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PRECAMBRIAN GEOLOGY OF THE HACKETT RIVER AREA, DISTRICT OF MACKENZIE, N.W.T.

R.A. Frith

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F.C. Taylor

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Preface

The Hackett River area lies just south of the Arctic Circle, some 500 km northeast of Yellowknife. It is underlain chiefly by volcanic rocks and greywacke-mudstones of the Archean Yellowknife Supergroup that forms part of the Slave Province of the Canadian Shield. Although observations were made on the geology by early explorers, including Captain George Back and R. King who journeyed to the shores of the Arctic Ocean between 1833 and 1835, via the river that now bears Back's name, reconnaissance mapping of the area was not completed until almost 130 years later.

The Yellowknife Supergroup rests on, and is intruded by, a remobilized Archean granitoid basement complex, and is also intruded by synvolcanic plutons and by the extensive, differentiated Regan Intrusive Suite. Proterozoic strata include the platformal sequence of Goulburn Group sediments and two sets of diabase dyke swarms.

Copper mineralization was found in 1956, and after the discovery of economic mineral deposits in the early to mid 1970s the Geological Survey of Canada undertook systematic 1:250 000 scale mapping and compilation of data to outline the mineral resources of this part of the Northwest Territories. The present report by Dr. Frith resulted from this study, and incorporates data from other more detailed work on economic geology, volcanology, geophysics and geochemistry. The accompanying multicoloured geological map includes a compilation of earlier maps that were published by the Department of Indian and Northern Affairs and also unpublished maps provided by mineral exploration companies.

The sodic character of the volcanic rocks and the high lead and silver contents of their associated massive sulphide deposits are notable aspects of this part of the northwest Canadian Shield. Significant amounts of zinc, lead, copper and silver, with minor gold, are present in the potential ore deposits of this area. Gold occurrences are also associated with parts of extensive banded iron formations.

R.A. Price
Assistant Deputy Minister
Geological Survey of Canada

Préface

La région de la rivière Hackett se situe immédiatement au sud du cercle polaire arctique, à quelque 500 kilomètres au nord-est de Yellowknife. Elle repose surtout sur des roches volcaniques et des grauwackes-pélites du supergroupe archéen de Yellowknife, qui fait partie de la province des Esclaves du Bouclier canadien. Bien que les premiers explorateurs, notamment le capitaine George Back et R. King qui ont navigué sur la rivière Back, nommée en honneur à ce premier explorateur, jusqu'à la côte de l'océan Arctique entre 1833 et 1835, aient fait des observations sur la géologie de la région, ce n'est qu'environ 130 ans plus tard que la cartographie de reconnaissance de cette région a été terminée.

Le supergroupe de Yellowknife repose sur un socle métamorphique granitoide archéen remobilisé; le socle métamorphique ainsi que des plutons synvolcaniques et la vaste suite intrusive de Regan, dont les composantes ont été formées par différenciation, ont fait intrusion dans le supergroupe de Yellowknife. Les couches protérozoiques comprennent la séquence des sédiments du groupe de Goulburn, accumulés dans un milieu de plate-forme, et deux ensembles de groupes de filons de diabase.

Une minéralisation cuprifère a été découverte en 1956; à la suite de la découverte de gisements de minéraux à valeur commerciale entre 1970 et 1975, la Commission géologique du Canada a entrepris des travaux de cartographie systématique à l'échelle de 1/250 000 et de compilation de données en vue de délimiter les ressources minérales de cette partie des Territoires du Nord-Ouest. Le présent rapport, préparé par M. Frith, résulte de cette étude et présente des données recueillies lors d'études plus détaillées sur la géologie des ressources naturelles, la volcanologie, la géophysique et la géochimie. La carte géologique polychrome annexée comprend une compilation de cartes antérieures publiées par le ministère des Affaires indiennes et du Nord et de cartes inédites fournies par des sociétés d'exploration minérale.

La nature sodique des roches volcaniques et la teneur élevée en plomb et en argent des gisements de sulfures massifs qui leur sont associés sont remarquables dans cette partie du Bouclier canadien du nord-ouest. D'importantes quantités de zinc, de plomb, de cuivre et d'argent, et de plus faibles quantités d'or, sont présentes dans les gisements minéraux éventuels de cette région. Des venues aurifères sont également associées à certaines parties des vastes formations ferrifères rubanées.

R.A. Price, sous-ministre adjoint
Commission géologique du Canada

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PRECAMBRIAN GEOLOGY OF THE HACKETT RIVER AREA, DISTRICT OF MACKENZIE, N.W.T.

Abstract

The map area is underlain entirely by Precambrian rocks of predominantly Archean age. The oldest rocks are remobilized granitoids that were emplaced into ensialic volcanic and sedimentary strata. The granitoid and locally the supracrustal rocks were altered by subsequent deformation, metamorphism and intrusion during an event analogous to the Kenoran Orogeny.

The Yellowknife Supergroup has been divided into three groups of generally decreasing age. The Hackett River Group, the oldest, consists of three formations that distinguish dominantly sedimentary (Siorak Formation), volcano-sedimentary (Ignerit Formation) and volcanic (Nauna Formation) supracrustal rocks. The succeeding Beechey Lake Group is an extensive unit of greywacke-mudstone. The Back Group, the youngest, is composed primarily of volcanic rocks. The variety of rock types, discontinuous strata, and interfingering of volcaniclastic sedimentary rocks, result in a complex stratigraphy that can only be precisely defined in local sections.

Chemical studies of the volcanic rocks show a uniquely sodic, calc-alkaline family of dacite, andesite and basalt flows and pyroclastics. Field studies indicate the importance of cauldron subsidence and subaerial deposition.

Structural, petrographic and chemical studies of the Regan Intrusive Suite reveal that quartz diorite, tonalite, melanogranodiorite, leucogranodiorite and late muscovite-bearing granites were intruded over the full range of orogenesis. The composition of the major and trace element constituents of the granites suggests that some may not be co-genetic with the rest of the suite.

Orogeny ended with intrusion of northeast-trending diabase dykes (Malley Diabase) during a tensional phase related to early Proterozoic circum-Slave tectonism. Platform deposits of the Goulburn Group unconformably overlie bedrock in the northeast of the area.

Sulphide deposits rich in Pb, Ag, and Zn formed during the waning phase of Archean volcanism in basins and calderas. The Hackett River and Back volcanics are overlain by extensive banded iron formations, parts of which are auriferous.

Résumé

La région cartographiée repose entièrement sur des roches précambriennes à prédominance archéenne. Les roches les plus anciennes sont des granitoides ayant retrouvé leur mobilité, qui se sont disposés en strates volcaniques et sédimentaires ensialiques. Les roches granitoides et, par endroits, les roches supracrustales ont été ultérieurement altérées par des phénomènes de déformation, de métamorphisme et d'intrusion au cours d'un événement analogue à la phase tectonique kénoréenne.

Le supergroupe de Yellowknife a été divisé en trois groupes d'âge généralement décroissant. Le groupe de Hackett River, le plus ancien, est constitué de trois formations dans lesquelles prédominent respectivement des roches sédimentaires (formation de Siorak), des roches volcano-sédimentaires (formation d'Ignerit) et des roches volcaniques (formation de Nauna) supracrustales. Le groupe suivant, celui de Beechey Lake, est une vaste unité de grauwacke-mudstone. Le groupe de Back, le plus récent, se compose principalement de roches volcaniques. La diversité des types de roches, la discontinuité des strates et l'interdigitation des roches sédimentaires volcano-clastiques forment une stratigraphie complexe qui ne peut être définie avec précision que dans des sections locales.

L'étude chimique des roches volcaniques révèle l'existence d'une famille sodique et calco-alcaline unique de roches pyroclastiques et de coulées de dacite, d'andésite et de basalte. Les études faites sur le terrain font ressortir l'importance de la subsidence en chaudron et de la sédimentation subaérienne.

D'après des études structurales, pétrographiques et chimiques de la suite intrusive de Regan, des diorites quartziques, tonalites, mélanogranodiorites, leucogranodiorites et, plus récemment, des granites à muscovite ont subi des intrusions pendant toute la durée de la phase orogénique. La composition des éléments majeurs et traces des granites laisse supposer que certains ont une genèse différente de celle du reste de la suite.

L'orogénie s'est terminée par l'intrusion de filons de diabase à orientation nord-est (diabase de Malley) pendant une phase de tension associée à l'activité tectonique qui a entouré la province des Esclaves au début du Protérozoique. Des dépôts de plate-forme du groupe de Goulburn reposent en discordance sur le socle dans le nord-est de la région.

Des gisements de sulfures riches en Pb, Ag et Zn se sont formés pendant la décroissance du volcanisme archéen dans des bassins et des calderas. Sur les roches volcaniques des formations de Hackett River et de Back reposent de vastes formations de fer rubanées, dont certaines parties sont aurifères.

SUMMARY

The Hackett River area in the northeastern Slave Structural Province is composed of the Yellowknife Supergroup, intrusive plutons of the Regan Intrusive Suite, extensive areas of hybrid rocks derived from the Yellowknife Supergroup, and other minor rock types.

The Yellowknife Supergroup is separated into three groups: the Hackett River Group of felsic to intermediate flows and pyroclastics, the Beechey Lake Group of turbiditic greywacke-mudstones, and the Back Group of felsic to basic flows and pyroclastics.

The Hackett River Group is made up of a basal volcanogenic, metasedimentary unit (Siorak Formation), an overlying subaqueous and subaerial volcanic succession (the Nauna Formation), and an overlying subaqueous volcanic flow and pyroclastic unit (Ignerit Formation). Massive sulphide deposits occur along the length of the volcanic belt and are localized between the top of the Nauna and the Ignerit formations, a horizon which, in one deposit, is related to a change from subaerial to subaqueous deposition.

The Beechey Lake Group is a thick, homogeneous succession of well bedded sediments with a bulk composition close to granodiorite. The group is similar in appearance to turbidites that make up a large part of the Slave Province. Chemical analyses indicate that the turbidites are less mafic than in the Yellowknife type area, and they become even less so at their base toward the conformable contact with the volcanic rocks, where they are distinctly silicic (SiO_2 = 80%) and locally carbonaceous (up to 20%). The longest banded iron formation known in the Slave Province occurs along the east margin of the Hackett River greenstone belt.

The Back Group is a younger, separate volcanic succession that unconformably overlies the Beechey Lake Group. The group evolved around a cauldron subsidence centred 18 km south of the map area, and is composed of basalt and andesite flows, dacite volcanic domes, and felsic pyroclastic breccias and tuffs. It is intruded by gabbro sills, related to pillowed basalt flows that occur along its northern part. The base of the succession commonly contains conglomerate beds, with clasts that range from 4 m blocks of volcanic rubble to pea-size. Like the Hackett River Group, the sediment overlying the volcanics is locally more siliceous and carbonaceous and is interlayered with banded iron formation.

Hybrid rocks make up a large part of the Mara River Complex in the western half of the area. Contacts with Yellowknife Supergroup rocks are commonly gradational, and migmatites derived from volcanic as well as sedimentary rocks are present. Irregular intrusions of muscovite-rich granite and pegmatite occur in nearby metasedimentary rocks. Within the complex they occur as leucosome within the migmatite, but are far more heterogeneous.

The Regan Intrusive Suite consists of about 100 individual plutons, three quarters of which are granodiorite or tonalite made up of biotite, plagioclase, microcline and quartz with or without hornblende. Most are medium to coarse, even grained unaltered rocks, but some plutons contain microcline megacrysts. The plutons are mostly subrounded, but have near vertical contacts, suggesting they have a cylindrical shape at depth. Some plutons are zoned, with compositions grading from diorite at the margins to near granite at the core. The composition of the zones

SOMMAIRE

La région de Hackett River, située dans le secteur nord-est de la province tectonique des Esclaves, renferme des roches du grand groupe de Yellowknife ainsi que des roches plutoniques faisant partie de la série des roches intrusives de Regan. Elle comprend également de vastes étendues de roches hybrides provenant du grand groupe de Yellowknife ainsi que divers autres types de roches de moindre importante.

Le grand groupe de Yellowknife se divise en trois parties: le groupe de Hackett River (coulées de lave de composition intermédiaire à felsique et pyroclastiques), le groupe de Beechey Lake (grauwackes et shistes argileux de type turbidite) et celui de Back (coulées de laves felsiques à mafiques et pyroclastiques).

Le groupe de Hackett River se compose, à la base, de métasédiments contenant des fragments de roches ignées (formation de Siorak). Au-dessus de cette formation se trouve celle de Nauna (une succession de roches volcaniques de milieu subaquatique et subaérien) sur laquelle repose la formation de Ignerit (coulées volcaniques subaquatiques et pyroclastiques). Des dépôts de sulfures massifs se retrouvent dans la zone volcanique, entre le sommet de la formation Nauna et celle de Ignerit. Il s'agit d'un horizon qui représente, durant une étape, un changement du mode de sédimentation (subaérien à subaquatique).

Le groupe de Beechey Lake est constitué d'une épaisse succession homogène de sédiments bien stratifiés dont la composition générale se rapproche de celle d'une granodiorite. Les roches de ce groupe ressemblent aux turbidites qui constituent la majeure partie de la province des Esclaves. Les analyses chimiques révèlent que ces turbidites sont moins mafiques que celles du type Yellowknife et de moins en moins mafiques vers la base; au contact en concordance avec les roches volcaniques, elles sont siliceuses (SiO_2 = 80 %) et carbonacées par endroits (jusqu'à 20 %). La plus longue formation de fer rubanné de la province des Esclaves se situe le long de la bordure est de la zone de roches vertes de Hackett River.

Le groupe de Back est une succession plus jeune de roches volcaniques qui repose en discordance sur le groupe de Beechey Lake. Ce groupe s'est constitué autour d'un effondrement circulaire dont le centre se trouve à 18 km au sud de la région cartographiée. Il se compose de coulées basaltiques et andésitiques, de dômes volcaniques de dacite ainsi que de tufs et de brèches pyroclastiques felsiques. Le groupe de Back est recoupé par des filons-couches gabbroïques associés à des laves basaltiques coussinées qu'on retrouve au nord. La base des strates se compose généralement des lits de conglomérats contenant des blocs de 4 m de diamètre jusqu'à des fragments de la taille d'un pois. Comme dans le cas du groupe de Hackett River, les sédiments qui recouvrent les roches volcaniques sont plus siliceux et carbonacés par endroits et sont interstratifiés avec une formation de fer rubanné.

Le roches hybrides constituent la majeure partie du complexe de Mara River, dans le secteur ouest de la région. Les contacts avec les roches du grand groupe de Yellowknife sont généralement graduels; on y retrouve des migmatites provenant des roches volcaniques et sédimentaires. Les métasédiments situés à proximité contiennent des intrusions irrégulières de granite et de pegmatite riches en muscovite. Dans le complexe, elles se présentent sous forme de minéraux leucocrates dans la migmatite, mais sont beaucoup plus hétérogènes.

La série de roches intrusives de Regan est constituée d'une centaine de plutons distincts dont les trois quartz appartiennent à la catégorie des granodiorites et des tonalites. Ces intrusions contiennent de la biotite, du plagioclase, de la microcline ainsi que du quartz, avec ou sans hornblende. La granulométrie de la plupart de ces plutons varie de moyenne à grossière. Les roches sont à grains non altérés de même taille; certains plutons contiennent cependant des phénocristaux de microcline. La plupart des plutons sont subarrondis mais présentent des contacts

is similar to that of the individual plutons, suggesting a similar fractionation process. Granites make up about one quarter of the suite, but geochemical studies suggest they are not a simple differentiate of the Regan Intrusive Suite protolith magma, but were derived by melting of a pre-existing crust that was somehow enriched with extraneous alkalis.

Proterozoic platform rocks of the Goulburn Group unconformably overlie the Beechey Lake Group in the northeast corner of the map area. They are flat lying or dip at shallow angles due to minor warping along open north-trending folds which also affect the basement. The base of the group is the Western River Formation, a poorly sorted limy conglomerate, argillite, quartzite, siltstone and dolomite. The conglomerate contains clasts of angular Archean rocks comparable to the Beechey Lake Group (of various metamorphic grades), quartz pebbles and felsic volcanic clasts. The Western River Formation is overlain by the Burnside River Formation of pink to white sandstone or quartzite with abundant crossbedding and ripple marks. The Goulburn Group is intruded at and near its base by gabbro sills up to 130 m thick that have a high aeromagnetic expression.

The area is cut by northwest-trending Mackenzie Diabase dykes. They are possibly contemporaneous (1260-1190 Ma) with the sills intruding the Goulburn Group and other large scale basic intrusions in the northwestern Canadian Shield, such as the Muskox.

Deformation of the Yellowknife Supergroup occurred during the Archean (D1, D2 and D3), the earliest forming downwarping of volcanic margins and large scale folding (wave lengths several kilometres) within the marginal metasediments. This produced a widespread bedding foliation in the metasediments, defined by mica, which is overprinted by a second, almost contemporaneous pure strain foliation that did not fold the rocks, except where they are heterogeneous, such as at volcanic margins where the direction of folding is at high angles to the contact. Foliation is commonly parallel to that produced during D1, but where bedding and D2 foliation intersect at an angle, "Z" type bedding-cleavage intersections are consistent across strike for many kilometres.

Large uplifted regions along the length of the Hackett River greenstone belt include a dome-like structure at the north end (Hackett River gneiss dome) and an anticlinorial structure at the south end. Both structures formed during D2, when regional thermal metamorphism was at or near its peak. Plutons of the Regan Intrusive Suite intruded during D2 or closely following D2, but before D3 formed a regional upright cleavage. D3 cleavage cuts muscovite in pegmatite, showing that it formed when thermal metamorphism was essentially over.

A fourth phase of deformation is related to gentle warping of the Proterozoic Goulburn Group along north-south axes. Associated cleavage extends into the Archean basement metasediments, but it is evident only at or near the contact with the Goulburn. This deformation is associated with east-west compression within the Queen Maud block of the Churchill Structural Province.

Metamorphism ranges from greenschist to upper amphibolite facies as outlined by the biotite, cordierite-staurolite and sillimanite isograds. Sub-biotite grade rocks include greywacke-mudstones that extend from the Goulburn unconformity in the northeast to the Back River. Typical pelitic

presque verticaux, ce qui laisse croire que leur forme est cylindrique en profondeur. Certains plutons sont zonés: on observe une variation de leur composition qui passe de dioritique en bordure à presque granitique vers le centre. La composition des différentes zones est la même que celle des plutons individuels, ce qui laisse croire à un processus de fractionnement similaire. Les granites constituent le quart de la série; cependant, certaines analyses géochimiques suggèrent que ces granites ne sont pas simplement le résultat de la différenciation entre les éléments du magma d'origine de la série de roches intrusives de Regan mais qu'ils pourraient plutôt provenir de la fusion d'une croûte préexistante qui aurait été enrichie en roches alcalines.

Les roches de plate-forme du Protérozoïque du groupe de Goulburn reposent en discordance sur celles du groupe de Beechey Lake dans le secteur nord-est de la région cartographiée. Les strates sont horizontales ou présentent un faible pendage à cause d'une légère déformation le long de plissements dont la structure directionnelle porte surtout vers le nord et qui touchent également le soubassement. À la base de ce groupe, on retrouve la formation de Western River: conglomérat calcaire mal trié, argilite, quartzite, microgrès et dolomite. Le conglomérat se compose de fragments anguleux de roches archéennes semblables à celles du groupe de Beechey Lake (à divers stades de métamorphisme), des petits cailloux de quartz ainsi que des fragments de roches volcaniques felsiques. La formation de Western River se trouve au-dessous de celle de Burnside River constituée de grès roses et blancs ou de quartzite et dans laquelle on peut observer de nombreuses rides de plage et stratifications entrecroisées. La base du groupe de Goulburn et la zone avoisinante sont recoupées par des filons-couches de gabbro dont l'épaisseur peut atteindre 130 m et qui apparaissent nettement sur une carte aéromagnétique.

La région cartographiée est traversée par les dykes de diabase Mackenzie ayant une direction nord-ouest. Il est possible que ces dykes datent de la même époque (1260-1190 Ma) que les filons-couches du groupe de Goulburn et que d'autres importantes intrusions mafiques du nord-ouest du Bouclier canadien (comme le Muskox).

La déformation du grand groupe de Yellowknife s'est produit au cours de l'Archéen (D1, D2 et D3). La déformation la plus ancienne a engendré un pli synclinal dans les bordures volcaniques ainsi qu'un plissement à grande échelle (longueur d'onde de plusieurs kilomètres) dans les métasédiments côtiers. Cette déformation a engendré une shistosité répandue à grande échelle dans les métasédiments et observable à cause de l'orientation prise par les micas. Elle est recoupée par une seconde foliation presque contemporaine qui n'a pas plissé les roches sauf dans les zones où ces dernières sont hétérogènes (comme dans les bordures volcaniques où la direction du plissement est presque perpendiculaire au contact). La foliation est généralement parallèle à celle de la phase D1, mais là où la stratification et la foliation D2 se recoupent à angle, les recoupements stratification-clivage de type "Z" s'observent sur plusieurs kilomètres dans la direction des couches.

On retrouve d'importantes régions de soulèvements dans la zone de roches vertes de Hackett River, dont une structure en dôme au nord (le dôme de gneiss de Hackett River) et un anticlinal au sud. Ces deux structures ont été formées durant la phase de déformation D2, lorsque le métamorphisme thermique régional avait atteint (ou presque) son degré le plus élevé. Les plutons de la série intrusive de Regan apparurent pendant la phase D2 ou peu de temps après, mais certainement avant que la phase de déformation D3 n'engendre un clivage régional vertical. Le clivage D3 touche la muscovite dans la pegmatite, ce qui prouve que cette déformation a eu lieu lorsque le métamorphisme thermique était presque terminé.

assemblages include chlorite, muscovite, quartz and albite. Common, but not always present, are graphite, pyrite, tourmaline, hematite, calcite, and rarely stilpnomelane. Only chlorite is developed within volcanic rocks.

Biotite first appears as small blades aligned parallel to the foliation formed by D1 or D2 which becomes progressively more common upgrade. Garnet may occur where compositions are more mafic. Near the cordierite-staurolite isograd large crystals of andalusite are present.

Cordierite with staurolite defines the cordierite-staurolite isograd, and these porphyroblasts are common in rusty schists cut by quartz veins which increase in abundance toward the sillimanite isograd and beyond. Cordierite is commonly altered.

Sillimanite gneiss and schist occur around the Hackett River gneiss dome, associated with migmatization adjacent to the Mara River Complex. Around the Hackett River gneiss dome sillimanite is retrograde after kyanite, and is associated with clear, locally gem quality, cordierite, anthophyllite, garnet, chlorite, quartz, biotite, plagioclase and ilmenite. The presence of kyanite in this part of the Slave Province is significant, as it suggests a lateral variation in geothermal gradient. Horizontal isograds were uplifted during doming causing retrogression of kyanite to sillimanite.

Two types of mineral deposit occur in the map area: layered massive sulphides, and free gold in banded iron formation. The most economically promising are the massive sulphide deposits of the "A" deposit at Camp lake, one of several of the Hackett River area mineral deposits, controlled (1986) by Cominco Ltd.; and the Yava deposit near Aitch Lake, controlled (1986) by Brascan Ltd. No economically important deposits of gold have been outlined in the banded iron formation overlying the Hackett River greenstone belt, but several showings north of the Back Group have been explored since the 1950s.

Hackett River mineral deposits include the "A" zone, the "Jo" zone, the "Jo-South" zone, "East-Cleaver Lake" zone, "Finger Lake" zone and the "Booth Lake" zone. All are within 100 m of the contact between the Ignerit Formation and the Beechey Lake Group. The deposits are stratiform and occur in saucer-shaped volcano-sedimentary basins. The strata are both detrital and chemical in origin, and generally consist of coarse volcanic breccias at the base that fine upward into fine detrital tuff mixed and interlayered with chemically deposited material. All deposits have been metamorphosed to at least sillimanite grade. Deposition was initially from explosive volcanism, followed by more quiescent conditions in offshore basins. Deposition took place in 5 cycles that formed: (1) a lower volcaniclastic mafic chloritic sediment with chert, limy and argillaceous interlayers (Siorak Formation), (2) coarse andesitic volcanic breccia with an andesitic matrix mixed with finer pyroclastic and volcaniclastic sediments marking the start of an explosive volcanic phase; (3) mixed volcaniclastic and aluminous sediments, now highly altered and characterized by sillimanite "spots" or porphyroblasts, transected by funnel-shaped "conduit" type rocks of quartz and sulphide minerals with a "chicken-wire" patterned texture of muscovite surrounding quartz aggregates; (4) a predominantly chemical (limy, cherty) and tuffaceous sediment with some argillaceous layers that are contemporaneous with deposition of bedded

Une quatrième phase de déformation est liée au léger plissement du groupe d'âge protérozoïque de Goulburn le long d'un axe nord-sud. Le clivage qui en résulte s'observe jusque dans les métasédiments archéens du soubassement. Cependant, ce clivage n'est évident qu'au contact avec le groupe de Goulburn ou à proximité de celui-ci. Cette déformation est associée à une compression exercée selon l'axe est-ouest dans le secteur Queen Maud de la province tectonique de Churchill.

Le métamorphisme s'étend du faciès shistes verts au faciès supérieur amphibolite comme en témoignent les isogrades de la biotite, cordiérite-staurotide et sillimanite. Parmi les roches ayant presque atteint l'isograde de la biotite, on retrouve les grauwacke-shistes argileux qui s'étendent de la discordance de Goulburn au nord-est jusqu'au groupe de Back River. Les assemblages pélitiques types comprennent la chlorite, la muscovite, le quartz et l'albite. On observe souvent également (quoique pas toujours) le graphite, la pyrite, la tourmaline, l'hématite, la calcite et, rarement, le stilpnomélane. La chlorite n'est présente que dans les roches volcaniques.

La biotite se présente d'abord en petites plaquettes orientées parallèlement à la foliation engendrée par D1 ou D2 et sa teneur augmente progressivement. La présence de grenat peut être observée dans les roches de composition plus mafique. On retrouve des phénocristaux d'andalousite près de l'isograde cordiérite-staurotide.

L'isograde cordiérite-staurotide est déterminé par la présence de ces deux minéraux. On les retrouve souvent sous forme de phénocristaux dans les shistes rouillés entrecoupés par des veines de quartz dont la quantité augmente à mesure qu'on s'approche de l'isograde de la sillimanite et même au-delà de celui-ci. La cordiérite est généralement altérée.

Les gneiss et les shistes à sillimanite se retrouvent près du dôme de gneiss de Hackett River et sont associés à la migmatisation adjacente au complexe de Mara River. Près du dôme de gneiss de Hackett River, la sillimanite apparaît après la kyanite comme minéral de métamorphisme régressif et elle est associée à la cordiérite (d'assez bonne qualité par endroits pour produire des gemmes), à l'anthophyllite, au grenat, à la chlorite, au quartz, à la biotite, au plagioclase et à l'ilménite. La présence de kyanite dans cette région de la province des Esclaves est significative car elle suggère une variation latérale du gradient géothermique. Les isogrades horizontaux ont été soulevés lors de la formation du dôme, entraînant un métamorphisme régressif de la kyanite à la sillimanite.

Deux types de gisements se présentent dans la région cartographiée: sulfures massifs stratifiés et or natif dans une formation de fer rubanné. Les plutons prometteurs sont le gisement "A" de Camp lake, l'un des nombreux gisements de la région de Hackett River exploité par la compagnie Cominco (1986) et le gisement Yava, près de Aitch Lake, exploité par la compagnie Brascan Ltd. (1986). Aucun gisement d'or économiquement important n'a été signalé dans la formation de fer rubanné située au-dessus de la zone de roches vertes de Hackett River. Par contre, plusieurs affleurements avec indices ont été examinés au nord du groupe de Back depuis 1950.

Le gisement de Hackett River comporte différentes zones: "A", "Jo", "Jo-South", "East-Cleaver Lake", "Finger Lake" et "Booth Lake". Toutes ces zones se trouvent à moins de 100 m du contact entre la formation Ignerit et le groupe de Beechey Lake. Les gisements sont stratiformes et se présentent dans des bassins volcano-sédimentaires en forme de coupole inversée. Les strates sont à la fois d'origine chimique et détritique; elles sont généralement constituées par des brèches volcaniques à gros fragments à la base. La taille des fragments diminue en allant vers de sommet pour former des tufs détritiques à grains fins mêlés et interstratifiés avec des éléments issus de la sédimentation chimique. Tous les gisements ont subi un métamorphisme au moins équivalent à celui de la zone sillimanite. La première phase de sédimentation a d'abord été d'origine massive sulphides; and (5) Beechey Lake siliceous, carbonaceous mudstones followed by turbiditic greywacke-mudstones. Although considerable variation occurs among the discrete sulphide deposits in the region, they all have chalcopyrite, galena, and sphalerite associated with pyrite, pyrrhotite and magnetite.

The Yava deposit formed in a depression caused by subsidence of a volcanic cauldron. The basin is presently on its side, providing a stratigraphic cross-section of the geology. The cauldron is floored by pillowed flows of basalt and andesite overlain by subaerial andesitic and felsic welded ignimbrites and tuffs. The mineral deposits are located along the interface between the subaerial and subaqueous strata and are associated with carbonaceous, sulphide-bearing tuffs and local banded iron formation. The sulphides of the Yava deposit were likely derived from the underlying ignimbrites, fed through, now altered, pipe-like conduits of porous volcanic fragmental rocks.

Assays of massive sulphides from the Hackett River and Yava deposits are atypical of massive sulphides elsewhere in the Canadian Shield. Hackett River samples are high in lead and zinc relative to copper, and high in silver/gold ratios. This is related to the volcanic source rocks which are calc-alkaline rather than tholeiitic. Chemical studies of foot-wall rocks in the Camp lake area show lower Na_2O and CaO, higher K_2O, and more variable MgO, Al_2O_3 and SiO_2 values than in stratigraphically equivalent rocks near the deposit. This suggests hydrothermal leaching of base- and precious-metals from foot-wall rocks that were deposited as chemical sediments in offshore basins.

Gold showings occur along the northeast margin of the Back Group volcanic rocks, north of Fidler Lake, in slaty mudstones that have been folded and sheared. The mineralization, present where quartz is abundant, includes amphibole, chlorite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite and iron oxides.

Development work has shown that at least 20 million tons of potential ore is present in the Hackett River area deposits and possibly as much as 2 million tons in the Yava deposit. The deposits have significant levels of zinc, lead, copper and silver with minor gold.

volcanique, suivie par une seconde phase plus calme dans des bassins au large. La sédimentation peut être divisée en cinq cycles qui ont engendré la formation: (1) de roches sédimentaires à fragments ignés mafiques et chloriteux interstratifiés avec du chert, du calcaire et de l'argile (formation de Siorak); (2) d'une brèche volcanique andésitique à fragments grossiers ayant une matrice andésitique et de sédiments plus fins contenant des pyroclastiques et des fragments d'origine volcanique, marquant le début d'une phase de volcanisme explosif; (3) d'un mélange de sédiments alumineux et à fragments d'origine volcanique très altérés caractérisés par la présence de phénocristaux de sillimanite, entrecoupés par des "conduits" de roches en forme d'entonnoir contenant des sulfures et des agrégats de quartz, lesquels sont entourés de muscovite formant une texture polygonale; (4) de sédiments à prédominance chimique (chert, calcaire) et tufacée accompagnés de certaines couches argileuses du même âge que les sulfures massifs stratifiés; (5) de shistes argileux carbonacés et siliceux suivis de grauwacke-shistes argileux de type turbidite. Malgré les variantes qui existent entre les gisements de sulfures massifs de la région, ils contiennent tous de la chalcopyrite, de la galène et de la sphalérite accompagnées de pyrite, pyrrotine et magnétite.

Le gisement de Yava s'est formé dans une dépression causée par l'effondrement circulaire d'un terrain volcanique. Le bassin a basculé sur le côté, offrant ainsi un coupe stratigraphique de la géologie. On retrouve à la base du bassin des laves basaltiques et andésitiques coussinées recouvertes par des ignimbrites et des tufs subaériens lithifiés, de composition andésitique et felsique. Les gisements se situent entre les strates contenant les sédiments subaériens et subaquatiques et sont associés à des tufs carbonacés contenant des sulfures et à une formation locale de fer rubanné. Les sulfures du gisement de Yava proviennent fort probablement des ignimbrites sous-jacentes, amenés par des cheminées de roches volcaniques détritiques maintenant altérées.

Les analyses des gisements de sulfures massifs de Hackett River et de Yava révèlent une composition qui n'est pas typique de celle des autres gisements du Bouclier canadien. Les échantillons prélevés à Hackett River présentent une forte teneur en zinc et en plomb comparée à leur teneur en cuivre. Le rapport argent/or est également élevé. On explique ce phénomène par la nature calco-alcaline plutôt que tholéitique des roches volcaniques d'origine. Les analyses chimiques des roches encaissantes de la région de Camp Lake démontrent une teneur moins élevée en Na_2O et CaO, plus élevée en K_2O et plus variable en MgO, Al_2O_3 et SiO_2 que dans les roches appartenant à un niveau stratigraphique équivalent situées à proximité du gisement. Les éléments laissent croire à une lixiviation hydrothermique des métaux communs et précieux à partir des roches encaissantes jusque dans les bassins au large où il y aurait eu sédimentation chimique.

On retrouve de l'or dans la bordure nord-est du groupe de roches volcaniques de Back, au nord de Fidler Lake, dans des shistes argileux plissés et cisaillés. Les zones minéralisées se situent là où le quartz est abondant et contiennent des amphibolites, de la chlorite, de la pyrite, de la pyrrhotine, de la chalcopyrite, de l'arsénopyrite et des oxydes de fer.

Les travaux effectués dans la région de Hackett River ont démontré que les gisements recèlent au moins 20 millions de tonnes de minerai potentiel. Quant au gisement de Yava, il recèlerait environ 2 millions de tonnes. Ces gisements présentent des teneurs élevées en zinc, en plomb, en cuivre et en argent ainsi que de petites quantités d'or.

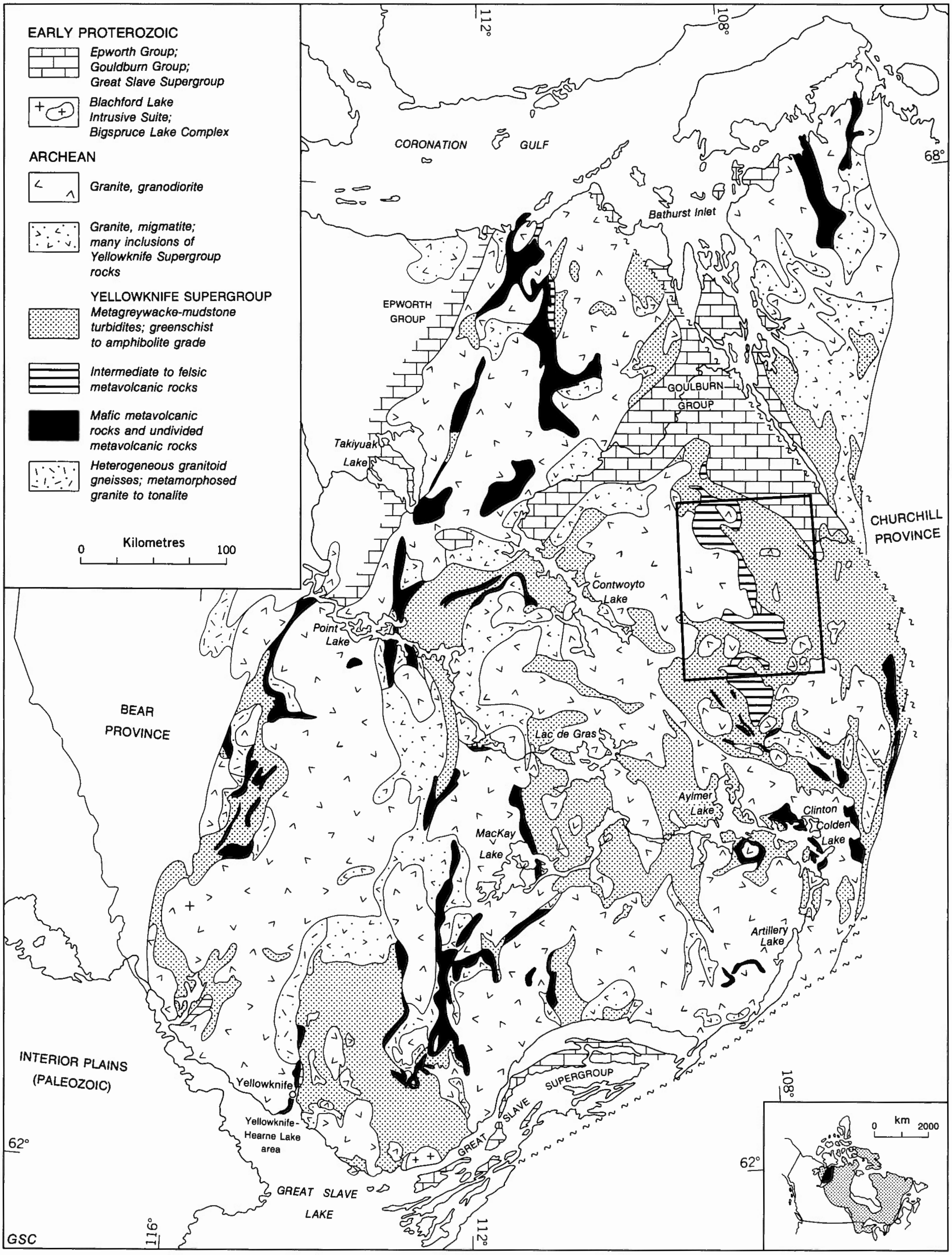

Figure 1. Simplified geological map of the Slave Province showing the area covered by this report (from Henderson, 1985).

INTRODUCTION

This report describes the geology of the Hackett River area (NTS 76 F east half, 76 G west half), which was mapped at various scales for final 1:125 000 scale publication. The main purpose of the work was to map areas that had only been studied by helicopter reconnaissance and to compile other more detailed mapping carried out in the economically important regions of Hackett River and Aitch Lake.

Location and access

The area is located just south of the Arctic Circle, bounded by longitudes 107 and 109° and latitudes 65 and 66°. The centre of the area is about 500 km northeast of Yellowknife (Fig. 1) and 150 km south of an Inuk settlement on Bathurst Inlet. Access to most parts of the area was by ski or float plane. Boat access was limited to the Back River, as other rivers are too shallow for practical use. The most inaccessible areas were reached by helicopter.

Fieldwork was carried out in 1975 and 1976, between 1 June and mid-August.

Previous work

Apart from casual geological observations of early explorers (Back, 1836; King, 1836; Anderson, 1855) and prospectors, there was no systematic geological mapping of the area until 1 inch to 8 mile reconnaissance work by the Geological Survey of Canada (Wright, 1957; Fraser, 1964). Tremblay (1971) mapped, at 1:125 000 scale, selected parts of the east half of the area, which included the Goulburn Group in the northeast corner and some areas around Regan Lake and Tikiraq Lake. Figure 2 outlines the previous geological mapping in the area.

Mineral exploration in the Hackett River area by an amalgamated group of mining concerns (Bathurst-Norsemines Ltd.) began in 1975 and included; mapping, geophysical surveying and diamond drilling. A group of deposits were outlined containing an estimated 20 million short tons of potential ore (McNeil, 1976).

Mineralized gossans in the Aitch Lake area, which were initially outlined by the Geological Survey of Canada (Wright, 1957), were staked in 1971. Geochemical sampling, mapping, geophysical surveying and diamond drilling were carried out by the Yava Syndicate which outlined a 1 to 2 million short ton massive sulphide deposit. The Geological Survey of Canada carried out an integrated, detailed study of the Aitch Lake area (summarized by Cameron and Durham, 1975).

The map accompanying this report (Map 1619A, in pocket) was compiled, in part, from earlier maps published by the Department of Indian and Northern Affairs and from unpublished maps provided by mineral exploration interests. Published maps included 2 inch to 1 mile compilations from economically important areas (Padgham et al., 1975a, 1976; Jefferson et al., 1976a, b). Unpublished maps at various scales were provided by Cominco Ltd. (Wilton, 1975) and by the Yava Syndicate (Roscoe, 1975; see Fig. 2).

Studies on various economic aspects of the area were carried out by Shegelski and Thorpe (1972), Sangster (1972a, b), Franklin (1976), Taylor (1976), Nicholls (1976) and Casselman (1977). Frith and Percival (1978) studied the stratigraphy, structure and metamorphism of the Siorak Formation around the Hackett River gneiss dome. A number of geophysical studies (Boyd et al., 1975) and geochemical studies (Cameron, 1975; Cameron and Durham, 1974a, b, 1975; Cameron and Lynch, 1975; Ewing, 1979) were carried out. Henderson (1975a) investigated the pyritic and carbonaceous metasediments that overlie the uppermost volcanics at the Yava sulphide deposit, and Baragar (1975) reported on volcanic rocks, near the southern part of the map area, that form part of the Back Group. A caldera complex has been identified and studied in detail by Lambert (1975, 1978, 1982b). Thorpe (1972) reported lead isotope work on sulphide occurrences in the Slave Province that included the mineral deposits from the present area. Wanless (1970) and Frith and Loveridge (1982) summarized radiometric work carried out in the area. Petrological and geochemical studies of the Regan Intrusive Suite, an important rock unit in the map area, have been reported separately (Hill and Frith, 1982).

