeper level rocks to the west. Early premetamorphic movements along this structure may have provided the relief necessary for the production and deposition of the Keskarrah Group conglomerates. The latest movements along it are postmetamorphic. A second set of northerly trending structures are steeply easterly dipping, postmetamorphic reverse faults. The third set includes east-trending, brittle faults with short displacements. Finally, a northeasterly trending fault set that is best developed in the western domain is correlative with the post 1.84 Ga dominantly transcurrent fault set so prominently developed in the Wopmay Orogen to the west.

At least three distinct periods of metamorphism affected the rocks in the map area. The oldest produced the orthogneissic rocks of the western domain that largely predate sedimentation and volcanism of the Yellowknife Supergroup. The youngest is low-grade Paleoproterozoic metamorphism that is represented by the actinolite-bearing assemblages of the east-trending Paleoproterozoic diabase dyke set.

The most prominent metamorphic pattern in the area is attributed to late Archean metamorphism that affected the Yellowknife Supergroup and older plutonic and gneissic rocks of the region. The metamorphic grade ranges from lower greenschist to upper amphibolite in a low-pressure facies series. The metamorphic pattern is defined by chlorite, biotite, cordierite, sillimanite, and migmatite zones, primarily in the Contwoyto and Itchen formations. The lowest grade rocks occur in the west-central part of the eastern domain in a short, northerly trending trough. The metamorphic grade increases both to the east and the west with the less complete western metamorphic field gradient steeper than that to the east. Both gradients, however, are steeper than most such gradients in the Slave Province. The highest grade rocks,

ouest du domaine, ces plis montrent une asymétrie en forme de «s» et sont de style, sinon de dimension, identique aux plis de flambement lobés et cuspidés du domaine limitrophe. Deux autres phases ou événements de déformation ont modifié les foliations associées à ces plis. Enfin, dans la partie ouest du domaine, une grande dépression structurale aurait été à l'origine du plongement vers l'intérieur des principaux axes de pli; on y trouve les roches les plus faiblement métamorphisées et les roches de niveau stratigraphique le plus élevé du Supergroupe de Yellowknife au niveau d'érosion actuel.

Plusieurs ensembles de failles d'âges, d'orientations et de milieux divers se rencontrent dans toute la région. La structure la plus ancienne et probablement de durée de vie la plus longue est la zone de cisaillement ductile limitrophe qui a mis a nu les roches de niveau plus profond vers l'ouest. Des mouvements prémétamorphiques précoces survenus le long de cette structure ont vraisemblablement engendré le relief nécessaire à la production et à la mise en place des conglomérats du Groupe de Keskarrah. Les mouvements les plus tardifs survenus le long de cette structure sont postmétamorphiques. Un deuxième système de structures à orientation vers le nord comporte des failles inverses postmétamorphiques à fort pendage vers l'est. Le troisième faisceau comprend des failles cassantes à courts rejets orientées est-ouest. En dernier lieu, un faisceau de failles orientées nord-est est le mieux développé dans le domaine de l'ouest. Il peut être mis en corrélation avec le faisceau de failles principalement de coulissage d'âge postérieur à 1,84 Ga, qui est remarquablement développé dans l'orogène de Wopmay à l'ouest.

Les roches de la région cartographique ont subi au moins trois périodes distinctes de métamorphisme. La période la plus ancienne a produit les orthogneiss du domaine de l'ouest qui sont pour la plupart antérieurs à la sédimentation et au volcanisme du Supergroupe de Yellowknife. La période la plus récente correspond à un métamorphisme de faible degré au Paléoprotérozoïque qui est exprimé par des paragenèses à actinote de l'essaim de dykes de diabase paléoprotérozoïque à orientation est-ouest.

La structure métamorphique la plus importante de la région est attribuée au métamorphisme de l'Archéen tardif qui a touché les roches du Supergroupe de Yellowknife et les roches plutoniques et gneissiques plus anciennes de la région. Le degré de métamorphisme va du faciès inférieur des schistes verts au faciès supérieur des amphibolites dans un ensemble de faciès de basse pression. La zonéographie métamorphique est définie par des zones à chlorite, à biotite, à cordiérite, à sillimanite et à migmatite, principalement dans les formations de Contwoyto et d'Itchen. Les roches les plus faiblement métamorphisées se trouvent dans le centre ouest du domaine de l'est dans une cuvette courte à orientation nord. Le degré de métamorphisme augmente vers l'est et vers l'ouest, et le gradient métamorphique moins complet à l'ouest est plus fort que celui à l'est. Cependant, tous deux sont plus forts que la plupart des metasedimentary migmatites, occur in the western domain in paragneiss that is possibly correlative with the Contwoyto and/or Itchen formations of the eastern domain. The greenschist grade Keskarrah Group, the youngest member of the Yellowknife Supergroup, is associated with the lowest grade rocks of the older members of the Yellowknife Supergroup. A close temporal association exists between metamorphism and deformation of the supracrustal rocks, with the peak of metamorphism largely postdating the major folding events. An exception is the formation of the major structural depression in which are preserved the lowest grade rocks and highest stratigraphic levels in the central part of the area; this depression presumably is partly responsible for the local steepness of the metamorphic gradients.

gradients de la Province des Esclaves. Les roches les plus fortement métamorphisées sont des migmatites d'origine sédimentaire qui se rencontrent dans les paragneiss du domaine de l'ouest, lesquels sont peut-être en corrélation avec les formations de Contwoyto, d'Itchen ou les deux, du domaine de l'est. Le Groupe de Keskarrah métamorphisé au faciès des schistes verts, soit le membre le plus jeune du Supergroupe de Yellowknife, est associé aux roches les plus faiblement métamorphisées des membres plus anciens du Supergroupe de Yellowknife. Il existe une association temporelle étroite entre le métamorphisme et la déformation des roches supracrustales, le métamorphisme le plus intense étant en grande partie postérieur aux principales phases de plissement. La formation de la grande dépression structurale fait exception; on y trouve les roches les plus faiblement métamorphisées et les niveaux stratigraphiques les plus élevés de la partie centrale de la région. De plus, elle est vraisemblablement en partie à l'origine des forts gradients de métamorphisme trouvés par endroits dans la région.

Most economic mineral showings and deposits within the area are either gold associated with iron-formation in the Contwoyto Formation or base-metal mineralization associated mainly with the mafic volcanic units. Minor Cu and Ni showings occur in shear zones in layered amphibolites of the Perrault Lithodeme and in associated altered gabbros. Zinc-copper-lead mineralization associated with siliceous graphitic rocks and quartz-rich layers within mafic volcanic rocks of the Peltier Formation occurs at several localities. Gold associated with sulphide-bearing silicate iron-formation is found north and east of the intermediate and felsic volcanic centre in the Contwoyto Formation. The largest deposit in the area, the REN deposit, consists of about 1.1 million tonnes containing about 6.5 g/tonne gold.

La plupart des indices et des gisements à valeur économique de la région sont liés soit à l'or associé aux formations de fer de la Formation de Contwoyto, soit aux minéralisations de métaux communs associées principalement aux unités volcaniques mafiques. De petits indices de Cu et de Ni se rencontrent dans les zones de cisaillement dans les amphibolites stratiformes du Lithodème de Perrault et dans les gabbros altérés associés. Une minéralisation de Zn-Cu-Pb associée à des roches graphitiques siliceuses et des couches riches en quartz se rencontre à plusieurs endroits dans les roches volcaniques mafiques de la Formation de Peltier. De l'or est associé à de la formation de fer sulfurée à faciès silicaté dans la Formation de Contwoyto au nord et à l'est du centre volcanique de composition felsique et intermédiaire. Le gisement le plus important de la région, le gisement REN, contient environ 1,1 million de tonnes de minerai dont la teneur approximative en or est de 6,5 g/t.

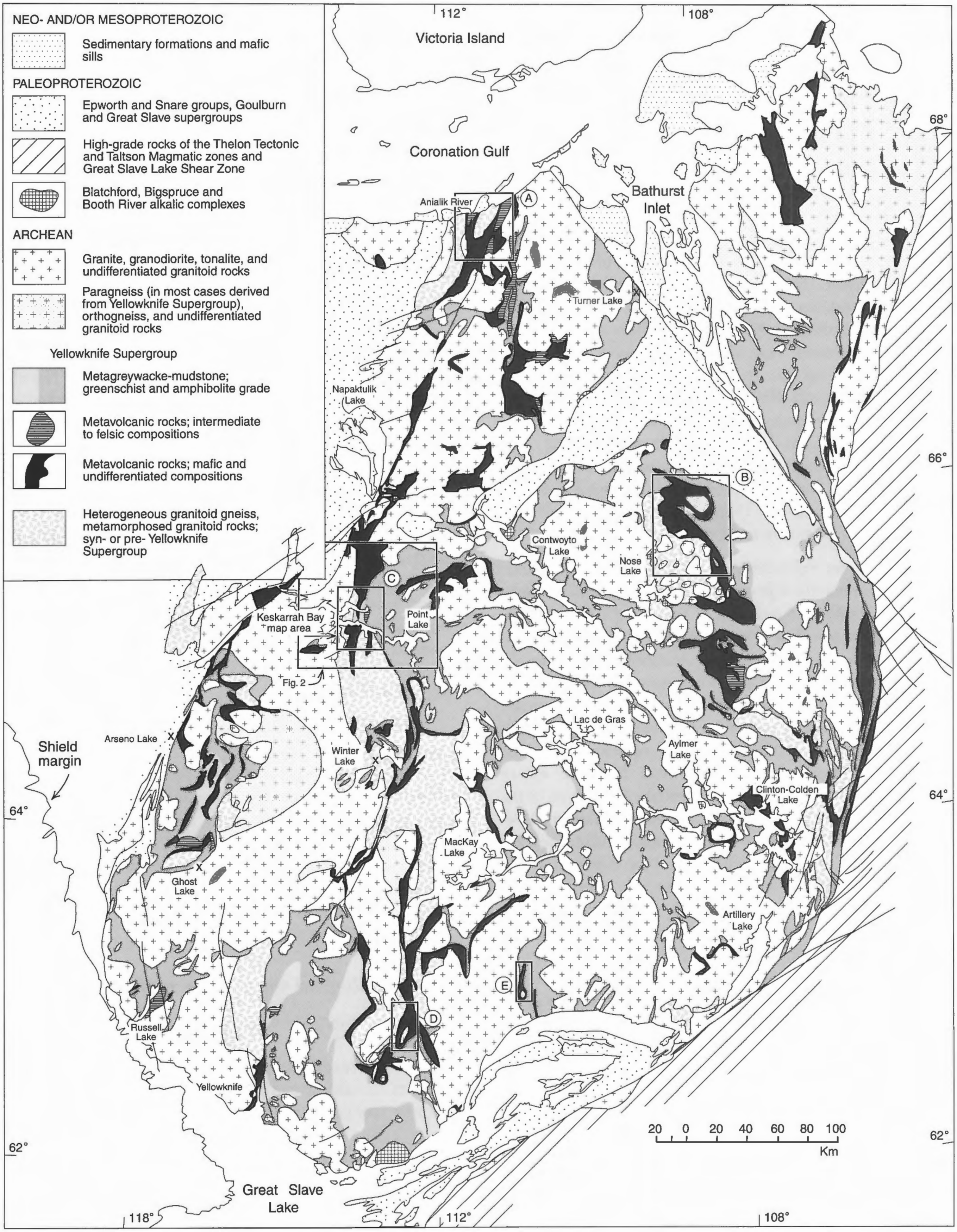
## INTRODUCTION

An unusually well preserved and complete sequence of Archean supracrustal rocks occurs in the Keskarrah Bay area at Point Lake (Fig. 1). Regional geological mapping of the area provides a framework for examining and understanding the geological evolution of this region that may well apply elsewhere in the Slave Province.

Point Lake is in the west-central part of the Slave Province, an Archean craton that has remained relatively stable with respect to much of the surrounding terrane since the close of the Archean 2.5 Ga ago. The Slave Province is bounded by rocks that were highly deformed during the Paleoproterozoic or by Paleoproterozoic to Paleozoic rocks that are minimally deformed to undeformed and that rest unconformably on the Slave Province (Fig. 1).

***Figure 1.***

*General geology of the Slave Structural Province. The location of the Keskarrah Bay area in the west-central part of the province is indicated. Other areas on the map, identified as A, B, C, D, and E, contain synvolcanic granitoid intrusions and are referred to in the text. Specific localities in the Slave Province referred to in the text are marked 'X'. The geological map is modified primarily after McGlynn (1977) and Hoffman and Hall (1993) and other published sources.*


NEO- AND/OR MESOPROTEROZOIC
Sedimentary formations and mafic sills
PALEOPROTEROZOIC
Epworth and Snare groups, Goulburn and Great Slave supergroups
High-grade rocks of the Thelon Tectonic and Taltson Magmatic zones and Great Slave Lake Shear Zone
Blatchford, Bigspruce and Booth River alkalic complexes
ARCHEAN
Granite, granodiorite, tonalite, and undifferentiated granitoid rocks
Paragneiss (in most cases derived from Yellowknife Supergroup), orthogneiss, and undifferentiated granitoid rocks
Yellowknife Supergroup
Metagreywacke-mudstone; greenschist and amphibolite grade
Metavolcanic rocks; intermediate to felsic compositions
Metavolcanic rocks; mafic and undifferentiated compositions
Heterogeneous granitoid gneiss, metamorphosed granitoid rocks; syn- or pre- Yellowknife Supergroup
112°
108°
Victoria Island
Coronation Gulf
Bathurst Inlet
68°
Anialik River
A
Turner Lake
Napaktulik Lake
66°
B
Contwoyto Lake
Nose Lake
C
Keskarrah Bay map area
Point Lake
Fig. 2
Lac de Gras
Aylmer Lake
Arseno Lake
Shield margin
Winter Lake
64°
Clinton-Colden Lake
MacKay Lake
Ghost Lake
Artillery Lake
E
D
Russell Lake
Yellowknife
20 0 20 40 60 80 100
Km
62°
Great Slave Lake
118°

The Archean supracrustal rocks of the Slave Province are part of the Yellowknife Supergroup (Henderson, 1970). They consist dominantly of metamorphosed greywacke-mudstone turbidites and mafic to felsic metavolcanic rocks and so are broadly similar to the supracrustal rocks in most Archean granite-greenstone terranes elsewhere in the world. In contrast to most of these other terranes, however, the area underlain by metasedimentary rock in the Slave Province greatly exceeds that underlain by metavolcanic rock (Fig. 1). A volumetrically minor assemblage of conglomerate and shallow-water sandstone locally unconformably overlies the main metasedimentary-metavolcanic succession. Even rarer are occurrences of quartz-rich metasedimentary rocks and some felsic metavolcanic rocks and iron-formation that predate the main Yellowknife Supergroup succession. All three assemblages, however, are currently considered part of the Yellowknife Supergroup. Representatives of the two younger assemblages occur within the Keskarrah Bay area. Slightly more than half the province is underlain by Archean granitoid rocks intrusive into the Yellowknife Supergroup. Preserved locally are granitoid to granitoid gneiss remnants that are considered to be synchronous with or to predate the Yellowknife Supergroup (e.g. Frith et al. (1986), Henderson et al. (1987), Lambert and van Breemen (1991), Thompson et al. (1994)).

Rocks of the Yellowknife Supergroup occur in a series of large, dominantly supracrustal domains. One of the most complete of these is found east of Yellowknife in the southern part of the province (Fig. 1), where a large area of meta-greywacke-mudstone turbidite is discontinuously bounded by largely mafic volcanic sequences, some of which mantle complex granitoid and granitoid gneiss terranes that contain varied amounts of gneiss that predates the Yellowknife Supergroup. Where there are no gneissic rocks, the supracrustal rocks are bounded, and to some extent intruded, by granitoid rocks that postdate all or most of the Yellowknife Supergroup granitoid rocks. Minor shallow-water sedimentary rocks occur locally, unconformably overlying the volcanic rocks and, less commonly, the greywacke-mudstone turbidites. Several interpretations have been proposed for this terrane, with tectonic models ranging from a continental, fault-bounded rift basin in which the locus of volcanism was controlled by the bounding fault systems (McGlynn and Henderson, 1970; Lambert, 1977, 1988; Henderson, 1981, 1985), to an oceanic island arc (Folinsbee et al., 1968) with all variations in between (Helmstaedt and Padgham, 1986; Hoffman, 1986; Kusky, 1986, 1989, 1990a, b; Fyson and Helmstaedt, 1988; and others).

None of the areas in the Slave Province that are dominated by supracrustal rocks represent a complete basinal segment. However, at Point Lake in the Keskarrah Bay area, extensive Yellowknife Supergroup deposits do contain a well preserved and reasonably well exposed supracrustal complex. In the Keskarrah Bay region, steep reverse faulting approximately parallel to the margin of the supracrustal domain has repeated a series of sections through the supracrustal sequence, normal to the regional strike of the units.

The region surrounding the Keskarrah Bay area is of considerable economic interest. Some sulphide-bearing silicate facies iron-formation associated with one of the major sedimentary formations contains high gold values (Bostock, 1968, 1980) and indeed the Lupin mine, a major gold producer at the national scale, is developed in iron-formation in this unit at Contwoyto Lake, about 85 km northeast of the area (Kerswill, 1993). A 13.6 million tonne Cu-Zn-Pb-Ag deposit is found at Izok Lake, 20 km north of the area (Bostock, 1980; Morrison, 1993).

The area mapped is on Point Lake in the District of Mackenzie, at a latitude between 65°08′ and 65°29′N and a longitude between 112°45′ and 113°15′W. The geological map of the area (Map 1679A, Henderson, 1988) includes an additional area extending 10′ to the west that was subsequently mapped by Easton (1981). The approximately 900 $km^2$ area is about 325 km north of Yellowknife and was mapped at a scale of 1:50 000. Point Lake is part of the Coppermine River system, a popular canoe route that drains north into Coronation Gulf at Coppermine. Access to the area is easiest by float-equipped aircraft available for charter in Yellowknife. The area is also accessible from Great Slave Lake by either the Snare River or Yellowknife River systems, and then by a series of lakes and streams as described by Stockwell (1933), across the divide and into Point Lake.

The terrane is typical of much of the Canadian Shield — generally flat and featureless. Areas underlain by volcanic rocks tend to have greater relief and better exposure than those underlain by metasedimentary rocks. The granitoid terrane is intermediate in relief and quality of exposure. Point Lake is 375 m above sea level and the surrounding hilly terrain reaches about 500 m. Local relief reaches 70 m in the volcanic terrane. The country is mostly barren of trees although some quite substantial coniferous trees are found in some of the more sheltered valleys.

## *Other geological work in the region*

European exploration of the region was begun by Samuel Hearne in 1771 and is briefly summarized by Bostock (1980). Although geological observations were made by some of the early explorers, the first expedition whose main purpose was geological was undertaken by C.H. Stockwell in 1932 (Stockwell, 1933). Stockwell and crew canoed up the Yellowknife River from Great Slave Lake to Point Lake and down the Coppermine River as far as Rocknest Lake. They returned by paddling up the Coppermine to its headwaters at Lac de Gras, then south through MacKay Lake and along the Barnston River to the east arm of Great Slave Lake. Stockwell recognized an 'Early Precambrian' metavolcanic and metasedimentary succession extensively intruded by granitoid bodies that he included in his Point Lake-Wilson Island group. At Point Lake, Stockwell recognized and described in considerable detail a chlorite-bearing granite that he considered to lie unconformably below the volcanic and sedimentary rocks of the Point Lake-Wilson Island group. Despite more than half a century of geological work throughout the Slave Province, this locality at Keskarrah Bay (previously known informally as Richardson Bay) on Point Lake remains the most unequivocal example in the Slave Province of granitoid basement to some, if not all, of the Archean supracrustal succession of the region.

The first systematic geological mapping of the Keskarrah Bay area was undertaken in 1959 as part of the Geological Survey of Canada's 'Operation Coppermine 1959' (Fraser, 1960). This helicopter-supported reconnaissance over the northwestern part of the District of Mackenzie resulted in the outlining of the Archean granitoid rocks and Yellowknife Supergroup metavolcanic and metasedimentary terranes of the northwestern Slave Province. Following the discovery of gold associated with iron-formation in the metasedimentary rocks at the northwest end of Contwoyto Lake in 1961, the region underlain by the iron-formation-bearing metasedimentary rocks was intensely prospected during the early sixties. The Itchen Lake area, which includes the Keskarrah Bay area, was mapped at a scale of 1:250 000 by Bostock (1966, 1967a, b). The most complete description of the region to date is provided by Bostock (1980). With the discovery of the major base-metal prospect immediately northwest of Itchen Lake by Texas Gulf Inc. in 1974, interest in the area was renewed for both base metals and gold.

The Keskarrah Bay area was mapped at a scale of 1:50 000 in 1976 (Henderson and Easton, 1977; Henderson, 1977), following a reconnaissance visit to the area to see the unconformity between granitoid basement and rocks of the Yellowknife Supergroup originally described by Stockwell (Henderson, 1975a). Due to increasing interest in the economic potential of the area, most of the area and surrounding terrain was mapped at a scale of 1:31 680 by the Geology Division of Indian and Northern Affairs Canada (Bau, 1979; Goodwin et al., 1979; King et al., 1980a, b; Easton, 1981; Jackson, 1982), as summarized in Figures 2 and 3. A structural-metamorphic study of the area was undertaken by Jackson (1982, 1983, 1984, 1985, 1989a) and a similar study was done on the mainly metasedimentary terrane to the east (King et al., 1980a, b; King, 1982; King and Helmstaedt, 1989). Kusky (1989, 1990a, 1991) and Kusky and De Paor (1991) also studied the tectonics of the area. Corcoran et al. (1997) have mapped parts of the Keskarrah Group within the map area. The area to the west, which includes the older granitoid gneiss terrane, was mapped and described by Easton (1981, 1985) and Easton et al. (1982). Part of the work of Easton (1981) has been included on the Keskarrah Bay map (Henderson, 1988).


### *Acknowledgments*

The field work was greatly aided by the enthusiastic and capable assistance of R. Michael Easton (senior assistant), Susan Boyce and Edward Lisle (student assistants), and Virginia Taylor (cook). The map of the Keskarrah Bay area (Henderson, 1988) was significantly improved as a result of critical reviews by Valerie A. Jackson (Indian and Northern Affairs Canada) and Janet E. King (Geological Survey of Canada). Dr. W.A. Padgham, former director of the Geology Division, Indian and Northern Affairs Canada, kindly gave permission for the inclusion of parts of the geology of map areas NTS 86H3 and 86H6 (Easton, 1981), which made the map of the Keskarrah Bay area much more complete. Extensive use was made of Valerie A. Jackson's thesis (Jackson, 1989a) on the metamorphism and structural evolution of the area, which resulted in a much more complete review than would otherwise have been possible. The continued interest of Mikkel Schau in the area and the discussions that resulted, particularly concerning the Keskarrah Group, are particularly appreciated. John Kerswill reviewed and provided helpful comments on the Contwoyto Formation and Economic Geology sections of the report. Wouter Bleeker critically reviewed the original manuscript and his comments and suggestions have clarified both my thinking and the resulting final report.


## GENERAL GEOLOGY

The Keskarrah Bay area (Fig. 4) is situated in the west-central Slave Province, on the western margin of an extensive area of Archean Yellowknife Supergroup supracrustal rocks. These metasedimentary rocks extend through Contwoyto Lake to the eastern margin of the Slave Province and at least 100 km southeast of the area (Fig. 1). Supracrustal rocks can be traced continuously into the large, Yellowknife-Supergroup-dominated domain east of Yellowknife, in the southern Slave Province. A more local context is shown in Figure 2.

The map area can be divided into two distinct domains separated by a major northerly trending ductile shear zone (Fig. 4). The eastern domain is dominated by supracrustal rocks of the Yellowknife Supergroup. The western domain consists of complex orthogneiss, paragneiss possibly related to rocks of the Yellowknife Supergroup, and foliated granitoid rocks that largely postdate the Yellowknife Supergroup. This latter domain represents a much deeper structural level than the locally low-grade supracrustal-dominated domain to the east.

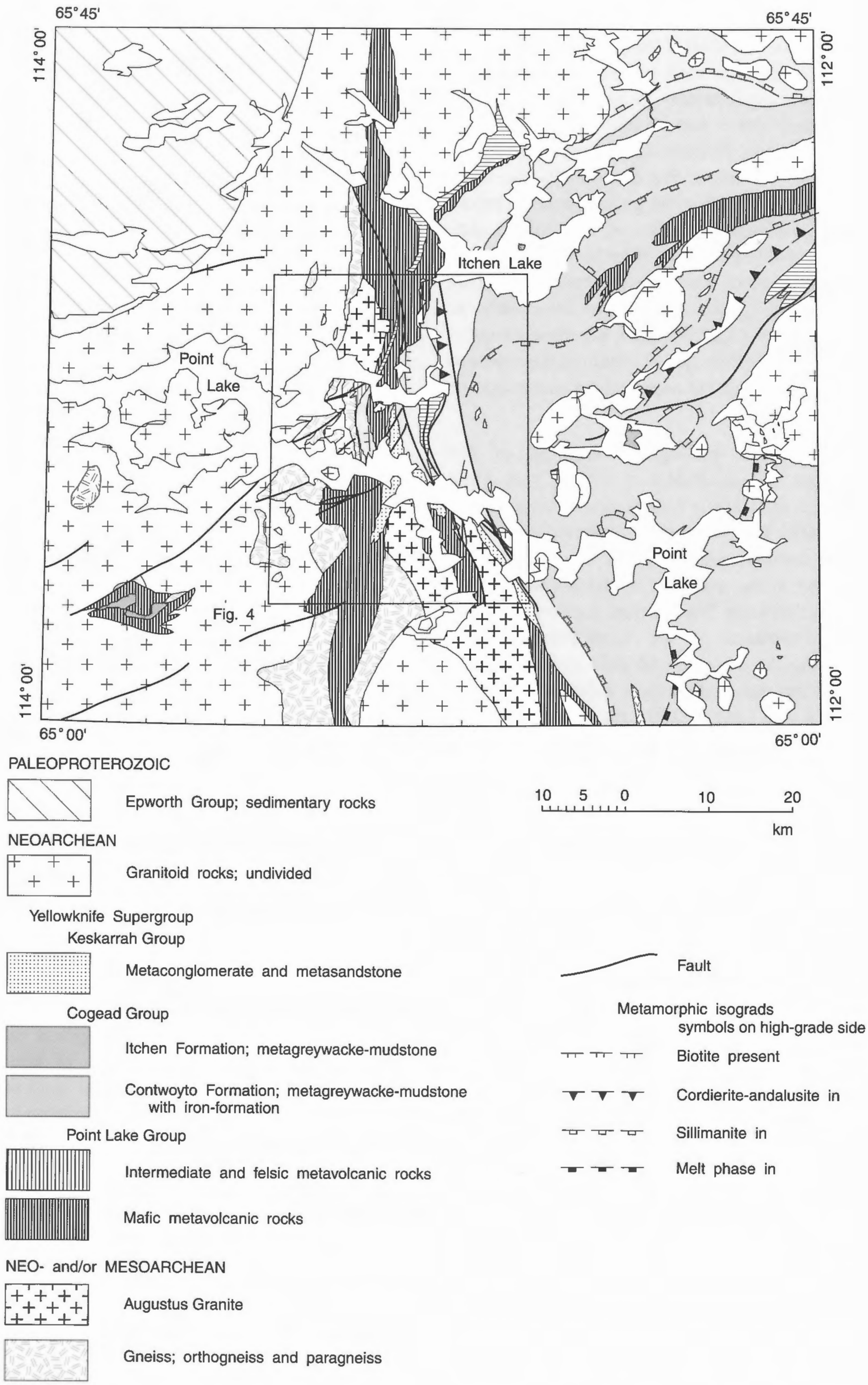



***Figure 2.*** *General geology of the Point Lake region. Sources of information are given in Figure 3.*

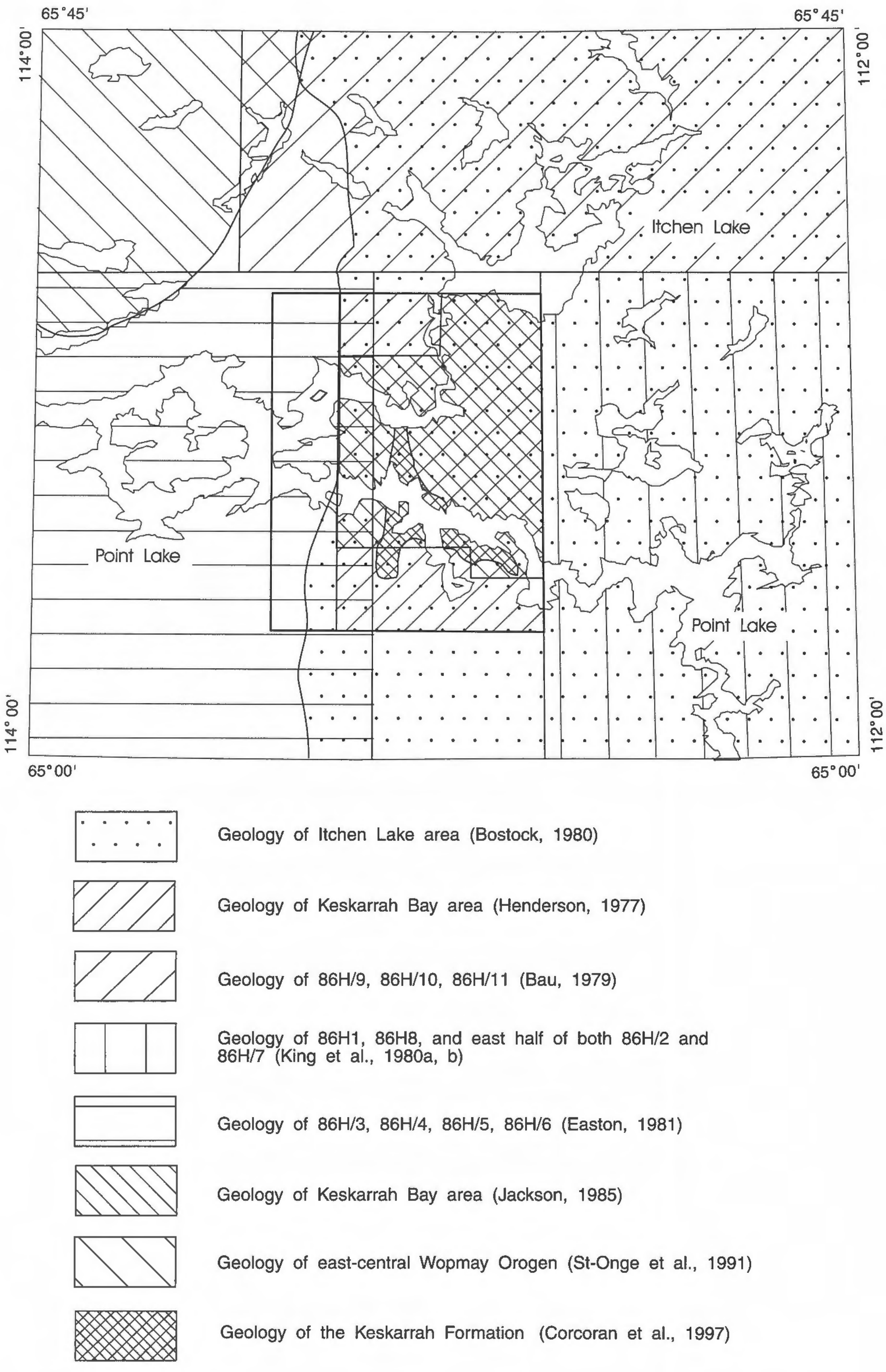



***Figure 3.*** *Other geological work in the Keskarrah Bay area and surrounding region.*

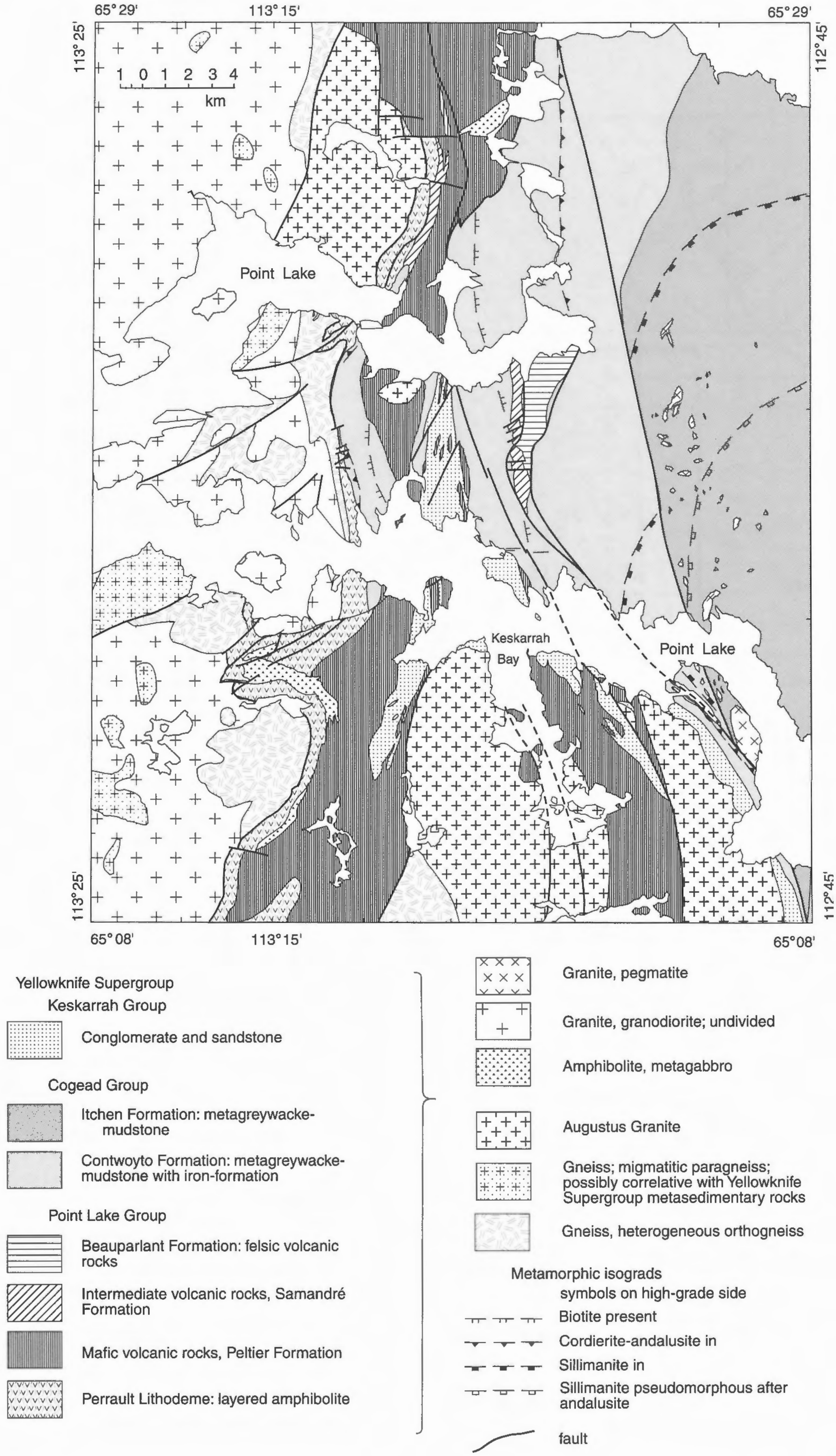



***Figure 4.***

*General geology of the Keskarrah Bay area.*

Within the eastern supracrustal domain, the Point Lake Group includes volcanic rock units of the Yellowknife Supergroup, which mostly occur in the western part of the domain. Mafic volcanic rocks of the Peltier Formation dominate and consist mainly of pillowed and massive flows with lesser amounts of volcaniclastic units and contemporaneous dykes and sills, the largest of which have been mapped separately. Along most of the western margin of the supracrustal domain is the Perrault Lithodeme, a mainly mafic, highly deformed, layered amphibolite that is considered to be of supracrustal origin. Volcanic rocks of intermediate composition are much less abundant and are represented by smaller units associated with the mafic volcanic sequence of the Peltier Formation and by the Samandré Formation in the volcanic dome that is found along an anticlinal axis within the metasedimentary domain east of the main sequence of mafic volcanic rocks. Felsic volcanic rocks of the Beauparlant Formation are the main component of this dome. Small dolostone units are associated with these felsic volcanic rocks. Minor base-metal mineralization in the metavolcanic units has attracted interest in the past.

The Cogead Group includes the two sedimentary formations of the Yellowknife Supergroup that dominate the region. The Contwoyto and Itchen formations consist of turbiditic metagreywacke-mudstone, the dominant supracrustal lithology throughout the Slave Province. The two formations differ by the presence of layers to lenses of iron-formation within the Contwoyto Formation. The silicate-sulphide facies of these iron-formation bodies are locally gold-bearing and, at Contwoyto Lake 75 km east-northeast of the area, they are mined at the Lupin mine, currently the largest gold mine in the Northwest Territories.

The Keskarrah Group, a volumetrically much smaller sedimentary assemblage, unconformably overlies parts of the Cogead and Point Lake groups. It consists of conglomerate, shallow-water sandstone, and turbidite facies.

The Augustus Granite, a high-level intrusion cut by mafic dykes, some of which are thought to represent feeders to the overlying volcanic rocks (Stockwell, 1933), occurs in both the eastern supracrustal domain and the western granitoid gneiss and foliated granitoid domain. It contains zircons that are over 450 million years older than the oldest Yellowknife Supergroup rocks of the region. Although the Augustus Granite is clearly unconformably overlain by conglomerates of the Keskarrah Group, as originally recognized by Stockwell (1933), the original contact relationship between the granite and adjacent rock units is equivocal because of extensive shearing of observed contacts or lack of exposure.

The Yellowknife Supergroup and older rocks have been metamorphosed to varied degrees in a low-pressure, high-temperature facies series that is generally characteristic of the Slave Province as a whole (Thompson, 1978). The lowest grade rocks (subbiotite) occur in the central part of the area. Grade increases eastward to regional sillimanite grade. The gradient to the west is steeper, but both gradients have been telescoped to some extent by postmetamorphic reverse faulting.

The structure of the area is dominated by northerly trends of late Archean age that have been reinforced by a series of Paleoproterozoic reverse faults. The Archean structure is moderately to steeply dipping with eastward dips dominating. The Paleoproterozoic reverse faulting has repeated the sequences, from Augustus Granite up through the Yellowknife Supergroup rocks from the volcanic-dominated sequence in the west to the easternmost sequence where only sedimentary rocks overlie the granite.

The Yellowknife Supergroup is intruded by two suites of Archean rocks. The most extensive suite occurs in the western part of the area and consists of a heterogeneous assemblage of largely massive granite to granodiorite. The second suite consists of two-mica granite and pegmatite and is emplaced in the most highly metamorphosed metasedimentary rocks in the easternmost part of the area.

A small outlier of Paleoproterozoic dolostone, presumably correlative with parts of the Epworth Group to the northwest (Fig. 2), unconformably overlies the Archean rocks at one locality. The Archean rocks are also intruded by east-trending Paleoproterozoic diabase dykes and north-northwesterly trending Mesoproterozoic Mackenzie diabase dykes. The area was glaciated during the Quaternary, resulting in the deposition of discontinuous till and a series of westerly trending eskers.

## ORTHOGNEISS AND PARAGNEISS

The domain west of the major shear zone through the area consists of both granitoid rocks that postdate all or most of the Yellowknife Supergroup and a large proportion of orthogneiss and paragneiss (Fig. 5). Gneiss makes up approximately two thirds of the rock in tectonic contact with the supracrustal domain to the east, although the size of gneissic areas and the proportion of gneiss to younger granitoid rocks decrease abruptly to the west. Orthogneiss also occurs (Fig. 6) southwest of the main body of Augustus Granite southeast of Keskarrah Bay, at the southern margin of the map area (Fig. 7).

Only the area east of latitude 113°15′W was mapped originally. The entire granitoid domain from the shear zone within the Keskarrah Bay map area to about 40 km west was mapped by Easton (1981) at a scale of 1:30 000. Mappable inclusions of gneiss in the otherwise relatively homogeneous granitoid rocks that postdate all or most of the Yellowknife Supergroup all but disappear a few kilometres beyond the western margin of the present map area. The only significant exceptions are occurrences of gneiss found

## Table of Formations

| Eon | Era | Period/ Epoch | Group/Suite | Formation/ Lithodeme | Map symbol | Lithology |
|---|---|---|---|---|---|---|
| | Cenozoic | Quaternary | | | $Q_u$ | unconsolidated gravel, sand, and silt |
| | | | | unconformity | | |
| Proterozoic | Mesoproteozoic | | | Mackenzie | $P_{md}$ | diabase, gabbro dykes |
| | | | | intrusive contact | | |
| | Paleoproterozoic | | Epworth Gp (?) | Rocknest Fm (?) | $P_{cb}$ | dolostone |
| | | | | unconformity | | |
| | | | | | $P_d$ | diabase, gabbro dykes, weakly altered |
| | | | | intrusive contact | | |
| Archean | Neoarchean | | | | $A_{gb}$ | biotite-muscovite granite and pegmatite |
| | | | | | $A_{ga}$ | biotite (hornblende) granite, granodiorite |
| | | | | intrusive contact | | |
| | | | | | $A_a$ | amphibolite, metagabbro sills and dykes, locally with ultramafic lenses, considered at least in part contemporaneous with Yellowknife Supergroup but also includes intrusions possibly as young as Paleoproterozoic |
| | | | | intrusive contact | | |
| | | | Yellowknife Supergroup | | | |
| | | | Keskarrah Gp. | | $A_{Kc,s}$ | conglomerate, sandstone |
| | | | | unconformity | | |
| | | | Cogead Gp. | Itchen Fm | $A_{Ic,s,p}$ | metagreywacke, siltstone, and mudstone metamorphosed to lower to upper amphibolite facies |
| | | | | Contwoyto Fm | $A_{Ccl,b,c,s}$ | metagreywacke, siltstone, and mudstone, also iron-formation and minor thin carbonate beds to laminae, metamorphosed to greenschist and lower to upper amphibolite facies; conformably overlies Peltier Formation of Point Lake Group |
| | | | | contact not defined | | |
| | | | | | $A_{pgn}$ | gneiss, migmatitic paragneiss, possible high-grade equivalent of Itchen and/or Contwoyto formations? |
| | | | | contact not defined | | |
| | | | Point Lake Gp. | | $A_{cb}$ | dolostone with volcaniclastic layers |
| | | | | Beauparlant Fm | $A_B$ | felsic volcanic rocks |
| | | | | Samandré Fm | $A_S$ | intermediate volcanic rocks |
| | | | | Peltier Fm | $A_{Pm}$ | mafic volcanic rocks |
| | | | | Perrault Lithodeme | $A_{PR}$ | layered amphibolite, strongly sheared, derived from mafic volcanic rocks |
| | | | | sheared contact | | |
| | Neo/ Mesoarchean? | | | Augustus Granite | $A_A$ | granite, weakly to moderately metamorphosed, locally abundant mafic dykes and inclusions; unconformably overlain by Keskarrah Group, possibly intrusive into Point Lake Group |
| | | | | contact not defined | | |
| | Mesoarchean? | | | | $A_{ogn}$ | gneiss, heterogeneous orthogneiss |

at the northern margin of the Yellowknife Supergroup outlier 12 km west of the map area and at a second locality about 12 km to the north-northwest (Easton, 1981; Fig. 2).

Easton (1981, 1985) and Easton et al. (1982) subdivided the gneiss into several units based on lithology and cross-cutting relationships. The relationships between these various gneiss units are complex, with several of the units commonly present in a single outcrop. As shown on the map (Henderson, 1988) of the Keskarrah Bay map area, the various gneiss units have been combined into two units consisting dominantly of either orthogneiss or paragneiss. Areas are shown where a large number of gneiss inclusions are found in the granite to granodiorite that intrudes the gneiss and the dominant inclusion type is identified. For more detailed information on the occurrence and distribution of the various gneiss types, see the map of Easton (1981) where the relative proportions of the various gneiss units are indicated on an outcrop-by-outcrop basis.

***Figure 5.*** *Well exposed shoreline outcrop of compositionally heterogeneous granitoid gneiss of the western foliated granitoid to gneissic domain, in a rarely seen gently plunging open fold. Note also dykes and veins of later granite. GSC 1995-114G*

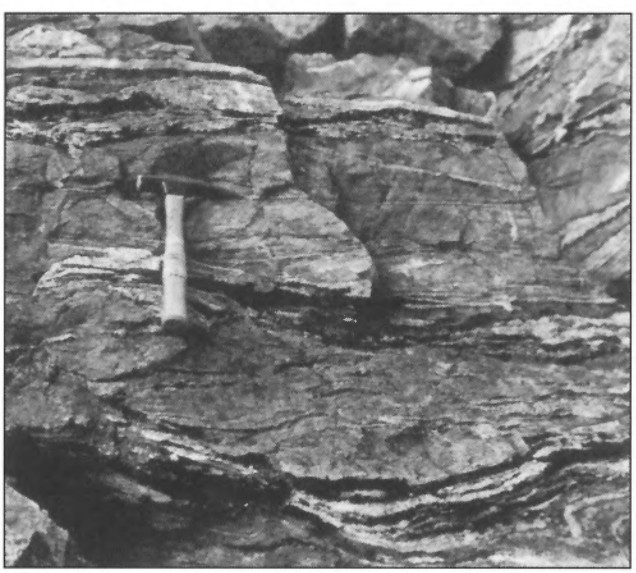


***Figure 6.*** *Layered granitoid gneiss southwest of the main body of Augustus Granite, west of Keskarrah Bay. GSC 1995-114A*

### *Contacts*

The gneisses are intruded by an extensive suite of granitoid rocks that are part of a major and as yet radiometrically undated batholith. The granitoid rocks are assumed to largely postdate the Yellowknife Supergroup and extend over 100 km to the west (Easton, 1981; St-Onge et al., 1991). The younger granitoid rocks form veins, dykes, and sills within the gneissic areas. The size and number of gneiss inclusions in the granitoid rocks decrease to the west. The gneisses are also intruded by a suite of northerly trending, almost concordant, metamorphosed mafic dykes that are most abundant near the contact of the gneisses with the supracrustal rocks of the Yellowknife Supergroup. Easton (1981, 1985) suggested that these intrusions may be feeders to the adjoining metamorphosed mafic volcanic rocks of the Yellowknife Supergroup.

In most places, the contact between the western gneiss and granitoid domain and the Yellowknife Supergroup to the east is a vertical to moderately east-dipping mylonite zone that involves the younger granitoid rocks as well as the gneisses and the Yellowknife Supergroup. As a result, gneisses in the map area are typically in tectonic contact with Yellowknife Supergroup rocks. The actual contact, which is rarely exposed, is a sharply defined, fine-grained mylonite. The degree of deformation decreases to both east and west over several hundred metres. The boundary mylonite zone is generally northerly trending, but is locally folded into s-asymmetric buckle folds with wavelengths up to 4 or 5 km and axial traces having a north-northeasterly trend. The folds in the Yellowknife Supergroup die out within a few kilometres of the contact; their extent in the granitoid-gneiss domain to the west is not defined. On the basis of the presence of a 50 to 100 m thick unit of quartz-pebble conglomerate between weathered gneiss and the layered amphibolites of the Perrault Lithodeme south of the large island in the southern part of Point Lake, Easton (1981, 1985) suggests that an unconformable contact may be preserved at that locality.

North of the north arm of Point Lake, the boundary mylonite extends roughly along strike from the south shore of the arm. Here, however, Augustus Granite occurs between the Yellowknife Supergroup and the gneisses, with

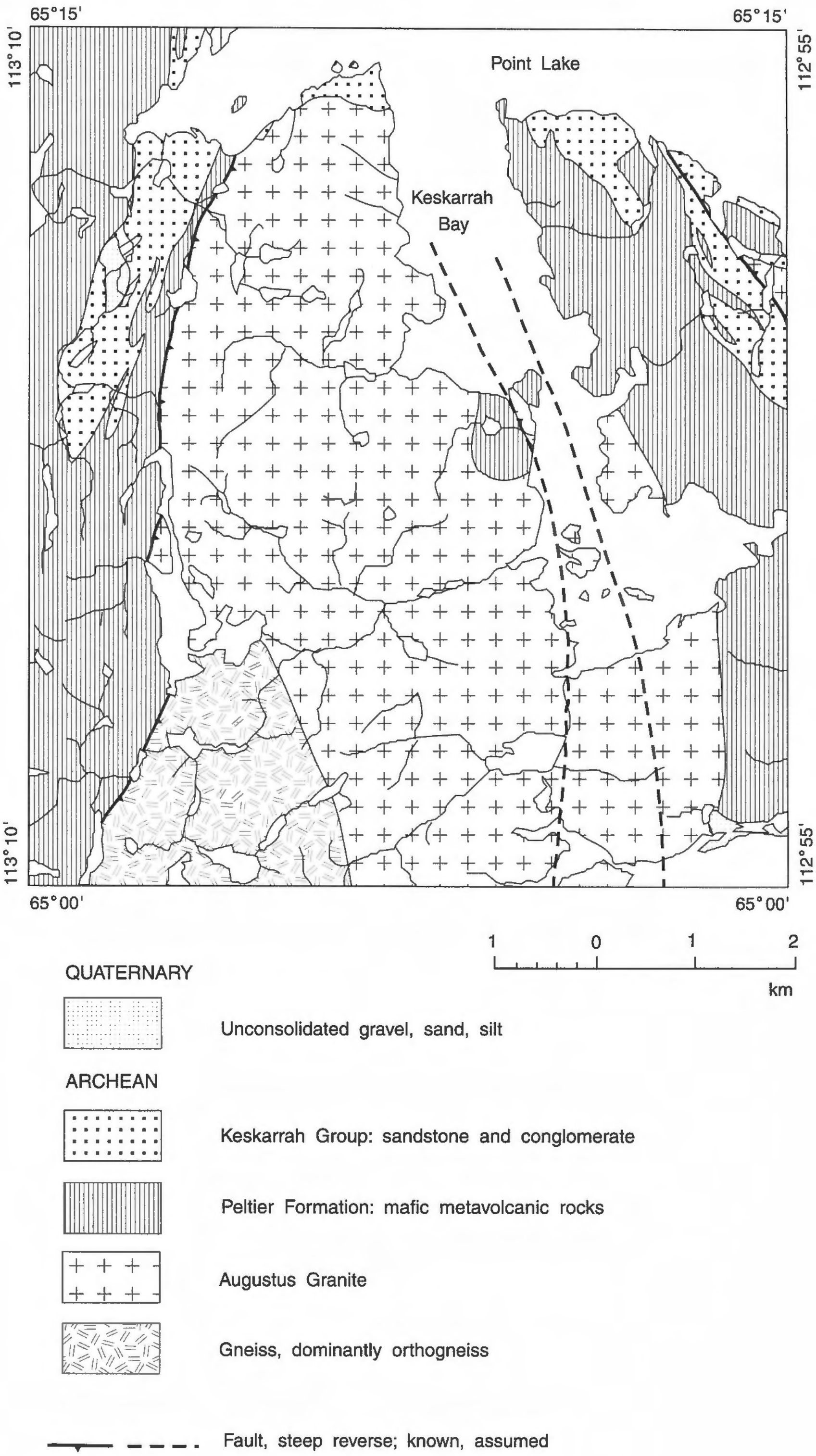



***Figure 7.***

*Area of orthogneiss in the eastern supracrustal domain southwest of the main body of Augustus Granite that is not shown on Map 1679A. This is the only known occurrence of such gneiss within the eastern domain. The shear zone that separates the granitoid gneiss and the Augustus Granite from the volcanic rocks to the west may be another segment of the en échelon shear system (similar to the main boundary shear zones) between the granitoid-and-gneissic-dominated and supracrustal-dominated domains.*

the main mylonite zone extending only a few kilometres north of Point Lake between the volcanic rocks of the Yellowknife Supergroup and the Augustus Granite. The contact between the western edge of the Augustus Granite and the gneisses to the west is also a major ductile shear zone that may represent the en échelon continuation of the main boundary structure within the map area. This structure apparently extends to the north beyond the map area for at least another 50 km (Bostock, 1980; Gebert, 1994).

### *Orthogneiss*

The orthogneiss consists of a heterogeneous assemblage of strongly deformed and metamorphosed granitoid phases and a significant component of amphibolite of largely undetermined origin. A relatively minor paragneiss component is locally present within the dominantly orthogneissic suite. The gneisses range in composition from diorite to granite. Light grey to dark grey, biotite- and/or hornblende-bearing, tonalitic to granodioritic rocks dominate. The gneisses are typically well layered and range from millimetre-scale laminations to units several metres thick (Fig. 5, 8). In places, concordant layers and zones of amphibolite to amphibolitic gneiss dominate (Fig. 8). Younger metamorphosed and deformed mafic sills and dykes are also present (Fig. 9). In general, the proportion of mafic units increases eastward towards the boundary shear zone. At the shear zone, the gneiss complex contains blocks and inclusions of a layered amphibolite that is similar to the thin-layered amphibolite of the adjacent Perrault Lithodeme and may represent tectonically eroded blocks derived from it. The gneisses are intruded by concordant to crosscutting dykes, sills, lenses, and irregular bodies up to several hundred metres thick of more leucocratic, white to pink granodiorite, granite, aplite, and pegmatite whose ages vary as can be seen by their differing degrees of deformation (Fig. 10). The proportion of these younger phases is highly varied. The youngest are thought to be related to phases of the extensive granitoid batholith to the west.

***Figure 8.*** *Tightly folded, thinly layered granitoid gneiss with prominent, similarly deformed, amphibolitic layer. GSC 1995-114L*

***Figure 9.*** *Mylonitic granitoid orthogneiss with less deformed amphibolite layer containing granitic veins. GSC 1995-114P*

***Figure 10.*** *Folded mylonitic intermediate gneiss with irregular, less deformed, locally crosscutting pegmatite. GSC 1995-114H*

In general, the gneisses have a northeasterly trend similar to the Archean structural and lithological trends in many areas of the southwestern Slave Province west of Point Lake and Yellowknife (Lord, 1942; Henderson, 1985, 1994). At the margin of the gneiss domain, the trend swings parallel to the ductile shear zone that defines the margin. West of this zone, the gneiss structure is complex. Easton (1981) reports complex interference patterns that suggest up to three phases of deformation; Jackson (1989a) illustrates locally developed recumbent folds refolded by later upright folds. Kusky (1991) notes the presence of folded mafic dykes that are less tightly folded than the granitoid gneisses they intrude. Stretching and mineral lineations with steep to moderate, easterly to northeasterly plunges (Kusky, 1991) or moderate to shallow northeast plunges (Jackson, 1989a) are present in these rocks.

The gneisses of more mafic and intermediate composition are generally well foliated due to their higher mafic mineral content. However even in the more leucocratic granitic rocks, a foliation is commonly produced by the flattening of quartz into lenticles or ribbons. Original igneous textures are rarely if ever preserved. The best preserved orthogneiss has a recrystallized granulated texture and includes 1 to 2 mm anhedral, generally rounded plagioclase grading smoothly to an anhedral quartzofeldspathic intergrowth of equidimensional grains one tenth the size (Fig. 11). In these less deformed rocks, the fabric is

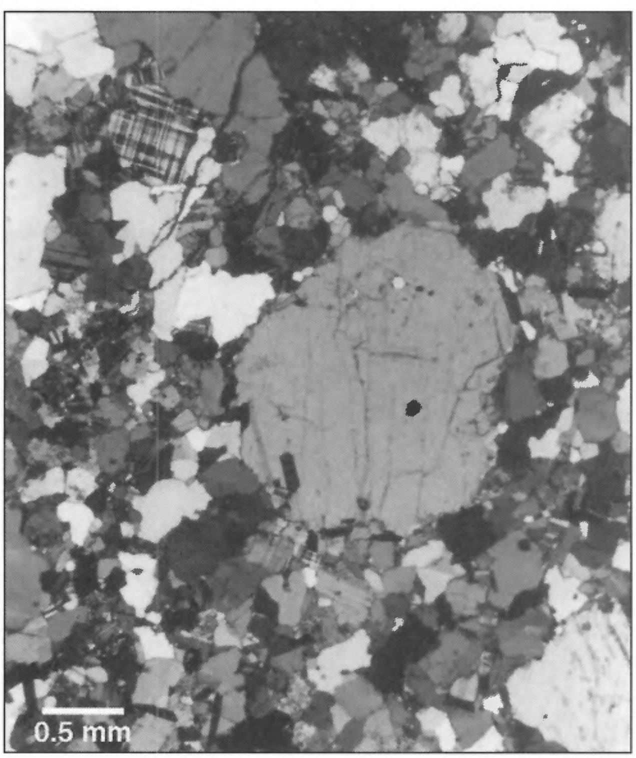



***Figure 11.*** *Recrystallized granodiorite gneiss with relict rounded plagioclase porphyroclasts in a finer quartzofeldspathic matrix. Cross-polarized light.*

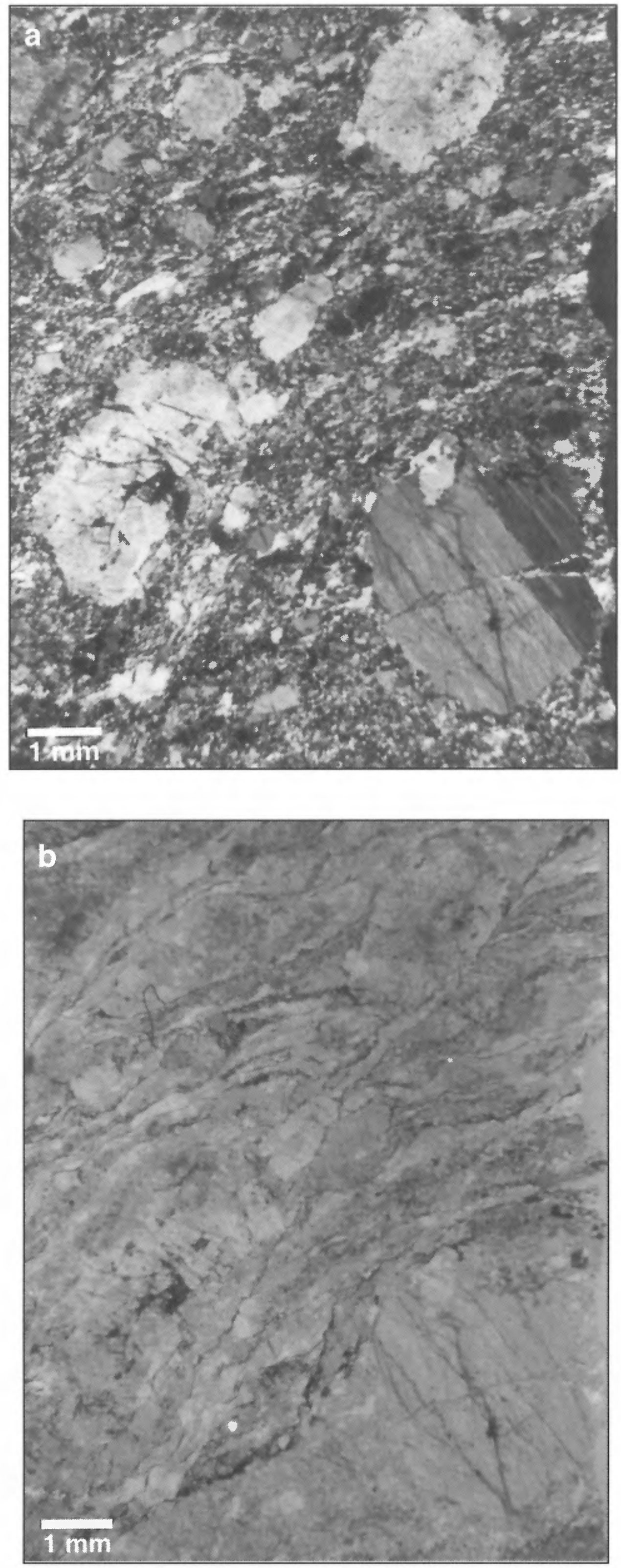



***Figure 12.*** *Mylonitic granite gneiss with fractured feldspar porphyroclasts in a fine matrix within which the foliation is defined by quartz ribbons.* ***a)*** *Cross-polarized light,* ***b)*** *plane-polarized light.*

expressed only by the orientation and, to a lesser extent, the concentration of fine flakes of green-brown biotite. Much of the gneiss is mylonitic throughout the domain, but it is dominantly so towards the boundary shear zone. The mylonitic gneisses commonly contain coarser feldspar porphyroclasts in a much finer matrix. In addition, their stronger foliation is expressed by compositionally defined fine laminae and quartz ribbons (Fig. 12).

The gneisses consist of varied assemblages of plagioclase, quartz, microcline, biotite, hornblende, and some minor titanite. Epidote is almost everywhere present and chlorite is common, locally in patchy seams. Some chemical data from these gneisses and related rocks are presented by Easton (1985). Both the amphibolites and amphibolitic gneisses together with the younger, less deformed amphibolite dykes and sills in the complex have been completely recrystallized into hornblende- and plagioclase-bearing assemblages, indicating an extended if not continuous history of amphibolite-grade metamorphism. Near the boundary shear zone, the gneisses are altered. The rocks are commonly salmon to brick-red, the plagioclase is extensively saussuritized, and the biotite is altered to chlorite. Locally the rocks have undergone brittle fracturing.

Easton (1981, 1985) and Easton et al. (1982) subdivided the orthogneiss within the map area into four units based on lithology and crosscutting relationships. The oldest component consists of interlayered amphibolite, biotite metatonalite-granodiorite, and biotite-hornblende metagranodiorite-granite; it has been recognized only as inclusions in the second unit, a tonalite to hornblende diorite to granodiorite orthogneiss. The third unit is another mafic gneiss consisting of hornblende granodiorite to amphibolite with amphibolite locally forming up to 40 per cent of the unit. The youngest unit is a nebulitic monzogranite orthogneiss that typically contains abundant amphibolitic inclusions to layers of partly assimilated amphibolitic gneiss. Granitoid phases of this orthogneiss crosscut the other gneissic units and are themselves intruded by phases of granitoid rocks that are assumed to postdate all or most of the Yellowknife Supergroup.

