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PRE-CARBONIFEROUS GEOLOGY OF THE NORTHERN PART OF THE ARCTIC ISLANDS

H.P. Trettin

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Northern Heiberg Fold Belt, Clements Markham Fold Belt, and Pearya; northern Axel Heiberg and Ellesmere islands

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A. B.S. Norford and A.E.H. Pedder
B. T.T. Uyeno, G.S. Nowlan, R.V. Tipnis, and C.R. Barnes
C. M.J. Copeland and D.C. McGregor
D. T.A. de Freitas

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Cover illustration
Exposures of Pearya on Harley Ridge, east of the head of M'Clintock Inlet, view east; relief about 1 km. (For explanation, see Figure 126.)

Critical reviewers

R. Thorsteinsson
T. de Freitas

Author's address

P.O. Box 76
Manson's Landing, British Columbia
V0P 1K0

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PREFACE

Northern Ellesmere and Axel Heiberg islands contain unique exposures of pre-Carboniferous rocks significant to the geological history of the circum-polar region. A large area in northeasternmost Ellesmere Island has been selected as the site of a National Park because of its scenic, environmental, and geological interest. The remainder of the region has economic potential apparent from showings of copper, zinc, and lead minerals.

This area was first explored in 1875, but systematic exploration by the Geological Survey of Canada did not begin until 1953. Because of the remoteness of the area, its rugged topography, and complex geological history, a coherent geological framework has emerged only recently. This framework is portrayed in two companion reports: Bulletin 430, published in 1994, which covers the southern part of region, and this bulletin, which covers the northern part.

M.D. Everell
Assistant Deputy Minister
Earth Sciences Sector

PRÉFACE

Des affleurements uniques de roches pré-carbonifères riches d'enseignement sur l'histoire géologique de la région circumpolaire se rencontrent dans le nord de l'île d'Ellesmere et de l'île Axel Heiberg. Une vaste partie de l'extrême nord-est de l'île d'Ellesmere a été choisie comme site pour un parc national en raison de l'intérêt panoramique, environnemental et géologique quelle présente. Le reste de la région offre un potentiel économique, comme en témoignent des traces de cuivre, de zinc et de plomb.

La région a été explorée pour la première fois en 1875, mais la Commission géologique du Canada n'en a commencé l'exploration systématique qu'en 1953. En raison de l'éloignement de la région, de son relief élevé et de la complexité de son histoire géologique, ce n'est que récemment qu'on a pu élaborer un cadre géologique cohérent. Celui-ci est décrit dans deux rapports complémentaires : le Bulletin 430, publié en 1994, qui couvre la partie sud de la région, et le présent bulletin, qui couvre la partie nord.

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

Frontispiece: *Exposures of Pearya on west side of M'Clintock Inlet (**M'Clintock Inlet**), view to northwest.* uPЄC: *carbonates of Succession 2 (Neoproterozoic and/or Cambrian);* uPЄS: *schist of Succession 2 (Neoproterozoic and/or Cambrian);* LOum: *predominantly ultramafic rocks of M'Clintock West body of Thores Suite (Lower Ordovician);* g: *granitoid plutons within M'Clintock West body (Lower Ordovician);* OMI: *Maskell Inlet Complex (Lower Ordovician?);* OCD: *Cape Discovery Formation (Caradoc);* OCD1: *member A of Cape Discovery Formation (Caradoc);* OMC: *M'Clintock Formation (Caradoc–Ashgill);* OA: *Ayles Formation (Ashgill);* OTR: *Taconite River Formation (Ashgill);* OZC: *Zebra Cliffs Formation (Ashgill);* OZC1: *Zebra Cliffs Formation, Member A, lower resistant unit (Ashgill);* OOC: *Ooblooyah Creek Formation (Ashgill);* SDR: *Danish River Formation (Lower Silurian);* CC: *Canyon Fiord Formation (Carboniferous);* Q: *Quaternary sediments. Oblique air photograph NAPL T404R-15.*

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PRE-CARBONIFEROUS GEOLOGY OF THE NORTHERN PART OF THE ARCTIC ISLANDS

Northern Heiberg Fold Belt, Clements Markham Fold Belt, and Pearya; northern Axel Heiberg and Ellesmere islands

Abstract

This report describes and interprets the geology of three tectono-stratigraphic belts in the northernmost part of the Canadian Arctic Archipelago that differ in structural trend and in aspects of their stratigraphy and tectonic histories. The southeast-trending Northern Heiberg Fold Belt of Axel Heiberg Island contains about 8 km of strata ranging in age from Early Cambrian or older to Early Devonian. The southwest-trending Clements Markham Fold Belt of northern Ellesmere Island contains 4 to 5 km of strata ranging from Early Cambrian or older to Late Silurian. Pearya is limited to northernmost Ellesmere Island and has highly diverse structural trends. It comprises a Mesoproterozoic crystalline basement and probably more than 8 km of supracrustal strata that extend in age from Neoproterozoic to Late Silurian. Pearya is interpreted as a suspect terrane with Caledonian affinities that probably was accreted to the Clements Markham Fold Belt in Late Ordovician time. The strata of all three provinces consist of a considerable variety of sedimentary and volcanic rocks that were partly metamorphosed under greenschist to lower amphibolite facies conditions. Orogenies of late Mesoproterozoic–early Neoproterozoic and Early–Middle Ordovician ages were confined to Pearya. Several disturbances occurred in Pearya and the Clements Markham Fold Belt in Late Ordovician–earliest Silurian time. A Late Silurian–Early Devonian orogenic event, apparent in the Northern Heiberg Fold Belt, probably also affected Ellesmere Island. The Late Devonian–Early Carboniferous Ellesmerian Orogeny involved the entire report area. Six generations of granitoid intrusions, ranging in age from late Mesoproterozoic to Late Devonian, are of synorogenic or postorogenic origin, whereas granitoid intrusions of late Early Carboniferous and Late Cretaceous ages are of rift origin. An ultramafic-mafic suite is of Early Ordovician age, and mafic plutons range in age from Ordovician(?) to Late Cretaceous. Small showings of copper minerals occur in volcanic and carbonate rocks of the Clements Markham Fold Belt and Pearya.

Résumé

Le présent rapport donne une interprétation et une description de la géologie de trois domaines tectonostratigraphiques situés dans l'extrême nord de l'archipel Arctique canadien et différant quant à leur direction structurale et à divers aspects de leur histoire stratigraphique et tectonique. La zone de plissement de Northern Heiberg, de direction sud-est, est située dans l'île Axel Heiberg et comporte environ 8 km de strates dont l'âge varie du Cambrien précoce ou avant au Dévonien précoce. La zone de plissement de Clements Markham, de direction sud-ouest, est située dans le nord de l'île d'Ellesmere et renferme de 4 à 5 km de strates dont l'âge s'échelonne du Cambrien précoce ou avant au Silurien tardif. La Pearya, circonscrite à l'extrême nord de l'île d'Ellesmere, présente des directions structurales très variées. Elle comporte un socle cristallin mésoprotérozoïque et probablement plus de 8 km de strates supracrustales datant du Néoprotérozoïque au Silurien tardif. Elle est interprétée comme un terrane suspect d'affinités calédoniennes qui a probablement été accrété à la zone de plissement de Clements Markham à l'Ordovicien tardif. Les strates de ces trois provinces se composent d'une grande variété de roches sédimentaires et volcaniques qui ont été partiellement métamorphisées dans des conditions variant du faciès des schistes verts au faciès des amphibolites inférieur. Les orogenèses du Mésoprotérozoïque tardif-Néoprotérozoïque précoce et de l'Ordovicien précoce-moyen ne se sont manifestées que dans la Pearya. Plusieurs perturbations sont survenues en Pearya et dans la zone de plissement de Clements Markham pendant l'intervalle Ordovicien tardif-Silurien initial. Un épisode orogénique survenu pendant l'intervalle Silurien tardif-Dévonien précoce, dont les traces sont visibles dans la zone de plissement de Northern Heiberg, a probablement touché aussi l'île d'Ellesmere. L'orogenèse ellesmérienne du Dévonien tardif-Carbonifère précoce a affecté l'ensemble de la région couverte par le présent rapport. Six générations d'intrusions granitoïdes, dont l'âge s'échelonne du Mésoprotérozoïque tardif au Dévonien tardif, sont d'origine syntectonique ou post-tectonique; des intrusions granitoïdes de la fin du Carbonifère précoce et du Crétacé tardif proviennent de rifts. Une suite ultramafique-mafique remonte à l'Ordovicien précoce, et des plutons mafiques datent de l'Ordovicien(?) au Crétacé tardif. De petites traces de minéraux cuprifères se rencontrent dans des roches volcaniques et carbonatées de la zone de plissement de Clements Markham et de la Pearya.

Summary

The Northern Heiberg Fold Belt differs from the Hazen and Clements Markham fold belts of adjacent Ellesmere Island with respect to structural trend and Silurian–Early Devonian stratigraphy and tectonic history. It includes: (1) mafic metavolcanics and interbedded carbonates of probable Early Cambrian or older age (Jaeger Lake Formation, >425 m); (2) carbonates of probable Early Cambrian or older age (Aurland Fiord Formation, >600 m?); (3) thick, deep-water deposits of quartzite and phyllite of late Early Cambrian age (Grant Land Formation); (4) condensed deep-water deposits of radiolarian chert and minor resedimented carbonates of late Early Cambrian to Early Silurian age (Hazen Formation); (5) arc-type calc-alkaline andesite and basalt of probable Early Silurian age (Svartevaeg Formation, Member A, 1 km); (6) arc-derived sediment gravity-flow deposits and minor volcanics of late Early Silurian age (Svartevaeg Formation, Member B, >600 m); and (7) nonmarine and paralic sandstone, mudrock, and conglomerate of Early Devonian and (?)older age (Stallworthy Formation, 4 km).

An angular unconformity between the Svartevaeg and Stallworthy formations indicates a Late Silurian–Early Devonian deformation that can be interpreted as representing a plate collision that terminated the subduction regime. An angular unconformity between the Stallworthy Formation and Lower Carboniferous strata probably represents the Ellesmerian Orogeny. The northwesterly structural trends of this fold belt are parallel or subparallel to those in the central part of the Sverdrup Basin and in the Boothia Uplift and may represent reactivated Precambrian basement structures. Incompetent units of pre-Devonian age form complex minor folds. Competent units form extensive thrust sheets that were transported both to the northeast and to the southwest. The fold belt is intruded by an undated gabbro pluton and by small granitoid plutons and felsic dykes that have yielded Late Devonian zircon ages (370–360 Ma). Inherited zircon in both types of intrusions was derived from Paleoproterozoic sources.

The Clements Markham Fold Belt is a heterogeneous tectonic province that lies between the Hazen Fold Belt on the southeast and Pearya on the northwest. Structural trends are mainly west-southwest, parallel with the overall orientation of the belt, but anomalous westerly to northwesterly trends occur in northwestern parts that may be underlain at depth by Pearyan basement. The Clements Markham Fold Belt is composed of deep-water sediments similar to those of the Hazen Fold Belt, but also includes volcanics, and a larger proportion of shallow-marine sediments. The strata are assigned to two major successions, A and B, that predate and postdate, respectively, sedimentary overlap in latest Llandovery time.

Succession A is present in five outcrop belts that differ in the age range of the rocks and in stratigraphy. The stratigraphy of the southeastern belt is similar to that of the Northern Heiberg Fold Belt. It includes: (1) tholeiitic mafic metavolcanics and interstratified sediments of probable Early Cambrian or older age (Yelverton Formation, >1 km; probably equivalent to the Jaeger Lake Formation); (2) the Grant Land Formation; (3) the Hazen Formation; and (4) shallow-marine carbonates, possibly olistoliths, of Early Silurian age (Yelverton Pass beds, about 100–200 m).

The remaining four belts contain Ordovician to Lower Silurian rocks. The stratigraphy (Hazen, Fire Bay, Kulutingwak and Phillips Inlet formations, Mount Rawlison Complex, map unit OSv) varies from one belt to another, but all contain subalkaline and alkalic suites of felsic to mafic volcanics that become younger from northwest to southeast. Associated with the volcanics are: shallow-marine carbonates or carbonate olistoliths; deep-water clastic sediments derived from a variety of sources including volcanics, carbonates, serpentinite, and Succession 2 of Pearya; and radiolarian chert.

Succession B overlaps Succession A and parts of Pearya. The lower part, latest Llandovery to early Ludlow in age, consists of flyschoid sediments assigned to two units that differ in lithology and detrital composition (Danish River Formation, late Llandovery, >500 m; Lands Lokk Formation, latest Llandovery to early Ludlow, >1 km). The upper part comprises a variety of predominantly shallow-marine carbonate and clastic sediments of middle to late Ludlow age (Markham River Formation, 166 m, and its facies equivalent, the Piper Pass Formation, ≥100 m).

Pearya is characterized by a distinct stratigraphy and tectonic history, and by highly diverse structural trends. It is interpreted as a suspect terrane that probably was accreted prior to latest Llandovery time but retained a certain stratigraphic identity in its northern part until the end of the record in the Late Silurian. The main outcrop area on the north coast of Ellesmere Island is divisible into three fault-bounded domains - Northeast, Central, and Southwest Pearya - that differ in structural trend and in the age range of the strata. Several minor, fault-bounded uplifts, located outside of the main outcrop area, are surrounded by Succession B of the Clements Markham Fold Belt (Imina Inlet, Yelverton Inlet, and Ayles Fiord inliers).

The rocks of Pearya are assigned to five successions:

1. A crystalline basement formed by plutonism and metamorphism in late Mesoproterozoic–early Neoproterozoic time, consisting mainly of granitoid gneiss, with minor amounts of schist, amphibolite and metasediments.

2. Unnamed metasediments and metavolcanics, ranging in age from Neoproterozoic to Early Ordovician, which probably unconformably overlie Succession 1, although the contacts are concealed, sheared, or faulted. Phyllite, marble, quartzite, and schists are abundant; conglomeratic greywacke (diamictite), greywacke, felsic and tholeiitic mafic metavolcanics, and metachert are less common. The metamorphic grade ranges from lower greenschist to lower amphibolite facies. Two widespread marker units, a diamictite that is probably glaciogenic in origin and Late Neoproterozoic (Varanger) in age, and shelf carbonates of probable Early Cambrian age, permit tentative lithological correlations. Felsic volcanics with a Tremadoc[1] zircon age (ca. 503 +8/-2 Ma) occur near the top of the succession.

3. A variably metamorphosed, intensely deformed unit of pre-late Middle Ordovician age, composed of arc-type andesite and basalt with some carbonates, clastics, and chert (Maskell Inlet Complex). The faulted contact with Succession 2, which is unconformably overlain by lower Caradoc strata of Succession 4, is interpreted as a suture. Succession 3 is tentatively correlated with an ultramafic-mafic-granitoid suite, interpreted as a subarc plutonic complex, that has yielded an Arenig (481 +7/-6 Ma) U-Pb age (Thores Suite).

4. Clastics, carbonates, and volcanics of Caradoc–Ashgill age, which overlie parts of Successions 2 and 3 with angular unconformity (Egingwah Group: Cape Discovery Formation, 1 km; M'Clintock Formation, >1 km; Ayles Formation, 1 km).

5. A thick sedimentary succession of Ashgill to Late Silurian age, divisible into two parts: (A) Clastic and carbonate sediments of Ashgill age that overlie Succession 3 with a low-angle unconformity, and parts of Succession 2 with a high-angle unconformity (Harley Ridge Group; Taconite River Formation, 0->600 m; Zebra Cliffs Formation, 0.3->1 km). (B) Clastic and carbonate sediments with an age range of Ashgill to Late Silurian that represent different facies configurations during three different time intervals. During a later part of Ashgill time, a large, shallow-marine shelf, which received clastic and minor carbonate sediments (Lorimer Ridge Formation, 813 m), was bordered on the northwest by a submarine slope or basin that received resedimented carbonates and mudrock, and contains a graptolitic fauna (Ooblooyah Creek Formation, ±400 m). This facies differentiation probably resulted from vertical movements, also indicated by a low-angle unconformity at the base of the Lorimer Ridge Formation. During the subsequent, latest Ordovician to early Ludlow interval, two additional deep-water belts developed in the previous shelf region that were separated by shallow-marine carbonates (lower Marvin Formation). The record of the two southeastern clastic belts is limited to a unit of sandstone, conglomerate, and mudrock of middle Llandovery and (?)older age (Cranstone Formation, ±1 km); the record of the northwestern belt, to parts of the Danish River (±230 m) and Lands Lokk formations.

[1]The stratigraphic age is Late Cambrian with confidence limits in the Middle and Late Cambrian according to a time scale by Tucker and McKerrow (1995), published after the completion of this report.

During middle to late Ludlow or Pridoli time, the entire area was probably covered by shallow-marine carbonate and clastic sediments preserved in only a few areas (upper Marvin Formation, ±150 km to >500 m; Crash Point beds, >100 m).

Unconformities and intrusions indicate two orogenies prior to terrane accretion: the late Mesoproterozoic to early Neoproterozoic Grenville Orogeny, which was accompanied by granitoid plutonism at 1.1–1.0 and 0.965 Ga; and the Early–Middle Ordovician M'Clintock Orogeny, which is interpreted as the collision of an island arc (Succession 3 and Thores Suite) with continental blocks of similar composition (Successions 1 and 2) on two sides. The event is dated by a syntectonic granodiorite with an Arenig (475±1 Ma) monazite age. The accompanying metamorphism ranges from subgreenschist to lower amphibolite grade. The rectangular to arcuate trend of the southeastern part of the orogen probably reflects a re-entrant on an earlier rifted margin.

Pearya is related to the Caledonides by the Grenville age of its crystalline basement and by an Early–Middle Ordovician event (M'Clintock Orogeny) that involved ultramafic complexes. In contrast, the crystalline basement rocks in the rest of the Arctic Islands and North Greenland are of Paleoproterozoic and Archean ages, and there is no evidence for an Ordovician deformation or of a corresponding clastic wedge.

If Pearya is indeed exotic, it was probably accreted between Llandeilo and latest Llandovery time, most likely during the Ashgill, when a signficant disturbance, marked by the unconformity at the base of Succession 5, occurred in Pearya. The mode of accretion remains uncertain because present fault contacts between Pearya and Succession A of the Clements Markham Fold Belt are probably younger than the event. The absence of extensive thrust faulting during the critical interval, Caradoc to early late Llandovery, suggests that it was not a head-on collision. On the other hand, a hypothesis of oblique collision, partitioned into limited compression in northwestern parts of the region and sinistral strike-slip farther southeast, is permissible. The strike-slip, tentatively inferred from Pearya's affinities with the Caledonides, probably occurred on extensive linear faults or fault zones, such as the Emma Fiord Fault Zone, that were subsequently overlapped by Succession B and reactivated later under different stress conditions.

Pearya and the Clements Markham Fold Belt were subjected to orogenic activity from latest Silurian to Early Carboniferous time. In northwestern Ellesmere Island the following events can be distinguished: (1) folding of strata of the Clements Markham Fold Belt; (2) dextral movement of Central Pearya; (3) southeastward thrusting of the heated basement gneiss, which resulted in Barrovian metamorphism of lower amphibolite and greenschist grade in the adjacent Clements Markham Fold Belt. These movements probably occurred in Late Silurian or Early Devonian time, prior to the intrusion of the large Cape Woods Pluton, which has a Middle Devonian (390±10 Ma) U-Pb sphene age.

Farther southeast in the Clements Markham Fold Belt, chevron-type folding may have preceded the deposition of Middle–Upper Devonian clastic sediments (Okse Bay Formation), the base of which is concealed. These strata, which are tilted but not folded, are overlain by Carboniferous–Permian and Triassic formations with a low-angle unconformity that corresponds to the Ellesmerian Orogeny.

Small, post-tectonic granitoid intrusions are common in northwestern Ellesmere Island, and one has yielded a Late Devonian ^{40}Ar-^{39}Ar hornblende age (ca. 364±2 Ma), about co-eval with the intrusions on northern Axel Heiberg Island.

The project area has considerable mineral potential, but has not been explored systematically by industry. During the present geological reconnaissance project, four small showings of copper minerals, including tennantite and chalcocite, were found in Early Cambrian (or older) to Late Silurian carbonate and volcanic strata of Pearya and the Clements Markham Fold Belt.

Sommaire

La zone de plissement de Northern Heiberg diffère des zones de plissement de Hazen et de Clements Markham dans l'île d'Ellesmere voisine quant à la direction structurale et la stratigraphie et à l'histoire tectonique au Silurien-Dévonien précoce. Cette zone comprend (1) des roches métavolcaniques mafiques et des roches carbonatées interstratifiées datant probablement du Cambrien précoce ou avant (Formation de Jaeger Lake, >425 m); (2) des roches carbonatées datant probablement du Cambrien précoce ou avant (Formation d'Aurland Fiord, >600 m?); (3) des dépôts épais de quartzite et de phyllade d'eau profonde de la fin du Cambrien précoce (Formation de Grant Land); (4) des dépôts condensés d'eau profonde de radiolarite et de roches carbonatées resédimentées en quantités mineures dont l'âge s'échelonne de la fin du Cambrien précoce au Silurien précoce (Formation de Hazen); (5) des andésites et des basaltes calco-alcalins de type arc datant probablement du Silurien précoce (Formation de Svartevaeg, Membre A, 1 km); (6) des dépôts sédimentaires d'arc dus à des coulées gravitaires et des roches volcaniques peu abondantes datant de la fin du Silurien précoce (Formation de Svartevaeg, Membre B, >600 m); et (7) des grès, des mudrocks et des conglomérats non marins et paraliques du Dévonien précoce et(?) avant (Formation de Stallworthy, 4 km).

La présence d'une discordance angulaire entre les formations de Svartevaeg et de Stallworthy atteste une déformation au Silurien tardif-Dévonien précoce qu'on peut interpréter comme résultant d'une collision de plaques et qui a mis fin au régime de subduction. Une discordance angulaire entre la Formation de Stallworthy et les strates du Carbonifère inférieur représente vraisemblablement l'orogenèse ellesmérienne. Les directions structurales nord-ouest de cette zone de plissement sont parallèles ou subparallèles à celles de la partie centrale du bassin de Sverdrup et à celles du soulèvement de Boothia et représentent peut-être des structures de socle précambriennes remobilisées. Des unités incompétentes pré-dévoniennes sont déformées en plis mineurs complexes. Des unités compétentes apparaissent dans de vastes nappes de charriage qui ont été emportées vers le nord-est et le sud-ouest. La zone de plissement est recoupée par un pluton gabbroque non daté et par de petits plutons granitodes et dykes felsiques qui, d'après la datation des zircons, remontent au Dévonien tardif (370-360 Ma). Des zircons hérités dans les deux types d'intrusions sont dérivés de sources paléoprotérozoïques.

La zone de plissement de Clements Markham constitue une province tectonique hétérogène qui est située entre la zone de plissement de Hazen au sud-est et la Pearya au nord-ouest. Les directions structurales sont principalement ouest-sud-ouest, parallèles à l'orientation générale de la zone de plissement, mais on rencontre des directions atypiques ouest à nord-ouest dans des secteurs au nord-ouest dans lesquels il pourrait y avoir en profondeur un socle pearyen. La zone de plissement de Clements Markham comporte des roches sédimentaires d'eau profonde semblables à celles de la zone de plissement de Hazen, mais elle comprend également des roches volcaniques et une plus grande proportion de roches sédimentaires de mer peu profonde. On attribue ces strates à deux successions majeures, A et B, respectivement antérieure et postérieure au recouvrement sédimentaire au Llandovérien terminal.

La Succession A se rencontre dans cinq ceintures d'affleurement qui diffèrent quant à leur intervalle d'âges et leur stratigraphie. La stratigraphie de la ceinture sud-est est semblable à celle de la zone de plissement de Northern Heiberg. Elle comprend (1) des roches métavolcaniques mafiques tholéiitiques et des roches sédimentaires interstratifiées datant probablement du Cambrien précoce ou avant (Formation de Yelverton, >1 km; probablement équivalente à la Formation de Jaeger Lake); (2) la Formation de Grant Land; (3) la Formation de Hazen; et (4) des roches carbonatées de mer peu profonde, peut-être des olistolites, datant du Silurien précoce (lits de Yelverton Pass, environ 100-200 m).

Les quatre autres ceintures renferment des roches dont l'âge s'échelonne de l'Ordovicien au Silurien inférieur. Leur stratigraphie (formations de Hazen, de Fire Bay, de Kulutingwak et de Phillips Inlet, Complexe de Mount Rawlinson, unité cartographique OSv) varie d'une ceinture à

une autre, mais elles contiennent toutes des suites subalcalines et alcalines de roches volcaniques felsiques à mafiques qui deviennent progressivement plus jeunes en passant du nord-ouest au sud-est. Les roches suivantes sont associées aux roches volcaniques : roches carbonatées de mer peu profonde ou olistolites carbonatés; roches clastiques d'eau profonde dérivées de sources diverses, notamment de roches volcaniques, de roches carbonatées, de serpentinites, de la Succession 2 de la Pearya; et radiolarites.

La Succession B recouvre successivement la Succession A et des parties de la Pearya. La partie inférieure, qui date du Llandovérien terminal au Ludlowien précoce, comporte des roches flyschoïdes qui sont attribuées à deux unités de lithologie et de composition détritique différentes (Formation de Danish River, Llandovérien tardif, >500 m; Formation de Lands Lokk, Llandovérien terminal au Ludlowien précoce, >1 km). La partie supérieure comprend diverses roches carbonatées et clastiques essentiellement de mer peu profonde qui remontent au Ludlowien moyen à tardif (Formation de Markham River, 166 m, et son équivalent de faciès, la Formation de Piper Pass, ≥100 m).

La Pearya se caractérise par une stratigraphie et une histoire tectonique distinctes, ainsi que par des directions structurales très diverses. Elle est interprétée comme un terrane suspect qui a probablement été accrété avant le Llandovérien terminal, mais qui a conservé une certaine identité stratigraphique dans sa portion septentrionale jusqu'au Silurien tardif, âge des roches les plus récentes reconnues. L'aire d'affleurement principale sur la côte nord de l'île d'Ellesmere peut être divisée en trois domaines limités par des failles - la Pearya nord-est, la Pearya centrale et la Pearya sud-ouest -, qui diffèrent eu égard à la direction structurale et à l'intervalle d'âges des strates. Plusieurs de soulèvements mineurs, limités par des failles, situés a l'exterieur de l'aire d'affleurement principale, sont entourés par des roches de la Succession B de la zone de plissement de Clements Markham (boutonnières d'Imina Inlet, Yelverton Inlet et Ayles Fiord).

Les roches de la Pearya se répartissent en cinq successions :

1. Un socle cristallin façonné par plutonisme et métamorphisme au Mésoprotérozoïque tardif-Néoprotérozoïque précoce et composé essentiellement de gneiss granitoïdes, avec des quantités mineures de schistes, d'amphibolites et de roches métasédimentaires.

2. Des roches métasédimentaires et métavolcaniques innommées, dont l'âge s'échelonne du Néoprotérozoïque à l'Ordovicien précoce, qui recouvrent vraisemblablement en discordance la Succession 1, bien que les contacts soient cachés, cisaillés ou faillés. On trouve en abondance des phyllades, des marbres, des quartzites et des schistes et, en quantités moindres, des grauwackes conglomératiques (diamictites), des grauwackes, des roches métavolcaniques felsiques et mafiques tholéiitiques et des cherts métamorphisés. Le degré de métamorphisme varie du faciès des schistes verts inférieur au faciès des amphibolites inférieur. Deux unités repères répandues, une diamictite probablement d'origine glaciogène datant du Néoprotrozoïque tardif (Varangérien) et des roches carbonatées de mer peu profonde datant probablement du Cambrien précoce, permettent d'établir des corrélations lithologiques provisoires. Des roches volcaniques felsiques, dont la datation du zircon donne un âge du Trémadocien[1] (503 +8/-2 Ma), se rencontrent près du sommet de la succession.

3. Une unité inégalement métamorphisée et intensément déformée, antérieure à la fin de l'Ordovicien moyen, qui est composée d'andésites et de basaltes de type arc et d'une certaine quantité de roches cabonatées, de roches clastiques et de cherts (Complexe de Maskell Inlet). Le contact faillé avec la Succession 2, qui est recouverte en discordance par des strates du Caradocien inférieur de la Succession 4, est interprété comme une suture. La Succession 3 est

[1]L'âge stratigraphique est le Cambrien tardif, avec des limites de confiance au Cambrien moyen et au Cambrien tardif selon une échelle chronologique établie par Tucker et McKerrow (1995) et publiée après achèvement du présent rapport.

provisoirement corrélée avec une suite ultramafique-mafique-granitoïde, interprétée comme un complexe plutonique sub-arc, qui donne un âge arénigien (481 +7/-6 Ma) selon la méthode U-Pb (Suite de Thores).

4. Des roches clastiques, carbonatées et volcaniques du Caradocien-Ashgillien, qui sont séparées par une discordance angulaire de certaines parties des Successions 2 et 3 (Groupe d'Egingwah : Formation de Cape Discovery, 1 km; Formation de M'Clintock, >1 km; Formation d'Ayles, 1 km).

5. Une épaisse succession sédimentaire dont l'âge s'échelonne de l'Ashgillien au Silurien tardif, qui est divisible en deux parties : (A) des roches clastiques et carbonatées de l'Ashgillien, qui recouvrent avec discordance à angle faible la Succession 3, et avec discordance à angle fort une partie de la Succession 2 (Groupe de Harley Ridge; Formation de Taconite River, 0->600 m; Formation de Zebra Cliffs, 0,3->1 km); (B) des roches clastiques et carbonatées datant de l'Ashgillien au Silurien tardif, qui représentent diverses configurations de faciès au cours de trois intervalles d'âges distincts. Plus tard à l'Ashgillien, une vaste plate-forme épicontinentale, sur laquelle se sont accumulés des sédiments clastiques et des quantités mineures de sédiments carbonatés (Formation de Lorimer Ridge, 813 m), jouxtait au nord-ouest un talus ou bassin sous-marin sur lequel se sont accumulés des roches carbonatées et des mudstones resédimentés et qui contient une faune graptolitique (Formation d'Ooblooyah Creek, ±400 m). Cette différenciation de faciès résulte probablement de mouvements verticaux, dont atteste également la présence d'une discordance à angle faible à la base de la Formation de Lorimer Ridge. Pendant l'intervalle subséquent de l'Ordovicien terminal au Ludlowien précoce, deux autres ceintures de roches d'eau profonde se sont formées sur l'ancienne plate-forme, ceintures séparées par des roches carbonatées de mer peu profonde (partie inférieure de la Formation de Marvin). Les deux ceintures de roches clastiques du sud-est ne sont représentées aujourd'hui que par une unité de grès, de conglomérats et de mudstones datant du Llandovérien moyen et(?) avant (Formation de Cranstone, ±1 km); la ceinture au nord-ouest est représentée par des parties des formations de Danish River (±230 m) et de Lands Lokk. Au cours de l'intervalle du Ludlowien moyen à tardif ou Pridolien, l'ensemble de la région a vraisemblablement été recouvert de sédiments carbonatés et clastiques de mer peu profonde qui, aujourd'hui, ne sont conservés que par endroits (partie supérieure de la Formation de Marvin, ±150 km à >500 m; lits de Crash Point, >100 m).

La présence de discordances et d'intrusions témoigne de deux orogenèses antérieures à l'accrétion du terrane : l'orogenèse grenvillienne, du Mésoprotérozoïque tardif au Néoprotérozoïque précoce, qua accompagné un plutonisme granitoïde à 1,1-1,0 et à 0,965 Ga; et l'orogenèse de M'Clintock, de l'Ordovicien précoce-moyen, interprétée comme la collision d'un arc insulaire (Succession 3 et Suite de Thores) avec des blocs continentaux de composition semblable (Successions 1 et 2) de deux côtés. L'âge de cet événement est indiqué par un complexe syntectonique de granodiorite dont la monazite datée de l'Arénig (475 ± 1 Ma). Le degré du métamorphisme contemporain varie du faciès proche des schistes verts au faciès des amphibolites inférieur. La configuration rectangulaire à arquée de la partie sud-est de l'orogenèse reflète probablement un rentrant le long d'une ancienne marge de divergence.

La Pearya s'apparente aux Calédonides par l'âge grenvillien de son socle cristallin et par un événement datant de l'Ordovicien précoce-moyen (orogenèse de M'Clintock) qui a touché des complexes ultramafiques. Par contraste, les roches du socle cristallin dans le reste de l'archipel Arctique et dans le Groenland septentrional datent du Paléoprotérozoïque et de l'Archéen, et lon y trouve aucun indice de déformation ordovicienne ou de prisme de roches clastiques correspondant.

Si le terrane de la Pearya est réellement allochtone, il a probablement été accrété pendant l'intervalle Llandéilien-Llandovérien terminal, très vraisemblablement à l'Ashgillien, lorsque s'est produite dans la Pearya une importante perturbation marquée par la discordance à la base de la

Succession 5. Le mode d'accrétion reste incertain parce que les contacts de faille actuels entre la Pearya et la Succession A de la zone de plissement de Clements Markham sont probablement plus jeunes que cet événement. L'absence de chevauchements importants au cours de l'intervalle critique, soit du Caradocien au début du Llandovérien tardif, laisse supposer qu'il n'y a pas eu collision frontale. Est plausible en revanche l'hypothèse d'une collision oblique, marquée par une compression limitée dans les secteurs nord-ouest de la région et un décrochement senestre plus loin au sud-est. Ce décrochement, déduit provisoirement à partir des affinités de la Pearya avec les Calédonides, a probablement eu lieu le long de failles linéaires ou de zones de failles de vaste étendue, par exemple la zone de failles d'Emma Fiord, lesquelles ont été ultérieurement recouvertes par la Succession B et remobilisées par la suite sous régime de contraintes différent.

La Pearya et la zone de plissement de Clements Markham ont été soumises à une activité orogénique du Silurien terminal au Carbonifère précoce. La séquence d'événements suivante est reconnue dans le nord-ouest de l'île d'Ellesmere : (1) plissement des strates de la zone de plissement de Clements Markham; (2) mouvement dextre de la Pearya centrale; (3) chevauchement vers le sud-est du socle gneissique chauffé, qui a engendré un métamorphisme de type barrowien du faciès des amphibolites inférieur et du faciès des schistes verts dans la zone de plissement adjacente de Clements Markham. Ces mouvements ont probablement eu lieu au Silurien tardif ou au Dévonien précoce, avant l'intrusion du vaste Pluton de Cape Woods, dont les sphènes ont été datés du Dévonien moyen (390 ± 10 Ma) par la méthode U-Pb.

Plus au sud-est dans la zone de plissement de Clements Markham, la formation de plis de type en chevron a peut-être eu lieu avant le dépôt de sédiments clastiques au Dévonien moyen-tardif (Formation d'Okse Bay), dont la base est cachée. Ces strates, qui sont basculées mais non plissées, sont séparées des formations sus-jacentes du Carbonifère-Permien et du Trias par une discordance à angle faible correspondant à l'orogenèse ellesmérienne.

De petites intrusions granitodes post-tectoniques abondent dans le nord-ouest de l'île d'Ellesmere. Une d'entre elles, dont la hornblende a été datée du Dévonien tardif par la méthode ^{40}Ar-^{39}Ar (environ 364 ± 2 Ma), est à peu près contemporaine des intrusions dans le nord de l'île Axel Heiberg.

La région étudiée présente un potentiel minéral considérable, mais n'a pas encore été explorée de manière systématique par le secteur privé. Au cours du présent projet de reconnaissance géologique, quatre petites traces de minéraux cuprifères, notamment de tennantite et de chalcosite, ont été découvertes dans des strates carbonatées et volcaniques du Cambrien précoce (ou avant) au Silurien tardif dans la Pearya et la zone de plissement de Clements Markham.

CHAPTER 1

CONTENTS

INTRODUCTION

This is the second and final part of a comprehensive report on the pre-Carboniferous geology of northern Ellesmere and Axel Heiberg islands. It presents systematic descriptions of all stratigraphic, metamorphic, and intrusive units in the northern three subprovinces, except for Middle–Upper Devonian strata at Yelverton Pass and de Vries Glacier, in the *Tanquary Fiord*[1] map area, recently described by Mayr (1992).

LOCATION AND ACCESSIBILITY OF REPORT AREA

The report area covers the northernmost parts of Axel Heiberg and Ellesmere islands (Fig. 1, in pocket). The nearest airline terminal is at Resolute Bay on Cornwallis Island where charter aircraft can be obtained. The weather station at Eureka on Ellesmere Island maintains an air strip suitable for large aircraft all year round. An airstrip suitable for medium-sized airplanes (such as the Douglas DC3) is available during the summer months at the head of Tanquary Fiord, the seasonal headquarters of the Ellesmere Island National Park Reserve. This area, which includes a northeastern part of the report area, is subject to special regulations concerning aircraft landing, camping, and sampling.

In northern Axel Heiberg Island, lowlands with possible landing sites for STOL aircraft equipped with balloon tires are present around Rens Fiord and Eetookashoo Bay (*Cape Stallworthy*). Northernmost Ellesmere Island lies in the northern half of the glacier-covered Grantland Mountains. Most of the region requires helicopters for effective fieldwork, but possible landing sites for STOL aircraft are present on gravel bars and river terraces. Snow and weather conditions limit the season for aircraft-supported geological fieldwork from about early July to early or middle August. On clear days the Grantland Mountains can be traversed by helicopter without difficulty. On days with cloud cover higher than about 700 m, the north coast region is still accessible from the south via Yelverton Pass (*Tanquary Fiord* and *Yelverton Inlet*) and Piper Pass (*Clements Markham Inlet–Robeson Channel*). On warm days the north coast is commonly covered by fog.

PREVIOUS GEOLOGICAL WORK AND PRESENT INVESTIGATIONS

The first geological exploration of parts of northeasternmost Ellesmere Island was carried out in 1875 and 1876 by members of a British naval expedition led by Sir George Nares (Feilden and de Rance, 1878). Reconnaissance mapping by the Geological Survey of Canada (GSC) was initiated in the same area by R.G. Blackadar in 1953 (Blackadar, 1954). R.L. Christie, also of the Geological Survey, explored the north coast

[1]All National Topographic map sheet names are italicized throughout the text.

of Ellesmere Island between Ward Hunt Island and Nansen Sound in 1954 (Christie, 1957) and parts of northeastern Ellesmere Island in 1957 and 1958 (Christie, 1964). His work formed part of a multidisciplinary project organized by G. Hattersley-Smith of the Canadian Defence Research Board. All these early explorations were done on foot or with dogs and sleds.

In 1955, in the course of the helicopter-supported Operation Franklin of the GSC, E.F. Roots made a brief landing at the Svartevaeg Cliffs of northern Axel Heiberg Island (Roots, 1963). In 1957, R. Thorsteinsson explored parts of northern Axel Heiberg Island and Fire Bay at Emma Fiord, Ellesmere Island, using dogs and sleds (Thorsteinsson and Tozer, 1960, p. 8, 10, 11). P.E. Fricker, a member of the Jacobsen-McGill University Arctic Research Expedition led by F. Müller, carried out airplane-supported fieldwork on northern Axel Heiberg Island in 1961 (Fricker and Trettin, 1962). I began geological fieldwork in northern Axel Heiberg and northwestern Ellesmere islands in 1961 and 1962 (Trettin, 1969a) as part of an aircraft-supported project of the GSC directed by R. Thorsteinsson that was based at Eureka (Operation Eureka). T.O. Frisch and I participated in another aircraft-supported program of the GSC in northeastern Ellesmere Island, organized by R.L. Christie in 1965 and 1966 and continued independently in 1967. Frisch investigated metamorphic and plutonic rocks on the north coast (Frisch, 1974). My investigations were concerned mainly with the sedimentary and volcanic strata, but also included some metamorphic and plutonic rocks (Trettin, 1969b, 1971b). Most of the work during the 1960s was done on foot from fly camps with some traverses by Piper Super Cub airplanes or small helicopters. For logistical reasons we commonly worked alone, combining camp moves with geological traverses and returning to base camp infrequently.

In 1975 I began a new program intended to complete the reconnaissance of the pre-Carboniferous rocks in northern Ellesmere and Axel Heiberg islands and also took on overall responsibility for mapping those parts of northern Ellesmere Island not covered during Operation Eureka. U. Mayr was responsible for mapping the Carboniferous to Tertiary strata (see below, Geological Maps). Extending until 1992, the study of the pre-Carboniferous rocks comprised 11 field seasons, and part or all of each season was spent in the present report area. This program involved re-investigation of areas reconnoitered during the 1960s and exploration of previously unmapped terrains. Other geologists were invited to participate in this program whenever sufficient helicopter transport was available. Although most of the work still was done from fly camps, greater use was made of helicopters. Larger machines with turbine engines, used from 1977 onward, and widely spaced gas caches permitted more extensive flights. In order to cover this large and rugged area and to cope with its changeable weather conditions, I continued to work alone much of the time, carrying additional fuel in the helicopter during camp moves and traverses. Nevertheless, I was accompanied by student assistants during two entire seasons and revisited key areas with colleagues whenever this was logistically feasible.

For the record, here is a brief summary of individual field seasons:

1. 1975. I organized a helicopter-supported field program for northwestern Ellesmere Island with base camps at Tanquary Fiord and south of Kulutingwak Fiord (*Yelverton Inlet*). I investigated parts of the Hazen Fold Belt, Clements Markham Fold Belt, and Pearya (Trettin, 1976), and T.O. Frisch (1976) studied the crystalline rocks of the Clements Markham Fold Belt and Pearya. U. Mayr (1976) mapped Devonian to Tertiary strata and studied the Devonian to Permian stratigraphy. D.G. Wilson (1976) was responsible for the Mesozoic and Tertiary stratigraphy.

2. 1977. I organized a similar helicopter-supported program, mainly for northeastern Ellesmere Island, that was based on camps at Lake Hazen, Clements Markham Inlet, and Tanquary Fiord. During that summer I investigated parts of Pearya and the Clements Markham and Hazen Fold belts and began a study of the Central Ellesmere Fold Belt on southwestern Judge Daly Promontory. U. Mayr continued mapping the Carboniferous to Tertiary rocks. Stratigraphic responsibilities were divided as follows: Carboniferous and Permian - U. Mayr (1992), Mesozoic - A.F. Embry (1991), Tertiary - A.D. Miall (1979, 1980).

3. 1979. I continued my investigations of Pearya and the Central Ellesmere, Hazen and Clements Markham fold belts. Working out of fly camps, I received helicopter support from A.F. Embry who studied Mesozoic strata of the Sverdrup Basin from base camps at Eureka and Tanquary Fiord.

4. 1980. I carried out extensive helicopter traverses of the entire project area from a base camp at Tanquary Fiord, and additional foot traverses from fly camps reached by a helicopter of the Polar Continental Shelf Project based at Eureka.

5. 1981. Helicopter support from a Petro-Canada field party based at Tanquary Fiord enabled me to do about one month of stratigraphic studies in Pearya at M'Clintock Inlet and Disraeli Fiord.

6. 1982. I organized another helicopter-supported field program based at Tanquary Fiord. As previously, I investigated parts of Pearya and of the Central Ellesmere, Hazen, and Clements Markham fold belts while U. Mayr continued the mapping and stratigraphic studies begun in 1975. D.G. Long (1989a, b) studied lower Paleozoic strata of the Central Ellesmere Fold Belt south of the project area, and A.K. Higgins and N.J. Soper (1983) investigated the Lake Hazen Fault Zone near Tanquary Fiord.

7. 1984. Assisted by G. Stewart, I carried out stratigraphic studies from fly camps in the Central Ellesmere and Hazen fold belts. In addition I made two airborne traverses of parts of the Clements Markham and Hazen fold belts. Logistical support was provided by a helicopter of the Polar Continental Shelf Project based at Eureka and by airplanes based at Resolute.

8. 1986. I re-investigated much of the Northern Heiberg Fold Belt and a western part of the Clements Markham Fold Belt (Trettin, 1987a). I was assisted by G. Check and again received logistical support from the Polar Continental Shelf Project out of Eureka and Resolute.

9. 1988 and 1990. I directed a new helicopter-supported program based at Tanquary Fiord. In 1988 parts of Pearya and the Clements Markham Fold Belt were studied by M. Bjornerud (1989), Y. Ohta (Ohta and Klaper, 1992), and me, and parts of the Hazen Fold Belt by E. Klaper (1990). L. Maurel (1989) investigated the structure of Carboniferous to Cretaceous formations exposed along Yelverton Pass.

10. 1990. Studies of the Clements Markham Fold Belt and Pearya were made by M. Bjornerud and her assistant, K. Hajcek (Bjornerud, 1991; Hajcek, 1992), E. Klaper (1992a, b; Klaper and Ohta, 1993) and me, while D.G. Esson, a senior assistant, carried out stratigraphic and structural work in the Hazen Fold Belt (in Trettin, 1994). M.J. Cecile (Hofmann et al., 1994), M.K. Kos'ko, and B.G. Lopatin (Lopatin et al., 1993) participated in the fieldwork for two weeks.

11. 1992. I re-investigated parts of the Northern Heiberg and Clements Markham fold belts with helicopter support from B. Beauchamp, who was carrying out studies of upper Paleozoic strata from a base camp at Otto Fiord.

SCOPE AND ORGANIZATION OF REPORT

The report area is stratigraphically and structurally the most complex part of the Innuitian Orogen but has been studied far less than areas of comparable complexity in the Appalachian and Cordilleran orogens. This is due to the remoteness of the region, short field seasons, and difficult terrain and weather conditions, all of which contribute to high operating costs. As a result, much of our geological knowledge is still at the reconnaissance level.

Chapters 2 to 4 provide systematic, self-contained descriptions of the three stratigraphic-structural provinces. Although the discussion is generally limited to pre-Carboniferous rocks, descriptions of Carboniferous and Cretaceous plutons are included for comparative purposes. Tectonic interpretation is kept to a minimum. Chapter 5 summarizes and interprets the stratigraphy and tectonic history of the entire report area. Chapter 6 briefly discusses the economic geology of the study area.

The text is supplemented by five appendices. Appendix 1 provides descriptions of relevant stratigraphic sections, including some that have been published previously. Appendix 2 summarizes the stratigraphic and lithological units of the Neoproterozoic to Lower Ordovician Succession 2 of Pearya. Appendix 3 lists most of the X-ray diffraction and point count analyses; some additional data are presented in the text. Appendices 4A and 4B tabulate chemical analyses of volcanic rocks and granitoid intrusions, respectively, along with petrographic information. Appendix 4C contains an unpublished isotopic age determination by J.E. Gabites; all other age determinations have been published elsewhere. The paleontological appendices 5A (macrofossils), 5B (conodonts), 5C (ostracodes and spores), and 5D (cyanobacteria, algae, and sponge spicules) list all relevant identifications, published and unpublished.

LITHOLOGICAL NOMENCLATURE, ANALYSES, AND INTERPRETATION

Sedimentary rocks

The procedures and nomenclature used to describe sedimentary rocks are explained in Trettin, 1994, Chapter 3, p. 30-31.

Volcanic rocks

Volcanic rocks were examined in thin section and analyzed by X-ray diffraction and chemical methods. All are altered or metamorphosed to varying extent. For example, plagioclase has mostly been albitized and mafic minerals have generally been replaced by chlorite, although remnants of clinopyroxene may be preserved. Thus petrography is of limited use for the identification of the original rocks. Lithological classifications are based primarily on stable trace element ratios (after Winchester and Floyd, 1977, fig. 6). The results - even from highly altered suites - are fairly consistent, suggesting that the trace element ratios were not severely affected. However, these elements are not entirely immune to changes during regional metasomatism and weathering (Murphy and Hines, 1986; Brewer and Atkin, 1989; Wang and Glover, 1992; Kuschel and Smith, 1992; Rubin et al., 1993), and some identifications obtained by this method in the course of the present study indeed are suspect, in view of petrographic evidence.

An alternative method names rocks on the basis of major element composition according to the classification of Irvine and Baragar (1971). The results are more diverse and partly inconsistent with the trace element classifications. Some minor discrepancies are probably due to terminological problems; for example, the distinction between andesite and dacite is arbitrary, "simply because this distinction is extremely vague in the literature" (Irvine and Baragar, 1971, p. 537). Larger differences, however, are probably the result of compositional changes during submarine weathering, hydrothermal activity, or metamorphism[1]. Nevertheless, in some units the major element assignments are consistent and compatible with the trace element assignments and provide valuable additional information by indicating, for example, whether basalt or andesite belong to the calc-alkaline or tholeiitic clans. On the other hand, Irvine and Baragar were not able to distinguish consistently between the more siliceous members of the two series - the rhyolites especially, and to some extent also the dacites - and placed all rhyolites in the calc-alkaline series. To avoid misleading inferences about the origin of the rocks, the term calc-alkaline has been eliminated from the major element classifications of the rhyolites.

The interpretation of the tectonic environment of highly altered ancient volcanics is a complex problem that cannot always be solved conclusively. The tentative interpretations in this report are based mainly on generalized lithology in conjunction with the stratigraphic-structural setting. The characteristics of volcanics from major plate tectonic settings such as mid-ocean ridges, volcanic arcs (oceanic or continental), backarc basins, continental flood basalt provinces, and rift zones are reasonably well known and have been summarized in overview papers and recent textbooks (e.g., Wilson, 1988), but exceptions to these generalizations should also be noted (e.g., Davis et al., 1993).

Tectonic discrimination diagrams for basaltic rocks based on TiO_2, Zr, Y, and Nb have also been used to determine the tectonic setting (in conjunction with other criteria), and two of these (Pearce and Cann, 1973, fig. 3, and Meschede, 1986, fig. 1) are presented for all rocks classified as basalt on the Winchester-Floyd diagram (including undifferentiated andesite/basalt). The usefulness of these diagrams, however, is limited. First, they rarely provide unique assignments, and second, they do not take into account possible contamination by crustal sources. Also, they fail to correctly identify continental basalts, which plot mostly in the volcanic arc and mid-ocean ridge fields (Wang and Glover, 1992). More detailed petrological studies, involving isotopes and a broader spectrum of trace elements, may be able to resolve some of the remaining problems.

Granitoid intrusions

Granitoid rocks were analyzed by point count in conjunction with X-ray diffraction analyses (for plagioclase/K-feldspar ratios) and classified according to Streckeisen (1976). Major element analyses (Appendix 4B, Tables 1 and 2) provide the alumina index (Shand, 1943), important for defining the chemical characterization and origin of the rocks (cf. Barbarin, 1990, and references therein). The identification of the sources and tectonic environments of granitoid intrusions is a complex problem that requires far more detailed field and laboratory studies than were feasible during this project. However, highly significant information has come from geochronological studies that have determined not only the probable age of crystallization of the rocks, but also, in various cases, the presence and approximate age of inherited zircon. In addition, special analyses for Nb, Rb, Ta, Y, and Yb were made to test the applicability of tectonic discrimination diagrams by Pearce et al. (1984, figs. 4a and 4b). The results are presented and discussed in Appendix 4B.

[1]The Irvine-Baragar classification program makes a partial correction for alteration by removing Ca associated with CO_2 in calcite and by adjusting Fe_2O_3 to be less than TiO_2 + 1.5.

PHANEROZOIC TIME SCALE

Correlations between rocks dated by isotopic and paleontological methods depend on an absolute time scale that is in a state of flux and requires frequent updating. The time scale used here has been adapted from a recent compilation by Okulitch (1995). The Cambrian to Devonian part of that scale (Fig. 2, in pocket) is based on the comprehensive chart of Harland et al. (1990) with corrections by Bowring et al. (1993), Claoué-Long et al. (1992), Compston and Williams (1992), Compston et al. (1992), Cooper (1992), Kleffner (1989), Roden et al. (1990), Tucker et al. (1990), and other authors.[1]

GEOLOGICAL MAPS

A set of eight geological maps of northern Ellesmere and Axel Heiberg islands has been published separately (Mayr and Trettin, 1995a, b; Trettin, 1995a, b; Trettin and Frisch, 1995; Trettin and Mayr, 1995a, b, c). They cover the pre-Carboniferous geology of the entire area discussed in Trettin (1994) and this report, and in addition the Carboniferous to Tertiary geology of areas newly mapped or remapped between 1975 and 1982. For areas left blank on the maps, the reader is referred to a series of 1:250,000 scale geological maps in a publication by Thorsteinsson (1974).

U. Mayr was responsible for the mapping and compilation of the Carboniferous to Tertiary geology and I for the compilation of the pre-Carboniferous geology. T.O. Frisch participated in the preparation of the *Yelverton Inlet* sheet. In addition, the maps incorporate contributions by M.G. Bjornerud, R.L. Christie, A.F. Embry, J.C. Harrison, A.K. Higgins, E.M. Klaper, L. Maurel, A.D. Miall, K.G. Osadetz, Y. Ohta, J.N. Soper, and D.G. Wilson. Specific maps are referred to individually, and are listed in the references (e.g., Mayr and Trettin, 1976; Trettin and Mayr, 1996, etc.).[2]

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I thank G. Check, D.G. Esson, and G. Stuart for their willing and capable assistance in my own field work. The field operations would have been impossible without the dedicated and capable help of many other persons: the student assistants of my colleagues; our cooks and camp managers; our helicopter pilots and engineers; the pilots of the airplanes that transported and supplied our camps and, last but not least, G.M. Hobson, the former Director of the Polar Continental Shelf Project, and his hard-working and courteous staff at Resolute Bay and Eureka.

[1]A more recent compilation by Tucker and McKerrow (1995), which affects some Cambrian and Ordovician units, will be referred to in footnotes only. Map legends and the correlation chart (Fig. 2) remain based on Okulitch (1995).

[2]The entire set is available under the following title: Trettin, H.P. and Mayr, U. (compilers) 1997: Geological maps and correlation chart of northern Ellesmere and Axel Heiberg islands, District of Franklin, Northwest Territories. Geological Survey of Canada, Maps 1881A to 1888A, scale 1:250 000.

CHAPTER 2

GEOLOGY OF THE NORTHERN HEIBERG FOLD BELT

CONTENTS

INTRODUCTION

The Northern Heiberg Fold Belt comprises the pre-Carboniferous rocks of northern Axel Heiberg Island (*Cape Stallworthy-Bukken Fiord*; see also Fig. 1a, b). The terminology was introduced as part of a revised stratigraphic-structural framework for the pre-Carboniferous rocks in the northern part of the Arctic Islands that also included the Hazen and Clements Markham fold belts and the Pearya Terrane (Trettin, 1987b). Although the outcrop area is small – it is only about 68 km long and up to 44 km wide – it represents a distinct subprovince of the Franklinian mobile belt that differs from the Hazen and Clements Markham fold belts with respect to structural trend and Silurian-Lower Devonian stratigraphy and tectonic history.

STRATIGRAPHY

The Northern Heiberg Fold Belt includes probably 7 to 8 km of sedimentary and volcanic strata of Early Cambrian, or older, to Early Devonian age that are assigned to five formations.

Jaeger Lake Formation (map unit ЄJ, Early Cambrian or older)

Definition

The name, Jaeger Lake Formation, is here proposed for a thick, fault-bounded unit of interstratified mafic volcanic and carbonate rocks in northern Axel Heiberg Island. The type section is at Greenstone Lake, north of eastern Rens Fiord (Appendix 1; *Cape Stallworth-Bukken Fiord*, section GL).

Based on fieldwork by Fricker in 1960 and by Trettin in 1961 and 1962, this unit was introduced as map unit 1d of the Rens Fiord Complex (Fricker and Trettin, 1962) or as the volcanic unit of that complex (Trettin, 1969a). The Rens Fiord Complex comprised unfossiliferous lithological units of presumed Early Silurian and/or older age that could not be placed in stratigraphic order. After a re-examination in 1986 (Trettin, 1987a), the lithological terminology was replaced by the names, Grant Land and Hazen formations, established in Ellesmere Island (Trettin, 1971a), and by two informal stratigraphic units confined to Axel Heiberg Island, named the Aurland

Fiord beds and the Jaeger Lake assemblage - the latter identical with the volcanic unit of the Rens Fiord Complex. To complete the stratigraphic framework of the Northern Heiberg Fold Belt, the two informal units are redefined as formations in this report.

Distribution, contact relations, and thickness

The Jaeger Lake Formation occurs in two belts of fault blocks. One belt extends from north of central Rens Fiord across two small islands within the fiord to southeast of central Rens Fiord. It comprises eight, small fault blocks or outcrop areas bounded by faults or lineaments of the Rens Fiord Fault Zone. North of Rens Fiord the Jaeger Lake Formation is in fault contact with the Grant Land Formation, but farther southeast it is surrounded by water or overburden. The other outcrop belt comprises three, narrow, elongate fault slices extending from the east side of Rens Fiord to the west side of Eetookashoo Bay. There the Jaeger Lake Formation is thrust over the Grant Land Formation on the southwest and separated by an assumed normal fault from outcrops of the Grant Land and Hazen formations on the northeast. The stratigraphic bottom and top of the formation are not exposed. It has a minimum thickness of 425 m in the type section.

Lithology

The Jaeger Lake Formation consists of interstratified volcanics and carbonates. Northeast of Greenstone Lake (Appendix 1) three dolostone interbeds, 79, 66, and 5 m thick, are present, the middle one grading laterally to recrystallized limestone. The dolostone is light grey to medium grey, microcrystalline to fine crystalline[1], and mostly massive to medium bedded. It contains hemispherical stromatolites, and quartz or chert stringers are common.

The volcanic rocks are dark green or dusky red and include flows, flow breccias, and tuffaceous greenschist. In the type section the flows are a few decimetres thick and amygdaloidal at top and bottom. The volcanics are composed mainly of albite and chlorite with minor mica and opaque minerals. Quartz and carbonate veinlets and replacements are ubiquitous.

Classifications of seven analyzed samples are summarized in Table 1 (see also Appendix 4A, Tables 1, 2-1, 3-1). The trace element analyses are fairly consistent and lie in the fields of andesite/basalt and subalkaline basalt on the Winchester-Floyd diagram (Fig. 3). The major element analyses, on the other hand, are diverse and unsuitable for purposes of

Table 1

Jaeger Lake Formation: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1	andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
1	andesite/basalt	1) hawaiite[1]; 2) calc-alkaline (high alumina) andesite (K-poor)
2	andesite/basalt	tholeiitic picrite basalt[2] (K-poor and average)
1	subalkaline basalt	calc-alkaline dacite (average)
1	subalkaline basalt	calc-alkaline (high alumina) andesite (K-poor)
1	subalkaline basalt	calc-alkaline (high alumina) basalt (K-rich)

[1]Hawaiite is a sodic alkali basalt (Irvine and Barager, 1971); the two interpretations represent duplicate analyses of the same sample.
[2]Picrite contains 25% (or more) of normative olivine (Irvine and Baragar, 1971).

[1]The nomenclature for carbonate crystal size has been adopted from Leighton and Pendexter (1962) and Drummond (1963) and used in previous reports by the writer (e.g., Trettin, 1978, 1979, 1994), but differs from commonly used terminology introduced by Folk (1959).

2-1 mm	very coarse crystalline
1-0.5 mm	coarse crystalline
0.5-0.25 mm	medium crystalline
0.25-0.12 mm	fine crystalline
0.12-0.06 mm	very fine crystalline
0.06-0.004 mm	microcrystalline
0.06-0.03 mm	coarse microcrystalline
0.03-0.004 mm	fine microcrystalline
<0.004 mm	cryptocrystalline

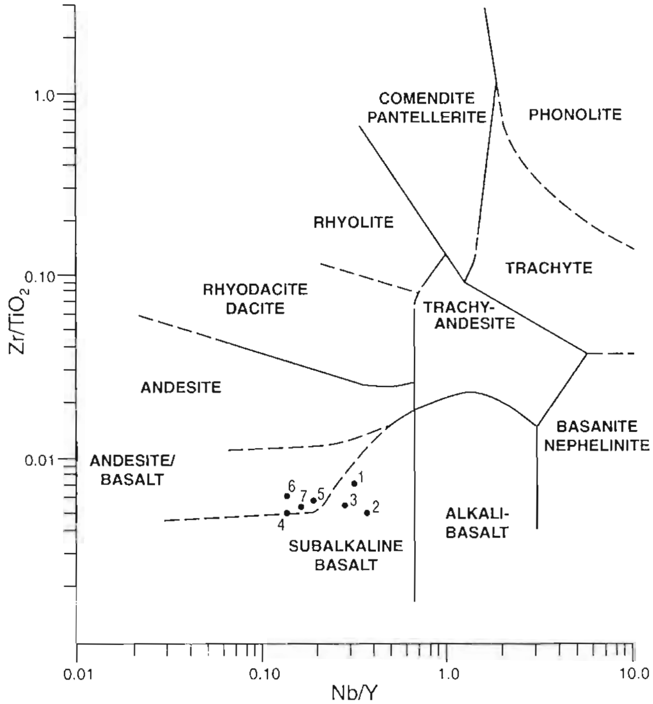


Figure 3. Jaeger Lake Formation: stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).

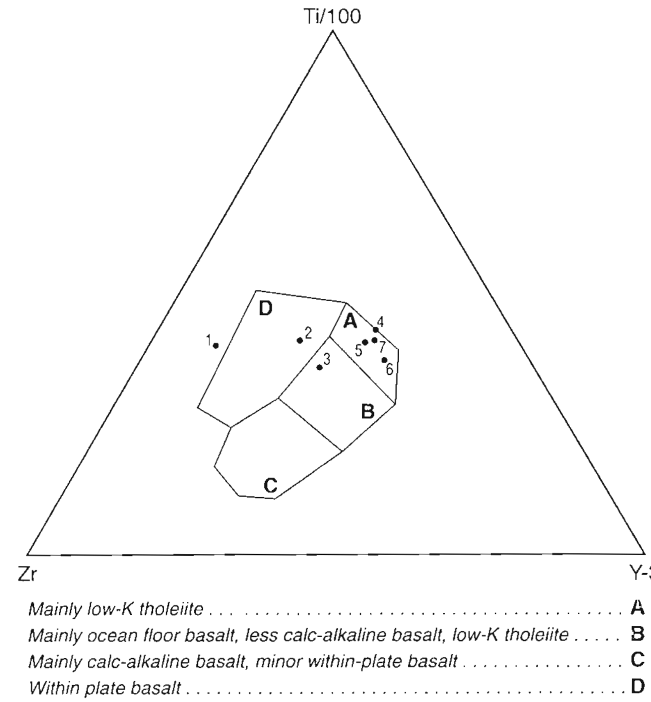


Figure 4. Jaeger Lake Formation, tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).

classification and interpretation because of alteration. The sample classified as calc-alkaline dacite, for example, is a mafic rock containing quartz veinlets and replacements. Moreover, the Winchester-Floyd diagram does not confirm the presence of hawaiite, and the Pearce-Cann diagram (Fig. 4) does not confirm the presence of calc-alkaline basalt or basaltic andesite.

Metamorphism

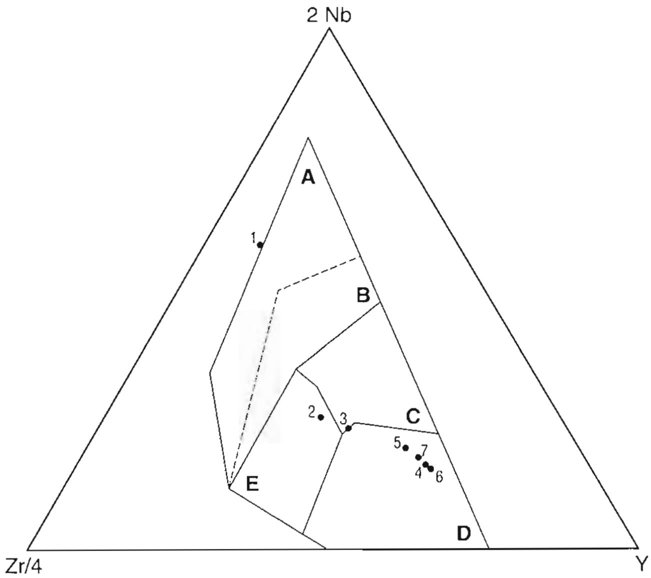
The mineral composition of the volcanics, characterized by albite and chlorite, could be attributed to hydroythermal alteration (spilitization) alone, regional metamorphism of greenschist grade, or both. The fact that the Grant Land Formation shows metamorphism of lower greenschist grade militates against the first explanation.

Mode of origin

The carbonates of the Jaeger Lake Formation are of shallow-marine, peritidal origin. The origin of the volcanics is uncertain. The classifications based on major elements must be disregarded in this context because of the altered state of the rocks, and the tectonic discrimination diagrams do not provide unique answers. For example, on the Pearce-Cann diagram (Fig. 4) four out of seven analyses plot in the field of low-K tholeiite, defined by samples from volcanic island arcs (Pearce and Cann, 1973; Pearce, 1976) whereas on the Meschede diagram (Fig. 5) the same four analyses lie in a field occupied mainly by volcanic arc and normal mid-ocean ridge basalts. Moreoever, both settings are difficult to accept from a geological point of view. A mid-ocean ridge origin conflicts with the shallow-water origin of the associated carbonates, and a volcanic arc origin with the inferred age because the Proterozoic and Early Cambrian were times of extensional tectonics at the North American continental margins (Bally et al., 1989). Neoproterozoic volcanics or dykes of extensional origin have been reported from the Canadian Cordillera (Gabrielse and Campbell, 1992; Souther, 1992), eastern Alaska (Young, 1982), Melville Island (Thorsteinsson and Tozer, 1962; Heaman et al., 1992), and the Maritimes (Greenough and Papezik, 1986; Williams et al., 1985), and Lower Cambrian volcanics of the same origin from northern Alaska (Moore, 1987).

Age and correlation

The fact that the Jaeger Lake Formation has been thrust over the Grant Land Formation suggests it is



Within plate alkali basalt . . . . A

Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B

Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C

Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D

Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . E

Figure 5. *Jaeger Lake Formation, tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1).*

older, i.e., Early Cambrian or Proterozoic in age. The unit is similar to the Yelverton Formation of the Clements Markham Fold Belt both in gross lithology and in the chemistry of the volcanics (compare Figures 3 to 5 with Figures 25 to 27) and probably correlative with it.

Aurland Fiord Formation (map unit ЄA, Early Cambrian or older)

Definition

The name, Aurland Fiord Formation, is here proposed for a thick, fault-bounded carbonate unit in northern Axel Heiberg Island. The type section southwest of Aurland Fiord (*Cape Stallworthy–Bukken Fiord*, section SWAF) has been traversed, sampled, and examined petrographically, but requires more fieldwork before a systematic description can be published.

The unit was introduced as map unit 1d of the Rens Fiord Complex (Fricker and Trettin, 1962) or as the carbonate unit of that complex (Trettin, 1969a), and later renamed the Aurland Fiord beds (Trettin, 1987a; Trettin et al., 1991; see above, Jaeger Lake Formation).

Distribution, contact relations, and thickness

The Aurland Fiord Formation occurs in four different settings:

1. A fault slice of the Aurland Fiord Formation located west of Jaeger Lake has been thrust upon the Grant Land Formation and is overlain by the Grant Land Formation with a concealed contact.

2. A fault slice extending from east of Rens Fiord to southeast of Eetookashoo Bay has been thrust upon member B of the Svartevaeg Formation, and is probably separated from the adjacent Grant Land Formation by a normal fault.

3. South of Rens Fiord, the formation is represented by erosional remnants of the extensive Aurland Fiord thrust sheet, which lies on the Grant Land and Hazen formations.

4. Southwest of Aurland Fiord, the formation is represented by steeply dipping fault blocks that are flanked by the Hazen Formation and Quaternary sediments.

In summary, the stratigraphic top and bottom of the formation are not exposed, but it is possible that the Aurland Fiord Formation is directly overlain by the Grant Land Formation within the Jaeger Lake thrust sheet. Photogrammetry suggests a minimum thickness of about 600 m in the type section.

Lithology

The Aurland Fiord Formation consists mainly of dolostone with lesser amounts of variably recrystallized dolomitic limestone or marble, and minor amounts of phyllite and chert.

Around Aurland Fiord, dolostone is predominant. The rock is mostly medium grey but varies from medium light to medium dark grey. Laminated rocks and intraformational conglomerate are abundant and tepee structures are present in some of these strata (Fig. 6). Discontinuous, crinkled laminae reminiscent of algal/microbial laminites, and some small domes a few centimetres or less in diameter are also present, but no well developed stromatolites were observed. Massive strata are less common.

Figure 6. *Aurland Fiord Formation southwest of Aurland Fiord (***Cape Stallworthy–Bukken Fiord***): laminated dolostone showing tepee structure, and intraformational conglomerate (cm-scale on hammer handle). ISPG photo 2638-3.*

The dolostones are cryptocrystalline to phanerocrystalline, commonly microcrystalline and show some relic micritic textures, distinct or vague peloids (20 to 180 μm in one sample), and coated grains. Simple and composite oncoids occur in a calcareous bed (Trettin, 1969a, plate 1). Breccias are common; many probably are tectonic but solution breccias may also be present. Quartz veinlets, replacements, and cavity fills are ubiquitous.

In addition to dolostone, calcareous rocks are present in the Eetookashoo Bay thrust sheet. Immediately northeast of Rens Fiord, the lower 60 m of the sheet consists of silty and sandy, laminated to thin bedded dolostone and calcareous marble. The middle and upper parts are composed mainly of laminated microcrystalline dolostone with minor amounts of laminated marble and both are partly brecciated. A stratigraphic section of the same fault slice, about 3 km northeast of Rens Fiord, is 158 m thick and consists chiefly of variably recrystallized limestone with 21 m of calcareous, silty and sandy phyllite and 24 m of dolostone, 49 to 94 m above the base of the section (Trettin, 1969a, p. 7).

Metamorphism

The metamorphic grade of this formation is difficult to determine because of its predominantly dolomitic composition and the scarcity of phyllosilicates. The recrystallized state of the calcite is compatible with the greenschist grade of metamorphism apparent in the Jaeger Lake and Grant Land formations.

Mode of origin

The laminated dolostones were probably deposited in peritidal settings. This is inferred from the common occurrence of flat-pebble conglomerates and the presence of tepee structures (Assereto and Kendall, 1977) and possible stromatolites. The pisolites and possible solution breccias suggest that the strata have undergone vadose diagenesis (cf. Peryt, 1983 and references therein). The origin of the massive dolostones is uncertain.

Further interpretation of the Aurland Fiord Formation depends on its age relations with the Jaeger Lake Formation. If older, it probably represents a unit of the Franklinian Shelf that predates the Deep Water Basin; if younger, it represents a carbonate platform of more limited extent that developed upon the Jaeger Lake volcanic edifice. This interpretation is preferred because of the similarity of the formation to the carbonate units within the Jaeger Lake Formation.

Age and correlation

The Aurland Fiord Formation has yielded neither macrofossils nor microfossils. The fact that it has been thrust over the Lower Cambrian Grant Land Formation suggests that it is older; i.e., Early Cambrian or late Neoproterozoic in age. In the correlation chart (Fig. 2) the Aurland Fiord Formation is placed beneath the Grant Land Formation and correlated with the Lower Cambrian Ella Bay Formation and Nesmith beds, but this correlation is speculative.

Grant Land Formation (map unit ЄG, Lower Cambrian)

Definition

The Grant Land Formation – proposed by Trettin (1971) and later revised (Trettin, 1994) – comprises a thick succession of variably metamorphosed siliciclastic sediments that are exposed mainly in the southern Grantland Mountains of Ellesmere Island with a type section at Hare Fiord (*Otto Fiord*). There, the formation lies stratigraphically above the Nesmith beds, an informal unit of resedimented carbonates, and below the Hazen Formation. It consists mainly of interbedded sandstone (metamorphosed to quartzite) and mudrock (metamorphosed to slate, phyllite, or schist) with small amounts of granule and fine pebble conglomerate and intraformational conglomerate. The formation is coloured in hues of grey, greenish grey, and greyish purple red[1] ("maroon"). Three members (A, B, and C), distinguished in reference sections at Hare Fiord (*Otto Fiord*) and near the head of Tanquary Fiord (*Tanquary Fiord)* are probably of regional extent but have been mapped only locally. The thickness of the formation is probably 1.5 km or greater.

Quartzite, multicoloured phyllite, and minor granule conglomerate in the Northern Heiberg Fold Belt are assigned to the Grant Land Formation because of their stratigraphic position beneath the Hazen Formation and macroscopic and microscopic similarity with the strata in the southern Grantland Mountains. A subdivision into members was not possible because of the reconnaissance nature of the fieldwork and the complex structure of the formation.

The initial mapping of the Northern Heiberg Fold Belt in 1960 to 1962 preceded the erection of the Grant Land and Hazen formations in Ellesmere Island. Equivalents of these formations were assigned to informal map units. map unit 1a of the Rens Fiord Complex (Fricker and Trettin, 1962; see above, Jaeger Lake Formation), later referred to as the sandstone unit of the Rens Fiord Complex (Trettin, 1969a), corresponds entirely to the Grant Land Formation and was first equated with that formation by Thorsteinsson and Trettin (1972a, b). Map unit 1b of Fricker and Trettin (1962), referred to as "cherty and argillaceous strata" in Trettin (1969a), included equivalents of the Grant Land and Hazen formations, first distinguished in Trettin (1987a).

The formation is also exposed in the Clements Markham Fold Belt (Chapter 3, Succession A, Southeastern outcrop belt).

Distribution, contact relations, and thickness

The Grant Land Formation is exposed in a broad belt that extends from Cape Thomas Hubbard across Rens Fiord to the southern extremity of the fold belt. It is overlain by the Hazen Formation, and possibly underlain by the Aurland Fiord Formation. Both contacts are covered and their nature is uncertain. The thickness of the formation has not been established because of its complex structure.

Lithology

The formation consists mainly of interstratified light grey quartzite and multicoloured phyllite with small amounts of granule conglomerate. The quartzite occurs mainly as extensive flat-bedded strata, millimetres to metres in thickness, but crosslaminated or crossbedded strata also are present. The quartzites studied in thin section are poorly to moderately sorted. The sand fraction consists largely of quartz (mainly monocrystalline but also composite and metamorphosed) with minor amounts of feldspar (albite and minor K-feldspar), amounting to 2 to 6 per cent in a few point count analyses (Trettin, 1969a, p. 6). The sand is embedded in a matrix of white mica, chlorite, and secondary(?) quartz, probably formed by the alteration of feldspar (Trettin, 1994, p. 95).

Phyllite and slate are mainly greenish grey or, less commonly, greyish purple red. These rocks are composed of quartz, feldspar, and white mica, with trace amounts of biotite in some specimens.

Metamorphism

The mineral composition and slaty or phyllitic texture of the mudrocks indicate metamorphism in the lower greenschist facies.

Mode of origin

Studies in Ellesmere Island indicate that the formation was derived from crystalline terrains and supracrustal sediments of the Canadian Shield and deposited in submarine fans and canyons or channels of the Franklinian Deep Water Basin (Trettin, 1994, p. 96, 97).

Age and correlation

Trace fossils (Hofmann et al., 1994) and regional stratigraphic relations indicate a late Early Cambrian age. The Grant Land Formation is correlative with shelf deposits of the Ellesmere Group (Trettin, 1994), and with the Polkorridoren Group of North Greenland, which is similar in lithology (Higgins et al., 1991a, b).

[1]The terminology of the Geological Society of America (Goddard et al., 1963) is used throughout this report to describe the colour of fresh rock surfaces.

Hazen Formation (map unit Є-SH, Lower Cambrian to Lower Silurian)

Definition

The Hazen Formation - erected by Trettin (1969b) and later modified (Trettin, 1994) - is a condensed succession of deep-water sediments exposed mainly in the Hazen Fold Belt of Ellesmere Island with a type section at St. Patrick Bay, Archer Fiord (*Lady Franklin Bay*). It lies stratigraphically between the Grant Land or Kane Basin formations and the Danish River Formation. Two informal members with a southeastward-younging, diachronous contact are distinguished: a lower carbonate member composed of resedimented carbonates, mudrock, and minor chert and sandstone, and an upper chert member, composed of radiolarian chert and interlaminated mudrock, locally with minor amounts of resedimented carbonates.

Chert and minor phyllite and resedimented carbonates in the Northern Heiberg Fold Belt are assigned to the Hazen Formation because of their stratigraphic position above the Grant Land Formation and lithological similarity to the strata in the Hazen Fold Belt (Trettin, 1987a). The chert was originally included in map unit 1b of the Rens Fiord Complex (Fricker and Trettin, 1962) or in the "argillaceous and cherty strata" (map unit Oy) of that complex (Trettin, 1969a).

The formation is also exposed in the Clements Markham Fold Belt (see Chapter 3, Succession A, Southeastern and Southwestern belts).

Distribution, contact relations, and thickness

The formation has been mapped separately in a few small areas around Aurland Fiord and north of Rens Fiord, west of Greenstone and Jaeger lakes, but unrecognized small outcrop areas may occur within larger areas mapped as Grant Land Formation. The Hazen Formation overlies the Grant Land Formation in a syncline southeast of Aurland Fiord, but the contact is covered. Contacts with the Lower Silurian Svartevaeg Formation, exposed in only two small areas southwest of Aurland Fiord, are faulted. The thickness of the Hazen Formation is uncertain because of tight folding and complex faulting but is probably greater than 100 m.

Lithology

In the section southeast of Aurland Fiord (*Cape Stallworthy-Bukken Fiord*, inset E, section EAF), the lower 59 m of the carbonate member (Appendix 1, section southeast of Aurland Fiord) consists mainly of laminated dolomitic lime mudstone and calcareous dolostone with smaller proportions of carbonate conglomerate and calcarenite.

The lime mudstone is medium dark grey, slightly argillaceous, and contains euhedral, coarse microcrystalline to very fine crystalline dolomite crystals. The argillaceous material consists of quartz and phyllosilicates, mainly white mica. The lamination is due to vertical variations in the concentration of submicroscopic carbonaceous matter, and to a minor extent, of dolomite. Rare chert spheroids, 20-40 μm in diameter, probably represent recrystallized radiolarian tests (Fig. 7). With increasing dolomite content, these lime mudstones grade to dolostone.

The conglomerates are composed of flat pebbles and cobbles (observed maximum length 10 cm) of lime mudstone or dolostone that are commonly laminated. These clasts are either embedded in a matrix of dolomitic lime mudstone or calcareous dolostone or are separated by vugs lined with chalcedony and quartz.

A sample of calcarenite is medium dark grey, laminated, and shows both normal and reverse graded bedding, with grain size ranging from silt to granule grade. It consists of elongate carbonate fragments aligned in several preferred orientations. The fragments are composed of recrystallized, commonly twinned calcite.

Chert, the dominant rock type of the chert member, is medium dark grey and occurs typically in beds one to a few centimetres thick, which may show a vague or distinct flat lamination. Radiolarian tests are preserved in some strata (Fig. 8). The chert contains variable, but generally small amounts of phyllosilicates, probably mainly white mica and minor chlorite, which, together with opaque material, are concentrated in undulating solution zones. Veinlets of quartz and chalcedony are common.

Metamorphism

The metamorphism of the Hazen Formation is unequally developed, but some of the chert was

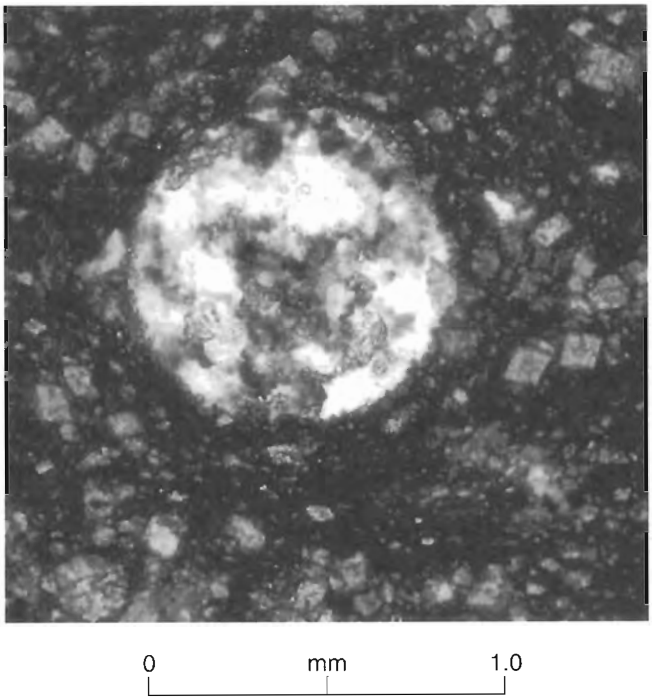


*Figure 7. Photomicrograph (cross-polarized light) of dolomitic lime mudstone with recrystallized radiolarian test, filled with quartz and carbonate; carbonate member of Hazen Formation at section southeast of Aurland Fiord (**Cape Stallworthy–Bukken Fiord**). ISPG photo 4227-11.*

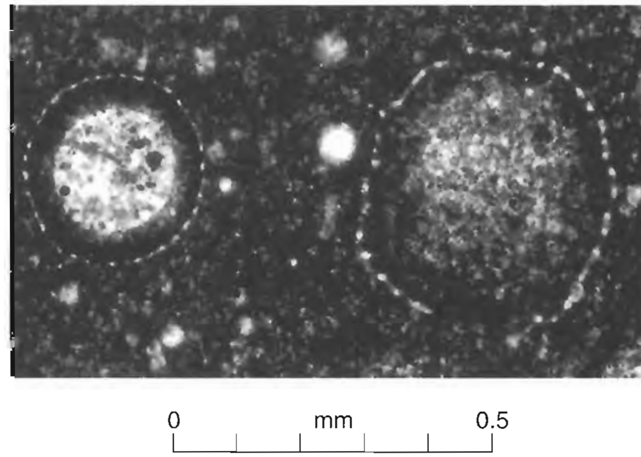


Figure 8. Photomicrograph of recrystallized radiolarians in chert of Hazen Formation southwest of Aurland Fiord. Comparison with Figure 7 reveals differences in size and structure. ISPG photo 4227-14.

metamorphosed in the lower greenschist facies. These rocks have a sheared, stretched texture, and contain white mica and chlorite, rather than clay minerals.

Mode of origin

Analogy with the exposures in the Hazen Fold Belt (Trettin, 1994) suggests that the carbonate sediments were derived from shelf and/or slope settings and redeposited in deeper slope and/or basinal environments. The radiolarian chert is probably a basinal deposit.

Age and correlation

Fossil collections from the Hazen Fold Belt indicate an age range from latest Early Cambrian to Early Silurian, early late Llandovery (Trettin, 1994). No fossils were recovered from the Hazen Formation in the Northern Heiberg Fold Belt. The Hazen Formation is lithologically similar to, and correlative with, the combined Vølvedahl and Amundsen Land formations of the North Greenland Fold Belt (Higgins et al., 1991a, b).

Svartevaeg Formation (map units Ssv1 and Ssv2, Lower Silurian)

Definition and history of investigation

The Svartevaeg Formation is here redefined as a thick succession of volcanic and sedimentary rocks unconformably overlain by the Stallworthy Formation. The base of the Svartevaeg Formation is not exposed. The type section, located about 15 km southeast of Cape Stallworthy in the vicinity of the Svartevaeg Cliffs[1] (*Cape Stallworthy-Bukken Fiord*, inset C, section SV), has been examined in reconnaissance fashion only. The formation is divisible into two members. Member A consists mainly of andesitic and basaltic flows and tuffs, and Member B mainly of volcanic-derived argillaceous to conglomeratic sediments with lesser amounts of tuff.

The Svartevaeg Cliffs were briefly investigated by Roots (1963) in 1955. After the initial mapping and stratigraphic investigation, the pre-Carboniferous volcanic and sedimentary rocks in this area were

[1]The name *svarte vaeg*, meaning black wall, was proposed by Sverdrup (1904), who discovered and named Axel Heiberg Island, for a spectacular series of sombre cliffs on the northeastern coast of the island.

assigned to the Svartevaeg Group, a reconnaissance level unit with two divisions (Fricker and Trettin, 1962), subsequently redefined as a formation with two members (Trettin, 1963, 1969a). In this area, the Svartevaeg Formation overlies the Lower Devonian and (?)older Stallworthy Formation in a structural sense, but the contact is mostly concealed, and its nature is difficult to determine. Prior to 1986 it was interpreted as a normal stratigraphic contact, although a fault was not ruled out originally (Fricker and Trettin, 1962). This implied a Devonian age for the Svartevaeg Formation, in spite of the fact that Silurian fossils were found in resedimented carbonate clasts.

Crucial for the present redefinition is a belt of volcanic-derived sediments and tuff east of Eetookashoo Bay and Rens Fiord that contains Wenlock graptolites near the top and is overlain unconformably by the Stallworthy Formation. The rocks are similar in composition to Member B of the Svartevaeg Formation, but are finer in clast size and more intensely deformed. These strata, along with smaller outcrop belts of similar rocks in an area southwest of Aurland Fiord and north of Bukken Fiord, were originally referred to as map unit 2 (Fricker and Trettin, 1962; Trettin, 1963) and later assigned to the Lands Lokk Formation, a unit established in Ellesmere Island (Trettin, 1969a; see below, Chapter 3).

Fieldwork in 1986 indicated that the Svartevaeg Formation is related to the Lower Silurian strata northeast of Eetookashoo Bay and Rens Fiord, and that the Stallworthy–Svartevaeg contact southwest of the Svartevaeg Cliffs is a thrust fault (Trettin, 1987a). These impressions were confirmed in 1992 when Lower Silurian graptolites were found in Member B of the Svartevaeg Formation in the type section. Accordingly, the outcrop belts of sedimentary and tuffaceous rocks at Eetookashoo Bay and Aurland Fiord (referred to as the Eetookashoo Bay and Bukken Fiord beds in Trettin, 1987a and in Trettin et al., 1991) are now included in Member B of the Svartevaeg Formation.

Distribution, contact relations, and thickness

The Svartevaeg Formation occurs in three main outcrop areas that have different structural and stratigraphic settings:

1. An area 7.5 to 23.5 km southeast of Cape Stallworthy, which includes the type section, is underlain by both members. There the Svartevaeg Formation overlies the Stallworthy Formation along a southwest-verging thrust fault and its base is not exposed (*Cape Stallworthy–Bukken Fiord,* cross-section A–A′*)*. On the southeastern periphery, Member B is unconformably overlain by late Early Carboniferous (Viséan) strata of the Emma Fiord Formation. The major structure in this area is a southeast-plunging syncline complicated by minor faults. The minimum thickness of the formation is greater than 1.6 km.

2 An area extending from northeast of Eetookashoo Bay to northeast of Rens Fiord is underlain by a part of Member B. The member is overlain by the Stallworthy Formation with angular unconformity (Fig. 19) on the northeast, and overthrust by the Aurland Fiord Formation on the southwest. It forms tight and complex minor folds. The stratigraphic thickness of the exposed part of Member B has not been determined.

3. An area southwest of Aurland Fiord contains two steeply dipping, narrow outcrop belts of Member B that are both in fault contact with the Hazen Formation. The stratigraphic thickness of these exposures is also unknown.

In summary, the Svartevaeg Formation is exposed in three main areas. It is unconformably overlain by the Stallworthy Formation northeast of Eetookashoo Bay and Rens Fiord, and by the Emma Fiord Formation in the Svartevaeg Cliffs. Regional stratigraphic relations suggest that it may be underlain by the Hazen Formation, but the Hazen–Svartevaeg contacts are faulted where exposed. The Svartevaeg Formation has a minimum thickness of about 1.6 km in the type section.

Lithology

Member A

Member A, confined to the Svartevaeg Cliffs, has a minimum thickness of about 1 km in the type section, but the thickness increases towards the northwest. It consists largely of massive and resistant volcanic rocks with minor amounts of volcanogenic sandstone and siltstone and some carbonate olistoliths. Flows predominate over tuffs: of 19 random samples, 15 are flow rocks, three are tuffs, and one is a breccia of uncertain origin. The flows are porphyritic; all contain phenocrysts of plagioclase, and 9 samples contain subordinate amounts of clinopyroxene, partly altered to chlorite. The plagioclase in 16 samples is albite; in the remaining three, it is labradorite. Minor amounts of hornblende and actinolite are present in a few samples, and orthopyroxene(?) and olivine(?) may be present in one sample. The groundmass of the flow rocks consists of chlorite, albite, and opaque minerals. Replacements and veinlets of calcite, quartz, and epidote are common. The tuffs contain volcanic rock fragments and crystals, mainly of albite and rarely of clinopyroxene.

Classifications of the chemically analyzed samples are summarized in Table 2 (see also Figs. 9, 10, 11, and Appendix 4A, Tables 1, 2-2, 3-2). The trace element classifications (Fig. 9) are consistent and indicate that the rocks are in the fields of andesite (12) or andesite/basalt (8). The major element analyses show a greater diversity, but emphasize calc-alkaline (high alumina) andesite and basalt (13 out of 20 samples, i.e., 65%). The presence of calc-alkaline basalt is confirmed by the Pearce-Cann diagram (Fig. 10).

Carbonate clasts up to boulder grade occur in the northeasternmost exposures of the member, not far above the Svartevaeg Thrust. The rocks are highly recrystallized, but echinoderm columnals and a colonial coral are recognizable in thin sections. The presence of volcanic material within some clasts may indicate that the carbonates developed on volcanic substrates.

Member B

Type section. The best exposures of this member are in an area about 12 to 13 km southeast of Cape Stallworthy. Three major units can be distinguished there. The lower unit, estimated to be more than 300 m thick, is composed mainly of volcanogenic sandstone with minor mudrock, conglomerate, and tuff, and has a fossiliferous limestone conglomerate at the top. The second unit, with an estimated thickness of more than 200 m, is composed mainly of mudrock with an upward-increasing proportion of volcanogenic sandstone. It is recessive and mostly covered in the lower part. The upper 112 m is represented by units

Table 2

Svartevaeg Formation, Member A: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1	andesite	calc-alkaline dacite (K-poor)
5	andesite	calc-alkaline (high alumina) andesite (average 3, K-rich 2)
1		calc-alkaline (high alumina) andesite (K-poor)
2	andesite	calc-alkaline (high alumina) basalt (average 1, K-poor 1)
1	andesite	hawaiite
1	andesite	sodic trachyte
1	boundary andesite–andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
1	andesite/basalt	tholeiitic dacite (K-poor)
1	andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
3	andesite/basalt	calc-alkaline (high alumina) basalt (2 average, 1 K-rich)
1	andesite/basalt	tholeiitic basalt (K-rich)
1	andesite/basalt	mugearite[1]
1	andesite/basalt	trachybasalt[2]
Summary of major element classifications		
1	calc-alkaline dacite	
8	calc-alkaline andesite	
5	calc-alkaline basalt	
1	tholeiitic dacite	
1	tholeiitic basalt	
1	sodic trachyte	
1	trachybasalt	
1	mugearite	
1	hawaiite	

[1]Mugearite is a member of the sodic alkali olivine basalt series characterized by an intermediate composition (Irvine and Baragar, 1971).

[2]Trachybasalt is a member of the potassic olivine basalt series (Irvine and Baragar, 1971).

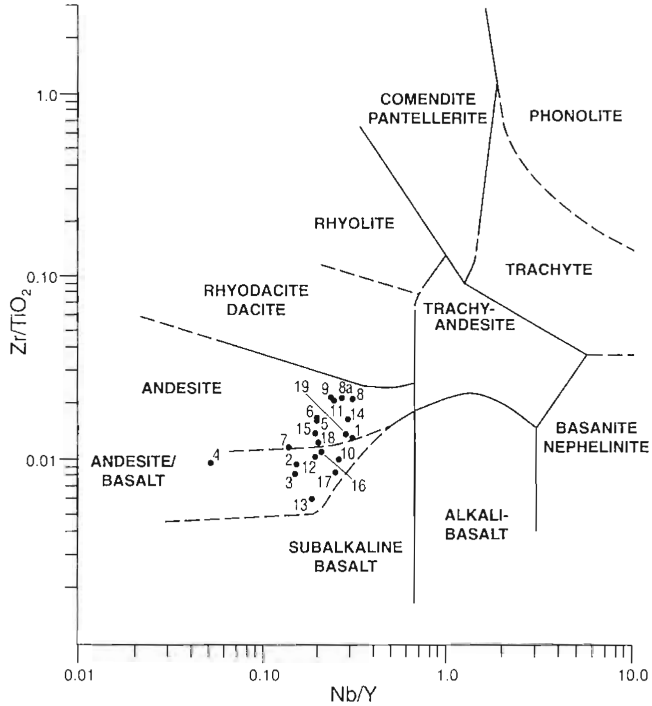
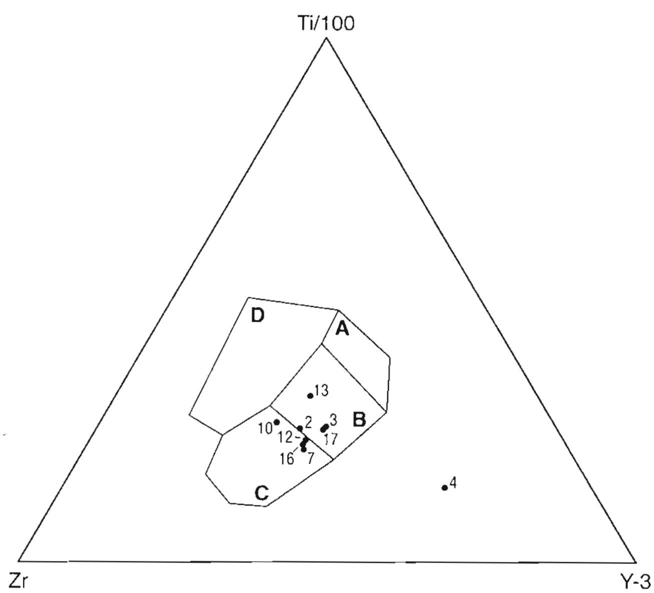
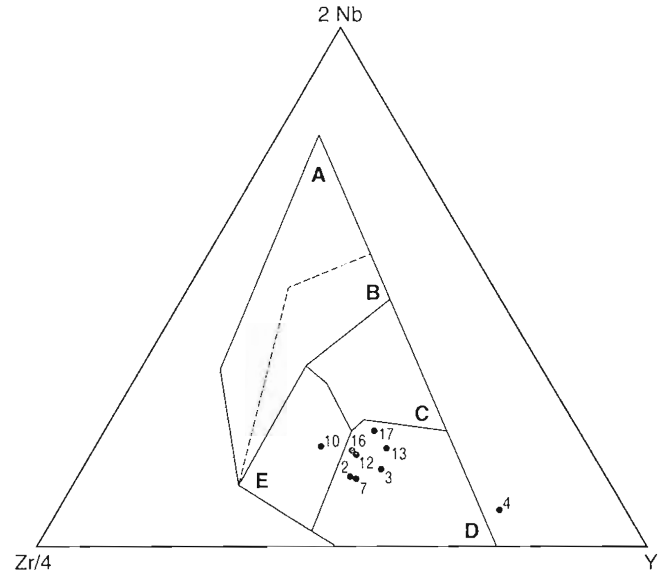


Figure 9. Svartevaeg Formation, Member A: stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).



Mainly low-K tholeiite . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . D

Figure 10. Svartevaeg Formation, Member A: tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).



Within plate alkali basalt . . . . A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . E

Figure 11. Svartevaeg Formation, Member A: tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1).

1 to 18 of the Svartevaeg section (Appendix 1). The third unit is resistant and consists mainly of thick-bedded to massive volcanogenic sandstone and tuff with lesser amounts of mudrock and volcanic conglomerate. The lower 134 m of this unit are represented by units 19 to 35 of the Svartevaeg section. Based on these estimates and measurements, Member B has a minimum thickness of more than 600 m, but the real thickness may be considerably greater. In addition to the reconnaissance section mentioned, some short sections were measured in detail to establish the pattern of sedimentation (Fig. 12).

Sedimentary rocks. The clastic sediments are divisible into relatively coarse grained and fine grained deposits. The former are found in commonly lenticular units that are metres in thickness and occur in exposures subparallel with the southeasterly strike. Detailed sections reveal two types of stratification:

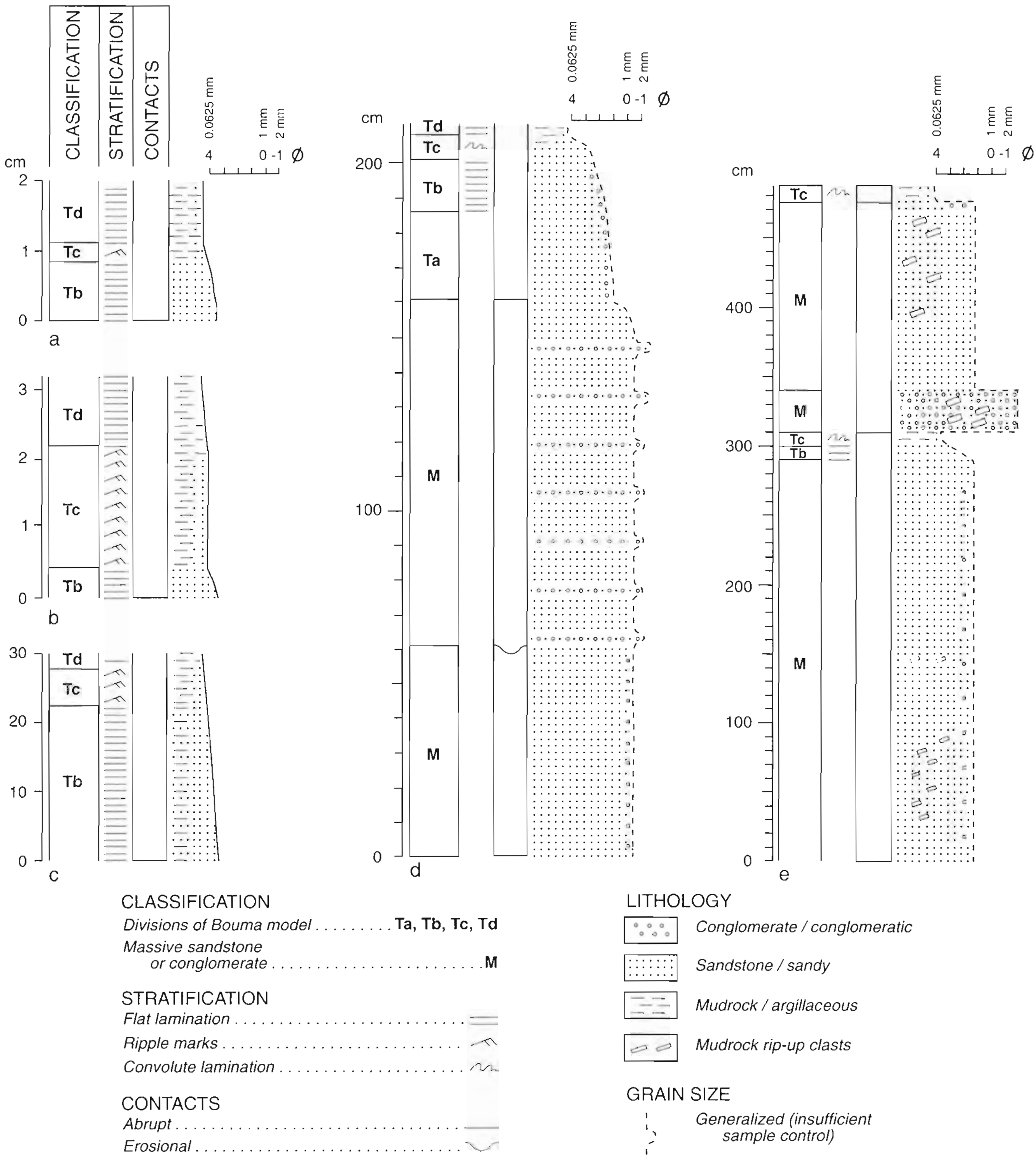


Figure 12. *Svartevaeg Formation, Member B: logs of selected sediment gravity flow deposits of different scales; a, b, and c are interpreted as levee and overbank deposits, d and e as channel deposits.*

1. Massive, poorly sorted beds of conglomerate, conglomeratic sandstone, and/or medium to very coarse grained sandstone, a few decimetres to several metres thick, that commonly occur at the base of the sedimentary deposits. They contain rip-up clasts of mudrock, millimetres to more than 10 cm long. In one case, a massive unit is overlain abruptly by a unit, 12 cm thick, of

relatively fine grained sediments (fine grained sandstone to coarse grained siltstone) that has convolute laminae (Fig. 12e, top); in other instances massive units are overlain erosionally by another massive bed or by a bed with a Bouma sequence.

2. Bouma sequences, commonly of $T_{a\text{-}d}$ type, that are decimetres or more in thickness and frequently have coarse grained, pebbly sandstone at the base (Fig. 12d, top).

The fine grained deposits, consisting of very fine grained sandstone and siltstone, contain flat laminae, crosslaminae, or convolute laminae. Bouma sequences of $T_{b\text{-}d}$ type are common and measured examples are 2 to 30 cm thick (Fig. 12a–c). Sole marks, such as flute casts, grooves, and ridges were observed at the base of some sandstone beds, but the exposures were not suited for paleocurrent studies.