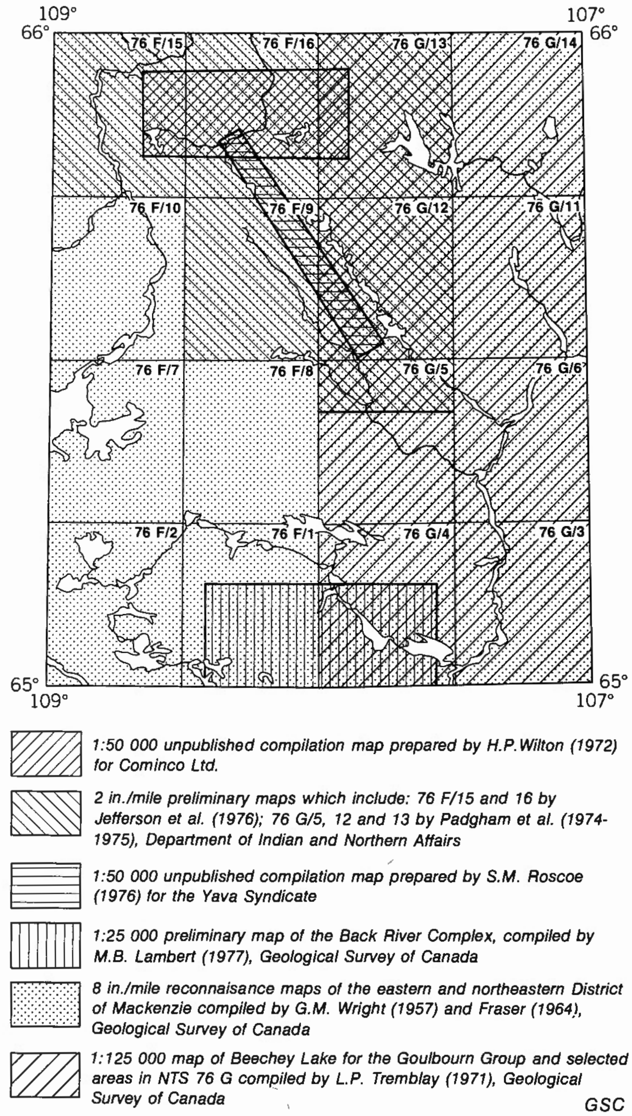

Figure 2. Previous work carried out in the Hackett River area.

Acknowledgments

During the mapping phase of this study the author was capably assisted by Jean Hill, John Hill and Richard Boudreau in 1975, and by John Hill, John Percival and John Ostler in 1976. The author is particularly indebted to John Hill and John Percival who carried out thesis studies in the area under the auspices of the Geological Survey of Canada. The co-operation and logistic support accorded by R. Hornal, W. Padgham, M. Braden, and L. Beaumont of the Resident

Geologist's office of the Department of Indian and Northern Affairs in Yellowknife is gratefully acknowledged. S. Roscoe and L. Saliken of the Yava Syndicate provided logistic support and kindly permitted subcharter of their helicopters. B. Mioduszewska and H. Boronowski of Cominco Ltd. were most helpful and co-operative.

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GENERAL GEOLOGY

The geology of the map area is similar to that in other parts of the Slave Province in its gross structure, lithology and metamorphism, but there are important differences that make this part of the northwest Canadian Shield unique. The metavolcanic and metasedimentary rocks that make up about 60% of the surface area were deposited at approximately the same time as supracrustal rocks elsewhere in the Slave Province, but the volcanic rocks are notably sodic and the massive sulphide deposits associated with them are high in lead and silver, which contrasts with massive sulphides found elsewhere in the Canadian Shield. The plutonic rocks, which intruded the supracrustals at the close of the Archean are about 100 Ma years younger. They are also sodic, but are contemporaneous with late kinematic plutons found elsewhere in the Slave Province.

The Table of Formations (Table 1) catalogues the mappable rocks of the area, their age and relationship to each other, and includes the principal rock types found in each unit. For descriptive purposes the principal rocks have been divided into supracrustal rocks of the Yellowknife Supergroup and granitoid rocks. The latter comprise the basal complex areas, the synvolcanic intrusions and the anorogenic granitoid plutons (Stockwell, 1972) that mark the close of the Archean in this part of the Canadian Shield. A third, areally minor, group of rocks includes Proterozoic diabase dykes, platform metasedimentary rocks of the Goulburn Group and gabbro sills that intrude it.

Table 1. Table of formations

UNIT[1]	FORMATION	RELATIONSHIP	LITHOLOGY[2]
Qu		Deposited on erosional unconformity	Sand and gravel
Pm	Mackenzie Diabase	Intrudes A and A	Diabase/gabbro
Ad	Gabbro sills	Intrudes ABL and AW	Gabbro
AB	GOULBURN GROUP (AW-AB) Burnside River Formation	Conformable with AW	Quartzite, conglomerate, argillite
AW	Western River Formation	Unconformable with A	Argillite, siltstone,quartzite
AM	Malley Diabase	Intrudes A rocks	Diabase/gabbro
AR	Regan Intrusive Suite	Intrudes AB, ABL, AH, AM	Granodiorite, tonalite, quartz diorite, granite
Ad	Amphibolite dykes	Intrusive into AM	Hornblende amphibolite
As	Synvolcanic plutons	Intrudes AH	Tonalite, granodiorite
Ap	Pegmatite	Intrudes AS, AH, ABL	Trondhjemite
AB	YELLOWKNIFE SUPERGROUP (As-AB) Back group	Interfingers and overlies ABL	Andesite, dacite, basalt
ABL	Beechey Lake Group	Conformable with AH	Greywacke, mudstone, carbonaceous mudstone, banded iron formation
AH	Hackett River Group		Undifferentiated intermediate to felsic volcanic rocks, paragneiss
AI	Ignerit Formation	Conformable with AN and AS	Intermediate to felsic volcanics and volcanogenic metasedimentary rocks
AN	Nauna Formation	Unknown	Intermediate to felsic volcanic rocks
AS	Siorak Formation	Unknown	Volcanogenic metasedimentary rocks
AM	Mara River Complex	Unknown - may predate AH in part	Gneiss, migmatite, pegmatite and unmapped plutonic rocks

[1]Time-scale after Frarey (1981) Qu = Quaternary; P = Paleohelikian; A = Aphebian; A = Archean

[2]Rock classification scheme is outlined in the Appendix.

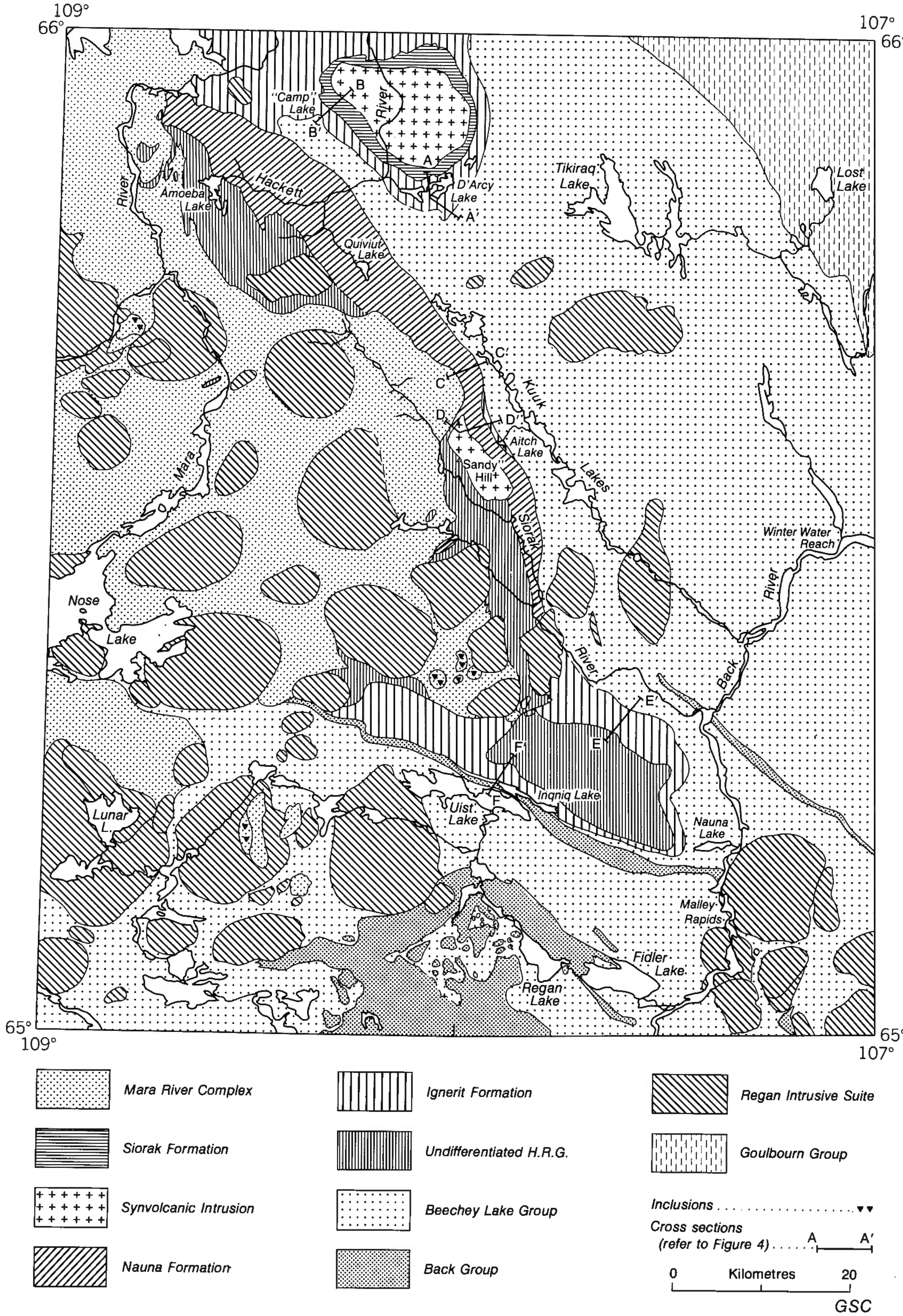


Figure 3. A sketch map of the Hackett River Group and environs showing the subdivisions of the group and geographic localities mentioned in the text. Sections are shown in Figure 4.

Archean

Archean rocks underlie 95% of the map area. They consist of metavolcanic and metasedimentary supracrustal rocks and granitoid plutons and metamorphic complexes that either intrude or are lifted up into the supracrustal rocks.

Yellowknife Supergroup

The supracrustal rocks of the Yellowknife Supergroup (Henderson, 1975a, b) make up about 60% of the bedrock in the area. The supergroup is divided into three groups: the Hackett River Group, composed of volcanic rocks and volcanogenic sediments; the Beechey Lake Group, composed of metasedimentary rocks; and the Back Group, composed primarily of volcanic rocks.

Stratigraphic studies of the Yellowknife Supergroup in the map area (Frith and Percival, 1978) determined that the Back River Group overlies and interfingers with the Beechey Lake Group, which conformably overlies the Hackett River Group. Angular discordance is locally present within the Back Group, particularly at the base where volcaniclastic quartz-pebble conglomerates are locally evident.

Geochronological studies of the supergroup in the northeastern Slave Province (Frith and Loveridge, 1982) showed that the volcanic rocks, synvolcanic plutons and sedimentary rocks that make up the supergroup were deposited within a limited time, about 2669 ± 15 Ma ago. Isotopic age determinations are indicated on the pocket map and are summarized in the Appendix.

Hackett River Group

The Hackett River Group, initially named and described by Frith and Percival (1978), includes all of the supracrustal rocks that make up the informally termed Hackett River greenstone belt (Frith and Hill, 1975; R.A. Frith et al., 1977; Padgham et al., 1975b). The group is divided into four map units: the Siorak Formation, made up of gneissic and schistose rocks that enclose the core of the Hackett River

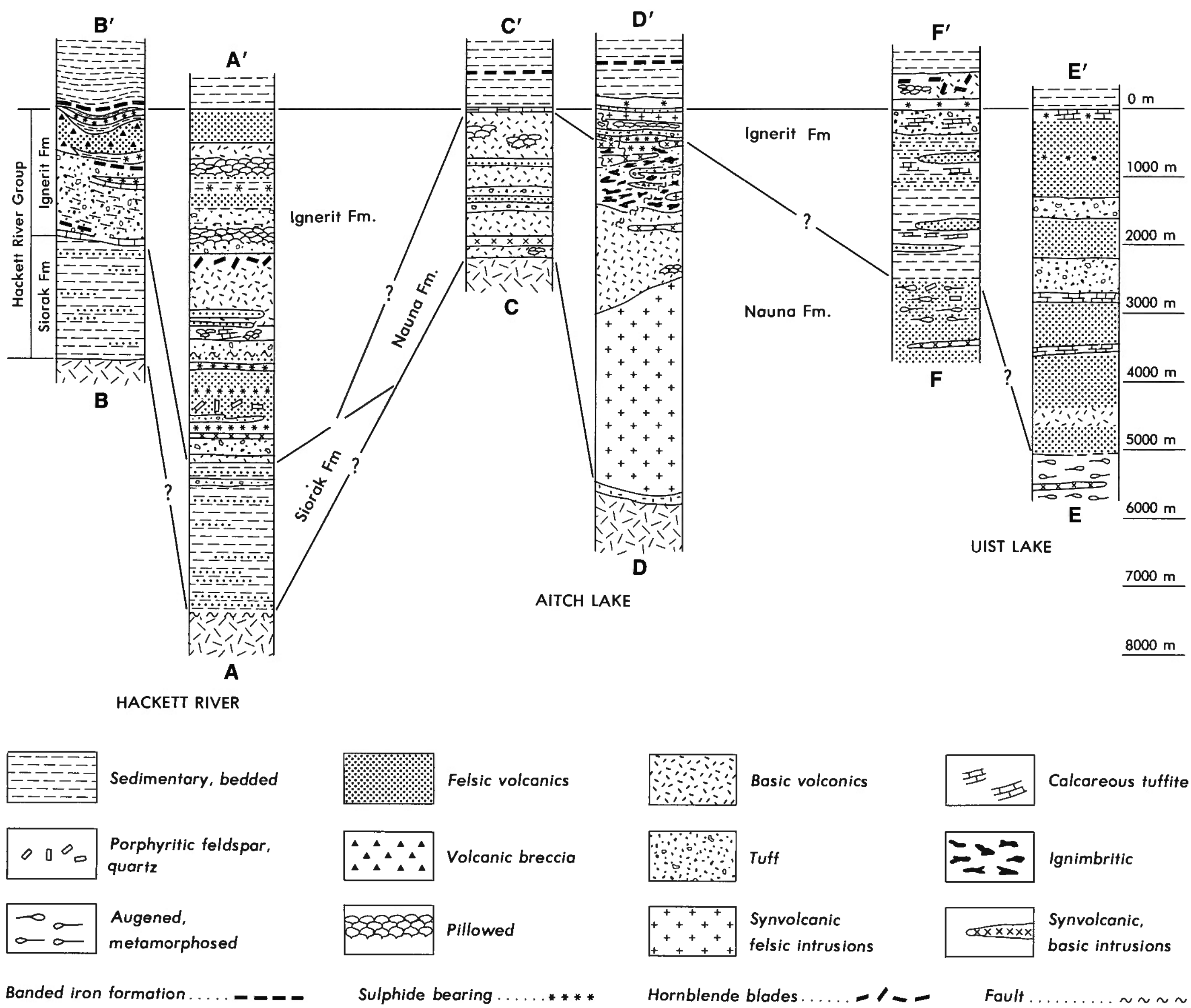


Figure 4. Type sections (A-A' and D-D') and representative sections of the Hackett River Group after Frith and Percival (1978). The locations of the sections are shown in Figure 3.

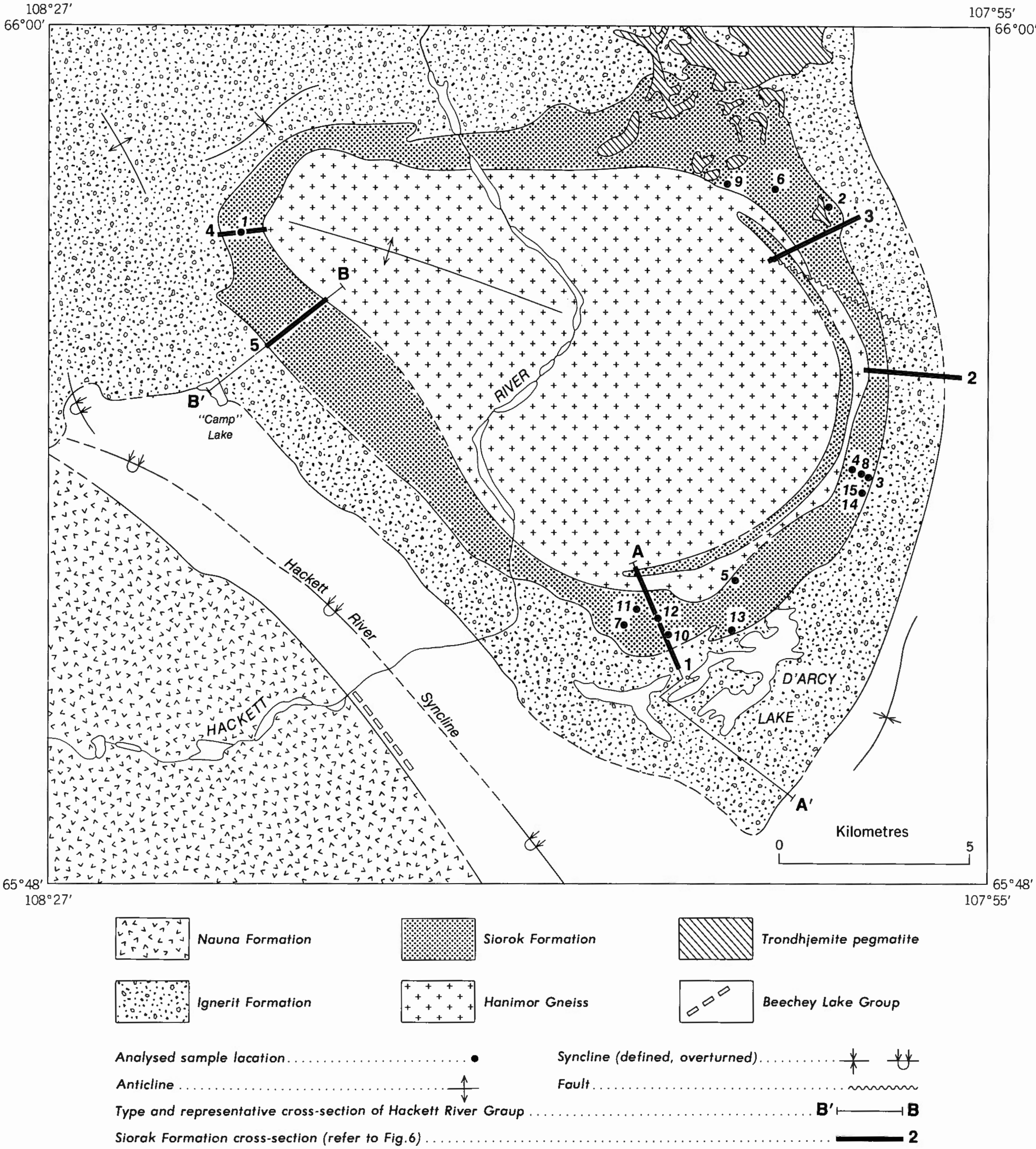


Figure 5. Sketch map of the Hackett River gneiss dome showing the distribution of the Siorak Formation and the location of analyzed samples. Major synclines and anticlines are shown, including the Hackett River syncline, southwest of the gneiss dome. Sections are shown in Figure 6.

gneiss dome; the Nauna Formation, a basic and felsic metavolcanic succession; the Ignerit Formation, a mixed metavolcanic and metasedimentary succession that overlies most of the Siorak and Nauna formations, and an undifferentiated unit of highly metamorphosed and locally migmatized metavolcanic rocks. The distribution of the Hackett River Group and its type and representative sections are shown in Figures 3 and 4. The following summary is described and substantiated in more detail in subsequent sections.

The Hackett River Group is an irregular shaped volcanic belt that is homoclinal at its centre, where top determinations in graded tuff and in pillowed andesite and basalt indicate consistent tops to the northeast. Towards the northwest, near Amoeba Lake, the belt is more highly metamorphosed and primary depositional features are mostly obliterated. The apparent thickness and the shape of this part of the belt, however, suggest that the volcanics were folded so that the west limb now faces the Mara River. There is a large overturned syncline, referred to as the Hackett River syncline by Jefferson et al. (1976b), between the northeast limb and the Hackett River gneiss dome (Fig. 5). The axial zone of this syncline is within metasedimentary rocks of the Beechey Lake Group. The underlying volcanic rocks are presumed to be thicker southwest of this axis, but thin towards the northeast, where they are uplifted to form the outward-facing mantle rocks of the Hackett River gneiss dome.

The Hackett River Group around the Hackett River gneiss dome consists largely of felsic volcanic rocks of the Ignerit Formation, underlain by the Siorak Formation metasedimentary rocks. The gneiss dome, composed of Hanimor gneiss, represents a synvolcanic pluton that intruded the Siorak Formation, probably as a sill, and was subsequently metamorphosed and deformed. Anatectic pegmatites, formed from the Hanimor gneiss, cut across its foliation and across that of the Siorak and Ignerit formations.

In the southern part of the belt, between the Siorak River and Uist Lake, the volcanic rocks wrap around and face away from the highly metamorphosed and deformed core of a structure referred to as the Malley Rapids anticlinorium. The rocks in the central part of the structure are most likely highly metamorphosed equivalents of the Hackett River Group and related synvolcanic plutons. South of the structure, carbonaceous and pyritiferous mudstones of the Beechey Lake Group separate the Hackett River Group from distal volcanic rocks of the Back Group. These mudstones thin towards Nose Lake and eventually pinch out, leaving a conformable gossan horizon between the Back and Hackett River groups.

The top of the Hackett River Group is overlain by conformable, volumetrically minor, chemogenic and carbonaceous members of the Beechey Lake Group, which in the Camp lake area are the locus of mineral deposition.

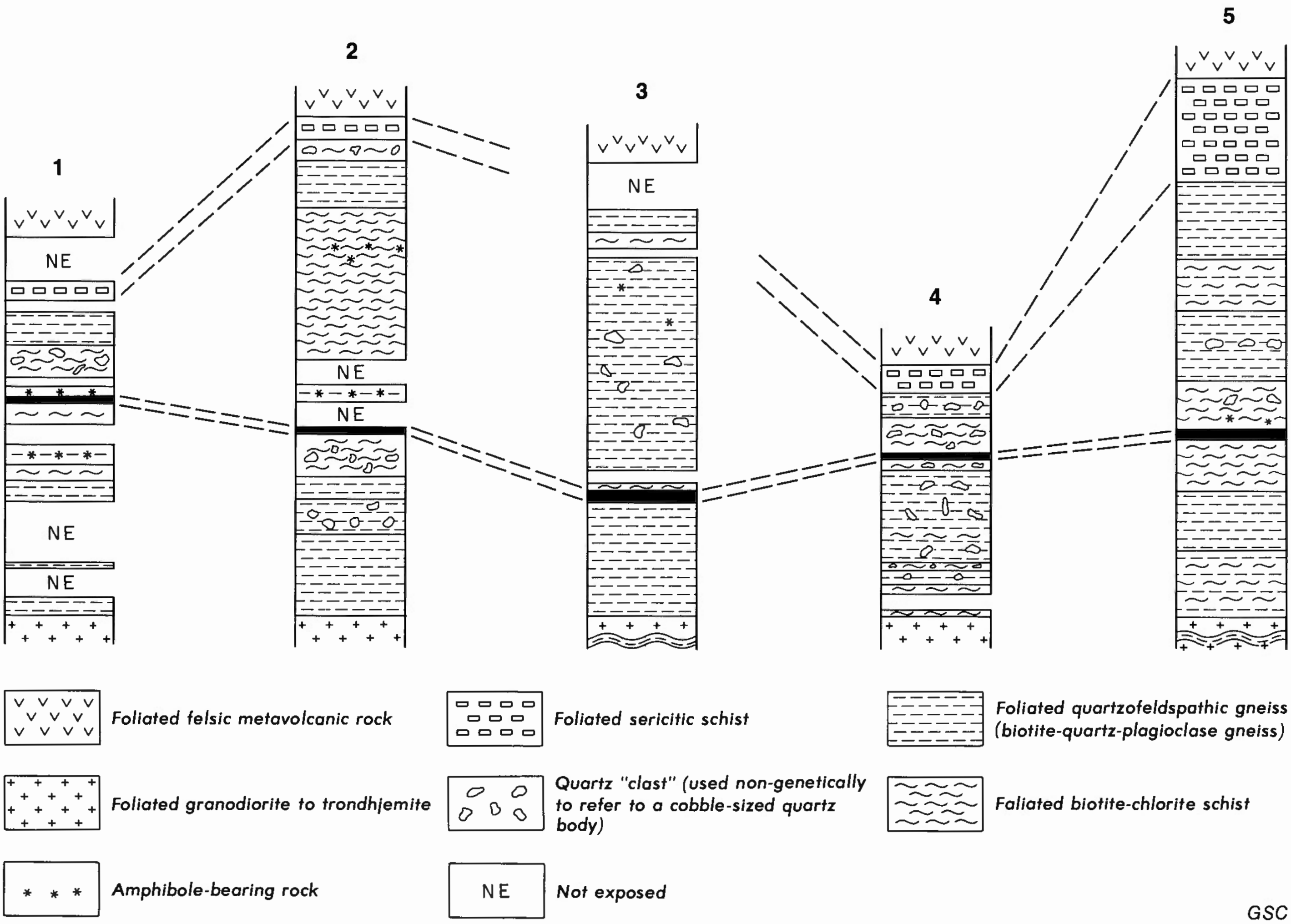


Figure 6. Sections through the Siorak Formation. Vertical scale is only relative. The locations of the sections are shown in Figure 5.

The basal rocks of the Hackett River Group are in contact with granitoid rocks including synvolcanic plutons such as the Hanimor gneiss, the Mara River Complex and plutons of the Regan Intrusive Suite. The contact relationship between the Hackett River Group and the Regan Intrusive Suite is clearly intrusive. Sharp, commonly xenolithic border phases, and chilled margins are present. However, the relationship between the Hackett River Group and the Mara River Complex is less certain. Near the Mara River, migmatites derived from the Hackett River Group are interlayered with biotite-bearing granodiorite gneiss and migmatite of uncertain origin. South of Sandy hill, contacts between distinctively volcanic rocks and deformed and metamorphosed postvolcanic migmatites and gneiss are gradational.

Intrusive rocks make up an important part of the Hackett River Group, generally as 1-2 m thick sills that are probably contemporaneous with volcanism as they are chemically similar to the volcanic rocks they intrude. However, they are slightly more leucocratic than the larger sills, such as the Hanimor gneiss and the Sandy hill pluton. Plutons of the Regan Intrusive Suite locally intrude the base of the Hackett River Group.

Siorak Formation. The Siorak Formation described by Frith and Percival (1978) is a highly metamorphosed and deformed, but contiguous formation that forms the base of the Hackett River Group around the Hackett River gneiss dome (Fig. 5). It is made up of biotite schist, quartzofeldspathic gneiss, sericitic schist and amphibole gneiss. Quartz aggregate clasts, possibly formed by deformation of quartz veins, are characteristically present in the more mafic rocks. The original thickness is unknown, but judging from mapped widths and the compression due to folding, it may be as little as 500-1000 m. Despite local folding into tight isoclines, the stratigraphic order of the individual members of the formation is maintained around the gneiss dome (Fig. 6).

The contact of the Siorak with the overlying Ignerit Formation is conformable and gradational, as are intraformational contacts. Bedding and other primary sedimentary features have been mostly obliterated by metamorphic recrystallization. Pegmatites developed in the Hanimor gneiss cut randomly across both the Siorak and Ignerit formations.

The lowermost rocks are interlaminated quartzofeldspathic gneiss and biotite schist which are approximately 250-350 m thick. The gneiss is a dark grey, equigranular, foliated and partly layered rock consisting mainly of quartz, plagioclase and biotite, with cordierite, chlorite, sillimanite, kyanite, garnet, gedrite, cummingtonite and apatite locally evident. The biotite-chlorite schist is medium- to coarse-grained, green to grey and made up primarily of biotite, chlorite, quartz and plagioclase with locally developed cordierite, apatite and ilmenite. A layering observed at some localities gives the rock a bedded appearance. Elliptical to round quartz aggregates, 1-30 cm long, are common in some areas, as portrayed in Figure 7A.

A mafic marker is present in all of the sections, as shown in Figure 6. It is a dark green gneiss or schist, consisting mainly of medium- to coarse-grained equigranular amphibolite (anthophyllite-gedrite, cummingtonite) with or without cordierite, garnet, biotite, chlorite, staurolite, quartz, plagioclase, ilmenite, magnetite and chalcopyrite. It is 20 m thick and occurs 310-475 m above the base of the formation. Rounded 1-30 cm quartz clasts are also common. The mafic gneiss is overlain by an interlaminated quartzofeldspathic gneiss and biotite schist which is 100-150 m thick and is lithologically similar to the gneiss underlying the mafic rock.

The uppermost rocks are mostly sericitic schists. They form a 30-50 m thick zone around the base of the Hanimor gneiss where they occur as arcuate inliers and as isolated, diffusely bounded inclusions within the gneiss. The sericitic schists are continuous, except around the northeast margin. The rocks are buff brown to rusty, medium- to fine-grained and consist mostly of sericite, quartz, plagioclase and biotite with or without sillimanite. Foliated, dark green, coarse grained hornblende, plagioclase, cummingtonite-bearing gneiss, occurs sporadically as thin layers or as discontinuous lenses throughout the schist, but rarely makes up more than 10% of outcrops.

Within the Ignerit Formation, at the base of the mineralized succession, mafic gneiss with cordierite, sillimanite and garnet is present, similar to the mafic gneiss of the Siorak Formation. It is also of similar chemical composition (Table 2, analysis 5).

Nauna Formation. The Nauna Formation is made up of vertically to steeply dipping, bedded volcanic flows and both mafic and felsic pyroclastics. It extends the length of the Hackett River volcanic belt and its thickness ranges from an estimated 2350 m near the centre of the belt to an apparent thickness of 8000 m or more southwest of Hackett River.

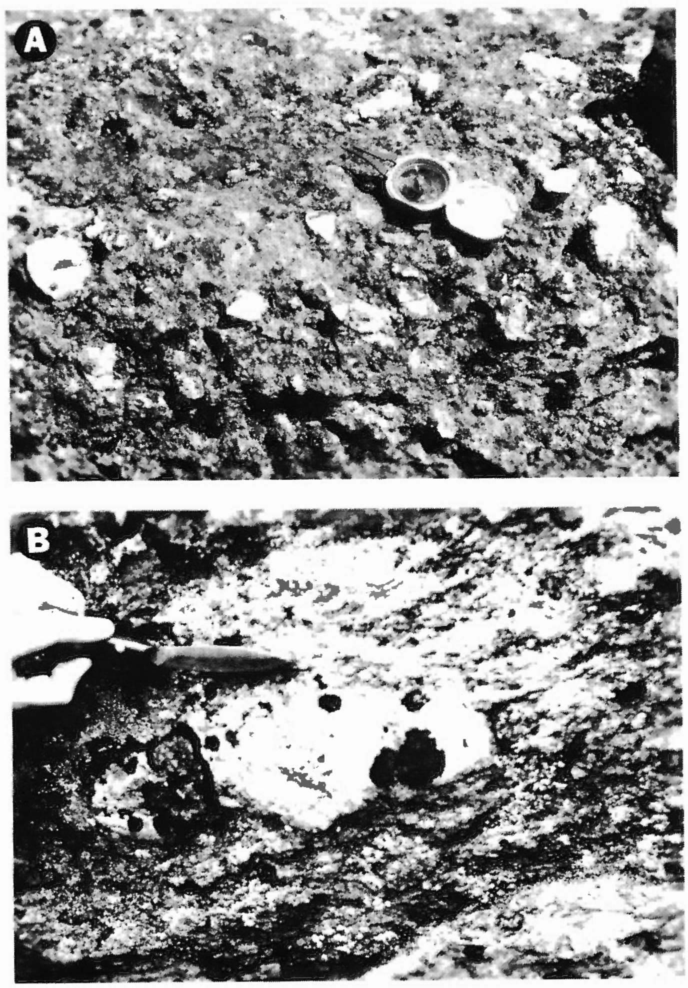


Figure 7. Siorak Formation

A. Rounded quartz aggregate clasts in biotite-chlorite schist near D'Arcy Lake. GSC 203339-J.

B. Granitoid aggregate in mafic gneiss near Chair Lake. GSC 203337-B

In the Aitch Lake region two cross-sections, C-C' and D-D' were studied in detail (Fig. 4). In section C-C' the contact of the Nauna Formation with the Mara River Complex is sharp and steeply dipping. The contact rocks are fine grained, pyritiferous basic volcanics that have been amphibolitized and locally mylonitized. A few metres from the contact, the basic volcanics are less deformed and amphibolitized and some pillow-like structures are present, suggesting that the basal rocks were subaqueous. The succession is about 650 m thick and lithologies are of relatively constant composition, except for gabbro sills, up to several metres thick, that are presumed to have been intruded contemporaneously.

In section C-C' (Fig. 4) the basal volcanic rocks are overlain by a 45 m thick succession of dacite tuffs and aphanitic quartz-eye dacite flows. Like the basal rocks, sporadic mylonite zones parallel a vertical to subvertical foliation. Fine secondary sericite is present in the more felsic rocks. Above these rocks is a thick, partly pillowed andesite flow with 5-10 m interlayers of graded dacite tuff, topped by pyritiferous, graded tuff beds, a few centimetres thick (Fig. 8). The top of section C-C' is marked by an increase in the proportion of tuffaceous interlayers and then by a sequence of conformable calcareous volcanic breccias, which form part of the overlying Ignerit Formation.

Table 2. X-ray fluorescence whole-rock and emission spectrograph trace element analyses (in ppm) of metasedimentary rocks from the Siorak Formation. Locations are shown in Figure 5

	1	2	3	4	5	6	7	8
SiO_2	76.8	79.8	79.2	62.4	56.3	54.9	56.7	48.9
TiO_2	0.29	0.09	0.11	1.06	0.93	1.31	0.57	0.85
Al_2O_3	12.5	10.0	9.6	15.8	18.5	16.4	14.5	14.8
FeO	2.10	1.20	3.00	3.70	8.80	12.50	15.60	12.50
Fe_2O_3	0.00	0.00	0.00	0.40	0.00	0.80	0.10	1.30
MnO	0.02	0.01	0.03	0.04	0.14	0.23	0.15	0.23
MgO	1.75	1.67	4.33	4.86	8.40	8.40	8.50	13.00
CaO	1.08	2.13	0.00	2.77	2.38	1.28	0.15	0.38
Na_2O	3.70	2.30	0.20	3.90	2.00	1.20	1.10	0.60
K_2O	0.52	0.58	2.16	2.68	0.24	0.17	0.11	3.18
P_2O_5	0.04	0.02	0.01	0.28	0.22	0.19	0.09	0.19
CO_2	0.90	0.70	2.70	1.30	1.80	3.50	nd	nd
Total	99.70	98.50	103.34	99.19	99.71	99.58	99.37	99.43
Ti	1600	500	600	5800	4900	7500	3100	4200
Mn	109		156	230	770	1300	810	1300
Ba	280	110	360	430	52	93	61	580
Co	34	20	120	19	82	51	127	50
Cr				6	160	390	28	130
Cu	32	32	24			1100	200	13
Mo						7	120	
Ni				12	81	160	37	160
Sr	74	65	13	120	56	41	20	
V				100	150	320	30	260
Y						43	51	45
Yb	5.5							
Zr	250	130	150	250	150	180	360	190

	9	10	11	12	13	14	15
SiO_2	50.0	53.3	61.9	49.1	60.4	57.0	79.5
TiO_2	0.27	0.99	1.14	1.12	1.15	0.99	0.13
Al_2O_3	11.3	15.3	15.1	16.6	13.8	16.2	12.2
Fe_2O_3*	8.50	10.20	8.05	14.40	9.83	10.30	1.05
MnO	0.40	0.13	0.09	0.16	0.18	0.12	0.00
MgO	12.90	11.40	4.55	8.00	4.80	9.95	2.15
CaO	15.90	0.75	3.12	2.13	3.35	0.53	0.13
Na_2O	0.20	0.48	3.27	3.40	5.20	0.55	0.20
K_2O	0.05	0.40	0.57	0.39	0.21	0.31	3.06
P_2O_5	0.09	0.28	0.29	0.21	0.32	0.20	0.01
Total	99.61	93.23	98.08	95.51	99.24	96.15	98.43

Note:

Quartzofeldspathic gneiss (1-3); Biotite chlorite gneiss (4); Mafic gneiss (5-14); Sericite schist (15); *includes FeO as Fe_2O_3; nd = not determined.

Analyses 1-8 and trace elements were done by the Geological Survey of Canada and 9-15 by F. Dunphy, Queen's University. Major oxides of all analyses were reported initially by Percival (1978).

In section D-D' (Fig. 4) the presence of isolated outcrops of amphibole gneiss, stratigraphically above the granitoid complex, suggests the lower rocks are metamorphosed andesite or basalt. The basic gneiss is intruded by a large synvolcanic granodiorite-tonalite sill which is 3000 m thick.

In section D-D' (Fig. 4) a 720 m thick succession of andesite overlies the granodiorite-tonalite sill. The succession is made up of steeply dipping, faintly foliated andesite flows and pyroclastic rocks with minor dacite tuff. At the contact with the sill, the rocks are steeply dipping and consist of faintly foliated andesite flows and pyroclastic rocks with minor dacite tuff. At the contact with the sill, the rocks are locally brecciated by faults, which parallel and cut the contact at high angles. The volcanic rocks within 200 m of the sill are little deformed, apart from the brecciation. Thin section studies show that regional metamorphism is sub-biotite in grade. Within the andesite succession are several irregular elongated bodies of comparable composition, but of coarser grain size. These may be andesite sills. Although bedding is faint, pillow structures were observed 3 km along strike, indicating that at least parts of the succession were deposited under water. This contrasts with the overlying ignimbrites, which contain welded textures that have been interpreted as criteria for subaerial deposition (Frith and Roscoe, 1980).

The ignimbritic succession of section D-D' (Fig. 4) is a relatively homogeneous 1500 m thick sequence of andesitic and dacitic tuffs, welded tuffs and lapillae tuffs. In detail, the tuffs are made up of small irregular biotite-bearing fragments (Fig. 9) that have been interpreted as squashed pumice (M.B. Lambert, personal communication, 1976). Near the top of the succession, discontinuous, 150 m thick, andesitic strata of uncertain origin are present. They are medium grained, grey green, and form roughly conformable layers bounded by ignimbrite, but pinch out along strike or terminate against faults. They have been interpreted as sills, as some contacts show crosscutting relationships (Frith and Roscoe, 1980) but some may be subaerial flows with locally developed intrusive relationships. The ignimbrite succession

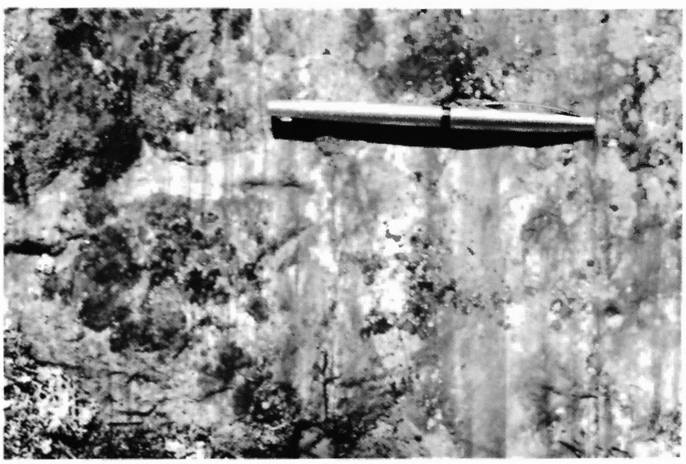


Figure 8. Thinly laminated tuff with graded bedding within the Nauna Formation (see Fig. 4, section C-C'). GSC 203335-X

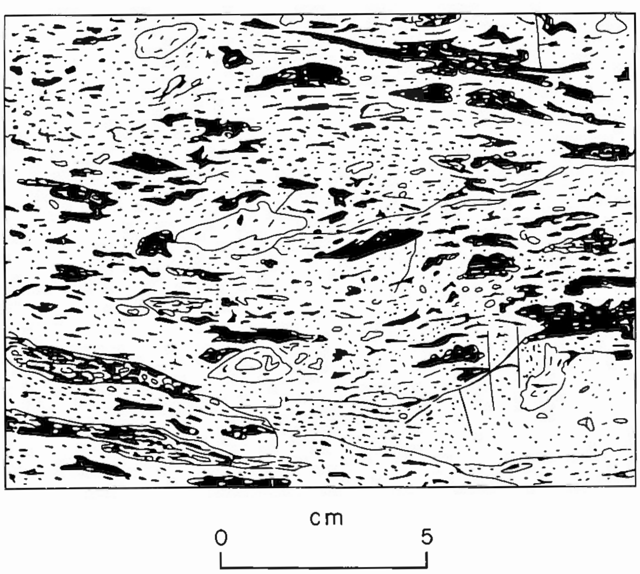


Figure 9. Ignimbrite from the Nauna Formation in the Aitch Lake area. The rock is of andesitic composition. The tracing from a polished slab shows light coloured clasts of quartz-eye porphyry and darker fiamme of biotite-plagioclase derived from squashed pumice fragments (after Frith and Roscoe, 1980).