### *Paragneiss*

Two large areas and several smaller areas dominated by paragneiss enclaves are found within the younger granitoid rocks. For the most part, they are west of the area dominated by orthogneiss. Locally, small amounts of paragneiss are associated with the orthogneiss. Beyond the map area on a regional scale, paragneiss dominates the domain underlain by gneiss, but to the west, it becomes increasingly diluted by intrusive granitoid phases (Easton, 1981).

Most of the paragneiss consists of biotite-rich layers with varied proportions of a variety of granitoid phases present as interlayers, lenses, or crosscutting dykes and sills. In places, the biotite-rich layers contain several millimetre- to centimetre-sized patches of pinite representing altered cordierite. Easton (1981, 1985) also reported the occurrence of sillimanite and microcline in some gneisses. White mafic-poor tonalitic layers to lenses millimetres to several centimetres thick may represent leucosome phases derived from partial melting of the original metasedimentary rocks. Other less deformed meta-igneous sills, dykes, and irregular bodies have a more heterogeneous composition ranging from tonalite through to granite and including aplite and pegmatite. Easton (1981) noted the similarity of this paragneiss to the high-grade equivalents of the typical Yellowknife Supergroup metagreywacke and mudstone that are represented within the map area by the Contwoyto and Itchen formations. Kusky (1991) found occurrences of quartzite associated with the metasedimentary gneiss.

Mafic rocks constitute a minor part of the paragneiss suite. Some are plagioclase-hornblende-quartz-biotite rocks in which the millimetre- to centimetre-thick layering is defined by both the texture and proportion of the minerals; they may represent a volcaniclastic protolith. Other mafic units consist of more homogeneous amphibolite layers of varied thickness and may represent sills emplaced into the dominantly metasedimentary succession at various times during its history.

### *Geochronological data*

No complete geochronological data have been reported from the gneisses to date. According to Easton (1981, 1985), the preliminary data of Krogh and Gibbins (1978) from the gneiss complex come from a younger crosscutting granodiorite gneiss that intrudes paragneiss. White zircons from the gneiss are about 2600 Ma, or about the middle of the range of ages for the intrusions that largely postdate the Yellowknife Supergroup in the Slave Province (van Breemen et al., 1992; Villeneuve and van Breemen, 1994). Brown zircons from the same sample have a minimum age of 2730 Ma, which is towards the old end of the age range of many metavolcanic rocks of the Yellowknife Supergroup (van Breemen et al., 1992; Villeneuve and van Breemen, 1994). Kusky (1991, citing C. Isachsen, pers. comm., 1990), reports a preliminary age of 2.9 Ga for a gabbroic gneiss from the north shore of the north arm of Point Lake. Northrup et al. (1997) report an age range of between 3.22 and 2.82 Ga for these rocks.

### *Discussion*

The gneiss domain has analogues elsewhere in the Slave Proviince including the Sleepy Dragon Complex northeast of Yellowknife (Davidson, 1972; Henderson, 1985; Lambert, 1988; James, 1990; James and Mortensen, 1992; Bleeker, 1996; Bleeker et al., 1997), the Kangguyak gneiss belt in the northernmost Slave Province (Jackson, 1989b; Barrie, 1993; McEachern, 1993), the Healey complex in the eastern Slave Province (Henderson and Thompson, 1981), and the complex at Grenville Lake in the western Slave Province about 75 km west-southwest of the gneiss complex at Point Lake (Frith, 1993). All these terranes are characterized by their lithological heterogeneity, which contrasts strongly with the relative simplicity of the Yellowknife Supergroup rocks adjacent to them. Most, but not all, of these terranes are devoid of high-grade equivalents of Yellowknife Supergroup rocks. The age range of the various components can be large, ranging from some granitoid gneiss that predates the Yellowknife Supergroup through synchronous granitoid intrusions, to extensive granitoid rocks that postdate all or most of the Yellowknife Supergroup granitoid plutons. James (1990) and James and Mortensen (1992) suggested that the Sleepy Dragon Complex at the level presently exposed represents a late Archean mid-crustal environment that was subsequently uplifted to its present structural position, an interpretation that is considered to possibly apply at Point Lake.

Within the Keskarrah Bay area, a marked structural break separates the gneiss and later granitoid domain to the west and the Yellowknife Supergroup domain to the east. The orthogneiss domain represents a long and complex history of mid-crustal deformation and intrusion that is not easily correlated with that which took place at higher structural levels in the supracrustal domain to the east (Jackson, 1989a). The older gneisses are extensively intruded by the more homogeneous granitoid rocks that largely postdate the Yellowknife Supergroup, which dominates the domain to the west. There is little evidence of this plutonic event in the Yellowknife Supergroup rocks to the east other than minor granitoid dykes, sills, and lenses in the immediately adjacent layered amphibolite of the Perrault Lithodeme and the pegmatites and biotite-muscovite granite of the higher grade Itchen Formation at the east side of the map area. In the supracrustal domain to the east, Yellowknife Supergroup metasedimentary rocks are at subbiotite grade within 2 km of the break. Even the regional northeasterly trends within the granitoid-gneiss domain contrast with the dominantly northern trends of the supracrustal area.

The heterogeneity and complexity of the gneisses and the long history that is implied led Henderson and Easton (1977) and Easton (1981) to suggest that the gneisses may represent a basement terrane to the Yellowknife Supergroup. This interpretation was most completely developed by Easton (1981, 1985) and Easton et al. (1982), who described a possible unconformable contact south of the large island in the main part of Point Lake, between the gneiss and the Yellowknife Supergroup, marked by a quartz-pebble conglomerate. They also suggested that the concordant to slightly discordant mafic intrusions near the contact between the gneisses and the Perrault Formation may represent part of a Yellowknife Supergroup mafic volcanic feeder complex in the basement. They reported the local occurrence of gneissic clasts in parts of the Keskarrah Group conglomerate, which further supports an early exposure of granitoid gneisses. The chemistry of the metagreywacke-mudstone suite was regarded as compatible with a mixed volcanic and gneissic provenance. In a geochronological study of single zircons from the greywacke to the east, Schärer and Allègre (1982) found that almost a quarter of the zircons analyzed were significantly older than the volcanic rocks of the Yellowknife Supergroup; they concluded that ancient continental rocks were available to contribute to the Yellowknife Supergroup.

The high proportion of largely post-Yellowknife Supergroup granitoid rocks in the western domain and their almost complete absence in the immediately adjacent Yellowknife Supergroup domain make it unlikely that the mylonitized contact between the gneisses and the adjacent Yellowknife Supergroup was originally an unconformity. The shear zone at the contact must represent a considerable amount of displacement. The fact that the deformation involves both granites and gneisses indicates that a significant part of the displacement occurred during or after the formation of the bulk of the Slave Province granitoid rocks (2.62-2.58 Ga) that largely postdate the Yellowknife Supergroup (van Breemen et al., 1992). Preliminary geochronological data on weakly deformed granodiorite veins that intrude the gneisses and are thought to be correlative with the granitoid plutons to the west give an age of 2600 Ma (Krogh and Gibbins, 1978; Easton et al., 1982). This of course does not preclude the possibility that some or all of the gneisses may predate the Yellowknife Supergroup; it does, however, indicate that the present contact between the gneisses and the Yellowknife Supergroup is not likely to have been an unconformity.

The possible location of the unconformity at the quartz-pebble conglomerate and the possible volcanic feeder system in the gneiss described by Easton et al. (1982) and Easton (1985) are equivocal and should be reexamined. At least one other occurrence of what could be interpreted as either quartzite or, more likely given their environment, highly deformed quartz veins, is found in the layered amphibolite of the Perrault Lithodeme. The Perrault Lithodeme also contains sills and veins of variously deformed gabbro, which suggests that their emplacement was synchronous with deformation of the unit. The nearly concordant mafic dykes that occur in the gneiss within the contact deformation zone could also be intrusions related to this deformation.

Easton (1981, 1985) and Easton et al. (1982) observed that the paragneiss that dominates the gneisses in the gneiss-granitoid domain within and beyond the map area bears a strong resemblance to high-grade equivalents of the Yellowknife Supergroup metasedimentary greywacke-mudstone. If this paragneiss is indeed correlative with the Yellowknife Supergroup, it is greatly out of context with the chlorite-grade metasedimentary rocks only a few kilometres to the east. It would, however, support the suggestion that the western domain represents a mid-crustal environment that was uplifted relative to the higher level Yellowknife Supergroup domain to the east. The present erosion surface of the domain represents a structural level that contained both the deepest level Yellowknife Supergroup rocks and the presumably older granitoid gneisses, all of which were engulfed by circa 2.6 Ga granitoid intrusions before being differentially uplifted relative to the higher level Yellowknife Supergroup domain to the east.

## AUGUSTUS GRANITE

The Augustus Granite is the dominant granitic unit within the Yellowknife Supergroup supracrustal domain, occurring near its border with the mixed older gneiss and the largely post-Yellowknife Supergroup granitoid domain to the west. Because of the lack of named geographic features in the area, the 'Augustus Granite' is named for Augustus, the Inuit guide who contributed much to the survival of the ill-fated Franklin expedition that passed through the area on its way to the Coronation Gulf (Franklin, 1823). The Augustus Granite is important in understanding the evolution of this part of the Slave Province, although it has been interpreted in a variety of ways since its original discovery.

Its importance was first recognized by Stockwell (1933) who, during the first geological reconnaissance into the central Slave Province in 1932, described it and its relationship as basement to the Archean metasedimentary and metavolcanic rocks. Although Stockwell did not see an exposure of the Archean unconformity surface, he based his interpretation on the similarity of the granite to granite boulders in the immediately adjacent conglomerate, the decrease in size of the boulders away from the granite, and the lack of any contact-metamorphic effect. He also recognized mafic dykes within the granite that he suggested may represent feeders to the nearby mafic volcanic succession. During subsequent helicopter reconnaissance of the northern Slave and Bear provinces (Fraser, 1960), the Augustus Granite was not recognized as a distinct unit. During 1:250 000 scale reconnaissance mapping of the Itchen Lake map area, what is considered here to be the Augustus Granite was mapped as part of two hybrid units (Bostock, 1980), one consisting of felsic and/or mafic volcanic rocks with hypabyssal intrusions, the other being a diorite agmatite. Both were considered to have been derived from Yellowknife Supergroup supracrustal rocks and intruded by late Archean granitoid rocks. An exposure of the unconformity was found by Henderson (1975a). U-Pb dating of zircons from the granite give an age of about 3.15 Ga (R.K. Wanless, pers. comm., 1975; Krogh and Gibbins, 1978; Henderson et al., 1982), which was interpreted to indicate that the Augustus Granite was about 450 million years older than the 2.72-2.66 Ga age range of most Yellowknife Supergroup felsic volcanic rocks (van Breemen et al., 1992).

The Augustus Granite occurs in three main areas. The largest is south and west of Keskarrah Bay, although it is not as extensive as indicated on Map 1679A (Henderson, 1988). In the southwestern part of the domain, the area extending from the crudely L-shaped lake on the western boundary of the granite body south to the southern map border (Fig. 7) is dominated by orthogneiss similar to that found in the western part of the area (Unit Aogn). The two other large areas are in the southeast corner of the map area and north of the northern arm of Point Lake. In addition, a smaller body is found south of the north arm and is completely mantled by mafic volcanic rocks. A second smaller body is present in a fault slice that is also surrounded by Yellowknife Supergroup rocks, between the two large areas of Augustus Granite in the southern part of the region. In most cases, the granite forms the lowest part of a tectonic panel, the western boundary of the granite being a major tectonic contact. The eastern boundary of the granite is typically sheared where it is structurally overlain by volcanic rocks. However, it is an unconformity in the easternmost panel where it is overlain by conglomerate of the Keskarrah Group. In both cases, the age of the supracrustal rocks decreases everywhere away from the granite. Volcanic rocks dominate in the western panels whereas sedimentary rocks occur above the granite in the east.

### *Contacts*

In the northern part of the area, the contact between the Augustus Granite and the layered amphibolite of the Perrault Lithodeme to the east, although rarely exposed, is sharp and sufficiently sheared and metamorphosed so that any criteria for recognizing primary relationships are not preserved. In the immediate vicinity of the contact, the igneous texture of the granite is lost and the rock is finer grained and foliated. The Perrault Lithodeme is a highly deformed, thinly layered amphibolite that is considered to be of mafic volcanic origin. The sheared contact is part of the major ductile shear zone that separates the Yellowknife Supergroup from the western granitoid and granitoid gneiss domain. The en échelon continuation of the shear zone system is found along the west side of the Augustus body and extends at least 50 km north beyond the map area.

South of Point Lake in the western part of the area, the contact with the Peltier Formation volcanic rocks is sharp and typically sheared. The best known exposure is on the north shore of the large eastern bay at the south end of Keskarrah Bay. There the contact is straight and sharp although locally undulating. Both the granite and overlying volcanic rocks are foliated near the contact. The greenschist-grade volcanic rocks in the contact area seem to be volcaniclastic although deformed pillows are present a few metres higher in the section. The basal volcanic rocks are intruded by thin mafic lenses to sills and by boudins of mylonitized aplite to pegmatite that are sufficiently recrystallized that their relationship if any to the Augustus Granite is equivocal. Nowhere are dykes of Augustus-type granite known to intrude the volcanic rocks. On the other hand, no granite dykes of any type are found elsewhere in the Peltier Formation mafic volcanic rocks.

Another intriguing but incompletely exposed contact between the volcanic rocks and the Augustus Granite is found on the western side of Keskarrah Bay where outcrops of granite nearest to the volcanic rocks are considerably altered and sheared. In thin section, however, the granite is seen to consist of altered and deformed feldspar with the quartz retaining much of its igneous texture. This is unusual as in most shear zones quartz is typically more easily deformed than feldspar. The altered granite closely resembles a slightly deformed equivalent of the granite in the Archean weathered horizon below an unconformity surface, which will be described below. While it is tempting to argue that this is evidence for an unconformity with a weathered horizon between the granite and overlying volcanic rocks, under certain conditions, feldspar in a granite can undergo brittle fracturing, hydration, alteration, and deformation without the quartz being significantly affected (Janecke and Evans, 1988).

A similar situation exists above the small lens of Augustus Granite 3 km east of Keskarrah Bay. The northern part of the granite is overlain by conglomerate of the Keskarrah Group whereas the eastern part of the body is adjacent to mafic volcanic rocks. The granite becomes increasingly deformed towards the contact with the supracrustal rocks, yet in thin section, quartz, although more deformed than in the previously described locality, is less deformed than feldspar, which occurs in a fine matrix of altered and recrystallized grains. Even if the alteration of the rock were due to weathering, given the degree of deformation it seems unlikely that the original unconformity has been preserved and that the overlying conglomerate and mafic volcanic rocks are allochthonous. Similarly, east of Keskarrah Bay, a conglomerate lens of indeterminate size is present near the contact between the Augustus Granite and the Peltier Formation mafic volcanic rocks. It consists of deformed quartz-rich clasts in a biotite-rich quartzofeldspathic matrix and is similar to the conglomerate of the Keskarrah Group seen elsewhere above the granite. The conglomerate lens might suggest proximity to an unconformity surface. However, given the deformation along the contact and the quality of the exposure, the presence of the lens cannot be taken as evidence for conformity of the volcanic rocks above the granite.

The contact between the Augustus Granite and the overlying conglomerates and sandstones of the Keskarrah Group contrasts strongly with that between the granite and the mafic volcanic rocks. In many places, an unconformity is well preserved, particularly where the contact is at an angle to the northerly trend of the regional faults. Map 1679A shows several localities where the unconformity is exposed.

A small but striking example of this is where the unconformity was first recognized in the bay west of Keskarrah Bay (Henderson, 1975a). There, a section across the fractured granite surface shows several cobbles that have fallen into the fractures as the conglomerate accumulated (Fig. 13, 14). More exposures of the unconformity are found to the east, at the north end of the eastern panel of Augustus Granite. At these localities, the granite below the unconformity is altered due to weathering prior to deposition of the conglomerates of the Keskarrah Group. The exposed unconformities are overlain by either a coarse, poorly sorted, angular, heterolithic conglomerate with granitoid and minor mafic clasts or, where the conglomerate is not present, a thin lag deposit of angular quartzite followed by increasingly coarser grained and less mature, gritty, quartz-rich sedimentary rock to quartz-pebble conglomerate of the lower Keskarrah Group. The eastern margin of this block of the Augustus Granite provides a map-scale

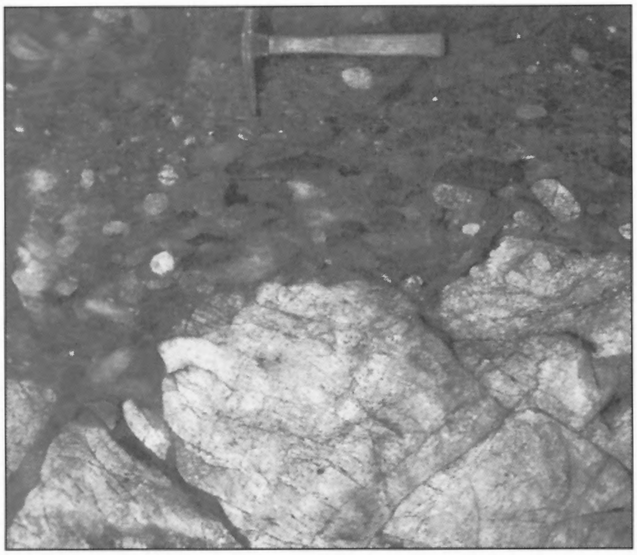


***Figure 13.*** *Irregular unconformity surface between the leucocratic Augustus Granite and overlying granite and mafic volcanic cobble-bearing conglomerate of the Keskarrah Group. This exposure is 1.8 km west of the mouth of Keskarrah Bay as noted on Map 1679A. See Figure 14 for detail of the lower left corner of the photograph. GSC 202729F*

perspective on the topography of the unconformity surface with apparent local relief of several hundred metres. The conglomerates of the Keskarrah Group occur in depressions in the surface; the higher areas are overlain by coarse-grained, thick-bedded, greywacke-mudstone turbidites, also considered to be part of the Keskarrah Group. As with the exposures to the north, the granite immediately adjacent to the unconformity is weathered. The basal conglomerate, which is typically, although not always, angular, is dominated by clasts of similarly altered Augustus Granite. Higher in the sequence, the clasts are more rounded and heterolithic, but remain dominantly granitoid in composition.

Southwest of Keskarrah Bay, the Augustus Granite is in contact with a heterogeneous assemblage of dominantly fine-layered orthogneiss to foliated granitoid rocks (Fig. 6, 7). Contact relationships between the two units are poorly known. Given the presence of at least one dyke of Augustus Granite in the gneiss, the occurrence of local inclusions of the gneiss within the granite, and the presumed long and complex history of the gneiss compared to that of the granite that still retains its igneous textures, the Augustus Granite probably intruded the gneiss.

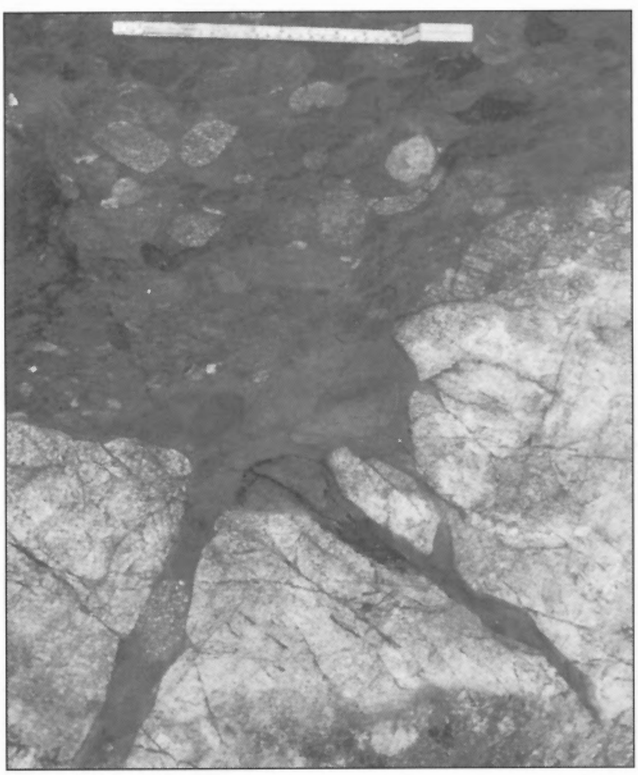


***Figure 14.*** *Section across the irregular and fractured unconformity surface of the Augustus Granite. Note the fracture that contains cobbles of the overlying conglomerate. GSC 2027290*

The western margins of almost all the Augustus Granite bodies are prominent faults. The only exception is the small unit of Augustus Granite between the northern and southern arms of Point Lake. Nowhere was the actual fault between the granite and adjacent unit observed. South of Point Lake, the series of tectonic panels start at their structural base with a major shear zone against Yellowknife Supergroup rocks of the previous panel to the west. As the contact is approached over a distance of a few metres to tens of metres, the granite becomes increasingly foliated to mylonitic. A similar transition is seen in the mafic volcanic rocks of the Peltier Formation, the most common unit against which the Augustus Granite is faulted. The western boundary fault of the northernmost occurrence of the granite is marked by a prominent lineament near which the granite becomes increasingly foliated to gneissic.

### *Lithology*

The Augustus Granite is typically a megascopically homogeneous, variably deformed, light-weathering, white to pinkish-grey to greenish-grey to grey, medium-grained, even-grained, weakly to moderately metamorphosed granite. Locally, it presents textures suggestive of a high level of emplacement. It is everywhere metamorphosed to low grade, which contrasts with the largely post-Yellowknife Supergroup intrusions in the region that are unmetamorphosed. Megascopically, quartz, which is varied in abundance, is typically iridescent. Mafic minerals form medium-grained clots consisting of very fine-grained chlorite or biotite. Deformation grades from extensive fracturing with chlorite and locally biotite filling the fractures to cataclastically crushed granite to zones of mylonite that have undergone ductile deformation. The most highly deformed granite occurs in zones several metres to tens of metres wide along the fault-bounded western margins of the various granitic areas. Similar lightly deformed zones are also found locally within the granitic areas. South of Point Lake, the number and width of the more deformed zones increase towards the south.

No pegmatitic phases related to the Augustus Granite are known within the granite and no dykes or veins of unequivocal Augustus Granite are known to intrude the Yellowknife supracrustal rocks, although some veins of Augustus Granite intrude the orthogneiss south of the body at Keskarrah Bay. Locally and particularly in the south, the Augustus Granite is intruded by dykes and veins of fresh, massive, pink, medium-grained biotite granite possibly related to the large 2.64 Ga (U-Pb zircon) granodiorite intrusion that is found south of the area (the Keskarrah batholith of Bostock, 1980; Fig. 2).

## *Petrography*

The Augustus Granite can be divided into three intergradational petrographic zones, which are considered to be an expression of the level of emplacement and variations in the composition and degree of deformation of the granite (Fig. 15). These zones are not apparent megascopically.

A zone of hypersolvus granite consisting almost entirely of perthite and quartz is found adjacent and parallel to the unconformity between the Augustus Granite and the overlying Keskarrah Group conglomerate (Fig. 15). It is most common in the easternmost block of Augustus Granite, but also occurs at the northern end of the main block west of Keskarrah Bay. Hypersolvus granite was not found in the block north of Point Lake, even next to the contact with the Yellowknife Supergroup.

The rock is typically massive, medium grained, and even grained, with a slightly deformed, but clearly recognizable, igneous texture (Fig. 16). The feldspar consists of stubby laths to anhedral grains of perthite, in some cases with Carlsbad twins. Anhedral inclusions of plagioclase are rare. The perthitic feldspar is only weakly altered, with fine dusty alteration products. Quartz occurs in large, strained, equidimensional, anhedral aggregates to blocky equant

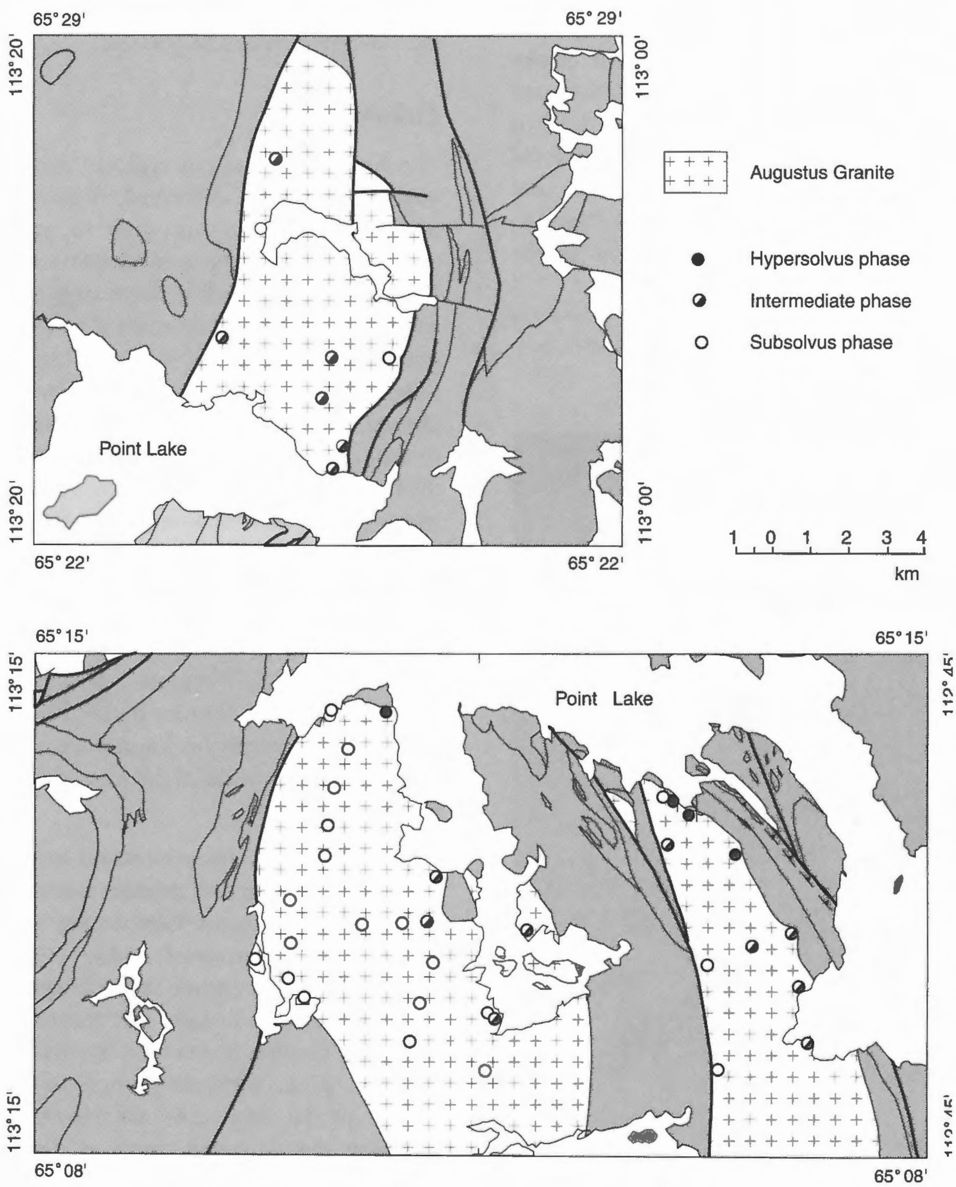



*Figure 15. Distribution of hypersolvus, intermediate, and subsolvus phases of the Augustus Granite. Note that known hypersolvus occurrences are everywhere immediately below the unconformity between the Augustus Granite and the Keskarrah Group.*

grains that in some cases are suggestive of the squarish outline of β-quartz (Fig. 16). No primary mafic minerals are preserved, but some dark amoeboid areas making up less than 1 per cent of the rock and consisting of decussate aggregates of biotite, chlorite, and opaque oxides, may represent altered original biotite.

Although the original igneous texture is visible, the rock has been deformed and subsequently metamorphosed. The feldspar is invariably fractured and slightly displaced along cleavage planes with the fine fractures filled with sericite, chlorite, and carbonate (Fig. 17). In some cases, the grain margins are finely granulated. Quartz is strongly strained and broken into domains with the interdomain margins and the margins of the grains themselves granulated. Quartz-filled fractures up to 0.3 mm wide extend across several grains. The mineral assemblages in the fracture fillings and the decussate mafic mineral aggregates suggest that the granite was metamorphosed to mid- to upper-greenschist facies.


*Figure 16. Photomicrograph of the hypersolvus phase of the Augustus Granite. All the feldspar in the rock is perthite. Note the squarish outline of quartz in the centre of the photomicrograph that is suggestive of β-quartz. Cross-polarized light.*

Major-oxide chemical analyses of the hypersolvus phase are presented in Table 1. The rock contains approximately equal proportions of $Na_2O$ and $K_2O$, but differs significantly from an average granite in its very low amount of CaO, $FeO_{total}$, and $TiO_2$.

The second zone, characterized by the occurrence of both perthite and a second feldspar, is present in all three blocks of Augustus Granite, typically west or south of rocks of the previously described hypersolvus phase (Fig. 15). The granite generally contains slightly more mafic minerals than the hypersolvus phase, but rarely more than a few per cent. In the block of Augustus Granite north of Point Lake, the otherwise similar granite contains a significantly higher proportion of mafic minerals. These rocks are typically more deformed than the rocks of the hypersolvus zone and, although aspects of the original igneous texture are still present, deformational textures dominate. Perthite still dominates although some plagioclase is present (Fig. 18). In the least deformed examples, the plagioclase has a more euhedral crystal form than the perthite in the same rock and in some cases there is a suggestion of compositional zoning


*Figure 17. Photomicrograph of the more deformed hypersolvus phase of the Augustus Granite. Note the granulation along the margins of coarse perthite grains and the network of chlorite-filled fractures. Cross-polarized light.*

**Table 1.** Major-element chemical analyses and their averages (Av) from three phases of the Augustus Granite. The hypersolvus phase contains only perthitic feldspar whereas the intermediate phase consists of both perthite and some plagioclase. The subsolvus granite is dominated by plagioclase with minor interstitial microcline. The average granite is that of LeMaitre (1976).

| | Hypersolvus phase | | | | Intermediate phase | | | | Subsolvus phase | | | | Average granite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H-393 | H-618 | H-673 | Av | H-448 | H-607 | H-658 | Av | H-556 | H-743 | H-747 | Av | |
| $SiO_2$ | 77.9 | 78.2 | 78.4 | 78.2 | 72.6 | 75.1 | 75.0 | 74.2 | 70.8 | 72.1 | 70.0 | 71.0 | 71.30 |
| $TiO_2$ | 0.06 | 0.05 | 0.06 | 0.06 | 0.27 | 0.19 | 0.27 | 0.24 | 0.26 | 0.08 | 0.18 | 0.17 | 0.31 |
| $Al_2O_3$ | 12.5 | 11.4 | 12.0 | 12.0 | 13.5 | 12.3 | 13.1 | 13.0 | 14.8 | 16.4 | 16.4 | 15.7 | 14.32 |
| $Fe_2O_3$ | 0.2 | 0.5 | 0.2 | 0.3 | 0.4 | 0.0 | 0.1 | 0.2 | 0.4 | 0.3 | 0.4 | 0.4 | 1.21 |
| FeO | 0.0 | 0.2 | 0.2 | 0.1 | 1.4 | 1.2 | 1.4 | 1.3 | 2.1 | 0.5 | 1.0 | 1.2 | 1.64 |
| MnO | 0.00 | 0.02 | 0.00 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.05 |
| MgO | 0.20 | 0.48 | 0.15 | 0.28 | 0.67 | 0.71 | 0.80 | 0.73 | 2.35 | 0.29 | 0.88 | 1.17 | 0.71 |
| CaO | 0.00 | 0.40 | 0.00 | 0.13 | 1.35 | 0.54 | 0.73 | 0.87 | 0.71 | 2.42 | 1.65 | 1.59 | 1.84 |
| $Na_2O$ | 2.7 | 3.3 | 3.6 | 3.2 | 3.4 | 3.5 | 4.7 | 3.9 | 5.4 | 5.7 | 5.6 | 5.6 | 3.68 |
| $K_2O$ | 4.50 | 3.81 | 3.76 | 4.02 | 3.69 | 3.71 | 2.11 | 3.17 | 0.81 | 1.34 | 1.71 | 1.29 | 4.07 |
| $P_2O_5$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.01 | 0.03 | 0.03 | 0.09 | 0.03 | 0.06 | 0.06 | 0.12 |
| $CO_2$ | 0.0 | 0.5 | 0.0 | 0.3 | 0.0 | 0.3 | 0.0 | 0.1 | 0.1 | 0.2 | 0.5 | 0.3 | 0.05 |
| $H_2O$ | 0.5 | 0.4 | 0.3 | 0.4 | 0.6 | 0.6 | 0.5 | 0.6 | 1.8 | 0.7 | 1.3 | 1.4 | 0.77 |
| | 98.6 | 99.3 | 98.7 | | 98 | 98.2 | 98.76 | | 99.6 | 100.1 | 99.7 | | 100.07 |


*Figure 18. Photomicrograph of the intermediate phase of the Augustus Granite. Although perthite is the dominant feldspar, some plagioclase with albite twinning occurs in the centre of the photograph. Cross-polarized light.*

expressed by both extinction angle and concentration of alteration products. This would suggest that the plagioclase is a primary igneous mineral and was not formed by recrystallization of perthite through deformation and metamorphism in the sense of Day and Brown (1980) or Madhavan and Leelanandam (1979).

The degree of deformation and metamorphism is greater than in the hypersolvus zone. The coarser feldspar grains tend to be broken along the previously described fractures such that individual pieces form slightly reoriented aggregates. Some plagioclase laths are slightly kinked and there is a greater amount of granulated material around the feldspar grains. The original blocky quartz masses have a more amoeboid shape and are finely polygonal, in some cases with one or two larger strained domains. The decussate masses of mafic minerals consist mainly of coarser grains of biotite and opaque oxides, and chlorite is absent or found in greatly reduced amounts. The metamorphic assemblages filling fractures consist largely of biotite, white mica, and reduced amounts of chlorite. Feldspar alteration products are coarser grained.

Major-oxide chemical analyses for a few examples of this phase of the Augustus Granite are shown in Table 1. This phase differs from the previously described hypersolvus phase in that it contains a greater proportion of CaO, $FeO_{total}$, MgO, and $TiO_2$ although the amount of the first two is still less than in an average granite.

The third zone dominates the Augustus Granite terrane west of Keskarrah Bay, but is also present in the other areas underlain by the granite (Fig. 15). West of Keskarrah Bay, it is found in the western two thirds of the unit. At the southwestern corner of Keskarrah Bay, a slightly deformed equivalent of this phase appears to be intruded by a similarly deformed dyke of granite of the second zone, which suggests an age relationship. Where best preserved in the northern part of the outcrop area, the granite has an equigranular, igneous texture. It is dominated by blocky subhedral grains of finely albite-twinned to untwinned, moderately to strongly altered plagioclase and contains only minor amounts of anhedral microcline (Fig. 19). As such, it is compositionally distinct from the other two zones, which contain a significantly greater proportion of potassium feldspar. Quartz typically occurs in equidimensional polycrystalline anhedral masses of a size similar to that of the feldspar. In one example, however, in the northwestern part of the unit near the unconformity with the Keskarrah Group, the quartz has a distinct blocky to squarish outline similar to the β-quartz outlines seen in some of the Augustus hypersolvus granite and quartz-phenocryst-bearing felsic volcanic rocks (Fig. 20). The granite typically contains less than 3 or 4 per cent mafic minerals, which consist of laths to decussate masses of chlorite and in some cases are suggestive of altered biotite. This alteration or low-grade metamorphism that affects both the mafic minerals and the feldspars is similar to that seen in the other two zones.


*Figure 19. Photomicrograph of the subsolvus phase of the Augustus Granite, dominated by subhedral, untwinned to finely twinned plagioclase with minor anhedral microcline. Cross-polarized light.*

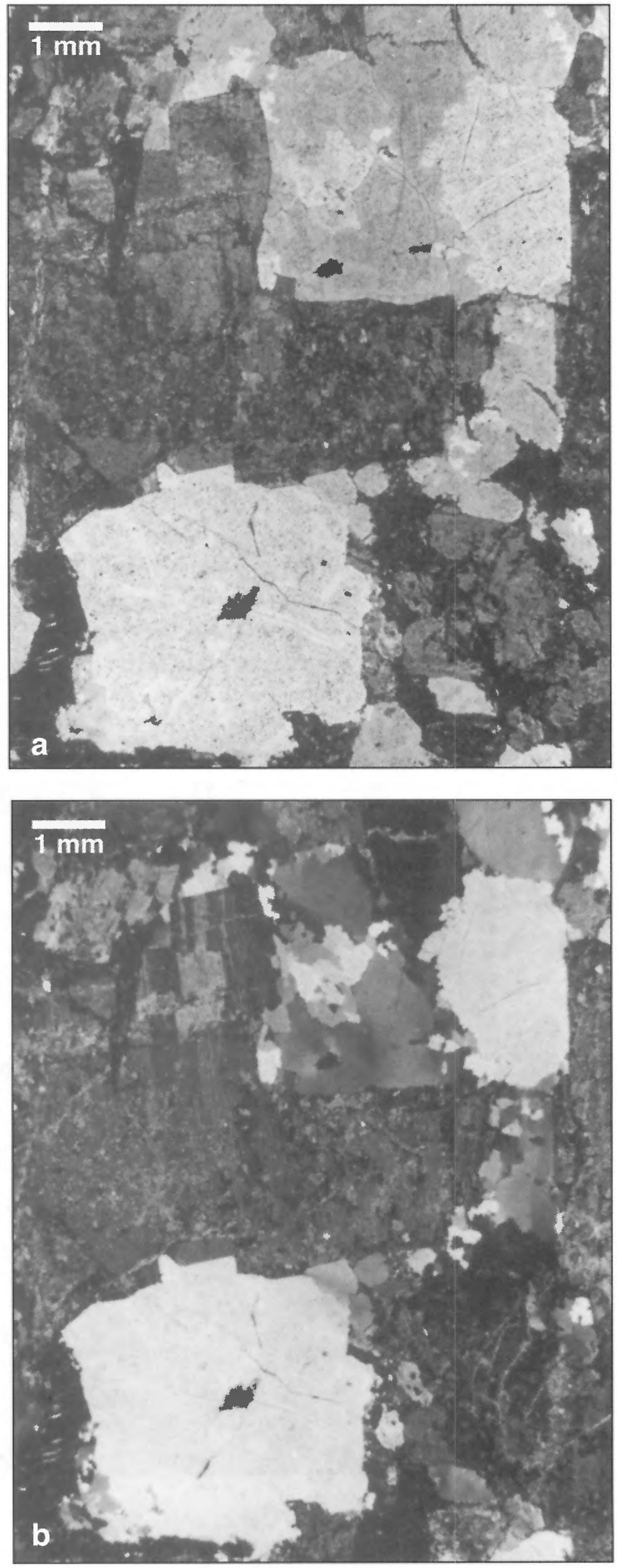



*Figure 20. Photomicrograph of square β-quartz outlines in quartz of the subsolvus phase of the Augustus Granite from close to the locality illustrated in Figure 13. **a)** Plane polarized light, **b)** cross-polarized light.*

Even where it is best preserved, the rock contains fine, through-going fractures filled with saussurite and chlorite. The degree of deformation increases both to the south and west with increasing development of ductile shear zones. With increasing deformation the quartz becomes more polygonized and deformed into discrete lensoid shapes to interconnected anastomosing ribbons wrapped around the more resistant feldspar porphyroclasts (Fig. 21). The plagioclase becomes less commonly twinned and some of the twins are kinked. The grains themselves become increasingly rounded with granulated margins. In its most deformed state, the rock is a mylonite consisting of rounded porphyroclasts of plagioclase in a fine-grained matrix of quartz, plagioclase, and microcline. The metamorphic grade also increases slightly to the south and west and fine-grained biotite and epidote are present instead of the chlorite and saussurite that are found to the north and northeast.

This phase of the granite is at least present if not dominant in the other areas underlain by the Augustus Granite. North of Point Lake, it, like the rest of the Augustus Granite in this block, has a higher mafic mineral content, but is otherwise similar to that seen to the south. The small body of Augustus Granite between the two arms of Point Lake that is mantled by mafic volcanic rocks has a moderately well preserved igneous texture similar to that seen in the northern part of the Augustus Granite south of the lake. In the eastern block of Augustus Granite, only two examples of the plagioclase-dominant granite were encountered; its extent is unknown, but is presumed to be relatively small, and it may well form inclusions or small intrusions in the other phases.

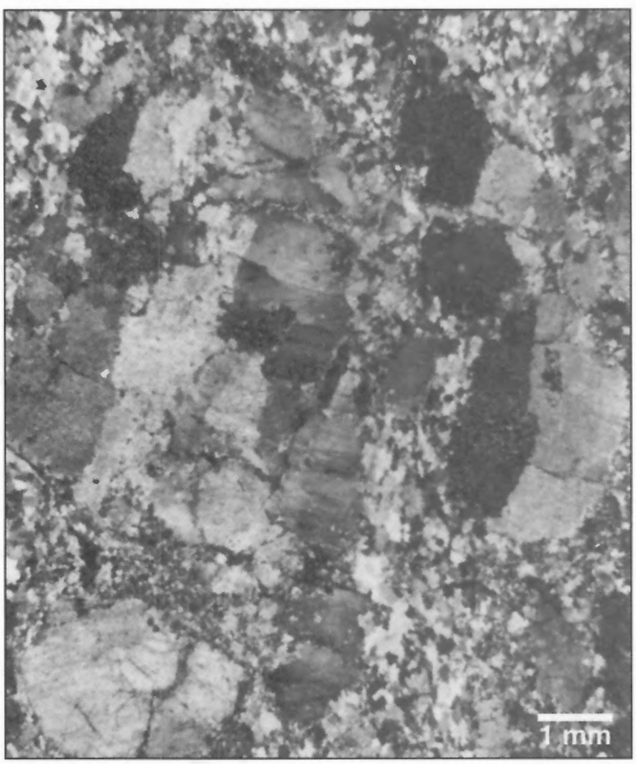



***Figure 21.*** *Photomicrograph of the strongly deformed subsolvus phase of the Augustus Granite from near the boundary fault west of Keskarrah Bay. Quartz is completely polygonized and deformed into elongate lenses or ribbons and feldspar occurs as fractured and rounded porphyroclasts with granulated margins in a finer quartzofeldspathic matrix. Cross-polarized light.*

### *Archean weathering effects*

In many places below the unconformity, the Augustus Granite is characterized by a variably developed weathered horizon. The petrography and chemical effects of this alteration have been discussed by Schau and Henderson (1983) and are summarized here.

The weathered zone is visible in outcrop as it forms a distinct zone, up to several metres wide, in which the normally white to pinkish to greenish-white granite becomes distinctly 'waxy' yellow to brownish due to the breakdown of feldspar and mafic minerals (Fig. 22) and commonly resembles a quartz-eye porphyry. Any foliation present is more strongly developed in the altered granite. In places, the boundary with the relatively fresh granite is quite sharp and is vaguely cuspate.

In thin section, the rock is seen to contain feldspars altered to a very fine-grained, brownish matte of sericite and saussurite, together with minor resolvable chlorite and

***Figure 22.*** *Augustus Granite with altered zone in foreground due to weathering prior to deposition of the Keskarrah Group. The original igneous texture is still recognizable, but original feldspar has been replaced by alteration products. GSC 1995-114K*

carbonate and, at appropriate grade, minor biotite (Fig. 23). In some cases in which the regolith is undeformed, the relict outlines of the original feldspar crystals are evident. Potassium feldspar tends to be more resistant to alteration. In some cases, relict perthite can be recognized and the optically continuous potassium feldspar intergrowths are preserved whereas the plagioclase is completely altered. The mafic minerals normally present in the unaltered granite as decussate masses of biotite or chlorite are not preserved. Quartz remains largely unaffected by the alteration to the extent of retaining the same shape and position as in the unaltered rock (Fig. 23).

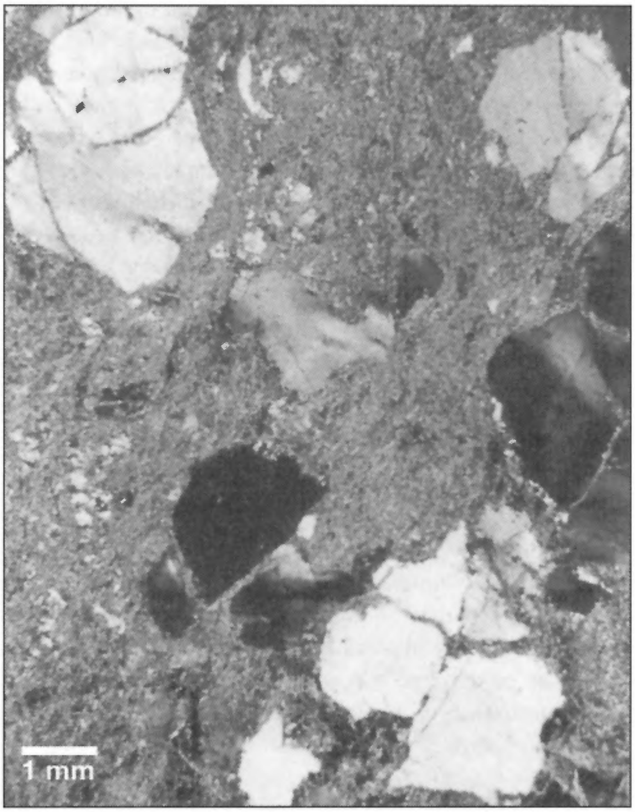



***Figure 23.*** *Photomicrograph of a sample from the weathered zone in the Augustus Granite. The original feldspar (perthite) has been almost completely replaced by alteration products. The original form and position of igneous quartz have been retained. Cross-polarized light.*

Chemically, the increase in ferric iron and water and the decrease in sodium are indicative of oxidation, hydration, and leaching during weathering (Table 2). The increase in magnesium, calcium, and $CO_2$ in the weathered granite is expressed by the greater abundance of dolomite formed during diagenesis (Schau and Henderson, 1983).

### *Mafic dykes and inclusions*

The Augustus Granite contains abundant, unevenly distributed mafic dykes and inclusions. Locally, they appear to occupy a greater area than the host granite, although the proportions are commonly difficult to estimate as the mafic bodies typically form better outcrops than the granite. Substantial outcrops of mafic rocks projecting upward through low granite felsenmeer are not unusual and are most dominant in the northwestern part of the northernmost block of the granite where, in places, the granite forms veins or enclaves between the mafic bodies. They are generally less abundant in the main body of Augustus Granite west of Keskarrah Bay, although the distribution is highly varied.

**Table 2.** Major-element chemical analyses from the weathered zone of the Augustus Granite regolith compared with averages of analyses from the three phases of the Augustus Granite (Table 1).

| | Weathered Augustus Granite | | | | | Augustus Granite averages from Table 1 | | |
|---|---|---|---|---|---|---|---|---|
| | H-396 | H-393 | H-673 | H-618 | H-618[1] | Hypersolvus | Intermediate | Subsolvus |
| $SiO_2$ | 68.1 | 78.2 | 76.6 | 78.0 | 77.2 | 78.2 | 74.2 | 71.0 |
| $TiO_2$ | 0.29 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.24 | 0.17 |
| $Al_2O_3$ | 21.1 | 11.7 | 12.3 | 13.6 | 12.9 | 12.0 | 13.0 | 15.7 |
| $Fe_2O_3$ | 0.9 | 0.6 | 0.8 | 0.3 | 0.9 | 0.3 | 0.2 | 0.4 |
| FeO | 0.0 | 0.6 | 0.2 | 0.7 | 0.0 | 0.1 | 1.3 | 1.2 |
| MnO | 0.00 | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.02 | 0.02 |
| MgO | 0.57 | 1.92 | 1.62 | 0.84 | 0.74 | 0.28 | 0.73 | 1.17 |
| CaO | 0.00 | 0.55 | 0.79 | 0.47 | 0.71 | 0.13 | 0.87 | 1.59 |
| $Na_2O$ | 0.2 | 0.0 | 0.5 | 0.1 | 0.0 | 3.2 | 3.9 | 5.60 |
| $K_2O$ | 6.09 | 3.83 | 3.65 | 3.95 | 3.91 | 4.02 | 3.17 | 1.29 |
| $P_2O_5$ | nf | nf | nf | nf | nf | 0.00 | 0.03 | 0.06 |
| $CO_2$ | 0.0 | 0.8 | 1.5 | 0.3 | 0.6 | 0.3 | 0.1 | 0.3 |
| $H_2O$ | 2.7 | 1.8 | 1.8 | 1.6 | 1.8 | 0.4 | 0.6 | 1.3 |
| | 100.0 | 100.1 | 99.9 | 100.0 | 99.4 | | | |

[1] Weathered cobble of Augustus Granite in Keskarrah Group conglomerate

They are least common in the eastern block, being rare in the northern part, but increasing somewhat in abundance to the west and south.

At least two sets of dykes are present within the granite, not including members of the unaltered and, at 1.2 Ga, significantly younger Mackenzie swarm. Although the dykes have varied orientations, those oriented either north or east dominate. The dykes oriented east are commonly porphyritic and locally contain minor small inclusions of the granite they intrude. Dykes with a similar trend occur throughout the map area and, as they are not involved with Archean structures, they are assumed to be Proterozoic.

The other grouping of mafic intrusions consists of generally northerly trending dykes together with dykes of varied orientation and irregular intrusions. Most are of a fairly uniform gabbroic composition although some local variations exist. Northrup (1993) reports the occurrence of minor 50 m scale dykes and stocks of altered pyroxenite in the Augustus Granite on the western side of Keskarrah Bay. Although many laterally extensive, parallel-sided dykes are present, some of the mafic intrusions have blocky to elongate rhombohedral shapes and are not particularly continuous. In places, rectilinear intersections of metagabbro with no evident crosscutting relationships are suggestive of a single emplacement into the complexly fractured granite. Elsewhere, low-angle intersections between dykes that differ slightly in composition, texture, and deformational fabric are suggestive of protracted emplacement during deformation. The intrusions are medium- to fine-grained, massive to weakly foliated with relict diabasic textures locally preserved. The fine-grained margins of the dykes are typically sheared. The mafic intrusions have been metamorphosed to the extent that all igneous mafic minerals have been replaced by amphiboles and in most cases the plagioclase has been recrystallized. The intrusions are petrographically similar to the east-trending dykes both within the Augustus Granite and elsewhere in the map area.

This grouping of generally northerly trending intrusions is most common within the Augustus Granite, although lens-shaped to pod-shaped gabbroic intrusions that are similar in many respects are present in the mafic mylonites of the Perrault Lithodeme where it is in contact with the Augustus Granite and elsewhere along it to the south. It is suggested in the section on the Perrault Lithodeme that the occurrence of these lenses may be related to the deformation that formed the mylonites and major structures at the present-day western margin of the supracrustal structural basin. If this is indeed the case, then this may explain the greater abundance of these intrusions in those parts of the Augustus Granite near these major structures and their relative rarity in the granite bodies to the east.

Because of the mapping scale and the degree of deformation and metamorphism, it is commonly difficult to differentiate with confidence between older mafic inclusions and some of the more irregular mafic intrusive bodies. The inclusions are the least common of the mafic bodies within the granite. They are generally finer grained and more foliated than the mafic intrusions. Their contact with the granite is irregular and commonly shows little reaction with it. Locally, they contain narrow veins of granite. They are typically rather featureless with no relict structures such as pillows to clarify their possibly mafic volcanic origin, although Northrup et al. (1997) report the occurrence of pillows in some mafic inclusions. Other than grain size, little distinguishes them petrographically from the mafic intrusive rocks in the granite.

### *Geochronology*

A preliminary zircon $^{207}Pb/^{206}Pb$ age of 3.02 Ga was determined by R.K. Wanless (pers. comm., 1975) for the granite a few tens of metres south of the unconformity shown on the map west of Keskarrah Bay. A 3152 ± 2 Ma U-Pb (zircon, three points) age was determined for the granite from the western side of Keskarrah Bay (Krogh and Gibbins, 1978; T.E. Krogh, pers. comm., 1981). The data from a second sample collected from the original unconformity locality, combined with Wanless' original data, resulted in a discordant and noncollinear array of points suggesting an age of about 3090 ± 60 Ma, which was considered generally consistent with the 3152 ± 2 Ma age of Krogh and Gibbins (1978) (Henderson et al., 1982). These data were considered unusual in that the common lead content was very high, ranging from 21 to 51 per cent of the total lead for the six fractions analyzed, and were in strong contrast with the data of Krogh and Gibbins (T.E. Krogh, pers. comm. to W.D. Loveridge, 1981). This was attributed to the incorporation into the zircon of ambient common lead from the country rock at the time of erosion of the unconformity. Loveridge (in Henderson et al., 1982) pointed out that the isotopic composition of the common lead in the zircon "...is consistent with its derivation from the basement terrane at the time of unroofing, but not with the 'modern day' lead composition currently existent in most crustal rocks" and that the zircons were sufficiently uraniferous so that enough radiation damage to the zircon structure could have occurred within the time available to have permitted diffusive penetration of about 2.7 Ga common lead into the zircon at the time of formation of the unconformity.

Zircons and titanite from a sample of the easternmost body of the Augustus Granite have also been analyzed (Table 3; Fig. 24, 25; Appendix 1). The material analyzed consisted of four single zircons and a single titanite grain. The zircon ages fall into two groups separated by about

**Table 3.** U-Pb analytical data from the Augustus Granite. Fractions AA, BA, BB, and BC are single abraided zircons and fraction T is titanite.

| | Wt. (µg) | U (ppm)[a] | Pb* (ppm)[a] | Blanks U(pg) | Blanks Pb(pg) | Pb* (ng) | Th/U [b] | $^{206}Pb/^{204}Pb$ | $Pb^c$ (ppm)[c] | $^{206}Pb/^{238}U$ [d] | $^{207}Pb/^{235}U$ [d] | $^{207}Pb/^{206}Pb$ [d] | $^{207}Pb/^{206}Pb$ Age[e] (Ma) | Disc. (%)[f] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA | 3 | 202 | 159 | 0 | 5 | 0.5 | 0.942 | 1763 | 2.3 | 0.6107 ± 0.11 | 20.650 ± 0.12 | 0.24522 ± 0.05 | 3154.2 ± 1.5 | 3.24 |
| BC | 4 | 75 | 59 | 0 | 5 | 0.2 | 0.794 | 2217 | 0.1 | 0.6287 ± 0.13 | 21.302 ± 0.13 | 0.24573 ± 0.04 | 3157.4 ± 1.3 | 0.51 |
| BA | 8 | 113 | 91 | 0 | 5 | 0.7 | 0.905 | 5991 | 0.1 | 0.6230 ± 0.09 | 22.015 ± 0.10 | 0.25628 ± 0.03 | 3224.0 ± 0.9 | 3.99 |
| BB | 4 | 52 | 43 | 0 | 5 | 0.2 | 0.759 | 1041 | 0.8 | 0.6484 ± 0.14 | 22.958 ± 0.14 | 0.25681 ± 0.06 | 3227.2 ± 2.0 | 0.21 |
| T | 51 | 41 | 26 | 0 | 10 | 1.3 | 1.24 | 507 | 1.9 | 0.4708 ± 0.09 | 15.104 ± 0.17 | 0.23269 ± 0.12 | 3070.6 ± 3.7 | 22.84 |

Augustus Granite: Sample H-350, Location 65°08.7′N 112°48.7′W

* Radiogenic lead
[a] Sample weight error of ±0.001 mg included in concentration uncertainty
[b] Th/U from $^{208}Pb^*/^{206}Pb^*$ and $^{207}Pb^*/^{206}Pb^*$ age
[c] Common lead in sample
[d] Errors are one standard error of mean expressed as a percentage of ratio
[e] Errors are two standard errors of mean expressed in millions of years
[f] Discordance on line through the point from concordia to origin

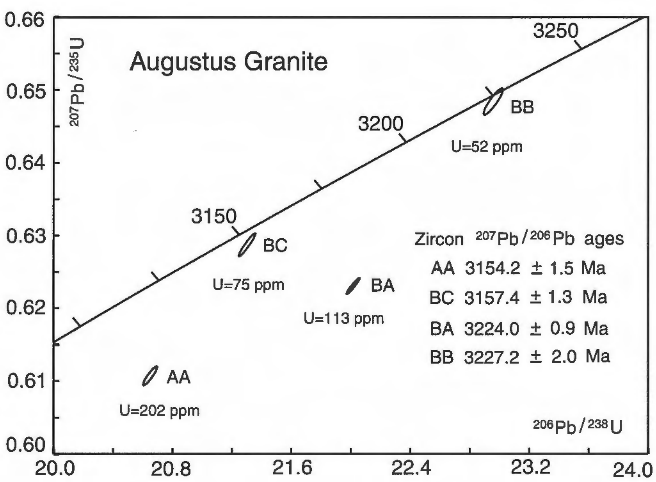



*Figure 24.*

*U-Pb concordia diagram for zircons from the Augustus Granite.*

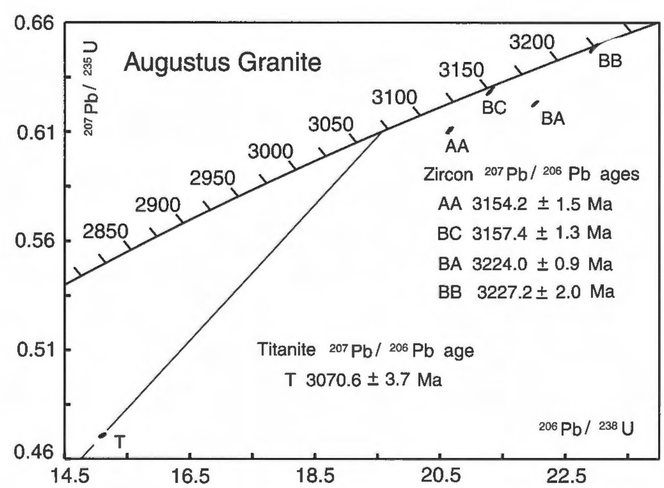



*Figure 25.*

*U-Pb concordia diagram for titanite and zircons from the Augustus Granite.*

70 Ma. One of the zircons was nearly concordant (0.51 per cent) with a $^{207}Pb/^{206}Pb$ age of 3157.4 ± 1.3 Ma that, together with a second 4 per cent discordant zircon, provides a discordia line that intersects concordia at 3156 ± 3 Ma. The second group consists of a zircon that is about 0.21 per cent discordant with a $^{207}Pb/^{206}Pb$ age of 3227.2 ± 2.0 Ma and a 4 per cent discordant grain that has a similar $^{207}Pb/^{206}Pb$ age of 3224.0 ± 0.9 Ma. Northrup et al. (1997) report a preliminary U-Pb zircon age of 3.22 Ga for the Augustus Granite, which is similar to the age of these older grains. The single titanite grain analyzed at 22.84 per cent is much more discordant than any of the zircons and has a $^{207}Pb/^{206}Pb$ age of 3070.6 ± 3.7 Ma.

Davis and Hegner (1992), assuming a crystallization age of 3.155 Ga for the granite, report an initial $\varepsilon_{Nd}$ value of +3.4 and a $T_{DM}$ age of about 3.1 Ga for a sample of the Augustus Granite. They suggest that a time-integrated depleted source for the granite is indicated. Since the U-Pb (zircon) and $T_{DM}$ ages are similar, they consider that the granite was derived from a source with a very short residence time in the crust since its extraction from the mantle.

## *Discussion*

### Environment of emplacement

Perhaps the most important aspect of the Augustus Granite is the occurrence of hypersolvus textures in parts of it. Single-feldspar granites consisting only of potassium-rich alkali feldspar with exsolved plagioclase lamellae form when the feldspar crystallizes under conditions such that the solidus does not intersect the feldspar solvus (Tuttle and Bowen, 1958). This is strongly influenced by water pressure since at lower water pressures the solvus and solidus do not intersect and only a single alkali feldspar is precipitated. As the water pressure increases the solidus is depressed, eventually intersecting the solvus and resulting in the crystallization of two feldspars. If the water pressure is equal to the total pressure, then the hypersolvus phases of the granite crystallized at shallow depths. On the other hand, a dry melt, in which the water pressure was less than the total pressure, could crystallize at greater depths and have similar textures (Martin and Bonin, 1976). This effect is also influenced by the presence of calcium, which tends to reduce the separation between solvus and solidus. Parsons (1978) suggests a water pressure on the order of 1 kbar or less for the crystallization of a hypersolvus granite of near-granite minimum composition. It would appear then that the rocks of the hypersolvus phase of the Augustus Granite represent emplacement and crystallization at shallow crustal levels.

The significance of the second phase containing both perthite and plagioclase is less clear. It has been suggested that the original perthite of hypersolvus granite can break down to two discrete feldspars as a result of deformation at the margin of the intrusion associated with the granite's emplacement, as in the case of the Elchuru alkaline pluton, Andhra Pradesh (Madhavan and Leelanandam, 1979). Later deformation and metamorphism unrelated to its emplacement can be another mechanism, as in the case of the Scituate Granite, Rhode Island (Day et al., 1980; Day and Brown, 1980). Martin and Bonin (1976) note the common association of hypersolvus and subsolvus granites and suggest that the subsolvus phase forms from the hypersolvus phase as a result of to the introduction of water and refusion of the still hot, crystallized hypersolvus phase. They consider an intermediate stage consisting of perthite in a subsolvus matrix, which they call transolvus, to be the result of the incomplete fusion of the hypersolvus phase and to be relatively rare. However, some to most of the perthite that is texturally similar to that of the hypersolvus zone persists in the intermediate zone of the Augustus Granite, along with elongate laths of rather strongly zoned plagioclase but no end-member crystals of potassium feldspar. This is not the product that would be expected from either of these mechanisms. The plagioclase laths may represent earlier feldspar crystallized from the melt prior to its final emplacement high in the crust where the rest of it crystallized under hypersolvus conditions.