The sandstones are greenish grey. Combined point count and size analyses of four sandstones of different grain size are listed in Trettin (1969a, Appendix, Table V, p. 63). The chief components are volcanic rock fragments, which are abundant in the medium to very coarse grained sandstones (58 to 74%), but are absent from the very fine grained sandstones; and feldspar, most common in the very fine grained sandstones and decreasing with increasing grain size (69-10%). X-ray diffraction (XRD) analyses show that the feldspar, both in rock fragments and individual grains, consists largely of albite (Appendix 3, Table 1). Chlorite, carbonates, and opaque minerals, partly replacing mafic minerals such as clinopyroxene, range from 2 to 7 per cent combined, and unidentifiable matrix minerals, mainly chlorite, from 4 to 10 per cent. Quartz and chert range from trace amounts to 1 per cent, and some chert fragments show ghosts of radiolarians.

XRD analyses indicate relatively high percentages of quartz (mean 54%; F/F+Q 34.4%; corrected 48%), but most of the quartz must occur in veinlets and replacements because primary quartz and chert are rare.

The mudrocks are medium dark grey and largely of siltstone grade.

The conglomerates are massive and commonly several metres thick (e.g., 4.2, 5.5, 7.5 m). They are composed mainly of volcanic rocks with or without limestone clasts. Of 12 analyzed samples of volcanic clasts from a mixed volcanic and carbonate conglomerate, eight were flow rocks, two were conglomerates, one was a crystal-lithic tuff, and another was either a conglomerate or a lithic tuff. The clasts have the same mineral composition as the volcanic rocks in Member A and the lower part of Member B. The plagioclase is mainly albite with labradorite preserved in two out of 12 samples. The mafic silicates have mostly been altered to chlorite, but remnants of clinopyroxene are preserved sporadically. Quartz, calcite, and epidote alteration are common whereas prehnite is rare.

Chemical classifications of the conglomeratic clasts are summarized in Table 3 (see also Figs. 13, 14, 15 and Appendix 4A, Tables 1, 2-3, 3-3). On the Winchester-Floyd diagram (Fig. 13), nine trace element compositions are in the field of andesite/basalt, and three are in the field of andesite. Major element classifications indicate mainly calc-alkaline andesite (9) with minor calc-alkaline dacite (2) and tholeiitic basalt (1). Most rocks are K-poor.

The limestone clasts commonly contain fossils. In addition, a fossiliferous limestone olistolith, 5 m long and enclosed in volcanogenic sandstone, is present about 60 m above the base of the member.

Table 3

Svartevaeg Formation, Member B (conglomerate clasts): classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1	andesite	calc-alkaline dacite (K-poor)
2	andesite	calc-alkaline (high alumina) andesite (K-poor)
1	andesite/basalt	calc-alkaline dacite (K-poor)
7	andesite/basalt	calc-alkaline (high alumina) andesite (6 K-poor, 1 average)
1	andesite/basalt	tholeiitic basalt (K-poor)

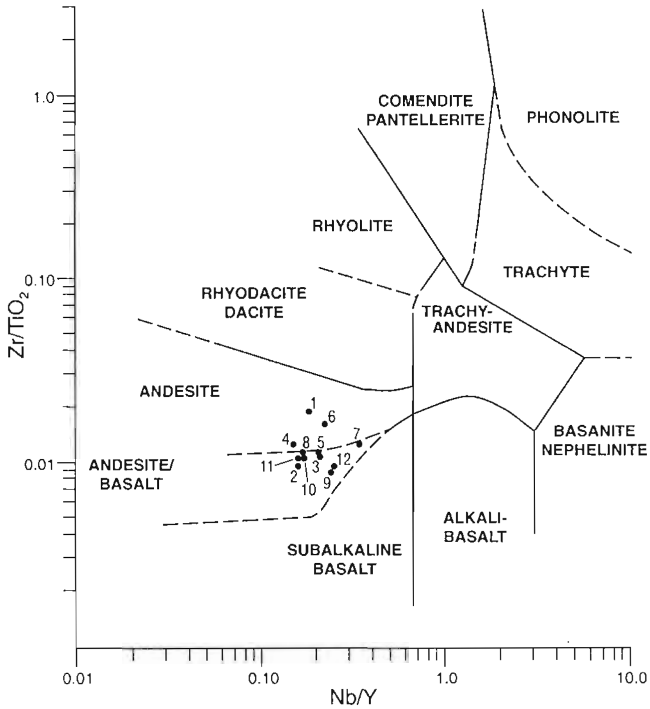
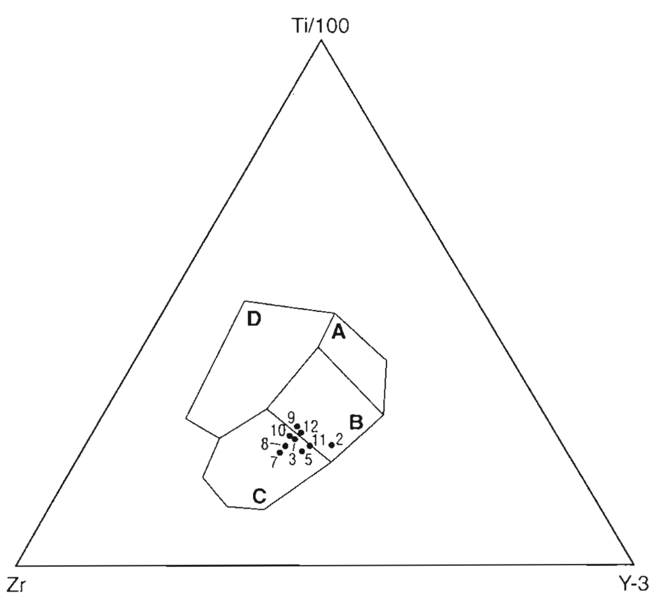
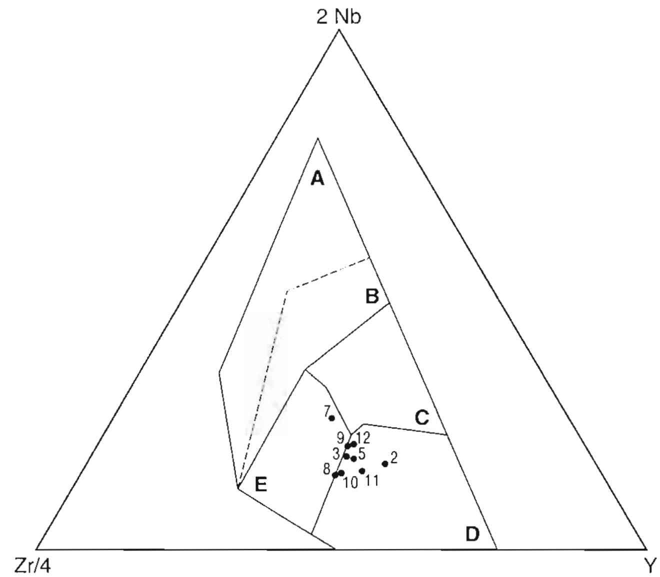


***Figure 13**. Svartevaeg Formation, Member B: conglomerate clasts, stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).*



Mainly low-K tholeiite . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . D

***Figure 14**. Svartevaeg Formation, Member B: conglomerate clasts, tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt . . . . A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . E

***Figure 15**. Svartevaeg Formation, Member B: conglomerate clasts, tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1).*

The following invertebrates were identified in the conglomerates and olistolith: echinoderm columnals, solitary and colonial corals (*Favosites* sp., ?*Syringopora* sp., columnarids, cystiphyllids), stromatoporoids, brachiopods (?*Howellella* sp.), trilobites (*Encrinurus* sp.), ostracodes, and bryozoa (identification by B.S. Norford, Appendix 5A, GSC locs. 47511, 47505, 47506 and additional thin section observations). In addition the cyanobacteria/algae *Whetheredella* sp. cf. *W. silurica*, and *Girvanella* sp. (identifications by T. de Freitas, Appendix 5D, GSC loc. C-194934-2) were identified in thin section, the latter encrusting a bryozoan (Fig. 16). *Whetheredella* is mainly a reef dweller.

Volcanic rocks. Volcanic rocks in the lower and middle parts of the member are difficult to distinguish from volcanogenic sandstones. Strata interpreted as tuff are greenish grey, massive, and resistant to weathering. Units in the lower part of the upper major unit (Svartevaeg section, units 24-35) are 2 to 28.5 m thick. They are laminated, thin-bedded or massive, do not

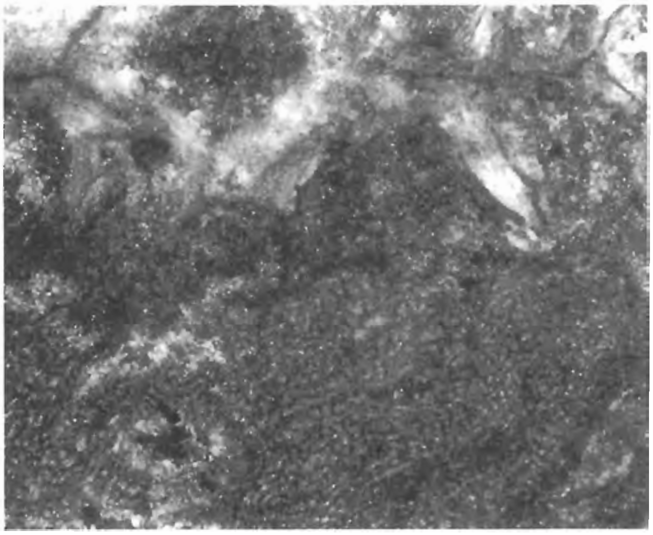


Figure 16. *Photomicrograph (ordinary light) showing* ***Girvanella*** *encrusting bryozoan in carbonate cobble from Svartevaeg Formation, Member B. ISPG photo 4248-3.*

occur in Bouma sequences, and are not associated with dark grey mudrocks. Like the volcanogenic sandstones, they are composed chiefly of altered volcanic rock fragments and crystals of plagioclase with minor amounts of clinopyroxene, volcanic quartz, etc., but lack detrital quartz and chert. The plagioclase is mainly albite and only one out of 11 samples contains labradorite. Veinlets and replacements composed of quartz and calcite are common.

Only one volcanic flow was recognized in the lower part of the upper major unit (Appendix 1, Svartevaeg section, unit 27). A typical sample is porphyritic and amygdaloidal, with phenocrysts of plagioclase in a groundmass of plagioclase, chlorite, minor quartz, and opaques. XRD analysis indicates that the plagioclase is largely or entirely labradorite. The amygdules contain chlorite and quartz.

Ten analyzed samples (including the volcanic flow mentioned) are classified as andesite on the basis of trace element ratios, and, more specifically, as calc-alkaline (high alumina) andesite on the basis of major elements (Table 4; Fig. 17; Appendix 4A, Tables 1, 2-4, 3-4).

In contrast to the lower and middle parts of the member, volcanic rocks are common in the upper 60 m of the upper major unit. One sample from this interval is a tuff composed of volcanic rock fragments and crystals of plagioclase (andesine according to XRD) and clinopyroxene, all cemented by chlorite. It is classified as a calc-alkaline (high alumina) basalt on the basis of major element composition (Appendix 4A, Tables 1, 2-4, no. 12). Another sample is a volcanic breccia that includes fragments of unmetamorphosed limestone, suggesting a waterlain tuff or tuffaceous sediment rather than a flow rock. The volcanic rock fragments contain phenocrysts of labradorite, diopsidic clinopyroxene, and opaque minerals in a matrix of very fine crystals and dark brown, altered volcanic glass. The limestone pebbles contain brachiopod and mollusc fragments, an ostracode, abundant coated grains, and unidentified microbial-algal structures. Limestone fragments, mostly less that 10 cm but up to 1.8 m in diameter, with Silurian solitary corals and brachiopods were reported from this locality by Roots (1963, p. 517).

East of Eetookashoo Bay and Rens Fiord. The following summary description is based on an earlier report (Trettin, 1969a, p. 14, 15) because the rocks have not been re-investigated in recent years. Member B consists mainly of dark to medium grey, in part slaty mudrock with lesser proportions of volcanogenic sandstone and tuff, and at least one bed of carbonate conglomerate. Sandstone and tuff both are greenish

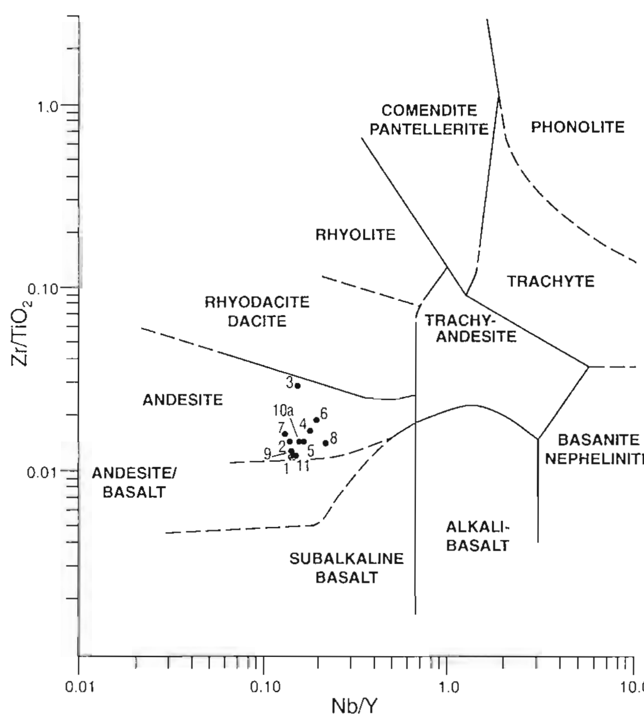


Figure 17. *Svartevaeg Formation, Member B: volcanic strata, stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).*

Table 4

Svartevaeg Formation, Member B: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
11	andesite	calc-alkaline (high alumina) andesite (8 K-poor, 2 average, 1 K-rich)
1		calc-alkaline (high alumina) basalt (K-poor)

grey and difficult to distinguish. Units identified as volcanogenic sandstone were less than 2 m thick whereas units identified as tuff were up to 10 m thick. Most sandstones are fine to medium grained but contain granule to pebble-sized chips of dark grey mudrock or chert, and some also include large rip-up clasts of mudrock. Graded bedding occurs both in sandstones and tuffs, but is more subtle than in the type section, and sole marks, such as grooves and ridges, are present.

Point count analyses of six samples of tuff and volcanogenic sandstone (volcanic arenite) are reported in Trettin (1969a, Appendix, Table I, p. 60, 61). Like the rocks of the type section, they are composed chiefly of volcanic rock fragments (23-78%) and feldspar (16-28%), but include higher proportions of carbonate (1-30%), quartz (1-22%), and chert or chalcedony (0-9%).

The conglomerate consists of limestone pebbles and cobbles in a sandy matrix. The carbonate clasts include echinoderm columnals, bryozoa, gastropods, brachiopod fragments and corals (*Favosites* sp., *Halysites* sp., and a cystiphyllid; identified by B.S. Norford, Appendix 5A, GSC loc. 47510).

Southwest of Aurland Fiord. In the area southwest of Aurland Fiord, greenish grey volcanogenic sandstone and pebble conglomerate and medium to dark grey mudrock (siltstone) are exposed. Both massive and graded sandstone and conglomerate beds, comparable to channel deposits of the type section, are present. Two massive, nongraded sandstone beds are 10 cm and 5 m thick, respectively. The grain size of the sandstones fluctuates from medium to very coarse, and pebbles and rip-up clasts of mudrock are present. Two, 10-cm-thick, graded pebble conglomerates are overlain by sandstone and a typical graded sandstone is 8 cm thick. The strata are interpreted as turbidites consisting of T_a divisions only. The conglomerates are finer than in the type section and the maximum observed clast diameter is 2 cm. Siltstones contain flat laminae and ripple marks.

Point count analysis of a sandy pebble conglomerate (maximum grain size 6 mm) indicated the following composition (numbers indicate precentages):

Volcanic components	(60% total)
Volcanic rocks:	34
Feldspar:	13
Chlorite:	12
Opaque:	1
Nonvolcanic components	(39% total)
Quartz, quartzite:	21
Chert:	12
Carbonate:	6
Phyllite:	<1

The nonvolcanic component is larger than in samples from the Svartevaeg Cliffs.

Metamorphism

The partial preservation of pyroxene, andesine and labradorite indicates that the metamorphism of the volcanics is generally below greenschist grade. The common replacement of these minerals by albite and chlorite is probably due to hydrothermal activity. More detailed work is required to determine the metamorphic grade of the slaty mudrocks, which may be of greenschist grade in the sense that clay minerals have recrystallized to chlorite and white mica.

Mode of origin

Member A

The trace element compositions, indicating andesite and andesitic basalt (Fig. 9) and the major element compositions, indicating mainly calc-alkaline rocks with some tholeiitic and alkaline rocks (Table 3), strongly suggest a volcanic arc origin. The tectonic discrimination diagrams (Figs. 10, 11) for the mafic rocks (i.e., those identified as andesite/basalt in Fig. 9) do not provide a unique answer but emphasize two alternative interpretations: mid-ocean ridge (ocean floor) basalt and volcanic arc origin (calc-alkaline) basalt. The high proportion of andesite and the great thickness of associated sedimentary rocks militate against a mid-ocean ridge environment and support the volcanic arc origin.

Member B

Trace and major element compositions of the tuffs and volcanogenic sediments in the type section (Table 4) strongly suggest derivation from a volcanic arc, and this is supported by the tectonic discrimination diagrams, especially Figure 14. The primary structures of the sediments demonstrate deposition by turbidity currents and subaqueous debris flows in deep-water settings. The coarse grained, lenticular, commonly massive deposits probably represent channel fills and the fine grained Bouma sequences, levee and overbank deposits.

The fact that the volcanogenic sediments in the Svartevaeg Cliffs are coarser than those at Eetookashoo Bay and Rens Fiord suggests derivation from easterly or northeasterly sources. The detrital chert and quartz, on the other hand, must have been sourced from the west or southwest as they are far more common in the two western outcrop belts. The carbonate conglomerates and olistoliths were probably derived from small reefs constructed on the arc by colonial corals, stromatoporoids, bryozoans, and microbes such as *Whetheredella* and *Girvanella*.

The inferred easterly or northeasterly provenance of the volcanogenic material implies an eastward shift of the arc, and this raises the problem of the relation between the two members of the Svartevaeg Formation. Although Member A is overlain by Member B in the type section, the two may be highly diachronous lithofacies representing an arc and lateral sedimentary-pyroclastic equivalents, respectively. It is conceivable that the volcanic flow rocks of Member A terminate not far west of the Svartevaeg Cliffs and change laterally into volcanogenic sediments and tuff. Thus the sedimentary strata east of Eetookashoo Bay and Rens Fiord, assigned to Member B, may be partly correlative with Member A in the Svartevaeg Cliffs (Fig. 18) although the available, rather limited fossil evidence (see below) does not indicate this.

Another problem is whether Member B represents a forearc or a backarc basin, and this depends on the orientation of the related subduction zone. Regional relations, discussed in the concluding section of Chapter 5, suggest a forearc setting.

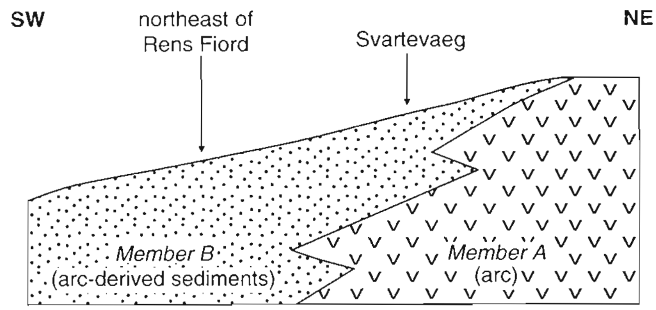


Figure 18. *Interpreted stratigraphic relations of Members A and B of the Svartevaeg Formation.*

Age and correlation

Two significant graptolite collections were made. The first, from the lower part of the upper major unit of Member B near the type section, includes *Monograptus* aff. *M. speciosus* Tullberg of probably late Telychian age and *Monograptus* aff. *M. parapriodon* Bouček, which probably ranges from early late Llandovery (*turriculatus* Zone) to mid-Wenlock (*rigidus* Zone; identifications by B.S. Norford, Appendix 5A, GSC locs. C-194829 and C-194828). The second, found about 15 m below the top of the outcrop belt east of Rens Fiord, includes *Cyrtograptus* sp. and *Monograptus* aff. *M. flemingi* of Wenlock, probably late Wenlock age (GSC loc. 52319; identification by J.W. Kerr and R. Thorsteinsson *in* Trettin, 1969a, reproduced in Appendix 5A).

Two macrofossil collections from resedimented carbonates are in accord with the graptolite collections, but provide only lower age limits for the host rocks. A carbonate olistolith, about 60 m above the base of Member B in the type section, contained a variety of macrofossils, including *Encrinurus* sp. and ?*Howellella* sp., which indicate a late Llandovery to Pridoli age (GSC loc. 47511; identification by B.S. Norford *in* Trettin, 1969a, p. 25, reproduced in Appendix 5A); and carbonate clasts from a conglomerate of unspecified stratigraphic position in outcrops east of Eetookashoo Bay yielded macrofossils of Llandovery or Wenlock age. They included a species of *Halysites* similar to a species in the Offley Island Formation of northwestern Greenland identified as *H. catenularius* by Poulsen (GSC loc. 47510; identification by B.S. Norford *in* Trettin, 1969a, p. 17, 18, reproduced in Appendix 5A). The Offley Island Formation is late Llandovery in age (Hurst, 1980 and references therein).

Other collections of macrofossils and conodonts from carbonate clasts were undiagnostic (see further identifications by Norford and Nowlan in Appendices 5A and 5B, respectively).

In conclusion, it is established that Member B includes strata of late Early Silurian (latest Llandovery to late Wenlock) age. Member A remains undated, but probably was deposited rapidly and may be only slightly older than Member B in the Svartevaeg Cliffs. Moreover, the structural and stratigraphic relations discussed above suggest that Member A in the Svartevaeg Cliffs may be correlative with part of Member B in the outcrop belt east of Rens Fiord and Eetookashoo Bay.

The top of Member B of the Svartevaeg Formation in the outcrop belt east of Rens Fiord and Eetookashoo Bay is correlative with strata in the lower or middle part of the Lands Lokk Formation of northwestern Ellesmere Island (Chapter 3). Lower parts are correlative with the Danish River Formation and probably also with the Fire Bay Formation.

Stallworthy Formation (map units Ds1, Ds2, and Ds3, Early Devonian and (?)older)

Definition

The Stallworthy Formation was introduced as a group with three divisions (A, B, and C) by Fricker and Trettin (1962) and redefined as a formation with three members by Trettin (1964, 1969a). It is a thick succession of siliciclastic sediments, Early Devonian and possibly Silurian in age, that overlies the Svartevaeg Formation with angular unconformity. The lower part (Members A and B) consists mainly of quartzose sandstone and red siltstone with lesser amounts of chert conglomerate and breccia; the upper part (Member C) mainly of red and green weathering mudrock with lesser amounts of sandstone and very small amounts of pebble conglomerate and argillaceous limestone. The composite type section is located about 7 and 27 km south-southeast of Cape Stallworthy (*Cape Stallworthy–Bukken Fiord*, sections S and ERF). The lower part was measured on the ground in 1962 and is graphically represented in Trettin (1969a, fig. 4). The upper part was traversed, and an approximate thickness was established by photogrammetry.

Distribution, contact relations, and thickness

Intermittent outcrops of the Stallworthy Formation occur in a belt extending from Cape Stallworthy for about 44 km to the southeast. Along the southwestern border of the outcrop belt, the Stallworthy Formation overlies Member B of the Svartevaeg Formation with angular unconformity (Fig. 19). On the northeast side, it is overthrust by Member A of the Svartevaeg Formation. Its stratigraphic top is not preserved. Graphic measurements in the vicinity of the type section suggest a total thickness of about 4 km. This estimate is based on assumed average dips of 56° and 70° for Members B and C, respectively (Member A is absent here), and an absence of faults, but these assumptions may be erroneous.

Lithology

Member A

About 25 km southeast of Cape Stallworthy, Member A is about 300 m thick (1,000 ft. in the original estimate). The thickness decreases rapidly in a northwestward direction and the member is absent north of an unnamed small glacier. Two major units are distinguished: a relatively thin but resistant basal unit composed of conglomerate and sandstone, and a recessive upper unit composed mainly of siltstone.

The lower major unit is about 76 m thick in the section east of Rens Fiord (ERF), 26 km southeast of Cape Stallworthy. The basal 11 m is composed of massive chert pebble conglomerate that weathers buff, red, and yellow. The pebbles are subrounded to rounded, mainly 1 to 3 cm, but up to 8 cm long, and embedded in a sandy matrix. This ledge-forming unit is overlain by about 30 m of medium-bedded quartzose sandstone and chert pebble conglomerate. The maximum diameter of the pebbles decreases upward to about 1.3 cm. The upper 43 m consists of less resistant quartzose sandstone.

The upper major unit is made up mainly of moderate red weathering mudrock, largely siltstone, with minor proportions of quartzose sandstone.

A sandstone sample collected about 12 m above the base of the member has the following composition according to point count analysis (numbers indicate percentages):

Quartz, quartzite	60
Chert, chalcedony	30
Opaques	5
Feldspar	2
Mudrock intraclasts	2
White mica	1
Chlorite	tr

Monocrystaline, more or less rounded grains of quartz are most abundant, but a few euhedral or subhedral grains of volcanic quartz also are present. Quartzite grains are fairly common, and some are

Figure 19. Angular unconformity between Svartevaeg Formation, Member B (Ssv2) *and Member A of Stallworthy Formation* (Ds1)*; about 2.5 km northeast of Rens Fiord, view to northeast, relief about 150 m (Cape Stallworthy–Bukken Fiord). (For graphic log of local stratigraphy, see Trettin, 1969a, p. 17, fig. 4). In this view, the angular discordance is small because the exposures are about parallel with strike. ISPG photo 4239.*

schistose and include white mica. Chert, mostly unmetamorphosed but partly phyllitic or recrystallized to quartzite, is more abundant than chalcedony. The white mica occurs partly as matrix and partly as relatively large flakes.

The grain size ranges from 0.2 to 2 mm, and the sorting is poor. Quartz and quartzite grains are mostly subrounded to rounded whereas the chert grains are subangular to subrounded. Quartz in optical continuity forms the cement.

Member B

Member B shows considerable variation in thickness along strike with a maximum of about 780 m near the type section. The member consists mostly of quartzose sandstone and chert conglomerate and breccia with lesser amounts of siltstone. Sandstone and siltstone commonly show medium-scale crossbedding. The rocks are unfossiliferous except for rare, indeterminable plant remains. The fragments of conglomerate and breccia range in grade from granules to cobbles, pebbles being most abundant. Some conglomerates are well indurated and resistant, others are poorly indurated and recessive. Cobbles, pebbles, granules, and much of the coarse sand fraction consist of chert, but the proportion of quartz increases with decreasing grain size. The rocks weather in hues of grey, red, and brown.

A medium grained sandstone has the following composition (numbers indicate percentages):

Quartz, quartzite	93
Chert, chalcedony	4
White mica	1
Mudrock intraclasts	1
Feldspar	1
Opaques	tr

The grains are rounded to well rounded, moderately well sorted, and cemented by quartz.

Member C

Member C, generally poorly exposed and recessive, is estimated to be in the order of 2400 m thick. The predominant rock types are medium-red weathering, laminated to thick bedded, coarse grained mudrock (siltstone) and interbedded greenish grey and dark grey weathering finer grained mudrock. Several units of greyish green or red weathering sandstone and pebble conglomerate, partly crossbedded, are intercalated with the mudrocks. Quartz and chert are the most abundant components of the sandstone and conglomerate, but some strata also contain calcareous and tuffaceous material. A bed of dark grey, argillaceous limestone yielded fish bones and pelecypods. Indeterminable brachiopods, gastropods, and pelecypods were collected from several beds of red siltstone.

Modal compositions of three samples of sandstone and one sample of pebble conglomerate are listed in Trettin (1969a, p. 61). These rocks are composed of varying proportions of carbonate rock fragments, commonly lime mudstone (19-72%), quartz and quartzite (15-59%), feldspar (1-17%), volcanic rock fragments (1-17%), chert (1-13%), chlorite (trace to 6%), and minor amounts of metamorphic rock fragments, mudrock intraclasts, white mica, and opaques.

Metamorphism

The absence of a pervasive metamorphic fabric and the sub-greenschist grade of the unconformably underlying Svartevaeg volcanics suggest that the metamorphic grade of the Stallworthy Formation is generally below the greenschist facies. It remains to be determined if, or to what extent, clay minerals in fine grained mudrocks have recrystallized to chlorite and white mica.

Mode of origin

Members A and B probably were deposited in nonmarine environments, including alluvial fan and fluvial settings. This is concluded from the coarse grade of the sediments, abundance of redbeds, facies and thickness changes over short distances, the common occurrence of medium-scale cross-stratification, and the absence of marine invertebrates. Member C, characterized by multicoloured mudrocks with a limited fauna of pelecypods, brachiopods, and fish was probably deposited in brackish water or shallow-marine delta environments.

The great thickness of the formation and the common occurrence of coarse grained clastic sediments suggest derivation from an upland source, abundant sediment supply, and accumulation on a rapidly subsiding coastal plain. The compositional maturity of the sediments (mostly quartz and chert) and the good rounding of the quartz are probably indicative of the source rocks rather than the intensity of weathering and abrasion during the Late Silurian–Early Devonian, because, associated with the highly mature quartz sandstones, are some texturally immature chert breccias (Member B) and compositionally immature tuffaceous and calcareous lithic sandstones (Member C).

The most important sources were probably the Grant Land Formation, which provided the rounded quartz and some feldspar, and the Hazen Formation, which provided the chert. These two formations are exposed in the central and northwestern parts of the Northern Heiberg Fold Belt, where they are unconformably overlain by Carboniferous formations, but concealed in the northeastern part of the Hazen Fold Belt and in most of northwestern Ellesmere Island, where they are covered by Silurian strata. These relations suggest derivation from a westerly or southwesterly direction (cf. Chapter 5). The chert breccia in the lower part of the formation must have been derived from proximal sources. The sparse volcanic and carbonate materials in Member C, on the other hand, were probably derived from Silurian or contemporaneous volcanics and carbonates.

The transition from Member B to Member C is marked by a decrease in average clast size and a shift from fluvial to paralic depositional environments. These changes were likely caused by erosional levelling of the source area, tectonic subsidence, a eustatic rise of sea level, or a combination of these factors.

Age and correlation

Fossil fish, collected in 1961 from Member C, about 1.3 to 1.5 km above the base of the formation, are of Early Devonian, late Lochkovian or early Pragian age (GSC loc. 47521; identification by R. Thorsteinsson, in Trettin, 1969a, p. 22; reproduced in Appendix 5A with a modified age assignment by R. Thorsteinsson and H.P. Schultze). Additional collections were made by H.P. Schultze in 1972, and scales from these collections were studied by Vieth (1980) who found them to be similar to scales from the Red Canyon River Formation in west-central Ellesmere Island, and favoured an early Pragian age.

The Stallworthy Formation is lithologically similar to syntectonic sediments of the Boothia Uplift, such as the Peel Sound, Prince Alfred, and Snowblind Bay formations, which have an overall age range from late Ludlow to late Lochkovian (Thorsteinsson, 1980; de Freitas and Mayr, 1992a, b), and at least its lower and middle parts probably are correlative with these units. The upper part may be correlative with the Red Canyon River Formation, a syntectonic unit of early Pragian age, deposited on the northwestern margin of the Bache Peninsula Arch (Trettin, 1978), as suggested by Vieth (1980).

PHANEROZOIC INTRUSIONS

Phanerozoic intrusions include the undated gabbroic Aurland Fiord Pluton, small granitoid plutons and a swarm of felsic dykes and plugs, all of which are Late Devonian in age, and mafic dyke swarms that are probably Cretaceous in age.

Aurland Fiord Pluton (map unit b, undated gabbro)

This pluton is located on the southwest side of Aurland Fiord. It appears to intrude the Hazen Formation, but the contact is covered. The exposures are about 3 km long and up to 900 m wide. The pluton is composed of medium grained hornblende-clinopyroxene gabbro. A typical sample consists of plagioclase (53%), pyroxene (largely or entirely clinopyroxene, 23%), hornblende (16%), intergrowths of quartz and K-feldspar (4%), quartz (1%), K-feldspar (? 1%), biotite (1%), opaques (1%), and apatite (trace). The plagioclase is zoned from calcic andesine to sodic labradorite acccording to optical determinations. Probe determinations on another sample gave an average plagioclase composition of An_{53} and identified the pyroxene as augite. The average end-member composition of five analyzed grains is $Wo_{39.12}$, $En_{37.45}$, $Fs_{23.43}$ (G.M. Le Cheminant, pers. comm., 1987). XRD analyses of seven samples suggest that amphibole and pyroxene are present in roughly equal proportions.

No minerals suitable for age determination were found in a large sample submitted for dating. The age of the pluton is unknown and several different correlations are plausible:

1. It may represent a sub-arc pluton related to the Lower Silurian Svartevaeg Formation.

2. It may be related to the Upper Devonian granitoid intrusions discussed below, because a Late Devonian granitoid intrusion in northwestern Ellesmere Island has mafic rocks associated with it (Chapter 3).

3. It may be co-eval with the basaltic volcanics of the Upper Cretaceous Strand Fiord Formation (Embry and Osadetz, 1988; Embry, 1991) and related dykes and sills, and with the Upper Cretaceous Wootton Intrusive Complex of Northern Ellesmere Island (Trettin and Parrish, 1987).

Upper Devonian granitoid intrusions (map units Dg, Dgd, Dqd, Dqd*)

On the west coast of northernmost Axel Heiberg Island, south-southwest of Cape Thomas Hubbard, four, aligned, small plutons intrude quartzite and phyllite or slate of the Lower Cambrian Grant Land Formation. The plutons form a belt, about 4.4 km long, that trends south-southwest, subparallel with the predominant structural trend in this area. A sample of the largest pluton (third from the north) is a medium grained, metaluminous (A/CNK = 0.90-0.92; A/NK > 1; Appendix 4B, Table 1, no. 10-3) granodiorite, composed of oligoclase (40%), K-feldspar (12%), quartz (18%), hornblende (17%), biotite (12%), and chlorite (1%) with trace amounts of opaque minerals and apatite. The northernmost pluton consists of medium grained, peraluminous (A/CNK = 1.12-1.23; Appendix 4B, Table 1, nos. 10-1, 10-2) tonalite, and a typical sample consists of zoned oligoclase-andesine (48%), quartz (26%), biotite (26%), and trace amounts of chlorite, apatite, and magnetite.

U-Pb (zircon) analysis of the tonalite revealed a preponderance of Precambrian zircons with a mean age of about 2 Ga (Trettin et al., 1992). Lower intercepts indicate crystallization of the pluton between 370 and 360 Ma, i.e., in the Late Devonian, Frasnian or Famennian (Fordham, 1992). An ^{40}Ar-^{39}Ar determination on biotite from the same sample had consistent total fusion and plateau ages of 360 ± 2 Ma, about mid-Famennian. These recent determinations confirm and refine a previous K-Ar (biotite) age of 367 ± 25.5 Ma (recalculated from Lowden et al., 1963).

A large fault block about 4 km southeast of Cape Stallworthy is composed of granitoid intrusions and thermally metamorphosed mudrock, chert, and carbonates. The granitoid rocks consist mainly of plagioclase (oligoclase-andesine or albite) with or without small amounts of K-feldspar. The mafic minerals have mostly been altered to chlorite, but small amounts of biotite and hornblende are preserved. Epidote and calcite alteration also occur, and apatite is a common accessory. One analyzed sample is a medium grained tonalite, another is a medium grained metaluminous (A/CNK = 0.97-0.98; Appendix 4B, Table 1, no. 11-1) quartz diorite transitional to tonalite. This intrusion is comparable in mineral composition to the dated plutons north of Rens Fiord and probably also Late Devonian in age.

Upper Devonian felsic dykes and plugs (map unit Dta)

South of eastern Rens Fiord, 12 or more plugs and dykes of porphyritic felsite intrude the Grant Land Formation. They form a belt, 11 km long and up to about 1 km wide, that is parallel with the southeasterly structural trend. Individual plugs and dykes range in length from a few metres to about 2 km. The intrusions are similar in mineralogy and texture. Phenocrysts, mainly of plagioclase (zoned from sodic andesine to sodic labradorite or altered to albite) with small proportions of K-feldspar, and of biotite partly replaced by chlorite, are set in a groundmass of feldspar with variable amounts of quartz, minor amounts of biotite and chlorite, and varying amounts of secondary calcite and dolomite. Two specimens with little carbonate alteration were analyzed chemically. Major element classification, according to Irvine and Baragar (1971), places them in the fields of rhyolite and calc-alkaline dacite, respectively, whereas trace element ratios (after Winchester and Floyd, 1977) place both in the field of trachyandesite. Such discrepancies are common in the Precarboniferous volcanics of northern Ellesmere and Axel Heiberg islands. The trace elements have generally given more consistent results and therefore the term trachyandesite is preferred, assuming that the matrix quartz is of replacement origin. The rocks are peraluminous and metaluminous (Appendix 4B, Table 1, nos. 12-1, 12-2).

U-Pb (zircon) analysis yielded results similar to that of the tonalite north of Rens Fiord (Trettin et al., 1992). Discordant zircon with Precambrian inheritance had an upper intercept age of 2436 Ma. Lower intercepts, combined with a nearly concordant determination, provided an age of 368 ± 3 Ma, close to the Frasnian-Famennian boundary (Fordham, 1992).

Upper Cretaceous(?) mafic dykes

Northerly trending dyke swarms are common in the Grant Land and Aurland Fiord formations south of Rens Fiord. These rocks are relatively unaltered. A specimen of a typical dyke that cuts the Aurland Fiord and Grant Land formations consists largely of labradorite, clinopyroxene, and opaque minerals, with minor amounts of sericite and chlorite. Subparallel dyke swarms, common in Carboniferous to Cretaceous formations of northern Axel Heiberg Island (Thorsteinsson and Trettin, 1972a, b), are probably related to Cretaceous volcanism (Embry, 1991).

STRUCTURAL GEOLOGY

Description of structures

The Northern Heiberg Fold Belt is divisible into six major domains, described below from northeast to southwest. The boundaries of the domains are shown in Figure 20. The structures discussed below are portrayed in the *Cape Stallworthy-Bukken Fiord* map sheet, including insets Ca and D, and cross sections A-A′ and B-B′ (Trettin, 1995).

Domain 1

Members A and B of the Svartevaeg Formation constitute the northeasternmost domain. On the southwest side of the domain, Member A is thrust over the Stallworthy Formation along the northeast-dipping Svartevaeg Thrust. The fault is mostly covered, but bedding attitudes of 68° in adjacent outcrops of Member A suggest the dip is steep at the surface. Member B forms a broad, southeast-plunging syncline broken by minor faults. Trettin's (1995b) cross section A-A′ assumes that the structure of Member B is controlled to some extent by that of Member A, a thick, massive, volcanic unit, and the underlying Svartevaeg Thrust. If so, the Svartevaeg Thrust probably flattens at depth.

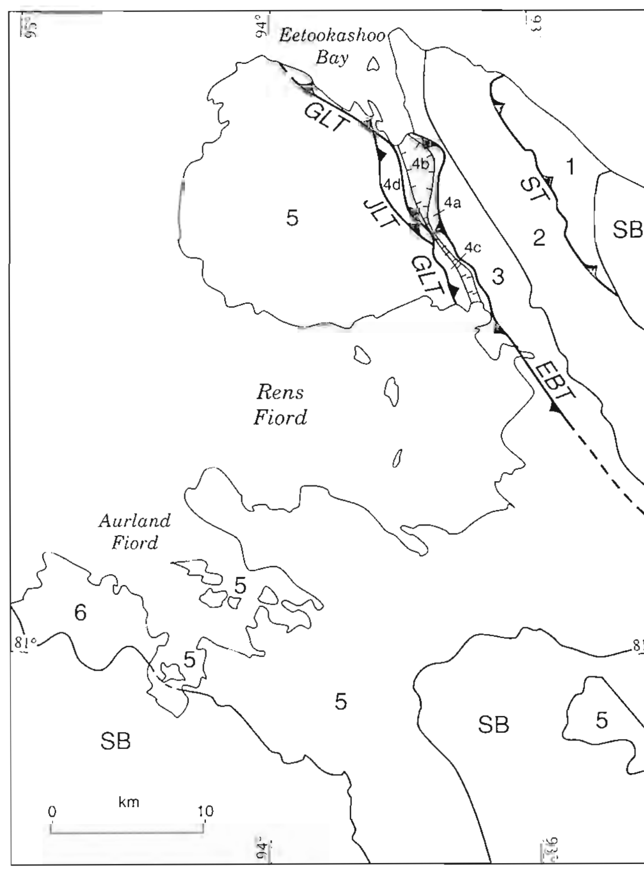


Figure 20. Structural domains (1–6) of Northern Heiberg Fold Belt and boundary faults. EBT: *Eetookashoo Bay Thrust,* GLT: *Greenstone Lake Thrust,* JLT: *Jaeger Lake Thrust,* ST: *Svartevaeg Thrust,* SB: *strata of the Sverdrup Basin.*

Domain 2

The Stallworthy Formation forms a panel that dips steeply northeast, approximately parallel with the upper part of the Svartevaeg Thrust. In contrast to the older formations, no folds are recognized in the Stallworthy beds. Southeast of Cape Stallworthy, an uplifted block of granitoid intrusions and metamorphic rocks occurs within the Stallworthy Formation and is bounded by steeply dipping faults.

Domain 3

This domain consists of Member B of the Svartevaeg Formation. Its northeastern limit is defined by the angular unconformity at the base of the Stallworthy Formation, and its southwestern limit by the Eetookashoo Bay Thrust (see below). The strata show minor folds and faults, similar to those in the Grant Land Formation. The fact that these folds are smaller, tighter, and more complex than the major syncline formed in Member B in Domain 1, demonstrates that they are not controlled by the massive volcanics of Member A. Either Member A is absent due to a facies change as suggested above (Fig. 20) or Member B is separated from Member A by a décollement.

Domain 4

This domain is characterized by closely spaced southeast-trending reverse and normal faults that displace the oldest units of the fold belt. Vergence is northeast in the northeasternmost part, and southwest in the central and southwestern parts of the domain. Four subdomains are distinguished in the vicinity of Jaeger Lake, Greenstone Lake, and northeastern Rens Fiord (cf. cross section A–A′ in Trettin, 1995). *Subdomain 4a* consists of a sheet of the Aurland Fiord Formation that has been transported northeastward over Domain 3 along the Eetookashoo Bay Thrust. *Subdomain 4b* comprises scattered outcrops of the Grant Land and Hazen formations. The contacts of this subdomain are not exposed, but photogeological interpretation and age relations suggest that it is bounded by inward-dipping normal faults on both sides. *Subdomain 4c* consists of a sheet of the Jaeger Lake Formation that has been thrust over the Grant Land Formation along the southwest-verging Greenstone Lake Thrust. Near Eetookashoo Bay, two additional thrust faults splay off the main thrust where it curves in a more westerly direction. *Subdomain 4d* is a thrust sheet that has been transported southwestward over the Hazen and Grant Land formations of Domain 5 along the Jaeger Lake Thrust. The sheet consists of the Aurland Fiord Formation and the overlying Grant Land Formation. The concealed contact between these two units is tentatively identified as a stratigraphic contact but its nature is uncertain. The Jaeger Lake Thrust, which is exposed only in a small area west of Jaeger Lake, probably splays off the Greenstone Lake Thrust in a drift-covered area between Greenstone and Jaeger lakes and rejoins it farther northwest.

The subsurface structure of this complex area is difficult to interpret because of inadequate exposure, insufficient structural data, and uncertainty about stratigraphic relations. Because the predominant vergence in this domain is southwest, it is possible that the northeast-verging faults also are southwest-verging faults at depth that are overturned to the northeast at shallow levels. Such overturning is common in orogenic belts in general, and demonstrable in the Kulutingwak Anticlinorium of the Clements Markham Fold Belt (Trettin and Frisch, 1995, inset, cross section A–A′; see also Fig. 77). If this is not the case, then one set of thrust faults is probably younger than the other and truncates it at depth.

Domain 5

Domain 5 is underlain mainly by the Grant Land Formation with minor infolds or fault slices of the Hazen Formation. Both units are tightly and complexly folded. In addition, fault-bounded blocks or sheets of the Jaeger Lake and Aurland Fiord formations, and small granitoid intrusions and felsic dykes and plugs of Late Devonian age are present.

The Jaeger Lake Formation occurs as a south-trending belt of eight small exposures that extends from north of Rens Fiord across two islands to the largely drift-covered plain south of the fiord. The exposures north of the fiord form a series of blocks that are separated from the surrounding Grant Land Formation by short, north- and east-striking faults. The exposures south of Rens Fiord are surrounded by Quaternary sediments, but lineaments in the Quaternary sediments suggest that they also are bounded by faults. These faults and lineaments constitute the Rens Fiord Fault Zone.

The Aurland Fiord Formation occurs as erosional remnants of gently undulating thrust sheets (i.e., klippen) emplaced upon the tightly folded Grant Land and Hazen formations. A small klippe north of Rens

Fiord is probably rooted in the Jaeger Lake Thrust, exposed about 2.5 km to the northeast. One extensive klippe and four smaller klippen south of Rens Fiord overlie the Aurland Fiord Thrust. Four isolated exposures of the same formation, occurring on islands in eastern Aurland Fiord and on the peninsula north of Aurland Fiord, may form part of the same widespread thrust sheet, but their structural setting is obscure. The thrust may be rooted in a steeply dipping fault southwest of Aurland Fiord (Domain 6) that separates the Aurland Fiord and Hazen formations. If so, tectonic transport was southwest to northeast. Northeastward transport may also be indicated by the vergence of minor folds in underlying strata of the Hazen Formation (Fig. 21).

The Grant Land Formation is intruded by a south-trending belt of four, small, granitoid plutons in an area south-southwest of Cape Thomas Hubbard and by a southwest-trending belt of felsic dykes and plugs south of Rens Fiord. Both sets of intrusions, as mentioned, have yielded Late Devonian radiometric ages.

Domain 6

This domain, located on the southwest side of Aurland Fiord, comprises steeply dipping blocks or slices of the Aurland Fiord and Hazen formations and of Member B of the Svartevaeg Formation, which are bounded by steeply dipping faults. A major fault in this domain, as previously mentioned, may represent the root of the Aurland Fiord Thrust of Domain 5 (see above). The Hazen Formation appears to be intruded by the gabbroic Aurland Fiord Pluton but the contact is concealed.

Ages of deformation

Three major deformations are apparent in northern Axel Heiberg Island. The two earlier events, which are restricted to the pre-Carboniferous rocks, are reviewed below. The early Tertiary Eurekan Orogeny, which affected the Sverdrup Basin along with the older rocks, has been discussed elsewhere (Thorsteinsson and Tozer, 1960, 1970; Fischer, 1984, 1985; Okulitch and Trettin, 1991).

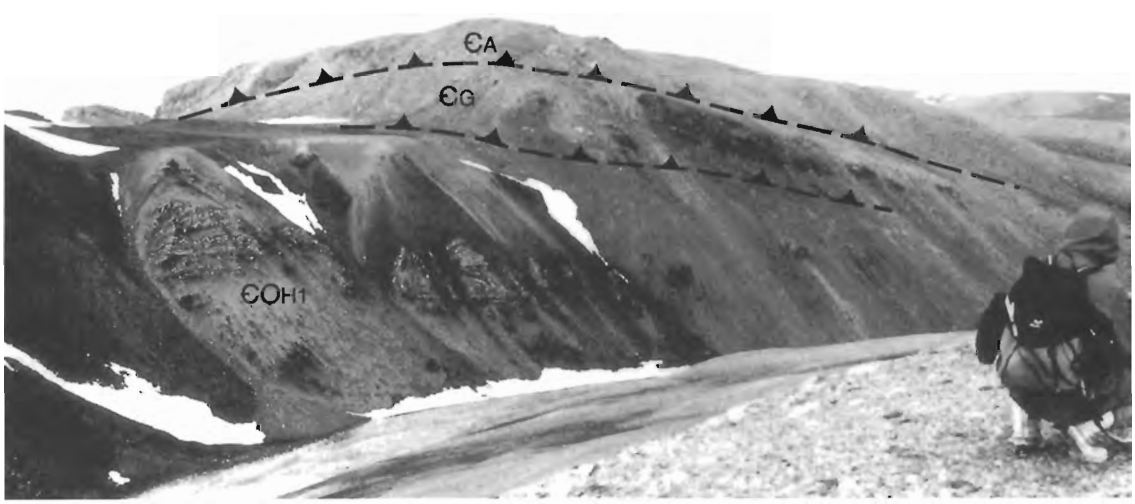


Figure 21. *Carbonate member of Hazen Formation (ЄOH1) overlain by thrust sheets of Grant Land Formation (ЄG) and Aurland Fiord Formation (ЄA), about 1.8 km east-southeast of central Aurland Fiord* ***(Cape Stallworthy-Bukken Fiord****, inset E), view to the north. Minor folds in the Hazen Formation seem to verge east-northeast but they have not been examined closely. ISPG photo 2638-2.*

Late Silurian–Early Devonian deformation

A major compressional event in Late Silurian–Early Devonian time is indicated by an angular unconformity between Member B of the Svartevaeg Formation and the Stallworthy Formation (Fig. 19). The age of the deformation is bracketed by graptolites of Wenlock (probably late Wenlock) age, 15 m below the unconformity, and by Early Devonian, late Lochkovian or early Pragian-aged fish, about 1.3 to 1.5 km above it. This deformation probably coincided with movements of the Boothia Uplift within the late Ludlow to early Pragian interval (Thorsteinsson, 1980; de Freitas and Mayr, 1992a, b), but is too poorly constrained for a precise correlation.

In the outcrop belt northeast of Eetookashoo Bay and Rens Fiord, Member B of the Svartevaeg Formation shows tight and complex folds whereas the Stallworthy Formation forms a monocline. This relation is diagrammatically represented in cross section A–A′ by Trettin (1995) but not apparent in Figure 19, which presents a view perpendicular to the cross section. The marked difference in structural style below and above the unconformity is not sufficiently explained by differences in lithology but strongly suggests that the folding occurred before the deposition of the Stallworthy Formation. This conclusion also applies to the folds in the Hazen and Grant Land formations, which are comparable to those in Member B of the Svartevaeg Formation in this domain. The broad and more open syncline formed by Member B in the Svartevaeg Cliffs, on the other hand, is probably controlled by the structurally competent volcanic Member A, as mentioned earlier. The folding was probably accompanied by faulting, but the age of most faults is uncertain and none can be assigned to this deformation with any assurance.

Devonian–Early Carboniferous deformation (Ellesmerian Orogeny)

A second angular unconformity separates the Sverdrup Basin from the entire lower Paleozoic succession. The youngest strata beneath it are mid-Early Devonian (Stallworthy Formation, Member C) and the oldest above it, late Early Carboniferous, Viséan, in age (Emma Fiord Formation). This event can probably be correlated with the extensive Ellesmerian Orogeny, which is restricted in age to the latest Devonian and earliest Carboniferous in the Central Ellesmere and Parry Islands fold belts, but may have commenced somewhat earlier in the northern regions (Thorsteinsson and Tozer, 1970; Harrison et al., 1991; Harrison, 1995).

Because of the limited preservation of Devonian strata, it is difficult to distinguish these structures from older ones, but two major thrust faults are tentatively attributed to this event:

1. The Svartevaeg Thrust affects the Stallworthy Formation and appears to be unconformably overlain by undisturbed strata of the Borup Fiord Formation. This implies an age younger than mid-Early Devonian (Pragian) and older than late Early Carboniferous (Namurian).

2. The age of the Aurland Fiord Thrust is probably constrained by two generations of intrusions:

   (a) On the northeast side of the largest klippe, dykes and plugs of Late Devonian age intrude the Grant Land and Hazen formations, but not the Aurland Fiord Thrust sheet (see above). The setting suggests that the intrusions were overlain by the thrust sheet prior to erosion, but the contact is not preserved (Trettin, 1995b, inset D).

   (b) North-trending mafic dykes cut the contact between the Aurland Fiord and Grant Land formations at the southern end of the klippe. These dykes are probably Cretaceous in age because they are relatively unaltered and form part of a dyke swarm that cuts formations of the Sverdrup Basin.

CHAPTER 3

GEOLOGY OF THE CLEMENTS MARKHAM FOLD BELT

CONTENTS

INTRODUCTION

The concept of the Clements Markham Fold Belt was introduced as part of a new stratigraphic-structural framework for the northern regions that also included the Hazen and Northern Heiberg fold belts and the Pearya Terrane (Trettin, 1987b). The fold belt comprises all the pre-Carboniferous rocks of northern Ellesmere Island that lie between Pearya on the northwest and the Hazen Fold Belt on the southeast. It extends across northern Ellesmere Island from the Lincoln Sea in the northeast to Nansen Sound in the southwest, a distance of about 450 km, and is up to 70 km wide (Fig. 1a, b). Its overall orientation is west-southwest, slightly arcuate, and almost parallel with the Hazen Fold Belt (Fig. 1a, b). The boundaries are concealed or faulted.

The Clements Markham Fold Belt differs from Pearya with respect to structural trend and pre-upper Llandovery stratigraphy, and from the Hazen Fold Belt in important aspects of its stratigraphy and lithology. The Hazen and Clements Markham fold belts both consist mainly of deep-water sediments and share a number of formations, but the Clements Markham Fold Belt also includes several generations of volcanics and a higher proportion of shallow-marine sediments.

STRATIGRAPHY

The Clements Markham Fold Belt includes an estimated 4 to 5 km of sedimentary and volcanic strata that range in age from Early Cambrian or older to Late Silurian. They are assigned to two successions, A and B, that predate and postdate, respectively, the onset of widespread and uniform flysch sedimentation in the latest Llandovery.

Succession A

Definition

Succession A comprises all strata older than the Danish River Formation. Exposures are limited to five separate outcrop belts that differ in age range and stratigraphy (Fig. 22).

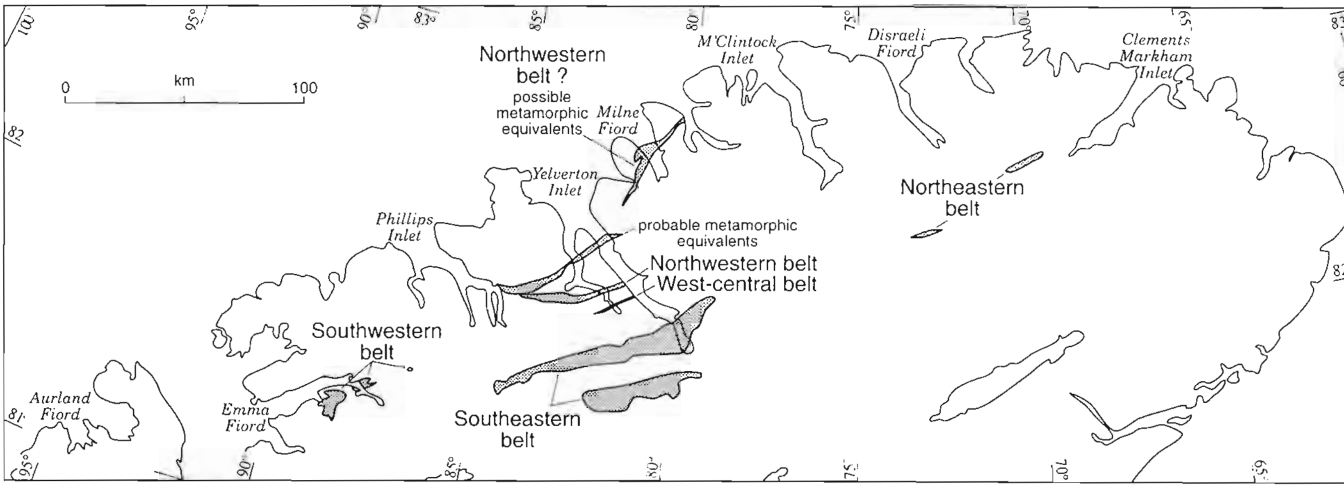


Figure 22. Generalized outcrop areas of Succession A of Clements Markham Fold Belt. (Northwestern belt includes outcrops of Succession B.)

Southeastern belt

The Southeastern belt includes four major units that range in age from Early Cambrian, or older, to Early Silurian.

*Yelverton Formation (map unit Є*Y*, Early Cambrian or older)*

Definition. The name, Yelverton Formation, is here proposed for a thick, fault-bounded assemblage of variably metamorphosed mafic volcanics and interstratified metamorphosed carbonates, mudrock and chert, exposed northeast and southwest of the head of Yelverton Inlet. The stratigraphic base and top of the formation are not exposed. The type section is located southwest of Yelverton Inlet (*Otto Fiord,* section SWYI) and a part of it is described in Appendix 1 (section southwest of Yelverton Inlet).

The formation was previously referred to as the Yelverton assemblage (Trettin and Mayr, 1981; Mayr et al., 1982; Mayr and Trettin, 1990; Trettin et al., 1991).

Distribution, contact relations, and thickness. The Yelverton Formation underlies an area, 93 km long and up to 8 km wide, that extends from southeast of Phillips Inlet (*Otto Fiord*) to northeast of the head of Yelverton Inlet (*Tanquary Fiord* and *M'Clintock Inlet*). The formation is in fault contact with Silurian flysch on the northwest (Lands Lokk Formation and undifferentiated Lands Lokk and Danish River formations). On the southeast it is thrust over the Grant Land Formation in the area southwest of Yelverton Inlet (Fig. 23).

Strata of the Grant Land Formation are associated with the Yelverton Formation in several small areas adjacent to the southern part of Yelverton Inlet. Although most occurrences are fault-bounded, the Grant Land Formation may overlie the Yelverton with a stratigraphic contact in a syncline southwest of the inlet (*Otto Fiord*).

A partial section in the southwestern part of the outcrop area comprises 464 m of strata (Appendix 1, section southwest of Yelverton Inlet; *Otto Fiord*). The total thickness of the formation is estimated to be greater than 1 km.

Lithology. The Yelverton Formation consists of metamorphosed volcanic rocks and a smaller proportion of metasediments, chiefly original limestone and mudrock with minor chert and dolostone.

Volcanic and hypabyssal rocks. In the type section, volcanic units and associated sills range in thickness from less than 2 m to about 100 m. The maximum thickness of volcanic units in this area is probably in the order of several hundred metres. The rocks are composed mainly of albite and chlorite with varying proportions of actinolite, epidote, calcite, dolomite, and quartz. Remnants of pyroxene, partly replaced by actinolite, are preserved in some samples. Both flows and tuffs are present but are generally difficult to distinguish because of alteration and metamorphism. Apart from rare pillow structures (Fig. 24), the flows

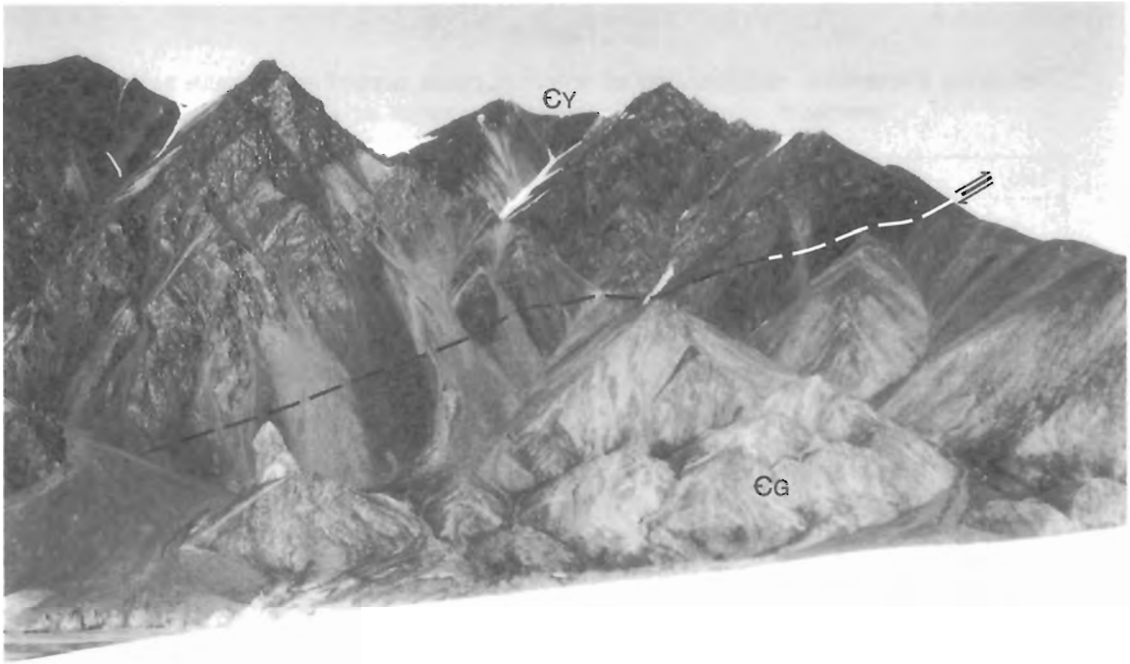


Figure 23. Thrust fault placing Yelverton Formation (€Y) on Grant Land Formation (€G), vicinity of section southwest of Yelverton Inlet, view east (Otto Fiord). ISPG photo 1878-1.

are distinguished by a relatively weak schistosity and, in thin section, by the presence of a framework of plagioclase microlites. The rocks interpreted as tuffs lack such a framework and have a better developed, commonly undulating schistosity. They are transitional to the tuffaceous phyllites discussed below.

Classifications of 18 analyzed samples are summarized in Table 5 (see also Figs. 25, 26, 27 and Appendix 4A, Tables 1, 2-5, 3-5). The trace element classifications (Fig. 25) are in the fields of andesite/basalt (5) and subalkaline basalt (2; one on the boundary with alkali basalt). The major-element

Figure 24. Pillow basalt in Yelverton Formation, southeast side of Yelverton Inlet (Tanquary Fiord). ISPG photo 648-21.

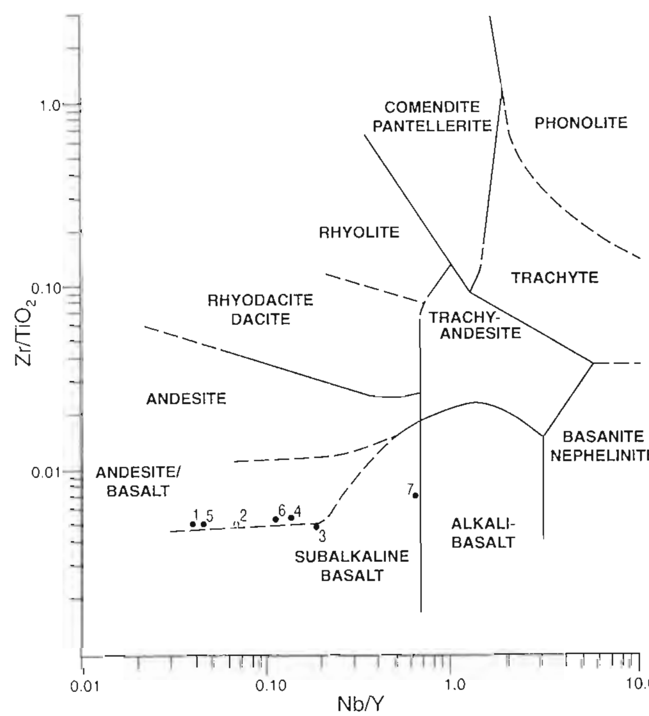


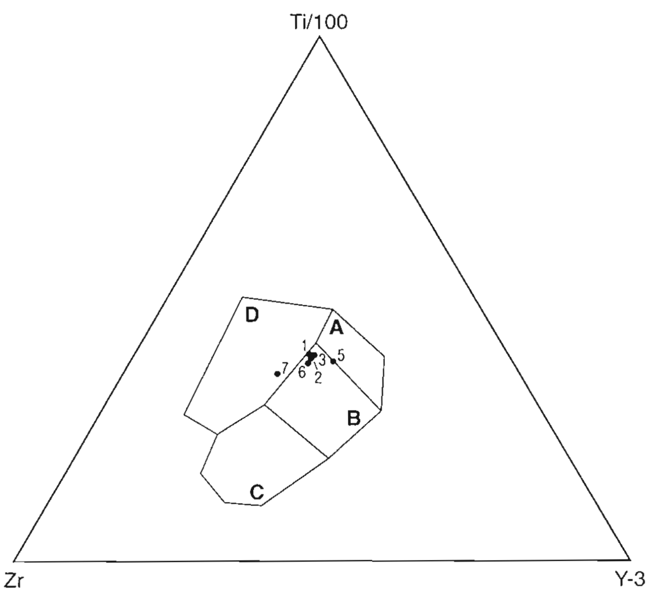
Figure 25. Yelverton Formation, stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).

Table 5

Yelverton Formation: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

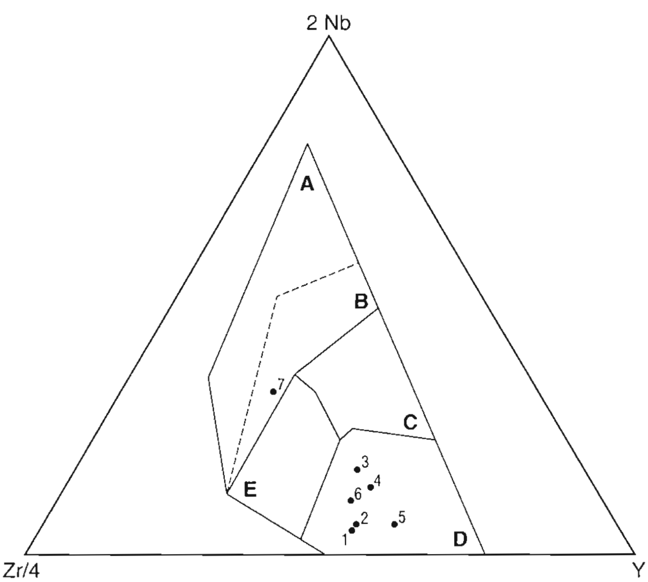
No.	Trace elements	Major elements
1		tholeiitic andesite (K-poor)
4	andesite/basalt	tholeiitic basalt (K-poor 2, average 2)
8		tholeiitic basalt (K-poor 3, average 4, K-rich 1)
1	andesite/basalt	tholeiitic picrite basalt[1] (K-poor)
1	subalkaline basalt	tholeiitic basalt (average)
1	subalkaline basalt	tholeiitic picrite basalt (K-poor)
1		alkalic picrite basalt (sodic)
1		hawaiite[2]

[1]Picrite basalt contains 25% (or more) of normative olivine (Irvine and Baragar, 1971).
[2]Hawaiite is a sodic alkali basalt (Irvine and Baragar, 1971).



Mainly low-K tholeiite . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . D

Figure 26*. Yelverton Formation, tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt . . . . A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . E

Figure 27*. Yelverton Formation, tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1)*

classifications are fairly consistent with each other and with the trace element classifications. They indicate mainly tholeiitic compositions: tholeiitic basalt (13), tholeiitic picrite basalt (2), tholeiitic andesite (1), with minor sodic alkali basalt (2). K-poor (8) and average (7) compositions are predominant.

The rocks tentatively interpreted as sills are similar to the flows with regard to mineral composition and alteration state and differ only by a slightly coarser crystal size.

Metasediments. In the type section, sedimentary units range in thickness from 1 to 138 m. They are composed of variably recrystallized limestone and phyllite with smaller proportions of chert and dolostone.

The most common rock type is a medium dark grey, schistose lime mudstone. Individual units range in thickness from 1 to 15 m. Some rocks are relatively pure, others contain scattered dolomite (mean content 6%; Appendix 3, Table 2) and/or detrital material - mainly quartz of silt to sand grade, rarely white mica and chlorite. Quartz veinlets and replacements are common. A medium grey, highly sheared, dolomitic limestone on the southwest side of Yelverton Inlet contains tectonically flattened oncoids.

Dolostones range in crystal size from microcrystalline to medium crystalline, are less metamorphosed than associated limestones, and contain quartz veinlets and replacements (Appendix 3, Table 3).

The chert, which is medium dark grey and closely associated with limestone, is probably of replacement origin because neither radiolarians nor sponge spicules were seen in thin sections.

Phyllites range in thickness from 0.7 to 21.9 m in the type section. Non-tuffaceous phyllites are mostly medium dark grey, and some samples show flat laminae. According to uncorrected XRD analyses, they are composed chiefly of quartz (mean 71%) with smaller proportions of albite, mica, chlorite, dolomite, calcite, and K-feldspar (Appendix 3, Table 4). Tuffaceous phyllites are greenish grey and characterized by relatively high concentrations of plagioclase (up to 24%) and/or chlorite, which ranges up to 29 per cent (Appendix 3, Table 5). The presence of a detrital component is indicated by a relatively high quartz content (mean 56%).

Metamorphism. Most volcanic rocks have a schistose texture and a mineral composition compatible with the greenschist facies. Relics of pyroxene, however, are preserved in some volcanic samples from southwest of Yelverton Inlet, indicating that the metamorphism was incomplete. The texture and mineralogy of the phyllites, on the other hand, is entirely compatible with the lower greenschist facies.

The lime mudstones are recrystallized to varying extent. Recrystallization is relatively weak in the region southwest of Yelverton Inlet where many rocks are microcrystalline, and strong in the area northeast of Yelverton Inlet where medium crystalline rocks are present. Some weakly recrystallized lime mudstones show a schistosity defined mainly by the concentration and orientation of the smeared-out carbonaceous matter.

Mode of origin. The mode of origin of the Yelverton Formation is uncertain because of conflicts between interpretations based on geological information and trace element composition. On the Pearce-Cann diagram (Fig. 26) the trace element ratios plot mainly in the field of ocean floor basalt, and on the Meschede diagram (Fig. 27) in a field occupied by both normal mid-ocean ridge basalt (synonymous with ocean floor basalt) and volcanic arc basalt.

From a geological viewpoint, a normal mid-ocean ridge (ocean floor) assignment is difficult to reconcile with the presence of shallow-marine carbonates because ocean floor volcanics are normally overlain by radiolarian chert. A volcanic arc origin would conflict with the inferred age. As mentioned earlier (Chapter 2, Jaeger Lake Formation), the North American continental margins, including the Arctic, were characterized by extensional tectonics and volcanism during the latest Proterozoic–Early Cambrian interval. If the Yelverton volcanics are indeed of this age, they probably were erupted during a rift or early drift stage, and the conflicting trace element compositions are probably due to crustal contamination (Wang and Glover, 1992).

The mafic-tholeiitic major element composition of the volcanics is compatible with this interpretation but does not prove it because tholeiitic basalt also occurs in volcanic island arcs. The two settings can be distinguished by K-content (Pearce, 1976), but the Yelverton Formation is too altered to rely on this criterion.

Age and correlation. The age of the Yelverton Formation is uncertain as neither macrofossils nor microfossils have been obtained even though a number of large limestone samples were analyzed for insoluble microfossils. An Early Cambrian or older age is suggested by the fact that it has been thrust over the Grant Land Formation.

The Yelverton Formation is similar to the Jaeger Lake Formation of northern Axel Heiberg Island with respect to the overall lithological composition - both consist mainly of volcanics and carbonates - and the chemical composition of the volcanics (compare Figs. 3, 27). The Jaeger Lake Formation also is considered to be Early Cambrian or older in age because it has been thrust over the Grant Land Formation.

Grant Land Formation (map unit ЄG, Lower Cambrian)

Distribution, contact relations, and thickness. In the Clements Markham Fold Belt, the Grant Land Formation (see Chapter 3, Grant Land Formation, Definition) is restricted to the Southeastern belt of

Succession A. It occurs as a discontinuous series of exposures, 71 km long, that extends from northeast of the upper reaches of Yelverton Inlet to south of Phillips Inlet (*Tanquary Fiord* and *Otto Fiord*). In the central and western part of this belt, the formation is in fault contact with upper Paleozoic formations on the southeast, and overthrust by the Yelverton Formation from the northwest. In addition, small exposures occur within an outcrop belt of the Hazen Formation southwest of the head of Yelverton Inlet. As already mentioned, it is possible that the Grant Land Formation overlies the Yelverton Formation with a stratigraphic contact in a syncline southwest of Yelverton Inlet, in the northwestern extremity of *Otto Fiord* map area.

The thickness of the Grant Land Formation has not been established because of its complex structure; probably more than a few hundred metres of strata are exposed. As mentioned earlier, the formation is probably more than 1.5 km thick in the Hazen Fold Belt.

Lithology. In the main outcrop belt, the formation consists chiefly of quartzite and original mudrock that has been metamorphosed to slate or phyllite, with small amounts of granule conglomerate. Thick or massive sandstone units, comparable to those at Hare and Tanquary fiords, are common. Most mudrocks are coloured in hues of green or grey, but some are greyish red purple.

About 175 m of strata, lying directly beneath the overthrust Yelverton Formation in the section southwest of Yelverton Inlet, were studied in detail. They consist mainly of pyritic mudrock, metamorphosed to slate or phyllite, with small amounts of interbedded sandstone. The rocks are grey but weather rusty brown, owing to limonite stain derived from pyrite, which is common both in mudrocks and sandstones. Some mudrocks are bimodal and contain quartz and feldspar of very fine to medium sand grade. Most sandstones are very fine grained and silty. Sandy units range in thickness from 0.5 to 30 cm and commonly include interlaminated mudrocks. Flat lamination is the predominant primary structure.

The sandstones are composed of quartz (81%), albite (13%), chlorite (3%), mica (2%), and calcite (1%); (average of 5 XRD analyses, Appendix 3, Table 6). Heavy mineral analyses have not been made, but tourmaline is common in thin sections. Sand-grade quartz and feldspar are embedded in a diagenetic pseudomatrix composed mainly of quartz and white mica with trace amounts of biotite. In some rocks this matrix is replaced by calcite. The quartz sand appears to have been well rounded originally, but now is more angular as a result of pressure solution. The mudrocks (Appendix 3, Table 7) have a smaller quartz content (67%), a similar feldspar content (albite 10%, K-feldspar 2%), and higher contents of chlorite and mica (10% and 9%, respectively). The absence, in the mudrocks, of purple-red colour, and of chlorite pseudomorphous after glauconite suggests that these strata may be correlative with the lower part of Member B in the Hare Fiord–Tanquary Fiord region. The relatively high feldspar content of the mudrocks and sandstones (F/F+Q averages 13% and 15%, respectively) supports this correlation (cf. Trettin, 1994, p. 91, 94).

Apart from this section, no other detailed observations have been made. Six grab samples of fine to very coarse grained, in part pebbly sandstones from two localities, are nearly pure quartzites, whereas one sample of very fine grained sandstone from another locality contains between 5 and 8 per cent each of feldspar (mainly albite), mica, and chlorite (Appendix 3, Tables 8–10).

Metamorphism. Mudrocks have a slaty cleavage or crenulated schistosity that cuts the stratification at varying angles. The mineral composition of mudrocks and sandstones is indicative of the lower greenschist facies.

Mode of origin. Studies in the Tanquary Fiord and Hare Fiord regions indicate that the sediments were derived from cratonic sources and redeposited in submarine fan environments (Trettin, 1994, p. 96, 97).

Age and correlation. The Grant Land Formation is late Early Cambrian in age and correlative with the Ellesmere Group of the Central Ellesmere Fold Belt (Trettin, 1994, p. 97).

Hazen Formation (map unit Є–SH, Lower Cambrian to Lower Silurian)

Distribution, contact relations, and thickness. The Hazen Formation (see Chapter 2, Hazen Formation, occurs both in the Southeastern and Southwestern belts of Succession A of the Clements Markham Fold Belt. In the Southeastern belt it is exposed as a discontinuous belt of nunataks, extending from south of Yelverton Inlet for about 49 km to the southwest (*Tanquary Fiord* and *Otto Fiord*). In this area it overlies the Grant Land Formation, which is represented by local occurrences of partly silicified purple mudrock. The contact has not been seen but is probably similar to the contact in the Osborn Range, north of Tanquary Fiord, where chertified strata of the Hazen Formation overlie greenish grey and purple red mudrocks with an abrupt contact that either is conformable or represents a submarine disconformity (Trettin, 1994, p. 80). The contact relations with the Yelverton Pass beds are uncertain (see below).

The thickness of the formation has not been determined because of its structural complexity. Analogy with the northern part of the Hazen Fold Belt suggests that it does not exceed a few hundred metres (cf. Trettin, 1994, fig. 85).

Lithology. In this area the formation is made up mainly of chert, both primary and secondary in origin, with small amounts of slaty or phyllitic mudrock, and of resedimented carbonates. A division into the carbonate and chert members is not feasible because of extensive chertification.

The primary chert can be recognized by the presence of ghosts of radiolarians: spherical casts, about 0.1 to 0.3 mm in diameter, that are filled with radiating chalcedony and are free of the submicroscopic carbonaceous impurities characteristic of the background (cf. Figs. 7, 8). The host rock contains minor amounts of uniformly distributed, finely microcrystalline white mica and minor chlorite, representing recrystallized argillaceous material.

Mudrock is medium dark grey, commonly flat-laminated, and composed mainly of quartz and calcite with smaller amounts of feldspar and dolomite, and trace amounts of white mica (Appendix 3, Table 12).

The carbonates consist chiefly of lime mudstone with lesser proportions of calcarenite, and calcareous and cherty pebble conglomerate. Most rocks are medium dark grey and pyritic.

Lime mudstones show flat lamination or, less commonly, small-scale crosslamination. Some cryptocrystalline (micritic) calcite is preserved but most of the calcite has recrystallized and is now in the 5 to 50 μm range. The lime mudstones contain variable amounts of microcrystalline dolomite and of silt-grade quartz and minor feldspar (Appendix 3, Table 11). Some rocks, transitional to calcarenite, contain micritic peloids of silt to very fine sand grade and rare skeletal fragments that are poorly preserved.

The clasts of the calcarenite consist mainly of lime mudstone and rare fossil fragments, including echinoderm ossicles. Some lime mudstone clasts have a clotted, peloidal texture. Most quartz grains are well rounded.

Bouma sequences of lime mudstone and calcarenite are present and a typical turbidite (Fig. 28) displays the following stratigraphy:

Division D: 4.2-6.4 cm (2.2 cm)
Lime mudstone: silty, slightly quartz sandy; flat lamination

Division C: 3.0-4.2 cm (1.2 cm)
Lime mudstone: calcarenitic; contains quartz of silt to medium sand grade; flat lamination and small-scale crosslamination

Division B: 2.8-3.0 cm (0.2 cm)
Calcarenite: coarse grained; contains quartz of silt to very coarse sand grade; indistinct flat lamination

Division A: 0-2.8 cm (2.8 cm)
Calcarenite: coarse and very coarse grained with granules up to 3 mm long; contains quartz of silt to very coarse sand grade; structureless

Conglomerates are typically composed of clasts of lime mudstone, which may be laminated and variably silty and sandy. The clasts are flat with rounded edges and mainly of pebble grade, but range in diameter up

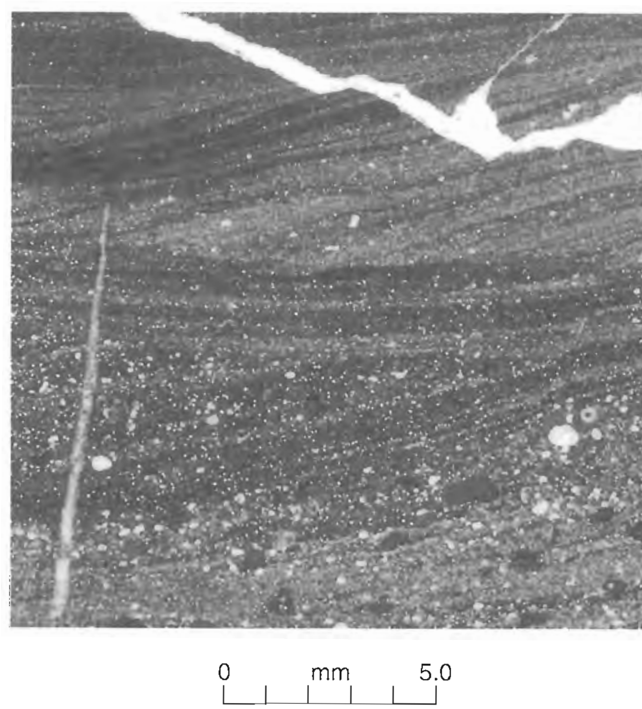


Figure 28. *Photomicrograph (ordinary light) of crosslaminated, graded, impure calcarenite-calcisiltite in turbidite of Hazen Formation at Yelverton Pass (Tanquary Fiord). Note well-rounded quartz grains and larger elongate clasts of lime mudstone. ISPG photo 2260-159.*

to 10 cm. They are embedded in a calcareous matrix that may be replaced by chert (Fig. 29).

Diagenetic changes, in temporal order, include minor dolomitization, extensive recrystallization of lime mud, and extensive chertification (Fig. 29).

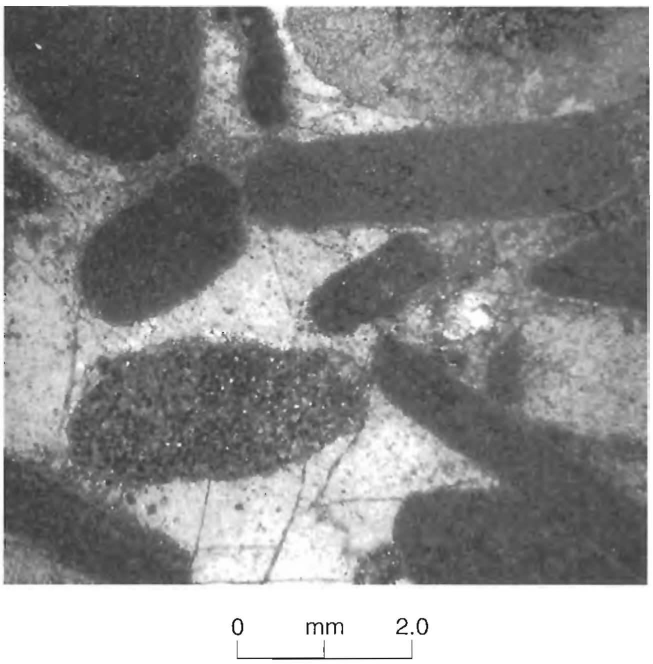


Figure 29. Photomicrograph (cross-polarized light) of limestone clasts (dark) in chertified matrix (light); Hazen Formation at Yelverton Pass (**Tanquary Fiord**). ISPG photo 4227-15.

Metamorphism. Thin sections suggest that the metamorphism is of lower greenschist grade in the sense that clay minerals have recrystallized to white mica and chlorite, but more detailed studies are required to verify this.

Mode of origin. The predominance of radiolarian chert indicates deposition in a deep-water basin without significant detrital input. The flat-pebble conglomerates probably represent resedimented slope deposits. The carbonate sediments in the Hazen Fold Belt clearly were derived from the Franklinian Shelf of central Ellesmere Island because they increase in clast size and abundance from northwest to southeast. The calcarenite and pebble conglomerate at Yelverton Pass are coarser than those in the central and northwestern parts of the Hazen Fold Belt and were probably derived from a different source.

Age and correlation. In the Hazen Fold Belt the Hazen Formation ranges in age from late Early Cambrian to Early Silurian and is correlative with the combined Vølvedahl and Amundsen Land groups of the North Greenland Fold Belt (Higgins et al., 1991a, b). No diagnostic fossils were found in this area.

Yelverton Pass beds (map unit SYP, *Lower Silurian)*

Definition. The informal name, Yelverton Pass beds, is here proposed for a fossiliferous limestone unit exposed in the northern part of Yelverton Pass, a valley leading from north of Tanquary Fiord to Yelverton Inlet (*Tanquary Fiord*). Chertified equivalents overlie the Hazen Formation, but the nature of the contact is uncertain. The unit was previously referred to as the Yelverton Pass limestone (Trettin et al., 1991).

Distribution, contact relations, and thickness. Two outcrops of limestone are present on the northeastern side of Yelverton Pass, about 24 km north-northwest of Yelverton Lake. The main outcrop is unconformably overlain by the Carboniferous Borup Fiord Formation and its base is concealed. It is estimated to contain about 100 to 200 m of strata.

A unit of chertified, fossiliferous carbonate rock, overlying the Hazen Formation on the southwestern side of the Pass, is tentatively correlated with the limestone on the northeastern side. It differs from the dark grey Hazen Formation by its yellowish grey colour. The gently dipping contact with the Hazen Formation, obscured by the chertification, appears to be abrupt. It either represents an unconformity or a low-angle normal fault and is shown as an assumed fault on the geological map (*Tanquary Fiord).*

Lithology. On the northeast side of the pass, the lowest outcrops consist of a pebble conglomerate composed of fossil fragments (mainly solitary and colonial corals, stromatoporoids, and echinoderms) and clasts of lime wackestone in a matrix of silty lime wackestone. The fossils and rock fragments are commonly in solution contact, and solution zones are also present within the matrix.

The overlying limestone contains scarce to abundant microscopic fragments of echinoderms, corals, bryozoans, ostracodes, molluscs and algae, as well as micritic peloids. The rocks probably represent wackestones and/or grainstones, but their original texture has been obscured by veins and pervasive recrystallization.

Metamorphism. Conodonts have an alteration index of 4, indicating temperatures between 190 and 300°C

(Epstein et al., 1977). The rocks do not show the schistosity and intensive twinning of calcite crystals characteristic of the greenschist facies.

Mode of origin. The conglomerate probably either represents a lag deposit or talus on the margin of a carbonate platform. The overlying limestones, judging from their skeletal content and light grey colour, probably formed in an oxygenated subtidal shelf setting.

The relationship between the Yelverton Pass beds and Hazen Formation is uncertain, but the marked difference in depositional environment and the abruptness of the contact argue against a conformable one. It is possible that these carbonates were deposited on an intrabasinal structural high, and that the contact with the Hazen Formation is unconformable. Alternatively, the contact may be a listric normal fault, and the beds may represent two or three olistoliths derived from shallow-marine carbonates that overlie volcanic edifices farther northwest. Shallow-marine carbonates of slightly older, early to middle Llandovery age, are associated with map unit OSv in the West-central belt, discussed later in this chapter.

Age and correlation. Corals from the basal strata, first reported by Nassichuk and Christie (1969), are assigned by Pedder to Estonian stages equivalent to the middle or late Llandovery (Appendix 5A, GSC locs. 74813, 74814, C-54807). Conodonts from the overlying strata belong to the late Llandovery *celloni* Zone or are slightly older (Uyeno, Appendix 5B, GSC loc. C-54790). The beds are approximately correlative with resedimented carbonates at the top of the Hazen Formation at Caledonian Bay, which lie between chert of the Hazen Formation that is middle or late Llandovery, and strata of the Danish River Formation that are latest Llandovery in age (Norford, *in* Trettin, 1979).

Southwestern belt

The Southwestern belt, which extends from Fire Bay, on the southeast side of central Emma Fiord for about 43 km to the northeast, includes four separate outcrop areas (*Cape Stallworthy-Bukken Fiord*, and *Otto Fiord*). The best exposures are at Fire Bay, where the stratigraphy described below was established.

Hazen Formation (map unit Є–SH, Lower Cambrian to Lower Silurian)

Distribution, contact relations, and thickness. The Hazen Formation (see Chapter 2, Hazen Formation, Definition) is exposed in three of the four outcrop areas of the Southwestern belt. Extensive exposures are present at Fire Bay and minor exposures 5 and 21 km northeast of Emma Fiord.

In all three outcrop areas, the Hazen Formation is the oldest exposed unit and its base and lower part are concealed. At Fire Bay it is overlain by the Fire Bay Formation. The contact is concealed in some areas and faulted in others, and its nature is problematic (see Fire Bay Formation). In the two other areas, the formation is in fault contact with the Fire Bay and Lands Lokk formations, respectively.

The stratigraphic thickness of the exposures has not been established because of their exeedingly complex structure.

Lithology. At Fire Bay the formation consists mainly of medium dark grey chert that is variably argillaceous and replaced to a minor extent by carbonate minerals. Casts of radiolarians, 0.1 to 0.15 mm in diameter, are preserved in some rocks. Also present are some carbonate olistoliths, discussed below under a separate heading.

Metamorphism. The metamorphism of the Hazen Formation appears to be below greenschist grade, but the degree of recrystallization of the clay minerals has not been investigated.

Mode of origin. The predominance of radiolarian chert indicates deposition in a deep-water basin that had no significant detrital input.

Age and correlation. In the Hazen Fold Belt, and probably also in the Southeastern Belt of Succession A, the full age range of the formation is latest Early Cambrian to early late Llandovery (Trettin, 1994, p. 113, 114), but, as mentioned, the lower part of the formation is concealed in the Southwestern belt. Several graptolite collections of Ordovician age were made at Fire Bay, but their stratigraphic positions within the formation are uncertain. The oldest is of early Middle Ordovician (Llanvirn-Llandeilo) age (Norford, Appendix 5A, GSC loc. C-194930). Two other collections from similar settings have given comparable but less specific ages (Norford, Appendix 5A, GSC locs. C-194944, C-194945). Two slightly younger collections are Caradoc in age and probably represent the early Caradoc and Llandeilo *Climacograptus bicornis* Zone or possibly the late Caradoc *Dicellograptus clingani* Zone (Norford, Appendix 5A, GSC locs. C-171530, C-171532). The graptolite collections are within the age range of faunules from the chert member in the Hazen Fold Belt (cf. Trettin, 1994, p. 235, 236).

Carbonate olistoliths in the Hazen and Fire Bay formations (map unit Oo, lower Middle Ordovician)

Distribution, contact relations, and thickness. At Fire Bay, fault-bounded, lenticular carbonate bodies of similar lithology and age are exposed in the northwestern part of the outcrop area of the pre-Carboniferous strata. Nine are shown on the map (*Cape Stallworthy–Bukken Fiord*, inset B) and others may be present. They occur in the upper part of the Hazen Formation (2), at the Hazen-Fire Bay contact (6; this includes the olistolith in the Fire Bay 2 section), and in the lower half of the Fire Bay Formation, below unit B2 (1; Fig. 30). The bodies range in length from a few metres to about 250 m, and in thickness from a few metres to perhaps a few tens of metres.

Lithology. The olistoliths are composed of partly recrystallized lime mudstone, with or without skeletal material; skeletal wackestone; skeletal grainstone; packstone composed of ooids, coated grains, and gastropod fragments; and fine microcrystalline dolostone. Macrofossils are scarce, but well preserved gastropods were found at one locality. Microscopic fragments represent echinoderms, bryozoans, trilobites, gastropods, corals(?) and *Girvanella*, which partly occurs in coated grains.

Metamorphism. The alteration index of five out of seven conodont samples is 3 to 3.5, corresponding to temperatures of about 110° to 155°C, but the full range is 2.5 to 4 (100°–200°C; Epstein et al., 1977), i.e., generally below the greenschist facies.

Mode of origin. Lithology and fauna indicate that the carbonates were originally deposited in shallow subtidal to intertidal shelf environments although they are now associated with sediments of deep-water origin. The distribution of the olistostromes suggests derivation from a source to the north-northwest. The setting of the source rocks is uncertain as strata of this age are concealed in the northwestern part of the Clements Markham Fold Belt. However, shallow-marine carbonates of Caradoc–Ashgill age associated with volcanics (see below, Kulutingwak Formation) are exposed in the Northwestern belt. It is possible that the olistostromes were derived from similar strata of older age. Carbonates are also present in the Maskell Inlet Complex of Pearya, a volcanic-sedimentary assemblage of uncertain pre-Caradoc age, tentatively assigned to the Arenig (Chapter 4).

The fact that olistostromes of the same age (see below) are associated with strata of the Hazen and Fire Bay formations suggests emplacement during a single event of submarine sliding, no older than late Llandovery, that affected the source beds as well as the Hazen and Fire Bay formations.

Age and correlation. Conodonts are of early to late Whiterockian (late Arenig to early Llanvirn) age

Figure 30. Carbonate olistoliths (Oo) in the Hazen Formation (Є-SH) and Fire Bay Formation, Members B and A (SF2) east of head of Fire Bay; view to the north. ISPG photo 4007-31.

(Nowlan, Appendix 5A, GSC locs. C-97241, C-97242, and C-97244; Nowlan *in* Trettin and Nowlan, 1990), slightly older than the oldest graptolites from the Hazen Formation. A gastropod from a different locality, identified as ?*Palliseria* sp., is probably also Whiterockian in age (Norford, Appendix 5A, GSC loc. C-171528).

As mentioned earlier, shallow-marine carbonates of this age are not known to be exposed in the report area. In the Hazen Fold Belt, correlative deep sea sediments occur in the Hazen Formation; in the Central Ellesmere Fold Belt, correlative shallow-marine sediments occur in the Bay Fiord and Bulleys Lump formations (Trettin, 1994).

Fire Bay Formation (map units SF, SF1, SF2, *and* SF3, *Lower Silurian)*

Definition. The name, Fire Bay Formation, is here proposed for a succession of sedimentary and volcanic rocks that lies stratigraphically between the Hazen and Danish River formations. The formation is divisible into three members, named in order upward A, B, and C (Fig. 31). The composite type section is located south and southeast of Fire Bay (*Cape Stallworthy-Bukken Fiord*, inset B, sections FB1, FB2, FB3). The rocks were previously assigned to Member B of the Lands Lokk Formation (Trettin, 1969a), or to the Fire Bay assemblage (Trettin and Nowlan, 1990) both of which are now abandoned (see below, Lands Lokk Formation) but these two units also included strata that are now assigned to the Hazen Formation.

Distribution, contact relations, and thickness. The Fire Bay Formation is exposed in the vicinity of Fire Bay (*Cape Stallworthy-Bukken Fiord*) and in two smaller areas, southwest and northeast of a bend near the head of Emma Fiord (*Otto Fiord*).

At Fire Bay the contact with the Hazen Formation is concealed in some areas and faulted in others. Talus suggests an abrupt change from radiolarian chert to mudrock. The nature of the contact is problematic because there is a gap in the fossil record. Graptolites of late Llandovery age occur near the base of the Fire Bay Formation, but graptolites of Late Ordovician and Early Silurian age have not been recovered from the Hazen Formation. A subaerial unconformity can be ruled out because of the deep-water origin of both formations. The simplest explanation would be that the upper part of the Hazen Formation is condensed and poor in fossils, and that the contact is a normal stratigraphic boundary. However, the stratigraphic-structural setting of the carbonate olistoliths (see above) indicates an episode of submarine sliding that also affected the Fire Bay and Hazen formations. This implies that the base of the Fire Bay Formation may be a gravitational normal fault, at least in the northwestern part of the Fire Bay area where carbonate olistoliths are present. The contact between the Hazen and Fire Bay formations in the outcrop area northeast of Emma Fiord, known only from overflights and airphoto interpretations, appears to be faulted. The concealed contact with the overlying Danish River Formation at Fire Bay is probably conformable.

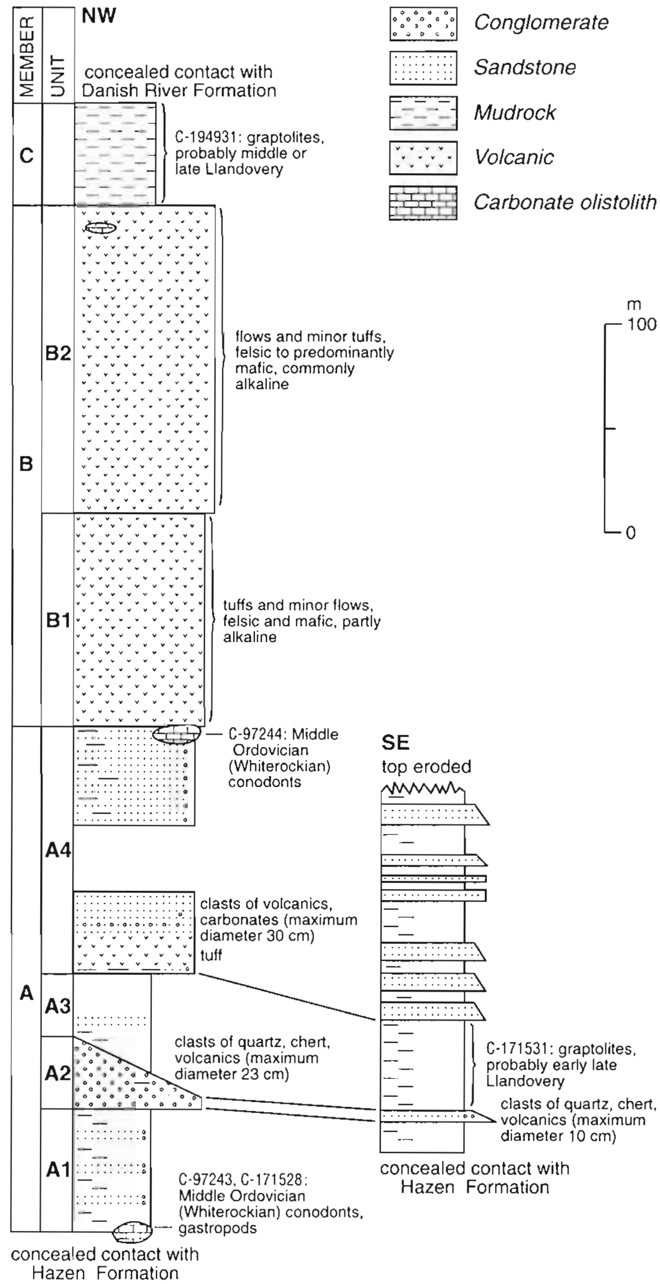


Figure 31. *Generalized stratigraphy of the Fire Bay Formation. The thickness of most units is uncertain.*

The thickness of the Fire Bay Formation is uncertain because of its complex structure and the difficulty of obtaining bedding attitudes in the massive volcanic rocks. Available data suggest a thickness of between 500 and 600 m.

Lithology. Member A consists mainly of clastic sediments with a small proportion of volcanics. The stratigraphy varies markedly over short distances, and correlation of stratigraphic sections is difficult. To cope with this complexity, the member has been divided horizontally into a northwestern and a southeastern facies (map units SF1N and SF1S of *Cape Stallworthy-Bukken Fiord*, inset B) and vertically into four major units, A1 to A4, that are shown in the stratigraphic sections only (Figs. 32, 37). The northwestern facies is coarser and has a higher volcanic content than the southeastern facies. The vertical subdivision is based on a chert- and quartz-rich conglomeratic marker in the lower part of the member (unit A2), overlain and underlain by recessive argillaceous units (A1 and A3) in both facies. This relation is important because it helps to determine the stratigraphic position of a diagnostic graptolite collection from an isolated outcrop area (see below, Age and correlation). No stratigraphic markers are recognized in the middle and upper parts of the member, which are included in a relatively thick, undifferentiated unit (A4). Carbonate olistoliths in this member have been discussed above under under a separate heading.

Unit A1, northwestern facies. In the northwestern facies, unit A1 has a minimum thickness of perhaps 60 m in the Fire Bay 1 section (Fig. 32) where its base is faulted. Largely covered and recessive, it probably consists mainly of mudrock. Intermittent outcrops consist of greenish grey, fine to coarse grained sandstones and pebbly sandstones with minor mudrock and rare pebble conglomerate.

XRD analyses of sandstones and pebbly sandstones reflect the relatively high content of chert and quartz (mean 75%; Appendix 3, Table 13). Carbonates (calcite 18%, dolomite 2%) occur mainly as lithic grains and rare ostracode shell fragments or as veinlets and alteration. Small proportions of chlorite (3%) and albite (2%) are present, mostly in volcanic rock fragments. Grains of detrital chromite and serpentinite (Fig. 33), although rare, are significant from a tectonic point of view.