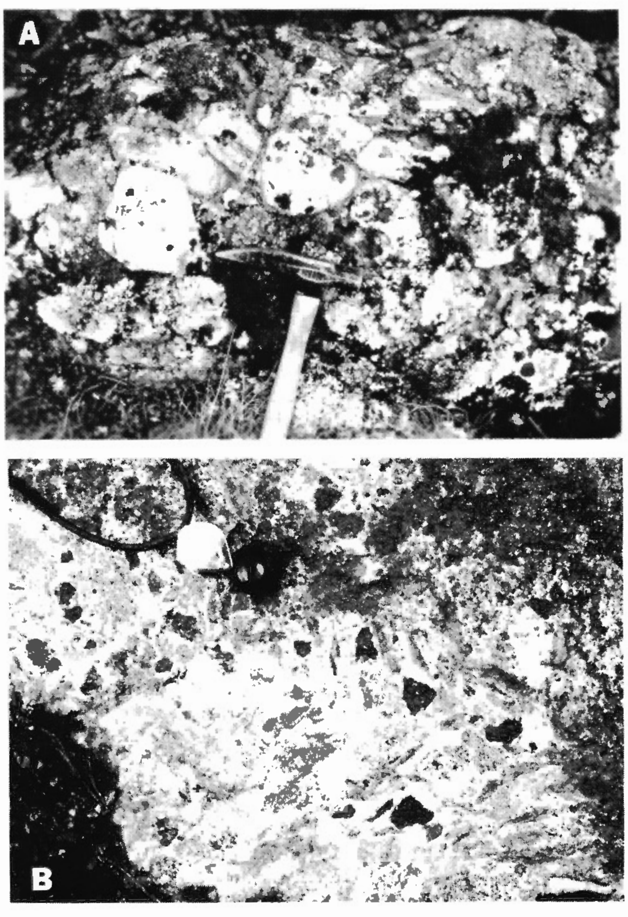


Figure 10. Nauna Formation volcanic rocks

A. Large clast volcanic breccia from the Qiviut Lake area. Felsic clasts 3-8 cm across are found in a mafic matrix, possibly of laharic origin. GSC 203335-Y
B. Polymictic volcanic breccia overlying a pillowed andesite from an area west of the Siorak River. GSC 203338-H

is capped by waterlaid tuffs that make up the mineralized strata of the Yava sulphide deposit, which is in the lowermost Ignerit Formation of this section.

In the Qiviut Lake area, northwest of section C-C' (Fig. 4) the basal rocks of the Nauna Formation consist of volcanic breccia (Fig. 10) and tuffs and quartz-eye dacite flows. The breccia clasts are dacites, whereas the matrix is dark and andesitic. The size of the clasts is variable, with some 20 cm or larger angular blocks. These rocks resemble the "mill-rock" (Sangster, 1972a) found in the basal part of the "A" zone, of the Hackett River sulphide deposit and have been referred to as 'lahar' by Franklin (1976). In other areas (Fig. 10) breccias are polymictic, indicating a variable lithology at the source.

South of Sandy hill, the Nauna Formation becomes progressively deformed and metamorphosed, and outcrop is scarce. The formation is exposed in a narrow zone intruded by granite and tonalite of the Regan Intrusive Suite. The country rocks are mostly amphibolitized andesites and basalts, that locally contain relict pillow structures. The Nauna Formation cannot be delineated southeast of the esker that parallels the Hackett River Group-Beechey Lake Group boundary, although it appears probable that much of the deformed and metamorphosed volcanic rock unit within the central part of the Malley Rapids anticlinorium is composed of metamorphosed and deformed equivalents of the Nauna Formation.

Ignerit Formation. The Ignerit Formation derives its name from the Inuktitut word for 'pyrite' (Frith and Percival, 1978). The unit is mainly volcanic, but is distinguished from the Nauna Formation by a greater abundance of chemogenic metasedimentary rocks which include dolomite, calcium carbonate, silicate iron formation, oxide iron formation, chert and sulphide-bearing volcaniclastic rocks. In addition, the rocks are locally argillaceous, mica and/or sillimanite having formed where regional metamorphic grade was sufficiently high. The principal rock types of the Ignerit Formation are bedded dacitic and andesitic flows and pyroclastics, separated and intercalated with chemogenic rocks. The various rock members are discontinuous along strike and a section from one part of the volcanic belt to another cannot be correlated, except in the broadest sense (Fig. 4). Three areas are described: the type section in the Hackett River area, the Yava deposit area, and the Uist Lake area.

Hackett River area. The type section, A-A' of Figure 4, is divided into four parts, each capped by a thin zone of sulphide-rich, commonly bleached, dacitic tuff. The lowermost part is in conformable contact with the Siorak Formation, where it grades from a sericitic tuff to a sericite-free variety. The tuff is about 100 m thick and is a buff to grey, partly rusty gneiss or schist with a heterogeneous appearance. Layering is accentuated by initial compositional variation. These rocks are in turn overlain by 25 m thick, pillowed andesite. The pillowed andesite is grey green with pillows measuring 40-80 cm across, but deformed, so that selvages and tops are mostly destroyed. The andesite contains hornblende phenocrysts and fragments of andesite are locally present. The second part of the section is 15 m thick and made up mostly of dacite tuff intercalated with layers of breccia containing felsic fragments in a mafic matrix. Pyrite-rich zones are also present in the breccia. The third part is a 20-30 m wide rusty andesite overlain by dacite tuff with pillowed to massive andesite, interlayered with massive dacite flows. These are in turn overlain by a hornblende porphyry, topped by a rusty diopside and carbonate-bearing bed. The uppermost member consists of massive and pillowed andesite with minor amounts of pyroclastic andesite and dacite, which is about 2000 m thick. In section A-A' the transition from the Ignerit Formation to the Beechey Lake Group is marked by minor gossan zones and finely bedded and locally carbonaceous mudstones that form part of the conformable overlying Beechey Lake Group.

In the reference section through the Camp lake mineral deposit (B-B' in Fig. 4, and 5 in Fig. 6) the Ignerit Formation is divided into four successive parts based on the dominant type of volcanism, which includes:

1. A lowermost dacitic, sedimentary-pyroclastic succession, with chemogenic rock types;
2. A lower fragmental andesite and dacite breccia-tuff (or lahar?) succession;
3. An upper dacitic sedimentary-volcanic detrital succession;
4. A mineralized detrital and chemo-sedimentary transitional succession.

The following descriptions are based on those of Casselman (1977) and the volcanogenic grouping of Frith and Roscoe (1980).

Part 1. This succession is made up principally of felsic tuffs with minor amounts of argillaceous tuff, cherty tuff and calc-silicate tuff. The latter suggest there were periods of slow deposition. The rocks are thickly bedded, but individual bedding planes are partly masked by regional upper amphibolite facies metamorphism. In general, the rocks are light grey to buff gneiss, with quartz eyes, plagioclase and locally discernible biotite, muscovite and faint fragmental clast outlines. The biotite is commonly streaked out along foliation planes that are locally accentuated by pyritic rust stains. The foliation parallels the bedding, which may be deduced from compositional variation; both generally dip 60° or less away from the Hackett River gneiss dome core.

The minor rocks were presumably deposited during quiescent times and include: beds, 30 cm thick or less, of rusty, fine grained, siliceous tuff composed of quartz, minor feldspar and sillimanite; siliceous tuff which contains quartz, feldspar, sillimanite, muscovite, biotite, and commonly quartz-eye phenocrysts and sulphides; argillaceous tuff containing up to 20% sillimanite and 20-40% muscovite and biotite; 5 cm to 2 m thick calc-silicate tuff beds, which make excellent marker horizons, and in which calcite has weathered out leaving a matrix much like the dacite tuff. The carbonate-bearing rocks are commonly layered with carbonate-cemented breccia at the base, fragmental to banded textures in the middle, and homogeneous carbonate and tuff detritus at the top.

Part 2. The rocks of this section form a fining-upward cycle of breccias, lapilli tuffs and tuffs of both dacitic and andesitic composition. Some of the basal, coarse grained, fragmental dacites, have been termed "mill-rock" (Sangster, 1972a) and referred to as a lahar by Franklin (1976). These breccias, along with some argillaceous tuff, make up the lowermost and discontinuous parts of the succession. The breccias contain 2-15 cm angular dacite fragments in a plagioclase-amphibole-biotite matrix. They form heterogeneous, poorly defined, lensoid strata overlain by more extensive andesitic breccia and andesitic lapilli tuffs. The breccias extend laterally for about 1200 m. They are heterogeneous in hand specimen, but appear homogeneous and relatively massive in outcrop. The fragments are dark grey to grey green and are made up of actinolite, quartz, feldspar, zoisite, chlorite, epidote, sphene and calcite in a saussuritized matted matrix of plagioclase. The finer grained fragments and the matrix are of similar composition, but the matrix is marginally darker due to the presence of biotite. Flattened and elongated andesite clasts are preserved where they have been protected by less abundant dacite clasts.

Part 3. The upper dacitic sedimentary section is composed of aluminous rocks characterized by volcanic detritus, mixed with variable proportions of argillaceous, siliceous, limy and other chemogenic sedimentary detritus, including minor sulphides. The section is 180-240 m thick but becomes thinner and eventually pinches out to the southeast over a distance of one kilometre. The base of the section overlies an irregular surface of fragmental andesitic and dacitic rocks, whereas the upper part of the section is bounded by carbonaceous and sulphide bearing rocks of the succeeding Beechey Lake Group.

Part 4. The uppermost rocks of the section are made up of fine detrital and chemogenic metasediments that are complexly mixed to give highly variable rocks, both across and along strike. The lithologies are dominantly volcaniclastic beneath the 'ore' zones, chemogenic in the 'ore' zones and detrital towards the top. The thickness varies from 180 to 240 m. Regional metamorphism reaches upper amphibolite facies and rocks of this zone are commonly sillimanite-bearing.

The dominantly volcaniclastic rocks are mostly felsic tuffs and tuffites interbedded with up to 30 cm thick calc-silicate- and chert-bearing lenses and pods that are discontinuous along strike. The 'ore'-bearing strata are chiefly chemogenic and are composed of rocks rich in sulphides, chert and carbonate, commonly mixed with fine felsic detritus (discussed further in the economic geology section). The overlying rocks are transitional with the Beechey Lake Group. They are mostly fine detrital volcanogenic mudstones that interfinger with carbonaceous mudstones and greywackes of the Beechey Lake Group.

Yava deposit area. The Ignerit Formation in the Yava deposit area is a 620 m thick succession of volcanic rocks, volcanogenic sediments and dacite sills that form part of a caldera. A mineralized section forms the base of the Ignerit Formation, which overlies a footwall of Nauna Formation.

The basal mineralized succession consists of sulphide and siliceous tuffites (rocks with both pyroclastic and sedimentary detritus) and massive sulphides. Metamorphism in this area only reaches biotite grade and volcanic fragment outlines, graded bedding and other primary depositional features are evident. However, in the deposit area, oxidation causes the rocks to be rust coloured and pitted from the leaching of sulphide minerals.

The siliceous volcanic rocks that overlie the mineralized succession are light buff to grey, fine grained, bedded tuffites that are locally goethite stained. Over a 100 m section, alternating pyrite-rich and pyrite-poor beds occur. A 50-150 m thick succession of pillowed andesite is present within the tuffite succession, bounded at the contacts by similar goethite-stained, pyrite-bearing strata.

Dacite sills intrude the tuffaceous rocks of the section. Most are up to several metres thick, but one large sill occurs along the contact between the Ignerit Formation and the overlying Beechey Lake Group. The sills are light grey to buff and slightly darker on fresh surfaces than on weathered surfaces. The rocks are slightly leucocratic and contain less than 5% mafic minerals. The large sill contains both plagioclase and quartz phenocrysts and in thin section shows abundant carbon (Fig. 11) which is presumed to have been absorbed from the carbonaceous mudstones that form the basal rocks of the Beechey Lake Group. This implies that the sills are the youngest rocks in this part of the Ignerit Formation. Chemical analyses show that the sills are dacitic, but less silicic than the larger tonalite-granodiorite sill that intrudes the base of the Nauna Formation. It is proposed that the small upper sills formed during subsidence of the caldera.

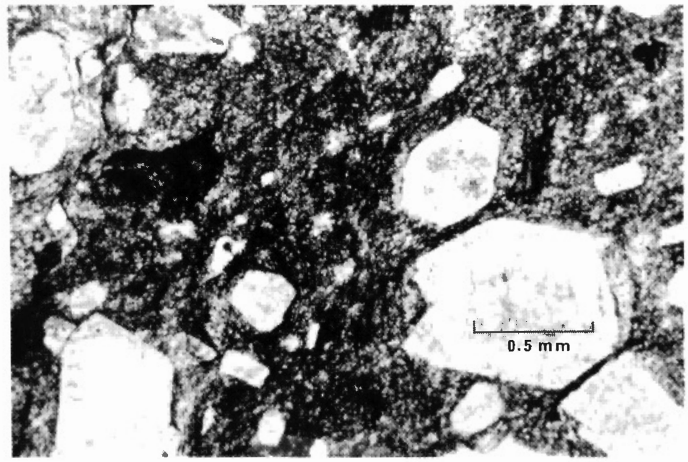


Figure 11. Photomicrograph (plane light) of a dacite sill that intrudes the contact between the Ignerit Formation and carbonaceous mudstones of the Beechey Lake Group. The matrix to quenched plagioclase phenocrysts is graphite-bearing, presumably derived from the overlying host rock. GSC 203647-M

The metasediments beneath banded iron formation higher in the section, which is discussed in the description of the Beechey Lake Group, are presumed to have been deposited in the caldera, as they thin away from the caldera centre.

Uist Lake area. The Uist Lake area Ignerit Formation flanks the southwest Malley Rapids anticlinorium (Fig. 3) and is shown in section F-F' of Figure 4. The formation is estimated to be 1000 m thick and is overlain to the southwest by carbonaceous mudstones of the Beechey Lake Group. Towards the core of the anticlinorium the rocks grade from layered felsic and andesitic tuffs with carbonate-bearing interlayers to plagioclase augen and biotite tonalite gneiss.

The rocks of the Ignerit Formation in the Uist Lake area are best preserved near the contact with the Beechey Lake Group. Top determinations in the overlying mudstones indicate that the succession faces southwest. The rocks of the unit are mostly grey, medium grained gneiss (tuffs?), with some variation in mafic constituents. The presence of garnet and staurolite suggests that the rocks were once partly composed of metasedimentary detritus. Tuffaceous carbonate-bearing lapilli tuffs (Fig. 12B) and breccias (Fig. 12C) occur and are readily identified in the field as the carbonate preferentially weathers out (Fig. 12A), even where metamorphosed to higher grades (Fig. 12D).

The presence of staurolite and chemical analyses show that most of the rocks are calcium-rich and excessively high in alumina. These criteria, and the layered sedimentary appearance, suggest that the rocks of the unit are volcanogenic metasediments that locally contain carbonate, probably of chemogenic origin.

Undifferentiated rocks. The supracrustal rocks of the Hackett River Group that could not be readily mapped at formational rank are shown as a separate unit. This unit consists of gneiss, schist and migmatite that were derived principally from the Nauna Formation, as determined from the presence of relict volcanic textures.

The Hackett River Group metavolcanic rocks in the northwest part of the volcanic belt, near Amoeba Lake, grade from recognizable volcanic strata of the Nauna Formation to gneiss and migmatite of enigmatic origin. They form

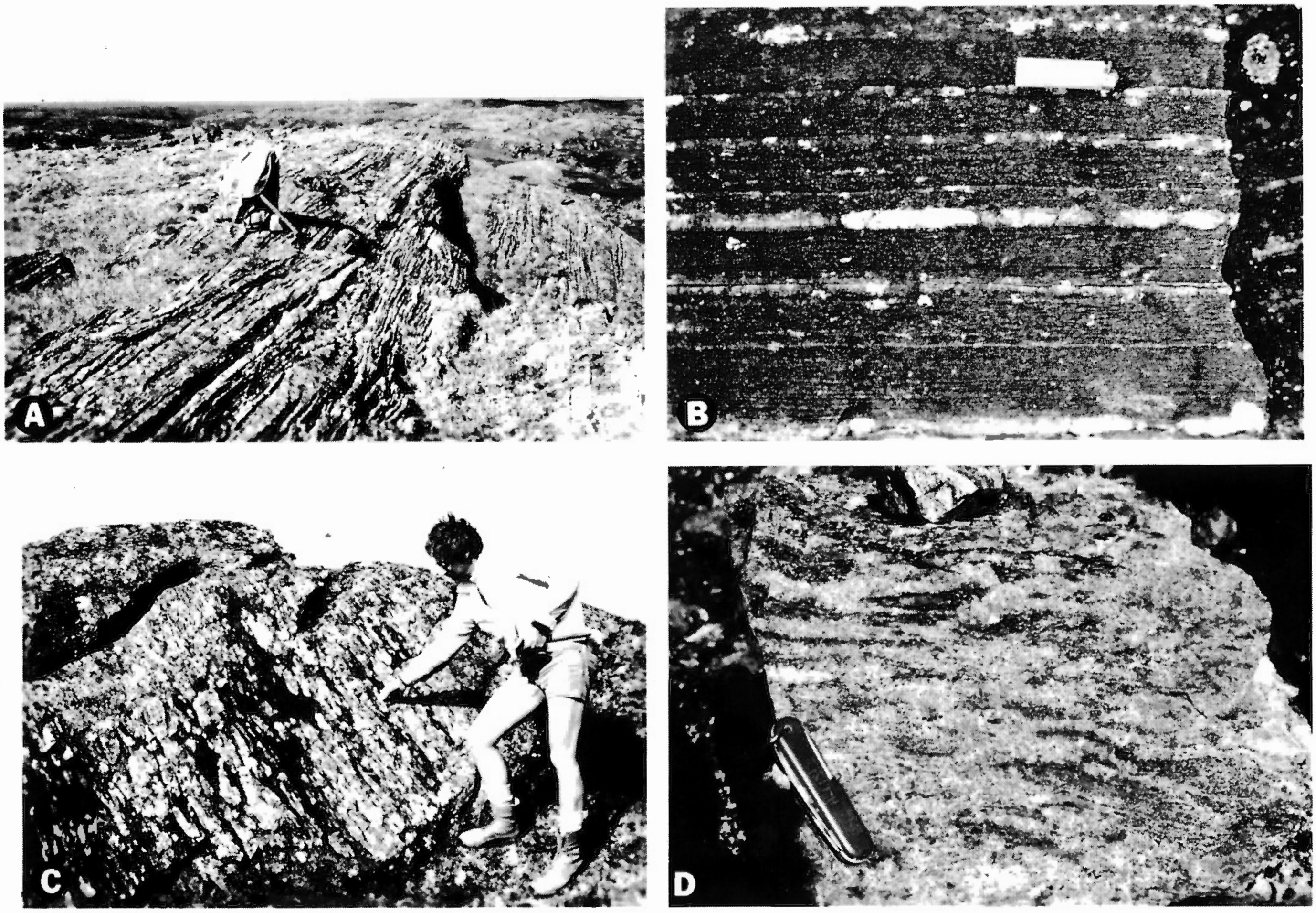


Figure 12. Ignerit Formation

A. Typical Ignerit Formation consisting of bedded tuffs and lapilli tuffs with void formed from leached-out carbonate, north of Uist Lake. GSC 203339-G

B. Finely bedded carbonate-bearing tuff from the Malley Rapids area. Light parts are felsic volcanic fragments. GSC 202957-G

C. Volcanic breccia from the Duck Lake area, on the south margin of the Hackett River gneiss dome. GSC 203338-W

D. Lapilli tuff from the Duck Lake area with biotite fragments, possibly derived from fiamme. GSC 203339-H

continuous members of dacitic, andesitic, and basaltic composition along with migmatite derived from them. They are commonly cut by dykelets of aplite and/or pegmatite.

In the northern part of the belt rocks of this unit are generally coarser grained than most of the Nauna Formation. Across strike, compositional changes are evident, but metamorphism has made variations less evident than in the Nauna Formation. Some volcanic tuffs and breccias were recognized between Qiviut Lake and Mara River.

Andesitic gneiss locally contains porphyroblasts of plagioclase and secondary black hornblende and is more homogeneous and uniform than the more felsic rocks of the unit. The local presence of rock fragment outlines, suggests some rocks are volcaniclastic. Towards the west margin, near Mara River, the rocks are granitized and potassium feldspar porphyroblasts and granite interlayers become prominent. Near the Mara River, coarse grained amphibolite, with hornblende porphyroblasts is present, probably derived by metamorphic recrystallization of gabbro sills.

The rocks along the west margin of the unit, near Mara River, are mixed with granodiorite, tonalite, migmatite and other granitoid plutons, many of which are discordant, xenolith-free and clearly intrusive. Others were probably formed by mobilization of migmatites into bulbous-shaped bodies. The contact between rocks of this unit and Mara River Complex migmatites is arbitrary. Where leucosome is approximately 50% or more, the rocks are mapped with the latter unit.

Volcanic rocks in the south-central area are poorly exposed. Most of the prominent outcrops are andesite, but some felsic tuffs occur in small, isolated outcrops, and so may be more abundant than outcrop suggests.

A remnant of volcanic rock is present within the Mara River Complex near the centre of the map area as a 2500 m long cigar-shaped body. It is composed of massive grey-green andesite flows with remnant pillow structures and flow-top breccias. Clasts 2-6 cm long are oriented parallel to remnant pillows.

Undifferentiated Hackett River Group strata occur in the core of the gently southeasterly plunging Malley Rapids anticlinorium. The rocks in the centre of the structure are highly deformed, light grey, biotite-plagioclase augen gneiss (Fig. 13). The gneiss contains sporadic 5 cm to 2 m wide amphibolite bands. These bands may be broken up by deformation into boudins, giving a false impression that they are inclusions in a magmatic host. The gneiss, in places, grades from a relatively homogeneous texture to one with a remnant volcaniclastic appearance. Lapilli-sized clasts may be observed in thin section. These rocks have been mapped as metamorphosed equivalents of andesite and dacite, even though synvolcanic or older plutonic rocks possibly make up part of the core area of the anticlinorium.

The contact on the southern margin with the Ignerit Formation is gradational and is drawn along an arbitrary line separating homogeneous gneiss from recognizable metavolcanic rocks.

Chemistry and petrogenesis

Siorak Formation. Analyses representative of the quartzofeldspathic gneiss, the biotite-chlorite schist, the mafic gneiss and the sericitic schist are listed in Table 2, and the locations of analyzed samples are shown in Figure 5. These analyses were carried out as part of a geochemical study by Percival (1978).

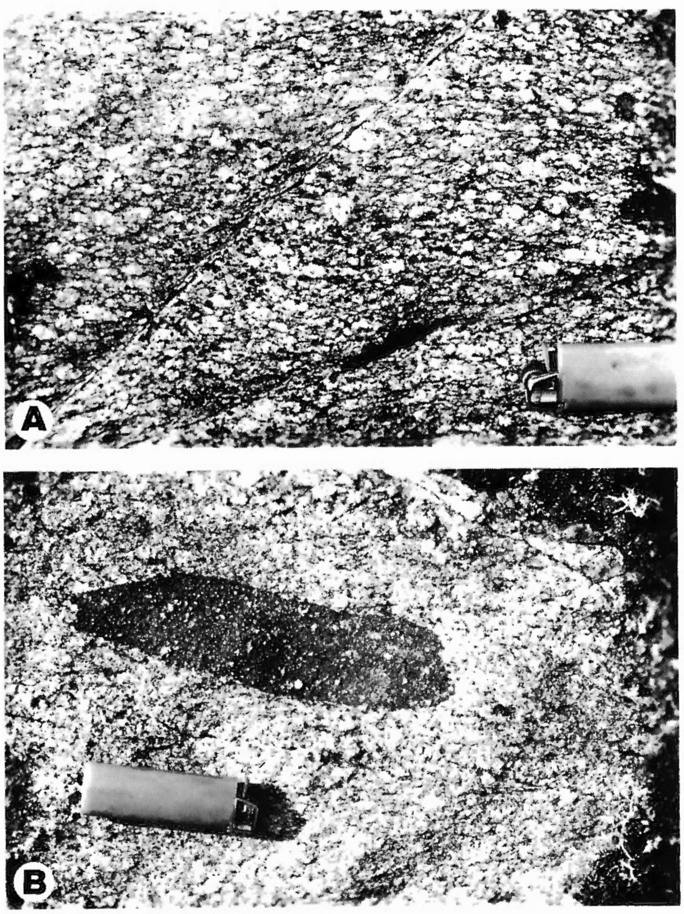


Figure 13. Undifferentiated Hackett River Group rocks

A. Typical augen plagioclase gneiss from the core region of the Malley Rapids anticlinorium. GSC 201996-R

B. Amphibolite in augen plagioclase gneiss, possibly boudinaged from a diabase dyke. GSC 201996-W

The quartzofeldspathic gneiss is high in silica, low in alumina and chemically similar to the dacites and dacite sills that form a volumetrically significant part of the Hackett River Group. The biotite gneiss and mafic gneiss have compositions similar to andesites of the area in all major oxides, except CaO, Na_2O and K_2O, which are the most variable (Table 2). A comparison of Siorak Formation silica to the normative colour index is shown in Figure 14.

Trace element analyses for Ag, As, B, Ba, Ce, Co, Cr, Cu, La, Mo, Ni, Pb, Sb, Sn, Sr, V, Y, Yb, Zn, and Zr were carried out on selected gneiss samples to determine if the gneiss could have been derived from a paleosol. The analyses showed no anomalous concentrations of elements normally found residual in minerals such as zircon, rutile or monazite (Roscoe, 1969).

Nauna and Ignerit formations. Approximately 500 whole-rock samples of Hackett River Group volcanics were analyzed for major element constituents during the course of various university thesis studies (Casselman, 1977; Ewing, 1977, 1979) and topical studies by the Geological Survey of Canada (Cameron and Durham, 1974b). The following account is a summary of current work to portray the geochemical make-up and post-depositional alteration of the volcanic rocks of the map area, as they pertain to the Hackett River Group.

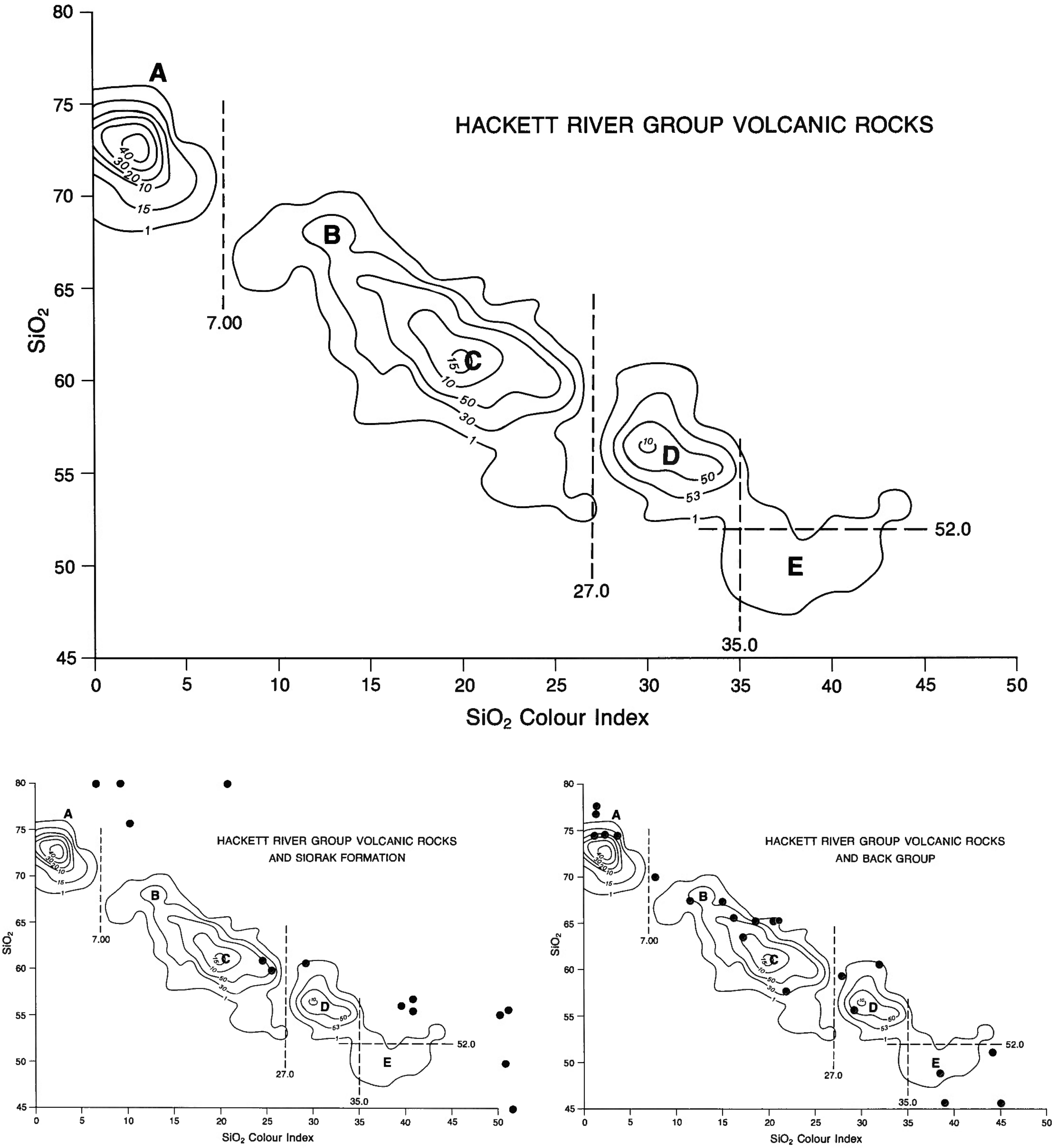
About 265 whole-rock analyses of the least altered volcanic rocks were culled from the least metamorphosed areas of the Hackett River Group, principally in the Aitch Lake area. These included volcanic flows, pyroclastics and synvolcanic sills. Additional analyses from the Hackett River area, Uist Lake area and the Regan Lake area were included to ensure the data were representative of the belt as a whole.

The volcanic rocks were classified according to SiO_2 and colour index. Frequency contours divide the data into five natural compositional types, as shown in Figure 14, which correspond closely to Streckeisen's (1976) chemical classification based on mesonormative quartz, plagioclase and potassium feldspar, and include the following principal rock compositions: (1) Siliceous dacites; (2) Dacitic tuffs; (3) Leuco-andesites; (4) Mela-andesites; (5) Basalts. Analyses of rocks that lie closest to the centre of the contoured areas were chosen as representative and typical of the Hackett River Group volcanic rocks and are outlined in Table 3.

The distinctive calc-alkaline composition of rocks from the Hackett River Group is evident in AFM diagrams, and has been illustrated elsewhere (Cameron and Durham, 1974b; Ewing, 1977). The calc-alkaline composition of the group is also seen in the distribution of trace elements, particularly Y, Zr, Ti and Cr as suggested by the graphical methods of Davies et al. (1979).

Chondrite normalized rare earth element patterns for andesites and dacites (Ewing, 1977, 1979) from the Hackett River Group form tight bundles with enriched light rare earth elements, little or no Eu anomalies and flat heavy rare earth element distributions. Study of the synvolcanic plutonic rocks of the Hackett River area suggests that both plutonic and volcanic rocks were melted from the crust, but with different degrees of partial melting, giving rise to related but slightly different magma compositions.

Geochemical comparison of major and trace element constituents with those of the Yellowknife area (Baragar, 1966) shows a decidedly more felsic and more pronounced calc-alkaline trend in the Hackett River Group rocks. However, the more felsic Yellowknife rocks do show some similarity to the rocks of this study area in their bulk composition and rare earth element signatures.



GSC

Figure 14. Density contoured silica vs colour index for several hundred least altered volcanic rocks from the Hackett River Group. Rocks falling closest to the centre of the contours were taken as compositionally representative of the group and are reproduced as Table 3.

Table 3. Representative chemical analyses from the least altered Hackett River Group volcanic rocks. Analyses have been normalized to 100, except for water (na = not analyzed).

	1	2	3	4	5	6	7	8	9	10	11
SiO_2	72.50	70.80	71.50	67.20	68.80	61.00	61.00	55.40	52.70	49.50	51.20
TiO_2	0.11	0.12	0.83	0.75	0.49	1.02	1.04	0.96	1.26	1.32	1.30
Al_2O_3	15.90	16.00	15.10	15.80	15.550	15.60	16.80	16.30	15.10	16.60	15.70
FeO	0.71	0.50	0.23	2.76	na	6.78	8.25	8.38	10.04	9.49	10.38
Fe_2O_3	0.51	0.50	2.31	0.10	4.51	1.01	0.93	0.81	1.03	1.63	1.64
MnO	0.00	0.00	0.04	0.08	0.00	0.14	0.13	0.19	0.23	0.19	0.20
MgO	0.52	0.52	0.90	2.64	3.45	3.07	2.21	5.47	7.60	6.59	6.76
CaO	1.66	1.70	1.32	5.44	0.96	4.71	4.70	7.28	8.91	9.30	8.22
Na_2O	6.14	6.95	5.46	2.63	5.18	2.84	3.60	4.29	2.44	4.15	3.49
K_2O	1.87	2.45	2.03	1.74	1.22	2.95	1.03	0.40	0.69	0.22	0.65
P_2O_5	0.06	0.07	0.28	0.19	1.07	0.21	0.23	0.21	0.00	0.24	0.25
S	0.01	0.30	na	0.17	na	0.06	0.12	0.07	0.00	0.10	0.09
CO_2	0.00	0.10	na	0.51	na	0.01	0.00	0.30	0.02	0.61	0.10
H_2O	0.60	0.40	na	1.00	1.65	1.50	1.90	1.50	2.50	1.90	2.50

Notes:

A Siliceous volcanic rocks (70-75% SiO_2)
- 1 Dacitic sill, Ignerit Formation-Aitch Lake area.
- 2 Dacitic ignimbrite, Nauna Formation-Aitch Lake area.
- 3 Dacitic tuff, Ignerit Formation-D'Arcy Lake area.

B Felsic tuffs (65-70% SiO_2)
- 4 Dacitic tuff, Ignerit Formation-Aitch Lake area.
- 5 Aluminous metadacite, undifferentiated Hackett River Group.

C Leucocratic andesite (60-65% SiO_2)
- 6 Pillowed andesite, Ignerit Formation-Aitch Lake area.
- 7 Andesitic ignimbrite, Nauna Formation-Aitch Lake area.

D Melanocratic andesite (52-65% SiO_2)
- 8 Andesitic ignimbrite, Nauna Formation-Aitch Lake area.
- 9 Pillowed andesite, Nauna Formation-Aitch Lake area.

E Basalt (48-52% SiO_2)
- 10 Gabbroic sill, Nauna Formation-Aitch Lake area.
- 11 Basaltic ignimbrite, Nauna Formation-Aitch Lake area.

F Analyses were done at the Geological Survey of Canada. All analyses except for 3 and 5 were provided by E.M. Cameron and C.C. Durham.

The narrow time framework for the age of the Yellowknife Supergroup volcanic rocks (Frith and Loveridge, 1982) implies a single pan-Slave episode of ensialic volcanism that likely occurred along mini-plate or block margins (Frith and Roscoe, 1980). The Hackett River volcanic belt probably formed from the coalescence of volcanic centres spaced 40-70 km apart that were located along deep crustal faults. Subaerial deposition and caldera collapse formed an integral part of the volcanism (Lambert, 1978).

Beechey Lake Group

The Beechey Lake Group, which extends over almost half of the map area, is made up mostly of bedded greywackes (Gilbert, 1954) and mudstones (Twenhofel, 1937) and their metamorphosed equivalents. Minor rocks (<2%) include; carbonaceous mudstone, banded silicate and oxide iron formation, chert and pyroclastic rocks. The rocks are variously metamorphosed from greenschist to upper amphibolite grade and structurally are mostly isoclinally folded with steeply dipping to overturned attitudes.

Greywackes and mudstones. The greywackes and mudstones that make up most of the group occur in 10-40 cm thick beds, but in places beds are several metres thick or are only laminations. In general, areas of high relief are underlain by thickly bedded greywackes. Typical exposures of greywacke and mudstone are shown in Figure 15A, B and C. The Beechey Lake Group beneath the Back Group in the vicinity of Keish lake is more argillaceous than elsewhere in the area. Furthermore, the rocks have a near vertical cleavage but the bedding near the volcanic interface is gently dipping towards the centre of the Back River Volcanic Complex.

Primary sedimentary features present in the Beechey Lake Group include graded bedding and complete to incomplete Bouma cycles (Bouma, 1962) that have sharp contacts between beds and continuity along strike. These are characteristic of turbiditic deposition (Kuenen, 1964). Postdepositional, nontectonic, soft-sediment deformational structures such as load casting, shale rip-ups, pre-consolidation faulting, slumping and dewatering structures are common (Fig. 15D, E).

Typically, least metamorphosed rocks are grey to khaki on weathered surfaces and light to medium grey on fresh surfaces. Finer grained mudstones are commonly dark grey. Variations in overall appearance are mostly due to metamorphic grade, which changes the rocks from a grey bedded, relatively uniform sandstone and shale to a schistose or gneissic porphyroblastic rock. Metamorphism commonly does not destroy bedding, as variations in composition across strike result in different proportions of metamorphic minerals. The more highly metamorphosed rocks may be rust to buff on weathered surfaces and are locally friable and mottled on fresh surfaces.

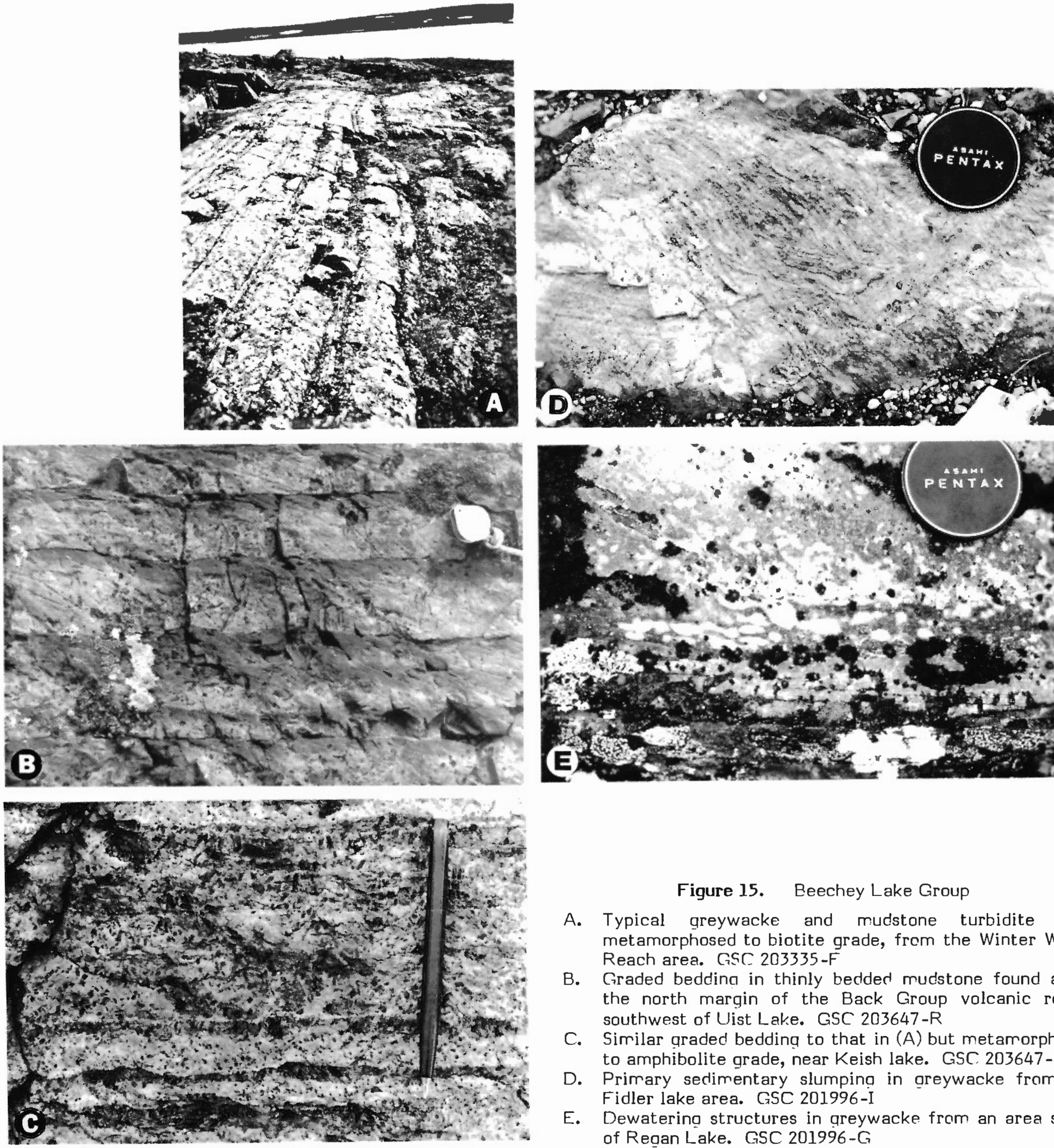


Figure 15. Beechey Lake Group

A. Typical greywacke and mudstone turbidite beds metamorphosed to biotite grade, from the Winter Water Reach area. GSC 203335-F
B. Graded bedding in thinly bedded mudstone found along the north margin of the Back Group volcanic rocks, southwest of Uist Lake. GSC 203647-R
C. Similar graded bedding to that in (A) but metamorphosed to amphibolite grade, near Keish lake. GSC 203647-Q
D. Primary sedimentary slumping in greywacke from the Fidler lake area. GSC 201996-I
E. Dewatering structures in greywacke from an area south of Regan Lake. GSC 201996-G

Table 4. Modal analyses of Beechey Lake Group greywackes from the Winter Water Reach area

	1	2	3	4	5	6
Quartz	32	25	39	32	34	33
Plagioclase	6	3	4	5	6	5
Rock fragments	3	3	3	1	1	2
Matrix	58	68	55	63	60	61

Thin section study shows that these rocks contain fewer lithic fragments than the greywackes in the Yellowknife area (Henderson, 1975b). These rocks are closer in modal composition to the Contwoyto Lake greywackes (Tremblay, 1976). Some modal analyses, based on 500 counts per thin section, for typical coarse grained greywacke from the Winter Water Reach area, are shown in Table 4. Framework minerals include sand sized quartz and plagioclase. Quartz grains are mostly single crystals or polygonized single grains. Larger quartz grains are angular to subrounded and tend to maintain their detrital outline, whereas smaller grains are generally more sutured. Plagioclase (albite to andesine) occurs chiefly as subrounded, untwinned or simply twinned crystals. Lithic fragments are a minor component of the framework, are best recognized in the least metamorphosed rocks, and in general are rare in the Beechey Lake greywackes. This may be partly due to higher grades of regional metamorphism and deformation in the study area, but it most likely indicates a higher proportion of more granulated material derived from volcanic rocks or unconsolidated tuffaceous detritus.