The third phase of the Augustus Granite, found mostly on the western sides of the various blocks of the unit, contains a high proportion of plagioclase, much less microcline, and no perthite; it represents a more calcic and less potassic compositional variant of the granite. Although generally quite highly deformed, where it is best preserved at the north end of the block west of Keskarrah Bay, it has an igneous texture, locally with quartz with the squarish outline suggestive of β-quartz similar to that seen in some of the hypersolvus granite. Like the hypersolvus textures, the occurrence of β-quartz is compatible with emplacement of the granite at shallow depths.

In summary, the Augustus Granite represents a high-level granite of varied composition that in the larger blocks is more potassic to the northeast and east and more calcic to the west and south, as expressed by the feldspar mineralogy and limited chemical data. The present erosion level in the two large southern blocks of the Augustus Granite represents a section through the granite that increases in depth from the north and northeast to the south and southwest, away from the unconformity with the Keskarrah Group, as expressed by the textures in the granite and also by the increasing number and ductility of the faults. The compositional gradient seems to follow this trend generally, but not totally.

## Geological evidence for the time of emplacement

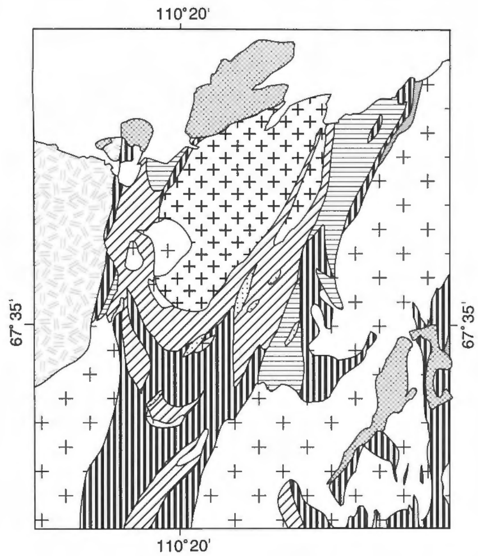
Although the Augustus Granite is clearly unconformably overlain by conglomerate of the Keskarrah Group, on geological grounds there is reason to suspect that it may not be part of a pre-Yellowknife Supergroup basement complex. Elsewhere in the Slave Province, rocks predating the Yellowknife Supergroup consist of structurally and lithologically complex, high-grade gneisses and deformed and metamorphosed plutons that contain a component that is significantly older than the Yellowknife Supergroup (i.e. >150 Ma) (e.g. Frith et al., 1986; Henderson et al., 1987; Bowring et al., 1989; James and Mortensen, 1992) and as such are out of context with the nearby relatively low-grade rocks of the Yellowknife Supergroup in which primary supracrustal textures and structures are commonly well preserved. In contrast, the Augustus Granite is a relatively homogeneous, high-level pluton with well preserved primary igneous textures that has been metamorphosed only to low grade. Although a major part of the Augustus Granite has been deformed, a case can be made for much of the deformation postdating the Yellowknife Supergroup, as will be discussed later. The most convincing hypersolvus textures and examples of β-quartz, the best evidence for shallow emplacement of the body, are found at several localities immediately below the unconformity with the overlying Keskarrah Group (Fig. 15). This would suggest that little tilting and minimal erosion of the granite have occurred since the time of its emplacement and the deposition of the youngest unit of the Yellowknife Supergroup, the Keskarrah conglomerate of the Keskarrah Group.

The Augustus Granite is in contact with orthogneissic rocks southeast of Keskarrah Bay. Contact relationships are poorly known, but at least one dyke of Augustus Granite is known in the gneiss and inclusions of gneiss do occur locally within the granite. This, together with the apparent long and complex polymetamorphic, deformational, and intrusive history implied by gneiss such as this (Passchier et al., 1990) and the preservation of the original igneous mineralogy and textures of the Augustus Granite, would suggest that the Augustus Granite is younger. No geochronological data are available from the gneisses preserved near this contact, but poor and incomplete data from similar gneisses in the granitoid gneiss and foliated granitoid domain a few kilometres to the west suggest that although components of the gneiss are as old as zircons from the Augustus Granite, they are generally younger (3.22-2.60 Ga) (Krogh and Gibbins, 1978; Easton, 1981, 1985; Kusky, 1991; Northrup et al., 1997).

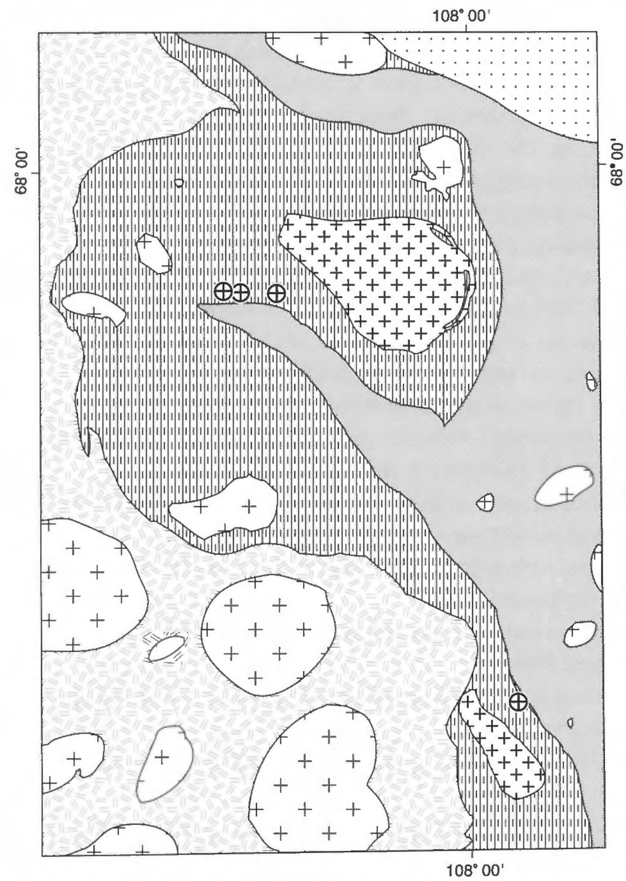
Setting aside for a moment the geochronological data on the Augustus Granite, one possibility to consider is that the Augustus Granite represents a synvolcanic intrusion associated with Yellowknife Supergroup volcanism, possibly emplaced into the accumulating volcanic pile while volcanism was still active. The intrusion is approximately concordant with associated, dominantly mafic volcanic rocks of the Peltier Formation and sheared, probably volcanic rocks of the Perrault Lithodeme. No unequivocal dykes of Augustus Granite in the volcanic rocks have been recognized although the only granitoid intrusions known in the Peltier Formation are highly deformed granitoid sills immediately adjacent to a contact between the Peltier Formation and the Augustus Granite. The Augustus Granite does contain some inclusions of mafic, possibly volcanic, rock that could have been derived from Yellowknife Supergroup volcanic rocks. The granite contains numerous altered mafic intrusions as described above, although many of these are considered to be either syndeformational intrusions related to major shearing at the margin of the supracrustal domain, or through-going Paleoproterozoic dykes. Some may represent post-granite-emplacement feeders to the volcanic sequence as originally suggested by Stockwell (1933). Indeed, Northrup et al. (1997) have reported preliminary U-Pb zircon ages of 2.67 and 2.69 Ga from two such dykes, and these ages are compatible with that of Peltier Formation mafic volcanic rocks adjacent to the Augustus Granite.

Large, high-level, synvolcanic granitoid intrusions associated with Yellowknife Supergroup volcanic rocks are known elsewhere in the Slave Province. They are typically exposed in the cores of domal or anticlinal structures and are mantled by Yellowknife Supergroup volcanic rocks (Fig. 26). The Augustus Granite is similar in many respects to the Amacher Granite in the Hearne Lake area, 90 km east-northeast of Yellowknife (Henderson, 1985). The Amacher Granite is mantled by concordant mafic volcanic rocks and locally contains mafic inclusions possibly derived from the volcanic carapace. It also shows textures suggestive of shallow emplacement and has been metamorphosed in context with the volcanic rocks. As the dominantly mafic volcanic sequence contains local felsic volcanic centres, it has been suggested that these centres could be extrusive equivalents of the Amacher intrusion.

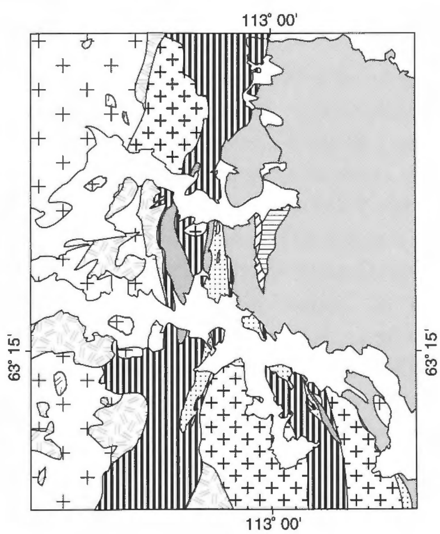
At Brislane Lake, 90 km east-northeast of the Amacher Granite (Fig. 26), another mafic volcanic sequence capped by felsic volcanic rocks is cored by metatonalite. This granitoid was originally considered to predate the Yellowknife Supergroup on the basis of its metamorphosed state and the presence within it of metamorphosed mafic dykes possibly representing feeders to the volcanic rocks (Heywood and Davidson, 1969). Such dykes occur only in the metatonalite and the mafic volcanic sequence; they were not seen in the felsic metavolcanic rocks and metasedimentary rocks. The tonalite, however, has a U-Pb (zircon) age of 2673 +6/-4 Ma (Frith et al., 1991), which is within the age range of most Yellowknife Supergroup volcanic rocks. Frith et al. (1991) also determined an imprecise age for the felsic metavolcanic rocks associated with the complex that is compatible with the 2.67 Ga age of the metatonalite.



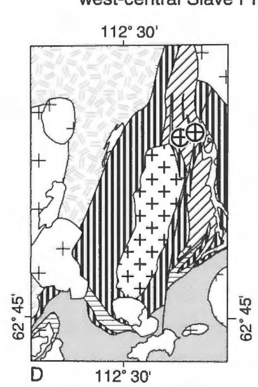

A Anialik River igneous complex, Hepburn Island area , northern Slave Province

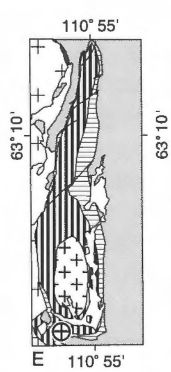



B Synvolcanic plutons, Hackett River area, eastern Slave Province




C Augustus Granite, Keskarrah Bay area, west-central Slave Province




D Amacher Granite, Yellowknife-Hearne Lake area, southern Slave Province

E Brislane tonalite, Benjamin Lake area, southern Slave Province

NEOPROTEROZOIC

Franklin mafic sills

PALEOPROTEROZOIC

Goulburn Supergroup

ARCHEAN

Granitoid rocks, undivided

Yellowknife Supergroup

Conglomerate, sandstone

Greywacke-mudstone

Undivided heterogeneous volcanic rocks

Mainly felsic volcanic rocks

Mainly intermediate volcanic rocks

Mainly mafic to intermediate volcanic rocks

Synvolcanic granitoid rocks

Granitoid gneiss

⊕ Base metal deposit

5 0 5 10 15
km

The Hanimor gneiss, a metatonalite in the northeastern Slave Province, also occurs in the core of a domal structure. It is mantled by biotite and sericite schists, quartzofeldspathic gneiss, and amphibole gneiss, followed by dacitic to andesitic flows and volcaniclastic rocks with associated carbonate rocks and iron-formation, all at amphibolite metamorphic grade (Fig. 26; Frith, 1987). The tonalitic core has U-Pb (zircon) ages of 2666 +20/-28 Ma (Frith and Loveridge, 1982) and 2681 +4/-2 Ma (unpub. age by O. van Breemen, J.E. King, and W.J. Davis, quoted in van Breemen et al., 1992). Like the situation at Brislane Lake, all primary textures have been lost due to metamorphism and deformation. Some 30 km to the south, however, a much better preserved intrusion has been metamorphosed only to greenschist grade (Fig. 26). Frith (1987) interpreted it as a sill occurring within the volcanic section. Primary textures are well preserved within the intrusion and are essentially identical to those of the intermediate phase of the Augustus Granite, which contains both perthite and plagioclase together with quartz with squarish outlines.

Finally, in the northernmost Slave Province, the Anialik River igneous complex occurs in an elongate dome mantled by largely mafic and intermediate volcanic rocks of the Yellowknife Supergroup (Fig. 26). Although largely tonalitic in composition, the complex is much more heterogeneous than the previous examples with several dioritic phases, areas dominated by several generations of felsic dykes, and some heterogeneous orthogneiss (Abraham et al., 1994 and references cited therein). U-Pb zircon ages from various phases range from 2705 Ma to 2678 Ma, the latter being the approximate age of the mantling volcanic sequence (Abraham et al., 1994).

A feature linking several of these examples is the occurrence of base-metal mineralization in the volcanic rocks intruded by the synvolcanic granitic intrusions. Cann et al. (1985) and Seyfried and Janecky (1985) suggested that heat from shallowly emplaced synvolcanic intrusions could raise the temperature and mobilize seawater within the volcanic rocks, which would allow the leaching of metals and sulphur from the rocks and result in their eventual deposition at the surface as concentrated base-metal deposits. Examples of the close association of base-metal deposits and synvolcanic plutons in the Slave Province include three Zn-Pb-Ag deposits aggregating 14 750 000 tonnes in the Bathurst-Norse camp, a few kilometres west of the Hanimor intrusion, and the 1 350 000 tonne Yava deposit that occurs stratigraphically above the synvolcanic granite body 30 km to the south (Frith, 1987; Energy, Mines, and Resources Canada, 1989). At Brislane Lake, an 800 000 tonne Zn-Pb-Ag body is associated with the volcanic rocks that mantle the synvolcanic pluton (McGlynn, 1971; Energy, Mines, and Resources Canada, 1989). Volcanic rocks mantling the Amacher synvolcanic granite east of Yellowknife contain the 1 200 000 tonne Sunrise and 750,000 tonne Bear Zn-Pb deposits (Atkinson, 1991). In the Anialik River area, no major base-metal deposits have been discovered, although Petch et al. (1992) note the occurrence of abundant stratiform massive sulphide and sulphide stringer zones controlled by synvolcanic structures. In the Keskarrah Bay area, numerous base-metal showings occur in the volcanic rocks near the Augustus Granite although to date, no significant base-metal deposits have been discovered.

Some consideration should be given to the possibility that the Augustus Granite represents a high-level, synvolcanic intrusion emplaced into the accumulating, largely mafic volcanic sequence, on the basis of its internal characteristics, its apparent close concordancy to the supracrustal rocks, and the presence of other similar discussed examples elsewhere in the Slave Province.

**Figure 26.**

*Synvolcanic granitoid intrusions that are similar in many respects to the Augustus Granite occur at several localities throughout the Slave Province. They commonly occur as dome-like structures mantled by Yellowknife Supergroup rocks, mainly mafic volcanic rocks, and have textures characteristic of high-level granites and/or synvolcanic ages. Several have significant base-metal deposits associated with the mantling volcanic rocks. Location of various areas shown in Figure 1. Sources of information: A - Jackson (1989b), Relf (1994); B - Jefferson (1976), Padgham and Jefferson (1976), Frith (1987); C - Henderson (1988); D -Henderson (1985); E - Heywood and Davidson (1969).*

### Geochronological evidence for the time of emplacement

The greatest difficulty in interpreting the Augustus Granite as a synvolcanic pluton is that the best U-Pb ages on zircon from the granite range from 3225 to 3152 Ma and a single, somewhat more discordant titanite grain from the granite has an age of 3070 Ma. The best estimate for the age of the Peltier Formation volcanic rocks that mantle the pluton is 2.67 Ga (Northrup et al., 1993; Isachsen et al., 1993). There is no indication of an isotopic disturbance in the Augustus zircons at this age. This presents a major difficulty for the hypothesis of a synvolcanic origin for the granite.

One possible explanation is that the zircon in the rock is xenocrystic. There is little doubt that some xenocrystic zircon is present, as the sample from the eastern part of the intrusion contains two 3156 Ma zircons while two other zircons are about 70 Ma older (Fig. 24, 25; Table 3; Appendix 1). Supporting this interpretation is the anomalously low uranium content ranging from 52 to 202 ppm for all four of the zircons analyzed. In general, zircons from granite have a relatively high uranium content. Indeed,

**Table 4.** Uranium concentration in zircon fractions from granitoid rocks of the Slave Province. The zircons from the Augustus Granite have anomalously low uranium contents compared to those from granites of the Slave Province in particular and also from most other granitoid rocks of the province. A 'fraction' is a single zircon or group of zircons of similar character from a given rock. The 'other' category includes a quartz diorite, a diorite, and an anorthositic gabbro. Data from Geological Survey of Canada (1987, 1988, 1990, 1991, 1992a, b, 1993).

| | Number of rocks | Number of fractions | Minimum - maximum content of U(ppm) in fractions for all rocks | Average range of minimum - maximum spread per rock | Average U(ppm) | Median U(ppm) |
|---|---|---|---|---|---|---|
| Augustus Granite | 1 | 4 | 52-202 | 150 | 111 | |
| granite | 10 | 54 | 148-1796 | 698 | 677 | 538 |
| granodiorite | 10 | 43 | 81-1133 | 201 | 444 | 395 |
| tonalite | 10 | 51 | 40-751 | 187 | 322 | 242 |
| other | 3 | 14 | 60-533 | 181 | 193 | 189 |

many Archean granites in the Slave Province have proven difficult to date using zircons because zircons with a relatively high uranium content have a high degree of lattice damage caused by 2.6 Ga of uranium decay. This damage has resulted in excessive lead loss and highly discordant ages (van Breemen et al., 1992). Of the 176 zircon fractions from 30 granite, granodiorite, and tonalite samples from the Slave Province that have been reported (Geological Survey of Canada, 1987, 1988, 1990, 1991, 1992a, b, 1993), two zircons from the Augustus Granite are the second and third least uraniferous of all fractions analyzed, the least uraniferous at 40 ppm coming from a tonalite (Table 4). While uranium concentration in zircon is not a particularly efficient discriminator of rock composition, zircons from granites do tend to have higher uranium concentrations, and the range of concentration between fractions within a given granite is considerably greater (Table 4). In both respects, the zircons from the Augustus Granite are anomalous compared to those from other granites of the Slave Province; this could be explained if they were xenocrysts, derived from an older, presumably more mafic parent to the granite.

Since hypersolvus granites such as the Augustus Granite typically form from water-poor melts (Martin and Bonin, 1976) and since the dissolution of zircon and the diffusion of zirconium are greatly reduced in such melts (Harrison and Watson, 1983), xenocrystic zircon is more likely to survive. If the zircons analyzed from the Augustus Granite are xenocrystic, one might expect a rim of zircon precipitated from the Augustus Granite melt. This is not an unusual occurrence in zircons from granitoid rocks (Williams, 1992). Ideally such zircons would plot along a discordia line, the upper intercept giving the age of the core material and the lower intercept, the age of the rim material, usually the age of the rock that contains them This is clearly not the case with the Augustus Granite, as two of the fractions are all but concordant and no line drawn through any combination of the other more discordant zircons comes close to a 2.7 Ga lower intercept age, the expected age if the Augustus Granite were a synvolcanic intrusion.

Zircons are not usually found in peralkaline granites because of the high solubility of zirconium in melts of that composition compared to those of other granitoid compositions (Watson, 1979). Chemically, the Augustus Granite is a normal peraluminous granite and magmatic overgrowths on any zircon xenocrysts would be expected. One explanation could be the low diffusivity of zirconium in relatively dry melts, which would tend to retard the formation of zircon to some degree (Harrison and Watson, 1983). Another contributing factor might be the methodology used in the selection and preparation of zircon for geochronological analysis; any zircon precipitated from the granite melt, either as rim material on xenocrystic material or as discrete crystals, could have been preferentially excluded. The zircons selected for analysis are typically the highest quality crystals, which generally means those with lowest uranium content. They are then abraded to remove the outer portion of the grain, which has undergone the greatest lead loss, and as a result the data tend to be much more concordant. While this procedure tends to produce high quality data, it is conceivable that low-uranium xenocrystic zircon may have been selected over possibly higher uranium zircon precipitated from the Augustus melt and that any younger rim material may have been preferentially removed.

There are cases where both xenocrystic zircon and melt-precipitated zircon occur as discrete grains with no younger rim material on the older phase, as determined by ion probe spot analyses. The Parks Pond Pluton in Maine contains 3.1 and 2.1 Ga unrimmed xenocrystic zircon in addition to 410 Ma zircon crystals formed from the melt (Williams, 1992). Another example is a metagabbro from the Gotthard Massif in Switzerland, which contains both 870 Ma euhedral magmatic zircon and 3.17-1.27 Ga xenocrystic mantle-derived zircon (Gebauer et al., 1988). The xenocrystic zircon appears to have been unaffected by the magmatic event, but has been altered to some degree by later eclogite-grade Caledonian metamorphism at 468 Ma.

The titanite data also present a problem when considering a possible 2.7 Ga age for the Augustus Granite. The single titanite grain from the same sample as the previously discussed zircons has a 23 per cent discordant $^{207}Pb/^{206}Pb$ age of 3.07 Ga (Fig. 25; Table 3; Appendix 1). This age is difficult to interpret. If the titanite at 3.07 Ga and the youngest zircon at 3.16 Ga are both magmatic, then the Augustus Granite would have taken about 90 Ma to cool to about 600°C, the generally accepted closing temperature for titanite (Heaman and Parrish, 1991), from the time of crystallization of the zircons. This is unlikely if the Augustus Granite were a high-level granite emplaced within a kilometre of the surface, as it would probably have cooled quickly. On the other hand, if the titanite were xenocrystic, the same 600°C blocking temperature makes it unlikely that the primary age of the titanite would survive granite melting conditions.

There is evidence that the 600°C blocking temperature of titanite may not be absolute under all conditions. Tucker et al. (1987, 1990) and Tucker and Krogh (1988) describe several cases in the Norwegian Caledonides where the isotopic signature of titanite formed in ca. 1.6 Ga gneiss is retained through amphibolite-facies Caledonian metamorphism. In particular, a migmatitic tonalite gneiss near Tingvoll, Norway, emplaced and migmatized over a short time at 1686 Ma, was later recrystallized and partially remelted under 650-750°C conditions at 396 Ma during the Caledonian Orogeny (Tucker et al., 1990). Leucosome pods contain populations of light-coloured or clear, morphologically distinct, new titanite and zircon that are nearly concordant at 396 Ma, as well as darker, older titanite and zircon that are much more discordant along the same discordia line with an upper intercept of 1686 Ma. Both titanite and zircon from the tonalite gneiss also plot on the same discordia line. In this case, the older isotopic signature was preserved in the older titanites despite exposure to conditions above its normal blocking temperature of about 600°C. Tucker et al. (1990) suggest that this was due to relatively short exposure of the titanite to these conditions, which did not allow lead loss through diffusion to go to completion. On the other hand, on the basis of the recovery of both titanite and zircon with a 810 Ma memory from a 35 Ma, high-level, subvolcanic hornblende syenite from Yunnan, China, Zhang and Schärer (1996) question whether titanite actually has a blocking temperature and suggest that the mineral is always a closed system at its temperature of crystallization.

Taken alone, none of this data is particularly compelling evidence for interpreting either the zircon or the titanite in the Augustus Granite as xenocrysts. Such an origin, however, cannot be excluded and may provide a possible solution to the paradox whereby the geological evidence points to the Augustus Granite being a high-level, subvolcanic, synvolcanic pluton presumably related to the 2.7 Ga Yellowknife Supergroup volcanic rocks that partly mantle it, while the geochronological data, when taken at face value, suggest that the Augustus Granite is much older. The preferred interpretation is that the Augustus Granite is a high-level granite that was emplaced into the accumulating dominantly mafic Peltier Formation volcanic edifice.

## YELLOWKNIFE SUPERGROUP

The Yellowknife Supergroup as it is now defined includes all Archean rocks of supracrustal origin within the Slave Province. Following his expedition to Point Lake, Stockwell (1933) included these rocks in his Point Lake-Wilson Island group. Henderson (1938) introduced the term 'Yellowknife group' to include the Archean metasedimentary and metavolcanic rocks east of Yellowknife in the southern Slave Province. Other geologists extended this nomenclature to similar rocks throughout the Slave Province. The Yellowknife group was subsequently raised to supergroup rank to better reflect the diverse nature of its supracrustal rocks and was formally defined to include all Archean supracrustal rocks within the Slave Province (Henderson, 1970). In light of the large amount of geochronological data that has become available in the last two decades, this perhaps too all-encompassing definition would appear to have outlived its usefulness. On the basis of currently available U-Pb geochronology, the apparent time span represented by rocks of the Yellowknife Supergroup is on the order of the length of the Phanerozoic. Padgham (1992) and Padgham and Fyson (1992) have recently reviewed the geology of the Yellowknife Supergroup.

The Yellowknife Supergroup can be divided into three lithologically and chronologically distinct parts reflecting differing tectonic environments. The most extensive of these consists of the vast domains of metagreywacke-mudstone turbidites that are locally bounded by and less commonly contain units of mafic to felsic volcanic rocks. Together they make up over 99 per cent of the area of the province underlain by Archean supracrustal rocks (Fig. 1). Although the metavolcanic rocks and metagreywacke-mudstones are considered to be conformable in most parts of the Slave Province, detailed work in the southern Slave Province has shown that angular unconformities exist within the volcanic sequences and that they represent significant time breaks (Padgham, 1987; Isachsen and Bowring, 1994; Bleeker, 1996). Most geochronological ages from these rocks range from 2.72 to 2.66 Ga (van Breemen et al., 1992; Villeneuve and van Breemen, 1994) although in the northern Slave Province, ages as young as 2616 ± 3 Ma have been recognized in lithologically similar rocks (Henderson et al., 1995).

A second part of the Yellowknife Supergroup consists mainly of granitoid- and volcanic-clast conglomerates and shallow-water sandstones. They unconformably overlie the metavolcanic rocks and, less commonly, the meta-greywacke-mudstone turbidites. Although volumetrically very minor, they occur at several localities in the western part of the Slave Province. The youngest granitoid clasts in the conglomerates have been dated at about 2.60 Ga, which is within the 2.63-2.59 Ga period of intrusion of the vast granitoid batholiths of the Slave Province.

The third part of the Yellowknife Supergroup is older than the other two and has been recognized in only a few localities in the western Slave Province. It also is lithologically distinct, consisting largely of very quartz-rich sandstones to orthoquartzites with lesser amounts of felsic volcanic rocks, iron-formation, and quartz-pebble conglomerate. Detrital zircons from the sandstones predate the dominant greywacke-mudstone and volcanic parts of the Yellowknife Supergroup. Some associated felsic volcanic rocks immediately north of Yellowknife are about 2.83 Ga (Isachsen and Bowring, 1997) and, in the central Slave Province, such rocks may be as old as 3.3 Ga (M.E. Villeneuve, unpub. data, 1995, in Villeneuve et al., 1997).

In the Keskarrah Bay area, the greywacke-mudstone and volcanic rocks of the Yellowknife Supergroup are unconformably overlain by conglomerates and associated sandstones. No evidence of the older quartzites have been recognized to date.

In the Point Lake region, Bostock (1980) divided the Yellowknife Supergroup into several lithostratigraphic units at the formation rank. These include a dominantly volcanic unit, the Point Lake Formation, which was further subdivided into a series of unnamed map units based on compositional and textural criteria. The metasedimentary rocks consisting of greywacke-mudstone turbidites were assigned to the Contwoyto or Itchen formations. They are distiguished primarily by the presence of iron-formation in the Contwoyto Formation and its absence in the Itchen Formation. A third metasedimentary formation, the Keskarrah Formation, consists of conglomerates and sandstones.

In this report, it is proposed that Bostock's (1980) original Point Lake Formation be raised to group rank and that a series of volcanic formations, corresponding largely to Bostock's (1980) volcanic rock units, be defined. For the two greywacke-mudstone turbidite units, it is proposed that a new group-rank unit be defined, the Cogead Group, that would include the Contwoyto and Itchen formations as originally defined by Bostock (1980). These two group-rank units are representative of the dominant part of the Yellowknife Supergroup of the Slave Province. It is further proposed that Bostock's (1980) Keskarrah Formation be raised to group rank to form a unit that consists of three lithologically distinct map-scale facies. The Keskarrah Group unconformably overlies rocks of both the Point Lake and Cogead groups and as such is an example of the youngest part of the Yellowknife Supergroup.

Within the map area, the rocks of the Yellowknife Supergroup are everywhere metamorphosed, albeit at low grade in the central part of the area. For simplicity, however, the prefix 'meta' is omitted in the terminology of supracrustal rocks in the following discussion.

## *Point Lake Group*

The Point Lake Group includes all the volcanic units of the Yellowknife Supergroup within the Keskarrah Bay area. The term 'Point Lake Formation' was originally defined by Bostock (1980) to include all the volcanic rocks and intercalated sedimentary rocks in the Point Lake region. Bostock (1980) also reviewed the previous nomenclatural history of the unit. It is proposed that Bostock's Point Lake Formation be raised to group rank, which would allow the various volcanic subunits, most of which were identified if not named by Bostock, to be given formation rank where appropriate. The group was named after Point Lake.

Within the map area, the group is dominated by mafic volcanic units that include the Peltier Formation and the related Perrault Lithodeme. The Peltier Formation consists mainly of pillowed and massive basalt and associated sills and other intrusions. The Perrault Lithodeme is a highly deformed layered amphibolite that occurs adjacent to the major tectonic break separating the foliated granitoid and granitoid gneiss terrane to the west from the Yellowknife Supergroup terrane. It is considered to be a tectonic unit derived from the Peltier Formation, rather than a stratigraphic unit. Minor volcanic units of mafic and intermediate composition also occur within the Keskarrah Group sandstone and conglomerate facies. These units are thought to represent tectonic slices of Peltier Formation volcanic rocks within the Keskarrah Group, rather than products of volcanism contemporaneous with the younger sedimentation.

A small centre of felsic to intermediate volcanic rocks is found in the central part of the area. It includes the Beauparlant Formation, a rhyolite, and the Samandré Formation, which consists of intermediate volcanic rocks. A minor unit of carbonate rock, consisting of discontinuous lenses of dolostone and limestone, occurs locally at the contact between the intermediate and felsic volcanic rocks and the overlying greywacke-mudstone turbidites and is also considered part of the Point Lake Group.

The individual formations of the group are described in the following sections.

## Peltier Formation

The Peltier Formation is the name proposed for the major volcanic unit of the area. It consists dominantly of pillowed and massive mafic metavolcanic rocks and associated sills and other intrusions of metagabbro and is of undetermined thickness. Due to the lack of named geographical features in the area, it is named after Joseph Peltier, a member of Franklin's expedition (1819-1822) that passed through the area on its way north along the Coppermine River in search of the Northwest Passage. Regionally, the Peltier Formation and the adjacent layered amphibolites of the Perrault Lithodeme separate the extensive domain of granitoid rocks, foliated granitoid rocks, and granitoid gneisses to the west from the area underlain mainly by metasedimentary rocks of the Yellowknife Supergroup that extends over 40 km to the east (Fig. 2). Similar mafic volcanic rocks occur continuously for 60 km north of the map area (Bostock, 1980; Fig. 1). The mafic volcanic rocks extend at least 15 km south of the map area and their highly deformed and migmatized equivalents, possibly as much 60 km (Fraser, 1969).

### *Structural setting*

South of Point Lake the Peltier Formation occurs within a series of tectonic panels, the westernmost of which is structurally the most complex with the Peltier Formation occurring in a synclinal structure so that the steeply dipping volcanic rocks face away from both the Augustus Granite to the east and the Perrault Lithodeme to the west, although both contacts are tectonic. In the core of the syncline, the volcanic rocks are unconformably overlain by Keskarrah Group sandstone and conglomerate. The western margin of the panel is the major shear zone that juxtaposes the foliated granitoid and granitoid gneiss domain and the mafic volcanic rocks of the Point Lake Group. The folds associated with the cuspate-lobate morphology of the shear zone extend well into the western limb of the synclinal structure. In the panel east of Keskarrah Bay, the Peltier Formation occurs in a steeply dipping homoclinal succession, which also faces away from the Augustus Granite, and into the Keskarrah Group. In the small, wedge-shaped panel to the east, the sequence is much thinner and greatly deformed, and conglomerate occurs on both sides of the volcanic rocks of the Peltier Formation. The Peltier Formation is not found in the easternmost panel, where the Augustus Granite is overlain directly by conglomerates of the Keskarrah Group. This suggests that the Peltier Formation, if it occurred this far east, was eroded prior to deposition of the sedimentary units. In this regard, Bostock (1980) reports the occurrence of a major unit of mafic volcanic rocks that begins a few kilometres south of the map area, on strike with the unconformity between the Augustus Granite and the Keskarrah Group (Fig. 2).

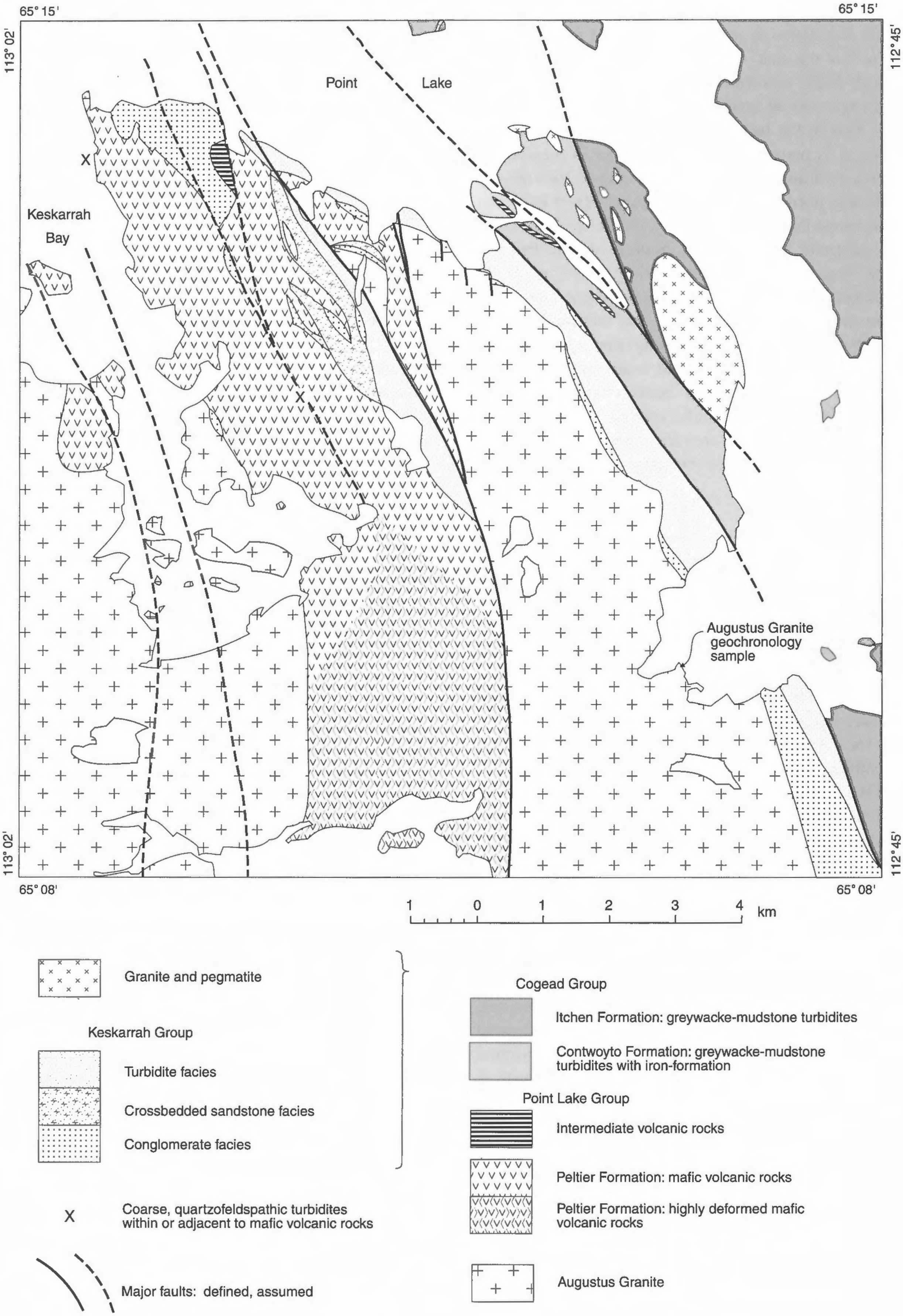
On the peninsula between the two arms of Point Lake, the Peltier Formation occurs in an anticlinal structure that faces into the overlying Contwoyto Formation and has a small body of Augustus Granite at its core. This structure could not be traced with any confidence to the north across the lake because of the greater degree of deformation in the western part of the formation and the resulting lack of facing indicators near the lake. Farther north, pillows generally face east, suggesting that the Peltier Formation is dominantly a homoclinal succession in this area. The northernmost part of the volcanic unit is significantly wider than elsewhere in the map area, a feature that may be due at least in part to fault repetition.

Throughout the unit, narrow, northerly trending shear zones are found in which generally well preserved, primary volcanic structures such as pillows have been obliterated. These shear zones are typically only a few metres wide and are separated by several to many tens of metres of relatively minimally deformed volcanic rocks. One of the largest shear zones mapped within the formation is found north of the northern arm of Point Lake and is locally several tens of metres wide. Another, much wider, major shear zone may occur in the central part of the unit east of Keskarrah Bay (Fig. 27). The unit south of Keskarrah Bay consists over its entire width of a layered amphibolite, similar in most respects to the Perrault Lithodeme to the west. Layering trends within this part of the Peltier Formation are very irregular due to outcrop-scale folding and contrasts strongly with the rest of the unit to the north, which has a constant northerly trend. This wide zone thins to a narrow zone within the homoclinal, east-facing succession in the northern part of the volcanic belt, although details of the transition are not understood. The smaller scale ductile shears are thought to be related to the major mapped shear zones that occur throughout the area.

### *Contacts*

Contacts between Peltier Formation mafic volcanic rocks and other units are generally not well exposed within the map area. A fairly extensive Quaternary cover is found in many parts of the area; in addition, the mafic volcanic rocks tend to weather less than the more recessive sedimentary rocks. Thus, while the contact with the adjacent unit can commonly be accurately located at map scale, the actual contact itself may not be exposed. A further complication results from shearing throughout much of the area, which is prominently expressed by the series of northerly trending shear zones. In areas where a mechanical contrast existed across northerly trending contacts, that contact commonly became a focus for shear that obscured pre-shearing relationships between the units.

The contacts between the Augustus Granite and the volcanic rocks of the Peltier Formation are discussed in some detail in the section on the Augustus Granite. All the


65° 15'
65° 15'
113° 02'
112° 45'
Point
Lake
Keskarrah
Bay
X
Augustus Granite
geochronology
sample
113° 02'
112° 45'
65° 08'
65° 08'
1 0 1 2 3 4 km
Granite and pegmatite
Keskarrah Group
Turbidite facies
Crossbedded sandstone facies
Conglomerate facies
X
Coarse, quartzofeldspathic turbidites
within or adjacent to mafic volcanic rocks
Major faults: defined, assumed
Cogead Group
Itchen Formation: greywacke-mudstone turbidites
Contwoyto Formation: greywacke-mudstone
turbidites with iron-formation
Point Lake Group
Intermediate volcanic rocks
Peltier Formation: mafic volcanic rocks
Peltier Formation: highly deformed mafic
volcanic rocks
Augustus Granite

contacts are sheared, particularly along the mapped faults where the volcanic rocks occur west of the granite. In areas where the volcanic rocks are situated east of the granite, they face away from it and the contacts are straight, sharp, and invariably sheared to some degree. Inclusions of mafic volcanic rocks occur within the granite. Only one example of granite dykes or veins has been recognized in the Peltier Formation, on the north shore of the large eastern bay at the south end of Keskarrah Bay, at the contact with the Augustus Granite. There, thin boudins of granite are present within the sheared volcanic rocks, but they have been so recrystallized that it is impossible to determine whether they are related to the Augustus Granite.

A few exposed contacts between the Peltier Formation and the greywacke-mudstone turbidites of the Contwoyto Formation are found between Itchen and Point lakes and south of the north arm of Point Lake. At several localities between Point Lake and the river draining Itchen Lake, pillowed volcanic rocks at the contact are slightly bleached and only weakly sheared. They are overlain by a black slate that is locally rusty due to the presence of disseminated pyrite and minor volcanogenic siltstone layers less than 10 cm thick containing little or no quartz. At at least one locality, a 3 m thick unit of siderite iron-formation, a common feature of the Contwoyto Formation, occurs within a metre or so of the contact. These rocks grade into the typical greywacke-mudstone turbidites of the formation. Minor thin units of black slate or shale similar to that immediately above the contact are found within the volcanic sequence close to the contact, suggesting that the contact may not represent a significant time break. On the south shore of the north arm of Point Lake, the contact between the mafic volcanic rocks and the Contwoyto Formation to the west is exposed. There, the volcanic sequence at the contact consists of mafic volcaniclastic units interlayered with siliceous carbonate rocks in units up to 6 m thick that are sharply overlain by greenish, quartz-bearing greywackes and mudstones of the Contwoyto Formation. The rocks are folded but appear to be conformable.

The Keskarrah Group sandstones and conglomerates are in contact with the Peltier Formation at several localities, but the relationship remains somewhat equivocal due to subsequent deformation of the rocks. In most places where they are best preserved, the pillowed volcanic rocks of the Peltier Formation face the similarly facing crossbedded sandstones or conglomerates of the Keskarrah Group. They are close to concordant in most cases, although rocks of the Keskarrah Group east of the mouth of Keskarrah Bay seem to have a regional low-angle discordant relationship. The contact surface between the two units is typically sheared. Where the Peltier Formation is overlain by conglomerate, the clasts at the base of the sequence are typically also volcanic, and granitic clasts are not found in the conglomerate for up to several tens of metres above the contact. This is not the case where conglomerate overlies granite, which suggests that while the contact between the Peltier Formation and the Keskarrah Group is sheared, it does not represent a major amount of movement. The Keskarrah Group contains bodies of mafic and, to a lesser extent, intermediate volcanic rock as well as sharp projections of mafic volcanic rock into the conglomerates and sandstones. The mafic bodies are similar in all respects to the Peltier Formation, but again because of the sheared contacts it is difficult to determine whether these flows were extruded into the accumulating Keskarrah Group sediments or whether they represent tectonic slices of mafic material derived from the Peltier Formation itself. Corcoran et al. (1996) indicate that where the volcanic rocks were mapped in detail, they face towards the adjacent Keskarrah Group sedimentary rocks.

***Figure 27.***

*Distribution of shear zones and rock types southeast of Keskarrah Bay. Also shown are locations of examples of very coarse-grained quartz-rich turbidites in close association with the Peltier Formation. The location of the Augustus Granite U-Pb geochronology sample described in Appendix 1 is shown in the southwest corner of the map.*

*Lithology*

The Peltier Formation is similar in many respects to other dominantly mafic volcanic sequences in the Slave Province such as those at Yellowknife (Henderson and Brown, 1966) or in the Cameron River belt (Lambert, 1988). It consists primarily of pillowed mafic volcanic rocks with lesser amounts of massive flows, fragmental deposits, synvolcanic mafic intrusions, as well as minor intermediate to felsic volcanic units and sedimentary rocks including carbonate and pelitic units. The proportion of the components varies considerably from place to place.

The pillowed mafic volcanic rocks occur in flow units a few metres to several tens of metres thick. They are fine grained, even grained, typically dark green to dark grey-green, and weather pale green to grey through reddish brown-green to dark green with, in general, greenschist-grade rocks being lighter than those metamorphosed to amphibolite facies. The pillow selvages are prominently developed and outline pillows that are a few tens of centimetres to more than 1 m in diameter. In at least one instance, magnetite fills voids between pillows (Fig. 28). The pillows are typically elongate parallel to the strike of the unit, due to a combination of the primary shape of the structure and tectonic flattening, with the degree of flattening or elongation of the structure becoming extreme as shear zones within the unit are approached. Vesicles to quartz-filled amygdules are common towards the pillow selvage and concentrated towards the top of the structure. Possible variolitic pillowed flows, a common feature in the Kam Group at Yellowknife (Henderson and Brown, 1966), are known to occur only on the small point on the west side of Keskarrah Bay (Fig. 29). The ease of determining the facing direction of flow units by either pillow morphology or distribution of vesicles suggests that flow attitudes are typically steep.

Massive flows are intimately associated with the pillowed lavas and resemble them in many respects such as colour and grain size. They are also similar to the presumed synchronous intrusive sills that are found throughout the unit, although the sills are typically coarser grained than the flows. In addition, the massive flows can be recognized by the presence of flow-top breccias. St. Seymour et al. (1988) note that some flow units consist of massive material at the base followed by a pillowed zone and capped by pillow breccia. No zones within the Peltier Formation were recognized in which massive flows were the only flow type present.

Mafic volcaniclastic units are common throughout the Peltier Formation, mainly as relatively thin units between flows. They are particularly abundant just north of the northern arm of Point Lake. They vary from flow-top breccias to extensive units over 10 m thick. They typically have a pitted weathered texture due to the common occurrence of carbonate. Clast sizes range from about 10 cm to very fine-grained material. The clasts are typically angular and tectonically steeply elongated with an aspect ratio commonly between 2:1 and 8:1. East of the northern end of Keskarrah Bay, a mafic volcanic conglomerate with rounded clasts occurs immediately below the contact with the Keskarrah Group, from which it is separated by mafic flows.

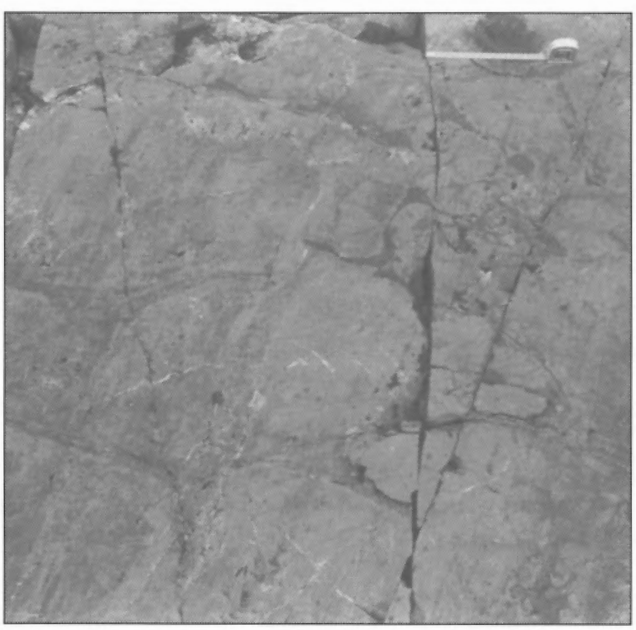


*Figure 28. Pillow structures in mafic volcanic rocks associated with sedimentary rocks of the Keskarrah Group 3.4 km northwest of the mouth of Keskarrah Bay. Note the presence of magnetite (darker grey areas) filling voids between pillows in the upper left part of photograph. GSC 163037*

Minor, localized occurrences of intermediate volcanic units are found in the Peltier Formation. A major unit of intermediate volcanic rocks occurs north of the northern arm of Point Lake, presumably stratigraphically above the Peltier Formation if the anticline-syncline pair mapped south of the arm extends north across the arm; it was mapped separately and is described in the following section. Several similar, thin, pinkish-grey, intermediate volcanic units are found in the Peltier Formation east of this unit. The largest is approximately 60 m thick, although most average only a few metres in thickness. They are volcaniclastic with angular, elongated clasts up to 10 cm long. Many are graded. Carbonate is commonly part of the matrix of these volcaniclastic breccias. In some cases, the units grade upward from coarse breccia through finer volcaniclastic material in a carbonate-rich matrix to almost pure carbonate at the top. Although they are most abundant near the large intermediate unit, a few rare units occur elsewhere in this part of the formation as well as between the north and south arms of the lake. Northrup et al. (1993) report the occurrence of a rhyodacite layer within the Peltier Formation east of Keskarrah Bay, from which they determined a preliminary, nearly concordant age of 2667 Ma. St. Seymour et al. (1988) have mapped thin felsic volcanic units on the eastern limb of the anticlinal structure between the two arms of Point Lake and on the southern shore of Point Lake about 1 km west of the contact with the

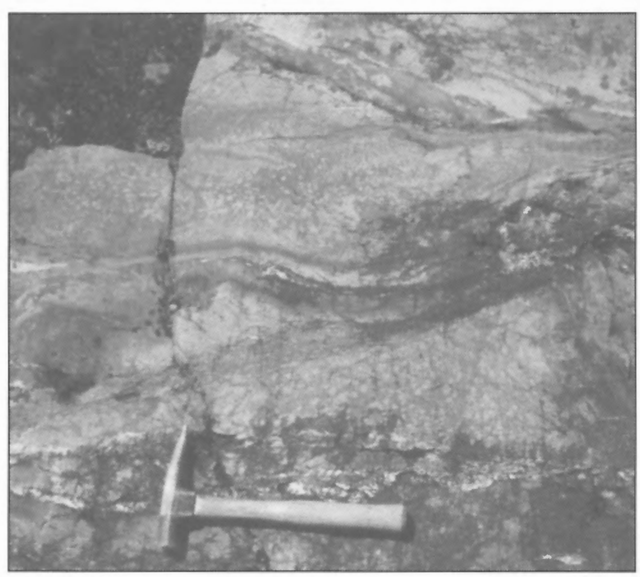


*Figure 29. Unusual variolitic pillowed mafic volcanic rocks from an island in Keskarrah Bay. GSC 1996-146G*

Keskarrah Group, west of Keskarrah Bay. No intermediate volcanic rocks were recognized in the main part of the Peltier Formation west of Keskarrah Bay.

Limited chemical data from volcanic rocks near the main part of Point Lake indicate that these rocks are mainly olivine normative tholeiitic basalts, although material from the small island south of the volcanic rocks of the Peltier Formation between the north and south arms of Point Lake is relatively high in alumina (St. Seymour et al., 1988). These latter rocks are also slightly calc-alkalic. Interpretation of trace element and rare earth element proportions suggests extrusion of the volcanic rocks in a variety of possible tectonic environments with 'within-plate' or 'continental' environments being most dominant (St. Seymour et al., 1988).

Intrusive sills and less commonly dykes of metagabbro are found throughout the Peltier Formation; their metamorphic grade and composition are similar to those of the mafic flows in which they are emplaced. They vary greatly in size from units a few metres wide up to large bodies several hundreds of metres wide and several kilometres long that have been mapped separately. They are distinguished from the massive extrusive flows that they resemble superficially by their commonly coarser texture, chilled contacts, and lack of extrusive features such as flow-top breccias. Their distribution throughout the Peltier Formation is uneven. They are particularly abundant west of the river between Itchen and Point lakes and in that part of the unit south of Point Lake and west of Keskarrah Bay. Some metagabbro intrusions west of the river between Itchen and Point lakes, including parts of the large mapped body, are unusual in that they contain megascopic iridescent blue quartz. Isachsen et al. (1993) report the presence of a diorite intrusion in the westernmost belt of the Peltier Formation west of Keskarrah Bay with a preliminary age of 2674 ± 3 Ma.

*Associated sedimentary rocks*

Units of black carbonaceous shale to schist are a minor local component within the volcanic sequence. The black shale units vary from a few centimetres to 10 m wide and have been traced over 30 m along strike. They commonly consist of layers about 1 cm thick defined by slight variations in composition and texture. They are commonly sulphide bearing with disseminated pyrite and, less commonly, with pyrite-rich layers and concretions. The sulphide is usually pyrite or pyrrhotite although some minor sphalerite and chalcopyrite has been recognized (Lisle, 1977). The sulphides occur in carbon-rich layers, although not all carbon-rich layers contain suphides; the carbon is mainly amorphous carbon, rarely graphite (Lisle, 1977).

Coarse quartz-rich sandstone is contained in the black pelitic units at at least three localities. West of the contact between the Augustus Granite and the Peltier Formation, on the shore of Point Lake west of Keskarrah Bay, a 10 m thick unit of black shale within the volcanic rocks contains a series of 10 cm thick layers of graded sandstone consisting of angular quartz and altered feldspar up to 5 mm across. On the east side of the north end of Keskarrah Bay, pelitic sedimentary rocks are exposed discontinuously over 2 km along the shore. In most places, the contact with mafic volcanic rocks of the Peltier Formation was not observed although at the south end of the bay (Fig. 27), pelitic rocks are contained within the volcanic sequence. At one locality about 1 km from the north end of the bay, a 10 m sequence of strongly cleaved, black, largely rusty shale contains a series of yellow, centimetre-scale, graded felsic tuff that is similar to the felsic tuffs occurring at many localities in the greywacke-mudstone turbidites of the Burwash Formation east of Yellowknife (Henderson, 1985) (Fig. 30). Also present within the sequence are five or six graded, very coarse-grained, quartz-rich sandstones ranging in thickness from 5 cm to 1 m (Fig. 31). The third locality is within the Peltier Formation, 1.5 km east of the northern end of the contact between the Augustus Granite and the Peltier Formation at the eastern side of Keskarrah Bay (Fig. 27). As before, the black, rusty shale sequence contains centimetre- to metre-thick, coarse-grained, quartz-rich sandstone. All the sandstone consists mainly of angular quartz, moderate amounts of unaltered to altered plagioclase, and minor microcline in a sparse matrix of fine quartz and altered feldspar. A major-element chemical analysis of sandstone from the third locality is provided later in the chemical analyses table in the section on the Keskarrah Group. An exclusively

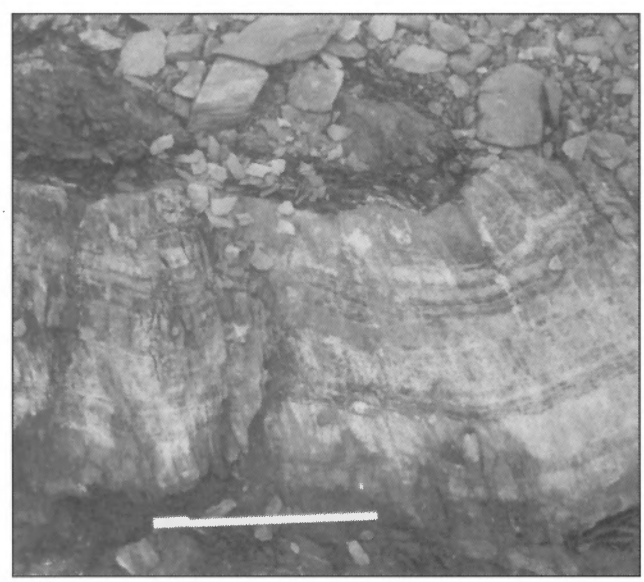


***Figure 30.*** *Thin, yellow, felsic volcanic tuff in black carbonaceous mudstone in close association with mafic volcanic rocks of the Peltier Formation on the east shore of Keskarrah Bay. GSC 1996-146F*

***Figure 31.*** *Thick, massive, coarse-grained, quartz-rich turbidite in a sequence of black carbonaceous mudstones in the same outcrop as that in Figure 30. GSC 1996-146D*

granitoid provenance is indicated. Corcoran et al. (1997) report the occurrence of several other thin sandstone units within the volcanic sequence.

A small outcrop area of granite-clast conglomerate, similar in many respects to the Keskarrah Group conglomerate to the north, is found about 2 km north-northwest of the last-mentioned locality, more or less on strike. Its contact relationship with the surrounding mafic volcanic rocks is unknown.

Units of carbonate rocks occur locally within the mafic volcanic flow sequence, particularly north of Point Lake. They are found in brown to orange-brown recessive units typically less than 2 m thick, although a series of dolostone layers up to 30 m thick occurs on the south shore of the north arm of Point Lake near the western contact between the Peltier and Contwoyto formations. Their composition ranges from nearly pure carbonate to carbonate with a significant proportion of volcaniclastic detritus. As mentioned previously, carbonate is also associated with some of the thin intermediate volcaniclastic units in the Peltier Formation.

*Other mafic volcanic units*

Volcanic units are found not only in the Peltier Formation, but also in the Keskarrah Group. South of Point Lake, these bodies are, with one exception, mafic and lithologically similar to the Peltier Formation. The one exception is the intermediate volcanic unit on the east side of the Keskarrah Group conglomerates, east of Keskarrah Bay. Contacts between the volcanic rocks and the sedimentary rocks of the Keskarrah Group are invariably straight and sharp, and also sheared to some degree. It is difficult to determine the nature of the contact prior to shearing and to decide whether these volcanic lenses represent synsedimentary volcanism or tectonic slices of the Peltier Formation emplaced within the Keskarrah Group. The volcanic rocks and the associated sedimentary rocks of the Keskarrah Group have consistent facings. The individual bodies vary from small lenses to significant units several hundred metres in width. Mafic volcanic rocks have also been mapped as extensions from the main body of Peltier Formation volcanic rocks into the Keskarrah Group both east and west of Keskarrah Bay. The mafic volcanic rocks consist of pillowed and massive flows, minor volcaniclastic rocks, and mafic sills, as in the Peltier Formation. Limited chemical data from volcanic rocks in the Keskarrah Group on the peninsula northwest of Keskarrah Bay suggest that these rocks are relatively high in Fe and Ti compared to the compositions indicated by most data from the Peltier Formation (St. Seymour et al., 1988). In general, the volcanic units within the Keskarrah Group are more deformed than the Peltier Formation, although in many cases primary features such as pillows are recognizable and usable as facing indicators (Corcoran et al., 1996).

North of the lake, the volcanic lenses have a much more heterogeneous composition. Contacts with the adjacent conglomerates of the Keskarrah Group are rarely exposed. The volcanic lenses at the margins of the Keskarah Group tend to be more mafic and similar to the volcanic rocks of the Peltier Formation, whereas those within the Keskarrah Group are commonly of more intermediate composition. Chemical data from one of the lenses indicate relatively high-alumina basaltic andesite to andesite compositions (St. Seymour et al., 1988). Some volcanic lenses, particularly at the north end of the Keskarrah Group exposure, are light coloured due to alteration and carbonation. The associated conglomerate is dominated by similar light-coloured volcanic clasts.

*Discussion*

The Peltier Formation is typical of many volcanic units in the Slave Province in that it occurs at the margin of a large area of dominantly metagreywacke-mudstone. Slave Province volcanic sequences vary continuously from dominantly mafic units to assemblages that consist of a high proportion of intermediate and felsic volcanic rock. The Peltier Formation occurs at the mafic end of the spectrum and contains only minimal amounts of intermediate or felsic material. In this respect it is similar to the Kam Group at Yellowknife (Henderson and Brown, 1966; Helmstaedt and Padgham, 1986) and to the Cameron River mafic volcanic belt 80 km northeast of Yellowknife (Lambert, 1988).

The Peltier Formation and its equivalents north and south of the map area occur in a relatively narrow zone along the western side of the Yellowknife Supergroup supracrustal domain over a north-south distance of about

115 km. There is little evidence to indicate its extent in any other direction. West of the domain-bounding major shear zone are mainly granitoid rocks that largely postdate the Yellowknife Supergroup and gneiss. Migmatitic metasedimentary rocks and amphibolites in the complex suite of high-grade gneiss close to the shear zone are possible Yellowknife Supergroup correlatives, although the proportion of amphibolite to metasedimentary migmatite is very low. A small enclave of a mafic volcanic and metasedimentary rock is found 15 km west (Easton, 1981; Fig. 2). To the east, except for the large amoeboid area of volcanic rocks west of Contwoyto Lake (Bostock, 1980; Fig. 1), volcanic units do not reappear within the extensive domain of metasedimentary rock for over 200 km. Although this extensive metasedimentary domain is punctuated by extensive granitoid batholiths, volcanic rocks are brought up by them or are in part mantled by them only in the above-mentioned centre east of the outcrop area of the Peltier Formation. Did the Peltier Formation extend any significant distance beyond its present outcrop area?

Although little is known about the extent of the Peltier Formation, some evidence could indicate its original direction of flow. Baragar (1984), among others, has suggested that pillowed flows develop as a series of lava tubes conducting the lava away from its eruptive locus, presumably a series of elongate fissures. This would suggest that the high proportion of moderately elliptical pillows in most presumably steeply dipping sections (as opposed to very elongate 'mattresses', which are rarely if ever seen on the present horizontal outcrop surfaces) flowed downslope, more or less perpendicularly to the present outcrop surface that is closer to the dip direction than to the strike direction of the flow.

Parts of the Peltier Formation are atypical of many mafic volcanic seqences in that they are structurally complex. In addition to local folding, the formation is strongly disrupted by a series of northerly trending shear zones the most important of which is found west of the unit where highly deformed layered amphibolite, mapped as the Perrault Lithodeme, is thought to represent the equivalent of the Peltier Formation. On structural grounds, these highly deformed rocks may represent the lowest stratigraphic level of the original volcanic sequence, but any basal contact information has been lost because of deformation.

The volcanic rocks are conformably overlain by the greywacke-mudstone turbidites of the Contwoyto Formation. As is commonly the case in the Slave Province, the contact is abrupt and there is no evidence of any resumption of mafic volcanism after greywacke sedimentation began. South of Point Lake, the Peltier Formation is overlain by conglomerates and sandstones of the Keskarrah Group. The exposed contacts are straight, sharp, and invariably sheared so that at outcrop scale they appear to be conformable, although a low-angle, more regional discordance is apparent at map scale. Mafic volcanic clasts, however, make up a large component of the clast population of the overlying conglomerates, which if derived from the Peltier Formation would indicate significant erosion.