Unit A1, southeastern facies. The uppermost strata, exposed at locality L1 (*Cape Stallworthy-Bukken Fiord*, inset B), consist of dark grey mudrock. The remainder is largely concealed and probably underlies the upper part of a covered interval that separates the

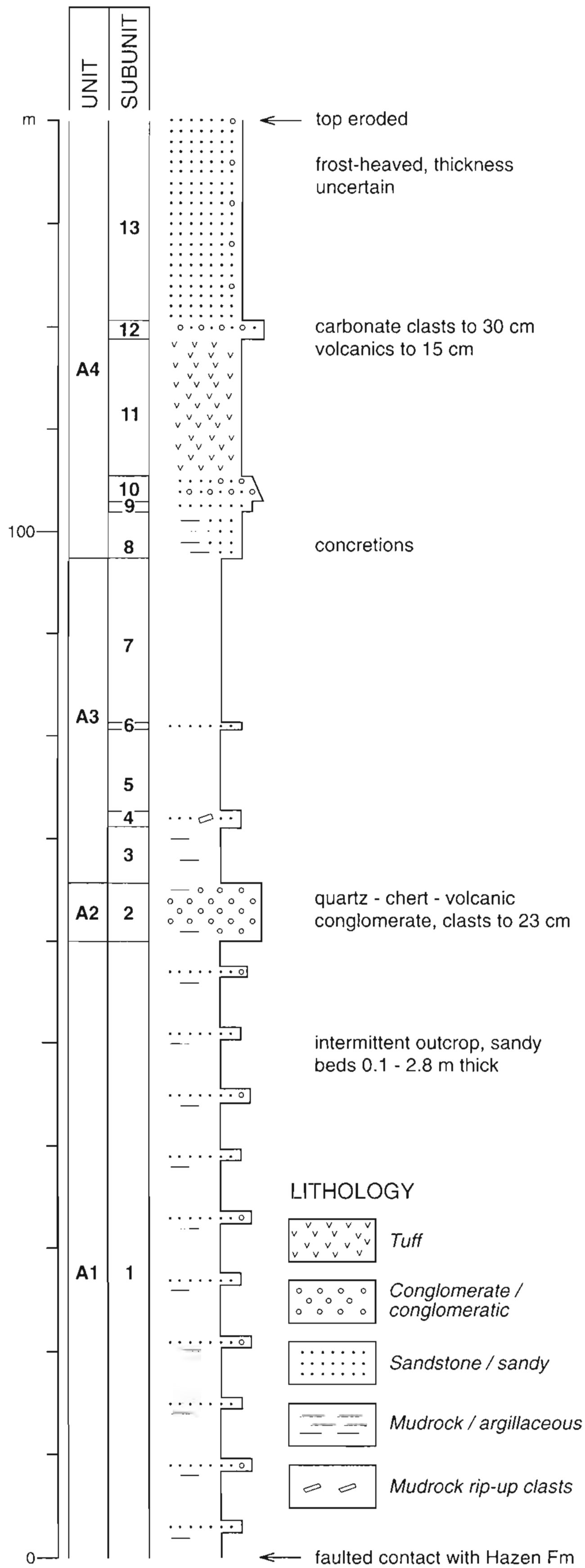


Figure 32. *Fire Bay Formation, Member A, northwestern facies at Fire Bay 1 section.*

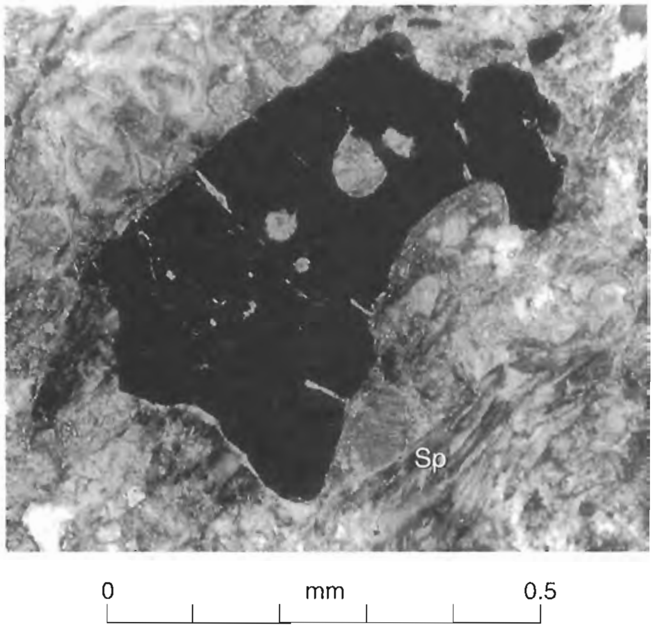


Figure 33. Photomicrograph (ordinary light) of detrital chromite (dark) and serpentinite (Sp) in pebbly sandstone of Fire Bay Formation, Member A, unit A1, northwestern facies. ISPG photo 4227-1.

Figure 34. Thick-bedded pebble conglomerate of Fire Bay Formation, Member A, unit A2, northwestern facies at Fire Bay 1 section; 1.5 m staff for scale. ISPG photo 4007-14.

Figure 35. Close-up of pebble conglomerate at Fire Bay 1 section; light grey clasts are quartz, quartzite, and chert, dark grey clasts are volcanic rocks. ISPG photo 4007-11.

Hazen and Fire Bay formations in the area southeast of Fire Bay.

Unit A2, northwestern facies. The northwestern facies is represented by unit 2 of the Fire Bay 1 section. It consists of a medium grey, sandy conglomerate, 5.8 m thick, that contains lenses of mudrock (Figs. 32, 34, 35). The conglomeratic beds show an indistinct flat stratification and are about 10 cm to 1 m thick. The clasts are mainly of pebble grade but quartzose clasts are up to 9 cm, and volcanic clasts up to 23 cm long.

The conglomerate was also examined at localities L5 and L6 (*Cape Stallworthy-Bukken Fiord*, inset B). The apparent thickness at these localities is 12 m and 34 m, respectively, and the maximum clast size, 11 and 9 cm.

Point count analysis of a thin section of sandy pebble conglomerate from the Fire Bay 1 section indicate the following composition (numbers indicate percentages):

Quartz:	45	Common quartz, vein quartz, quartzite (probably including highly recrystallized chert)
Chert:	27	Unmetamorphosed and recrystallized, in part slightly argillaceous
Volcanics:	23	Volcanic rock fragments of different compositions
Feldspar:	2	
Phyllite:	1	
Chlorite:	1	
Carbonates:	1	Veinlets and replacements

Unit A2, southeastern facies. The following short section describes exposures of the southeastern facies at locality L1.

Overlying strata concealed, possibly unit A3

Unit A2
0-1.25 m: **Chert pebble conglomerate**, medium dark grey, with abundant coarse grained, poorly sorted, and chert-rich sandy matrix; conglomeratic clasts are most abundant in upper 20 cm and attain a maximum diameter of 10 cm at a height of 1 m

1.25-2.15 m: **Sandstone**, medium dark grey, with rare chert pebbles; indistinct lamination

2.15-4.40 m: **Sandstone**, pebbly, upward fining; coarse grained at base, fine grained at top; rich in volcanic rock fragments, feldspar; indistinct flat lamination in lower 2.15 m; indistinct convolute lamination in upper 10 cm

- abrupt contact -

Unit A1
Mudrock, medium dark grey

Point count analyses, listed below, indicate that the lower part of unit A2 consists mainly of detrital chert whereas the upper part includes a substantial proportion of volcanogenic material (numbers indicate percentages).

	1.0 m (%)	4.3 m (%)	
Quartz:	1	3	"Common" (i.e., monocrystalline, more or less rounded) quartz; minor quartzite, volcanic quartz (Fig. 36)
Chert:	87	23	Variably argillaceous
Volcanics:	4	34	Rock fragments of different compositions
Feldspar:	1	34	
Carbonates:	7	6	Veinlets and replacements

XRD analyses of the pebbly sandstone indicate that the feldspar is albite and the carbonate, ferroan dolomite or ankerite (Appendix 3, included in Table 14).

Similar sandstones, containing both volcanogenic material (rock fragments and albite) and substantial amounts of detrital chert are exposed near a northeasterly flowing creek, 2.9 km south-southwest of Fire Bay (*Cape Stallworthy-Bukken Fiord*, inset B, south-southeast of fossil locality F12; XRD analyses are included in Appendix 3, Table 14). These rocks are overthrust by the Hazen Formation on the west and

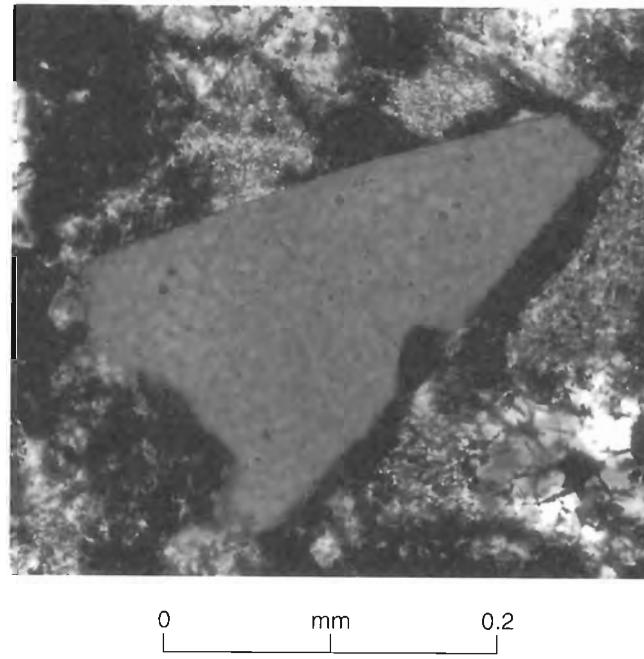


Figure 36*. Photomicrograph (cross-polarized light) of volcanic quartz in pebbly sandstone of Fire Bay Formation, Member A, unit A2, southeastern facies. ISPG photo 4227-18.*

bordered on the east by unit A3. The contact between units A2 and A3 is covered at this locality.

Unit A3, northwestern facies. In the Fire Bay 1 section, the northwestern facies of unit A3 is 32 m thick but largely covered and recessive. It probably consists mainly of mudrock, but includes two resistant, massive beds of sandstone (Fig. 32). The lower bed, 1.7 m thick, is medium to coarse grained with some granules and rip-up clasts, and part of it shows reverse graded bedding. The upper bed is 0.5 m thick.

XRD analysis of a sample of medium grained sandstone indicates a high proportion of quartz (86%, rounded common quartz, and chert) and small amounts of calcite (5%, fragments of limestone and replacements), albite (4%), and chlorite (4%). Small amounts of mica, serpentinite, and chromite are also present.

Unit A3, southeastern facies. The southeastern facies has a minimum thickness of 45 m in the Fire Bay 3 section where its base is concealed (Figs. 37, 38). Recessive and poorly exposed, it consists mainly of medium dark grey mudrock with lesser amounts of very fine grained, silty sandstone. Flat lamination and graded bedding are common. Scattered outcrops farther south or southwest (*Cape Stallworthy-Bukken Fiord,* inset B, localities F12, L2, L3, and L4) include

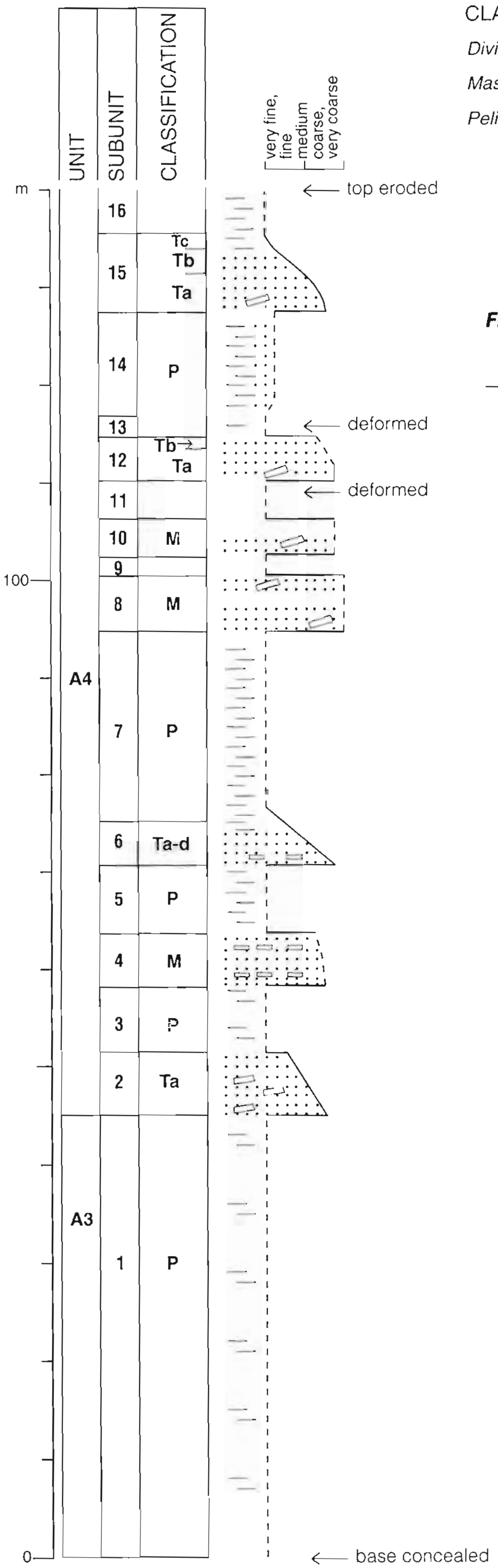


Figure 37. *Fire Bay Formation, Member A, southeastern facies at Fire Bay 3 section.*

the graptolite locality discussed below (Age and correlation).

XRD analyses of samples from these localities (Appendix 3, Table 15) demonstrate the compositional similarity of the graptolitic bed with the other outcrops. All samples are relatively rich in quartz (mean 87%) and generally contain only a few per cent or less of albite, mica, chlorite, and carbonates. One sample, however, has a larger proportion of albite (15%) and two have larger proportions of dolomite (12% and 22%).

Unit A4, northwestern facies. Unit A4 is incompletely exposed in the Fire Bay 1 and 2 sections, which have a combined thickness of 86 m. The true thickness probably is greater than the incomplete thickness of 105 m in the Fire Bay 4 section.

The lower 38 m of the northwestern facies, represented by the top of the Fire Bay 1 section (Fig. 32), includes the following rock types:

1. Lithic-crystal tuff (or resedimented tuff) of coarse sand grade (13.5 m; unit 11).

2. Two beds, 2.4 m and 1.7 m thick (units 10 and 12), of massive, sandy conglomerate grading upward to conglomeratic sandstone. Unit 12 contains carbonate boulders up to 35 cm in diameter and volcanic cobbles up to 15 cm in diameter.

3. Sandstone, very fine to coarse grained, commonly in beds 0.5 to 1 m thick, with some interbedded mudrock or fine pebble conglomerate (units 8, 9, 13).

The upper part of unit A4 may be represented by the lower 48 m of the Fire Bay 2 section (Appendix 1).

Figure 38. Fire Bay 3 section, looking north. Ledges are formed by sandy units (massive sandstones or Bouma sequences) several metres thick; intervening recessive intervals are underlain by mudrock and probably also by thin, fine grained sandstone beds. ISPG photo 4007-18.

This interval consists mainly of volcanogenic sandstone with minor amounts of pebble conglomerate and very small amounts of siltstone. Some beds are 1 to 10 cm thick, but most are about 1 m thick.

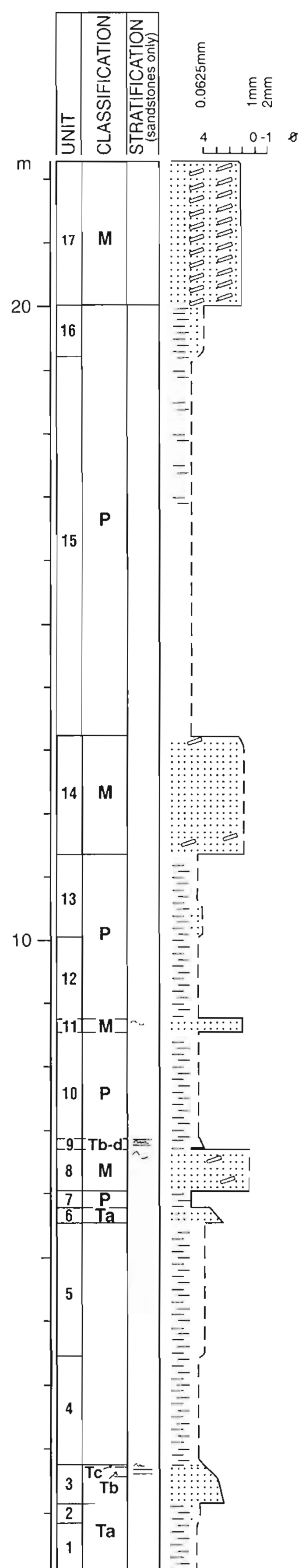
A 19-m-thick lenticular body of dolostone, and 4 m of dark grey chert are intercalated between this sandstone and volcanic rocks of Member B of the Fire Bay Formation (unit B1). They are interpreted as submarine slides (olistostromes) of Middle Ordovician carbonates from the Hazen Formation.

The sandstones are composed mainly of volcanic rock fragments and albite with small amounts of chlorite. Detrital quartz and chert, if present at all, are subordinate (Appendix 3, Tables 16, 17). Some rocks also contain carbonate grains. Sandstones lacking detrital quartz and chert are difficult to distinguish from tuffs. The latter consist of variable proportions of volcanic rocks, albite, and chlorite and have high F/F+Q ratios (Appendix 2, Table 18). Both rock types are altered by carbonates to varying degrees.

Unit A4, southeastern facies. This part of Member A consists of alternating coarse and fine grained strata, dominated by sandstone or mudrock, respectively. Three partial sections have been measured (Appendix 1): Fire Bay 3 section (units 2-16), a reconnaissance description of the lower 105 m of unit A4 (Figs. 37, 38); Fire Bay 4 section, a detailed description of a 22 m interval within the lower part of unit A4 (Fig. 39); and Fire Bay 5 section, a brief description of an interval of unknown stratigraphic position within a large fault block of folded strata located directly south of Fire Bay (Fig. 40, Appendix 1).

Predominantly sandy units either are massive or represent Bouma sequences (Table 6). The massive beds listed range in thickness from 0.22 to 5.8 m. Most are medium to coarse grained or coarse grained and do not show upward-fining except in the uppermost part. Some show an indistinct convolute lamination in the upper part. Rip-up clasts are common.

The Bouma sequences range in thickness from 19 to 645 cm, but thinner sequences are also present. Turbidites of T_a, T_{ab}, $T_{a\text{-}c}$, $T_{a\text{-}d}$, and $T_{b\text{-}d}$ type have been recorded. T_a turbidites differ from massive sandstones by marked upward fining. Their basal layers range in grade from very fine to coarse grained



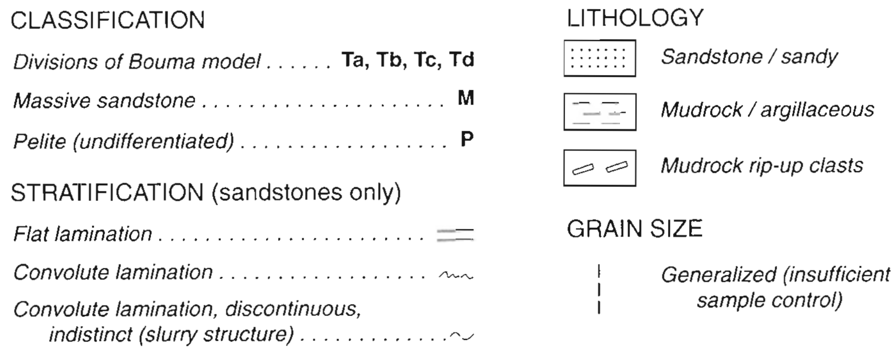


Figure 39. *Detailed section of an interval within the Fire Bay Formation, Member A, unit A4, southeastern facies at the Fire Bay 4 section.*

sandstone, and some beds contain rip-up clasts in their lower parts. The top layers are usually very fine grained sandstones or siltstones.

Mudrock-dominated intervals consist either of mudrock alone or of mudrock with thinly interstratified sandstone. In the stratigraphic sections studied, these intervals range in thickness from about 20 cm to about 20 m and show abundant flat lamination and fairly common convolute lamination. They probably represent D divisions, C divisions, and, where sandstone is present, B divisions of the Bouma model.

Most sandstones are similar in composition to those of the northwestern facies. They consist largely of volcanic rock fragments and feldspar with no more than a few per cent each of quartz, chert, chlorite, and white mica, and variable proportions of secondary carbonates. XRD analyses indicate high F/F + Q values (averages are 38% and 29% for sections 3 and 4, respectively; Appendix 3, Tables 19 and 20; corrected values are estimated at 53% and 41%), but some quartz-rich sandstones with F/F + Q values of 11 to 12 per cent occur in the Fire Bay 5 section (Appendix 3, Table 21). The feldspar is largely or entirely albite. Carbonate alteration consists of calcite, dolomite, and ferroan dolomite or ankerite. Ankerite is abundant in the Fire Bay 4 section.

Mudrock samples show a similar compositional variation, documented by albite-rich samples from the Fire Bay 3 and 4 sections (F/F + Q values are 27 and 23%; Appendix 3, Tables 22, 23), and by quartz-rich samples from the Fire Bay 5 section (F/F + Q is 10%; Appendix 3, Table 24). Mica and chlorite amount to generally less than 5 per cent, and ferroan dolomite or ankerite alteration is common in some rocks.

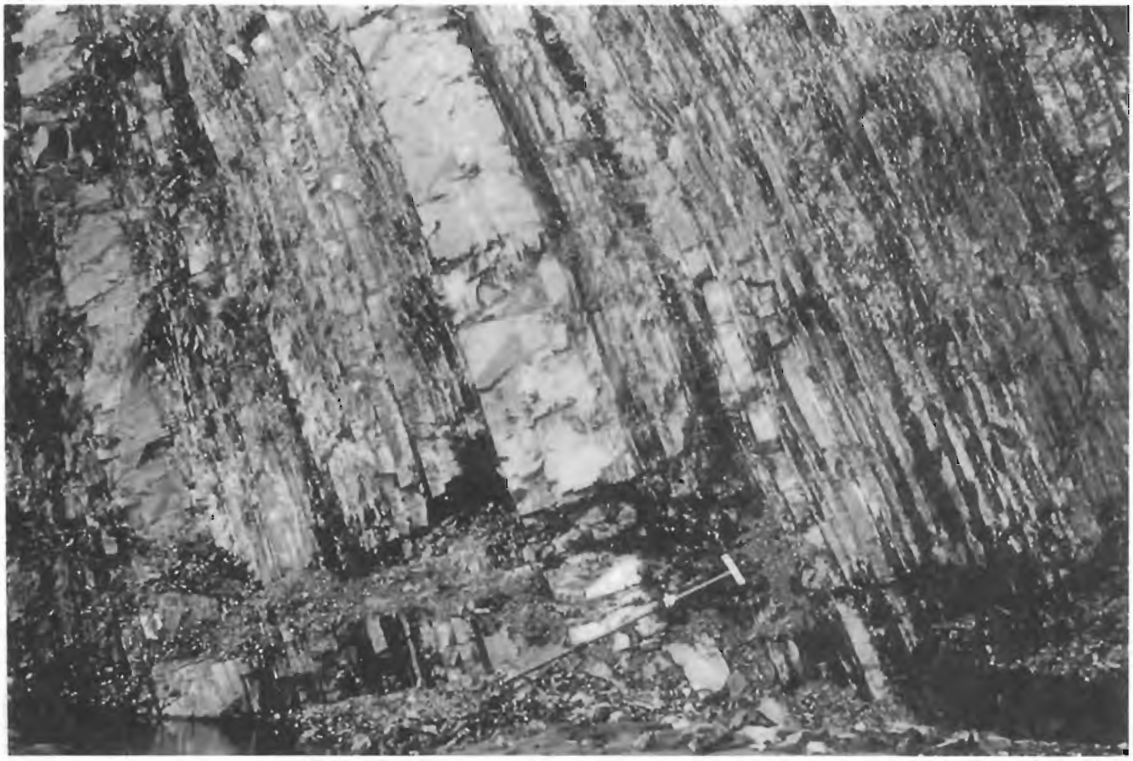


Figure 40. *Fire Bay Formation, Member A, interval in unit A4, southeastern facies, at the Fire Bay 5 section. In the centre (centre of measuring staff) a $T_{a\text{-}d}$ turbidite composed of graded, very fine and fine grained sandstone, about 50 cm thick. This unit is overlain and underlain by interstratified sandstones and mudrocks that commonly represent $T_{a\text{-}d}$ and $T_{b\text{-}d}$ turbidites. Sandstone beds are a few mm to about 12 cm thick. The measuring staff is 1.5 m long. ISPG photo 4007-36.*

Table 6

Fire Bay Formation, Member A, unit A4, southeastern facies: data on massive sandstones and turbidites

Section FB	Unit	Classification	Thickness (m)	Coarsest ss grade	Remarks
3	8	M	5.8	cs	Rip-up clasts abundant
4	17	M	2.3	m-cs	Some rip-up clasts
4	14	M	1.85	m-cs	Rip-up clasts and/or pebbles in lower 40 cm and at top
4	8	M	0.65	cs	Some rip-up clasts; slurry structure in upper 10 cm
4	11	M	0.22	m-cs	Indistinct convolute laminae in upper 6 cm
3	2	T_a	6.45	m	Rip-up clasts to 5 cm long in lower 0.4 m; small rip-up clasts at 3 m
5	2	T_a	0.35	cs	
4	6	T_a	0.24	f	
3	12	T_{ab}	4.7	cs	Rip-up clasts in lower 0.9 m
3	15	$T_{a\text{-}c}$	8.0	m	Rip-up clasts to 5 cm long in lower part
4	3	$T_{a\text{-}c}$	0.61	f-m	
5	7	$T_{a\text{-}d}$	0.5	f	
3	6	$T_{a\text{-}d}$	4.5	m-cs	Rip-up clasts in lower part
5	9	$T_{a\text{-}d}$	2.2	cs	
4	9	$T_{b\text{-}d}$	0.19	vf	

Minor amounts of fine grained tuff are probably present in the southeastern facies but are difficult to distinguish from volcanogenic sandstone and siltstone.

Member B consists largely of volcanic rocks with rare carbonate olistoliths. It is divisible into a lower recessive unit (B1) and an upper resistant unit (B2).

Unit B1. Unit B1 has an apparent thickness of 102 m in the Fire Bay 2 section (Appendix 1) but this measurement is unreliable because of unresolved structural complications.

Four out of seven analyzed samples are tuffs (crystal, crystal-lithic, lithic-crystal, and vitric), two are flows, and one is either a flow breccia or a tuff. All feldspar has been altered to albite and most mafic silicates have been altered to chlorite, but some clinopyroxene is preserved. Quartz and carbonate alteration also are common. The chemical classifications of seven analyzed samples are summarized in Table 7 (see also Appendix 4A, Tables 1, 2-6, 3-6 and Figs. 41–43) and further discussed below. Briefly, felsic compositions predominate over intermediate to mafic compositions.

Unit B2. The thickness of this unit is difficult to establish because of the massive character of the volcanics and structural complications. Graphic measurements based on air photographic interpretation and available bedding attitudes suggest a thickness of 150 to 200 m.

Eleven out of 13 analyzed samples are flows, and two are tuffs. Intermediate or calcic plagioclase and K-feldspar that may have been present originally have been replaced by albite, and all mafic silicates by chlorite. Quartz and carbonate alteration are common and chertification has also occurred. Some flows contain amygdules of calcite and chlorite. Classifications of 13 analyzed samples are summarized in Table 7 (see also Appendix 4A, Tables 1, 2-6, 3-6, nos. 8-20) and further discussed below. In contrast to unit B1, intermediate to mafic, partly alkaline compositions are more common than felsic compositions. A small carbonate olistolith occurs in the uppermost part.

Member C occurs mainly as rubble, and its thickness cannot be determined directly. Assuming a horizontal width of 380 m and a uniform dip of 25° northwest, obtained from the underlying volcanics, an apparent thickness of 160 m results. However, complex minor folds are present in the adjacent Danish River

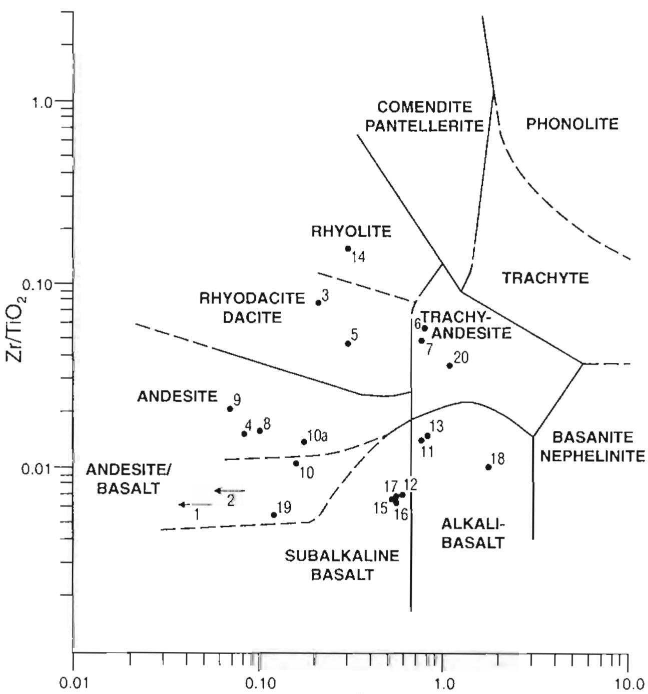
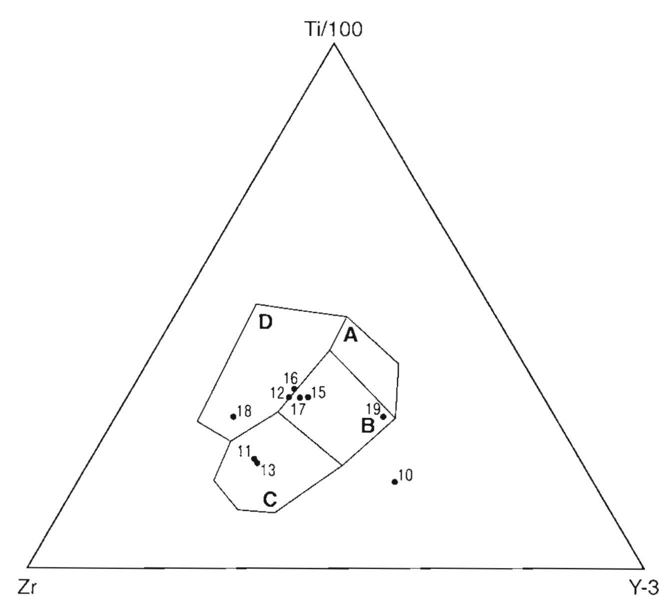
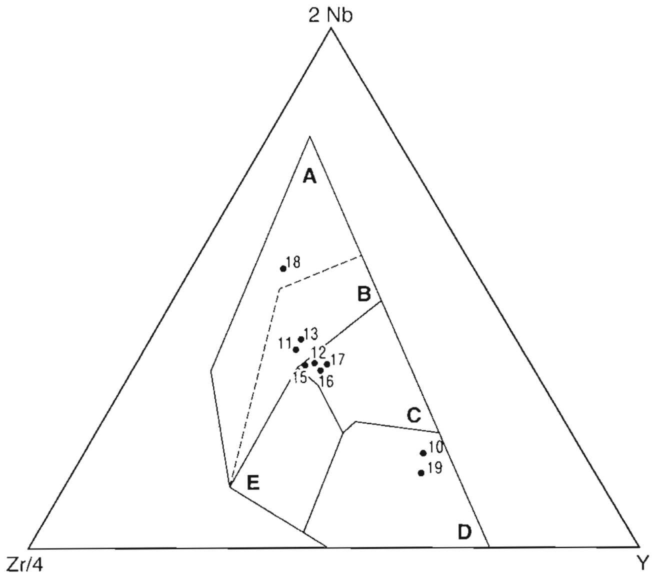


***Figure 41.** Fire Bay Formation, Member B, classification of volcanic rocks according to stable trace element ratios (after Winchester and Floyd, 1977, fig. 6), analyses nos. 1 to 7 from subdivision B1, nos. 8 to 20 from subdivision B2.*



Mainly low-K tholeiite . . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . . D

***Figure 42.** Fire Bay Formation, Member B, tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt	A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt	B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt	C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type)	D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type)	E

Figure 43. *Fire Bay Formation, Member B, tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1).*

Formation, and the structurally incompetent lithology of Member C suggests an even more complicated style of deformation. Assuming 200, 300, or 400 per cent structural thickening, the thickness would be 80, 53, or 40 m, respectively. These considerations suggest that the true thickness of Member C is less than 100 m and possibly in the order of 50 m.

The member consists of dark grey mudrock, in part sandy and variably dolomitic, that contains some flat laminae and sparse, poorly preserved graptolites.

XRD analysis of three mudrock samples indicate quartz (75.7%), carbonates (dolomite 7.7%, calcite 3.0%), feldspar (albite, 7.3%; K-feldspar, trace), mica (3.3%), and chlorite (2.7%). A sample of sandy mudrock contains fine grained sand of quartz, feldspar, and chert in an argillaceous matrix. XRD analysis indicates quartz (85%) and albite (10%) with minor mica, chlorite, and dolomite (2% each).

Metamorphism. The partial preservation of pyroxene indicates that the metamorphism of the volcanics is below greenschist grade. The pervasive albite and chlorite alteration are therefore attributed to hydrothermal alteration, a common feature in submarine volcanics (Erzinger, 1989). More detailed work is required to determine the metamorphic grade of slaty mudrocks, which may be of greenschist grade in the sense that clay minerals have recrystallized to chlorite and white mica.

Mode of origin

Member A. The abundance of Bouma sequences demonstrates deposition mainly by turbidity currents in deep-water settings below the shelf edge. The massive conglomerates were probably transported by subaqueous debris flows. The marked southeastward decrease in average size grade indicates a northwesterly source. This is not contradicted by a few, nonquantitative observations on flute marks (Appendix 1, Fire Bay 5 section, unit 4) that suggest strike-parallel southwestward flow in the southeastern facies. It is possible, for example, that transverse sediment gravity flows from the northwest were deflected into longitudinal directions in the axial part of a subbasin within the large Deep Water Basin of northern Ellesmere Island.

The detrital rock fragments and individual minerals that constitute the clastic sediments of Member A can be assigned to five genetic groups. Their provenance is discussed below, in order of decreasing abundance.

1. The volcanic rock fragments, feldspar, and chlorite, which together make up the bulk of the sediments, were derived from volcanic sources of uncertain age.

2. Detrital chert probably constitutes one or a few per cent of the sediment volume and is most abundant in the pebble and coarse sand fractions, especially of unit A2. The presence of radiolarians suggests derivation from the Hazen Formation. Some chert was metamorphosed prior to erosion and redeposition.

3. Detrital quartz also makes up one or a few per cent of the sediment volume. It is abundant in the mudrocks of unit A3 (southeastern facies) and fairly common in the conglomerate of unit A2. The coarsest clasts in the latter unit were derived from quartz veins. The concentration of chert and vein quartz in unit A2 indicates a certain degree of sediment maturation within the source area, perhaps achieved during a hiatus in tectonic activity.

4. Carbonate clasts, which constitute only a small fraction of one per cent of the sediment volume, were either derived from uplifted older carbonates, also represented by the olistoliths, or from contemporaneous carbonate banks that bordered the basin on the northwest.

5. Chromite and grains of serpentinite, present in very small quantity in the northwestern facies of units A1 and A3, indicate a minor ultramafic source. Potential source rocks include the Lower Ordovician (Arenig) Thores Suite of the M'Clintock Inlet area (Chapter 4) and rocks related to map unit ds on Kleybolte Peninsula (*Cape Stallworthy–Bukken Fiord*; see Phanerozoic intrusions).

Member B. The relatively high proportion of alkaline rocks, indicated by both trace element and major element analyses (Fig. 41; Table 7), indicates a weakly extensional tectonic regime - a strongly extensional regime would have produced tholeiitic flood basalts.

The origin of the non-basaltic, predominantly felsic rocks is problematic. The small number of analyses obtained suggests a bimodal composition of the volcanic suite as a whole, but this remains to be confirmed. If so, the felsic rocks probably were generated by partial melting of a sialic basement, and crustal contamination (Wang and Glover, 1992) may explain both some aberrant trace element classifications (Appendix 4A, Table 1, nos. 1, 10, 14) and the confusing picture presented by the tectonic discrimination diagrams (Figs. 42, 43). On the other hand, an arc origin could be inferred from the presence of three samples, classified as andesite/basalt on the basis of trace element ratios and as calc-alkaline (high alumina) andesite on the basis of major element composition. However, it should be borne in mind that calc-alkaline andesite can originate by basement melting in an extensional environment (Davis et al., 1993).

Member C. Member C, a dark grey graptolitic mudrock unit overlying a volcanic edifice, is analogous to graptolitic mudrocks of the Cape Phillips Formation

Table 7

Fire Bay Formation, Member B: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
Unit B1		
2	rhyodacite-dacite	rhyolite (K-poor)
1	andesite	rhyolite (K-poor)
2	trachyandesite	rhyolite (K-poor and average)
2	prob. andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
Unit B2		
1	(rhyolite[1])	mugearite[3]
2	(andesite[2])	rhyolite (K-poor)
1	trachyandesite	rhyolite (K-poor)
1	(andesite/basalt[2])	rhyolite (K-poor)
1	andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
4	subalkaline basalt	mugearite
1	alkali basalt	calc-alkaline dacite (K-poor)
2	alkali basalt	mugearite
Summary of major element classifications		
9	rhyolite (calc-alkaline)	
1	dacite (calc-alkaline)	
3	andesite (calc-alkaline)	
7	mugearite[3]	

[1]Petrography indicates mafic composition (compatible with major element classification).
[2]Petrography indicates felsic composition (compatible with major element classification).
[3]Mugearite is a member of the alkali basalt series characterized by an intermediate composition (Irvine and Baragar, 1971).

that overlie a carbonate buildup at the margin of the Franklinian Shelf (Trettin, 1979; de Freitas, 1991a). In contrast to the overlying Danish River Formation, these units were probably not deposited from seafloor-hugging, normal turbidity currents, but from dilute suspensions higher in the water column.

Age and correlation. A graptolite collection from locality F12 (*Cape Stallworthy-Bukken Fiord*, inset B) is of Early Silurian, probably early late Llandovery age and may represent the *turriculatus* Zone (Norford, Appendix 5A, GSC loc. C-171531). The collection comes from an isolated outcrop area of mudrock that has been assigned to the southeastern facies of unit A3 on the basis of location, structural setting, and mineral composition (see below, Lithology). Graptolites from Member C are of Early Silurian, probably middle or late Llandovery (Aeronian or Telychian), age (Norford, Appendix 5A, GSC loc. C-194931), but a middle Llandovery age is unlikely because of their stratigraphic position hundreds of metres above GSC loc. C-171531.

The upper Llandovery biostratigraphy of the project area is not well enough known to determine the precise correlation of the Fire Bay Formation. Available information suggests that Members A and B predate the Danish River Formation and are correlative with uppermost parts of the Hazen Formation in the Hazen Fold Belt, for example at Caledonian Bay, Cañon Fiord (Trettin, 1979, 1994). Member C, deposited on a bathymetric high, may be correlative with basal parts of the Danish River Formation, deposited in bathymetric lows. The Fire Bay Formation is probably also correlative with unfossiliferous lower parts of the Svartevaeg Formation.

West-central belt

The West-central belt comprises only one unit, map unit OSv.

Map unit OSv *(Lower Silurian and (?)Ordovician)*

Definition. Map unit OSv comprises volcanic rocks and associated minor limestone, has uncertain stratigraphic relations, and occurs in fault blocks within the Emma Fiord Fault Zone. The unit was assigned to the Kulutingwak Fiord assemblage by Trettin and co-authors (1987, 1991).

Distribution, contact relations, and thickness. The map unit forms a narrow outcrop belt that extends from Yelverton Inlet for about 19 km to the southwest into the area south of Kulutingwak Fiord (*Yelverton Inlet* and *Otto Fiord*). It is separated by faults from the Lands Lokk Formation on the southeast and from the Danish River Formation on the northwest. The stratigraphic base of the unit is concealed, its top is not preserved, and its thickness is uncertain.

Lithology. Three out of four samples of volcanic rocks represent flows, the fourth is a lithic and crystal tuff. Thin sections and XRD analyses indicate that both tuff and flows are composed mainly of albite and chlorite with or without actinolite. In addition, there are small amounts of K-feldspar and quartz, and trace amounts of apatite. Chemical analyses of the four samples indicate intermediate, predominantly alkaline compositions (Table 8, Fig. 44 and Appendix 4A, Tables 1, 2-7, 3-7).

At one locality, remnants of a limestone bed overlie the volcanic rocks on a dip slope. The limestone consists of echinoderm ossicles that are mostly in solution contact although some interstitial lime mud is preserved.

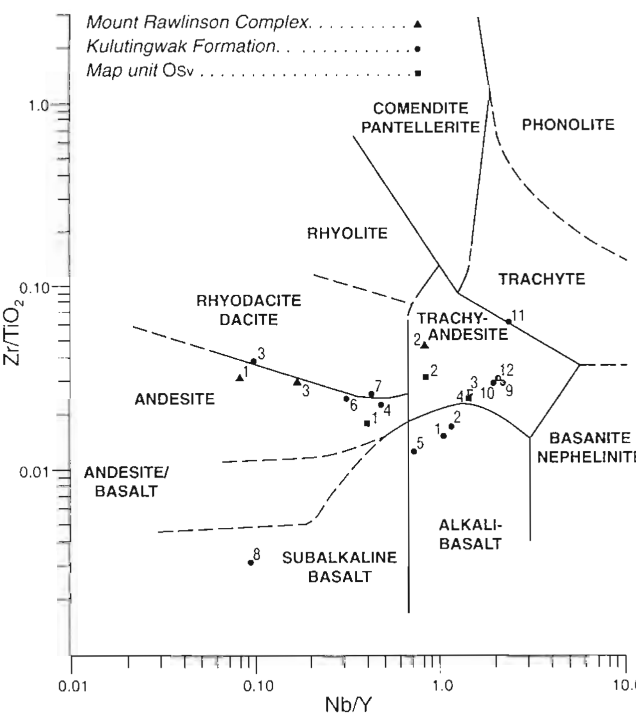


Figure 44. Map unit OSv, Kulutingwak Formation, and Mount Rawlinson Complex, classification of volcanic rocks according to stable trace element ratios (after Winchester and Floyd, 1977, fig. 6).

Table 8

Map unit OSv: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1	andesite	calc-alkaline (high alumina) andesite (average)
2	trachyandesite	calc-alkaline (high alumina) andesite (average and K-rich)
1	trachyandesite	tristanite[1]

[1]Tristanite is a member of the potassic alkali basalt series characterized by an intermediate composition (Irvine and Baragar, 1971).

Metamorphism. The mineral composition of the volcanics conforms with the lower greenschist facies of regional metamorphism but may be the result of hydrothermal alteration (cf. Erzinger, 1989), because neither the volcanics nor the limestone have a metamorphic fabric.

Mode of origin. The fact that three out of four trace element analyses indicate alkaline compositions suggests a weakly extensional tectonic regime. Further analytical work is required to establish the significance of the andesitic composition - whether it reflects subduction or crustal melting caused by mafic intrusion at depth.

Age and correlation. Conodonts from the limestone are tentatively assigned to the early or middle Llandovery (Barnes, Appendix 5B, GSC locs. C-54800 and C-54801). The limestone therefore is older than the Fire Bay Formation, and younger than the Kulutingwak Formation (see below). The age of the underlying volcanics is uncertain. Map unit OSv may extend from earliest Llandovery down into the Ordovician. The unit is correlative with the upper part of the chert member of the Hazen Formation.

Northwestern belt

The Northwestern belt of Succession A comprises several outcrop areas located southwest and northeast of the upper reaches of Kulutingwak Fiord. The most important exposures occur in the Kulutingwak Anticlinorium (*Yelverton Inlet*, inset) where two major units, the Kulutingwak and Phillips Inlet formations, have been established.

Kulutingwak Formation (map units OK, OK1, *and* OK2, *Upper Ordovician)*

Definition. The name, Kulutingwak Formation, is here proposed for a sedimentary-volcanic assemblage that underlies the Danish River Formation. The formation is divisible into two members. The lower member, A, consists of tuff and tuffaceous sediments, volcanic flows, and minor marble; the upper member, B, mainly of marble. The type section is in the western part of the Kulutingwak Anticlinorium. It has been traversed and sampled, but has not been measured and described in detail.

Member B was introduced as map unit Ols (Ordovician limestone) by Trettin (1971b). Note that the Kulutingwak Formation, as defined here, is not identical with the Kulutingwak Fiord assemblage of Trettin and co-authors (1987, 1991), which is now referred to as map unit OSv.

Distribution, contact relations, and thickness. The Kulutingwak Formation proper is exposed in four separate areas west and east of the northern part of Kulutingwak Fiord. It is the oldest known unit in this area and its base is concealed. The Kulutingwak Formation is overlain by the Danish River Formation in the west-central part of the Kulutingwak Anticlinorium, probably with a disconformable contact. The minimum thickness of the formation, difficult to establish because of tight folding and complex faulting, is estimated at 300 to 400 m.

Possible metamorphic equivalents of the Kulutingwak Formation, exposed farther north in the footwall of the Petersen Bay Fault, are discussed below under a separate heading.

Lithology

Member A. This member is more than 100 m thick and composed of tuffaceous phyllite, volcanogenic sandstone, volcanic flows, and thin units of marble.

Volcanic flows. Most flows are intensely altered by carbonates, and few of the samples collected were suited for analysis. Trace element analyses of eight samples (Table 9 and Fig. 44; also Figs. 45, 46; Appendix 4A, Tables 1, 2-8, 3-8, nos. 1-8) indicate three compositional groups: in the boundary field of rhyodacite-dacite and andesite (4 analyses); subalkaline basalt (1); and alkali basalt (3). Major element classifications form three groups: rhyolite (1 analysis); calc-alkaline rocks (dacite 1, andesite 2); and sodic alkaline rocks (sodic trachyte 2, hawaiite 1). Discrepancies in the classification of individual samples indicate considerable alteration, and this is supported by petrographic observations.

The rocks classified as andesite or dacite (Fig. 44) show no significant differences in thin section or XRD analyses. In all samples, phenocrysts or microphenocrysts of albite are embedded in a groundmass of albite with minor chlorite, quartz, and opaque minerals. XRD analyses suggest that one andesite also contains small amounts of K-feldspar. Corrected F/F + Q values are greater than 80 per cent and suggest that the rocks are andesite and quartz-bearing andesites rather than dacites.

Three rocks classified as alkali basalt are porphyritic, containing phenocrysts or microphenocrysts of albite and actinolite-chlorite (probably replacements of pyroxene) in a groundmass composed of the same minerals with a higher proportion of opaques than present in the andesites/dacites.

Tuffaceous phyllites. The phyllites are medium grey to medium dark grey and commonly show a faint flat lamination due to differences in the content of carbonate minerals and submicroscopic carbonaceous(?) impurities. Thin sections show sand-grade crystals of albite and felsic volcanic rock fragments in a matrix of silt to fine sand-grade albite, quartz, mica, chlorite and carbonates. The carbonates occur as minute veinlets, replacements, and probably also as recrystallized grains. Two rock types can be distinguished on the basis of XRD analysis and petrography:

1. Plagioclase-rich tuff (9 XRD analyses; Appendix 3, Table 25) consists mainly of albite (mean 60%) with lesser amounts of quartz (18%), mica (11%; mainly biotite), chlorite (6%), and carbonates (calcite 3%, dolomite <1%). Trace element analyses (see above, Table 9; also Appendix 4A, Tables 1, 2-8, 3-8 nos. 13-16) indicate basic-alkaline compositions, in accord with high feldspar-quartz ratios (F/F + Q: uncorrected mean 76%, corrected mean about 90%).

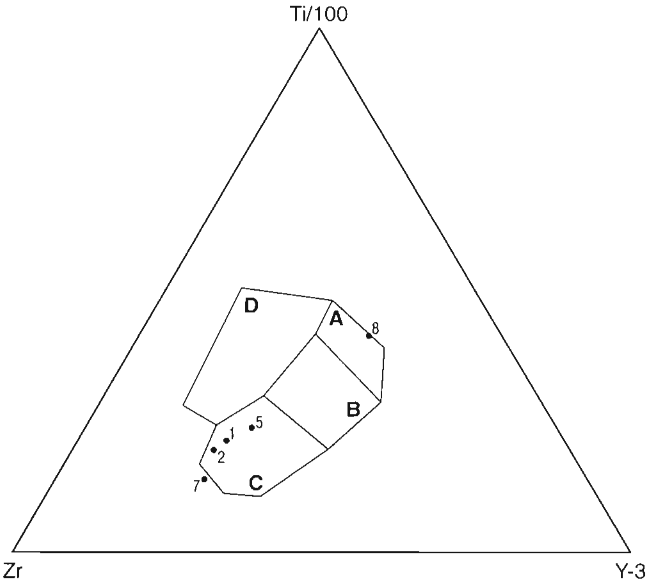
2. Quartzose and feldspathic tuff or siltstone (5 XRD analyses; Appendix 3, Table 26) has higher proportions of quartz (mean 60%), lower proportions of albite (22%) and correspondingly smaller F/F + Q ratios (uncorrected mean 26%; corrected mean about 37%). Another significant difference is that the mica (mean 4%) does not include biotite. Chlorite (mean 2%) and carbonate percentages (calcite 7%, dolomite 6%) are comparable to those in the plagioclase-rich tuffs. These rocks represent either tuffs of felsic to intermediate composition, or more basic tuffs that contain some detrital quartz.

Table 9

Kulutingwak Formation, Member A: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

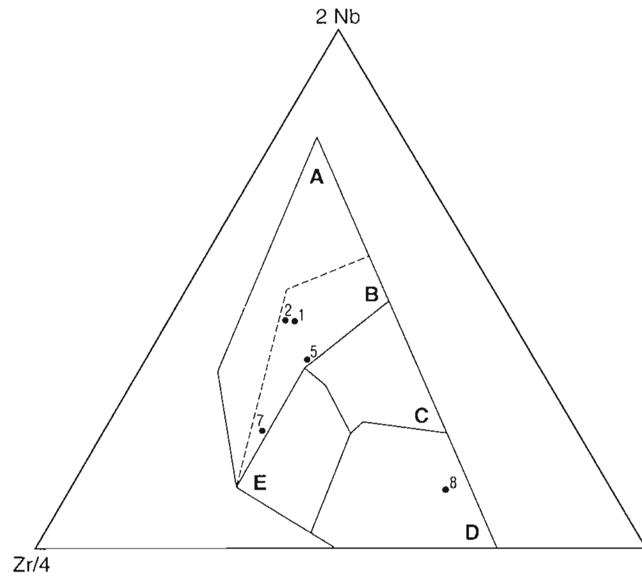
No.	Trace elements	Major elements
Mainly flows (with one flow breccia or tuff)		
1	rhyodacite-dacite[1]	rhyolite (K-poor)
1	rhyodacite-dacite[1]	sodic trachyte
1	andesite[2]	calc-alkaline dacite (K-poor)
1	andesite	sodic trachyte
1	subalkaline basalt	calc-alkaline (high alumina) andesite (K-poor)
1	alkali basalt[3]	calc-alkaline (high alumina) andesite (K-poor)
2	alkali basalt	hawaiite[4]
Tuffaceous phyllite		
2	trachyandesite	
1	trachyte[5]	

[1]Close to border with andesite.
[2]Close to border with rhyodacite-dacite.
[3]Close to border with subalkaline basalt.
[4]Hawaiite is a sodic alkali basalt (Irvine and Baragar, 1971).
[5]Close to border with trachyandesite.



Mainly low-K tholeiite . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . D

Figure 45*. Kulutingwak Formation, tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt . . . . A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . , ... E

Figure 46*. Kulutingwak Formation, tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1).*

Tuffaceous sandstone. This rock type is light grey or medium light grey. The maximum clast size varies from fine sand to fine pebble grade and commonly is of coarse or very coarse sand grade. Point count analyses are not feasible because of the poor definition of the grain boundaries. Five XRD analyses (Appendix 3, Table 27) indicate that the rocks are composed mainly of quartz (mean 68%) and albite (19%), with minor amounts of white mica (2%) and chlorite (2%), and variable proportions of dolomite (6%) and calcite (4%). Thin sections show that some of the feldspar and quartz occur in grains of volcanic and hypabyssal rock fragments of felsic to intermediate composition. Several types of quartz are present, including monocrystalline detrital quartz, vein quartz, and volcanic quartz (euhedral crystals with rounded corners, embayments, and inclusions of volcanic material of felsic composition). Calcite and dolomite occur in veinlets, as replacements, or as monocrystalline grains in the tuffaceous phyllites.

Marble. Beds are generally no more than a few metres thick, light grey, and composed mainly of calcite with or without variable amounts of dolomite, quartz, albite, and mica. A unit of recessive, dark grey, calcareous phyllite with impurities of siliciclastic silt and very fine grained sand (quartz, albite, minor mica and chlorite) occurs directly below Member B in the central part of the northern structural culmination.

Member B. Member B is probably about 200 to 300 m thick and consists of light grey, cliff-forming marble, locally with minor amounts of intercalated volcanic material. The marble is composed mainly of calcite, with or without dolomite and siliciclastic impurities of silt to fine sand grade, chiefly quartz, with minor feldspar and mica. The calcite usually is recrystallized and intensely twinned. In spite of this metamorphism, ghosts of echinoderm ossicles and relics of a micritic matrix are apparent in some thin sections.

Metamorphism. The metamorphism of the clastic and volcanic rocks, characterized by mica (mainly white mica, locally biotite), chlorite, actinolite, and albite, is of greenschist grade. The carbonate rocks, except for certain dolostones, have a schistose texture, and the crystals are intensely twinned.

Conodonts from Member B are altered and pitted, probably as a result of hydrothermal activity (G.S. Nowlan, pers. comm., 1992) that also affected the alteration indices. Specimens from three localities (*Yelverton Inlet,* inset, F1, F3, and F4) have an alteration index of 5, indicating temperatures of 300 to 480°C (Rejebian et al., 1987), but specimens from one locality (F2), where dolostone overlies sedimentary serpentinite, have an anomalously low index of 1 (50-80°C; Epstein et al., 1987).

Mode of origin. The origin of the volcanics is difficult to determine because of the small number of relevant analyses. It is clear, however, that alkaline rocks, which probably formed in a weakly extensional tectonic regime, are present. This suite comprises two flow rocks, classified as alkali basalt (based on trace elements) and as hawaiite (based on major elements), and possibly two other flows and three tuffaceous phyllites. It is possible that the extension was imposed on a volcanic arc, represented by a single sample classified as subalkaline basalt (based on trace elements) and as calc-alkaline (high-alumina) andesite (based on major elements). However, as mentioned earlier, partial melting of a continental plate, caused by extension and mafic intrusion at depth, can also produce andesite with chemical characteristics of arc rocks (Davis et al., 1993). The remainder of the flows are andesitic and felsic rocks of uncertain significance.

The two trace element discrimination diagrams provide contradictory tectonic assignments. On the Meschede diagram (Fig. 46) four basaltic samples lie in the field of within-plate basalt, but on the Pearce-Cann diagram (Fig. 45) the same samples lie in or near the field of calc-alkaline basalt of arc origin. As mentioned earlier, such discrepancies may indicate contamination by crustal sources (Wang and Glover, 1992).

The carbonates of Member B were deposited on the volcanic edifice, probably in shallow-marine settings.

Age and correlation. A U-Pb age determination was made on an andesite sample from the structural high south of the Kulutingwak Anticlinorium (*Yelverton Inlet*, inset) by J.E. Gabites of the University of British Columbia (Appendix 4C). Two out of three discordant analyses provide a weighted mean of 449.7 + 3.5/-9 Ma, approximately on the Caradoc–Ashgill boundary with confidence limits in the late Caradoc and latest Ashgill according to the adopted time scale (Fig. 2).

Numerous samples of limestone or dolostone from the Kulutingwak Anticlinorium and vicinity were analyzed for conodonts, but only six yielded identifiable material. One collection from the northeastern end of the structural high southeast of the Kulutingwak Anticlinorium (*Yelverton Inlet*, inset, F4) is of unspecified Caradoc or Ashgill age (Nowlan, Appendix 5B, GSC loc. C-171516); the other one is probably Ordovician (C-171514). A third collection from the same high, but farther southwest, is of undifferentiated Arenig to Ashgillian aspect (ibid. C-171515). The stratigraphic position of these three collections has not been determined, but petrographic characteristics suggest they came from Member B. Three collections from Member B within the Kulutingwak Anticlinorium are of unspecified Middle Ordovician to Devonian age (ibid., C-97491, C-171526, C-171527). Combined with the isotopic age determination, the conodonts suggest an Ashgill age for Member B.[1]

The Kulutingwak Formation is correlative with part of the chert member of the Hazen Formation and probably with a part the Mount Rawlinson Complex of the Northeastern belt (see below). Correlations with Pearya are uncertain, but Member A may be equivalent to the volcanic M'Clintock Formation, and Member B to the overlying dolomitic Ayles Formation (see Chapter 4).

Probable and possible metamorphic equivalents of the Kulutingwak Formation on the southeastern flank of the Mitchell Point Belt

The Mitchell Point Belt, a fault-bounded tract of Proterozoic gneiss of Pearya (see Chapter 4, Succession 1), extends from southeast of Ayles Fiord to southeast of Phillips Inlet (Yelverton Inlet), and is flanked by metamorphic strata of uncertain age both on the northeast and the southwest. The metamorphic rocks on the southeastern flank form two, narrow and elongate outcrop belts separated by a glacier and a structural re-entrant or offset. Although both are bordered by the Mitchell Point Belt on the northwest, they are flanked by different units on the southeast: the southwestern outcrop belt by the Danish River Formation of the Clements Markham Fold Belt, and the northeastern outcrop belt by Succession 2 of Pearya (see Chapter 4). The two belts differ in lithological detail but are both divisible into two lithological units, one composed predominantly of schist, the other of marble. They were previously treated as an independent informal unit, the Petersen Bay assemblage (Trettin and Frisch, 1987). However, the southwestern outcrop belt (map units OKs and OKc) is related to the Kulutingwak Formation because of location, structural setting, and lithology, and is considered as a probable metamorphic equivalent of that formation. The assignment of the northeastern outcrop belt (map units OKs? and OKc?) to the Kulutingwak Formation is less certain.

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[1]According to Tucker and McKerrow (195), the zircon age lies within the Caradoc, and a Caradoc or Caradoc–Ashgill age is possible for Member B.

The metamorphic rocks on the northwestern flank of the Mitchell Point Belt (map units s and sq), on the other hand, are here treated as lithological units of Succession 2 of Pearya (Appendix 2), although correlation with the Kulutingwak Formation, as suggested for map unit s by Ohta and Klaper (1992), cannot be ruled out.

Southwestern outcrop belt of metamorphic rocks (map units* OKs *and* OKc*). The southwestern outcrop belt extends from the east coast of Phillips Inlet to about 5 km northeast of Yelverton Inlet. On the northwest side it is separated from the Mitchell Point Belt by the steeply dipping Petersen Bay Fault, which is interpreted as an overturned thrust fault in this area (see Figs. 76, 77). On the southeast side it is flanked by a triangular outcrop area of metamorphosed strata of the Danish River Formation, that in turn is flanked on the southeast by the Kulutingwak Formation. The nature and, locally, the precise location of the contact with the Danish River Formation have been obscured by metamorphism, but there is no evidence that the contact is a major fault.

Most of this belt is underlain by map unit OKs, which consists mainly of schist with lesser amounts of amphibolite and thin units of marble, and is probably equivalent to Member A of the Kulutingwak Formation. The metamorphic grade of the schist decreases from lower amphibolite facies in the northwest to upper greenschist facies in the southeast (see Structural geology). The following lithological summary is based partly on XRD and probe analyses in Trettin and Frisch (1987), but mainly on a detailed petrological study by Klaper and Ohta (1993), which contains some additional chemical and mineralogical information not reproduced here.

The schists have a complex and variable mineral composition. All contain fairly large proportions of quartz, and most have smaller proportions of plagioclase (mainly andesine), mica (mainly biotite and white mica, minor paragonite) and chlorite (mainly ripidolite). In addition, amphibole (hornblende, in part tschermakitic, minor gedrite) is present in most rocks, and calcite and minor dolomite, scapolite, and margarite are present in some. The metamorphic foliation is defined, in part, by the mica. Discordant, late-stage porphyroblasts consist of mica, amphibole, staurolite, and kyanite. Major and trace element analyses of six amphibole-bearing schists plot in the igneous field of a Niggli diagram, whereas two analyses of metapelites plot in the argillaceous sediment field (Klaper and Ohta, 1993, fig. 6).

Amphibolites consist mainly of amphibole with lesser proportions of plagioclase and small amounts of mica and/or chlorite. Five samples of probable igneous origin, analyzed for Zr/TiO_2 versus Nb/Y were classified (after Winchester and Floyd, 1977, fig. 6) as andesite (3), andesite/basalt (1) and subalkaline basalt (1). Relatively high contents of Ni and Cr support a volcanic interpretation (op. cit.).

Map unit OKc consists of extensive marble units mappable from air photographs, but are no more than a few tens of metres thick. Some lie along the contact with the Mitchell Point Belt (Figs. 76, 77) others lie within map unit OKs. The marble consists of intensely twinned calcite with varying proportions of dolomite, quartz, tremolite, or white mica. Strata northeast of Kulutingwak Fiord contain large calcite crystals reminiscent of fractured echinoderm ossicles (Fig. 47). This skeletal(?) material is embedded in microcrystalline to very fine crystalline (about 15–18 μm) twinned calcite with minor dolomite and quartz. The rock appears to be a metamorphosed wackestone. No conodonts were recovered from several large samples. The mode of origin of the strata is largely obscured by the metamorphism. However, the light grey colour of the marble, and probable presence of echinoderm ossicles may indicate a shallow-marine origin.

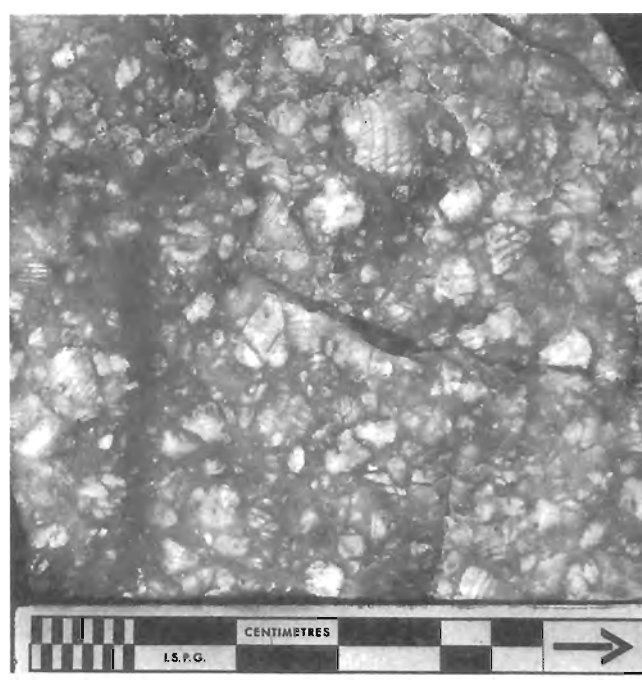


Figure 47. *Marble of Kulutingwak Formation (map unit* OKc*) interpreted as metamorphosed crinoidal limestone. ISPG photo 2761.*

Northeastern outcrop belt of metamorphic rocks (map units* OKS? *and* OKC?*). This belt extends from southwest of Petersen Bay to the southwest side of Ayles Fiord. On the northwest side it is in fault contact with the Mitchell Point Belt along the Petersen Bay Fault and on the southeast side with strata of Succession 2 of Pearya (Neoproterozoic to Lower Ordovician).

Map unit OKs?, possibly equivalent to Member A of the Kulutingwak Formation, is composed mainly of schist with local occurrences of hornblendite and minor amphibolite. Schist exposed southeast of Petersen Bay consists predominantly of quartz with smaller amounts of albite, mica (biotite and white mica), chlorite, and garnet (Appendix 3, Table 28). These rocks clearly represent nonvolcanic, quartzose and pelitic metasediments. Samples from southeast of Milne Fiord, composed of quartz, feldspar (mainly albite, minor oligoclase(?), K-feldspar), and mica (biotite, white mica), with or without amphibole (probably hornblende), and calcite are comparable in mineralogy to tuffaceous strata in the Kulutingwak Anticlinorium, but detailed chemical analyses are required to verify this. Amphibolite-grade schist, containing staurolite, has been reported by Frisch (1976) from northeast of Milne Fiord.

Small lenses of hornblendite and minor amphibolite occur southeast of Petersen Bay, and a large body is present on the northeast side. These rocks are composed almost entirely of amphibole (probably hornblende), with or without smaller proportions of biotite or chlorite, plagioclase (mainly andesine) and minor quartz. They probably represent metamorphosed igneous rocks of mafic composition, but require further study.

Map unit OKc?, a relatively thick marble exposed on the southeast side of Milne Fiord, is possibly equivalent to Member B of the Kulutingwak Formation.

Phillips Inlet Formation (map units SP, SP1, *and* SP2, *Early Silurian or older)*

Definition. The name, Phillips Inlet Formation, is here proposed for a clastic unit that occurs as fault slices within the lower part of the Kulutingwak Formation. In spite of the limited exposure and uncertain stratigraphic relations, these sediments merit a stratigraphic name because of their unusual composition and potential tectonic significance. The bulk of the formation consists of detrital serpentinite, and these rocks are referred to as Member A. A relatively thin, nonserpentinitic, polymict conglomerate that overlies the serpentinite in a structural sense is tentatively included in the formation as Member B. It is possible, however, that the original stratigraphic order has been reversed by faulting, or that Member B represents an unrelated fault slice. The type section of the formation is in the core of the northeastern Kulutingwak Anticlinorium (*Yelverton Inlet*, inset). It has been traversed and sampled but has not been measured and described in detail.

Distribution, contact relations, and thickness. The Phillips Inlet Formation is exposed as lenticular fault slices in four areas in the core of the northeastern Kulutingwak Anticlinorium, west of the upper reaches of Kulutingwak Fiord. The two western slices lie within Member A of the Kulutingwak Formation, and the two eastern exposures between Members A and B.

Most exposures consist of strata of Member A. Member B is present as outcrop in the westernmost area, where it overlies Member A with an abrupt contact, and as rubble in the eastern part of the central-eastern outcrop area where it lies between Member A of the Phillips Inlet Formation and Member A of the Kulutingwak Formation.

Lithology. Member A, probably more than 300 m thick in the type section, consists mainly of fragmental serpentinite with small amounts of serpentinitic calcarenite. The sedimentary character of the rocks is commonly obscured by shearing, but clearly apparent in the eastern and western parts of the east-central outcrop area where primary structures are well preserved (Fig. 48).

The rocks range in grade from siltstone to boulder conglomerate, but cobbles and boulders are uncommon. Whereas most rocks are poorly sorted and massive (Fig. 49), some are thin-bedded or laminated. These latter show some graded bedding (Fig. 50), both normal and reverse, rare small-scale crosslamination, and a medium-scale foreset (Fig. 48), comparable to an isolated foreset in the Grant Land Formation (Trettin, 1994, fig. 71).

The fragments vary from angular to rounded, and roundness increases with clast size. Most are subspherical or ellipsoidal in shape, but flat rip-up clasts of serpentinite mudrock are also present (Fig. 49). Conglomeratic sandstones and conglomerates have a clast-supported texture.

The clasts are composed largely of serpentine with some talc and carbonate alteration and small amounts of opaque minerals. The serpentine within individual

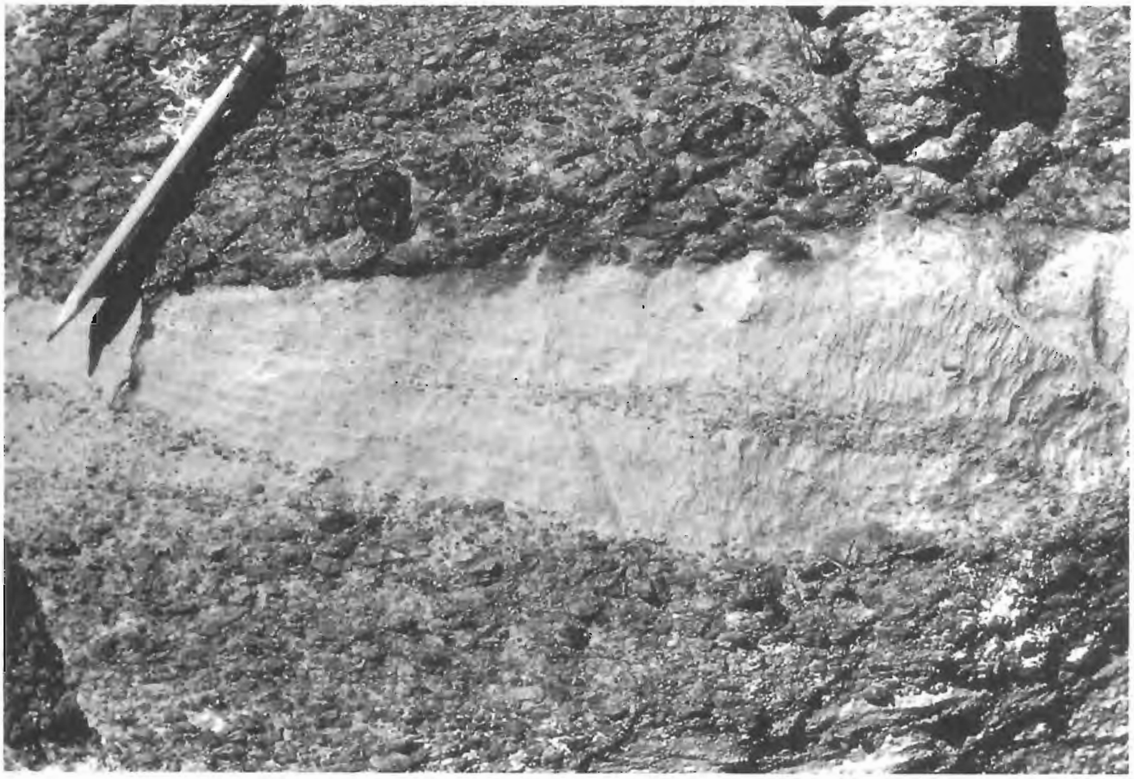


Figure 48. Graded serpentinite conglomerate (dark) and crossbedded calcarenite (light) with sand and fine pebbles of serpentinite; Phillips Inlet Formation, Member A, centre of northeastern Kulutingwak Anticlinorium. ISPG photo 3765-1 (by M. Kos'ko).

0 mm 5.0

Figure 49. Photomicrograph (ordinary light) of poorly sorted serpentinite sandstone with intraclast of serpentinite mudrock (dark) of Phillips Inlet Formation, Member A. Note imbrication above intraclast. ISPG photo 2761-3.

clasts differs in crystal size, crystal orientation, and mineral composition, indicating that serpentinization occurred before deposition.

Whole-rock XRD analysis of a selected sample by G.M. Le Cheminant (pers. comm., 1987) showed that the serpentine is mainly antigorite with small lizardite or chrysotile components. A microprobe analysis of the opaque minerals revealed chromite, magnetite, and cobalt-bearing pentlandite.

A thin unit of serpentinitic calcarenite occurs in the lower part of the exposures at the northeastern end of the structural culmination area (Fig. 48). The rocks are composed mainly of carbonate grains, ranging in size grade from fine sand to granules, with lesser amounts of serpentinite grains and small amounts of chromite and unidentified opaque minerals. Some carbonate grains have distinct, oval outlines, others are amalgamated. The serpentinite grains, and some opaque grains, are well rounded, but the chromite is commonly euhedral. The carbonate grains are composed chiefly of calcite with lesser proportions of dolomite and tremolite. Most are recrystallized but remnants of a micritic texture are preserved. XRD

Figure 50. Photomicrograph (ordinary light) of serpentinite sandstone and mudrock of Phillips Inlet Formation, Member A, showing flat lamination with some graded bedding and indistinct crosslamination in middle layer. ISPG photo 2761-4.

analysis of two samples, combined with thin section inspection, identified calcite (69-71%), dolomite (8-11%), tremolite (9-11%), and serpentine (9-12%).

Member B is estimated to be between a few and 10 m thick. It consists of massive, clast-supported, pebble to boulder grade conglomerate (Fig. 51). Thin sections show the following detrital components: microcrystalline dolostone with ghosts of coated grains; monocrystalline carbonate grains; quartzite of sandstone grade, with or without minor feldspar; quartzite of siltstone grade; aggregates of vein quartz; monocrystalline quartz grains; felsic volcanics or fine grained intrusions; chert; and flakes of white mica. XRD analyses of two samples identified quartz (60-85%), dolomite (12-38%), plagioclase (1%), and calcite, mica, chlorite, and K-feldspar (trace amounts to 1% each). Serpentinite fragments were seen only in a tectonic(?) breccia.

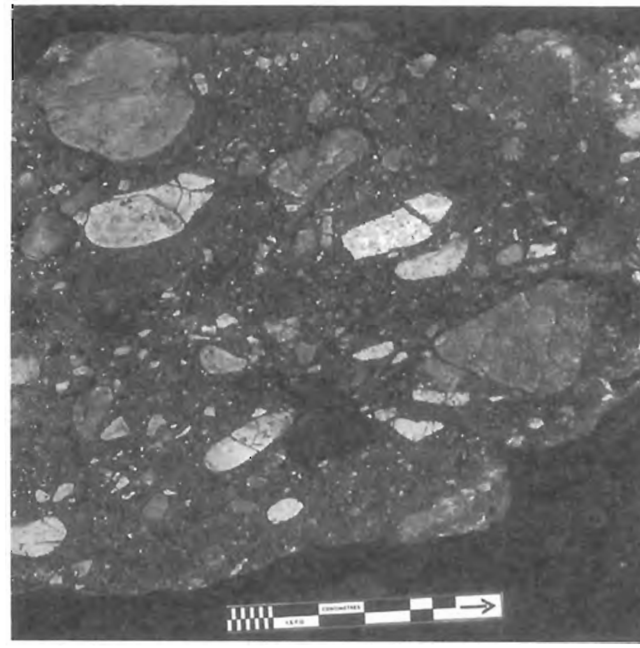


Figure 51. Poorly sorted, sandy polymict conglomerate; light coloured clasts are carbonate rocks; Phillips Inlet Formation, Member B, centre of northeastern Kulutingwak Anticlinorium. ISPG photo 1563-2.

Metamorphism. The mineral composition is compatible with the lower greenschist facies.

Mode of origin. Member A was derived mainly from serpentinized ultramafic rocks that probably represent either oceanic lower crust or mantle, or a sub-arc plutonic complex, such as the Lower Ordovician Thores Suite of Pearya (see Chapter 4, Phanerozoic intrusions). The source terrain of Member B included dolostone, quartzite, felsic volcanics, and chert – rock types characteristic of the Neoproterozoic to Lower Ordovician Succession 2 of Pearya (see Chapter 4).

The predominantly massive stratification of both members suggests deposition mainly by debris flows. Although debris flow deposition can occur both in alluvial and deep-water environments, the stratigraphic setting supports the second alternative.

Sedimentary serpentinite is a rare rock type (cf. Lockwood, 1971), and this appears to be the first published occurrence from Canada. Elsewhere it has been reported from the Norwegian Caledonides (Ordovician; Stigh, 1980; Sturt et al., 1991), the basal Great Valley sequence of California (Jurassic; Phipps, 1984), and the basal Tethys succession in the Alps and Appennine (Jurassic-Cretaceous; Folk and McBride, 1978; Bernoulli and Weissert, 1985; Caby et al., 1987).

The scarcity of such sediments in the geological record can be explained by the relative scarcity of serpentinitic source rocks and the mechanical and chemical instability of this material during subaerial weathering and transport. It is possible, therefore, that it was derived from submarine sources. Two types of deposits have been discovered in modern oceans:

1. Talus derived from submarine fault scarps formed in serpentinized oceanic crust, for example at the Gorringe Bank, southwest of Portugal (La Gabrielle and Auzende, 1982), and in the Cayman Trough of the Carribean (Stroup and Fox, 1981).

2. Mudflows derived from submarine serpentinite diapirs. Examples occur in the fore-arc region of the Mariana Arc (Fryer and Fryer, 1987; Fryer et al., 1990a, b). Calcified chimneys in these diapirs are a potential source of carbonate clasts.

In both cases, graded bedding, flat lamination, and crossbedding have not been reported, but this may be due to the limitations of deep sea investigations. However, an integrated interpretation of the entire Phillips Inlet Formation should explain not only the serpentinitic material of Member A but also the terrigenous material of Member B. Although it is conceivable that one part of the sediments was derived from submarine sources and another part from terrestrial sources, it would be simpler to assume that all sediments are terrigenous. If so, subaerial exposure must have been brief and the sediments must have been buried rapidly without significant mechanical reworking. This would have been the case, for example, if the serpentinitic detritus were derived from coastal cliffs and transported to a marine basin through a submarine canyon and channel system without residing, for any length of time, in high-energy coastal plain and shelf environments.

Age and correlation. The stratigraphic position and age of the formation are uncertain because its contacts are faulted and no fossils or isotopically datable material have been recovered from it. Tentative age assignments can therefore be based only on regional lithological relations and on the structural setting of the formation.

Small amounts of ultramafic detritus occur in two units of Pearya (see Chapter 4): Member A of the Cape Discovery Formation of early Caradoc age, and the Taconite River Formation of Ashgill (Richmondian) age. Small amounts of chromite and serpentine are also present in the lower part of Member A (units A1 and A3) of the Fire Bay Formation, which is early late Llandovery in age. The fact that the Phillips Inlet Formation occurs as thrust slices within the lower part of the Kulutingwak Formation, suggests that it is younger than the latter and more likely correlative with the lower part of the Fire Bay Formation than with the Cape Discovery or Taconite River formations, but this inference is very indirect, and a Caradoc or Ashgill age cannot be ruled out.

Northeastern belt

Mount Rawlinson Complex (map units OR *and* ORc*, Middle Ordovician and (?)younger)*

Definition. The name, Mount Rawlinson Complex, is here proposed for a volcanic-sedimentary assemblage exposed on nunataks in northeastern Ellesmere Island. The rocks are know only from a few helicopter landings and their stratigraphy is poorly understood. The type area is located northwest of the head of Clements Markham Inlet (*Clements Markham Inlet–Robeson Channel*, locality of age determination). The rocks were originally assigned to the Kulutingwak Fiord assemblage (Trettin et al., 1987) and later referred to as the Mount Rawlinson assemblage (Trettin et al., 1991).

Distribution, contact relations, and thickness. The complex is exposed in two structurally aligned belts of nunataks. The Mount Frere outcrop belt, located west and northwest of the head of Clements Markham Inlet, in the vicinity of Mount Rawlinson and Mount Frere, is about 15 km long and up to 3.5 km wide. On the northwest side of the belt, at the highest topographic level, volcanic rocks of the Mount Rawlinson Complex are overlain by the Danish River Formation with what appears to be an angular unconformity. On the southeast side and lowest topographic level, volcanic rocks of the Mount Rawlinson Complex are thrust over a sheet of dolostone and phyllite, that in turn is thrust over the Lands Lokk Formation. The thrust sheet is tentatively included in the Mount Rawlinson Complex as map unit ORc. Elsewhere the volcanic rocks are thrust directly upon the Lands Lokk Formation. Thus the stratigraphic base of the complex is concealed. Assuming no internal faults, graphic measurements suggest a thickness of 1.5 ± 0.5 km.

The Disraeli Glacier outcrop belt, about 23 km long and up to 1.5 km wide, comprises four nunataks at the upper reaches of Disraeli Glacier, 36 km south of the head of Disrali Fiord (*M'Clintock Inlet*). These exposures also lie between the Lands Lokk Formation on the southeast and the Danish River Formation on the northwest, but the northwestern contact is a steeply dipping fault. The thickness of the complex has not been determined in this area.

Lithology. Near Mount Frere, map unit OR is composed mainly of tuff and volcanic flows with lesser proportions of calcareous and dolomitic marble, and chert. The volcanic rocks are made up of quartz, albite, K-feldspar (microcline), chlorite, white mica, epidote, calcite, and dolomite, and contain abundant veins and veinlets of carbonates and quartz. Classifications are listed in Table 10 (see also Fig. 44 and Appendix 4A, Tables 1, 2-9, 3-9). The trace element ratios are in the field of andesite and in the boundary area of rhyodacite/dacite and trachyandesite. The major element compositions, which represent rhyolite, have probably been altered by addition of silica.

Map unit ORc consists of dolostone and phyllite. A sample of dolostone is yellowish grey and laminated and contains quartz of silt and very fine sand grade, and pyrite. A sample of phyllite is composed of quartz, altered feldspar, dolomite, white mica and prehnite(?). In addition to sedimentary quartz, it may contain some altered felsic pyroclasts.

The Disraeli Glacier belt consists of tuff or tuffaceous sediments with a large proportion of chert. The tuffaceous rocks, ranging in grade up to fine pebble conglomerate, are intensely altered by carbonate and unsuited for chemical analysis. They are composed of rock fragments, both felsic and mafic in composition, and crystals of quartz and feldspar. The chert is medium dark grey, partly laminated, and contains relatively well preserved radiolarians (Fig. 52).

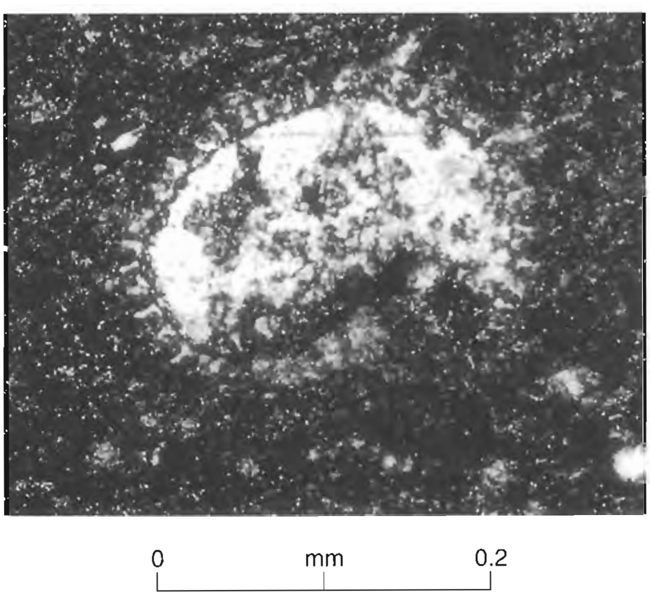


Figure 52. *Photomicrograph (ordinary light), showing ghost of radiolarian test in chert of Mount Rawlinson Complex at Disraeli Glacier. ISPG photo 2260-142.*

Table 10

Mount Rawlinson Complex near Mount Rawlinson: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1	andesite[1]	rhyolite (K-poor)
1	andesite	rhyolite (average)
1	trachyandesite	rhyolite (K-poor)

[1]On border with rhyodacite/dacite.

Metamorphism. The rocks conform to the lower greenschist facies both in mineral composition and texture.

Mode of origin. More chemical analyses of volcanic rocks are required to determine the tectonic setting of the complex. The few trace element analyses that have been obtained lead to similar conclusions as those from the Kulutingwak Formation. The presence of trachyandesite suggests an extensional regime that was imposed either on a volcanic arc or on a continental plate. The carbonates, judging from their light grey colour, are probably of shallow-marine origin and were deposited on the volcanic edifice, whereas the radiolarian chert was probably laid down in adjacent, deeper water settings.

Age and correlation. A volcanic flow rock from the lower or middle part of the complex yielded a zircon age of 454+9.7/-4.6 Ma (Trettin et al., 1987). The stratigraphic age is late Caradoc with confidence limits in the Llandeilo and near the Caradoc–Ashgill boundary, respectively, according to the adopted time scale (Fig. 2).[1] Considering the thickness of the complex, strata of Ashgill and possibly Llandovery age may be present in its undated upper part.

The isotopic age determination suggests at least partial correlation with Member A of the Kulutingwak Formation and the M'Clintock Formation of Pearya (see Chapter 4). This determination is significantly older than the conodont age from map unit OSv. However, the Mount Rawlinson Complex is structurally aligned with map unit OSv, which is also bordered by the Danish River Formation on the

[1]The age is mid-Caradoc according to Tucker and McKerrow (1995).

northwest and the Lands Lokk Formation on the southeast. It is possible, even probable, that the undated upper part of the Mount Rawlinson Complex is correlative with the undated or concealed lower part of map unit OSv.

Succession B

Definition

Succession B includes the Danish River Formation and the overlying Lands Lokk, Markham River, and Piper Pass formations. The Danish River Formation overlaps the five belts of Succession A and parts of Pearya.

Danish River Formation (map unit SDR, *Lower Silurian)*

Definition

The Danish River Formation is a thick succession of sandstone, mudrock, and minor conglomerate, characterized by flyschoid primary structures and a mixed siliciclastic and calcareous-dolomitic detrital composition. It overlies the Hazen Formation in the Hazen Fold Belt, and the Cape Phillips or Allen Bay formations in the Central Ellesmere Fold Belt (Trettin, 1994). Within these belts, the formation is diachronous with an overall age range from Early Silurian (latest Llandovery) to Early Devonian (Emsian), but Devonian strata seem to be preserved only in the Central Ellesmere Fold Belt and immediately adjacent parts of the Hazen Fold Belt. The type section is located in west-central Ellesmere Island, north of Danish River and northeast of Caledonian Bay, on the east side of Cañon Fiord (*Greeley Fiord East, Greeley Fiord West, and Cañon Fiord*). There the formation lies stratigraphically between the Hazen and Eids formations and is divisible into three members (Trettin, 1979). Members A and C are composed mainly of interbedded sandstone and mudrock, and Member B consists mainly of conglomerate and sandstone. This subdivision is applicable only to the Caledonian Bay area because the conglomerate has not been recognized anywhere else.

Exposures in the Clements Markham Fold Belt represent a tongue of the lower part of the formation that lies stratigraphically between the Hazen and Lands Lokk formations and is restricted in age to the Early Silurian (latest Llandovery and possibly Wenlock). The same strata were previously assigned to the Imina group [*sic*], erected as a reconnaissance unit in northwestern Ellesmere Island (Christie, 1957), and subsequently redefined as a formation (Trettin, 1969a). This formation, although widely mapped in northern and central Ellesmere Island (Trettin, 1969b, 1971a, b, 1978, 1979), was abolished because of the absence of a representative section anywhere in northern Ellesmere Island (cf. Trettin, 1994, p. 116, 117).

Distribution, contact relations, and thickness

A nearly continuous belt of exposures, 390 km long and up to 47 km wide, extends from Kleybolte Peninsula to south of central Clements Markham Inlet (Fig. 1).

The Danish River Formation overlies, in different parts of the Clements Markham Fold Belt, the Fire Bay Formation, the Kulutingwak Formation, or the Mount Rawlinson Complex. The concealed contact with the Fire Bay Formation is probably conformable because both formations are of deep-water origin and close in age. The contact with the Kulutingwak Formation in the Kulutingwak Anticlinorium is tentatively interpreted as a disconformity because of an apparent age gap (strata of early to early late Llandovery age seem to be missing), but requires further study.

The contact with the Mount Rawlison Complex is exposed at Mount Frere but has not been examined on the ground. Air observations and air photographic interpretation suggest that it is abrupt. The Danish River Formation is nearly flat-lying, but the Mount Rawlinson Complex dips steeply northwest, which implies either a low-angle fault or an angular unconformity. A low-angle normal fault would be anomalous in this area, which is dominated by low-angle thrusts and by high-angle normal or reverse faults. A low-angle thrust fault also is unlikely because it would place younger on older strata, almost in the correct stratigraphic position, and because the Danish River Formation appears to be undisturbed. The Mount Rawlinson–Danish River contact is therefore interpreted tentatively as an angular unconformity. The Danish River Formation is probably overlain with a conformable contact by the Lands Lokk Formation.

The thickness of the Danish River Formation has not been established because of structural complexities. Photogeological interpretation suggests that no less than 500 m of strata are exposed in a fold on the west side of the unnamed peninsula between Kulutingwak Fiord and Yelverton Inlet (*Yelverton Inlet*). The true thickness is probably much greater as neither underlying nor overlying strata are exposed in this area.

Lithology

The Danish River Formation is composed mainly of sandstone with lesser proportions of mudrock and small amounts of granule or fine pebble conglomerate. In addition, two or more carbonate olistoliths are present that are discussed later.

Primary structures and grain size variations. Beds of sandstone and mudrock, studied at Fire Bay and north of central Emma Fiord (25 examples), can be grouped into three types:

1. Massive sandstones (4 examples; Fig. 53), ranging in observed thickness from 60 to 200 cm. Some have bimodal grain size distributions and show limited graded bedding. A matrix of very fine or fine grained sand contains a less abundant population of medium to very coarse grained sand and granules that shows a slight upward decrease in the size of the coarsest fraction. These beds are transitional to the Ta turbidites mentioned below.

2. Massive sandstones with convolute laminae in the upper part (6 examples), ranging in observed thickness from 30 to 310 cm. Some show an intervening flat lamination (B division?) and could be classified as T_{a-c} turbidites; however the laminae are less distinct than in normal turbidites.

3. Sandy turbidites (15 examples), ranging in recorded thickness from 3.5 to 126 cm. The following types were recognized: T_a (3), T_{ab} (2), T_{a-c} (4; Fig. 54), T_{a-d} (4), T_{b-d} (1), and T_{c-d} (1). The size of the coarsest clasts at the base of these graded units ranges from very fine sand to granules. C- and D- divisions are composed mainly of siltstone but may include very fine grained, silty sandstone.

Many sandy turbidites and massive sandstones have sole marks, mainly grooves and ridges, and less abundant flute marks (see below, Figs. 57, 58).

Mudrocks have not been studied; they are poorly exposed and their primary structures are commonly obscured by cleavage.

Figure 53*. Massive sandstone beds separated, with sharp contacts, by thin beds of slaty mudrock; Danish River Formation, north of Emma Fiord (****Cape Stallworthy-Bukken Fiord****). ISPG photo 4007-29.*

Figure 54*. T_{a-c} turbidite in the Danish River Formation at Fire Bay, Emma Fiord (****Cape Stallworthy-Bukken Fiord****); cm-scale on hammer handle. ISPG photo 4007-21.*

Composition and textural features. *Sandstone.* The sandstones of the Danish River Formation in the Clements Markham Fold Belt are similar in composition and texture to those in the Hazen Fold Belt. They are composed mainly of quartz with a significant but smaller proportion of carbonates, and minor amounts of mica, chlorite, feldspar, chert and metamorphic and volcanic rocks fragments (Figs. 55, 56). Point count analyses are difficult to make and the results are not reproducible, mainly because of the recrystallization and amalgamation of the fine fractions – the carbonate minerals tend to mask other minerals owing to their high birefringence. Instead, an approximate average composition has been established from 57 XRD analyses (Appendix 3, Table 29) in conjunction with carbon analyses and microscopic observations. The procedures and results are summarized in Table 11.

The sorting varies from moderate to good. Most grains are subangular or angular as a result of diagnetic-metamorphic processes, but some relics of more rounded outlines are preserved.

Mudrock. Comparison of uncorrected XRD data (Appendix 3, Tables 29, 30) shows that the mudrocks are similar in mineral composition to the sandstones. However, in the mudrocks, the mica and chlorite contents are slightly larger, the carbonate content is slightly smaller, and chert and rock fragments are absent.

Conglomerate. Typical granule conglomerates have higher contents of vein quartz, quartzite, chert, quartzose schist or phyllite, and carbonates than the sandstones, and this is reflected in the XRD values (cf. Appendix 3, Tables 29, 31). Skeletal fragments are present in some limestone clasts.

Paleocurrent directions

Paleocurrent measurements were made north of the upper reaches of Emma Fiord (Fig. 59, loc. P1) and east of Fire Bay (Fig. 59, loc. P2), using flute marks, and grooves and ridges (Figs. 57, 58). The directions were recorded as pitch; i.e., as the angle they form in the bedding planes with horizontal lines marked on the bases of turbidites with the aid of a level. These angles were converted to paleocurrent azimuths by adding them to (or subtracting them from) the strike of the beds, inferred from air photographs, thus avoiding the use of a compass. This method is applicable only if the

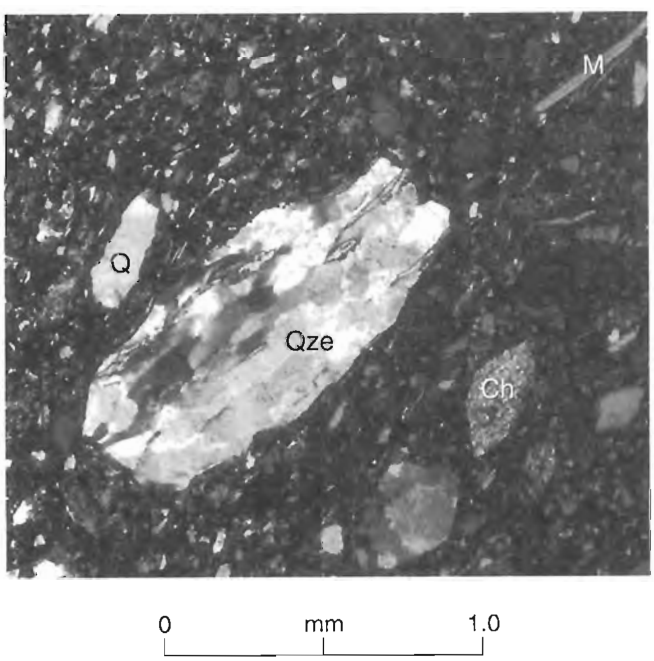


Figure 55. *Photomicrograph (cross-polarized light) of poorly sorted, bimodal sandstone at base of massive sandstone bed in the Danish River Formation north of Emma Fiord, showing muscovite-bearing quartzite* (Qze), *quartz* (Q), *white mica* (M), *and chert* (Ch). *ISPG photo 4227-6.*

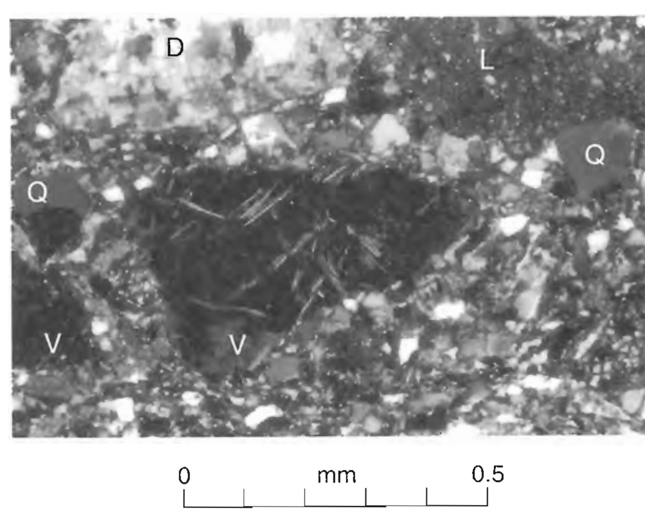


Figure 56. *Photomicrograph (cross-polarized light) of poorly sorted sandstone of Danish River Formation, showing mafic volcanic rock fragments* (V), *dolostone* (D), *lime mudstone* (L), *and quartz* (Q). *ISPG photo 4248-2.*

Table 11

Danish River Formation: approximate average composition of sandstones

Quartz (60%):	Mainly monocrystalline grains; minor vein quartz, quartzite, and chert; standard deviation of uncorrected XRD data: 11.7%
Feldspar (5%):	Largely or entirely albite (about 4%), but incompletely metamorphosed strata contain K-feldspar (average 1%); commonly twinned, commonly altered (sericite, epidote); a very small proportion of albite occurs in volcanic rock fragments
Mica (6%):	Mainly white mica, but trace amounts of biotite are present in incompletely metamorphosed strata; occurs separately as relatively large flakes of sedimentary mica, in fragments of phyllite or schist, and probably also as metamorphic mica developed from original clay minerals. XRD analysis also includes sericite within altered feldspar (standard deviation of XRD data is 4.1%)
Chlorite (6%):	Large flakes, commonly associated with mica, represent altered biotite; relatively fine grained material may represent detrital chlorite and metamorphosed clay minerals; also occurs in fragments of schist, phyllite, and rare volcanic material (standard deviation of XRD data is 5.7%)
Carbonates (23%):	Average dolomite content 11.5%, calcite content 10.6%, but proportion varies considerably (D/D+C of uncorrected values has standard deviation of 52%); both occur as multicrystalline grains, single crystals, replacements, and veinlets
Chert:	(Included in percentage of quartz, above); abundant in coarser rocks (point count results range up to 8%); occurs mainly in the medium grained sand to fine pebble fraction; partly recrystallized to quartzite but recognizable by extinction pattern
Phyllite, schist:	(Included in percentages of quartz, mica, chlorite and feldspar) generally present in trace amounts only but more abundant in coarser rocks (point count results range up to 3%); composed mainly of quartz and mica with variable amounts of chlorite and possibly feldspar
Volcanics:	(Included in percentages of albite and chlorite) generally scarce or absent but up to a few per cent are present in samples from Fire Bay; compositions are variable

Calculation procedures:
1. Calcite and dolomite contents were calculated from average XRD values, using correction factors obtained from 22 combined carbon and XRD analyses (see Appendix 3, Introduction).
2. Mica and chlorite percentage represent unconcorrected XRD data.
3. Combined quartz and feldspar content was obtained by subtraction of mica, chlorite, calcite, and dolomite from 100 per cent. It was then partitioned into quartz, K-feldspar, and albite using corrected ratios for F/F+Q and P/P+Kf (see Appendix 3, Introduction).

***Figure 57**. Flute marks in the Danish River Formation, north of Emma Fiord, showing transport from northeast to southwest (lower left to upper right). ISPG photo 4007-19.*

***Figure 58**. Grooves and ridges and small flute marks in the Danish River Formation east of Fire Bay, showing transport from northeast (right) to southwest (left). ISPG photo 4007-23.*

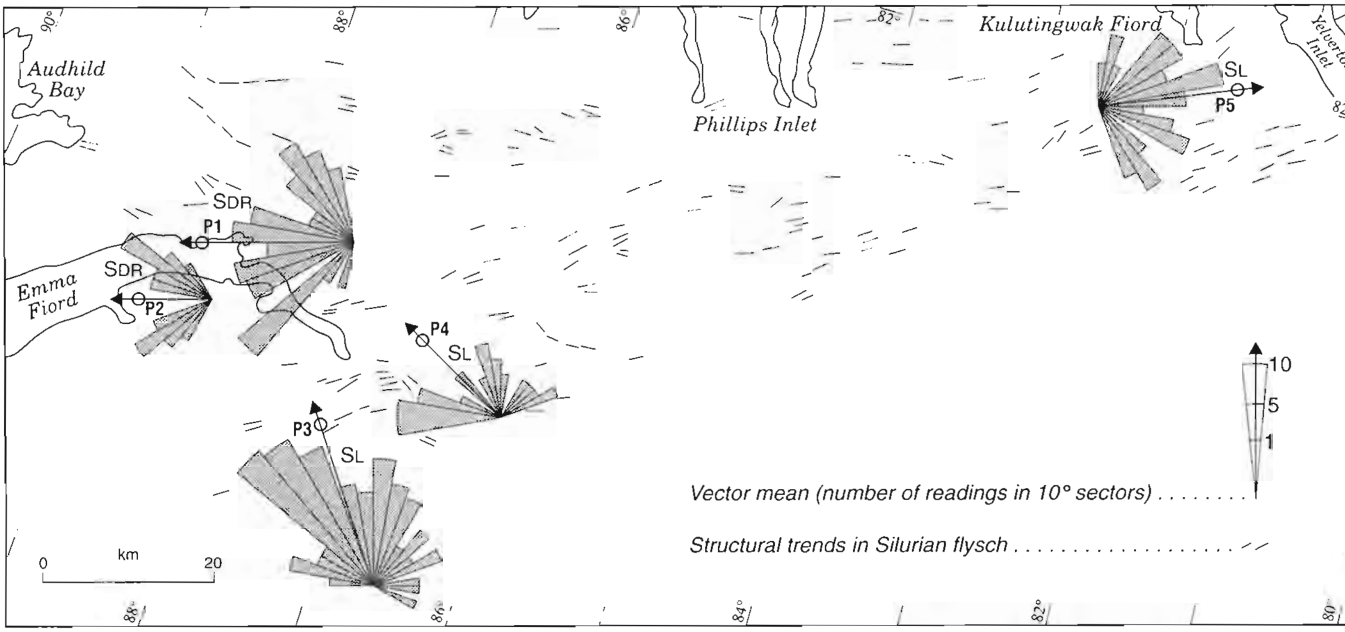


Figure 59. Paleocurrent directions in the Danish River (SDR) *and Lands Lokk formations* (SL) *in northwestern Ellesmere Island (P1-P5: locality numbers). Small circles indicate localities where determinations were made. For interpretation of flow patterns, see Figures 161 and 162.*

beds dip steeply, if they are about parallel with adjacent axial planes, and if the fold axes are horizontal. Where the fold axes are not horizontal, a correction for plunge has to be added or subtracted (see Trettin, 1971a, p. 67–69). At Fire Bay, plunge determinations were made on the crests of minor folds. Twenty-five measurements indicate transport from northeast to southwest, the vector mean being parallel with strike.