Scattered 2-10 cm thick beds of pebbly greywacke occur near the contacts with rocks of the Hackett River and Back groups. The bulk of the pebbly grains are rounded quartz aggregates, presumably of quartz vein origin. Other grains are rounded, rusty to grey chert, felsic volcanic or andesitic rock fragments. It is noteworthy, that no potassium feldspar is found in the Beechey Lake Group, neither as a framework, nor as a matrix constituent. In Cambrian greywackes derived from the Grenville Province, Middleton (1972) noted that distinctive perthitic K-feldspar grains were completely albitized by diagenetic processes but preserved the relict perthitic textures. Since the abundance of quartz in the Yellowknife area necessitates a granitoid, as well as a volcanic provenance (Pettijohn, 1970) it is concluded that such an albitization process was also operative in the Archean depositional basins of the Slave Province.

Carbonaceous mudstones. Thinly bedded, black, fissile carbonaceous and siliceous mudstones occur along the east margin of the Hackett River volcanic belt. Pyrite is a common accessory mineral. Along the contact with the volcanic rocks the mudstones are interbedded with greywackes and mudstones that are associated with finely bedded chert and silicate iron formation. The unit generally ranges in thickness from 10-50 m, but it thickens to as much as 300 m, near Aitch Lake.

Thin sections show fine grained carbon in the matrix with concentrations along lamination planes (Fig. 16A). Larger clasts of quartz and felsic volcanic fragments are commonly present in varying proportions as isolated grains (Fig. 16B). Biotite and euhedral pyrite are secondary minerals, as they cut across bedding laminations. Lens-shaped aggregate quartz grains of similar size are present, probably formed from vein quartz or siliceous volcanic fragments. In places, these rocks are obviously siliceous and fractured, with the fractures now filled with calcite and quartz.

Carbonaceous mudstones (Fig. 16C) also occur south of Uist Lake between volcanic rocks of the Hackett River Group and the overlying Back Group. The mudstones are intercalated with tuffites, and pyritiferous mudstones which form spectacular, but barren, gossans that extend for several kilometres.

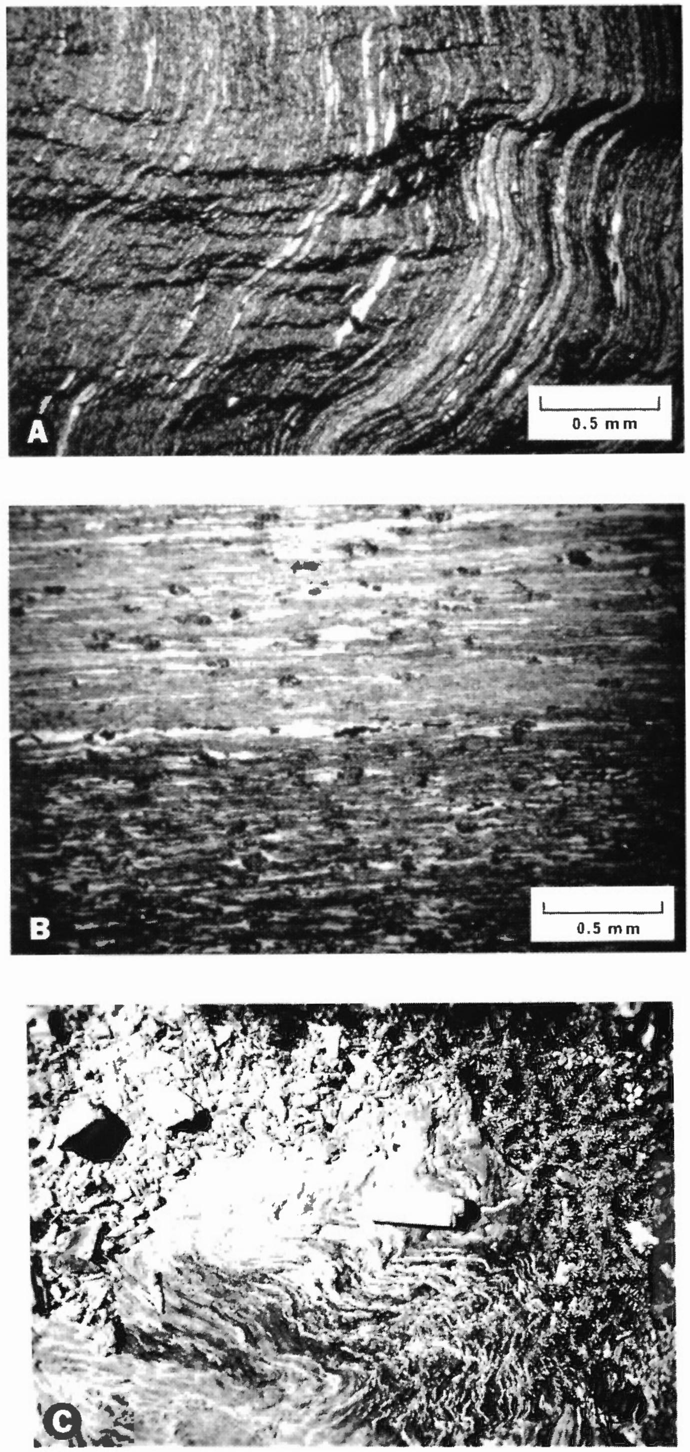


Figure 16. Carbonaceous mudstones, Beechey Lake Group

A. Photomicrograph (plane light) of crenulated carbonaceous mudstone from the Aitch Lake area.
B. Photomicrograph (plane light) of carbonaceous mudstone with lithic volcanic fragments, Uist Lake area.
C. Pyrite-bearing carbonaceous mudstone, Uist Lake area. GSC 203339-E

Cherts and banded iron formation. The chert and banded iron formation found east of the main limb of the Hackett River volcanic belt is possibly the most extensive in the Slave Province. It outcrops intermittently for more than 50 km. Aeromagnetic maps indicate that this iron formation is a continuous band. Iron formation, some of which is gold-bearing (see Mineral deposits), also occurs within the greywacke-mudstone sequence in the northeastern part of the area, near the unconformity with the Proterozoic Goulburn Group and in various places overlying parts of the Back Group. More extensive bands of similar stratigraphic level, as much as 30 km in length, are present near the south margin of the area near Wolverine lake (Baragar, 1975; Henderson, 1975a; Lambert, 1976).

The banded iron formation along the east margin of the Hackett River belt, near Aitch Lake, is as much as 650 m above the volcanic-sedimentary contact and overlies carbonaceous mudstone and greywacke. Along the remaining part of the belt iron formation is less than 200 m from the contact. Iron formation in the Aitch Lake area is 1-5 m thick and is underlain and overlain by finely bedded mudstone. Chert is present as part of the iron formation, in beds up to 5 cm thick. Magnetite is more prevalent in the lower part of the iron formation, whereas the upper parts contain more silicate, principally as amphibole. Banding, as 1 mm laminations is common through the iron formation, except where secondary amphibole has grown across bedding planes.

Polished section studies show that pyrite and magnetite are the principal iron-bearing minerals, but pyrrhotite is present locally. Goethite is a common alteration product. In some thin sections, framboidal pyrite is present. Magnetite occurs as fine, but disseminated grains or as graded layers less than 0.5 cm thick. The magnetite is inclusion free, commonly rounded, and forms discrete grains which are not in contact with each other, indicating it is of detrital origin, or has been reworked from chemically deposited minerals. Postdepositional magnetite with euhedral outlines is locally present, as an alteration product.

Quartz is the principal matrix mineral. Amphibole is present as highly zoned, twinned grunerite-cummingtonite and as blue-green hornblende. Chlorite occurs as an alteration product of amphibole. Clinozoisite, possibly prehnite, and almandine, form minor constituents. Fine- and coarse-grained secondary biotite is present in the more mafic bands. Plagioclase, generally untwinned, occurs in some of the coarse grained bands.

The iron formation is of the Algoma type (Gross, 1965) formed by volcanic associated, chemogenic deposition with greywacke.

Chemistry of greywackes and mudstones. No systematic attempt was made to study the geochemistry of the Beechey Lake Group greywacke and mudstone. However, 23 whole-rock analyses from the area were carried out from regions in the vicinity of volcanic belts to provide background information for soil, lake water and volcanic metallogenic studies (Cameron and Durham, 1974b). The analyses have been grouped according to rock type, averaged, and presented with standard deviations and contrasted with greywacke from the Yellowknife area (Table 5, Fig. 17).

Table 5. Average whole-rock chemical analyses of Beechey Lake Group rocks with one standard deviation, compared to Yellowknife area greywackes and mudstones

	1	2	3	4	5
SiO_2	71.40	74.90 ± 2.80	64.50 ± 4.70	65.00 ± 4.00	66.60
TiO_2	0.66	0.43 ± 0.11	0.59 ± 0.07	na	0.64
Al_2O_3	14.40	11.80 ± 1.20	14.30 ± 1.50	15.70 ± 2.10	15.30
FeO	3.60	1.60 ns	4.20 ns	na	4.51
Fe_2O_3	0.10	0.60 ± 0.20	0.50 ± 0.20	4.49 ± 1.07	0.70
MnO	0.06	0.01 ± 0.11	0.07 ± 0.04	0.03 ± 0.01	0.00
MgO	2.02	0.60 ± 0.90	2.41 ± 1.89	2.47 ± 1.21	2.74
CaO	1.66	1.52 ns	2.09 ± 2.89	1.91 ± 1.81	1.71
Na_2O	3.05	1.28 ± 1.91	1.60 ± 1.55	2.71 ± 0.60	3.12
K_2O	1.58	2.76 ± 1.06	2.87 ± 1.95	2.40 ± 0.86	1.92
LOI	12.00	1.80 ± 0.90	2.40 ± 0.06	na	2.57
CO_2	na	0.00	0.16 ns	na	1.38
C	na	2.70 ± 1.70	4.50 ± 5.20	na	na
S	na	0.14 ± ns	0.14 ± 0.06	na	na

Notes:

1 Siliceous mudstone, just south of Camp lake, Hackett River area (Percival, 1978)

2 Average of 7 siliceous, carbonaceous mudstones, Aitch Lake area (Cameron and Durham, 1974a)

3 Average of 6 carbonaceous greywackes, Aitch Lake area (Cameron and Durham, 1974a)

4 Average of 10 greywackes and mudstones, Malley Rapids area (unpublished partial analyses) (E.M. Cameron and C.C. Durham, personal communication, 1976)

5 Average of 6 Burwash Formation greywackes and mudstones from the Yellowknife area (Henderson, 1975b)

In 4 total iron was calculated as Fe_2O_3; na = not analyzed; ns = not statistically valid.

The analyses are biased in favour of samples located close to the volcanic-sedimentary contact and are notably siliceous, as shown by rocks from the Hackett River and Aitch Lake areas. Both have a SiO_2 content similar to the felsic volcanic tuffs, flows and small intrusive sills of the adjacent belt. Volcanic ash probably formed the principal detrital source for the greywacke and the mudstone in the Aitch Lake area, as these rocks are less siliceous and contain more carbon, alumina, and potash (Table 5, analysis 3). Analyses of greywacke from the Winter Water Reach of the Back River are more characteristic of the map area and compare most favourably with the Burwash Formation from the Yellowknife area.

Isotopic studies of banded iron formation. Isotopic ratios of sulphur, carbon, and oxygen from the Aitch Lake area iron formation were carried out at the Baas-Becking Geobiological Laboratory in Australia and are shown in Table 6. The ratios for carbon are within the range normally accepted as indicating a biological origin (-20 to -40 for C13).

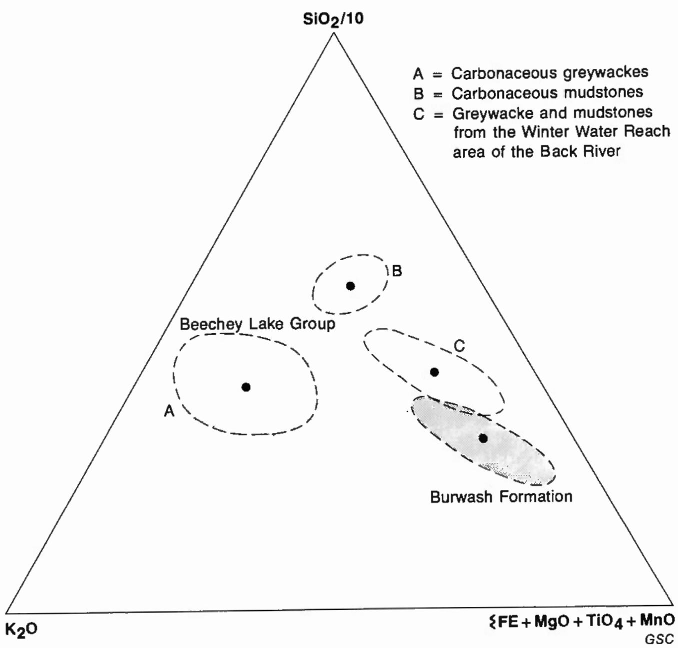


Figure 17. Average values for the major oxide compositions for rocks of the Beechey Lake Group, compared with values from the Burwash Formation, Yellowknife area. The shaded areas approximate single standard variations as shown in Table 5.

Back Group

The Back Group, defined by Frith and Percival (1978), consists of intermediate, felsic and minor mafic volcanic flows and pyroclastic rocks that erupted in and around a cauldron subsidence structure, centred 18 km south of the map area (Fig. 18), as delineated by Lambert (1976). A more comprehensive account of the Back Group is contained in reports by Lambert (1976, 1978, 1982a, b).

Classification of the Back Group volcanic rocks was carried out by specific gravity measurements in the field and by a visual estimate of the mafic index. The rocks were divided into dacite, andesite or basalt. The field classification was checked by chemical analyses and was found to correspond closely to Streckeisen's (1976) chemical classification. Synvolcanic metagabbro is volumetrically significant in the area and is described with the basalts.

For descriptive purposes, the Back Group in the map area is divided into the Regan Lake area, which is the northern part of the Back River caldera complex, and into the extensive distal parts located in the Uist Lake and Malley Rapids area, which flank the Malley Rapids anticlinorium and continue to Casey lake, a few kilometres east of the southeast corner of the map area.

Regan Lake area. North of Regan Lake, the Back Group conformably overlies metasedimentary rocks of the Beechey Lake Group. However, slight angularities are present locally between the two groups where dacite and quartz pebble conglomerate commonly occur at the base of the Back Group. In places this conglomerate is a volcanic rubble composed of clasts of dacite and andesite several metres across that fill irregular depressions. At other localities, bedded conglomerates, several centimetres to several metres thick (Fig. 19), continue intermittently along strike for several kilometres. The lithic conglomerate clasts are 10-20 cm in diameter, poorly sorted, and made up primarily of dacite and quartz in a mudstone and carbonate matrix. Small lenses of 1-3 cm thick quartz pebble conglomerate locally interlayer the underlying greywacke-mudstones within a few metres of the contact.

Along the northwest margin of the group, north of Keish lake, the Beechey Lake Group overlies the Back Group volcanic rocks, indicating a transgressive stratigraphy, where sedimentation was both contemporaneous and older than

Table 6. Isotopic carbon and oxygen analyses of Beechey Lake Group iron formation from near Aitch Lake

Sample	% carbon (organic)	δC-13 PDP (organic)	% carbon (carbonate)	δC-13 PDP (carbonate)	δO-18 SMOW (carbonate)
A	3.8457	-29.2‰	0		
B	0.0069	-23.5‰	0.08	-5.3‰	+11.49‰
C	0.4618	-26.8‰	0.19	-11.0‰	+15.61‰

PDP. A carbon isotope standard called the PeeDee Belemnite.

SMOW. An oxygen standard, Standard Mean Ocean Water.

Data courtesy of D.Z. and J.H. Oehler, Baas Becking Geobiological Laboratory, Canberr, and J.B. Henderson.

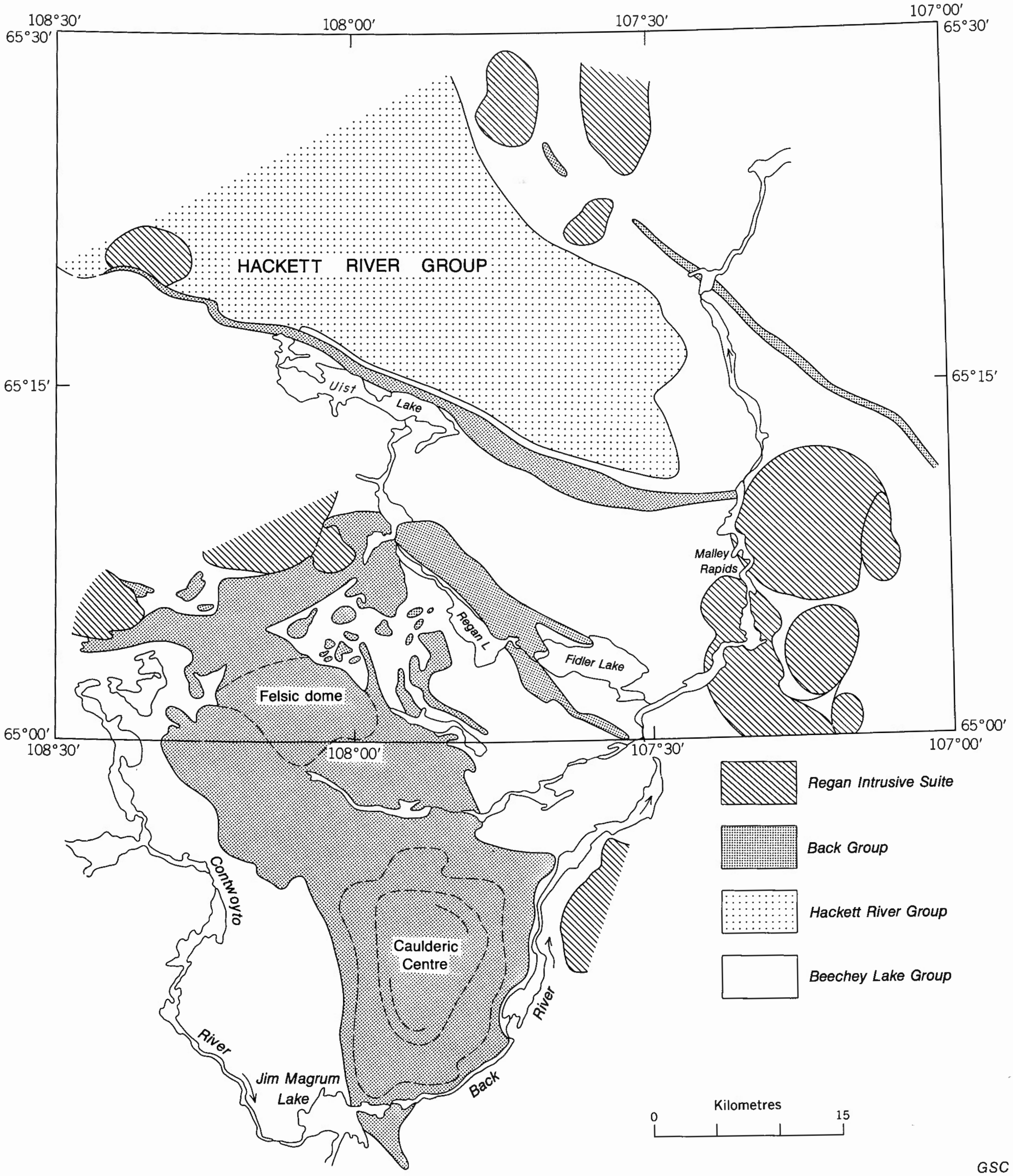


Figure 18. Distribution of the Back Group within and to the south of the map area (modified from Lambert, 1982b).

Figure 19. Beechey Lake Group conglomerates underlying the Back Group near Keish and Boucher lake. GSC 203647-G

volcanic deposition. Banded iron formation is present along the north margin of the Back Group from this area to Fidler lake.

The Back Group in the Regan Lake area is divided into four parts, three of which contain a distinctive lithology. A northwest-trending segment north of Regan Lake, is composed primarily of andesite flows and pyroclastic rocks. North of Keish lake an east-northeast-trending segment is made up primarily of pillow basalt. Between Keish lake and Boucher lake dacite forms dome-like configurations. The volcanic rocks between these areas are made up of dacite and andesite flows and pyroclastic rocks, that are locally contemporaneous with volcaniclastic sedimentation.

The stratigraphy of the Back Group has not been established (M.B. Lambert, personal communication, 1980) but it is likely that the oldest strata, in this area, are pillowed andesites, succeeded by felsic volcanic rocks that form domes or areally restricted flows, breccias and tuffs.

Andesites. Andesites, commonly pillowed, are the most abundant rocks of the Back Group. They are either leucocratic or melanocratic. Pillows are commonly 20-80 cm in length, but due to low dips do not provide abundant top determinations. The pillows are rounded in the leucocratic andesites and oblong in the melanocratic andesites. Pillows are rarely longer than twice their width and have locally amygdaloidal upper margins containing carbonate and/or quartz.

Typically, leucocratic pillowed andesites are light to medium grey-green, aphanitic rocks. They are commonly fractured, but rarely foliated, except where regional metamorphism has attained high grades, such as in the Malley Rapids area.

Greenschist metamorphism has converted the melanocratic andesites to uniform greenstones, but locally saussuritized plagioclase phenocrysts are evident. In thin section, the rocks are chloritized and saussuritized and may contain as much as 10% opaques, commonly magnetite.

Some porphyritic andesite, andesite breccia and tuff are present as scattered, volumetrically minor rocks within the Back Group. The andesites are commonly massive and contain abundant remnant, 20-200 µm plagioclase phenocrysts. The largest area of massive porphyritic andesite is located southeast of the southeast lobe of the Uist Lake pluton. Brecciated andesite occurs, possibly as flow-top breccias, which are locally intercalated with lapilli and coarse grained tuffs. At other localities, rocks of andesite composition occur as finely laminated volcanogenic sediment, interbedded with coarser andesite tuff.

Basalts and metagabbros. Basalt occurs north of Keish lake in a tongue-shaped east-west belt and along the south margin of the Uist Lake pluton. The basalt north of Keish lake is tilted northward, and is underlain and overlain by greywackes and mudstones of the Beechey Lake Group. The overlying rocks are interlayered with intraformational iron formation. Similar basalts, along with dacite tuffs and a dacite dome, are found between the tongue-shaped belt and the basalt south of the Uist Lake pluton. The two basalt areas may be continuous at depth.

The basalt north of Keish lake forms a relatively uniform sequence of pillowed and fractured rocks. The basalt is commonly hornblende-bearing and dark to medium green. Fractures and voids are filled with carbonate. Gossan horizons occur at the top of the succession in thin dacite tuffs and felsic breccias, cemented by basaltic volcaniclastic detritus and carbonate. The overlying Beechey Lake Group is made up of greywacke, mudstone and intraformational, pyritiferous iron formation.

The basalt south of the Uist Lake pluton is similar to that north of Keish lake. Pillows are better preserved and range from 20 cm to 1 m in length. Less viscous basalts with hornblende phenocrysts have elongated pillows, commonly more than twice the pillow width and are less fractured.

Much of the southern margin of the basalt is intruded by metagabbro that has recrystallized to hornblendite. The metagabbros are probably sills, as they are compositionally similar to the basalt. They are locally very coarse grained, with hornblende crystals up to 2 cm in length.

Dacites. Dacites occur as massive, near surface domal flows or as tuffs, lapilli tuffs and breccias. Dacitic tuffs are of limited extent and are present only near the base of pillowed basalt or andesite. Massive dacite occurs as ovoid domes, surrounded by Beechey Lake Group mudstones. The dacite domes may predate the andesite or basalt flows, even though locally the basalt overlies the dacite. Some domal dacites, such as the one near Quartermoon lake, contain subaerial breccia-lahars along their flanks (Lambert, 1977, 1982b) indicating that they were probably stratigraphically higher and older than the surrounding basalts. The dome southwest of the Uist Lake pluton shows evidence of diapiric emplacement, as the margins contain fragments that appear flattened, parallel to the margins and elongated vertically. At the top of the basalt succession, north of Keish lake, a thin carbonate-cemented dacite breccia is present between the basalt and the overlying Beechey Lake Group (Fig. 20).

Figure 20. Felsic volcanic breccia, possibly of laharic origin, on the top of pillowed basalts north of Keish lake. The matrix is carbonate and fine grained basaltic tuff. GSC 201996-N

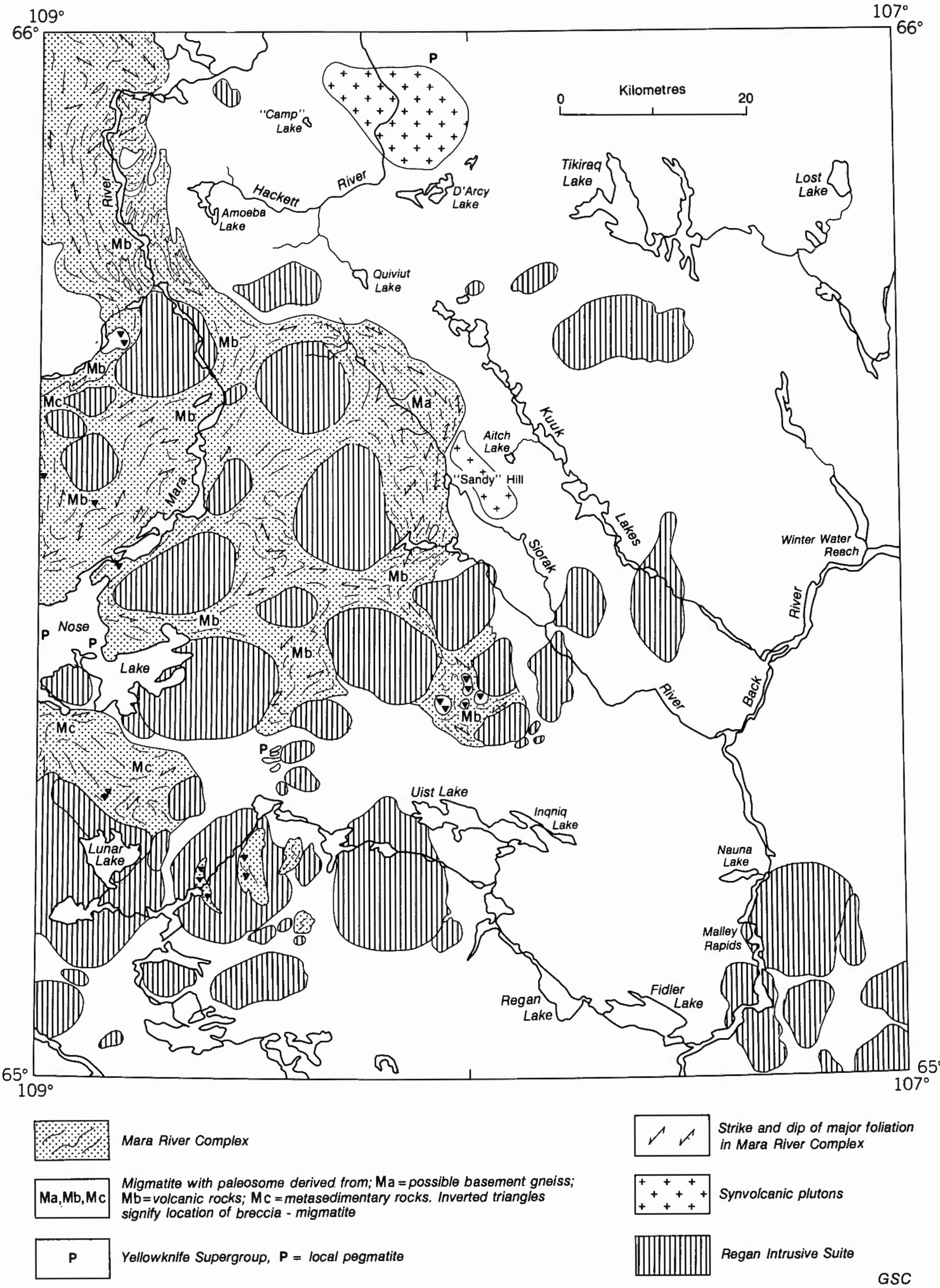


Figure 21. Distribution of the Mara River Complex.

This seemingly isolated occurrence of breccia may overlie other volcanic rocks at depth or it may represent a small felsic volcanic centre that is interstratified with Beechey Lake Group metasediments.

Uist Lake-Malley Rapids area. A narrow belt of mostly felsic volcanic rocks occurs on both sides of the Malley Rapids anticlinorium. It extends from the Kuuk Lakes to Casey lake on the northeast limb of the structure, and from Casey lake, intermittently, almost to Nose Lake, on the southwest limb. These rocks are intraformational on both limbs and are underlain and overlain by Beechey Lake Group metasedimentary rocks. In the Uist Lake area, metasedimentary rocks form a wedge-shaped belt between the Back Group and the Hackett River Group. This belt extends from the Back River area, to about 20 km west of Uist Lake, where it gradually pinches out. Its presence is marked by a gossan horizon. The volcanic rocks in the Uist Lake region are more deformed and metamorphosed than those of the Regan Lake region.

Northeast of the Malley Rapids anticlinorium, the volcanic rocks are 500-1000 m thick and are underlain by up to 3500 m of greywacke-mudstone of the Beechey Lake Group. Part of the belt has been metamorphosed to a greater degree than that outlined by the staurolite-cordierite isograd and the volcanic rocks are notably gneissic or schistose. In general, the rocks are a light grey green with plagioclase and darker green retrograded chlorite as the only recognizable mafic mineral. Rare quartz-eye phenocrysts are present in the most felsic rocks. Calcite is a common accessory mineral. Across the belt, the composition varies from dacite to andesite. Remnant lapilli are evident locally. Variation also occurs along strike. Northeast of the Back River the belt is basaltic, whereas southeast of the river andesite breccia with carbonate fracture fillings is present, interlayered with basaltic to dacitic tuff. The basic rocks locally contain pillow-like structures and in hand specimen are fine- to medium-grained, dark green and slightly gneissic.

Granitoid rocks

The granitoid rocks of the map area include the Mara River Complex, synvolcanic plutons and an extensive postkinematic comagmatic suite of plutons known as the Regan Intrusive Suite.

The Mara River Complex is mostly a hybrid rock unit derived from possibly older granitoid and supracrustal rocks that have been migmatized and deformed. The complex occurs chiefly in the western part of the area. Extensive overburden covers much of the complex and many of its contacts with other rock units.

Synvolcanic plutons include: the Hanimor gneiss that forms the core of the Hackett River gneiss dome in the Hackett River area and the sandy hill pluton, that intrudes the base of the volcanic succession, where the volcanic belt narrows along its principal north-northwest limb.

The Regan Intrusive Suite and related plutons number more than 100 in the map area and environs. The suite is composed mostly of granodiorite and tonalite with lesser amounts of quartz diorite and granite.

Mara River Complex

The distribution of the Mara River Complex is outlined in Figure 21. The complex is made up of granitoid gneiss, migmatite and anatectite derived from the Yellowknife Supergroup and from possibly pre-supergroup granitoid rocks. The complex may also include a number of plutons that belong to the Regan Intrusive Suite. Contacts of gneiss with migmatites are gradational and the proportion of leucosome is highly variable. Contacts with plutonic rocks of the Regan Intrusive Suite are not well delineated due to the lack of compositional, topographic and colour contrast. Within the Mara River Complex, most subunits were not delineated. The dominant local lithology is indicated on the map (in pocket). The nature of the contacts and description of the most abundant rock types are outlined below, grouped according to petrogenetic type.

Contact relationships. West of Aitch Lake, the contact between the basal volcanic rocks and the Mara River Complex is sharp. The rocks on both sides of the contact are sheared and regional metamorphic isograds imply that the complex moved up relative to the volcanic rocks. Foliation within the tonalite and granodiorite gneiss that make up this part of the complex, parallels the contact and is presumed to have formed during uplift when conditions of metamorphism gave rise to plastic deformation.

Gradational contacts occur in the Mara River to Amoeba Lake area. The Hackett River Group becomes increasingly gneissic and migmatitic towards the west. Although migmatite is defined in this study as a rock that contains more than 50% leucosome, this distinction is not easily determined where volcanic rocks are felsic. The basic volcanic rocks are mostly andesite and these become coarse grained biotite and/or hornblende bearing gneiss or banded migmatite. The leucosome is commonly plagioclase and quartz. Volcanic rocks near the Mara River form "islands" of gneiss and migmatite that locally retain primary volcanic features, yet are surrounded by gneiss and/or migmatite of uncertain origin.

The Mara River Complex south of Nose Lake contains an oval area (Salop, 1971) of granitoid gneiss, migmatite and plutons of quartz diorite, granodiorite, tonalite and granite. Metasedimentary gneiss, schist and migmatite occur within a plutonic granodiorite in the southern part of the oval and are interpreted as septa or roof pendants. The contact of the migmatites in the northeastern part of the oval with the surrounding metasediments of the Beechey Lake Group is gradational, but sharper than expected solely from prograde regional metamorphism. This suggests, as in the Sandy hill area, that the oval moved up relative to the surrounding Beechey Lake Group.

Migmatites derived in part from paragneiss. Common migmatites in the Mara River Complex are derived from metasedimentary mudstones and greywackes, analogous to those of the Beechey Lake Group (Fig. 22). Along the south margin of the complex, between Nose Lake and Lunar Lake, east striking migmatites dip subvertically. They contain biotite, plagioclase and quartz-bearing paragneiss or paraschist relicts, some of which have relict bedding, sillimanite and porphyroblast ghosts that resemble porphyroblastic members of the Beechey Lake Group. The migmatites have highly variable leucosome contents, both along and across strike. They are locally interlayered with medium, equigranular granite that contains abundant muscovite and large potassium feldspar megacrysts. These granites commonly contain brown-stained quartz and also have gradational contacts with the migmatites, suggestive of an anatectic mode of origin that favoured more leucocratic layers parallel to the foliation (beds?). The migmatites grade into a more homogeneous type of migmatite characterized by rusty brown schlieren of biotite-dominant schist.

Pegmatites. Large, spectacular pegmatites are developed within septa of the Beechey Lake Group in the narrows area of Nose Lake and southeastward toward Uist Lake. Although mapped as separate units the pegmatites are similar in almost every respect to the leucosome that makes up the

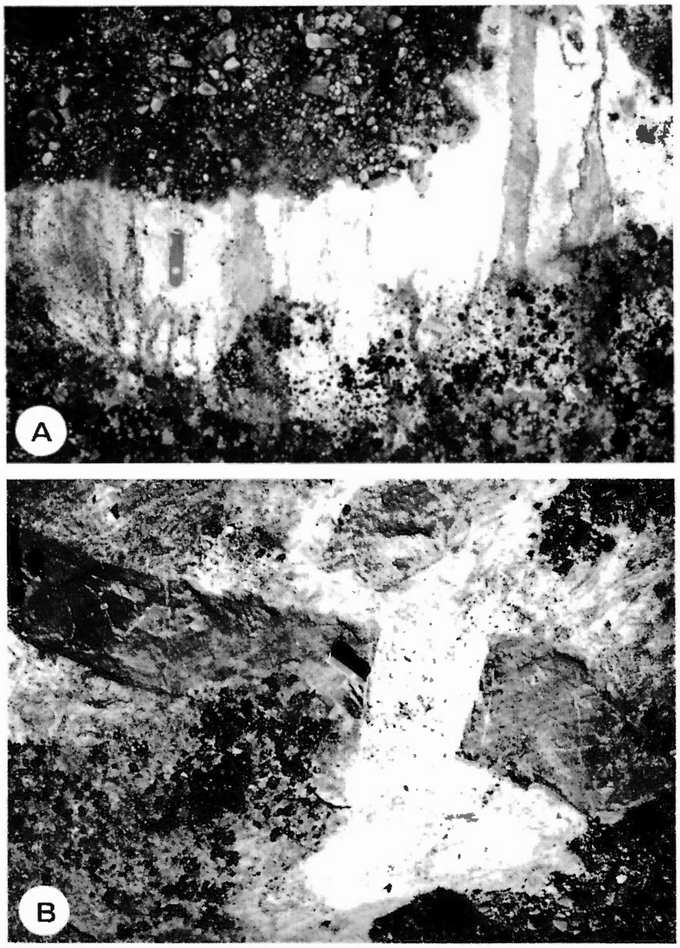


Figure 22. Mara River Complex

A. Schlieren migmatite probably derived from greywacke-mudstone of Beechey Lake Group, from an area west of the Mara River. GSC 203337-K

B. Agmatite developed by in situ partial melting of paragneiss, from an area west of the Mara River. GSC 203334-L

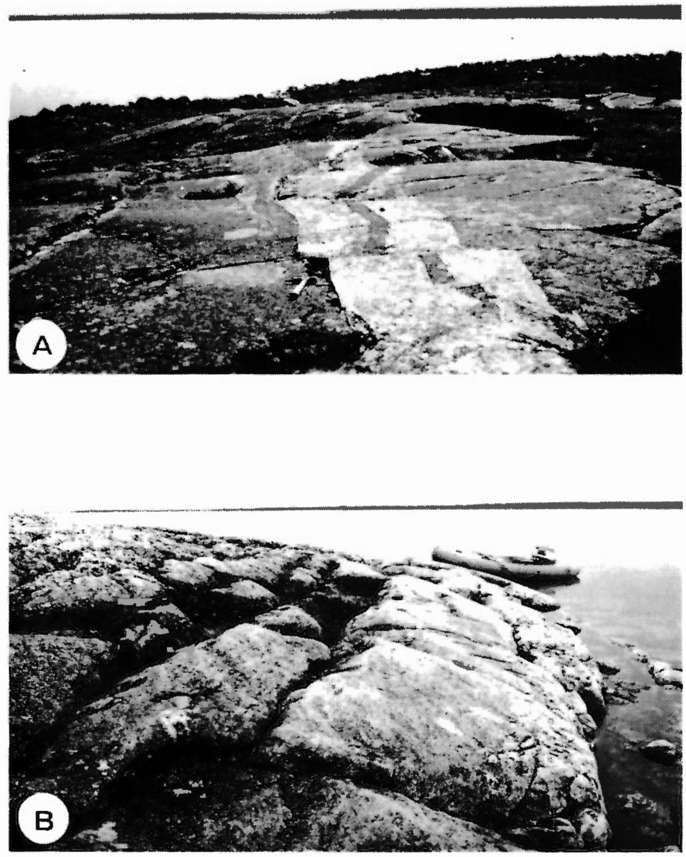


Figure 23. Mara River Complex

A. Diorite gneiss, probably formed from volcanic rocks, cut by multiple injections of pegmatite, east of Nose Lake. GSC 203337-U

B. Some of the larger pegmatites cutting the complex near the contact with the Beechey Lake Group, southeast shore of Nose Lake. GSC 203337-T

migmatites of the complex, only on a grander scale. The pegmatites are made up of crystals of microcline, albite, and quartz that locally measure up to 20 cm across. Muscovite books up to 10 cm wide are present on the promontory of Nose Lake. Other minerals include biotite, black euhedral tourmaline, pin-head sized zircon and garnet. Quartz and feldspar may form a graphic texture, indicating eutectic crystallization. Some islands in Nose Lake are made up entirely of pegmatite with a layered appearance caused by multiple emplacement (Fig. 23). West of the Mara River, randomly oriented pegmatite intrusions are undeformed, suggesting anorogenic formation.