Preliminary geochronological data suggest that the Peltier Formation is about 2.67 Ga, on the basis of data from thin intermediate volcanic units and mafic intrusions within the sequence (Isachsen et al., 1993; Northrup et al., 1993). This is close to the young end of the 70 Ma age spectrum that includes most of the Yellowknife Supergroup volcanic rocks in the Slave Province (Villeneuve and van Breemen, 1994). Isachsen et al. (1993) also note the occurrence of older inherited zircons within the Peltier Formation, which would suggest that the mafic magma had access to older crust.

Although now structurally disrupted, the Peltier Formation seems to mantle the Augustus Granite, a high-level granite interpreted here as probably synvolcanic (see the section on the Augustus Granite). Where it is in contact with the Augustus Granite, the Peltier Formation invariably faces away from the granite. The only exception is in the easternmost tectonic panel south of Point Lake, where the granite is unconformably overlain by conglomerate of the Keskarrah Group; any Peltier Formation that may have been present originally has been removed by erosion that occurred before or during deposition of the Keskarrah Group. Indeed, a few kilometres south of the area, a major unit of mafic volcanic rock occurs above the Augustus Granite (Bostock, 1980). Similar mantling of large synvolcanic granitoid plutons by mafic to intermediate and felsic volcanic units is seen at several localities throughout the Slave Province (Fig. 26).

Small mafic volcanic units that are lithologically similar to the Peltier Formation have been mapped as lenses within the Peltier Formation, or as projections from the formation into the Keskarrah Group. They could represent volcanism that was contemporaneous with sedimentation of the Keskarrah Group (Henderson and Easton, 1977; Corcoran et al., 1995). This would then indicate that volcanism similar to that which occurred during deposition of the Peltier Formation took place during sedimentation of the Keskarrah Group or that sedimentary rocks of the Keskarrah Group are contemporaneous with the Peltier Formation. However, preliminary evidence indicates that the Keskarrah Group may contain detrital zircons as young as 2605 Ma (Isachsen and Bowring, 1994), whereas the best estimates for the age of the Peltier Formation are about 2.67 Ga (Isachsen et al., 1993; Northrup et al., 1993). In addition, sedimentary rocks of the Keskarrah Group represent an environment in which layers and lenses of pillowed and massive volcanic rocks would not be expected to be found (see further discussion in the section on the Keskarrah Group). Furthermore, the sedimentary rocks of the Keskarrah Group do not contain the synvolcanic sills that are associated with the mafic volcanic units, which might be expected if they were all contemporaneous. A simpler solution might be that the mafic volcanic units within the outcrop area of the Keskarrah Group are part of the Peltier Formation that lies unconformably below the Keskarrah Group and that is exposed as basement highs (Corcoran et al., 1997) and/or fold culminations and tectonic slices of the Peltier Formation emplaced into the Keskarrah Group. It is of interest to note that these lenses of mafic volcanic rocks occur only in the Keskarrah Group and not in the closely associated Contwoyto Formation.

Several small occurrences of coarse-grained, quartz-rich sandstone to conglomerate have been found closely associated with the Peltier Formation at several localities. Nowhere are these sedimentary rocks unequivocally interbedded with the Peltier Formation. Their irregular, discontinuous distribution within the Peltier Formation and their lithological affinity with some facies of the Keskarrah Group suggest that they may represent a tectonic juxtaposition of Keskarrah Group rocks within the Peltier Formation.

## Perrault Lithodeme

The Perrault Lithodeme is the name proposed for a thinly layered amphibolitic unit that occurs immediately east of the foliated granite and granitoid gneiss domain on the western side of the map area. Because of the lack of named geographic features in the area, it is named after Ignace Perrault, a member of the second Franklin expedition that passed through the area in 1821. The unit was originally recognized by Bostock (1980), who interpreted it as a mafic volcanic tuff. A good, well exposed reference section is found on the northern shore of the main part of Point Lake.

The unit trends generally northward almost completely across the map area. It is locally folded into several s-asymmetric, northeasterly trending buckle folds with wavelengths up to 4 or 5 km and axial traces that die out within a few kilometres in adjacent units. These structures are presumed to be related to the major shear zone found between the Perrault Lithodeme and the foliated granite and granitoid gneiss domain to the west. Their style is probably a result of differences in competence between the original rock units (Ramsay, 1967). The unit dips steeply to the east over most of its extent, but more moderately near the large fold south of Point Lake. The Perrault Lithodeme has an average width of about 700 m, but is locally much wider, presumably because of fault repetition. It extends 50 km north, beyond the Keskarrah Bay map area (Bostock, 1980; Gebert, 1994), and has been traced another 7 km south of the map area (Easton, 1981).

*Contacts*

To the west, the Perrault Lithodeme is sharply bounded by several granitoid rock units within the major ductile shear zone. These include a variety of granitoid gneisses, some of which may in part predate the Yellowknife Supergroup, the Augustus Granite, and several granitoid phases that largely postdate the Yellowknife Supergroup. At the contact, layering and foliations in the gneisses and granitoid rocks are mostly concordant with layering in the Perrault Lithodeme. Inclusions of Perrault-like layered amphibolite are common in the deformed granitoid rocks that largely postdate the Yellowknife Supergroup, particularly close to the contact with the Perrault Lithodeme. None were noted within the Augustus Granite. The dominantly granitoid orthogneiss also contains various amphibolitic phases, some of which may be related to the Perrault Lithodeme. Highly deformed, discontinuous layers, lenses, and blocks of granitoid rocks occur locally within the Perrault Lithodeme, particularly near the contact, and may represent deformed and disaggregated intrusions related to granitoid units west of the contact (see also Kusky, 1991). Easton (1981) suggested that evidence exists for a possible unconformable contact between the amphibolite and the orthogneiss adjacent to it at one locality on the southern shore of Point Lake at the westernmost mapped occurrence of Perrault-like rocks. He bases this suggestion on the occurrence of a 50 to 100 m wide unit of quartz-pebble conglomerate between weathered gneiss and the layered amphibolite.

The eastern contact of the Perrault Lithodeme and either the dominantly mafic pillowed volcanic rocks of the Peltier Formation or the volcanic rocks of more intermediate composition, is gradational. Closer to the Perrault Lithodeme, the pillows become increasingly deformed or obliterated and an increasingly prominent foliation and subtle but increasingly prominent layering are developed (Northrup, 1993). The contact with the greywacke-mudstone turbidites of the Contwoyto Formation is sharp and the immediately adjacent metasedimentary rocks are significantly more altered and deformed than those farther east.

North of Point Lake, the northerly limit of the Perrault Lithodeme within the map area coincides approximately with the end of the shear zone adjacent to the Augustus Granite. In this region, the main strand of the shear zone is stepped to the west, to the other side of the Augustus Granite, in an en échelon arrangement. It extends north for at least another 50 km and, over much of this distance, is associated with similar laminated amphibolite rocks (Bostock, 1980).

*Lithology*

Throughout its extent, the Perrault Lithodeme consists primarily of a dark green- to dark greenish-grey to grey-weathering, dark grey-green, fine-grained to very fine-grained, layered amphibolite (Fig. 32, 33). In general the layering follows the overall local trend of the units, but in some places, it is tightly folded into small-scale folds (Fig. 34). Layering is on a centimetre scale and ranges from laminae less than 1 mm wide to layers several centimetres wide. Layering is primarily compositionally defined, with everything from dark grey to light grey, more feldspathic layers through to darker green, amphibole-rich layers. Individual layers commonly have sharp boundaries at hand-specimen or outcrop scale, but in some cases they grade into one another. Some of this gradational layering resembles a graded sedimentary sequence, hence its original interpretation as a volcanic tuff (Henderson and Easton, 1977; Bostock, 1980). In many cases, the rock has a strongly developed foliation typically parallel to layering. Layering is commonly not very continuous, being cut off along layer/foliation-parallel shears at all scales.

Over much of its area, the unit consists primarily of actinolite to actinolitic hornblende and plagioclase with minor and varied amounts of biotite, chlorite, titanite, opaque minerals, carbonate, and quartz. Layering is defined by variations in the proportion of amphibole and plagioclase (Fig. 35). Amphibole occurs as pale green to blue-green, subhedral to euhedral, lath-like crystals typically oriented parallel to layering and ranging in size from less than 0.05 mm to just under 1 mm. Colour variations seem to be random throughout the unit. Layers composed entirely of amphibole tend to be finer grained, more strongly foliated, and appear more amorphous with individual crystals less clearly defined. The coarsest grained, most euhedral amphibole occurs in the most plagioclase-rich layers. The plagioclase content varies from minor scattered grains to more common aggregates to plagioclase-dominant layers. It occurs in polycrystalline lenses 0.2 to 2 mm long to layers one or more centimetres wide that in all cases consist of polycrystalline aggregates of anhedral grains 0.02 to 0.15 mm long, usually with minimal alteration. As with the

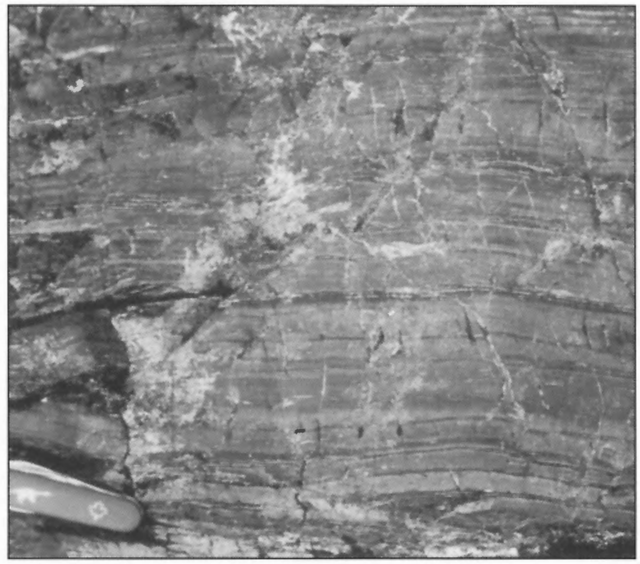


***Figure 33.*** *Layered amphibolite of the Perrault Lithodeme with more diffuse layering than in Figure 32. The layers here are compositionally less distinct than in Figure 32 and commonly grade smoothly from one to another. The knife handle is 2 cm wide. GSC 1995-114D*

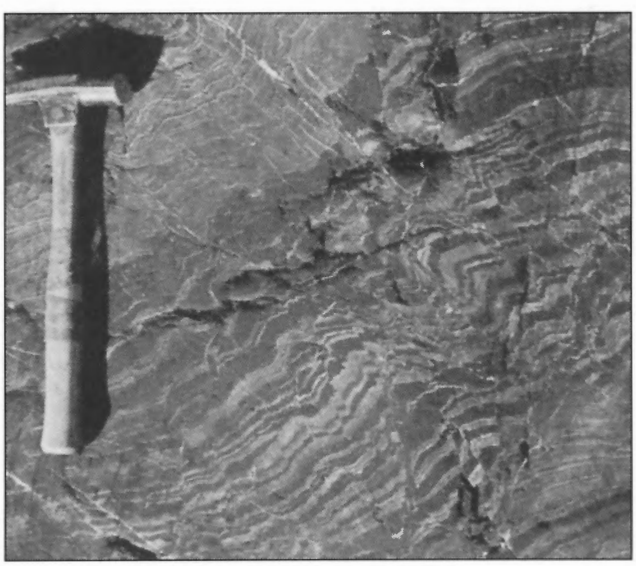


***Figure 32.*** *Amphibolite of the Perrault Lithodeme with sharply defined, thin, lighter feldspathic layers and darker amphibolitic layers. GSC 1995-114I*

***Figure 34.*** *Folded layered amphibolite of the Perrault Lithodeme with sheared cutoffs. GSC 1995-114J*

amphibole, the coarsest grains are found within the widest plagioclase-rich layers. Higher grade equivalents of these layered amphibolites occur as inclusions within the foliated granitoid and granitoid gneiss complex to the west and in the cuspate nose of the fold south of Point Lake. These rocks are also compositionally laminated to layered, but the dominant assemblage is olive-green hornblende and plagioclase. As in the lower grade rocks, in some cases the compositional layering is faithfully reflected in the orientation of the elongate hornblende crystals whereas in other cases, the orientation is random in a rock with granular texture.

In addition to the feldspar-rich and amphibole-rich layering, thin laminae of layer-parallel, fine-grained quartz are very common whereas carbonate seams and lenses are less abundant. Sulphide-rich laminae form thin rusty zones. Lighter grey, larger scale, layered zones a few tens of centimetres to a metre or so wide, composed of chlorite, tremolite, plagioclase, and carbonate, occur locally and presumably represent altered equivalents of the normal amphibolites.

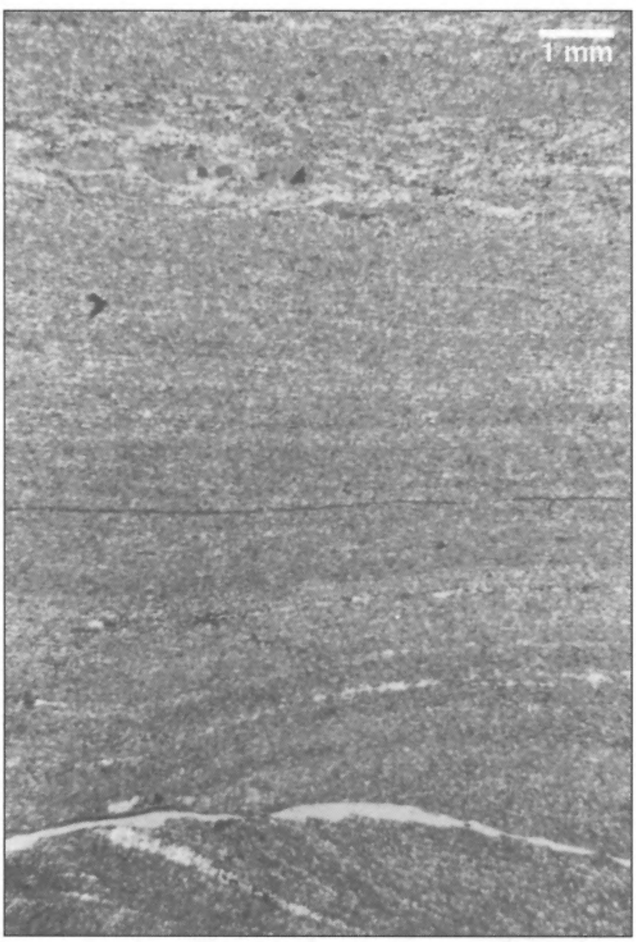



*__Figure 35.__ Photomicrograph of layered amphibolite of the Perrault Lithodeme. The layering is defined by fine-scale compositional and to a lesser degree textural variation. Plane-polarized light.*

Sills to lenses to rounded equidimensional bodies of leucocratic granitoid are found at many localities within the unit, but usually closer to the western contact. Their maximum width is about 1.5 m whereas some of the small equidimensional bodies are centimetres across (Fig. 36). They are mostly small, individual occurrences averaging 10 cm in thickness and are most abundant at the thinnest part of the unit between the two arms of Point Lake where locally they form up to 50 per cent of the sequence. They are invariably highly deformed, consisting of coarser grained, in some cases zoned, porphyroclasts of plagioclase, some with bent albite twinning, in a granulated quartz-plagioclase-biotite matrix.

Numerous sills or, more commonly, boudined sills and lenses of metagabbro are found throughout the unit. They weather dark brownish red or more commonly dark green, are dark grey-green and equigranular, and vary from fine grained to coarse grained. They are everywhere distinctly coarser grained than the associated layered amphibolites (Fig. 37). Their thickness ranges from a few centimetres to several hundred metres, and the largest units are shown on the map as discrete amphibolite bodies. They vary from essentially undeformed in the case of the larger bodies to highly deformed with a strongly developed foliation (Fig. 38) although, despite the loss of primary textures, they are still recognizable as metagabbro. Even within a single outcrop area, the degree of deformation, grain size, and composition of individual bodies vary. The metagabbro is at the same metamorphic grade as the associated layered amphibolite. The mineral assemblage consists mainly of plagioclase, actinolite to actinolitic hornblende, and an

*__Figure 36.__ Layered amphibolite of the Perrault Lithodeme containing tectonic clasts of granitoid material presumably derived from prekinematic to synkinematic granitoid veins. The hammer handle is about 3 cm wide. GSC 1995-114B*

opaque phase. Minor phases typically include chlorite, epidote, clinozoisite, carbonate, and titanite. In the larger, coarsest grained, least deformed metagabbro, primary igneous textures are preserved although the original igneous minerals have been replaced or altered (Fig. 39). With increasing strain, the plagioclase is completely recrystallized into a diffuse mosaic and the coarse-grained mafic minerals are broken along their cleavage planes into lensoid aggregates surrounded by zones of higher strain (Fig. 40). The metagabbro also varies in composition from gabbro to anorthositic gabbro, as is clearly apparent at outcrop scale. Bostock (1980) originally reported the occurrence of serpentine, chlorite, tremolite, anthophyllite, and magnetite-bearing ultramafic phases at the nose of the cuspate fold south of Point Lake and at several other localities north and south of the map area. He presented chemical analyses from both the gabbroic and ultramafic phases (Bostock, 1980). Ultramafic rocks also occur within the western part of the large metagabbro body about 2.5 km south of Point Lake. Kusky (1991, 1992) suggested that ultramafic units are common within the unit. Northeast of Yellowknife, similar gabbroic to ultramafic intrusions occur at the contact between highly deformed mafic volcanic rocks of the

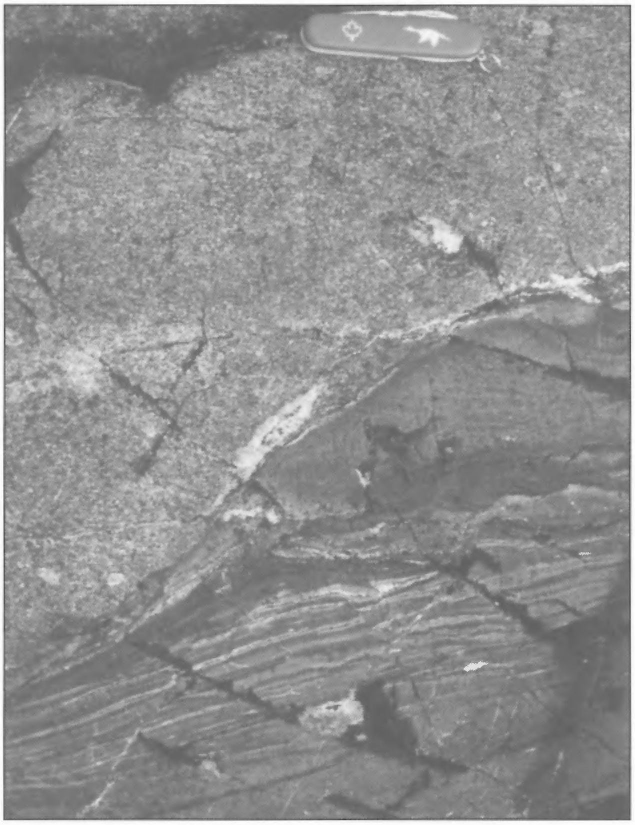


*Figure 37. Layered amphibolite of the Perrault Lithodeme cut at a low angle by weakly deformed, fine-grained metagabbro. The knife handle is 2 cm wide. GSC 1995-114F*

*Figure 38. Strongly deformed, coarse-grained, metagabbro in layered amphibolite of the Perrault Lithodeme from the same outcrop as that in Figure 37. The knife handle is 2 cm wide. GSC 1995-114E*

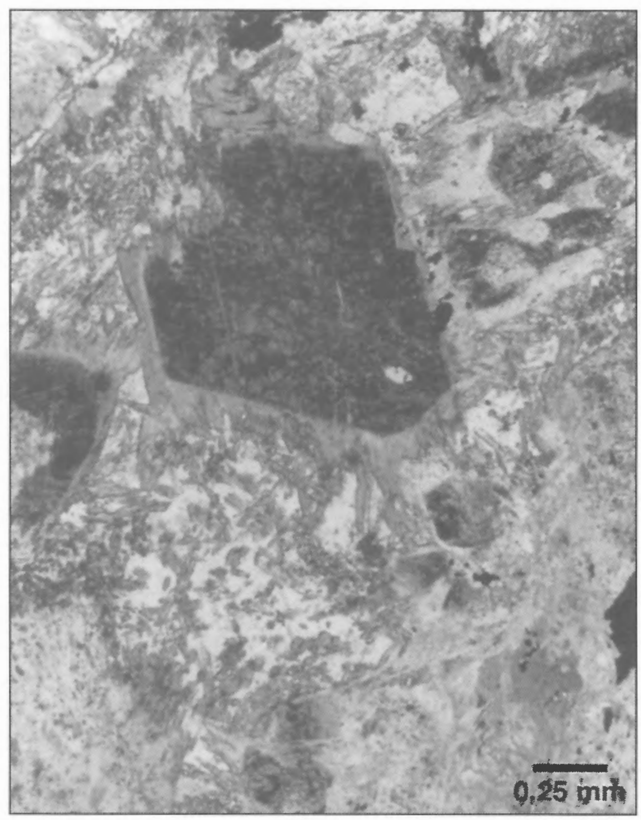



*Figure 39. Photomicrograph of minimally deformed metagabbro in layered amphibolite of the Perrault Lithodeme. Dark euhedral hornblende is overgrown by lighter, fine-grained, prismatic, actinolitic amphibole. Plane-polarized light.*

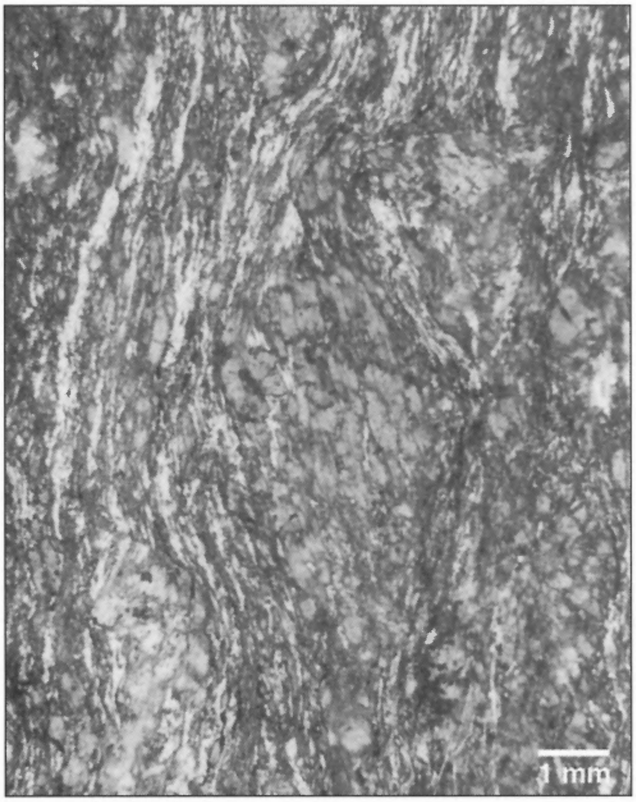


*Figure 40. Photomicrograph of highly deformed metagabbro in layered amphibolite of the Perrault Lithodeme. The rock has been completely recrystallized, but original, coarse-grained amphibole remains relatively intact as lensoid shapes whereas plagioclase is strung out as fine, elongate lenticles. Plane-polarized light.*

Yellowknife Supergroup and adjacent deformed granitoid gneiss and foliated granitoid rocks of the Sleepy Dragon Complex (Lambert and van Staal, 1987; James, 1990) and within quartz-rich sedimentary rocks that occur locally at this contact (Bleeker et al., 1997).

*Discussion*

There is little doubt that the Perrault Lithodeme is the locus of a high degree of strain associated with the major ductile fault that separates the granitoid rocks to the west from the supracrustal rocks of the Yellowknife Supergroup to the east (Bostock, 1980; Henderson, 1988; Kusky 1991, 1992; Northrup, 1993). More difficult to determine is the nature of the protolith prior to deformation.

Bostock (1967a, 1980) originally interpreted the unit as a mafic tuff, an interpretation accepted by Henderson and Easton (1977), Easton (1981), and Henderson (1988). He based his interpretation on the similarity between the thin compositional layering and depositional layering in sedimentary sequences, with some graded layers, scour and fill structures, and local conglomeratic facies being recognized.

Mafic volcaniclastic deposits, while not a dominant facies, do occur in many mafic volcanic sequences. One of the largest units of mainly mafic volcaniclastic material, the Payne Lake Formation, is found about 110 km east-northeast of Yellowknife (Lambert, 1988). A much smaller example, also in the southern Slave Province, occurs at the south end of the nearby Cameron River Formation, where the thin distal part of the formation is composed of coarse- to fine-grained, mafic, volcaniclastic, sedimentary rocks that contrast with the pillowed to massive flows that form the main part of the formation (Henderson, 1985). Locally, mafic, volcaniclastic, sedimentary rocks are associated with the flows, but they are discontinuous and their thickness is typically less than 30 m (Lambert, 1988). In all cases the mafic volcaniclastic rocks flank, and are considered to have been derived from, the adjacent sequences dominated by mafic flows. If the Perrault Lithodeme were a mafic volcaniclastic deposit, its stratigraphic relationship to the adjacent volcanic rocks would be anomalous as the unit would be stratigraphically below the only potential source preserved.

It is difficult to explain the layered amphibolite as a sedimentary deposit. Submarine mafic volcanism generates relatively small volumes of volcaniclastic material as part of the volcanic process, as is evident in most of the thick mafic volcanic sequences of the Yellowknife Supergroup. A more productive process could be the production of epiclastic deposits derived from the erosion of uplifted mafic volcanic sequences. It would, however, be difficult to mechanically differentiate such detritus into a series of more or less feldspar-rich layers, the source rock presumably being a basalt that at best consisted of extremely fine phenocrysts of mafic minerals and feldspar in an abundant glassy matrix. A sedimentary deposit derived from such a source would most likely consist almost entirely of lithic clasts. The differentiation of such volcanic detritus through sedimentary processes into thinly interlayered, more felsic and more mafic layers from a single source is difficult to achieve. In order to get the more felsic layering, a second, more felsic source would be necessary. Detritus from such a source would then have to alternate and mix with material from the mafic source to produce the relatively uniform, centimetre-scale layering of the texturally constant, but compositionally varied, deposit whose thickness reaches several hundred metres. The presence of alternating compositional layering and thin planar layers that in some cases grade from one into another suggests a turbiditic mode of deposition in the basin. In such a scenario, one would also expect a pelitic component, such as that found in such abundance in the greywacke-mudstone turbidites of the associated Contwoyto and Itchen formations. Although a volcaniclastic component may have been present in the precursor to this unit, a totally sedimentary origin for it seems unlikely.

A simpler solution would be to derive the Perrault Lithodeme from the Peltier Formation by deformational processes as suggested by Kusky (1991, 1992) and Northrup (1993). The unit is severely deformed. It is gradational with the adjacent mafic volcanic unit of the Peltier Formation, with the degree of deformation generally increasing towards the tectonic contact with the adjacent granitoid domain to the west, which, at the contact, consists of mylonitic granitoid rocks.

DeVore (1969) suggested that the segregation of a heterogeneous mineral assemblage into defined layers is an energetically more favourable arrangement that is a consequence of the deformation the rock underwent. Robin (1979) argued that deformational layering in an originally homogeneous rock under metamorphic conditions can result when one chemical component of the rock can diffuse more rapidly than others due to stress-induced pressure gradients. Tobisch et al. (1991), in a study of the transformation of a homogeneous granitoid to a layered mylonite, concluded that layered structures developed due to a complex interaction between deformation, metamorphic-chemical changes, and fluid flow. In this regard, Prinz and Poldervaart (1964) describe and illustrate the transition of diabase dykes, where intersected by a mylonite zone, from undeformed rocks with their primary mineralogy and textures to a layered amphibolite that is strikingly similar to the layered amphibolites of the Perrault Lithodeme. The adjacent Peltier Formation, a potential protolith consisting mainly of mafic pillowed to massive flows and lesser amounts of intrusive mafic sills, is a compositionally homogeneous unit. In detail, minor compositional heterogeneities exist such as the variation between pillow rinds and cores (Baragar et al., 1979), which could represent initial compositional gradients that the deformational processes could further enhance.

Associated with the layered amphibolites in the Peltier Formation are metagabbro bodies of varied size, composition, and degree of deformation even at outcrop scale. They are more variable than the relatively more homogeneous and apparently more deformed layered amphibolites. They are concentrated within the unit although some of the amphibolite that is abundant within the adjacent foliated granitoid and granitoid gneiss domain to the west, particularly near the contact with the Peltier Formation, may be related to them. Metagabbro bodies in the adjacent Contwoyto Formation metasedimentary rocks are rare. The only examples known are found within a few hundred metres of the Perrault-Contwoyto contact and are most abundant south of Point Lake, but also occur in the Contwoyto Formation between the two arms of the lake. This suggests that at least some of these mafic intrusions are associated with the deformation that defines the unit and were emplaced, for the most part, late in the structural evolution of the unit.

Relatively rare layers to lenses to equidimensional pieces of deformed granitoid rocks are found locally. Whereas some, particularly those close to the contact, could conceivably represent tectonically eroded clasts from the adjacent granitoid and granitoid gneiss domain, most of them more likely represent deformed dykes, veins, and sills related to granitoid intrusions emplaced in the precursor to the Perrault Lithodeme. As such, they indicate that deformation on this structure was active after emplacement of the intrusions. Most intrusions emplaced after the volcanism associated with the Yellowknife Supergroup are within the 2620-2585 Ma age range (Villeneuve and van Breemen, 1994). Metamorphic textures in the actinolite to actinolitic hornblende-plagioclase mineral assemblage that occurs throughout both the layered amphibolite and the associated metagabbro, together with the ductile behaviour of quartz and the brittle-ductile behaviour of feldspar (Kusky, 1991), suggest that deformation took place while the rocks were still at about the transition between greenschist grade and lower amphibolite grade.

In summary, the Perrault Lithodeme is found at the boundary between the well preserved, relatively low-grade Yellowknife Supergroup supracrustal domain and a complex domain of granitoid gneiss, foliated granitoid rocks, and high-grade supracrustal rocks of varied ages. It is suggested that the unit was derived from ductile shearing of a precursor that was similar to and continuous with what has been preserved as the mafic volcanic rocks of the Peltier Formation. Thus, this unit is not a stratigraphic unit. The actual contact between the two domains is a late Archean major ductile shear zone. The Perrault Lithodeme is a mappable tectonic unit formed as a consequence of deformation and is considered to have been derived from the adjacent mafic volcanic rocks of the Peltier Formation. This tectonic juxtaposition of contrasting domains is similar to that seen elsewhere, in particular in the Sleepy Dragon Complex (James and Mortensen, 1992) in the southern Slave Province, the Healey complex (Henderson and Thompson, 1982) in the eastern Slave Province, and the Hinscliffe complex (Henderson and Schaan, 1993) and the Kangguyak gneiss belt (Relf, 1994; Relf et al., 1994) in the northern Slave Province. Kusky (1991, 1992) interpreted these rocks as part of a "... strongly tectonized remnant of Archaean oceanic lithosphere".

### Volcanic rocks of felsic and intermediate composition

The small volcanic centre near the centre of the map area between the main part of Point Lake and its northern arm is composed of felsic and intermediate volcanic rocks. The more intermediate rocks of the Samandré Formation occur on the western side of the volcanic complex whereas the more rhyolitic Beauparlant Formation is found in the centre of the complex and to the east. Volcanic rocks of intermediate composition are also found north of the northern arm of

Point Lake, next to and to some extent within the mafic volcanic Peltier Formation. Intermediate volcanic rocks are also associated with the Keskarrah Group both south of Point Lake and on the peninsula between the northern arm and the main body of the lake. A small unit of intermediate volcanic rocks occurs within the Contwoyto Formation on the south shore of Point Lake, near the eastern boundary of the map area, and may be correlative with the main volcanic centre 10 km to the north-northwest.

The volcanic rocks of the central volcanic centre occur in a northerly trending structure that opens towards the north where it is obscured by the northern arm of Point Lake. No volcanic rocks were recognized on the northern shore of the arm although a volcanogenic facies of the Contwoyto Formation is present both north and east of the volcanic complex. The rocks everywhere within the complex have a weakly to moderately developed, northerly to north-northeasterly trending, easterly dipping foliation that dips steeply in the western part of the complex and moderately in the eastern part. The associated deformation together with at least two post-metamorphic, easterly dipping reverse faults have caused telescoping of the complex into its present shape. Because of deformation, the small number of facings, and the relatively poor exposure in the area, the structural disposition of the complex is unclear.

T.E. Krogh (pers. comm., 1979) determined a preliminary three-point U-Pb (zircon) age of about 2680 Ma for a sample from the volcanic centre.

### *Beauparlant Formation*

The Beauparlant Formation is the name proposed for the mainly rhyolite unit that dominates the volcanic centre. Because of the lack of named geographic features in the area, the formation is named after Gabriel Beauparlant, a member of the second Franklin expedition that passed through the area in 1820 and 1821 (Franklin, 1823). Although the unit is poorly exposed, a reasonably representative and fairly complete reference section can be seen along the southern shoreline of the north arm of Point Lake. The contact between the Beauparlant Formation and the Contwoyto Formation to the east is largely a fault. Where not faulted, it typically consists of a transition zone up to 150 m wide that includes one or more units of dolomitic carbonate, felsic volcanic rocks, and pelitic, locally sulphide-bearing, sedimentary rock. The contact between the relatively homogeneous, more felsic Beauparlant Formation and the more heterogeneous, but generally intermediate Samandré Formation is conformable and gradational over a few metres.

The felsic volcanic rocks of the Beauparlant Formation weather white to pale buff, yellow, or rarely pink and are very fine grained with some quartz and/or feldspar phenocrysts. The more felsic compositions are typically massive whereas the more dacitic compositions are weakly to moderately foliated. The rock consists of a very fine-grained quartzofeldspathic groundmass with or without minor fine biotite and white mica. Phenocrysts where present form only two or three per cent of the rock and consist of euhedral to recrystallized quartz and feldspar. The northern part of the formation is dominated by massive rhyolite with lesser amounts of volcanic breccia lapillistone with clasts typically less than 20 cm in length (Fig. 41). Near the eastern contact of the volcanic rocks with the Contwoyto Formation where a carbonate unit is locally present, the volcanic breccias commonly have a carbonate matrix (Fig. 42).

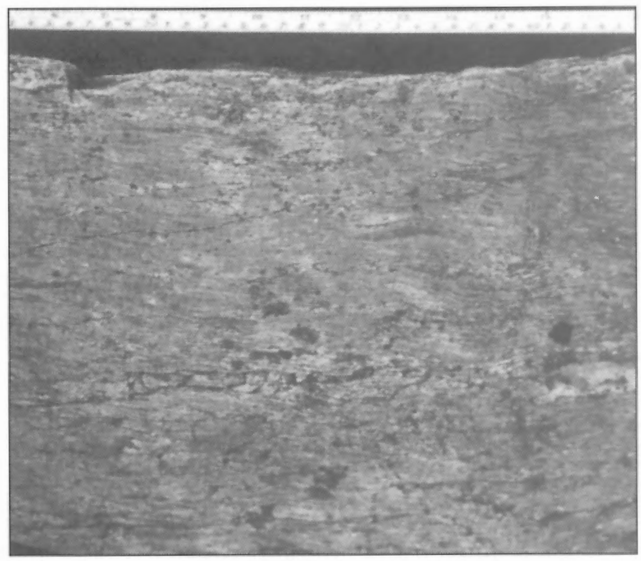


***Figure 41.*** *Fine-grained felsic lapillistone of the Beauparlant Formation. GSC 1995-114M*

***Figure 42.*** *Carbonate-cemented felsic volcanic breccia of the Beauparlant Formation. GSC 1995-114R*

The southern quarter of the unit consists of thinly layered volcaniclastic deposits. Similar volcanogenic sedimentary rocks occur within a zone in the Contwoyto Formation east and northeast of the volcanic centre.

The volcaniclastic deposits are generally moderately to well foliated with the steeply elongated clasts in the volcanic breccias typically having a 4:1 or 5:1 aspect ratio. Because of their siliceous composition, the massive felsic volcanic rocks do not contain much in the way of diagnostic metamorphic mineral assemblages. The volcaniclastic deposits in the southern part of the unit contain a coarse-grained biotite and cordierite assemblage possibly indicating that they have been either hydrothermally altered as part of the volcanic event or, being distal products from the volcanic centre presumably to the north, mixed with the more pelitic background material. Since the rocks of the Contwoyto Formation to the east are at amphibolite grade and those to the west are at greenschist grade, the rocks of the Beauparlant Formation are at the transition between greenschist and amphibolite grade.

*Samandré Formation*

The Samandré Formation is the name proposed for a dominantly volcaniclastic unit of heterogeneous composition that is dominated by dacite and that occurs on the western side of the volcanic centre. It is named after François Samandré, also a member of Franklin's second expedition (Franklin, 1823). A good reference section through the formation is found along the shoreline of Point Lake. The steeply dipping conformable contact of the Samandré Formation with the rhyolite of the Beauparlant Formation is gradational over a few metres and marked by the appearance of more mafic material in the volcaniclastic rocks, both in the matrix and in the clasts. The steeply dipping contact with the greywacke-mudstones of the Contwoyto Formation to the west is a discontinuous mixed zone of varied content and thickness consisting of carbonate rocks, volcanic units, pelitic layers, and rare iron-formation.

The mainly volcaniclastic rocks of the Samandré Formation are more heterogeneous than the rocks of the Beauparlant Formation, with the clast composition ranging from rhyolite to amphibolite. Volcanic breccia is more common on the eastern side of the unit towards the north. There, the elongate clasts, up to 20 cm long, occur in a dark amphibole-rich matrix that locally contains a calc-silicate mineral assemblage, suggesting an original carbonate component (Fig. 43). In places, the breccia exhibits a crude bedding defined by variation in clast composition. The most common facies is a fine-grained, dark grey weathering, light grey, volcaniclastic rock that is layered on a scale of 10 cm or less. Like the metarhyolite, it consists of a fine interlocked quartzofeldspathic groundmass, but with a much higher mafic content. Variations in the content of biotite, muscovite, and less commonly amphiboles define layering on a fine scale. This facies dominates the central, western, and southern parts of the unit although minor examples of coarser grained volcanic breccia are found throughout. Layering is defined by compositional variations and, in one case at least, is texturally graded. In places, particularly to the north, this facies is massive and homogeneous, but its composition is similar to that of the layered volcaniclastic rocks.

The rocks throughout are moderately to strongly foliated with clasts typically steeply elongated with a 4:1 or 5:1 aspect ratio. The metamorphic mineral assemblages are varied, with hornblende-plagioclase-garnet assemblages; locally, their more felsic phases contain cordierite, commonly in the southern half of the unit. The bulk of the unit in the northern half is garnet-free although garnet does occur at the northern end of the unit near its contact with the Beauparlant Formation.

The isolated volcanic centre, consisting of Beauparlant Formation rhyolite and Samandré Formation dacite and surrounded by greywacke-mudstone turbidites, is a relatively small example of a type of volcanic centre that occurs in several localities in the Slave Province. These centres consist of dominantly felsic volcanic rocks in a more or less equidimensional or elliptical pattern as opposed to the more linear patterns of the much more common mafic-dominated volcanic sequences. Other examples of this type of centre include the felsic centre at Clan Lake, 55 km north of Yellowknife (Hurdle, 1984, 1987), the complex at Russell Lake, 85 km west-northwest of Yellowknife (Henderson, 1985; Jackson, 1990), and the centre dominated by felsic volcanic breccia near Ghost Lake, 175 km north-northwest of Yellowknife (Henderson, 1994). The largest example of

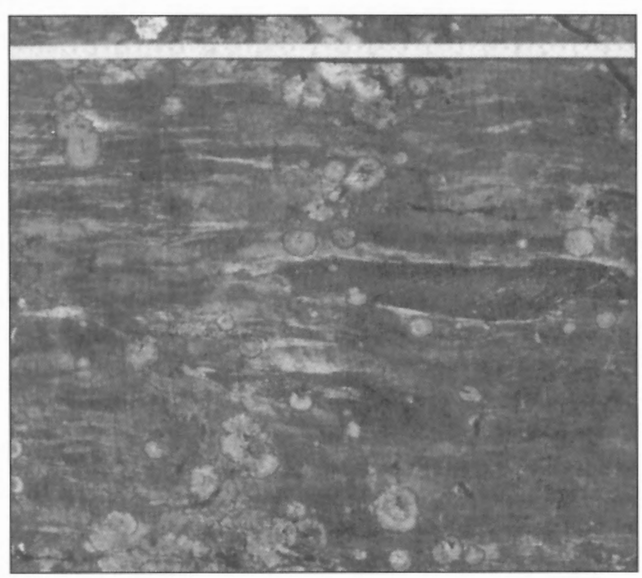


***Figure 43.*** *Intermediate volcanic breccia of the Samandré Formation with mafic clasts in a calc-silicate-rich matrix. GSC 1995-114N*

this type is the Back River volcanic complex in the eastern Slave Province (Lambert, 1981). It has been shown in the Back River and Clan Lake examples that volcanism was at least in part synchronous with greywacke-mudstone sedimentation (Hurdle, 1984, 1987; Lambert et al., 1990). This is difficult to demonstrate unequivocally in the Samandré-Beauparlant volcanic complex. However, it may be the case here as well should the apparently felsic volcanogenic turbidite facies within the Contwoyto Formation immediately north and east of the complex, and the previously mentioned and later described thin felsic volcanic units within the Contwoyto Formation 10 km to the southeast, be correlative with the main centre.

*Other volcanic units of intermediate composition*

North of the northern arm of Point Lake, a zone of grey-weathering, metavolcanic rocks is situated between the dark green mafic volcanic rocks of the Peltier Formation and the dark green, thinly layered, mylonitic amphibolite of the Perrault Lithodeme. Quartz-rich metagreywacke is found at the southern end of the zone.

The unifying feature of these rocks is their light weathering colour that ranges from white to light grey to pinkish grey to greenish grey and that contrasts strongly with the dark colour of the mafic units to the east and west. Throughout the zone, the rocks are strongly deformed and have well developed cleavage. Much of the unit consists of fine-grained rock, layered on the scale of a few centimetres, locally with fragmental textures. The fine-grained, quartzofeldspathic matrix contains varied proportions of heterogeneously distributed fine biotite, muscovite, and epidote, with minor coarser grained subhedral crystals of feldspar and more rarely quartz. Coarser grained volcanic breccia with steeply plunging, elongated clasts up to 5 cm long are a minor component. In places, the rocks are clearly flows with deformed, but recognizable, pillow structures. Minor layers of black shale, locally hosting minor sulphide, and centimetre-thick brown layers to lenses of carbonate rock are also present in the zone. In the mafic, dominantly pillowed flows of the Peltier Formation to the east, pinkish-grey dacitic units occur at several localities within a few hundred metres of the zone.

Largely on the basis of their lighter colour, these rocks are interpreted to be of more intermediate composition than the adjacent mafic volcanic units. While dacitic rocks are present in this zone, some of the lighter coloured material could be the product of alteration associated with metamorphism and deformation.

A discontinuous unit of grey, commonly feldspar-phyric, locally coarsely clastic, intermediate volcanic rocks occurs within the Contwoyto Formation on a small island 7 km east of Keskarrah Bay. It is about 30 m thick and extends to the south shore of Point Lake. Several other similar, thinner, intermediate volcanic units are found onshore to the southeast within the Contwoyto Formation. These thin units are roughly on strike with the Beauparlant-Samandré volcanic centre 10 km north-northwest and may represent distal deposits from this centre. U-Pb zircon geochronological data from one of these layers are discordant and do not form a linear array on a concordia diagram (Mortensen et al., 1988). $^{207}Pb$-$^{206}Pb$ ages for the four zircon fractions analyzed range from 2827 to 2680 Ma. Mortensen et al. (1988) suggest that if none of the zircons are xenocrystic and if they represent a single igneous population, the 2827 Ma age would represent a minimum age for volcanic crystallization. Given that the Contwoyto Formation that contains these volcanic rocks conformably overlies the mafic volcanic rocks of the Peltier Formation, which have a preliminary age of 2.67 Ga (Northrup et al., 1993), and that beyond the map area, thin felsic volcanic units within the Contwoyto Formation 5 km south of the Lupin mine at Contwoyto Lake contain zircons with a $^{207}Pb/^{206}Pb$ age of 2661 ± 1 Ma (Mortensen et al., 1988), some of these zircons could be xenocrystic.

Intermediate volcanic rocks are associated with the Keskarrah Group at two localities. Two kilometres east of Keskarrah Bay on the southern shore of Point Lake, a foliated, greenish-yellow dacite occurs at the boundary between Peltier Formation mafic volcanic rocks and Keskarrah Group conglomerate. At least one metre-thick layer of Keskarrah Group conglomerate occurs within the dacite, suggesting that the dacite may be more closely related to the Keskarrah Group than to the Peltier Formation. A lens of similar, locally foliated, homogeneous, greenish-yellow dacite is found in the central part of the Keskarrah Group conglomerate between Point Lake and its northern arm. One kilometre southeast of this lens, a dacite volcanic breccia unit up to 140 m wide with dacitic to locally rhyolitic, 2 to 3 cm clasts in a carbonate-rich matrix occurs at the eastern margin of the Keskarrah Group conglomerate. The relationships between these intermediate volcanic rocks and the Keskarrah Group are not well enough understood to state unequivocally whether the volcanic rocks are part of the Keskarrah Group, whether they occur unconformably below it, or whether they are structurally emplaced within it.

**Archean carbonate rocks**

Minor thin beds of limestone and/or dolostone occur locally within the mafic and felsic to intermediate volcanic rock units and with the greywacke-mudstone turbidites of the Contwoyto Formation. They are described in the sections on those units. The thickest carbonate rocks occur at the contact between the mafic or intermediate-felsic volcanic units and the Contwoyto Formation.

In most places where the contact between the Peltier and Contwoyto formations was seen, mafic volcanic rocks are overlain directly by mainly argillaceous sedimentary rocks. However, several units of brown-weathering, grey, siliceous dolostone up to 6 m thick are interlayered with mafic volcaniclastic rocks up to 2 m thick at the western contact between the two formations, near the southern shore of the northern arm of Point Lake.

Carbonate rock units are most abundant with the felsic and intermediate Beauparlant and Samandré formations of the volcanic centre in the central part of the map area. They occur on both the eastern and western sides of the volcanic centre, primarily at the contact between the volcanic rocks and the overlying greywacke-mudstone turbidites of the Contwoyto Formation. Their varied degree of development and their local absence suggest that they are probably not a continuous stratigraphic unit.

The carbonate rocks typically occur in a mixed zone at the contact and consist of interlayered volcaniclastic sedimentary units, shale, and less commonly iron-formation. They consist of either medium grey limestone where associated with argillaceous sedimentary rocks, or orange to brown dolostone where associated with the volcanic rocks. On the eastern side of the volcanic complex, they are exclusively dolostone and are typically much coarser grained due to their higher metamorphic grade. They form thin layers a few centimetres thick to units over 60 m thick. In most cases, the units contain thin layers to scattered broken pieces of chert and calc-silicate material that may represent siliceous, pelitic, and/or volcaniclastic laminae or thin beds within the dominantly carbonate unit. The thicker units are layered, the layers being most commonly less than 10 cm thick and defined either by the presence of noncarbonate material or by sharp textural changes. In many cases, the carbonate units are strongly sheared to the extent that most primary depositional features have been lost (Fig. 44). The thickest carbonate-dominated unit occurs on the eastern side of the complex and is about 150 m thick although only 85 per cent of the sequence is exposed. Carbonate units make up about 70 per cent of the exposed part of the sequence, with about 25 per cent being a unit of thin-bedded, yellow tuff separated by black shale and the remainder a unit of gossany shale. Similar facies are seen elsewhere in the unit and, at least at one other locality, they also include silicate and oxide iron-formation.

Volcanic breccia below the carbonate units in the volcanic centre commonly has a carbonate matrix (Fig. 42). Elsewhere within the complex, a carbonate matrix is less common in similar breccias.

The occurrence of significant carbonate rock units at the transition between predominantly intermediate to felsic volcanic rocks and the typical greywacke-mudstone turbidites of the Yellowknife Supergroup is not uncommon elsewhere in the Slave Province. In the High Lake area in the northern Slave Province, for example, similar facies are seen at the transition between dominantly felsic volcanic rocks and the greywacke-mudstone turbidites (Henderson, 1975a), with stromatolites occurring in carbonate rocks units at two localities (Henderson, 1975b). A similar transitional sequence, consisting of thin-bedded, siderite-chert iron-formation, massive dolostone, and massive carbonaceous mudstone commonly containing pyrite, occurs at the eastern contact between the Back River volcanic complex (Lambert, 1981) and adjacent greywacke-mudstone turbidites in the eastern Slave Province (Henderson, 1975a). Carbonate rock units occur elsewhere in the complex, commonly at the top of volcanic cycles, and include both stromatolitic dolostone (Lambert et al., 1990, 1992) and oolitic to pisolitic dolostone (Lambert, 1978). On the basis of the presence of oolites and stromatolites and the occurrence of carbonate clasts in debris flows associated with rhyolite lava domes, Lambert et al. (1992) suggest that at least some of this carbonate was deposited as a primary sediment (as opposed to later alteration or replacement of noncarbonate material). The carbonate rock units around the small felsic centre at Point Lake are too deformed or recrystallized for any primary textures or structures to have been preserved. It seems reasonable to suggest, however, that these carbonate rocks may have originally been deposited as primary carbonate, possibly related to carbonate-precipitating hydrothermal springs associated with the volcanic complex. They may have been the source of the thin carbonate layers that occur within the greywacke-mudstone turbidites of the Contwoyto Formation a few kilometres north, west, and south of the volcanic centre.

***Figure 44.*** *Thin layer of strongly deformed and sheared limestone (on right) overlying intermediate volcanic rocks of the Samandré Formation at the contact between the Samandré and Contwoyto formations. GSC 1995-114S*

## *Cogead Group*

It is proposed that the two large Archean metagreywacke-mudstone formations within the Keskarrah Bay map area be included as members of the Cogead Group. The term 'Cogead' comes from the name Samuel Hearne used for what later came to be known as Contwoyto Lake (Hearne, 1795).

Within the map area, the Cogead Group consists of the Contwoyto and Itchen formations, both of which were originally defined by Bostock (1980). The Contwoyto and Itchen formations both consist of greywacke-mudstone turbidite and its more highly metamorphosed equivalents. They are found between Point Lake and Contwoyto Lake and beyond to the east (Fig. 1, 2). They are part of the greywacke-mudstone turbidite facies that dominates the Yellowknife Supergroup throughout the Slave Province and underlies approximately half the province (Fig. 1). Bostock (1980) originally distinguished the two formations on the basis of the presence of abundant iron-formation in the Contwoyto Formation and its absence in the Itchen Formation. Silicate iron-formation in the Contwoyto Formation hosts the gold deposits of the Lupin mine at Contwoyto Lake, about 90 km east-northeast of the map area.

### Contwoyto Formation

The Contwoyto Formation consists mainly of greywacke-mudstone turbidites that underlie the central part of the map area. It is the most extensive supracrustal unit of the area. In general, it is similar to the other turbidite units that dominate the supracrustal rocks of the Slave Province, but it does differ from them in several respects. Its defining feature is the presence of abundant iron-formation (Bostock, 1980), which serves to distinguish it from the more highly metamorphosed greywacke-mudstone of the Itchen Formation to the east. The Contwoyto Formation in the area also contains minor amounts of fairly widely distributed thin layers to laminae of carbonate rocks. Such layers are not normally found in the greywacke-mudstone facies in most other places in the province. Overall, the formation is less well exposed than the associated volcanic units and primary features are best observed on shoreline and island exposures.

The Contwoyto Formation has not been dated directly in the map area. Thin intermediate to felsic volcanic units 8 km east of the mouth of Keskarrah Bay contain zircons that range in age from 2827 to 2680 Ma (Mortensen et al., 1988) and that are considered in this report to be largely xenocrystic. Beyond the map area, thin felsic volcanic units 5 km south of the Lupin mine at Contwoyto Lake contain zircons with a $^{207}Pb/^{206}Pb$ age of 2661 ± Ma (Mortensen et al., 1992), which is identical to the age of a felsic volcanic tuff unit found in the greywacke-mudstone turbidite of the Burwash Formation east of Yellowknife (Bleeker and Villeneuve, 1995).

A detrital suite of zircons from the Contwoyto Formation was analyzed by Schärer and Allègre (1982) from a locality on the north shore of the north arm of Point Lake close to the boundary between the chlorite and biotite zones. The ages of well over half the suite, within error (± 28 Ma), fall within the range of most volcanic rocks of the Yellowknife Supergroup (2.73-2.66 Ga) and another quarter of the ages are significantly older. A few are between 2.63 and 2.58 Ga and one, at 2.38 Ga, is Paleoproterozoic. Taken at face value, the youngest ages would represent the maximum age of sedimentation of the Contwoyto Formation. However, the Contwoyto Formation in the Contwoyto Lake area is intruded by 2.58 Ga biotite-muscovite monzogranite and pegmatite, and the Itchen Formation, thought to be synchronous with or younger than the Contwoyto Formation, is intruded by 2.61 Ga biotite-hornblende diorite to quartz diorite (van Breemen et al., 1990). This suggests that the youngest of the young detrital ages are not valid criteria for establishing the maximum age of sedimentation of the Contwoyto Formation. It is conceivable that the detrital zircons were recovered from an unrecognized outcrop of the turbidite facies of the younger Keskarrah Group (<u>see</u> later section on the Keskarrah Group), which might possibly explain the young age of at least some of these zircons.

The rocks of the Contwoyto Formation are everywhere metamorphosed to a low-pressure facies series. Within the map area, metamorphic grade varies from subbiotite greenschist facies through cordierite-, andalusite- and regional sillimanite-bearing assemblages of amphibolite facies (Fig. 45). At greenschist facies and up into lowermost

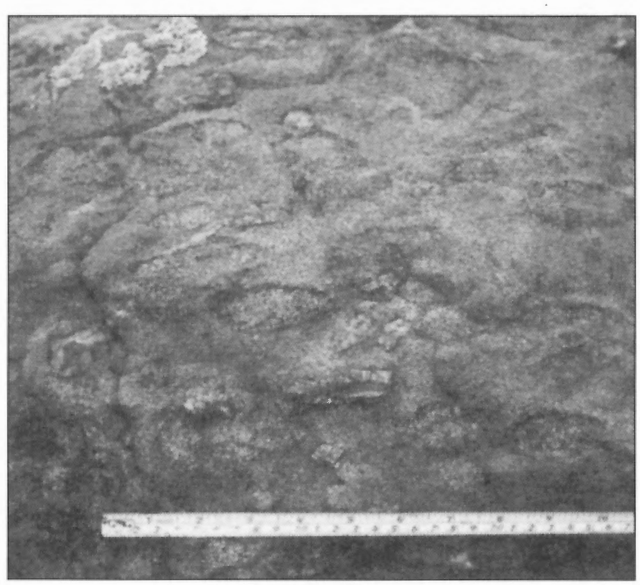


***Figure 45.*** *Amphibolite facies metasiltstone-mudstone turbidites of the Contwoyto Formation containing porphyroblasts of diffusely defined cordierite and more sharply defined andalusite. GSC 1996-146N*

amphibolite facies, primary structures and textures are commonly well preserved. At higher grades, the metasedimentary rocks are extensively recrystallized, to the point that in places, bedding is obscured.

As with the other supracrustal units in the area, the Contwoyto Formation is generally northerly trending. Several phases of deformation are evident at outcrop scale; however, given the relatively poor exposure, the lack of through-going marker units, and the scale of mapping, it was not possible to outline larger scale structures that are no doubt present, given the variation in facings of the beds.

### *Contacts*

Because the Contwoyto Formation is relatively poorly exposed, contacts between it and other associated units are not commonly visible. Those that are, are commonly sheared, largely because of extensive, northerly trending faulting and the contrast in competency between the Contwoyto Formation and the adjacent volcanic formations.

The Contwoyto Formation conformably overlies mafic volcanic rocks of the Peltier Formation. This relationship and locations where it can be seen are described in the section on the Peltier Formation. West of the Itchen River, an important feature of the contact is the presence of black shale or mudstone similar to that of the Contwoyto Formation, among the pillowed mafic volcanic flows near the contact. This suggests that the contact between the mafic volcanic rocks and the Contwoyto Formation may not represent a significant break in time.

Original contact relations with the Samandré and Beauparlant formations in the small felsic to intermediate volcanic centre between the two arms of Point Lake surrounded by the Contwoyto Formation are unclear owing to structural complexities and poor exposure. In the section on intermediate and felsic volcanic units, it is suggested that volcanism was probably in part synsedimentary. This suggestion is based on the correlation of the volcanic centre with thin felsic volcanic units along strike 10 km southeast in the Contwoyto Formation, on the presence of distinctive volcanogenic turbidites within the Contwoyto Formation east and northeast of the centre, and on the similarity between this volcanic centre and others in the province such as the felsic volcanic complex at Clan Lake north of Yellowknife (Hurdle, 1984, 1987) and the Back River volcanic complex (Lambert et al., 1990), which are at least in part synchronous with sedimentation of the associated greywacke-mudstone turbidites.

The boundary between the Contwoyto and Itchen formations is defined by the last occurrence of iron-formation (Bostock, 1980). On the basis of the original regional geological mapping between Point and Contwoyto lakes, Bostock (1980) suggested that the two greywacke-mudstone units occupy an arcuate basin partly bounded by volcanic rocks (Fig. 1). The Contwoyto Formation occurs mainly along the northern and western side of this area dominated by metasedimentary rocks. Bostock (1980) noted that amphibolitic rocks similar to the silicate iron-formation units seen in high-grade rocks of the Contwoyto Formation are also found in migmatitic metasedimentary rock at the south side of the basin remnant, and he suggested that these high-grade metasedimentary rocks might also belong to the Contwoyto Formation. He went on to conclude that "The symmetry of the greywacke-turbidite basin, with volcanic rocks at its periphery, suggests that the Contwoyto Formation lies beneath the rocks of the Itchen Formation, but the structural complexity of these rocks is such that an intertonguing relationship is also possible." Within the Keskarrah Bay map area, much of the boundary between the Contwoyto and Itchen formations is a fault. The area where the normal stratigraphic contact between the two formations presumably occurs south of Itchen Lake is so poorly exposed that little can be said as to its nature, other than that the existence of a significant angular discordance is not indicated. Given that scattered bedding facing indicators seem to show that the formations are more than likely folded on a scale of one or more kilometres, it is unlikely that the contact in the area is properly represented by a single line. Folding of the contact surface, whether originally a single horizontal surface or a complex interfingering facies boundary, would most likely result in the repetition of the two formations at the present erosion surface. Thus, the boundary as drawn on the map, which is that of Jackson (1985), should be thought of as the easternmost occurrence of the Contwoyto Formation. Zones of fold-repeated Itchen Formation rocks may well be present to the west.

The only known exposed contacts of the Keskarrah Group conglomerate and the Contwoyto Formation are on small islands on either side of the area of Keskarrah Group conglomerate immediately north of Keskarrah Bay. On a small island on the northern side of the conglomerate, the conglomerate is cut into disrupted Contwoyto Formation silt and mudstone, suggesting an erosional contact although the strike of both is similar and the dips differ by only 10° (Fig. 46). On a small island east of the large area of conglomerate, Keskarrah Group conglomerate contains clasts of mudstone similar to that of the Contwoyto Formation. Since the Keskarrah Group clearly unconformably overlies both mafic volcanic rocks of the Peltier Formation and the Augustus Granite, and the Contwoyto Formation conformably overlies the Peltier Formation, this would suggest that the Contwoyto Formation is also unconformably overlain by Keskarrah Group conglomerate. The contact between the shallow-water facies of the Keskarrah Group and the Contwoyto Formation has not been seen where these rocks occur together east of Keskarrah Bay. A fault is present between the Contwoyto Formation and the turbidite facies of the Keskarrah Group near the southeastern corner of the map area (Fig. 27).

At one locality along its faulted boundary with the Itchen Formation just north of the main part of Point Lake, the Contwoyto Formation is assumed to be unconformably overlain by a small area of Paleoproterozoic dolostone. The actual contact is not exposed.

In addition to stratigraphic contacts, two units have an intrusive relationship with the Contwoyto Formation. Where the Contwoyto Formation is at its highest metamorphic grade in the southeasternmost part of its outcrop area, it is intruded mainly by pegmatite that is presumably related to the more abundant Archean pegmatite and two-mica granite suite that intrudes the Itchen Formation. Minor metagabbro sills are found along the westernmost part of its outcrop area, adjacent to the finely layered to laminated amphibolite of the Perrault Lithodeme. These sills are isolated, northerly trending bodies a few metres wide that typically occur within a few hundred metres of the Contwoyto Formation-Perrault Lithodeme contact. They are most abundant south of Point Lake, but also occur between the two arms of the lake. They are similar to mafic sills and lenses that are also found in the Perrault Lithodeme. Because of their close proximity to the Perrault Lithodeme, they are thought to be related to it, and they may have formed as a result of the deformation that resulted in the present state of the Perrault Lithodeme. For further discussion of these mafic sills, see the section on the Perrault Lithodeme.

***Figure 46.** Unconformable contact between disrupted, thin-bedded siltstone and mudstone of the Contwoyto Formation on the left and overlying conglomerate of the Keskarrah Group. On the outcrop surface, the two units appear to be almost concordant, but their dips differ by about 10°. Small-scale erosional scours are seen on the unconformity surface. GSC 163054*

*Lithology*

The bulk of the Contwoyto Formation consists of mudstone with lesser amounts of siltstone and minor greywacke turbidite. Intercalated iron-formation, the defining feature of the formation, occurs in regionally distributed, overlapping iron- oxide-, carbonate-, and silicate-rich types. Thin carbonate layers to laminae within the pelitic and siliciclastic sequence are much less abundant and more regionally restricted.