In the area north of Emma Fiord, folds are absent. The determinations were made on relatively steeply inclined, southeast-dipping thrust sheets, and it was impossible to determine the original horizontal direction. Assuming that the beds have been rotated about horizontal axes, and excluding rotation about vertical axes, the mean of 72 determinations again is parallel with strike from northeast to southwest and identical with the mean direction at Fire Bay, but the structural assumptions may not be valid.

Metamorphism

Regional metamorphism of greenschist facies is developed in a belt extending from southwest of Phillips Inlet to northeast of Yelverton Inlet, adjacent to the Mitchell Point Belt or Kulutingwak Formation, over a width of about 10 km or more. In the sandstones, three metamorphic facies of decreasing rank can be distinguished from northwest to southeast, based on the following mineral assemblages: (1) Metamorphic biotite (with or without minor white mica and chlorite), oligoclase or albite (K-feldspar absent). (2) White mica, chlorite and albite (detrital biotite and K-feldspar absent). (3) Trace amounts of detrital biotite and minor amounts of K-feldspar preserved, but clay minerals recrystallized to chlorite and white mica; associated mudrocks have a slaty cleavage.

The third facies, indicative of incomplete regional metamorphism, is characteristic of the Danish River Formation in most of the Clements Markham Fold Belt.

Mode of origin

Most conclusions about the origin of the Danish River Formation in the Hazen and Central Ellesmere fold belts (Trettin, 1994, p. 128, 129) are also applicable to the exposures of the formation in the Clements Markham Fold Belt. The common occurrence of Bouma sequences (and associated massive sandstones) indicates deposition by sediment gravity flows in a deep-water basin. The detrital components of the sandstones can be assigned to three kinds of source rocks, but only the first two are significant quantitatively:

1. Derived from quartz-rich source terrains of essentially sialic composition: quartz, feldspar, mica, chlorite, and metamorphic rock fragments (nearly 3/4 of rock volume).

2. Derived from uplifted carbonate rocks, closely associated with the sialic source rocks: calcareous and dolomitic grains, homogeneously mixed with silicates (about 1/4 of rock volume).

3. Derived from secondary chert associated with carbonate rocks or primary chert of deep-water origin: chert grains (a few per cent of rock volume).

In the southeastern part of the Deep Water Basin, the Danish River Formation contains carbonate clasts derived from penecontemporaneous strata of the Franklinian Shelf. They differ from the terrigenous carbonate material listed above (under 2) by coarser clast sizes, presence of skeletal material, smaller proportions of associated siliciclastic material, and a less homogeneous mixing (Trettin, 1978, 1979).

The preservation of unstable detrital components, such as carbonate grains and biotite, indicates compositional immaturity; i.e., rapid, predominantly mechanical weathering in the source area.

The near absence of relatively fresh volcanogenic materials such as volcanic rock fragments and shards or phenocrysts of quartz and feldspar suggests that the bulk of the sandstones was not produced by penecontemporaneous volcanism. The origin of the small amounts present in some sandstones east of Fire Bay is uncertain. The only significant volcanic unit that may be partly co-eval with the Danish River Formation is the Svartevaeg Formation of the Northern Heiberg Fold Belt, but derivation from that unit is incompatible with the recorded paleocurrent directions. On the other hand, the material may have been derived from slightly older Ordovician to Lower Silurian volcanic units, such as the Kulutingwak Formation and the Mount Rawlinson Complex, which were uplifted along the northwestern margin of the Deep Water Basin. The paleocurrent directions are subparallel with the predominant transport directions in the Hazen Fold belt, but the coarser grain size indicates greater proximity to the source area.

Age and correlation

In the type section at Caledonian Bay, the Danish River Formation ranges in age from latest Llandovery (late Telychian) to early Lochkovian; i.e., earliest Devonian (Norford *in* Trettin, 1979, 1994). In the Clements Markham Fold Belt, its age range is restricted to the late Llandovery by graptolites from the underlying Fire Bay Formation and the overlying Lands Lokk Formation, which are both Telychian age.

A poorly preserved graptolite collection found in uppermost strata of the Danish River Formation in an area northeast of Emma Fiord in 1962 included forms tentatively identified as *Monograptus* cf. *M. priodon* and *Monograptus* cf. *M. undulatus* by J.W. Kerr and R. Thorsteinsson (*in* Trettin, 1969a - reproduced in Appendix 5A, GSC loc. 52315). In the Cape Phillips Formation, *M. priodon* ranges in age from early late Llandovery (*turriculatus* Zone) to early Wenlock (Melchin, 1989; Lenz and Melchin, 1990), whereas *M. undulatus* ranges from latest early to late middle Llandovery (*cyphus* to *convolutus* zones). Taken at face value, the combined age ranges would place the collection at the middle-late Llandovery boundary, but this assignment appears to be too old, and the presence of *M. undulatus* must be questioned.

The Danish River Formation is lithologically similar to the Merqujoq Formation, a flyschoid unit in North Greenland confined to an interval within the late Llandovery (Hurst and Surlyk, 1982; Higgins and Soper, 1985; Larsen and Escher, 1985, 1987). The two units are probably approximately correlative although the base of the flysch may be slightly diachronous, ascending in age from northeast to southwest, the direction of paleocurrent transport and progradation in the southeastern part of the Deep Water Basin.

Limestone olistoliths in the Danish River Formation (map unit SDRo*)*

A lenticular olistolith, a few tens of metres long and perhaps 10 m thick, occurs within the lower part of the Danish River Formation at a locality 3.4 km southwest of the head of the western arm of Kulutingwak Fiord (*Yelverton Inlet*, inset). At the base, carbonate fragments, in part ellipsoidal, are embedded in a sandy matrix. Samples represent a slightly recrystallized lime mudstone/wackestone that contain rare to abundant coated grains and echinoderm ossicles. The shallow-marine origin of the rocks, apparent from their petrography, is confirmed by the following isotopic values:

Sample no.	$\delta\ ^{13}C$	$\delta\ ^{18}O$
C-171522	+5.1	+27.1
C-171524	+0.6	+25.0

(determined by Krueger Enterprises, Inc., Cambridge, Massachusetts; courtesy M. Bjornerud). No conodonts were obtained from several large samples processed for microfossils.

Another olistolith, metres in length and thickness, occurs within the Danish River Formation east of Fire Bay (*Cape Stallworthy-Bukken Fiord*, inset B), but its contacts are covered. A sample of wackestone examined in thin section consists of peloids, coated grains, and echinoderm fragments with some recrystallized brachiopod, mollusc, trilobite and algal fragments, including *Rhabdoporella* sp. (T. de Freitas, Appendix 5D, GSC loc. C-194940). This olistolith yielded conodonts of unspecified Middle or Late Ordovician (Chazyan to Gamachian) age (Nowlan, Appendix 5B, GSC loc. C-194940), distinctly older than the Danish River Formation but slightly younger than the olistoliths in the Hazen and Fire Bay formations. Analogy with the olistoliths in the Hazen and Fire Bay formations suggests derivation from a northwesterly source. The conodont alteration index of 3 indicates a temperature between 110 and 300°C (Epstein et al., 1977).

Lands Lokk Formation (map units SL, SLpv, SLq, SLqcg, and SLp, Lower and Upper Silurian)

Definition

The Lands Lokk Formation, named for a cape in northwesternmost Ellesmere Island (Trettin, 1969a), is here redefined as a clastic unit that overlies the Danish River Formation and is locally overlain by shallow-marine carbonate and clastic units such as the Markham River Formation. It is composed of mudrock, sandstone and minor pebble conglomerate that commonly occur in Bouma sequences. The Lands Lokk has a higher proportion of mudrock, which typically is dark grey, and a detrital composition poorer in carbonate material and richer in quartz, chert, and locally volcanogenic material than does the Danish River Formation. Partial sections of two different facies, located 8 km northeast of Emma Fiord (*Otto Fiord*, section NEEF) and 8.5 km south of Emma Fiord (Hvitland Peninsula 1 section, *Otto Fiord*, section HVP1) constitute the composite type section.

The formation was originally divided into three members (Trettin, 1969a). Member A, the oldest unit, was recognized in Axel Heiberg and Ellesmere islands, Members B and C were recognized in Ellesmere Island only. This subdivision is abandoned in the present report. The strata of Member A on Axel Heiberg Island are re-assigned to the Svartevaeg Formation (Chapter 2), and the strata of Member B on Ellesmere Island to the Hazen and Fire Bay formations, as discussed earlier in this chapter. New fossil collections show that the original Members B and C are essentially co-eval lithofacies although the strata equivalent to Member C prograded over the strata equivalent to Member A.

Distribution, contact relations, and thickness

Outcrop areas of the Lands Lokk Formation form a discontinuous belt, 394 km long and up to 30 km wide, that extends across northern Ellesmere Island from south of Emma Fiord to southwest of the Lincoln Sea (Figs. 1, 60).

The contact relations of the Danish River and Lands Lokk formations are difficult to establish because most contacts are faulted. A stratigraphic contact is probably present in an area 22 to 32 km northeast of the head of Emma Fiord (*Otto Fiord*), but it is covered. It is defined by a seemingly abrupt upward change from light coloured, fairly resistant sandstone and minor mudrock to dark grey, recessive mudrock and minor sandstone. Considering the deep-water origin of the two formations, a subaerial unconformity is unlikely.

Northwest of Markham River (*Clements Markham Inlet–Robeson Channel*), the formation is disconformably overlain by the Markham River Formation. Southeast of Markham River and Clements Markham Inlet it is probably overlain by the Piper Pass Formation, a facies equivalent of the Markham River Formation, but the contact is faulted.

The Lands Lokk Formation has a minimum thickness of about 1 km in the Hvitland Peninsula 2 section (*Otto Fiord*, section HVP2), but the total thickness in that area may be 2 km or greater.

Lithology

Lithofacies, primary structures, and grain size variations. Because present subdivisions of the Lands Lokk Formation are lateral rather than vertical, variations in macroscopic lithology are discussed by area and lithofacies (Fig. 60). Vertical and lateral variations in lithology are reasonably well known only in the area southeast and east of Emma Fiord (*Otto Fiord*) where two major facies, the mudrock-volcanogenic facies (SLpv) and the sandstone-mudrock facies (SLq), have been mapped and investigated in varying detail. Three different lithofacies, SLp, SLq, and SLqcg were mapped in an area

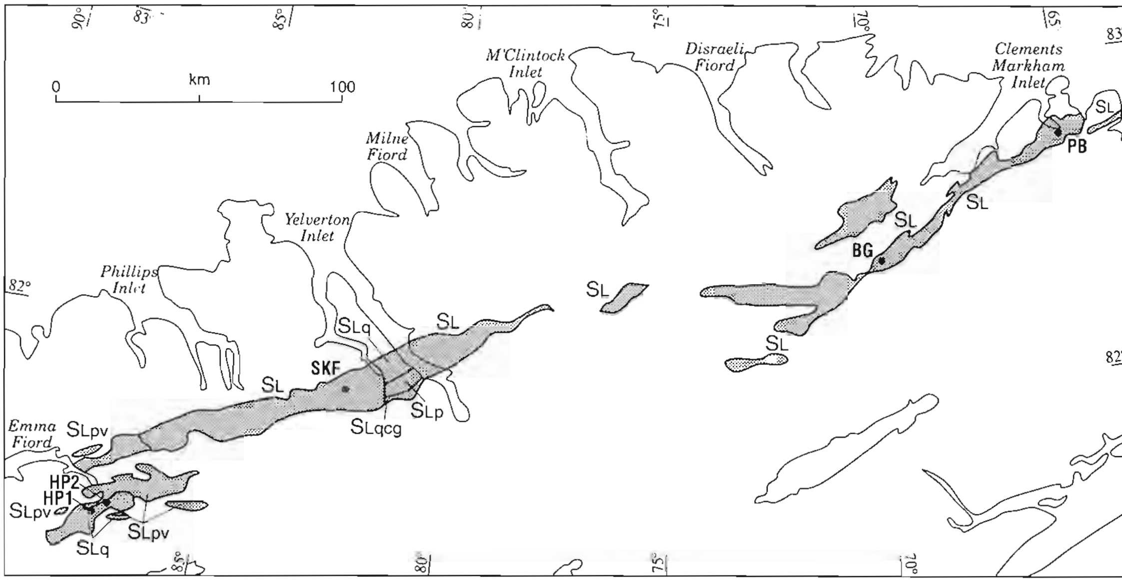


***Figure 60**. Lands Lokk Formation, distribution, map units, and section localities* (BG: *Barrier Glacier;* HP1, HP2: *Hvitland Peninsula 1 and 2 sections;* PB: *Parker Bay;* SKF: *south of Kulutingwak Fiord;* SL: *undifferentiated Lands Lokk Formation,* SLpv: *mudrock-volcanogenic facies,* SLq: *sandstone-mudrock facies,* SLqcg: *sandstone-mudrock-conglomerate facies).*

southwest of the southeastern part of Yelverton Inlet (*Otto Fiord*), but their stratigraphic relations are uncertain. In the rest of the area the formation has remained undivided (SL).

South and east of upper Emma Fiord. In this area the formation is divisible into two map units characterized by mudrock and volcanogenic strata (SLpv), and quartzose sandstone and mudrock (SLq) respectively. Both have yielded graptolites of the same age ranges, which demonstrates that they are essentially co-eval lithofacies. However, the sandstone-mudrock facies prograded over the mudrock-volcanogenic facies in a northwestward direction. This is apparent from stratigraphic relations and paleocurrent directions in the vicinity of the Hvitland Peninsula 1 section, where map unit SLq overlies a tongue of the lower part of map unit SLpv. These two map units are bordered on the northeast by the undivided Lands Lokk Formation. The boundary of the undivided Lands Lokk Formation shown on the map (*Otto Fiord*) indicates differences in ground control rather than lithology.

Mudrock-volcanogenic facies (map unit SLpv). The thickness and stratigraphy of this facies is uncertain because of its complex structure. It consists mainly of medium grey to medium dark grey, commonly laminated, mudrock and minor quartzose sandstone. A smaller proportion of the facies consists of volcanogenic sediments that decrease in abundance in a northeastward direction. A partial section of the facies, about 600 m thick, was measured in 1962 in a reconnaissance fashion (Trettin, 1969a, fig. 9). It is divisible into two major units. The lower unit, with an apparent thickness of about 355 m, but possibly repeated by folding, is recessive and consists mainly of dark grey, commonly laminated, fine and coarse grained mudrocks, that contain early Ludlow graptolites in the lower part. The upper unit, 253 m thick and resistant, is composed of medium and coarse grained volcanogenic sandstone and interbedded mudrock. The volcanogenic deposits show thin to thick bedding and some crosslamination.

Sandstone-mudrock facies (Map unit SLq). Structural traverses combined with airphoto interpretation indicate a minimum thickness of 1 km in the Hvitland Peninsula 2 section. The lower 793 m of the facies are exposed in the Hvitland Peninsula 1 section where it overlies the mudrock-volcanogenic facies (map unit SLpv). A reconnaissance description of the entire section (Fig. 61) was supplemented by detailed descriptions of 13 representative short intervals (Fig. 62). The grain size distributions shown for these detailed sections, although based on numerous hand specimens and thin sections, are generalized.

The bulk of the section consists of sandstone and mudrock with no more than a few centimetres of granule to fine-pebble conglomerate in two units (nos. 16 and 36, Fig. 61). Most rocks are nonvolcanogenic, but volcanogenic sandstone and

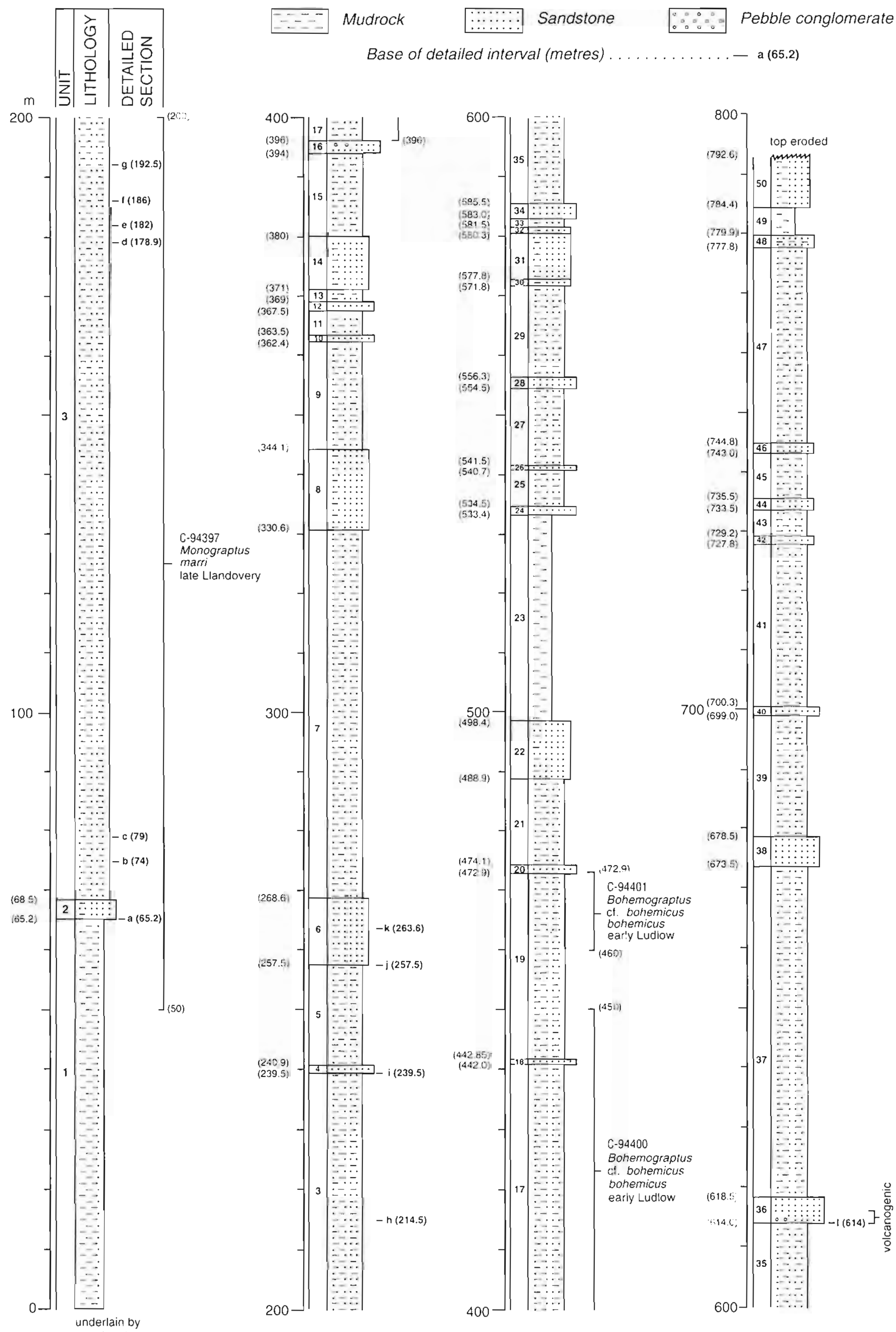


***Figure 61**. Lands Lokk Formation, sandstone-mudrock facies (map unit SLq), Hvitland Peninsula 1 section (Otto Fiord, locality HP1 of Fig. 60).*

minor pebble conglomerate occur in at least one unit (unit 36, 514-616 m). Sandstone and mudrock, generally interstratified on a millimetre to decimetre scale, have mostly been lumped in the overall description, but two distinct mudrock units, 6.2 and 4.5 m thick (units 23 and 49), and 11 sandstone units, 0.8 to 5 m thick (units 4, 10, 12, 18, 20, 24, 26, 28, 34, 38, 40) are described separately.

The sandstone and conglomerate units described in detail can be classified as Bouma sequences of seven different types or as massive sandstones. Their thicknesses and grain size distributions are summarized in Table 12. Massive sandstones (designated M in Fig. 62 and Table 12) do not show persistent graded bedding, although it may occur at the very top, and are mostly unstratified, although indistinct, flat or undulating, laminae may occur at different levels. Some massive sandstones contain rip-up clasts of mudrock.

Table 12

Lands Lokk Formation, Hvitland Peninsula 1 section: statistics of Bouma sequences

	N	Thickness (cm)	Grain Size (phi units)	
			base	top
T_a	6	3-448	(-2.5)–2.5	1.5–4
T_b	12	1–18	3.5–4	3–4.5
T_c	3	1–3	3.5–4.5	4–4.5
T_{ab}	13	3–346	0.5–3	2–4.5
$T_{a\text{-}c}$	2	8.3–9.9	1.5–2.5	3.5
$T_{a\text{-}d}$	1	137.5	0.5	3.5
T_{bc}	3	1.5–4	3–3.5	3.5–4.5
M	3	16–69	1–2.5	1.5–2.5
P	35	0.2–28.5		

M designates massive sandstones and P undifferentiated turbidites, including C and D divisions.

Phi scale:

4 = 1/16 mm
very fine grained sand
3 = 1/8 mm
fine grained sand
2 = 1/4 mm
medium grained sand
1 = 1/2 mm
coarse grained sand
0 = 1 mm
very coarse grained sand
-1 = 2 mm
granules
-2 = 4 mm
pebbles

Overall, the grain sizes range from coarse silt to fine pebble grade, and the thicknesses of the Bouma sequences from 1 to 448 cm. A typical $T_{a\text{-}d}$ turbidite is shown in Figure 63. The greatest thicknesses are attained by T_a (Fig. 64) and T_{ab} turbidites and by massive sandstones, and the coarsest sediments occur at the base of these types of deposits. In contrast, T_b, T_c, and T_{bc} turbidites are relatively thin (1-18 cm), and consist mostly fine or very fine grained sandstone at the base.

The intercalated mudrocks (designated P in Fig. 62) are probably all of silt grade, but their original grain size and primary structure is difficult to establish because of pervasive recrystallization and cleavage. Many show flat lamination and some show small-scale crosslamination, suggesting D or C divisions, respectively. In the measured intervals (Fig. 62), the mudrock units range in thickness from 0.2 to 28.5 cm but are rarely more than 10 cm thick. Lenses of very fine grained sandstone, millimetres in thickness, have been observed in one mudrock unit (designated PS in Fig. 62, detailed interval g).

Southwest of Yelverton Inlet and south of Kulutingwak Inlet. On the southwest side of the southeastern part of Yelverton Inlet (*Yelverton Inlet* and *Otto Fiord*), three different lithofacies have been mapped. Map unit SLp consists mainly of mudrock; map unit SLq of quartzite and mudrock; and map unit SLqcg of sandstone, pebble conglomerate, and mudrock. The stratigraphic position of these units is uncertain, but analogy with the exposures on Hvitland Peninsula suggests that the mudrock facies occurs in the lower part, and the conglomeratic facies in the upper part of the formation.

Interbedded sandstone, mudrock, and pebble conglomerate also were noted in an area south of Kulutingwak Inlet, about 27 km southwest of the southeastern part of Yelverton Inlet, and mapped as undifferentiated Lands Lokk Formation (*Otto Fiord*, loc. SKI). The conglomerate occurs in the A-division of a $T_{a\text{-}c}$ turbidite, which is composed of sandstone and mudrock in the upper part (Fig. 65). The A-division, 110 cm thick, cuts into an underlying sandstone and fills a channel 5 cm deep and 15 cm wide. The pebbles are mainly 0.5 to 1 cm in diameter, but some range up to 2 cm. The proportion of pebbles decreases upward within the A-division, but the maximum pebble size decreases only slightly. The conglomeratic turbidite is underlain and overlain by sandy and argillaceous turbidites of $T_{a\text{-}c}$, T_{bc}, and T_b type, commonly with medium to coarse grained sandstones in its base.

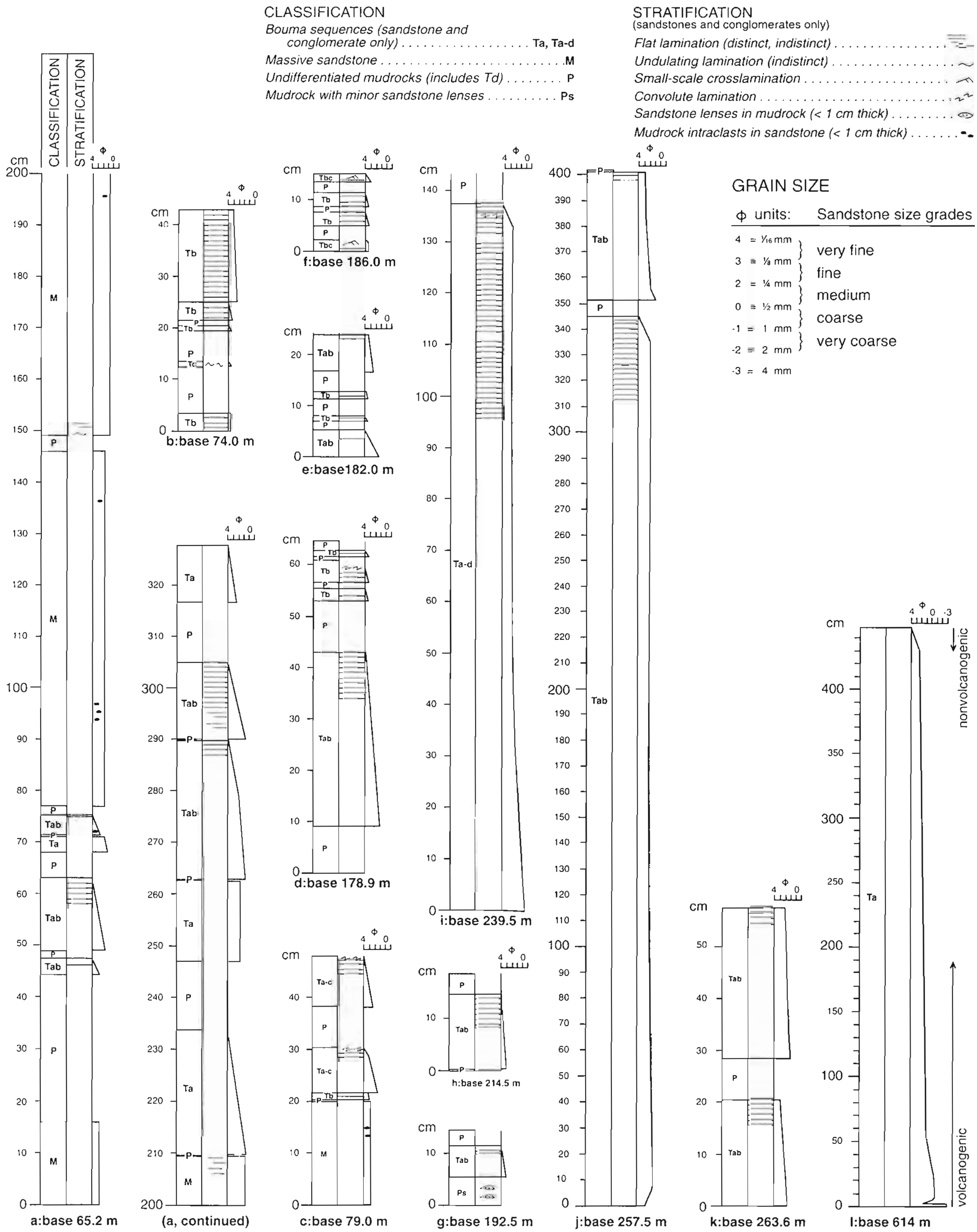


Figure 62. Lands Lokk Formation: detailed sections of the sandstone-mudrock facies (map unit SLq), Hvitland Peninsula 1 section.

Figure 63*. Lands Lokk Formation, sandstone-mudrock facies (map unit* SLq*), Hvitland Peninsula 1 section,* $T_{a\text{-}d}$ *turbidite at 580 m. ISPG photo 2638-6.*

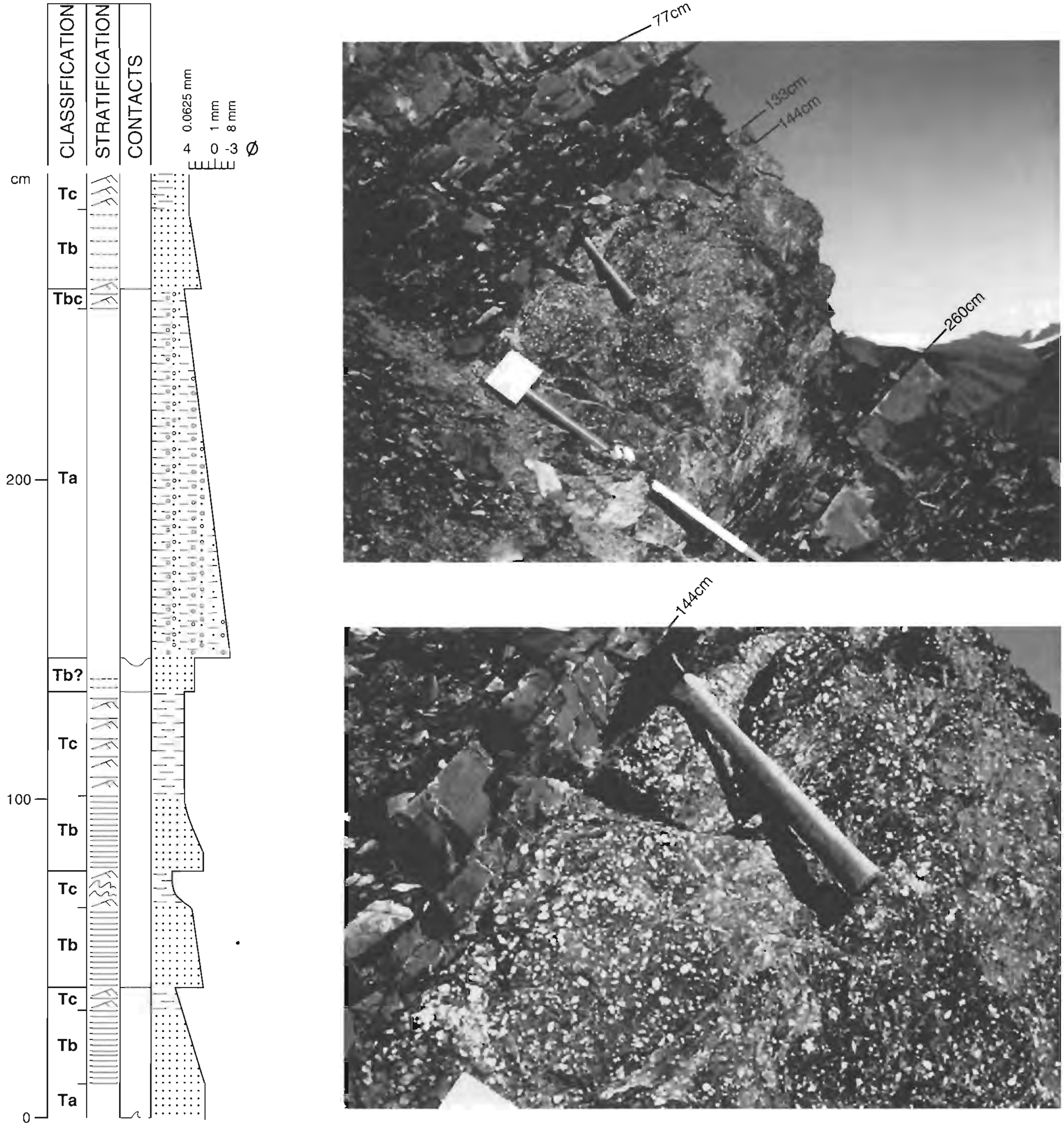
Figure 64*. Lands Lokk Formation, sandstone-mudrock facies (map unit* SLq*), Hvitland Peninsula 1 section:* T_a *turbidite, 448 cm thick with volcanogenic sediment in lower part; base of measuring staff at 614 m; detailed interval i of Figure 61. ISPG photo 2638-1.*

Barrier Glacier to Lincoln Sea. Exposures of the Lands Lokk Formation are widespread in the Clements Markham Inlet area, extending from a large ice cap in the southwest to the coast of Lincoln Sea in the northeast. In most of this region the Lands Lokk Formation consists of medium dark grey, partly slaty mudrock, or of interbedded mudrock and very fine to fine grained sandstone, both of which are darker and less calcareous-dolomitic than the Danish River Formation. Typical grain size distributions and primary structures are represented by short detailed sections measured at Barrier Glacier and south of Parker Bay (*Clements Markham Inlet*, BG and SPB; Figs. 66, 67). The turbidites, varying in thickness from 1 to 116 cm, represent T_a, T_b, T_{ab}, $T_{a\text{-}c}$, $T_{a\text{-}d}$, T_{bc}, and $T_{b\text{-}d}$ Bouma sequences. Massive sandstones also are common and range in thickness from 5 to 72 cm. Except for an area northwest of Markham River (see below), medium or coarse grained sandstone was not observed, even at the base of relatively thick sandstone units. Some nongraded sandstones that contain flat laminae and small-scale crosslaminae may have been deposited by contour currents.

In addition to these sediments, which are typical of the formation in general, unusual rock types were seen at several localities southeast of Clements Markham Inlet. Greenish grey mudrock and sandstone and purplish grey mudrock are present at Parker Bay. Calcareous mudrock, sandstone and pebble conglomerate were noted at Parker Bay and south of central Clements Markham Inlet.

Anomalous rock types are also present northwest of Markham River, where the Lands Lokk Formation is disconformably overlain by the Markham River Formation. There the upper part of the Lands Lokk Formation consists mainly of medium dark grey mudrock that is intensely bioturbated and veined and partly replaced by carbonate. At the top of the formation, a coarse clastic unit, which differs in stratification and mineral composition from more typical developments of Lands Lokk strata (Appendix 1, Markham River section; not included in Fig. 71) is exposed locally. The lower 34.5 m consists mainly of quartzose and micaceous sandstone (about 75%), lesser interstratified siltstone, and a trace of fine-pebble conglomerate. The sandstone is fine to very coarse grained and contains flat laminae, some small-scale crosslaminae, and is bioturbated. The upper 2 m are rubble of fissile mudrock.

Composition and textural features. *Sandstone and pebble conglomerate.* Most of the sandstones and conglomerates are quartzose and cherty (Fig. 68); very small proportions are volcanogenic or calcareous-dolomitic.



CLASSIFICATION

Divisions of Bouma model . . . . **Ta, Tb, Tc**

STRATIFICATION

Flat lamination (distinct, vague) . . . .

Crosslamination . . . .

Convolute lamination . . . .

CONTACTS (including sole marks etc.)

Abrupt . . . .

Channal . . . .

Flame structure . . . .

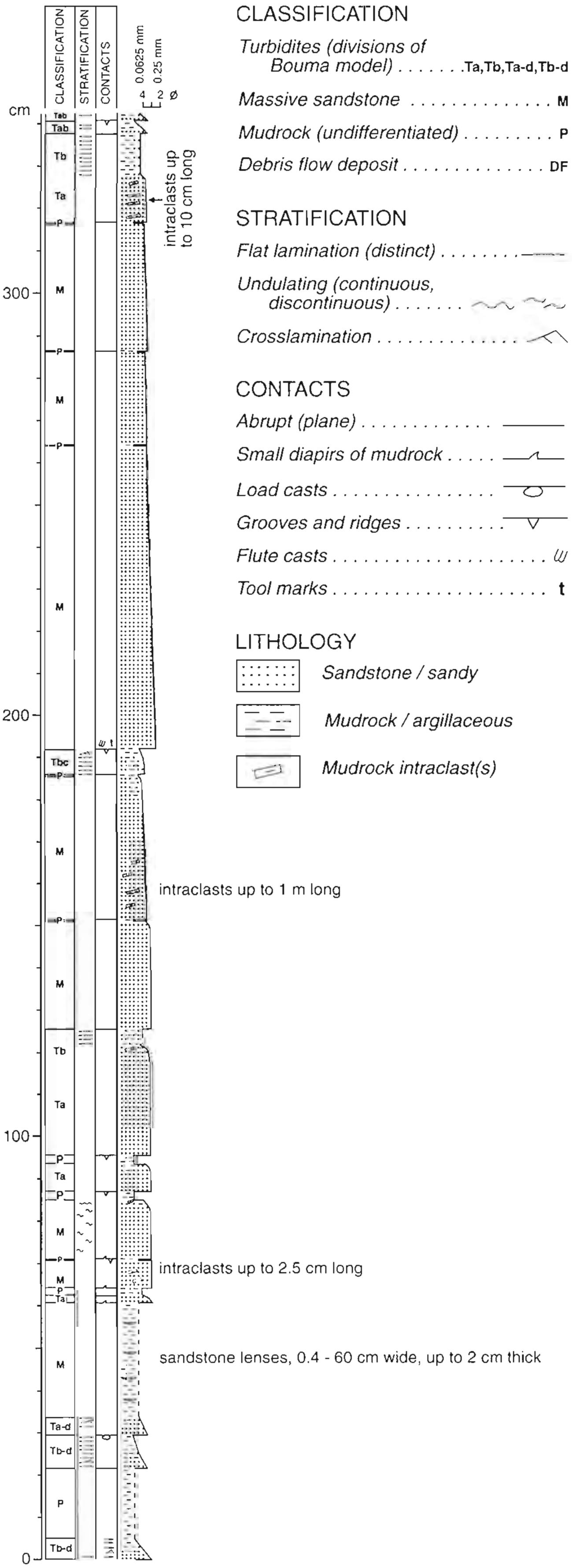
LITHOLOGY

Conglomerate / conglomeratic

Sandstone / sandy

Mudrock / argillaceous

Figure 65*. Lands Lokk Formation, turbidites with pebble conglomerate in section south of Kulutingwak Fiord (Otto Fiord, locality SKF of Fig. 60). The graded bedding and sequence of primary structures indicate that the section is inverted (see photograph). The original orientation is restored in the graphic log. ISPG photos 648-17 and 18.*

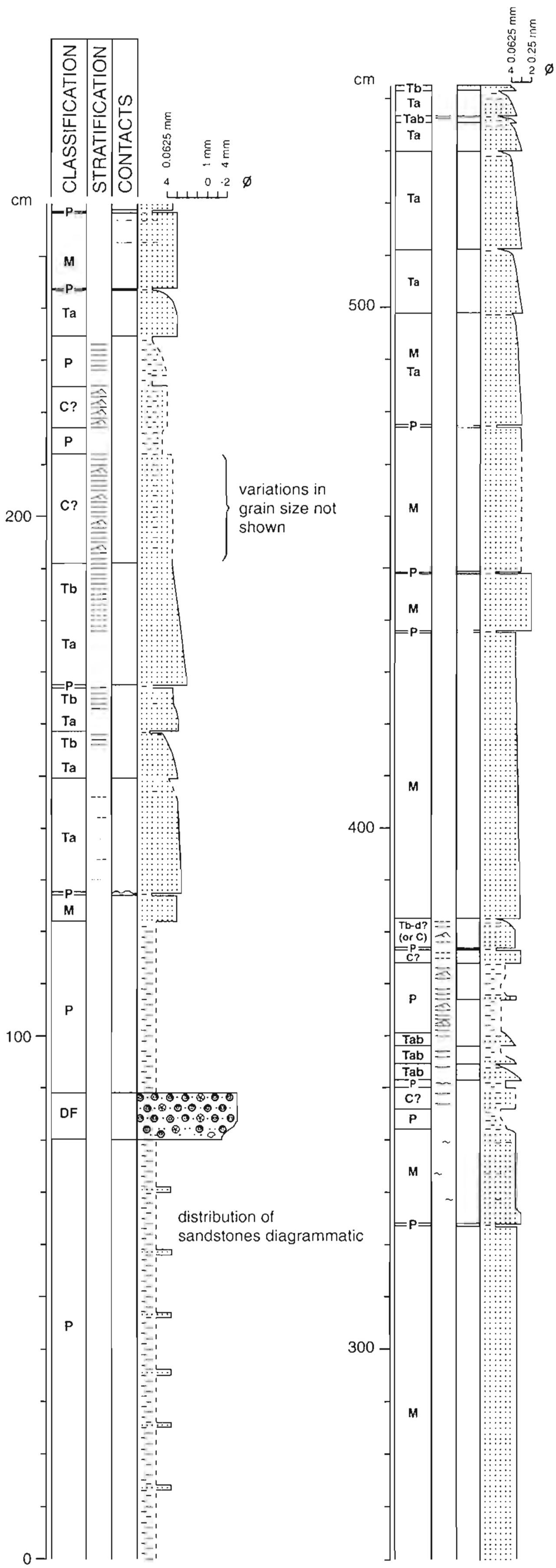


Quartz-chert sandstone. The composition of 16 specimens from three localities has been established by point count analyses (Table 13), and the petrographic observations have been supplemented by XRD analyses on 59 samples (Appendix 3, Table 32). According to the point count analyses, quartz and chert make up 63 to 96 per cent of the rock volume (mean values of grouped data). The proportion of chert varies with location and grain size. It is highest in the sandstone-mudrock facies in the Hvitland Peninsula 1 section (the mean of the grade class means is about 50%), intermediate south of Parker Bay (21%), and lowest south of Kulutingwak Fiord (5%). On Hvitland Peninsula the average percentage of chert decreases with grain size, from 73 in coarse grained sandstones to 21 in fine grained sandstones. The proportion of quartz varies inversely, increasing from 23 to 42 per cent.

The chert is pure or variably argillaceous. Argillaceous chert fragments show preferred orientations of recrystallized mica and chlorite, and some microscopic folds. Ghosts of radiolarians, similar to those in the Hazen Formation, are apparent in a few grains. Most of the quartz is monocrystalline, but quartzite, vein quartz, and semicomposite aggregates of recrystallized chert also are present. The feldspar content varies from trace amounts to 11 per cent and commonly averages a few per cent. XRD analyses show that the feldspar is mostly plagioclase (albite where determined) although trace amounts to a few per cent of K-feldspar occur in some samples. Pressure solution has strongly affected the shape of chert, feldspar, and quartz grains, although remnants of an originally rounded outline are apparent in some quartz grains.

Chlorite ranges from trace amounts to 6 per cent in the point count analyses, but up to 19 per cent in the XRD analyses. The remainder of the siliciclastic fraction comprises trace amounts to a few per cent of white mica, schist or phyllite, and argillaceous sediments. Trace amounts of biotite and tourmaline are present in nearly all thin sections, but volcanic material (trace amounts to 1%) were identified only in samples from south of Kulutingwak Inlet. The proportion of combined calcite and dolomite varies from trace amounts to 24 per cent in the point-counted samples. Most of this material occurs as replacement, but some detrital grains are present.

Figure 66. Lands Lokk Formation, detailed section of turbidites at Barrier Glacier (Clements Markham Inlet–Robeson Channel, locality BG of Fig. 60)



CLASSIFICATION

Turbidites (divisions of Bouma model) . . . . **Ta, Ta-d, Tbc**

Massive sandstone . . . . **M**

Mudrock (undifferentiated) . . . . **P**

Debris flow deposit . . . . **DF**

STRATIFICATION

Flat lamination (distinct, vague, vague and discontinuous) . . . .

Undulating (continuous, discontinuous) . . . .

Crosslamination . . . .

CONTACTS

Abrupt (plane, undulating) . . . .

LITHOLOGY

Sandstone / sandy

Mudrock / argillaceous

Oncoids (concentric, radiating structure)

Ostracodes

***Figure 67**. Lands Lokk Formation, detailed section of turbidites south of Parker Bay (Clements Markham Inlet–Robeson Channel, locality PB of Fig. 60).*

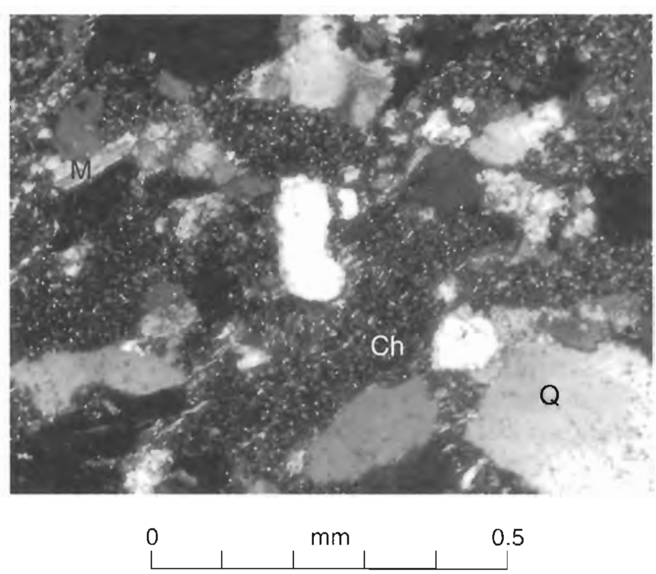


***Figure 68**. Photomicrograph (cross-polarized light) of sandstone of Lands Lokk Formation, sandstone-mudrock facies (map unit SLq), Hvitland Peninsula section. The rock is composed mainly of of quartz (Q) and chert (Ch) with minor carbonate (C) and white mica (M). ISPG photo 4248-1.*

Table 13

Lands Lokk Formation: point count analyses (in %) of quartzose sandstones

	Hvitland Peninsula 1 section, Member B								South of Kulutingwak Fjord		South of Parker Bay	
	coarse N=4		medium-coarse N=3		medium N=1	fine-medium N=1	fine N=3		fine to coarse N=2		very fine-fine N=2	
	Range	$\bar{X}$	Range	$\bar{X}$			Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$
Quartz	19–27	22.5	27–35	30.0	33	47	40–45	42.3	78–81	79.5	68–70	69.0
Chert	70–75	73.3	56–63	60.3	53	37	18–25	21.0	4–6	5.0	20–22	21.0
Feldspar	tr–3	1.5	1–4	2.7	3	4	4–11	7.0	4–6	5.0		tr
Carbonate	tr–3	1.3	1–6	3.0	8	3	6–24	17.3	2–4	3.0	4–4	4.0
Muscovite	tr–1	tr	1–1	1.0	2	2	2–4	2.7	1–2	1.5	2–2	2.0
Biotite		tr		tr	tr	tr		tr				tr
Chlorite		tr	tr–3	1.0	1	4	2–4	3.0	1–6	3.5		tr
Schist-phyllite		tr		tr	tr	tr	1–2	1.3	2–2	2.0	2–4	3
Argillaceous sediments		tr	tr–2	0.7	tr	3	1–6	3.0				
Volcanics									tr–1	0.5		
Opaque materials		tr		tr	tr	tr	0–3	1.3		tr		tr

Quartz-chert conglomerate. A pebble conglomerate in the section south of Kulutingwak Fiord (Fig. 65), containing clasts up to 2 cm in diameter, consists mainly of quartz and quartzite with minor amounts of chert and schist in a sandy and argillaceous matrix. In contrast, a granule conglomerate in the Hvitland Peninsula 1 section (Fig. 61, unit 16 at 395 m) is composed predominantly of chert with lesser amounts of quartz.

Volcanogenic sandstone and conglomerate. Volcanogenic sandstones with or without a siliciclastic component are fairly common in the mudrock-volcanogenic facies (map unit SLpv) northeast of Emma Fiord. Point count analyses of three specimens of medium and coarse grained sandstone are summarized in Appendix 3 (Table 33), and XRD analyses of volcanogenic and mixed specimens in Table 34. The main constituents are feldspar, largely albite (mean of point count analyses 35%), volcanic rock fragments (20%), quartz (16%; commonly with volcanic features), chlorite (10%), and carbonate alteration (10%), with minor amounts of chert (5%), and white mica (2%), etc. The volcanic rock fragments range in composition from felsic to mafic and may include some recrystallized volcanic glass.

A thin bed of volcanogenic conglomerate of granule to fine-pebble grade, overlain by very coarse to medium grained volcanogenic sandstone, is present in the sandstone mudrock facies (map unit SLq) in the Hvitland Peninsula 1 section (Fig. 61, unit 36 at 614 m). Composed mainly of volcanic and hypabyssal rock fragments of felsic to mafic composition, grains of feldspar, quartz (including volcanic and vein quartz), chert, and carbonate minerals, these sediments are similar to sedimentary rocks of the Fire Bay Formation.

Calcareous-dolomitic pebble conglomerate and sandstone. Conglomerate and sandstone containing significant amounts of detrital carbonate occur at a few localities in *Clements Markham Inlet–Robeson Channel* map area. A pebble conglomerate in the lower part of the Parker Bay section (Fig. 66), 9 cm thick, is composed chiefly of calcareous and dolomitic oncoids with some algae and rare ostracodes in a matrix of very fine to coarse, calcareous and siliciclastic sand (Fig. 69).

A conglomerate of granule to fine-pebble grade south of central Clements Markham Inlet consists mostly of limestone clasts with some indeterminable skeletal materials and calcite grains with radial-axial structure. The grain contacts are solution surfaces. Another conglomerate (maximum clast size 7 mm) from this area is made up mainly of quartz and chert, but contains about 20 per cent carbonate materials, including fragments of lime mudstone and dolostone.

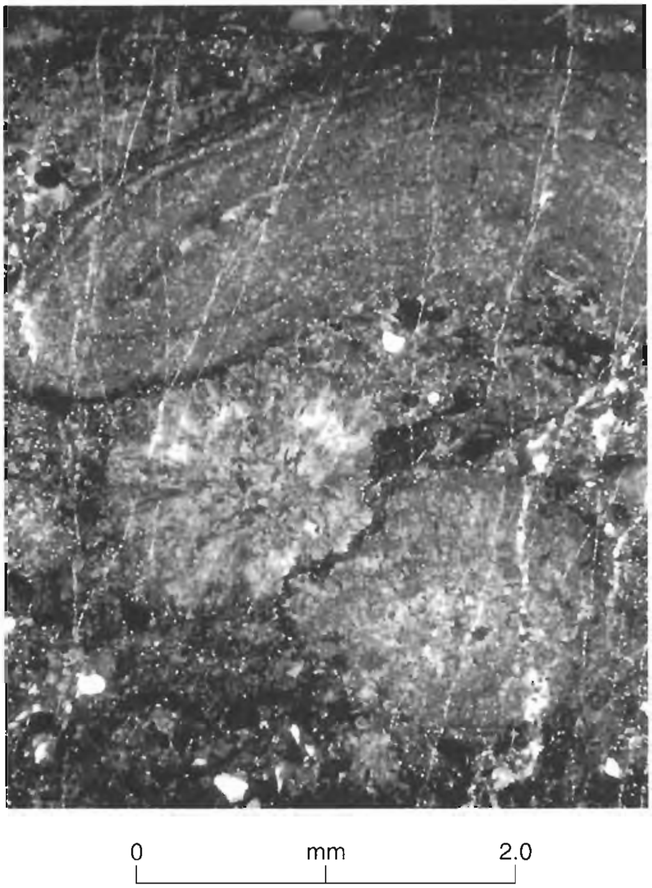


Figure 69. Photomicrograph (cross-polarized light) of oncoid and radiating algal structures in pebble conglomerate of Lands Lokk Formation at Parker Bay. ISPG photo 4248-4.

Three specimens of calcareous sandstone contain 16 to 36 per cent calcite and up to 4 per cent of dolomite (uncorrected XRD values, Appendix 3, Table 35), in addition to quartz, chert, white mica, chlorite and metamorphic rock fragments.

Mudrock. According to uncorrected XRD analyses, the average coarse grained mudrock (siltstone) is composed mainly of quartz (79%) with lesser amounts of chlorite (8%), mica (6%), feldspar (6%, mainly albite), and smaller amounts of calcite and dolomite (combined 2%; Appendix 3, Table 36). Fine grained mudrocks have a lower content of quartz (average 51%), and higher contents of mica and chlorite (27% and 17%; Appendix 3, Table 37).

Paleocurrent directions

A total of 178 determinations were made in the vicinity of the Hvitland Peninsula 1 and 2 sections (Fig. 59, locs. P3 and P4), and in an area southwest of Yelverton Inlet (loc. P5). Flute marks and grooves and ridges on steeply dipping sandstone beds were used as indicators, and the same geometric procedures were used as for the Danish River Formation (see above).

The strikes of beds and axial planes were determined on air photographs, the plunges of the fold axes by field measurement. Structural control is best in the Hvitland Peninsula 1 section where the strata occur on the northern limb of a major syncline that plunges 2° southwest. At the other two localities average plunges of minor folds were used, introducing errors in the order of 10° or less.

On Hvitland Peninsula the indicators consistently show flow from southeast to northwest, at high angles to the structural trend. At Yelverton Inlet, average flow was from southwest to northeast, about parallel with strike.

Metamorphism

Metamorphism is restricted to slaty cleavage development in mudrocks, and locally also in sandstones. This implies recrystallization of clay minerals to microcrystalline white mica and chlorite in preferred directions. The survival of detrital biotite and K-feldspar in many sandstone samples shows that the coarser detritus is mostly unmetamorphosed.

Mode of origin

Primary structures show that most sandy and conglomeratic deposits were deposited by sediment gravity-flows, especially by turbidity currents, and this probably also applies to the coarse grained mudrocks. These flyschoid characteristics, along with the graptolitic fauna and the predominantly dark grey colour of the mudrocks, indicate that most of the formation was laid down in deep basinal environments. On the other hand, the multicoloured beds south of Clements Markham Inlet, and the bioturbated and nongraded beds at the top of the formation northwest of Markham River, were probably deposited at shallower depths.

The volcanic components (rock fragments, feldspar, quartz, chlorite, and mica) may have been produced by contemporaneous eruptions, by erosion of a contemporaneous terrestrial arc, or by erosion of uplifted older rocks. The fact that this material is confined to the vicinity of Emma Fiord suggests that it may have been derived from the volcanic arc represented by the Svartevaeg Formation (Chapter 2).

The nonvolcanogenic detrital components were derived from four kinds of sources, listed in the order of decreasing abundance:

1. Most of the quartz sand and associated subordinate feldspar was probably derived either from crystalline basement rocks or from quartzose sandstones of Proterozoic or early Paleozoic age. The second alternative is supported by the scarcity of feldspar, although part of the basement-derived feldspar was probably destroyed by weathering or diagenesis.

2. The presence of radiolarian ghosts indicates that most of the chert was derived from condensed deep-water deposits comparable to the Hazen Formation and to the Amundsen Land Group of North Greenland (Higgins et al., 1991a, b). Some source rocks were folded and weakly metamorphosed.

3. A minor low-grade metamorphic source supplied fragments of schist, and probably also some of the mica, chlorite, quartz, and feldspar.

4. Oncoids and skeletal grains were probably derived from the Marvin Formation of Pearya.

Paleocurrent studies and facies relationships south of Emma Fiord demonstrate that the sandstone-mudrock facies was deposited on a submarine fan that prograded southeast to northwest. The regional flow patterns and provenance relations are discussed in Chapter 5.

Age and correlation

Age-diagnostic graptolites from the Fire Bay Formation indicate that the base of the Lands Lokk Formation can be no older than latest Llandovery (Telychian). The oldest fossil found in the Lands Lokk Formation is *Monograptus marri* Perner of late Llandovery (Telychian) age, found in the lower 50 to 200 m of the sandstone-mudrock facies (map unit SLq) in the Hvitland Peninsula 1 section (Norford, Appendix 5A, GSC loc. C-94397). *Monograptus* cf. *M. priodon* of unspecified late Llandovery–Wenlock age occurs in the mudrock-volcanogenic facies (map unit SLpv) northeast of upper Emma Fiord (Kerr and Thorsteinsson *in* Trettin, 1969a, GSC loc. 52315, reproduced in Appendix 5A).

The upper part of both facies has yielded graptolites of probable early Ludlow age, including *Monograptus* cf. *M. colonous*, cf. *M. varians*, and cf. *M. nilssoni* (Kerr and Thorsteinsson *in* Trettin, 1969a, GSC locs. 52314, 52323, 52312, reproduced in Appendix 5A), and *Bohemograptus* cf. *B. bohemicus bohemicus* (Norford, Appendix 5A, GSC locs. C-94400, C-94401).

A spore collection from the upper part of the formation in an area northwest of Markham River (*Clements Markham Inlet–Robeson Channel*) ranges in age from Late Silurian to Lochkovian (McGregor, Appendix 5D, GSC loc. C-54946, see also GSC loc. C-54943). In this area the upper age limit of the Lands Lokk Formation is constrained by ostracodes from the overlying Markham River Formation that are probably no younger than late Ludlow (Copeland, Appendix 5C, GSC loc. C-94377), and consequently the Lands Lokk–Markham River contact must lie within the Ludlow. A more specific constraint on the upper age limit of the Lands Lokk Formation is provided by conodonts of late (but not latest) Ludlow age from the Piper Pass Formation (see below), which is in fault contact with the Lands Lokk Formation.

In summary, the Lands Lokk Formation ranges in age from latest Llandovery (latest Telychian) to early Ludlow.

Those parts of the Lands Lokk Formation that are rich in sandstone and conglomerate are lithologically similar to and approximately correlative with two other conglomeratic flyschoid units: Member B of the Danish River Formation at Caledonian Bay, which is Ludlow in age (Trettin, 1979, 1994; Chapter 4), and the Nordkronen Formation of North Greenland, which comprises conglomeratic units of middle Wenlock and early Ludlow ages (Hurst and Surlyk, 1982; Larsen and Escher, 1985, 1987; Higgins et al., 1991a, b). The Nordkronen conglomerates typically contain chert with ghosts of radiolarians and quartzite, along with clasts of basement rocks. However, in addition to these coarse sediments, the Lands Lokk Formation also includes mudrock-rich units that may be equivalent to the Wulff Land Formation of North Greenland.

The lower part of the Lands Lokk Formation is correlative with at least a part of the Svartevaeg Formation. The youngest preserved fossils from the Svartevaeg Formation are probably late Wenlock in age, but strata of early Ludlow age may have been present prior to erosion at the unconformity that is overlain by the Stallworthy Formation. This age relation is important for the provenance of the volcanic material in the Lands Lokk Formation.

Markham River Formation (map unit SMR*, Upper Silurian)*

Definition

The name, Markham River Formation, is here proposed for a unit of dolomitic and clastic sediments and spiculitic chert that overlies the Lands Lokk Formation. The type section is located northwest of Markham River (*Clements Markham Inlet–Robeson Channel*, section MR). The unit was introduced as the Markham River beds (Trettin et al., 1991).

Distribution, contact relations, and thickness

The Markham River Formation occurs as a belt of small outcrops, 29.5 km long and up to 6 km wide, in the hills northwest of Markham River. Some outcrops represent erosional remnants, others small fault blocks.

The contact with the underlying Lands Lokk Formation, which is marked by an abrupt change from clastic to carbonate sediments, probably represents a disconformity. The top of the formation is not preserved. It has a minimum thickness of 166 m in the type section (Appendix 1; Figs. 70, 71).

Lithology

The Markham River Formation consists of interstratified dolomitic carbonate rocks, cherty and dolomitic spiculite, and clastic sediments. The carbonate rocks comprise a basal nodular dolostone, dolostone, dolomitic oncolite, and calcareous and dolomitic skeletal grainstone; the clastic sediments comprise conglomerate, sandstone, and minor siltstone.

The lower 3.5 m consist of a nodular and mottled dolostone that is conglomeratic in appearance (Fig. 72a, b). The nodules are up to 10 cm in diameter and have ellipsoidal or irregular, rounded shapes. The rock is microcrystalline to finely crystalline, and contains silt- and sand-sized quartz, cherty and dolomitic spicules, and finely disseminated pyrite. Nodules seen in thin section are bounded by solution surfaces (Fig. 72c). They are commonly medium grey; the matrix is medium dark grey.

Ordinary dolostone, represented mainly in the upper part of the section, is mostly microcrystalline and contains variable proportions of quartz silt and sand.

Beds of dolomitic oncolite are 5 to 70 cm thick and associated with other types of dolostone or mudrock.

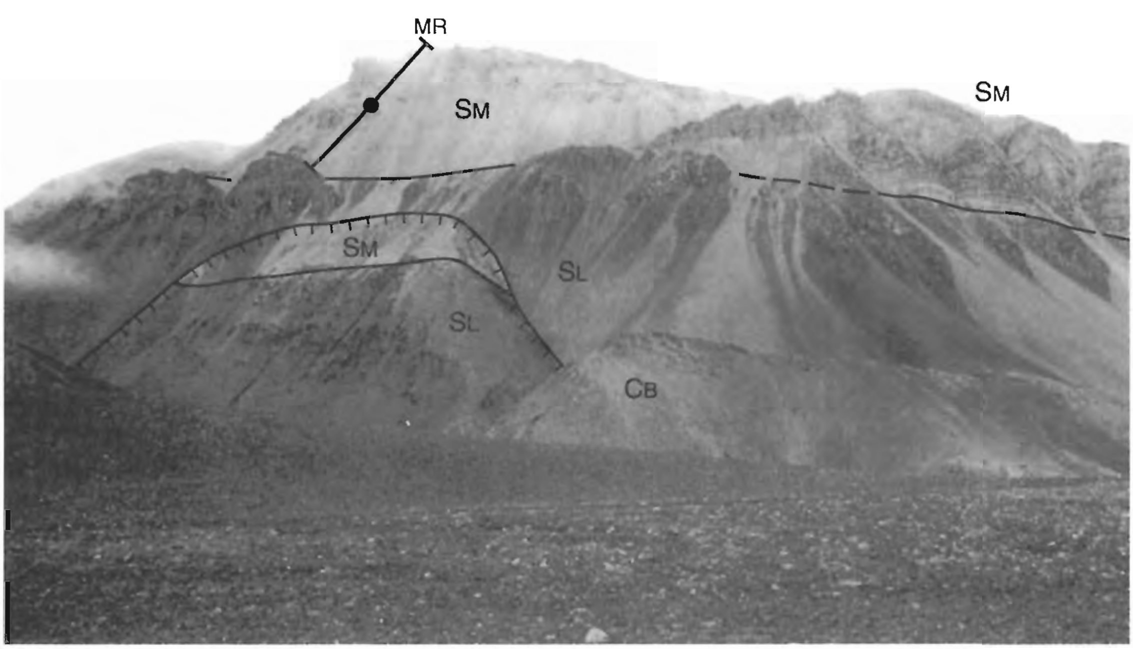
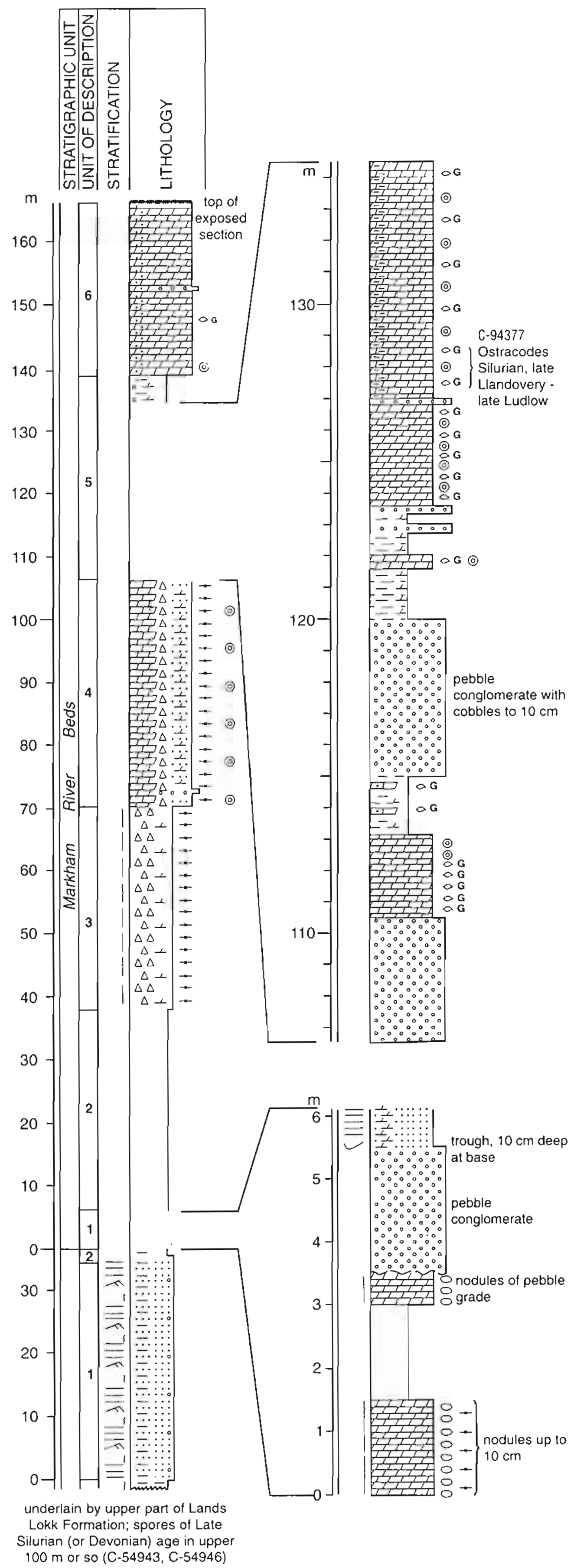


Figure 70. *Setting of Markham River section* (MR); SL: *Lands Lokk Formation,* SM: *Markham River Formation (slumped block in centre-left foreground),* CB: *Borup Fiord Formation; fault contact with Lands Lokk Formation is hidden by ridge. ISPG photo 1878-47.*



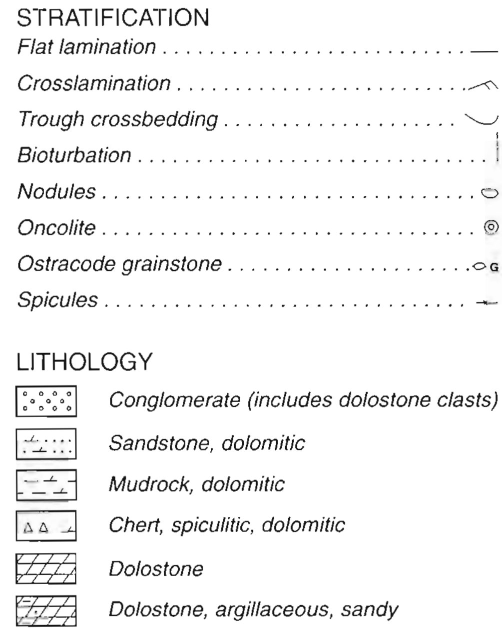


***Figure 71**. Markham River section.*

The beds consist of spheroidal or ellipsoidal oncoids 1 to 18 mm in diameter. Most are embedded in a matrix of dolomite and quartz of silt to very fine grained sand grade, with minor white mica, but some are in pressure solution contact. Individual oncoids contain poorly defined, cloudy clots, about 20 to 80 μm in diameter, surrounded by relatively clear material (Fig. 73). Both clots and interstitial material consist of finely microcrystalline (about 8-27 μm) dolomite, but the clots show relics of a cryptocrystalline texture. The oncoids have a crude concentric layering. Usually two, but up to six layers can be distinguished that differ in darkness and in the relative abundance of the clots. In some specimens, the layering has been enhanced by selective chert replacement.

The grainstones are composed chiefly of skeletal material and to a lesser extent of nonskeletal coated grains, and quartz sand and silt (Fig. 74). The skeletal material comprises ostracode shells or shell fragments that are lined with fibrous calcite, and poorly preserved mollusc fragments (gastropods and/or pelecypods) with dark micritic coatings. Nonskeletal coated grains commonly have quartz-grain cores. The cement consists mainly of dolomite.

Spiculite forms a thick unit 38 to 70.5 m above the base of the formation and is interbedded with other rock types in the overlying 36 m. It varies in colour from medium light to medium dark grey and is massive

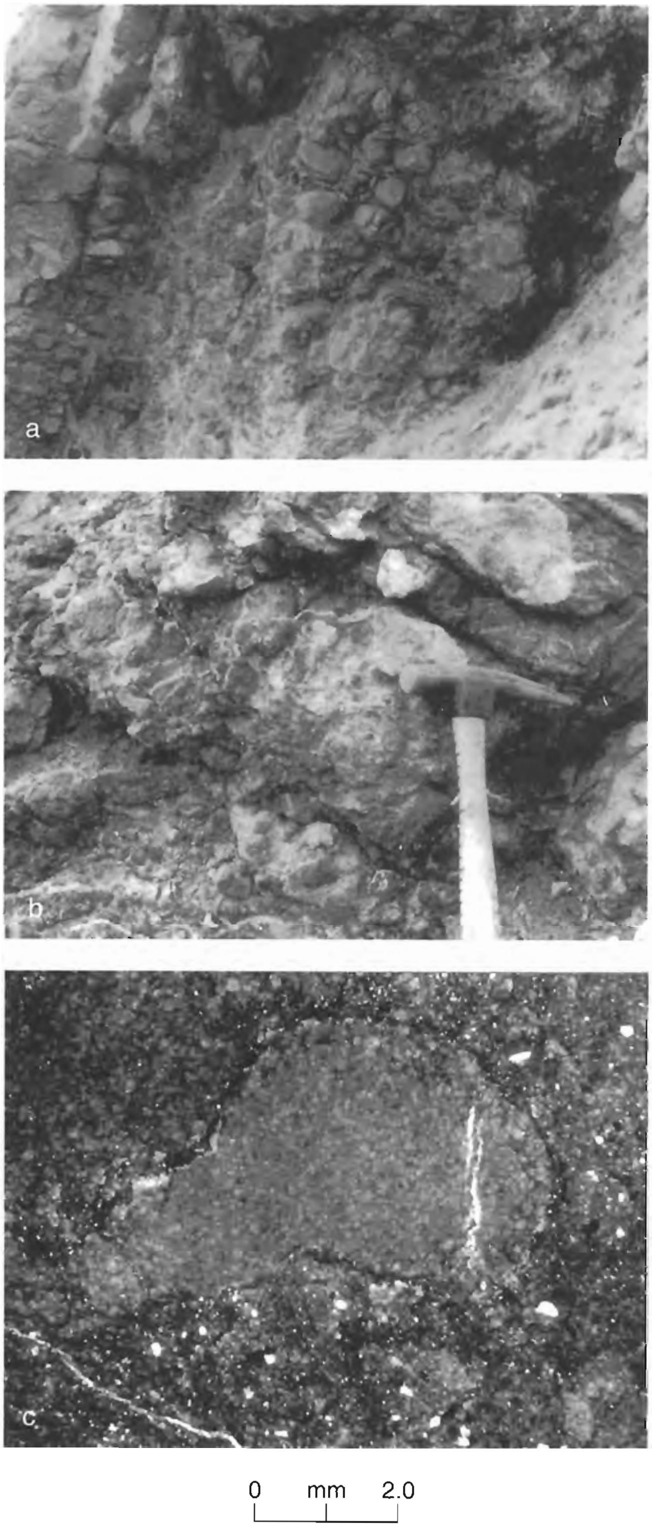


Figure 72. *Nodular dolostone at base of Markham River Formation:* ***a.*** *Distant view, showing stratification;* ***b.*** *Close-up;* ***c.*** *Photomicrograph (cross-polarized light). ISPG photos 1878-49, 1878-51, 4227-7.*

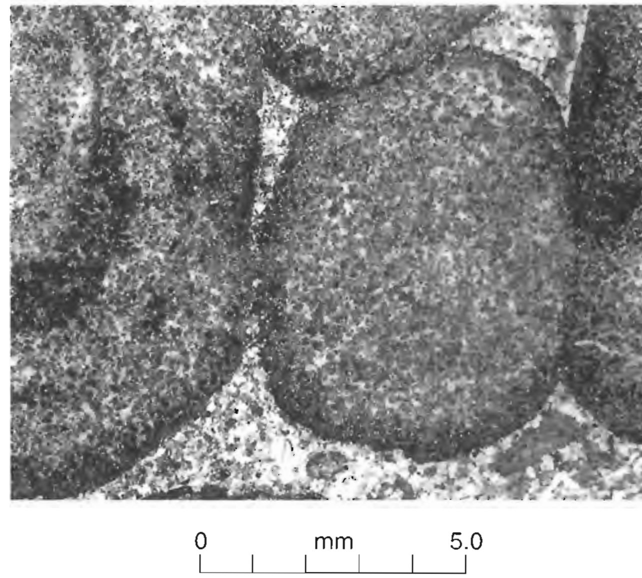


Figure 73. *Photomicrograph (cross-polarized light) of oncolite in Markham River Formation. All oncoids show clotted, microbial(?) fabric and one shows an indistinct concentric layering. ISPG photo 2260-172.*

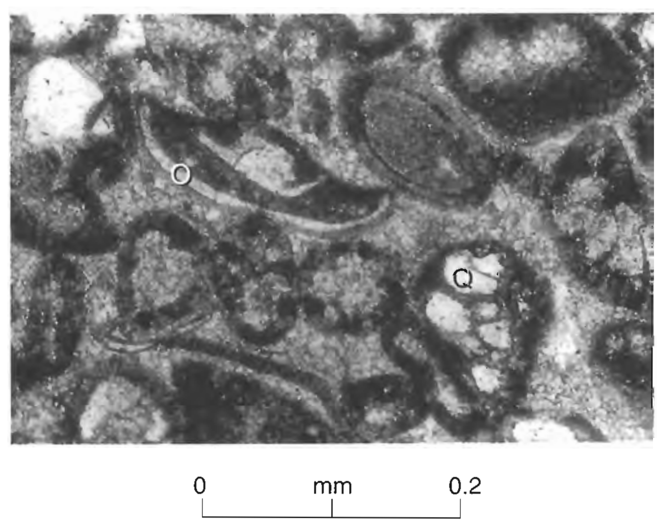


Figure 74. *Photomicrograph (ordinary light) of grainstone in Markham River Formation, composed mainly of ostracode shells or shell fragments (O) and some coated grains with quartz grains (Q) in the core. ISPG photo 2260-153.*

and partly argillaceous. Silicified ostracodes, comparable in size to those in the grainstones, are common. The siliceous spicules are replaced by dolomite to a varying extent. Two samples of spiculite, analyzed by XRD, contain 18 and 63 per cent of that mineral.

In four thin sections examined, the "spicules appear to be mainly simple monaxons. However, in one thin section the following types are present: diactines, strongyles, and amphistrongylate oxeas. They are not particularly diagnostic but are common in hexactinellid sponges, which, during the Silurian, were generally confined to basinal and to platform slope settings" (T.A. de Freitas, pers. comm., 1994).

Seven recorded conglomerates range in thickness from 0.2 to 5 m. The lowest occurs 3.5 m above the base of the formation, contains clasts of dolostone, similar to that in the lower 3.5 m, and probably marks an internal disconformity. Although the conglomerates are mainly of pebble grade, they include cobbles up to 10 cm in diameter. The clasts are composed of the following materials (not in order of abundance): single crystals of rounded quartz; semicomposite or composite vein quartz; quartzose siltstone; very fine grained quartz-chert sandstone; very fine to coarse grained, tightly cemented quartz sandstone with and without K-feldspar and minor proportions of white mica; stretched or sheared metaquartzite; unmetamorphosed chert; stretched chert or chalcedony; cherty slate; and microcrystalline dolostone with or without rare ostracodes or spicules. The proportions of these materials vary from sample to sample, but siliciclastic material is generally more abundant than dolomitic material. A conglomerate of granule to fine-pebble grade at 107 m is composed of quartz (72%), K-feldspar (1%), and dolomite (27%) according to XRD analysis.

Sandstone is a minor component, occurring as thin units. It is present at 5.5 to 6.1 m, and, interbedded with other rock types, between 70.5 and 106.5 m. The sandstone is thin-bedded, flat-laminated or crosslaminated, and mainly fine grained although it may contain some chert granules. Two samples analyzed by XRD are composed of quartz and chert (mean 74%), dolomite (24%), feldspar (2%), and trace amounts of mica. The quartz was probably subrounded to rounded originally but now is subrounded to angular as a result of pressure solution and marginal replacement by dolomite. Some dolomite grains are rounded.

Beds of poorly exposed siltstone, found between 113 and 123 m, are medium light grey, coarse grained, and sandy. Two samples analyzed by XRD are composed of quartz (mean 79%), feldspar (K-feldspar 5%, plagioclase 4%), carbonates (dolomite 5%, calcite 1%), and white mica (5%).

Metamorphism

The metamorphism of the Markham River Formation is below greenschist grade.

Mode of origin

The marked lithological variations in this unit reflect extremely variable depositional conditions, probably indicative of tectonic activity. Preliminary inferences can be summarized as follows:

1. The basal nodular dolostone probably originated in a subtidal setting. This is inferred from its relatively dark colour and the presence of finely disseminated pyrite and sponge spicules. Nodular textures, common in subtidal and basinal carbonate rocks, have been attributed to: differential submarine cementation, burrowing, compaction and pressure solution, disaggregation by bottom currents, disaggregation by sliding, or combinations of these processes (cf. Mullins et al., 1980). In the present examples, pressure solution is apparent in thin section, but it may not have been the only process that produced this texture.

2. Grainstones are generally considered indicative of high-energy environments above wave base. The preponderance of ostracodes of uniformly small size suggests restricted-marine conditions (Copeland, Appendix 4C, GSC loc. C-94377).

3. The oncoids are probably of bacterial origin because of their clotted texture (Chafetz and Folk, 1984). Early diagenetic dolomitization in a restricted superhaline setting may be indicated by the preservation of detailed internal structures (Muir et al., 1982).

4. Spiculites are relatively rare in the geological record and this has been explained by undersaturation of sea water with respect to silica, causing solution of opaline material. Special conditions are required for their survival, for example: protection by organic filaments; deposition in deep, cold water; or upwelling that favours a high rate of sponge production. The hexactinellid forms identified by T. de Freitas are suggestive of basinal and platform slope settings.

5. The pebble conglomerate and sandstone were derived from sources that included quartzose sandstone and carbonate rocks. The conglomerates are not of intraformational origin, but the presence of sponge spicules and ostracodes in some carbonate clasts demonstrates a certain affinity of the source rocks with the Markham River Formation. This implies that strata similar to parts of the Markham River Formation were uplifted and eroded not far away. Rapid redeposition, perhaps in an arid climate, is required to explain the survival of the carbonate detritus. The association of the conglomerates with autochthonous carbonate sediments suggests deposition in shallow-marine settings adjacent to coastal cliffs that may represent an active fault scarp. If so, the material likely was reworked and redeposited by waves and nearshore currents. The alternation of coarse clastic sediments with carbonates indicates sea level fluctuations that may have been caused by local tectonism.

Age and correlation

Ostracodes are the only identifiable fossils found in the Markham River Formation – no conodonts or spores were obtained from analyzed specimens. They were identified as cf. *Silenis mavii* and cf. *Silenis symmetricus* (Copeland, Appendix 4C, GSC loc. C-97377). The genus ranges in age from late Llandovery to late Ludlow. Both species have been reported from the Baltic region where *mavii* is Wenlock and *symmetricus* early Ludlow in age. A Llandovery to early Ludlow age, however, can be ruled out for the Markham River Formation because the underlying Lands Lokk Formation has yielded spores of Late Silurian or Early Devonian age in this area (McGregor, Appendix 4C, GSC loc. C-54946; see above). The Markham River Formation therefore is probably middle or late Ludlow in age and correlative with the Piper Pass Formation, the upper part of the Marvin Formation, and possibly also with the Crash Point beds (see Chapter 4). It is related to the upper Marvin Formation by the predominance of carbonate rocks and the presence of spiculites.

Piper Pass Formation (map unit SPP, Upper Silurian)

Definition

The name, Piper Pass Formation, is here proposed for a fault-bounded unit of limestone and minor mudrock in northeastern Ellesmere Island. The type section is located on the southwest side of Piper Pass (*Clements Markham Inlet–Robeson Channel*). It has been examined but not measured and described in detail because of its structural complexity. The strata were originally assigned to the Marvin Formation (Trettin, 1971a) and later informally referred to as the Piper Pass beds (Trettin et al., 1991).

Distribution, contact relations, and thickness

The Piper Pass Formation is exposed in a belt, 74 km long and up to 3.3 km wide, that extends from northeast of Piper Pass to northwest of lower Clements Markham Glacier (*Clements Markham Inlet–Robeson Channel*). It is separated by steeply dipping faults from the Lands Lokk Formation on the northwest and the Grant Land Formation on the southeast. The slice is about 400 m wide on the southwest side of Piper Pass where it is tightly folded. Probably no more than 100 m of strata are represented here.

Lithology

The formation is composed mainly of lime mudstone with smaller proportions of lime wackestone or packstone and calcareous-dolomitic mudrock. The lime mudstone is medium dark grey, carbonaceous, variably argillaceous, and commonly sheared and recrystallized. Small amounts of skeletal material are present in some specimens. Three specimens analyzed by XRD are composed mainly of calcite (70-80%) with minor quartz (13-23%), plagioclase (2-4%), dolomite (0-3%), and mica (0-3%). The wackestone and packstone contain abundant fragments of echinoderms, bryozoans, corals, brachiopods, trilobites, and ostracodes in a matrix of variably dolomitic lime mud (Fig. 75). The mudrocks are medium dark to dark grey, calcareous or dolomitic, carbonaceous, and slaty. A specimen analyzed by XRD consists of quartz (41%), calcite (35%), mica (8%), chlorite (7%), feldspar (plagioclase 6%, K-feldspar 1%), and dolomite (3%).

Metamorphism

Conodonts have an alteration index of 5 (Uyeno, Appendix 4B), indicating temperatures of 300 to 480°C (Rejebian et al., 1987).

Mode of origin

A subtidal setting below wave base is suggested by the preponderance of dark grey strata. The skeletal wackestones/packstones either represent *in situ* skeletal

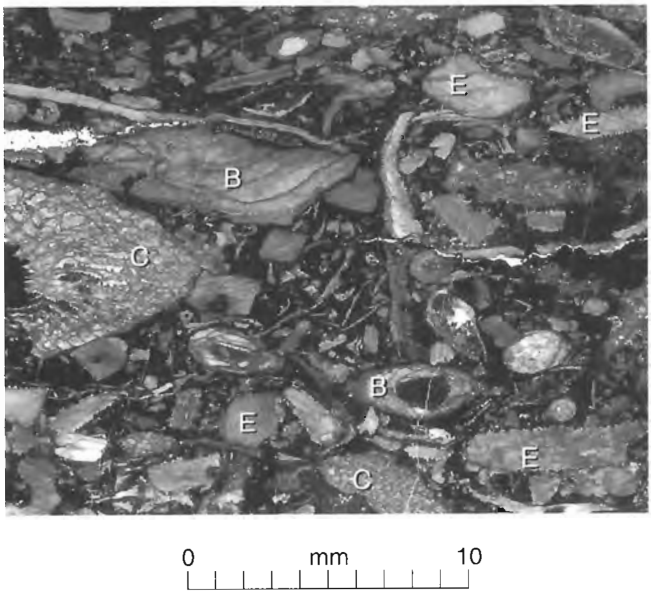


***Figure 75**. Photomicrograph (ordinary light) of skeletal packstone in Piper Pass Formation at Piper Pass (**Clements Markham–Robeson Channel**). Skeletal material is composed mainly of echinoderms (E), tabulate corals (C), and brachiopods (B). ISPG photo 2260-161.*

deposits or proximal subaqueous debris flows deposited at a shelf margin. The second interpretation is supported by the regional setting because the Piper Pass Formation includes the southeasternmost exposures of shelf-type carbonate and clastic sediments of Ludlow age on the northwestern margin of the Franklinian Deep Water Basin (see Chapter 5, mid-Early to Late Silurian depositional pattern).

Age and correlation

The Piper Pass Formation is the only unit of the Clements Markham Fold Belt rich in fossils, and it is relatively well dated. Five conodont collections have been obtained and all indicate Late Silurian ages. This is in accord with the fact that the underlying Lands Lokk Formation extends into the early Ludlow. The most diagnostic faunule probably represents the *latialata* Zone of latest Ludlow age (Uyeno, Appendix 5B, GSC loc. C-54931); another has a possible age range from late early to early late Ludlow (lower part of the *siluricus* Zone; GSC loc. C-54924). An early Late Silurian age was inferred by Bolton (Appendix 5A, GSC loc. 36957) for the brachiopod *Atrypella phoca* collected by Christie (1964, p. 28) from the north side of Clements Markham Glacier. The age assignments for the more recent macrofossil collections are less specific. A collection that includes *Encrinurus*, aff. *Sphaerexochus* sp., *Kirkidium* sp., and *Eospirifer?* sp. is of unspecified Wenlock to early Pridoli, probably Ludlow age (Norford, Appendix 5A, GSC loc. C-54926). Species of the undiagnostic genera *Favosites* and *Syringopora* are present in another collection (ibid., GSC loc. C-54932).

In summary, the Piper Pass Formation definitely includes strata of late Ludlow age, but has a possible age range from late early to latest Ludlow. It is approximately correlative with the Markham River Formation and with the upper part of the Marvin Formation and the Crash Point beds of Pearya. The Piper Pass Formation is lithologically similar to the upper part of the Marvin Formation and may represent an outer-shelf facies equivalent of that unit.

Bourne Complex (map unit DB*, Middle Devonian or older)*

Definition

The Bourne Complex is a hybrid unit composed of volcanic and sedimentary rocks with abundant hypabyssal mafic intrusions. The unit, named for a cape on Ellesmere Island (*Cape Stallworthy–Bukken Fiord*), was introduced as the Bourne group [*sic*] by Christie (1957) and renamed the Bourne Complex by Trettin (1969a). This summary is concerned only with the volcanic and sedimentary strata of the complex; the intrusions are discussed later, in the context of the Phanerozoic intrusions of the Clements Markham Fold Belt.

Distribution, contact relations, and thickness

The Bourne Complex is exposed on northwestern Kleybolte Peninsula of Ellesmere Island, and on two adjacent small islands, Krueger and Fjeldholmen. It is bounded on the southeast by the Kleybolte Fault Zone, which separates it from a serpentinized ultramafic body (map unit ds), the Danish River Formation, and upper Paleozoic strata. The base of the volcanic and sedimentary succession is concealed and its top is eroded; its thickness is unknown.

Lithology

The stratigraphy of the unit is unknown because of structural complexities, poor exposure, and the abundance of intrusions. The volcanic rocks include tuffaceous green phyllite and andesite flows. The green phyllites are composed of actinolite, epidote, albite, quartz, carbonates, and opaque minerals. The following summary of the flows is based on a detailed study by Henry (1991) of samples from Fjeldholmen and Krueger islands. Most rocks are porphyritic and difficult to distinguish from dykes or sills. Phenocrysts consist mainly of plagioclase (albite) and clinopyroxene, with or without hornblende or orthopyroxene. Secondary minerals include chlorite, sericite, actinolite, calcite, sphene, epidote and quartz. Some rocks contain amygdules with chlorite and calcite. Trace element ratios (after Winchester and Floyd, 1977, fig. 6) place the volcanic flows in the fields of andesite and andesite/basalt. The demonstrated mobility of the major elements precludes their use for lithological classification.

Sedimentary or metasedimentary strata are poorly exposed. Light greenish grey, partly laminated, silty phyllite or slate and dark grey argillite and hornfels crop out on Kleybolte Peninsula (Trettin, 1969a); sandstone composed of medium grained quartz and feldspar in a chloritic matrix, on Fjeldholmen Island (Henry, 1991).

Metamorphism

The argillaceous and tuffaceous sediments, characterized by chlorite and albite and by a slaty or phyllitic texture, are in the lower greenschist facies. The survival of clinopyroxene shows that the metamorphic grade of the volcanics is below greenschist grade.

Mode of origin

Values of Hf, Th, and Ta, plotted on a discrimination diagram (Wood, 1980), suggest that the volcanic flows originated at a destructive plate margin (Henry, 1991), an interpretation that is in accord with their andesitic composition. The chlorite and feldspar in the sedimentary rocks may be of volcanic origin.

Age and correlation

The age of the volcanic rocks was investigated by Henry (1991) by means of ^{40}Ar-^{39}Ar analyses on primary hornblende phenocrysts. Three porphyritic andesites from Fjeldholmen Island yielded apparent ages of 378 ± 7 Ma, 380 ± 14 Ma, and 394 ± 20 Ma. Combining the first two, a best-estimate average of 380 ± 10 Ma was obtained - Givetian according to Fordham (1992).

These determinations may indicate the age of crystallization of the volcanics, as assumed by Henry (1991). If so, these strata may be correlative or partly correlative with the siliclastic Okse Bay Formation at Yelverton Pass, which has yielded palynomorphs of undifferentiated Givetian or Frasnian age (Mayr, 1992). However, the ^{40}Ar–^{39}Ar ratio may have been affected by argon loss caused by the intrusion of dykes that probably are significantly younger because of differences in chemical composition and inferred tectonic environment (see below).

PHANEROZOIC INTRUSIONS

Phanerozoic intrusions include small granitoid plutons of Late Devonian and unknown ages; mafic dykes and sills of Cretaceous and older ages; and an ultramafic body of unknown age.

Late Devonian granitoid intrusions south-southeast of Phillips Inlet (map units Dtn and D?qm)

A small plug of tonalite intrudes turbidites of the undifferentiated Danish River Formation and Lands Lokk Formation in an area about 19 km south-southeast of the head of Phillips Inlet (*Otto Fiord*, map unit Dtn). Point-counts indicate the following composition: oligoclase-andesine (56-60%), quartz (18%), hornblende (9-19%), biotite (3-13%), chlorite (trace to 3%), and trace amounts of clinopyroxene, epidote, apatite, zircon, and opaques. Two chemically analyzed samples are metaluminous (A/CNK = 0.81-0.83; A/NK >1; Appendix 4B, Table 1, nos. 13-1, 13-2).

No minerals suitable for U-Pb dating were recovered from this pluton. A ^{40}Ar–^{39}Ar determination on hornblende gave a plateau age of 364.1 ± 2.0 Ma (Trettin et al., 1992), early Famennian (Fordham, 1992). Because this is a high-level intrusion emplaced into weakly metamorphosed strata, cooling must have been rapid and the present age is probably close to the age of crystallization.

The presence of clinopyroxene indicates at least partial derivation from mantle sources. This pluton is approximately co-eval with the dated pluton on northern Axel Heiberg Island, south-southwest of Cape Thomas Hubbard (*Cape Stallworthy-Bukken Fiord*, map unit Dta).

Less than 1 km south of the dated tonalite, a larger, more mafic intrusion, about 2.5 km long and up to

1.5 km wide (map unit D?qm) is exposed. A representative sample is a monzonite composed of plagioclase (oligoclase-andesine, 34%), K-feldspar (34%), clinopyroxene (19%), biotite (8%), hornblende (2%), quartz (3%), and opaques. Ultramafic rocks composed of olivine, clinopyroxene and serpentine locally occur at its border. The intrusion is known only from a brief reconnaissance in 1962 and further study is required. Mineralogy and setting suggest it is related to the dated tonalite.

Granitoid intrusions of uncertain age

Southeastern Kleybolte Peninsula (map unit K?sy*)*

Small granitoid plugs intrude thermally metamorphosed sediments of Succession 2 of Pearya on southeastern Kleybolte Peninsula, adjacent to Audhild Bay (*Cape Stallworthy–Bukken Fiord*). Two are shown on the map but others are present. The northern pluton is a quartz-bearing hornblende syenite, composed mainly of microcline with lesser amounts of unaltered hornblende and small amounts of quartz. Two hornblende concentrates yielded K-Ar ages of 73.6 ± 3.5 Ma and 84.2 ± 3.9 Ma (Wanless et al., 1978), Late Cretaceous. These determinations either reflect the age of crystallization or argon loss during a Late Cretaceous rift event, evident from volcanism and intrusion (Trettin and Parrish, 1987; Embry and Osadetz, 1988; Embry, 1991b). A post-Viséan thermal event is documented by unusually high degrees of thermal alteration in palynomorphs from the nearby Emma Fiord Formation (Utting et al., 1989).

Fire Bay, Emma Fiord

A small plug of granitoid porphyry, metres in diameter, intrudes the Danish River Formation in an area east of Fire Bay (*Cape Stallworthy–Bukken Fiord*, inset B, loc. L7). Phenocrysts of biotite, up to 6 mm in diameter, and smaller phenocrysts of albite and quartz are set in a groundmass of the same minerals. The structure of the albite is obscured by sericite and calcite, but some chessboard twinning is apparent. In its present altered state the rock is a porphyritic dacite, but the chessboard twinning indicates albitization of K-feldspar (Smith, 1974, p. 287). The age of the host rock implies that the intrusion can be no older than late Early Silurian (latest Llandovery).

In the same general area, a fragment of leucocratic tonalite was found in the overburden (M.J. Cecile, pers. comm., 1990). The sample is brecciated and composed mainly of albite and quartz with minor amounts of chlorite and opaque minerals and some relics of hornblende(?). Again, the presence of chessboard-twinned albite suggests that K-feldspar was present originally.

Mafic dykes of the Bourne Complex (included in map unit DB, ages uncertain)

Earlier investigations (Christie, 1957; Trettin, 1969a *in* Wanless et al., 1978) indicated that hypabyssal mafic intrusions are abundant in the Bourne Complex of Ellesmere and Krueger islands (see above). The rocks are unmetamorphosed diabases or gabbros, composed chiefly of clinopyroxene and calcic plagioclase. Henry (1991) distinguished two sets of steeply dipping dykes on Fjeldholmen and Krueger islands that differ in trend, texture, chemical composition, distribution, and probable age.

The more prominent, easterly trending set is characterized by abundant and commonly very coarse plagioclase phenocrysts. Analyses of Zr/TiO_2 versus Nb/Rb are mainly in the field of subalkaline basalt, and to a lesser extent, of alkali basalt, according to Winchester and Floyd (1977, fig. 6). On the Hf-Th-Ta diagram of Wood (1980) they plot in a field occupied by both mid-ocean ridge and within-plate basalts. These rocks are younger than the volcanic flows of the Bourne Complex that have yielded a Middle Devonian ^{40}Ar–^{39}Ar age (Henry, 1991; see above). The fact that they do not intrude the adjacent Nansen Formation may indicate that they are older than Late Carboniferous.

Earlier whole-rock K-Ar analyses on five samples of east-striking (strike is 097° at 92°25′W longitude) diabase and gabbro intrusions from the southwestern coast of Krueger Island (Wanless et al., 1978) yielded widely scattered results that probably reflect varying amounts of argon loss and/or gain:

- 230 ± 22 Ma (microporphyritic diabase from chilled margin)
- 201 ± 20 Ma (microporphyritic diabase)
- 142 ± 6 Ma (fine grained diabase)
- 136 ± 14 ma (microporphyritic diabase from chilled margin)
- 98 ± 4.5 Ma (medium grained gabbro)

The less abundant northerly trending set straddles the boundary between alkali basalt and basanite-nephelite on the Winchester Floyd diagram and lies in the field of within-plate basalt and differentiates on the the Hf-Th-Ta diagram of Wood. It intrudes the Nansen Formation and may be related to the Late

Cretaceous Hansen Point volcanics, which are exposed on the unnamed peninsula southeast of Aurland Fiord (*Cape Stallworthy–Bukken Fiord* and *Otto Fiord*).

Dunite-serpentinite on Kleybolte Peninsula (map unit ds, undated)

On western Kleybolte Peninsula (*Cape Stallworthy–Bukken Fiord*), an ultramafic body, nearly 9 km long and up to 1 km wide, occurs between two branches of the Kleybolte Fault Zone. It is bordered by the Bourne Complex on the northwest and by the Danish River Formation and unconformably overlying upper Paleozoic strata on the southeast. This body is known only from reconnaissance work in 1961 (Trettin, 1969a, p. 45). Where examined, it consisted of dunite and serpentinite. The dunite was composed mainly of Mg-rich olivine ($Fo_{90}Fa_{10}$) with minor chromite and talc. The serpentinite showed a mesh structure that was probably inherited from the dunite.

The age and origin of this body are unknown. It may represent a sub-arc pluton that is related to the volcanics of the Bourne Complex; an ultramafic differentiate of mafic intrusions within the Bourne Complex; or remnants of oceanic crust that mark a tectonic suture. It is interesting to note that detrital serpentinite and chromite occur in the Phillips Inlet and Fire Bay formations. If derived from equivalents of this body, the intrusion must be older than late Llandovery.

STRUCTURAL GEOLOGY

Description of structures

External boundaries of fold belt

Boundary with Hazen Fold Belt

The boundary of the Clements Markham Fold Belt with the Hazen Fold Belt is exposed only in the northeastern part of the study area (*Clements Markham Inlet–Robeson Channel*) where it coincides with the Porter Bay Fault, the southeasternmost element of the Feilden Fault Zone. Farther southwest it is concealed by glaciers and by strata of the Sverdrup Basin. The Porter Bay Fault juxtaposes Lower Cambrian strata on the southeast with Silurian and upper Palezoic strata on the northwest. These relations imply (1) that the fault has a dip-slip component; and (2) that it was active (or re-activated) in post-Carboniferous time. A dextral strike-slip component is suggested by the braided appearance of the Feilden Fault Zone. This sense of movement is in accord with the fact that the Porter Bay Fault is a northwest-directed thrust in a re-entrant at Piper Pass; elsewhere its vergence is uncertain because of poor exposure.

Boundaries with Pearya

At the surface, Middle Ordovician to Lower Silurian strata of the Clements Markham Fold Belt are separated from uplifted older rocks of Pearya by a series of steeply dipping faults. The same rocks probably underlie northwestern parts of the Clements Markham Fold Belt, but their extent in the subsurface is unknown.

Boundaries with Northeast Pearya. Northeast Pearya is bounded on the southeast and south by the Mount Rawlinson and M'Clintock Glacier faults, and on the west by the Yelverton Fault (*Clements Markham Inlet* and *M'Clintock Inlet*). The westernmost part of the M'Clintock Glacier Fault is well exposed and has been traversed on the ground. It is a south-directed thrust fault offset by minor transverse faults with dextral and sinistral displacements (Bjornerud, 1989). Larger transverse faults with dextral or sinistral offsets are inferred beneath Milne and M'Clintock glaciers.

Boundary with Mitchell Point Belt of Central Pearya (Petersen Bay Fault) and associated regional metamorphism. The Mitchell Point Belt, composed of Proterozoic gneiss of Succession 1 of Pearya (see Chapter 4), is separated from the Clements Markham Fold Belt by the Petersen Bay Fault (Figs. 76–80), which extends from southwest of Phillips Inlet to the southwestern shore of Ayles Fiord, a distance of more than 130 km. On the southeast side it is bordered, from southwest to northeast, by: (1) the Danish River Formation; (2) probable metamorphic equivalents of the Kulutingwak Formation (map units OKc and OKm), and (3) possible metamorphic equivalents of the Kulutingwak Formation (map units OKc? and OKm?). In its present configuration, the Petersen Bay Fault is a southeast-directed thrust. It dips gently northwest in an area southwest of Milne Fiord and steeply northwest on the northeast side of Yelverton Inlet. Adjacent to Kulutingwak Fiord it is overturned to the north and about parallel with the north-verging foliation of Succession 1 (Figs. 76, 77).

The gneissic foliation in the Mitchell Point Belt trends southwest and is generally parallel to the Petersen Bay Fault, with some variation. In the vicinity of Yelverton Inlet and Kulutingwak Fiord, at a distance from the fault, structures in the Danish River Formation are oriented westerly to northwesterly and

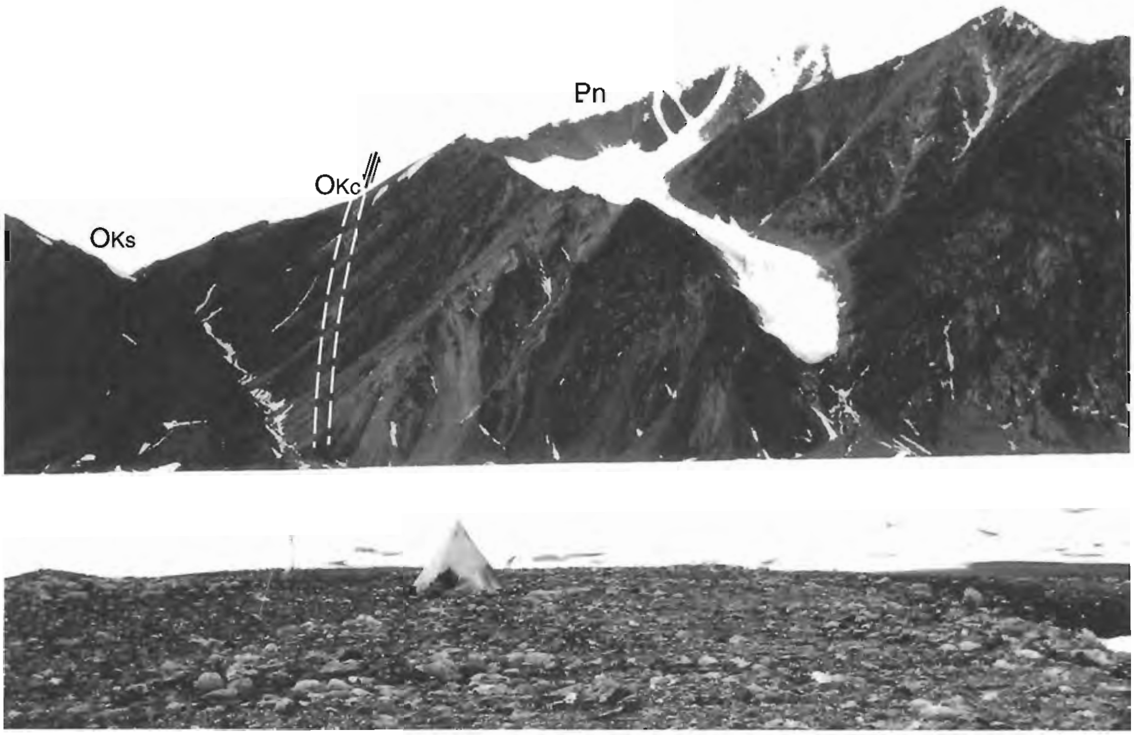


Figure 76. Petersen Bay Fault on the west side of Kulutingwak Fiord, view west-southwest. Succession 1 of Pearya (Pn) *in fault contact with marble of the Kulutingwak Formation* (OKc), *farther south amphibolite-grade schist* (OKs) *of the same formation. The foliation of the gneiss and the Petersen Bay Fault dip south-southwest. The latter is interpreted as an overturned thrust fault. ISPG photo 648-9.*

trend towards the fault at moderate to high angles. In the vicinity of the fault, a belt about 0.25 to 3 km wide, these trends are deflected clockwise, into fault-parallel directions. The same clockwise deflection is seen farther northeast, between Milne Fiord/Milne Glacier and Ayles Fiord, where the Mitchell Point Belt is bordered by strata of Succession 2 of Pearya (Neoproterozoic to Lower Ordovician, see Chapter 4).