Chemical analyses of similar pegmatites near Cat Lake gave granite compositions comparable to granites found elsewhere in the region and mapped as part of the Regan Intrusive Suite (Hill and Frith, 1982). However, at least three types of granite are known in the area; one of them, like the pegmatites of the Hackett River area, derived by anatexis from in situ or nearby metasedimentary rocks.

Migmatites derived in part from metavolcanic rocks. Dioritic gneiss and migmatite with dioritic or amphibolitic paleosome are common along the south margin of the Mara River Complex between the Siorak River and Nose Lake. Like the Amoeba Lake to Mara River area, remnant "islands" of volcanic rocks are preserved in a "sea" of more leucocratic migmatite and gneiss. These remnants contain volcanic structures and textures such as fine grain size and pillows. Banded dioritic migmatite east of a tonalite pluton along the southeast shore of Nose Lake contains remnant gossans. Other gossans are found in migmatite 15 km north of Uist Lake. Agmatitic migmatite is present along the west shore of the Mara River (Fig. 22B). Elsewhere, the paleosome may be a hornblende-plagioclase-bearing, medium, even grained, black to dark grey rock with local plagioclase porphyroblasts. The leucosome is locally coarse grained and contains quartz, plagioclase and biotite. The proportion of paleosome is highly variable and small areas of relatively clean diorite gneiss are present within areas mapped as migmatite (Fig. 23A).

Agmatitic diorite-migmatite is formed northeast of the Malley Rapids anticlinorium, near the centre-line of the map area. Small subrounded intrusions are riddled with diorite and quartz diorite inclusions (Fig. 24B). Although many of the inclusions are remnants of andesite, others are homogeneous, medium grained, equigranular, partly digested basic intrusive rock, chemically related to the Regan Intrusive Suite (Hill and Frith, 1982). This type of migmatite likely formed as a result of plutonism rather than by regional metamorphism. The diorite inclusions are discussed in more detail in the description of the Regan Intrusive Suite.

Twenty kilometres west-southwest of Uist Lake, an oval area of Mara River complex was uplifted into Beechey Lake Group amphibolite facies rocks. This part of the Mara River Complex is made up of granodiorite gneiss, with a foliation that cuts across the contact with the Beechey Lake Group. The complex contains irregular shaped bodies of quartz diorite gneiss and migmatite derived in part from basalt or gabbro. Pegmatitic leucosome locally reacted with paleosome to form a coarse amphibolite, containing plagioclase glomeroporphyroblasts that weather out in 3-5 cm sized fragments (Fig. 24C).

Synvolcanic intrusions

A large synvolcanic intrusion referred to as the Hanimor gneiss, forms the bulk of the core of the Hackett River gneiss dome, and another intrudes the basal part of the volcanic belt in the Sandy hill area (Fig. 25). In addition to these large intrusions, there are many small sills and dykes within the volcanic succession that are too small to map at the scale of this study. They have been described with the Hackett River Group. These hypabyssal rocks intrude the Hackett River Group, and chemical studies have shown they are probably cogenetic with the volcanic rocks they intrude (Cameron and Durham, 1974b). Some of the sills postdate the onset of Beechey Lake Group sedimentation (Frith and Roscoe, 1980). Parts of the core area of the Malley Rapids anticlinorium may also be plutonic and synvolcanic in origin, as suggested by rare earth element data, but due to polyphase

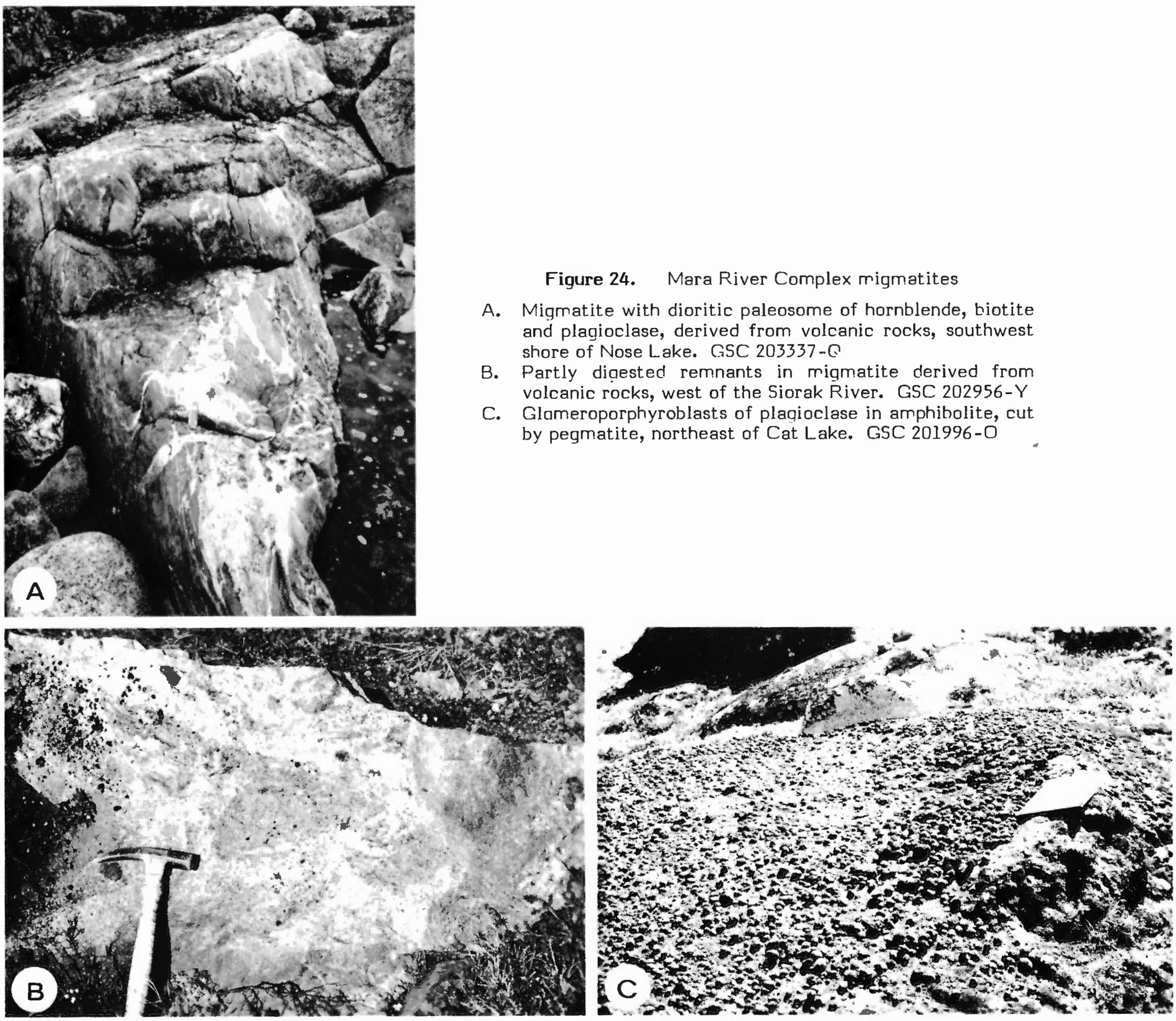


Figure 24. Mara River Complex migmatites

A. Migmatite with dioritic paleosome of hornblende, biotite and plagioclase, derived from volcanic rocks, southwest shore of Nose Lake. GSC 203337-Q

B. Partly digested remnants in migmatite derived from volcanic rocks, west of the Siorak River. GSC 202956-Y

C. Glomeroporphyroblasts of plagioclase in amphibolite, cut by pegmatite, northeast of Cat Lake. GSC 201996-O

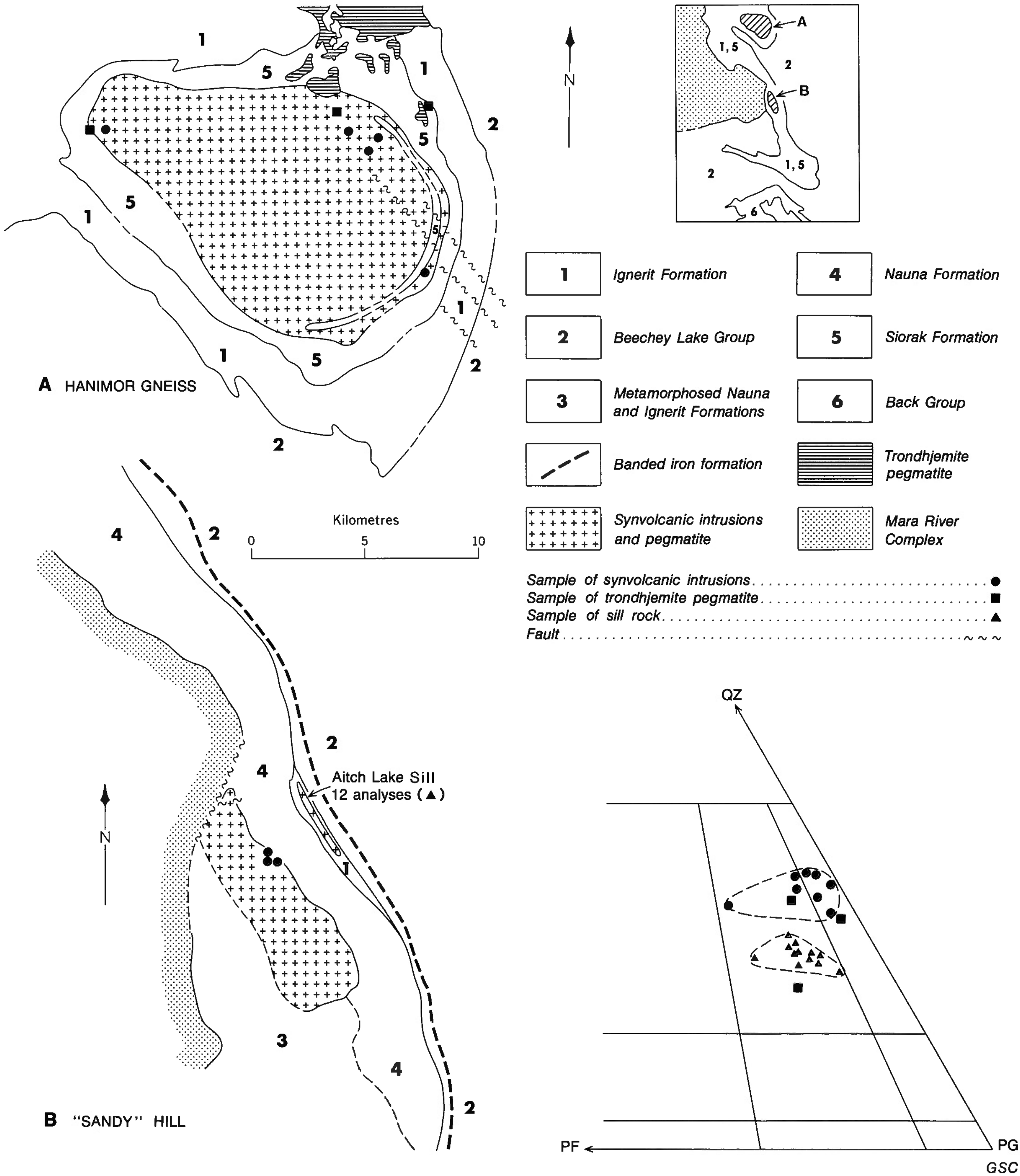


Figure 25. Distribution of synvolcanic rocks at Hackett River and Aitch Lake, showing the location of samples analyzed and a Streckeisen diagram illustrating the mesonormal compositional similarity of the larger intrusions of tonalite and granodiorite and the difference between these and the smaller sill rocks of the Ignerit Formation at Aitch Lake.

deformation and metamorphic recrystallization, this relationship is not certain and these rocks have been grouped within the more enigmatic Mara River Complex.

Hanimor gneiss. This forms the core of the Hackett River gneiss dome and is composed mostly of tonalite and granodiorite gneiss, and anatectic pegmatite of trondhjemite and granodiorite composition. In places pegmatite makes up as much as 20% of outcrops.

The contact zone between core rocks and the surrounding metasedimentary Siorak Formation (mantling gneiss of the gneiss dome) is highly deformed. Parts of the mantling gneiss occur as inclusions or as remnants within the Hanimor gneiss. Some anthophyllite-bearing mafic gneiss, characteristic of the Siorak Formation gneiss, occurs near the centre of the core and a long crescent-shaped remnant is found along the east margin of the Hanimor gneiss.

Studies of the Hackett River gneiss dome have shown that it is a relatively late structure (Fyson and Frith, 1979). At least two phases of folding predate domal uplift. Furthermore, the core-mantle contact, at the time of doming, was a zone of maximum extension (Dixon, 1975). Some of the Hanimor gneiss is little deformed, possibly due to the local presence of tectonic shadow zones, found between the dominantly horizontal and dominantly vertical stress domains (Dixon, 1975). Pegmatite dykes cutting the Hanimor gneiss and the mantling Siorak Formation are little deformed and probably formed during regional metamorphism, as described in a subsequent section.

The Hanimor gneiss tonalite is mostly heterogeneous and consists of veined and variably foliated, light grey, medium grained rock that contains about 33% quartz, at least 50% andesine, 10% biotite and/or hornblende, and a small but variable percentage of potassium feldspar. The foliation, defined by biotite and flattened quartz, is best developed near the core margins. Near the centre and in the northeast part of the structure, the gneiss is uniform, coarse grained, less heterogeneous and the rocks are more biotite-rich, pink, and commonly rust-stained by retrograde goethite.

The pegmatites that makes up part of the Hanimor gneiss, and are most abundant in the northeast, were most likely derived by anatectic processes (Percival, 1978). Most commonly they are light grey trondhjemites made up of quartz, plagioclase and biotite. They are massive, irregular to bulbous, up to 10 m across, and extend up to several kilometres in length. Locally they coalesce and criss-cross each other in seemingly haphazard anastomosing patterns.

The Hanimor gneiss tonalite was dated by U-Pb zircon techniques at 2666 Ma, which is consistent with the age of the Yellowknife Supergroup (Frith and Loveridge, 1982). The same rocks were dated by Rb-Sr whole-rock isochron techniques giving a date of 2570 Ma, which approximates the age of regional metamorphism and intrusion of the Regan Intrusive Suite, dated by U-Pb zircon techniques at 2588 Ma (Frith and Loveridge, 1982).

Sandy hill pluton. This synvolcanic intrusion at the base of a vertically to steeply inclined volcanic succession near Aitch Lake (Fig. 25) has been interpreted as a high level sill on the basis of its chilled margins, and its even grained texture which includes stubby, zoned plagioclase grains. The rock is generally light grey, medium-to coarse-grained, of tonalite or granodiorite composition, commonly containing albite-microcline perthite, composite grains of wormy intergrown quartz and feldspar, and minor biotite and magnetite.

The irregular contact of the south margin is well exposed and cuts across the volcanic stratigraphy. Thin section study showed that the pluton is retrograded to greenschist facies, as exemplified by clouded plagioclase and chloritized biotite. Secondary stilpnomelane is present in both the pluton and the overlying basic volcanic rocks. The north margin of the pluton is overlain by massive domes of dacite and andesite breccia, but the exact nature of the contact is obscured by a vertical fault. The western contact is obscured by overburden including a large northwest-trending esker. Isolated outcrops of country rock on the southwest margin consist of deformed amphibolite, probably derived from metabasalt or metagabbro which has been mapped as part of the Mara River Complex.

Table 7. whole-rock analyses of tonalite and related rocks from the Hanimor gneiss that forms the core of the Hackett River gneiss dome

	1	2	3	4	5	6	7	8
SiO_2	73.60	73.00	74.50	78.00	77.20	74.50	79.60	76.10
TiO_2	0.37	0.36	0.32	0.17	0.26	0.08	0.09	0.00
Al_2O_3	14.00	13.90	13.70	11.60	12.10	15.50	11.80	15.60
FeO	1.20	1.70	1.50	1.30	1.30	na	na	na
Fe_2O_3	0.47	0.73	0.95	0.33	0.42	0.50	0.36	0.10
MgO	1.50	1.70	0.45	0.90	0.86	2.62	1.43	0.53
CaO	2.90	1.25	2.48	0.44	0.55	0.47	0.60	1.02
Na_2O	3.90	5.25	4.52	5.02	5.20	6.35	5.42	5.90
K_2O	1.21	1.33	0.90	1.20	0.86	2.62	1.43	0.53
P_2O_5	0.09	0.09	0.08	0.00	0.04	0.02	0.00	0.08
Total	100.05	100.38	99.57	99.11	99.20	100.14	99.36	99.42

Notes:

1-5. Hackett River gneiss dome core gneiss.
6-8. Hackett River gneiss dome pegmatites.

Analyses 1-7 were carried out by F. Dunphy, Queen's University, except for the FeO determinations and analysis 8, which were determined by analysts at the Geological Survey of Canada.

The pluton has sharp contacts with the overlying volcanic rocks, but the basal contact is sheared and the underlying mafic volcanic rocks are amphibolitized. The overlying volcanic rocks show only local recrystallization to amphibolite.

Chemistry of the synvolcanic plutons. The synvolcanic plutonic rocks and pegmatites that make up the core of the Hackett River gneiss dome have been analyzed by Percival (1978). The Sandy hill pluton and a sill several hundred metres thick between the Beechey Lake Group and the Hackett River Group volcanic rocks have been analyzed by Cameron and Durham (1974b). In addition, rare earth element analyses have been carried out on whole-rock samples from the Hanimor gneiss and on parts of the Malley Rapids anticlinorium (Ewing, 1979). The major elements in rocks that form the core of the Hackett River gneiss dome are shown in Table 7 and their major leucocratic constituents are plotted on a quartz-microcline-plagioclase diagram (Fig. 25).

Synvolcanic rocks from the Hanimor gneiss and the Sandy hill pluton are clearly comparable, but they differ from the thinner intraformational sills that intrude the upper levels of the volcanic pile. Rare earth element analyses from the Hanimor gneiss tonalite can be genetically linked to the volcanic rocks of the Ignerit Formation in the Hackett River area. Both rock types contain similar light rare earth element/chondrite ratios, which has been attributed to a variation in the amount of residual hornblende or garnet in the initial source rock.

Analyses of pegmatite from the Hanimor gneiss and the adjacent Siorak Formation are similar in all major oxides, except for CaO, MgO and TiO_2 which are notably lower. On the other hand, Na_2O is higher. These data are consistent with Percival's (1978) interpretation that these pegmatites were derived in situ, by anatexis from a tonalite host rock.

Comparison of major oxide constituents with the volcanic rocks of the Hackett River Group (Fig. 26) shows that the Hanimor gneiss and the trondhjemitic pegmatite values plot in areas not filled by the volcanic rocks. They are more alkalic than the andesites but less alkalic than the dacitic rocks of the group. The trondhjemitic pegmatites are the most sodic, as would be expected from rocks formed by the partial melting of plagioclase-rich tonalite.

Regan Intrusive Suite

The Regan Intrusive suite is the only major group of plutonic intrusions in the map area. About 75 bodies have been mapped. The suite is divided into five map units: granite, leucogranodiorite, melagranodiorite, tonalite and quartz diorite. The plutons, with the possible exception of some granites, form a genetic suite that is described in more detail by Hill and Frith (1982). The following is an outline of their lithologies, contact relationships, distribution and age.

Most of the plutons have a single characteristic lithology. Typically the rocks are medium grained and contain subhedral to euhedral plagioclase, hornblende and biotite with interstitial quartz and microcline. Accessory minerals include augite, monazite, zircon, sphene, epidote (including allanite), apatite, garnet, tourmaline and

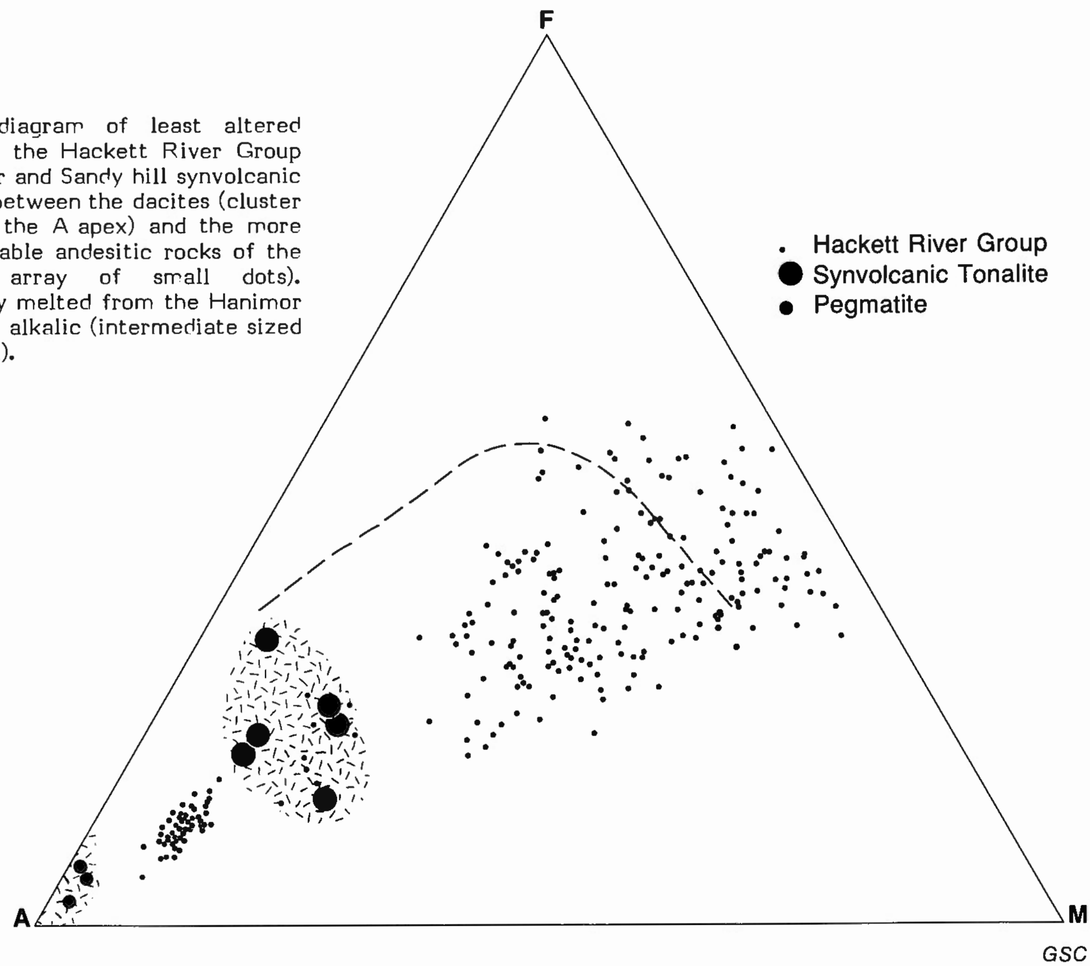


Figure 26. AFM diagram of least altered volcanic rocks from the Hackett River Group showing the Hanimor and Sandy hill synvolcanic plutons (large dots) between the dacites (cluster of small dots near the A apex) and the more compositionally variable andesitic rocks of the group (scattered array of small dots). Pegmatites, probably melted from the Hanimor gneiss, are the most alkalic (intermediate sized dots near the A apex).

iron oxides. Whereas some granites are muscovite-bearing, other rocks contain phenocrysts of plagioclase or poikilitic microcline. They are massive to slightly gneissic and the mafic rocks are commonly more gneissic than the felsic ones. Where foliation is present, it is generally steep and tends to parallel the contacts, giving each intrusion a concentric fabric. This is less evident in plutons intruded into volcanic rocks, where contacts are irregular.

Contact relationships are generally grossly concordant into steeply dipping strata. In detail, however, discordant relationships occur, particularly with volcanic rocks. Xenoliths are locally abundant near the margins of the intrusions where they are commonly oriented parallel to contacts.

A steeply dipping mineral foliation is present, suggesting that the rocks crystallized during emplacement. The zoned Uist Lake pluton has a fine grained margin, suggesting that it cooled from margin to centre, and steeply inclined lineations implying vertical flow. Compositional gradation from a mafic margin to a felsic centre indicates sequential crystallization and differentiation.

Host rocks show varying degrees of contact metamorphism. Granites, which tend to be more abundant in the southeast part of the area, have 200-300 m wide metamorphic aureoles in Beechey Lake Group metasediments. The melagranodiorites and the quartz diorites commonly intrude higher grade schist and gneiss and thus have narrow or no metamorphic aureoles. Granodiorites in the southeast corner of the area intrude biotite grade rocks which have been hornfelsed. Porphyroblasts in metasedimentary rocks are generally retrograded near plutonic contacts. Pegmatites are locally abundant where regional metamorphism is highest, but these are anatectites related to regional metamorphism and not to plutonic differentiation.

Within plutons, where more than one rock type is present, felsic intrusions consistently cut mafic intrusions. Where compositional zoning is evident more felsic rocks postdate mafic rocks except near the margins where the chill zone may be more leucocratic and older than later phases. The suite, as a whole, postdates the Yellowknife Supergroup and both major phases of regional deformation. It also postdates the peak of regional metamorphism, as porphyroblasts near the plutonic rocks are always retrograded.

The Regan Intrusive Suite is anorogenic in the sense of Stockwell (1961). The plutons, for the most part, contain no penetrative post-emplacement fabric except for an upright, usually faint, local northeasterly trending cleavage.

Radiometric dating of the suite (Frith and Loveridge, 1982) established a U-Pb zircon, 2588 ± 8 Ma age for the Uist Lake pluton. Fyson and Frith (1979) concluded, on the basis of structural studies in the Hackett River area, that intrusion of the plutons took place shortly after the second phase of deformation (D2) of the Beechey Lake Group, as the plutons have flattened existing foliations (S1 and S2). Deformation and plutonic emplacement were approximately contemporaneous, with some notable exceptions. The granite plutons southeast of Kuuk Lakes cut across S1 and S2 but intrusion was contemporaneous with the development of a third phase of deformation (D3). These granites probably represent the last phase of Archean plutonism in the map area.

Rb-Sr whole-rock age determinations of the Regan Intrusive Suite gave dates that are younger than the 2588 Ma determined by U-Pb zircon techniques. They range from 2350 ± 37 Ma for the Uist Lake pluton to 2449 ± 30 Ma for the Kuuk Lakes granite. No explanation is proposed for these discrepancies, except to suggest that the whole-rock systems may have been reset or kept open by thermal metamorphic events associated with early Proterozoic orogenesis in the Churchill Province, east of the Thelon Front (Frith and Loveridge, 1982). K-Ar age determinations of micas, give values that average 2300 ± 196 Ma with a low of 1950 Ma from the Malley Rapids granite and a high of 2535 Ma from the Kuuk Lakes granite. All radiometric data are tabulated in a later section.

Granites. Granites make up about one quarter of the Regan Intrusive Suite, as defined by Hill and Frith (1982). The largest intrusions occur southeast of Kuuk Lakes, west of Malley Rapids and within the Mara River Complex, near Lunar Lake. The Kuuk Lakes granite consists of four irregular shaped plutons, partly surrounded by the cordierite-staurolite isograd. This configuration and the location of the isograd suggest that the plutons are connected at depth.

The larger granite plutons contain light grey, medium grained, equigranular, mostly massive rocks. Some plutons are locally porphyritic, whereas others contain rounded inclusions of more basic granitoid rocks. The Lunar Lake and Kuuk Lakes plutons have muscovite rather than biotite, whereas the Malley Rapids granite has more biotite than muscovite.

The granite plutons are commonly well jointed and frost heaved, so that in situ rock is angular rubble. Only one outcrop was observed around Lunar Lake in a felsenmeer covering several hundred hectares.

Smaller granite plutons in the southwest corner of the map area and west of Mara River are muscovite-bearing and contain medium- to coarse-grained equigranular quartz, plagioclase and microcline. Phenocrysts of microcline are common. Granites within or close to the Mara River Complex, contain numerous pegmatites, but these were probably formed by anatectic processes. An exception is aplite pegmatite in the central parts of the Uist Lake pluton, where dykes up to 6 m across are present. These dykes are medium grained, equigranular, buff, and contain quartz, feldspar, and about 1-3% biotite and accessories. Pegmatite occurs as irregular, generally white, patchy veins of alaskite. Together aplite and pegmatite make up less than 1% of the suite.

Geochemical studies of granites in the map area show three genetic types. One type, formed by magmatic differentiation from a more mafic parent magma, is comagmatic with the Regan Intrusive Suite. The larger granite plutons, such as the Malley Rapids granite, formed deeper in the crust than the small granite stocks and were emplaced as melts into biotite grade host rocks. Smaller granite stocks formed locally from melting metasedimentary source rocks. The $^{87}Sr/^{86}Sr$ initial ratios of the Kuuk Lakes granite (0.713 ± 0.0205, Frith and Loveridge, 1982) imply older source rocks, possibly metasediments analogous to those of the Beechey Lake Group.

Granodiorites. Granodiorite makes up about 40% of the Regan Intrusive Suite. Plutons of this composition are most abundant in the Mara River, Uist Lake and Tikiraq Lake area where regional metamorphism is above the cordierite-staurolite isograd. The granodiorites are divided into melagranodiorites and leucogranodiorites based on mesonorm groupings (Streckeisen, 1976; Hill and Frith, 1982).

Granodiorite plutons range in size from less than 1 to 15 km across, and are mostly round or oval in plan. Granodiorite also makes up a significant proportion of the zoned and polyphase plutons of the area. The granodiorites contain plagioclase, quartz, biotite, hornblende and microcline. Phenocrysts of hornblende or plagioclase and oikocrysts of microcline are locally present, but generally the rocks are buff to pink, medium grained, equigranular and massive on outcrop scale. Locally, hornblende, biotite and plagioclase are preferentially oriented outlining a faint gneissosity, particularly near pluton margins. More felsic phases are rare in the melagranodiorites, but minor amounts occur in the more leucocratic granodiorites, where they form irregular aplitic or pegmatitic dykes which are generally less than a metre wide.

Tonalite. Tonalite plutons make up at least one third of the Regan Intrusive Suite in the map area. They occur mostly as small ovoid bodies intruded into Beechey Lake Group metasediments, upgrade from the cordierite-staurolite isograd. Tonalite plutons occur within the Mara River Complex, such as those near the volcanic rocks just east of the Siorak River and along the east shore of Nose Lake. These plutons contain numerous inclusions of quartz diorite and diorite that are chemically part of the Regan Intrusive Suite (Hill and Frith, 1982). Tonalite also makes up almost 50% of the zoned Uist Lake pluton, where it forms an outer margin and the most voluminous inner phase. Tonalite may have been the parent magma for the Uist Lake pluton, which differentiated to form quartz diorite and granodiorite.

Quartz diorite. A few plutons of quartz diorite occur as oblong stocks within the Mara River Complex near Lunar Lake and along the east margin of the Malley Rapids granite. Quartz diorite and diorite also occur within zoned plutons, such as the Uist Lake pluton, and as inclusions in tonalite and granodiorite plutons, such as those between Kuuk Lakes and Nose Lake. Chemical analyses of quartz diorite and diorite inclusions have smooth curves of compositional variation with other members of the Regan Intrusive Suite, which strongly supports their being comagmatic with the suite and not related to the volcanic rocks of the area (Hill and Frith, 1982).

Quartz diorite plutons are mostly medium grained, equigranular, grey to black, and made up of hornblende, biotite and plagioclase, with only minor amounts of quartz and microcline. Hornblende is locally porphyritic and clinopyroxene is present in some rocks.

Proterozoic

Proterozoic rocks include the Goulburn Group of platformal metasedimentary rocks that unconformably overlie the Archean craton in the northeastern part of the map area, and two sets of diabase dykes, only one of which is known to cut the Archean. One dyke swarm, trending northeast, is referred to as the Malley Diabase; the other, of less constant strike, forms part of the Mackenzie Diabase dyke swarm that trends north-northwest. Gabbro sills, possibly related to one of these swarms, occur within the Goulburn Group, mostly along the unconformity with the Archean.

Malley Diabase

The Malley Diabase, named after the Malley Rapids on the Back River, occurs as a swarm of northeast-trending dykes that are most abundant in the southeastern part of the area. They are typically 5-10 m wide and extend along strike for up to 12 km.

The dykes in the Kuuk Lakes area show chilled margins and laths of twinned, zoned plagioclase (elongated 4:1) and rounded augite crystals in a matrix of fine grained plagioclase and augite. In the Uist Lake area the pyroxenes are amphibolitized and the feldspars are saussuritized. This may be due to deuteric alteration or to early Proterozoic hydrothermal metamorphism associated with the Churchill Province orogeny (Frith and Loveridge, 1982).

These dykes intrude the Yellowknife Supergroup and the Regan Intrusive Suite plutons, but are not known to intrude the Goulburn Group. However, the dykes are not common in the Beechey Lake Group near the unconformity, so their pre-Goulburn Group age cannot be established with certainty.

Goulburn Group

The Goulburn Group has been studied by Tremblay (1971) and by Campbell and Cecile (1976, 1981) and is therefore only briefly described in this report.

The unconformity along the Goulburn Group-Beechey Lake Group contact is well defined and generally dips less than 10° (Fig. 27). The base of the Goulburn Group in this map area is the Western River Formation and consists of poorly sorted conglomerate made up of quartz and angular fragments, cemented by a limy mudstone. The fragments are mostly siliceous metagreywacke, schistose greywacke, felsic volcanic rocks and quartz pebbles.

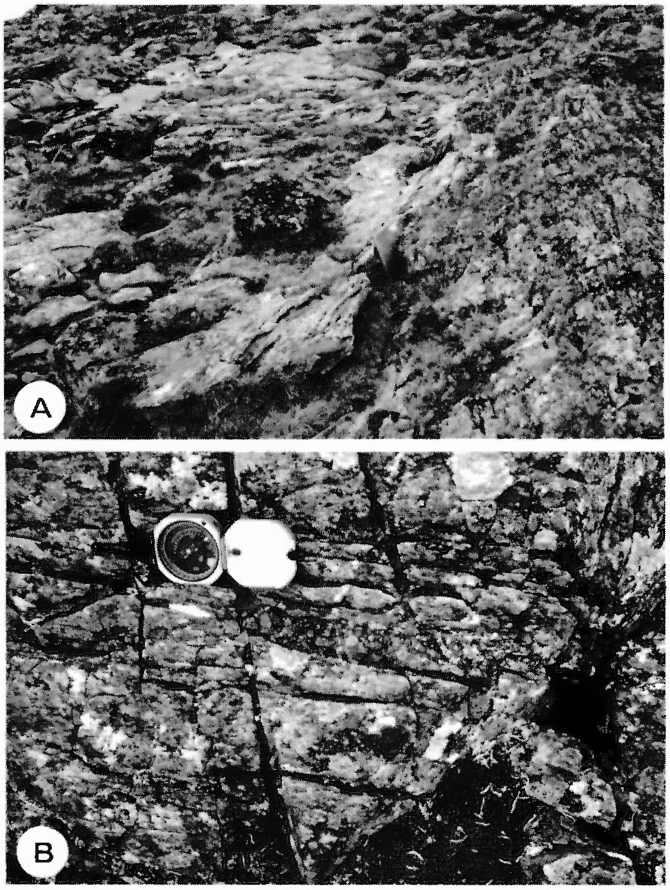


Figure 27. Proterozoic rocks

A. Gently dipping carbonate-bearing sandstones of the Western River Formation unconformably overlying steeply dipping beds of the Beechey Lake Group, northeast of Tikiraq Lake. GSC 203334-Z

B. Highly fractured Beechey Lake Group greywacke at the basal unconformity with the Goulburn Group, northeast of Tikiraq Lake. Fractures are filled with angular to rounded clasts of the underlying rock and rounded pebbles of quartz, which are both cemented by carbonate. GSC 203335-A

The unconformity is irregular and the underlying rock is highly fractured and filled with dolomitic sand and conglomerate. The fractures probably extend beneath the unconformity, as fracture fillings with dolomite and quartz occur several kilometres from the Goulburn Group-Beechey Lake Group contact.

Western River Formation

The formation as described by Tremblay (1971) consists of a basal conglomerate member; a lower argillite member, consisting mostly of grey argillite, white quartzite and dolomite; and a red siltstone member containing minor argillite.

Burnside River Formation

This formation conformably overlies the Western River Formation and consists mostly of gently folded pink or reddish-white sandstone or quartzite. Bedding is not well developed, but primary depositional features such as crossbedding and ripple marks are present in places. Grains are well sorted with very little sericitic matrix.

Gabbro sills

Tremblay (1971) described the gabbro sills as thick (up to 130 m), locally transgressive and dyke-like in places. In thin section they resemble the Mackenzie Diabase dykes, being fresh and containing 50-55% plagioclase, 5% quartz-feldspar intergrowth, and 30-40% pyroxene, with minor deuteric alteration. The sills, like the Mackenzie Diabase, contain magnetite that gives the rock a strong aeromagnetic expression. The sills may be contemporaneous with the Mackenzie Diabase.

Mackenzie Diabase

The Mackenzie Diabase dyke swarm occurs sporadically throughout the northwestern Canadian Shield. The dykes are most abundant in the Slave Province where they commonly range in size up to 30 m wide and many tens of kilometres long. The dykes are considered contemporaneous and possibly cogenetic with the Muskox intrusion, the Coppermine lavas, and sill rocks in localities such as the east arm of Great Slave Lake (Fahrig and Jones, 1969). The best age of these dykes is from a Rb-Sr study which yielded values between 1260 and 1190 Ma (Patchett et al., 1978).

STRUCTURAL GEOLOGY

Regional deformation in the map area is best demonstrated in the Beechey Lake Group greywackes and mudstones which show effects of three principal deformations, D1, D2 and D3. The areas that have been least metamorphosed commonly have planar or linear features of all three deformations. In higher grade areas polyphase small scale folding occurs, the distinction between D1 and D2 is less apparent, and D3 may be absent. All of the supracrustal rocks have been further deformed by the intrusion of plutons and this aspect is treated separately in the section on the Regan Intrusive Suite.