Greywacke, siltstone, and mudstone facies

The Contwoyto Formation within the map area consists mainly of interlayered, thin-bedded siltstone and mudstone and only relatively rare occurrences of beds up to 60 cm or more in thickness of somewhat coarser grained greywacke (Fig. 47, 48, 49). These thicker beds tend to occur in zones rather than in isolated single beds. The proportion of thicker and coarser grained beds tends to be slightly higher to the west. The siltstone, which weathers grey to buff-grey, is typically 10 cm thick or less and forms parallel-sided, laterally continuous layers at outcrop scale. From a sharply bounded base against the underlying mudstone, the siltstone grades upward into the commonly dark grey to black mudstone that forms the top of the unit. The proportion of siltstone and mudstone is highly varied, but overall, the mudstone dominates. The siltstone is mostly featureless, the

***Figure 47.** Thin-bedded siltstone and mudstone of the Contwoyto Formation. GSC 1996-146I*

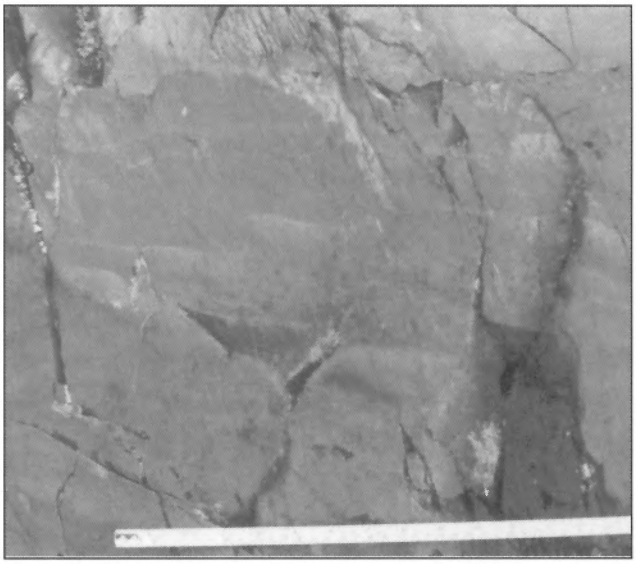


*Figure 48. Medium-bedded, very fine-grained, argillaceous siltstone and mudstone of the Contwoyto Formation with faintly developed climbing ripples indicating current direction towards the left. GSC 1996-146J*

*Figure 49. Relatively rare, moderately thick-bedded, fine-grained, graded greywacke of the Contwoyto Formation overlain by a similar thickness of finely laminated oxide iron-formation. GSC 1996-146K*

most common sedimentary structure being fine, parallel laminations with less common ripple laminations (Fig. 47, 48). The thicker, coarser grained beds more commonly have basal scours that in some cases have been deformed into load and flame structures, and contain angular mudstone clasts. These features are characteristic of sediments deposited from turbidity currents (Bouma, 1962; Pickering et al., 1989; Mutti, 1992).

Iron-formation is intimately associated with the siltstone and mudstone; in places, siltstone layers are found in thick iron-formation units and locally, iron-formation replaces pelite in some siltstone-mudstone sequences. These features are discussed more completely below.

Thin lenses to layers of intermediate to felsic volcanic rocks occur within the normal turbidites and mudstones of the Contwoyto Formation at the southeastern outcrop area of the formation, on the south shore of Point Lake; the largest of these are shown on the map. A greater number of much thinner felsic volcanic layers are found at the faulted contact between the Contwoyto Formation and the turbidite facies of the Keskarrah Group (Fig. 27). There, within the Contwoyto Formation, the volcanic rocks form 3 m to 5 m thick units in an unusual, black, thin-bedded to laminated, silicified argillite that is up to 20 m thick and that also contains 3 cm to 15 cm thick layers of laminated limestone. These volcanic horizons occur approximately on strike, 10 to 15 km from the Samandré-Beauparlant intermediate-felsic volcanic centre to which they may well be related.

A distinct lithofacies of probable volcanogenic affinity within the Contwoyto Formation extends 2 to 3 km east and northeast of the Samandré-Beauparlant intermediate-felsic volcanic centre. In this region, the sedimentary rocks are still graded, interlayered psammite and pelite, but the psammitic part of the beds weathers white to light grey to yellowish buff. The beds average about 5 cm in thickness and are very regular at outcrop scale. The coarsest part of the psammitic layers contains little or no coarse-grained quartz, the graded aspect of the unit being due to gradual compositional change expressed by the colour. These rocks, which are all metamorphosed to amphibolite facies, are much more muscovitic than the normal metasedimentary rocks and their pelitic layers commonly contain very coarse-grained books of biotite. Whereas this lithofacies dominates in many places, in the eastern and northeasternmost exposures, this facies is intermixed with zones of the normal, more quartz-rich siltstone and greywacke. Iron-formation, mainly silicate facies, is interspersed within this lithofacies.

The paucity of quartz and the weathering aspects of these rocks are similar in some respects to the rare groups of felsic tuff units that occur in the Burwash Formation east of Yellowknife (Henderson, 1985; Bleeker, 1996). However, the tuffs in the Burwash Formation occur within the normal turbidite sequence in groups of five or six layers of yellow, centimetre-thick, strongly graded, volcaniclastic material separated by thin, black, pelitic layers. The beds in the Contwoyto Formation tend to be thicker and much more abundant, and in many areas they totally dominate the outcrop. Due to their higher metamorphic grade, primary structures and textures are poorly preserved. The rocks may represent epiclastic deposits derived almost exclusively from an intermediate to felsic volcanic source, as opposed to the normal sandstone and siltstone of the Contwoyto Formation that have a mixed provenance with a significant granitoid component. Their proximity to the Samandré-Beauparlant felsic volcanic complex makes the complex a prime candidate for the source of the detritus; should this prove to be so, it would be further evidence for the coevality of volcanism and sedimentation of the Contwoyto Formation.

### Petrography

The Contwoyto Formation greywackes are similar to greywackes elsewhere in the Slave Province in that they consist of quartz, fine-grained lithic clasts, and feldspar in an abundant matrix. Most of the following discussion refers to the lower grade, coarser grained greywacke, since textural and compositional information is more difficult to resolve in the finer grained siltstone (Fig. 50, 51). Areas containing unusually coarse-grained greywacke are known within the area and are shown on Map 1679A (Henderson, 1988) as Contwoyto Formation. The most extensive example occurs south of the main part of Point Lake, east of Keskarrah Bay, above the conglomerate of the Keskarrah Group and the easternmost panel of Augustus Granite. This coarser grained greywacke is now considered to be a facies of the Keskarrah Group (Fig. 27) and is discussed in greater detail in the following section on the Keskarrah Group. Another example of coarse-grained greywacke occurs on the northern shore of the main part of Point Lake, west of the Peltier Formation, and may also be part of the Keskarrah Group turbidite facies; indeed it occurs along strike about 2 km south of a small, unmapped occurrence of Keskarrah Group conglomerate at the contact between the Peltier and Contwoyto formations.

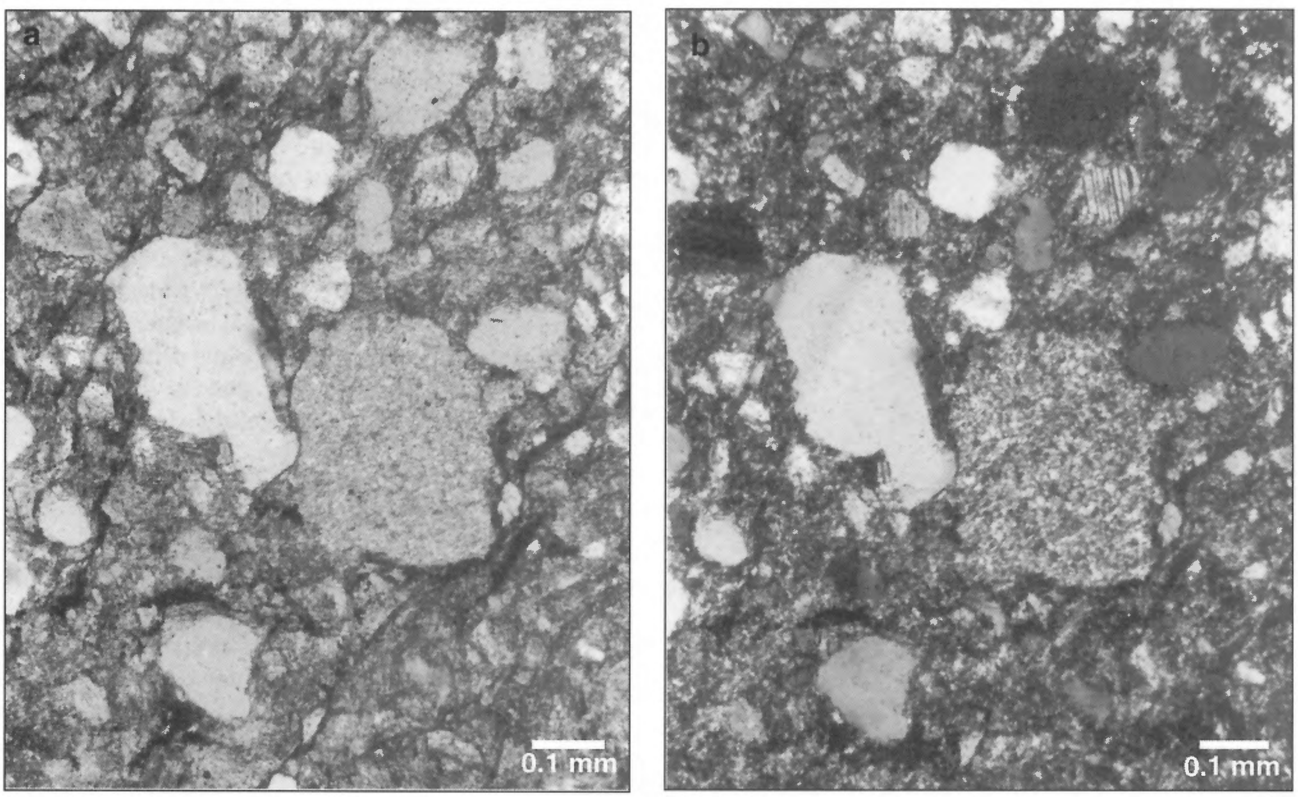



***Figure 50.*** *Photomicrographs of medium-grained greywacke of the Contwoyto Formation. The sandstone is dominated by angular to subrounded quartz grains with lesser amounts of 'lithic clasts' consisting of a very fine-grained aggregate of quartzofeldspathic material with lesser amounts of white mica, chlorite, and other minerals that are thought to represent altered feldspar (centre of photomicrograph). Two relatively rare examples of the fresh plagioclase can be seen in the upper part of the photomicrograph. Although a well developed pressure solution cleavage is evident, the individual grains are not particularly deformed in this case.* ***a)*** *Plane-polarized light,* ***b)*** *cross-polarized light.*

The Contwoyto Formation greywackes have a grain size of 0.5 mm or less. Within a given rock, there typically is a smooth, continuous gradation in grain size down to that of the metamorphic minerals, chlorite and biotite, that dominate the matrix. The matrix, consisting of quartz, feldspar, chlorite and/or biotite, and white mica with a grain size typically 0.02 mm or less, forms about one third of the rock. Most of the greywacke has a well developed foliation expressed by the orientation of metamorphic minerals, elongation of weaker clasts, and discontinuous pressure-solution laminae (Fig. 50).

Quartz, the most abundant clast type, constitutes up to about one third of the rock. It generally consists of small, angular, anhedral, monocrystalline grains, but rarer coarser grains are commonly complexly polycrystalline. Feldspar, most commonly plagioclase, is much less abundant, but more difficult to quantify. It varies from relatively unaltered, albite-twinned, angular, and in some cases subhedral grains, through increasingly altered grains in which twinning is obscure or absent, to diffusely bounded grains that are difficult to differentiate from fine-grained rock fragments. Rare examples of perthitic feldspar were noted.

Rock fragments of several types make up about one quarter of the greywacke. Granitoid fragments, consisting of aggregates of quartz and feldspar, are an easily recognized component. However, because of the typically fine grain size of the greywacke, they are a relatively minor constituent, although a few identifiable clasts are present in most sections. Most rock fragments consist of very fine-grained mineral aggregates. They range from sharply defined, monomineralic 'chert-like' grains through diffusely bounded quartzofeldspathic aggregates that also include chlorite and white mica among other minerals. These aggregates are similar to the matrix of the sandstone and can be differentiated from it by their relative internal homogeneity. The origin of these fine-grained lithic clasts is less clear. The quartz-rich grains could represent recrystallized chert or silcrete, formed by weathering of the source terrain as discussed later for similar material in the Keskarrah Group greywackes. The origin of the quartzofeldspathic material is more equivocal. Many such fragments may represent altered feldspar, into which they seem to grade in some cases. Some of them may be felsic volcanic material. Rare examples of mafic to intermediate volcanic clasts containing fine feldspar microlites are present

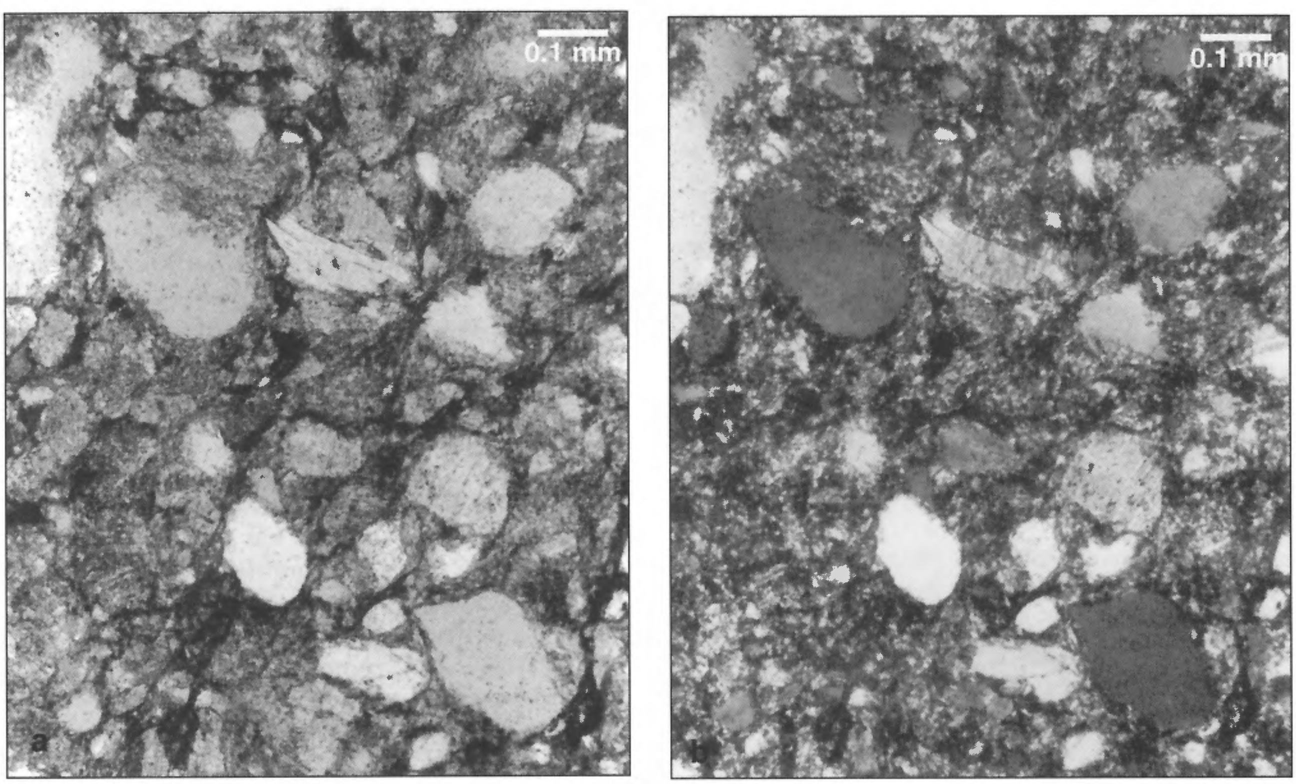



***Figure 51.*** *Photomicrographs of the same greywacke as in Figure 50. Relatively fresh plagioclase grains are seen in the central and left-central parts of the photo, and in the upper central part, a vaguely defined altered granitoid clast is visible immediately to the left of a detrital muscovite flake.* ***a)*** *Plane-polarized light,* ***b)*** *cross-polarized light.*

**Table 5.** Major-element chemical analyses of metagreywackes and metamudstones from the Contwyoto Formation.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 70.0 | 64.6 | 69.8 | 72.1 | 66.07 | 57.0 | 57.8 | 53.47 |
| $TiO_2$ | 0.59 | 0.64 | 0.56 | 0.44 | 0.64 | 0.56 | 0.72 | 0.93 |
| $Al_2O_3$ | 10.9 | 15.8 | 13.3 | 13.10 | 15.24 | 15.0 | 18.90 | 20.56 |
| $Fe_2O_3$ | 1.0 | 0.1 | 0.4 | 0.95 | 0.70 | 0.9 | 1.45 | 1.25 |
| FeO | 9.6 | 4.4 | 6.5 | 3.66 | 4.52 | 8.6 | 6.40 | 7.10 |
| MnO | 0.05 | 0.09 | 0.1 | 0.06 | 0.06 | 0.09 | 0.10 | 0.09 |
| MgO | 2.54 | 4.3 | 2.7 | 2.10 | 2.73 | 3.7 | 3.52 | 4.79 |
| CaO | 0.91 | 1.1 | 2.2 | 1.35 | 1.70 | 3.88 | 0.93 | 1.24 |
| $Na_2O$ | 1.2 | 2.5 | 2.7 | 2.00 | 3.10 | 0.9 | 1.21 | 2.19 |
| $K_2O$ | 0.57 | 2.5 | 1.1 | 2.54 | 1.91 | 4.79 | 4.02 | 3.51 |
| $P_2O_5$ | 0.08 | 0.11 | 0.07 | 0.06 | 0.12 | 0.10 | 0.04 | 0.16 |
| $CO_2$ | 0.1 | 0.3 | <0.1 | | 0.38 | 2.9 | | 0.10 |
| $H_2O$ | 3.2 | 3.3 | 2.1 | | 2.48 | 2.7 | | 4.61 |
| LOI | 0.0 | | | 2.17 | 0.08 | 0 | 4.39 | 0.11 |
| | 100.74 | 99.7 | 101.6 | 100.53 | 99.73 | 100.1 | 99.99 | 100.11 |

1 Contwoyto Formation greywacke from sequence containing iron-formation (Sample H-210-6)
2 Contwoyto Formation greywacke (Sample 464b, Bostock, 1980)
3 Contwoyto Formation greywacke (Sample 468b, Bostock, 1980)
4 Contwoyto Formation greywacke (Sample 81-V-373 (1a), Jackson, 1989a)
5 Burwash Formation at Yellowknife, average greywacke (Henderson, 1975c)
6 Contwoyto Formation silty mudstone from a sequence containing iron-formation (Sample H-210-5)
7 Contwoyto Formation mudstone (Sample 81-V-373 (1c), Jackson, 1989a)
8 Burwash Formation at Yellowknife, average mudstone (Henderson, 1975c)

locally. Argillaceous clasts are very rare. Detrital muscovite and coarse chlorite, possibly representing retrograde detrital biotite, are minor constituents.

Table 5 presents major-element chemical analyses for Contwoyto Formation greywacke and silty mudstone in an outcrop sequence that also contains iron-formation. The greywacke is significantly richer and the mudstone is somewhat richer in iron than other rocks analyzed from the Contwoyto Formation. The iron content of greywackes and mudstones not known to be closely associated with iron-formation is similar to that obtained from the Burwash Formation greywacke-mudstone turbidites near Yellowknife, which are not known to contain iron-formation.

## Iron-formation

The presence of iron-formation is the defining characteristic of the Contwoyto Formation. It is of significant economic interest as over 100 gold occurrences associated with iron-formation are present in the Contwoyto Formation between Point Lake and Contwoyto Lake (Lhotka and Nesbitt, 1989); one of these is the Lupin mine, 85 km east-northeast of the area, which produced about 78 000 kg of gold between 1982 and 1995.

Although widely distributed within the map area, iron-formation is by no means everywhere the same or evenly distributed throughout the Contwoyto Formation. It occurs throughout the formation in a series of partly overlapping zones defined by the dominant iron minerals (Fig. 52). Iron-formation has not been recognized in several large areas of the Contwoyto Formation, including an area east of the Peltier Formation that extends 6 km south from Itchen Lake and a 4 km area south of the north arm of Point Lake between the Peltier Formation and the Perrault Lithodeme. It is not clear whether iron-formation does not exist in these regions or whether it simply has not yet been found because of relatively poor exposure. The aeromagnetic map of the Contwoyto Formation outcrop area gives a more complete indication of the varied distribution of oxide-rich iron-formation. As shown in Figure 53, oxide-rich iron-formation is significantly more concentrated in four centres within the area in which it is present.

Iron-formation units at varied scales are interlayered with the mudstone, siltstone, and greywacke that make up the bulk of the Contwoyto Formation. The thicker units also commonly contain a few thin, graded, siliciclastic siltstone layers up to 10 cm thick (Fig. 54). In a few cases, centimetre-scale layers of limestone or dolostone occur with the iron-formation units; they are similar to the carbonate layers that occur locally with the mudstone, siltstone, and fine greywacke of the main part of the Contwoyto Formation, described later. The iron-formation units tend to be layer-parallel and laterally continuous at outcrop scale. Tremblay (1976) reports that in the Contwoyto Lake area where extensive stripping of iron-formation exposures had been undertaken in the course of mineral exploration, individual

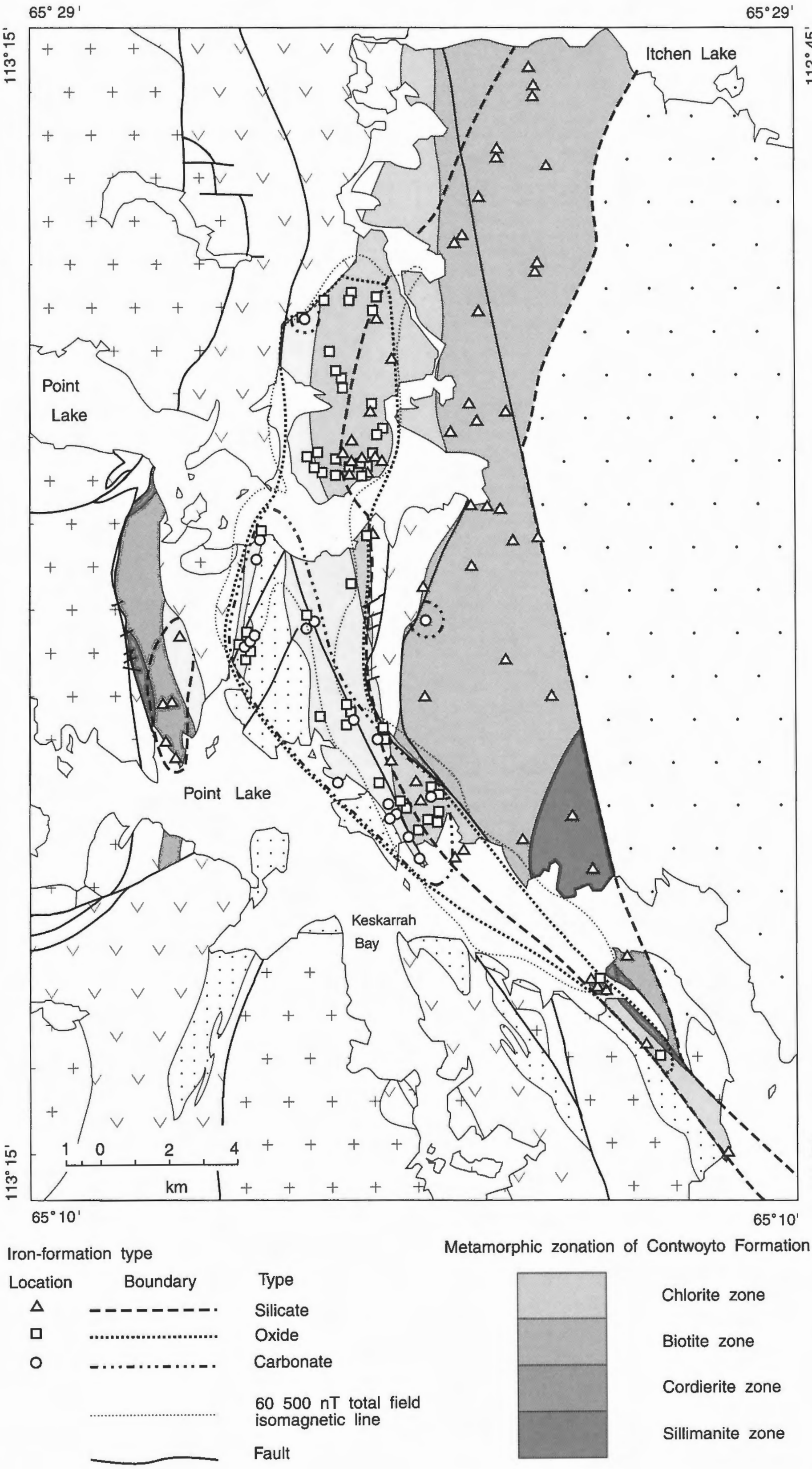



***Figure 52.***

*Distribution of oxide-, silicate-, and carbonate-dominated iron-formation in the Contwoyto Formation. Metamorphic zones in the Contwoyto Formation are also shown. Note that the stratigraphic zonation, iron-formation zonation, and metamorphic zonation are all approximately parallel.*

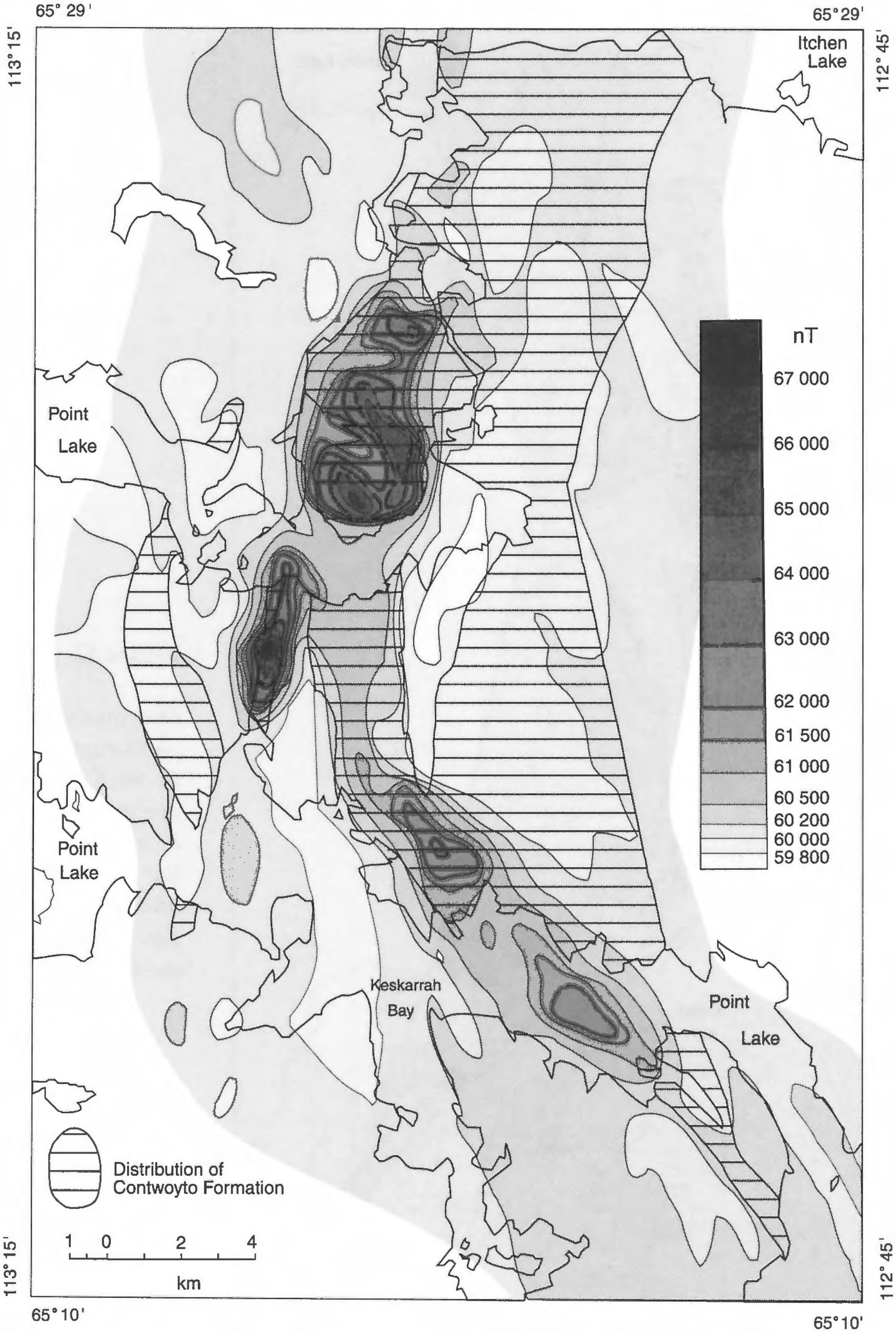



***Figure 53.*** *Map showing regional aeromagnetic data and the distribution of the Contwoyto Formation. As would be expected, the highest magnetic anomalies correspond closely to the oxide iron-formation zone within the Contwoyto Formation, as shown in Figure 52. Note that oxide iron-formation is unevenly distributed throughout the zone, but is concentrated in four distinct centres. Total field isomagnetic lines from Geological Survey of Canada (1979a, b, c, d).*

units are typically less than 700 m in length with exceptional units reaching 1500 m. More recent detailed ground and geophysical mapping suggests, however, that individual units may exceed several kilometres in strike length and that many scattered outcrops of apparent discrete iron-formation units are actually tightly folded portions of the same unit (J.A. Kerswill, pers. comm., 1997). The iron-formation units vary widely in thickness, ranging from some possibly structurally repeated units over 50 or 60 m thick, to thin, centimetre-thick units that occur above graded siltstone turbidite, in place of the argillaceous pelitic interval that normally overlies the siliciclastic turbidity-current deposit.

The proportion of iron-formation in the Contwoyto Formation as a whole seems to be highly varied and is difficult to estimate. At one locality just west of the Keskarrah Group conglomerate on the northern arm of Point Lake, a 175 m thick sequence of dominantly mudstone, siltstone, and fine greywacke contains 13 per cent iron-formation made up of about 90 per cent oxide iron-formation and about 10 per cent carbonate iron-formation with a trace of silicate iron-formation at the top of one of the oxide units. The iron-formation occurs in a series of eight or nine units in the lower two thirds of the sequence with the carbonate type being more common towards the top. The units range

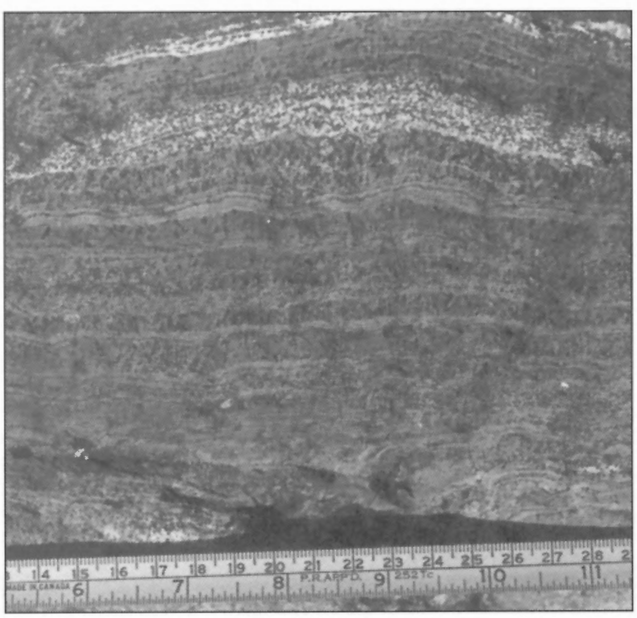


*__Figure 54.__ Thin-bedded silicate iron-formation of the Contwoyto Formation. The light-coloured layers at the top are very rich in quartz whereas the darkest grey layers are silicate iron-formation in which individual amphibole crystals are evident. The thin, finely laminated lighter grey layers are siltstone similar to that common in the main part of the Contwoyto Formation. GSC 162976*

in thickness from 10 cm to 8 m. In general, iron-formation tends to be more abundant in the mudstone-dominated sequences, although this is not always the case.

Recrystallized chert layers as a relatively pure phase are a common, but minor, component in most iron-formation units of each type. However, the dominant iron-mineral-rich layers typically contain a varied amount of quartz, and the variation of these two components is what defines the typically very fine laminations of these chemical sedimentary rocks.

The oxide, carbonate, and silicate mineralogical facies of the four facies of iron-formation originally defined by James (1954) are abundant within the map area (Fig. 52). Only James' sulphide facies, consisting of pyrite in carbonaceous shale, has not been recognized. Sulphide minerals are found in varied proportions associated with iron-formation dominated by iron silicates. Indeed, Kerswill (1993) uses the term 'sulphide-rich banded iron-formation' to describe iron-formation that contains more than five modal per cent iron sulphide and/or arsenide minerals. Following the suggestion of Trendall (1983) and Klein (1983), among others, the term 'facies' will not used henceforth, to avoid the possible implication that these mineralogical types necessarily indicate a primary sedimentological environment. Figure 52 shows the occurrence of various iron-formation types encountered in the course of systematic mapping of the area and so is at best a minimum estimate. The distribution of the various iron-formation types is, to a considerable degree, regionally controlled, although there is considerable overlap at both regional and outcrop scales. The type plotted in Figure 52 is the dominant type at that locality. Representative major-element chemical analyses of a sample of each of the three iron-formation types are shown in Table 6.

Oxide-rich iron-formation occurs in the central part of the Contwoyto Formation outcrop area where, on the basis of its aeromagnetic signature, its concentration is varied (Fig. 53). Although its distribution is roughly parallel to both map unit and metamorphic trends, it appears to end abruptly about midway between Itchen and Point lakes. It occurs in units up to 60 m thick (excessively thick units may be structurally duplicated) that contain black to bluish-black, massive magnetite laminae to layers up to 10 cm thick. Most commonly, however, the oxide-rich iron-formation is finely laminated down to the approximately 0.1 mm grain size of the rock. The laminations are defined by the varied proportions of magnetite and quartz, which can occur in up to equal proportions, together with the relatively minor iron-rich chlorites between adjacent laminae (Fig. 49, 55, 56).

With one known exception, carbonate-rich iron-formation is found in a more restricted area within the area in which oxide-rich iron-formation is present. The one exception is near the eastern margin of the Beauparlant-Samandré

**Table 6.** Major-element chemical analyses of carbonate, oxide, and silicate iron-formation and limestone from the Contwoyto Formation.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 40.3 | 44.8 | 42.0 | 44.3 | 48.5 | 45.0 | 45.7 | 5.8 |
| $TiO_2$ | 0.17 | 0.09 | 0.12 | 0.17 | 0.49 | 0.15 | 0.18 | 0.03 |
| $Al_2O_3$ | 4.1 | 2.5 | 4.4 | 5.4 | 14.0 | 4.6 | 5.3 | 1.4 |
| $Fe_2O_3$ | 6.0 | 32.6 | 36.3[1] | 31.0[1] | 8.3 | 4.7[1] | 4.8[1] | 0.3 |
| FeO | 19.6 | 15.2 | 12.2[1] | 14.7[1] | 20.3 | 37.7[1] | 36.7[1] | 1.2 |
| MnO | 0.11 | 0.04 | 0.14 | 0.10 | 0.17 | 0.09 | 0.12 | 0.50 |
| MgO | 2.36 | 1.3 | 1.5 | 1.3 | 3.48 | 3.2 | 3.7 | 0.57 |
| CaO | 9.26 | 0.56 | 1.7 | 1.4 | 2.11 | 2.3 | 2.6 | 50.11 |
| $Na_2O$ | 0.9 | 0.5 | 0.7 | 0.2 | 0.0 | 0.3 | 0.3 | 0.0 |
| $K_2O$ | 0.30 | 0.85 | 0.3 | 0.1 | 0.0 | 0.1 | 0.1 | 0.27 |
| $P_2O_5$ | 0.11 | 0.13 | 0.5 | 0.15 | 0.02 | 0.21 | 0.14 | 0.02 |
| S | 0.17 | 0.00 | <0.01 | <0.01 | 0.24 | 0.06 | <0.01 | 0.00 |
| C | | | | | | 0.24 | | |
| $CO_2$ | 15.7 | 0.4 | 2.2 | 0.2 | 0.5 | <0.1 | 0.1 | 38.5 |
| $H_2O$ | 0.9 | 0.1 | 0.5 | 1.1 | 0.4 | 2.2 | 2.1 | 0.0 |
| LOI | 0.0 | 1.2 | | | 1.6 | | | 0.0 |
| | 100.0 | 100.3 | 102.6 | 100.2 | 100.1 | 100.9 | 101.8 | 98.7 |

[1] Semiquantitative
1 Contwoyto Formation carbonate iron-formation (H-298-5)
2 Contwoyto Formation oxide iron-formation (H-123-1)
3 Contwoyto Formation oxide iron-formation (464c, Bostock, 1980)
4 Contwoyto Formation oxide iron-formation (312, Bostock, 1980)
5 Contwoyto Formation silicate iron-formation (H-62-2)
6 Contwoyto Formation silicate iron-formation (360a, Bostock, 1980)
7 Contwoyto Formation silicate iron-formation (364a, Bostock, 1980)
8 Contwoyto Formation limestone (H-46-2)

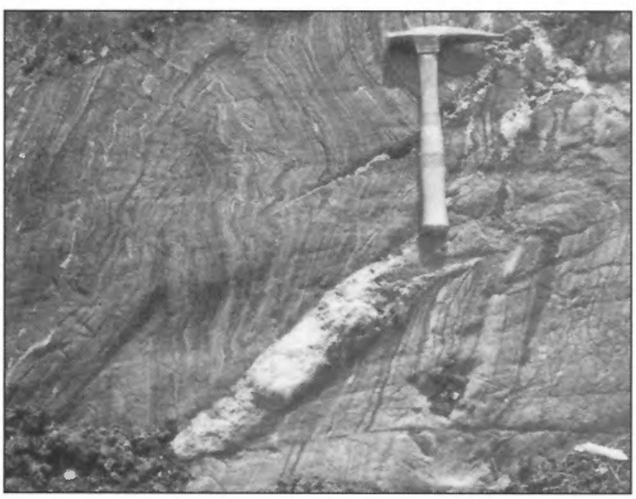


*Figure 55. Tightly folded, finely laminated oxide iron-formation of the Contwoyto Formation.*

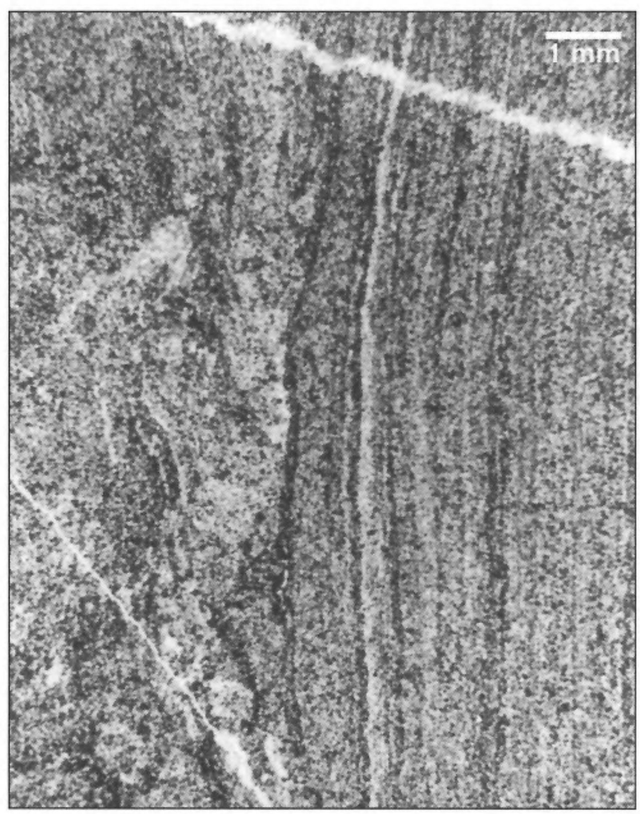



*Figure 56. Photomicrograph of oxide iron-formation of the Contwoyto Formation. Fine laminations are defined by variations in proportions of fine-grained magnetite, quartz, and to a much lesser extent iron chlorite. The left half of the photomicrograph is a local synsedimentary disruption possibly due to slumping of otherwise parallel-laminated sediment. Plane-polarized light.*

intermediate to felsic volcanic centre in the higher grade Contwoyto Formation. Carbonate-rich iron-formation is composed mainly of siderite with lesser amounts of ankerite (Lhotka and Nesbitt, 1989). It typically occurs as a sequence of dark-purple- to reddish-weathering, dark grey units 5 to 10 cm thick that are commonly finely laminated. The interlayered, pelitic material commonly contains a large component of iron-rich chlorites (Fig. 57, 58). As in the oxide-rich type, the laminations are due to variations in the proportion of siderite, which invariably is the dominant phase, and lesser amounts of magnetite, quartz, and chlorites (Fig. 59). Oxide iron-formation and less commonly silicate iron-formation tend to be associated with the carbonate-rich type at a variety of scales from regional through outcrop to individual layers.

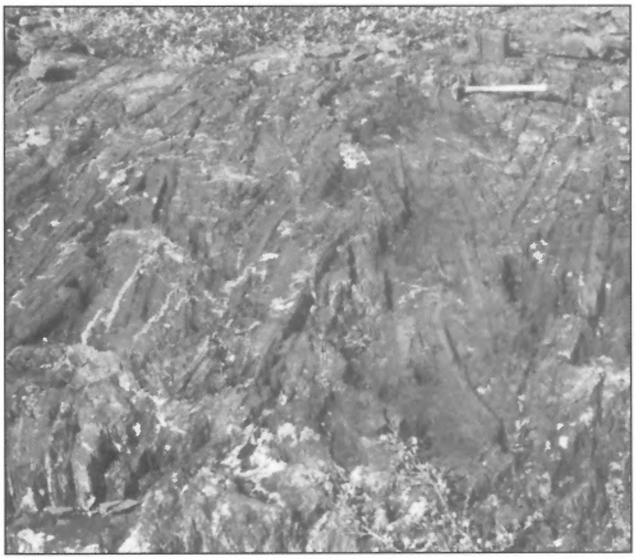


*Figure 57. Tight, steeply plunging folds in carbonate iron-formation. Slightly lighter coloured, more resistant, dark reddish-purple, finely laminated siderite layers are interlayered with dark green to black, iron-rich, pelitic layers. GSC 1996-146S*

*Figure 58. Interlayered siderite in thin, finely laminated units interlayered with more recessive, more strongly cleaved, iron-rich pelite. GSC 1996-146B*

The largest part of the Contwoyto Formation in the map area contains silicate-rich iron-formation. It occurs primarily in the east, in the higher grade parts of the formation, but also in a small area in the westernmost part of the formation (Fig. 52). As with the other iron-formation types, there is significant overlap with the other types of iron-formation. Silicate-rich iron-formation occurs in lenses a few tens of metres long and tens of centimetres thick, as well as in more continuous units with scales similar to those seen for the other types. It consists typically of dark-green- to rusty-weathering units with strongly developed layering that is mineralogically and texturally defined. The presence of thin layers, lenses, and nodules of recrystallized chert also emphasizes the layered aspect of the units. The mineralogy is controlled by metamorphic grade, with the lower grade

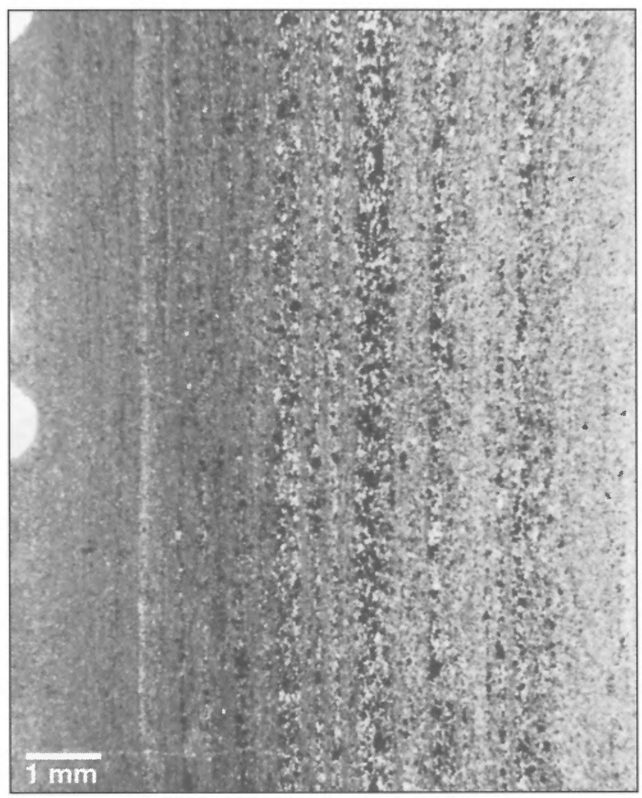



*Figure 59. Photomicrograph of laminated siderite iron-formation. The laminations are defined by compositional and textural variations. The rock consists mainly of siderite (grey), magnetite (opaque), and minor quartz (white) with minor iron chlorite. Plane-polarized light.*

occurrences in the west dominated by iron-rich chlorites and stilpnomelane (Fig. 60). At higher grades, the iron-formation consists of highly varied proportions of grunerite, garnet, and hornblende, as well as quartz (Fig. 61, 62, 63). In one thick unit, 10 per cent of the layers are composed mainly of grunerite in radiating rosettes over 1 cm in diameter and another 10 per cent are garnet amphibolite layers in which garnet forms over one quarter of the rock. The remaining 80 per cent of the unit consists of layers 2 to 5 cm thick of fine-grained, sulphide-bearing amphibolite. The sulphide-bearing, silicate-rich iron-formation contains pyrite at lower grades whereas at higher grades, it contains pyrrhotite with less common arsenopyrite and loellingite. Some higher grade, sulphide-bearing iron-formation is enriched in gold (Bostock, 1968, 1980; Lhotka and Nesbitt, 1989). The silicate-rich type contrasts strongly with the other types of iron-formation in the area, which are not known to contain significant sulphide or gold. Magnetite where present typically occurs in minor amounts. The mineralogy of these units has been described and discussed by Bostock (1977), Ford (1988), Lhotka and Nesbitt (1989, 1990), Ford et al., (1990), and references cited therein.

Ford (1988), Lhotka (1988), Lhotka and Nesbitt (1989, 1990), and Ford et al. (1990) define a pelitic subdivision of the silicate iron-formation type that is based on a greater abundance of more aluminous mineral phases, which they interpret as being due to the incorporation of normal aluminous clastic sedimentary material during sedimentation. This mixing of input is evident in the lower grade rocks where centimetre-scale, ripple-laminated, siliciclastic, turbiditic siltstone to fine-grained greywacke is locally present within thick silicate iron-formation units. The quartzofeldspathic siltstone contains scattered amphibole crystals whereas what would otherwise be the argillaceous, pelitic division of the turbidite is dominated by iron silicates (Fig. 54).

The pelitic layers interbedded with individual iron-formation layers to units are richer in iron than the pelitic sedimentary rocks of the bulk of the formation, as shown by the occurrence of garnet and less commonly staurolite where these rocks have been metamorphosed to amphibolite grade (Jackson, 1989a). Garnet and staurolite are rarely if ever seen in metamorphosed Contwoyto Formation greywackes and pelitic rocks that are far from iron-formation units.

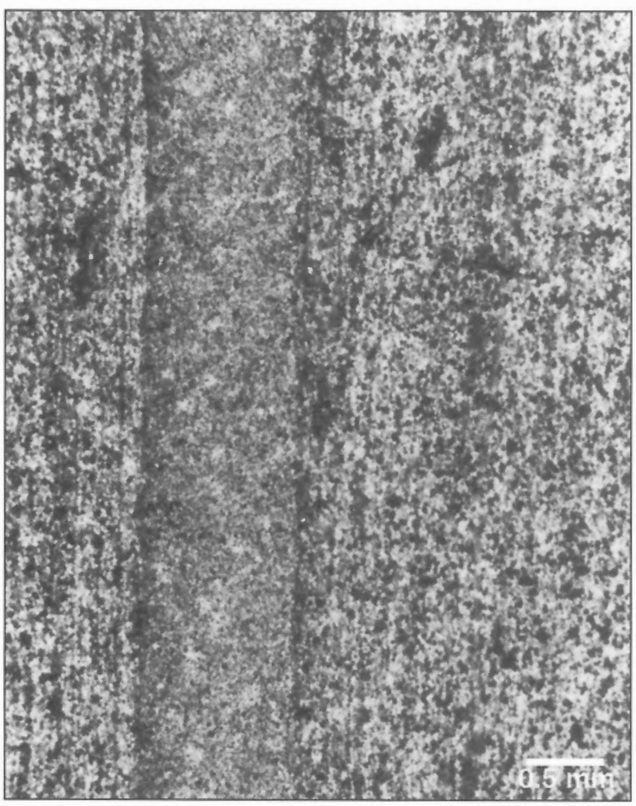



***Figure 60.*** *Photomicrograph of laminated, low-grade silicate iron-formation. As with the oxide and carbonate iron-formation which this iron-formation resembles texturally, the fine laminations are the result of textural and mineralogical variations. Plane-polarized light.*

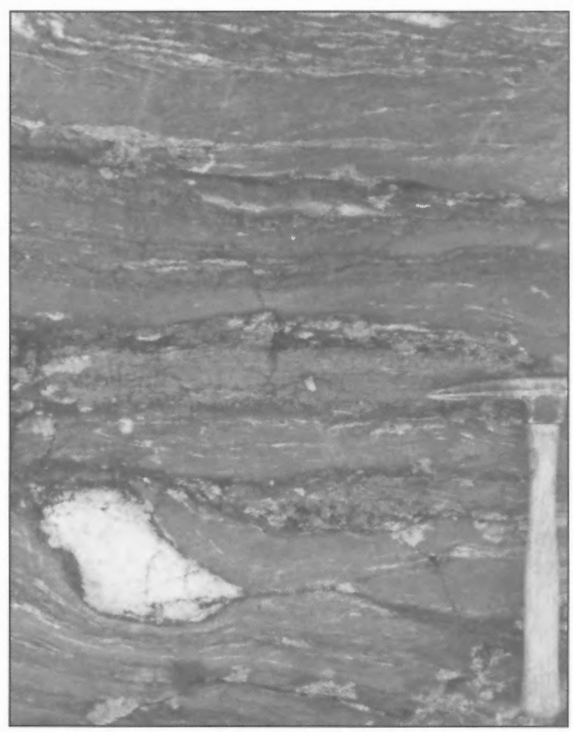


***Figure 61.*** *Amphibolite-grade Contwoyto Formation containing thin silicate iron-formation units. Layers at hammer head and narrow part of handle are composed almost entirely of garnet. GSC 1996-146W*

Carbonate rocks

An unusual feature of the Contwoyto Formation in the map area is the sparse occurrence of carbonate beds within the normal siltstone-greywacke-mudstone sequence. Carbonate units in similar abundances are unknown in the Yellowknife Supergroup greywacke-mudstone turbidite units elsewhere in the Slave Province.

Carbonate beds are known at over 20 localities in a zone up to 4 km wide and about 30 km along strike (Fig. 64). The carbonate layers are independent of, associated with, or in places within, iron-formation. They occur individually or in groups of up to five or six in an outcrop area. They are typically parallel-sided and range is thickness from a few centimetres to 10 or 15 cm with less common examples up to 1.5 m thick. Most are finely layered to laminated, with the layering defined by textural variations and by proportions of noncarbonate material (Fig. 65; Table 6). The carbonate is either limestone or dolostone, the latter being more common. The noncarbonate material includes tremolite-actinolite, clinozoisite, minor quartz, garnet, and biotite. The thicker units commonly contain interbedded, thin, continuous, siliceous layers and are commonly sheared; the parts that are richer in carbonate material locally form a carbonate mylonite whereas those that are more siliceous are disharmonically folded (Fig. 66).

*Discussion*

The Contwoyto Formation is a mudstone and siltstone turbidite sequence with a very low proportion of relatively coarse-grained, thick-bedded greywacke units. As such it contrasts with the Itchen Formation, with which it occurs in the sedimentary basin, and with many other turbidite sequences of the Yellowknife Supergroup that are found elsewhere in the Slave Province. The low proportion of thick, coarse-grained beds implies a relatively low sedimentation rate. Factors that influence sedimentation rate in a turbidite sequence include the size of the basin and the location of the sedimentary remnant preserved within it. Tectonic activity in the source area is also important as it influences uplift, erosion, and production of siliciclastic sediment in the source area. It also generates seismic shocks, which initiate slumping in shallow-water sediment reservoirs; this slumping produces the turbidity currents that ultimately deliver the sediment to its site of

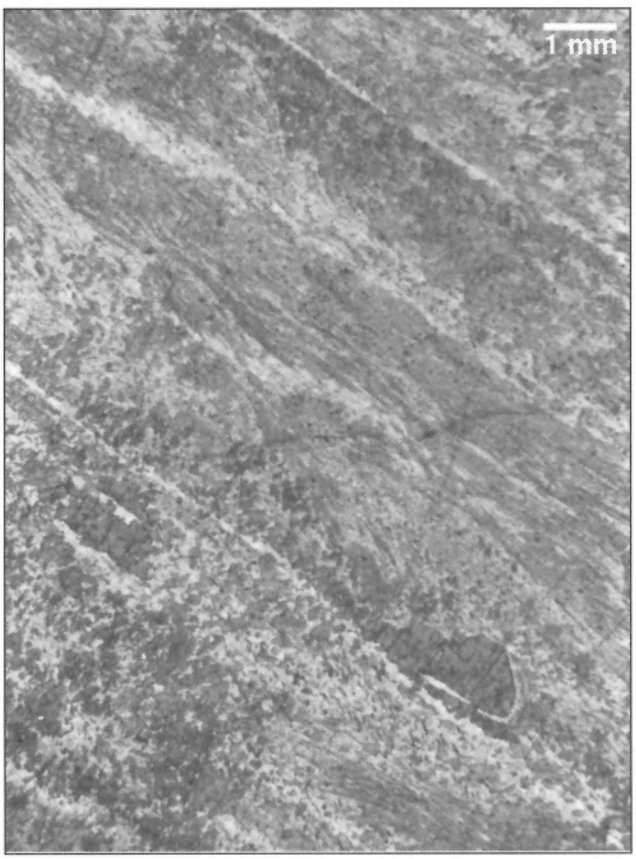



***Figure 62.*** *Photomicrograph of amphibolite-grade silicate iron-formation. The primary compositional layering is well preserved and defined by grunerite-rich (medium grey) and quartz-rich layers with minor irregularly shaped garnet (high relief mineral). Plane-polarized light.*


***Figure 63.*** *Completely recrystallized, coarse-grained, garnet-rich iron-formation with lesser amounts of grunerite and quartz. Plane-polarized light.*

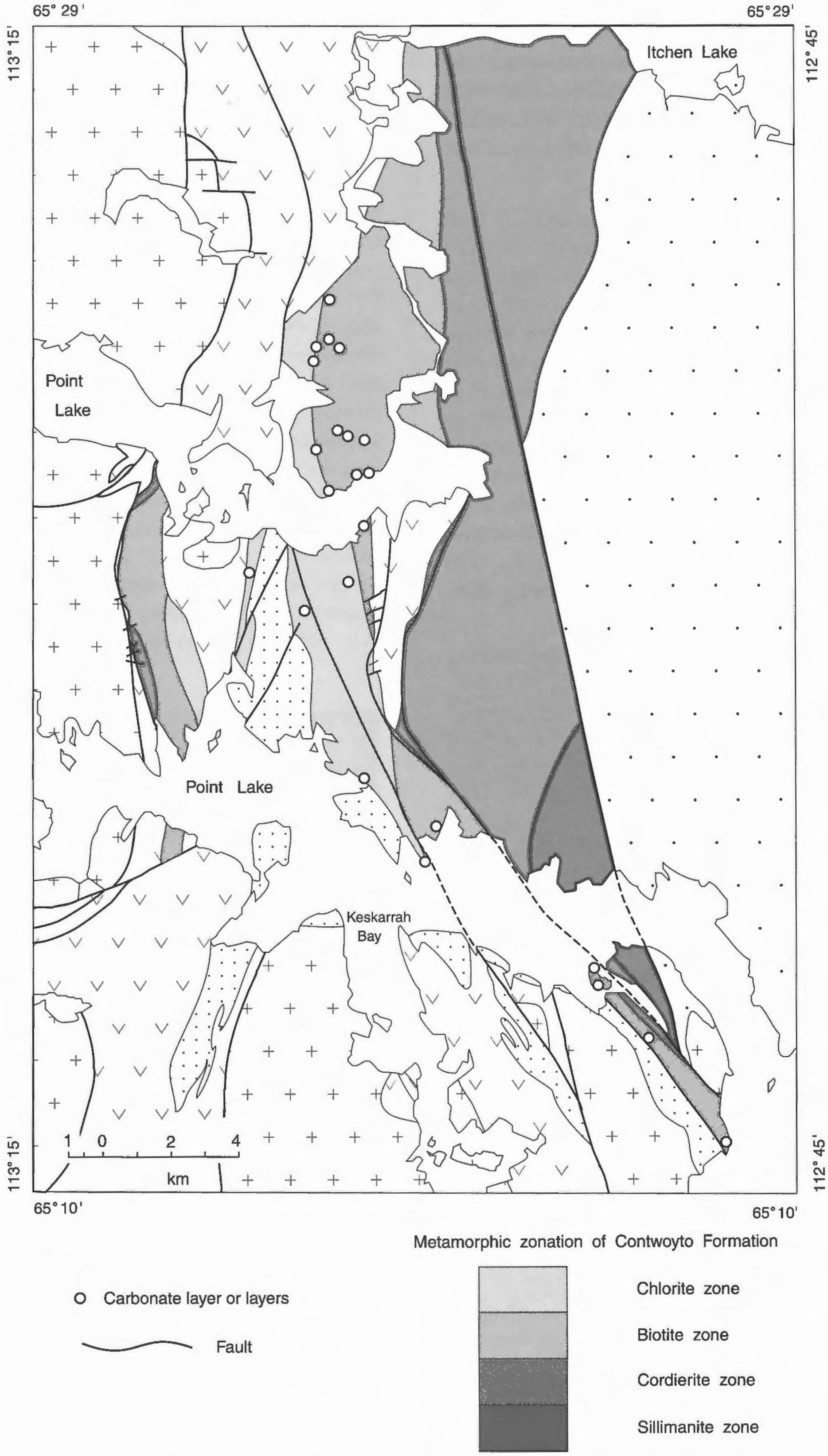



***Figure 64.*** *Occurrences of thin beds of limestone or dolostone in the Contwoyto Formation.*

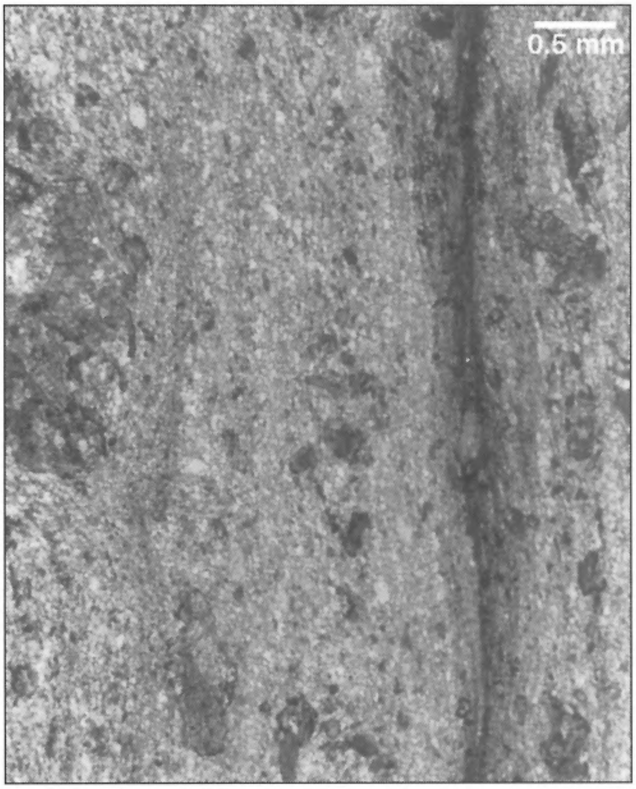



*Figure 65.* *Photomicrograph of a layer in a turbidite sequence in the Contwoyto Formation. The high-relief minerals are tremolite-actinolite, clinozoisite, and garnet. Minor quartz is also present. Plane-polarized light.*

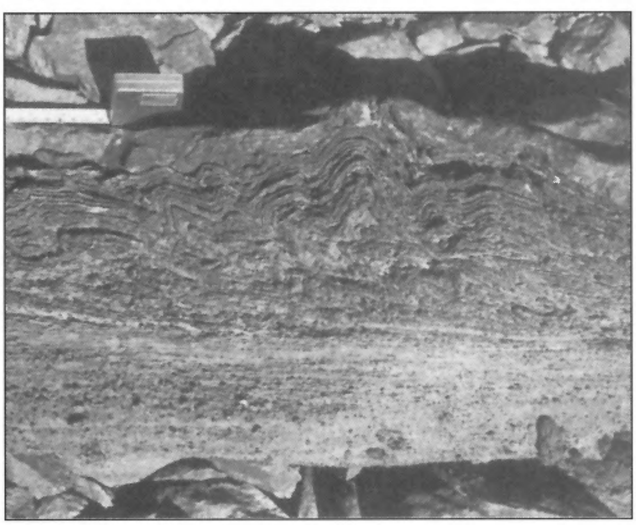


*Figure 66.* *A relatively thick carbonate unit in a siliciclastic turbidite sequence in the Contwoyto Formation. The lower part of the layer is strongly sheared whereas the upper part is disharmonically folded with thin layering defined by interlayered carbonate and siliceous material. GSC 1996-146U*

accumulation. The most important factor, however, is the sea-level stand during sedimentation (Mutti and Normark, 1987; Pickering et al., 1989). Lower levels result in an increased rate of sediment delivery into the basin whereas higher levels retard it. Given the paleogeographic/tectonic isolation of the preserved remnant of the Contwoyto Formation, the relative importance of these factors is difficult to estimate.