Along the entire length of the fault, the footwall rocks show a relatively high grade of metamorphism, commonly of lower amphibolite facies, that diminishes and dies out toward the southeast (Trettin, 1971b; Frisch, 1974, 1976). At the southeastern limit of this metamorphic belt, detrital biotite disappears and is replaced by chlorite. Farther northwest, metamorphic biotite, chloritoid, garnet, staurolite, and kyanite appear, and chloritoid eventually disappears (Klaper and Ohta, 1993). Garnet compositions reveal peak metamorphic conditions of 600°C and 600 MPa. Isograds trend northeast-southwest, roughly parallel to the fault, but cross the structural trends at intermediate angles (op. cit.).

The metamorphism must be younger than the Danish River Formation and the structural trends within it, but older than late Early Carboniferous, the age of the oldest strata of the Sverdrup Basin. In order to date the metamorphism, two samples from the footwall of the fault were analyzed by the ^{40}Ar-^{39}Ar method (Roddick *in* Trettin et al., 1992; this paper supersedes preliminary results by Roddick, cited in Bjornerud, 1991). Muscovite from a pegmatite yielded an age of 322 ± 2 Ma, Namurian (Okulitch, 1995), and clearly too young, owing to argon loss. Hornblende from a schist of the Kulutingwak Formation (map unit OKs) had a complex release spectrum that demonstrates excess argon in the highly irregular early release of ^{39}Ar. The next 42 to 96 per cent of release shows a more persistent pattern, but may also have been affected by argon loss. The plateau age of this fraction is 433 ± 3 Ma, late Llandovery according to the adopted time scale (Fig. 2). The minimum age is 424 Ma, late Ludlow, and the maximum age 436 Ma, about medial Llandovery. If the time scale is reliable, then the Llandovery ages are too old to be compatible with the stratigraphic and structural information.

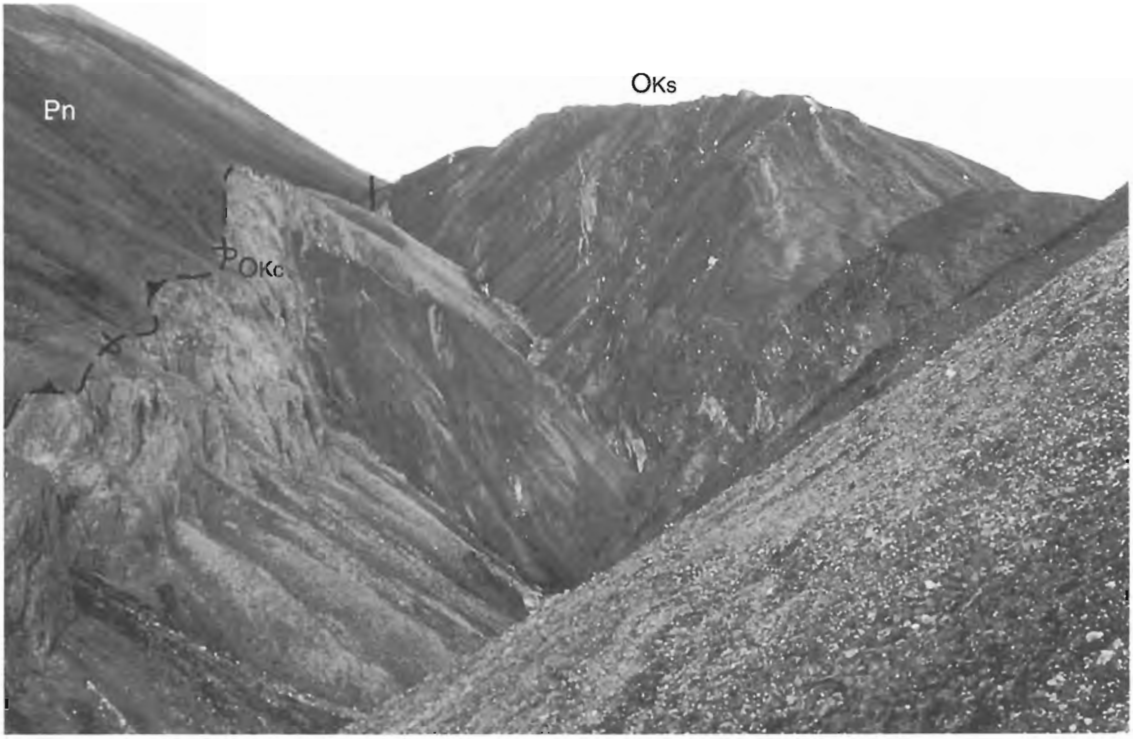


Figure 77. *Petersen Bay Fault on the east side of Kulutingwak Fiord, view east-northeast. Succession 1 of the Pearya Terrane* (Pn) *here forms a recessive weathering mylonite. Adjacent to the fault a resistant marble bed* (OKc) *and amphibolite-grade schist and minor marble* (OKs) *of the Kulutingwak Formation. The fault is an overturned thrust that dips steeply east-southeast. ISPG photo 648-8.*

The late Ludlow age is acceptable but requires confirmation, preferably by a different dating method.

Boundaries with Southwest Pearya. Southwest of Phillips Inlet, a southwestward-projecting block of Succession 2 of Pearya is separated by steeply dipping faults from the surrounding Danish River Formation and, at a distance, from subhorizontal outliers of Carboniferous formations that unconformably overlie the Danish River Formation. The base of the Carboniferous strata is topographically lower than the top of Succession 2, indicating that uplift occurred or recurred in post-Carboniferous time.

Emma Fiord Fault Zone

The Clements Markham Fold Belt is broken by numerous strike-parallel faults, including the Emma Fiord Fault Zone and the Inlet Head Fault (*Otto Fiord* and *Yelverton Inlet*)). These structures have been mapped from air photographs with some ground checks, but have not been examined in detail. Most important appears to be the steeply dipping Emma Fiord Fault Zone, which has been traced from Emma Fiord (*Otto Fiord*) to northeast of Yelverton Inlet (*Yelverton Inlet*) for a distance of nearly 150 km. Projected farther northeast, it appears to splay off the M'Clintock Glacier Fault, but the junction is covered by an unnamed glacier. The zone consists of longitudinal faults locally offset by crossfaults. Generally, the Emma Fiord Fault Zone separates the Danish River Formation on the northwest from the Lands Lokk Formation on the southeast, but also involves upper Paleozoic, Cretaceous, and Paleogene formations in its southeastern part (*Otto Fiord*). Northeast and southwest of the head of Kulutingwak Inlet, narrow, elongate fault blocks of map unit OSv lie within the fault zone.

The zone clearly was active during the Eurekan Orogeny when the southeastern block was elevated relative to the northwestern block, probably by normal rather than reverse faulting. Activity prior to the deposition of the Danish River Formation is suggested by the absence of any outcrops of Pearya southeast of it. It also forms an important boundary within Succession A of the Clements Markham Fold Belt, separating the Northwestern and Southwestern belts. The West-central belt, which occurs as fault blocks

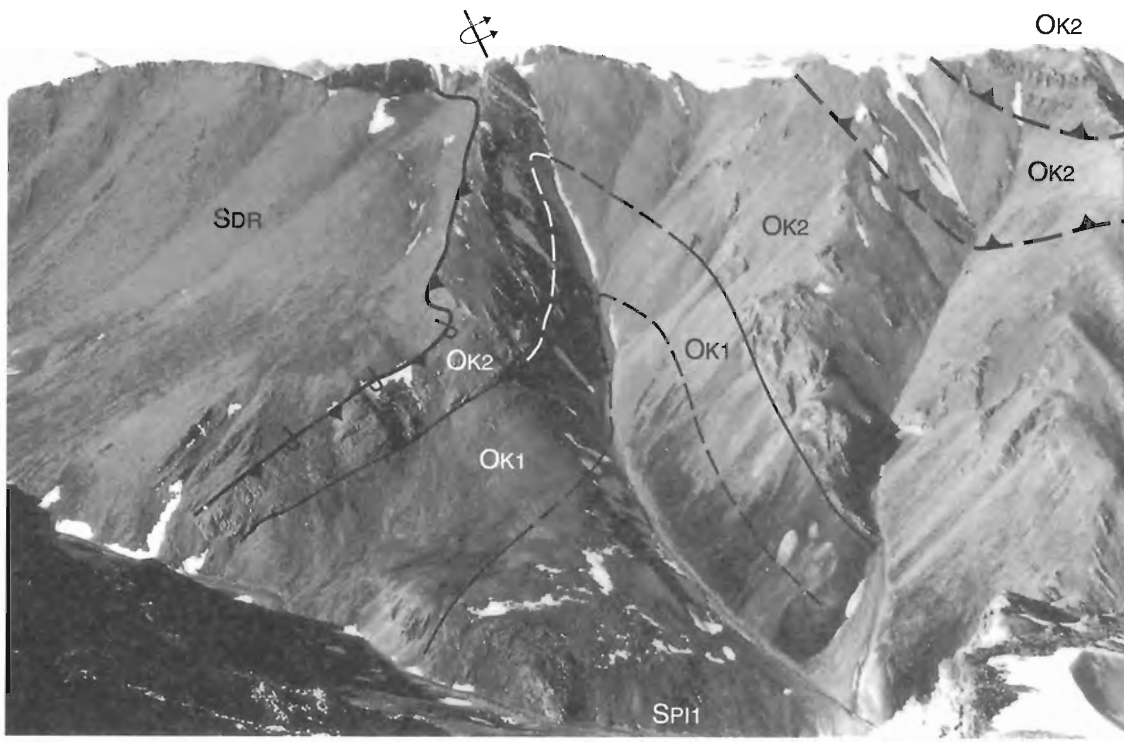


Figure 78. Core of Kulutingwak Anticlinorium, looking west (Cape Stallworthy–Bukken Fiord). SPI1: *Phillips Inlet Formation, Member A;* OK1, OK2: *Members A and B of Kulutingwak Formation;* SDR: *Danish River Formation. ISPG photo 3605-1.*

within the fault zone, is more closely related to the Northwestern and Northeastern belts than to the Southwestern belt.

Style of folding and associated faulting

The Clements Markham Fold is characterized mainly by consistent, southwesterly to westerly structural trends, slightly arcuate and convex to the southeast on a regional scale, with some divergent, westerly to northwesterly trends in the northwestern part. Typical minor folds near Barrier Glacier are shown in Figures 81 and 82.

A transect of the Clements Markham Fold Belt exposed along Yelverton Pass and Yelverton Inlet was studied by E.M. Klaper in 1990. The following generalizations have been abstracted from her summary (Klaper, 1992a, b), which is based on detailed studies at four localities. The entire width of the fold belt is characterized by open to tight, complex chevron folds. Fold axes plunge moderately southwest or northeast, and axial planes are vertical or dip steeply northwest or southeast. The wavelength of outcrop-scale folds ranges from several metres to tens of metres, but their asymmetry indicates that they are second-order features on larger folds. The geometry of the first-order folds is difficult to determine, but they seem to be more open and rounder than typical chevron folds, with wavelengths from several hundred metres to 2 km. Carbonates and sandstones usually have a brittle fracture cleavage and mudrocks a slaty cleavage. The common multilayer sequences of sandstone/mudrock and carbonate/mudrock display convergent and divergent cleavage fans, symmetrical about the axial plane, and cleavage refraction occurs across layers of different competence. Slaty cleavage of mudrocks overprints an earlier bedding-parallel fissility that is probably diagenetic and subsequently was reactivated as bedding-parallel shear. A locally developed bedding-cleavage intersection lineation is parallel to observed fold axes. The competent layers in these folds generally show a parallel (class 1B) or a similar or chevron (class 2) geometry (Ramsay and Huber, 1987). Competent layers of similar folds show only minor variations in orthogonal thickness. Fold hinges reveal brittle features such as outer-arc extensional cracks, limb thrusts, and hinge collapse. These features, and the growth of bedding plane slickenfibres perpendicular to the fold axes on the fold limbs, indicate that a flexural slip mechanism was

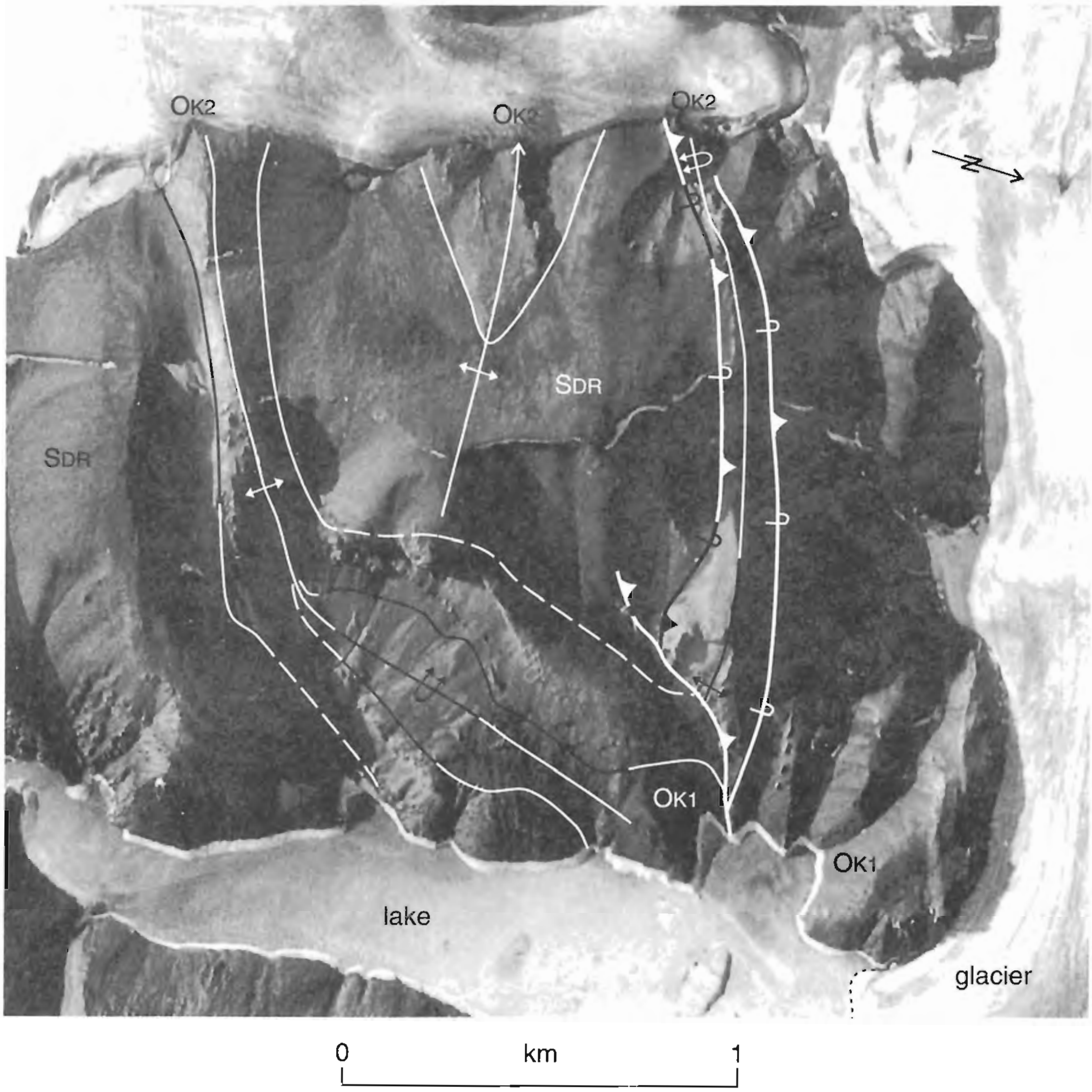


Figure 79. West-central part of Kulutingwak Anticlinorium (see Trettin and Frisch, 1995, inset, structural cross section A–A'). Folds and thrust faults are controlled and outlined by resistant, massive carbonates of Member B of the Kulutingwak Formation (OK2). *Member A of the Kulutingwak Formation* (OK1) *and the Danish River Formation* (SDR) *are darker, more recessive, and generally more structurally complex. The steep slope above the lake reveals a strongly overturned first-order anticline, which becomes upright at the highest levels. The central anticline farther north is interpreted as a second-order fold that involves the overturned part of the first-order anticline. Still farther north is another first-order anticline bounded by thrust faults. The anticline and the thrusts are partly upright and partly overturned to the south. Relief about 500 m. Part of air photograph NAPL A-16734-12. ISPG photo 2369-1.*

dominant during folding. Bed-length measurements on outcrop-scale folds indicate 50 to 70 per cent shortening. This is a minimum value because thrust faulting, bedding-parallel shear, and volume changes associated with pressure solution and cleavage have not been considered. In the northwesternmost part of the transect, chevron folding of the Danish River Formation was overprinted by a nearly coaxial crenulation folding with a locally penetrative crenulation cleavage.

Structural studies near the head of Kulutingwak Fiord, west of Klaper's transect, reveal a more complex style of deformation. The area is covered mainly by the Lower Silurian Danish River Formation, with smaller exposures of older strata in the Kulutingwak

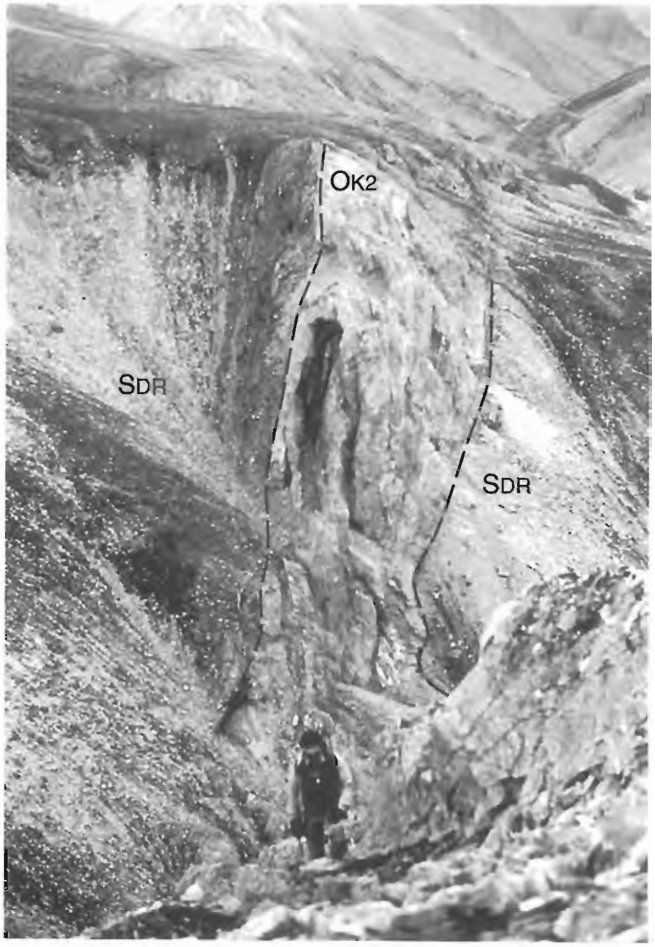


Figure 80. Southwestern extremity of Kulutingwak Anticlinorium, about 3 km east of its termination, view east. An isoclinal anticline formed in marble of Member B of the Kulutingwak Formation (OK2) *is slightly overturned to the south in its uppermost part and separated by steeply dipping faults from strata of the Danish River Formation* (SDR) *on both sides. ISPG photo 3578-3.*

Figure 81. Hinge of chevron-type anticline in the Lands Lokk Formation near Barrier Glacier (Clements Markham–Robeson Channel). ISPG photo 1360-39.

Figure 82. Anticline-syncline pair in the Lands Lokk Formation near Barrier Glacier with backlimb thrust. Mudrock in the core of the anticline shows slaty cleavage. Hammer for scale. ISPG photo 1360-42.

Anticlinorium east of upper Kulutingwak Fiord (*Yelverton Inlet*, inset). This doubly-plunging structure is about 35 km long. It has a slightly arcuate, southwesterly to westerly trend with a curvature of about 15°, and a topographic relief of about 800 m. The basic structure is controlled and outlined by massive, resistant carbonates of Member B of the Kulutingwak Formation. The underlying incompetent volcanic and sedimentary strata of Member A are exceedingly complex in structure.

The northeastern and southwestern parts of the anticlinorium are separated by a deeply incised, broad valley with Quaternary cover. The northeastern part of the anticlinorium is upright but thrust upon the Danish River Formation along a northwest-dipping fault that flattens at depth (*Yelverton Inlet*, inset, cross section B–B′). Thrust slices of fragmental serpentinite and polymict conglomerate (Phillips Inlet Formation) are exposed in the core of the structure (Fig. 78). The northwestern limb is overthrust from the northwest by an extensive sheet of complexly folded schist, quartzite, and marble, assigned to Succession 2 of Pearya, and locally also by small thrust slices of Members A and B of the Kulutingwak Formation.

In the southwestern part of the anticlinorium several folds are present. The main anticline, in the south, is strongly overturned to the southeast in its lower part, but upright and locally overturned to the northwest in its upper part (Figs. 79, 80; *Yelverton Inlet*, inset, cross section A-A′). The overturned part is deformed by three second-generation folds, a broad central anticline and flanking synclines. Farther north, Member B of the Kulutingwak Formation forms an isoclinal anticline that is partly upright and partly overturned to the northwest and bounded by thrust faults that also are upright or overturned.

Detailed structural studies of the Danish River Formation in the vicinity of the anticlinorium have revealed the presence of three generations of structures (Bjornerud, 1991; Hajcak, 1992; Bjornerud and Bradley, 1994):

1. Pre-lithification structures that are not of tectonic origin include the convolute bedding, contorted crossbedding, and flame structures typical of turbidites. Also present are slump folds, up to 5 m in amplitude. They are bounded by undisturbed beds above and below and their axial planes are parallel to bedding.

2. Pre-lithification tectonic structures include:

   a) Clastic dykes, 1-5 cm wide, composed of sand grains and demonstrating dilational offsets of bedding. When bedding is restored to horizontal they dip about 30° southwest.

   b) Small, mutually cross-cutting reverse faults, along which sandy sediments have been entrained. When bedding is restored to horizontal, the inferred maximum principal stress (acute bisector of the faults) plunges moderately south.

   c) Cuspate similar isoclinal folds with axial planes at moderate to high angles to bedding. Hinge surfaces through the cuspate crests of the folds define a spaced cleavage. These folds differ from post-lithification cuspate folds by the lack of competence contrast between coarse grained and fine grained layers.

   d) Networks of surfaces with sedimentary layering oblique to bedding, occurring both as single and conjugate sets.

   All these structures, which have counterparts in cores from accretionary prisms obtained by the Ocean Drilling Project, are attributed to fluid escape during a tectonic stress regime.

3. Post-lithification features include chevron folds, associated pressure solution cleavage and calcite veins, and younger thrust faults.

An anomalous structural style is displayed by strata of the Danish River Formation north of upper Emma Fiord (*Cape Stallworthy-Bukken Fiord*, inset A) where paleocurrent determinations were made (see above). There, tops face persistently southeast in a belt at least 700 m wide instead of showing the closely spaced reversals, indicative of tight folding, that are characteristic of the rest of the Clements Markham Fold Belt and most of the Hazen Fold Belt. Variations in dip suggest imbricate thrusts, but the faults are concealed. Another anomalous feature is a slaty cleavage that strikes northwest at high angles (69-88°) to bedding trend, and dips northeast at intermediate angles (42-45°).

Age of deformation

Disturbances in Late Ordovician(?)-Early Silurian time are indicated by the following observations:

1. Air observation and air photo interpretation suggest an angular unconformity between the Mount Rawlinson Complex (Caradoc and (?)younger) and the Danish River Formation near Mount Frere, northwest of Markham River (see Danish River Formation and *Clements Markham Inlet-Robeson Channel*). If so, faulting, uplift, and erosion occurred prior to the deposition of the Danish River Formation in the latest Llandovery.

2. In the Kulutingwak Anticlinorium, The Danish River Formation overlies the Kulutingwak Formation. A structural discordance is not apparent, but the limited information on the age of the Kulutingwak Formation suggests a disconformity with a hiatus extending from late Ashgill(?) to early late Llandovery.

3. The coarse clastic sediments of the Fire Bay Formation (upper Llandovery) were probably derived from uplifted sources to the northwest that included volcanic, carbonate, and minor ultramafic rocks. Submarine sliding on the southeastern slope of this uplift involved the Fire Bay Formation itself, Middle Ordovician carbonate olistoliths, and Ordovician chert of the Hazen Formation.

4. The abrupt contact between the Yelverton Pass beds (early late Llandovery) and the Hazen Formation probably represents either an

unconformity or a listric normal fault, indicating movement either before or after the deposition of the beds.

5. An early deformation of the Danish River Formation is indicated by pre-lithification structures (Bjornerud, 1991; Hajcek, 1992; Bjornerud and Bradley, 1994).

A Late Silurian–Early Carboniferous orogeny is apparent from a high-angle unconformity that separates the strata of the Clements Markham Fold Belt from those of the Sverdrup Basin. In the report area, the age of the deformation is bracketed by fossils of late Ludlow and Viséan ages. The orogeny consisted of a complex series of events that will be reviewed in Chapter 5, in conjunction with information from Pearya and from exposures of the Middle–Upper Devonian Okse Bay Formation at Yelverton Pass and de Vries Glacier studied by Mayr (1992).

CHAPTER 4

GEOLOGY OF PEARYA

CONTENTS

INTRODUCTION

Pearya is a geological province of northern Ellesmere Island characterized by a distinct geological record that ranges in age from Mesoproterozoic to Late Silurian, and by highly diverse structural trends. Coherent outcrops are confined to an area 350 km long and up to 85 km wide, that is situated on the north coast of the island between Clements Markham and Imina inlets (Fig. 1a, b). The main outcrop area is divisible into three fault-bounded domains, Northeast, Central, and Southwest Pearya (Fig. 1b), that differ in structural trend and in the age range of the strata. In addition there are some smaller inliers. Concealed rocks of Pearya probably underlie northwestern parts of the Clements Markham Fold Belt.

The concept of Pearya has a long and complicated history that reflects changes in tectonic paradigm. The name was introduced by Schuchert (1923) for an inferred Precambrian borderland or geanticline, contiguous with the Canadian Shield in the subsurface, that supplied clastic sediments to the Franklinian Geosyncline. Although located mainly in the present offshore region, it included crystalline basement rocks in northernmost Ellesmere.

Pearya was abolished by Thorsteinsson and Tozer (1960) who assigned all pre-Carboniferous rocks of northern Ellesmere and Axel Heiberg islands to the Franklinian Eugeosyncline, in accord with the geosynclinal concepts of Kay (1951). Investigations in the 1960s demonstrated that the eugeosyncline comprised two different tectonic elements: a southeastern, exclusively sedimentary deep-water basin, named the Hazen Trough; and a northwestern, tectonically active belt, characterized by shallow-marine and nonmarine sediments, volcanics, and granitic to ultramafic plutonic rocks, for which the name Pearya Geanticline was retained (Trettin, 1973). In a first application of plate tectonic concepts, the geanticline was interpreted as an arc developed on the Arctic continental margin above a southeast-dipping subduction zone (ibid.).

The next phases in plate tectonic interpretation were dominated by the terrane concept (e.g., Coney et al., 1980). Churkin and Trexler (1980, fig. 2) portrayed the entire magmatic belt, including northern Axel Heiberg Island, as an allochthonous tectonostratigraphic terrane of oceanic origin, named Pearya, but provided no proof, discussion, or references supporting this interpretation. After further studies, however, it became possible to outline a less extensive terrane, confined to a part of northern Ellesmere Island, that differed in stratigraphy and tectonic history from the rest of the Arctic Islands, but had some tectonic affinities with the Caledonides (Trettin, 1987b). The rest of the original geanticline was assigned to the Northern Heiberg and Clements Markham fold belts.

The basic concepts and terms of the 1987 paper are retained here, but with the following major modification. The age of accretion, originally considered to be latest Silurian, is now inferred to be older than partial sedimentary overlap in the latest Llandovery. On the other hand, northern parts of the terrane retained a certain stratigraphic identiy until the end of the record in the Late Silurian. If the post-accretionary strata are considered an integral part of Pearya – and stratigraphic relations demand this – then it must be regarded as a geological province that survived its terrane stage. This required a name change, from Pearya Terrane back to Pearya. The broader regional relations of the terrane, and the time, site, and mode of its accretion to the Clements Markham Fold Belt are discussed in Chapter 5.

STRATIGRAPHY

The rocks of Pearya were originally assigned to four successions that included the crystalline basement (Succession 1) and probably more than 8 km of metamorphosed or unmetamorphosed supracrustal strata (Successions 2 to 4). The upper part of the original Succession 4 is here re-assigned to a separate unit, Succession 5, which is further divided into a lower and an upper part (5A and 5B). The five first-order units are separated by important unconformities, or, in the case of Successions 2 and 3, by major faults interpreted as a tectonic suture.

Succession 1 (map unit Pn, Proterozoic)

Definition and history of investigation

Succession 1 constitutes the crystalline basement of Pearya (Trettin, 1987b). Consisting mainly of granitoid gneiss with minor schist, amphibolite, quartzite, and marble, it was formed by plutonism and metamorphism in late Mesoproterozoic to earliest Neoproterozoic time. The major outcrop areas are referred to as the Cape Columbia, Deuchars Glacier, and Mitchell Point belts; minor occurrences as the Ayles Fiord, Yelverton Inlet and Imina Inlet inliers (Figs. 1a, b, 83). These informal names replace the previous stratigraphic terms, Cape Columbia group [*sic*] or Cape Columbia Complex, used in earlier publications with different connotations (see below). The major outcrop areas differ in structural setting and trend, and to a lesser degree in lithology.

Based on samples collected by Aldrich in 1876, Feilden and de Rance (1878) mapped "mica schist and altered rocks" in the vicinity of Cape Columbia. Peary (1907, p. 213) briefly noted the presence of gneiss in this area. Blackadar (1954) reported a variety of gneisses, and granitoid and pegmatitic dykes between Cape Columbia and Cape Aldrich, which he assigned to a new unit, the Cape Columbia group [*sic*]. Christie (1957, 1964) extended this reconnaissance unit westward to Disraeli Fiord and Ward Hunt Island and discovered additional outcrop areas at M'Clintock Inlet and between Ayles Fiord and Phillips Inlet. In addition to gneiss, he included in the Cape Columbia group occurrences of schist, crystalline limestone, and quartzite now assigned to Succession 2, and an undated intrusion on Ward Hunt Island also discussed in that context (Appendix 2, lithological units; *M'Clintock Inlet*). A large fault-bounded block of metasediments with a minor occurrence of metamorphosed granitoid rocks was discovered by Trettin (1964) between Henson Bay and Phillips Inlet. He assigned the metasediments to the Cape Columbia Group, later renamed the Cape Columbia Complex (Trettin, 1969a), and interpreted the granitoid rocks as a metamorphosed Devonian intrusion. The metasediments are here included in Succession 2, and the granitoid rocks to the Imina Inlet Inlier of Succession 1.

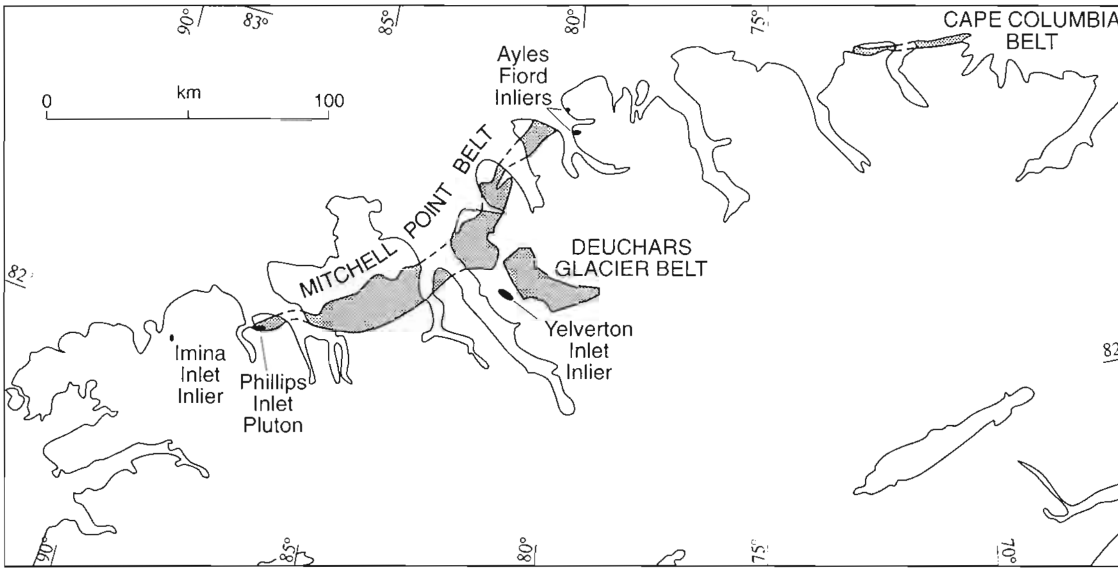


***Figure 83**. Generalized outcrop areas of Succession 1, Pearya.*

Frisch (1974), in the first systematic study of the metamorphic complex of northern Ellesmere Island, distinguished three lithological units (op. cit., fig. 29): rocks of amphibolite-facies, mainly mica-quartz-feldspar gneiss and associated amphibolite, and minor marble and metasyenite (map unit 1a); rocks of amphibolite to greenschist facies (map unit 1b); and rocks of greenschist facies (map unit 1c). He restricted the Cape Columbia Complex to the exposures of map unit 1a in the vicinity of Cape Columbia and Cape Aldrich. Succession 1 of this report is identical to Frisch's map unit 1a, but includes additional outcrop areas discovered in the course of this project, such as the Deuchars Glacier Belt (Trettin and Frisch, 1981, 1987), and the Yelverton Inlet Inlier (Bjornerud, 1989).

Stratigraphic relations (Christie, 1957) and K-Ar age determinations (Blackadar, 1960; Frisch 1974) demonstrate that the crystalline basement is older than late Middle Ordovician, but do not permit a specific age assignment. Rb-Sr isochrone and U-Pb zircon determinations by Sinha and Frisch (1975, 1976) showed that the basement was formed by granitoid intrusion and regional metamorphism in late Mesoproterozoic-early Neoproterozoic time, a conclusion confirmed by more recent U-Pb age determinations (see below).

Distribution, contact relations, and lithology

Scattered outcrop areas of Succession 1 (Fig. 1a, b) extend from Cape Aldrich (*Clements Markham Inlet-Robeson Channel*) to northeast of Imina Inlet (*Cape Stallworthy-Bukken Fiord*). The base of Succession 1 is concealed. The contact with Succession 2 is interpreted as an unconformity. The structural settings and lithologies of the major outcrop areas are summarized below.

Cape Columbia Belt

The Cape Columbia Belt, about 39 km long and up to 6 km wide, is exposed on the north coast of Ellesmere Island between Cape Aldrich and Cape Albert Edward (*Clements Markham Inlet-Robeson Channel* and *M'Clintock Inlet*). On Arthur Laing Peninsula (*Clements Markham Inlet-Robeson Channel*), the Cape Columbia belt proper is bounded on the south by the Parr Bay Fault, which separates it from muscovite-rich schist (map unit Ps) that either represents a retrograde part of the Cape Columbia Belt (Frisch, 1974) or belongs to Succession 2 (Appendix 2). The muscovite-rich schist, in turn, is bounded on the south by a lineament, mapped as an assumed fault, that splays off the Parr Bay Fault and separates it from Succession 2 (map unit L1-3).

The following lithological summary has been abstracted from a comprehensive description by Frisch (1974). The belt is underlain largely by gneiss with lesser proportions of amphibolite, granitic and pegmatite dykes, schist, quartzite, and marble. Post-crystalline deformation and retrograde metamorphism are ubiquitous. The most abundant rock type is a banded garnetiferous gneiss, composed mainly of feldspar and quartz with varying proportions of biotite. The feldspar consists of microcline, plagioclase (An_{22-32}), and perthite. The garnets are almandines with grossular components. Crystal size is fine to medium, but feldspar porphyroblasts are commonly 0.05 to 1 cm, and up to 18 cm long. The porphyroblasts developed before, during, and after deformation, and have all been affected by late cataclasis, commonly resulting in lensoid shapes (augen). Retrograde rocks have more sodic plagioclase compositions (An_{17-22}), show replacement of garnet by biotite and quartz, and may contain variable amounts of muscovite and chlorite.

Hornblende-bearing rocks are classified as amphibolite or hornblende gneiss, depending on their hornblende content (larger or smaller than 50%, respectively). These rocks are well foliated, except for layers rich in quartz and feldspar. Amphibolites are composed of hornblende, calcic oligoclase (An_{25-27}), quartz, and garnet (almandine with andradite and grossular components), and may contain scapolite and sphene. Retrograde effects and cataclasis are less marked than in the granitic gneisses.

Deuchars Glacier Belt

The crescent-shaped Deuchars Glacier Belt underlies an unnamed mountain range between Yelverton Inlet and Milne Glacier (*M'Clintock Inlet* and *Yelverton Inlet*) where it is separated by steeply dipping faults from surrounding strata of Succession 2 (map unit Y2). The overall length of this belt is about 37 km, and the maximum width 12 km.

Specimens collected from 13 localities during brief helicopter landings indicate that this belt is composed mainly of granitoid rocks with lesser proportions of schist and very small amounts of amphibolite. The granitoid rocks are composed of quartz, albite, microcline, biotite, and white mica, with or without small amounts of chlorite. In their present altered state, they are mainly granodiorites and granites, including leucocratic varieties of both rock types (Appendix 3, Tables 38, 39). A specimen of tonalite may represent an altered granodiorite because some albite shows chessboard twinning, indicative of original K-feldspar (Smith, 1974, p. 287). Alumina indices of seven analyzed samples of granite, granodiorite, and tonalite range from 1.13 to 1.30 and indicate peraluminous compositions (Appendix 4B, Table 1, nos. 1-1 to 1-7). The crystal size varies from fine to coarse and is mainly medium or coarse. Some rocks are massive, others have a secondary gneissic foliation, with the mica defining discontinuous, undulating S-planes that wrap around tectonically abraded feldspar crystals (Fig. 84). The quartz, both in gneissic and massive rocks, commonly shows signs of cataclasis and recrystallization. The mica is generally much finer grained than the feldspar. The originally massive character of these rocks, prior to the development of a secondary foliation in some of them, suggests a plutonic origin. Retrograde metamorphism of lower greenschist facies is apparent from the sodic composition of the plagioclase.

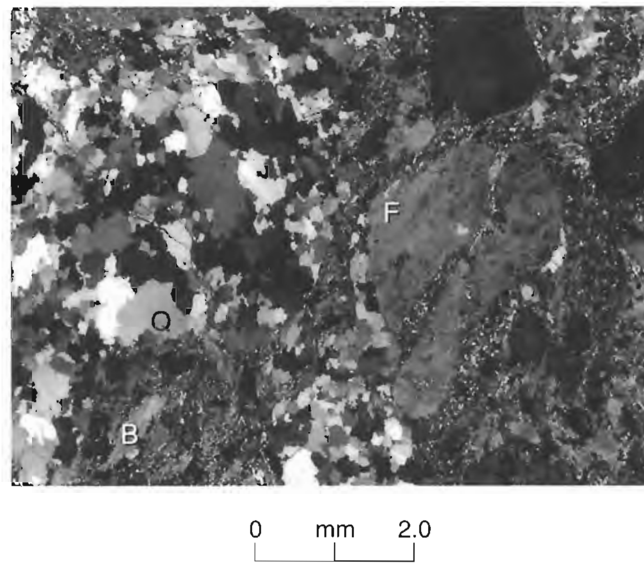


Figure 84. Photomicrograph (cross-polarized light) of granitoid gneiss of Deuchars Glacier Belt. Foliation, defined by concentration of biotite (B) *wraps around coarse abraded feldspar crystals* (F); *quartz* (Q) *is highly recrystallized. ISPG photo 2260-178.*

The schists consist chiefly of quartz, plagioclase, and biotite with or without small proportions of white mica and K-feldspar and rare chloritoid (Appendix 3, Table 40). The plagioclase compositions, in different specimens, range from albite to andesine. The rocks show a thin, flat or undulating compositional layering caused by variations in the proportion of biotite. Quartz and feldspar are generally fine crystalline, but abraded lenses (augen) of fine and medium grained feldspar occur in some rocks. The origin of the schists is uncertain. They may represent sheared border phases of plutons and/or metamorphosed and altered volcanic or sedimentary strata.

An examined specimen of amphibolite is fine crystalline and composed mainly of hornblende and plagioclase, with small amounts of biotite and quartz. The rock shows a vague compositional layering, at variance with the orientation of the hornblende crystals.

Yelverton Inlet Inlier

This small inlier, situated about 5 km southeast of the Deuchars Glacier Belt, is surrounded by strata of Succession 2 (map units Y2 and Y3), and consists of feldspathic gneiss (Bjornerud, 1989).

Ayles Fiord Inliers

The Ayles Fiord Inliers are located on the northeastern side of northwestern Ayles Fiord and lie on strike with the Mitchell Point Belt. They are small, fault-bounded exposures of gneissic rocks that are surrounded by metasediments of Succession 2 (map unit A). Five occurrences have been mapped (*M'Clintock Inlet*, *Yelverton Inlet*), but others may be present. The largest forms the core of an anticline, about 2.9 km long, in which granitoid gneiss is overlain by schist and quartzite (see Succession 2, Figs. 85, 86; also Frisch, 1974, fig. 12A). The contact between Successions 1 and 2 in this structure is dicussed later, in the context of Succession 2 (map unit A). Samples from the anticline are fine to medium crystalline granites and granodiorites. The texture indicates cataclasis and recrystallization, especially of the quartz. The sodic composition of the plagioclase, identified as albite by XRD analysis, demonstrates that the basement rocks have been affected by the same greenschist-grade metamorphism as the overlying schist.

Samples from other exposures represent well foliated, leucocratic augen gneiss of quartz monzonitic composition (Frisch, 1974, p. 31); well foliated, locally augen-textured granitic gneiss that contains shredded amphibolite masses (op. cit., p. 32); and a cataclastic leucocratic gneiss (see Succession 2, Figs. 87, 88), which is tonalitic in its present composition, but probably contained K-feldspar originally because the albite shows chessboard-twinning.

Mitchell Point Belt

The Mitchell Point Belt, 127 km long and up to 15 km wide, extends from southwest of Phillips Inlet (*Otto Fiord*) to the southeastern coast of Ayles Fiord (*Yelverton Inlet*). On the northwest it is separated from metamorphic rocks tentatively assigned to Succession 2 (map units sq, W2, scq, and c; see Appendix 2), and from the Upper Cretaceous Hansen Point volcanics and Wootton Intrusive Complex (Trettin and Parrish, 1987, and Chapter 3, Phanerozoic Intrusions) by the Mitchell Point Fault Zone. On the southeast it is

***Figure 85**. Contact between gneiss of Succession 1* (Pn) *and interstratified schist and quartzite of Succession 2, map unit A (banded) in anticline northeast of lower Ayles Fiord (**M'Clintock Inlet**), view to the south. Note complex structure of Succession 2. The contact is interpreted as an unconformity that acted as a décollement. ISPG photo 3168-13.*

Figure 86. Sharp contact between gneiss (below) and schist and quartzite (above) on eastern (left) flank of anticline shown in Figure 85. ISPG photo 3168-18.

separated from the Danish River Formation and from probable and possible metamorphic equivalents of the Kulutingwak Formation by the Petersen Bay Fault. Parts of this belt have been investigated on the ground in varying detail, and summaries of published or unpublished observations are given below. Other parts are known only from brief helicopter landings, but petrographic observations and XRD analyses (Appendix 3, Table 41) of representatative samples conform with the descriptions of the better known areas.

Coastal area between Ayles Fiord and Petersen Bay. The northernmost exposures are mainly quartzdioritic to quartz monzonitic leucocratic gneiss (Frisch, 1974, p. 33–35). The rocks are composed chiefly of plagioclase (An_{18-22}), microcline perthite, quartz, and intergrown biotite and muscovite. Crystal size is fine to medium, and layers of coarser grained augen gneiss occur in more even-grained rocks. Cataclastic texture is common. Schistose layers, in part garnetiferous, are

Figure 87. Complex fault relations between gneiss of Succession 1 (Pn) and map units A (schist and quartzite), and M4 (phyllite, metavolcanics, etc.) of Succession 2 on the northeastern side of Ayles Fiord (M'Clintock Inlet), view to the northeast. ISPG photo 978-4.

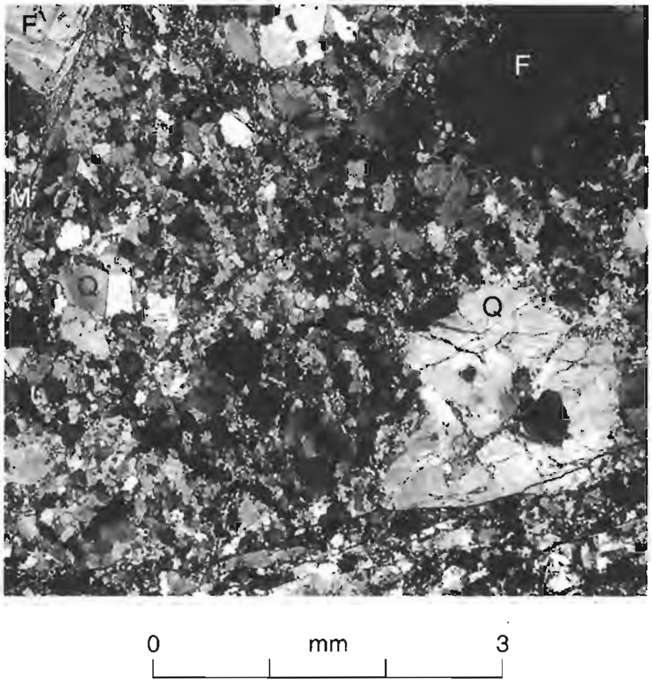


Figure 88. Photomicrograph (cross-polarized light) of basement gneiss (Pn) *shown in Figure 87. The rock consists mainly of quartz* (Q), *Feldspar* (F; *microcline and albite) with minor amounts of muscovite* (M) *concentrated in intersecting cleavages. The crushed texture is typical of these rocks. ISPG photo 2260-170.*

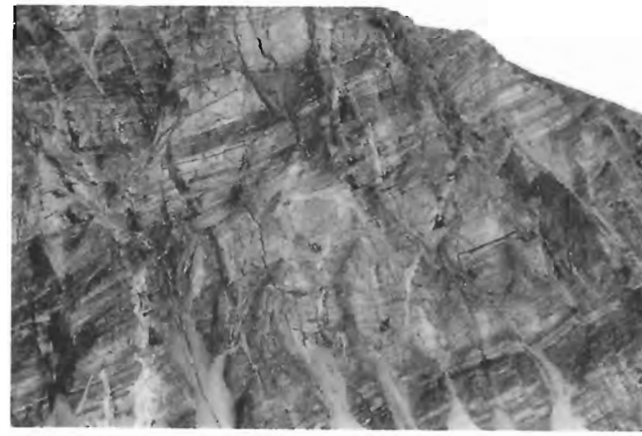


Figure 89. Granitoid gneiss of Mitchell Point Belt west of Kulutingwak Fiord (**Yelverton Inlet**), *view to the west. ISPG photo 1505-9.*

intercalated with granitic gneiss on the coast of Ayles Fiord. Marble associated with gneiss northeast of Milne Fiord may belong to Succession 2.

Northeast side of Yelverton Bay and Yelverton Inlet (Fig. 89). The superb exposures of Succession 1 in this area were divided by Frisch (1974, p. 39–45) into two zones. The northwestern zone consists of relatively homogenous leucocratic gneiss cut by numerous mafic dykes of different ages. The gneiss is composed of quartz, plagioclase (An_{23-25}), microcline perthite, biotite, muscovite, and minor garnet. The rocks are medium crystalline or contain augen-textured feldspar, 1 to 2 cm long with or without feldspar porphyroblasts up to 10 cm long. Banding, due to variations in biotite content, is common. Hornblende-bearing gneiss, associated with thin layers of amphibolite, is rare. The southeastern zone includes biotite gneiss, hornblende gneiss, and amphibolite. The amphibolites range in thickness from less than 10 cm to about 10 m and represent metamorphosed mafic dykes and sills.

Unnamed peninsula southeast of Mitchell Point. In this area, augen gneiss, banded gneiss, and amphibolite dominate over rusty weathering mica schist, and rare quartzite and marble (Klaper and Ohta, 1993).

Wootton Peninsula. Samples collected by the writer on northeastern Wootton Peninsula, about 11 km southwest of Kulutingwak Fiord, immediately southeast of the Mitchell Point Fault, represent leucocratic albite-bearing biotite granodiorite with a well foliated gneissic texture. Rocks on southwestern Wootton Peninsula, near Phillips Inlet, studied by Ohta and Klaper (1992, p. 155) are "porphyritic, two-mica granites with K-feldspar phenocrysts" that locally show augen structure. These authors also reported "small inclusions of micaceous gneisses and schists" and less common inclusions of "hornblende-bearing schists and zoned skarns".

Western peninsula in Phillips Inlet (Yelverton Inlet and Otto Fiord). On the unnamed western peninsula in Phillips Inlet, two hilly outcrop areas of Succession 1 are separated by a valley covered by Quaternary sediments. The northeastern outcrop area is underlain by banded gneiss, the foliation of which dips steeply southeast. An analyzed sample is a quartz monzonitic augen gneiss composed of calcic oligoclase, quartz, microcline, biotite, and white mica.

The southwestern area is underlain by the Phillips Inlet Pluton. The rocks were massive originally, but have undergone considerable deformation and recrystallization. This involved brecciation and rotation of feldspar; growth of white mica and chlorite between feldspar aggregates, producing an irregular, wavy foliation; and introduction and/or remobilization of quartz. A thin section of an isotopically dated sample consists of albite (32%), microcline (14%), quartz (23%), chlorite (19%), mica (10%; mainly white mica, minor green biotite), calcite (1%), and opaque minerals (trace). Two chemically analyzed samples

(Appendix 4B, nos. 2-1, 2-2) have alumina indices ranging from 1.21 to 1.42. Thus, in their present altered state, the rocks are peraluminous granodiorites.

Imina Inlet Inlier

This small inlier occurs about 1.5 km due east of Imina Inlet (*Cape Stallworthy-Bukken Fiord*) within an extensive fault block of metasediments of Succession 2 (map unit cqps). The ice-covered contacts between Successions 1 and 2 are interpreted as faults. A typical specimen from this outcrop is a peraluminous granite composed of quartz (41%), feldspar (36%; albite about 19%, microcline 17%, perthitic intergrowths common), white mica (15%), green, partly chloritized biotite (7%), and accessory minerals (combined point count, XRD, and chemical analysis). The texture is schistose, and some feldspar crystals have been tectonically abraded.

Metamorphism

In parts of the Cape Columbia Belt, metamorphism of lower amphibolite grade is preserved. It is represented by almandine and hornblende, and by plagioclase compositions ranging from calcic oligoclase to sodic andesine (Frisch, 1974). Oligoclase or andesine and hornblende are also preserved in parts of the Mitchell Point Belt (Frisch, 1974). Elsewhere the original metamorphism has been overprinted by ubiquitous retrograde metamorphism, commonly characterized by chlorite, white mica, and albite.

Mode of origin

How large is the intrusive component of this crystalline complex and what is its origin? How large is the metamorphic component and what was the nature of the protoliths? The limited information bearing on these important problems is summarized below.

Those granitoid gneisses that have a predominantly massive original texture are probably of plutonic origin. They are common, especially in the Deuchars Glacier Belt. Samples from that belt and from the Phillips Inlet Pluton submitted for U-Pb dating (see below) contain abundant xenocrystic zircon, indicating at least partial derivation from crustal sources. The present peralkaline chemical composition of the Deuchars Glacier Belt and Phillips Inlet Pluton and their mineralogy are compatible with a crustal origin (see review by Barbarin, 1990, and references therein), but do not prove it because of the altered state of the rocks. For a discussion of inconclusive trace element analyses, see Appendix 4B.

The presence of a metasedimentary component is indicated by occurrences of quartzite and marble in the Cape Columbia and Mitchell Point belts, provided these are genuine parts of Succession 1 rather than fault slices or infolds of Succession 2. In either case they probably represent a miogeosynclinal suite.

Age and correlation

Early K-Ar determinations yielded Ordovician to Jurassic ages listed in Table 14 and discussed later in

Table 14

Pearya, Succession 1: K-Ar age determinations. Column 1 gives the original age, column 2 the corrected age according to current decay constants

Age (Ma) 1	Age (Ma) 2	Location	Reference
465±19	474	Cape Columbia Belt	Frisch, 1974, p. 26
445±18	453	Cape Columbia Belt	Wanless et al., 1968
403±17	411	Cape Columbia Belt	Wanless et al., 1968
389±21	397	Cape Columbia Belt	Wanless et al., 1968
354±15	361	Ayles Fiord Inliers	Wanless et al., 1970
325±14	332	Mitchell Point Belt, N. of Phillips Inlet	Wanless et al., 1965
261±12	267	Imina Inlet Inlier	Wanless et al., 1965
189±9	193	Mitchell Point Belt, S. of Hansen Point	Wanless et al., 1974
177±8	181	Mitchell Point Belt, S. of Hansen Point	Wanless et al., 1974

this section. The Proterzoic age of Succession 1 was first established by means of a six-point Rb-Sr isochrone determination of 742±12 Ma (corrected value 726 Ma; initial $^{87}Sr/^{86}Sr$ ratio 0.7112±0.0007), based on widely scattered samples from the Mitchell Point Belt (Sinha and Frisch, 1975). This result was interpreted as a minimum age.

Subsequent analyses from the Cape Columbia Belt (Sinha and Frisch, 1976) indeed yielded substantially older ages. Rb-Sr determinations yielded a nine-point isochrone age of 1083±18 Ma (corrected value 1060 Ma) and an additional six-point isochrone of 512±90 Ma (corrected value 501 Ma). The initial $^{87}Sr/^{86}Sr$ ratios were 0.7057±0006 and 0.7189±0.00030. Two zircon concentrates provided discordant U-Pb minimum ages of 926 and 980 Ma.

In more recent age determinations, the U-Pb zircon method has been used exclusively. Two samples of massive granitoid rocks from the Deuchars Glacier Belt, probably of plutonic origin, yielded discordant data that suggested xenocrystic inheritance from an older source. The upper concordia intercept indicated a crystallization age of 1037 + 25/-36 Ma (Trettin et al., 1987).

A significantly younger age was obtained from a sample from the Phillips Inlet Pluton. One out of five zircon fractions was nearly concordant and yielded an age of 965±2 Ma; the remaining four were discordant due to inheritance (Trettin et al., 1992).

Four zircon fractions of a sample from the Mitchell Point Belt south of Mitchell Point had discordant ages of 965, 1070, 1083, and 1108 Ma (Lopatin et al., 1993).[1]

In summary, the U-Pb (zircon) data indicate two phases of granitoid intrusion, the first between 1.0 and 1.1 Ga, and the second at 965±2 Ma. The Rb-Sr isochrone age of 1060±18 Ma from the Cape Columbia Belt is comparable to the U-Pb (zircon) data from the Deuchars Glacier Belt and suggests that widespread metamorphism was related to the earlier (1.0-1.1 Ga) intrusive event. On the other hand, the 726 Ma±12 Ma Rb-Sr isochrone age from the Mitchell Point Belt and the subordinate 501±90 Ma isochrone from the Cape Columbia Belt are not supported by other data, and their significance remains uncertain.

The K-Ar ages in Table 14 reflect various degrees of argon loss during Phanerozoic events. Parts of Succession 1 must have been subjected to amphibolite-facies conditions at least twice during the Paleozoic when younger successions were metamorphosed: during the Early-Middle Ordovician M'Clintock Orogeny when Succesions 2 and 3 were metamorphosed; and in post-Llandovery, probably Late Silurian to Middle Devonian time, when the Kulutingwak Formation and parts of the Danish River Formation were metamorphosed. Moreover, Ordovician and Lower Devonian granitoid intrusions and Upper Cretaceous felsic volcanics (Trettin and Parrish, 1987) all contain inherited zircon with upper intercept ages indicative of derivation from Succession 1 (Trettin et al., 1987, 1992). This implies that deeper parts of the basement must have been subjected to upper amphibolite facies conditions prior to the intrusion or eruption of these rocks because anatexis commonly begins in the sillimanite facies (e.g., Sevigny et al., 1989).

The late Mesoproterozoic-early Neoproterozoic metamorphism and granitoid plutonism of Pearya coincides with the world-wide Grenvillian Orogeny, which affected the Grenville Province of eastern North America, southwestern Scandinavia, and parts of East Greenland and Spitsbergen. On the other hand, it did not affect the Precambrian basement exposed in the rest of the Arctic Islands and North Greenland (cf. Frisch and Trettin, 1991). This is further discussed in Chapter 5, in the context of the regional relations of Pearya.

Succession 2 (Neoproterozoic to Lower Ordovician)

Definition

Succession 2 comprises metasedimentary and metavolcanic rocks of probable Neoproterozoic to Early Ordovician age that differ in lithology or metamorphism from all other successions. Phyllite, marble, quartzite, and schist are the most common rock types whereas conglomeratic greywacke (diamictite), greywacke, metavolcanics, and metachert are less abundant. The metamorphic grade ranges from lower greenschist to lower amphibolite facies and is mainly of greenschist facies.

[1]The same paper (Lopatin et al., 1993) reports U-Pb determinations on detrital zircon from the Grant Land Formation. Five highly discordant fractions are close to a regression intercepting concordia at 2147±94 and 15±47 Ma. The analyses confirm that the zircon was not derived from Succession 1 of Pearya, and is in agreement with previous conclusions (Trettin et al., 1987; Trettin, 1994, p. 96).

The stratigraphy of the succession is poorly known because of its structural complexity, absence of fossils, scarcity of isotopic age determinations, and the reconnaissance nature of the fieldwork. Instead of formal stratigraphic units two different kinds of map units are used, recurrent lithological units, and preliminary stratigraphic units of local extent.

Parts of Succession 2 were originally included in the abandoned Mount Disraeli and Cape Columbia groups (Blackadar, 1954; Christie, 1957, 1964). Map units 1b and 1c of Frisch (1974) consisted mainly of rocks here assigned to Succession 2, but also included rocks now interpreted as metamorphic equivalents of Ordovician and Silurian formations of the Clements Markham Fold Belt.

Distribution, contact relations, and thickness

This is the most widely exposed succession of Pearya (Fig. 1a, 90), and scattered outcrops extend from Arthur Laing Peninsula (*Clements Markham Inlet–Robeson Channel*) to Kleybolte Peninsula (*Cape Stallworthy–Bukken Fiord*).

The exposed contacts between Successions 1 and 2 are faulted or sheared, but the apparent absence from Succession 2 of granitoid intrusions of late Mesoproterozoic–early Neoproterozoic age strongly suggests an important unconformity. More specifically, this unconformity would be an angular unconformity or a nonconformity, depending on the presence or absence of stratification in Succession 1. The fault contact with Succession 3 is interpreted as a suture (see, Structural geology and Chapter 5). Succession 2 is overlain with angular unconformity by Middle Ordovician (lower Caradoc) strata of Succession 4, or by Upper Ordovician (Ashgill) strata of Sucession 5. The unconformable relations with Successions 1 and 4 imply that Succession 2 represents a major phase of subsidence and deposition that followed the late Mesoproterozoic–early Neoproterozoic Grenvillian Orogeny and was terminated by the Early–Middle Ordovician M'Clintock Orogeny (see below, Tectonics).

The thickness of the succession is unknown but is estimated to be no less than 2 km.

Lithological units

Lithological units are designated as follows on the 1:250,000 scale maps:

c: carbonate rocks
p: phyllite
q: quartzite
s: schist
t: chert
v: volcanics
w: greywacke/sandy mudrock
x: conglomeratic greywacke (diamictite) and interbedded mudrock

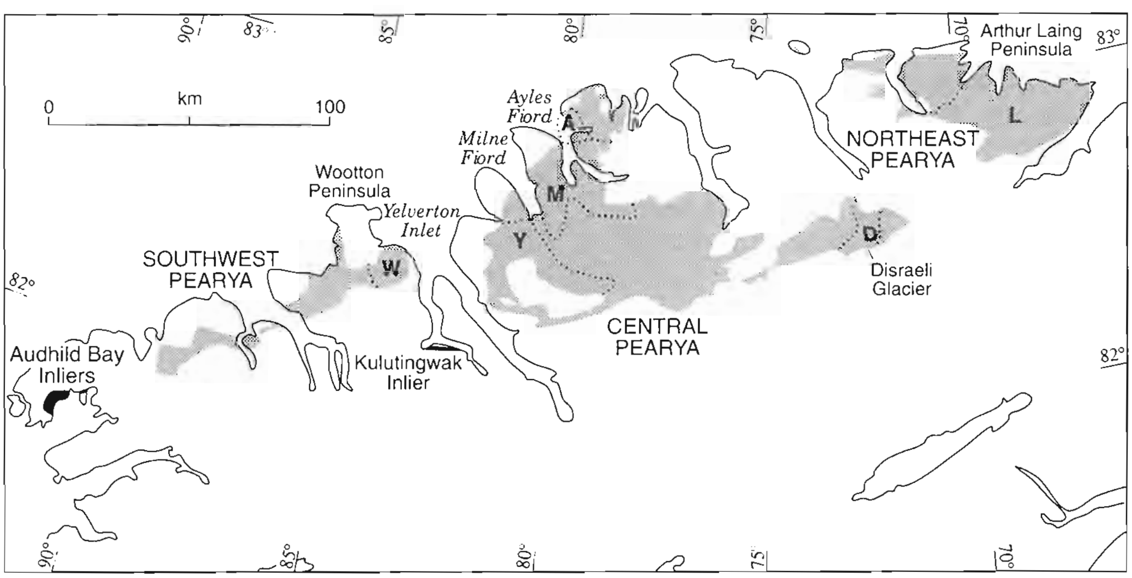


Figure 90. *Generalized outcrop areas of Succession 2 and areas in which preliminary stratigraphic units have been established (A: Ayles Fiord, D: Disraeli Glacier, L: Arthur Laing Peninsula, M: Milne Fiord-Milne Glacier, W: Wootton Peninsula, Y: Yelverton Inlet).*

The lithological units are summarized in Appendix 2 by area and will not be reviewed here.

Preliminary stratigraphic units

A tentative stratigraphic order has been established in six areas (Fig. 90 and Table 15). The local lithostratigraphic units are designated by combined upper-case letter and number symbols, or, in one case, by an upper-case letter only. They are listed below in alphabetic order:

A: Northeast of lower Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*), unit A

D: East and west of the upper reaches of Disraeli Glacier (*M'Clintock Inlet* and *Clements Markham Inlet–Robeson Channel*), units D1 to D3

L: Arthur Laing Peninsula (*Clements Markham Inlet–Robeson Channel*), units L1 to L6

M: East of Milne Fiord and Milne Glacier (*Yelverton Inlet* and *M'Clintock Inlet*), units M1 to M5

W: Northeastern Wootton Peninsula (*Yelverton Inlet*), units W1 to W3

Y: Northeast of Yelverton Inlet (*Yelverton Inlet*), units Y1 to Y4

None of these units are well enough known to be defined as formal stratigraphic units, but some are clearly of formational rank, and two of these, which probably have equivalents in other areas, are given informal names in addition to the letter-number symbols (L2: Gypsum River diamictite, L4: Mount Hornby carbonates).

Although no diagnostic fossils have been found in Succession 2, three important stratigraphic markers are present:

1. A diamictite that is probably glaciogenic in origin and late (but not latest) Neoproterozoic (Varanger) in age (nomenclature of Harland et al., 1993).
2. A thick, cliff-forming carbonate unit, probably not more than a few hundred metres stratigraphically above the diamictite, which has yielded sponge spicules of probable Phanerozoic age and likely is Early Cambrian in age.
3. A radiometrically dated phyllite and tuff unit of Early Ordovician age, which occurs in the upper part of the succession.[1]

Using these markers and some other lithological correlations, the 22 lithostratigraphic units listed above can be reduced to a total of 13, falling into six generalized age groups. The key units are map unit A at Ayles Fiord, map units L1 to L6 on Arthur Laing Peninsula, and map units M1 to M4 east of Milne Fiord and Milne Glacier (M1 to M4), although M4 is problematic. In addition, two fault-bounded units from northeast of Yelverton Inlet (Y1) and from northeastern Wootton Peninsula (W1) have been inserted into this framework (Table 15). It should be noted that the tentative framework presented here is incomplete, probably with major gaps in the earlier part of the Neoproterozoic and within the Cambrian, between units L5 and M1. Some of the missing pieces in this puzzle may be represented by lithological units of unknown stratigraphic position. Because of the uncertain age of most units and space limitations on the maps, the customary upper-case letter symbols indicating Period are not used for Succession 2, but tentative ages are mentioned on the legends.

A brief summary of the major age groups and generalized lithostratigraphic units follows. A systematic description of all lithostratigraphic units with references to analytical data is given in Appendix 2, along with the descriptions of the lithological units.

Units of assumed Neoproterozoic, pre-Varanger age

The informal age designation, pre-Varanger, is used for all strata above Succession 1 and below the Gypsum River diamictite (map unit L2) and its equivalents. The stratigraphy of this interval is largely unknown, but three distinct units (1 to 3, below) are recognized and some other units that have a rather uncertain position.

1. Map unit A. Map unit A comprises schist, quartzite, and marble exposed northeast of the northwestern part of Ayles Fiord (*M'Clintock Inlet*). The fact that several inliers of Succession 1 occur within map unit A (Figs. 85, 87) suggests it represents the oldest part of Succession 2. The lowermost parts of map unit A are probably exposed in an anticline about 13 km southeast of the mouth of Ayles Fiord. There, light-grey gneiss of Succession 1 with a weak, secondary

[1]This unit is Late Cambrian in age according to the time scale of Tucker and McKerrow (1995).

Table 15

Pearya, Succesion 2: age and correlation of lithostratigraphic units

Age	Wootton Peninsula	NE of Yelverton Inlet	NE of Milne Fjord –Milne Glacier	NE of Ayles Fjord	Disraeli Glacier	Arthur Laing Peninsula
Early Ordovician[1]			M5 quartzite (may be thrust sheet of older rocks)			
Early Ordovician[1]			M4 phyllite, minor carbonates, volcanics (±900 m) (503 Ma near top)			
Early Ordovician and/or Cambrian			M3 marble, minor dolostone (>150 m?)			
Early Ordovician and/or Cambrian			M2 phyllite, schist, mafic metavolcanics, quartzite, carbonates			
Early Ordovician and/or Cambrian			M1 dolostone, marble, minor phyllite, tuff (base concealed)			
Cambrian						L6 (top eroded) quartzite, minor phyllite (multicoloured, glauconitic) (base concealed)
Cambrian		Y4 phyllite, carbonates; minor tuff			D3 (top faulted) mudrock, minor greywacke	L5 (top eroded) photogeological unit; phyllite, quartzite near base
Cambrian	W3 marble, dolostone	Y3 marble, dolostone			D2 dolostone (>300 m) (fault)	L4 Mount Hornby carbonates: marble, dolostone, minor quartzite (sponge spicules) (?>300 m)
Cambrian and/or latest Neoproterozoic	W2 (stratigraphy uncertain)	Y2 (stratigraphy uncertain)				L3 photogeological unit, multicoloured quartzite and phyllite at top
Neoproterozoic, Varanger	W2 diamictite	Y2 diamictite				L2 Gypsum River diamictite; diamictite, minor phyllite (±200 m)
Neoproterozoic pre-Varanger	W2 (stratigraphy uncertain; base concealed)	Y2 (stratigraphy uncertain; base concealed)			D1 quartzite, phyllite, minor tuff, carbonates (base concealed)	L1 volcanogenic conglomerate and sandstone; quartzite, phyllite; minor tuff, carbonates (base concealed)
Neoproterozoic pre-Varanger	W1 (top eroded) quartzite, phyllite (base concealed, thrust over W2)	Y1 (top eroded) quartzite, phyllite (base concealed, thrust over Y2)				
Neoproterozoic pre-Varanger				A (top eroded) schist, quartzite, minor carbonates (sheared nonconformity?)		
Earliest Neoproterozoic and/or older				Succession 1 granitoid gneiss		

[1]Unit M4 is probably Late Cambrian.

foliation is abruptly overlain by medium-dark-grey, pyritic mica schist (Figs. 85, 86) that probably represents a metamorphosed mudrock deposited in an oxygen-poor environment. The overlying strata consist of interbedded mica schist and very fine to medium grained quartzite. The gneiss-schist contact may represent the inferred nonconformity between Successions 1 and 2, but probably functioned as a detachment during Ordovician and later deformations because the internal structure of map unit A is more complex than the contact between it and Succession 1. Moreover, the absence of a basal conglomerate or arkosic sandstone suggests that lowermost strata of map unit A may have been removed by differential movements along this surface.

Marble and interbedded marble, schist, and quartzite reported from an area farther northwest (Frisch, 1974, p. 29) probably occur in the upper part of map unit A.

2. Map units Y1 and W1. Y1 and W1 probably include the oldest exposed strata of Succession 2 in the area northeast of Yelverton Inlet and on northern Wootton Peninsula (*Yelverton Inlet*), respectively. In contrast to map unit A at Ayles Fiord, however, they are not in contact with Succession 1 and probably are younger than map unit A. The two are tentatively correlated because both consist of sandy and pelitic metasediments.

Part of map unit Y1 occurs as a thrust sheet within the northern part of an extensive outcrop area of map unit Y2, northeast of Yelverton Inlet. This sheet consists of interstratified quartzite and argillaceaous phyllite or schist. The quartzite is composed of poorly sorted, very fine to very coarse sand grains and granules of quartz and minor feldspar in a metamorphosed silty-argillaceous matrix. The average feldspar content, according to uncorrected XRD analyses, is only 4.7 per cent (Appendix 3, Table 79, corrected value about 8%) but some laminae are rich in feldspar. Albite is dominant over K-feldspar, but the mineral commonly shows chessboard twinning, indicative of albitized K-feldspar. These are the kind of strata one would expect at the base of Succession 2, but which are absent from map unit A at lower Ayles Fiord. Similar rocks, also assigned to map unit Y1, occur in an uplifted fault block about 2.5 km northeast of Yelverton Inlet.

Map unit W1 on northeastern Wootton Peninsula has locally been thrust over the diamictite-bearing map unit W2 of probable Varanger age (see below) and is assumed to be older than the latter. Its base and top are not exposed. The unit is composed of quartzite and interbedded argillaceous phyllite or slate. It occurs mainly as felsenmeer and primary structures are generally obscure, but medium-scale planar crossbedding is locally preserved. The quartzite is very fine to very coarse grained with maximum grain sizes up to granule grade and moderately or poorly sorted. The feldspar content is low (2% in XRD analyses; Appendix 3, Table 88), but may have been diminished by diagenetic or metamorphic processes that transformed it into a matrix of white mica, chlorite, and quartz.

3. Map unit L1. The upper strata of the pre-Varanger part of Sucession 1 are represented by map unit L1 on Arthur Laing Peninsula (*Clements Markham Inlet)*, and are overlain by strata of assumed Varanger age (map unit L2). The base of map unit L1 is concealed. An estimated 200 m of strata, truncated at the top by a fault, are exposed on the northeastern limb of an anticline southeast of the head of Markham Fiord. In ascending order, the following three units are distinguished:

1. Volcanic pebble conglomerate; cobbly, composed mainly of felsic volcanic rock fragments with minor sand-grade quartz and feldspar.

2. Volcanogenic pebble conglomerate, pebbly sandstone, and sandstone, all composed of felsic volcanic rock fragments, chert(?), and sand grade quartz and feldspar. Also present are felsic tuff and a porphyritic flow (andesite?; Fig. 91, no. 1; Table 16; Appendix 4A, Tables 1, 2-10, 3-10).

3. Calcareous marble, argillaceous phyllite, and calcareous-dolomitic phyllite.

Other rock types in the area include quartzite, quartzose and volcanogenic sandstone, quartzose and dolomitic siltstone, and interlaminated slate and microcrystalline dolostone.

The uppermost part of map unit L1 is exposed in a small area northwest of the mouth of Gypsum River (*Clements Markham Inlet).* It comprises felsic tuff, very fine to medium grained quartzite, and thin units of dolostone and calcareous and dolomitic marble.

Units of uncertain position (parts of map units Y2, W2, and D1). Map unit Y2 (*Yelverton Inlet* and *M'Clintock Inlet*) contains a considerable variety of rock types including the diamictite and overlying clastic metasediments discussed below. The remainder, probably equivalent to middle and upper parts of the interval discussed here, comprises: interbedded dark grey phyllite or staurolite-bearing schist (map unit

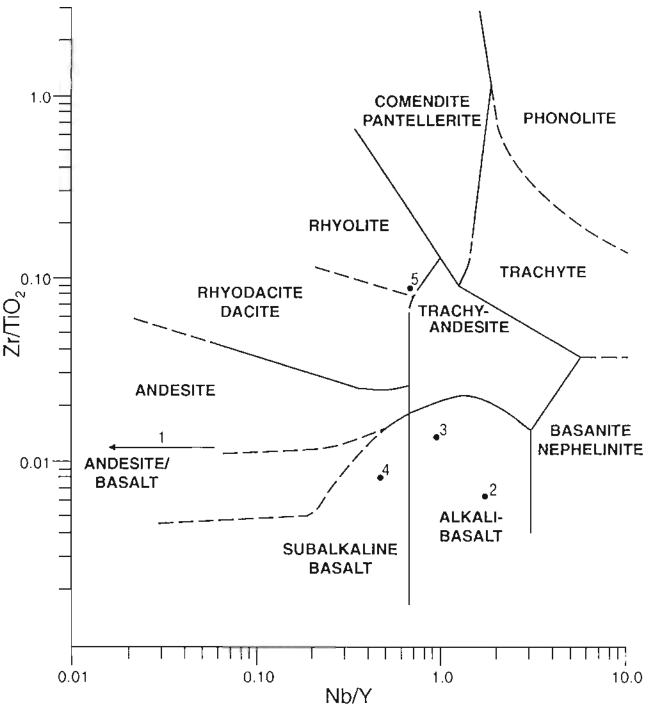


Figure 91. *Volcanic rocks of Succession 2: stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6); no. 1: map unit L1 southeast of Markham Fiord; nos. 2 and 3: map unit D1 at Disraeli Glacier; no. 4: map unit M2v north of upper Ayles Fiord; no. 5: map unit 4 northeast of Milne Glacier.*

Y2ss) and quartzite (possibly including map unit Y2?qs); carbonate units (map unit Y2c) that are thinner than map unit Y3 and not mappable from air photographs; dark grey, sheared and stretched chert, and minor occurrences of felsic volcanics. Chert has not been seen anywhere else in Succession 2 and the rocks may represent fault slices of the Hazen Formation. However, detrital chert is present in the diamictite, along with other lithic fragments that were probably derived from the lower part of Succession 2.

Map unit W2 on Wootton Peninsula comprises equivalents of the Gypsum River diamictite, of assumed Varanger age, as well as other rock types that are probably both older and younger than the diamictite. The latter include phyllite, thin units of marble and dolostone, and minor quartzite.

Map unit D1 at Disraeli Glacier (*M'Clintock Inlet* and *Clements Markham Inlet*) includes: quartzite and quartzose siltstone; phyllite, including calcareous-dolomitic and tuffaceous varieties, and minor amounts of crystal tuff and marble, which is calcareous and dolomitic, and in part silty and sandy. The quartzite consists of rounded, poorly sorted sand grains, granules, and fine pebbles of quartz in a matrix of chlorite, mica, and silt-sized quartz. Two analyzed samples of tuff are alkali basalt according to their trace element compositions (Fig. 91, nos. 2, 3; Table 16; Appendix 4A, Tables 1, 2-10, 3-10, nos. 2, 3). The discordant major element classifications (calc-alkaline andesite and dacite) probably reflect alteration. The trace element ratios lie in the fields of within-plate basalt and of calc-alkaline basalt on the Pearce-Cann diagram (Fig. 92), and in the field of within-plate alkali basalt on the Meschede diagram (Fig. 93).

Map unit D1 is in fault contact with a carbonate unit (D2) comparable to the Cambrian Mount Hornby carbonates (L4), and its stratigraphic position is uncertain. The tentative assignment to the pre-Varanger part of the Neoproterozoic is based on similarities with map unit Y1 – both contain bimodal quartzite – and with map unit L1, which it resembles in overall lithological composition.

Units of assumed Varanger age

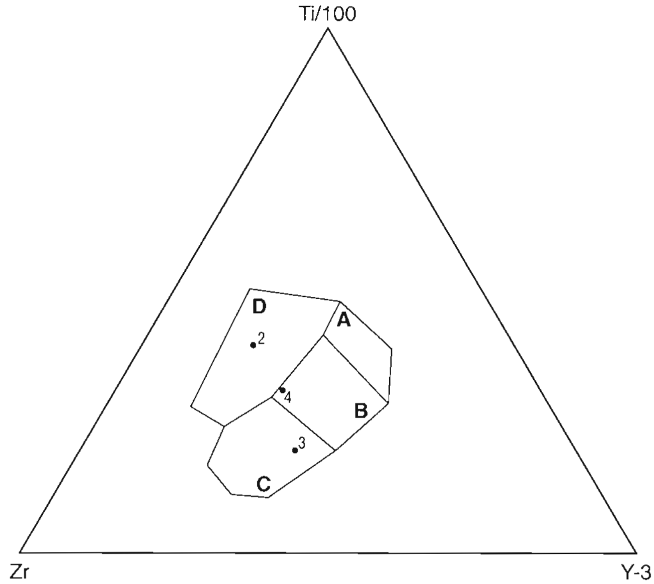
4. Map unit L2 (Gypsum River diamictite) and equivalents. Diamictite has been mapped separately on Arthur Laing Peninsula (*Clements Markham Inlet)* as map unit L2 and is included with other rock types in several other units briefly discussed below. Map unit L2, also referred to as the Gypsum River diamictite, should eventually be redefined as a formation, but the information available now is insufficient for that purpose. Where examined, the stratigraphic base and top of the unit were concealed, and the exposures were unsuited for detailed measurement and description

Table 16

Pearya, Succession 2: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

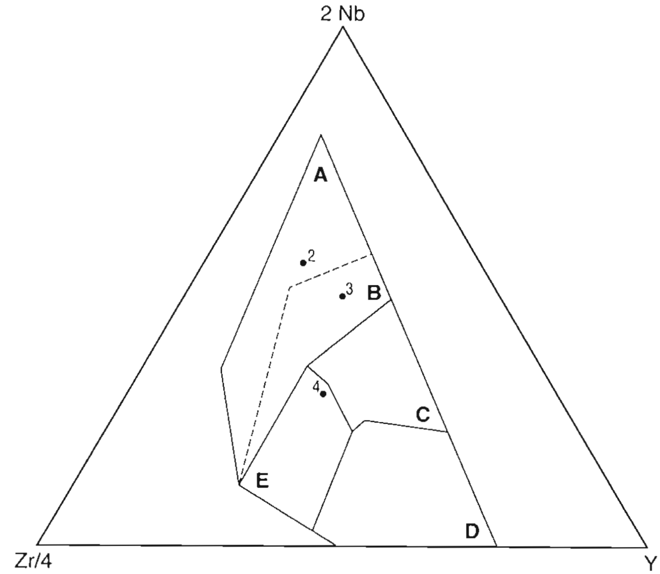
No.	Trace elements	Major elements
Map unit L1		
1	andesite	rhyolite (K-poor)
Map unit D1		
1	alkali basalt	calc-alkaline dacite (K-poor)
1	alkali basalt	calc-alkaline andesite (K-poor)
Map unit M2v		
1	subalkaline basalt	tholeiitic basalt (K-poor)
Map unit M4		
1	rhyolite[1]	rhyolite

[1]Close to boundary with rhyodacite/dacite.



Mainly low-K tholeiite . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . D

***Figure 92**. Volcanic rocks of Succession 2: tectonic environments inferred from trace element ratios (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt . . . . A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . E

***Figure 93**. Volcanic rocks of Succession 2: tectonic environments inferred from trace element ratios (after Meschede, 1986, fig. 1).*

because of their massive character and lack of attitude control.

Judging from the topographic relief of nearly horizontal strata near Mount Disraeli, the unit is at least 200 m thick. It consists chiefly of diamictite, with lesser amounts of interlaminated original mudrock that has been metamorphosed to phyllite or slate. The diamictite is more resistant to weathering than all other rock types on Arthur Laing Peninsula, except for the Mount Hornby carbonates. Outcrops southeast of Markham Fiord are intensely altered by limonite.

The diamictite could, alternatively, be classified as conglomeratic greywacke and greywacke. A coarse fraction consisting of relatively sparse pebbles and cobbles and more abundant sand is embedded in a recrystallized argillaceous matrix (Figs. 94–96) that is probably primary.

Cobbles and large pebbles consist of carbonate rocks, predominantly silty and sandy dolostones. Smaller pebbles are composed of carbonate rocks, calcareous sandstone and siltstone, mudrock, and chert. The sand fraction includes a considerable variety of detrital grains: well rounded quartz; siltstone fragments; grains of chert that are pure or argillaceous, unmetamorphosed or stretched; volcanic rock fragments of felsic or intermediate composition; altered pyroclastic material; feldspar, predominantly albite; relatively large flakes of biotite; aggregates of chlorite; phyllite composed mainly of white mica and folded on a microscopic scale; fine grained schist, composed mainly of quartz and white mica; and detrital chalcedony.

The mud fraction is composed chiefly of quartz with lesser amounts of feldspar, calcite, dolomite, chlorite, and mica. Zircon and tourmaline are relatively common heavy minerals. The interbedded phyllites or slates are comparable in composition to the matrix of the diamictites.

The lithic clasts are reminiscent of rock types in the upper part of the pre-Varanger Succession 1. This may imply an unconformity at the base of the Gypsum River diamictite.

The Gypsum River diamictite (map unit L2) is an unusual unit that has no counterpart in the entire

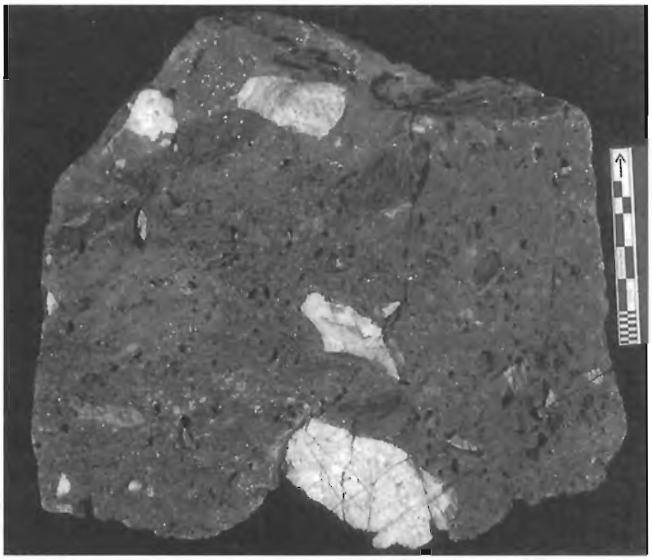


*Figure 94. Gypsum River diamictite (Mount Disraeli Belt, map unit L2) southeast of head of Markham Fiord (**Clements Markham–Robeson Channel**). Light coloured pebbles are carbonate rocks. ISPG photo 1878-36.*

*Figure 95. Diamictite in map unit Y2, northeast of Yelverton Inlet (**Yelverton Inlet**). ISPG photo 1025-2 (by T.O. Frisch).*

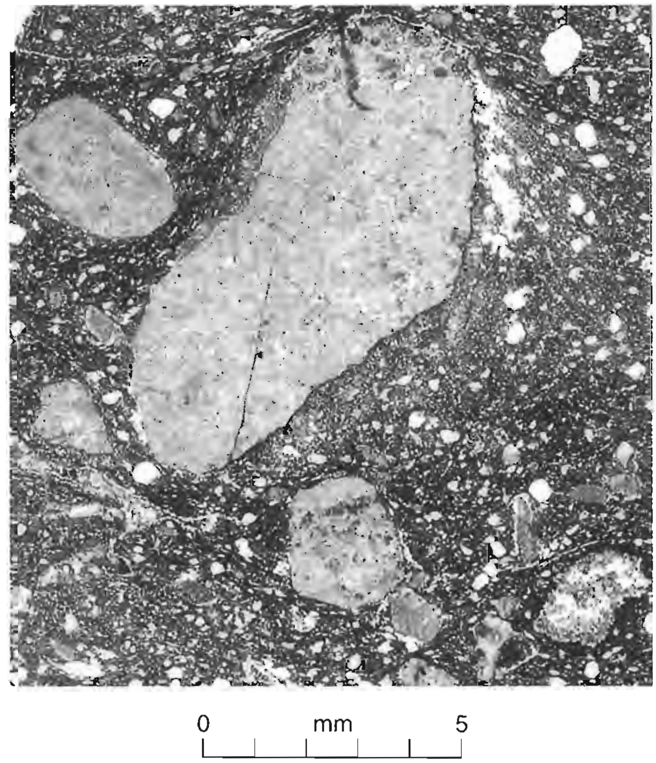


Figure 96. Photomicrograph (cross-polarized light) of diamictite in map unit W2 on Wootton Peninsula. Pebbles, granules, and sand grains of microcrystalline dolostone and quartz sand and silt (clear) in recrystallized argillaceous matrix. ISPG photo 2761-5.

Precambrian to Tertiary stratigraphy of the Arctic Islands. On the other hand, it is similar in composition and texture to upper Neoproterozoic diamictites in other regions, including the Cordillera (Aitken, 1991), central East Greenland (Hambrey and Spencer, 1987), and Svalbard (Harland et al., 1993) that are of glaciogenic origin, although this has not yet been proven for the present unit. The largely massive diamictites characteristic of map unit L2 are probably mainly "subglacially-deposited meltout or lodgement till, or waterlain till deposited close to the grounding line of a floating glacier tongue" (Fairchild et al., 1989, Table 1) or subaqueous debris flow deposits derived from such tills. In other regions the term diamictite has also been applied to laminated, fine grained, clastic sediments with ice-rafted dropstones, but this rock type has not been recognized in Succession 2.

The Varanger glaciation involved two glacial episodes separated by an interglacial. If the Gypsum River diamictite is indeed glaciogenic in origin and Varanger in age, why is only one glaciogenic unit present in Pearya? Perhaps map unit L2 represents the older glaciogenic unit and the younger one has been removed by erosion at an unconformity that occurs either at the base of map unit L3 or within it.

The overall time limits of the Varanger glaciation are tentatively placed at 610±10 to 590±20 Ma by Harland and co-authors (1993, table 1). It coincides with the Varanger Epoch, the older of two epochs recognized by Harland and others (1982, 1990) within the Vendian Period.[1]

Diamictites comparable in composition and texture to map unit L2 occur in several other areas. Northeast of Yelverton Inlet they are included in the upper part of map unit Y2 (*Yelverton Inlet*, map units Y2x and Y2xq; compare Figs. 94, 95); on northeastern Wootton Peninsula in map unit W2 (*Yelverton Inlet*); and between Phillips and Imina inlets in map unit cqps (*Otto Fiord* and *Cape Stallworthy-Bukken Fiord;* see Appendix 2). The internal stratigraphy of map unit Y2 is poorly known and that of the other two units is unknown.

In addition, Succession 2 includes phyllites and greywackes different in composition and texture, but nevertheless reminiscent of the typical diamictite of map unit L2. These rocks are characterized by poorly sorted sand, predominantly of well rounded quartz, randomly distributed either in an abundant recrystallized argillaceous matrix or in laminated phyllite. On Arthur Laing Peninsula such rocks occur within the undivided map unit L1-4, close to mapped outcrops of L2. They have also been observed in map unit Y2 (northeast of Yelverton Inlet; *Yelverton Inlet*) and in the map unit pwqc south of Cape Richards (*M'Clintock Inlet*; see Appendix 2).

Units of assumed latest Neoproterozoic and/or Cambrian age

This age group comprises strata assigned to map unit L3 on Arthur Laing Peninsula (*Clements Markham Inlet),* that lie between the diamictites (map unit L2 and probable equivalents) and carbonates of probable Early Cambrian age (map unit L4 and probable equivalents). The Proterozoic–Cambrian boundary is disconformable in most of the world (Myrow and Hiscott, 1993; Landing, 1994). If the assumed ages for map units L2 and L4 are correct, then a disconformity is probably present at the base of map unit L3, within it, or at its top, but this has not been confirmed because the contacts of map unit L3 were covered where examined.

5. Map unit L3 and equivalents (parts of map units Y2 and W). Map unit L3 is a recessive, poorly known unit. The uppermost part consists of very fine grained, silty quartz sandstone and slaty or phyllitic mudrock, both coloured in hues of grey, red, and brown. The lower and upper contacts are concealed.

Strata equivalent to map unit L3 may be present in the upper parts of map units Y2 and W2 but have not been differentiated from older parts of these units.

Units of assumed Cambrian age

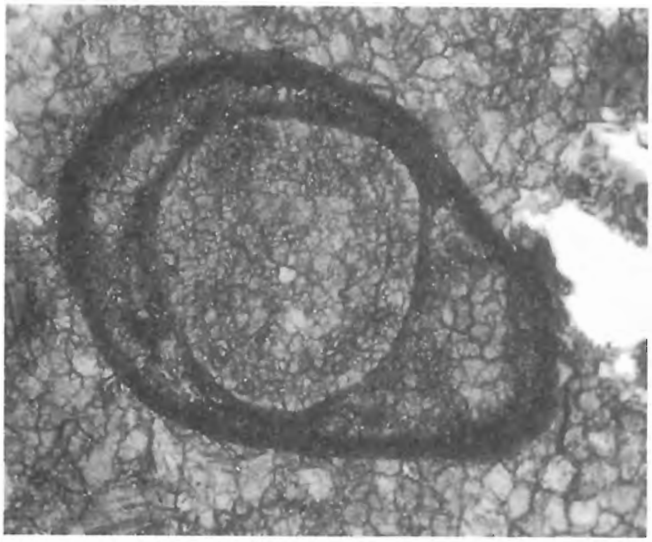
Three successive units on Arthur Laing Peninsula, L4, L5, and L6, and their equivalents in other areas are tentatively assigned to the Cambrian.

6. Map unit L4 (Mount Hornby carbonates) and equivalents. Map unit L4, informally referred to as the Mount Hornby carbonates, is a cliff-forming succession of potentially formational rank. It has a minimum thickness of 300 m, inferred from the topographic relief of nearly horizontal strata on central Arthur Laing Peninsula (*Clements Markham Inlet).* The contact with map unit L3 was covered where examined. The unit consists mainly of carbonate rocks, but also includes minor amounts of quartzite. The carbonate rocks are medium light to medium dark grey, variably recrystallized, and partly replaced by quartz or chert. Some original textures are preserved and the following rock types have been identified: lime mudstone; packstone composed of micritic peloids and broken ooids; sandy and dolomitic oncolite (Figs. 97, 98); oncolitic flat-pebble conglomerate; massive, microcrystalline dolostone, and microcrystalline to very finely crystalline dolostone, containing silt and very fine sand grade quartz, and thin flat laminae and small-scale crosslaminae. The quartzite is medium to medium dark grey, and the quartz is fine to coarse grained and well rounded. Some rocks contain intraclasts of carbonate rocks, others have a dolomitic matrix.

[1]The International Union of Geological Sciences (Plumb, 1991) has accepted three periods/systems in the Neoproterozoic that are defined by absolute age boundaries as follows – Tonian: 1000-850 Ma; Cryogenian: 850-650 Ma; Neoproterozoic III: 650 to base of Cambrian. The name, Cryogenian implies a glaciogenic origin for the most characteristic deposits of this period, but the absolute time limits chosen are clearly too old. It would have been more useful to define the Cryogenian on the basis of paleoclimatic-lithological criteria, as proposed by Harland and co-authors (1993) for the Varanger Epoch.

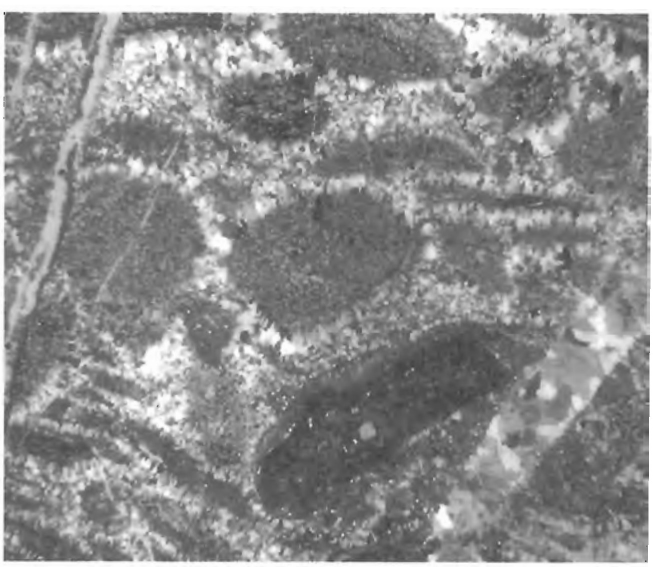
Acid leaching of a partly silicified oncoidal-peloidal limestone produced fragmentary spicules (Fig. 99) that were probably derived from a hexactinellid sponge of unspecified Phanerozoic age (T. de Freitas, Appendix 5C, GSC loc. C-194741). If so, map unit L4 is probably Early Cambrian in age because it occurs not far above the Varanger diamictites.

Map unit Y3, a carbonate unit exposed northeast of Yelverton Inlet (*Yelverton Inlet* and *M'Clintock Inlet*), is tentatively correlated with the Mount Hornby carbonates because it occurs probably no more than a few hundred metres above strata comparable to the Gypsum River diamictite. The unit is estimated to be several hundred metres thick, and consists of cliff-forming dolostone and variably recrystallized limestone that are light to medium grey, partly silty



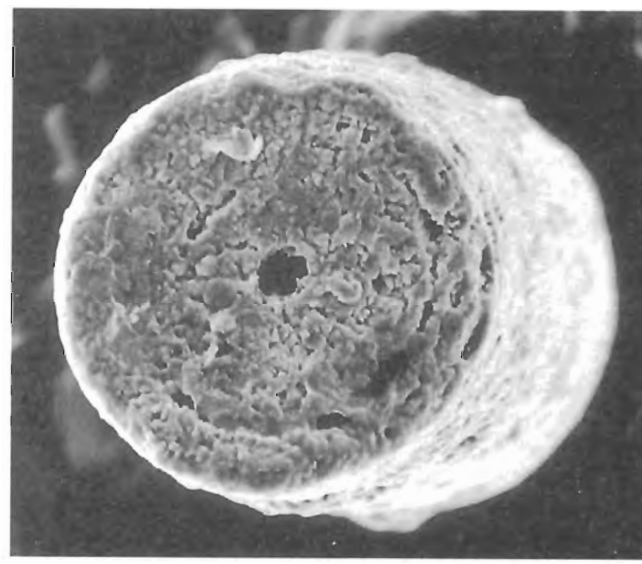
0 mm 0.5

***Figure 97**. Photomicrograph (cross-polarized light) of coated grain (microscopic oncoid) in dolostone of map unit L4 (Mount Hornby carbonates) on southeastern Arthur Laing Peninsula. ISPG photo 4227-16.*

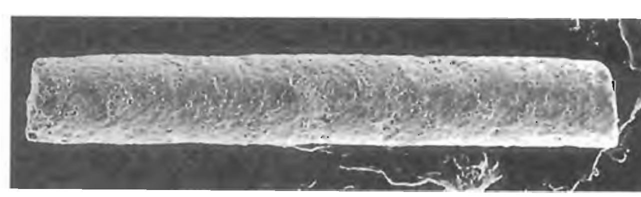


0 mm 2

***Figure 98**. Photomicrograph of oncolite, largely replaced by quartz, in map unit L4, southeastern Arthur Laing Peninsula (**Clements Markham–Robeson Channel**). ISPG photo 4227-9.*



0 mm 0.04



0 mm 0.2

***Figure 99**. SEM photographs of a sponge spicule from map unit L4 (Mount Hornby carbonates) on southeastern Arthur Laing Peninsula (**Clements Markham Inlet**). ISPG photos 4092-61 and 4092-28 by D.H. McNeil.*

and sandy, and show some silica replacement. The contacts of map unit Y3 have not been observed.

Map unit W3, a carbonate unit on northeastern Wootton Peninsula (*Yelverton Inlet*), is correlated with the Mount Hornby carbonates because it overlies the diamictite-bearing map unit W2 in a synclinal structure. The contact has not been observed. Widespread carbonate rocks on northwestern Wootton Peninsula that are in fault contact with map unit W2 are tentatively assigned to map unit W3. These strata consist mainly of microcrystalline dolostone and variably recrystallized lime mudstone, some of which are pale red.

Map unit D2, a cliff-forming carbonate unit at Disreali Glacier (*M'Clintock Inlet* and *Clements Markham Inlet*) comprises probably more than 300 m of medium to medium dark grey dolostone partly replaced by quartz and minor chert. It is in fault contact with map unit D1 and overlain by dark grey clastic strata (map unit D3) that on air photographs are reminiscent of map unit L5.

7. Map unit L5 and equivalents. Map unit L5 of Arthur Laing Peninsula is known mainly from photogeological interpretation. It is a dark, recessive unit that overlies the lighter Mount Hornby carbonates in synclinal structures. Its base has not been seen exposed and its top is not preserved. Basal strata of the unit, exposed in a syncline west of lower Doidge Bay (*Clements Markham Inlet),* consist of interlaminated light grey, very fine grained quartzite, and dark grey phyllitic siltstone.

Map unit Y4 is a dark, recessive unit that overlies lighter carbonates of map unit Y3 on the southwest side of Milne Glacier (*Yelverton Inlet* and *M'Clintock Inlet*). If, as assumed, map unit Y3 is correlative with the Mount Hornby carbonates, then map unit Y4 must be equivalent to map unit L5. Map unit Y4 is composed of light to medium dark grey or greenish grey phyllite, metavolcanics, and carbonate beds that are a few metres thick. Green and red, calcareous-dolomitic phyllite observed in an area southwest of Milne Glacier (*M'Clintock Inlet*), is provisionally included in this unit because it seems to overlie map unit Y3.

Map unit D3 overlies map unit D2 with an abrupt contact at Disraeli Glacier (*M'Clintock Inlet*). It consists of an estimated 60 to 100 m of mudrock and minor greywacke. The mudrock is medium dark grey and variably calcareous-dolomitic. The greywacke consists of sand to pebble-grade clasts of chert, felsic volcanics, carbonate rocks, and mudrock in an argillaceous matrix. If, as tentatively assumed, map unit D2 is correlative with the Mount Hornby carbonates (map unit L4), then map unit D3 is probably correlative with L5.

8. Map unit L6. This unit is exposed only in a small graben on southeastern Arthur Laing Peninsula (*Clements Markham Inlet)* and is bordered on three sides by map unit L4. The structural relations imply that it is younger than map unit L4. If so, it must also be younger than map unit L5, which overlies L4 in other areas. This unit consists of greenish- and purplish-grey weathering quartzite and minor phyllite. The quartzite is very fine and fine grained and partly laminated. In addition to quartz it contains some albite, chlorite, and white mica; the last two minerals are partly pseudomorphous after glauconite. It is interesting to note that chlorite and white mica, pseudomorphous after glauconite, are common in the Ellesmere Group and in the upper part of the Grant Land Formation, both of which are Early Cambrian in age (Trettin, 1994, chapters 3, 4).