D1 structures

The earliest structures (D1) are produced by large scale downwarping of volcanic homoclines and large scale folding of sedimentary strata into isoclinal folds measuring tens of kilometres on a limb. Each limb may also be folded into F1 isoclines. Between the Hackett River gneiss dome and the main homoclinal limb of the Hackett River volcanic belt is a principal F1 syncline referred to as the Hackett River

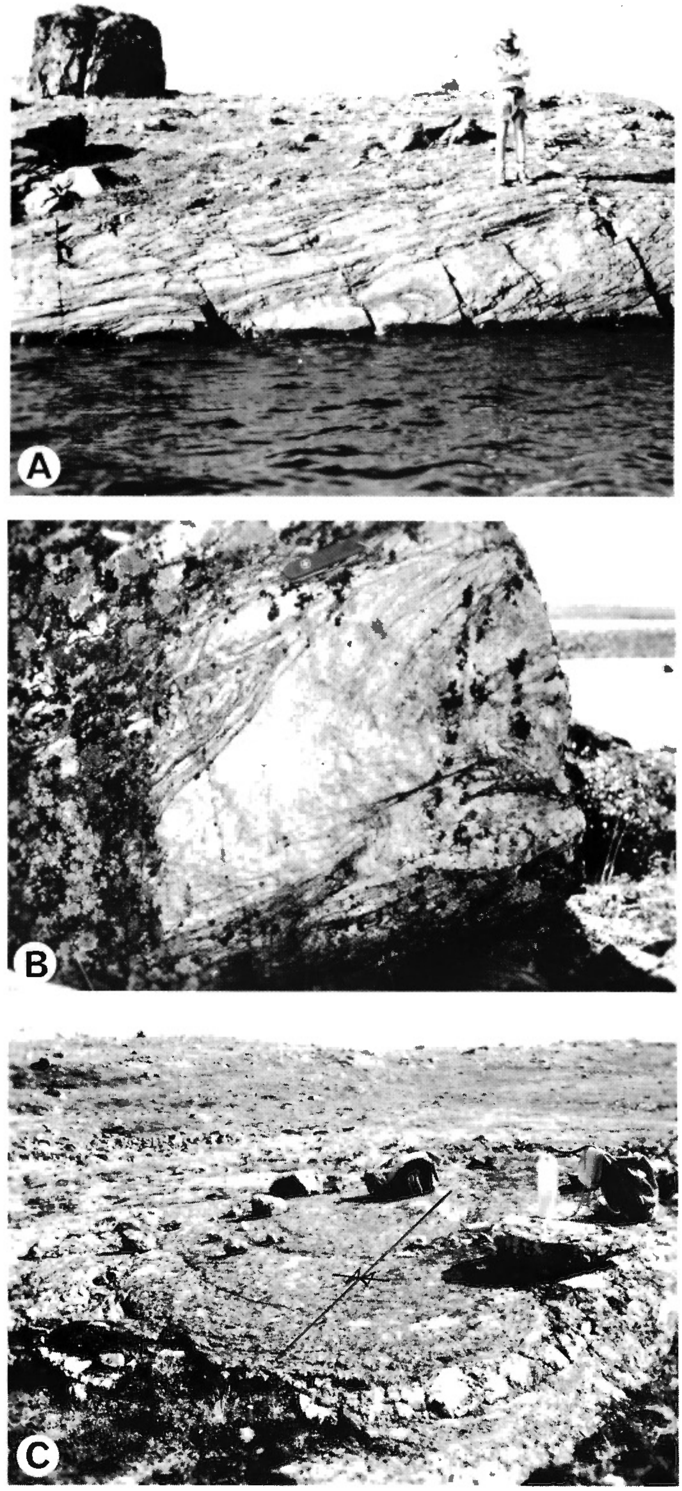


Figure 28. Structures, Hackett River gneiss dome

A. East-verging F2 folds in tuffaceous metasediments of the Ignerit Formation, near D'Arcy Lake. GSC 203334-F
B. East-verging F2 folds in quartzofeldspathic gneiss of the Siorak Formation, near D'Arcy Lake. GSC 203336-Y
C. An F2 fold in mafic gneiss of the Siorak Formation, near D'Arcy Lake, showing a near horizontal synformal fold axis (indicated on the photograph). GSC 203336-U

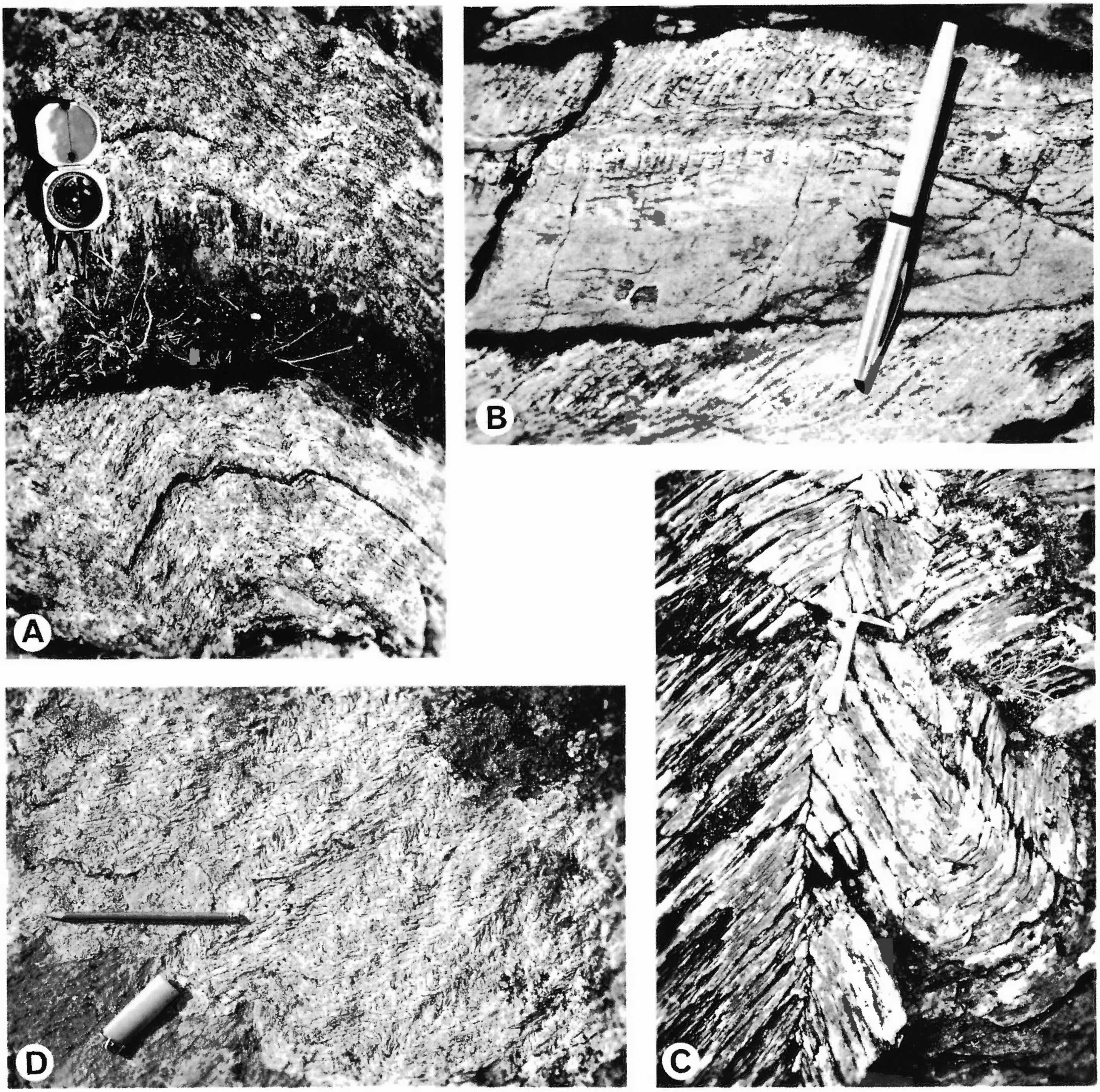


Figure 29. Structures, Malley Rapids anticlinorium

A. Crenulation cleavage (S3) in sulphide-bearing carbonaceous mudstones of the Beechey Lake Group, north of Uist Lake. GSC 203337-I
B. S3 cleavage cutting an S1 or S2 foliation that parallels the bedding, Uist Lake area. GSC 203337-H
C. An F3 fold with associated cleavage cutting S1-S2 foliation planes in Beechey Lake mudstones from the Uist Lake area. GSC 203337-G
D. Herring bone F3 folds with cleavage cutting S1-S2 in augen gneiss, north of Ingniq Lake. GSC 201996-U

syncline by Jefferson et al. (1976b). Some smaller folds which occur on the northeast limb of this structure do not have bedding-cleavage around the fold closures and are assumed to be F1 folds.

In the area underlain by metasedimentary rocks between the Hackett River and Back River are axial planar S1 cleavages that developed with F1 isoclinal folds. The foliation-cleavage is parallel or at small angles to the bedding (S0). Trends of S0-S1 reveal directions of F1 fold axes even though closures are rarely observed because of near horizontal axial plunge. The presence of folds is deduced by top reversals. In general, S0 and S1 strike parallel to the northwest-trending principal segment of the Hackett River volcanic belt.

Foliation-cleavage (S1) in metasediments is most commonly defined by alignment of muscovite, biotite and flattened quartz. In areas of sub-biotite metamorphism it is defined by chlorite and sericite, whereas in highly metamorphosed terranes S1 is displayed by alignment of biotite and staurolite. Inclusions of quartz in biotite, seen under the microscope, may also define S1 (Fyson and Frith, 1979) or an earlier unrecognized phase of folding.

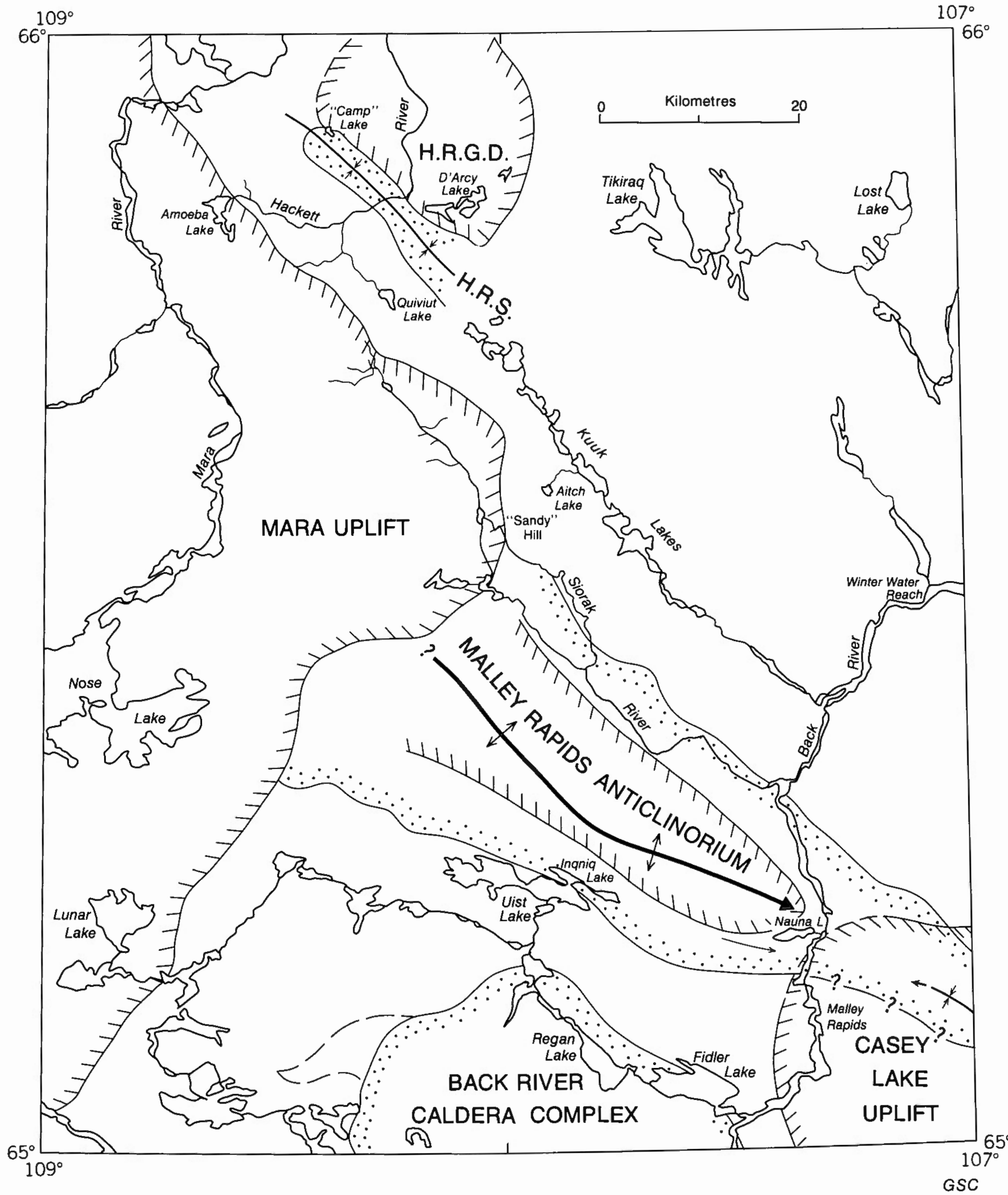


Figure 30. Major structural elements of the area. Uplift areas are indicated by slash border markings, whereas depressed areas are bordered by a small circle pattern. Although the Hackett River gneiss dome (HRGD) is shown as a positive area, the uplift is later than the Hackett River syncline (HRS) and the Malley Rapids anticlinorium.

In the Siorak Formation gneiss, located around the Hackett River gneiss dome, S1 is defined by segregated leucocratic layers and planar alignment of amphibole. In the same area amphibole rosettes lie on S1 surfaces.

D2 structures

Nearly all supracrustal rocks in the map area have a cleavage, gneissosity or schistosity (S2). This is commonly the most prominent regional structure but it may only be distinguished from an S1 cleavage where it overprints it at an angle. It forms steeply dipping surfaces that generally strike northwest to north parallel to or intersecting S0-S1 at small angles. In the Beechey Lake Group greywackes and mudstones the S2 foliation is defined in the same way as in S1.

The style of D2 folding is variable (Fig. 28). In the Takiraq Lake to Back River area large scale folds (F2) with limbs measurable in kilometres may be traced on air photographs. These folds commonly have well developed S1 foliations parallel or subparallel to the bedding which wraps around fold closures. In the Hackett River and Malley Rapids areas F2 folds are smaller, commonly a few metres between axes, and the S2 surfaces cut S0 and S1 at angles greater than 10°. Around the Malley Rapids anticlinorium, F2 folds are rare. D2 tightens existing F1 folds by pure shear, causing consistent "Z" intersections of S2 on S0-S1 as S2 is more northwesterly trending in this area as opposed to north-trending S0-S1. In the Fidler lake-Back River area, F2 folds are only evident where F2 axes have been steepened by D3 warping. The style of folding in this area is more open with "M" or "W" buckle folds evident.

D3 structures

A discontinuous but widespread subvertical foliation (S3) strikes northeast across older structures. Where regional metamorphism is low grade, S3 is commonly a crenulation or fracture cleavage. In more highly metamorphosed areas it may be a prominent structure, imparting a herringbone appearance (Fig. 29D).

Crenulation cleavage is locally associated with D3 folding where metasediments have been buttressed against plutonic rocks. An example of this occurs southeast of the Kuuk Lakes granite (Fig. 30).

S3 foliation is defined by retrograde muscovite or biotite in the higher grade metamorphic rocks, indicating that D3 took place after the peak, but before the close, of regional metamorphism. S3 cleavages cut porphyroblasts in the sediments. Similarly, muscovite, found in pegmatite formed by regional metamorphism, is crenulated by D3. The Goulburn Group, which is probably younger than 2.0 Ga is unaffected by D3. Since metamorphic minerals have grown along S3 foliation surfaces, D3 is most likely a late orogenic development (Fyson and Frith, 1979).

Hackett River gneiss dome and environs

The structure of the Hackett River gneiss dome and nearby rocks is described by Frith et al. (1977), Fyson and Frith (1979). East of the gneiss dome, bedding (S0), S1 and S2 dip at shallow angles. The strike remains relatively constant in a northwestern direction, as if foliations were rotated from steep orientations, about horizontal to subhorizontal axes. Later structures are not present. The deformations are consistent with regional patterns rather than with emplacement of the gneiss dome.

Foliations, including S2, in the surrounding Beechey Lake Group are steeply dipping and are cut by small plutons of the Regan Intrusive Suite. Some of the plutons must be older, as they are cut by S2. Fyson and Frith (1979) have proposed that the plutons along the main north-northwest-trending limb of the Hackett River volcanic belt were emplaced sequentially towards the southwest. North of the Hackett River gneiss dome, S0 and S1 are gently dipping and S2 is steeply inclined. South and east of the gneiss dome, shallow to horizontal dips outline a possible pluton or gneiss dome in the subsurface.

S1 foliations around plutons southeast of the gneiss dome are flattened indicating a post-S1 emplacement. Other plutons, such as the Takiraq Lake granodiorite, truncate both S1 and S2 and deflect the cordierite-staurolite isograd surface, hence postdating all these developments.

The constant vergence of recumbent folds in and around the Hackett River gneiss dome requires that they formed prior to doming. However S1 and S2 surfaces were modified during late D2. Uplift was complete before D3 as S3 cleavage planes are upright. Examples of structures in and around the Hackett River gneiss dome are shown in Figure 28.

Malley Rapids anticlinorium and environs

The Malley Rapids anticlinorium is probably a D2 structure. The metasediments at the nose of the anticlinorium are folded in tight isoclines that plunge southeast. S1 foliations wrap around the hinges of these folds implying they are F2 structures. Similar folds are present within the Hackett River Group strata which border the anticlinorium. Porphyroblasts within the Beechey Lake Group, along the south limb of the anticlinorium near Uist Lake, are cleaved by S2 and S3. At the southeast end of the structure cordierite and staurolite postdate S1.

Back Group volcanic rocks along the southwest margin of the anticlinorium form a narrow belt both underlain and overlain by metasedimentary rocks of the Beechey Lake Group. The belt is intruded by plutons of the Regan Intrusive Suite near the Back River. Northeast of the structure the same belt is deflected by the Malley Rapids granite, but continues southeast where it forms a synclinal structure east of Casey lake, just outside the map area (Frith, 1982a, b). The south limb of the syncline was probably continuous before intrusion of the plutons. The eastern part of the belt forms a synclinal structure which dips west. Near the Back River the axial plunge of the anticlinorium becomes flat lying and west of the river the central part of the synclinal structure coincides with the axial zone of an F2 anticlinorium (Fig. 30). The hinge zone of the Casey lake syncline shows minor structural relationships that indicate it is an F1 structure (Frith, 1982a, b). If the anticlinorium is an F2 structure then it developed from a structurally low area, and the deformational history is similar to that outlined for the Hackett River gneiss dome.

The core of the anticlinorium is made up of plagioclase augen gneiss formed during upper amphibolite facies regional metamorphism and then deformed by D2. Foliation planes (S2) within the augen gneiss are steeply inclined near the centre but dip towards the centre near the flanks, suggesting that uplift continued after the development of a steeply inclined plagioclase augen gneiss foliation.

The metasediments and volcanogenic sediments that make up the southern limb of the anticlinorium north of Uist Lake are cut by an upright northeast-trending S3 cleavage. Some D3 warping of earlier planar features is evident from mapping patterns, and small chevron folds are present locally (Fig. 29D). The S3 cleavage parallels a northeast-trending Malley Diabase dyke swarm, which is not affected by the cleavage.

METAMORPHISM

Metamorphism in the map area took place in the late Archean and again locally during the early Proterozoic. The Archean metamorphism was regional and ranges from sub-biotite greenschist to upper amphibolite facies. Only the supracrustal rocks and the metamorphic complexes are affected by Archean events. Proterozoic metamorphism is restricted to thermal effects that are not generally visible in the rocks but are sufficiently high to reset K-Ar systems in minerals.

Metamorphic studies were generally restricted to the Beechey Lake Group and the Siorak Formation which commonly contain pelitic assemblages. These rocks are divided by isograds into five zones which include: sub-biotite grade rocks; biotite grade rocks; staurolite-cordierite-bearing rocks; sillimanite-bearing rocks; and kyanite-bearing rocks.

Sub-biotite grade rocks

Sub-biotite, generally chlorite-bearing, rocks of the Beechey Lake Group occur in a 15 km wide zone that extends from the Goulburn Group unconformity, in the northeastern part of the area, to the Back River. Typical metamorphic mineral assemblages include chlorite, muscovite, quartz and albite. Other minerals of more sporadic distribution are graphite, pyrite, tourmaline, hematite and calcite. Near the Goulburn Group unconformity, metasediments near intraformational iron formation contain stilpnomelane. Some volcanic rocks southwest of Aitch Lake are also sub-biotite grade, and the large synvolcanic sill west of Aitch Lake also contains stilpnomelane (Fig. 31).

Biotite grade rocks

Biotite grade rocks occur between the biotite isograd, which is drawn where biotite is first visible in hand specimen, and the staurolite-cordierite isograd, where these minerals first appear. North of Tikiraq lake, thin section control was used to study metamorphic reactions and to precisely define the isograds.

Biotite first appears as small blades roughly aligned in S1. Upgrade, the biotite is coarser and forms small porphyroblasts, some of which may overgrow S1 (Fig. 32). Biotite growth probably outlasted D1. Aggregate biotite orientation suggests that it has locally replaced amphiboles mimetically.

Biotite is commonly retrograded to chlorite, but muscovite, which is also normally oriented parallel to S2, is commonly fresh, implying that muscovite grew during D2 and was retrogressive.

Garnet occurs sporadically within the biotite zone near the cordierite-staurolite isograd. At one locality near Malley Rapids, the metasediments are more mafic than usual and garnet is abundant.

Andalusite is locally present near the cordierite-staurolite isograd, as rosettes of pink bladed crystals 3-6 cm long. Temperature-pressure conditions were probably below the saturolite-cordierite isograd.

Staurolite-cordierite-bearing rocks

The first appearance of staurolite with cordierite is used to define the lower limit of rocks within this zone. However, both minerals are commonly present which suggests the following reaction:

muscovite + chlorite = staurolite + cordierite + biotite

The first appearance of staurolite is commonly as small, brown, pin-head-sized porphyroblasts that likely formed from lower temperature reactions than the one shown above and

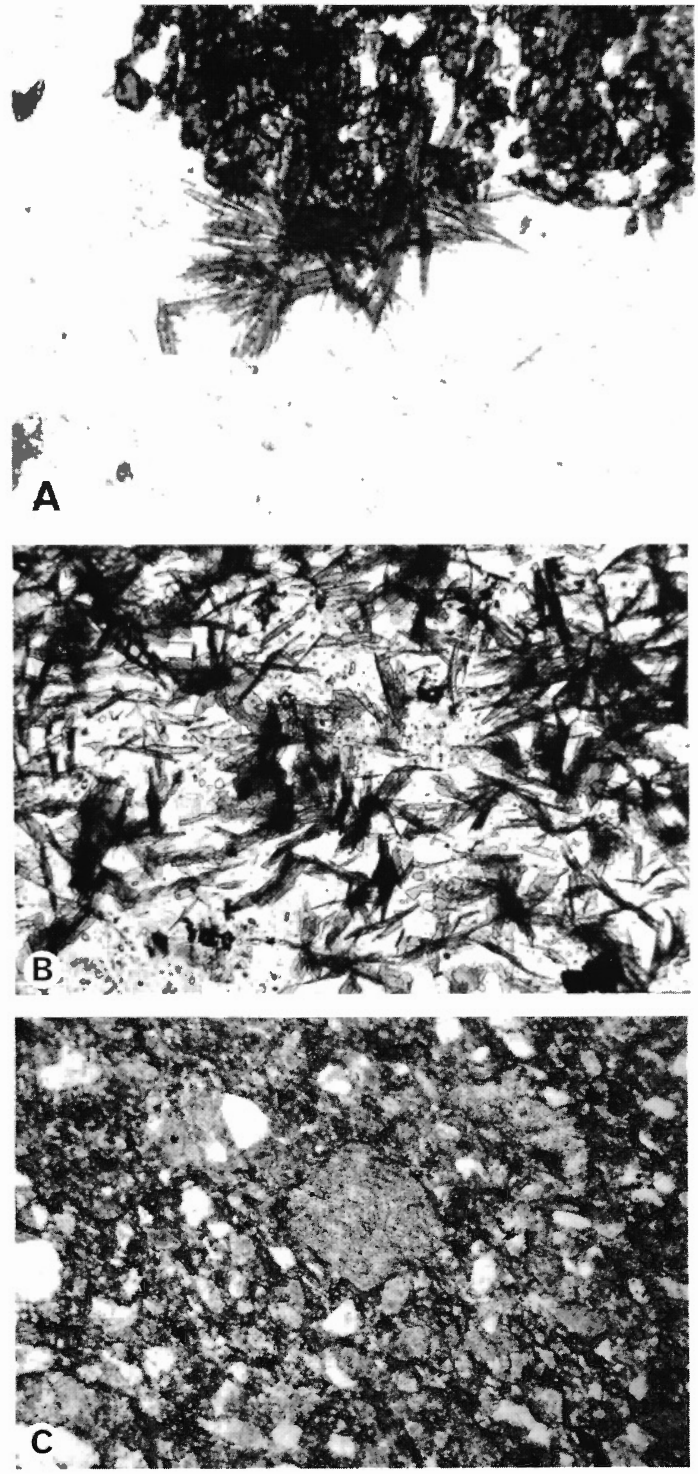


Figure 31. Sub-biotite greenschist rocks

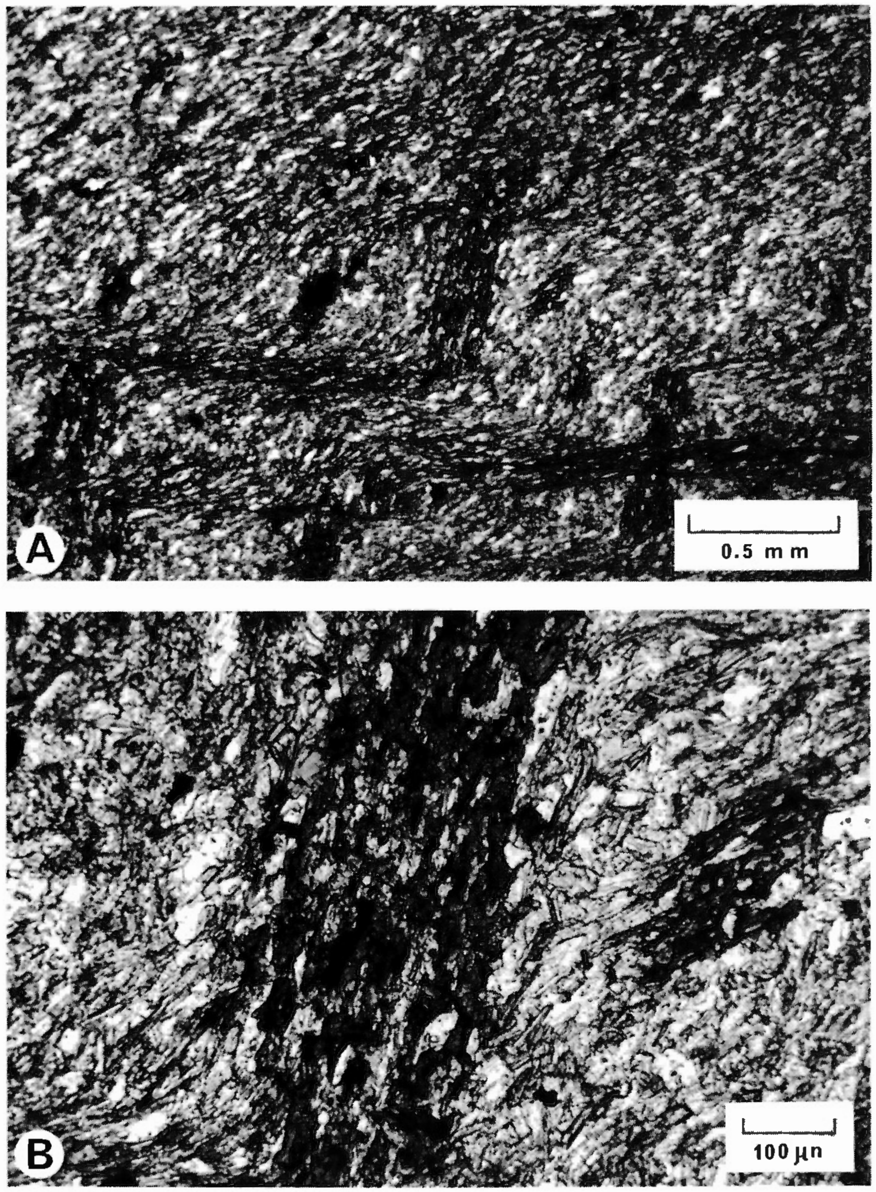
A. Stilpnomelane in a matrix of plagioclase and quartz banded iron formation near the Goulburn Group unconformity. GSC 203647-O
B. Stilpnomelane around the margin of primary hornblende. A synvolcanic granodiorite-tonalite sill from the Sandy hill area. GSC 203647-N
C. Typical Beechey Lake Group greywacke with chlorite and sericite aligned along a primary foliation plane. Quartz, plagioclase and rock fragments are also present. Winter Water Reach area. GSC 203647-K

Figure 32

Biotite grade rocks

Photomicrographs of porphyroblasts of biotite that have overgrown quartz aligned along S1. Muscovite has grown parallel to S2 crenulation cleavages. Beechey Lake Group greywacke-mudstones from just west of Tikiraq Lake.

A GSC 203647-L; B GSC 203647-P



would, by definition, be in the biotite zone. More typically, staurolite associated with cordierite is euhedral and poikilitic (Fig. 33). Typical assemblages include cordierite, staurolite, quartz, plagioclase, biotite and muscovite.

Cordierite occurs as anhedral 2-4 cm long grains that are commonly poikilitic and retrograded. Cordierite porphyroblasts are readily identified on outcrop as they weather out differentially, but in some rocks studied under the microscope they occur as matrix-sized grains that are difficult to distinguish from quartz, particularly where retrogression is absent. This suggests that cordierite may be more abundant in the field than realized. Retrograded cordierite is composed of a fine mat of sericite, pinite and chlorite outlined by unretrograded poikiloblasts of quartz and other minerals. Some examples of cordierite and staurolite porphyroblasts are illustrated in Figure 33.

Sillimanite-bearing rocks

Sillimanite-bearing rocks occur mostly around the Hackett River gneiss dome and where Beechey Lake Group metasediments have been migmatized in and around the Mara River granitoid complex.

A sillimanite isograd sets the lower limit for sillimanite-bearing rocks in the Hackett River area (Percival, 1978). The upper limit is difficult to define as sillimanite is present as a retrograde mineral in kyanite-bearing rocks. In general, the zone between the two isograds is sillimanite-bearing and devoid of kyanite. Upgrade from the kyanite isograd, sillimanite is still common, and kyanite is only present locally. The sillimanite between the two isograds is fibrolite. It occurs in fine grained rocks containing quartz, plagioclase, muscovite, staurolite and pinitized cordierite in both the Beechey Lake Group and Siorak Formation metasediments.

Southwest of the Hackett River gneiss dome, in the Beechey Lake Group, sillimanite coexists with quartz, plagioclase, biotite, garnet and retrograded cordierite and staurolite. In aluminous volcaniclastic rocks of the Ignerit Formation, garnets up to 4 cm in diameter occur in a sillimanite, quartz, plagioclase and biotite bearing gneiss. At the Camp lake mineral deposit, aluminous and volcaniclastic metasediments make up the mineral deposit host rock, and have the same metamorphic mineral assemblages. Casselman (1977) noted sillimanite with muscovite, biotite, quartz and plagioclase.

In the Siorak Formation, sillimanite is most abundant in quartzofeldspathic gneiss. It occurs as fibrolite intergrown with cordierite (Percival, 1978). The fibrolite is in equilibrium with quartz, plagioclase, biotite, muscovite and cordierite. In some rocks sillimanite bundles wrap mimetically around crenulations. Sillimanite needles may be broken, deformed, or overgrown and in some thin sections appear "snow-balled".

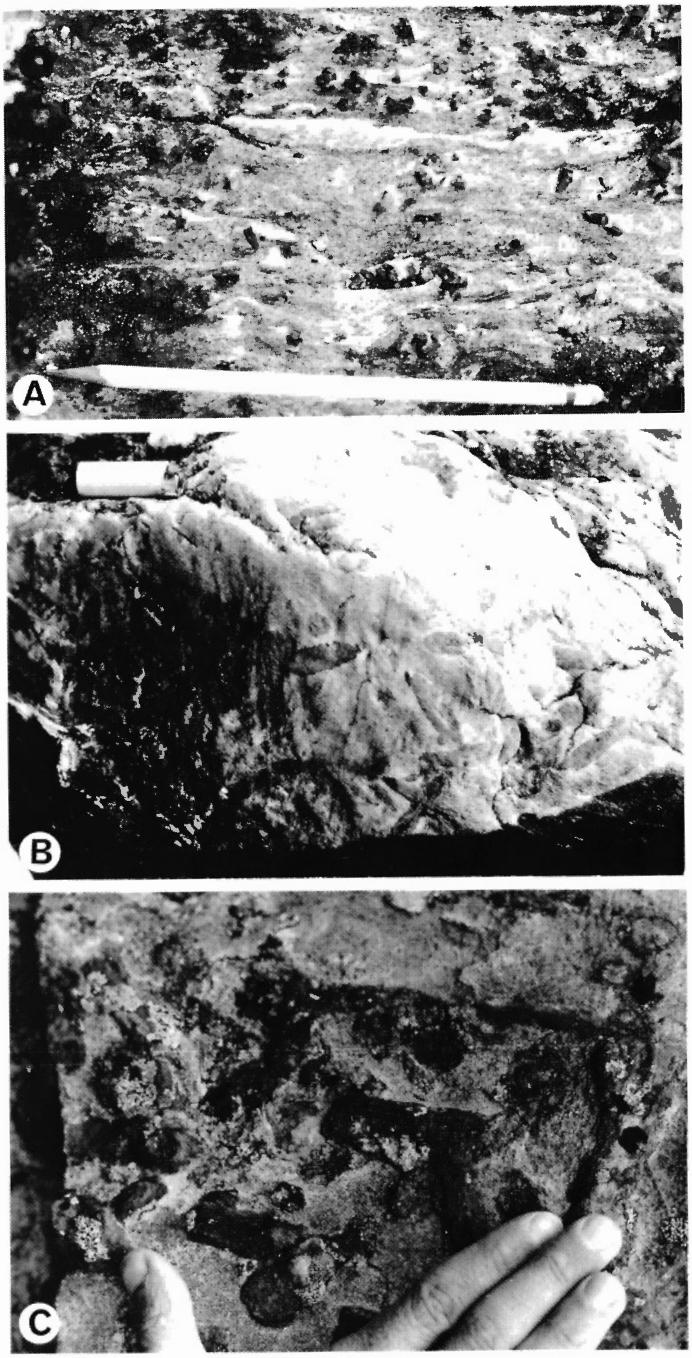


Figure 33. Cordierite-staurolite-bearing rocks

A. Euhedral staurolite in biotite schist from the Beechey Lake Group found near the cordierite-staurolite isograd near Malley Rapids. GSC 202957

B. Cordierite porphyroblasts cut by S2 and S3 cleavage, Uist Lake region. GSC 203337-J

C. Cordierite porphyroblasts in muscovite-biotite schist, Beechey Lake Group, exhibiting irregular form and orientation, northwest of the Uist Lake pluton. GSC 203647-J

Kyanite-bearing rocks

Kyanite-bearing rocks occur only in the Siorak Formation. Padgham et al. (1975a) first reported kyanite from the southeast margin of the Hackett River gneiss dome. Other occurrences have been described by Frith and Hill (1975), Sterenberg (in Percival, 1978) and by Percival (1978, 1979).

Metamorphism in the Hackett River gneiss dome progrades towards its centre. Kyanite is most prevalent in the inner mafic and quartzofeldspathic gneiss (Fig. 34A) where it is associated with anthophylite, chlorite, cordierite, biotite, quartz and ilmenite. Where retrograded to sillimanite in the outer zones, kyanite is present in the cores of cordierite, along with staurolite, biotite, plagioclase, quartz and ilmenite (Fig. 34B).

Percival (1979) suggested there was a lateral variation in geothermal gradient from the Hackett River gneiss dome to the adjacent Beechey Lake Group, based on studies of regional textures. Fyson and Frith (1979) deduced from regional structures that the Hackett River gneiss dome was emplaced after or during the latter phases of D2, lifting isograd surfaces from kyanite-stable to sillimanite-stable conditions.

Cordierite associated with kyanite-bearing rocks is locally of gem quality and occurs as large, anhedral shaped grains, up to 10 cm long (Fig. 34C). Since cordierite is commonly pinitized and cleaved in lower pressure rocks, it is concluded that thermal metamorphism of the Hackett River gneiss dome mantle rocks, outlasted D2 which commonly transects cordierite porphyroblasts in the Beechey Lake Group. Cordierite may be formed at higher temperatures and pressures from chlorite, which breaks down to biotite, cordierite and sillimanite. Chlorite is an abundant mineral throughout the Siorak Formation.

CORRELATION OF STRUCTURE, METAMORPHISM AND PLUTONISM

The Hackett River and Malley Rapids regions were studied in detail in order to establish relationships between deformation, metamorphism and plutonism.

Structural sequence and regional metamorphism

In the Hackett River area, 2680 Ma metasedimentary and volcanic rocks were deposited, possibly on granitoid basement whose existence is inferred from stratigraphy and similar relationships observed elsewhere in the Slave Province (Frith, 1973; Baragar and McGlynn, 1976). Geochronological data from the core of the Hackett River gneiss dome (Frith and Loveridge, 1982) are only consistent with the emplacement of a synvolcanic intrusion of tonalitic composition. The supracrustal rocks were deformed and subsequently metamorphosed, as porphyroblasts postdate axial planar features attributed to D1.

The lowest grade rocks lie east of the Hackett River area and have platy minerals that are aligned in S1. Towards the Hackett River, at the biotite isograd, porphyroblasts of biotite are similarly aligned in S1. Progressively, porphyroblasts overgrow S1 (Fig. 32). Microscopic quartz trails that parallel S1 are present in biotite porphyroblasts, indicating that thermal metamorphism outlasted D1.

In the staurolite-cordierite zone, porphyroblasts of staurolite also overgrow S1 (Fig. 35A, B) but with increase in metamorphic grade they become swirled and oriented parallel to S2, indicating that locally, regional metamorphism was continuous through D1 and D2 (Fig. 35C).

In the sillimanite zone, just east of the Hackett River gneiss dome, fibrolite parallels S2. Where fibrolite crystallized as sillimanite, it is bent or kinked parallel to S2, indicating that in the sillimanite zone, post-D1 metamorphism was greater than post-D2.

In the Malley Rapids area the lowest grade of metamorphism occurred during D1. Secondary minerals such as chlorite and muscovite are mostly oriented parallel to S2 in a matrix of plagioclase, quartz and lithic fragments, many of which retain detrital shapes (Fig. 31C). In higher grades of metamorphism, secondary biotite most commonly grows to

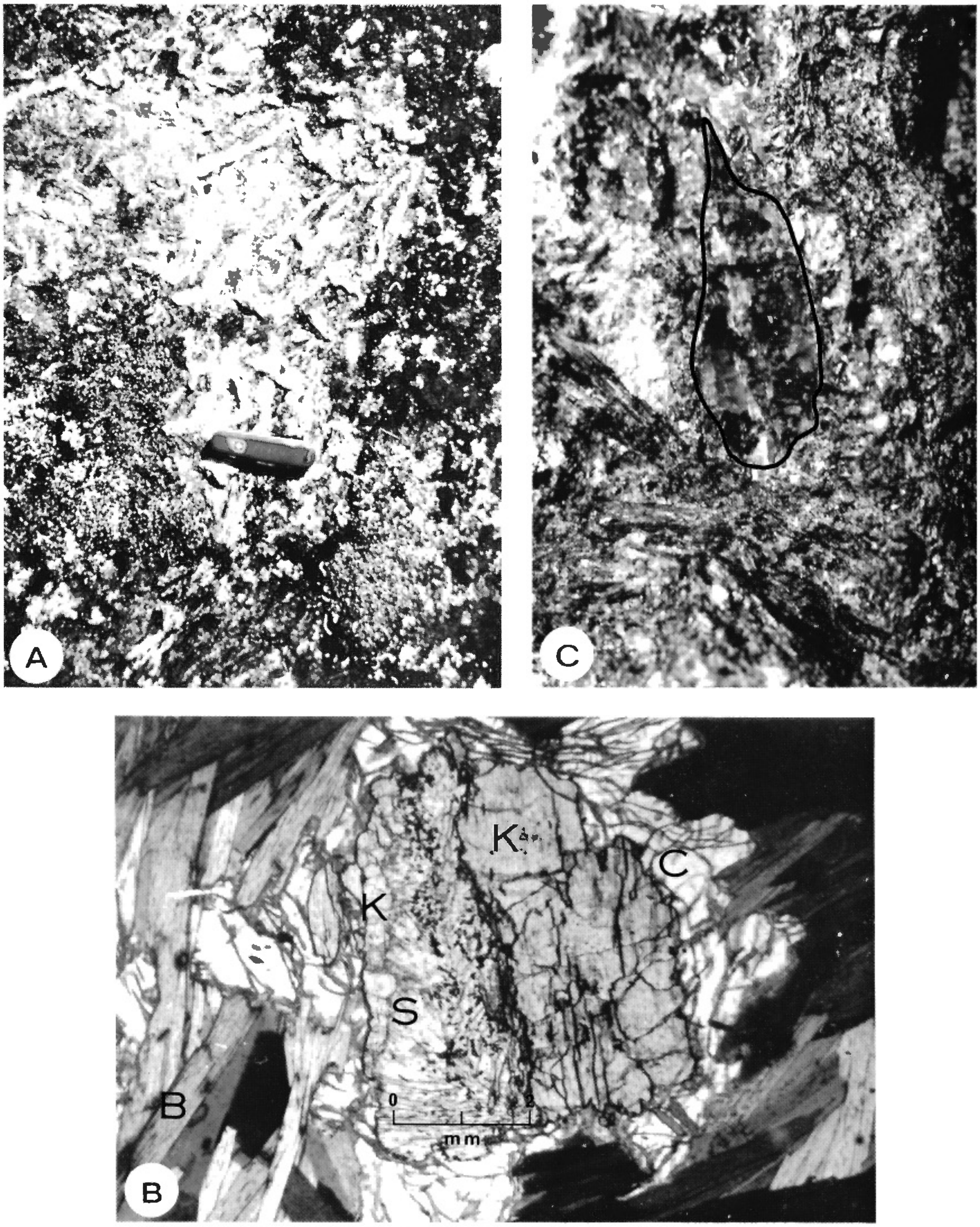


Figure 34. Kyanite-bearing rocks

A. Coarse kyanite, partly retrograded to sillimanite, in Siorak Formation gneiss on the east side of the Hackett River gneiss dome. GSC 203505-A
B. Photomicrograph (plane light) of a grain of kyanite from the Siorak Formation, partly overgrown by sillimanite and subsequently by cordierite (after Percival, 1978). **B**, biotite; **K**, kyanite; **S**, sillimanite; **C**, cordierite.
C. Clear purple gem quality cordierite, about 10 cm long, in Siorak Formation mafic gneiss from the east side of the Hackett River gneiss dome. Nearby rocks contain retrograded kyanite. GSC 203339-Y

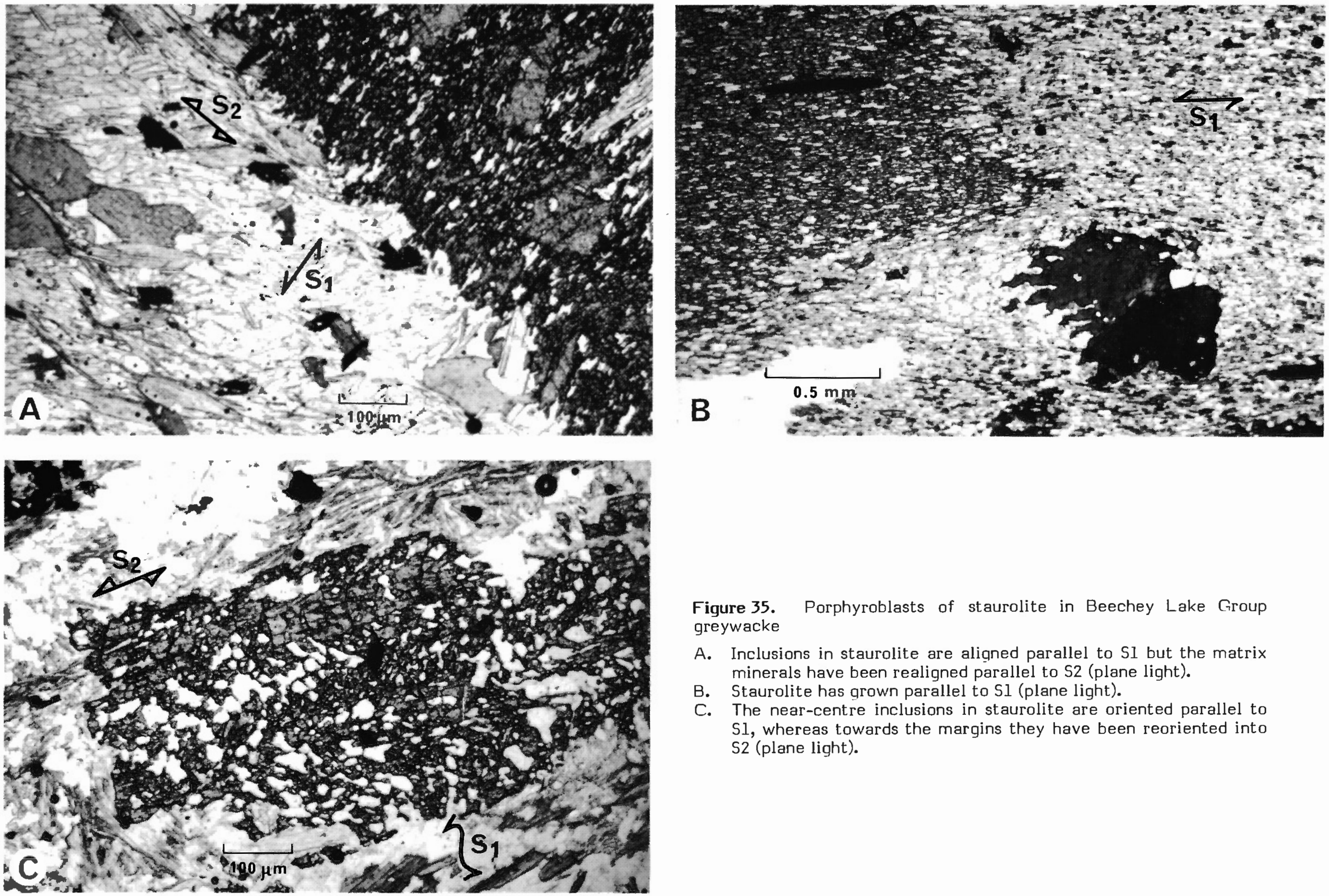


Figure 35. Porphyroblasts of staurolite in Beechey Lake Group greywacke

A. Inclusions in staurolite are aligned parallel to S1 but the matrix minerals have been realigned parallel to S2 (plane light).
B. Staurolite has grown parallel to S1 (plane light).
C. The near-centre inclusions in staurolite are oriented parallel to S1, whereas towards the margins they have been reoriented into S2 (plane light).

the exclusion of chlorite, but is similarly oriented parallel to S1. Porphyroblasts of andalusite or cordierite appear to be in equilibrium with platy minerals, but they overgrow S1. Staurolite is commonly present with garnet, but is not in equilibrium with either cordierite or andalusite. Sillimanite as opposed to fibrolite, typically replaces muscovite and only biotite, quartz and plagioclase are in equilibrium with it.