Given that the stratigraphic top of the formation has not been recognized and given the lack of any real understanding of the structural geometry of the unit, it is impossible to estimate the thickness of the Contwoyto Formation. Elsewhere in the Slave Province, the estimated thickness of similar turbidite units ranges from 300 to 1500 m (Moore, 1956; Ross, 1962; McGlynn and Ross, 1963), although for the Burwash Formation east of Yellowknife, estimates are somewhat higher, for example 4500 m at Yellowknife (Henderson, 1975c) and approximately 10 to 12 km in the central part of the basin (Bleeker and Beaumont-Smith, 1995). Most Phanerozoic turbidite complexes are typically 1500 m thick or less (Mutti and Normark, 1987), although modern fans located largely on oceanic crust, such as the Bengal fan, can be over 20 km thick (Einsele et al., 1996). Since these extremely thick submarine fans accumulate largely on oceanic crust, they are unlikely to be preserved in the rock record (Mutti and Normark, 1987).

The time period represented by the Contwoyto Formation is also difficult to estimate, but, as a comparison, large Phanerozoic turbidite complexes (which include periods of nondeposition represented by unconformities) typically accumulate over 10 million years or less (Mutti and Normark, 1987). Turbidite sequences with no unconformity-bounded sedimentation breaks commonly accumulate in less than one million years (Mutti and Normark, 1987).

The siltstone and fine-grained, poorly sorted greywacke beds that are interlayered with the mudstone are the result of sedimentation from turbidity currents. The individual layers are laterally continuous, typically parallel sided, start abruptly with the coarsest grained material above the underlying mudstone, and grade upward, commonly discontinuously, into the pelagic mudstone at the top of the bed. At least part of the Bouma (1962) sequence of sedimentary structures reflecting a waning current regime is commonly present. Evidence for the reworking of the sediment subsequent to deposition has not been recognized although there are examples of partial erosion and removal of material by subsequent turbidity currents. Any postdepositional reworking of turbidity-current deposits by bottom currents is commonly due to thermohaline circulation in open oceanic settings (Hollister, 1993; Stanley, 1993). The resulting deposit, a contourite, is a thin deposit of well sorted, fine sand to mud with normal or reverse grading and with sharp upper and lower contacts that contains abundant laminations defined by concentrations of heavy minerals. Mutti and Normark (1987) have suggested that most modern submarine fans on passive margins of open oceans are affected to some extent by bottom currents whereas turbidite sequences formed in more restricted environments such as narrow interplate or intraplate basins tend not to be. The apparent lack of evidence of reworking in the Contwoyto Formation suggests a more restricted environment.

The provenance of the Contwoyto Formation has not been identified, but the composition and textures of the greywackes give some indication as to its nature, if not its location. The heterogeneity and angular shape of the clasts suggest that most of the material was not recycled from an older sedimentary source. The clast population is dominated by angular anhedral quartz. Relatively minor amounts of well preserved feldspar grade into much higher proportions of diffusely bounded, fine-grained, quartzofeldspathic aggregates with chlorite and white mica that may represent altered or weathered feldspar. If this is the case, the proportion of feldspar clasts, fresh or altered, is large. The textural immaturity of the material would indicate that the mineral proportions represent those of the source terrain. The presence of some quartz-feldspar aggregates in the sandstone indicates the existence of a granitoid and/or granitoid gneiss component in the source terrain. All this suggests that the proportion of material derived from granitoid rocks or granitoid gneisses in the sediments is large, as suggested by Schau and Henderson (1983). Other components include mafic-intermediate to felsic volcanic clasts, the latter being difficult to distinguish from the more altered grains of feldspar. Felsic volcanic rocks have been regarded as a major component of the Yellowknife Supergroup greywackes elsewhere in the Slave Province (e.g. Henderson, 1975c). The low percentage of quartz and feldspar phenocrysts in associated preserved felsic volcanic rocks suggests that the amount of felsic volcanic material required to supply the sediment for the Contwoyto Formation would have to have been extremely large. Given the high proportion of typically anhedral, complexly polycrystalline quartz and the low proportion of euhedral forms in the Contwoyto Formation greywackes, a felsic volcanic source may not have been a major contributor. A dominantly granitoid provenance is perhaps a simpler explanation. The fine-grained, polycrystalline, chert-like aggregates of quartz are a minor component that may represent recrystallized silcrete. If true, this would be a further indication of alteration due to weathering in a dominantly granitoid source terrain.

Iron-formation associated with greywacke-mudstone turbidites in the Yellowknife Supergroup is found at many localities throughout the Slave Province, but the Contwoyto Formation seems to have the greatest known concentration of such deposits extending over a large area. Although iron-formation occurs throughout the Contwoyto Formation, because of poor exposure in parts of the area and because of the scale and style of mapping, it is impossible to say whether it is more abundant in one geographic or stratigraphic part of the formation than in another or whether it occurs more or less randomly throughout.

The general consensus is that most iron-formation is ultimately the product of volcanogenic hydrothermal processes (Gross, 1996a). The main alternative theory is that it is the product of extensive weathering (e.g. Lepp, 1987). Iron-formation occurs as discrete, easily definable units up to several tens of metres in thickness. At the time it accumulated, iron-rich minerals were the dominant sediment type, but other material was also deposited, such as the thin, rippled, siliciclastic siltstone layers that occur within the iron-formation units. The normal background hemipelagic and pelagic material that together with the low-density tail deposits of individual turbidity-current deposits form a major part of the Contwoyto Formation, are not uncommonly replaced by iron-formation within the iron-formation units. This suggests that the individual iron-formation units accumulated relatively quickly, fast enough to overwhelm in most cases the presumably continuously accumulating terrigenous and pelagic argillaceous sediments.

Because of the absence of continuous exposure and the lack of stratigraphic and structural control, the lateral extent and constancy of thickness of individual iron-formation units are difficult to determine. Iron-formation sedimentation may be due to precipitation of iron-rich minerals from the water column. If this should be the case, then the expected product would be a more or less uniform blanket. On the other hand, if the units were not extensive because of primary rather than deformational effects, their lenticular nature may be related to the basin botton topography at the time of sedimentation. The iron-rich solutions may have been delivered as a series of brine density currents that ponded in local topographic lows where iron-rich minerals precipitated, along the lines of the genetic model for sedimentary exhalative (Sedex) Zn-Pb deposits (Gross, 1996a,b; Lydon, 1996). In any case, the fact that iron-formation is found throughout the Contwoyto sequence suggests that iron delivery was sporadic and that while iron was being deposited, the normal introduction of siliciclastic turbidity-current deposits did not necessarily stop. Although no specific sources have been recognized, the iron may well have come from local hydrothermal sources, each of which would have been active for a relatively short period of time.

Within the map area there is a distinct, and to some degree overlapping, zonation of iron-formation types, as illustrated in Figure 52. The generally north-south zonation is roughly parallel to the trend of the stratigraphic units in the area and to the regional metamorphic zonation. The bulk of the silicate-rich iron-formation occurs in higher grade rocks. Oxide-rich and carbonate-rich iron-formation occur mainly in the lower grade metamorphic zones. The oxide-rich iron-formation, although overlapping the carbonate-rich iron-formation, extends both north and south into somewhat higher grade rocks. The zonation of iron-formation types is to some degree a response of iron-formation precursor minerals to metamorphic conditions, but there is also evidence of probable primary sedimentological or diagenetic control on some of the mineralogy of these rocks.

Since the Contwoyto Formation is everywhere metamorphosed to lower greenschist or higher grade, the preserved iron-formation minerals are metamorphic assemblages. The various lowest grade occurrences of iron-formation illustrated in Figure 52 are dominated by either iron-rich carbonate, magnetite, or less commonly iron-rich silicates. In each case, however, layers, laminations, or disseminated grains of the other phases are typically present. This variation on such a fine scale may be a result of compositional or textural variations of the precursor sediments or of variation due to diagenetic processes. At higher metamorphic grades, the iron-formation is much more homogeneous with regard to type. The dominant mineral is grunerite, which can be produced by either the reaction of siderite with quartz or the breakdown of iron-rich chlorites during metamorphism (Haase, 1982). Of interest is the fact that magnetite does not take part to any significant degree in any of the metamorphic reactions, behaving as an indifferent phase under metamorphic conditions (Haase, 1982; Klein, 1983). Since oxide-rich iron-formation is not found at higher grades in the Contwoyto Formation in the area, yet is so abundant at lower grades, it probably was never present in the amphibolite-grade rocks. Thus the present distribution of oxide-rich iron-formation may be to some extent related to primary sedimentary or at most diagenetic controls.

Sulphide minerals, either finely disseminated or concentrated in thin layers to laminations, occur only in higher grade silicate iron-formation. They are not known to occur in either the lower grade carbonate or oxide iron-formation in the area. The presence of sulphide minerals in the higher grade rocks could be a primary feature of these rocks, restricted to iron-formation in regions that were eventually metamorphosed at higher grades. On the other hand, the sulphur may have been introduced into the iron-formation, possibly from the sedimentary rocks that contained them, during metamorphism.

The beds of impure limestone or dolostone in the central part of the Contwoyto Formation are also an unusual feature of the formation as they are rarely seen interbedded with turbidites elsewhere in the Slave Province. On the other hand, carbonate units occurring with mainly felsic to intermediate volcanic formations are not uncommon. They are typically relatively minor units, in many cases associated with iron-formation and, in at least two areas where the rocks are well preserved, they contain stromatolites (Padgham, 1974; Henderson, 1975b; Lambert et al., 1990). These volcanic-associated carbonate rocks are also present in the Keskarrah Bay area where they occur with the Beauparlant-Samandré volcanic centre and possibly represent hydrothermal spring deposits related to volcanic processes. They are the probable source of the carbonate layers in the turbidites. The carbonate was presumably introduced from its hydrothermal source into the mainly siliciclastic basin as clastic carbonate detritus in turbidity currents (Tucker and Wright, 1990), or it may have precipitated directly from seawater (Sumner, 1997) or from sporadic brine density currents analogous to those that may have formed the iron-formation. The carbonate beds are too recrystallized and in many cases too deformed for any primary sedimentary textures or structures to have been preserved.

### Itchen Formation

The Itchen Formation, like the Contwoyto Formation, is a major unit of metamorphosed greywacke-mudstone turbidites of regional extent that is found in the eastern part of the map area and extends continuously to the east over 170 km (Fig. 1; Bostock, 1980; King et al., 1991). As originally defined by Bostock (1980), the Itchen Formation is distinguished from the adjacent Contwoyto Formation to the west primarily by its lack of iron-formation.

Within the map area, the contact between the two greywacke-mudstone turbidite units is usually a fault, but to the north, it is assumed to be a normal stratigraphic contact. Contact relations with the Contwoyto Formation are discussed in the section on the Contwoyto Formation. On the basis of his more regional mapping of the two formations, Bostock (1980) was unable to decide unequivocally whether the Itchen Formation overlies or interfingers with the Contwoyto Formation; he was of the opinion that, in general, the Itchen Formation is probably younger than the Contwoyto Formation. Within the map area, the Itchen Formation is locally intruded by pegmatite veins and a few small stocks and one pluton of two-mica granite.

Throughout the map area, the Itchen Formation is everywhere metamorphosed to amphibolite grade; much of it is above the sillimanite isograd. As a result, the original greywacke-mudstones have been extensively recrystallized and most primary sedimentary textures and structures have not been preserved (Fig. 67). Indeed, despite the compositional contrast between layers, even bedding can be difficult to recognize although in other instances, facings are still evident. This is no doubt, due in part to the greater proportion and greater thickness of greywacke beds relative to the intervening hemipelagic and pelagic rocks in the Itchen Formation compared to the Contwoyto Formation. This lithological contrast between the two formations can also be seen east of the area where in addition the Itchen Formation locally contains calcareous concretions, a feature not seen in the Contwoyto Formation (Fig. 68; Bostock, 1980; King et al., 1988, 1989).

***Figure 67.*** *Metagreywacke turbidites of the Itchen Formation are relatively thicker bedded than the turbidites of the Contwoyto Formation. They are at amphibolite grade, with coarse-grained cordierite dominating the thin, slightly darker grey, pelitic layers and, in somewhat finer form, the psammitic layers. Despite the high metamorphic grade, primary features such as grading and mudstone inclusions are still evident. GSC 1996-146CC*

The Itchen Formation consists of dark grey metagreywacke that weathers dark grey to grey to brownish grey, occurring in beds of highly varied thickness, with beds 50 to 70 cm not uncommon. The metagreywacke is interlayered with dark grey to black pelite that in many cases is only one tenth the thickness of the greywacke. The pelitic layers contain sharply to diffusely bounded, very poikilitic, blue-grey cordierite grains up to 8 cm long and less abundant, more euhedral, grey to pinkish andalusite, along with medium-grained quartz, plagioclase, biotite, and muscovite. At higher grade, fibrolitic sillimanite is present. At the highest grades in the area, sillimanite forms pseudomorphs after original andalusite crystals (Fig. 69). The greywackes contain a similar assemblage with, depending on their composition, greatly reduced proportions of cordierite and andalusite. Garnet is much less common than in the Contwoyto Formation and, where present, tends to be more common in the metagreywacke. Staurolite is quite rare, occurring mainly as inclusions in cordierite. Because of metamorphic recrystallization, even the lowest grade mid-cordierite zone rocks have lost all detrital textures. Certain zones within the formation have undergone retrograde metamorphism resulting in a greenish rock with abundant chlorite. The extent of these zones has not been determined and may be related to late shearing associated with unrecognized faults.

***Figure 68.*** *Light coloured carbonate metaconcretion (below hammer) in cordierite-bearing psammite. The concentrically zoned concretion contains a calc-silicate mineral assemblage. GSC 1996-146M*

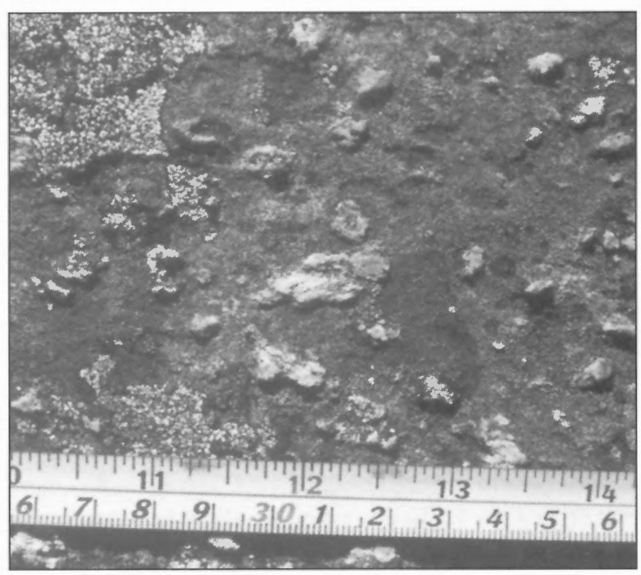


***Figure 69.*** *Coarse-grained sillimanite pseudomorphous after andalusite in the highest grade part of the Itchen Formation. GSC 1996-146Z*

## *Keskarrah Group*

The Keskarrah Group consists of three conglomerate and sandstone units located mainly in the central part of the map area. The unit was originally discovered and its stratigraphic importance recognized by Stockwell (1933) during his reconnaissance into the area. Bostock (1980) described the unit, outlined its distribution, and named it the Keskarrah Formation after Keskarrah Bay, a geographic feature named for Keskarrah, a Yellowknife hunter who guided the first Franklin expedition between Fort Enterprise and Point Lake in 1820.

It is proposed that the Keskarrah Formation be raised to group rank in recognition of the presence of three distinct, formation-scale facies. These include the dominant conglomerate facies and a commonly crossbedded sandstone facies as described by Bostock (1980). In addition, it is suggested that a coarse-grained, thick-bedded turbidite facies in the southeastern part of the area is also part of the Keskarrah Group (Fig. 27). These facies have not yet been given formal stratigraphic names as the stratigraphic relationships between the conglomerates and the shallow-water sandstones are not yet understood. Associated with the conglomerates and crossbedded sandstones are kilometre-scale lenses of mafic to intermediate volcanic rocks that are not considered part of the group.

### Contacts

The Keskarrah Group overlies the Augustus Granite, the mafic volcanic rocks of the Peltier Formation, and the greywacke-mudstone turbidites of the Contwoyto Formation. No Archean rock units are known to overlie the Keskarrah Group. The best preserved primary contacts are between the Keskarrah Group and the Augustus Granite, where a well preserved unconformity surface is recognized (Fig. 13, 14). In places, a weathered horizon in the granite is associated with the unconformity. The longest strike length of this contact is on the easternmost side of the Augustus Granite where the relief on the contact reaches several hundred metres. A more complete discussion of these contact relations is presented in the section on the Augustus Granite.

Contacts between the mafic volcanic rocks of the Peltier Formation and the Keskarrah Group are exposed locally and are invariably sheared to some degree. This is also true of the contacts with mafic volcanic lenses within the Keskarrah Group. As a result, the primary nature of the contact at outcrop scale is usually equivocal. The contact is typically straight and sharp, but in some cases relief reaches 1 m at outcrop scale. Although the contact is sheared, top determinations can usually be made on either side and within a few metres of the contact. Volcanic and sedimentary rocks on either side of the contact in almost all cases face in the same direction. At map scale, pillow orientation suggests that a low-angle discordance exists between volcanic flows and the basal contact and bedding within the Keskarrah Group, although it is also possible that the pillow structures have undergone tectonic transposition. This discordance is most apparent east of Keskarrah Bay. As discussed previously in the section on the Peltier Formation, small lenses of Keskarrah-like conglomerate and sandstone occur within or at the base of the volcanic sequence. The contact between the lenses and the volcanic sequence was not seen, but, like the mafic lenses within the Keskarrah Group, these lenses may also be tectonic slices, particularly given their proximity to known or suspected shear zones (Fig. 27).

Contact relations between the Keskarrah Group and the greywacke-mudstone turbidites of the Contwoyto Formation are poorly known because of a lack of exposure, particularly north of the main part of Point Lake. The only known exposure of the contact is on a small island just north of the large eastern area of Keskarrah Group on the northern side of the lake. The conglomerate cuts down into the siltstone suggesting an erosional contact, although the strike of both is similar and the dips differ by only 10° (Fig. 46). South of the lake, Contwoyto Formation rocks in contact with the Keskarrah Group have been mapped in two of the structural panels east of Keskarrah Bay. In the eastern panel, the Keskarrah Group conglomerate overlying the Augustus Granite is stratigraphically overlain by greywacke shown as Contwoyto Formation on the map. It is suggested below that on lithological grounds, a case can be made for these rocks being part of the Keskarrah Group. They are also stratigraphically continuous with the underlying conglomerate facies and are bounded to the east by a shear zone that separates them from the Contwoyto Formation greywacke-mudstone turbidites. In the western panel, a very poorly exposed sequence of greywacke-mudstone, assumed to belong to the Contwoyto Formation, occurs next to Keskarrah Group sandstone, but no contacts were seen.

### Structural setting

In the western part of the area, the Keskarrah Group occurs in tight, upright to west-verging, synclinal structures both north and south of the main part of Point Lake. To the east, the outcrop areas of Keskarrah Group are mostly east facing. Little can be said about the area of conglomerate on the north shore of the lake, north of Keskarrah Bay, because of the lack of known facings.

Bedding units within the Keskarrah Group, like the other supracrustal units in the area, are almost everywhere northerly trending and steeply dipping. The only exception is at the northern end of the Augustus Granite west of Keskarrah Bay, where the trends are more easterly and dips are as low as 35°, presumably due to the sheltering effect of the adjacent granite body. The rocks in the Keskarrah Group are variably deformed with best preserved conglomerate occurring in the east. This is best seen above the Augustus Granite in the southeastern part of the area and also in the small area north of the Augustus Granite west of Keskarrah Bay. Elsewhere, deformation is more intense but still varied, with zones in which the conglomerate cobbles are only minimally deformed separated by generally narrower zones in which even the granitoid clasts are elongate (Fig. 70, 71). Thus, the style of deformation is similar to that seen in the adjacent Peltier Formation. Zones of minimally deformed pillows are separated by narrow zones of more intensely deformed rocks in which primary structures are highly strained or obliterated.

At a regional scale, the Keskarrah Group overlies the Peltier Formation and Augustus Granite in the south whereas in the north it occurs mainly on the Contwoyto Formation, east of the area underlain by the Peltier Formation. This suggests the existence of an angular discordance between the Keskarrah Group and the other two units, which would indicate at least some deformation of the Peltier and Contwoyto formations before deposition of the Keskarrah Group.

### Conglomerate facies

The conglomerate facies is by far the most abundant facies within the Keskarrah Group and varies considerably in composition throughout its outcrop area. Although the conglomerate is usually homogeneous at outcrop scale, in places it is crudely layered due to variations in the maximum size of the clasts. The layers are a few to several tens of metres thick. Layering is also defined locally by lenses to discontinuous, metre-thick layers of coarse, crossbedded sandstone a few metres to several tens of metres long (Fig. 72). The clast population is dominated by granitoid

***Figure 70.*** *Relatively rare example of Keskarrah Group conglomerate containing minimally deformed to undeformed granitoid and mafic volcanic clasts. GSC 163010*

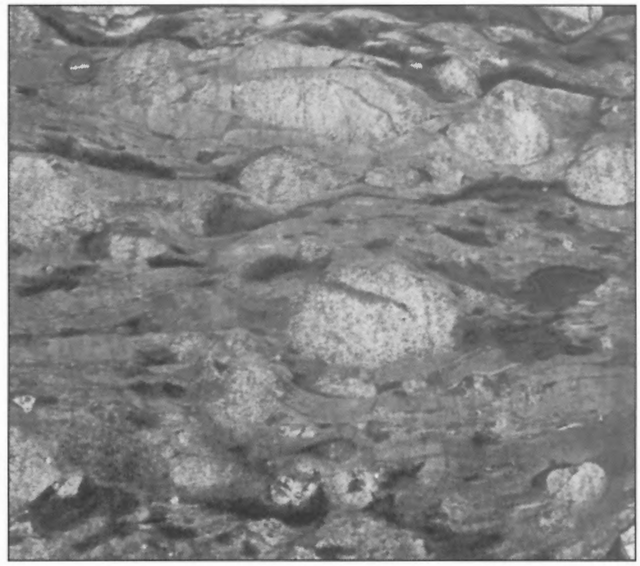


***Figure 71.*** *A more typical, moderately to strongly deformed example of Keskarrah Group conglomerate than that shown in Figure 70. The conglomerate consists mainly of severely strained, largely mafic volcanic clasts, some of which are almost unrecognizable, and typically coarser, much less deformed, granitoid clasts. The lens cap near the upper left corner is 5.5 cm in diameter. GSC 1996-146H*

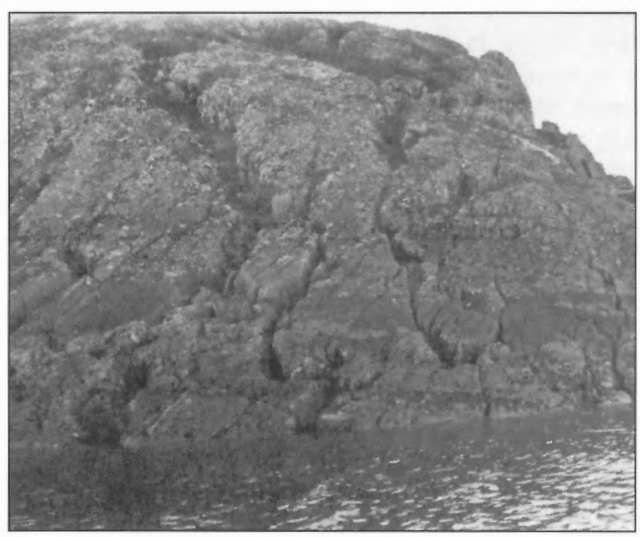


***Figure 72.*** *Keskarrah Group conglomerate with lensoid to discontinuous sandstone units near the waterline. GSC 163048*

and volcanic clasts, and their relative proportions vary from almost exclusively volcanic clasts in the outcrop area between the arms of the lake to dominantly granitoid clasts in the southeastern part of the area. Elsewhere, the mix is greater, but overall the proportion of mafic volcanic clasts is higher than that of granitoid clasts (Fig. 73). Vein-quartz cobbles are a minor, but ubiquitous, component whereas sedimentary clasts, although present locally, are rare. The conglomerate is clast-supported and this is commonly emphasized by deformation of the unit, particularly by the volcanic clasts that are more flattened (Fig. 71, 74). Clast size varies greatly, with the granite clasts being the largest in any given outcrop and reaching a maximum length of 1 m. The conglomerate is not well sorted. The granitoid clasts are well rounded in most outcrop areas. The only major exception is the granite-rich conglomerate above the Augustus Granite in the southeastern part of the area, in which the clasts are fairly angular. The weaker volcanic clasts are commonly more angular, a feature emphasized by deformation.

The Keskarrah Group outcrop area between the two arms of the lake is dominated by volcanic clasts that are much smaller than those seen elsewhere in the formation. To the north, intermediate to felsic volcanic clasts dominate with only minor examples of quartz-feldspar porphyry and quartz cobbles (Fig. 74). Clast size averages only a few centimetres. To the south, intermediate to felsic volcanic clasts dominate in the eastern part of the outcrop area, whereas mafic volcanic clasts dominate in the western part. Granitoid cobbles, although still less than 5 per cent of the clast population, are more common in the south and the average clast size for all rock types is much larger. One of the greatest differences between this northern conglomerate domain and those to the south is the abundance and variety of nonconglomeratic sedimentary units. These include metre-scale lenses to discontinuous layers of crossbedded sandstone that are compositionally similar to the enclosing conglomerate in that they are dominated by mafic volcanic rock fragments and lesser amounts of quartz (Fig. 75, 76). Also present are units of thick-bedded, massive, featureless, medium- to coarse-grained sandstone up to 15 m thick that is locally conglomeratic (Fig. 77). Less common are units of interlayered shale and turbidite-like sandstone; the sandstone is commonly graded and thin bedded, with beds 2 to 15 cm thick (Fig. 78). These sedimentary units occur at many localities throughout the conglomerate outcrop area. The lateral extent of individual units is unknown mainly because of the Quaternary cover. A distinctive black carbonaceous shale, commonly with disseminated sulphide, occurs next to the mafic volcanic unit at the southeast corner of the outcrop area. Similar black shale is found in the Keskarrah Group or Keskarrah-Group-like rocks south of the lake.

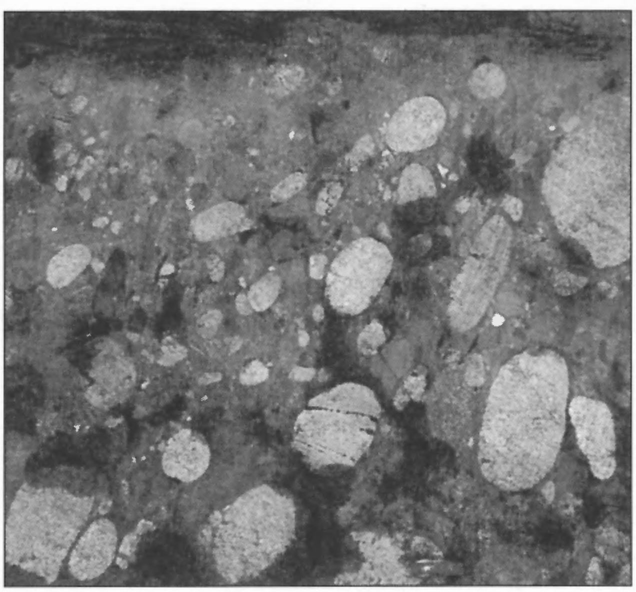


***Figure 73.*** *Moderately deformed Keskarrah Group conglomerate at the west side of the mouth of Keskarrah Bay. Easterly trending bedding is defined by a sandstone layer along the top of the photograph. The high angle between the bedding and the long axis of the cobbles suggests reorientation of the cobbles parallel to the regional, northerly trending foliation. The knife at the base of the photograph is 9 cm long. GSC 1996-146O*

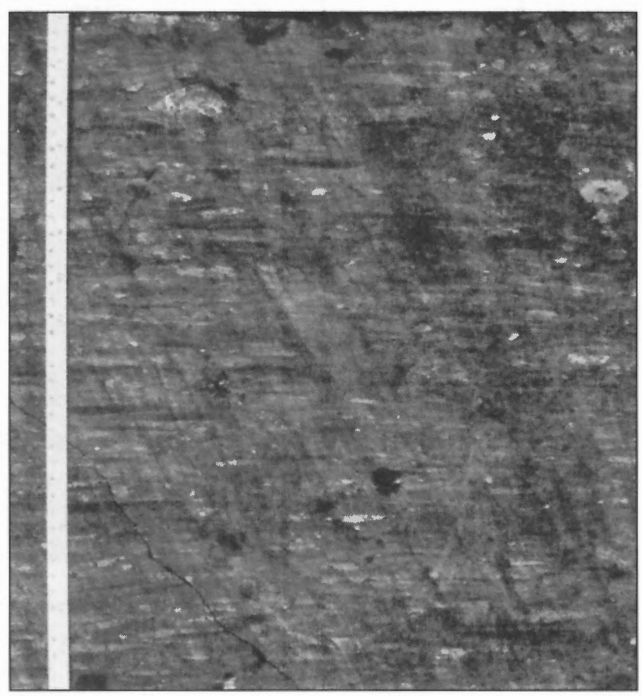


***Figure 74.*** *Strongly attenuated, fine-grained, volcanic clasts in conglomerate at the northernmost extent of the Keskarrah Group. GSC 1996-146T*

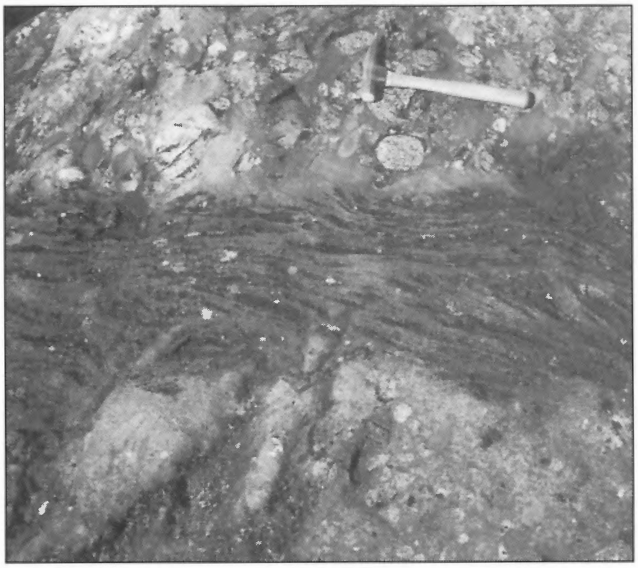


*Figure 75. Crossbedded, coarse-grained sandstone lens in conglomerate of the Keskarrah Group. GSC 1996-146A*

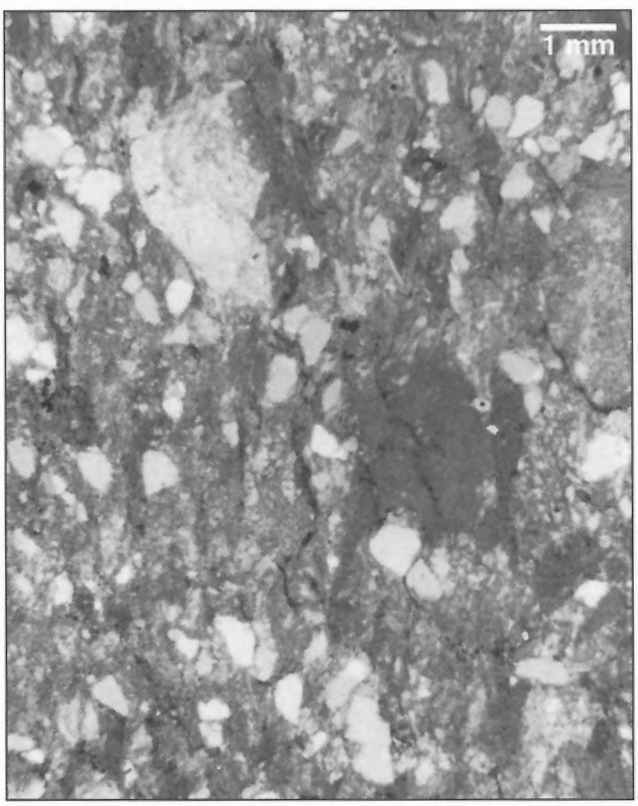



***Figure 76.*** *Photomicrograph of volcanic lithic sandstone in conglomerate. The sandstone, like the conglomerate that hosts it, is dominated by largely mafic volcanic rock fragments and a lower proportion of quartz, presumably mainly representing the granite component. Plane-polarized light.*

***Figure 77.*** *Layers to lenses of sparse-pebble conglomerate in weakly laminated to massive sandstone of the Keskarrah Group.*

***Figure 78.*** *Part of a sequece of thin-bedded, fine-grained turbidite in conglomerate of the Keskarrah Group.*

A kilometre-long zone of conglomerate that is not shown on the map is present on the west side of the Peltier Formation, west-southwest of the small lake in the volcanic unit. Its relationship to the volcanic rocks was not observed although at one locality, a thin unit of mafic volcanic rocks occurs within the conglomerate. At the northernmost exposure, the conglomerate occurs in two sequences about 6 m thick that are separated by a sharp contact. Each faces towards the west-facing volcanic rocks and grades upward into fine-grained interbedded sandstone and mudstone. The conglomerate is dominated by mafic volcanic clasts with minor granitoid clasts and other felsic clasts of undetermined origin. Maximum clast size is about 30 cm although most are less than 10 cm.

On the north shore to the southeast, the conglomerate in the large outcrop area has closer affinities with the conglomerate on the south shore than with that described above. Here the conglomerate consists of 25 to 40 per cent and locally up to 60 per cent white-weathering, well rounded, mainly granitoid clasts with minor amounts of granitoid gneiss cobbles that increase in size and abundance to the south. The length of these cobbles is commonly greater than 50 to 70 cm, but is more typically about 20 cm. Mafic volcanic clasts dominate, but are generally smaller. Lesser to minor amounts of intermediate volcanic clasts, quartz, porphyry, and rare, orange-red, ferruginous dolostone of a type present in the Peltier Formation, also occur. Sandstone lenses are also present.

South of the lake, the conglomerate is typically coarser grained and its granitoid clast component is much greater. The best preserved, least deformed conglomerate occurs just west of Keskarrah Bay where its moderate dip and easterly to northeasterly trend contrasts with the steep dip and strong northerly trends so common elsewhere in the map area. The regional northerly foliation that is so strongly developed in other conglomerate outcrop areas is at its weakest here, giving the clasts an imbricated aspect. The crossbedded, coarse-grained, discontinuous sandstone layers suggest a northeasterly sense of transport.

South of the bay west of Keskarrah Bay, the degree of deformation is much greater. Some granitoid clasts are elongated with a 2:1 aspect ratio, although deformation can vary considerably over a few tens of metres. The proportion of granitoid to mafic volcanic clasts is smaller than to the northeast. The maximum clast size is also smaller. The clast population is more heterogeneous than to the east, with a greater variety of granite types and more common granitoid gneiss clasts. The conglomerate is in contact with the crossbedded sandstone facies and is interlayered with it over a few tens of metres. North of the bay, on the bulbous peninsula in Point Lake proper, the conglomerate found between the large mafic volcanic units is more similar to that found to the north. It has a relatively small proportion of granitoid cobbles and also contains units of interlayered, thin-bedded siltstone and mudstone.

East of Keskarrah Bay, a major outcrop area of conglomerate unconformably overlies the Peltier Formation. The angle between the two is as great as seen anywhere between the Peltier Formation and the Keskarrah Group. The conglomerate is strongly deformed along its eastern margin. The boundary between the conglomerate and the enclosed unit of intermediate volcanic rocks and the Peltier Formation to the east could be a fault (Fig. 27). Near the intermediate volcanic unit, the population of volcanic clasts in the conglomerate is dominated by intermediate volcanic clasts and only minor granitoid cobbles. To the west, however, the conglomerate is dominated by deformed, subangular to angular, mafic clasts and occurs in crude units about 3 to 10 m thick, defined on the basis of the largest clasts. The rounded to subrounded granitoid clasts are much more homogeneous with most being derived from the same source, the Augustus Granite. The main difference in the clasts is their degree of foliation and alteration. At the unconformity, the conglomerate is dominated by mafic clasts with granitoid cobbles starting to be seen a few metres to 10 m higher in the section.

The lithologically most distinct Keskarrah Group conglomerate lies unconformably along the easternmost margin of the Augustus Granite in the southeastern part of the area. At most localities, it consists almost exclusively of Augustus Granite clasts and contains only very minor mafic clasts that, on textural grounds, are derived from mafic dykes rather than a mafic volcanic sequence (Fig. 79). Rare examples of vein quartz, greywacke, and mudstone clasts may also be present. The clasts consist of fresh granite and a lesser amount of altered granite similar to that seen at several localities immediately below the unconformity. They are typically angular to subangular although a varied proportion of more rounded cobbles may be present. At some localities, there is grading of clasts away from the unconformity and the proportion of altered granite clasts increases closer to the unconformity. No sandstone layers or lenses were observed within the conglomerate. The contact between the conglomerate and the adjacent greywacke-mudstone turbidite is abrupt; relief on the contact is a few tens of centimetres over a few metres. It is overlain by a few centimetres of granulestone and then by the greywacke with local granitoid clasts, suggesting a conformable stratigraphic contact.

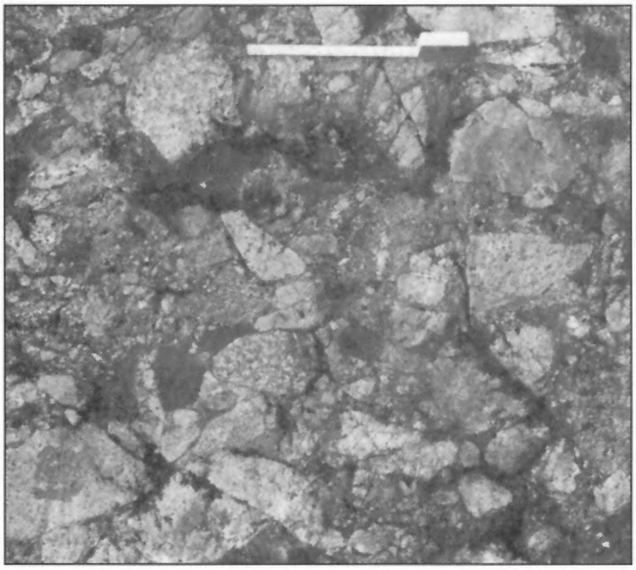


*Figure 79. Coarse-grained, angular, granite-dominated conglomerate from the easternmost occurrence of the Keskarrah Group. The granitoid clasts are all variably altered and from the Augustus Granite, which immediately underlies the conglomerate. The granite-dominated compositon and angular texture of these easternmost conglomerates are very different from those of Keskarrah Group conglomerates to the west. GSC 1996-146V*

A unique conglomerate is present 6.4 km east-southeast of the mouth of Keskarrah Bay at the westernmost of the two unconformity localities noted on the map. The Keskarrah Group section at this locality is illustrated in Figure 80. The section is unusual in that its lower, mainly conglomeratic, part is very quartz rich and is stratigraphically continuous with the upper part that grades from more immature, coarse-grained greywacke to siltstone and eventually to shale in the uppermost part. The weathered Augustus Granite is immediately overlain by a thin, coarse-grained, poorly sorted, angular, very quartz-rich lag deposit that also contains minor altered feldspar and rare detrital muscovite flakes. This is followed by the main conglomerate unit dominated by quartz cobbles in a quartz-rich matrix. Although varied, the quartz content of the matrix is greater than 50 per cent, and the quartz occurs as angular, polygonized, commonly fractured grains, some containing grains of altered feldspar similar to that seen in the Augustus Granite immediately below the unconformity (Fig. 81). Major-element chemical analyses for these quartz-rich rocks are provided in Table 7. There can be little doubt that this rock is derived from deeply weathered granite and has undergone minimal transport. It differs from conglomerates to the southeast in the degree of alteration of the source granite. The detritus consists mainly of quartz

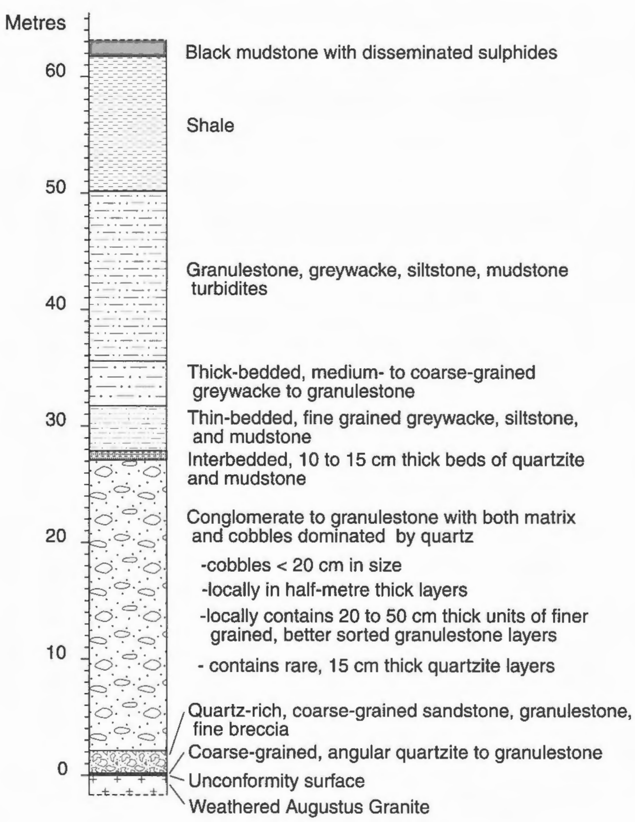



*Figure 80. Section through the Keskarrah Group immediately above the Augustus Granite, 6 km east-southeast of the mouth of Keskarrah Bay.*

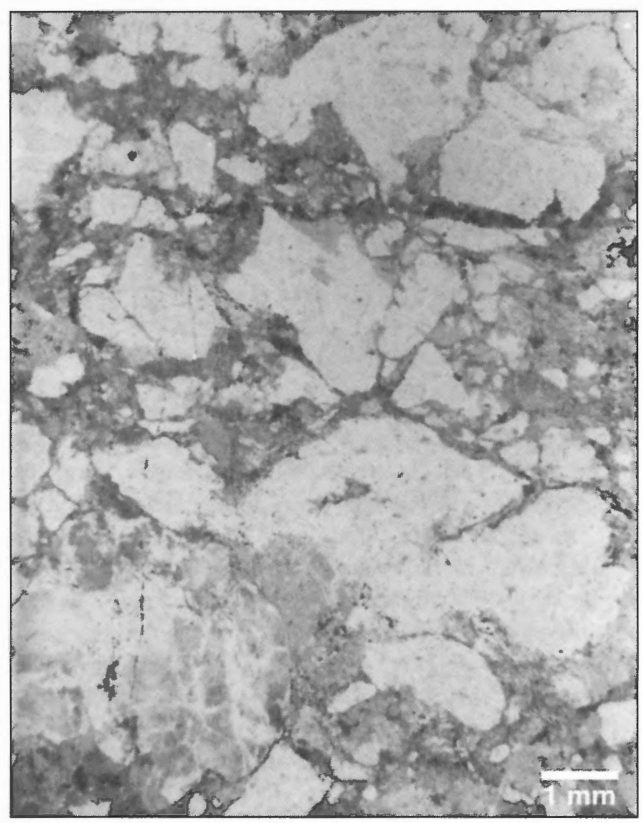



*Figure 81. Photomicrograph of an angular, very quartz-rich lag deposit immediately above the weathered unconformity surface shown in Figure 80. Plane-polarized light.*

**Table 7.** Major-element chemical analyses of Keskarrah Group sandstones and probably correlative quartz-rich rocks.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| $SiO_2$ | 71.2 | 86.8 | 66.0 | 69.13 | 91.4 | 79.8 | 85.1 |
| $TiO_2$ | 0.49 | 0.14 | 0.79 | 0.86 | 0.08 | 0.54 | 0.04 |
| $Al_2O_3$ | 12.5 | 5.4 | 16.7 | 15.15 | 4.4 | 7.7 | 6.9 |
| $Fe_2O_3$ | 0.5 | 0.0 | 0.2 | | 0.2 | 0.7 | 0.4 |
| FeO | 3.4 | 1.1 | 4.8 | 9.00[1] | 0.6 | 3.3 | 1.8 |
| MnO | 0.05 | 0.02 | 0.04 | 0.09 | 0.01 | 0.03 | 0.03 |
| MgO | 1.83 | 0.75 | 2.31 | 1.29 | 0.5 | 2.53 | 1.33 |
| CaO | 2.21 | 0.82 | 0.59 | 0.51 | 0.0 | 0.0 | 0.0 |
| $Na_2O$ | 0.6 | 0.0 | 0.4 | 0.24 | 0.0 | 0.0 | 2.6 |
| $K_2O$ | 2.05 | 1.26 | 2.59 | 0.84 | 1.08 | 1.51 | 0.11 |
| $P_2O_5$ | 0.06 | 0.2 | 0.08 | 0.06 | 0.0 | 0.0 | 0.0 |
| S | 0.03 | 0.07 | 0.00 | | 0.0 | 0.27 | 0.25 |
| $CO_2$ | 3.4 | 1.5 | 0.7 | | 0.1 | 0.0 | 0.1 |
| $H_2O$ | 2.2 | 0.4 | 3.2 | | 0.4 | 2.4 | 0.9 |
| LOI | | | | 2.93 | | | |
| | 100.5 | 98.5 | 98.4 | 100.00 | 98.8 | 98.8 | 99.6 |

[1] Total iron

1 Keskarrah Group sandstone (E-346-1)
2 Keskarrah Group sandstone (H-683-2)
3 Keskarrah Group muddy siltstone (E-346-6)
4 Jackson Lake Formation at Yellowknife, average of four sandstone analyses from Jenner et al., 1981
5 Keskarrah Group quartzite at unconformity with Augustus Granite (Fig. 80)
6 Keskarrah quartzite 60 cm above location of sample in analysis 5 (Fig. 80)
7 Quartz-rich, coarse-grained turbidite associated with the Peltier Formation east of the central part of Keskarrah Bay (Fig. 27)

derived from veins and the granite itself, with only minor amounts of highly altered feldspar surviving. Unaltered feldspar was not seen in the conglomerate and quartzite and it first occurs in the coarse-grained greywacke that lies with apparent stratigraphic conformity above the coarser grained sedimentary rocks.

### Greywacke-mudstone turbidite facies

In the southeastern part of the area, a series of greywacke-mudstone turbidites overlies the conglomerate of the Keskarrah Group with apparent conformity (Fig. 27). On the map they have been included in the Contwoyto Formation, but there is reason to believe that this correlation may not be correct.

The contact between the conglomerate and greywacke facies is known to be exposed in only a few places, the best known of which is about 150 m southeast of the small bay 6.4 km east-southeast of the mouth of Keskarrah Bay. The greywacke sharply overlies the Keskarrah Group conglomerate with a few centimetres of coarse-grained grit followed by the turbiditic greywacke. Relief on the contact is about 30 cm over 5 m. The contact between the greywacke and the quartz-rich conglomerate-quartzite sequence a few hundred metres to the northwest (Fig. 80) also may be stratigraphically conformable. The contact between the Keskarrah Group turbidite facies and the Contwoyto Formation is an easterly dipping fault marked by a 10 m wide, highly deformed, sulphide-bearing shear zone of mixed greywacke, argillite, and limestone. The Contwoyto Formation at this break consists mainly of a black, thin-bedded argillite with thin units of limestone, somewhat thicker ashy layers, and several metre-thick dacite units. The normal greywacke-mudstone turbidites and silicate iron-formation that are characteristic of the Contwoyto Formation are also present. This is best seen along the north shore of the moderate-sized bay in Point Lake near the southeast corner of the map area.

The turbidite facies occurs in an easterly to northeasterly facing homocline dipping from 60° to 85° with a maximum outcrop width of about 700 m. It consists mainly of grey to buff-grey greywacke to siltstone in subtly graded beds up to one or more metres thick. Shale at the top of individual bedding units is thin or absent. In places, the bedding is indistinct. Locally steep-sided channels cut down several metres into the underlying beds. Besides grading, the most common sedimentary structures within the beds are parallel laminations. In Figure 80, the exposed sequence contains a thick unit of shale above the coarse-grained greywacke to siltstone turbidite that is more representative of the facies. It is capped by a black, carbonaceous mudstone with disseminated sulphide, a rare rock type that occurs elsewhere within other facies of the Keskarrah Group. The most distinctive feature of the greywacke facies is the presence of scattered granitoid pebbles to small cobbles in the greywacke beds, most commonly at the base of the bed (Fig. 82, 83). These are most common in the more basal parts of the facies above the conglomerate facies. In addition to the scattered pebbles, a lens of conglomerate consisting of strongly deformed quartz porphyry or altered granitoid clasts, was recognized within the turbidite. It occurs high in the section at or near the boundary shear zone that separates the turbidite from that of the Contwoyto Formation. No examples of iron-formation are known to be associated with this greywacke.

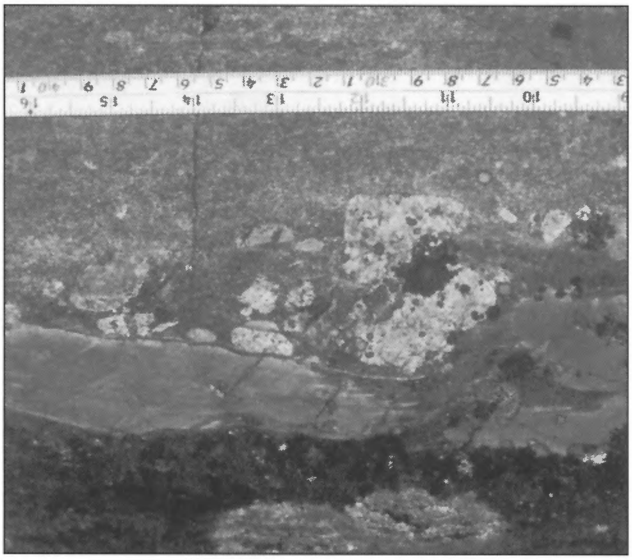


***Figure 82.*** *Coarse-grained granitoid pebbles at the base of a turbidite bed in the Keskarrah Group. GSC 1996-146X*

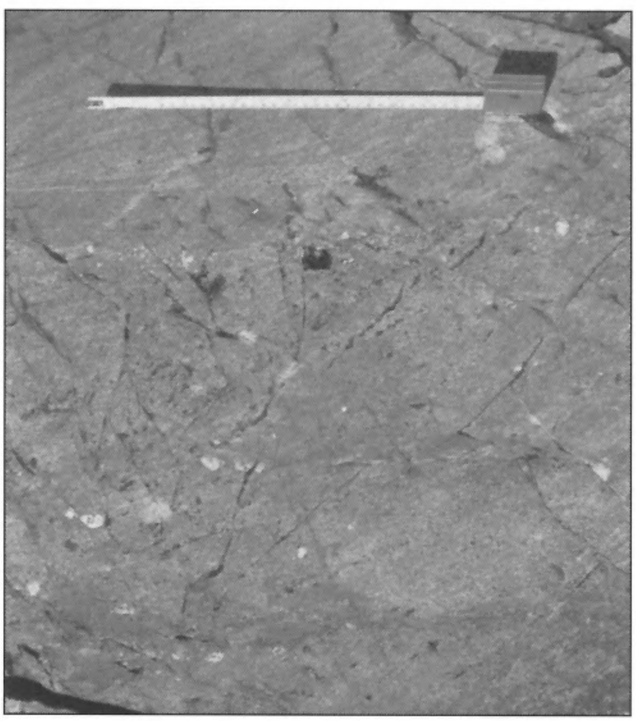


***Figure 83.*** *Thick-bedded, coarse-grained greywacke beds of the Keskarrah Group turbidite facies with scatted granitoid pebbles. Note the crosslaminated scour fill at the top of the photograph. GSC 1996-146R*

Apart from its commonly coarse texture with clasts up to several centimetres long, the greywacke is petrographically similar to that of the Contwoyto Formation. It consists of quartz, plagioclase, and a variety of rock fragments, all of which grade downward to arbitrarily defined, matrix-sized material (Fig. 84).

Quartz occurs invariably as anhedral angular grains that form up to half the rock. It is mainly monocrystalline, but many grains consist of multiple domains to highly polygonized grains. In some cases, the individual domains are intricately sutured in a rock whose minimal deformation is expressed by a weak fabric.

Feldspar is the least abundant of the major clast types, commonly making up less than one quarter of the rock or being completely absent. It is mainly plagioclase, although rare examples of perthite are present. The degree of alteration is highly varied, with some more altered examples grading into clasts of indeterminate origin.

Rock fragments are the most abundant clast type and vary from distinct granitoid clasts to fine-grained or cryptocrystalline leucocratic grains of indeterminate origin. Intact granitoid rock fragments are most abundant in the coarser grained greywacke, since they would have broken down to their constituent minerals in the finer grained sedimentary rocks. They consist of multiple-grained aggregates of quartz and feldspar with the feldspar ranging from clear, unaltered minerals to fine-grained aggregates of feldspar alteration products that are indistinguishable from many of the other fine-grained clasts in the rock. The much more abundant fine-grained clasts range from the presumably altered feldspar grains to very fine-grained quartzofeldspathic material to recrystallized chert-like grains, all of which have a different composition judging from their slight variations in texture and colour. Many of these grains have diffuse boundaries with one grain essentially grading into the next across a matrix that is composed in large part of the more comminuted equivalents of the coarser clasts. These finer grained clasts have been to some extent recrystallized as a result of middle- to upper-greenschist metamorphism that resulted in the growth of biotite-chlorite-white mica assemblages. Rare coarse muscovite occurs as a detrital phase.

## Crossbedded sandstone facies

The crossbedded sandstone facies of the Keskarrah Group occurs only south of Point Lake, both east and west of Keskarrah Bay. In both areas, it unconformably overlies the Peltier Formation mafic volcanic rocks although in most localities, shearing at the contact tends to obscure the relationship. West of Keskarrah Bay, the sandstone underlies the dominant conglomerate facies on the western limb of the synform, but is interlayered with the conglomerate on the eastern limb. The contact between the two was seen in only one locality on the western limb where the sandstone contains only minor thin lenses of conglomerate and sharply overlies the conglomerate, the contact having a relief of a few tens of metres. East of Keskarrah Bay, the dominant sandstone sequence contains a few mappable units of conglomerate, but the rocks are more highly deformed and less well exposed. More argillaceous, fine-grained sandstone, lithologically more similar to the greywacke-mudstone turbidites of the Contwoyto Formation, occurs east of the crossbedded sandstone; however, deformation and poor exposure obscure the stratigraphic relationships.

The sandstones typically weather, white to buff and less commonly yellow to greenish, and are grey on fresh surfaces. They are significantly lighter in colour than the greywackes of the Contwoyto Formation. They occur in generally parallel-sided beds that range from a few centimetres to 1 m in thickness and are commonly separated by thin, argillaceous interbeds (Fig. 85). Many beds contain small, tangential crossbeds, some of which are accentuated by brownish-weathering, recessive carbonate concretions (Fig. 86). Metre-scale crossbeds occur more rarely (Fig. 87). Other beds are essentially featureless or contain only parallel lamination due to, or at least accentuated by, deformation. The sandstone itself is medium grained to fine grained and, in hand specimen or at outcrop scale, scattered quartz grains seem to float in a much finer matrix. Conglomerate layers within the sandstone sequence are rare, occurring in thin, pebbly units of mafic volcanic and felsite pebbles near a contact with the conglomerate facies.

The sandstones are composed of varied proportions of quartz, lithic clasts, and feldspar in an abundant matrix (Fig. 88, 89). They are poorly sorted, with grain sizes of typically less than 1 mm grading down to matrix size. Some coarser grained sandstones have a maximum grain size of

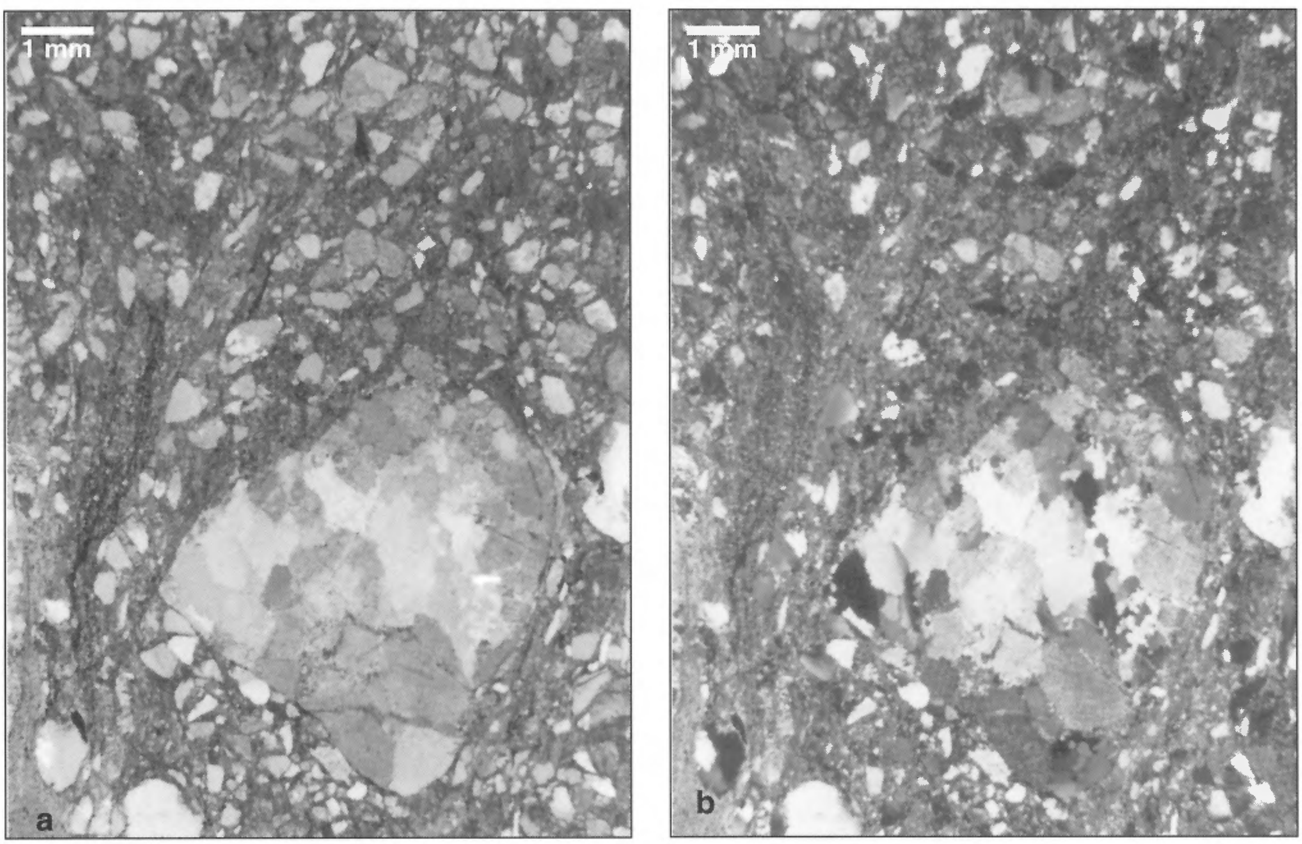



***Figure 84.*** *Photomicrographs of coarse-grained greywacke from the Keskarrah Group turbidite facies. The coarsest grains and some of the finer grained material are granitoid rock fragments consisting of aggregates of quartz and feldspar.* ***a)*** *Plane-polarized light,* ***b)*** *cross-polarized light.*

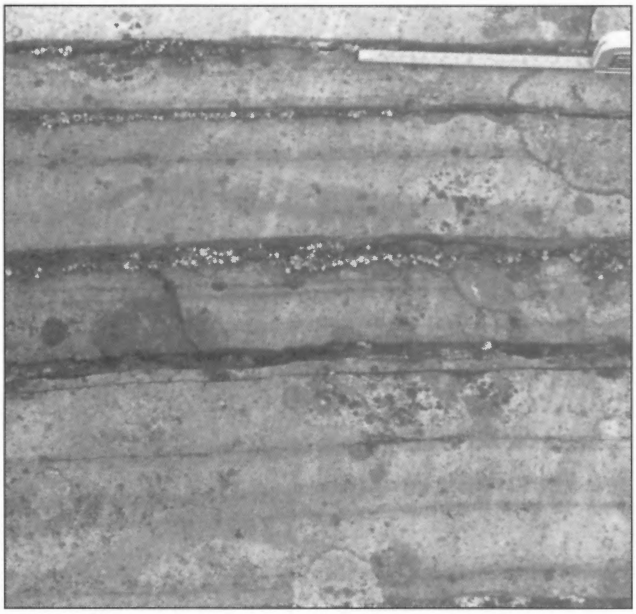


*Figure 85. Parallel-sided sandstone beds with thin, argillaceous beds to laminae in the shallow-water sandstone facies of the Keskarrah Group. GSC 163041*

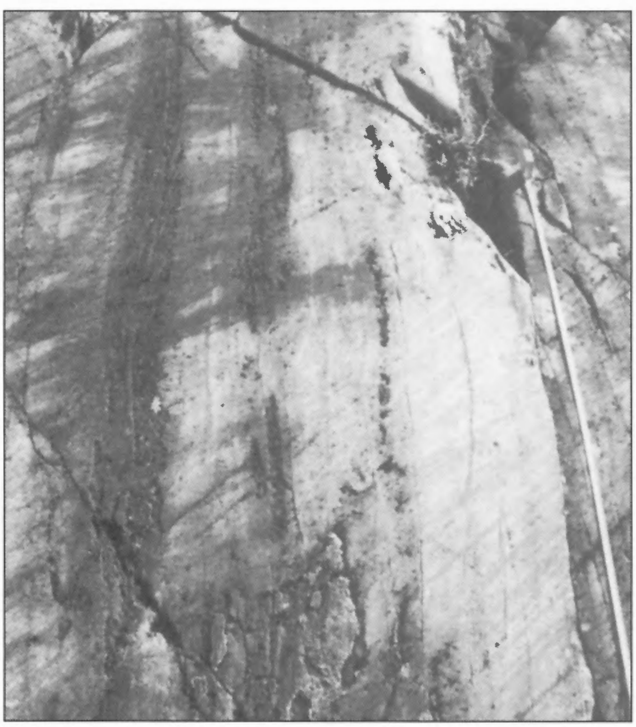


*Figure 86. Tangential crossbeds outlined by carbonate concretions in the shallow-water sandstone facies of the Keskarrah Group. GSC 1996-146Y*

3 mm or more. The varied degree of deformation is shown primarily by the softer rock fragments that are typically elongate and commonly wrapped around the more resistant quartz and feldspar. Quartz, occurring mainly as anhedral, angular, monocrystalline grains, forms between 35 and 60 per cent of the rock. While most grains are monocrystalline, many consist of two or more domains of irregular size with irregular sutured margins typical of plutonic quartz. Finely polycrystalline to almost chert-like quartz grains are less abundant but still common, and are more reminiscent of quartz in mylonite. Whereas some of the highly polygonized quartz grains are very clean, others contain small amounts of very fine chlorite and unidentified opaque material. This latter type is commonly more diffusely defined against the matrix and grades into some of the rock-fragment clasts. In a few cases, some of the quartz in a sample has thin, discontinuous, optically continuous quartz overgrowths of indeterminate generation.