Units of probable Cambrian and/or Early Ordovician age

This age group includes three successive units, M1 to M3, exposed east of Milne Fiord and Milne Glacier and in the vicinity of Ayles Fiord, that underlie a radiometrically dated unit of Tremadoc age (M4). They are probably younger than map units Y2 to Y4, from which they are separated by Milne Fiord and Milne Glacier.

9. Map unit M1. This is a carbonate-rich unit widely exposed between Milne Glacier and M'Clintock Inlet. The most prominent exposures are in an anticlinorium south of upper Ayles Fiord (*M'Clintock Inlet).* There, a resistant lower unit (map unit M1a), composed mainly of carbonate rocks and minor phyllite, appears to have been thrust over an upper, more recessive unit that contains a larger proportion of phyllite (map unit M1b). The base of map unit M1 is not known to be exposed. The carbonate rocks are light to medium dark grey and partly silty and sandy, very fine grained dolostones and calcareous marbles. The phyllites include medium dark grey, quartzose and carbonate-rich metasediments, as well as light brownish grey, albite-rich metamorphosed tuff.

10. Map unit M2. Map unit M2, composed of recessive weathering phyllite, schist, metavolcanics, quartzite, and thin carbonate units, overlies map unit M1 in anticlinal structures, but the contact is not exposed. The internal structure of the unit is complex and its stratigraphy is uncertain. Carbonate rocks and volcanics have been mapped separately north of central Ayles Fiord (map units M2c and M2v). Phyllite and schist are argillaceous, and partly calcareous and dolomitic. The metamorphism, represented by white mica, chlorite, chloritoid, biotite, garnet (spessartine with almandine and pyrope components in one sample; see section on Phanerozoic intrusions, Ayles Fiord Intrusion, host rock), or staurolite (Fig. 100), ranges from lower greenschist to lower amphibolite grade.

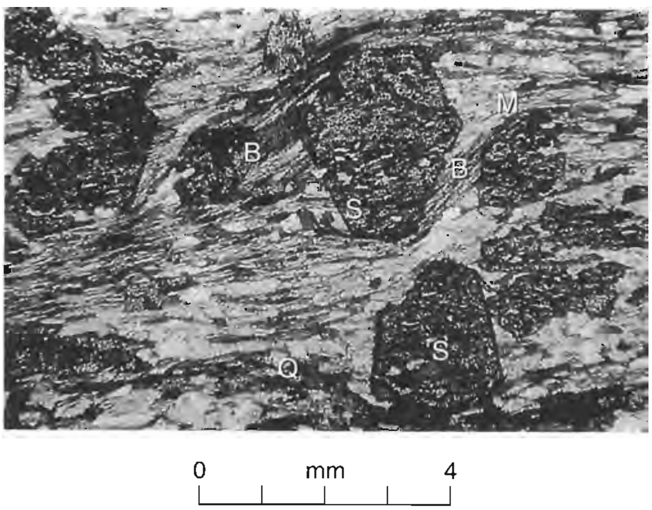


***Figure 100.** Photomicrograph (ordinary light) of schist in map unit M2 northeast of Ayles Fiord. **(M'Clintock Inlet)**, showing biotite* (B), *white mica* (M), *quartz* (Q), *and coarse porphyroblasts of staurolite* (S) *with numerous inclusions. ISPG photo 2260-64.*

The metavolcanics are phyllitic and probably consist mainly of tuff and lesser flows. A chemically analyzed flow rock is classified as subalkaline basalt on the basis of trace elements and as tholeiitic basalt on the basis of major elements (Table 10, Fig. 91, no. 4; Appendix 4A, Tables 1, 2-10, 3-10, no. 4). The Meschede plot (Fig. 93) suggests a within-plate tholeiite.

The carbonate rocks are medium or medium dark grey, variably calcareous, dolomitic, silty, or sandy, and show varying degrees of metamorphic recrystallization.

11. Map unit M3. Map unit M3, together with map units M4 and M5, is exposed in an arcuate belt that extends from northeast of Milne Glacier to northeast of middle Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*; Figs. 101-103). These three units, which were previously referred to as divisions 1 to 3 of the Milne Fiord assemblage (Trettin, 1987b), form a series of folds that are less complex than structures in the older parts of Succession 2. Map unit M3 is about 150 to 200 m thick (Appendix 1, sections northeast of Ayles Fiord and northeast of Milne Glacier) and has an abrupt lower contact. It consists mainly of medium light grey marble with some relic micritic texture, and of minor proportions of dolostone.

Units of established and possible Early Ordovician age

This age group includes a lower unit of phyllite and volcanic rocks with an Early Ordovician radiometric age (M4) and, provisionally, an upper unit of quartzite (M5), but the stratigraphic position and age of the latter are problematic.

12. Map unit M4. This unit overlies M3 with an abrupt contact and has an apparent thickness of about 900 m in the section northeast of Milne Glacier (Appendix 1). It consists mainly of phyllite with minor proportions of tuff and local carbonates. The phyllite is medium grey, medium dark grey, or greenish grey and partly calcareous-dolomitic. In the section northeast of Milne Fiord (Appendix 1) map unit M4 includes a 68 m thick sub-unit, composed of impure dolostone, lime mudstone and minor interlaminated phyllite. The strata contain flat laminae and small-scale cross-laminae. In the section northeast of Milne Glacier (Fig. 102) it contains two or more beds of tuffaceous schist in the lower and middle parts, and a sheared rhyolite flow or welded tuff (Table 16, Fig. 91, no. 5; Appendix 4A, Tables, 1, 2-10, 3-10, no. 5) in the uppermost part. The latter yielded a U-Pb (zircon) age of 503.2 +7.8/-1.7 Ma (Trettin et al., 1987), Tremadoc according to the adopted time scale (Fig. 2).[1]

13. Map unit M5. The lower contact of map unit M5 with M4 is abrupt in the section northeast of Milne Fiord and gradational in the section northeast of Milne Glacier. Its top is not preserved. It has a minimum thickness of 120 m in the section northeast of Milne Fiord (Fig. 103). An apparent thickness of about 550 m in the section northeast of Milne Glacier obtained by photogrammetry, appears to be excessive and suggests unrecognized structural repetitions.

[1]As mentioned earlier, according to Tucker and McKerrow (1995) the age is Late Cambrian with confidence limits in the Middle and Late Cambrian. It also allows a Late Cambrian age for map unit M5, which would be more acceptable than an Early Ordovician age.

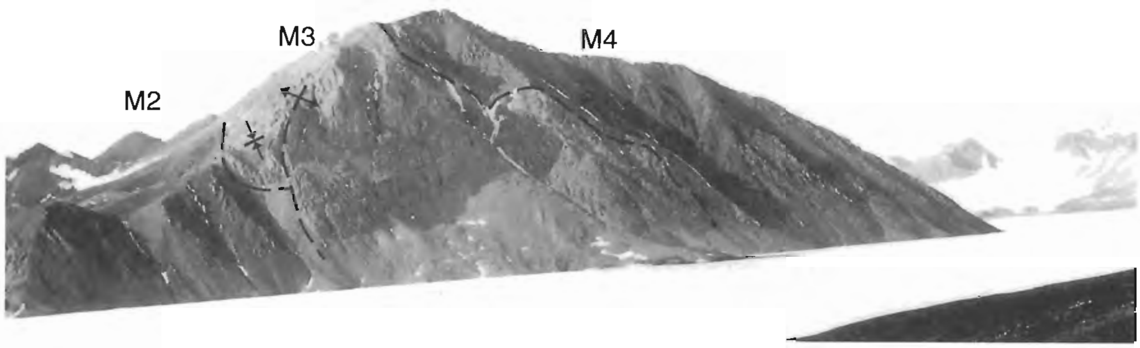


*Figure 101. Map units M2, M3 and M4 on southwest side of Ayles Fiord (**M'Clintock Inlet**), view southwest. All three units are complexly deformed, and the two most obvious folds are indicated. ISPG photo 978-60.*

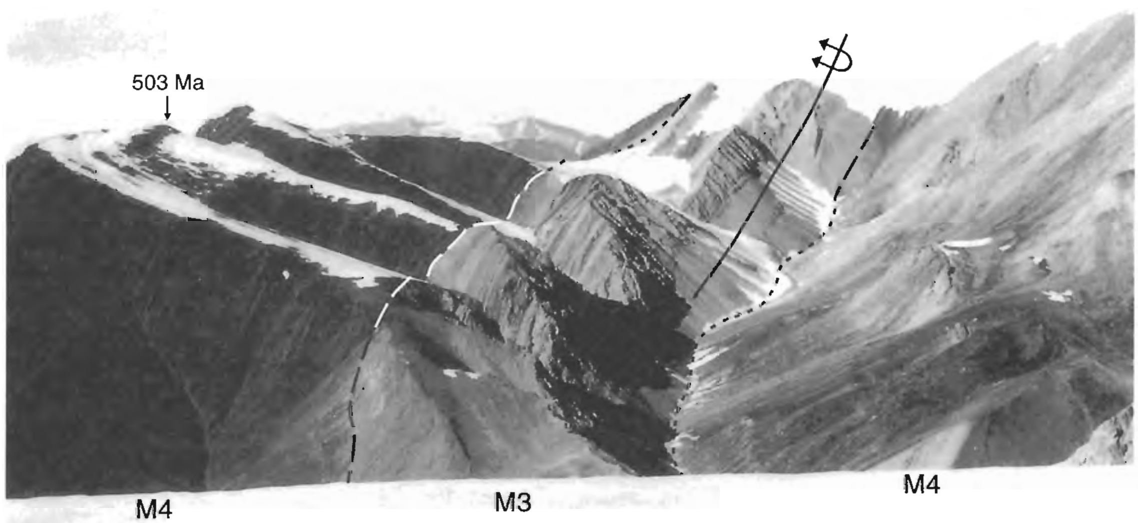


Figure 102. Map units M3 and M4 at section northeast of Milne Glacier, view north-northwest. ISPG photo 978-7.

Map unit M5 is composed almost entirely of a light grey, very fine to medium grained quartzite (Fig. 104) that contains trace amounts to a few per cent of plagioclase, mica, and/or chlorite. The quartz is generally well sorted and appears to have been rounded prior to diagenesis, but is strained and shows undulose extinction. Argillaceous phyllite is interbedded with the quartzite in the lower few metres of the section northeast of Milne Glacier.

If map unit M5 indeed overlies M4 with a stratigraphic contact, it must be Early Ordovician (Tremadoc–early Arenig?) in age.[1] On the other hand, a thick, monotonous unit of supermature quartzite would seem to fit better into the Proterozoic or Cambrian record of Succession 2 than into the Early Ordovician, a time characterized by volcanism and incipient orogeny (see below, Ages of deformation). This suggests that M5 may represent one or more

[1]The time scale of Tucker and McKerrow (1995) permits a Late Cambrian age.

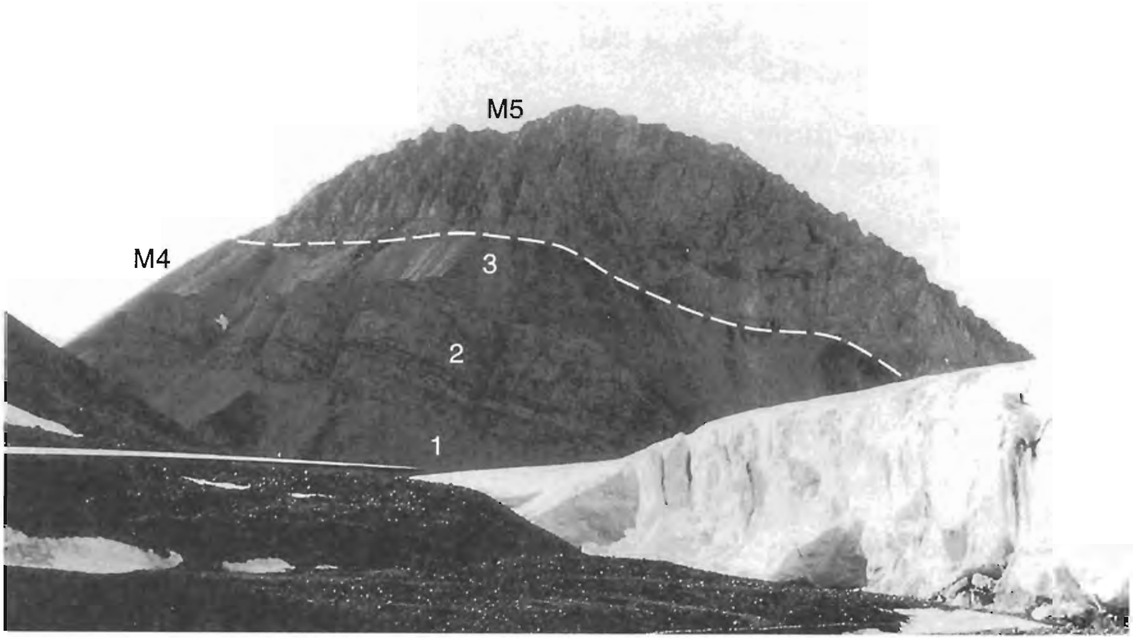


Figure 103. Upper part of map unit M4 (units 1-3 of description) and lower part of map unit M5 at section northeast of Milne Fiord, view southwest. ISPG photo 978-5.

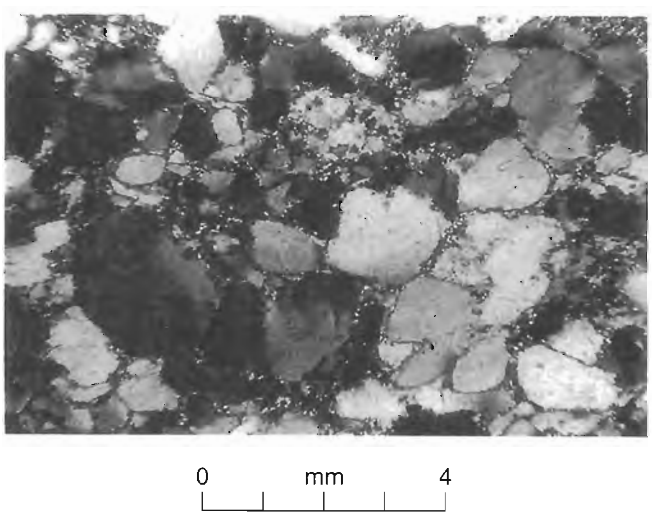


***Figure 104**. Photomicrograph (cross-polarized light) of quartzite in map unit M5. The rock consists almost entirely of quartz, which shows strain shadows, pressure solution, and relics of originally round outlines. ISPG photo 2260-132.*

thrust sheet(s) of older strata, but thrust faults have neither been identified in the field nor on air photographs, and this possibility is not expressed on the map (*M'Clintock Inlet*).

Succession 3: Maskell Inlet Complex (map units OMI, OMIc, Lower Ordovician?)

Definition

Succession 3 is identical to the original Maskell Inlet assemblage (Trettin, 1987b), here renamed the Maskell Inlet Complex. This is a structurally and stratigraphically complex unit composed of partly metamorphosed volcanic and sedimentary rocks that are in fault contact with Succession 2 and locally unconformably overlain by Middle Ordovician strata of the Cape Discovery Formation.

Distribution, contact relations, and thickness

The complex is exposed in two differently oriented outcrop belts, both of which are located in the northern and central parts of the *M'Clintock Inlet* map sheet. The main outcrop belt, 40 km long and up to 44 km wide, extends from Bromley Island in the north to south and southeast of Ayles Fiord. It is separated by faults from Succession 2 on the west and south, and from the Egingwah Group and the M'Clintock West body of the plutonic Thores Suite on the east and north. The base of the complex is concealed. On Bromley Island, it is overlain by the Cape Discovery

Formation with a high-angle unconformity. Its thickness has not been determined because of structural complexities but is estimated to be at least several hundred metres.

Three, fault-bounded, minor outcrop areas lie in an east-trending belt east of upper M'Clintock Inlet:

1. An outcrop area close to M'Clintock Inlet, 5.6 km long and up to 0.6 km wide, is limited by glaciers on the east and west. There, the Maskell Inlet Complex forms a thrust sheet that overrides Upper Ordovician strata on the south and is overthrust from the north by the M'Clintock East body of the Thores Suite (map unit Oum; see Fig. 156). A thin fault slice of marble within the M'Clintock East body may also belong to the Maskell Inlet Complex. The volcanic rocks are similar in composition to those west of M'Clintock Inlet.

2. Farther east, at Thores River, a fault slice of schist lies between ultramafic rocks of the Thores Suite and the Zebra Cliffs Formation. The structural setting is similar in some respects to that east of M'Clintock Inlet, but the intervening geology is concealed by a glacier.

3. Still farther east, on the east side of Disraeli Glacier, a narrow fault slice of highly altered chert(?) and volcanics(?) is intruded by the Disraeli Glacier Pluton. The assignment of these strata to the Maskell Inlet Complex is rather tentative.

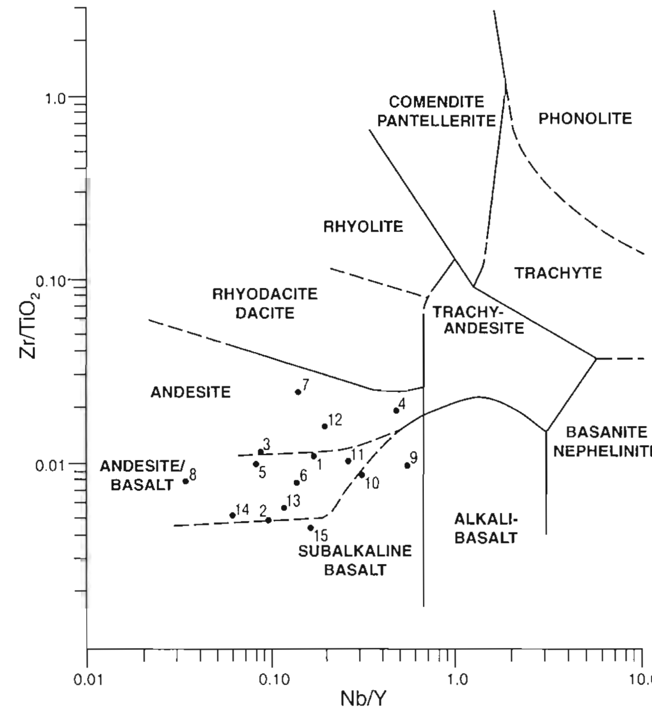


Figure 105. *Maskell Inlet Complex, stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).*

Lithology

Main outcrop area

The main outcrop area west of M'Clintock Inlet is underlain by volcanics and smaller proportions of sediments, mainly limestone, chert, and mudrock, with minor dolostone and sandstone. All rock types are metamorphosed or altered to varying degrees.

The volcanics, mainly tuffs and lesser amounts of flow rocks, are greenish grey, dark greenish grey, or dusky red. Their mineral compositions are dominated by albite and chlorite with varying proportions of quartz, epidote, calcite, actinolite, and clinopyroxene. The chemical and mineral composition of 12 analyzed specimens is summarized in Table 17 (also Appendix 4A, Tables 1, 2-11, 3-11, nos. 1-11 and 13). On the Winchester-Floyd diagram (Fig. 105), the analyses cluster in the fields of andesite (3), andesite/basalt (7), and subalkaline basalt (3). The major element classifications emphasize calc-alkaline andesite and basalt, but also include dacite, rhyolite, and alkali basalt. The discrepancies are probably due to major element alteration, especially the introduction of quartz. Amphibolite was observed on a nunatak west of the M'Clintock West body. It is composed of andesine (44% according to an XRD analysis), quartz (23%), hornblende (22%), chlorite (9%), and red-brown biotite (1%). The rock is an andesite according to its trace-element composition (Fig. 105, no. 13). In addition to these rocks, felsic tuffs are present but have not been analyzed for stable trace elements.

Relatively large exposures of light coloured carbonate rocks in the vicinity of Taconite Inlet and Taconite River have been mapped as unit OMIc. The stratigraphic position of these carbonates within the Maskell Inlet Complex is uncertain; they may represent more than one stratigraphic unit. Thinner or darker carbonate units are included in the undifferentiated map unit OMI. The following generalized description applies to all limestones of the main outcrop area. They are medium light grey to medium dark grey, rarely reddish or purplish in colour, and contain some laminae and graded beds. Most are impure lime mudstones, but calcarenites also are present. The

Table 17

Maskell Inlet Complex: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1	andesite	rhyolite (average)
2	andesite[1]	calc-alkaline (high alumina) andesite (K-poor, K-rich)
1	andesite	
1	andesite/basalt	calc-alkaline dacite (K-poor)
3	andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
1	andesite/basalt	calc-alkaline (high alumina) basalt (K-rich)
1	andesite/basalt	tholeiitic basalt (K-poor)
2	andesite/basalt	hawaiite[2]
1	subalkaline basalt	calc-alkaline (high alumina) andesite (K-rich)
1	subalkaline basalt	calc-alkaline (high alumina) basalt (K-poor)
1	subalkaline basalt	mugearite[3]
Summary of major element classifications		
1	rhyolite	
1	calc-alkaline dacite	
6	calc-alkaline andesite	
2	calc-alkaline basalt	
1	tholeiitic basalt	
2	hawaiite	
1	mugearite	

[1]One sample is nearly on boundary with andesite/basalt.
[2]Hawaiite is a sodic alkali basalt.
[3]Mugearite is a member of the sodic alkali olivine basalt series characterized by an intermediate composition (Irvine and Baragar, 1971).

coarse grained lime mudstones and calcarenites are composed of monocrystalline grains that probably represent recrystallized aggregates of lime mud because some of them show a relic cryptocrystalline texture in the extinction position under cross-polarized light. The dolomite fraction of the limestones does not exceed 5 per cent in uncorrected XRD determinations (Appendix 2, Table 102). Siliciclastic impurities, mostly of silt grade, make up 17 to 44 per cent of a few analyzed samples. They consist mainly of quartz with lesser proportions of albite and chlorite and very small amounts of white mica and K-feldspar. The dolostones are highly calcareous and also contain siliciclastic impurities (Appendix 2, Table 103).

The chert varies in colour from light to dark grey and is commonly medium dark grey. Some strata have thin, flat laminae due to vertical variations in the concentration of carbonaceous and argillaceous impurities. Thin sections show some poorly preserved skeletal fragments and ghosts of radiolarians.

The mudrocks are medium to dark grey and slaty or phyllitic. A typical specimen contains quartz (80%), chlorite (9%), mica (5%), and feldspar, (5%, mainly albite), according to uncorrected XRD data.

Sandstone appears to be rare. Two specimens are very fine and fine grained, respectively, and contain high proportions of carbonate grains and albite that are probably of volcanic origin.

East of upper M'Clintock Inlet

Volcanic flow rocks exposed on a nunatak southeast of the M'Clintock West body are similar to the volcanics of the main outcrop belt. They are composed mainly of albite, chlorite, epidote, and actinolite with some remnants of clinopyroxene (Appendix 4A, Tables 1, 2-11, 3-11 nos. 14, 15). Two samples are classified as andesite/basalt and subalkaline basalt, respectively, on the basis of trace elements (Fig. 105, nos. 14, 15), and as calc-alkaline andesite and calc-alkaline basalt on the basis of major elements.

Farther west, south of the M'Clintock East body, felsic tuff, schist, and minor impure marble are exposed. The tuff is composed mainly of quartz and albite with lesser amounts of chlorite, mica, and K-feldspar. The schist is laminated and consists of variable proportions of quartz and feldspar with smaller amounts of biotite and chlorite, and some rotated garnet crystals. Impurities of feldspar, tremolite, diopside, epidote, and quartz occur in the marble.

Thores River

In this area, the Maskell Inlet Complex is represented by a crenulated schist similar to the schist east of M'Clintock Inlet. A sample consists of quartz (58% according to an XRD analysis), feldspar (25%, mainly albite), chlorite (15%) and minor white mica (2%).

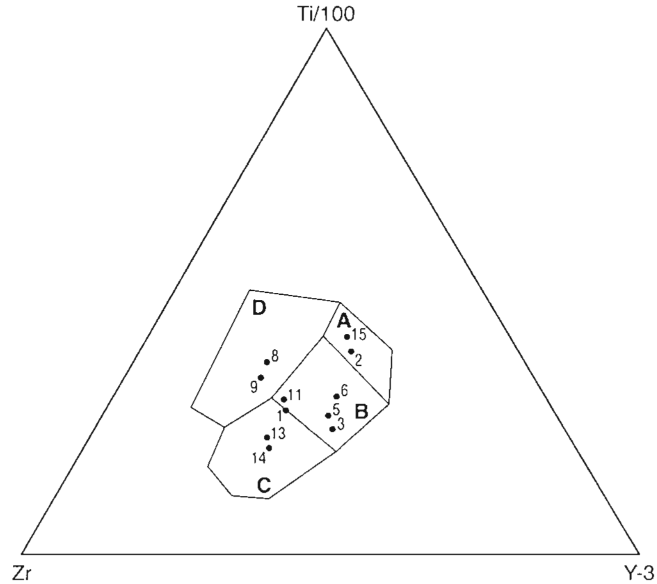
Metamorphism

The majority of the volcanic samples, characterized by albite and chlorite, conform to the lower greenschist facies. Others, retaining remnants of clinopyroxene, are incompletely metamorphosed. In both cases, the albitization and chloritization may have been caused by early phases of hydrothermal alteration. On the other hand, the amphibolite west of the M'Clintock West body and the schists east of M'Clintock Inlet and at Thores River are clearly metamorphic rocks of upper greenschist or lower amphibolite grade.

Mode of origin

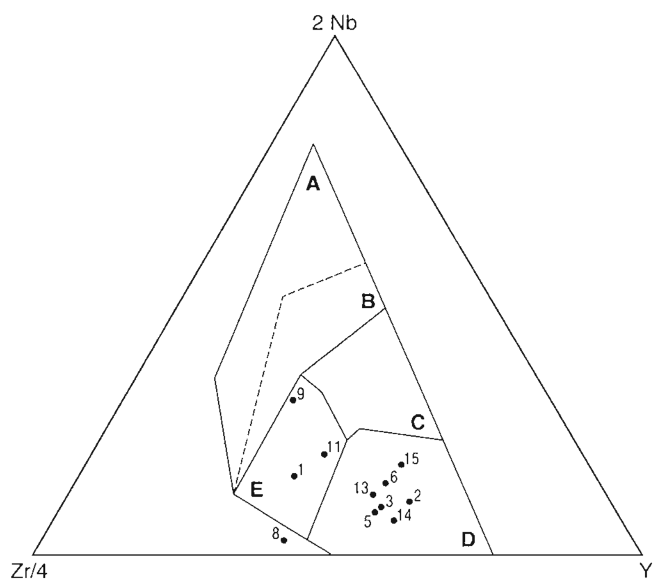
The volcanics of the Maskell Inlet Complex probably represent an arc. This is inferred both from the trace element classifications, which are dominated by andesitic basalt and andesite, and from the major element classifications, which are dominated by high-alumina calc-alkaline compositions (Table 17). This inference is not contradicted by the possible presence of tholeiitic and alkaline rocks also suggested by the major element classifications (cf. Baker, 1982; Wilson, 1988). The Pearce-Cann and Meschede tectonic discrimination diagrams (Figs. 106, 107) permit, but do not prove the arc interpretation.

Most carbonate sediments probably originated on shelves developed on volcanic edifices, although some may have been redeposited at greater depth. The radiolarian chert was probably deposited in adjacent basinal settings.



Mainly low-K tholeiite . . . . A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite . . . . . B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt . . . . D

Figure 106*. Maskell Inlet Complex, stable trace element ratios and inferred tectonic environments (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt . . . . A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt . . . . B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). . . . . D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) . . . . E

Figure 107*. Maskell Inlet Complex, stable trace element ratios and inferred tectonic environments (after Meschede, 1986, fig. 1).*

Age and correlation

Neither fossils nor minerals suitable for isotopic dating have been recovered from the Maskell Inlet Complex, and its precise age is uncertain. However, it must be significantly older than unconformably overlying sediments of the early Caradoc, Cape Discovery Formation. The volcanic rocks are tentatively correlated with the Thores Suite, which is interpreted as a subarc plutonic complex (see section on Phanerozoic Intrusions). A granitoid rock of this suite has yielded an Arenig zircon age.

Succession 4: Egingwah Group (Middle and Upper Ordovician)

Definition

Succession 4 is identical to the unconformity-bounded Egingwah Group, named for Egingwah Bay on the west side of central M'Clintock Inlet. It includes more than 3 km of carbonate, clastic, and volcanic rocks assigned to the Cape Discovery, M'Clintock, and Ayles formations. The group was introduced by Trettin (1991b), but the constituent formations were erected earlier (see below). In its original definition (Trettin, 1987b), Succession 4 also included units here re-assigned to Succession 5.

Cape Discovery Formation (map unit **OCD**, *Middle Ordovician)*

Definition

The Cape Discovery Formation (Trettin, 1969a) is a thick succession of clastic, carbonate, and minor volcanic rocks that overlies parts of Successions 2 and 3 with angular unconformity and is conformably overlain by the M'Clintock Formation. It is divisible into four members, named in order upward, A to D. The composite type section (Appendix 1) includes sections on the unnamed peninsula west of Maskell Inlet, north of Bethel Peak, and north of Egingwah Bay on the west side of M'Clintock Inlet (Figs. 108–110; *M'Clintock Inlet*).

Distribution, contact relations, and thickness

The formation underlies scattered areas east and west of M'Clintock Inlet (Fig. 108; *M'Clintock Inlet*). Its base is an angular unconformity underlain, at different localities, by low-grade metamorphic strata of

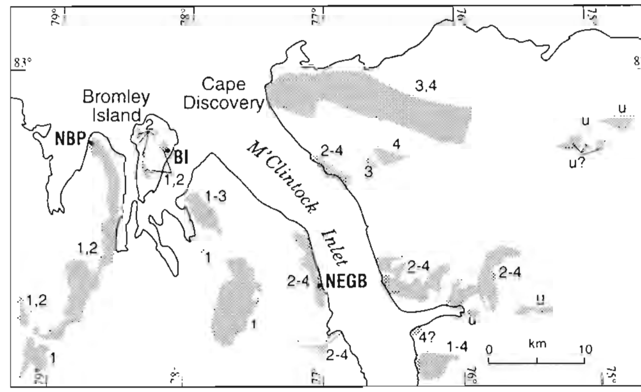


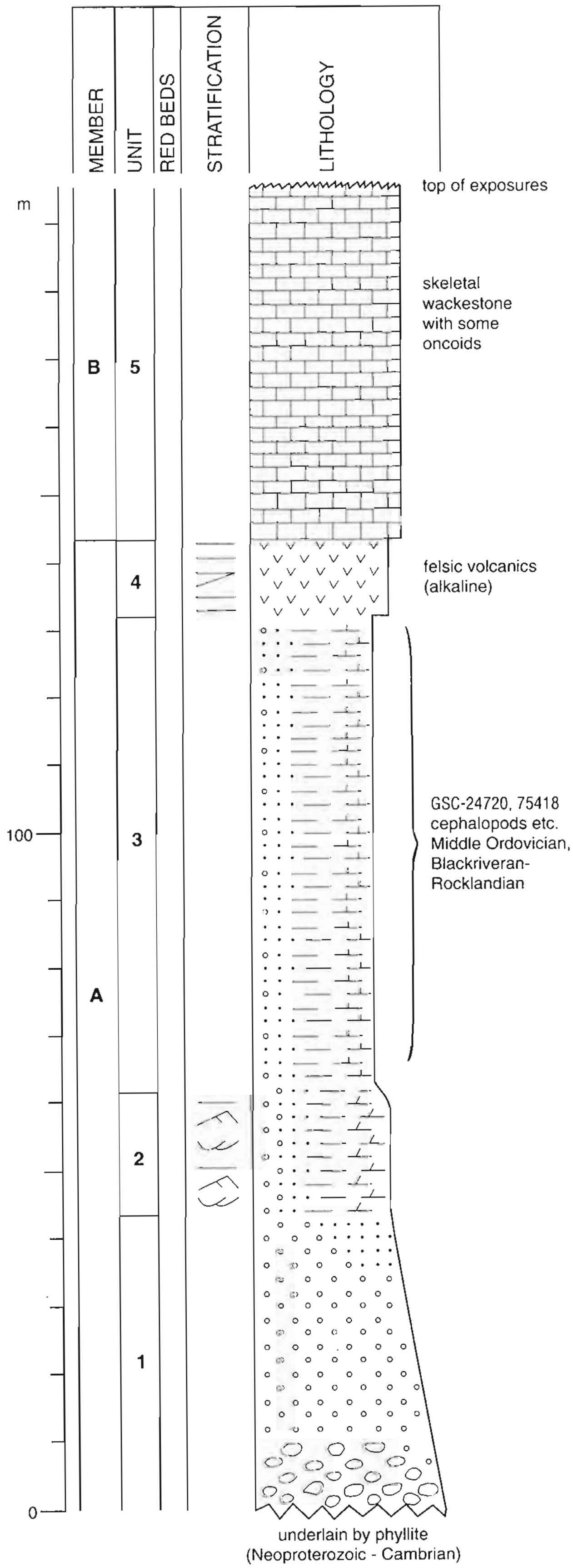
Figure 108. Cape Discovery Formation, stratigraphic sections and distribution of members. BI: *Bromley Island section;* NBP: *section north of Bethel Peak;* NEGB: *section north of Egingwah Bay; 1: Member A; 2: Member B; 3: Member C; 4: Member D;* u: *undifferentiated;* ?: *uncertain assignment to Cape Discovery Formation.*

Succession 2 (Fig. 111), the Maskell Inlet Complex, and a small part of the Bromley Island body of the Thores Suite (see Fig. 157). The Cape Discovery Formation is conformably overlain by the volcanic M'Clintock Formation. Its thickness is in the order of 1 km.

Lithology

***Member A (map unit* OCD1*)*.** Measured thicknesses vary from 44 m on northeastern Bromley Island to 144 m north of Bethel Peak. The member is no more than a few metres thick on southwestern Bromley Island and absent in the west-central part of this island, where it is overstepped by Member B. The thickness is considerably greater in a broad, fault-bounded outcrop belt southeast of Taconite Inlet, but the internal structure of this belt is poorly known. Photogeological interpretation indicates that a nearly horizontal, partial section between Egingwah Creek and Taconite River has a topographic relief of about 250 m. The section does not include the base or top of the member, and the total thickness of the member may exceed 300 m in this area.

At the type section, the member is divisible into three major units. The lower unit consists of conglomerate, which in the type section is 44 m thick and massive (Fig. 109, unit 1). Of boulder grade at the base (Fig. 112; maximum clast size 90 cm), it fines upward to pebble conglomerate. Boulder conglomerate is also present east of Taconite River, but on Bromley Island the conglomerate is of pebble grade. The



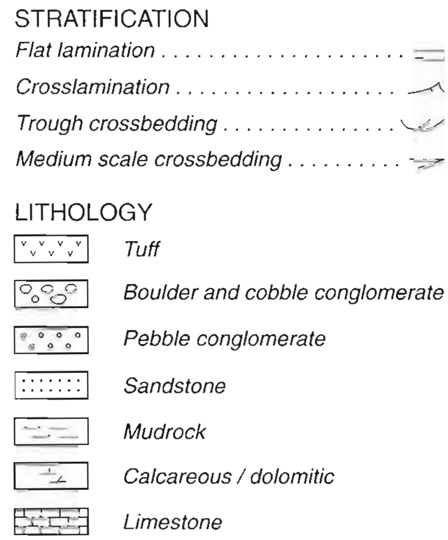


Figure 109*. Cape Discovery Formation, Members A and B, section northeast of Bethel Peak. Lower part of composite type section.*

conglomeratic clasts consist mainly of chert and siliceous volcanics with lesser proportions of phyllite and altered mafic or ultramafic rocks (for XRD analyses, see Appendix 3, Table 104).

The middle unit (Fig. 109, units 2 and 3) is made up of mudrock and sandstone with smaller amounts of pebble conglomerate. In the section north of Bethel Peak the lower 18 m of this unit are dolomitic and contain flat beds, some graded beds, and some medium-scale crossbeds. The next 70 m are indistinctly stratified. They are calcareous and dolomitic and contain a variety of fossils, including brachiopods, trilobites, corals, cephalopods, and algae or microbes. A similar fauna occurs at two localities on Bromley Island. It includes *Hedstroemia halimedoidea*?, probably a calcified cyanobacteria (T. de Freitas, Appendix 5D, 66TM-BR-4). The pebbles consist mainly of chert. The sandstones and the sandy matrix of the conglomerates are made up of variable proportions of chert, quartz, siliceous volcanic rock fragments, feldspar (mainly albite), chlorite, and carbonates (Appendix 3, Table 105). Analyzed specimens of mudrock consist mainly of quartz and carbonates, with smaller proportions of feldspar (mainly albite), chlorite, and mica (Appendix 3, Table 106).

The upper unit (Fig. 109, unit 4), composed of volcanic rocks, occurs at a few localities only and is absent on Bromley Island. In the section north of Bethel Peak it is 12 m thick and consists of pyroclastic material that contains some medium-scale crossbeds.

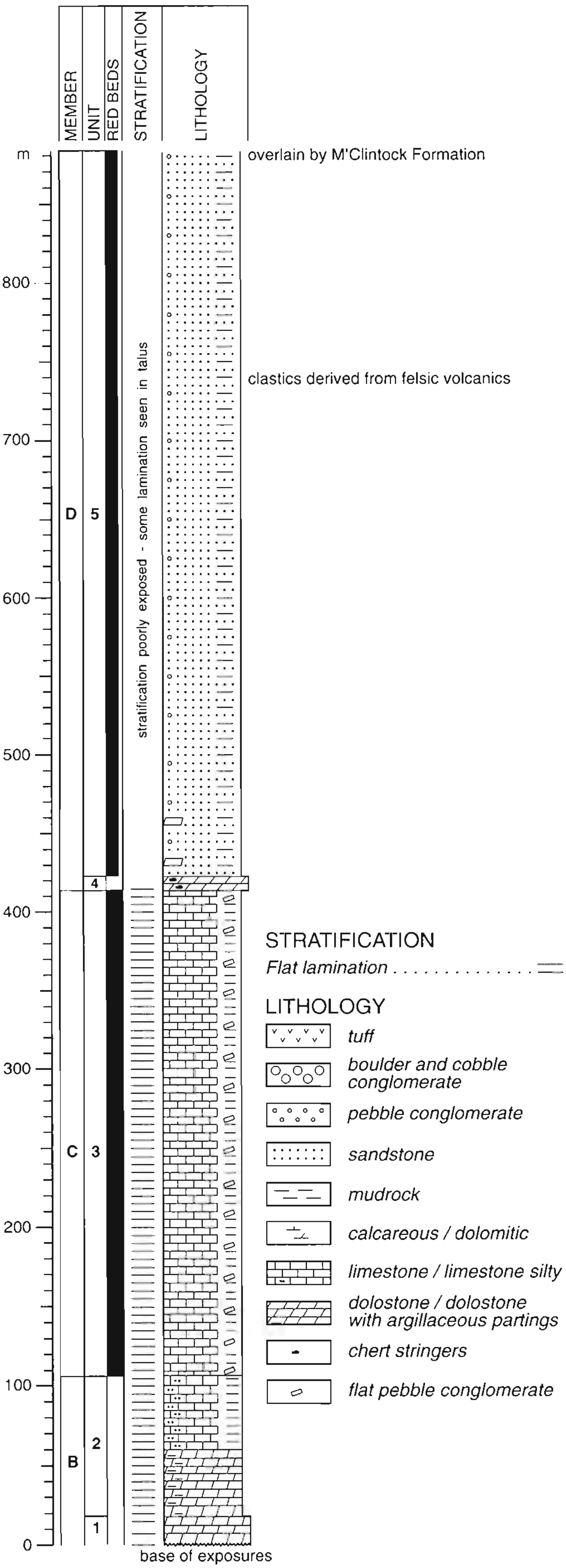


Figure 110. Cape Discovery Formation, Members B to D, section north of Egingwah Bay. Upper part of composite type section.

Trace element analyses on four samples from two different localities show a range of felsic to mafic, mostly alkaline compositions (Fig. 113; Table 18; see also Appendix 4A, Tables 2-12, 3-12). Discrepancies between the trace element classifications on the one hand, and three major element classifications indicating rhyolite, are probably due to the addition of quartz as veinlets and replacements. The presence of a large proportion of quartz in these rocks is confirmed by XRD analyses.

Member B (map unit* OCD2*). No complete section of this member is known. Minimum thicknesses are 52 m in the section north of Bethel Peak where the top is missing, and 107 m in the section north of Egingwah Bay (Fig. 110) where the base is missing. Composed of limestone, dolostone, and very small amounts of calcareous sandstone, it is the most resistant part of the Cape Discovery Formation. Two facies assemblages are distinguished.

The western facies is limited to Bromley Island and the unnamed peninsula west of Maskell Inlet. It is dominated by fossiliferous limestone, but also includes unfossiliferous limestone and dolostone, and minor amounts of calcareous sandstone. In the section north of Bethel Peak it is made up of argillaceous and dolomitic skeletal lime wackestone. Two representative samples consist of calcite (average XRD value 53%), dolomite (22%), and quartz (20%), with small amounts of feldspar (4%) and mica (1%). The skeletal material includes fragments of brachiopods, trilobites, gastropods, and *Girvanella*. Peloidal packstone with a rich skeletal content is represented by a sample from a locality north of Ayles Fiord. The skeletal fragments represent ostracodes, gastropods, echinoderms, and algae or microbes. The rock contains 12 per cent quartz and 4 per cent dolomite. Oncolitic grainstone, containing *Girvanella*, was collected from the west side of Maskell Inlet.

The eastern facies is best represented by the section north of Egingwah Bay, although the lower part of the member is concealed at that locality. The middle part consists mainly of dolostone and the upper part mainly of unfossiliferous lime mudstone, both with thinly interstratified mudrock. The dolostone is slightly argillaceous and calcareous, finely microcrystalline, and has thin, flat laminae due to vertical variations in the concentration of lime mud and submicroscopic carbonaceous impurities. The dolostone beds are about

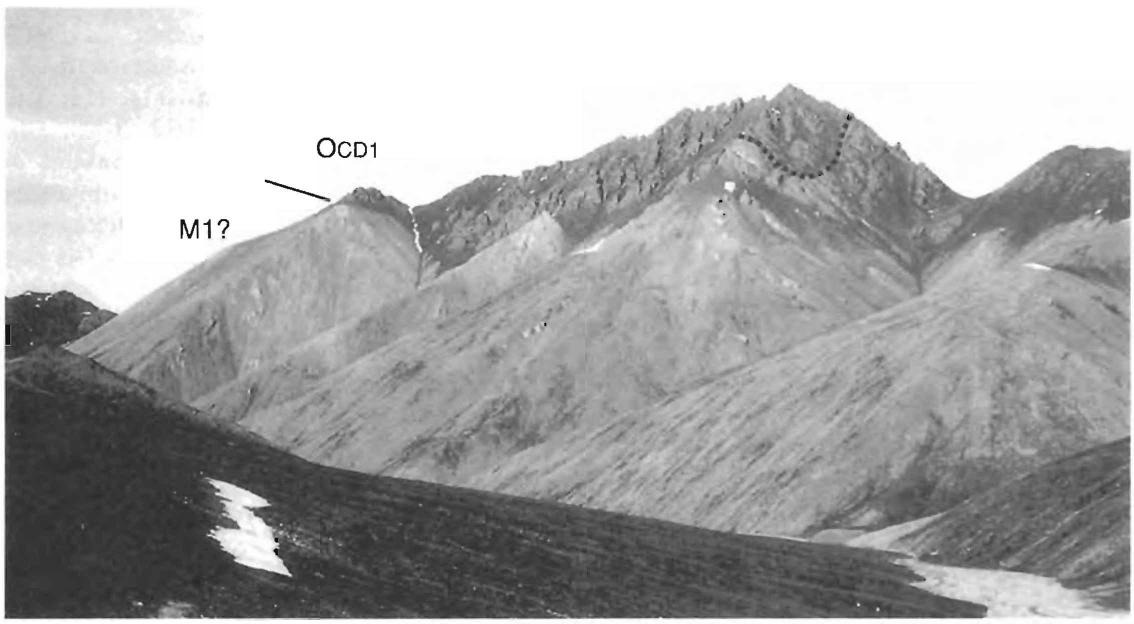


Figure 111. Redbeds of Cape Discovery Formation, Member A (OCD1), *lying unconformably on marble of Succession 2 (map unit M1?), north of Ayles Fiord (**M'Clintock Inlet**), view northeast. Contact between massive and well stratified parts of Member A (dotted line) reveals open synclinal structure. ISPG photo 978-51.*

***Figure 112**. Conglomerate of Cape Discovery Formation, Member A, a few metres above basal unconformity at section northeast of Bethel Peak. ISPG photo 1878-45.*

1 to 15 cm thick and separated by argillaceous layers. Some lime mudstones also are laminated. Greenish weathering calcareous mudrock, interlaminated with the limestone, contains some graded beds.

Member C (map unit **OCD3*)***. Member C, 307 m thick in the section north of Egingwah Bay, is uniform in lithology. It consists mainly of pale red to greyish red

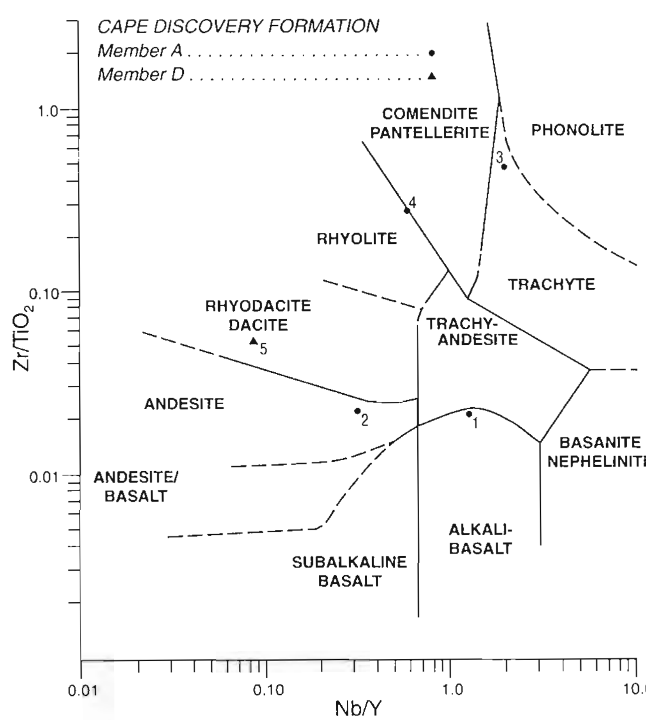


***Figure 113**. Cape Discovery Formation, stable trace element ratios and rock classification; circles represent analyses from Member A, triangle represents analysis from Member D (after Winchester and Floyd, 1977, fig. 6).*

Table 18

Cape Discovery Formation: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
Member A		
1	rhyolite[1]	rhyolite (K-poor)
1	andesite	rhyolite (K-rich)
1	trachyte	rhyolite (K-poor)
1	alkali basalt[2]	sodic trachyte
Member D		
1	rhyodacite/dacite	rhyolite (K-poor)

[1]Nearly on boundary with commendite/pantellerite (alkalic fesite).
[2]Nearly on boundary with trachyandesite.

limestone with siliciclastic impurities of mud to very fine sand grade, and small proportions of interlaminated calcareous mudrock and sandstone similar in colour and composition (Fig. 114). The limestone, mudrock, and sandstone commonly form intraformational conglomerates. The flat pebbles are bedding-parallel or moderately to steeply inclined and commonly in solution contact. Most carbonate rocks are lime mudstones, but peloidal packstones also are present. Typical samples of limestone and flat-pebble conglomerate consist of calcite (average 73% according

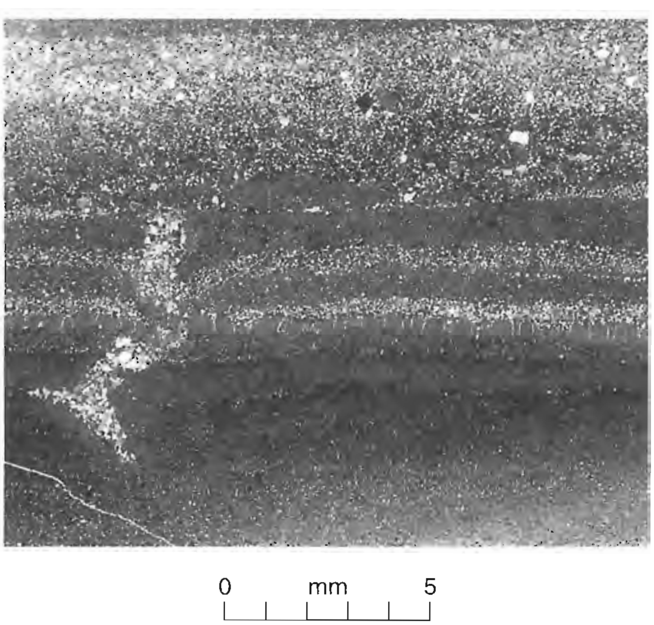


***Figure 114**. Photomicrograph (ordinary light) of lime mudstone interlaminated with sandy siltstone in Member C of Cape Discovery Formation. The rocks are pale red owing to finely distributed hematite (opaque) that shows vertical variations in concentration. Two burrows (lower left) are filled with silt and sand. ISPG photo 2260-160.*

to XRD analyses), quartz (23%), feldspar (3%, mainly albite), and trace amounts of mica, chlorite, and dolomite (Appendix 3, Table 107).

Member D (map unit **OCD4***).* This member is about 470 m thick in the section north of Egingwah Bay, where it is made up mainly of clastic sediments with small amounts of dolostone and volcanic rocks.

The clastic sediments are composed mainly of sandstone with lesser amounts of mudrock and fine-pebble conglomerate. The strata are pale red to greyish red, or, less commonly, medium grey. The stratification is difficult to determine because the member is represented mainly by talus and felsenmeer, but some flat and undulating laminae were seen. The sandstones are mainly fine grained although medium and coarse grained rocks also are present. Point count analyses indicate felsic volcanic rock fragments (40%) and feldspar (30%, mainly albite, minor K-feldspar), with smaller amounts of quartz (12%), carbonates (3%), opaque materials (15%), and trace amounts of chert(?) (Appendix 3, Tables 108, 109). The volcanic origin of at least part of the quartz is apparent from the shape of the grains - subhedral with rounded corners and some embayments - and their clarity. A typical mudrock consists of quartz (66%), dolomite (20%), feldspar (albite 7%, K-feldspar 1%), and chlorite (6%).

Dolostone predominates in the lower 9 m and occurs sporadically in the overlying 90 m. It is medium light grey and finely crystalline to predominantly microcrystalline. Dispersed silt and sand grains, as well as quartz and chert replacements account for an average 13 per cent of quartz in XRD determinations.

A red weathering porphyritic flow is associated with dolostone in the lower 9 m of the member in the section north of Egingwah Bay. Phenocrysts of albite are embedded in a groundmass of albite, quartz, K-feldspar, and opaque minerals. The rock is classified as a rhyodacite/dacite on the basis of stable trace elements and as a rhyolite on the basis of major elements (Fig. 113, no. 5; Appendix 4A, Tables 1, 2-12, 3-12).

Metamorphism

The mineral composition of the volcanic rocks conforms with the greenschist facies, but may be the product of hydrothermal alteration. A slaty cleavage is developed only locally, for example in the lowermost part of the section north of Bethel Peak. Conodonts from Member B have an alteration index of 4 or 5 (Tipnis, Appendix 5B, GSC loc. C-74987), corresponding to temperatures of about 200 to 300°C (Rejebian et al., 1987).

Mode of origin

Member A. The basal conglomerate in the section north of Bethel Peak is probably nonmarine in origin because of its position above an angular unconformity and the absence of fossils and carbonates. The coarse grade and massive bedding suggest deposition on an alluvial fan. The detritus clearly was derived from the units that underlie the unconformity. The Maskell Inlet Complex supplied volcanics and chert; Succession 2, phyllite; the Thores Suite, altered gabbro or peridotite. The marine origin of the overlying mixed carbonate and clastic sediments is apparent from their fauna. The alkaline volcanics in the upper part of the member indicate a rifting event.

Member B. A shallow subtidal shelf environment is inferred for the western facies assemblage from its diverse and fairly abundant fauna. On northwestern Bromley Island, where Member B oversteps Member A, it laps onto a paleotopographic high, underlain by plutonic rocks of the Thores Suite and surrounding strata of the Maskell Inlet Complex. Unfossiliferous, flat-laminated, fine microcrystalline dolostone in the eastern facies assemblage of Member B may have formed by early diagenetic replacement in a restricted superhaline setting.

Member C. Greyish red weathering colours, absence of fossils, and presence of intraformational conglomerates suggest a peritidal setting.

Member D. The volcanic detritus was probably derived from penecontemporaneous felsic volcanics that are also represented by a flow within the member. The depositional environment of the clastic sediments is uncertain. The dolostone was probably deposited in a shallow-marine or peritidal setting.

Age and correlation

The ammonite *Gonioceras* sp. from Member A in the section north of Bethel Peak indicates a Blackriveran–Rocklandian (early Caradoc) age (Sinclair, *in* Christie, 1964, p. 21, GSC loc. 24720). Other collections from Member A are less diagnostic but compatible with that assignment (Norford, Appendix 5A, GSC locs. 75416-75418).

Macrofosils, such as *Maclurites* sp. and *Palaeophyllum* sp., from Member B on the unnamed peninsula west of Maskell Inlet are of unspecified Blackriveran–Trentonian (early and middle Caradoc) age (Norford, Appendix 5A, GSC loc. 69206). Conodonts from the same area include *Periodon aculeatus* Hadding, which ranges in age from early Llandeilo to early Caradoc (Tipnis, Appendix 5B, GSC loc. C-74987). Combined with the fossils from Member A, this conodont collection places Member B into the early Caradoc.

No fossils have been found in Members C and D, and the oldest fossil from overlying strata, occurring at the top of the M'Clintock Formation, is Ashgill in age. Thus the age of the contact between the Cape Discovery and M'Clintock formations is poorly constrained. It is tentatively placed into the mid-Caradoc.

M'Clintock Formation (map units **OMC, OMC$_C$**, *Middle and Upper Ordovician)*

Definition

The M'Clintock Formation is a thick succession of volcanic rocks with minor volcanogenic sediments and limestone that lies stratigraphically between the Cape Discovery and Ayles formations. Most of the composite type section coincides with cross section B–B′ on Trettin and Mayr's (1995c) map (*M'Clintock Inlet*, inset B), located on the west side of M'Clintock Inlet, northwest of Egingwah Bay. This extensive and structurally complex section is known only from reconnaissance traverses. The uppermost 88 m of the type section and the contact with the Ayles Formation are located about 4 km south of cross section B–B′. A description of this part (adapted from Trettin, 1969b) is included in Appendix 1 (section north of Egingwah Creek).

The unit was introduced as the M'Clintock group [*sic*] by Christie (1957) and redefined as a formation by Trettin (1969b). The original subdivision into two members, A and B, is abandoned here because Member B represents a local facies that does not warrant member status.

Distribution, contact relations, and thickness

The M'Clintock Formation is widely exposed in an area extending from southeast of M'Clintock Inlet to west of Markham Fiord (*M'Clintock Inlet* and *Clements Markham Inlet*). It overlies the Cape Discovery Formation with an abrupt but probably conformable contact because volcanics are present in

Member D of that formation. The contact with the overlying Ayles Formation is also conformable. East of M'Clintock Inlet, on Marvin Peninsula, the M'Clintock Formation is overlain by the Taconite River Formation with a low-angle regional unconformity.

The thickness of the formation has not been established. Graphic measurements along cross section B–B′ (*M'Clintock Inlet)* suggest a minimum thickness of 1 km, but the true thickness may be considerably greater.

Lithology

The M'Clintock Formation consists mainly of volcanic rocks with lesser amounts of volcanogenic sediments and minor limestone. The associated dykes and sills are probably genetically related to the volcanics. The volcanic rocks are mainly medium grey or greenish grey, rarely red. In the examined samples (40 thin sections), flows and tuffs are represented in roughly equal proportions. Both rock types are composed of albite, chlorite, and quartz, with or without calcite, epidote, actinolite, clinopyroxene, and K-feldspar.

Trace element analyses of 19 samples (Table 19, Fig. 115; also Appendix 4A, Tables 1, 2-13, 3-13) indicate predominantly intermediate to mafic compositions, chiefly subalkaline (andesite/basalt-8, subalkaline basalt-3, andesite-2, rhyodacite/dacite-1), but with a significant proportion of alkaline rocks (trachyandesite-4, alkali basalt-1). Major element classifications of 22 samples present a similar picture, but with a higher proportion of felsic rocks (7), probably as a result of silica alteration. The subalkaline rocks are mainly calc-alkaline and to a lesser extent tholeiitic.

Volcanogenic sediments encountered on south-central Marvin Peninsula and western Ferbrache Peninsula are similar in texture and composition. The following remarks are based on petrographic and chemical analyses of talus collected during brief helicopter visits; the stratigraphic setting and primary structures were not recorded. The rocks contain particles of silt to cobble grade and are generally poorly sorted. They are composed mainly of quartz and feldspar (albite with small proportions of K-feldspar in some samples), and relatively small proportions of felsic volcanic rock fragments. Much of the quartz appears to be volcanic in origin, but small amounts of quartzite and vein quartz (?) are present in a few samples.

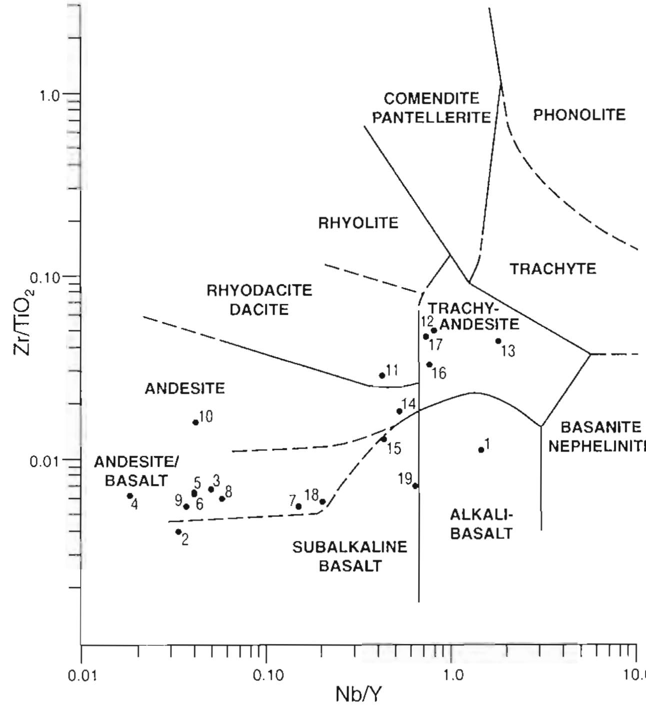


***Figure 115.** M'Clintock Formation, stable trace element ratios and rock classification (after Winchester and Floyd, 1977, fig. 6).*

On northern Marvin Peninsula, limestone associated with the M'Clintock volcanics has been mapped separately as unit O_{MCc}, because it is useful as a structural marker. The outcrops examined are no more than a few metres thick and consist of slightly dolomitic lime mudstone that is intensely veined and partly recrystallized. They occur within the volcanic succession and are probably older than the strata west of M'Clintock Inlet discussed below.

Two beds of limestone, separated by about 77 m of volcanic rocks, occur at the top of the formation in the Egingwah Creek section (Appendix 1). The three units combined were originally referred to as Member B of the M'Clintock Formation (Trettin, 1969b). However, these carbonates have not been seen anywhere else and evidently represent a local facies. The lower limestone is 4.9 m thick and consists of slightly silty and sandy lime mudstone with sparse favositid corals. Bedding is poor although fine, wavy laminae are apparent in places. The upper limestone is a laminated, fine to coarse grained, tuffaceous calcarenite. The rock is composed mainly of grains of lime mudstone with minor amounts of chloritized shards(?), and rare skeletal material.

Table 19

M'Clintock Formation: classification of volcanic rocks according to trace and major elements. (Left column indicates number of analyses.)

No.	Trace elements	Major elements
1		rhyolite (K-poor)
1	rhyodacite/dacite	calc-alkaline dacite (K-poor)
1		calc-alkaline dacite (average)
1	andesite	calc-alkaline dacite (average)
1	andesite	calc-alkaline (high alumina) andesite (K-poor)
1		calc-alkaline (high alumina) andesite (average)
3	andesite/basalt	calc-alkaline (high alumina) andesite (K-poor)
2	andesite/basalt	calc-alkaline (high alumina) basalt (K-rich)
1	andesite/basalt	tholeiitic basalt (K-rich)
1	andesite/basalt	tholeiitic picrite basalt[1] (K-poor)
1	andesite/basalt	hawaiite[2]
2	subalkaline basalt[3]	calc-alkaline (high alumina) andesite (K-poor)
1	subalkaline basalt	tholeiitic basalt (K-rich)
2	trachyandesite	rhyolite (K-poor)
1	trachyandesite	calc-alkaline dacite (K-poor)
1	trachyandesite	(major element classification impossible, high MgO, K-rich series)
1	alkali basalt	calc-alkaline (high alumina) andesite (K-poor)
1		mugearite[4]
Summary of major element classifications		
3	rhyolite (K-poor)	
4	calc-alkaline dacite (K-poor 3, average 1)	
8	calc-alkaline andesite (K-poor 7, average 1)	
2	calc-alkaline basalt (K-rich)	
2	tholeiitic basalt (K-rich)	
1	tholeiitic picrite basalt (K-poor)	
1	hawaiite	
1	mugearite	

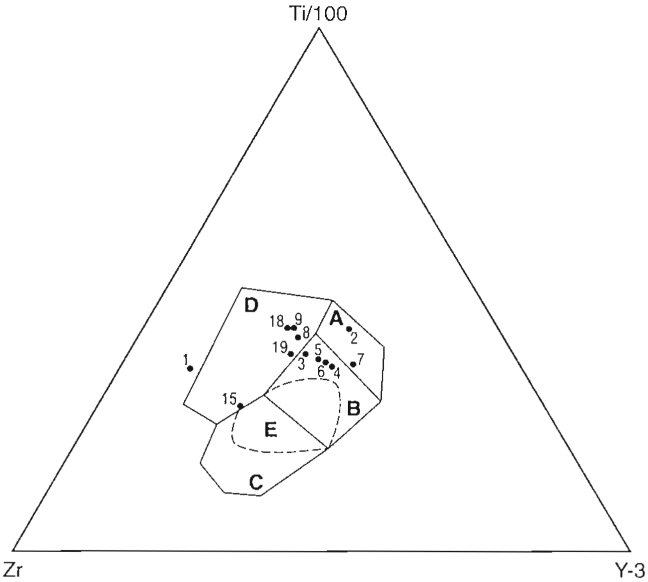
[1]Picrite contains 25% (or more) of normative olivine (Irvine and Baragar, 1971).
[2]Hawaiite is a sodic alkali basalt (Irvine and Baragar, 1971).
[3]One sample is nearly on boundary with andesite/basalt.
[4]Mugearite is a member of the sodic alkali basalt series characterized by an intermediate composition (Irvine and Baragar, 1971).

Metamorphism

The sporadic preservation of pyroxene indicates that regional metamorphism was below greenschist facies. The ubiquitous albitization and chloritization are therefore attributed to hydrothermal alteration, also apparent from abundant quartz and calcite veinlets and replacements.

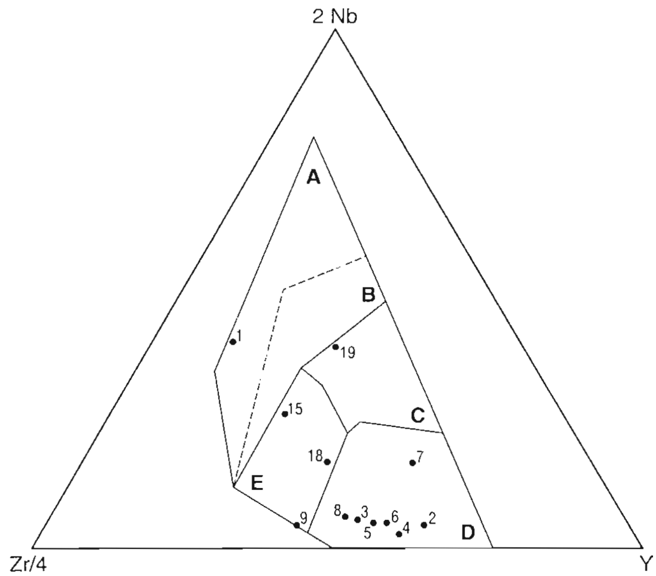
Mode of origin

The preponderance of calc-alkaline andesitic basalt and andesite, inferred from the combined major and trace element classifications, suggests a volcanic arc environment. The presence of subordinate tholeiitic basalt and alkaline rocks is compatible with that assignment (cf. Baker, 1982; Wilson, 1988, etc.). The tectonic discrimination diagrams (Figs. 116, 117) do not provide unique answers, but on the Meschede diagram (Fig. 117) 10 out of 12 analyses of mafic rocks plot in two fields commonly occupied by volcanic arc basalt (along with rocks from other settings). The alkaline rocks probably indicate a weakly extensional tectonic regime that was superimposed on the arc regime.



Mainly low-K tholeiite .... A
Mainly ocean floor basalt, less calc-alkaline basalt, low-K tholeiite .... B
Mainly calc-alkaline basalt, minor within-plate basalt C
Within plate basalt .... D
Within plate basalt, continental .... E

***Figure 116.** M'Clintock Formation, stable trace element ratios and inferred tectonic environments (after Pearce and Cann, 1973, fig. 3).*



Within plate alkali basalt .... A
Within plate alkali basalt, within plate tholeiite, minor mid-ocean ridge basalt (plume type), volcanic arc basalt .... B
Mid-ocean ridge basalt (plume type), minor within-plate tholeiite, mid-ocean ridge basalt (normal), volcanic arc basalt, within-plate alkali basalt C
Mid-ocean ridge basalt (normal), volcanic arc basalt, minor within-plate tholeiite, mid-ocean ridge basalt (plume type). .... D
Volcanic arc basalt, within-plate tholeiite, minor mid-ocean ridge basalt (normal), within-plate alkali basalt, mid-ocean ridge basalt (plume type) .... E

***Figure 117.** M'Clintock Formation, stable trace element ratios and inferred tectonic environments (after Meschede, 1986, fig. 1).*

The stratigraphic setting implies an ensialic origin for the arc. The limestones represent short-lived local carbonate shelves on submerged parts of the volcanic buildup; the volcanogenic sediments were probably derived from subaerial parts of the edifice.

Age and correlation

The age of the base of the formation, as mentioned, is poorly constrained and tentatively placed in the middle Caradoc. *Paleofavosites* sp. was found in the type area in strata 70 m below the top of the M'Clintock Formation (Norford, Appendix 5A, GSC loc. 69207). This coral ranges in age from Late Ordovician (Richmondian) to Silurian, but a Silurian age can be ruled out for the top of the formation because fossils of Late Ordovician age also are present in the overlying Ayles, Taconite River, Zebra Cliffs, and Marvin formations.

The M'Clintock Formation is comparable in lithology to the Mount Rawlinson Complex and to Member A of the Kulutingwak Formation (Chapter 3). Limited biostratigraphic and radiometric information indicates that these three units are at least partly co-eval.

Ayles Formation (map units **OA, OA1, OA2,** *Upper Ordovician)*

Definition

The Ayles Formation is a thick, predominantly dolomitic carbonate unit that lies stratigraphically between the M'Clintock and Taconite River formations (Trettin, 1969a). The type section, described in Appendix 1, is on the north side of Egingwah Creek (*M'Clintock Inlet*, inset A).

Distribution, contact relations, and thickness

Outcrops of the Ayles Formation are restricted to the region west of the lower and middle reaches of M'Clintock Inlet. The contact with the M'Clintock Formation is covered but probably conformable because of the occurrence of carbonate rocks in the uppermost part of the M'Clintock Formation at Egingwah Creek. The contact with the Taconite River Formation is a low-angle regional unconformity.

Photogrammetry combined with ground-measured dips suggests a thickness of 1.1 to 1.3 km in the type section where the formation is bounded at the base by a fault.

Lithology

The Ayles Formation consists almost entirely of relatively pure dolostone with small amounts of silty dolostone and related dolomitic siltstone in the upper part. Two major units are present in the vicinity of Egingwah Creek.

Unit 1 has a minimum thickness of 586 m in the type section, where it is bounded at the base by a fault. Farther north in the Egingwah Creek Syncline, a structural cross section suggests a total thickness of about 750 m. The unit is massive, resistant, and light grey on air photographs. It consists of light grey to medium grey dolostone, which is mostly structureless but laminated to a minor extent. The parting thicknesses of the beds are 5 m or greater. Many rocks show a disturbed texture that may have been produced by burrowing prior to dolomitization; others are tectonically brecciated, and the fragments are commonly in solution contact. Stylolites are fairly common, as are millimetre-scale vugs on weathered surfaces.

The dolostone is free of clastic impurities, but most rocks contain small amounts of micritic calcite, ranging from 0.2 to 0.4 per cent in XRD analyses. Samples from the upper half of the unit also include small amounts of secondary chalcedony, ranging from 0.2 to 5.8 per cent (mean 2.0%). The dolomite ranges in size grade from microcrystalline to coarse crystalline but is mainly microcrystalline to fine crystalline. Ghosts of dolomitized or silicified fossils, such as solitary and colonial corals, gastropods, and echinoderm fragments occur in the upper part.

Unit 2, slightly darker on air photographs and less resistant than unit 1 and partly concealed, is 525 m thick according to an estimate based on photogrammetry and generalized dips, but the true thickness is probably less because of structural complexities.

The predominant rock type is a microcrystalline to fine crystalline dolostone with chalcedonic replacements or vug fills, recorded as 7 to 18 per cent quartz in XRD analyses. Less abundant are medium light grey to medium dark grey, microcrystalline, silty dolostone and related dolomitic siltstone. A typical specimen of dolostone consists mainly of dolomite (86%) with impurities of quartz (13%), and white mica (1%). A specimen of siltstone contains a smaller proportion of dolomite (49%), a larger proportion of quartz (42%), and small amounts of white mica (3%), albite (2%), chlorite (2%), and calcite (2%; uncorrected XRD analyses). The darker colour of unit 2 is due to submicroscopic carbonaceous impurities within the dolomite crystals. The beds are structureless, and parting thicknesses range from about 10 cm to a few metres.

Fossils, mainly corals with some gastropods, brachiopods, pelecypods, cephalopods, and echinoderm fragments are abundant in the lowermost few metres, and tabulate corals occur sporadically in the middle and upper parts of unit 2.

Metamorphism

The rocks show no textural or mineralogical evidence of metamorphism. The alteration index of the single conodont collection obtained could not be determined.

Mode of origin

The Ayles Formation represents a carbonate platform that developed on the M'Clintock volcanic edifice and received only insignificant amounts of siliciclastic sediments. The rich and varied benthonic fauna of unit 2 suggests a shallow subtidal setting.

Age and correlation

Diagnostic macrofossils from the upper part of unit 1 and the lowermost part of unit 2 are Ashgill (Richmondian or younger) in age (Norford, Appendix 5A, GSC locs. C-97394, C-97377). A collection from the upper part of Member B has a Trentonian to Richmondian (middle Caradoc to Ashgill) age range (Norford, Appendix 5A, GSC loc. C-69204). These fossils, combined with collections from the overlying Harley Ridge Group, restrict the Ayles Formation to the Richmondian.

Succession 5

Definition

Succession 5 (Fig. 118), introduced here, includes the Ordovician to Upper Silurian sedimentary rocks that unconformably overlie Succession 4. It is divisible into a lower part (5A) comprising the widespread, predominantly shallow-marine Harley Ridge Group of Late Ordovician age, and an upper part (5B) of Late

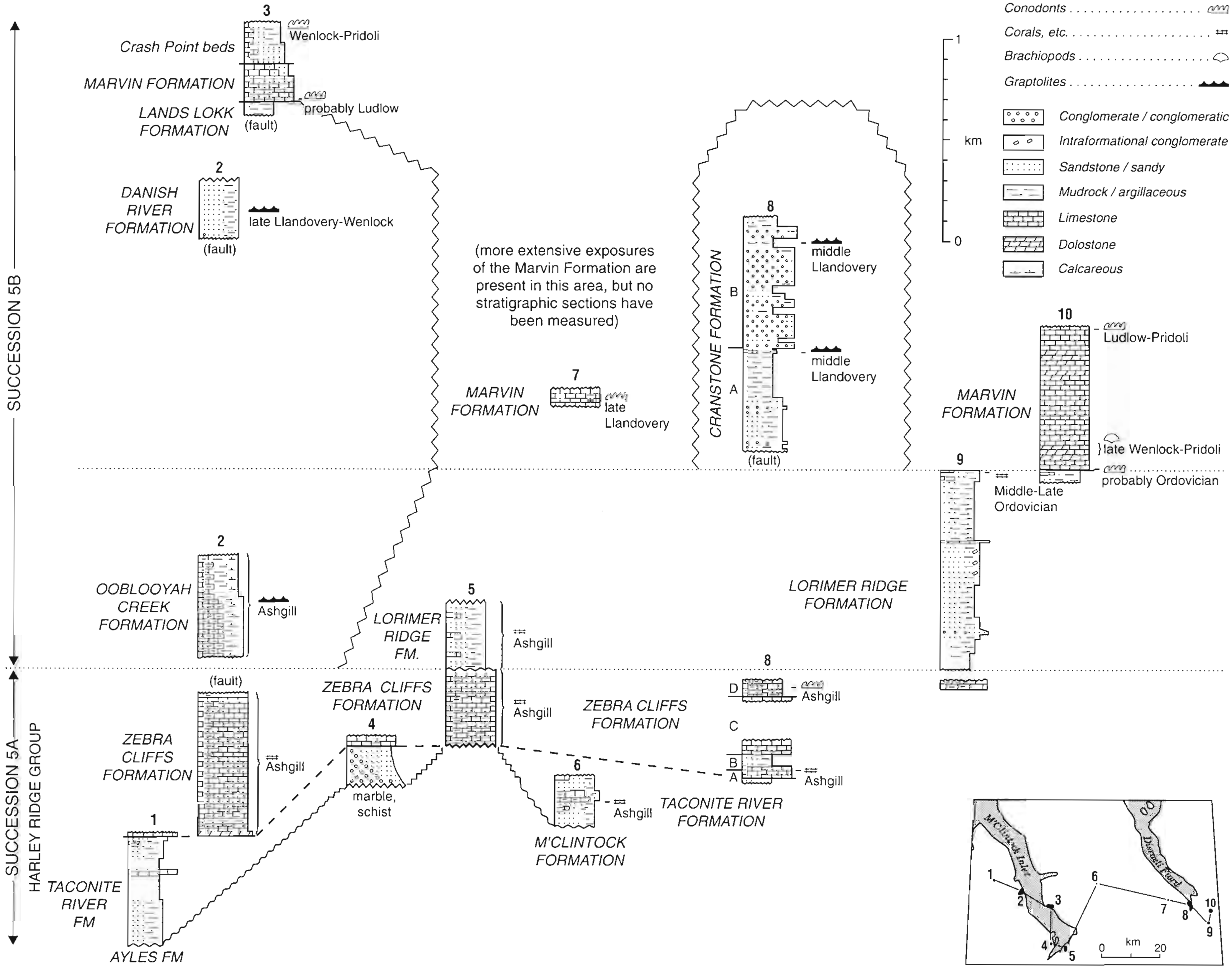


Figure 118. Succession 5, generalized stratigraphic sections and significant fossil occurrences. 1: Egingwah Creek; 2: Zebra Cliffs; 3: Crash Point; 4: west of upper reaches of M'Clintock Inlet; 5: Harley Ridge; 6: southern Marvin Peninsula; 7: fossil locality on southeastern Marvin Peninsula; 8: south of Disraeli Fiord; 9 Lorimer Ridge; 10: southeast of Disraeli Fiord.

Ordovician to Late Silurian age that shows complex facies variations. As mentioned earlier, the strata of Succession 5 were originally included in Succession 4 (Trettin, 1987b).

Succession 5A: Harley Ridge Group (Upper Ordovician)

Definition

Succession 5A is identical to the Harley Ridge Group, which is here redefined to comprise only the Taconite River and Zebra Cliffs formations. In the original definition (Trettin, 1987c, 1991b) it also included the Lorimer Ridge Formation. The latter is removed from the Harley Ridge Group because it is separated from the Zebra Cliffs Formation by an unconformity.

Taconite River Formation (map unit OTR, *Upper Ordovician)*

Definition. The Taconite River Formation is a unit of clastic and minor carbonate sediments that lies unconformably on the Egingwah Group or Succession 2 and is conformably overlain by carbonates of the Zebra Cliffs Formation (Trettin, 1969b). The type section at Egingwah Creek (Fig. 119; *M'Clintock Inlet*, inset B; description in Appendix 1), which was selected at a time when only a part of the outcrop area of the formation was known, is poorly exposed. A partial reference section on southern Marvin Peninsula is better exposed.

Distribution, contact relations, and thickness. Scattered exposures extend from west of M'Clintock Inlet to southeast of Markham Fiord (Fig. 119; *M'Clintock Inlet* and *Clements Markham Inlet–Robeson Channel*). In most of this area the basal contact is a low-angle regional unconformity, underlain by the Ayles Formation west of M'Clintock Inlet and by the M'Clintock Formation east of the inlet. West of the upper reaches of M'Clintock Inlet, however, the Taconite River Formation lies on Succession 2 with a high-angle unconformity (Fig. 120). The upper contact with the Zebra Cliffs Formation is conformable.

The formation is about 470 m thick at the type section. The thickness is greater than 600 m on a nunatak 16.5 km south of Markham Fiord (Fig. 119,

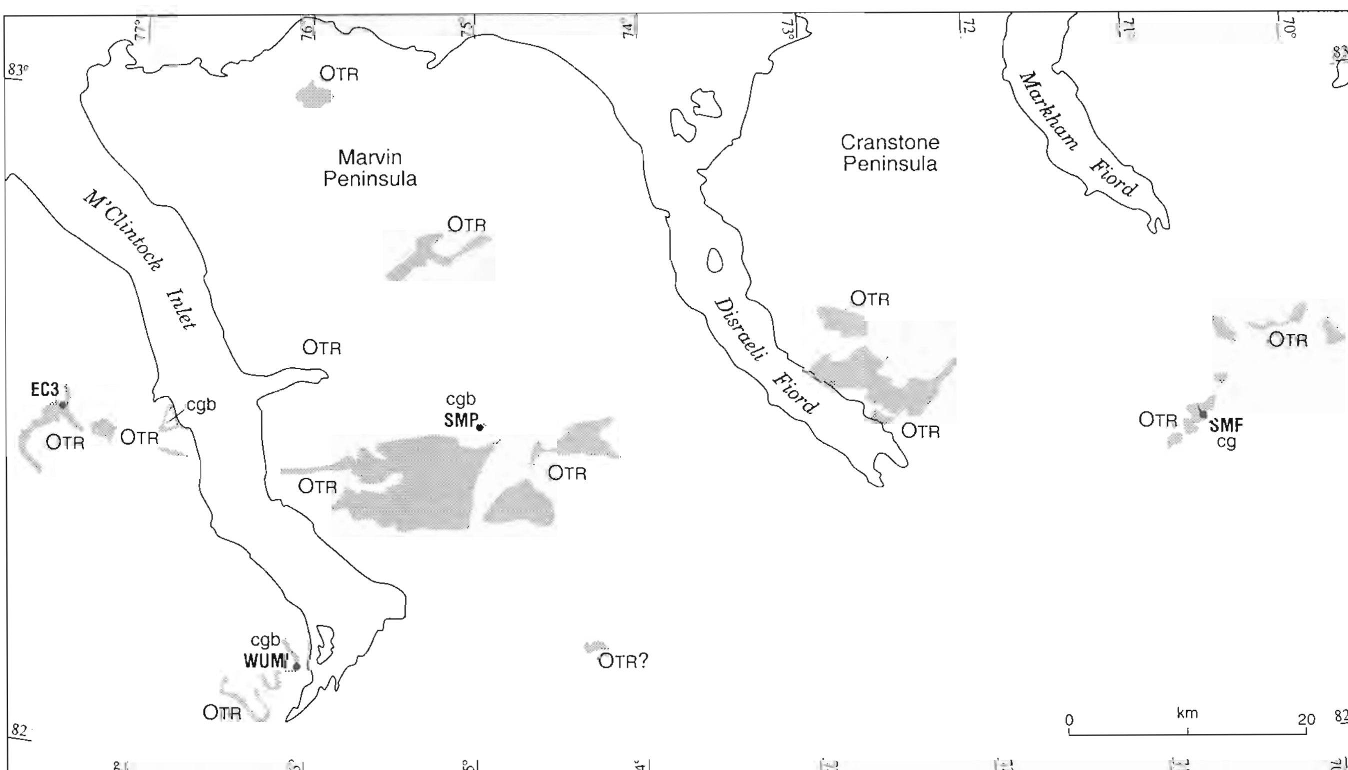


Figure 119. Main outcrop areas and stratigraphic sections of Taconite River Formation (OTR). *An additional outcrop is present south of the area shown, at M'Clintock Glacier* (**M'Clintock Inlet**). EC3: *Egingwah Creek 3 section;* SMF: *section south of Markham Fiord;* SMP: *southern Marvin Peninsula section;* WUMI: *section west of upper M'Clintock Inlet;* cgb: *conglomerate present at base of formation;* cg: *conglomerate higher in the section.*

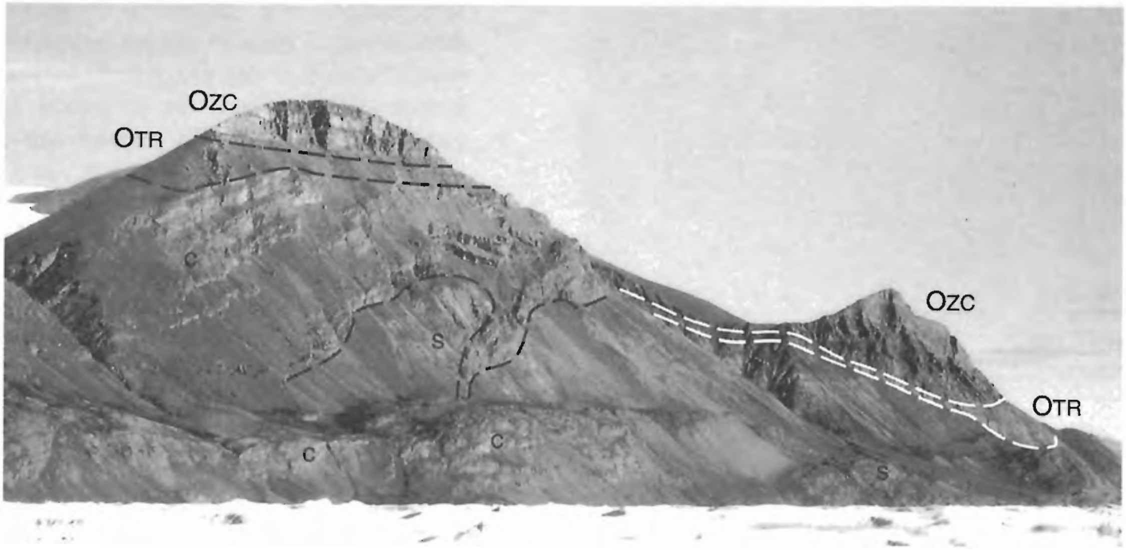


Figure 120. Exposures west of upper M'Clintock Inlet. Complexly folded schist (s) *and marble* (c) *of Succession 2 are overlain with angular unconformity by the Upper Ordovician Taconite River* (OTR) *and Zebra Cliffs* (OZC) *formations. ISPG photo 978-18.*

loc. SMF, *Clements Markham Inlet–Robeson Channel*), but decreases to a few tens of metres or less southwest of the upper reaches of M'Clintock Inlet. The formation is absent on Harley Ridge, east of the head of M'Clintock Inlet, where the Zebra Cliffs Formation lies on Succession 2 (see Zebra Cliffs Formation, Fig. 126).

Lithology. The sediments of the Taconite River Formation can be grouped into two recurrent lithofacies: (1) coarse conglomerate and minor sandstone, and (2) interbedded sandstone and mudrock with minor limestone, intraformational conglomerate, and fine-pebble conglomerate. The conglomeratic facies is quantitatively insignificant but important from a tectonic point of view, the sandy-argillaceous facies forms the bulk of the formation.

Conglomerate-sandstone facies. This facies was observed at the base of the formation at four localities in the southwestern part of its outcrop area.

1. In the area west and southwest of uppermost M'Clintock Inlet, the Taconite River Formation consists entirely of this facies, which attains a thickness of more than 70 m in a channel fill west of upper M'Clintock Inlet (Appendix 1, section west of upper M'Clintock Inlet and Harrison et al., 1994). Conglomerate, fining upward from coarse boulder grade (50 cm) to pebble grade, predominates in the lower 50 m or so. The boulders and cobbles in the lower part consist of marble and schist comparable to underlying rocks of Succession 2 (Fig. 121). The lowermost boulders are angular and tightly packed. Higher in the section, lenses of pebbly sandstone, showing horizontal bedding and metre-scale troughs, are present (Fig. 122).

2. Conglomerate, sandstone, and mudrock are exposed in a fault slice on the east side of M'Clintock Glacier (*M'Clintock Inlet).* The conglomerate weathers red and includes boulders up to 30 cm in diameter. Some clasts, composed

Figure 121. Clast-supported, angular boulders of marble, similar to underlying strata of Neoproterozoic-Cambrian age at base of Taconite River Formation, west of upper reaches of M'Clintock Inlet. ISPG photo 1360-20.

Figure 122. Pebbly sandstone showing horizontal bedding and scoop-shaped foresets, underlain and overlain by coarse conglomerate in lower part of Taconite River Formation west of upper reaches of M'Clintock Inlet. ISPG photo 1360-57.

of talc, calcite, and iron oxide with relic igneous textures, represent altered ultramafic or mafic rocks, others a variety of limestones, including fine-grained peloidal packstone-wackestone with skeletal fragments and lime mudstone.

3. Pebble and cobble conglomerate with boulders up to 70 cm in diameter are present in a syncline on central southern Marvin Peninsula (Fig. 119, loc. SMP, and Fig. 123). The conglomerate is poorly size-sorted, but shows a crude horizontal stratification. Tens of metres in thickness on the southern limb of the syncline, it is absent on the northern limb where the reference section was measured (Fig. 124). The pebbles and cobbles are made up of volcanic rocks, chert, and limestone.

Figure 123. Basal conglomerate of Taconite River Formation near section on southern Marvin Peninsula. Clasts are mainly volcanic rocks with some limestone and chert. ISPG photo 1360-37.

4. Reddish weathering cobble conglomerate with clasts up to 15 cm in diameter occurs in an anticline in the northern Zebra Cliffs (*M'Clintock Inlet*).

This lithofacies, however, is not restricted to the base of the formation. A reddish weathering conglomerate, more than 35 m thick, occurs in its uppermost part on the nunatak south of Markham Fiord mentioned earlier (Fig. 119, loc. SMF; *Clements Markham Inlet*). The unit is poorly stratified and composed mainly of pebbles and cobbles up to 25 cm in diameter, but also includes lenses, a few metres long, of crossbedded pebbly sandstone with troughs about 50 cm deep.

Sandstone-mudrock-carbonate facies. This lithofacies is represented by the type section at Egingwah Creek and by a better exposed, but incomplete reference section on southern Marvin Peninsula (Fig. 124). Sandstone and mudrock are coloured in hues of red, brown, green, and grey with redbeds most common on southern Marvin Peninsula. Flat or undulating laminae and small-scale crosslaminae, partly disturbed by burrows, are the characteristic primary structures.

The grain size of the sandstones is mainly very fine to fine, but ranges up to very coarse. Point count and XRD analyses (Appendix 3, Tables 110, 111) indicate considerable compositional variation. The most abundant component is quartz, followed by carbonates and feldspar. Chert, low-grade-metamorphic rock fragments, quartzite, white mica, biotite, chlorite, and opaque materials are present in lesser amounts, and volcanic and hypabyssal rock fragments in trace amounts. The average carbonate content is 16.5 per cent according to 20 XRD analyses of sandstone, but ranges up to 54 per cent in a quartzose and dolomitic calcarenite. The carbonate fraction consists of variably recrystallized fragments of limestone, dolomitic limestone, and dolostone, and individual crystals of calcite and dolomite. The dolomite content of the carbonate fraction (uncorrected XRD ratio D/D+C) varies from 0 to 100 per cent and averages 36 per cent. The uncorrected proportion of feldspar in the combined quartz+feldspar fraction averages about 12% (XRD ratio F/F+Q; corrected value about 18%). The feldspar fraction consists mainly of albite (82% uncorrected) and lesser K-feldspar.

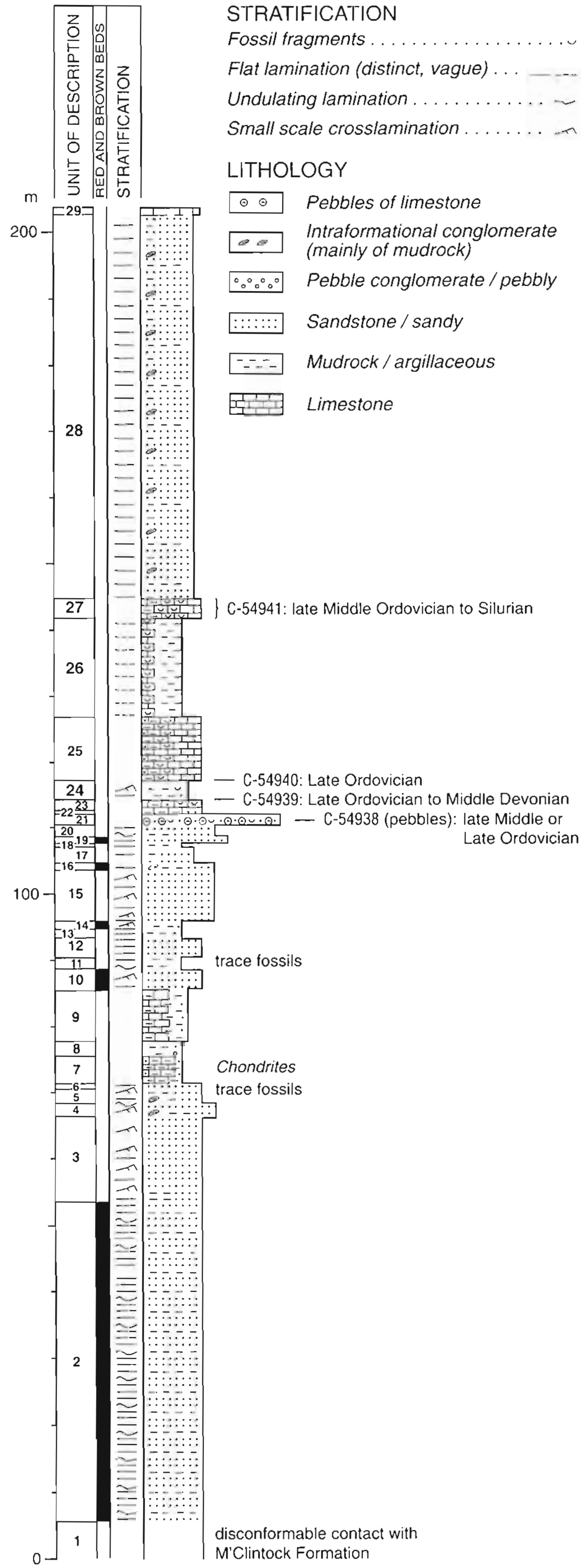


Figure 124. Taconite River Formation, reference section on southern Marvin Peninsula.

Most mudrocks are medium or coarse grained siltstones composed of quartz, carbonate grains, feldspar, mica, and chlorite. Their average XRD composition is similar to that of the sandstones (Appendix 3, Table 112), but shows larger percentages of mica and chlorite (9.5 versus 3), and smaller percentages of quartz (63 versus 72). The average carbonate content of 15 samples is about 21 per cent, but as high as 41 per cent in a sample not included in Table 112.

Intraformational conglomerates are composed mainly of mudrock and rarely of carbonate rocks.

Carbonate rocks, mainly limestone and minor dolostone, are a minor but ubiquitous component of this lithofacies. The type section includes a 22-m-thick limestone unit, and a 0.6-m-thick dolostone unit. In the section on southern Marvin Peninsula, limestone units range in thickness from a few decimetres to nearly 10 m. Dolostone is absent. Most common are skeletal lime wackestones and sparsely fossiliferous lime mudstones containing variable amounts of siliciclastic silt and sand. Corals, echinoderms, brachiopods, gastropods, trilobites, cephalopods, and dasycladacean algae are represented in the skeletal material.

Metamorphism. The preservation of detrital biotite in sandstones and mudrocks shows that the sand and coarse silt fractions are essentially unmetamorphosed; the finer fractions have not been studied.

Mode of origin. The Taconite River Formation represents a wide range of depositional environments, with coarse conglomerates of alluvial fan and fluvial aspect on one end of the spectrum and richly fossiliferous limestones of shallow subtidal aspect on the other end. The interbedded sandstones and mudrocks that make up the bulk of the formation probably were deposited in intermediate, shallow-marine to peritidal settings.

The composition of the clastic sediments indicates derivation from a considerable variety of source rocks. Quartzite, phyllite, and schist fragments were probably derived from Succession 2, and volcanic and hypabyssal rocks from the Maskell Inlet Complex and/or the M'Clintock Formation. The carbonate clasts may in part be of penecontemporaneous origin.

The distribution of the conglomerates suggests two main source areas of coarse clastic sediments, probably located south and west of the head of M'Clintock Inlet, and east or northeast of Markham Fiord, respectively.

Age and correlation. Diagnostic fossils from the Ayles and Zebra Cliffs formations imply a Late Ordovician (Richmondian) age for the Taconite River Formation. One collection from the Taconite River Formation (C-54938 from southern Marvin Peninsula) is Late Ordovician in age; the other five have broader ranges (Norford, Appendix 5A). The Taconite River Formation is correlative with a part of the chert member of the Hazen Formation.

Zebra Cliffs Formation (map unit Ozc, *Upper Ordovician)*

Definition. The name, Zebra Cliffs Formation, was introduced for a carbonate unit that lies conformably between the Taconite River and Imina (now Danish River) formations (Trettin, 1969b), with a type section at the Zebra Cliffs on the west side of central M'Clintock Inlet (Frontispiece and *M'Clintock Inlet*, inset B). There the formation was divided into three members A, B, and C. The Zebra Cliffs section is complex in structure and is, in part, difficult to access. It was traversed, but not measured and described in detail.

The Zebra Cliffs Formation is here redefined as a carbonate unit generally underlain by the Taconite River Formation and locally by metamorphic rocks of Succession 2. In most of its its distributional area it is overlain by the Lorimer Ridge Formation. At M'Clintock Inlet it is probably overlain by the Ooblooyah Creek Formation, but the contacts are faulted. Exposures south of Disraeli Fiord (Fig. 125, section SDF; *M'Clintock Inlet*; see Appendix 1) are used as the reference section for four newly defined members, named A to D in order upward. The new members, A and B, do not correspond to the original members (see below, Type section), and the original Member C, which differs from the rest of the formation by its darker colour and graptolitic fauna, is removed from the Zebra Cliffs Formation and redefined as the Ooblooyah Creek Formation.

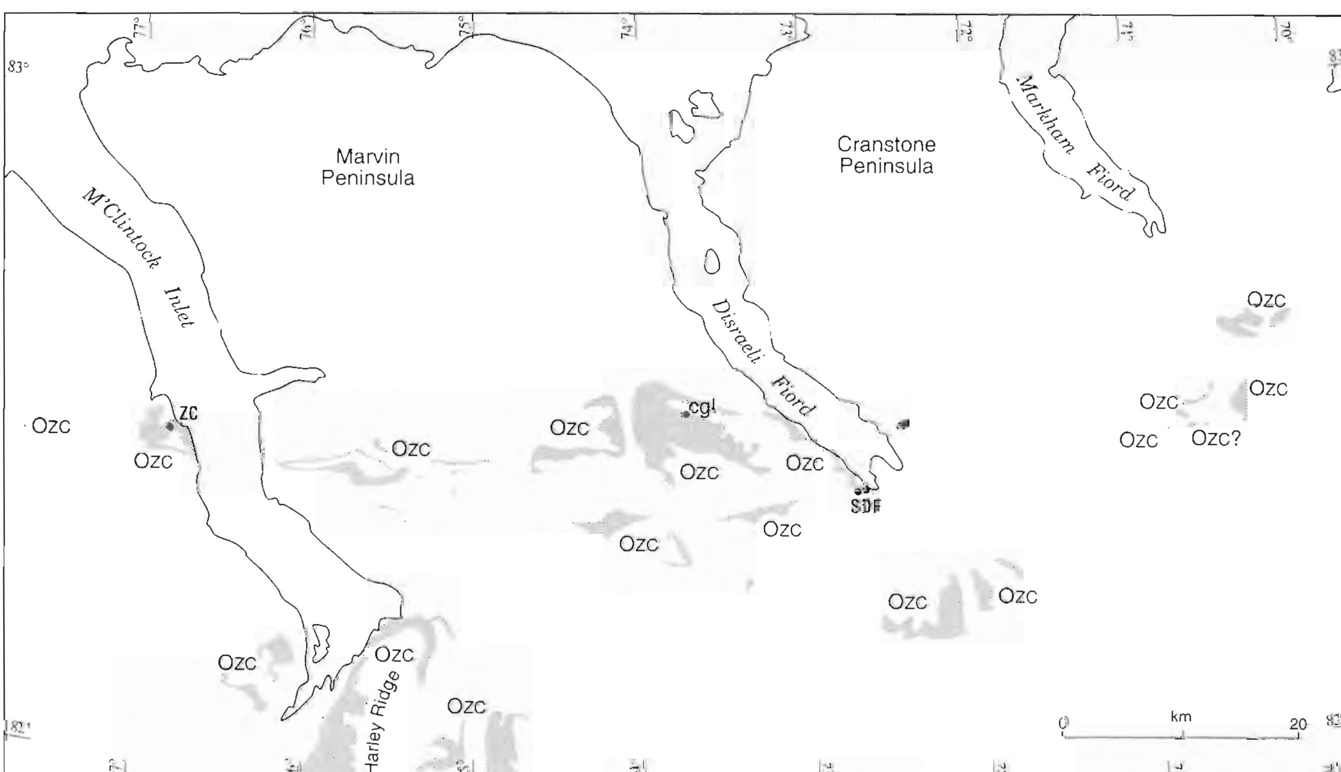


Figure 125. Zebra Cliffs Formation (Ozc), main outcrop areas and stratigraphic sections. Additional outcrops occur south of the area shown on Harley Ridge (M'Clintock Inlet). ZC: Zebra Cliffs section; SDF: section south of Disraeli Fiord; cgl: conglomerate west of Disraeli Fiord.

Distribution, contact relations, and thickness. Scattered outcrop areas of the Zebra Cliffs Formation extend from west of M'Clintock Inlet to southeast of Markham Fiord (Fig. 125). In most of this region the Zebra Cliffs Formation conformably overlies the Taconite River Formation, but on Harley Ridge, east of upper M'Clintock Inlet, it overlies Succession 2 with a high-angle unconformity (Fig. 126). As mentioned earlier, the Zebra Cliffs Formation is mainly overlain by the Lorimer Ridge Formation and locally probably also by the Ooblooyah Creek Formation, but the contacts with the latter are faulted (Frontispiece).

The thickness of the formation has not been determined precisely. The formation may be as thin as 300 m on northern Harley Ridge, where it laps onto a basement high, but increases in thickness to probably more than 1 km farther south on the ridge. A minimum thickness of about 550 m is indicated by photogrammetry for the type section in the Zebra Cliffs.

Lithology. *Macroscopic aspects.* The Zebra Cliffs Formation consists mainly of limestone with minor amounts of dolostone, mudrock, sandstone, and conglomerate. The limestone, chiefly wackestone or lime mudstone, contains a rich and diverse fauna, and is generally thinly stratified (about 2 to 20 cm) although massive beds are also present. Observations in four separate areas are summarized below.

Reference section. The section south of Disraeli Fiord (Appendix 1) contains the best exposures of the lower and upper parts of the formation (Members A, B, and D), but the middle part (Member C) is incomplete. There, Member A (Fig. 127) consists of 47 m of medium to medium dark grey skeletal lime wackestone. Beds are well defined, 5 to 25 cm thick, and bounded by slightly undulating surfaces. The unit contains a rich fauna of colonial and solitary corals, bryozoans, gastropods, and cephalopods.