The second phase of deformation (D2) in the Malley Rapids area involved recrystallization and growth of muscovite, biotite and chlorite, usually parallel to crenulation planes. Third phase deformation (D3) was similarly restricted to the formation of mica along S3 crenulation planes.

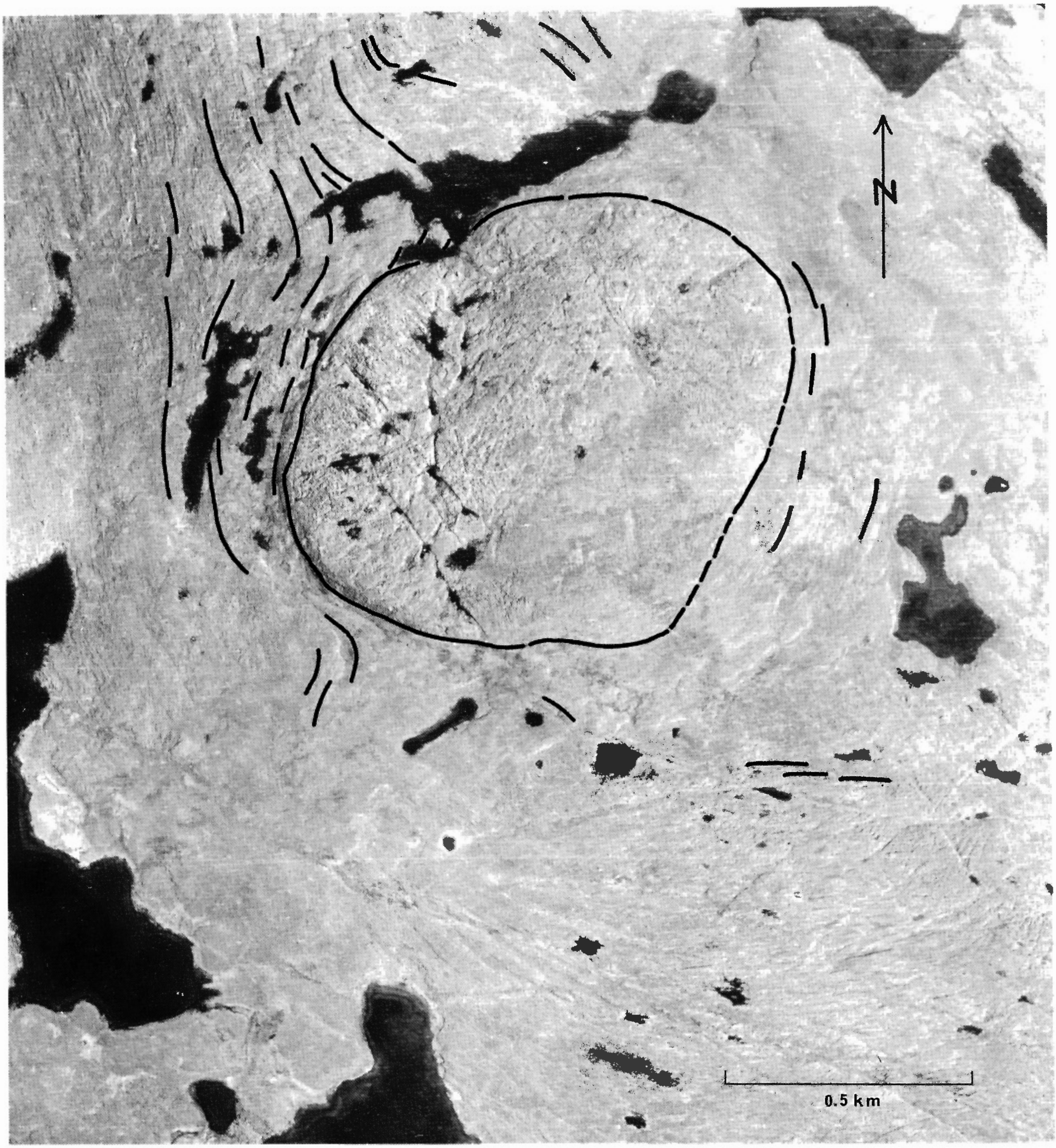


Figure 36. An air photograph (NAPL A 16317-102) of a stock of granodiorite that forms part of the Regan Intrusive Suite. Bedding-cleavage traces (S0 and S1) in the host Beechey Lake Group greywackes and mudstones and the pluton margins have been accentuated to show how the emplacement of the stock has pushed these planar features aside.

Structural sequence and plutonism

The Regan Intrusive Suite was emplaced sequentially in the Hackett River area (Fyson and Frith, 1979). Towards the southwest, bedding and planar features associated with D1 are gently dipping, whereas S2 planes are steeply inclined. Plutons may deflect S1, but are themselves cut by S2.

The Hackett River gneiss dome (Fig. 5) was uplifted after D2, as it modifies or postdates F2 folds. Southeast of the gneiss dome, some plutons were emplaced after D1 and during D2, as some are deformed by D2 (Fig. 36). Cleavage associated with D3 both postdates and predates granites. In a small pluton southeast of Nose Lake, granite pegmatite intruded parallel to S1 and S3. Xenoliths of metasedimentary rock in granite plutons may be crenulated by S3, as are pegmatites in the country rock. These relationships suggest that granitic rock formed at different times relative to D3. Granite plutons that predate D3, lack significant amounts of pegmatite, whereas granites that are contemporaneous or younger than D3 have abundant pegmatite. Rare earth element studies indicate there are probably three different types of granite found in the area.

Plutonism and regional metamorphism

The peak of regional metamorphism was contemporaneous with the final stages of D1. The Regan Intrusive Suite intruded after the peak of metamorphism.

Plutons that intrude high grade regionally metamorphosed metasediments do not have obvious contact aureoles. Host metasediments are generally devoid of porphyroblasts because they have been obliterated by retrograde hydrothermal metamorphism associated with intrusion. Away from the contact areas, remnant biotite schlieren grade into pseudomorphs of cordierite and andalusite, indicating that plutonism postdated the development of porphyroblasts in high grade regionally metamorphosed terranes.

The envelope rocks west of the Malley Rapids granite are hornfelsed, overprinting S1. Locally, the envelope rocks contain contact-metamorphic porphyroblasts of cordierite, andalusite, staurolite and garnet in a matrix of mica, plagioclase and quartz. The contact aureole varies in width from 250 to 600 m. A foliation is locally present within the aureole, parallel to the granite margins. D1 structures are in turn overprinted by the contact metamorphic porphyroblasts.

Table 8. Metamorphic mineral assemblages and possible reactions from Beechey Lake Group greywackes and mudstones and Siorak Formation paragneiss

Sub-biotite rocks:	
	stilpnomelane + muscovite[1] + albite + quartz (± graphite, calcite, tourmaline)
	chlorite + muscovite + quartz + albite (± graphite, tourmaline, magnetite, calcite)
Biotite zone:	
	biotite + muscovite + quartz + plagioclase (± chlorite, tourmaline, magnetite)
Staurolite-cordierite zone:	
	muscovite + chlorite or biotite + staurolite + cordierite (± graphite, muscovite, chlorite)
Sillimanite zone:	
	sillimanite + biotite + quartz (± plagioclase, biotite, cordierite, staurolite, magnetite, chlorite, garnet, retrograded muscovite)
Kyanite zone:	
	kyanite + quartz + plagioclase + biotite (± staurolite, cordierite, chlorite)

Possible prograde reactions[2]

1	stilpnomeland + phengite > biotite + chlorite + quartz + water	
2	chlorite + phengite > biotite + Al-rich chlorite + quartz	
3	staurolite + muscovite + chlorite > aluminosilicate + biotite	(a)
4	muscovite + chlorite > aluminosilicate + chlorite + biotite	(b)
5	staurolite + cordierite > aluminosilicate + biotite	(c)
6	staurolite + muscovite > aluminosilicate + garnet + biotite	(d)

[1]Muscovite or phengite
[2]Reactions (a) to (d) are shown on Figure 37

The presence of cordierite, staurolite and andalusite indicates that contact metamorphic pressure-temperature conditions were similar to those that affected the regionally metamorphosed porphyroblastic metasediments. The age of regional metamorphism is estimated to be 2570 Ma (Frith and Loveridge, 1982) and took place prior to emplacement of the Regan Intrusive Suite.

Estimates of temperature and pressure from experimentally derived mineral phases can be highly subjective. This study uses the petrogenetic grid devised by D.M. Carmichael (personal communication, 1980) based on the Holdaway (1971) aluminosilicate triple point that, in general, best compromises the geological, thermodynamic and experimental data (Day and Kumin, 1980).

The reaction used to trace the conditions of metamorphism over the present erosion surface was derived from thin section studies along a traverse between the Goulburn Group unconformity and the Hackett River gneiss dome. Twenty-eight mineral compositions were analyzed by microprobe (Percival, 1978).

Mineral assemblages and possible reactions from one metamorphic zone to another are given in Table 8. Metamorphic reactions deduced from these assemblages were used to trace the varying pressure and temperature conditions that affected the rocks now present at the erosion surface of the Beechey Lake Group (Fig. 37).

Studies of metamorphic zonation around the Hackett River gneiss dome (Percival, 1978) indicated that the dome was a thermal as well as a structural culmination. Whereas the Beechey Lake Group has mineral assemblages that are typically below bathazone 3 (Fig. 37), mineral assemblages within the Siorak Formation around the Hackett River gneiss dome, show both textural and compositional evidence of pressure retrogression from zone 4 to zone 3. Possible "paths" for the present erosion surface in P-T space for the Beechey Lake Group are shown as path 1.

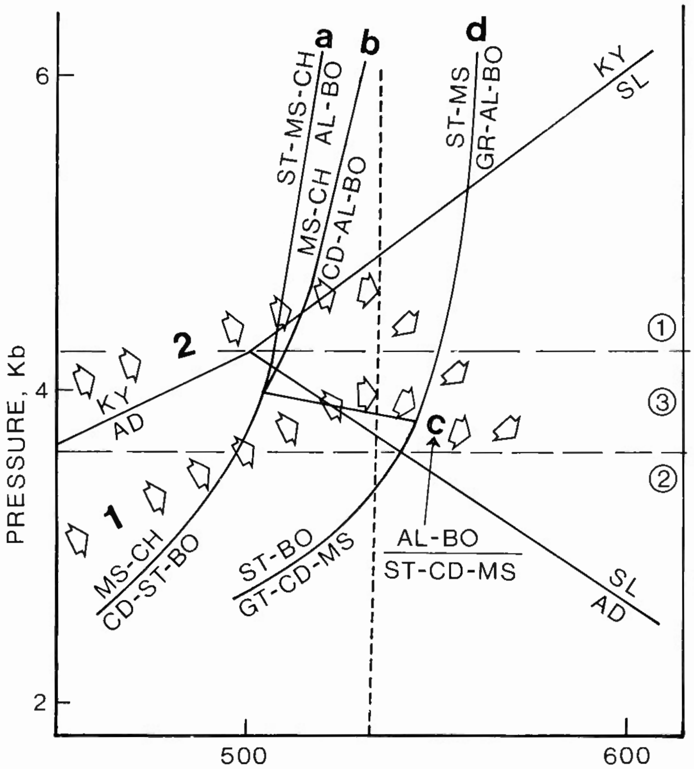


Figure 37. Temperature-pressure-time diagram for reactions listed a-d in Table 8. Track 1 represents probable conditions of metamorphism for high grade Beechey Lake Group metasediments, whereas track 2 denotes conditions for those of the Siorak Formation. The vertical dashed line is the thermal peak in both areas and the horizontal lines are bathazones (modified from Percival, 1979).

The different "paths" for the present erosion surface may have a bearing on Archean geothermal gradients. Percival (1979) suggested that the tonalitic core of the Hackett River gneiss dome was a low thermal conductor, a concept proposed elsewhere in the Canadian Shield (Joly, 1978; Schau, 1978). This may have caused a local depression in the geothermal gradients, which after uplift of the core, resulted in the high pressure and temperature conditions that were deduced from mineral assemblages in the gneiss dome and the surrounding Beechey Lake Group metasediments. These conclusions are compatible with structural studies, which showed that the dome region was a relatively depressed region, prior to D2 (Fyson and Frith, 1979).

Microprobe analyses of mineral compositions were used to determine conditions of temperature and pressure of metamorphism (Percival, 1978), using garnet-cordierite pairs (Currie, 1971; Henson and Green, 1971, 1972; Thompson, 1976; Holdaway and Lee, 1977) and garnet-plagioclase pairs (Ghent, 1976). Internal consistency among these methods was obtained between garnet-biotite and garnet-cordierite, indicating that temperatures of 562 and 550°C were attained. These intersect the kyanite-sillimanite boundary at a garnet control pressure between 4.2×10^5 and 5.1×10^5 KPa. The two paths shown in Figure 37 represent metamorphism at different levels in the crust during a regional event that involved normal geothermal gradients. The presence of kyanite in this part of the crust implies an Archean geothermal gradient of about 38°C/km, assuming a lithological density of 2.7 g/cm^3 (Hess, 1969).

ECONOMIC GEOLOGY

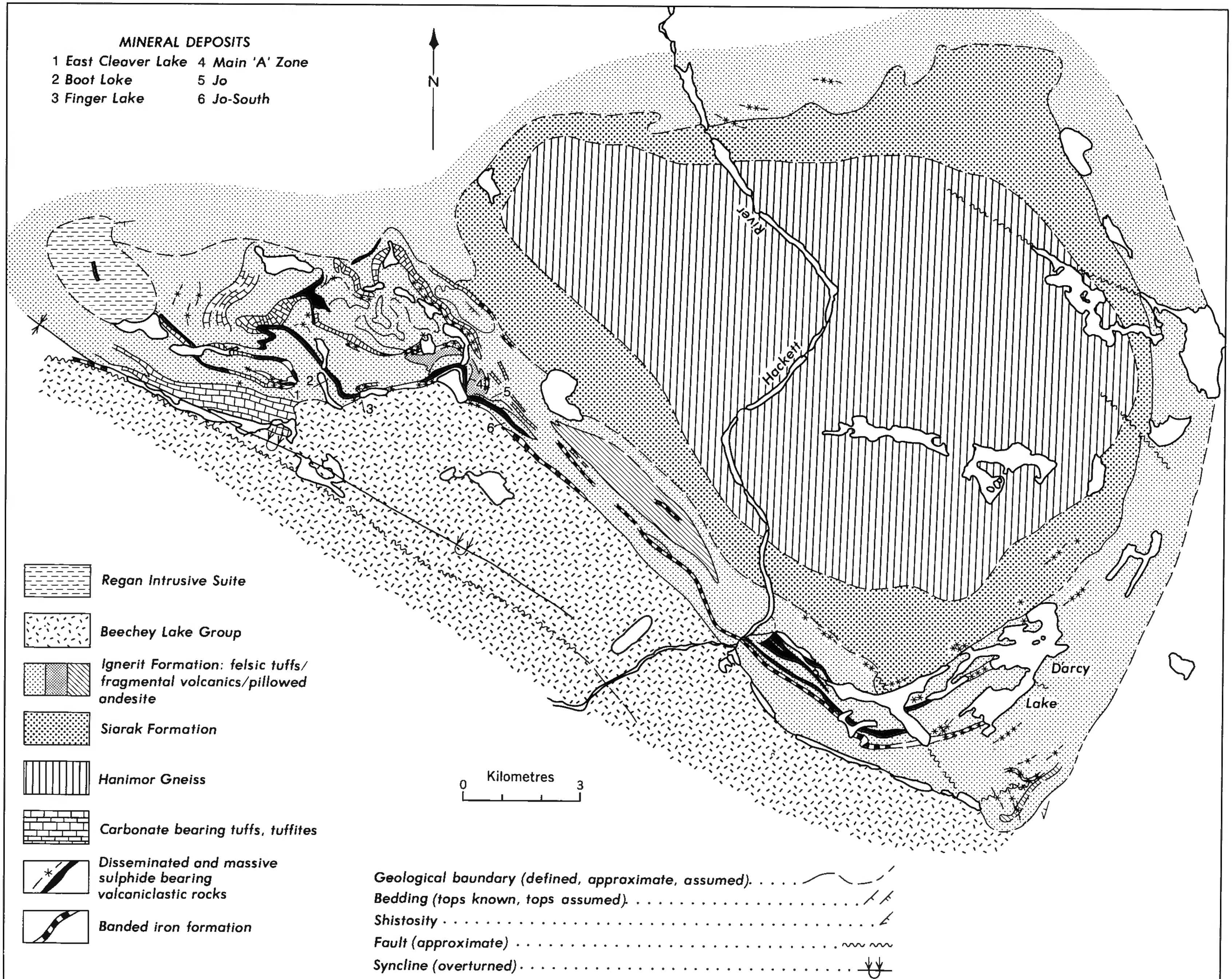
Two general types of mineral deposits are known in the map area: layered sulphides associated with the close of quiescent phases of volcanism, and free gold occurrences associated with banded iron formation that is located stratigraphically above, but near, the volcanic-sedimentary interface.

The most important sulphide deposits found so far occur in the Hackett River Group near Hackett River and near Aitch Lake. Gold occurrences in banded iron formation and associated rocks are found north of Regan Lake and Fidler Lake (Lord, 1951). These are associated with Back Group volcanic rocks.

Sulphide deposits

History of exploration

In 1956 Rio Tinto Exploration Ltd. discovered copper mineralization associated with gossans at Camp lake, near Hackett River. They carried out limited trenching and geophysical work but it was not until 1966 that the area around what is now known as the "A" zone was acquired by a group which became the Bathurst Inlet Mining Corporation Ltd. Geological mapping, prospecting, ground EM and drilling followed. Significant mineralization was encountered during the summer of 1969. Adjacent claims were staked in 1968 and 1969 by Norsemines Exploration Ltd. and Atlin-Yukon Mining Ltd. These companies amalgamated under the name Bathurst-Norsemines Ltd. which was incorporated in December, 1969.



GSC

Figure 38. Geological sketch map of the Hackett River area showing the location of the principal mineral deposits. All of the deposits are within the mineralized succession, shown in black.

Cominco Ltd. optioned the property in 1970, and in 1980 owned 44% of Bathurst Norsemines Ltd. Cominco's work included airborne EM and magnetic surveys, ground geophysics, geochemistry, geological mapping and diamond drilling. Exploration between 1970 and 1978 outlined a possible 20 million short tons of potential ore with significant concentrations of zinc, lead, copper and silver with minor amounts of gold (MacNeil, 1976).

In 1972, S.M. Roscoe, working on behalf of the Yava Syndicate, outlined the northern part of the Hackett River Group and staked gossans along or near the volcano-sedimentary contact. Further staking followed release of Geological Survey of Canada maps of geochemical surveys carried out the same year (Allan and Cameron, 1973). In 1974, drilling of the largest gossan near Aitch Lake indicated sulphide mineralization over a 40 m length with concentrations of zinc, lead, copper, silver and gold. In 1975 and 1976 Brascan Ltd. carried out geological mapping, geophysical and geochemical surveys, and diamond drilling on the property. About 1.25 short tons of potential ore was outlined (Saliken, 1976).

Hackett River mineral deposits

The claim groups optioned by Cominco Ltd. since 1976 include those from Bathurst Norsemines, the Zed Group from Ice Station Resources, and the T and B Group acquired from Spectroair Ltd. Together these consist of about 1100 claims over an area of about 440 hectares.

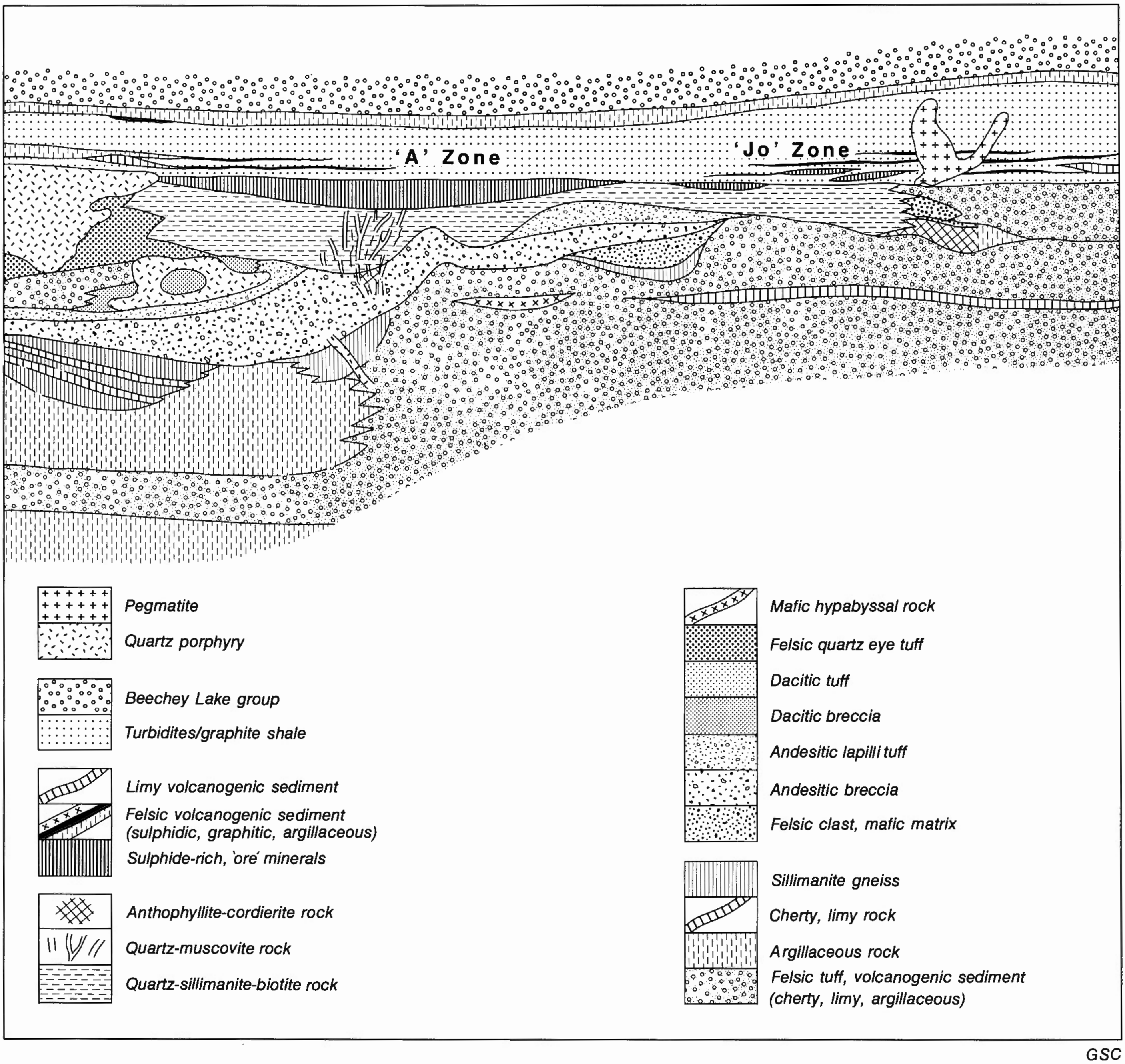


Figure 39. Depositional reconstruction of the "A" and "Jo" mineralized zones, Hackett River area. Legend numbers follow the depositional cycles referred to in the text.

There are six discrete mineral deposits in the area outlined in Figure 38 which include the "A" zone, the "Jo" zone, "Jo-South" zone, "East Cleaver Lake" zone, "Finger Lake" zone and the "Booth Lake" zone. All are located in the same mineralized succession, within 100 m of the contact between the Ignerit Formation and the Beechey Lake Group.

The sulphide deposits are stratiform and occur in saucer-shaped concentrations along the north limb of a syncline that separates the Hackett River gneiss dome from the principal limb of the Hackett River Group. The nature of this syncline is not defined because strata cannot be traced around the nose of the structure. No significant amount of mineralization has been found along the south limb. A southeast plunge in the southeastern part of the syncline has been deduced from minor structures within the core of the syncline. However, the northwestern part may plunge in the opposite direction (MacNeil, 1976).

Detailed mapping and description of the "A", "Jo" and "Jo-South" zones (Casselman, 1977; Wilton, 1975; Casselman and Mioduszewska, 1982) have clarified the geology of the deposits. The principal "A" and "Jo" zones are outlined below.

Geology of the "A" and "Jo" zones

The central area deposits comprise the largest concentration of sulphides discovered in the map area. A depositional reconstruction cross-section of the geology through the "A" and "Jo" zones is shown in Figure 39 (after Frith and Roscoe, 1980). The deposits in the upper part of the Ignerit Formation consist of sedimentary accumulations of volcanic detritus and chemogenic material that overlie a volcano-sedimentary unit, which in turn overlies a coarse grained volcanic pyroclastic unit. This whole sequence is a fining-upward cycle, with coarse volcanic breccias at the base and fine grained detrital and chemically deposited precipitates at the top. Initially, deposition was from explosive volcanism, followed by more quiescent deposition.

Cycle 1. The lowermost cycle, which overlies the Siorak Formation, is about 1000 m thick (Fig. 39) and is composed of felsic tuffs interlayered with minor amounts of cherty, limy or argillaceous matter. The tuffs have recrystallized to schist and gneiss with metamorphic mineral assemblages characteristic of rocks within the sillimanite to kyanite isograds.

Cycle 2. The second cycle is made up of breccias, tuffs and fine grained pyroclastic rocks. The breccias include some varieties with felsic clasts, and andesitic breccias which have clast and matrix of similar composition (mill-rock of Sangster, 1972a, b). Other rocks include andesitic lapilli tuffs, dacitic breccias, felsic tuffs with quartz eyes, and minor sills of both andesitic and dacitic composition. The deposition of the second cycle marks a change from felsic volcaniclastic sedimentation to a more chaotic, presumably, explosive deposition, with lahars, slump breccias and the occurrence of contemporaneous fault movements (Frith and Roscoe, 1980; Franklin, 1976).

Cycle 3. The third cycle includes aluminous volcaniclastic sediments that have been highly metamorphosed and altered. The following description has been taken mostly from Casselman (1977) and Casselman and Mioduszewska (1982).

(i) The most voluminous rocks are fine grained quartz, sillimanite, biotite, muscovite, garnet, sulphide and oxide-bearing schists and gneiss. They are massive to moderately foliated, grey to black with local sillimanite porphyroblasts. The spot-like porphyroblasts are uniformly distributed through the rock. The rocks of this cycle are thought to have formed by alteration, analogous to chlorite alteration, common in footwalls of Archean massive sulphide deposits of the Canadian Shield.

(ii) Second most abundant are the "conduit" rocks, thought to be altered by hot-spring fumerolic activity. The rocks consist of an anastomosing network of "conduits" 1-15 m wide that cut the footwall rocks beneath the "A" and "Jo" zones. Drill core studies indicate that the "conduit" rocks form a funnel-shape. The rocks are mostly quartz (70-80%) and muscovite with minor sillimanite, a trace of cordierite, and up to 5% sulphide minerals. There is a strong foliation in hand specimen and a lumpy "chicken-wire" texture due to muscovite chains surrounding elliptical aggregates of quartz 8-25 mm in diameter.

(iii) The "A" and "Jo" zones also contain volumetrically minor elliptical pods of anthophyllite, cordierite, garnet, biotite, sillimanite, quartz, sulphides and oxides. The rock is massive, coarse grained and dark grey.

Casselman (1977) grouped the footwall rocks by degree of alteration from both visual and chemical criteria into: (i) least altered, (ii) moderately altered and (iii) the most altered. Stratigraphically equivalent rocks were lower in Na_2O and CaO, and higher in K_2O and with variable amounts of iron oxides, MgO, Al_2O_3 and SiO_2.

Cycle 4. The fourth cycle of deposition is made up of chemogenic and volcanogenic sulphide ore minerals, graphitic and argillaceous sediment, felsic, volcaniclastic and limy sediment. The mineralized rocks extend along strike for approximately 2 km. The thicknesses were drilled, whereas at the "Jo-South" zone the strata are about 9 m thick (Casselman, 1977).

The mineralized "A" zone, as described by Casselman (1977), consists of four main rock types: (i) a lowermost succession of silicified felsic tuff, calc-silicate rock, sillimanite tuff with disseminated chalcopyrite, pyrite, pyrrhotite and magnetite; (ii) a rock containing 30-70% pyrite with sphalerite, galena, chalcopyrite, pyrite and pyrrhotite interlaminated with silicified, felsic, leached tuff, calc-silicate rock, and sillimanite-bearing tuff; (iii) calc-silicate rock with diopside, actinolite, garnet, biotite and sulphide minerals (5-10%), and (iv) an uppermost section of massive pyrite (30-70%) mixed with silicified felsic tuff, calc-silicate rock or sillimanite-bearing tuff with pods and disseminations of sphalerite, galena, and minor sulphide veins. In the "Jo-South" zone, graphitic carbon occurs with the uppermost part.

Cycle 5. Sedimentation of the Beechey Lake Group began with the deposition of carbonaceous mudstones that are fine grained, dark grey to black, finely laminated and commonly contain pyrite, causing rust staining. Near the "A" zone, the carbonaceous mudstones are interlayered with light coloured, finely laminated tuffites (rocks with both pyroclastic and detrital material), making the contact between the Ignerit

Formation and the Beechey Lake Group gradational over a few metres. The carbonaceous mudstone is in turn interlayered with carbon-free mudstone, over a similar thickness, followed stratigraphically by typical greywacke-mudstone turbidites.

Other rocks in the mineralized area. Quartz porphyry and pegmatite dykes intrude the "A" and "Jo" and "Jo-South" zones where they make up less than 5% of the rocks present. The quartz porphyry is a buff fine grained rock of dacitic composition with quartz phenocrysts in a matrix of finer grained quartz, biotite and plagioclase. The porphyries intrude as 1-2 m thick dykes that strike east and are subparallel to the volcanic strata, except in the "Jo-South" zone where they are discordant.

Mineral deposits. Two potential ore deposits have been outlined in the "A" zone[1]. The first, located in the eastern end of the deposit has been reported[2] to contain 0.02 oz. of gold, 7.1 oz. of silver, 0.5% copper, 1.18% lead and 8.16% zinc (/short ton) over a strike length of 275 m and an average thickness of 7 m. Drilling indicated that the deposit is still open at a depth of 180 m. The second deposit, located to the west, is of similar grade and at least 5 million short tons of potential ore have been reported. Lower grade stringer ore provides possible additional tonnages (MacNeil, 1976).

The "Jo" and "Jo-South" are depositionally similar to the "A" zone, but separated by an intra-basin barrier or footwall, and stratigraphically equivalent units thin away from the "A" zone as suggested in Figure 39. The "Jo" zone contains a cluster of small, high grade, layered sulphide deposits, whereas the "Jo-South" zone contains vein and disseminated sulphides at lower stratigraphic levels than either the "A" or "Jo" zones. Other deposits in the Hackett River area include the "East Cleaver Lake" zone, the "Boot Lake" zone and the "Finger Lake" zone. Of these the "East Cleaver Lake" zone is the largest, containing an estimated 3.6 million tons of potential ore.

Yava mineral deposit

The Yava deposit is the second most significant massive sulphide deposit found so far in the Hackett River greenstone belt. The geology has been described by Frith and Roscoe (1980). The following summary outlines some of the more salient features.

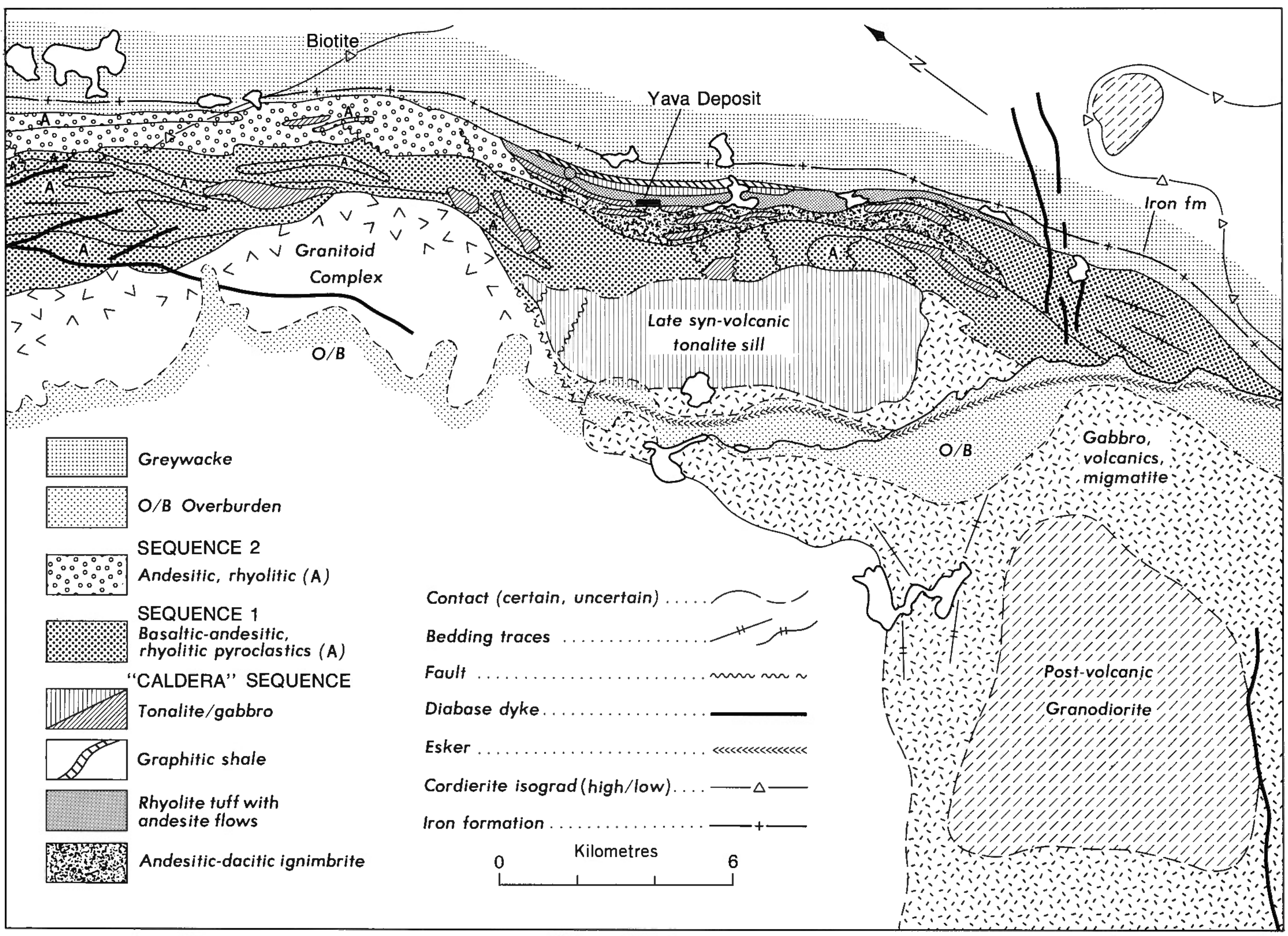


Figure 40. Geological map of the Aitch Lake area.

[1] Together, the deposits have been estimated to contain about 20 million short tons of potential ore with significant concentrations of zinc, lead, copper, silver and minor gold.

[2] All values reported here were derived from Mineral Development Sector open files of the Department of Energy, Mines and Resources, which are quoted in avoirdupois; corporation files of Bathurst Norsemines Ltd.; and Bathurst Inlet Mining Corporation Ltd.