Lithic clasts, the second most abundant component, make up from 25 to 50 per cent of the rock. The least common are plutonic clasts consisting of aggregates of quartz and feldspar or their highly altered equivalent; they are present everywhere but in the finest grained sandstones. Most lithic clasts are very fine grained and of heterogeneous composition. Individual lithic grains are internally homogeneous, which allows them to be distinguished from the matrix. The composition ranges from finely polycrystalline

*Figure 87. Large-scale crossbeds in shallow-water sandstone of the Keskarrah Group. GSC 1996-146BB*

quartz, to more quartzofeldspathic material with white mica and chlorite, to chlorite-feldspar aggregates and massive chlorite. Less commonly, aggregates of white mica and lesser amounts of quartzofeldspathic material are suggestive of a more pelitic source. The origin of most clasts, however, is difficult to determine unequivocally. The more mafic clasts, dominated by chlorite and in some cases containing slightly coarser grained, elongate feldspar microlites, are most likely representative of a mafic volcanic source. The more quartzofeldspathic clasts with varied amounts of white mica and chlorite could represent fine siltstone, intermediate or felsic volcanic material, or altered coarse-grained feldspar. The more siliceous clasts that grade with increasing purity into the finely polygonized quartz could be derived from a variety of sources such as chert, silcrete, or mylonitized quartz.

Feldspar is the least abundant component, typically forming less than 15 per cent of the rock. The most abundant and easily recognized grains are prominently albite-twinned, moderately to strongly altered plagioclase. Untwinned feldspar is less common and is also variably altered. Only a few examples of perthite similar to that in the nearby Augustus Granite were recognized. Similar feldspars also occur as granitoid lithic clasts. A common, but minor, component of the sandstones are millimetre-scale flakes of detrital muscovite, a mineral rarely if ever present in coarse form in the nearby Augustus Granite. Even less common in the sandstones are rare detrital biotite flakes, altered to chlorite.

The matrix is a varied component of the rock whose proportion depends on postdepositional events such as diagenesis, metamorphism, and deformation. It consists of a fine-grained assemblage of feldspar, quartz, and chlorite with varied amounts of white mica, epidote, and carbonate. It is gradational with the lithic clasts from which it was largely derived during diagenesis and metamorphism.

The results of major-element chemical analyses of the sandstones and a silty mudstone from this facies are provided in Table 7 along with an average of several analyses of sandstone from the Jackson Lake Formation at Yellowknife, to which this formation is lithologically similar.

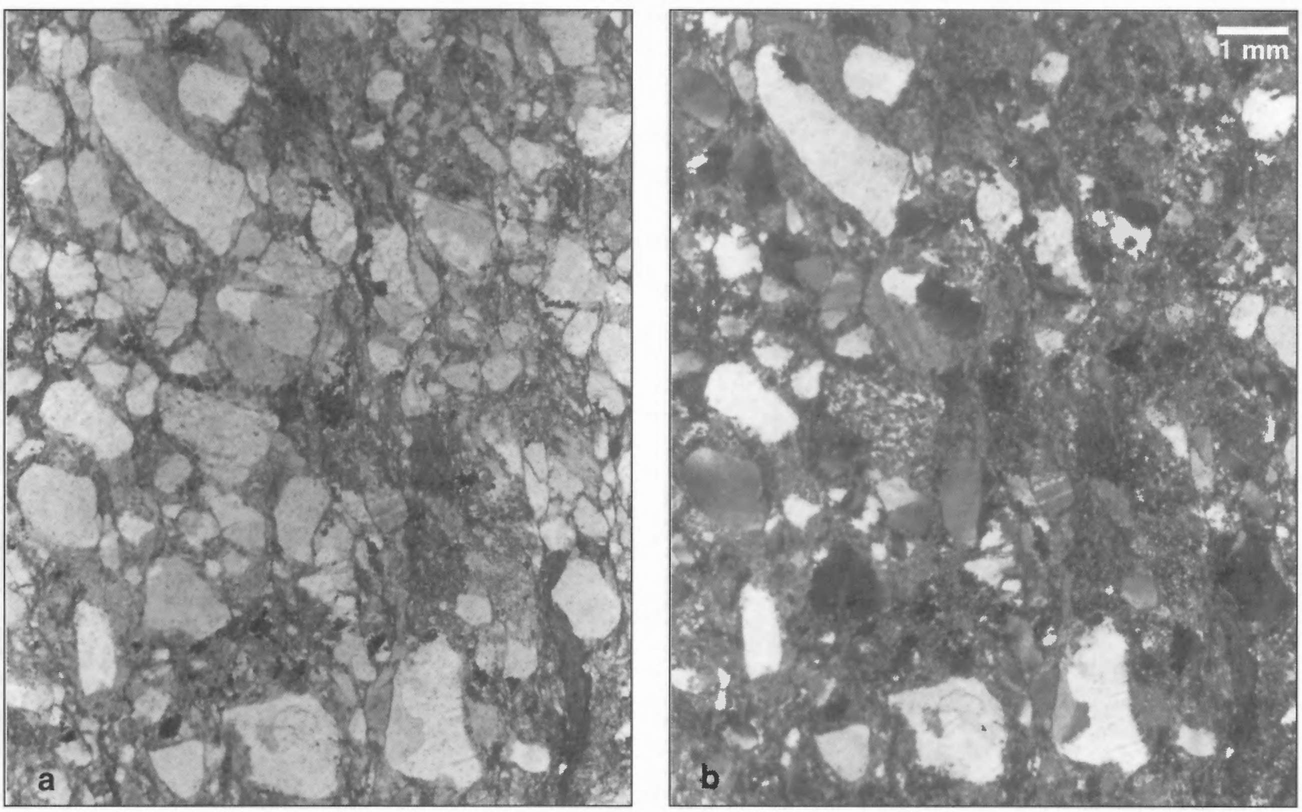



***Figure 88.*** *Photomicrographs of sandstone from the shallow-water sandstone facies of the Keskarrah Group. Quartz-rich clasts predominate and vary from single grains to polycrystalline grains from a variety of sources, from mylonite to possibly silcrete. Fresh feldspar is present in very small amounts, whereas abundant grains consisting largely of very fine quartzofeldspathic aggregates may represent feldspar altered before deposition.* ***a)*** *Plane polarized light,* ***b)*** *cross-polarized light.*

## Discussion

### *Provenance*

The clast population of the conglomerates indicates that the Keskarrah Group was derived from a source dominated by mafic volcanic and granitoid rocks. The mafic volcanic clasts are almost everywhere the most abundant. They are most likely to have been derived from the Peltier Formation volcanic rocks that, in many cases, immediately underlie them. Intermediate to felsic volcanic clasts are more common north of Point Lake where the only apparent external sources are the Samandré and Beauparlant formations to the east. The bulk of the granite clasts is also locally derived, primarily from the nearby Augustus Granite, although granitoid rocks and granitoid gneisses of other derivation are more abundant in the western Keskarrah Group.

The petrology of the sandstone facies suggests a provenance dominated by granitoid and to a lesser extent mafic volcanic rocks similar to that reflected in the associated conglomerate facies. In both shallow-water sandstone and turbidite facies, the angularity of the quartz together with the relatively low proportion of feldspar, much of which is strongly altered, suggest a local, extensively weathered source. The abundance of finely polygonized quartz is strongly reminiscent of that seen throughout much of the nearby Augustus Granite, as presently exposed. The presumed older granitoid gneisses that occur west of the boundary shear zone are another candidate, although the quartz in those rocks at the present erosion level is generally more annealed than much of the finely polygonized quartz in the sandstones. If the Augustus Granite had been a major contributor of quartz to the sandstone, then it would have been deformed to some degree prior to the deposition of the Keskarrah Group.

Traditionally, many fine-grained rock fragments in greywackes of the Yellowknife Supergroup have been interpreted as felsic and intermediate volcanic rock fragments (e.g. Henderson, 1985). This is clearly the case when such grains contain phenocrysts of quartz and/or feldspar although, given the grain size of the sandstone, examples of grains containing phenocrysts are rare. None were seen in the Keskarrah Group sandstones. On the other hand, since some of these fine-grained clasts are petrographically similar to altered feldspars in weathered granitoid rocks, they

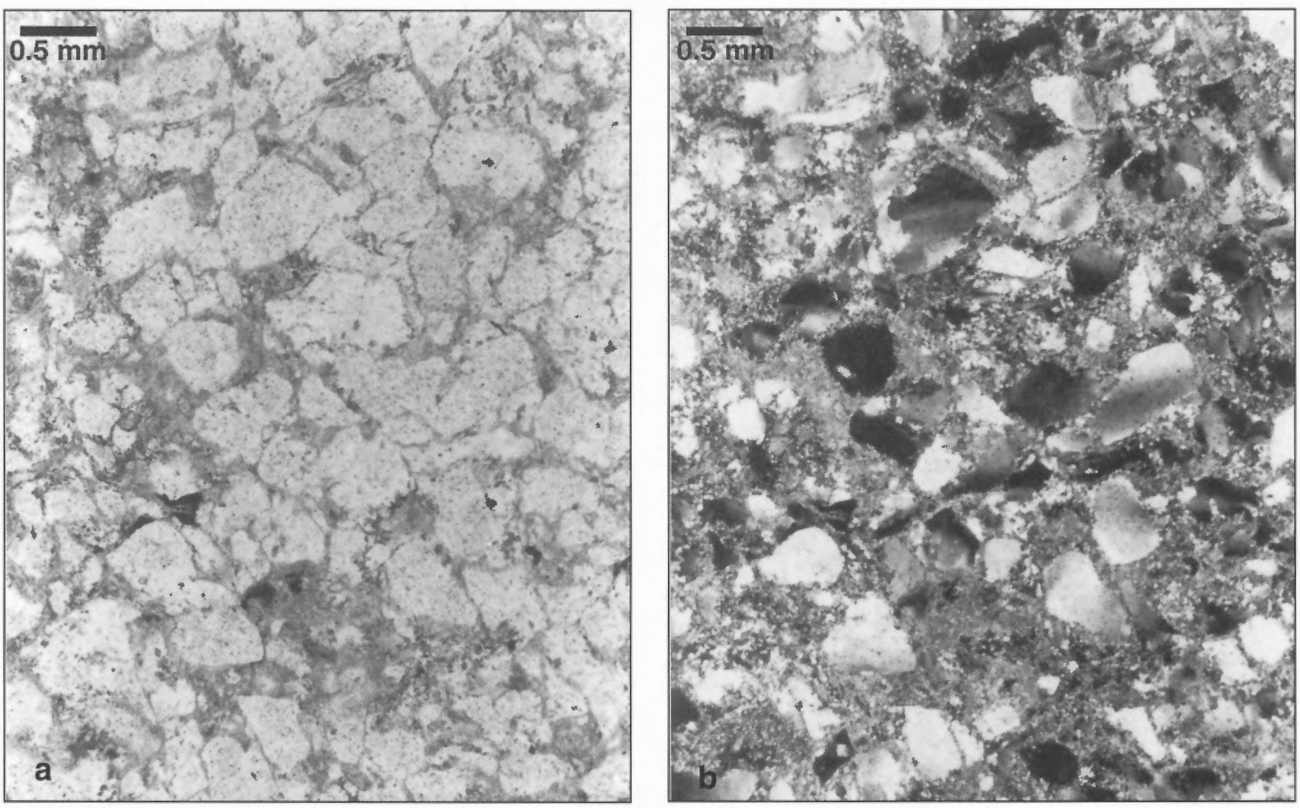



***Figure 89.*** *Photomicrographs of unusual, extremely quartz-rich, shallow-water sandstone from the Keskarrah Group. Over 90 per cent of the framework clasts are quartz and they vary from single-crystal quartz grains to finely polycrystalline quartz. The remainder, except for one or two grains of somewhat altered feldspar, are relatively soft, very fine-grained mineral aggregates dominated by white mica, which are commonly deformed against the quartz grains and may represent feldspar that was completely altered as a result of predepositional weathering.* ***a)*** *Plane-polarized light,* ***b)*** *cross-polarized light.*

may represent a granitoid component as well (Schau and Henderson, 1983). Given the ample evidence for a weathered source from the associated conglomerates and the weathered aspect of the underlying Augustus Granite (Schau and Henderson, 1983; this report), an extensive, weathered, granitoid domain may have been the source of these sandstones.

A component of some deeply weathered areas is silcrete, an extremely siliceous rock formed through the solution and precipitation of silica. It consists of quartz clasts of varied sizes in a matrix of microcrystalline quartz and chalcedonic silica (Summerfield, 1983). Detritus from such a source could have produced some of the more siliceous clasts that are recrystallized into fine-grained, dominantly quartz aggregates, as well as the overgrowths on some quartz grains. Fine-grained, polymineralic, lithic clasts are a major component of the sandstone, particularly if one includes the abundant and largely postdepositionally generated matrix thought to be largely derived from them. Whereas some of these clasts are clearly of mafic volcanic origin, the source of much of them is more equivocal, in large part due to extensive predepositional and postdepositional alteration.

*Environment*

Despite considerable subsequent deformation of the Keskarrah Group and the lack of a detailed sedimentological-stratigraphic analysis, the group is obviously dominated by a great abundance and thickness of conglomerate. An alluvial fan or associated fan delta is about the only environment in which a great thickness of conglomerate can be expected to accumulate; glacial tills are a second, rather remote possibility easily eliminated by the relatively good sorting of the conglomerate and the presence of texturally defined stratigraphic layers within the Keskarrah Group (Rust, 1979). Two sandstone facies are associated with the conglomerate. The crossbedded sandstone facies that presumably represents a shallow-water environment is found to the west. Although originally interpreted as subaerial deposits (Henderson and Easton, 1977; Bostock, 1980), Corcoran et al. (1995, 1996) and Corcoran and Mueller (1997) have recently suggested that this sandstone facies may represent a braidplain or shallow-water shoreface to wave-influenced shoreface to lower shoreface. In the easternmost exposures of the formation, the second sandstone facies consists of thick-bedded, coarse-grained turbidite and conformably overlies the Keskarrah Group conglomerate. The presence of a lens of conglomerate within this turbidite facies lead Kusky (1991) to conclude that the conglomerate, including the crossbedded sandstone facies, represents coalesced, upper-fan channel deposits of a submarine fan system. Although it seems unlikely that all of the formation represents a deep-water, submarine-fan environment, parts of the conglomerate probably did accumulate in deep water, as indicated by turbidite units a few metres to tens of metres thick within the conglomerate sequence, particularly in the northern parts of its outcrop area. Given then that the Keskarrah Group consists of a dominant, crudely layered, clast-supported, conglomeratic facies with associated fluvial to deep shoreface sandstone facies in the west and turbiditic sandstone facies in the east, it is considered to represent the remnants of a fan delta or fan delta complex. This was defined by Nemec and Steel (1988, p. 7) as "a coastal prism of sediments delivered by an alluvial fan system and deposited, mainly or entirely subaqueously, at the interface between the active fan and a standing body of water". As such, it represents the transition from subaerial to below wave base sedimentation over a distance of 10 or 15 km.

Thick accumulations of dominantly coarse sediment in an alluvial fan or fan delta imply a high-relief source with abundant sediment yield with an abrupt transition to low gradients, a situation best accommodated by a basin bounded by high-angle reverse, normal, or transcurrent fault systems (Fraser and Suttner, 1986). In the Keskarrah Bay area, such a fault system may be the early stages of the major, northerly trending, ductile fault zone and associated faults that separate the dominantly Yellowknife Supergroup supracrustal domain to the east from the mainly granitoid and granitoid gneiss domain to the west and contains the Keskarrah Group (see also Corcoran and Mueller, 1997). Evidence supporting this would be the change from shallow-water facies in the west to deeper water facies in the east. The greater heterogeneity of the granitoid clasts in the west implies greater input from the granitoid gneiss domain that may have become exposed as a result of faulting, whereas the eastern conglomerates are dominated by Augustus Granite clasts that reflect a more local source within the basin responding to smaller, associated faults of the system. Although much of the sandstone facies is crossbedded, the rocks are mostly too deformed to provide useful paleocurrent directions. One exception is the minimally deformed conglomerate west of the mouth of Keskarrah Bay where crossbedded sandstone lenses and layers suggest a northeasterly sense of transport.

*Age*

The unconformable relationship and the slight difference in trend between the Keskarrah Group and the underlying Peltier and Contwoyto formations suggest that the Peltier and Contwoyto formations were deformed to some degree prior to deposition of the Keskarrah Group. This would imply a time break of undefined duration. Preliminary geochronological data from detrital zircons recovered from a quartz-rich sandstone unit within the conglomerate facies range in age from 3.38 Ga to 2600 Ma (Isachsen et al., 1993). If the youngest age represents the age of the rock from which the conglomerate was derived, then the conglomerate is younger than 2600 Ma. Bostock (1980) reports K/Ar muscovite ages of 2560 ± 75 and 2660 ± 75 Ma from granitoid boulders taken from a Keskarrah Group conglomerate that he considers to be metamorphic ages.

*Volcanic units associated with the Keskarrah Group*

Lenses of mainly mafic, but also intermediate, volcanic rocks are associated with both the sandstone and conglomerate facies of the Keskarrah Group. These lenses are described and discussed in the sections on mafic volcanic rocks and intermediate and felsic volcanic rocks. Their original relationship to sedimentary rocks of the Keskarrah Group is equivocal because of extensive shearing at the contacts. One possibility is that the mafic volcanism was synsedimentary. In map view, projections of pillowed mafic volcanic rocks of the Peltier Formation extend into the Keskarrah Group; they might suggest a possible contemporaneous interfingering relationship between the two. However, the probable structural discordance between the Keskarrah Group and the Peltier and Contwoyto formations together with the apparent temporal separation of the Keskarrah Group and the Peltier Formation that could reach 70 Ma (Isachsen et al., 1993) make such a contemporaneous relationship unlikely. In addition, the association of alluvial-fan to fan-delta sedimentation and pillowed mafic volcanism is not common (Fraser and Suttner, 1986). Where known, pillowed mafic volcanic rocks are typically found with adjacent lacustrine deposits (e.g. Upper Triassic of Connecticut [Philpotts, 1992]) or basinal turbidites (e.g. Tertiary of California [Cole and Stanley, 1992]), but not interlayered with coarse-grained, alluvial or fan-delta deposits. Corcoran et al. (1996) suggested that the associated mafic volcanic rocks represent original topographic highs from which detritus was shed to form the conglomerates of the Keskarrah Group. The apparent interfingering in the contact areas of the Peltier Formation and the Keskarrah Group may be due to fold culminations and structural interleaving of the volcanic and sedimentary rocks by synsedimentary to postsedimentary faulting. By extension, the mafic to intermediate volcanic lenses may similarly be explained as Peltier Formation or other volcanic rocks isolated within the Keskarrah Group by folding and/or faulting.

*Quartzofeldspathic sandstones and conglomerates associated with the Peltier Formation*

Several small units of conglomerate and sandstone occur within the Peltier Formation and are described in the section on that unit. In summary, two conglomerate lenses similar to the main sequences of Keskarrah Group conglomerate occur in the Peltier Formation east of Keskarrah Bay, one just south of the large area of Keskarrah Group conglomerate along a possible fault within the Peltier Formation (Fig. 27) and the second at the sheared contact between the Peltier Formation and adjacent Augustus Granite. Given their close association with fault zones, both may be correlative with the Keskarrah Group, which implies that their present position is more likely due to structural rather than to stratigraphic events. Easton et al. (1982) report the occurrence of 50 to 100 cm of quartz-pebble conglomerate between the highly deformed volcanic rocks of the Perrault Lithodeme and the gneisses of the western granitoid and granitoid gneiss domain. They suggested that this conglomerate may occur at an unconformity between the gneisses and the volcanic rocks. Given the structural complexities of this highly tectonized zone, the significance of this conglomerate layer and any relationship it might have to the deformed mafic rocks remain in doubt.

Decimetre-thick sequences of black pelite containing massive, turbiditic sandstone beds up to 1 m in thickness are associated with the Peltier Formation at three localities, two east of Keskarrah Bay (Fig. 27) and one west of Keskarrah Bay in the narrow zone of Peltier Formation between the Keskarrah Group proper and the Augustus Granite. In all cases, the sandstones consist of coarse-grained, mainly angular quartz and moderate amounts of unaltered to altered plagioclase and microcline in a sparse matrix of fine-grained quartz and altered feldspar. An exclusively granitoid provenance is indicated and the sedimentary products have undergone significantly less posterosion sedimentary differentiation than the two sandstone facies of the Keskarrah Group. Two of the three localities are close to or associated with fault zones and the third, on the shore on the east side of Keskarrah Bay, could be as well. It is not yet clear whether some or all of these sandstones, like the conglomerate lenses, are correlative with the Keskarrah Group or whether they are synvolcanic with the Peltier Formation, which is a possibility if synvolcanic faulting exposed the Augustus Granite or some other granitoid source.

*Regional correlations*

Conglomerate-dominated units similar to those of the Keskarrah Group are a volumetrically minor rock type that occurs in several localities in the Slave Province. Roscoe et al. (1989) noted that they may be restricted to the western and northwestern parts of the province. The largest occurrence of these conglomerates is in the Winter Lake area south-southeast of the map area (Hrabi et al., 1995); there they occur discontinuously along a narrow zone over about 100 km and represent a southward extension of the Keskarrah Group conglomerates from the southeastern corner of the map area. As with the Keskarrah Group, the unit is dominated by polymictic conglomerate with lesser amounts of crossbedded and massively bedded sandstone facies (Hrabi et al., 1995). At Yellowknife, the Jackson Lake Formation bears a strong lithological and sedimentological resemblance to the Keskarrah Group and occurs in a similar structural setting (Henderson, 1975c). There the polymictic conglomerate facies at the base of the sequence is less abundant than the crossbedded sandstone facies, although thin units of conglomerate within the sandstone facies are much more common than in the Keskarrah Group. Also in the southern Slave Province, 75 km and 115 km northeast of Yellowknife respectively, the Raquette Lake Formation (Henderson, 1985) and the Beaulieu Rapids Formation (Roscoe et al., 1989; Rice et al., 1990) are associated with the mafic volcanic sequences that mantle the Sleepy Dragon granitoid and granitoid gneiss complex. However, Bleeker (1996) has suggested that in contrast to most of the other polymictic conglomerates of the Slave Province, the Raquette Lake Formation was deposited on a synvolcanic unconformity surface that predated the deposition of the extensive greywacke-mudstone turbidites in the region. In the western Slave Province near Arseno Lake, 140 km southwest of Keskarrah Bay, up to 450 m of amphibolite-grade, polymictic conglomerate unconformably overlie mafic volcanic rocks and are reported to interfinger with Yellowknife Supergroup metagreywacke (McGlynn and Ross, 1963; Frith, 1991). Volcanic rocks north of Point Lake include the conglomerate and quartzite near the south end of Napatulik Lake (Gebert, 1994) and that associated with the Anialik volcanic belt at the northern coast (Tirrul and Bell, 1980; Jackson, 1989b; Relf, 1994). West of Bathurst Inlet in the Turner Lake area, a narrow, 15 km long, discontinuous zone of polymictic conglomerate lies unconformably above Yellowknife Supergroup greywacke and minor iron-formation (Roscoe et al., 1988; Jefferson et al., 1990).

In most cases, there is evidence for an unconformity between the conglomerates and the associated Yellowknife Supergroup supracrustal rocks. In almost all cases, the conglomerates unconformably overlie mafic volcanic rocks of the Yellowknife Supergroup although at Keskarrah Bay, they also overlie immediately adjacent greywacke-mudstone turbidites and part of the Augustus Granite. The only real exception is the Turner Lake example where the conglomerates overlie only metasedimentary rocks; any volcanic rocks in the area are minor and remote from the conglomerates. Most examples of conglomerate represent the youngest Archean supracrustal rocks in the region. The two exceptions, the Raquette Lake Formation northeast of Yellowknife and the conglomerates near Arseno Lake in the western Slave Province, occur within the mafic volcanic–greywacke-mudstone sequence, although in both cases, the unconformity is developed on mafic volcanic rocks.

The conglomerates everywhere seem to be in metamorphic context with the rocks they unconformably overlie; most are at greenschist grade, but in areas where the grade of the metavolcanic or metasedimentary rocks is higher, so is that of the conglomerate. Preliminary dating of granitoid clasts or detrital zircons from some of the conglomerates has provided ages as young as 2600 Ma (Isachsen et al., 1993; Isachsen and Bowring, 1994; Villeneuve and van Breemen, 1994), which falls about midway in the range of ages of the batholithic intrusions that largely postdate the Yellowknife Supergroup (Villeneuve and van Breemen, 1994). Despite this, no unconformable relationship between any of these granites and the conglomerate is known.

Given the relative proportions by area of metasedimentary to metavolcanic rock throughout the Slave Province, this close association of the conglomerates with the mafic volcanic rocks must be of some significance. Mafic volcanic sequences and, where present, conglomerates and associated sandstones commonly occur at the margins of the supracrustal domains. This may indicate a possible link between early faulting (the event that resulted in sedimentation of the alluvial-fan to fan-delta conglomerate and sandstone) and the definition of the preserved Yellowknife Supergroup supracrustal domains. While there is everywhere an unconformity between the conglomerates and the associated Yellowknife Supergroup supracrustal rocks, these rocks remain approximately concordant. This suggests either that the volcanic rocks were only minimally deformed prior to deposition of the conglomerates or, if they were more intensely deformed, that they were transposed into near concordance by subsequent deformation.

## AMPHIBOLITE

Amphibolite units occur throughout the map area and are of varied ages, from Archean synvolcanic intrusions to highly discordant, probably Paleoproterozoic, metadiabase dykes. They are particularly common in the mafic volcanic and various granitoid units near the main structural break that separates the dominantly Yellowknife Supergroup domain from the dominantly granitoid to granitoid gneiss domain to the west. This is also where most of the largest amphibolite bodies occur.

Most amphibolite units have been described and discussed with the Archean units within which they occur or to which they are associated in the sections on the western granitoid gneiss domain, the Peltier Formation, and the Contwoyto Formation, but most comprehensively in the sections on the Augustus Granite and the Perrault Lithodeme. Peltier Formation mafic volcanic rocks contain abundant medium- to coarse-grained amphibolite sills that are considered to be synvolcanic. Layers to lenses of metagabbroic rock also occur within the Perrault Lithodeme, which is considered to be the highly deformed equivalent of the Peltier Formation. Metagabbroic bodies in the Perrault Lithodeme, however, have a much greater range of compositions, from ultramafic to leucogabbroic, although most are metagabbroic. In contrast to the highly deformed mafic volcanic rocks that make up the bulk of the unit, the coarser grained amphibolitic bodies exhibit highly varied degrees of deformation, ranging from amphibolitic schist to lenses in which relict igneous textures are still apparent. It was suggested previously that some of these amphibolitic intrusions were emplaced at various stages during the evolution of the major shear zone. Similarly, in the Contwoyto Formation, amphibolite lenses and layers too small to be mapped separately occur only near the shear zone where the Contwoyto Formation is in contact with the Perrault Lithodeme. In the Augustus Granite, a suite of variously deformed, blocky to elongate, rhombohedral amphibolite intrusions and dykes of slightly varied composition and degrees of deformation occur mainly near the shear zone. The intrusion of these bodies is thought to be related to movement along this structure.

A suite of east-trending amphibolite dykes that are considered to be Paleoproterozoic occurs throughout the area. These dykes are described in more detail in the following section on diabase dykes. Although primary igneous textures are commonly preserved in these rocks, no original mafic minerals are preserved, the feldspars are typically extensively altered and in some cases recrystallized, and fine actinolitic amphibole is commonly present.

Two thick, northwesterly trending, parallel-sided amphibolite bodies present contrasting contact relationships to the enclosing rocks. At the southern shore of the northern arm of Point Lake, an amphibolite body transects the northernmost Keskarrah Group rocks at a high angle. In the southeastern part of the map area, a similar amphibolite occurs at the contact between the Augustus Granite and the overlying Keskarrah Group turbidites. Their relationship to other amphibolitic units in the area or to each other is unknown.

## GRANITOID ROCKS THAT POSTDATE ALL OR MOST OF THE YELLOWKNIFE SUPERGROUP

### *Western foliated granitoid and granitoid gneiss domain*

An extensive domain containing in large part granitoid rocks that are presumed to postdate all or most of the Yellowknife Supergroup is found west of the major shear zone that separates it from the Yellowknife Supergroup supracrustal domain to the east. This granitoid-dominated terrane extends approximately 80 km west beyond the map area (Fig. 1, 2). It has been mapped by Easton (1981) and Easton et al. (1982), both within the map area and 40 km west of it.

Within the map area, the contact between the granitoid rocks and the older orthogneisses and paragneisses with which they are associated is intrusive with the larger gneiss bodies being essentially large enclaves in the granitoid domain. The gneisses are extensively intruded by dykes, sills, and irregular bodies of the younger granitoid rocks. The size and number of gneissic enclaves decrease westward and the enclaves all but disappear in the granitoid domain just beyond the present map area (Easton, 1981; Easton et al., 1982). The contact between the granitoid domain and the largely volcanic rocks of the Yellowknife Supergroup is a major shear zone. Rare sills and lenses of highly deformed granitoid rock occur locally in the layered amphibolites of the mylonitic Perrault Lithodeme. They are thought to be related to intrusions of the western granitoid domain, either as deformed small intrusions or as deformed, tectonically eroded blocks from the adjacent granitoid gneiss domain.

Granitoid rocks ranging in composition from granite to granodiorite to local tonalite dominate the domain. They are pink through white to grey, typically medium grained, and even grained, with biotite as the dominant mafic mineral and with local hornblende (Easton, 1981; Easton et al., 1982). Zones of microcline megacrystic granite approximately 1 km wide and 10 km long occur in the map area; they are larger and more abundant to the west (Easton, 1981). Several phases of intrusion are apparent on the basis of crosscutting relations and contrasting degrees of deformation. These include a suite of aplitic dykes that are commonly steeply discordant to the layered units in the domain, as well as muscovite-bearing pegmatites present in varied proportions that locally form large bodies approaching 1 km in length and in places constitute up to 80 per cent of the rock.

Much of the granitoid domain within the map area contains abundant inclusions of orthogneiss and paragneiss. Areas dominated by either of these inclusion types are indicated on the map. These rocks are described and discussed in an earlier section. The orthogneiss consists of several generations of heterogeneous, complexly deformed, quartzofeldspathic rocks. The complexity and limited preliminary geochronology suggest that a component of these gneisses may predate the Yellowknife Supergroup. The paragneiss, on the other hand, bears a strong lithological resemblance to high-grade equivalents of Yellowknife Supergroup metasedimentary rocks. Both the orthogneiss and the paragneiss contain amphibolites of largely unknown and probably varied origin that are particularly abundant close to the boundary shear zone. In some cases, the amphibolites are similar to the thinly layered amphibolites of the Perrault Lithodeme.

Most rocks in the granitoid domain have a weakly to moderately developed, northeasterly trending foliation similar to the structural trends seen in many places in the southwestern Slave Province between Yellowknife and western Point Lake. The elongate zones of megacrystic granite within the domain also parallel this trend. To the east, the foliation becomes more northerly directed and more strongly developed as the northerly trending boundary shear zone is approached. With the increasing degree of deformation, the original igneous textures of the granitoid rocks become granulated to mylonitic, quartz grains become elongate to ribboned, the mafic minerals are altered to chlorite, and the rocks become salmon pink. These rocks contain steeply to shallowly plunging, easterly to northeasterly trending stretching lineations (Jackson, 1989a; Kusky, 1989). In general, the pegmatites and, to a lesser extent, the aplitic dykes are less deformed. In one case, a pegmatite body within a few hundred metres of the structural break retains its igneous textures. This suggests that much of the deformation along the shear zone predated the emplacement of the pegmatites.

The intrusions in the granitoid complex are assumed to postdate all or most of the rocks of the Yellowknife Supergroup. They cut the metasedimentary and metavolcanic paragneiss inclusions that, on the basis of their similarity to high-grade Yellowknife Supergroup rocks elsewhere, are thought to be correlative with the Yellowknife Supergroup. Within the complex, about 10 km west of the map area, a large area of Yellowknife Supergroup volcanic and sedimentary rocks (Fig. 1) is intruded by phases of the granitoid complex (Easton, 1981; Easton et al., 1982). The only radiometric data from the complex are preliminary U-Pb zircons data that include a range of ages between 3.22 and 2.82 Ga for tonalite and granite gneisses (Northrup et al., 1997) and the age of the youngest phase of a granitoid gneiss in which the youngest zircons are about 2600 Ma (Krogh and Gibbins, 1978; Easton et al., 1982). This is about midway in the range of ages for intrusions throughout the Slave Province that postdate all or most of the Yellowknife Supergroup (van Breemen et al., 1992; Villeneuve and van Breemen, 1994). No granitoid dykes, sills, or plutons are known to intrude the Keskarrah Group although detrital zircon from these rocks give preliminary ages as young as about 2600 Ma (Isachsen et al., 1993). If these zircon ages represent the age of a component in the source terrain, then the intrusions in this suite or their higher level equivalents would have been emplaced and exposed to erosion prior to or during sedimentation of the Keskarrah Group.

### *Pegmatite and granite*

A swarm of small bodies of pegmatite and locally granite is found within the metasedimentary domain in the eastern part of the area. Most occur within the sillimanite-grade Itchen Formation east of the north-northeasterly trending fault between Point and Itchen lakes, in a diffuse, north-northeasterly trending, lens-shaped zone that terminates south of Point Lake at a large, elongate granite pluton. Only a few pegmatite bodies occur in the sillimanite-grade Contwoyto Formation west of the fault, mostly south of Point Lake, northwest of the large pluton. A few occur in the Itchen Formation east of the pluton, on the eastern side of Point Lake. A few others are found south of Itchen Lake, at some distance from the main concentration of pegmatite bodies, in lower grade Itchen and Contwoyto formation rocks. This granite and pegmatite suite and its geochemistry have been studied by McKinnon (1982).

The pegmatite occurs mainly as steeply dipping dykes, sills, and irregular intrusions within the metasedimentary rocks. These bodies are typically less than 10 m wide, most being 1 or 2 m wide, and tend to be more resistant to weathering than the generally more poorly exposed metasedimentary rocks that host them. Only the largest areas or concentrations of pegmatite are shown on the map. In general, the pegmatite bodies are typically larger and more abundant in the central part of the zone. The pegmatite weathers white, is white to pinkish on fresh surfaces, and varies widely in grain size, in rare cases grading into granite. It consists of plagioclase, microcline, quartz, and muscovite with lesser amounts of biotite, black tourmaline, and some rare garnet. Perthite and graphic granite are common. In some pegmatite bodies, biotite is more abundant than muscovite. No rare-element minerals were observed.

Granite is much less abundant than pegmatite. It forms a single pluton at the southern extremity of the zone, as well as a few small bodies at the western side of the central part of the pegmatite zone. The large pluton is a light grey, medium-grained to medium-fine-grained granite that weathers buff to pinkish white, is weakly foliated, and contains both muscovite and minor biotite. Its contact with the metasedimentary rocks is diffuse, with numerous dykes of both granite and pegmatite and inclusions up to 10 m wide occurring in the contact zone. Pegmatite is found throughout the granite in highly varied proportions. Several larger plutons of granite, some two-mica-bearing and with associated pegmatite, occur just beyond the map area to the east (Bostock, 1980; King et al., 1980a, b) and muscovite-biotite-bearing granite also occurs within the granite complex west of the Yellowknife Supergroup supracrustal domain. Except for the large granite body in the south, the granite is minimally deformed with igneous textures consisting mostly of anhedral forms with no preferred orientation. The southern pluton, possibly because of its proximity to major faults, is more deformed with a weakly developed fabric expressed by mica orientation and elongation of quartz.

This pegmatite and granite is similar to a suite of intrusions that are common throughout much of the Slave Province. They are particularly abundant as large batholiths in the east-central part of the province where they are the most abundant intrusion type in the dominantly metasedimentary domain (Fig. 1; Folinsbee, 1949, 1952; Barnes and Lord, 1954). They also occur in the central part of the metasedimentary domain and granitoid and granitoid gneiss complex northeast of Yellowknife where they are known as the Prosperous and Redout granites respectively (Henderson, 1985). Minerals in the pegmatite associated with the two-mica granite suite can include rare-element minerals containing Li, Be, and Ta-Nb, such as in the Yellowknife region (Kretz, 1968; Cerný, 1990) and at Aylmer Lake in the eastern Slave Province (Cerný et al., 1989). No rare-element minerals other than tourmaline have been recognized to date in the Keskarrah Bay area.

In a petrological and geochemical study of the pegmatite and granite of this suite, McKinnon (1982) concluded, on the basis of their bulk chemistry, that both the pegmatite and granite are the product of minimum melting of an average greywacke, an interpretation supported by oxygen and strontium isotope data. This is consistent with the fact that these granite-pegmatite systems are commonly found emplaced in relatively high-grade Yellowknife Supergroup metagreywacke-mudstone domains and could have been generated from the deeper level, higher grade equivalents of the rocks in which they were ultimately emplaced. It should be borne in mind, however, that in exposures of the partly melted equivalents of the Yellowknife Supergroup metasedimentary rocks, the leucosome phase is typically trondhjemitic and therefore not particularly close to the granite minimum melt compositions approached by these intrusions.

## PROTEROZOIC DIABASE DYKES

Two sets of diabase dykes are recognized in the area, an older, east-trending, Paleoproterozoic set and the north-northwesterly trending, Mesoproterozoic Mackenzie set.

### *East-trending diabase dykes*

Diabase dykes with an east trend occur throughout the area, but are much more abundant in granitoid terrane compared to metasedimentary-dominated terrane. They are typically up to 40 m wide and their trend varies from 070° and 120°. They have no apparent aeromagnetic expression, which may be due in part to their trend being more or less parallel to the flight lines on current aeromagnetic maps of the region (Geological Survey of Canada, 1979a, b, c, d) and to the masking effect of the strongly magnetic Mackenzie dykes and oxide iron-formation. The dykes weather dark green to black. The medium- to fine-grained rocks are finely porphyritic with plagioclase phenocrysts up to 1 cm in length, but more typically less than 5 mm. In the granitoid domain, they commonly contain angular to rounded inclusions of granite up to 5 cm wide (Fig. 90). Primary structures such as chilled margins and ophitic textures are common and the dykes present no deformational fabric. No primary pyroxenes are known and the mafic minerals consist mainly of brownish-green hornblende partly replaced by actinolitic to blue-green amphiboles that are pseudomorphous after the original mafic minerals (Fig. 91).

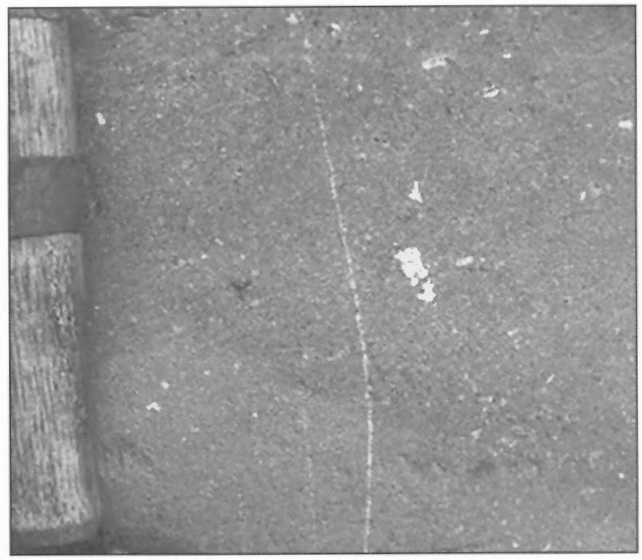


***Figure 90.*** *East-trending Paleoproterozoic diabase dyke that is typically sparsely porphyritic and locally contains small granitoid xenocrysts (coarse inclusion near centre of photograph). GSC 1996-146AA*

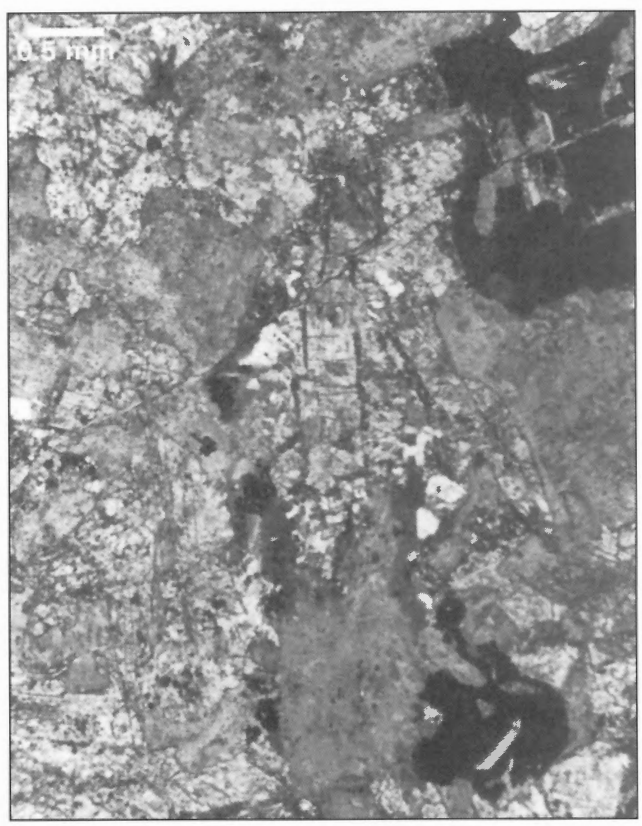



***Figure 91.*** *Photomicrograph of east-trending diabase dyke that is weakly metamorphosed and contain no primary pyroxene. Brownish-green hornblende is partly replaced by a matte of fine actinolitic amphibole. Plagioclase is considerably altered. Plane-polarized light.*

Plagioclase is in some cases well preserved, but is more commonly extensively altered. Some examples are completely recrystallized. Opaque minerals are abundant and are commonly altered to very fine-grained aggregates of leucoxene. Chlorite and epidote are common. Quartz is present locally, in some cases forming up to several per cent of the rock. It occurs as anhedral to slightly rounded grains up to 1 mm in size that are unevenly distributed in the rock and that are considered to be largely xenocrystic and analogous to the granitoid xenoliths referred to previously.

East-trending diabase dykes occur in many places in the Slave Province; they have been named the Dogrib and 'X' dykes in the southwestern Slave Province (McGlynn and Irving, 1975) and the MacKay dykes in the central and eastern Slave Province (Fahrig and West, 1986). The MacKay dykes at Lac de Gras, in the central Slave Province, have a trend similar to that of the dykes in the Keskarrah Bay area and are also porphyritic (LeCheminant, 1994), which strengthens the possible correlation. Preliminary U-Pb (baddeleyite) age determinations on the MacKay dykes suggest a 2.21 Ga age (LeCheminant and van Breemen, 1994). An important difference between the dykes at Keskarrah Bay and their probable correlatives in the central Slave Province and elsewhere is that the dykes in the Keskarrah Bay area are metamorphosed to greenschist grade whereas the dykes at Lac de Gras are fresh to weakly altered (LeCheminant, 1994). Thus, if the dykes at Keskarrah Bay dykes do correlate with the 2.21 Ga MacKay dykes, greenschist-grade metamorphism in the region would have occurred after 2.21 Ga.

LeCheminant (1994) and LeCheminant and van Breemen (1994) have suggested that these dykes, along with other dyke sets in the region and elsewhere in the Canadian Shield and beyond of similar, but not identical, ages, may be related to rifting associated with the progressive breakup of an Archean supercontinent. They further suggested that the eastern and southern margins of the Slave Province were formed during this event.

### *Mackenzie dykes*

The north-northwesterly trending Mackenzie dykes are the most prominent dyke set in the area if only for their very dominant aeromagnetic expression. They are part of a radial swarm of dykes that extend over 2400 km from their focus on Victoria Island out across the Canadian Shield (LeCheminant and Heaman, 1989). They are particularly abundant in the Slave Province where they occur as a series of high density dyke zones separated by zones in which the dykes are less common (LeCheminant, 1994). The Keskarrah Bay area is on the western margin of one of these high density zones with the margin approximately coincident with the western extent of the supracrustal rocks of the Yellowknife Supergroup on the peninsula between the two arms of Point Lake. The eastern margin of the zone is about 40 km east at the east end of Point Lake (Fig. 2).

In the Keskarrah Bay area, the dykes occur as reddish-brown- to black-weathering, medium- and even-grained diabase dykes in which primary ophitic textures, various igneous structures, and primary mineralogy are well preserved. The petrography and chemistry of the dyke swarm as a whole is described and discussed by Baragar et al. (1996). In addition to the ubiquitous chilled margins, other much less common primary structures include laminations to layering on a scale of 1 mm to tens of centimetres defined by variations in plagioclase and pyroxene proportions. In some cases, erosive scours truncate the layered diabase with the scour fill itself being laminated (Fig. 92, 93, 94). Examples of these structures occur on shoreline outcrops, 1.6 km east of the mouth of Keskarrah Bay, and at the contact between the Augustus Granite and mafic volcanic rocks of the Peltier Formation on the north shore of the southern part of Keskarrah Bay.

It is generally accepted that the Mackenzie dyke swarm formed as a result of uplift and extension associated with the emplacement of a mantle plume 1267 ± 2 Ma ago (LeCheminant and Heaman, 1989; Baragar et al., 1996). These dykes are the youngest rock units in the map area.

***Figure 92.*** *Igneous layering in a Mackenzie diabase dyke. The layering is defined by variations in the texture and composition of the diabase. Note the scour channel eroding an adjacent layer in the central part of the exposed dyke. GSC 1996-146P*

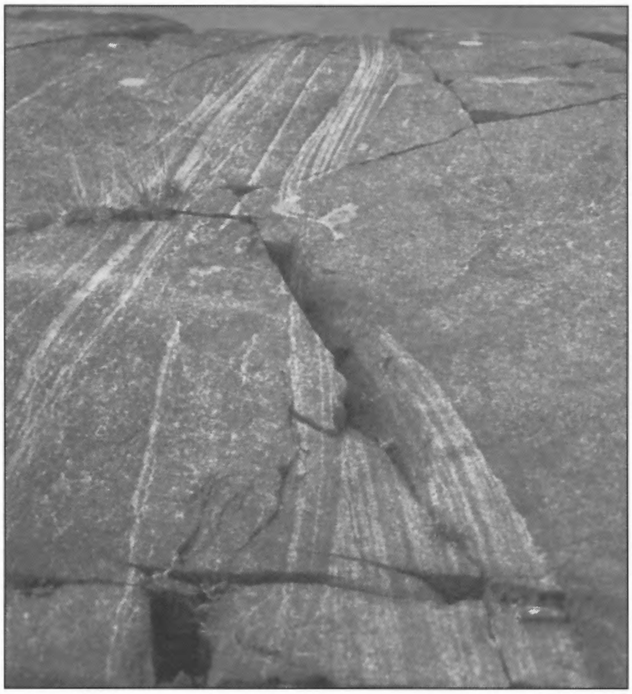


*Figure 93. Sharply defined igneous layering and laminations in a Mackenzie diabase dyke (See Figure 94 for a close-up view of the erosional truncation of the layering). The knife in the lower right corner is 9 cm long. GSC 1996-146C*

## PALEOPROTEROZOIC DOLOSTONE

A small, moderately dipping outlier of presumed Paleoproterozoic dolostone occurs 2 km north of Point Lake, sheltered against the western side of the fault scarp of the major structure that forms much of the boundary between the Contwoyto and Itchen formations. The dolostone is exposed discontinuously over an elongate, 500 $m^2$ area. It is a fine-grained, white to light grey rock that weathers light orange-brown and contains layers 15 to 20 cm thick (Fig. 95). The only primary sedimentary structures present are the bedding and the finer laminations. The rock is not sheared. In one place, it contains a clast of sheared granitoid rock similar to the underlying rock. The dolostone may be an outlier of the Rocknest Formation of the Wopmay Orogen (Grotzinger, 1986a, b), which is exposed some 50 km to the northwest (Fig. 2).

## QUATERNARY GEOLOGY

Much of the Keskarrah Bay map area is overlain by glacial, glaciofluvial, and glaciolacustrine deposits resulting from the Laurentide Ice Sheet, which reached its maximum extent from 18 000 to 13 000 B.P. and had retreated from the area by about 9000 B.P. (Dredge et al., 1997). The Quaternary geology of the Point Lake region has been mapped by Dredge et al. (1997) and the following summary is based on that work.

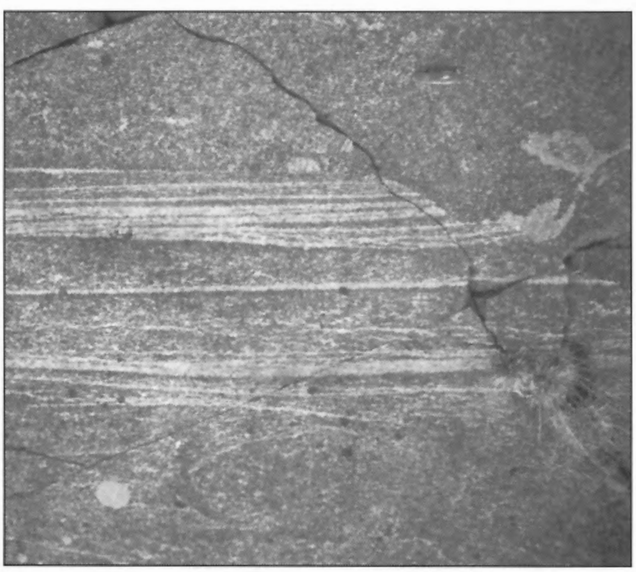


*Figure 94. Close-up view of layering and scoured truncation of layering in the Mackenzie diabase dyke shown in Figure 93. The knife in the upper right corner of the photograph is 9 cm long. GSC 1996-146DD*

*Figure 95. A small outcrop of gently dipping, presumed Paleoproterozoic dolostone unconformably overlying Archean rocks. This dolostone is a possible correlative of dolostone of the Rocknest Formation of the Wopmay Orogen. GSC 1996-146Q*

The Quaternary sediments are predominantly till with only minor amounts of glaciofluvial, glaciolacustrine, alluvial, and organic deposits. Till, a sediment deposited directly from glacier ice, is massive to weakly stratified and poorly sorted; clast size ranges from boulders through sand, silt, and clay. The greater part of the area is overlain by a single till unit. Its approximate distribution is shown on the bedrock geology map of the area (Henderson, 1988) by a stipple pattern indicating areas with low or nonexistent rock exposure. Areas without the pattern contain relatively minor and thin Quaternary cover. The till can be over 10 m thick. Till developed over Yellowknife Supergroup supracrustal rocks tends to have a more silty texture whereas that over granitoid and granitoid gneiss terrane has a more sandy texture.

Glaciofluvial deposits include eskers, kames and transverse ridges, and proglacial outwash. A series of six west-trending, sharp-crested, more or less intact, sand-dominated eskers spaced approximately 5 km apart is found in the eastern part of the area. To the west, the preserved esker deposits are much less continuous, more random, less sharp crested, and more irregularly oriented. Small outwash fans are locally associated with the eskers. Dredge et al. (1997) note that the eskers in the region can underlie, overlie, or cut into till, suggesting that fluvial activity occurred over an extended period of late glacial time. Kame and transverse ridge deposits, typically oriented perpendicular to the dominant esker trend, are scattered throughout the area and are particularly abundant to the east, southeast of the northern arm of Point Lake. Similarly, irregular, generally westerly trending, dendritic, subglacial or proglacial meltwater channels are best developed in the easternmost part of the area, south of Itchen Lake.

Glaciolacustrine deposits are associated with the larger lakes in the region; they represent the higher stand, glacial margin equivalents of these lakes that formed when drainage was blocked by ice or till dams. They form blanket sand deposits and raised beaches on the flanks of eskers. In the westernmost and easternmost parts of the area close to Point Lake, there is evidence of glaciolacustrine deposits as much as 35 m above the present lake level, but little evidence of lacustrine deposits in the central part of the area.

Small areas of organic deposits in the form of peat occur throughout the area. The largest of these extends over 5 km east of the northern arm of Point Lake. Frost heaving can affect any of the outcrop areas, but is most common in areas underlain by the Contwoyto and Itchen formations.

The dominant ice-flow direction in the area was westerly as indicated by glacial striae and various geomorphic landforms such as esker trends, drumlinoid forms, crag-and-tail, and roches moutonées. In addition, data on glacial striae suggest that an earlier southwesterly flow preceded the main ice flow and that final ice movement in the region was northwesterly. Radiocarbon data from outside the region suggest that the area was ice covered 10 000 years ago and that 1000 years later the ice margin was about 200 km east of the area (Dredge et al., 1997).

## STRUCTURAL GEOLOGY

The Keskarrah Bay map area can be divided into three structural domains (Fig. 96): the granitoid and granitoid gneiss domain in the west, the domain dominated by rocks of the Yellowknife Supergroup in the east, and an intervening, narrow boundary structural domain consisting of a major ductile shear zone.

### *Western structural domain*

The western structural domain consists mainly of massive to weakly foliated granite to granodiorite intrusions that largely postdate the Yellowknife Supergroup. Near the domain boundary are map-scale units and smaller inclusions of older orthogneiss in the granitoid rocks that decrease in abundance towards the west. Also present in the younger granite are map-scale units and smaller inclusions of paragneiss. Minor paragneiss is also associated with some of the orthogneiss units.

The main structural grain in the domain trends northeast and dips steeply in either direction. Thus, it contrasts strongly with the more northerly trends and steep to moderate easterly dips in the eastern structural domain. The trend in the western structural domain is strongly expressed on the aeromagnetic maps of the region (e.g. Geological Survey of Canada, 1980). The northeasterly trend is of regional extent in the southwestern Slave Province. For example, it is prominently developed at Ghost Lake (Henderson, 1994) and between Russell Lake and Yellowknife (Lord, 1942; Henderson, 1985). In the Yellowknife area, it is expressed in both Archean supracrustal as well as younger granitoid rocks west of Yellowknife and is also apparent in deep seismic anisotropy measurements (Silver and Chan, 1988). In the Keskarrah Bay map area, it is seen in all rock units, including the younger granitoid rocks and the older gneissic phases. As the eastern limit of the structural domain is approached, the northeasterly trend becomes more northerly and east-dipping, the fabric becomes more strongly developed, and the rocks become more mylonitic. In various parts of the structural domain, Jackson (1989a) reports shallowly to moderately northeasterly plunging stretching/mineral lineations whereas Kusky (1991) recognizes more moderately to steeply plunging, easterly to northeasterly trending stretching/mineral lineations.

Older structural elements have been recognized in the gneissic units of the structural domain, including gneissic layering and complex fold interference patterns that are cut by the younger granitoid phases (Jackson, 1989a). Similarly, Easton et al. (1982) and Easton (1985) report the

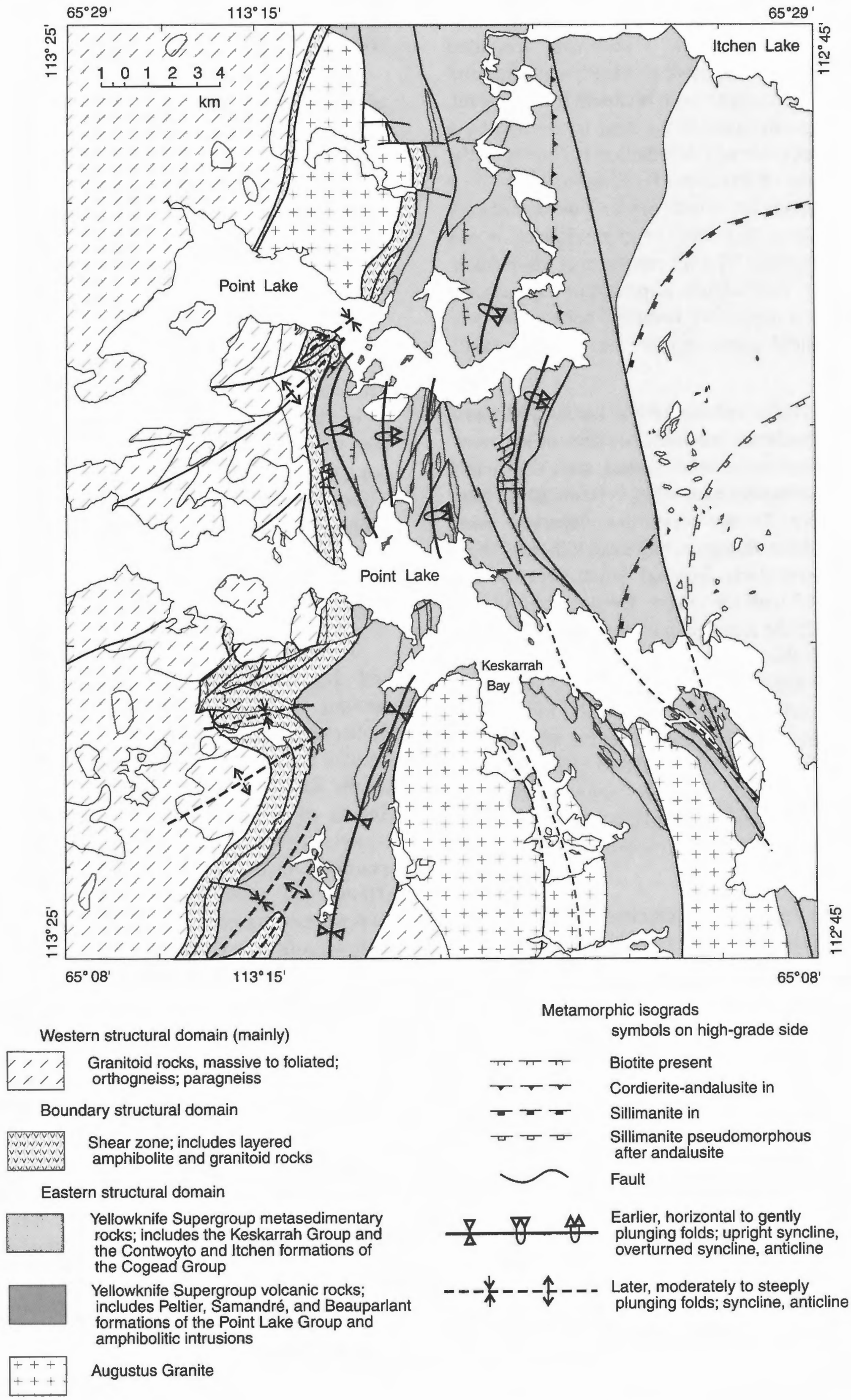



***Figure 96.*** *Main structural elements in the Keskarrah Bay area.*

occurrence of up to three generations of folding in the gneisses. Locally, west-vergent recumbent folds with wavelengths reaching tens of metres occur in the gneisses (Easton et al., 1982; Jackson, 1989a).

### *Boundary structural domain*

The boundary structural domain consists of a major, northerly trending, steeply to moderately east-dipping, ductile shear zone and associated structures. It involves rocks of both the western, largely granitoid, domain and the eastern, largely supracrustal, domain. The structural domain extends discontinuously across the map area with an en échelon overlap of segments north of the northern arm of Point Lake. The shear zone extends at least 50 km north of the area (Bostock, 1980; Gebert, 1994) and has been mapped 7 km south of the area (Easton, 1981). Furthermore, mylonites have been reported along strike 20 km south of the map area (Fraser, 1969).

The shear zone is most prominently expressed by the highly deformed, fine-grained amphibolites of the Perrault Lithodeme. These amphibolites are layered on a centimetre scale and are thought to largely represent highly attenuated, pillowed, volcanic rocks. The Perrault Lithodeme grades into the mainly pillowed, mafic volcanic rocks of the Peltier Formation to the east. It contains lesser amounts of lenses and layers of coarse-grained, variably deformed, mainly mafic, but compositionally varied amphibolites, at least some of which are thought to be syndeformational intrusions. Lower grade zones within the layered amphibolites are extensively chloritized. These rocks are discussed more completely in the section on the Perrault Lithodeme.