Member B is 48 m thick and composed mainly of sandstone and mudrock with interbedded limestone in the lower 9 m. The rock colours are hues of green and grey in the lower 9 m, and hues of grey and red in the upper 39 m of the member. The mudrock is coarse grained, the sandstone very fine to fine grained, and both are variably calcareous and dolomitic. The strata are bioturbated, but some flat and undulating laminae are preserved. The mudrock shows bedding-parallel burrow casts. Beds are about 0.5 to 1 m thick in the upper 39 m.

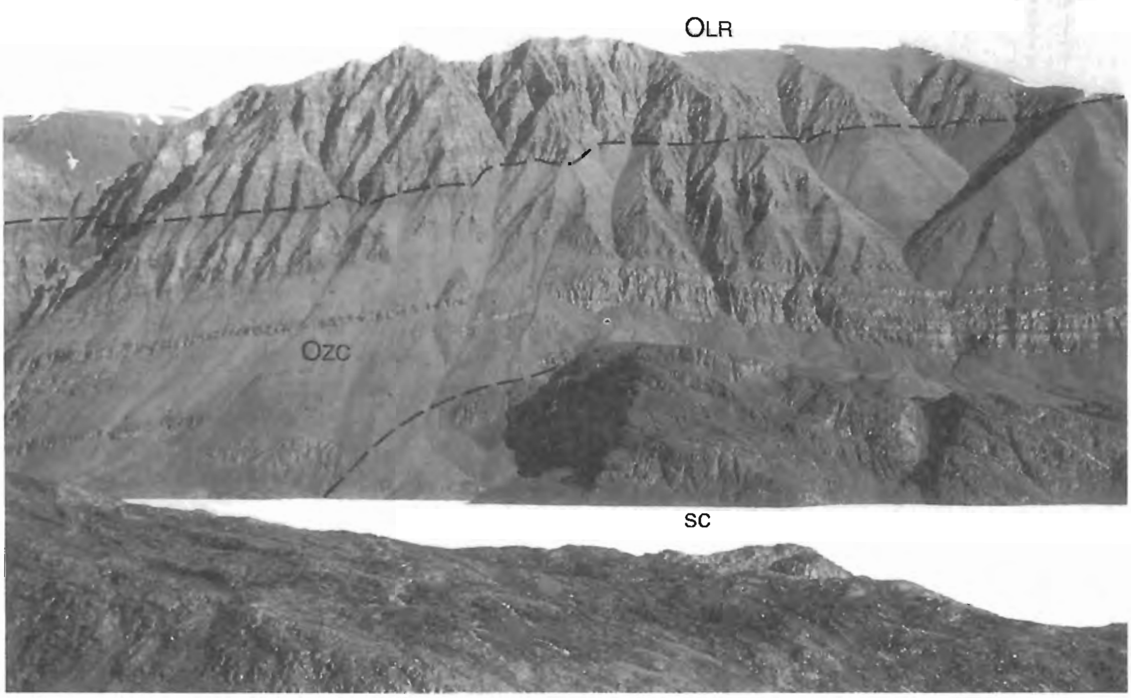


Figure 126. Exposures on east side of Harley Ridge, east of head of M'Clintock Inlet. Schist and marble of Succession 2 (sc) are overlain with angular unconformity by the Zebra Cliffs Formation (Ozc), in turn overlain with low angular discordance by the Lorimer Ridge Formation (Olr). Relief about 1 km. ISPG photo 978-2.

Member C is probably several hundred metres thick, but, because of poor exposure and structural complexities, only the lowermost and uppermost parts have been measured and described. The lower 48 m, represented by *in situ* rubble, consists of roughly two-thirds limestone and one-third mudrock and minor sandstone. The limestone is a bioturbated medium to medium dark grey skeletal wackestone or lime mudstone that contains common corals and fragments of various other biota, including gastropods, ostracodes, and trilobites. The mudrock is medium grey, coarse grained, and sandy; the sandstone, very fine grained, argillaceous, calcareous, dolomitic, and bioturbated.

The uppermost 23 m of Member C are composed of medium to medium dark grey lime mudstone and skeletal wackestone. The strata occur in 2- to 10 m-thick ledges and show parting surfaces at intervals of 5 to 20 cm.

Member D has a minimum thickness of about 55 m, and its upper contact is faulted. It consists mainly of medium to medium dark grey skeletal wackestone beds, 2 to 20 cm thick, separated by laminae of slightly darker, fissile wackestone (Fig. 128). Hexactinellid sponge spicules (T. de Freitas, Appendix 5C, GSC locs. C-96302, C-96303, C-96305), in part siliceous, but mostly replaced by calcite, are abundant (Fig. 129) and trilobite appendages are common. Also present is a massive bed of medium grey packstone, 5.5 m thick. It is composed mainly of lime mudstone clasts with lesser amounts of fragmental dasycladacean algae and trilobites.

Type section. In the Zebra Cliffs, the lower 22 m of the formation consists of ledge-forming, massive dolostone that is calcareous and slightly silty. It contains small lenses of chert and a sparse coralline fauna. This resistant unit also occurs on the east side of M'Clintock Inlet, where it is 22 to 23 m thick and composed of massive, fossiliferous limestone. This resistant unit is identical to the previous Member A and has been mapped east and west of central M'Clintock Inlet (Trettin, 1969a, fig. 15), but is now considered to be a local lithofacies within the lower part of the redefined Member A. The remainder of the redefined member consists of thinly stratified limestone and minor mudrock, similar to the strata of the redefined Member C. The thickness of Member A has not been determined, but is probably in the order of tens of metres.

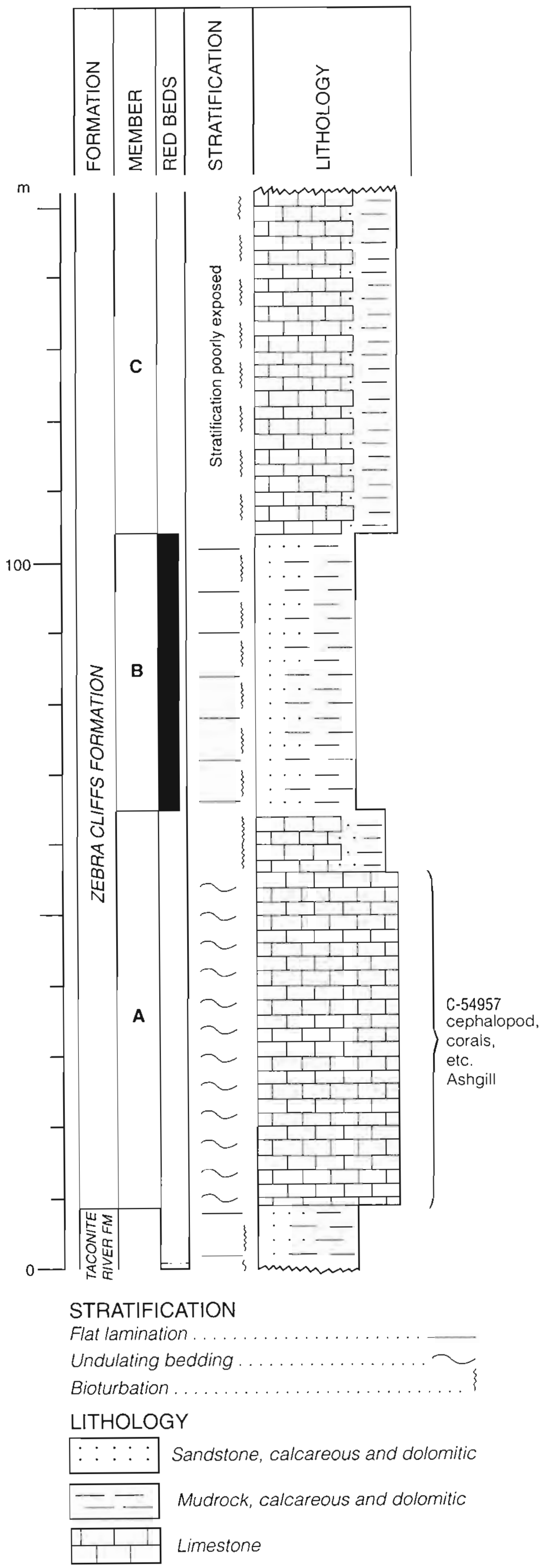


Figure 127. Lower part of Zebra Cliffs Formation at section south of Disraeli Fiord.

***Figure 128**. Thin bedded to laminated lime wackestone of Member D of Zebra Cliffs Formation at section south of Disraeli Fiord. ISPG photo 1878-16.*

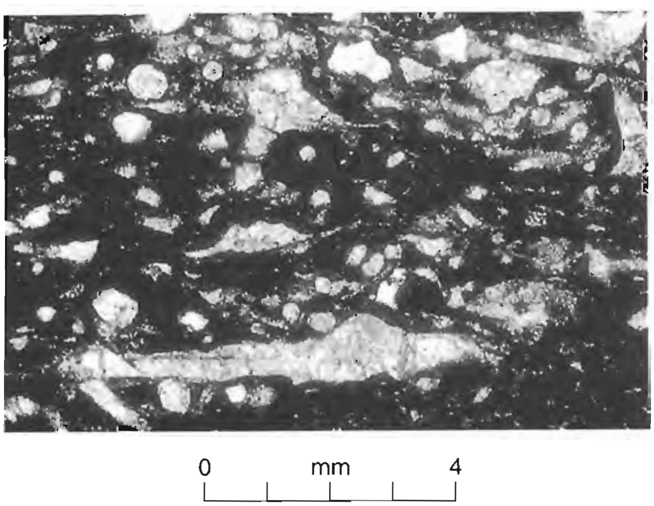


***Figure 129**. Photomicrograph (ordinary light) of sponge spicules in wackestone of Member D of Zebra Cliffs Formation. ISPG photo 2260-151.*

The redefined Member B is represented by a thin unit (estimated at 20 m or so) of red and greenish grey mudrock and very fine and fine grained sandstone.

The redefined Member C, which is probably more than 400 m thick, consists of predominantly thin bedded limestone and minor calcareous mudrock. The alternation of medium grey and medium dark grey strata, weathering in shades of yellowish grey, give the Zebra Cliffs their characteristic banded appearance. The limestones contain an abundant and diverse fauna of corals, bryozoans, gastropods, cephalopods, trilobites, and ostracodes, and rare graptolites.

West of Disraeli Fiord. Here pebble conglomerate, very fine to medium grained sandstone, and minor amounts of mudrock are associated with limestone in the lower part of a thrust sheet. The sandstone is medium grey to medium light grey and contains flat laminae and small-scale crosslaminae; the mudrock is red. The stratigraphic position of the clastic sediments is unknown, but the lithology suggests that they represent a coarse facies of Member B.

Harley Ridge. The extensive exposures of the Zebra Cliffs Formation in this area are poorly known. Thin bedded limestones and highly calcareous mudrock, similar to Member C and the upper part of Member A in the Zebra Cliffs, are abundant. Massive carbonate beds also are present, but have not been investigated. Lenticular carbonate bodies, several kilometres in length and tens of metres high, are exposed on the west side of the ridge, about 13 km southwest of its northeastern end (Fig. 130). Strata reminiscent of Members B and D have not been recognized.

Microscopic aspects. Most limestones are skeletal wackestones or lime mudstones with bioclasts. Macrofossils and derived skeletal fragments represent a great variety of biota, including colonial and solitary corals, echinoderms, brachiopods, bryozoans, trilobites, gastropods and cephalopods. The most abundant microfossils are ostracodes and cyclocrinitid dasycladacean algae.

Grainstone is relatively rare. A specimen from Harley Ridge consists mainly of fragments of corals, brachiopods, trilobites, molluscs, and dasycladacean algae. Some fragments have oncolitic envelopes of *Girvanella* (Fig. 131).

The dolomite content of the limestones is small, ranging from 1 to 6 per cent in XRD analyses (Appendix 3, Table 113). Siliciclastic impurities, mainly of mud grade, but including fine and very fine grained sand, average 12 per cent. They consist mainly of quartz with minor amounts of feldspar, mica, and chlorite. A skeletal wackestone transitional to mudrock has a much higher content of clastic impurities. In addition to calcite (44%) and minor dolomite (2%), it contains quartz (36%), albite (6%), chlorite (6%), and mica (6%). The variations in the darkness of the rocks are probably due to variations in the concentration of submicroscopic carbonaceous impurities.

Figure 130. Lenticular, nearly massive carbonate body (arrow) in Zebra Cliffs Formation, west side of Harley Ridge, about 13 km southwest of its northeastern end. ISPG photo 1360-54.

The sandstones are composed mainly of quartz and carbonates, with smaller amounts of feldspar (mainly albite), chlorite, mica (mainly white mica with trace amounts of biotite), chert, and low-grade metamorphic rock fragments (phyllite, low-grade schist). The carbonate grains consist of lime mudstone or single crystals of calcite and dolomite that may represent recrystallized aggregates. XRD analysis (Appendix 3, Table 114) indicates quartz (mean 63%), carbonates (21%; D/D+C=48%), feldspar (9%; P/P+Kf=84%), chlorite (3%), and mica (2%); (Appendix 3, Table 114, mean of 5 samples). The mudrocks are similar in composition to the sandstones (Appendix 3, Table 115), but differ by higher contents of chlorite (6%) and mica (4%).

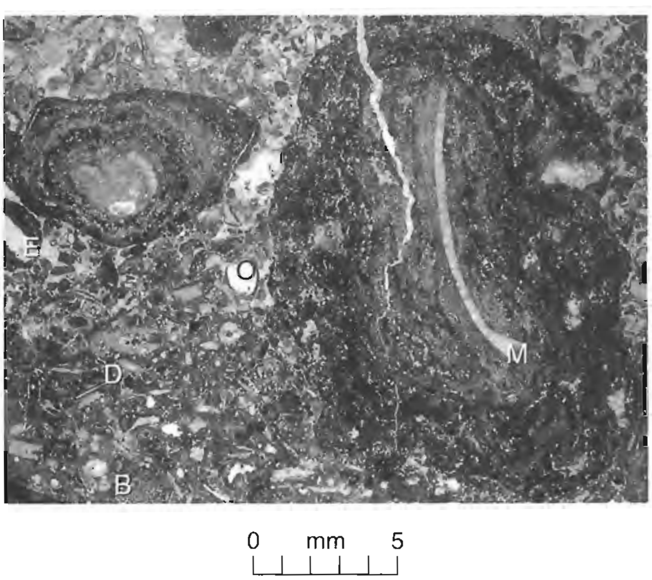


Figure 131. Photomicrograph (ordinary light) of grainstone of Zebra Cliffs Formation from Harley Ridge, composed of skeletal fragments, some of which have microbial coatings, forming oncoids. B: bryozoan, D: dasycladacean alga, E: echinoderm, M: mollusc, O: ostracode. ISPG photo 2260-162.

The pebbles of the conglomerate west of Disraeli Fiord are up to 1.5 cm in diameter and embedded in a sandy matrix. They represent the following materials (Fig. 132): chert (partly sheared, partly calcareous, possibly with sparse sponge spicules), carbonate rocks (peloidal grainstone, dolomitic lime mudstone, limestone with botryoidal texture, calcareous dolostone); a brachiopod fragment; sandstone (very fine grained, calcareous and dolomitic); quartzite (poorly sorted, medium grained); vein quartz (strained); schist (quartzose, highly calcareous); and volcanics (mafic, altered).

Metamorphism. Conodont alteration indices vary from 3.5 to 4.5 and indicate temperatures between 110 and 300°C (Epstein et al., 1977). The lower value was obtained from Member D in the section south of Disraeli Fiord (Nowlan, Appendix 5B, GSC locs. C-96699 to C-96701), the upper value from Harley Ridge (Dougherty, Appendix 5B, GSC loc. C-74849). The preservation of small amounts of detrital biotite in the sandstones confirms that the metamorphism of the sand fraction is below greenschist grade.

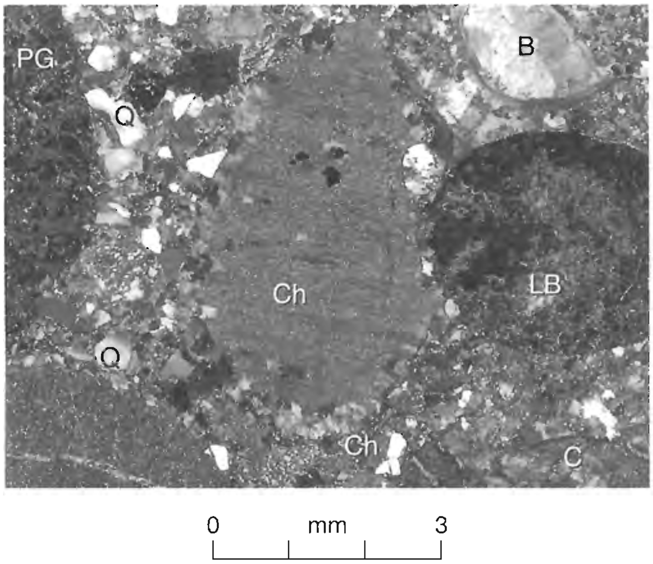


Figure 132. *Photomicrograph (cross-polarized light) of pebble conglomerate of Zebra Cliffs Formation from thrust sheet west of Disraeli Fiord. Pebbles include chert* (Ch), *peloidal grainstone* (PG), *limestone with botryoidal texture, probably of vadose origin* (LB), *and a brachiopod fragment* (B). *Pebbles are embedded in sandy matrix composed mainly of quartz* (Q) *and carbonate grains* (C), *with some chert, mica, and albite. ISPG photo 2260-177.*

Mode of origin. Members A and C, which together make up the bulk of the formation, represent oxygenated subtidal shelf environments that were favourable for benthonic life. The abundance of the rather fragile dasycladacean algae may indicate low energy conditions.

Member B, characterized by a high proportion of siliciclastic material and common redbeds, probably represents a brief regression and was deposited in progressively shallower settings that ranged from shallow subtidal to peritidal. The siliciclastic components were probably derived from the same terrestrial sources as the Taconite River Formation, but the associated carbonate clasts are probably of intrabasinal origin.

The deepest water settings are represented by Member D. The wackestones resemble pericratonic limestones with regard to thin stratification and dark hue (cf. McIlreath and James, 1978). The lime mud was probably generated on an adjacent shelf and transported into a slope or basinal setting by dilute turbid suspensions. The spicules were derived from sponges that lived somewhere below the shelf edge in settings that were neither anoxic nor stagnant, because recent forms prefer settings with currents moving at speeds of 1 to 3 km/h (T. de Freitas, Appendix 3C, GSC loc. C-96302). The packstone of Member D is interpreted as a subaqueous debris flow. A conodont from this bed is of "North Atlantic affinity" implying outer shelf-upper slope conditions rather than a faunal provice (Nowlan, Appendix 5B, GSC loc. C-96700, and pers. comm., 1987).

Age and correlation. The most diagnostic macrofossils (Sinclair, Appendix 5A, GSC loc. 24721; Norford, Appendix 5A; GSC locs. 69203, 69211, 69202) indicate a Late Ordovician (Richmondian) age. Other macrofossil collections and conodont faunules (Tipnis, Appendix 5B, GSC loc. C-96701; Nowlan, Appendix 5B, GSC loc. C-96700) have wider age ranges, but are compatible with that assignment. The Zebra Cliffs Formation is correlative with a small part of the chert member of the Hazen Formation.

Succession 5B (Upper Ordovician to Upper Silurian)

Definition

Succession 5B (Fig. 118) includes all those strata of Pearya lying between the Zebra Cliffs Formation and strata of the Sverdrup Basin. In contrast to Succession 5A, it shows pronounced facies changes that are probably tectonically controlled. A description of individual formations will be followed by a brief summary of facies variations through time.

Lorimer Ridge Formation (map unit OLR, *Upper Ordovician)*

Definition. The Lorimer Ridge Formation (Trettin, 1987b), is a siliciclastic and carbonate unit that lies stratigraphically between the Zebra Cliffs and Cranstone or Marvin formations. It is composed mainly of sandstone and mudrock with smaller amounts of limestone and rare conglomerate. The siliciclastic sediments are multicoloured and include a high proportion of redbeds. The type section is on the east side of Lorimer Ridge, about 9 km southeast of Disraeli Fiord (*M'Clintock Inlet*).

Distribution, contact relations, and thickness. Outcrops of the formation lie in a belt, 90 km long and up to 27 km wide, that extends from Harley Ridge to southeast of Markham Fiord (Fig. 133; *M'Clintock Inlet*, and *Clements Markham Inlet-Robeson Channel*). The lower contact, with the Zebra Cliffs

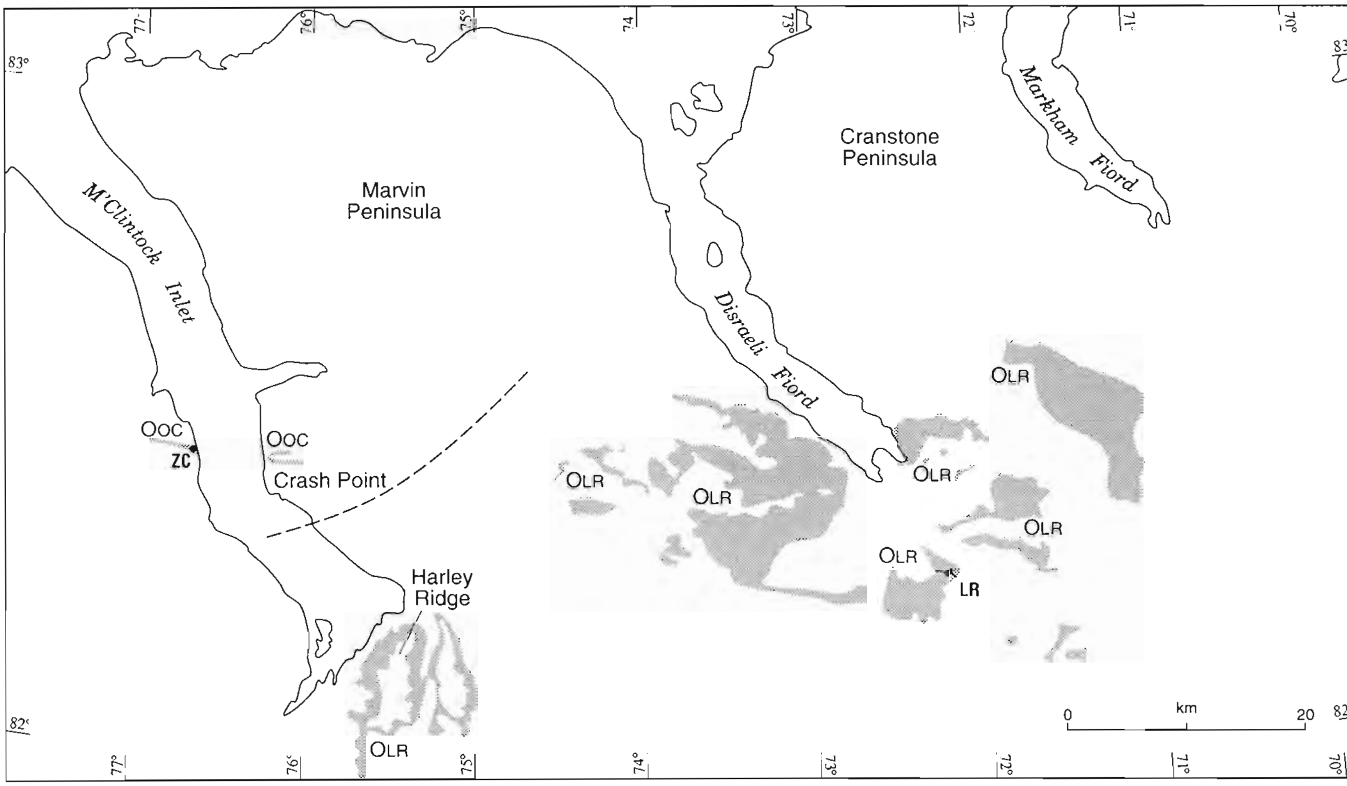


*Figure 133. Lorimer Ridge (OLR) and Ooblooyah Creek (OOC) formations, main outcrop areas and section localities. Additional outcrops of the Lorimer Ridge Formation occur south of the area shown, on Harley Ridge (**M'Clintock Inlet**). LR: Lorimer Ridge section. ZC: Zebra Cliffs section.*

Formation, is a low-angle unconformity on southern Harley Ridge (Fig. 126) and covered elsewhere. The Lorimer Ridge is overlain by the Marvin Formation in some areas and by the Cranstone Formation in others. The contact with the Marvin Formation is conformable, and the contact with the Cranstone Formation was covered where examined. The Lorimer Ridge Formation is 813 m thick in the type section (Fig. 134).

Lithology. Macroscopic aspects. The formation consists mainly of interbedded sandstone and mudrock with small amounts of limestone and rare pebble conglomerate. The siliciclastic sediments are greyish red, grey, or greenish grey. Redbeds are predominant and limestone is rare in the easternmost exposures, which include the type section. Farther west, for example in the section north of Thores River, limestone is more common and redbeds are subordinate (Table 20 and Fig. 135).

In the type section and in the section north of Thores River, the sandstones are mainly very fine and fine, rarely medium, grained (about 10% of samples). Most mudrocks are medium or coarse grained siltstones. The sandstones and mudrocks are generally bioturbated, but the original stratification is preserved to some extent. It consists mainly of flat or undulating laminae and, to a lesser extent, of small-scale crosslaminae. Sandstone in the section north of Thores River contains intraclasts of mudrock.

Conglomerate has been observed only in the type section. There, a unit of crossbedded pebble conglomerate and pebbly sandstone occurs 152.5 to 154.5 m above the base of the formation. Sets of cross-strata are about 25 cm thick (Fig. 136).

A discrete unit of medium to medium dark grey, silty and sandy limestone (lime mudstone with skeletal content), 7 m thick, occurs in the upper part of the type section (at 520-527 m; unit 12). The skeletal material consists of ostracodes, bryozoans, chain corals, brachiopods, and stromatoporoids. Coral-bearing limestone also is present in the upper 1 m of the formation.

In the section north of Thores River 1 (Fig. 134), four units of limestone, mainly lime mudstone with skeletal content and minor skeletal wackestone, are

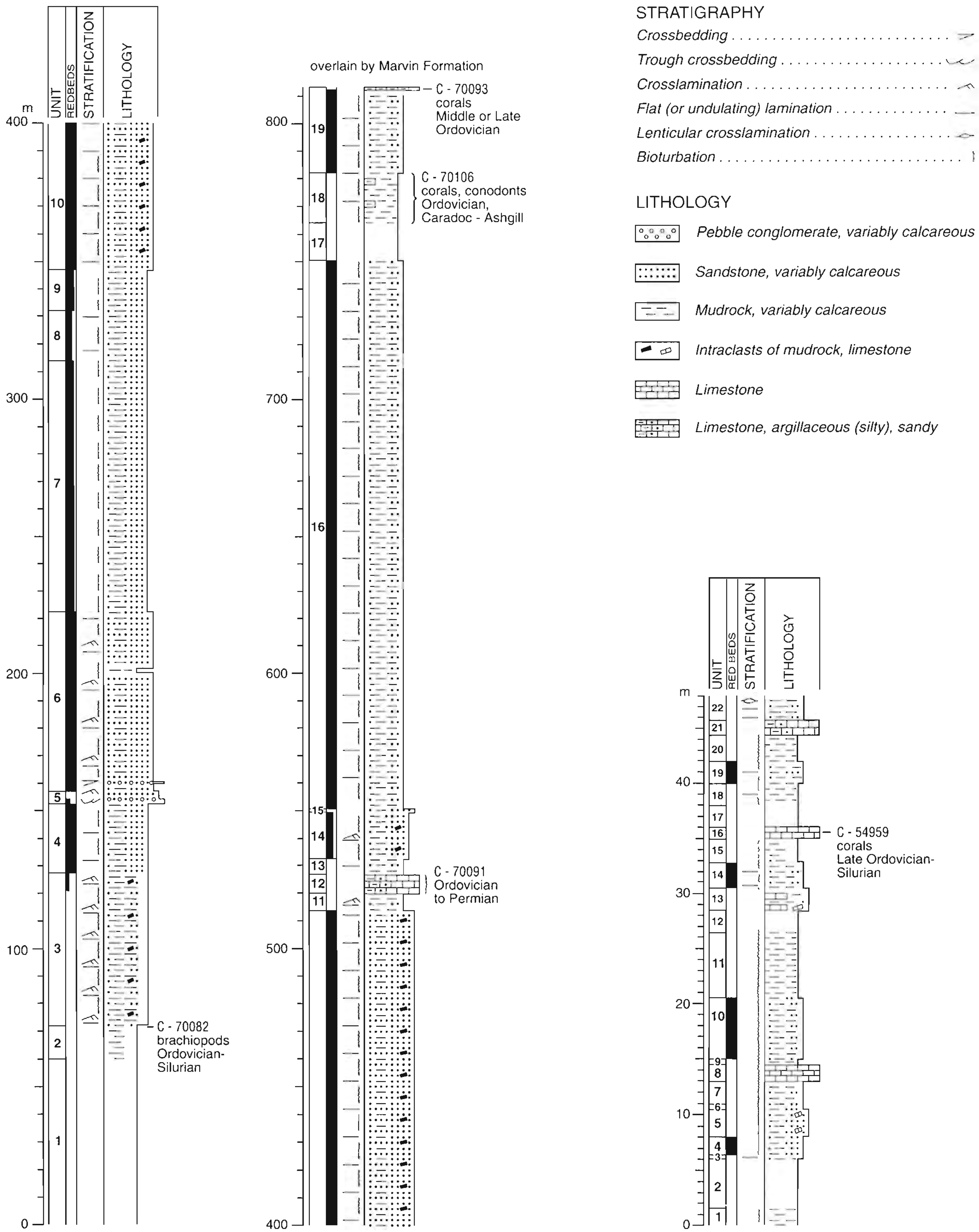


Figure 134. *Stratigraphic sections of Lorimer Ridge Formation. At left, type section at Lorimer Ridge (813 m), at right detailed partial section north of Thores River 1 (48 m).*

Figure 135. Lorimer Ridge Formation on east side of Disraeli Glacier, view east-northeast. Dark strata are redbeds. ISPG photo 1693-3.

present. The rocks are bioturbated, range in colour from light grey to medium dark grey, and contain varying proportions of siliciclastic mud and very fine grained sand.

Composition. A representative sample of sandy pebble conglomerate from the type section, analyzed by point count for silicates and by XRD for carbonate content has the following composition (numbers indicate percentages):

Carbonates	46	Lime mudstone with or without skeletal grains (ostracodes, bryozoans), in part silty and sandy; peloidal limestone; marble
Quartz	23	
Chert	20	Some relics of radiolarians
Feldspar	4	Mainly albite
Metamorphics	4	Phyllite, low-grade schist
Quartzite	1	
Granitoid rocks	1	
Chlorite	<1	
Opaques	<1	

The pebbles are mainly chert and limestone.

XRD analyses indicate that sandstone samples from the type section are composed of quartz (75%), carbonates (13%; mainly calcite, minor dolomite), feldspar (10%; mainly albite, minor K-feldspar), chlorite (1%), and mica (1%); (average of 22 samples; Appendix 3, Table 124). Thin section analysis is difficult because of the predominantly fine grain size and pervasive carbonate alteration. Estimates and a few point count analyses indicate that single grains of quartz are predominant. In addition, fine to medium grained sandstones may contain between 5 and 10 per cent of each of the following rock types: chert, low-grade schist or phyllite, and volcanic-hypabyssal rock fragments of predominantly felsic composition. Most of the chlorite and white mica recorded in the XRD analyses occurs in these rock fragments, but free chlorite and biotite also are present.

Samples of mudrock from the type section consist of quartz (65%), carbonates (22%; mainly calcite, less dolomite), albite (8%), chlorite (3%), and mica (2%); (average of 18 XRD analyses; Appendix 3, Table 125).

Metamorphism. A conodont collection from the uppermost part of the formation in the type section has an alteration index of about 3, indicating a

Figure 136. Crossbedded pebbly sandstone and minor pebble conglomerate of Lorimer Ridge Formation, type section, unit 5. ISPG photo 3168-5.

temperature of approximately 110° to 200°C (Epstein et al., 1977).

Mode of origin. The limestones, with their fairly abundant and diverse benthonic fauna, are of shallow subtidal aspect. The mudrocks and fine grained sandstones, which make up the bulk of the formation, probably were deposited in shallow subtidal to intertidal environments, the abundant redbeds suggesting intermittent subaerial exposure. The cross-bedded pebbly sandstone and pebble conglomerate may represent a tidal or estuarine channel.

The increase in the proportion of clastic sediments and redbeds towards the east or north-northeast suggests a shoreline in that direction. The source area included metamorphic and igneous rocks as well as radiolarian chert. The fact that the sediments are compositionally immature indicates that the source area was not subjected to prolonged chemical weathering.

Age and correlation. The coral *Sibiriolites sibiricus* Sokolov, which also occurs in the Zebra Cliffs Formation, indicates an Ashgill age (Norford, Appendix 5A, GSC loc. C-75494, C-10). Other, less specific collections of macrofossils (Norford, Appendix 5A) and conodonts (Tipnis, Appendix 5B), as well as fossils from the underlying Zebra Cliffs Formation and overlying Marvin Formation, are compatible with that assignment. The Lorimer Ridge Formation is correlative with the Ooblooyah Creek Formation.

Ooblooyah Creek Formation (map unit Ooc, Upper Ordovician)

Definition. The name, Ooblooyah Creek Formation, is here proposed for a graptolitic unit of calcareous-dolomitic mudrock and resedimented impure limestone that probably overlies the Zebra Cliffs Formation although the contacts are faulted. The type section is in the Zebra Cliffs (Frontispiece and *M'Clintock Inlet*, inset B). The strata were originally referred to as Member C of the Zebra Cliffs Formation (Trettin, 1969b) and later as the Disraeli Glacier beds (Trettin, 1991b).

Distribution, contact relations, and thickness. The Oobolooyah Creek Formation is exposed west and east of central M'Clintock Inlet, in the Zebra Cliffs and near Crash Point (*M'Clintock Inlet*, insets B and C). At both localities it lies between the Zebra Cliffs and Danish River formations with exposed or assumed fault contacts. Age relations suggest that stratigraphically it lies between the Zebra Cliffs and Cranstone formations, but the latter is not exposed in this area. If so, the contacts are probably conformble because the top of the Zebra Cliffs Formation is of outer shelf-upper slope origin and the Ooblooyah

Table 20

Lorimer Ridge Formation: lithology and rock colours

A. Type section	%
Pebbly sandstone and pebble conglomerate	0.2
Sandstone	0.3
Sandstone, minor mudrock	28.7
Sandstone and mudrock	32.6
Mudrock, minor sandstone	24.5
Mudrock (partly covered)	1.5
Mudrock and lime mudstone	2.2
Limestone	0.9
Covered	9.0
Greyish red	67.5
Mainly greyish red with up to about 20% grey	19.6
Mainly grey, minor greyish red	7.7
Grey	5.2
B. Short interval (48 m) in the lower part of the formation at the section north of Thores River	
Sandstone	5.2
Sandstone and mudrock	22.3
Mudrock, minor sandstone	11.5
Mudrock	31.3
Limestone, minor sandstone	12.1
Covered	17.7
Greyish red	33.8
Medium grey, greenish grey	66.2

Creek and Cranstone formations both are of deep water origin. The formation has an apparent thickness of more than 400 m in the Zebra Cliffs but may be repeated by isoclinal folds. On the other hand, significant parts of the formation may have been removed by faulting.

Lithology. In the Zebra Cliffs, the formation consists of lime mudstone, calcarenite, and mudrock. Calcareous beds are predominant in the lower 240 m or so. The lime mudstone and calcarenite are medium dark grey on fresh surfaces and weather in hues of grey and yellow. They consist mainly of calcite (mean 82%), with subordinate quartz (12%) and small amounts of mica and chlorite (2% combined; Appendix 3, Table 120). The calcite occurs mainly as single crystals of coarse silt to very fine sand grade that probably formed by the recrystallization of cryptocrystalline aggregates, relics of which are apparent in the extinction position under cross-polarized light. The mudrocks are medium dark grey or, less commonly, greenish grey. Three analyzed samples consist mainly of quartz (44%) and carbonates (calcite 26%, dolomite 10%), with lesser amounts of feldspar (10%, mainly albite), white mica (5%) and chlorite (5%); (XRD analyses; Appendix 2, Table 119). The sediments contain a sparse graptolitic fauna and some ostracode fragments.

Exposures are poor near Crash Point. Rubble and sparse outcrop consist of medium dark grey calcareous mudrock and laminated, graptolitic lime mudstone and calcarenite.

Metamorphism. The metamorphism is below greenschist grade and probably limited to the recrystallization of clay minerals. The silt-grade material, characterized by white mica and chlorite, is compatible with the greenschist facies but probably of detrital origin.

Mode of origin. The Ooblooyah Creek Formation is similar to parts of the Cape Phillips Formation and of the carbonate member of the Hazen Formation with respect the dark grey colour, graptolitic fauna, and lithological composition, and inferences about the origin of these units (Trettin, 1979, 1994) are applicable here. The sediments of all three formations probably originated on adjacent carbonate shelves and were redeposited in slope and basin environments from dilute turbulent suspensions that were generated by storms, earthquakes, or other agents.

Age and correlation. The most diagnostic graptolites are Ashgill in age and represent either the *complanatus ornatus* or the *pacificus* zones (Norford, Appendix 5A, C-59, C-60). The Ooblooyah Creek Formation is correlative with the Lorimer Ridge Formation.

Cranstone Formation (map units Sc, Sc1, *and* Sc2, *Lower Silurian)*

Definition. The Cranstone Formation, named after Cranstone Peninsula (*M'Clintock Inlet* and *Clements Markham Inlet–Robeson Channel*), is a thick succession of mudrock, sandstone, and conglomerate that overlies the Lorimer Ridge Formation. Its top is not preserved. The composite type section is located south of Disraeli Fiord, west of the lower reaches of Disraeli Glacier (*M'Clintock Inlet*, Figs. 137, 138, 139, and Appendix 1). The formation is divisible into a lower Member A and an upper Member B, which are readily mappable on air photographs.

Distribution, contact relations, and thickness. The formation has been mapped in three separate areas. An outcrop area west of the lower reaches of Disraeli Glacier and south of Disraeli Fiord (*M'Clintock Inlet*) includes the type section (section SDF). There the Cranstone Formation is in fault contact with the Zebra Cliffs Formation on the north, the Lorimer Ridge Formation on the northwest, and the Marvin Formation on the south, but a small outlier farther northwest overlies the Lorimer Ridge Formation with a concealed contact. The type section contains about 1 km of strata.

East of Disraeli Glacier, a northeast-trending belt of nunataks in the southwestern part of the *Clements Markham Inlet–Robeson Channel* map area is known only from brief visits by helicopter. The rocks are similar to those in the type section and represent both members. The Cranstone Formation overlies the Lorimer Ridge Formation in the two western nunataks, but the contacts are concealed. The topographic relief of the southwesternmost nunatak suggests a minimum thickness of about 350 m.

Farther north, an outcrop area on the east side of Markham Fiord is in fault contact with strata of Succession 2 (map unit L1-3) on three sides. Probably several hundred metres of strata are present that are similar in some respects to Member A in the type section although they are less tectonized at the microscopic scale. No fossils have been found, and underlying or overlying units are not exposed or preserved. These strata are tentatively assigned to the Cranstone Formation but may represent an otherwise unknown unit of post-Silurian age.

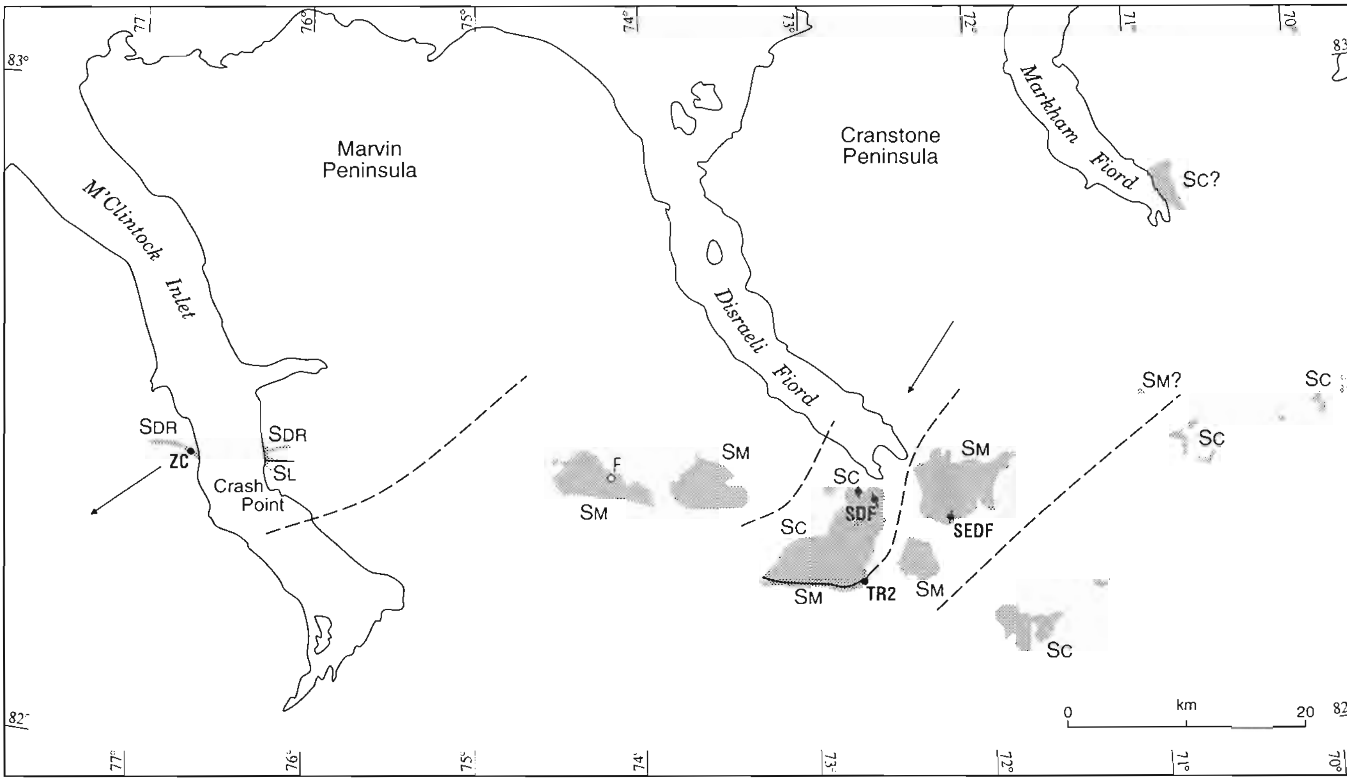


Figure 137. Generalized outcrop areas and stratigraphic sections of units of latest Ordovician to early Ludlow age. (Includes middle-late Ludlow strata of the undifferentiated Marvin Formation in the vicinity of Disraeli Fiord). SC: *Cranstone Formation;* SDR: *Danish River Formation;* SL: *Lands Lokk Formation;* SM: *Marvin Formation;* F: *Llandovery fossil locality;* SDF: *section south of Disraeli Fiord;* SEDF: *section southeast of Disraeli Fiord;* TR2: *section north of Thores River 2;* ZC: *Zebra Cliffs section. Arrows indicate probable direction of clastic transport.*

Lithology. The Cranstone Formation consists of conglomerate, mudrock, and sandstone. Conglomerate and sandstone are medium grey and weather in hues of olive grey and greyish brown; the mudrock is mainly medium dark grey and weathers in hues of olive grey. The following description is based on studies of the type section.

Macroscopic aspects (type section). *Member A.* Field measurements suggest a thickness of 416 m, but this estimate is unreliable because of poor exposure and folds in the upper part of the section. The member fines upward and is divisible into two major units, A1 and A2.

Unit A1, 218.5 m thick, is made up of mudrock, sandstone, and conglomerate. The lower 45 m consist of about 51 per cent mudrock, 41 per cent conglomeratic beds, and 8 per cent sandstone. The conglomeratic beds range in thickness from 0.5 to 3 m and consist of roughly equal proportions of conglomerate, conglomeratic sandstone, and conglomeratic mudrock. Conglomeratic clasts are mainly of pebble grade, but include cobbles up to about 15 cm in diameter. They support each other in the conglomerates, but are matrix-supported in the conglomeratic sandstones and mudrocks. Graded bedding, from pebble conglomerate upward to pebbly sandstone, is rare. Most beds are structureless except for a discontinuous, irregular lamination seen in one bed. The lateral extent of the conglomerates is unknown because of their limited exposure.

Sandy units with or without minor interlaminated mudrock are 0.4 to 3 m thick. Sandstone beds in a 1.5-m-thick sandy unit are 20 to 30 cm thick. A short section, about 61.5 m above the base of the formation, was studied in detail (Fig. 140). It consists mainly of sandstone, coarse to very fine in grain size, with lesser proportions of mudrock and conglomeratic sandstone. Some strata are structureless, others are flat-laminated. Crosslaminae are absent from this partial section, and perhaps from the entire member. The strata are interpreted as T_{ab}-type turbidites with a mean thickness of 39 cm. The rest of unit A1, which was examined only cursorily, is characterized by an upward decrease

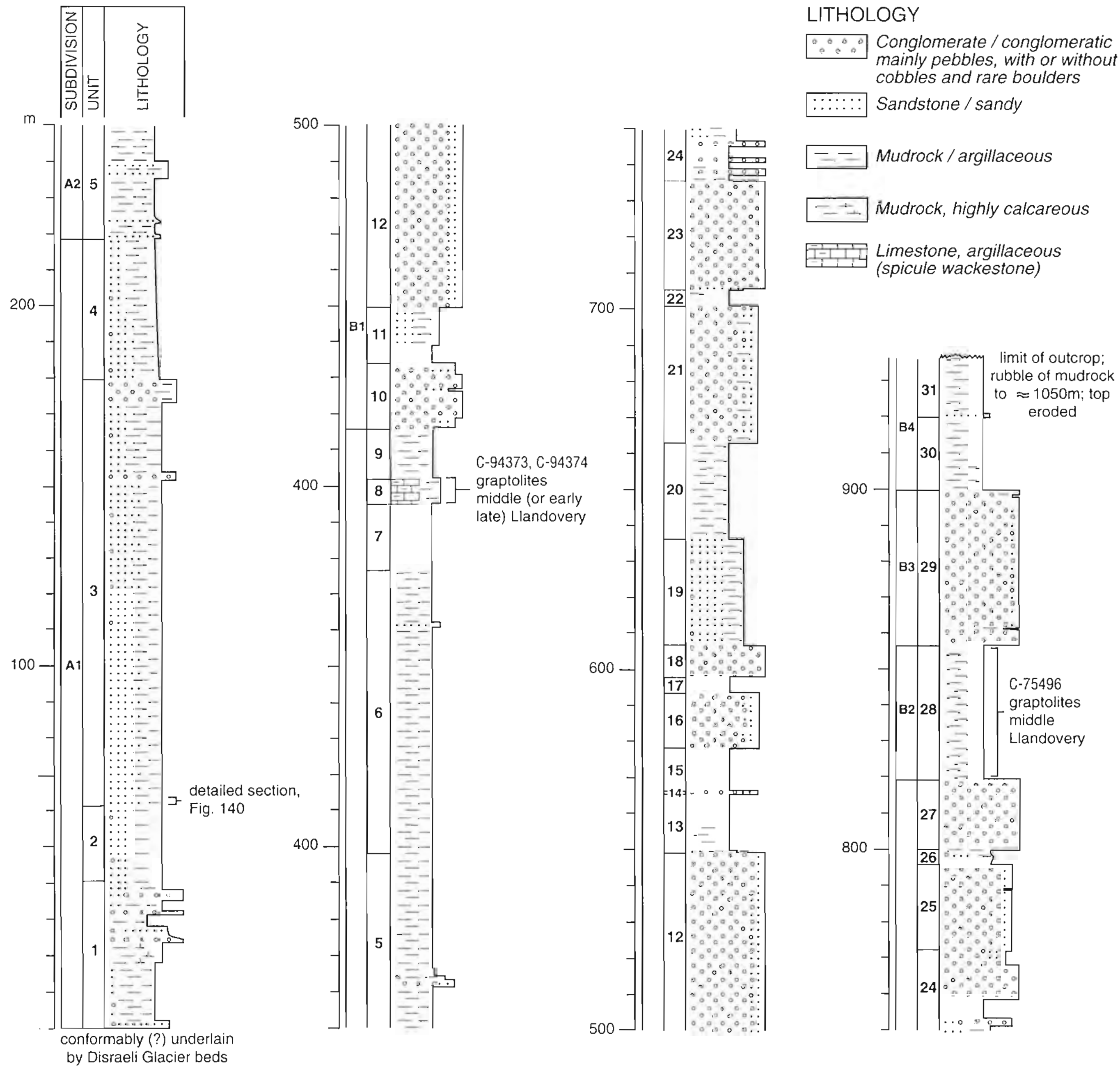


Figure 138. Stratigraphy of Cranstone Formation at the type section south of Disraeli Fiord (M'Clintock Inlet); for detail, see written log in Appendix 1.

in the proportion of sandstone and conglomerate and in the frequency and thickness of conglomeratic beds.

Unit A2, which constitutes the upper 197.5 m or so of the member, consists mainly of mudrock, commonly flat-laminated, with small amounts of sandstone and rare beds of pebble conglomerate in the lower part. The most prominent sandstone and pebble conglomerate, about 261 m above the base of the formation, is 2.5 m thick. Other sandstone beds are mostly 0.5 m thick, and at least one of these is a channel fill deposit. Interlaminated mudrock and argillaceous wackestone with abundant calcified sponge spicules occur 14 to 21 m below the top of the member in an area east of the type section.

Member B. This member has a minimum thickness of about 600 m and is divisible into four major units. Unit B1 is 403.5 m thick according to ground measurement and consists mainly of conglomerate

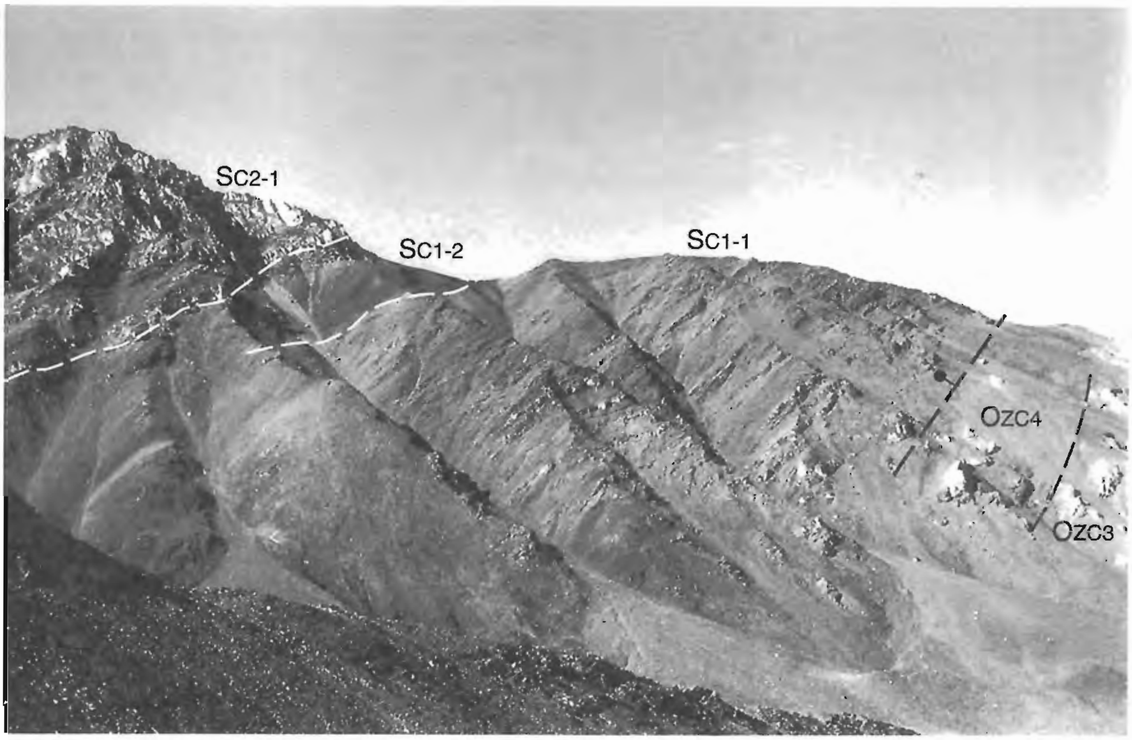


Figure 139. *Exposures of Members C and D of Zebra Cliffs Formation* (OZC3, OZC4) *and lower part of Cranstone Formation at section south of Disraeli Fiord* ***(M'Clintock Inlet).*** SC1-1, SC1-2: *Member A, units A1 and A2;* SC2-1: *Member B. ISPG photo 1878-9.*

(64%), with lesser proportions of mudrock (20%), and sandstone (16%).

Conglomerate beds range in thickness from 1 cm to 19.5 m. Most form thick-bedded or structureless bodies of unknown lateral extent, but lenticular beds, low-angle, concave foresets, and graded beds are also present (Fig. 141a, b). Most conglomerates are clast-supported, but some are matrix-supported. In well stratified beds, some elongate clasts show imbricate structure (Fig. 141c). The siliceous clasts are of pebble grade, but carbonate clasts range up to 40 cm in diameter (Fig. 141d). The sandstones form flat beds or lenses that are about 1 to 50 cm thick and either show a thin, flat stratification or concave low-angle crossbedding (Fig. 141a–c). Some lenses are only a few metres wide. The mudrocks occur as discrete units, up to 26.5 m thick; as lenses within conglomeratic units; or as laminae or thin beds interstratified with sandstones.

Unit B2 is 37 m thick and consists of mudrock that is commonly flat-laminated.

Unit B3 is about 43 m thick in the type section where it consists almost entirely of clast-supported conglomerate with only a few lenses of pebbly sandstone, sandstone, and mudrock. The conglomerate occurs as flat-lying beds, 0.5 to 4 m thick. Mudrock laminae or beds are 0.3 to 1.3 cm thick. About 1.2 km east of the type section, the unit consists of conglomeratic sandstone, conglomeratic mudrock, and mudrock.

Unit B4 is estimated to be 150 m thick on the basis of photogeological interpretation; only the lower 36.5 m were measured on the ground. It consists largely of flat-laminated mudrock, represented by felsenmeer, that is similar to the mudrock of unit B2, but also includes minor amounts of very fine to medium grained sandstone in an interval 20.5 to 36.5 m above its base.

Composition and textural features (type section). *Sandstone.* The compositions of five samples of sandstone are summarized in Table 21. Most grains are subangular or angular, but some quartz grains are subrounded to rounded. Many grains have been affected by pressure solution.

Conglomerate. The pebbles (Fig. 142a–c) represent a considerable variety of rock types, chiefly chert, vein quartz, quartzite, limestone, dolostone, calcareous sandstone, dolomitic siltstone, volcanic and hypabyssal rocks, and minor proportions of granitic rocks and granitoid gneiss. The cobbles are mostly limestone and

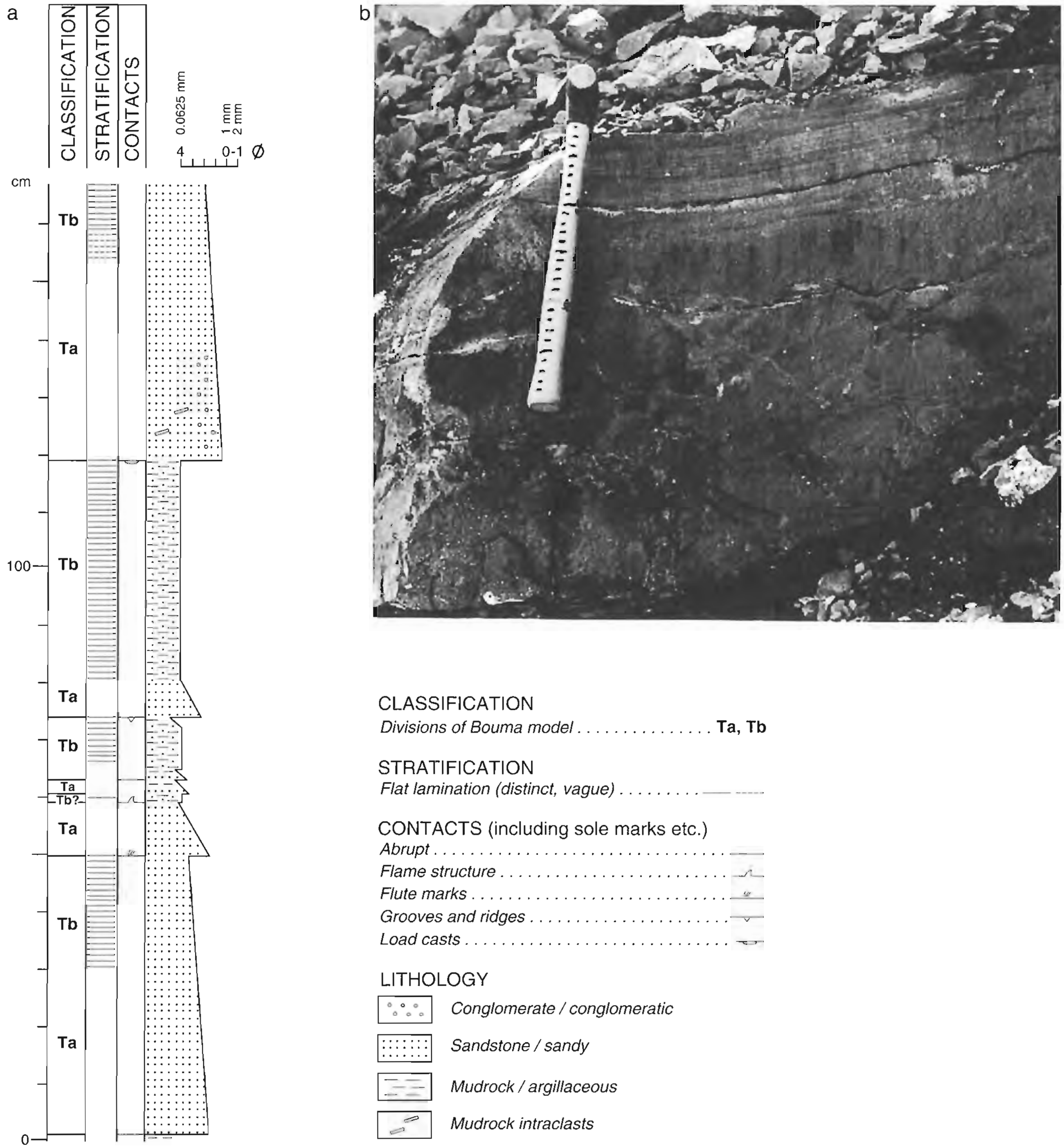


Figure 140. a. *Turbidites in unit A1 of Cranstone Formation, 61.5–63.17 m (columnar diagram);* ***b.*** $T_{a\text{-}b}$ *turbidite at top of detailed section. ISPG photo 1878-25.*

dolostone, but cobbles of siliceous rocks occur in the basal part of the formation (unit A1). Rare boulders of limestone (Fig. 141d) range up to 40 cm in diameter. Also present are boulders of sandstone that appear to have been derived from the Cranstone Formation itself. The matrix of the conglomerates consists of sand and/or mud, similar in composition to the interbedded sandstones or mudrocks.

Mudrock. XRD analyses (Appendix 3, Table 118) reveal a rather homogenous composition of quartz (mean 66%), carbonates (12%; about equal

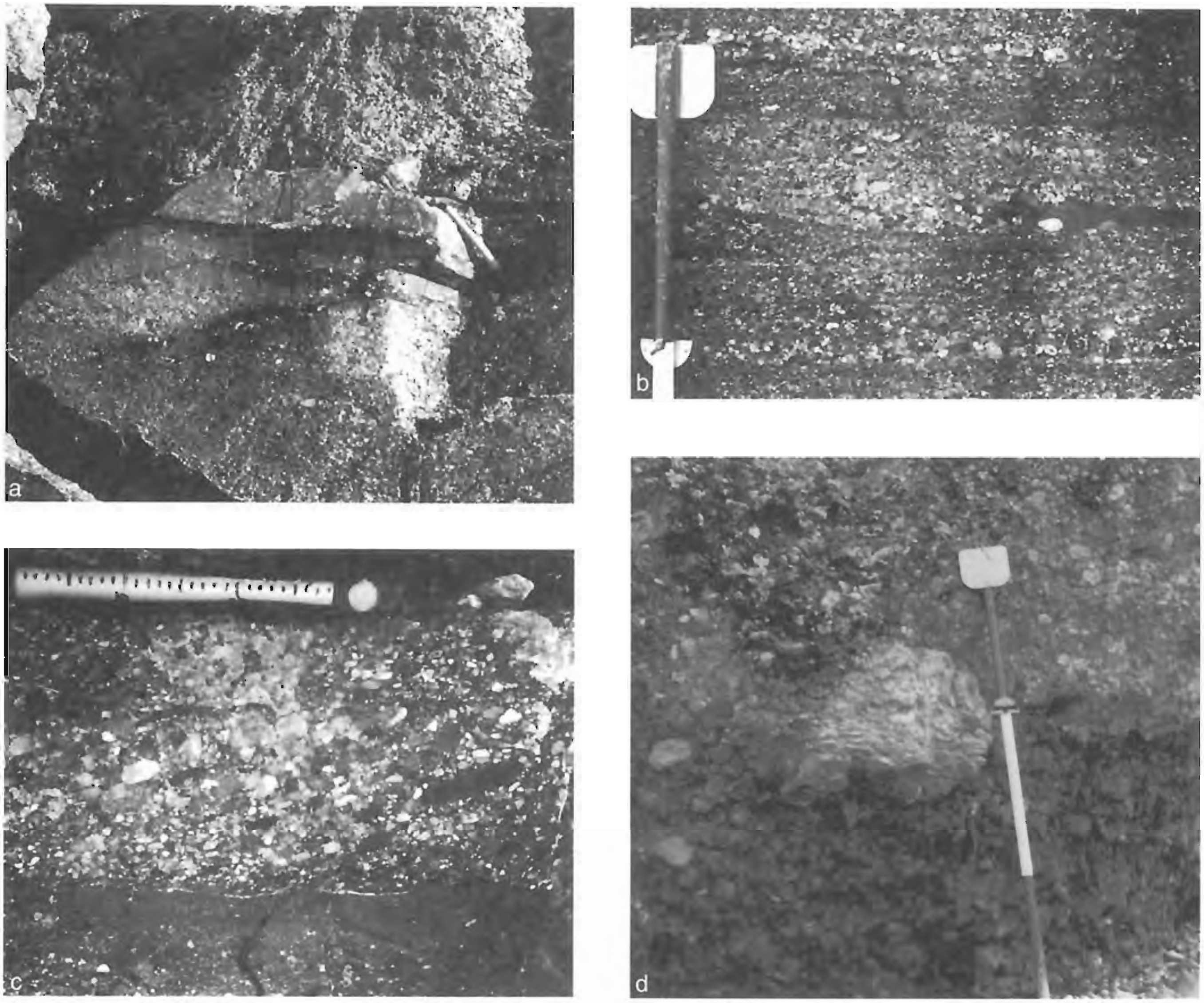


Figure 141. Cranstone Formation, unit B1 at section south of Disraeli Fiord; a. Predominantly massive pebble conglomerate with lenses of sandstone, showing flat lamination and shallow trough-crossbedding (hammer for scale). ISPG photo 1878-21; b. Clast-supported pebble conglomerate and sandstone showing flat and lenticular bedding (dark section of measuring staff is 50 cm long). ISPG photo 1878-29; c. Clast-supported pebble conglomerate with interbedded sandstone; pebble imbrication indicates flow from left to right (northeast to southwest). ISPG photo 1878-26; d. Limestone boulder in poorly sorted, massive pebble conglomerate. ISPG photo 1878-20.

proportions of calcite and dolomite), chlorite (10%), feldspar (6%, mainly albite), and white mica (6%). Subtle graded bedding is apparent in thin sections (Fig. 142d).

Exposures east of Markham Fiord. The strata are olive grey and consist mainly of calcareous mudrock and minor calcareous sandstone. The rocks have flat laminae, small-scale crosslaminae, and small flute casts. A sample of sandstone is medium grained, moderately sorted, and contains grains up to granule size. It is composed mainly of well-rounded quartz with lesser amounts of carbonate clasts - mainly fragments of lime mudstone - and small or trace amounts of feldspar, chert, and volcanic and metamorphic rock fragments.

Metamorphism. The preservation of detrital biotite in some sandstones indicates that the metamorphism of the coarse clastic fraction is below greenschist grade.

Table 21

Cranstone Formation: composition of sandstones (based on point count and XRD analyses in Appendix 3, Tables 116 and 117)

Quartz	40%	Single-crystal grains; semicomposite aggregates of vein quartz and/or recrystallized chert
Feldspar	13%	Mainly albite; partly sericitized
Carbonates	12%	Lime mudstone, dolostone, rare fragments of brachiopods, corals (Fig. 142a), echinoderms
Metamorphics	10%	Phyllite and low-grade schist, composed mainly of white mica and quartz with minor chlorite and feldspar
Chert	10%	Pure or argillaceous, unmetamorphosed or stretched and recrystallized
Quartzite	8%	Pure or including minor white mica and rare feldspar
Volcanic and hypabyssal rocks	4%	Mainly siliceous (rhyolite, dacite), some plagioclase-rich rocks with minor chlorite (trachyte, trachyandesite), some chlorite-rich rocks (andesite, basalt)
Minor components	2%	Granitoid gneiss, white mica, biotite, mudrock intraclasts

The mineral composition of the mudrocks is compatible with the lower greenschist facies, but is probably largely of detrital origin.

Paleocurrent directions. Only a few paleocurrent indicators were observed in the type section. Dip directions of foresets and imbricated pebbles in unit B2 suggest current flow from northeast to southwest (Fig. 141c). Grooves and ridges in unit A2 also have a southwesterly orientation, but do not indicate the sense of flow; i.e., whether it was to the northeast or to the southwest. The setting of the Cranstone Formation (Figs. 137, 161) and observations from the Danish River Formation (see below) support the second alternative.

Mode of origin. The presence of a graptolitic fauna indicates deposition in a deep-water environment. The sandstones, mudrocks, and minor conglomerates forming Bouma sequences were deposited by turbidity currents, and massive conglomerates with an argillaceous matrix probably by subaqueous debris flows. On the other hand, the clast-supported conglomerates must have been transported or winnowed by tractive currents, a process not uncommon in flyschoid deposits (Winn and Dott, 1977). Stratigraphic relations with the Marvin Formation suggest deposition in a graben that probably experienced growth faulting during the middle Llandovery (see Structural geology, Ages of deformation).

Some carbonate clasts were probably derived from flanking strata of the Marvin Formation. This is inferred from their anomalously large size and the presence of a favositid coral, indicating an age no older than Late Ordovician. The remaining sediments were probably derived from upland sources farther northeast, which included metamorphic and plutonic rocks, chert, and lesser proportions of volcanic and hypabyssal rocks.

Age and correlation. Two diagnostic graptolite collections, one from an unspecified level within Member A, and the other from Member B at 820 to 857 m, are both of middle Llandovery age (Norford, Appendix 5A, GSC locs. C-75497, C-75496) and may represent the late middle Llandovery *convolutus* Zone. A collection from the upper part of Member A (375-402 m) is of unspecified middle or earliest late Llandovery age (Norford, Appendix 5A, GSC loc. C-94374), but cannot be younger than middle Llandovery because of its stratigraphic position below C-75496. Older strata, of latest Ordovician to early Llandovery age, may be present in the unfossiliferous lower part of the formation. The formation either is correlative with the lower part of the Marvin Formation or with a hiatus within that formation that

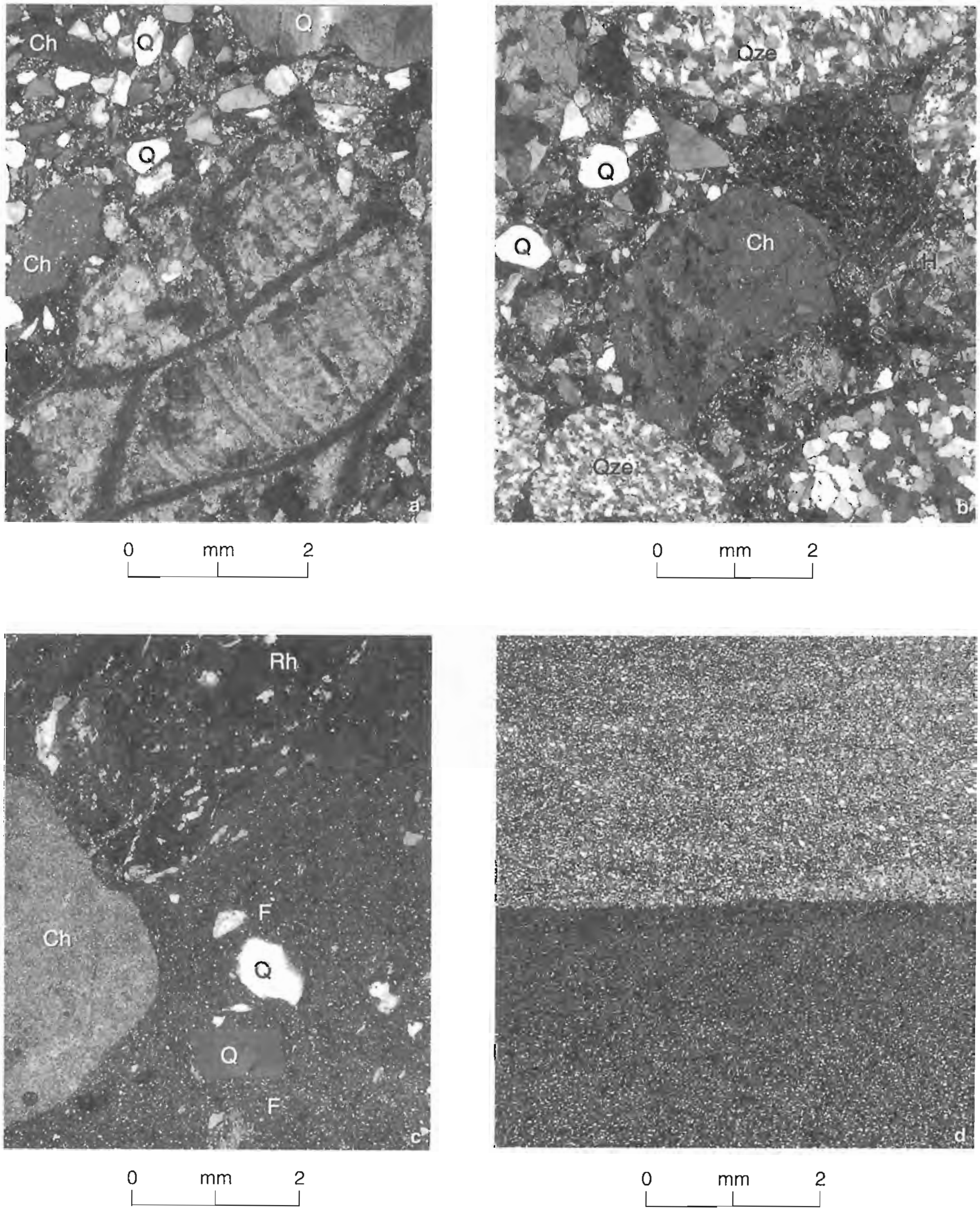


Figure 142. Photomicrographs of Cranstone Formation; a. Fragment of tabulate coral in granule-bearing quartz-chert sandstone from lowermost strata of unit A1 (cross-polarized light; Ch: *chert,* Q: *quartz). ISPG photo 2260-174;* **b.** *Pebble conglomerate from unit B3 (cross-polarized light;* C: *carbonate,* Ch: *chert,* H: *hypabyssal rock fragment,* Q: *quartz,* Qze: *quartzite,* V: *volcanic rock fragment). ISPG photo 2260-176;* **c.** *Poorly sorted sediment from unit B4 of Cranstone Formation. Pebbles of chert* (Ch) *and rhyolite* (Rh), *and sand grains of volcanic(?) quartz* (Q) *and feldspar in muddy matrix composed of quartz, carbonate, chlorite, feldspar, and white mica (cross-polarized light). ISPG photo 2260-173;* **d.** *Stratification in mudrock of unit B2 of Cranstone Formation (ordinary light). Dark layer shows graded bedding, light layer indistinct crosslamination. ISPG photo 2260-168.*

has not been firmly established. It also is correlative with an upper part of the chert member of the Hazen Formation, which has yielded graptolites of middle Llandovery age at Caledonian Bay, Cañon Fiord (Norford, *in* Trettin, 1979, p. 80).

Danish River Formation (map unit **SDR**, *Lower Silurian)*

Definition. The Danish River Formation is a thick succession of interbedded calcareous and dolomitic sandstone, mudrock, and minor conglomerate with flyschoid primary structures that overlies the Hazen Formation in the Hazen and Clements Markham fold belts (Trettin, 1994 and Chapter 3 of this report). Outcrops at M'Clintock Inlet, originally assigned to the Imina Formation (Trettin, 1969b) and later to the Cranstone Formation (Trettin, 1987b, 1991b) are here re-assigned to the Danish River Formation on the basis of lithology and age.

Distribution, contact relations, and thickness. The Danish River Formation is exposed in the Zebra Cliffs and near Crash Point, west and east of the central part of M'Clintock Inlet, respectively (*M'Clintock Inlet*, insets B and C, and Frontispiece). In the Zebra Cliffs, it lies between the Ooblooyah Creek Formation and the Carboniferous Canyon Fiord Formation. The lower contact is interpreted as a normal fault and the upper contact as an angular unconformity. Near Crash Point it lies with faulted contacts between the Ooblooyah Creek Formation and the uppermost part of the Lands Lokk Formation. Age relations suggest that the Danish River Formation lies stratigraphically between the Cranstone and Lands Lokk formations although the former is not represented in this area. If so, both contacts are probably conformable because of the deep water origin of all three units.

Lithology. The exposures in the Zebra Cliffs consist mainly of sandstone and mudrock. Fresh surfaces are coloured in hues of yellowish grey, light olive grey, or greenish grey; weathered surfaces are mostly yellowish grey. The strata contain Bouma sequences, commonly of $T_{a\text{-}c}$ type, with A-divisions that are 2 to 40 cm thick. Sole marks, such as grooves, ridges, and flute casts are present at the bases of some graded beds.

The sandstones are mainly fine and medium grained, but range from very fine to very coarse grained. The grains are subrounded to predominantly subangular. Sand and coarse silt are embedded in a matrix of carbonate and argillaceous material. Point count and XRD analyses of fine to medium grained sandstones (Appendix 3, Tables 121, 122) indicate that quartz and carbonates are abundant; feldspar, chert, and volcanic rock fragments less common; and chlorite, white mica, and metamorphic rock fragments present in minor or trace amounts. These analyses are generally comparable to those from the Clements Markham Fold Belt (Table 12), but differ in having larger contents of volcanic rock fragments (2-21%), chert (0-7%), and skeletal material. The volcanic rock fragments are altered and probably of andesitic-basaltic composition.

Paleocurrent directions. Eleven paleocurrent determinations made on flute marks and grooves and ridges suggest flow from northeast to southwest (azimuth 234° at 76°W longitude). However, no plunge determinations were made, and the results are valid only if the plunge is negligible.

Metamorphism. The preservation of detrital biotite indicates that the metamorphism of the coarser fraction is below greenschist grade.

Mode of origin. The presence of Bouma sequences indicates deposition in a submarine fan or basin floor environment. The sediments were derived from relatively remote terrestrial sources that included quartz-bearing rocks, chert, volcanics, and carbonates, and probably also from contemporaneous shelf carbonates of the Marvin Formation.

Age and correlation. The graptolite, *Monograptus* aff. *M. priodon*, collected from the Zebra Cliffs, indicates a late Llandovery or Wenlock age (Norford, Appendix 5A, C-68). The outcrops of the Danish River Formation at M'Clintock Inlet probably are correlative with those in the Clements Markham Fold Belt, which are of late Llandovery age.

Lands Lokk Formation (map unit **SL**, *upper Lower–lower Upper Silurian)*

Definition. The Lands Lokk Formation, established in the Clements Markham Fold Belt (Chapter 3) is a clastic unit that overlies the Danish River Formation and is locally overlain by shallow-marine carbonate and clastic units such as the Markham River Formation. A unit of mudrock exposed near Crash Point (*M'Clintock Inlet*, inset C) is assigned to the Lands Lokk Formation on the basis of stratigraphic position and lithology. It was previously referred to as map unit 9C (Trettin, 1969a) or Sp (Trettin, 1987c).

Distribution, contact relations, and thickness. The formation is exposed only in a small area near Crash Point on the east side of M'Clintock Inlet (*M'Clintock*

Inlet). There it is in fault contact with the Danish River Formation and overlain by the Marvin Formation with an abrupt but probably conformable contact (see Marvin Formation, Fig. 144). The thickness of the exposures is estimated to be in the order of 300 m.

Lithology. The exposures are difficult to access, but, from a distance, appear to be uniform in lithology. Three representative samples from the upper part are flat-laminated, sandy siltstones. The rocks are greenish grey and medium grey and weather in hues of olive green and brownish grey. They are composed of quartz (68%), carbonates (dolomite 7%, calcite 3%), feldspar (8%, mainly albite), chlorite (8%) and mica (7%; white mica and biotite) (average of 3 XRD analyses; Appendix 3, Table 123).

Metamorphism. The survival of detrital biotite indicates that the metamorphism of the silt to fine sand fraction is below greenschist grade.

Mode of origin. The strata examined were probably deposited in a subtidal shelf environment.

Age and correlation. In the Clements Markham Fold Belt (Chapter 3) the Lands Lokk Formation ranges in age from latest Llandovery to early Ludlow. No fossils have been recovered from the exposures at Crash Point. Their age is bracketed by fossils from the Danish River and Marvin formations that are undifferentiated late Llandovery-Wenlock and probable Ludlow, respectively. Except for the lack of bioturbation, the strata at Crash Point are similar to mudrocks at the top of the Lands Lokk Formation northwest of Markham River (*Clements Markham Inlet-Robeson Channel*) that are probably early Ludlow in age (Chapter 3).

Marvin Formation (map unit OSm, *Upper Ordovician to Upper Silurian)*

Definition. The name, Marvin Formation, was originally (Trettin, 1969b) proposed for a limestone near Crash Point on west-central Marvin Peninsula. The Marvin Formation lies stratigraphically between a unit of mudrock, originally designated map unit 9A and now assigned to the Lands Lokk Formation, and a unit of clastic and carbonate sediments, originally designated map unit 9C and now assigned to the Crash Point beds. Macrofossils indicated a Wenlock and/or early Ludlow (Silurian) age for the carbonates.

Subsequent mapping revealed the presence of several other outcrop areas of similar carbonate rocks located mainly in east-central parts of the *M'Clintock Inlet* map area and in adjacent parts of the *Clements Markham Inlet-Robeson Channel* map area. These strata overlie the Lorimer Ridge Formation and their tops are not preserved. Macrofossils and conodonts from this region indicate a Late Ordovician to Late Silurian age range and demonstrate that the exposures at Crash Point represent only a tongue of the upper part of the entire formation.

Accordingly, the Marvin Formation is here redefined as a carbonate unit that lies above the Lorimer Ridge or Lands Lokk formations, and locally is overlain by the Crash Point beds. A reference section southeast of Disraeli Fiord (Fig. 137; *M'Clintock Inlet*, loc. SEDF) is relevant for the southeastern exposures and the original type section near Crash Point at M'Clintock Inlet for the northwestern exposures.

Distribution, contact relations, and thickness. The southeastern exposures extend from the southeastern part of Marvin Peninsula (*M'Clintock Inlet*) to east of the upper reaches of Disreali Fiord (*Clements Markham Inlet-Robeson Channel*). These strata overlie the Lorimer Ridge Formation with a concealed but probably conformable contact, which is marked by a change from red-weathering clastic sediments to grey-weathering carbonates (Fig. 143). The formation has a minimum thickness of 576 m in the reference section southeast of Disraeli Glacier. A thickness of 740 m was measured by R. Gardner and D. Jones (student assistants of U. Mayr in 1977) in the same general area but along a different route.

The northwestern exposures are restricted to an area on the west side of central M'Clintock Inlet located north and northeast of Crash Point (*M'Clintock Inlet*,

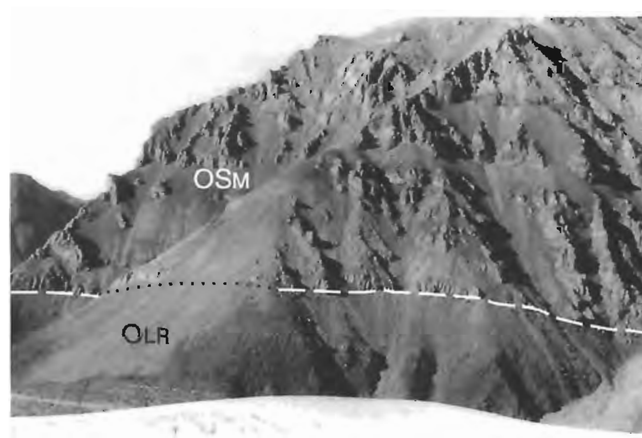


Figure 143*. Lorimer Ridge Formation* (OLr), *overlain by Marvin Formation* (OSm) *in vicinity of section southeast of Disraeli Fiord* (**M'Clintock Inlet**), *view to northwest. ISPG photo 1505-21.*

inset C). The lower contact, difficult to access where exposed, is abrupt but probably conformable (Fig. 144). The upper contact is gradational and conformable. This tongue of the upper part of the Marvin Formation is some 150 m thick.

***Figure 144.** Lands Lokk Formation (dark, recessive) overlain by Marvin Formation (light, resistant) near Crash Point, M'Clintock Inlet, view to south-southwest. ISPG photo 1693-18.*

Lithology. *Section southeast of Disraeli Fiord.* In the reference section, the Marvin Formation consists of about 80 per cent limestone and 20 per cent dolostone (Fig. 145 and Appendix 1). Five recurrent lithofacies are recognized.

Lithofacies S is a medium dark grey wackestone that contains abundant sponge spicules, mainly calcareous and less commonly siliceous, with lesser amounts of skeletal grains derived from ostracodes, brachiopods, trilobites, and echinoderms. Stringers of microcrystalline dolomite are common and chert lenses occur in some strata. The lithofacies is limited to an interval 155 to 211.5 m above the base of the formation.

Lithofacies F consists of medium grey to predominantly medium dark grey peloidal packstone/wackestone with fenestral structures (Fig. 146). The fenestrae are irregular or laminar, and some rocks show faint or distinct flat laminae. Skeletal grains, mainly fragments of trilobites and ostracodes(?) are scarce. Stringers of microcrystalline dolomite are less common than in lithofacies P (see below). This lithofacies occurs in three units in the upper part of the formation, between 460 m and the top of the section.

Lithofacies P is characterized by peloidal packstone/wackestone with skeletal fragments, and of related skeletal wackestone and lime mudstone. The rocks vary in colour from medium grey to medium dark grey. Skeletal material is rare to abundant, and represents a great variety of invertebrates such as brachiopods, trilobites, ostracodes, echinoderms, molluscs (including gastropods) and corals. Most peloids are small, about 0.02 to 0.2 mm in diameter, and relatively uniform in size, but larger peloids with a more variable diameter also are present. Stringers and irregular patches of microcrystalline dolomite are common. This lithofacies occurs intermittently throughout the section, except for the upper 54 m.

Lithofacies G comprises grainstone and peloidal packstone/wackestone transitional to grainstone. The rocks vary from medium dark grey to predominantly medium grey and are composed of abundant, fine to coarse peloids and of skeletal fragments derived mainly from pentamerid brachiopods, largely or entirely *Kirkidium* sp., and echinoderms. This rock type is present in five intervals between 30 and 516 m.

Lithofacies D consists of dolostone that varies in colour from medium light to medium dark grey. The crystal size is bimodal, microcrystalline, and microcrystalline to very coarse crystalline. The microcrystalline material forms stringers and irregular patches. Dolostone occurs in 13 major units, distributed throughout the section, except for the upper 112 m.

Crash Point section. In the type section, the Marvin Formation consists of limestone that is cliff-forming and thick bedded to massive in the lower 39 m, and alternatingly resistant and recessive in the next 65 m (Fig. 144). The rocks are fine to coarse grained peloidal packstones with skeletal content that is texturally transitional to grainstone or wackestone. The skeletal material was derived from brachiopods, echinoderms, trilobites, ostracodes, corals, gastropods, pelecypods, stromatoporoids, and calcified microbes (Fig. 147). Many fragments have micritic coatings. These strata represent lithofacies P and G, as described for the section south of Disraeli Fiord.

The uppermost part, about 50 m thick, is known only from a reconnaissance traverse. It consists of about two thirds limestone and one third interbedded sandstone. Ledge-forming limestone units are 3 to 6 m, and individual beds about 12 to 15 cm thick. Some are rich in macrofossils, such as corals, brachiopods, echinoderms, gastropods, and stromatoporoids. Algae or calcified microbes, including "*Solenopora*" (Fig. 148) and *Hedstroemia*, have been identified in thin sections (de Freitas, Appendix 5D, GSC loc. C-94307). Limestone samples represent skeletal wackestone and oncolite with a matrix of fine grained

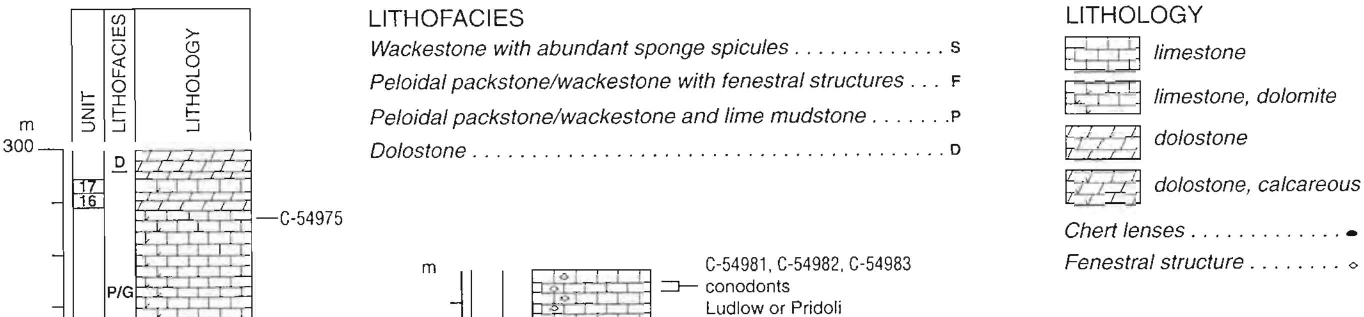
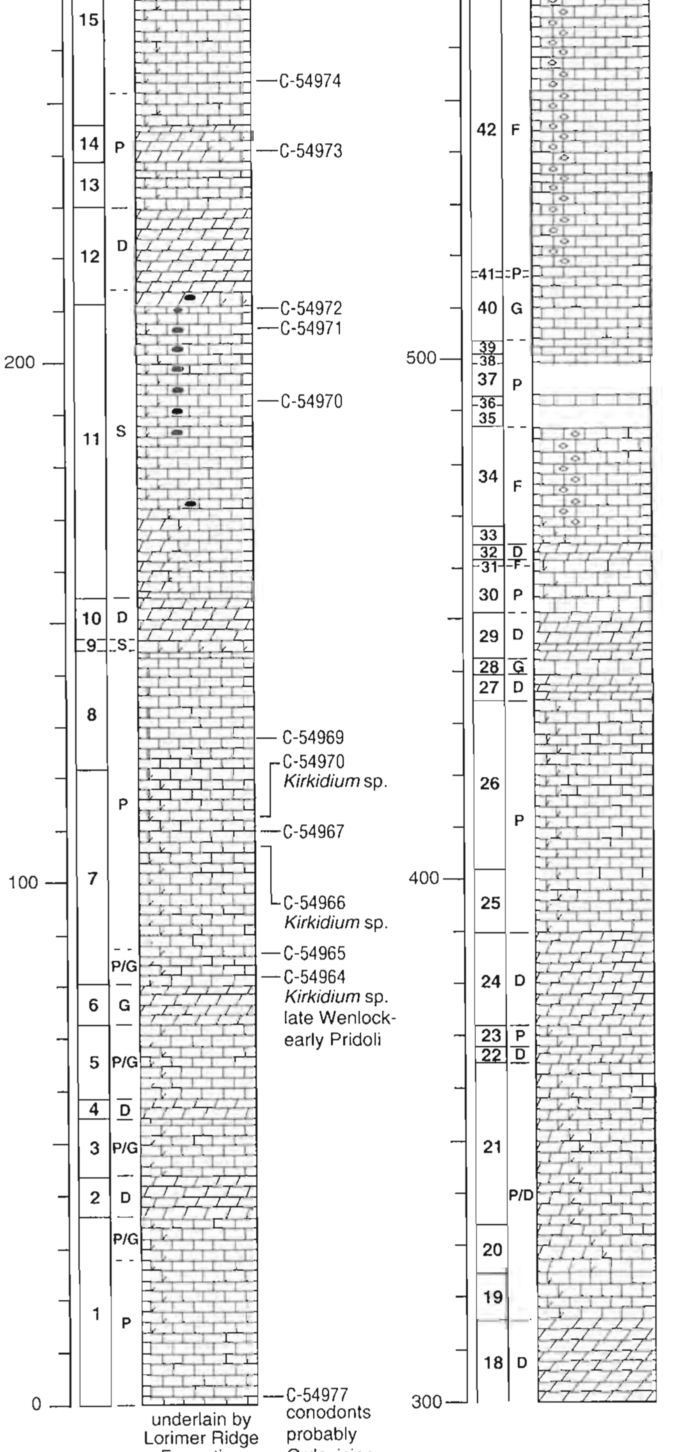



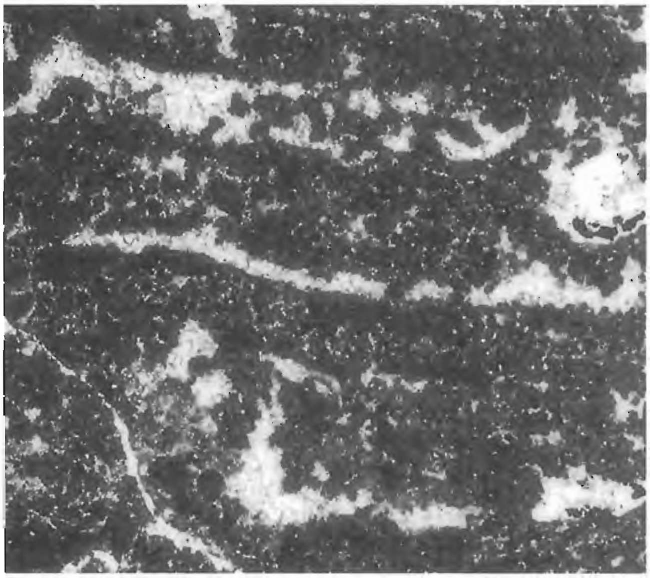
Figure 145. Marvin Formation, reference section southeast of upper Disraeli Fiord. Only the age of the most diagnostic collections is stated (for fossil identifications see Appendices 5A and 5B).

siliciclastic sand and silt (Fig. 149). Samples of sandstone are fine grained and flat-laminated. A specimen analyzed by XRD consists mainly of quartz (83%), with lesser amounts of carbonate (calcite 6%, dolomite 3%) and feldspar (5%), and small amounts of mica and chlorite (1% each). Part of the mica, chlorite, and quartz occurs in fragments of schist.

Metamorphism. Conodont alteration indices from the reference section range from 3 to 4.5 (B.J. Dougherty, Appendix 5B) and indicate temperatures between about 150 and 250°C, indices from the type section range from 1.5 to 2.5 (Dougherty, Appendix 5B, GSC locs. C-54916, C-54917, C-54988) and indicate temperatures of approximately 50 to 100°C (Epstein et al., 1977).

Mode of origin. *Section southeast of Disraeli Fiord.* Lithofacies S, spicular wackestone, probably was deposited in a relatively quiet subtidal environment, near sponge reefs (cf. de Freitas, 1991b), and also in the vicinity of communities of brachiopods, trilobites, ostracodes, echinoderms, etc. The mixed calcareous-siliceous composition of individual spicules indicates partial replacement of opal by calcite, which also is common in Upper Silurian sponge reefs of Cornwallis Island (Narbonne and Dixon, 1984).

Lithofacies F, fine-grained peloidal packstone-wackestone with fenestral structures, is similar to a major rock type in the Lower-Middle Ordovician Bulleys Lump Formation of southwestern Judge Daly Promontory, a carbonate buildup at the northwestern margin of the Franklinian Shelf. The peloids of this formation have been interpreted as microbial products, and the rocks as reefal microbialites as suggested by de Freitas (*in* Trettin, 1994, p.69–74; cf. de Freitas, 1991a).



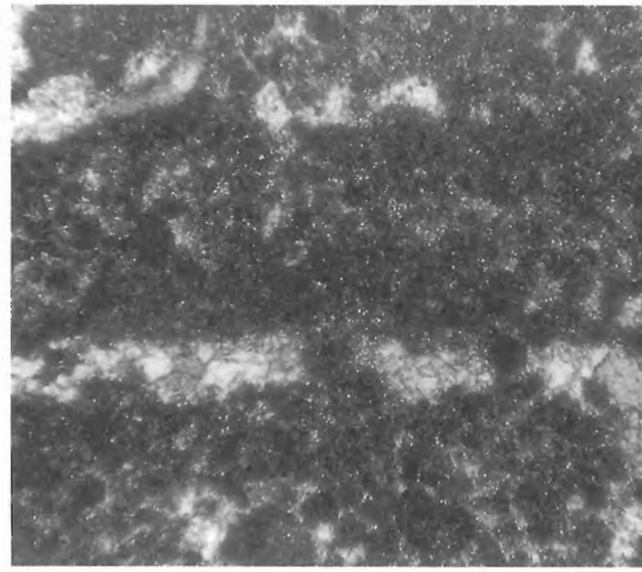


Figure 146. Photomicrographs (ordinary light) of fine grained peloidal packstone with laminar fenestrae in Marvin Formation, section southeast of Disraeli Fiord. ISPG photos 2260-169, 2260-121.

Lithofacies P, composed of peloidal packstone-wackestone (without fenestrae), skeletal wackestone, and mixtures of the two, probably represents a relatively quiet, shallow subtidal shelf environment inhabited by a rich, diverse benthic fauna.

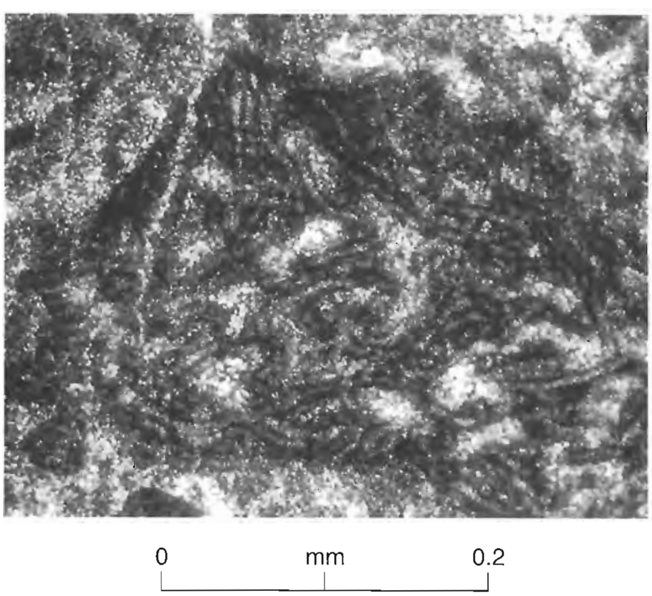


*Figure 147. Photomicrograph (ordinary light) of **Girvanella** in limestone of Marvin Formation at Crash Point. ISPG photo 2260-154.*

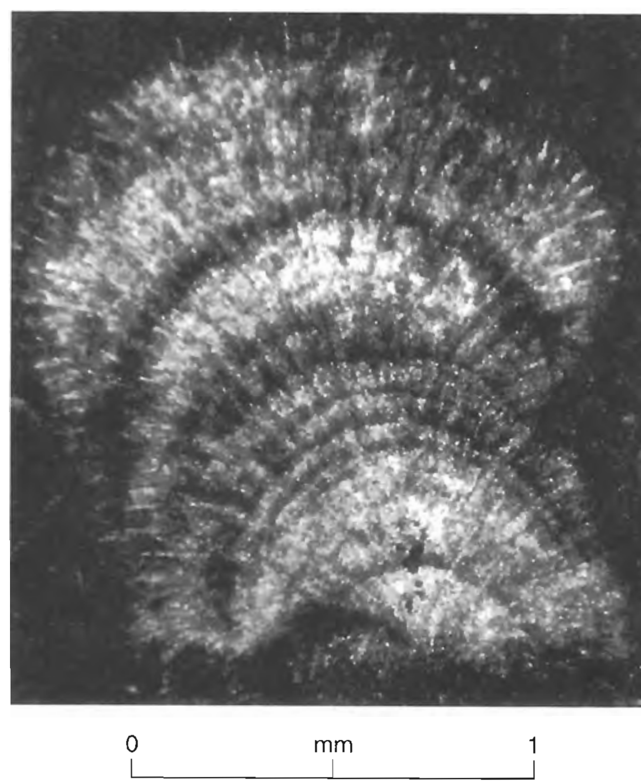


*Figure 148. Photomicrograph (ordinary light) of **Solenopora** in limestone of Marvin Formation at Crash Point. ISPG photo 2260-154.*

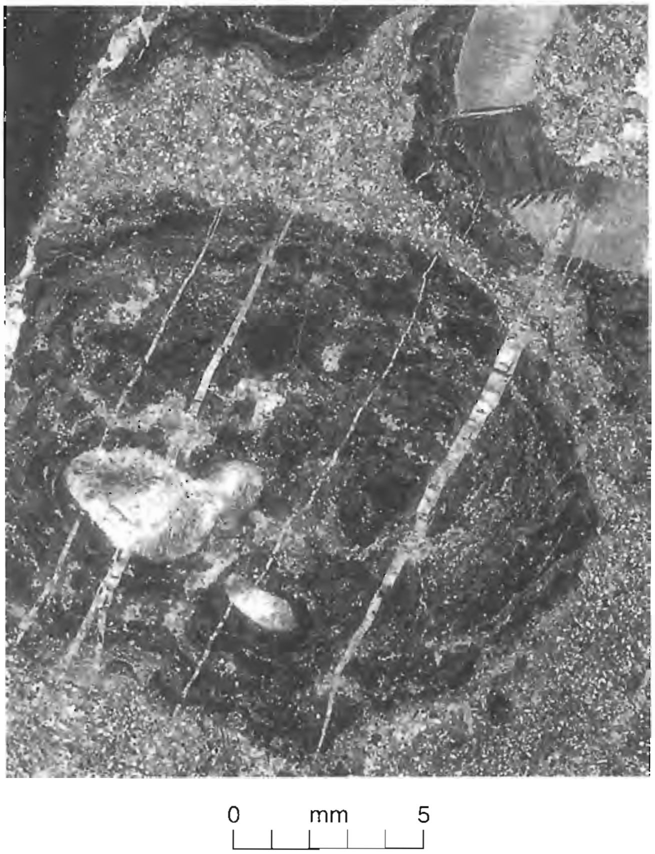


Figure 149. Photomicrograph (cross-polarized light) of oncolite in Marvin Formation at Crash Point. Skeletal fragments of bryozoan (lower right) and echinoderm columnal (upper left) encrusted by microbial-algal layers. Matrix consists of calcareous sandstone. ISPG photo 2260-180.

Lithofacies G, skeletal and peloidal grainstone characteristically contains shells of the large, robust brachiopod *Kirkidium*. This genus and related pentamerids are commonly associated with Silurian reef complexes and seem to have grown and accumulated in turbulent, warm waters within the photic zone (Boucot and Johnson, 1979).

In summary, the four limestone facies of the reference section represent quiet to turbulent subtidal settings. Lithofacies F is probably a reefal microbialite, and the other three facies may have developed in the vicinity of reefs.

Crash Point section. The limestones are comparable to lithofacies P and G of the reference section southeast of Disraeli Fiord and also represent quiet to turbulent, predominantly subtidal shelf environments (cf. de Freitas, Appendix 5D, GSC loc. C-94307). The presence of quartz sand shows that these strata were not deposited on a free-standing carbonate buildup, but on a shelf that received siliciclastic sediments from terrestrial sources, presumably to the north or northeast.