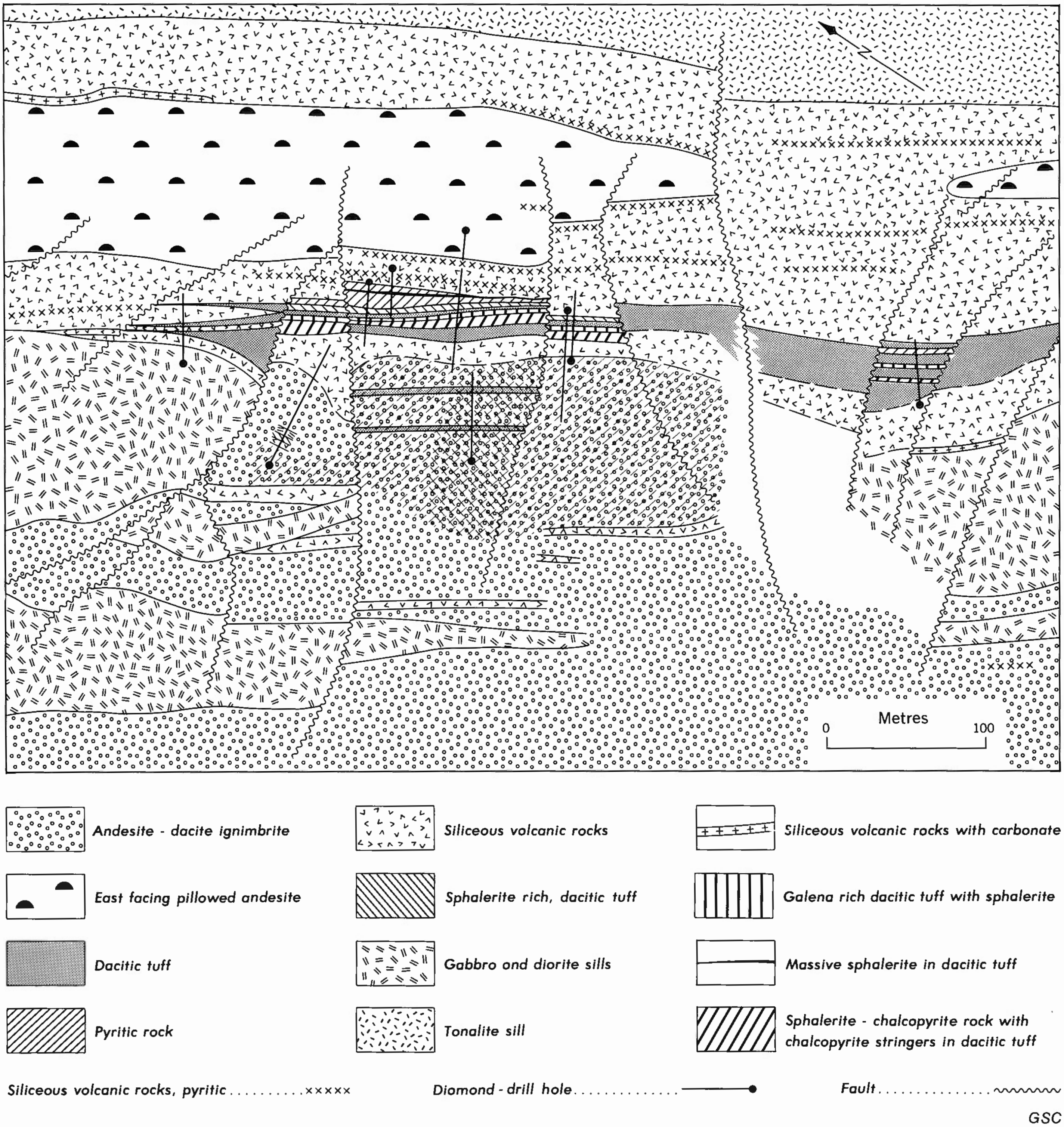


Figure 41. Geological map of the Yava deposit. Altered rock beneath the deposit is cross-hatched.

Geology of the Yava deposit

The Yava deposit is located near the centre of a basin whose presence was deduced from detailed regional mapping (S.M. Roscoe, personal communication, 1975). Subaerial welded tuffs occur beneath the Yava deposit in a saucer-shaped profile that thins along strike into volcanic rocks of subaqueous origin. The area also contains numerous basic and felsic sills, both above and below the deposit. These rock types and the presence of several high-angle faults (Fig. 40, 41) in the area show that the deposit is in a collapsed caldera that has been tilted to a near-vertical position. The rocks in the saucer-shaped basin thin towards a possible basement protuberance where the volcanic belt is narrowest (Fig. 40).

The caldera is floored by submarine flows of pillowed andesite, overlain by a thick succession of subaerial welded and unwelded ignimbrites and breccias of andesitic and dacitic composition. The massive sulphide deposit occurs near the top of the subaerial rocks in a transition zone to submarine deposition (Fig. 40). Overlying the massive sulphide deposit are waterlain tuffs with graded bedding, pillowed andesite flows and felsic sills. The sills are relatively late intrusions, as some postdate the lowermost carbonaceous units of the Beechey Lake Group. Carbon is incorporated in the sill at the volcanic-sedimentary interface (Fig. 11). Faults offset the basin strata, particularly the ignimbrites, but do not offset some of the larger sills.

Mineralization occurs as sulphide-rich bands of pyrite and pyrrhotite within volcaniclastic tuffs. The "mineralized" horizon, which extends for about 2.5 km, is in part sulphide iron formation, graphitic tuff, slate and, in places, contains carbonate. The iron formation is locally auriferous.

The Yava deposit and the Hackett River area deposits are unusual for Archean volcanogenic sulphide deposits. They are high in lead and zinc values, relative to copper.

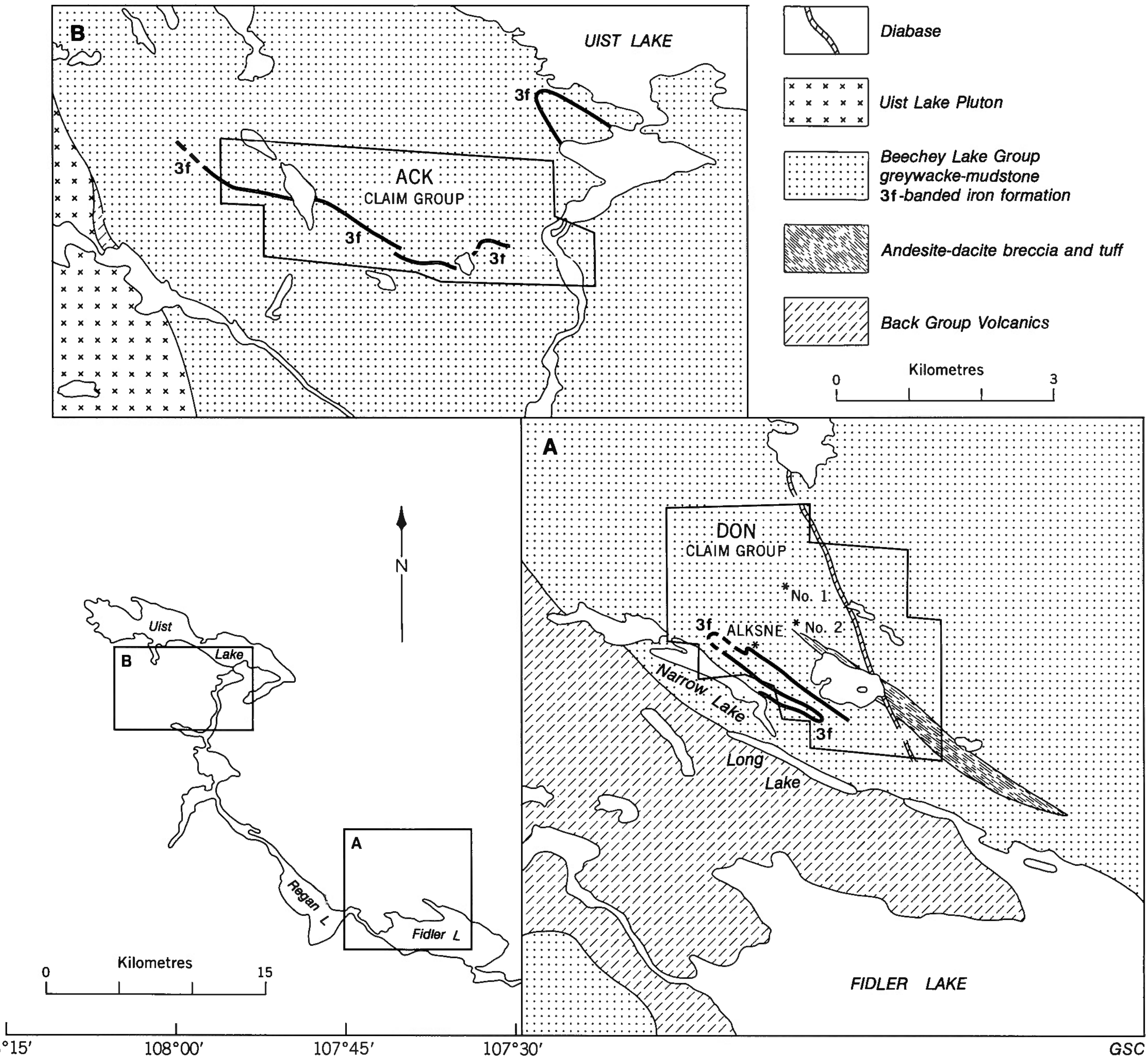


Figure 42. Geological sketch map of gold prospects near Regan Lake and Uist Lake.

The sulphides are layered and the presence of primary sedimentary structures indicates that, at least locally, they formed by sedimentary processes. Sphalerite mineralization is the most common and can be traced downward through 95 m in the thickest part of the deposit and laterally for about 600 m.

The deposit consists of four closely stacked mineralized groups of beds with metal ratios that vary progressively from bottom to top. Sphalerite, galena and chalcopyrite are the dominant ore minerals, and occur in massive to disseminated concentrations, interlayered with tuff and chert. Pyrite is conspicuous by its low concentration when compared with other Archean sulphide deposits (D.F. Sangster, personal communication, 1978).

The lowermost group of mineralized beds is the richest in chalcopyrite which occurs in stringers and along bedding lamellae. Under the microscope, chalcopyrite was also observed to have exsolved from sphalerite. The second mineralized group is thickest, containing massive, bedded, pale sphalerite and galena. The third group is silver-rich, despite a lower galena/sphalerite ratio, compared with the other mineralized groups. Tennantite was identified by Nicholls (1976). The fourth group of mineralized beds is characterized by a dark, 1 m thick bed of argentiferous and auriferous sphalerite that overlies argentiferous pyrite.

Footwall alteration was mapped from drillhole and surface information and its extent is outlined in Figure 41. Chemical analyses of the footwall rocks show marked depletion in soda. Outside the alteration zone, there are abnormalities that are only apparent in the whole-rock chemistry. They are not depleted in soda, but show high MgO and CO_2 contents, perhaps due to dolomitization. Alteration indices show a high degree of sericitization. The footwall rocks are less altered towards the southern margin of the basin where the ignimbrite beds thin out.

Metal grades outlined by drilling indicate a small deposit of 1.25 short tons that ranges in thickness from about 10-35 m, and extends along strike for about 160 m. It has been estimated to be about 90 m in depth (Saliken, 1976).

The origin of the metals has been linked to the footwall rocks (Frith and Roscoe, 1980). Ignimbrites were considered to be a likely source for the base and precious metals. A circulatory hydrothermal system was envisioned, through a relatively porous medium. Sulphides that circulated to the basin floor were deposited as chemical sediments on impervious felsic tuffites. Contemporaneous intrusion of sills may have promoted circulation by increased heat within the footwall ignimbrites, whereas faults may have aided fluid circulation to the basin floor. The deposit as a whole is concave rather than convex, which suggests that the basin may have been subsiding as volcanic rocks and detritus filled it. The heavier sulphides may have concentrated by downward sinking relative to fine mud, volcanic detritus and siliceous ooze.

Gold deposits

Interest in gold deposits in the area began in 1946 when claims north of Regan Lake were staked on behalf of the Don Cameron Exploration Co. Ltd. In 1947, Algood Mines was incorporated to acquire the ground and to explore it. Three showings were outlined (DON, SAM and ALKSNE) and have been described by Lord (1951). Falconbridge Nickel Mines Ltd. acquired Algood Mines Ltd. and during 1963 and 1964 explored existing prospects and outlined further deposits in the ALK group (Schiller and Hornbrook, 1964; Schiller, 1964).

Table 9. Age determinations from the map area (modified from Frith and Loveridge, 1982)

No.	Method	Lat. & Long.		Lithology - Location	Age (Ma)		Ref.
1	K-Ar biotite	65-06	107-12	Malley Rapids granite (RIS)	1950	± 105	1
2	K-Ar biotite	65-45	107-40	Tikiraq granodiorite (RIS)	2380	± 120	1
3	K-Ar biotite	65-47	107-47	Schist-Tikiriq Lake (BLG)	2475	± 80	3
4	K-Ar muscovite	65-24	108-54	Pegmatite-Nose Lake (MRC)	2374	± 54	2
5	K-Ar muscovite	65-58	107-30	Schist-Western R. Fm. (BLG)	2380	± 100	3
6	K-Ar muscovite	65-08	108-44	Granite-Lunar Lake (RIS)	2455	± 80	4
7	K-Ar muscovite	65-18	108-19	Pegmatite-NW of Uist Lake	2484	± 41	5
8	K-Ar muscovite	65-25	107-33	Kuuk Lakes granite (RIS)	2535	± 125	1
9	Rb-Sr isochron	65-11	108-10	Uist Lake granodiorite (RIS)	2350	± 37	5
10	Rb-Sr isochron	65-27	107-40	Kuuk Lakes granite (RIS)	2449	± 30	5
11	Rb-Sr isochron	65-33	107-52	Yava dacite (HRG)	2499		5
12	Rb-Sr isochron	65-56	108-03	Hanimor gneiss (HRG)	2570		5
13	U-Pb zircon	65-56	108-03	Hanimor gneiss (HRG)	2666	± 24	5
14	U-Pb zircon	64-44	107-58	Felsic volcanics (BG)	2670	± 4	6
15	U-Pb zircon	64-55	107-44	Greywacke (BLG)	2670	± 4	6
16	U-Pb zircon	65-13	108-10	Uist Lake granodiorite (RIS)	2588	± 8	5
17	Pb, 2nd isochron	65-55	108-16	Camp lake deposit (HRG)	2660		5
18	Pb, 2nd isochron	65-37	107-55	Yava deposit (HRG)	2660		5

Ref.
1 Wright, 1960
2 Frith, 1979
3 Tremblay, 1965, 1966
4 Fraser, 1965
5 Frith and Loveridge, 1982
6 Lambert and Henderson, 1980

Key:
RIS - Regan Intrusive Suite
BLG - Beechey Lake Group
MRC - Mara River Complex
HRG - Hackett River Group
BG - Back Group

Geology of the Regan Lake gold occurrences

The three gold occurrences north of Regan Lake are associated with beds of iron formation intercalated with beds of greywacke-mudstone turbidites, all of which are part of the Beechey Lake Group. The sediments overlie the Back Group volcanic rocks. Bedding strikes northwest and dips to the southwest. The auriferous strata are slaty mudstones that have been drag folded and then sheared along northeast sinistral faults (Faulkner, 1964). Where mineralized, the strata contain abundant quartz, biotite, and chlorite, with minor calcite and amphibole, probably grunerite-cummingtonite. Non-silicates include pyrite, pyrrhotite, arsenopyrite, chalcopyrite and native gold (Faulkner, 1964). The mineralized strata form part of an iron-rich succession of beds containing goethite, magnetite or hematite. An aeromagnetic signature of these beds is traceable for about 25 km. Repetition suggests that these strata have been folded.

On the DON group (Fig. 42) concordant lenses of quartz contain chlorite, arsenopyrite, carbonate and gold. Surface sampling, in 1947, of a fold closure in iron formation, gave 2.8 to 5.7 oz/ton. Elsewhere grades of 0.31 oz/ton across 0.67 m were obtained (file of Algood Mining Corporation, Mineral Resources Division, Department of Energy, Mines and Resources).

The ALKSNE claim group consists of lenticular quartz veins in slaty iron-rich mudstone scattered along a 350 m zone which includes some en echelon faulted segments. Grey to blue quartz, arsenopyrite and gold occur in 0.3-5.3 m thick intersections and assay between 0.12 and 0.44 oz/ton. Grab samples and drill core sections gave assays of 0.6-2.1 oz/ton (Lord, 1951; Schiller and Hornbrook, 1964).

The ACK group (Fig. 42) contains sulphide and gold mineralization in slaty, iron-rich mudstone. Schistosity is generally parallel to a northwesterly bedding. The mineralized rocks are mostly chloritized and amphibolitized, and wherever the bedding has been folded the fold closure area is mineralized with gold, quartz and arsenopyrite. Some gold-bearing rocks contain disseminated arsenopyrite and quartz veins and assay 0.43-0.64 oz/ton (Faulkner, 1964).

Hints for gold prospectors

The favourable indicators for gold mineralization in the map area are: (a) the occurrence of banded iron formation near the volcanic-sedimentary interface, which may commonly be traced from aeromagnetic maps; (b) the presence of quartz veins in and around the iron formation, particularly where folding is evident; (c) the occurrence of goethite, arsenopyrite, amphibole and pyrite in and around the iron formation.

GEOCHRONOLOGY

Isotopic age determinations have been carried out using K-Ar muscovite and biotite, Rb-Sr whole-rock isochron, U-Pb zircon concordia and Pb-Pb secondary isochron methods. The location of dated samples and the values obtained are shown on the map (in pocket) and are listed with co-ordinates in Table 9. Frith and Loveridge (1982) presented new and previous geochronological data from the area and discussed some of the tectonic and petrological ramifications.

REFERENCES

Allan, R.J. and Cameron, E.M.
1973: Geological Survey of Canada Maps 9-1972 to 15-1972 (Bear-Slave Operation, District of Mackenzie. Results on seven maps (scale 1:250 000) for lake sediment analyses).

Anderson, J.
1855: Chief Factor James Anderson's Back River Journal of 1855; Canadian Field Naturalist; 1940-1941, v. 54, p. 63-67, 84-89, 102-109, 125-126, 134-136; v. 55, p. 9-11, 21-26, 38-44.

Back, G.
1836: Narrative of the Arctic Land Expedition to the Mouth of the Great Fish River and Along the Shores of the Arctic Ocean, in the Years 1833, 1834 and 1835; reprinted by Hurtig, Edmonton, 1970.

Barth, F.W.
1959: Principles of classification and norm calculation of metamorphic rocks; Journal of Geology, v. 67, no. 2, p. 135-152.

Baragar, W.R.A.
1966: Geochemistry of the Yellowknife volcanic rocks; Canadian Journal of Earth Sciences, v. 3, p. 9-30.

1975: Miscellaneous data from volcanic belts at Yellowknife, Wolverine Lake and James River, N.W.T.; <u>in</u> Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 281-286.

Baragar, W.R.A. and McGlynn, J.C.
1976: Basement in the Canadian Shield: a review of the evidence; Geological Survey of Canada, Paper 76-14.

Bouma, A.H.
1962: Sedimentology of Some Flysch Deposits; a Graphic Approach to Facies Interpretation; Amsterdam, Elsevier, 168 p.

Boyd, J.B., Gibb, R.A., and Thomas, M.D.
1975: A gravity investigation within the Agricola Lake geochemical anomaly, District of Mackenzie; <u>in</u> Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 193-198.

Cameron, E.M.
1975: Integrated studies on mineral resource appraisal in the Beechey Lake belt of the northern shield; <u>in</u> Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 189-192.

Cameron, E.M. and Durham, C.C.
1974a: Follow-up investigations on the Bear-Slave geochemical operation; <u>in</u> Report of Activities, Part A, Geological Survey of Canada, Paper 74-1A, p. 53-60.

1974b: Geochemical studies in the eastern Slave Structural Province, 1973; Geological Survey of Canada, Paper 74-27.

Cameron, E.M. and Lynch, J.J.
1975: Hydrochemical studies in the Agricola Lake area; <u>in</u> Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 203-207.

Campbell, F.H.A. and Cecile, M.P.
1976: Geology of the Kilohigok Basin, Goulburn Group, Bathurst Inlet, District of Mackenzie; <u>in</u> Report of Activities, Part A, Geological Survey of Canada, Paper 76-1A, p. 369-377.

1981: Evolution of the Early Proterozoic Kilohigok Basin, Bathurst Inlet-Victoria Island, Northwest Territories; <u>in</u> Proterozoic Basins of Canada, ed. F.H.A. Campbell, Geological Survey of Canada, Paper 81-10, p. 103-132.

Casselman, M.J.
1977: Petrology and alteration of the Bathurst-Norsemines central area deposits, Northwest Territories; unpublished M.Sc. thesis, Carleton University, Ottawa.

Casselman, M.J. and Mioduszewska, B.M.
1982: The Bathurst Norsemines sulphide deposits, Hackett River, N.W.T.; in Precambrian Sulphide Deposits, Robinson Memorial Volume, ed. R.W. Hutchison, C.D. Spence and J.M. Franklin; Geological Association of Canada, Special Paper 25, p. 365-402.

Currie, K.L.
1971: The reaction 3 cordierite = 2 garnet + 4 sillimanite + 5 quartz, as a geological thermometer in the Opinicon Lake Region, Ontario; Contributions to Mineralogy and Petrology, v. 33, p. 215-226.

Day, H.W. and Kumin, H.J.
1980: Thermodynamic analysis of the aluminosilicate triple point; American Journal of Science, v. 280, p. 265-287.

Davies, J.F., Grant, R.W.E., and Whitehead, R.E.S.
1979: Immobile trace elements and Archean volcanic stratigraphy in the Timmins mining area, Ontario; Canadian Journal of Earth Sciences, v. 16, p. 305-311.

Dixon, J.M.
1975: Finite strain and progressive deformation in models of diapiric structures; Tectonophysics, v. 28, p. 89-124.

Ewing, T.E.
1977: Geochemistry of the Hackett River volcanics, Northwest Territories; unpublished M.Sc. thesis, New Mexico Institute of Mining and Technology, Soccoro, New Mexico.

1979: Two calc-alkaline volcanic trends in the Archean: trace element evidence; Contributions to Mineralogy and Petrology, v. 48, p. 1-7.

Fahrig, W.F. and Jones, D.L.
1969: Paleomagnetic evidence for the extent of Mackenzie igneous events; Canadian Journal of Earth Sciences, v. 6, p. 679.

Faulkner, G.N.
1964: Geological report on the ACK claim group in the Regan Lake area, District of Mackenzie, N.W.T.; Department of Indian and Northern Affairs, Assessment Report Number 017134.

Franklin, J.M.
1976: Role of laharic breccias in genesis of volcanic massive sulphide deposits; in Report of Activities, Part A, Geological Survey of Canada, Paper 76-1A, p. 293-300.

Frarey, M.J.
1981: A provisional standard for correlating the Precambrian rocks of the Canadian Shield: Discussion; in Current Research, Part C, Geological Survey of Canada, Paper 81-1C, p. 83-88.

Fraser, J.A.
1964: Geological notes on northeastern District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 63-40.

Fraser, J.A. (cont.)
1965: In Age Determinations and Geological Studies, Part I – Isotopic Ages, Report 5, ed. R.K. Wanless, R.D. Stevens, G.R. Lachance, and R.Y.H. Rimsaite; Geological Survey of Canada, Paper 64-17 (Part 1), p. 58.

Frith, R., Frith, R.A., and Doig, R.
1977: The geochronology of the granitic rocks along the Bear-Slave Structural Province Boundary, northwest Canadian Shield; Canadian Journal of Earth Sciences, v. 14, p. 1356-1373.

Frith, R.A.
1973: The geology of the Bear-Slave boundary in the Indin Lake area, District of Mackenzie; in Report of Activities, Part A, Geological Survey of Canada, Paper 73-1A, p. 146-148.

1979: In Age Determinations and geological studies: K-Ar Isotopic Ages, Report 14; ed. R.K. Wanless, R.D. Stevens, G.R. Lachance and R.N. Delabio; Geological Survey of Canada, Paper 79-2, p. 39.

1981: Preliminary account of the geology of the Beechey Lake-Duggan Lake map areas, District of Mackenzie; in Current Research, Part A, Geological Survey of Canada, Paper 81-1A, p. 333-339.

1982a: Geology, Beechey Lake-Duggan Lake map areas, District of Mackenzie: 1:125 000 scale map; Geological Survey of Canada, Open File 851.

1982b: Second preliminary report on the geology of the Beechey Lake-Duggan Lake map areas, District of Mackenzie; in Current Research, Part A, Geological Survey of Canada, Paper 82-1A, p. 203-211.

Frith, R.A., Fyson, W.K., and Hill, J.D.
1977: The geology of the Hackett-Back River greenstone belt – preliminary report; in Report of Activities, Part A, Geological Survey of Canada, Paper 77-1A, p. 415-423.

Frith, R.A. and Hill, J.D.
1975: The geology of the Hackett-Back River greenstone belt – preliminary account; in Report of Activities, Part C, Geological Survey of Canada, Paper 75-1C, p. 367-370.

Frith, R.A. and Loveridge, W.D.
1982: Ages of Yellowknife Supergroup volcanic rocks, granitoid intrusive rocks and regional metamorphism in the northeastern Slave Province; in Current Research, Part A, Geological Survey of Canada, Paper 82-1A, p. 225-237.

Frith, R.A. and Percival, J.A.
1978: Stratigraphy of the Yellowknife Supergroup in the Mara-Back rivers area, District of Mackenzie; in Current Research, Part C, Geological Survey of Canada, Paper 78-1C, p. 89-98.

Frith, R.A. and Roscoe, S.M.
1980: Tectonic setting and sulphide deposits of the Hackett River belt, Slave Province; Canadian Mining and Metallurgical Bulletin, v. 73, no. 815, p. 143-153.

Fyson, W.K. and Frith, R.A.
1979: Regional deformations and emplacement of granitoid plutons in the Hackett River greenstone belt, Slave Province, Northwest Territories; Canadian Journal of Earth Sciences, v. 16, p. 1187-1195.

Ghent, E.D.
1976: Plagioclase-garnet-Al_2O_3-quartz: a potential geothermometer-geobarometer; American Mineralogist, v. 61, p. 710-714.

Gross, G.A.
1965: Geology of iron deposits in Canada, volume 1: General geology and evaluation of iron deposits; Geological Survey of Canada, Economic Geology Report 22, 181 p.

Gilbert, C.M.
1954: Sedimentary rocks; in Petrography: An Introduction to the Study of Rocks in Thin Sections; p. 249-384, Freeman, San Francisco, 406 p.

Henderson, J.B.
1975a: Sedimentological studies of the Yellowknife Supergroup in the Slave Structural Province; in Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 325-330.

1975b: Sedimentology of the Archean Yellowknife Supergroup at Yellowknife, District of Mackenzie; Geological Survey of Canada, Bulletin 246, 62 p.

1985: Geology of the Yellowknife-Hearne Lake area, District of Mackenzie: a segment across an Archean Basin; Geological Survey of Canada, Memoir 414, 135 p.

Henson, B.J. and Green, D.H.
1971: Experimental study of the stability of cordierite in pelitic compositions at high pressures and temperatures; Contributions to Mineralogy and Petrology, v. 33, p. 309-330.

1972: Experimental study of the stability of cordierite in pelitic compositions at high pressures and temperatures; Part II, compositions without excess aluminosilicate; Contribution to Mineralogy and Petrology, v. 35, p. 331-354.

Hess, P.C.
1969: The metamorphic paragenesis of cordierite in pelitic rocks; Contributions to Mineralogy and Petrology, v. 24, p. 191-207.

Hill, J.D. and Frith, R.A.
1982: Petrology of the Regan Intrusive Suite, in the Nose Lake-Beechey Lake map area, District of Mackenzie, N.W.T.; Geological Survey of Canada, Paper 82-8, 26 p.

Holdaway, M.J.
1971: Stability of andalusite and the aluminum silicate phase diagram; American Journal of Science, v. 271, p. 91-131.

Holdaway, M.J. and Lee, S.M.
1977: Fe-Mg cordierite stability in high grade pelitic rocks based on experimental, theoretical and natural observations; Contributions to Mineralogy and Petrology, v. 63, p. 175-198.

Hutchison, W.W.
1982: Geology of the Prince Rupert-Skeena map area, British Columbia; Geological Survey of Canada, Memoir 394, 116 p.

Jefferson, C.W., Padgham, W.A., Bryan, M.P.D., Ronayne, E.A., Shegelski, R.J., Vandor, H., and Thorstad, L.E.
1976a: Geology NTS 76-F-15; Department of Indian Affairs and Northern Development, Economic Geology Series Map 1976-4 – preliminary edition (2 inch = 1 mile map with marginal notes).

Jefferson, C.W., Padgham, W.A., Bryan, M.P.D., Ronayne, E.A., Shegelski, R.J., Vandor, H., and Thorstad, L.E. (cont.)
1976b: Geology of Hackett River, NTS 76-F-16; Department of Indian Affairs and Northern Development, Economic Geology Series Map 1976-4 – preliminary edition (2 inch = 1 mile map with marginal notes).

Joly, W.T.
1978: Metamorphic history of the Archean Abitibi Belt; in Metamorphism in the Canadian Shield, ed. J.A. Fraser and W.W. Heywood; Geological Survey of Canada, Paper 78-10, p. 63-78.

King, R.
1836: Narrative of a Journey to the Shores of the Arctic Ocean in 1833, 1834 and 1835, Under the Command of Captain Back, R.N.; Richard Bentley, London.

Kuenen, P.H.
1964: Deep-sea sands and ancient turbidites; in Turbidites, ed. A.H. Bouma and A. Brouwer; Amsterdam, p. 3-33.

Lambert, M.B.
1975: Anatomy of a greenstone belt, Slave Province, N.W.T.; Geological Association of Canada, Special Paper 16, p. 331-340.

1976: The Back River Volcanic Complex, District of Mackenzie; in Report of Activities, Part A, Geological Survey of Canada, Paper 76-1A, p. 363-367.

1977: The southwestern margin of the Back River volcanic complex, District of Mackenzie; in Report of Activities, Part A, Geological Survey of Canada, Paper 77-1A, p. 179-180.

1978: The Back River volcanic complex – a cauldron subsidence structure of Archean age; in Current Research, Geological Survey of Canada, Paper 78-1A, p. 153-157.

1982a: The Back River volcanic complex, District of Mackenzie; Geological Survey of Canada, Open File 848 (1:25 000 map).

1982b: Felsic domes and flank deposits of the Back River volcanic complex, District of Mackenzie; in Current Research, Part A, Geological Survey of Canada, Paper 82-1A, p. 159-164.

Lambert, M.B. and Henderson, J.B.
1980: A uranium-lead age of zircons from volcanics and sediments of the Back River volcanic complex, eastern Slave Province, District of Mackenzie; in Current Research, Part C, Geological Survey of Canada, Paper 80-1C, p. 239-242.

Lord, C.S.
1951: Mineral industry of District of Mackenzie, Northwest Territories; Geological Survey of Canada, Memoir 261.

MacNeil, R.J.
1976: Twenty years of persistence at Bathurst-Norsemines is paying off; Canadian Mining Journal, v. 97/7, p. 28-38.

Middleton, G.V.
1972: Albite of secondary origin in Charney Sandstones, Quebec; Journal of Sedimentary Petrology, v. 42, p. 341-349.

Nicholls, P.R.J.
1976: The geology of Agricola Lake area with a study of the mineralization and associated hydrothermal alteration at anomaly 'Y', District of Mackenzie; unpublished B.Sc. thesis, Queen's University, Kingston.

Padgham, W.A., Bryan, M.P.D., Jefferson, C.W., Ronayne, E.A., and Sterenberg, V.Z.
1975a: Geology Agricola Lake, NTS 76-G-12; Department of Indian Affairs and Northern Development, Economic Geology Series 1975-2 – preliminary edition (2 inch = 1 mile map with marginal notes).

1975b: Geology of Index Lake, NTS 76-G-13 – preliminary edition; Department of Indian Affairs and Northern Development, Economic Geology Series 1975-2 (2 inch = 1 mile map with marginal notes).

Padgham, W.A., Sterenberg, V.Z., Bryan, M.P.D., Ronayne, E.A., and Jefferson, C.W.
1976: Geology 76-G-5; Department of Indian Affairs and Northern Development, Economic Geology Series, 1976-2.

Patchett, P.J., Bylund, G., and Upton, B.G.J.
1978: Paleomagnetism and the Grenville Orogeny: Raw Rb-Sr ages from dolerites in Canada and Greenland; Earth and Planetary Science Letters, v. 40, p. 349-364.

Percival, J.A.
1978: Stratigraphy, structure and metamorphism of the Hackett River gneiss dome, District of Mackenzie, N.W.T.; unpublished M.Sc. thesis, Queen's University, Kingston.

1979: Kyanite-bearing rocks from the Hackett River area, N.W.T.: implications for Archean geothermal gradients; Contributions to Mineralogy and Petrology, v. 69, p. 177-184.

Pettijohn, F.J.
1970: The Canadian Shield, a status report; in Symposium on Basins and Geosynclines of the Canadian Shield, ed. A.J. Baer; Geological Survey of Canada, Paper 70-40, p. 239-255.

Ridler, R.H.
1973: Automated contoured variation diagrams; in Volcanism and Volcanic Rocks; Geological Survey of Canada, Open File Report 164.

Roscoe, S.M.
1969: Huronian rocks and uraniferous conglomerates; Geological Survey of Canada, Paper 68-40.

1975: Geology of the Aitch Lake area; unpublished 1:50 000 scale map prepared for the Yava Syndicate.

Saliken, L.
1976: The Yava deposit; unpublished paper, Geoscience Forum, Yellowknife, December 1976.

Salop, L.I.
1971: Two types of Precambrian structures: folded gneiss ovals and gneiss domes; Bulletin of the Moscow Naturalists' Society, Geology Section, v. 46, p. 5-30 (Department of the Secretary of State, Ottawa, translation No. 518, 1972).

Sangster, D.F.
1972a: Geology of lead-zinc deposits in Canada; in Report of Activities, Part A, Geological Survey of Canada, Paper 72-1A, p. 48.

Sangster, D.F. (cont.)
1972b: Precambrian volcanogenic massive sulphide deposits in Canada: a review; Geological Survey of Canada, Paper 72-22, 44 p.

Schau, M.
1978: Metamorphism of the Prince Albert Group, District of Keewatin; in Metamorphism in the Canadian Shield, ed. J.A. Fraser and W.W. Heywood, Geological Survey of Canada, Paper 78-10, p. 203-213.

Schiller, E.A.
1964: Mineral industry of the Northwest Territories; Geological Survey of Canada, Paper 65-11.

Schiller, E.A. and Hornbrook, E.H.
1964: Mineral industry of District of Mackenzie, 1963; Geological Survey of Canada, Paper 64-22, p. 38-40.

Shegelski, R.J. and Thorpe, R.I.
1972: Study of selected mineral deposits in the Bear and Slave provinces; in Report of Activities, Part A, Geological Survey of Canada, Paper 72-1A, p. 93-96.

Stockwell, C.H.
1961: Structural provinces, orogenies and time classification of rocks of the Canadian Precambrian Shield; in Age Determinations by the Geological Survey of Canada, Geological Survey of Canada, Paper 61-17, p. 108-117.

1972: Revised Precambrian time scale for the Canadian Shield; Geological Survey of Canada, Paper 75-52, 4 p.

Streckeisen, A.
1976: To each plutonic rock its proper name; Earth Science Reviews, v. 12, p. 1-33.

1979: Volcanic rock classification after I.U.G.S. – Root names of effusive rocks; 25th circular, contribution no. 60, 5 p.

Taylor, S.
1976: The Yava property sulphide deposit, Hackett River, N.W.T.; unpublished paper, Suffel collection p. 19891-19909, University of Western Ontario, London.

Thorpe, R.I.
1972: Interpretation of lead isotope data for base metal and gold deposits, Slave Province, Northwest Territories; in Report of Activities, Part B, Geological Survey of Canada, Paper 72-1B, p. 72-77.

Thompson, A.B.
1976: Mineral reactions in pelitic rocks: I predictions of P-T-X (Fe-Mg) phase relations; II calculation of some P-T-X (Fe-Mg) phase relations; American Journal of Science, v. 276, p. 401-454.

Tremblay, L.P.
1965: In Age Determinations and Geological Studies, Part I – Isotopic Ages, Report 5, ed. R.K. Wanless, R.D. Stevens, G.R. Lachance, and R.Y.H. Rimsaite; Geological Survey of Canada, Paper 64-17 (Part 1), p. 31-33.

1966: In Age Determinations and Geological Studies, K-Ar Isotopic Ages, Report 6, ed. R.K. Wanless, R.D. Stevens, G.R. Lachance, and R.Y.H. Rimsaite; Geological Survey of Canada, Paper 65-17, p. 31-32.

Tremblay, L.P. (cont.)
1971: Geology of Beechey Lake map-area, District of Mackenzie: a part of the western Canadian Precambrian Shield; Geological Survey of Canada, Memoir 365, 56 p.

1976: Geology of northern Contwoyto Lake area, District of Mackenzie; Geological Survey of Canada, Memoir 381, 56 p.

Twenhofel, W.H.
1937: Terminology of the fine-grained mechanical sediments; National Research Council, Division of Geology and Geography, Annual Report for 1936-1937, Appendix 1, exhibit F, p. 81-104.

Wanless, R.K.
1970: Isotopic map of Canada; in Geology and Economic Minerals of Canada, ed. R.J.W. Douglas; Geological Survey of Canada, Economic Geology Report No. 1, map no. 1256A.

Wilton, H.P.
1975: Geology of the Bathurst-Norsemines region; unpublished compilation map of Cominco Limited, scale, 1 inch = 1/2 mile.

Wright, G.M.
1957: Geological notes on the eastern District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 56-10.

1960: In Age Determinations by the Geological Survey of Canada, Report 1 – Isotopic Ages; compiled by J.A. Lowdon; Geological Survey of Canada, Paper 60-17, p. 12-14.

APPENDIX

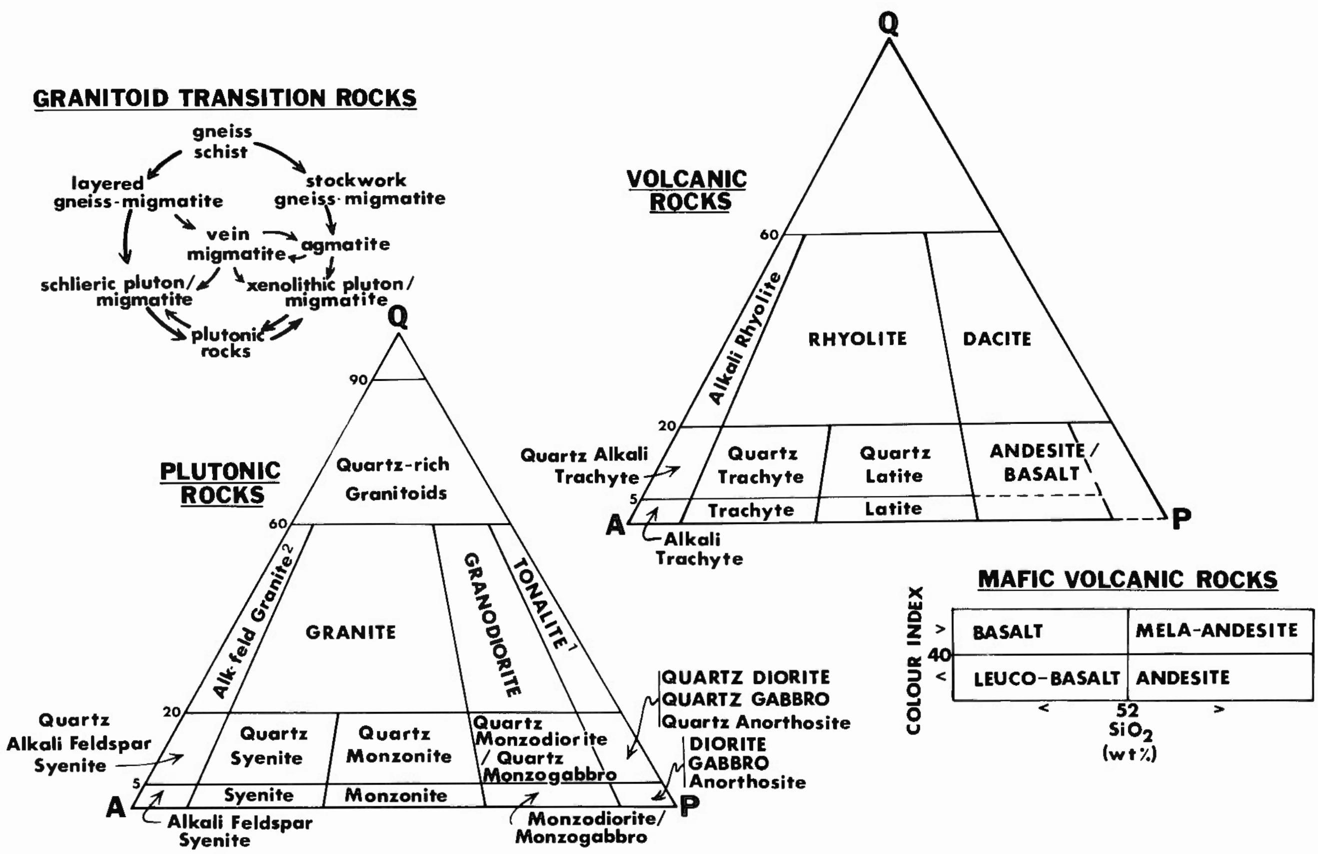
Rock Classification

A general scheme for classification of plutonic, volcanic and other granitoid rocks of the area is outlined in Figure 43.

Modal proportions of quartz and feldspar were used to classify plutonic rocks using the scheme defined by the International Union of Geological Sciences subcommission on the systematics of igneous rocks and summarized by Streckeisen (1976). Chemical analyses were calculated to give mesonormative mineral proportions for plutonic rocks using a computer program provided by K.L. Currie, which was adapted from Barth (1959). Correlation between pointcount and mesonorm calculations was illustrated in a quartz-potassium feldspar-plagioclase triangulation diagram for the Regan Intrusive Suite (Hill and Frith, 1982).

Transitions from plutonic rocks to gneiss and migmatite were classified according to a modified graphical scheme proposed by Hutchison (1982) and illustrated in Figure 43.

Volcanic rocks were treated to CIPW norm calculations which allows a mafic index to be calculated from the proportion of mafic minerals. This index was density contoured against the silica content after the method proposed by Ridler (1973). Typical examples from the contoured centres fall within the volcanic fields proposed by the IUGS subcommission (Streckeisen, 1979; see Fig. 14).



NOTE: 1 Trondhjemite where mafic index is 0-10
2 Alaskite where mafic index is 0-10

Figure 43. Igneous and granitoid transition rock classification adapted from Streckeisen (1976, 1979) and Hutchison (1982).

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