The easternmost granitoid and gneissic rocks of the western structural domain become increasingly mylonitic as the effect of the boundary ductile shear zone increases. The strain gradient decreases away from the contact between the amphibolites and the granitoid rocks over several hundred metres. Lineations in the shear zone are not common (Jackson, 1989a; Northrup, 1993). Rare kinematic indicators give inconsistent directions of movement (Northrup, 1993). The northeasterly trends in the western structural domain gently swing parellel with the northerly shear zone over several kilometres. As is locally the case in the Perrault Lithodeme, the granitoid mylonites have commonly undergone retrograde metamorphism. The rocks are commonly salmon to brick red, the plagioclase is strongly saussuritized, and biotite is altered to chlorite. This together with the abundant brittle fractures suggest that a late phase of deformation under lower metamorphic conditions affected the zone.

The main strand of the shear zone ends about 7 km north of the northern arm of Point Lake (Fig. 96). Here the shear zone involves the largely isotropic Augustus Granite. The zone of deformation is much narrower than that seen within the granitoid and gneissic rocks to the south. The shear zone system extends to the north beyond the map area with the establishment of a left-stepping, en échelon zone on the eastern side of the Augustus Granite.

The shear zone system in the southern two thirds of the area is folded into a series of north-northeasterly trending, lobate-cuspate buckle folds, the axial traces of which are oriented at a low, clockwise angle to the shear zone. The individual structures, up to several kilometres in wavelength, are highly varied in size and distribution. The individual s-asymmetrical folds apparently do not extend a great distance beyond the contact between the granitoid and supracrustal domains. The more lobate fold closures with granitoid gneiss cores have not been recognized more than a few kilometres from the contact with the layered amphibolites of the Perrault Lithodeme. Similarly in the Peltier Formation south of Point Lake, the axial traces of the folds, as defined by opposite pillow facings, can be traced only a few kilometres from the contact. Jackson (1989a) correlated this phase of folds with structures in the supracrustal domain to the east.

### *Eastern structural domain*

The eastern structural domain is dominated by supracrustal rocks of the Yellowknife Supergroup that have undergone polyphase deformation. The principal macroscopic structures are outlined by the outcrop pattern of the various lithological units and are dominated by a series of northerly trending folds. In the eastern part of the area, where there are no obvious lithological markers, the pattern is less clear. This is attributed in part to generally poorer exposure in the eastern metasedimentary domain and to the scale of mapping. Much of this part of the area has been mapped in greater detail by Jackson (1989a), who provided a detailed account of the various generations of structures at both megascopic and microscopic scales. What follows is a general account of the structural picture based in large part on the work of Jackson (1989a), although there is some variation in some of the interpretations.

Although the principal structural elements are the northerly trending, large-scale folds that involve all Archean supracrustal units, there is evidence for an earlier deformational event. The Keskarrah Group, together with the other members of the Yellowknife Supergroup, is involved in the large-scale, principal folding. Since it also overlies the Augustus Granite, the Peltier Formation mafic volcanic rocks, and the Contwoyto Formation greywacke-mudstone turbidites, an angular unconformable relationship implying prior deformation is indicated. The presence of this angular unconformity is also suggested by the map pattern of the Peltier Formation and the Keskarrah Group. Because of subsequent deformation, the amount of original angular discordance between the older units and the Keskarrah Group is not clear. As exposed on the present erosion surface, the apparent angular discordance is low-angled in most cases. However, subsequent major deformation may have reduced the angle.

At a few localities in the low-grade parts of the Contwoyto Formation, Jackson (1989a) has recognized outcrop-scale folds that, along with the foliation associated with these early folds, are deformed by a later fold generation. These early structures are suggested to have been originally high-amplitude, horizontally plunging, easterly trending isoclines with steeply dipping axial planes (Jackson, 1989a). Jackson (1989a) also noted the occurrence of horizontal, easterly trending, isoclinal folds in the layered amphibolite of the Perrault Lithodeme, which, after Henderson and Easton (1977) and Bostock (1980), was accepted as primary layering. Although the unit may originally have been in part volcaniclastic, it is also the locus of a major ductile shear zone involving granitoid intrusions that postdate all or most of the Yellowknife Supergroup. It therefore seems unlikely that early fold structures would survive the mylonitization event. These isoclinal folds may represent folding associated with local locking-up of the shear zone during deformation. The large-scale, easterly trending, structure outlined by the Perrault Lithodeme immediately south of Point Lake was also interpreted by Jackson (1989a) as an early fold on the basis of its easterly trend. She speculated that structures on a similar scale involving the layered amphibolite of the Perrault Lithodeme and adjacent units also occur beneath the northern and southern arms of Point Lake.

The principal map-scale deformational event imposed the prominent northerly grain on the eastern structural domain. It is expressed as northerly trending, generally steeply westerly verging folds with wavelengths of several kilometres. These structures are prominently developed on the peninsula between the two arms of Point Lake where major lithological contacts outline the fold pattern. Jackson (1989a) has suggested that macroscopic patterns on a similar scale also occur to the east where the structural domain is dominated by relatively homogeneous metagreywacke-mudstones of the Contwoyto and Itchen formations (Fig. 96). The kilometre-scale structures outlined by the elongate, northerly trending, curvilinear outcrop pattern of the Peltier Formation on the peninsula, the bulk of the Keskarrah Group, and the Beauparlant-Samandré volcanic complex suggest that these structures have horizontal to gently plunging fold axes. This is best exemplified by the western part of the Keskarrah Group, which, on the basis of outcrop pattern, seems to define a gentle, doubly plunging, synclinal structure. Most of these structures do not extend far in the axial direction, as shown by the western syncline-anticline pair in the Contwoyto and Peltier formations respectively. The syncline cored by the Keskarrah Group has not been traced north of the northern arm of Point Lake, but it does extend south beyond the Keskarrah Group outcrop area, into the Peltier Formation and out of the map area.

Mesoscopic, open to tight fold structures with varied trends and a prominent, steeply easterly dipping, axial planar foliation occur in the Contwoyto and Itchen formations (Jackson, 1989a; Fig. 57). Jackson noted that these structures, although generally steeply northeasterly plunging, have locally varied plunges and trends related to variations in strain, original orientation of layering prior to this generation of folding, later deformation, or a combination of these. In the west, where metamorphic grades are lower, these structures commonly have an 'S' sense of asymmetry; to the east, in higher grade areas, the folds are more open and symmetrical. The foliation associated with these structures in the higher grade, metasedimentary rocks is overgrown by cordierite and andalusite porphyroblasts (Jackson, 1989a). Although Jackson (1989a) correlated these structures with the previously described, larger scale folds of the area, the apparent contrast in plunge between the two suggests that the steeply plunging, smaller scale structures might represent a later generation of folding.

In addition to the macroscopic fold generations described above, Jackson (1989a) reports two additional generations of deformation that are defined largely on the basis of microstructural evidence involving the modification of earlier formed cleavage. The late foliations associated with these structures tend to be oriented at a high angle to the earlier, northerly trending cleavages (Jackson, 1989a). These late foliations were correlated with similar features that occur in the eastern part of Point Lake (King, 1982; King and Helmstaedt, 1989), although Kusky and De Paor (1991) consider these later fabrics in the higher grade rocks of eastern Point Lake to be deformed and recrystallized sedimentary ripple laminations.

Finally, in the central part of the area, an apparent structural depression of uncertain, but probably late, generation is considerably larger than any of the previously described folds. Judging from the outcrop pattern of various lithological units, in particular the Keskarrah Group, the axes of the principal folds, whose wavelengths are several kilometres, plunge towards the centre of the depression. This depression has contributed to the relative steepness of the metamorphic isograds compared to the regional pattern and to the preservation of the anomalously low-grade rocks that occur within it. It has also allowed the preservation of the highest stratigraphic levels of the Yellowknife Supergroup, i.e. the Keskarrah Group conglomerates and sandstones.

Steeply plunging stretching/mineral lineations are found throughout the structural domain. They are most evident in the elongated cobbles in the conglomerates of the Keskarrah Group, but are also evident in the vertically elongated pillows in the mafic volcanic sequences. Most volcanic clasts in the conglomerates are elongated, with aspect ratios up to 7:1 not uncommon. Even the granitoid clasts are locally elongated with aspect ratios up to 2:1. The lineations defined by the clasts are contained in the unit's steeply dipping foliation (Jackson, 1989a). It is not clear to which of the various fold generations, if any, this strong elongation is related. The plunge of the generally steep lineation is similar to that of the small-scale, moderately to steeply plunging folds, but, as Hobbs et al. (1976) point out, linear extension parallel to fold axes is problematical. An association with the previously mentioned, large-scale, structural depression could be possible. Similar steep linear structures are a common element in several parts of the Slave Province. Jackson (1989a) reports the occurrence of a moderately east-plunging lineation defined by biotite porphyroblasts that lies in the northerly trending foliation near the curving steep reverse fault immediately east of the Beauparlant Formation.

### *Faults*

The Keskarrah Bay area is broken by several groups of faults of varied ages, trends, and environments. Some earlier faults have been reactivated by younger faults.

The oldest and most prominent structure in the area is the previously discussed ductile boundary shear zone between the eastern and western structural domains. As the rocks in the shear zone have been metamorphosed up to amphibolite grade and the shear zone itself is locally folded, there is little doubt that the structure is Archean. It was suggested previously that the faulting that presumably led to the generation of the conglomerates may have been a precursor to what evolved into the major boundary shear zone. Although it is difficult to define when movement first took place along the structure, it has deformed intrusions that postdate all or most of the Yellowknife Supergroup. The shear zone juxtaposes the granitoid to supracrustal gneiss and foliated granitoid domain to the west, which presumably represents a deeper structural level, and the higher level, lower grade, dominantly Yellowknife Supergroup domain to the east. This implies a significant 'west-side up' vertical component along the structure. The amount of transcurrent movement along the shear zone is unknown, but not thought to be large, given the structure's en échelon style in the map area.

The narrow shear zones commonly found in many places in the Peltier Formation and in which primary features are lost may be of the same generation as the main shear zone. Similarly, the layers and lenses of mafic volcanic rocks thought to have been tectonically emplaced into the Keskarrah Group may have been emplaced along shears of this generation.

The second set of northerly trending faults is younger than the main mylonite zone, since the faults have not been deformed by any of the Archean deformational events. The presence of a small area of presumed Paleoproterozoic dolostone adjacent to the straight, easternmost fault of this generation suggests that the faults are Proterozoic. The faults are north to north-northwest trending, weakly curved, and steeply to moderately east-dipping in the few places in which they were observed. Two of them are apparently traceable across the map area, should correlations across Point Lake be correct. In the central part of the area, one fault is broken into several left-stepping, en échelon segments. The fault zones are a few metres to several tens of metres wide and contain mylonitic to brecciated granitoid rocks and schistose to phyllonitic, metavolanic and sedimentary rocks, commonly with broken quartz or carbonate veins and chlorite-bearing retrograde mineral assemblages. The fault zones are generally wider in the west.

Across the southern part of the area, this generation of faults defines a series of repeated, easterly facing, structural panels such that the east side of each fault represents a deeper stratigraphic and presumably structural level than the west side. This would imply an east-side-up component of movement. The strongly curved fault east of the Beauparlant Formation and its splay that displaces the volcanic complex are apparently rooted to the south in the easternmost of the north-northwesterly trending faults and may be part of this system. Stratigraphic boundaries and metamorphic isograds are displaced westward by this structure, suggesting that the faults are steep reverse faults. Given that stratigraphic boundaries, structural trends, and the faults are generally more or less parallel, the amount of transcurrent movement, if any, along the faults is difficult to estimate. There is a sinistral direction of transport of the isograds across the fault, but this may be more apparent than real if the isograds are moderately to gently west-dipping.

A set of short-displacement, east-trending faults is found at several locations in the area. The faults have no consistent sense of displacement. Their relationship to the northerly trending, steep, reverse faults is equivocal, but they could be older as they have been traced up to but not across the northerly trending faults.

The final fault set trends northeasterly and is most prominently developed in the western part of the area. As with the previous set, the faults in this set apparently do not have a consistent sense of displacement. They are assumed to be related to the dominantly dextral transcurrent fault set that is younger than 1.84 Ga and that is particularly densely developed in the Paleoproterozoic Wopmay Orogen, 50 km to the northwest (Hildebrand et al., 1987).

### *Discussion*

The oldest structures in the area are in the granitoid gneisses in the western structural domain. Interference patterns indicate that as many as three deformational phases or events took place prior to emplacement of the granitoid rocks that postdate all or most of the Yellowknife Supergroup (Easton et al., 1982). Since phases within these gneisses have preliminary ages as old as 2.9 Ga (C. Isachsen, cited by Kusky, 1991), some or all of these structures may predate the deposition or deformation of the Yellowknife Supergroup. Jackson (1989a) speculated that some of the long-limbed isoclines and rootless folds that are deformed by structures correlative with later deformational events in the Yellowknife Supergroup may also be correlative with early events in the deformational history of the Yellowknife Supergroup.

The oldest deformational event to have affected the Yellowknife Supergroup resulted in the angular discordance below the Keskarrah Group unconformity. It may have been accompanied or followed by early faulting along what is now the main break between the dominantly granitoid domain and the dominantly Yellowknife Supergroup domain. As well, related faults affected the Peltier Formation and the Augustus Granite, as shown by shear zones associated with these units. Erosion of the rising fault scarps provided detritus that became the Keskarrah Group. Continued faulting during and after sedimentation resulted in the tectonic interleaving of the older mafic volcanic rocks and the sedimentary rocks of the Keskarrah Group.

Several investigators have suggested that these faults were thrust faults (Hoffman, 1989; Kusky, 1991; Relf, 1992) in a fold and thrust belt resulting from a collision between older continental material represented by the gneissic domain and an accretionary wedge represented by the Yellowknife Supergroup. Kinematic indicators in the mylonites that suggest east-side-up motion support this (Kusky, 1991), although Northrup (1993) reported that the kinematic data from the mylonite zone do not give a consistent sense of motion.

At the present erosion level, the domain west of the main break apparently represents a deeper structural level than that to the east. If early movement along this structure was indeed east-side-up, then subsequent movement must have occurred in the opposite direction in order to end up with the present disposition of domains. Furthermore, some of the clasts in the Keskarrah Group conglomerates, particularly in the western exposures, are gneissic. The closest source would be the gneissic rocks exposed west of the main break. If this early structure was a thrust fault, then the early Yellowknife Supergroup would have overridden the gneiss domain making it inaccessible as a source of detritus for the Keskarrah Group conglomerates. In this scenario, a west-side-up structure would be necessary at some time to bring the overridden gneisses to the surface so that they could provide detritus for the Keskarrah Group .

The Keskarrah Group together with the Peltier and Contwoyto formations are deformed in the series of northerly trending macroscopic folds. On the basis of their map pattern, these folds were apparently originally horizontal, which would fit in with the idea of the previously mentioned fold and thrust belt, although their distribution is highly restricted. They are best developed near the main shear zone in the central part of the area, and they disappear to the north in an eastward-facing homocline and to the south where only one axial trace can be followed out of the area with any confidence. Although Jackson (1989a) has outlined one such structure on the bulbous peninsula on the north arm of Point Lake, the existence of such structures in the metasedimentary rocks to the east is equivocal because of poor exposure. Jackson (1989a) has noted that the mesoscopic folds with varied plunges in the metasedimentary rocks tend to be tighter closer to the boundary shear zone. She suggested that this may be due to the buttressing effect of the adjacent granitoid domain. The proximity of the horizontal folds to this domain may also be due to this effect.

Jackson (1989a) considered the large-scale structures to be of the same generation as the mesoscopic, mainly moderately to steeply plunging folds that are found mainly in the Contwoyto and Itchen formations. In this report, they are tentatively considered to be of a different generation on the basis of their apparent contrast in style and, in most cases, their scale. An important feature of the mesoscopic folds that occur throughout the metasedimentary rocks as noted by Jackson (1989a) is their common s-asymmetry, which suggests sinistral shear. This asymmetry is most strongly developed in the low-grade metasedimentary rocks. In the higher grade rocks to the east, these structures are more symmetrical (Jackson, 1989a). Easton (1985) and particularly Jackson (1989a) correlated these folds and the prominent spaced folds in the main shear zone that involve both the supracrustal rocks of the Yellowknife Supergroup and the granitoid and granitoid gneiss to the west. Although of a different scale, the folds in the shear zone have similar steep to moderate plunges and s-asymmetry. They also have a prominent lobe-and-cuspate form reflecting the contrast in ductility on either side of the shear zone (Ramsay, 1967).

The metamorphic peak near the main shear zone was interpreted by Jackson (1989a) to have been reached before or during the formation of these asymmetrical structures. Metamorphic textures in the actinolite to actinolitic hornblende-plagioclase mineral assemblage in the mafic mylonite, together with the ductile behaviour of quartz and the brittle-ductile behaviour of feldspar in the granitoid rocks (Kusky, 1991), suggest that the mylonite formed at elevated grade (Kusky, 1991) and so was probably approximately synchronous with the folding (Jackson, 1989a), perhaps reactivating an earlier structure.

As previously noted, the dominantly granitoid domain west of the main shear zone represents a deeper crustal level than the supracrustal domain to the east. This western structural domain is dominated by massive to deformed granitoid intrusions that are considered to postdate all or most of the Yellowknife Supergroup. Phases of these granitoid rocks locally intrude and are deformed in that part of the main shear zone consisting of Yellowknife Supergroup protoliths. The thermal anomaly associated with these granitoid rocks that postdate the Yellowknife Supergroup is thought to be responsible for the regional metamorphism in the area. If all this should be true, then emplacement of the granitoid rocks, the associated metamorphism, and deformation on the main shear zone would be roughly contemporaneous. If most of the movement along the main shear zone took place at elevated metamorphic conditions, then most of the uplift of the western structural domain would have taken place at about the same time. The steep lineations that are found throughout the area may be a reflection of this uplift. The brittle fracturing and alteration of the granitoid rocks and chloritized zones in the layered amphibolites of the shear zone presumably represent later adjustments and are probably of relatively minor significance.

The juxtaposition of complex assemblages of granitoid gneisses and foliated to massive granitoid rocks that were formed before, during, and after formation of the Yellowknife Supergroup along prominent shear zones, against relatively simple domains dominated by Yellowknife Supergroup rocks, is seen in several areas in the Slave Province. Such granitoid and granitoid gneiss complexes include the well known Sleepy Dragon Complex, east of Yellowknife (Davidson, 1972; Henderson, 1985; Kusky, 1991; James and Mortensen, 1992; Bleeker; 1996). Less well known examples include the complex northwest of Healey Lake in the eastern Slave Province (Henderson and Thompson, 1982), the Mara River complex in the Hackett River area to the north (Frith, 1987), the Kangguyak gneiss belt in the northernmost Slave Province (McEachern, 1993), and the Hinscliffe and Cotterill complexes of the southwestern Slave Province (Henderson and Schaan, 1993; Pehrsson et al., 1995). These high-grade rocks are typically of midcrustal affinity and in many cases do not contain supracrustal rocks that are considered to be correlative with the Yellowknife Supergroup. Where possible Yellowknife Supergroup correlatives are present, such as in the Cotterill Complex and in the Keskarrah Bay area, they are typically migmatitic and represent a relatively small component. Interpretations of the nature of the contacts between such mainly high-grade domains and the adjacent domains dominated by the Yellowknife Supergroup at particular localities vary from thrust-fault surfaces with implied displacements of many tens of kilometres (Kusky, 1991) to more or less intact unconformities (Easton, 1985; Henderson, 1985; Bleeker, 1996). An interpretation that may apply at Keskarrah Bay is that of James and Mortensen (1992). They propose an early premetamorphic to synmetamorphic thrusting of the supracrustal rocks over the gneiss and granite domain during premetamorphic to synmetamorphic contractional deformation. Following emplacement of major granite intrusions, an extensional event resulted in uplift and unroofing of the complex gneiss and granite domain.

The later sets of cataclastic, relatively low-temperature, transcurrent to steep reverse faults are all thought to be Proterozoic. Any relationship between the various sets is unknown, but some may be related to the east-west compressional event associated with the indentation of the Slave Province and part of the bordering Thelon Tectonic Zone into the western Churchill Province between 1.84 and 1.74 Ga (Henderson et al., 1990).

## METAMORPHIC GEOLOGY

At least three distinct periods of metamorphism are represented in the Keskarrah Bay map area, including an early period that affected the orthogneissic units of the western granitoid domain, a late Archean event that resulted in the prominent metamorphic pattern expressed most clearly in the supracrustal rocks of the Yellowknife Supergroup, and a regional, low-grade, presumably Paleoproterozoic event that is expressed most prominently in the east-trending diabase dykes.

### *Metamorphism predating the Yellowknife Supergroup*

The only evidence of metamorphism predating the Yellowknife Supergroup is in the orthogneisses of the foliated granitoid and granitoid gneiss domain west of the main shear zone. As described previously, the gneisses consist of a complex assemblage of several generations of interlayered to nebulitic amphibolites, and biotite- and/or hornblende-bearing metadiorite through granite phases. These gneisses are intruded and metamorphosed by younger, massive to foliated plutons, most of which are considered to postdate all or most of the Yellowknife Supergroup. There is little doubt that the gneiss components were metamorphosed before emplacement of the younger granitoid rocks. Geochronological data on these rocks are sparse, but one preliminary age on a gabbroic gneiss suggests that some components may be as old as 2.9 Ga (C. Isachsen, quoted by Kusky, 1991). Northrup et al. (1997) have suggested that zircons from the gneisses range in age from 3.22 to 2.82 Ga.

Some of the youngest, map-scale folds in the gneisses (Fig. 96) are considered to be correlative with folds in the Yellowknife Supergroup (Jackson, 1989a). Three generations of folds in the oldest of several gneiss units in this domain (Easton et al., 1982) have not been reliably correlated with any structural event in the Yellowknife Supergroup and are considered likely to predate the Yellowknife Supergroup. As both the leucocratic, presumably intrusive phase and the more mafic paleosome of these gneisses are folded, metamorphism was likely syndeformational or predeformational.

All these gneisses were affected by more recent metamorphism associated with the emplacement of the large volume of granitoid rocks that presumably postdate all or most of the Yellowknife Supergroup. As a result, evidence indicating metamorphic conditions during the earlier metamorphic event(s) has been obscured.

### *Late Archean metamorphism*

The most prominent metamorphic pattern in the area is attributed to the late Archean metamorphism that affected the Yellowknife Supergroup as well as older plutonic and gneissic rocks. The metamorphic pattern is most clearly shown by the distribution of metamorphic zones in the pelitic to psammitic rocks of the Contwoyto and Itchen formations east of the main shear zone and their possible equivalents in the foliated granitoid and granitoid gneiss domain to the west (Fig. 97). The metamorphic grade varies from greenschist to upper amphibolite and, as with most domains in the Slave Province, the regional variation defines a low-pressure facies series (Thompson, 1978; Bostock, 1980; Jackson, 1989a).

The metamorphism of the rocks of the Keskarrah Bay area has been studied in detail by Jackson (1989a). Her work includes detailed accounts of the mineralogy, mineral chemistry, mineral reactions, and geothermobarometry of rocks from the area. What follows is largely a summary of aspects of her comprehensive study.

The lowest grade rocks occur in a short, northerly trending trough slightly west of the Keskarrah Group on the peninsula between the arms of Point Lake. Low-grade rocks do not occur to any great extent north or south of the map area. Within the map area, the metamorphic grade increases both to the east and the west with the westerly gradient being significantly steeper and less complete due to interference by the main shear zone. East of the shear zone, some of the westernmost metasedimentary rocks of the Contwoyto Formation are in the cordierite zone. West of the shear zone, a discontinuous zone of metasedimentary migmatites occurs within the foliated granitoid and granitoid gneiss domain. On the basis of lithology, these are considered to be probable correlatives of the Yellowknife Supergroup that have undergone partial melting.

Although the eastern metamorphic gradient is not as steep, it is nonetheless steeper than most such gradients in the Slave Province. Within the map area, the metamorphic grade rises over about 10 km from lowest grade, subbiotite rocks to the first appearance of sillimanite. East of the sillimanite-in isograd and beyond the map area, the metasedimentary rocks remain at more or less constant grade over about 30 km (Bostock, 1980; King et al., 1980a; Fig. 2) before the first appearance of metasedimentary migmatite. This marks the start of a metamorphic zone similar to the zone of metasedimentary migmatites that occurs only 3 or 4 km west of the main shear zone. The relatively steep gradient within the map area is due at least in part to the late, steep, reverse faults that have telescoped the gradient (Jackson, 1989a).

### *Metamorphic zones in pelitic to psammitic rocks*

The lowest grade rocks are in the chlorite zone (Fig. 97). The mineral assemblage consists of detrital quartz and plagioclase with very fine-grained quartzofeldspathic material, chlorite, and white mica in the matrix. Lhotka and Nesbitt (1989) and Jackson (1989a) note the presence of biotite in iron-formation within the chlorite zone, which Jackson suggests is due to the more iron-rich composition of these rocks. Jackson (1989a) reports that the plagioclase composition is less than $An_{10}$. She also notes the occurrence of two chlorites, one with blue-purple and the other with khaki birefringence colours; both fall within the compositional range of ripidolite. The blue-purple type is more common in the more deformed western part the zone where, on the basis of textural and chemical information, it is considered to postdate the khaki type. Jackson (1989a) suggests that this chlorite may represent retrograde conditions. This may be related to late stages of deformation associated with the evolution of the nearby major shear zone.

The biotite zone begins with the first appearance of biotite as very fine-grained flakes interlayered with and morphologically similar to the associated chlorite and white mica. At higher grades, the biotite is coarser grained and locally forms porphyroblasts that are discordant to the foliation defined by the other phyllosilicates (Jackson, 1989a). Mineral assemblages are essentially similar to those of the chlorite zone with the addition of biotite. Plagioclase compositions are either less than $An_{10}$ or between $An_{20}$ and $An_{35}$ (Jackson, 1989a). According to Jackson (1989a), geochemical evidence is suggestive of retrogressive effects on the composition of chlorites and white micas, as in the chlorite zone. Because of reverse movement along the curved faults near the Samandré-Beauparlant volcanic centre, part of the biotite zone has been overridden by cordierite-zone rocks from the east (Fig. 97).

As is the case elsewhere in the Slave Province, the cordierite zone is easily recognized in the field with the abrupt appearance of coarse-grained porphyroblasts of highly poikilitic cordierite (Fig. 45). In the west, the cordierite zone is discontinuous, possibly due to truncation of the Contwoyto Formation by the major shear zone. The minerals are extensively altered, presumably because of deformation in the shear zone. In the eastern gradient, which involves both the Contwoyto and Itchen formations, the cordierite isograd trace is largely lost due to later faulting in the central part of the area and poor exposure in the north. It is best represented in the southeast. At the low-grade margin of the zone, modified detrital textures are still recognizable, but deeper into the zone, primary textures are

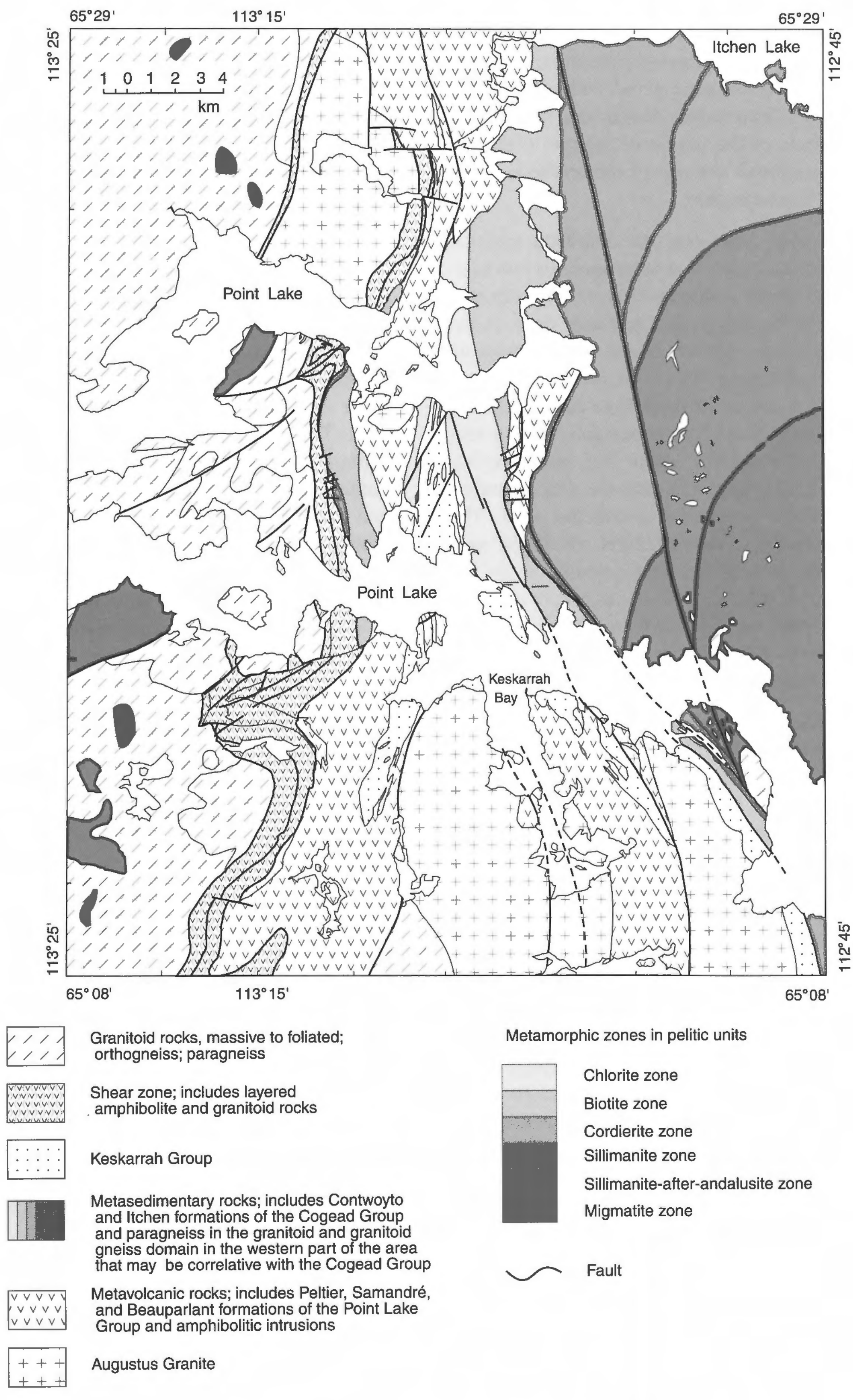



***Figure 97.*** *Metamorphic zonation in the Contwoyto and Itchen formations.*

lost due to recrystallization. Mineral assemblages most commonly include quartz, plagioclase, biotite, muscovite, cordierite, and andalusite, with less common or rare occurrences of garnet, staurolite, and several amphiboles in the more iron-rich pelitic rocks interlayered with iron-formation in the Contwoyto Formation. Andalusite first occurs 150 to 600 m upgrade of the cordierite isograd (Jackson, 1989a) and persists through the rest of the cordierite zone and well into the sillimanite zone.

The sillimanite zone represents the dominant regional grade east of the map area as it is present more or less continuously over about 30 km within and beyond the map area to where it meets the higher grade migmatite zone. It has not been preserved in the western metamorphic gradient east of the Perrault Lithodeme; the pelitic rocks to the west, beyond the shear zone, are in the migmatite zone. The sillimanite zone is defined by the first appearance in thin section of fibrolitic sillimanite, which becomes visible macroscopically at higher grades. It coexists with, mantles, and ultimately replaces andalusite across the zone. The highest grade zone in the eastern gradient within the map area is defined by the presence of aggregates of coarse sillimanite pseudomorphous after andalusite porphyroblasts. It has no particular petrological significance, but is a mappable feature that gives a better indication of the metamorphic pattern in the eastern part of the map area.

The highest grade zone within the map area is in the western foliated granitoid and granitoid gneiss domain where metasedimentary rocks, possibly correlative with metasedimentary rocks of the Yellowknife Supergroup in the eastern part of the area, are at migmatite grade. The leucosome layers represent both partial melts generated in situ and injected granitoid phases. The biotite-rich layers contain centimetre-scale, altered patches that may represent cordierite. Easton (1981, 1985) reports the occurrence of sillimanite and microcline in these high-grade rocks.

Jackson (1989a) has interpreted metamorphic pressure-temperature conditions in rocks along the erosion surface of the Contwoyto and Itchen formations. They range from about 415°C and 2 kbar for the biotite isograd to about 570°C and 3.5 kbar for the sillimanite isograd, on the basis of textural relationships between coexisting mineral phases and their observed sequential development that can be related to experimentally calibrated discontinuous reactions together with geothermobarometric measurements in the higher grade rocks.

### *Keskarrah Group*

The rocks of the Keskarrah Group have not been metamorphosed above greenschist grade. Most of the formation contains the metamorphic minerals white mica, chlorite, and carbonate. No biotite was seen in the shallow-water sandstone facies. Many of these rocks are mineralogically mature and compositional limitations might restrict the formation of biotite in some cases. Most, however, contain significant amounts of both chlorite and white micas, generally considered common reactants in the generation of biotite (Turner, 1981). Similarly, the conglomeratic facies is also largely devoid of biotite. Granitoid cobbles that were originally biotite bearing now contain only chlorite presumably pseudomorphous after the original biotite. Biotite-bearing assemblages do occur in the easternmost parts of the formation, south of Point Lake and east of the main mafic volcanic unit of the Peltier Formation east of Keskarrah Bay, in both the conglomeratic and the turbidite facies of the formation.

In all areas, the Keskarrah Group mineral assemblages are in metamorphic context with mineral assemblages of the other formations with which the Keskarrah Group is in contact. Thus, the Keskarrah Group and the Contwayto Formation are both in the chlorite zone where they are in contact on the peninsula between the two arms of the lake, and in the biotite zone in the southeast corner of the area. Although it can not be stated unequivocally that the older formations unconformably overlain by the Keskarrah Group were not metamorphosed prior to deposition of the group, any such metamorphism that took place would not have been greater than lower greenschist grade.

### *Volcanic rock units*

No specifically defined mineralogical metamorphic zones have been outlined for the mafic volcanic rock units because of the subjective transition of amphiboles with changing metamorphic conditions (Winkler, 1974). The lowest grade rocks of the Peltier Formation consist of a fine-grained assemblage of altered plagioclase, chlorite, and epidote. Actinolite appears at higher grades. The amphibole becomes increasingly hornblende-like, the plagioclase, coarser grained and cleaner, and the chlorite, less abundant. For the Peltier Formation on the peninsula between the arms of the lake, Jackson (1989a) drew two north-northwesterly trending isograds marking the first appearances of actinolite and hornblende. She noted that the high-grade zone was out of context with the adjacent chlorite-zone metasedimentary rocks and speculated that this apparent discordance might be attributed to reduced reaction temperatures due to the presence of $CO_2$-rich fluids in the mafic rocks or unrecognized structural complications. As for the volcanic rocks of the Peltier Formation west of Keskarrah Bay, Bostock (1980) indicated that greenschist-grade rocks in the central part of the volcanic outcrop area extend about 6 km south of the map area.

The layered amphibolite of the Perrault Lithodeme that forms part of the main shear zone consists of a generally higher grade assemblage than that seen in the adjacent mafic volcanic rocks of the Peltier Formation from which it largely evolved. It consists primarily of actinolite to actinolitic hornblende and plagioclase with minor, varied amounts of biotite, chlorite, leucoxene, opaque minerals, carbonate, and quartz; towards the westernmost parts of the unit, it consists of a clean, blocky textured, fine-grained assemblage of hornblende and plagioclase. Local chloritized zones of varied scales represent retrograde metamorphism associated with late movement along the shear zone.

The Samandré-Beauparlant intermediate to felsic volcanic complex is metamorphosed to upper-greenschist to lower-amphibolite grade with the metamorphic gradient across it apparently steeper because of telescoping of the complex by late faulting. The bulk of the felsic Beauparlant Formation contains minor, fine flakes of biotite and white mica in a quartzofeldspathic matrix with rare, relict phenocrysts of quartz and feldspar. South of the unit, however, the biotite is coarser grained and more abundant and coarse-grained cordierite porphyroblasts are present.

The more intermediate Samandré Formation on the western side of the complex is compositionally much more heterogeneous. The metamorphic mineral assemblages in the unit are varied and commonly consist of assemblages of hornblende-plagioclase-garnet and locally cordierite in the more felsic phases in the southern half of the unit. Most of the unit in the northern half is garnet-free although garnet does occur at the northern end of the unit near its contact with the Beauparlant Formation.

The metamorphic grade is apparently controlled by the reverse fault that transects the unit. The rocks in the hanging wall, which include the southern Samandré Formation and essentially all of the Beauparlant Formation, are at higher grade than the rocks to the west. On the other hand, on the basis of unpublished data from P.R. Considine (1990), Kusky (1991) reported the occurrence of the assemblage quartz+feldspar+garnet+riebeckite+enstatite in these rocks. He suggested that this assemblage together with the mineralogical textures are evidence that these rocks represent the granulite-grade equivalent of the adjacent greenschist- and lower-amphibolite-grade Contwoyto Formation. He further proposed that the anomalously high grade was due to these rocks being part of the base of a regionally extensive thrust.

### *Augustus Granite*

The Augustus Granite is also variably metamorphosed as indicated by the presence or absence of biotite and chlorite and their habit. The granite in the southern part of the area, west and immediately east of Keskarrah Bay, contains only chlorite- and epidote-bearing assemblages with the chlorite in many cases clearly pseudomorphous after single flakes of presumably original igneous biotite. In most examples of the Augustus Granite north of the north arm of Point Lake and in the southeastern part of the area, the mafic minerals consist of aggregates of fine-grained, decussate biotite that is thought to be the product of prograde metamorphism of the chlorite that replaced the original igneous biotite flakes. In a few places, particularly close to faulted or sheared contacts or shear zones within the granite, this decussate biotite is again partly chloritized, suggesting subsequent retrograde metamorphism associated with activity along the faults and shear zones. The granite in the southern part of the main Augustus Granite domain west and south of Keskarrah Bay locally contains fine flakes and seams of partly choritized biotite, but is mainly chlorite-epidote-bearing and devoid of biotite. It is much more deformed than that to the north. If the pattern seen in the other, more metamorphosed parts of the granite holds, then the chloritized southern part of the main body, like the bodies of Augustus Granite to the north and southeast, would have been metamorphosed to biotite grade and then retrograded during subsequent shearing of the region. The orthogneiss to the southwest of the main body of Augustus Granite contains abundant, largely fresh biotite except near the poorly defined contact with the Augustus Granite, suggesting that the contact may be a fault or shear zone.

The regional metamorphic pattern as seen in the pelitic rocks may be traceable into the Augustus Granite. The lowest grade trough, most clearly defined on the peninsula between the two arms of Point Lake, extends into the northern part of the main body of Augustus Granite, but not south beyond the map area. The higher grade, northern and southeastern bodies of Augustus Granite are both metamorphically in context with the supracrustal rocks to the east.

### *Proterozoic metamorphism*

A low-grade metamorphic event is recorded in the previously described, east-trending mafic dykes that are considered to be Paleoproterozoic and possibly 2.21 Ga. Megascopically, the dykes are well preserved with igneous textures and chilled margins being evident. In thin section, the original mafic minerals consist of pale green to blue-green, actinolitic amphibole that is pseudomorphous after the original igneous minerals, with the large, blocky crystals commonly fringed by fine, optically continuous, acicular laths of the same mineral (Fig. 91). Similar actinolitic amphibole also occurs independently throughout the rock. Some larger actinolitic crystals contain relict cores of olive-green to brown hornblende. The plagioclase is variably recrystallized and altered to epidote and clinozoisite. Chlorite varies from large patches possibly replacing biotite to very fine patches within the amphiboles. Ilmenite is altered to leucoxene.

This metamorphic assemblage is consistent throughout the area, which suggests that metamorphism was regionally uniform. Older lithological units in the area are locally metamorphically retrograded; this is normally associated with shearing or faulting, which is clearly not the case with these dykes. The older units commonly show minor evidence of retrograde metamorphism such as partial chloritization of biotite or the rimming of cordierite by pinite, which may be related to the metamorphism that affected these dykes.

### *Discussion*

Most workers agree that there was a close temporal association between metamorphism and deformation in the region (Bostock, 1980; Jackson, 1989a; King and Helmstaedt, 1989), with the peak of metamorphism largely postdating the major folding events. This conclusion is based mainly on peak-metamorphic cordierite and andalusite porphyroblasts overgrowing cleavages associated with folds. Both Jackson (1989a) and King and Helmstaedt (1989) recognize a foliation that postdates the thermal peak and that has not been related to a specific fold generation. Thus, the metamorphic isograd pattern, presumably an artifact of peak-metamorphic conditions, is not considered to have been folded, at least by the principal folding event.

In the lowest grade trough, Jackson (1989a) noted that the low-grade rocks are coincident with a major synclinal axis and suggested that the isograds in this low-grade region were involved in the folding. In this area, both structural trends and the metamorphic pattern are northerly trending. As previously noted, the structure verges steeply westward. However, little can be said about the steepness of dip of the isograd surfaces, which have an asymmetrical 'synformal' shape on a significantly larger scale than that seen in the largest folds in the rocks. The relatively steeper apparent dip of the isograds on the western metamorphic gradient that defines the asymmetry of the metamorphic pattern may be due to shearing that occurred after folding and after the metamorphic peak was reached and that was related to late movement along the main shear zone. That this shearing occurred is indicated by the greater alteration and the more abundant development of retrograde mineral assemblages on this gradient than the one to the east (Jackson, 1989a).

Whatever their actual attitude, the isograd surfaces are apparently significantly steeper in the map area than to the east. On the eastern gradient between the biotite and sillimanite isograds, there is an apparent temperature variation of about 150°C over 4 to 7 km. To the east, between the sillimanite isograd and the first appearance of a melt phase (Fig. 2), there is a temperature change of about the same magnitude over about 30 km, suggesting much flatter isograd surfaces. The reason for the presence of the relatively small trough of low-grade rocks in the map area is not clear. It is found largely in an indentation of the metasedimentary rocks between the greater mass of volcanic rocks to the north and the volcanic rocks and Augustus Granite to the south. Following on the previously mentioned suggestion of Jackson (1989a) that the isograd surfaces may be folded, this low-grade area may represent a structural depression of uncertain, but probably late, generation on a considerably larger scale than any of the defined folds. At the present erosion level, the depression exposes the highest stratigraphic levels, the Keskarrah Group, as well as the lowest grade rocks.

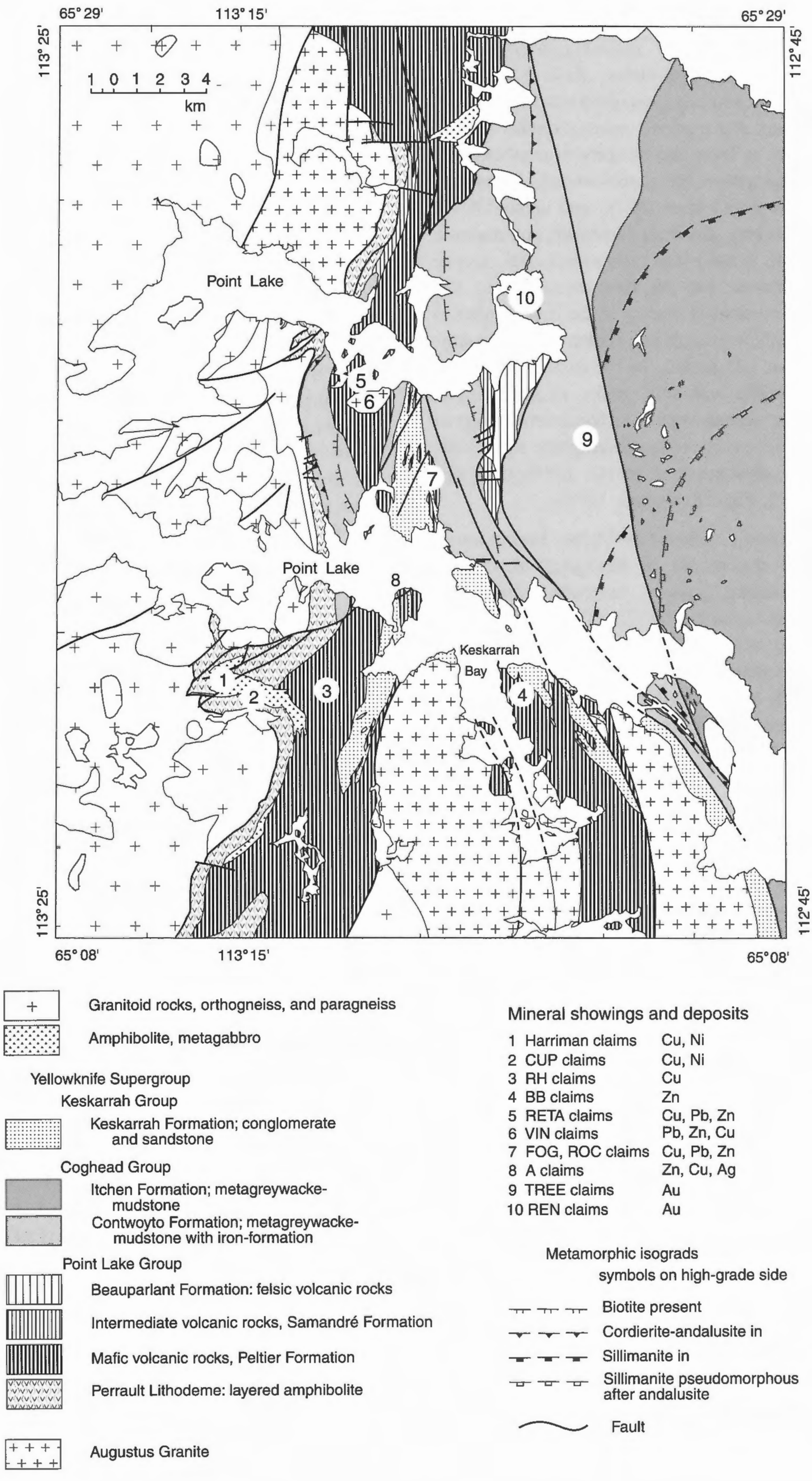
The significance of the low-grade Paleoproterozoic metamorphism that is expressed so prominently in the older diabase dykes is also unclear. It has little apparent variation within the area and could have been part of a much larger regional event. Throughout much of the Slave Province, most of the K-Ar ages on biotite from Archean rocks have been rejuvenated, presumably by a Paleoproterozoic thermal event. Only in the south and southeast, in an area 100 to 150 km from the margin of the province, does biotite retain an Archean or near-Archean age (Wanless, 1970). The average biotite K-Ar age in that area is about 2.5 Ga whereas in the rest of the province, including the map area, it is about 1.9 Ga. The low-grade metamorphism of the dykes and this rejuvenation of the biotite K-Ar ages may be related.

Compared to the Paleoproterozoic dykes, the effects of this younger metamorphism on the coarser grained, higher grade, Archean rocks is minor. The situation in the fine-grained, chlorite-zone rocks is less clear. Some of the fine-grained chlorite in these rocks may well represent retrograded biotite. This leaves open the possibility that the biotite zone boundary may be more an expression of Proterozoic retrograde metamorphism than Archean prograde metamorphism.

## ECONOMIC GEOLOGY

Most economic-mineral showings and deposits within the map area are either gold associated with iron-formation in the Contwoyto Formation or base-metal mineralization associated mainly with mafic volcanic units (Fig. 98). Only two of the gold showings, the REN deposit with 1.1 million tonnes at 6.5 g/tonne (Energy, Mines, and Resources Canada, 1989) and the 0.9 million tonne, up to 7.5 g/tonne TREE, TESS, and PINE claim groups occurrence (Schiller, 1965; Gibbins et al., 1991) have any significant resource estimates. However, the Lupin mine, 85 km east-northeast of the area, produced about 78 000 kg of gold between 1982 and 1995. The Izok Lake deposit, 16 km north of the northeast corner of the area, is a 13.6 million tonne Zn-Cu-Pb-Ag massive sulphide deposit (Morrison, 1993).

***Figure 98.*** *Major economic mineral showings and deposits in the Keskarrah Bay area.*


65° 29'
113° 15'
65° 29'
113° 25'
112° 45'
1 0 1 2 3 4
km
Point Lake
10
5
6
9
7
Point Lake
8
Keskarrah Bay
1
2
3
4
113° 25'
112° 45'
65° 08'
113°15'
65°08'
Granitoid rocks, orthogneiss, and paragneiss
Amphibolite, metagabbro
Yellowknife Supergroup
Keskarrah Group
Keskarrah Formation; conglomerate and sandstone
Coghead Group
Itchen Formation; metagreywacke-mudstone
Contwoyto Formation; metagreywacke-mudstone with iron-formation
Point Lake Group
Beauparlant Formation: felsic volcanic rocks
Intermediate volcanic rocks, Samandré Formation
Mafic volcanic rocks, Peltier Formation
Perrault Lithodeme: layered amphibolite
Augustus Granite
Mineral showings and deposits
1 Harriman claims Cu, Ni
2 CUP claims Cu, Ni
3 RH claims Cu
4 BB claims Zn
5 RETA claims Cu, Pb, Zn
6 VIN claims Pb, Zn, Cu
7 FOG, ROC claims Cu, Pb, Zn
8 A claims Zn, Cu, Ag
9 TREE claims Au
10 REN claims Au
Metamorphic isograds
symbols on high-grade side
Biotite present
Cordierite-andalusite in
Sillimanite in
Sillimanite pseudomorphous after andalusite
Fault

### *Base metals*

Staking in the area began in 1957, probably in the layered amphibolites of the Perrault Lithodeme, about 3 km south of Point Lake where the amphibolites trend east (1, Fig. 98). There, pyrrhotite and chalcopyrite mineralization occurs along shear planes in at least two easterly to northeasterly trending shear zones within the amphibolites. Assays on grab samples indicated less than 1% Ni and up to 4% Cu (McGlynn, 1971). Nearby disseminated bands and massive stringers of pyrrhotite, some pyrite, and minor chalcopyrite occur in sheared, chloritic and graphitic rocks (2, Fig. 98; Schiller, 1965), in a northerly trending shear zone in altered gabbro within the mafic metavolcanic rocks; they gave similar results for copper and nickel. To the east, within massive to pillowed mafic volcanic rocks of the Peltier Formation, a narrow gossan with a strike extent of up to 400 m has developed over siliceous and graphitic rocks containing massive to disseminated pyrite, pyrrhotite, and minor chalcopyrite (3, Fig. 98; Seaton, 1978).

In mafic volcaniclastic rocks of the Peltier Formation at the eastern side of the mouth of Keskarrah Bay, conformable and crosscutting, gossany, sulphide-bearing carbonate lenses contain up to 0.24% Zn (4, Fig. 98; Seaton and Hurdle, 1978). In the Peltier Formation near the southern shore of the northern arm of Point Lake, thin, conformable, quartz-rich layers containing 10% disseminated sulphides occur in metasedimentary rocks within the mafic volcanic sequence. Assays of associated gossans indicate 0.32% Cu, 0.36% Pb, 1.05% Zn, 0.17 g/tonne Au, and 14 g/tonne Ag (5, Fig. 98; Seaton and Hurdle, 1978). In the nearby small pluton of Augustus Granite, quartz veins in sheared, altered, and silicified granitoid rock contain anomalous concentrations of Pb, Zn, Ag, and Au (6, Fig. 98; Seaton et al., 1987). A zinc, copper, and lead soil anomaly is associated with felsic to intermediate, volcaniclastic rocks associated with the Keskarrah Group on the peninsula between the arms of Point Lake (7, Fig. 98; Seaton and Hurdle, 1978).

Minor, thin, black units of carbonaceous mudstone to schist occur locally in the mafic volcanic rocks of the Peltier Formation. They commonly contain sulphide with disseminated pyrite and pyrrhotite, and less commonly pyrite and pyrrhotite-rich layers and concretions. Some minor sphalerite and chalcopyrite are present (Lisle, 1977). Where present, the sulphides occur in carbon-rich layers although not all carbon-rich layers contain sulphide (Lisle, 1977).

The most impressive base-metal showing known in the area occurs in volcanic rocks associated with the Keskarrah Group. On the bulbous peninsula 3 km northwest of Keskarrah Bay, several thick units of deformed mafic volcanic rocks are, as discussed previously, considered to be structurally emplaced within the Keskarrah Group. A 1 m thick, layered sequence of pyrite, sphalerite, chert, and chalcopyrite occurs within the volcanic rocks at the northern shore of the peninsula and can be traced inland about 40 m (8, Fig. 98; Henderson, 1975a). A 1.5 m, drilled intersection of nearly massive sulphide mineralization assayed 4.8% Zn, 1.6% Cu, 0.2% Pb, 36 g/tonne Ag, and 0.7 g/tonne Au. Ground electromagnetic and magnetic surveys indicated limited depth extent (Seaton and Hurdle, 1978).

### *Gold*

All the known gold showings in the area are associated with sulphide-bearing, silicate-type iron-formation of the Contwoyto Formation. Although the Contwoyto Formation, with its various types of iron-formation, occurs over a wide area in the north-central part of the map area, the gold showings that have attracted the greatest interest are restricted to an area east of the Beauparlant-Samandré intermediate to felsic volcanic complex and east of the mouth of the river draining Itchen Lake (Fig. 98). Iron-formation-related gold showings, which occur sporadically throughout the Contwoyto Formation from Point Lake to Contwoyto Lake to the north-northeast of the map area, have been described and discussed in detail by Bostock (1968, 1980), Ford (1988), Lhotka (1988), Lhotka and Nesbitt (1989, 1990), Ford et al. (1990), and Kerswill (1993, 1996). The iron-formation units hosting these deposits are described in the section on the Contwoyto Formation.

Interest in iron-formation-hosted gold deposits in the area began shortly after the discovery of what was to become the Lupin mine at Contwoyto Lake, with the staking of the TREE, TESS, and PINE claim groups east of the Beauparlant-Samandré intermediate to felsic volcanic complex (9, Fig. 98) in 1963 by Giant Yellowknife Mines Ltd. These claims are on an isoclinally folded, silicate-type iron-formation unit that outcrops over a strike length of at least 240 m and has a geophysical expression over possibly twice that distance (Schiller and Hornbrook, 1964; Ford, 1988). The iron-formation units are up to 12 m thick and consist of several centimetre-scale layers defined by varied proportions of grunerite, quartz, hornblende, garnet, pyrrhotite, and arsenopyrite. The deposit is about 90 000 tonnes (Gibbins et al., 1991) and has a gold content up to 7.5 g/tonne on the basis of drill-core assays (Schiller, 1965). To the north, east of the mouth of the Itchen River, the REN deposit occurs in similar, sulphide-bearing, silicate iron-formation (10, Fig. 98); it is estimated at 1 100 000 tonnes grading about 6.5 g/tonne gold (Energy, Mines, and Resources Canada, 1989).

Like the Lupin mine, both these occurrences are located fairly close to the cordierite metamorphic isograd, the TREE occurrence being somewhat upgrade of it and the REN, immediately below it. None of the iron-formation at lower metamorphic grades within the area is known to be gold bearing (Lhotka and Nesbitt, 1989). These lower grade iron-formation units are mainly, but not exclusively, of the carbonate and oxide types. Sulphides are unknown in either of the latter types within the map area.

The origin of gold in the iron-formation of the area is controversial (Lhotka and Nesbitt, 1989, 1990; Ford et al, 1990; Bullis et al., 1994, 1996; Kerswill et al., 1996). Various models have been reviewed by Kerswill (1993). In the syngenetic model "... all components of a deposit including iron, silicon, calcium, sulphur, arsenic, gold, silver, copper, $CO_2$, and tungsten were deposited from hydrothermal fluids . . . directly onto the seafloor from plumes or brine pools or just below the sediment-seawater interface from fluids reacting with permeable sediment" (Kerswill, 1993). However, this model allows for subsequent "localized remobilisation and concentration of certain components (e.g., silicon, sulphur, arsenic, gold, silver and $CO_2$) during deformation and (or) metamorphism . . . ." (Kerswill, 1993). This mode of origin is favoured by several workers in the area. Bostock (1980) argued in favour of a syngenetic origin based primarily on the constancy of gold/silver ratios between one iron-formation at high metamorphic grade and a second at relatively low metamorphic grade. Since the movement of gold and silver would not be expected to be similar if the elements were introduced epigenetically during metamorphic conditions that varied from place to place, a syngenetic origin was favoured. He envisioned a situation in which local hot springs introduced fluids with constant Au/Ag ratios into the accumulating basin. Gibbins et al. (1991) suggested a syngenetic origin for the nearby, finely laminated to layered Lupin ore body, which consists of a 1200 m long ore zone within a 3 km long, silicate iron-formation similar in most respects (other than the size of the ore zone) to sulphide-bearing, silicate iron-formation within the map area.

In the epigenetic model, Kerswill (1993) indicates that "... some components of BIF [banded iron-formation]-hosted gold deposits were concentrated during chemical sedimentation (iron, some silicon and possibly calcium), but others that were essential to ore formation (sulphur, some silicon, arsenic, gold, silver, tungsten and $CO_2$) were added typically during vein-forming hydrothermal activity associated with much later deformation, metamorphism and (or) magmatism. . . . Sulphidation of relatively iron-rich host rocks adjacent to late shear zones and (or) veins is viewed as the principal ore forming process". Lhotka (1988), Lhotka and Nesbitt (1989), and Bullis et al. (1994) favour an epigenetic origin for gold associated with iron-formation of the Contwoyto Formation and they note that gold-enriched zones are characterized by abundant sulphides, hornblende at the expense of grunerite, and calc-silicates all in close association with late, crosscutting quartz veins. They suggested that these features in all occurrences tend to be symmetrical with respect to the quartz veins and disappear along strike from the late veins, indicating that the variation is not a primary or diagenetic facies change. They argue that all these features are related to the introduction of fluids associated with the formation of the quartz veins that postdated folding of the iron-formation. Because gold is rare or absent in iron-formation at lower metamorphic grade, they suggest introduction and emplacement of the gold during regional metamorphism.

Kerswill (1993, 1996) classified iron-formation-hosted gold deposits into stratiform and non-stratiform types on the basis of the dominant style of gold distribution. The Lupin mine as well as numerous other occurrences in the Point Lake-Contwoyto Lake region were assigned to the stratiform type. Within the map area, the TREE and REN gold occurrences are also probable stratiform types (Kerswill, pers. comm., 1997). The gold mineralization is explained by a hybrid or multistage model that recognizes the primary deposition during sedimentation of some components of the iron-formation such as iron, some silicon, calcium, sulphur, copper, gold, silver, and $CO_2$. However, it also allowed for the introduction of other components such as arsenic, tungsten, some silicon, and possibly more gold during later metamorphic/deformational events that clearly affect these deposits. Kerswill (1993) envisioned gold precipitating from gold-enriched solutions, in which it was carried in bisulphide complexes, that exhaled directly from hydrothermal vents onto the seafloor or reacted with permeable, iron-rich sediments just beneath the seafloor. The gold-enriched sulphide precipitate was superimposed on background sedimentation of silica and iron minerals from seawater enriched in those components that were derived from remote, contemporaneous volcanism and as such, not necessarily related to the hydrothermal vents that were the more local source of the gold and sulphur. Subsequent deformation and metamorphism allowed for the local concentration of elements already present and the introduction of additional material associated with metamorphic fluids.

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# APPENDIX 1

## U-Pb geochronology of the Augustus Granite

### Introduction

In order to confirm the age of the Augustus Granite, several samples of the granite were collected and prepared and one was analyzed since the only data available was unpublished (e.g. Krogh and Gibbins, 1978) or highly discordant (Henderson et al., 1982). As zircon is abundant in the sample and titanite, although rare, is present, analyses were made on both these accessory minerals.

### Geological context and description of the Augustus Granite sample

The sample analyzed was collected from the easternmost block of the Augustus Granite, about 900 m west of the unconformity with the overlying Keskarrah Group conglomerate (65°08.7′N 112°48.7′W; Fig. 27), where the Augustus Granite is a grey, medium- to coarse-grained, even-grained, metamorphosed, and somewhat crushed granite in which the original igneous texture is still evident. Petrographically, the granite contains both medium- to coarse-grained, anhedral, extensively fractured, weakly altered, moderately perthitic microcline and moderately altered, albitic plagioclase and is therefore part of the intermediate phase of the unit. The quartz occurs in polycrystalline, anhedral masses. The mafic minerals consist of irregular, decussate masses of biotite pseudomorphous after the original mafic mineral. Fine biotite also fills the larger fractures in the rock. Since its emplacement, the rock has been metamorphosed to biotite-zone greenschist grade. The projected cordierite isograd in the greywacke-mudstones of the Contwoyto Formation occurs approximately 3 km east of the sample locality.

### Zircon and titanite

The zircons analyzed were all nonmagnetic at 1° of side slope on the Frantz magnetic separator and originally greater than 74 μm in size prior to 3.5 hours of air abrasion to remove the outer margin of the grain. The population consisted of prismatic and equidimensional grains. Four, single-grain zircon fractions were analyzed. The prismatic zircons from which fraction AA (Table 3) was selected were colourless to pale pinkish brown, mainly clear, contained few or no fractures, and were mostly free of inclusions and visible cores. Etched, mounted grains from the population varied from crystals with strongly developed zoning to others that did not etch at all under the same HF vapour conditions, suggesting that uranium content varied from grain to grain. The equant grains (fractions BA, BB, and BC; Table 3) were clear and colourless through pale pink to pale brown. Most had no inclusions, visible cores, or fractures. Their morphology varied from simple euhedral to rounded faceless forms.

The titanite grains (fraction T) were magnetic between 0.6 and 1.8 amperes on the magnetic separator and were originally between 0.1 and 0.2 mm in size prior to one hour of air abrasion. The grains were brown with moderate to poor clarity although a few clearer grains were pale yellow. No inclusions or cores were apparent. Most of the grains were probably highly fractured as the population consisted entirely of broken pieces.

### Analytical methods

The analytical methods used were basically those described in Parrish et al. (1987). The U-Pb analytical data is summarized in Table 3 and plotted on concordia diagrams in Figures 24 and 25.

### Results

The results and significance of this data are discussed in the section on the Augustus Granite.

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