Age and correlation. Fossils from the southeastern outcrop areas. Conodonts fall into three age groups:

1. A faunule of probable Late Ordovician age occurs 2 to 3 m above the base of the formation in the reference section southeast of Disraeli Fiord (Uyeno, Appendix 5B, GSC loc. C-4977). Two diagnostic conodont faunules of Late Ordovician age have been obtained from the lower 33 m of the formation in the section north of Thores River (Uyeno, Appendix 5B). One represents the undifferentiated Faunas 11 to 13 (C-54987), the other probably Fauna 12 (C-54985), and both have a possible age range from late Edenian to Gamachian (Sweet and Bergström, 1986).

2. Conodont faunules of late Llandovery age (Uyeno, Appendix 5B, GSC locs. C-75386 to C-75388) were collected on east-central Marvin Peninsula, and one of these represents the mid-late Llandovery *inconstans* Zone.

3. Conodont faunules of probable Late Silurian (undifferentiated Ludlow–Pridoli) age were obtained from strata 573 to 574 m above the base of the formation (Uyeno, Appendix 5B, GSC locs. C-54981 to C-54983) in the reference section.

The most diagnostic macrofossil from these areas is the brachiopod *Kirkidium* sp., which ranges in age from late Wenlock to Pridoli and is most common in the Ludlow (Norford, Appendix 5A), especially in the Arctic (T. de Freitas, pers. comm., 1995). In the reference section it was collected from strata 82, 107, and 113 m above the base of the formation (C-54964, C-54966, C-54968), implying that the Upper Ordovician to middle Wenlock part of the formation is less than 82 m thick. Lithologically, the lower 82 m are not typical of condensed deposits (as represented, for example, by the Hazen Formation), and therefore the thin development of the Upper Ordovician to middle Wenlock part of the formation may indicate a disconformity somewhere within this interval. A possible hiatus of latest Ordovician to middle Llandovery age is shown on the correlation chart (Fig. 2) because of the apparent absence of faunas of that age, but no sedimentological evidence for a disconformity has been observed.

Fossils from the Crash Point section. Conodonts from the basal strata are probably Ludlow in age (Uyeno, Appendix 5B, GSC loc. C-74917). Conodonts from

48 m above the base have a possible age range from early Ludlow (Late Silurian) to Emsian (Devonian) (Uyeno, Appendix 5B, GSC loc. C-74917), but a Devonian age can be ruled out because the overlying Crash Point beds have yielded conodonts of Late Silurian age. *Kirkidium* sp. occurs in the basal strata, and in collections from 39 to 154 m above the base of the formation (Norford, Appendix 5A, GSC locs. 75421, 75422, 69208).

Summary. The lower part of the formation is represented only in the southeastern exposures. These strata range in age from Late Ordovician (Ashgill) to Late Silurian, probably early Ludlow, and are correlative with the combined Cranstone, Danish River, and Lands Lokk formations. An absence of diagnostic fossils of latest Ordovician to middle Llandovery age and the thin development of this part of the formation suggests a hiatus somwhere within this interval. The upper part, represented both at Crash Point and south of Disraeli Fiord, is Late Silurian in age. Regional relations suggest it is correlative with the Piper Pass Formation, which has yielded conodonts of middle and late Ludlow age, and with the Markham River Formation or lower parts of it.

Crash Point beds (map unit SCP*, Upper Silurian)*

Definition. The informal name, Crash Point beds, was introduced by Trettin (1987c, 1991b) for a unit of sandstone and limestone that overlies the Marvin Formation in the vicinity of Crash Point on the east side of M'Clintock Inlet. The strata were originally referred to as map unit 9C (Trettin, 1969b).

Distribution, contact relations, and thickness. The Crash Point beds are exposed in two small areas in the west-central part of Marvin Peninsula. The lower part overlies the Marvin Formation in the centre of a syncline northeast of Crash Point. The contact is conformable, gradational, and placed where sandstone becomes predominant in the section. About 83 m of strata are preserved in this setting. An upper part of the unit, at least a few tens of metres and possibly more than 100 m thick, occurs in a steeply dipping fault block on the southern flank of the syncline. The top of the unit is not preserved.

Lithology. The strata in the centre of the syncline consist mainly of sandstone with three units of limestone that range in thickness from 0.9 to 2.1 m. The sandstones are mostly flat-laminated and fine grained. Four sandstone samples analyzed by XRD (Appendix 3, Table 126) consist mainly of quartz (average 83%) with smaller amounts of feldspar (7%, mainly albite, minor K-feldspar), carbonates (6%, mainly calcite, minor dolomite), mica (2%, white mica and biotite), and chlorite (2%). Part of the mica, chlorite, and quartz occur in fragments of phyllite or schist. Highly calcareous sandstones, transitional to limestone, also are present.

The lowest of the three limestone units is a peloidal packstone that contains a large proportion of siliciclastic silt and very fine grained sand (Appendix 3, Table 128). The rocks contain slightly undulating laminae. Limestones in the uppermost part of the syncline are sandy skeletal packstones (Appendix 3, Table 128). The skeletal fragments, commonly in solution contact, were derived mainly from echinoderms and to a lesser extent from brachiopods, trilobites, bryozoans, and ostracodes.

Three lithofacies are distinguished in the fault block on the south side of the syncline. The predominant one consists of interstratified medium grey, very fine grained, silty sandstone and medium or dark grey, sandy siltstone. The rocks are flat-laminated or bioturbated. The sandstone and siltstone both are made up of quartz (69%), carbonate (10%; calcite 5%, dolomite 5%); mica (8%; white mica and biotite); feldspar (7%; mainly plagioclase), and chlorite (7%); (mean of 5 XRD analyses, Appendix 3, Table 127).

The second lithofacies consists of fine to medium grained sandstone and of sandy limestone transitional to calcareous sandstone. A typical sandstone, analyzed by XRD, consists mainly of quartz (81%), with lesser amounts of calcite (8%), feldspar (5%), mica (3%), chlorite (3%), and dolomite (1%). The limestones are skeletal packstones derived mainly from echinoderms, some of which had stalks as thick as 1.5 cm (Fig. 150). Also present are fragments of brachiopods, trilobites, bryozoans, and ostracodes. The strata show flat bedding and trough-crossbedding (Fig. 151).

The third lithofacies is a relatively pure, intensely recrystallized limestone with numerous calcite veins that occurs in massive units, 1 to 16 m thick. Some strata contain large brachiopods or pelecypods.

Metamorphism. The alteration index of conodonts varies from 1.5 to 2.5 and is mainly 2.0, conforming with alteration indices for the underlying Marvin Formation (Dougherty, Appendix 5B). An alteration index of 2 corresponds to temperatures of 60° to 140°C (Epstein et al., 1977). The preservation of detrital biotite confirms that the metamorphism is below greenschist grade.

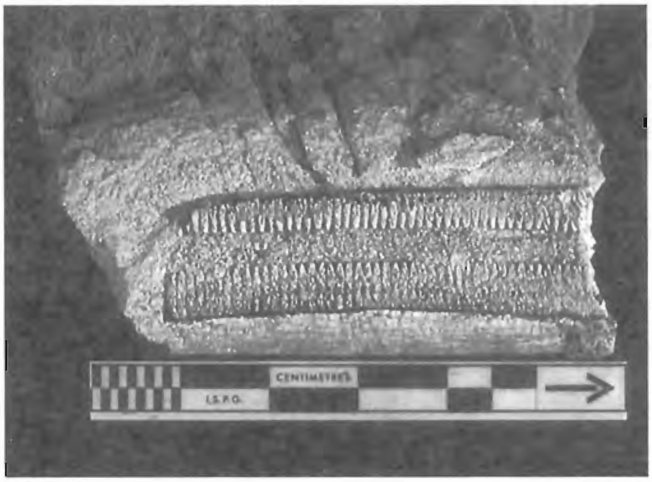


Figure 150. Large crinoid stem in Crash Point beds, fault block on south flank of Crash Point Syncline. ISPG photo 2203-2.

Figure 151. Trough-crossbedded sandstone in Crash Point beds, fault block on south flank of Crash Point Syncline. ISPG photo 1808-3.

Mode of origin. The inferred settings range from nearshore turbulent environments, indicated by crossbedding and relatively thick crinoid stalks, to quiet subtidal environments, represented by flat-laminated siltstones. The carbonate particles of the sandstones were derived from intrabasinal sources; the siliciclastic sediments from quartzose source rocks. The preservation of detrital biotite demonstrates that the sediments are compositionally immature.

Age and correlation. A conodont collection from the upper part of the unit is of undifferentiated Wenlock to Pridoli age (Uyeno, Appendix 5B, GSC loc. C-54997); however, a Wenlock age can be ruled out because of the probable Ludlow age of the underlying Marvin Formation. The Crash Point beds are comparable in some respects to the Markham River Formation, which is probably middle-late Ludlow in age. Both contain carbonates, sandstone, and mudrock, but the Markham River Formation also includes spiculite and conglomerate, which are absent from the Crash Point beds. The unit is tentatively placed into the late Ludlow but may extend into the Pridoli.

Facies development through time

Three broad intervals can be distinguished that show different facies configurations.

Late Ordovician (Ashgill). Two distinct facies are apparent: an extensive southeastern belt of shallow-marine clastic and minor carbonate sediments, assigned to the Lorimer Ridge Formation (813 m), and a more limited northwestern belt of graptolitic deep-water carbonates and mudrocks, assigned to the Ooblooyah Creek Formation (±400 m). A low-angle unconformity separating the Lorimer Ridge and Zebra Cliffs formations in the southeastern belt (or part of it) indicates weak positive movements and a slight amount of tilting. The northwestern belt may have developed by normal faulting at the same time.

Latest Ordovician (Ashgill) to early Ludlow. The northeastern deep-water belt persisted and two additional deep-water belts developed within the previous shallow-marine region. These three belts are separated by two belts of shelf carbonates assigned to the Marvin Formation.

Only the stratigraphic record of the southeastern carbonate belt is known. The thickness in this interval has not been precisely determined but is probably less than 100 m. The thin development of this part of the formation and an apparent absence of diagnostic fossils of latest Ordovician to early late Llandovery age suggest a hiatus somewhere within this interval.

The record of the three deep-water belts is fragmentary. In the central deep-water belt, about 1 km of fine to coarse clastic sediments are preserved that are assigned to the Cranstone Formation. The middle and upper parts of the formation have yielded graptolites of middle Llandovery age. The unfossiliferous lower part may be older. Sediments in the southeastern deep-water belt are also assigned to the Cranstone Formation but no information about the thickness and age of these deposits has been obtained.

In the northeastern clastic belt only a part of the Danish River Formation (>230 m) and the uppermost ±300 m of the Lands Lokk Formation are exposed. The Danish River Formation is of deep-water origin and probably latest Llandovery in age. The uppermost Lands Lokk Formation is of subtidal shelf origin and probably early Ludlow in age. Analogy with exposures in the Clements Markham Fold Belt suggests that the transition from deep water to shelf sedimentation occurred in the early Ludlow.

Middle to late Ludlow or Pridoli. The record for this interval, limited to the Crash Point section and to the middle and upper part of the section southeast of Disraeli Fiord, indicates that shallow-marine carbonate and clastic sediments overlapped the three clastic belts. The strata are assigned to the Marvin Formation (±150 m) and Crash Point beds (>100m ?) at Crash Point, and to the upper part of the Marvin Formation in the area section southeast of Disraeli Fiord (±500 m).

PHANEROZOIC INTRUSIONS

Pearya contains six or seven generations of plutonic intrusions that range in age from Early Ordovician to Late Cretaceous, and in composition from ultramafic to granitoid. In the following sections, these rocks are described in order of ascending age. In addition, it contains dykes and sills of different ages and compositions that have not been investigated.

Thores Suite (map units Oum and Og) Lower Ordovician ultramafic to granitoid complexes

Definition

The Thores Suite (Trettin, 1987b), named for Thores River (*M'Clintock Inlet*), consists of predominantly ultramafic and mafic plutonic rocks with lesser proportions of granitoid rocks. It is represented by five fault-bounded exposures, referred to as the M'Clintock West, M'Clintock East, Thores River, Bromley Island, and Ootah Bay bodies.

Distribution and contacts

Outcrops of the Thores Suite are confined to the northern part of the *M'Clintock Inlet* map area. The M'Clintock West body is as much as 12 km long and up to 6 km wide. Its easternmost part is nonconformably overlain by the Upper Carboniferous Canyon Fiord Formation (Frontispiece). The body is separated by a high-angle reverse fault from undated strata of Succession 2 on the south, and by a reverse or normal fault from the Upper Ordovician Ayles Formation on the north. On the west side it is bordered by the Maskell Inlet Complex, but the contact is concealed by a glacier.

The M'Clintock East body is 3.8 km long and about 1 km wide. It has been thrust southward over metavolcanics and metasediments of the Maskell Inlet Complex, which, in turn, are thrust over Upper Ordovician strata (see Structural geology, Fig. 156). It consists of two thrust slices of plutonic rocks that are locally divided by a thin fault slice of marble. On the north side the M'Clintock East body is separated from carbonates and evaporites of the Upper Carboniferous–Permian Mount Bailey Formation by a steeply dipping normal or reverse fault.

The Thores River body, about 2.2 km long and 100 to 200 m wide, lies approximately on strike with the M'Clintock East body. Steeply dipping faults separate it from the Maskell Inlet Complex on the north and the Mount Bailey Formation on the south (*M'Clintock Inlet*, inset D).

The Bromley Island body is 1.9 km long and up to 0.6 km wide. It is separated by steeply dipping faults from the surrounding Maskell Inlet Complex. This contact is locally unconformably overlain by nearly horizontal carbonates of Member B of the Cape Discovery Formation (see Structural geology, Fig. 157).

The Ootah Bay body, about 1 km long and as much as 170 m wide, is in fault contact with the Cape Discovery, M'Clintock, and Taconite River formations (*M'Clintock Inlet*).

Lithology

The Thores Suite consists mainly of an ultramafic-mafic assemblage, which in some bodies is intruded by a mafic to predominantly felsic assemblage (Table 22). In the M'Clintock West body the former is composed chiefly of serpentinite with local occurrences of wehrlite, clinopyroxenite, and gabbro (Frisch, 1974). The mafic-felsic assemblage occurs mainly as sheets or groups of sheets that are up to 10 m thick and as much as several hundred metres long, but felsic rocks also occur as small plugs. It comprises clinopyroxene-hornblende diorite, hornblende diorite (partly pegmatitic with large hornblende crystals), monzodiorite, quartz monzodiorite, leucocratic tonalite (trondhjemite), granodiorite, and granite. Six

Table 22

Rock types of the Thores Suite

ROCK TYPES \ OCCURRENCES	M'CLINTOCK WEST	M'CLINTOCK EAST	THORES RIVER	BROMLEY ISLAND	OOTAH BAY
Serpentinite	✓	✓		✓	✓
Wehrlite	✓	✓		✓	✓
Olivine clinopyroxenite		✓			
Clinopyroxenite	✓	✓	✓		
Hornblende clinopyroxenite		✓			
Clinopyroxene hornblendite		✓			
Plagioclase-clinopyroxene hornblendite		✓			
Gabbro	✓	✓		✓	
Hornblende gabbro		✓			
Clinopyroxene-hornblende diorite	✓		✓		
Hornblende diorite	✓				
Monzodiorite	✓	✓	✓		
Quartz monzodiorite	✓				
Tonalite (leucocratic = trondjhemite)	✓				
Granodiorite	✓				

analyzed samples of this assemblage (Appendix 4B, Table 1, 4-1 to 4-3; Frisch, 1974, Table VII) all are metaluminous (A/CNK = 0.035-0.98; A/NK > 1).

In the M'Clintock East body the ultramafic-mafic assemblage consists of layered cumulates that are either monomineralic clinopyroxenite or are composed of various mixtures of clinopyroxene and hornblende with or without lesser proportions of plagioclase and rare olivine and biotite. These rocks are classified as wehrlite, olivine clinopyroxenite, hornblende clinopyroxenite, clinopyroxene hornblendite, plagioclase-clinopyroxene hornblendite, gabbro, and hornblende gabbro. The mafic-felsic suite is represented by thin sheets of leucocratic rocks, including leuco- monzodiorite, that are separated by serpentinite.

In the Thores River body the ultramafic-mafic suite includes clinopyroxenite; the mafic-felsic suite includes pegmatitic hornblende diorite and sheared and altered monzodiorite and quartz diorite.

The Bromley Island body consists of gabbro and serpentinite with remnants of clinopyroxene, and biotite, and the Ootah Bay body of variably serpentinized wehrlite.

Mode of origin

The Thores Suite differs from layered mafic intrusions (such as the Bushveld, Skaergaard or Stillwater intrusions) by the apparent absence of orthopyroxene. On the other hand, the suite has features in common with ophiolites and with plutonic complexes underlying ensimatic volcanic arcs.

The standard ophiolite, which presumably represents ancient oceanic mantle and crust, consists of five major units (Coleman, 1977). The lowest unit, peridotite tectonite, may be present in the M'Clintock West body, but is not identifiable there because of pervasive serpentinization - a common feature of ancient ophiolites and their counterparts in modern oceans. The second and third units, cumulate complexes and leucocratic associates (or plagiogranite) are well represented, the apparent lack of orthopyroxene, and the presence of small amounts of K-feldspar notwithstanding. The absence of the upper two units of the standard ophiolite, sheeted dykes and pillow basalt, militates against the ophiolite interpretation, but could be attributed to faulting.

Deep erosion of ensimatic volcanic arcs, for example in Alaska and California, has revealed plutonic complexes that range in composition from granitoid to ultramafic and include abundant ultramafic cumulates (e.g., Irvine, 1974; Snoke et al., 1982; Burns, 1985; Beard, 1986). The Thores Suite is similar to some of these, for example to suite 1 of the Bear Mountain Igneous Complex, Klamath Mountains, California, characterized as "clinopyroxene-rich ultramafic and gabbroic rocks with subordinate dunite and hornblende-plagioclase pegmatoid" (Snoke et al., 1982). The most persuasive evidence for a sub-arc origin of the Thores Suite, however, is its structural association with the Maskell Inlet Complex. This interpretation is supported by plots of Rb, Nb, Y, Ta, and Yb on tectonic discrimination diagrams by Pearce and others (1984; see Appendix 4B, Figs. 172, 173 and Discussion).

Age and correlation

U-Pb determinations on zircon from a quartz monzodiorite in the M'Clintock West body gave an upper intercept age of 481 +7/-6 Ma (Trettin et al., 1982), Arenig according to the adopted time scale (Fig. 2). In contrast to present techniques, the zircon was not abraded at that time, thus a redetermination may yield a somewhat older age. Moreover, it only defines an upper age limit for the intruded ultramafic-mafic assemblage. Nevertheless, this age is in agreement with the fact that the Bromley Island body locally is unconformably overlain by Member B of the Cape Discovery Formation, which is early Caradoc in age. A K-Ar (hornblende) determination of 397 ± 20 Ma (recalculated from Wanless et al., 1968) on the same intrusion reflects Early Devonian cooling, perhaps after reheating and uplift.

Lower and Middle Ordovician granitoid intrusions

Ayles Fiord Intrusion (map unit LOgd, Lower Ordovician)

A concordant sheet of granodiorite intrudes the crest of a small anticline in schist of Succession 2 (map unit M2) immediately north of the middle part of Ayles Fiord and 14.4 km northwest of the head of the fiord. This is the only intrusion encountered in a few reconnaissance traverses of this area, but others may be present.

The host rock is a pyritic schist composed of quartz, biotite, and minor garnet. A probe analysis of three layers in a Mn- and Fe-rich zoned garnet indicated the following end-member composition: spessartine (42.08-48.60 molecular %), almandine (31.44-36.905%), pyrope (11.09-14.93%), andradite (4.57-6.435%), grossularite (2.99-4.035%), schorlite (0.31-0.385%), uvarovite (0.00-0.085%) (analysis by Mineralogical Laboratory, Geological Survey of Canada).

A typical sample of the granodiorite consists of feldspar (oligoclase 29%, K-feldspar 24%), quartz (31%), biotite (15%), chlorite (1%), and trace amounts of chlorite, tourmaline, zircon, monazite, and apatite. Quartz and feldspar form myrmekitic intergrowths. Microscopic sigmoidal folds involving feldspar are apparent in one thin section (Fig. 152). Two chemically analyzed samples are peraluminous (A/CNK = 1.10-1.13; Appendix 4B, Table 1, nos. 5-1, 5-2).

U-Pb analyses of zircon indicated that some crystals had Pb inheritance and others Pb loss (Trettin et al., 1992). Two analyses of monazite yielded a concordant U-Pb age of 475 ± 1 Ma, interpreted as the age of crystallization – Arenig according to the adopted time scale (Fig. 2). Biotite from the same sample gave a ^{40}Ar-^{39}Ar plateau age of 470.6 ± 2.5 Ma, indicating cooling to the closure temperature of biotite in the latest Arenig.

The conclusions concerning the mode of origin of this intrusion can be summarized as follows:

1. The presence of inherited zircon indicates that the granodiorite is at least partly crustal in origin, and this is supported by its peraluminous composition (cf. Barbarin, 1990, and references therein).

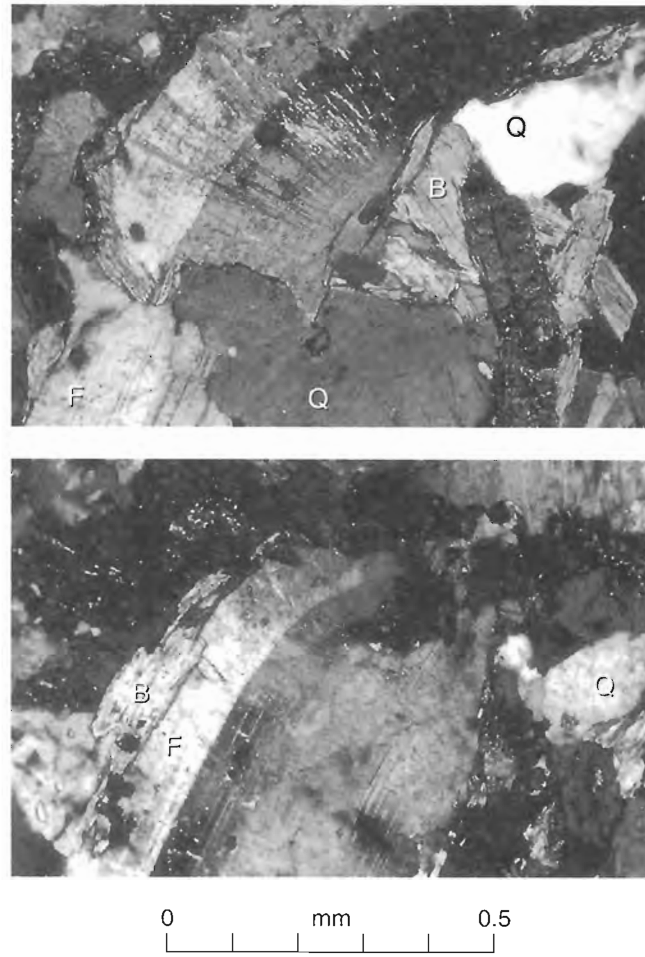


Figure 152. Photomicrograph (cross-polarized light) of Ayles Fiord granodiorite, showing bent feldspar crystal with quartz (Q) *and biotite* (B). *ISPG photos 3699-3, 3699-5.*

2. The relatively low metamorphic grade of the host terrain, which is upper greenschist to locally lower amphibolite facies, precludes an origin by partial melting *in situ*. If generated by anatexis of crustal rocks, this must have occurred at a lower level, perhaps in the sillimanite zone (cf. Sevigny et al., 1989).

3. Emplacement was broadly contemporaneous with the folding of the host rock and was followed by cooling to the blocking temperature of argon in biotite (580°C according to Harrison et al., 1985) within a few million years.

This age determination provides an upper limit for the onset of the M'Clintock Orogeny (see Structural geology, Ages of deformation).

Markham Fiord Pluton (map unit Ogd, *Middle Ordovician)*

The elongate, northwest-trending Markham Fiord Pluton (Figs. 153, 158; *Clements Markham Inlet–Robeson Channel*) is about 16 km long and up to 2.8 km wide. It is in fault contact with map units L1, L1?, and L4 of Succession 2, and upper Paleozoic formations, and the rocks commonly are shattered and altered. The pluton consists of fine to predominantly medium grained granodiorite, quartz monzodiorite, and tonalite with minor amounts of fine grained gabbro. Hornblende and biotite, the latter commonly altered to chlorite, are the predominant mafic silicates, but small amounts of clinopyroxene are also present. The plagioclase - oligoclase or andesine originally - is commonly altered to albite. Chemical analyses of five relatively unaltered samples indicate metaluminous to peraluminous compositions (A/CNK = 0.94-1.24, A/NK > 1; Appendix 4B, Table 1, nos. 6-1 to 6-5).

U-Pb analysis on unabraded zircon yielded an upper concordia-intercept age of 462 ± 11 Ma (Trettin et al., 1982), near the Llanvirn–Llandeilo boundary and with confidence limits in the late Arenig and Caradoc according to the adopted time scale (Fig. 2). A K-Ar determination on hornblende from a different locality gave an apparent age of 422 ± 37 Ma (Stevens et al., 1982).

The metaluminous to peraluminous composition of this pluton may indicate partial derivation from crustal sources (cf. Barbarin, 1990), although this is not confirmed by zircon inheritance. The presence of a mantle-derived component is indicated by sparse pyroxene. The Llanvirn–Llandeilo zircon age clearly indicates a relation with the M'Clintock Orogeny (see Ages of deformation), but the confidence limits are too wide to determine whether this is a syntectonic or post-tectonic intrusion.

Figure 153. *Markham Fiord Pluton (**Clements Markham–Robeson Channel**), view to the north, relief about 300 m. Quaternary sediments in the foreground overlie upper Paleozoic strata. In the left background (dark), iron-stained Proterozoic diamictite of Succession 2 (map unit L2). ISPG photo 1878-32.*

Cape Richards Intrusive Complex (map unit MOqm, *Middle Ordovician)*

The Cape Richards Intrusive Complex (Frisch, 1974) has two outcrop areas roughly circular or oval in shape and 4.1 and 6.4 km in diameter, which are surrounded by metasediments of Succession 2 (map unit pwqc, *M'Clintock Inlet*). In contrast to the Markham Fiord Pluton, the rocks are not shattered and mostly unaltered. Frisch distinguished outer zone rocks, chiefly quartz monzonite close to granodiorite, and inner zone rocks, chiefly hornblende syenite. These become progressively more felsic outward from the centre and contain riebeckite-bearing dykes. A sample of granodiorite that has been dated (see below) is weakly peraluminous (A/CNK = 1.04-1.05; Appendix 4B, Table 1, no. 7-1). Five samples of quartz monzonite, quartz syenite, clinopyroxene syenite, and syenite from the inner zone are metaluminous (A/CNK = 0.88-0.99, A/NK > 1; calculated from Frisch, 1974, Table VIII); a sample of riebeckite granite (ibid.) is peralkaline (A/CNK = 0.94, A/NK = 0.97).

Xenocrystic zircon from the Cape Richards Intrusive Complex had an upper intercept age of 1450 ± 400 Ma (Trettin et al., 1987). The age of crystallization is probably defined by a concordant sphene age of 463 ± 5 Ma, Llanvirn, with confidence limits at the Arenig–Llanvirn boundary and in the Caradoc.[1] A K-Ar hornblende age of 397 ± 18 Ma (Early Devonian) and a biotite age of 354 ± 15 Ma (latest Devonian; recalculated from Wanless et al., 1970) reflects cooling, perhaps after reheating and uplift earlier in the Devonian.

This intrusive complex is probably of hybrid origin, with the xenocrystic zircon derived from the crystalline basement of Pearya and the clinopyroxene from mantle sources. The age, which is considerably younger than the approximate 471 Ma cooling age of the Ayles

[1]The age is earliest Llandeilo with confidence limits in the Llanvirn and at the Llandeilo–Caradoc boundary according to Tucker and McKerrow (1995).

Fiord intrusion, suggests a post-orogenic origin, and this is compatible with its lithology and setting.

Disraeli Glacier Pluton (map unit O?g*, age uncertain)*

A narrow, northeast-trending pluton, located east of the lower reaches of Disraeli Glacier, intrudes highly altered chert(?) and volcanics(?) tentatively assigned to the Maskell Inlet Complex. The plutonic rocks are medium grained and generally brecciated, sheared, and altered. They are composed of variable proportions of quartz, plagioclase, K-feldspar, biotite, and rare hornblende. The plagioclase has been totally altered to albite, and most of the mafic siliciates have been altered to chlorite. Epidote and calcite alteration also are common. Petrographic analyses represent a broad spectrum of rock types including tonalite, granodiorite, granite, and monzodiorite. The major element compositions vary from metaluminous to peraluminous (A/CNK = 0.80-1.25; A/NK > 1; Appendix 4B, Table 1, nos. 8-1 to 8-7), and the trace element ratios also are widely scattered (Appendix 4B, Figs. 172, 173). These variations in lithology and chemical composition are probably not original features but are due to alteration. The location of the pluton suggests that it belongs to the Ordovician suite of granitoid intrusions.

Cape Fanshawe Martin Intrusion (map unit O?b, Early Devonian or older gabbro-peridotite)

The Cape Fanshawe Martin pluton, about 11 km long and 5 km wide, intrudes Succession 2 of Pearya (map unit A; *Yelverton Inlet* and *M'Clintock Inlet*). It was divided by Frisch (1974) into an olivine-rich central zone of ultramafic and mafic rocks (peridotite, troctolite, olivine-gabbroic anorthosite, pyroxenite, etc.), and a larger outer zone of mafic rocks (gabbro with and without orthopyroxene, anorthositic gabbro, anorthosite, olivine gabbro). Cryptic zoning is shown by olivine and plagioclase, which are more magnesian and calcic, respectively, in the inner zone than in the outer. Igneous layering, steeply inclined to vertical in attitude, and fluxion cumulate texture are especially common in the inner zone.

A K-Ar determination on biotite from the outer zone yielded a Devonian apparent age of 383 ± 16 Ma (recalculated from Wanless et al., 1968). It is comparable to the K-Ar determinations from the Ordovician M'Clintock West body and Cape Richards Intrusive Complex and probably also represents a cooling age. The crystallization age may be as old as Ordovician.

Cape Woods Pluton (map unit Dqm, Middle Devonian granitoid intrusion)

The Cape Woods Pluton (Frisch, 1974) on northwestern Wootton Peninsula (Fig. 154; *Yelverton Inlet*), a batholith underlying about 166 km^2, is the largest Phanerozoic intrusion in the Arctic Islands. It intrudes schist and minor marble and quartzite (map unit scq) of Succession 2. The country rocks are generally of greenschist grade, but sillimanite, kyanite, and staurolite are developed in the contact aureole. The intrusive rock is a medium grained biotite-quartz monzonite or granodiorite with abundant K-feldspar phenocrysts. One analyzed sample is slightly peraluminous (A/CNK = 1.05; calculated from Frisch, 1974, Table IX), another is metaluminous (A/CNK = 0.91; A/NK > 1; Appendix 4B, Table 1, no. 9-1). Aplite and pegmatite veins and segregations are common. The bulk of the intrusion is undeformed, but crush texture and foliation occur at its margin (ibid.).

Regression analysis of four zircon fractions, which included a significant proportion of xenocrystic material, yielded intercept ages of 369 +4/-5 Ma and ca. 1360 ± 200 Ma. The best estimate for the crystallization of the pluton was given by a sphene age of 390 ± 10 Ma (Trettin et al., 1987), Eifelian according to the adopted time scale, with confidence limits in the Early and Middle Devonian. A K-Ar (biotite) determination of 352 ± 15 Ma (recalculated from Wanless et al., 1974; earliest Carboniferous, with confidence limits in the Late Devonian and Early Carboniferous) reflects cooling.

The upper intercept age of the xenocrystic zircon suggests at least partial derivation from the gneissic basement of Pearya, and mafic silicates indicative of an additional mantle source are lacking. The tectonic significance of the pluton is discussed later in this chapter (Structural geology, Ages of deformation).

Petersen Bay Pluton (map unit Cmd, Lower Carboniferous granitoid intrusion)

This small pluton, about 1.3 km long and up to 0.7 km wide, is located 2 to 3 km south of the head of Petersen Bay (*Yelverton Inlet*). It intrudes metasediments of Succession 2 of Pearya (map unit Y2) and is truncated on the south by a major fault. Activity on this fault probably acounts for the disturbed texture and altered mineral composition of this intrusion. Analyzed samples consist of fine grained, metaluminous (A/CNK = 0.93-0.94, A/NK > 1) monzodiorite and peraluminous (A/CNK = 1.17; Appendix 4B, Table 1, nos. 14-1, 14-2) tonalite. The

***Figure 154**. Cape Woods Pluton* (Dqm) *on westernmost Wootton Peninsula (Yelverton Inlet), view east. The pluton intrudes schist with minor marble and quartzite of Succession 2* (scq) *and is bordered by Quaternary sediments* (Q)*. Part of oblique aerial photograph NAPL T408R-232.*

monzodiorite is composed of feldspar (albite 64%, K-feldspar 24%), biotite (6%), chlorite (2%), quartz (2%), epidote (1%), opaque minerals (1%), and trace amounts of hornblende and calcite. Nearly concordant U-Pb (zircon) analyses indicate an age of 334.5 ± 1.5 Ma (Trettin et al., 1992), late Early Carboniferous (Viséan) according to the adopted time scale. In the Arctic Islands the late Viséan is represented by the Emma Fiord Formation, the oldest unit of the Sverdrup Basin. Preserved only in a few, widely scattered areas, it consists of predominantly nonmarine, in part lacustrine clastic sediments (Thorsteinsson, 1974; Davies and Nassichuk, 1991; Utting et al., 1989; Mayr, 1992). The age relation with the Emma Fiord Formation indicates that the Petersen Bay Pluton is anorogenic in origin and the result of plume activity and/or rifting that initiated the Sverdrup Basin (cf. Beauchamp et al., 1989).

Wootton Intrusive Complex (map units Kb* and Kbg, Late Cretaceous biomodal complex)

The Wootton Intrusive Complex is exposed as a belt of nunataks extending from Phillips Inlet northeastward to the ice-covered centre of Wootton Peninsula (Fig. 155; *Yelverton Inlet*). The belt is about 30 km long and attains a maximum width of about 5.8 km in its central part. Structurally it lies within the Mitchell Point Fault Zone, which separates the Mitchell Point gneiss belt from metasediments of Succession 2 of Southwest Pearya (Trettin and Parrish, 1987; Ohta and Klaper, 1992). The contacts of the complex are mostly covered by a glacier; where exposed they are probably faulted. The Mitchell Point Fault Zone appears to be a long-lived zone of crustal weakness that has been reactivated at different times and under different stress regimes.

The lithology of the complex is known only from brief helicopter landings at five localities - the ice fields of Wootton Peninsula are difficult to access because they often are covered by fog.

Fifteen rock samples, studied in thin section in conjunction with XRD and some chemical analyses, represent 10 different rock types that can be assigned to three major lithological assemblages: gabbroic, felsic, and intermediate (hybrid) in composition (Table 23). Mafic rocks are far more abundant than

Figure 155. *Wootton Intrusive Complex* (Kb*), *Wootton Peninsula (Yelverton Inlet), view to the east. The complex is flanked on the northwest side by metasediments of Succession 2* (scq: *schist, minor marble and quartzite;* c: *marble) and on the southeast side mainly by gneiss of the Mitchell Point belt* (Pn). *A minor fault block with a complex internal structure is composed of metasediments of Succession 2* (S: *schist;* W2*: *phyllite, diamictite, marble, etc.) with a small inlier of volcanics and sediments assigned to the Cretaceous Hansen Point volcanics* (KHP). *The faults on the southeast side of the Wootton Intrusive Complex are part of the Mitchell Point Fault Zone. Part of oblique aerial photograph NAPL T405R-23.*

felsic ones, but the latter dominate in the central northwestern part (map unit Kbg) where they form a cliff about 2 km wide at the base and up to 600 m high. At other localities mafic rocks are cut by felsic dykelets that commonly contain dark xenoliths. Distinct compositional layering and indistinct flow structures occur in mafic rocks in the southern part of the complex (Ohta and Klaper, 1992). The layers are 5 to 10 cm thick and generally strike northeast. The gabbros and diorites also contain xenoliths of felsic gneiss, schistose amphibolite, and banded granitic gneiss (ibid.).

Zircon from a quartz monzonite, showing slight inheritance, provided a lower intercept age of 92.0 ± 1.0 Ma (Trettin and Parrish, 1987), Turonian according to Gradstein et al. (1994). The upper intercept age could not be determined precisely. The complex is nearly co-eval with the Marvin Pluton (see below) and partly co-eval with the basaltic Strand Fiord Formation of Axel Heiberg Island (Embry and Osadetz, 1988; Embry, 1991).

Together these intrusions and volcanics indicate a major rift event. The granitoid component, as indicated by U-Pb inheritance in zircon from this complex and from the slightly younger Hansen Point volcanics (Trettin and Parrish, 1987), is probably of crustal origin.

Marvin Pluton (map unit Kqm, Upper Cretaceous granitoid intrusion)

The Marvin Pluton, located on south-central Marvin Peninsula, is about 2.8 km long and up to 1.4 km wide. It intrudes the Upper Ordovician Taconite River Formation and is bounded on the north by a fault. Analyzed samples from different localities are fine to medium grained and similar in texture and mineral

Table 23

Rock types of the Wootton Intrusive Complex

Felsic assemblage
Granite, leucocratic, fine grained
Granodiorite, medium grained
Quartz monzonite, fine and medium grained (Appendix 4B, Table 1, no. 15-1; clinopyroxene present in two samples)
Intermediate assemblage
Quartz monzodiorite transitional to granodiorite, fine grained
Monzodiorite, melanocratic, fine grained, porphyritic (phenocrysts of plagioclase)
Clinopyroxene-hornblende-quartz gabbro, leucocratic, fine and medium grained
Gabbroic assemblage
Hornblende-clinopyroxene gabbro, medium grained
Clinopyroxene-hornblende gabbro, normal and melanocratic, fine and medium grained
Clinopyroxene gabbro, fine grained
Olivine gabbro, melanocratic, medium to coarse grained (forsterite and small amounts of orthopyroxene and biotite are present, but clinopyroxene predominates)

composition, which lies in the boundary fields of granodiorite, quartz monzodiorite, and quartz diorite. The chemical compositions are metaluminous (Appendix 4B, Table 1, nos. 16-1 to 16-5). Zoned plagioclase, (commonly oligoclase-andesine) predominates over K-feldspar, which is frequently associated with quartz in graphic intergrowths. Most of the quartz, however, occurs as separate crystals or in interstices. Green hornblende, the predominant mafic silicate, is accompanied by smaller proportions of clinopyroxene and minor biotite.

A large sample submitted for dating did not contain zircon. Two concentrates of little-altered hornblende yielded apparent K-Ar ages of 94.2 ± 10 and 91.6 ± 9.6 Ma, averaging 92.9 Ma (Stevens et al., 1982), Turonian (Gradstein et al., 1994). The same concentrate gave a ^{40}Ar–^{39}Ar plateau age of 94.2 ± 0.7 Ma (Trettin et al., 1992), latest Cenomanian. An apatite fission track date of 92.4 ± 6.4 Ma obtained by R.H. McCorkel (pers. comm., 1990) is in agreement with these data. The Marvin Pluton is approximately co-eval with the granitoid component of the Wootton Intrusive Complex.

STRUCTURAL GEOLOGY

Description of structures

Northeast Pearya

General characteristics

Northeast Pearya (*Clements Markham Inlet–Robeson Channel*, *M'Clintock Inlet*, and *Yelverton Inlet*), which contains key exposures of all five successions, is the largest, and stratigraphically and structurally the most complex domain of Pearya. It is up to 230 km long in a west-southwest direction and up to 90 km wide. On its southern and western sides, Northeast Pearya is in contact with the Clements Markham Fold Belt along the Mount Rawlinson, M'Clintock Glacier, and Yelverton faults (Fig. 1a and Chapter 3).

Northeast Pearya is divisible into a northeastern and a southwestern subdomain that differ in structural trend (see Ages of deformation, Fig. 158). On Marvin Peninsula and in the westernmost part of Cranstone Peninsula the boundary between the two subdomains coincides with a series of faults that form the southern limit of the M'Clintock Formation. On Marvin Peninsula this boundary marks a profound change in structural style. No outcrops of Succession 4 occur south of this line, and Succession 4 is absent near the head of M'Clintock Inlet and east of the lower reaches of M'Clintock Glacier where Succession 5 overlies Succession 2. Farther east on Cranstone Peninsula the M'Clintock Formation is entirely absent and structural relations are obscured by extensive ice fields. The location of the domain boundary in this area is arbitrary.

Southwestern subdomain

The Southwestern subdomain forms a highly arcuate belt of folds and strike-parallel faults. Trends are generally smooth and rounded but show a sharp right-angle bend on the inside of the belt, south of the upper reaches of Ayles Fiord (*M'Clintock Inlet*). The age of the exposures decreases from the periphery of the fold belt to its interior, with some reversals, and the structures will be described in that order.

Succession 1. Two uplifted fault blocks of Succession 1, the Deuchars Glacier Belt and the Yelverton Inlier, are surrounded by Succession 2 in the southwesternmost part of the Southwestern subdomain. The Deuchars Glacier Belt, about 30 km long and up to 12 km wide, is crescent-shaped in plan. The southwestern contact, examined on the ground, is a northeast-dipping high-angle reverse fault, named Deuchars Thrust. The other contacts are concealed by glaciers or difficult to access. Photogeological interpretation and helicopter observations suggest steeply dipping faults that may be reverse or normal. The trends of gneissic foliation and schistosity, which are mappable from air photographs, are arcuate and subparallel with the external contacts of the fold belt.

Succession 2. Extensive exposures of Succession 2 form the outer part of the subdomain. The structure of these rocks is generally too complex for resolution by reconnaissance mapping, but major folds, controlled by massive carbonate units (Y3, M1, and M3) and by a thick, massive quartzite unit (M5) have been mapped between Yelverton Inlet and Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*). Trends on the periphery of the subdomain are smoothly curved but form a sharp turn on the inside in an area south of the head of Ayles Fiord (*M'Clintock Inlet*). There, a complex anticlinorium formed in map unit M1 shows westerly and northerly trending anticlinal axes that are nearly perpendicular to each other. The configuration, although unresolved in detail, is reminiscent of interference structures formed by stresses of different orientation. The northwestern part of this outcrop belt of Succession 2 contains two granitoid bodies of Ordovician age, the Ayles Fiord Intrusion and the Cape Richards Intrusive Complex.

Succession 3 and Thores Suite. A continuous outcrop belt of Succession 3 (Maskell Inlet Complex) with two fault-bounded occurrences of the plutonic Thores Suite, the Bromley Island and M'Clintock West bodies, fringes Succession 2 on the northern and eastern sides of the subdomain in the region west of M'Clintock Inlet (*M'Clintock Inlet*). The contact between Successions 2 and 3, which is largely covered by overburden or younger strata, appears to be a series of strike-parallel linear faults, including the Oakley River Fault, that are locally offset by transverse faults. The internal structure of the Maskell Inlet Complex is difficult to resolve, but some folds and thrust sheets have been mapped in the area northeast of Ayles Fiord.

Smaller, fault-bounded exposures of Succession 3 and the Thores Suite are present in two areas east of the upper reaches of M'Clintock Inlet that are separated by glaciers. In the western area the Maskell Inlet Complex and the M'Clintock East body of the Thores Suite form a stack of imbricate fault slices that have been thrust southward upon Upper Ordovician strata (Fig. 156).

Successions 4 and 5 west of the lower reaches of M'Clintock Inlet. Scattered outcrops of the lowermost part of Succession 4, comprising Members A and B of the Cape Discovery Formation, unconformably overlie Successions 2 and 3 in the area between the upper reaches of Ayles Fiord and the northernmost part of Bromley Island (Fig. 157). These strata are flat-lying or moderately inclined, but not folded, in contrast to the underlying tightly folded strata of Successions 2 and 3. The unconformity at the base of the Cape Discovery Formation represents the M'Clintock Orogeny, discussed later in this chapter. Units younger than the Cape Discovery Formation are not preserved in this area.

Farther east, between Borup Point and the Zebra Cliffs, the area west of M'Clintock Inlet is underlain by complexly folded and faulted strata of Successions 4 and 5. Structural trends are southerly in the northern part of this area and easterly to northeastly in the southern part and conform with the overall trend of the subdomain. The largest structure is the Egingwah Creek Syncline, a severely faulted fold (*M'Clintock Inlet*, cross section B–B′) with a curving axis. It is controlled by the thick and massive volcanics and carbonates of the M'Clintock and Ayles formations, respectively.

Succession 5 east of the lower reaches of M'Clintock Inlet. Three second-order subdomains are apparent in the region east of the lower reaches of M'Clintock Inlet.

1. In the northern part of this area, Succession 5 forms west-trending faulted folds controlled mainly by the massive carbonate rocks of the Zebra Cliffs Formation. A faulted concentric syncline northeast of Crash Point, however, is controlled by the Marvin Formation. This area differs in structural style from the area adjacent on the north, underlain mainly by the M'Clintock Formation and assigned to the Northeastern subdomain, where regular and extensive folds are absent. This relation implies that the M'Clintock Formation either is absent in the subsurface of the present area or that it is separated from Succession 5 by a detachment surface.

2. The central part is underlain by south-directed imbricate thrust sheets of Succession 3 and the Thores Suite that have been mentioned earlier.

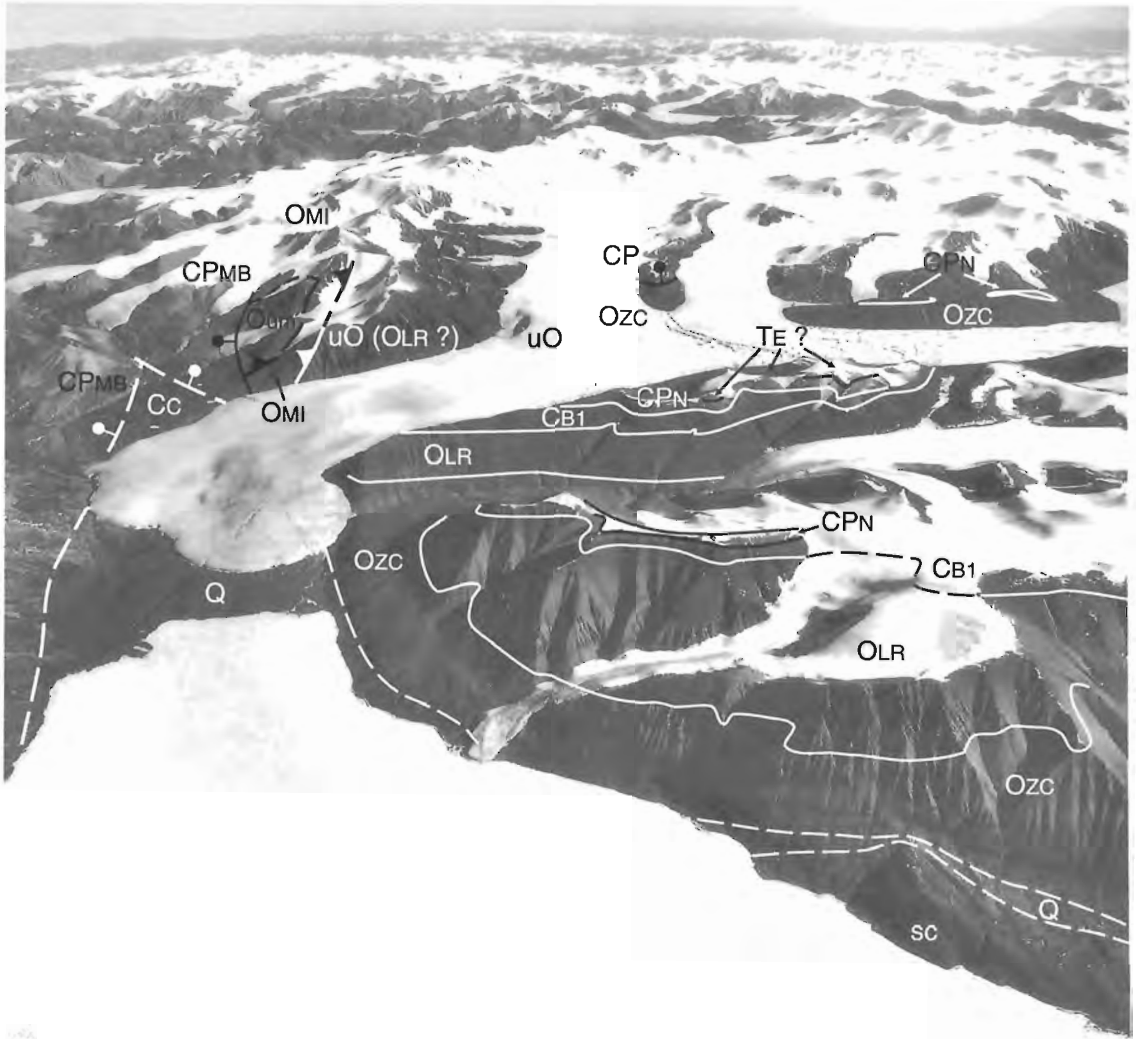


***Figure 156**. Geology east of head of M'Clintock Inlet. Important features are: (1) a high-angle unconformity between map unit sc of Succession 2 and the Zebra Cliffs Formation; (2) a low-angle unconformity between the Zebra Cliffs and Lorimer Ridge formations; (3) a low-angle unconformity between the Lorimer Ridge and Borup Fiord formations; (4) south-directed thrust faults involving the Thores Suite, Maskell Inlet Complex and Upper Ordovician strata.* (sc: *schist and marble of Succession 2;* Oum: *M'Clintock East body of Thores Suite;* OMI: *Maskell Inlet Complex;* Ozc: *Zebra Cliffs Formation;* OLR: *Lorimer Ridge Formation;* uO: *Taconite River, Zebra Cliffs, and Lorimer Ridge formations undifferentiated;* Cc: *Canyon Fiord Formation;* CB1: *Borup Fiord Formation;* CPMB: *Mount Bayley Formation;* CPN: *Nansen Formation;* TE?: *Eureka Sound Formation?;* Q: *Quaternary sediments). Part of oblique air photo NAPL T404L-19.*

3. The southern part consists of gently to moderately tilted strata of Succession 5A and of the Lorimer Ridge Formation that overlie Succession 2 with a high-angle unconformity. Successions 3 and 4 are absent here, probably as a result of Ashgill erosion (Figs. 120, 126). Succession 2 must have been consolidated by tight folding and metamorphism during the intervening M'Clintock Orogeny (see Ages of deformation) to such an extent that further folding was not possible. The structural configuration thus is analogous to that in the northwestern part of *M'Clintock Inlet*, where the Cape Discovery Formation is only weakly deformed.

Succession 5 in the vicinity of Disraeli Fiord and Disraeli Glacier. East and west of the upper reaches of Disraeli Fiord and the lower reaches of Disraeli Glacier, structural trends are diverse, and complex faulting is dominant over folding. An outcrop area of the Cranstone Formation immediately west of the lower reaches of Disraeli Glacier is bounded by

Figure 157*. Oblique aerial view (east-northeast) of Bromley Island and vicinity. The Cape Discovery Formation (*OCD1*: Member A,* OCD2*: Member B) lies unconformably on the following units: map unit pwqc of Succession 2 (foreground); the Maskell Inlet Complex (*OMI*;* OMIc *are carbonates within the complex), and the Bromley Island body of the Thores Suite* (Oum). b: *basic igneous intrusion (age uncertain),* BI: *Bromley Island section;* NPB: *section north of Bethel Peak. NAPL 408L-2.*

southwesterly and westerly striking faults. A major syncline within this outcrop area also trends southwest. Minor folds have locally been mapped within the Zebra Cliffs, Lorimer Ridge, and Cranstone formations.

Northeastern subdomain

This subdomain is underlain, from north to south, by Successions 1, 2, 4, and 5, Succession 3 being absent (Fig. 1a; *M'Clintock Inlet* and *Clements Markham Inlet-Robeson Channel*).

Succession 1. The crystalline basement of Pearya is represented by the Cape Columbia Belt, which is exposed on the north coast of Ellesmere Island between Parr Bay and Disraeli Fiord (*Clements Markham Inlet-Robeson Channel* and *M'Clintock Inlet*) and bounded on the south by the Parr Bay Fault. The gneissic foliation is roughly east-west, parallel or sub-parallel to the orientation of the outcrop belt, and dips vary from approximately 50°S to 80°N (Frisch, 1974). Complex isoclinal folds with steep to vertical or overturned axial planes are common (ibid.).

Succession 2. South and southeast of the Cape Columbia Belt, variably metamorphosed sedimentary and minor volcanic rocks of Succession 2 are exposed (*Clements Markham Inlet-Robeson Channel* and *M'Clintock Inlet*). The structure of this area is extremely complex, but rudiments of a stratigraphic framework and of a structural pattern have been established on Arthur Laing Peninsula (*Clements Markham Inlet*). There, the Neoproterozoic to Cambrian map units L1 to L5 show two preferred trends of complex folding and faulting: an older southwesterly trend, and a younger east-southeasterly trend that truncates and overprints it. However, intermediate and curving trends are also present.

Successions 4 and 5. Strata of Succession 4 cover most of northern Marvin Peninsula and adjacent parts of Cranstone Peninsula (*M'Clintock Inlet* and *Clements Markham Inlet–Robeson Channel*). This area is characterized by complex faults and an absence of well developed folds, probably because the structure is controlled by the massive volcanics of the widely exposed M'Clintock Formation. Extensive faults on northern Marvin Peninsula are subparallel to the east-southeast-trending structures of Succession 2 farther east on Arthur Laing Peninsula, and probably represent reactivated basement structures. The southeasternmost part of the subdomain, which is covered mainly by Succession 5, also is characterized by faults and an absence of well-developed folds.

Central Pearya and bordering faults

Central Pearya comprises the Mitchell Point Belt, which is underlain by Succession 1, and an area northeast of Ayles Fiord underlain mainly by unit A of Succession 2 with small inliers of Succession 1. A major northeast-plunging anticline in this area involves both successions (Fig. 85; *M'Clintock Inlet*).

The dominant feature of the Mitchell Point Belt is a southwest-striking foliation. Studies on the unnamed peninsula south of Mitchell Point have shown that this foliation is generally parallel to a distinct compositional layering (Klaper and Ohta, 1993). Isoclinal folds with axial planes parallel to foliation and compositional layering, and open folds refolding the earlier ones also were recognized. Mineral orientation lineations were parallel to the axes of the isoclinal folds (ibid.).

The Mitchell Point Belt is bounded by outward-directed reverse faults both on the southwest and northwest, and the flanking strata on both sides show amphibolite grade metamorphism. The Petersen Bay Fault, which thrusts the Mitchell Point Belt upon the Clements Markham Fold Belt on the southeast, has been discussed earlier (Chapter 3, Description of structures; Figs. 76, 77). It is bordered on the southeast by a belt, locally more than 10 km wide, in which the metamorphism decreases from lower amphibolite to lower greenschist facies. In the immediate vicinity of the fault, cataclasis and retrograde metamorphism of lower greenschist facies overprints the amphibolite grade metamorphism of the Mitchell Point Belt (Frisch, 1974; Klaper and Ohta, 1993).

The Mitchell Point Fault (*Yelverton Inlet*), which places the Mitchell Point Belt upon Succession 2, is about 90 km long and exposed in three areas:

1. On the northeast side of Yelverton Bay, granitoid gneiss is thrust over garnetiferous two-mica schist, quartzite, and marble of Succession 2 (map unit sq; Appendix 2) in a northwesterly direction. The attitude of this fault is probably controlled by the foliation of the gneiss, which dips southeast in this area.

2. On Wootton Peninsula the fault is intruded by the Late Cretaceous Wootton Intrusive Complex. On southwestern Wootton Peninsula the main fault splits into four branches that enclose three different fault blocks (Ohta and Klaper, 1992).

   (a) The southeastern block, which is bordered by the Mitchell Point Belt on the southeast, consists of felsic and pelitic garnet two-mica schist and amphibolite (map unit s). Measurements of schistosity and compositional layering indicate a major synform, the axis of which plunges south at about 20°. The fold postdates the schistosity and has no axial plane cleavage. These rocks are similar to the metamorphosed equivalents of the Kulutingwak Formation in the footwall of the Petersen Bay Fault (Ohta and Klaper, 1992) and to parts of Succession 2. Assignment to Succession 2 is preferred here because all other outcrops or possible metamorphic equivalents of the Kulutingwak Formation are confined to the southeastern side of the Mitchell Point belt.

   (b) The central block is composed of metasediments of Succession 2 (map unit W2*; see Ohta and Klaper, 1992 and Appendix 2), including diamictite. Also present are volcanic rocks and plant-bearing clastic sediments of the Upper Cretaceous Hansen Point volcanics, which probably overlie Succession 2 with an angular unconformity.

   (c) The northwestern block consists of the Wootton Intrusive Complex. The intrusion is separated by a fault from carbonates of Succession 2 (map unit c).

3. On the southeast side of Phillips Inlet, the Mitchell Point Fault is a reverse fault that thrusts gneiss of Succession 1 northwestward upon marble of Succession 2 of Southwest Pearya.

Southwest Pearya

Southwest Pearya is 116 km long, up to 33 km wide, and extends from the northeast side of Yelverton Bay to southwest of Phillips Inlet (*Yelverton Inlet* and *Otto Fiord*). It is underlain almost entirely by Succession 2 with a small inlier of Succession 1 in the extreme southwest. The northeastern part of Southwest Pearya is separated from the Mitchell Point Belt by the Mitchell Point Fault or Fault Zone. The southwestern part is separated from the surrounding Danish River Formation by high-angle faults of variable trend. The structural trends within the belt also are diverse. Westerly, southwesterly, southerly and southeasterly directions all are represented.

Uplifted fault blocks with a concentric internal structure are present in two areas. A north-trending uplift on eastern Wootton Peninsula (*Yelverton Inlet*) is cored by map unit W1 (Neoproterozoic, pre-Varanger). This unit is surrounded on three sides by map unit W2 (in part Neoproterozoic, Varanger), which in turn is surrounded by map unit W3 (Lower Cambrian?). The northern flank of the uplift is concealed by overburden and Yelverton Bay. The eastern flank is characterized by east-directed, imbricate thrust faults. The easternmost fault thrusts map unit W3 on the Upper Cretaceous Hansen Point volcanics, which demonstrates that these faults were active during the Eurekan Orogeny.

A rectangular uplift occurs at the southwestern end of Southwest Pearya, east of Imina Inlet (*Cape Stallworthy-Bukken Fiord*). There a small block of granitoid gneiss of Succession 1 is surrounded by mixed metasediments of Succession 2 (map unit cqps), which in turn are bordered on two sides by marble of Succession 2 (map unit c). All contacts are faulted.

Kulutingwak and Audhild Bay inliers

All three inliers are underlain by lithological units of Succession 2 (Appendix 2) and surrounded by Paleozoic strata. The Kulutingwak Inlier is a south-verging thrust sheet on the northwestern flank of the Kulutingwak Anticlinorium (*Yelverton Inlet*). The two Audhild Bay inliers are bounded by steeply dipping faults of unknown vergence (*Cape Stallworthy-Bukken Fiord*).

Age of deformation

Three orogenies and three disturbances are recognized in the stratigraphic-structural record of Pearya, apart from the early Tertiary Eurekan Orogeny. The following remarks are restricted to timing. For an interpretation of these events, see Chapter 5.

Late Mesoproterozoic-early Neoproterozoic Grenvillian Orogeny

A Grenville-age orogeny, accompanied by extensive granitoid plutonism and metamorphism, is inferred from isotopic ages of ca. 1.1-1.0 Ga and 965 Ma.

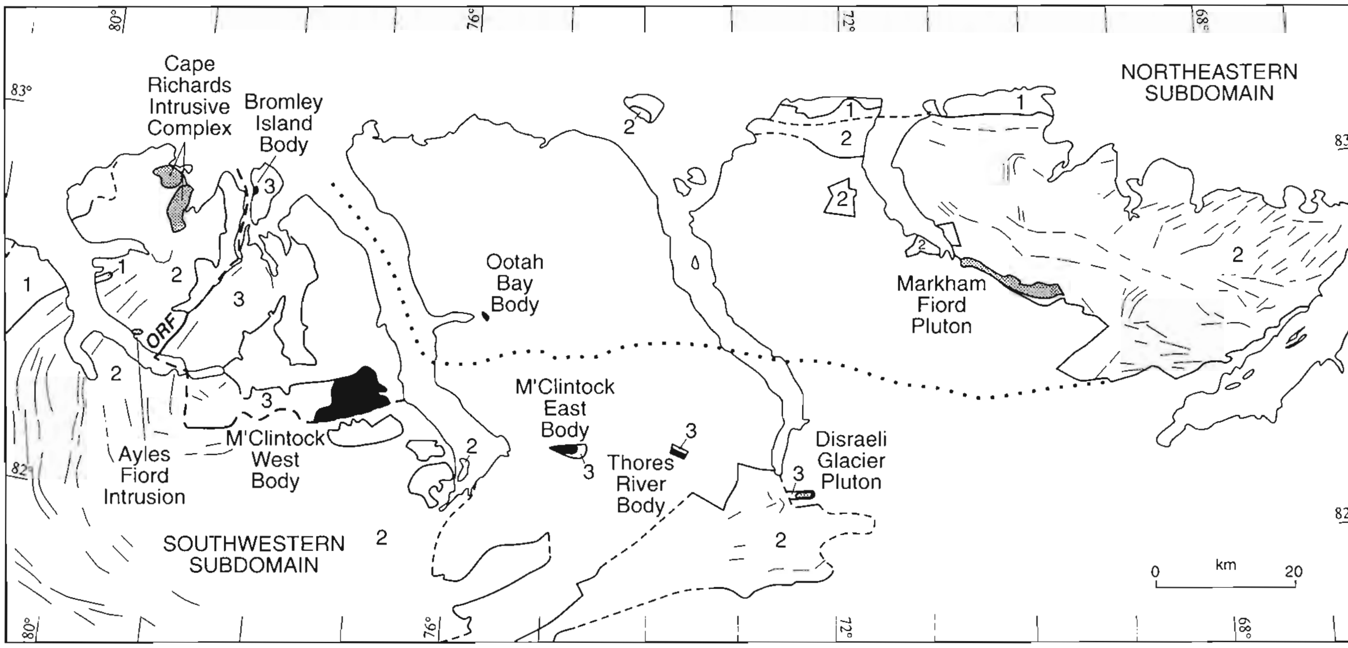
Early-Middle Ordovician M'Clintock Orogeny

A pre-Caradoc deformation, the M'Clintock Orogeny (Trettin, 1987b), is apparent from a high-angle unconformity at the base of Succession 4, that is exposed in the northwestern part of *M'Clintock Inlet*. The unconformity is best exposed north of the upper reaches of Ayles Fiord (Fig. 111), on the unnamed peninsula west of Maskell Inlet (Figs. 112, 157), and on Bromley Island (Fig. 157). It is underlain by intensely deformed strata of Succession 2 west of the Oakley River Fault and by similarly deformed strata of Succession 3 on Bromley Island, which lies east of the projected extension of the fault. In both areas it is overlain by sub-horizontal or gently tilted strata of the Cape Discovery Formation. On Bromley Island this formation also overlies a part of the Bromley Island body of the Thores Suite, which is in fault contact with surrounding strata of Succession 3.

The age of the deformation is bracketed by an Arenig zircon age of 481 +7/-6 Ma from the M'Clintock West body of the Thores Suite, and by fossils of early Caradoc age from Member A of the Cape Discovery Formation. The orogeny was accompanied by Barrovian metamorphism, which ranges up to lower amphibolite grade in exposures of Succession 2 south of the head of M'Clintock Inlet, and by the emplacement of granitoid intrusions that have provided more specific information on its age span. The syntectonic Ayles Fiord Intrusion has yielded a late Arenig monazite age of 475 ± 1 Ma, and the post-tectonic Cape Richards Intrusive Complex, a Llanvirn[1] sphene age of 463 ± 5 Ma.

The most important structure attributable to the M'Clintock Orogeny is the Oakley River Fault, which juxtaposes Successions 2 and 3 in the area between Maskell Inlet and Ayles Fiord (Fig. 158; *M'Clintock Inlet*). The present configuration shows that the fault originally was unconformably overlain by the Cape Discovery Formation but re-activated at a later time when the east side of the fault was elevated relative to the west side. The tight and complex folds in

[1]As mentioned previously, the age is earliest Llandeilo according to Tucker and McKerrow (1995).



LOWER ORDOVICIAN(?)

3 — *Succession 3: basalt, andesite, carbonate rocks, chert, etc. (variably metamorphosed)*

NEOPROTEROZOIC TO LOWER ORDOVICIAN

2 — *Succession 2: sedimentary and minor volcanic rocks (variably metamorphosed)*

LATE MESOPROTEROZOIC-EARLY NEOPROTEROZOIC

1 — *Succession 1: granitoid gneiss; minor schist, amphibolite, etc.*

INTRUSIONS

LOWER MIDDLE ORDOVICIAN

Granitoid intrusion

LOWER ORDOVICIAN

THORES SUITE: wehrlite, clinopyroxenite, gabbro; minor granitoid rocks

Major fault (interpreted as Lower-Middle Ordovician suture) . . . .

Generalized structural trends . . . .

***Figure 158**. Generalized map of the M'Clintock Orogen. The dotted line indicates the boundary between the two structural subdomains of Northeast Pearya. These subdomains comprise not only the M'Clintock Orogen, but also its unconformable cover (Successions 4 and 5). ORF: Oakley River Fault.*

Sucessions 2 and 3 also date back to the M'Clintock Orogeny because the Cape Discovery Formation is not folded in this area.

Although the unconformity is exposed only in a relative small area, differences in structural style and metamorphic grade between Successions 2 and 3 on the one hand, and Successions 4 and 5 on the other hand, indicate that all of Northeast Pearya was involved. This is confirmed by the presence of the Middle Ordovician Markham Fiord Pluton in the northeastern part of the domain, which has yielded a zircon age of 462 ± 11 Ma. However, it is uncertain whether Central and Southwest Pearya were involved because of the absence of Successions 3 to 5 and of dated Ordovician intrusions.

Late Ordovician-Early Silurian disturbances

Disturbances of Late Ordovician to Early Silurian age are apparent from low-angle unconformities and other stratigraphic relations, but folding or extensive thrust faulting are not apparent.

First disturbance (Ashgill)

An extensive disturbance is apparent from the unconformity at the base of the Harley Ridge Group (Succession 5A). Uplift was minimal west of M'Clintock Inlet where the Taconite River Formation overlies the Ayles Formation; moderate on Marvin Peninsula where it overlies the M'Clintock Formation; and pronounced at the head of M'Clintock Inlet where the Taconite River or Zebra Cliffs formations lie on metamorphic strata of Succession 2 (Figs. 120, 126). Succession 4, if deposited here, must have been removed by uplift and erosion prior to the deposition of the Taconite River Formation.

In order to date the metamorphism of Succession 2 in this area, muscovite from a schist west of the head of M'Clintock Inlet (*M'Clintock Inlet*, age determination locality in map unit sc) was analyzed by two different methods. Conventional K-Ar analysis yielded an apparent age of 452±5 Ma (Stevens et al., 1982) and ^{39}Ar–^{40}Ar analysis a disturbed release spectrum with a minimum age of 453 Ma (Trettin et al., 1992). Both dates are late Caradoc according to the adopted time scale. The M'Clintock Orogen was uplifted and deeply eroded before the deposition of the Cape Discovery Formation in the early Caradoc, and the schist was obtained from strata no more than a few hundred metres below the unconformity. These relations imply that the analyses do not date cooling after the thermal peak of the M'Clintock Orogeny, but after a later thermal event that may have been associated with early Caradoc rifting and volcanism represented by Member A of the Cape Discovery Formation, or with late Caradoc volcanism represented by the M'Clintock Formation.

Second disturbance (Ashgill)

A second, more limited disturbance, is apparent from a low-angle unconformity between the Zebra Cliffs and Lorimer Ridge formations that is exposed on Harley Ridge, east of the head of M'Clintock Inlet (Fig. 126). Uplift, erosion, and minor tilting in this area coincided approximately with pronounced subsidence farther northwest, where the graptolitic Ooblooyah Creek Formation was deposited. This subsidence may have been caused by co-eval normal faulting.

Third disturbance (Ashgill?–Llandovery)

The two deep-water basins that received the Cranstone Formation probably originated by graben faulting in latest Ordovician or early or middle Llandovery time – unfortunately, the lower part of the unit has not been dated. Further growth faulting probably occurred during the middle Llandovery, when several hundred metres (or more) of Cranstone sediments were deposited.

Late Silurian–Early Carboniferous Orogeny (Ellesmerian Orogeny and earlier events)

The geological history of Pearya was terminated by an orogeny indicated by an angular unconformity between Succession 5B and the Sverdrup Basin. The age of the event is bracketed by fossils of unspecified Late Silurian (late Ludlow or possibly Pridoli) and late Early Carboniferous (Viséan) ages (Mayr, 1992). The deformations included the first folding of Successions 4 and 5 and probably some refolding of Successions 2 and 3. The most important igneous event was the intrusion of the large Cape Woods Pluton, which has yielded an Eifelian U-Pb (sphene) age of 390±10 Ma.

CHAPTER 5

SUMMARY AND TECTONIC INTERPRETATION

CONTENTS

INTRODUCTION

The deformed Cambrian to Upper Devonian rocks of the Arctic Islands and North Greenland are assigned to the Franklinian mobile belt. Three first-order tectonic elements have previously been established in northern Ellesmere and Axel Heiberg islands (Trettin, 1991a; see Palinspastic restoration, Fig. 165). From southeast to northwest: (1) an unstable continental shelf, the Franklinian Shelf or Miogeosyncline (Thorsteinsson and Tozer, 1960), which is contiguous with the Arctic Platform, the relatively undisturbed cover of the Canadian Shield (Thorsteinsson and Tozer, 1970); (2) the Franklinian Deep Water Basin, earlier referred to as the Hazen Trough (Trettin, 1971); and (3) Pearya, a suspect terrane with Caledonian affinities. Some evidence suggested that Pearya was accreted to the Franklinian mobile belt in the latest Silurian.

The Deep Water Basin was divided into a southeastern subprovince composed exclusively of sedimentary rocks, and a northwestern subprovince composed of sedimentary and volcanic rocks. The Franklinian Shelf and the sedimentary subprovince of the Franklinian Deep Water Basin were traced from northeastern Greenland to Prince Patrick Island. In contrast, the volcanic subprovince was found to be restricted to northern Ellesmere and Axel Heiberg islands, and Pearya to northernmost Ellesmere Island.

Four fold belts were distinguished in the project area that correspond, to some extent, to the depositional provinces and subprovinces mentioned. The Central Ellesmere Fold Belt coincides largely with the Franklinian Shelf, and the Hazen Fold Belt with the sedimentary subprovince of the Deep Water Basin. A total correspondence is prohibited by the fact that the boundaries of the fold belts are fixed, whereas the shelf margin migrated southeast from late Early Cambrian to Early Devonian time. However, on Judge Daly Promontory, it was nearly stationary from Middle Cambrian to earliest Silurian time, and this position was chosen as the boundary between the two fold belts. This implies that the Central Ellesmere Fold Belt includes deep-water facies of Early Silurian to Early Devonian age in its northwestern part, and the Hazen Fold Belt shelf facies of Early Cambrian age in its southeastern part. The adopted boundary is meaningful because on Judge Daly Promontory the characteristic broad and open folds of the Central Ellesmere Fold Belt are controlled by thick and massive shelf carbonate units of late Early Cambrian to earliest Silurian age (Fig. 1a; *Lady Franklin Bay*). In contrast, complex and tight minor folds are characteristic of the Hazen Fold Belt (cf. Trettin, 1994, Chapter 2).

The strata of the northwestern sedimentary and volcanic subprovince of the Deep Water Basin were assigned to the Clements Markham Fold Belt in Ellesmere Island and to the Northern Heiberg Fold Belt in Axel Heiberg Island. These two belts differ in structural trend and in mid-Early Silurian to Devonian stratigraphy.

Fieldwork since 1988 has resulted in some revisions that concern primarily the Clements Markham Fold Belt and its relation with Pearya (cf. Klaper, 1992a, b). The Clements Markham Fold Belt no longer is regarded as simply a part of the sedimentary and volcanic subprovince of the Franklinian Deep Water Basin, but as a heterogenous and problematic entity. The strata of this fold belt are now assigned to two major successions, A and B, that predate or postdate, respectively, the onset of widespread flysch sedimentation in the latest Llandovery. Succession A consists of five separate belts that differ in age range and stratigraphy. The Southeastern belt is stratigraphically linked with the Northern Heiberg and Hazen fold belts and indirectly with the Franklinian Shelf. The stratigraphic and tectonic relations of the other belts, which include volcanics of Ordovician and Early Silurian age, are uncertain. It is possible that the Northwestern, West-central and Northeastern belts are related to Pearya, or that they represent a separate plate.

The basal unit of Succession B overlaps Succession A, as well as adjacent parts of Pearya and the entire Hazen Fold Belt. These relations suggest that the accretion of Pearya predates the latest Llandovery. Although Pearya ceased to be an allochthonous terrane at that time, it retained a stratigraphic identity in its northern part until the end of the record in the Late Silurian.

Major phases of geological history and organization of chapter

In the report area, three geological regions with uncertain stratigraphic, tectonic, and paleogeographic relations are recognized. They comprise (1) the Northern Heiberg Fold Belt and the southeastern part of the Clements Markham Fold Belt, (2) the central and northern parts of the Clements Markham Fold Belt, and (3) Pearya. The accretion of Pearya produced a unified depositional framework that persisted from mid-Early to Late Silurian time, to become obliterated during a Late Silurian to Early Carboniferous orogenic interval that probably had two major phases.

The organization of the chapter reflects this series of events. The first sections summarize the geological records, until mid-Early Silurian time, of the three regions mentioned. The next section discusses the accretion of Pearya to the Franklinian mobile belt, including evidence (suggestive but not conclusive) for the allochthoneity of the terrane, possible source areas, and, assuming that it is allochthonous, the time and mode of its accretion. This is followed by a summary of the depositional pattern that existed within the entire report area from mid-Early to Late Silurian time. The stratigraphic, intrusive, and structural record of the Late Silurian to early Carboniferous orogenic interval is summarized in the next section. In the final section, some plate-tectonic aspects of the mid-Early Silurian to Early Devonian events in the Northern Heiberg Fold Belt are discussed. A more comprehensive interpretation is not feasible because of insufficient information.

GEOLOGICAL RECORD OF NORTHERN HEIBERG FOLD BELT AND SOUTHEASTERN CLEMENTS MARKHAM FOLD BELT UNTIL MID-EARLY SILURIAN TIME

Introduction

The Northern Heiberg Fold Belt (*Cape Stallworthy–Bukken Fiord*) and the southeastern Clements Markham Fold Belt (*Cape Stallworthy–Bukken Fiord, Otto Fiord* and *M'Clintock Inlet*) have a similar Early Cambrian (or older) to mid-Early Silurian stratigraphy. No compressive deformation is apparent. Three units, or groups of units, are distinguished that represent major phases in the tectonic and depositional development of this region. They are (1) Early Cambrian or older volcanic and sedimentary units, (2) Lower Cambrian deep-water clastic sediments, and (3) Lower Cambrian to Lower Silurian condensed deep-water sediments.

Early Cambrian or older volcanic and sedimentary units: Jaeger Lake, Aurland Fiord, and Yelverton formations

The Jaeger Lake, Aurland Fiord, and Yelverton formations have not been dated but are considered to be Early Cambrian or older in age because they are thrust over the Grant Land Formation. The Jaeger Lake Formation of the Northern Heiberg Fold Belt and the Yelverton Formation of the Clements Markham Fold Belt both consist of interbedded volcanics and carbonates, with minor mudrock and chert in the latter. The Jaeger Lake Formation is more than 425 m, and the Yelverton Formation probably more than 1 km thick. The carbonates contain features indicative of shelf to peritidal deposition, such as oncoids in the Yelverton Formation, and stromatolites in the Jaeger Lake Formation. The volcanics are highly altered, or metamorphosed in the greenschist facies. Trace element analyses place both units in the fields of basaltic andesite and subalkaline basalt, and major element analyses suggest a tholeiitic composition for the Yelverton Formation. The tectonic origin of these rocks is not clear from their chemical composition. However, analogy with volcanics or dykes of late Neoproterozoic age in the Cordillera (Gabrielse and Campbell, 1992; Souther, 1992), eastern Alaska (Young, 1982), and Melville Island (Heaman et al., 1992), and Newfoundland (Greenough and Papezik, 1986; Williams et al., 1985), and with Lower Cambrian volcanics in northern Alaska (Moore, 1987) suggests that the Jaeger Lake and Yelverton formations resulted from intra-plate extension during the rift or early drift stages in the development of the Franklinian continental margin. The presence of shallow-water carbonates and absence of other members of the ophiolite suite such as radiolarian chert, sheeted dykes and ultramafic rocks, argue against a mid-ocean ridge origin.

The Aurland Fiord Formation of Axel Heiberg Island, more than 600 m in thickness, consists of shallow-marine dolostone and dolomitic limestone with minor amounts of phyllite and chert. The unit is not in contact with the Jaeger Lake Formation and it is unknown whether it is older or younger. If older, it probably represents a unit of the Franklinian Shelf; if younger, a carbonate platform developed on the Jaeger Lake volcanic edifice. In the correlation chart (Fig. 2) it is assumed that the unit underlies the Grant Land Formation and is correlative with the Lower Cambrian Nesmith beds of the Hazen Fold Belt.

Lower Cambrian deep-water clastic sediments: Grant Land Formation

The Grant Land Formation is known mainly from stratigraphic sections in the southwestern part of the Grantland Uplift of the Hazen Fold Belt (Trettin, 1994, p. 80–97). There it consists of about 1.5 km (or more) of variably feldspathic quartzite, varicoloured slate or phyllite, and small proportions of intraformational conglomerate and fine pebble conglomerate. The formation was derived from cratonic sources and deposited in submarine canyon and fan environments. Overlying the Nesmith beds, resedimented carbonates of Early Cambrian age, it represents the deep-water equivalent of the predominantly shallow-marine Ellesmere Group of the Central Ellesmere Fold Belt and is equivalent to the Polkorridoren Group of North Greenland.

In the Northern Heiberg Fold Belt and southeastern part of the Clements Markham Fold Belt, the Grant Land Formation consists of quartzite and varicoloured phyllite. The thickness of the formation is unknown because of its structural complexity.

Lower Cambrian to Lower Silurian condensed deep-water sediments: Hazen Formation

In the Hazen Fold Belt, the Hazen Formation overlies the Grant Land Formation and ranges in age from late Early Cambrian to early late Llandovery (Trettin, 1994, p. 97–114). About 240 m thick in the Bent Glacier section northwest of Tanquary Fiord (*Tanquary Fiord*), it is a highly condensed unit that represents a prolonged starved-basin phase in the development of the Deep Water Basin. A diachronous contact that ascends in age from northwest to southeast separates a carbonate-rich lower member from a chert-rich upper member.

In the Northern Heiberg Fold Belt and in the southeastern part of the Clements Markham Fold Belt, the Hazen Formation also overlies the Grant Land Formation, but its stratigraphy is poorly known because of structural complexities and poor exposure. In Axel Heiberg Island, the carbonate member is represented by about 60 m of lime mudstone with relic radiolarians and by carbonate pebble and cobble conglomerate. In the southeastern belt of the Clements Markham Fold Belt, carbonate sediments have been largely replaced by chert, but calcareous pebble conglomerate and calcarenite are locally preserved. Radiolarian chert is common in both areas.

In the Hazen Fold Belt, derivation of carbonates from the Franklinian Shelf is apparent from a marked southeastward increase both in the size grade and proportion of these sediments. The fact that carbonate clasts and associated detrital quartz in the southeastern Clements Markham Fold Belt are coarser grained than in the northwestern Hazen Fold Belt suggests a different source, possibly to the northwest.

Lower Silurian shelf carbonates or olistoliths: Yelverton Pass beds

The Yelverton Pass beds consist of an estimated 100 to 200 m of lime wackestone and skeletal conglomerate with conodonts and corals of early late Llandovery age. Chertified equivalents of the limestone overlie the Hazen Formation with an abrupt contact that either represents an unconformity or a low-angle fault, presumably a listric normal fault. If the second alternative is true, the beds probably represent two or more olistoliths derived from shallow-marine carbonates associated with volcanic edifices farther northwest (see below, map unit OSv).

GEOLOGICAL RECORD OF THE REMAINING PARTS OF THE CLEMENTS MARKHAM FOLD BELT UNTIL MID-EARLY SILURIAN TIME

Introduction

In the remaining four belts of Succession A, the record is restricted to strata of Ordovician and Early Silurian age. The stratigraphy varies from one belt to another, but the following generalizations can be made:

1. All belts contain volcanics, which are absent from strata of this age in the Southeastern belt of Succession A and in the Northern Heiberg Fold Belt. The volcanics decrease in age from Caradoc in the Northwestern and Northeastern belts through early Llandovery and(?) older in the West-Central belt, to early late Llandovery in the Southwestern belt. Their compositions range from felsic to mafic and are partly alkalic. The subalkaline rocks in the Northwestern, West-central, and Northeastern belts, mainly andesite and dacite, may represent an arc regime, but the rocks are too highly altered for confident interpretation of the tectonic environment. The alkaline rocks, trachyandesite or alkali basalt, indicate a weakly extensional tectonic regime.

2. Shallow-marine carbonates are associated with the volcanics in the Northwestern, West-central, and Northeastern belts, and carbonate olistoliths are common in the Southwestern belt at Fire Bay.

3. Deep-water clastic sediments are present in the Northwestern and Southwestern belts. They range

in size grade from mudrock to boulder conglomerate and were derived from a variety of sources, including volcanics, serpentinite, and (?)Succession 2 of Pearya.

4. Radiolarian chert is common in the Southwestern belt and present in minor amounts in the Northeastern belt.

Southwestern belt

Three different units are represented at Fire Bay on the south side of Emma Fiord (*Cape Stallworthy-Bukken Fiord*), the key area for the Southwestern Belt.

Ordovician-Lower Silurian(?) radiolarian chert: Hazen Formation

The Hazen Formation is represented by dark grey radiolarian chert of unknown thickness that has yielded graptolites of late Arenig-early Llandeilo and Caradoc ages. The lower part of the formation is concealed and the top is covered.

Carbonate olistoliths

Carbonate olistoliths with conodonts and gastropods of late Arenig-early Llanvirn (Whiterockian) age occur both in the upper Hazen Formation and in the lower Fire Bay Formation. The distribution of the olistoliths indicates derivation from northwesterly sources; their association with the Fire Bay Formation, emplacement in late Llandovery time.

Lower Silurian deep-water clastic sediments and volcanics: Fire Bay Formation

The Hazen Formation is abruptly overlain by the Fire Bay Formation, which is probably between 500 and 600 m thick and divisible into three members (Fig. 31). Member A, probably about 250 m thick, consists chiefly of sandstone, mudrock, and conglomerate that were derived from predominantly volcanic sources to the northwest and deposited in a deep-water setting by sediment gravity flows. Member B, probably between 200 and 300 m thick, is composed of volcanic flows and tuffs that range in composition from felsic to mafic and include a fairly abundant alkaline suite of trachyandesite and alkali basalt. Member C consists of dark grey graptolitic mudrock, probably tens of metres in thickness. The age of the formation, based on graptolites from Member A and from the Danish River Formation, is early late Llandovery.

West-central belt

Lower Silurian and(?) Ordovician volcanics and minor limestone: map unit **Osv**

Volcanic rocks, enclosed by two branches of the Emma Fiord Fault Zone in an area south-southeast of Kulutingwak Fiord (*Yelverton Inlet* and *Otto Fiord*), consist mainly of flows and tuffs of trachyandesite and andesite. At one locality the volcanics are overlain by a crinoidal packstone that has yielded conodonts of probable early to middle Llandovery age.

Northwestern belt

Two formations are distinguished in the Kulutingwak Anticlinorium (*Yelverton Inlet*, inset), the key area for this belt.

Ordovician (Caradoc-Ashgill) sedimentary and volcanic rocks: Kulutingwak Formation

The Kulutingwak Formation consists of an estimated 300 to 400 m of sedimentary and volcanic rocks, assigned to two members. Member A, probably more than 100 m thick, is made up of tuffaceous phyllite, volcanogenic sandstone, flows of alkali basalt, andesite, and dacite, and thin units of marble. Its base is not exposed. A volcanic rock yielded a U-Pb (zircon) age of 449.7 +3.5/-9 Ma, approximately on the Caradoc-Ashgill boundary according to the adopted time scale (Fig. 2).[1] Member B consists of 200 to 300 m of marble. It has yielded conodonts of unspecified Caradoc-Ashgill age and is probably Ashgill in age.

Early Silurian or older sedimentary serpentinite and polymict conglomerate: Phillips Inlet Formation

The Phillips Inlet Formation occurs as four fault slices within, or at the top of, Member A of the Kulutingwak Formation and is divisible into two members, A and B.

[1]The age is Caradoc according to Tucker and McKerrow (1995).

Member A comprises about 300 m of sandstone, siltstone, and pebble to boulder conglomerate composed mainly of fragmental serpentinite with lesser amounts of carbonate grains in some beds. The strata are mostly massive but some laminae, crossbeds, and normal or reversely graded beds are present. Member B consists of massive pebble to boulder conglomerate, metres in thickness, made up of sedimentary and volcanic rock fragments. Both members were probably deposited by sediment gravity flows in a deep-water environment. Member A was probably derived from altered oceanic crust or mantle, or from an island arc plutonic complex, such as the Lower Ordovician Thores Suite of Pearya. The clasts of Member B are reminiscent of rock types in Succession 2 of Pearya. The age of the formation is uncertain. It is tentatively correlated with Member A of the Fire Bay Formation, which contains trace amounts of detrital serpentinite and chromite, but an Ordovician age is not ruled out because ultramafic detritus also occurs in Caradoc and Ashgill strata of Pearya (Cape Discovery Formation, Member A and Taconite River Formation; see Chapter 4).

Northeastern belt

Ordovician (Caradoc and (?)younger) volcanic and minor sedimentary rocks: Mount Rawlinson Complex

The Mount Rawlinson Complex comprises volcanic and minor sedimentary rocks exposed in two, structurally aligned belts of nunataks. Nunataks northwest of Clements Markham Inlet (*Clements Markham Inlet-Robeson Channel*) are composed of probably more than 1 km of volcanic rocks, including trachyandesite, andesite, and dacite, and interbedded marble and chert. A volcanic flow rock from the lower or middle part of the complex has yielded a Caradoc U-Pb (zircon) age of 454 +9.7/-4.6 Ma, but younger rocks may be present in the upper part. Nunataks in Disraeli Glacier (*M'Clintock Inlet*) consist of altered tuff and radiolarian chert of unknown thickness and age.

GEOLOGICAL RECORD OF PEARYA UNTIL MID-EARLY SILURIAN TIME

Introduction

This geological province is structurally divisible into three, major, fault-bounded domains, Northeast, Central, and Southwest Pearya, and some minor inliers. Stratigraphically it is divisible into five successions that extend in age from Mesoproterozoic to Late Silurian.

Late Mesoproterozoic–Early Neoproterozoic crystalline basement: Succession 1

The crystalline basement of Pearya (Figs. 1a, b, 83) consists mainly of gneiss with lesser proportions of amphibolite and schist and small amounts of quartzite and marble. It was formed by granitoid intrusion and metamorphism mainly between 1.0 and 1.1 Ga. A second phase of granitoid intrusion occurred at ca. 965 Ma.

Neoproterozoic–Lower Ordovician metasedimentary and metavolcanic strata: Succession 2

Succession 2 consists mainly of shallow-marine sediments such as limestone, dolostone, quartzite, and mudrock, with lesser amounts of volcanics, diamictite, and chert, that have all been metamorphosed under lower greenschist to lower amphibolite facies conditions. The contacts with Succession 1 are concealed, faulted, or sheared, but the absence of Proterozoic granitoid intrusions suggests a major unconformity. The succession probably represents a cratonic basin or miogeocline that formed during a major period of subsidence between orogenies in late Mesoproterozoic–early Neoproterozoic and Early to early Middle Ordovician times.

The stratigraphy of this succession is poorly known because of its complex structure and the scarcity of fossils and radiometric age determinations. However, stratigraphic successions have been established in some areas, and three marker units have been identified that permit tentative lithological correlations and age assignments (Table 15):

1. A diamictite occurs in all major outcrop belts of Succession 2. The rock is generally massive and characterized by unsorted pebbles or cobbles, commonly of carbonates, in a matrix of greywacke and mudrock (Figs. 94–96). Typical exposures on Arthur Laing Peninsula (*Clements Markham Inlet-Robeson Channel*) are probably more than 200 m thick (Gypsum River diamictite). These rocks are closely comparable to glaciogenic diamictites in the Canadian Cordillera and in the Caledonides, especially Svalbard, which are late

Neoproterozoic in age. They are assigned to the Varanger Series of the Vendian System by Harland et al. (1993), considered to be approximately 610±10 to 590 ±20 Ma old.

2. Above the diamictite, but separated from it by a recessive clastic unit, occurs a widespread, cliff-forming carbonate marker. Typical exposures on Arthur Laing Peninsula have a minimum thickness of 300 m (Mount Hornby carbonates). The stratigraphic position of the carbonates, combined with an occurrence of Phanerozoic sponge spicules, suggests an Early Cambrian age.

3. A unit of phyllite and schist with minor carbonates and volcanics, exposed in the Milne Fiord–Ayles Fiord region (*Yelverton Inlet* and *M'Clintock Inlet*, map unit M4), is probably close to the top of Succession 2. A rhyolite in the uppermost part of the unit (Fig. 102) has yielded a U-Pb (zircon) age of 503 +8/-2 Ma, early Tremadoc according to current time scales.[1]

Using these markers, the total of 22 preliminary stratigraphic units identified in widely scattered, relatively small areas, can be can be reduced to 13 loosely defined units. In addition there are numerous lithological units of uncertain stratigraphic position.

Two major volcanic units are present. Flows, tuff, and volcanogenic clastic sediments of felsic composition are exposed on Arthur Laing Peninsula (*Clements Markham Inlet–Robeson Channel*, map unit L1). These rocks occur stratigraphically not far below the diamictite and probably are also late Neoproterozoic in age. Their tectonic significance is uncertain. Mafic volcanics are present within a complex metasedimentary unit at Ayles Fiord (*M'Clintock Inlet*, map units M2 and M2v), which is assumed to be probably Cambrian or earliest Ordovician in age. Chemical analyses suggest an extensional origin for the mafic rocks.

Lower(?) Ordovician volcanic and sedimentary rocks: Succession 3 (Maskell Inlet Complex)

Sucession 3, which is identical to the Maskell Inlet Complex, is composed of hundreds of metres (or more) of volcanic and sedimentary rocks that are intensely deformed and partly metamorphosed. The volcanics consist mainly of tuffs and flows of calc-alkaline andesite and basalt. The sediments comprise carbonates, radiolarian chert, and minor phyllite and sandstone. The complex is in fault contact with Succession 2 and with plutonic rocks of the Thores Suite, and its base is not exposed. It is unconformably overlain by Caradoc strata of Succession 4. Neither fossils nor age determinations have been obtained from the Maskell Inlet Complex, but it is tentatively correlated with the Lower Ordovician (Arenig) Thores Suite, which is interpreted as a subarc plutonic complex (see below). The lithology of the Maskell Inlet volcanics strongly suggests an arc origin, but does not indicate whether it originated on continental or oceanic crust. Its association with the ensimatic Thores Suite (see below) supports the second alternative.

Lower Ordovician ultramafic to granitoid rocks: Thores Suite

The Thores Suite consists of serpentinite, wehrlite, clinopyroxenite, and gabbro with minor granitoid differentiates that range in composition from diorite to leucocratic granite. The suite occurs as five separate bodies – the M'Clintock West, M'Clintock East, Thores River, Bromley Island, and Ootah Bay bodies – four of which are in fault contact with the Maskell Inlet Complex (Fig. 158; *M'Clintock Inlet*). Lithological similarities with ultramafic to granitoid suites in Alaska and California (cf. Irvine, 1974; Snoke et al., 1982; Burns, 1985; Beard, 1986) suggest that it represents an ensimatic subarc plutonic complex. A granitoid differentiate of the M'Clintock West body has yielded an Arenig U-Pb (zircon) age of 481 +7/-6 Ma (Trettin et al., 1982).

Early–Middle Ordovician M'Clintock Orogeny and related intrusions

An Early to early Middle Ordovician deformation, the M'Clintock Orogeny (Trettin et al., 1982), is evident from a high-angle unconformity exposed in the northwestern part of the *M'Clintock Inlet* map area. The unconformity is underlain, in different areas, by Successions 2 or 3 or the Thores Suite, and is overlain mainly by the basal conglomerate of Succession 4, assigned to Member A of the Cape Discovery Formation (Figs. 111, 112). The age of the event is bracketed by the Arenig radiometric age of the Thores

[1]The age is Late Cambrian according to Tucker and McKerrow (1995).

Suite and by early Caradoc fossils from the Cape Discovery Formation. The orogeny was accompanied by Barrovian metamorphism of greenschist and amphibolite grade and granitoid plutonism. The syntectonic Ayles Fiord Intrusion has yielded an Arenig monazite age of 475 ± 1 Ma, and the post-tectonic Cape Richards Intrusive Complex a Llanvirn sphene age of 463 ± 5 Ma.[1]

The unconformity is concealed in other parts of Northeast Pearya, but differences in structural style and metamorphic grade between rocks of Successions 2 and 3 on the one hand, and Successions 4 and 5 on the other hand, suggest that these areas also were affected. This conclusion is confirmed by the presence of the extensive Markham Fiord Pluton, which has a U-Pb zircon age of 462 ± 11 Ma, in the northeastern part of Northeast Pearya (Fig. 158; *Clements Markham Inlet–Robeson Channel*). Because of the absence of Successions 3 to 5 and of Ordovician granitoid intrusions, it is uncertain whether or not Central and Southwest Pearya were affected.

The following tectonic interpretation of the orogeny is based on the present distribution of Successions 1, 2, and 3 and the Thores Suite (Fig. 158). Succession 3 is interpreted as a volcanic arc, and the Thores Suite as the related subarc plutonic complex as mentioned above. The chemistry of the volcanics does not indicate whether the arc was built on continental or oceanic crust, but the composition of the Thores Suite implies an oceanic origin, as mentioned. The inferred island arc is flanked on two sides by continental fragments composed of a granitoid crystalline basement (Succession 1) and a predominantly shallow-marine cover (Succession 2). The western and southern boundary of the island arc consists of a series of southerly and westerly trending faults, including the Oakley River Fault, interpreted as a suture. The concealed eastern and northern limit of the island arc is probably also a suture. This setting suggests a Wilson-cycle that involved the breakup and re-unification of a cratonic province of limited extent that was characterized by a Grenville-age crystalline basement and a Neoproterozoic to Lower Ordovician supracrustal succession.

The rift or drift stages of the inferred tectonic cycle are represented only by tholeiitic volcanics of Succession 2 (map units M2 and M2v) that are assumed to be Cambrian or possibly earliest Ordovician in age. The subduction stage is represented by the Maskell Inlet Complex and the Thores Suite, which has yielded an Arenig U-Pb age. The subduction was followed by collisions on both margins during late Arenig to Llanvirn time. The bewildering variety of structural trends in Successions 2 and 3 suggests a complex pattern of collision that was probably caused by the nonlinear shape of the colliding plate margins.

Any structural interpretation of the M'Clintock Orogen must acccount for the arcuate trend of the folds and faults in the southwestern domain of Northeast Pearya. Although orogenic belts are normally only slightly sinuous, high-angle bends are not uncommon. They have been attributed to a variety of processes or factors, including:

1. Lateral variations in the magnitude of stress along strike.
2. Interaction or superposition of stresses with different directions.
3. Indentation of a straight continental margin by collision with a continental block of smaller width.
4. Horizontal ('oroclinal') bending of originally straight mountain fronts during plate rotations, caused by horizontal variations in the rate of seafloor spreading.
5. The influence of re-entrants on the rifted margins, which, in turn, may be controlled by basement structures.

It is important to note that in the M'Clintock Inlet area, arcuate trends are also displayed by Mesoproterozoic to Upper Silurian rocks younger than the orogeny itself. This permits two interpretations:

a. The arcuate trends date back to the M'Clintock Orogeny or earlier events and have been reactivated during later deformations.
b. They postdate Succession 5; i.e., originated during the Late Silurian–Early Carboniferous deformation discussed below or during the Eurekan Orogeny.

In the absence of detailed structural information, explanations of the arcuate trend can only be tentative. The first published synthesis of Pearya proposed oroclinal bending in latest Silurian–Early Devonian time (options 4 and a, above), caused by differential

[1]The age is Llandeilo according to Tucker and McKerrow (1995).

motions during transpressive accretion, and subsequent northwest-southeast compression during the Ellesmerian Orogeny (options 2 and b; Trettin, 1987b, 1991c).

The present re-appraisal focuses on the sharp, right-angle turn on the inside of the arcuate belt, displayed by an anticlinorium in Succession 2 south of the head of Ayles Fiord (*M'Clintock Inlet*, map unit M1). If this bend were caused by horizontal bending, then it should be the focal point of outward-radiating, triangular grabens, but this is not the case. On the other hand, the fact that the bend is sharp on the inside, near the inferred Ordovician suture, but rounded on the outside, suggests that it reflects a re-entrant on an older plate margin (options 5 and a, above). However, it is likely that a younger, northwest-southeast-directed compression deformed an originally rectangular trend into a trend that resembles a very open and somewhat rounded letter V. Such compression is evident from numerous southeast-verging thrust faults on the northwestern flank of the arcuate belt, between the lower reaches of Ayles Fiord and Maskell Inlet (*M'Clintock Inlet*).

Highly diverse structural trends are apparent in the Northeastern domain of the M'Clintock Orogen on Arthur Laing Peninsula (*Clements Markham Inlet–Robeson Channel*). An older set with a predominantly southwesterly trend is probably no older than Cambrian because it affects units of inferred Cambrian age. It is truncated by a southeasterly trending younger set parallel to the Markham Fiord Pluton and therefore probably no younger than Llanvirn or Llandeilo. Both major sets, as well intermediate or curved trends that also are present, may represent changing stress orientations during different phases of the same collisional event.

Middle–Upper Ordovician sedimentary and volcanic units: Succession 4 (Egingwah Group)

Succession 4 is identical to the Egingwah Group, which includes three conformable formations, each of which is more than 1 km thick. In upward order, they are the Cape Discovery, M'Clintock, and Ayles formations.

Caradoc clastic and carbonate sediments and minor volcanics: Cape Discovery Formation

The Cape Discovery Formation, about 1 km thick, is divisible into three members (Figs. 109, 110). Member A comprises (1) a nonmarine basal conglomerate that was derived from Successions 2 and 3 and the Thores Suite; (2) calcareous sandstone and mudrock of shallow-marine origin; and (3) felsic and alkaline volcanics indicative of a weakly extensional tectonic regime. Member B is composed of shelf carbonates, and Member C of impure reddish limestones that are of peritidal aspect. Member D consists mainly of sandy sediments derived from felsic volcanics and also includes minor amounts of felsic volcanics and dolostone. Members A and B have yielded fossils of early and middle Caradoc ages. The unfossiliferous Members C and D are assumed to be Caradoc in age.

Caradoc–Ashgill volcanic and minor sedimentary rocks: M'Clintock Formation

The M'Clintock Formation consists of more than 1 km of volcanic flows and tuffs with minor amounts of volcanogenic clastic sediments and limestone. The volcanics are intermediate to mafic and partly alkaline in composition. The preponderance of calc-alkaline andesite suggests an arc origin. The base of the formation is tentatively placed into the Caradoc. Corals from the uppermost strata are Ashgill (Richmondian) in age.

Ashgill dolostone: Ayles Formation

The Ayles Formation is composed of 1.1 to 1.3 km of dolostone and minor limestone with a benthonic fauna of Ashgill age. Nearly devoid of siliciclastic impurities, it represents a carbonate platform that was deposited on the rapidly subsiding, inactive volcanic edifice of the M'Clintock Formation.

Late Ordovician disturbance and associated sedimentary units: Succession 5A (Harley Ridge Group)

Succession 5A, which is identical to the Harley Ridge Group, comprises siliciclastic and carbonate sediments of Late Ordovician (Ashgill) age assigned to the Taconite River and Zebra Cliffs formations (Fig. 118). A regional unconformity at the base of the group indicates a first disturbance within the Late Ordovician. The Taconite River Formation disconformably overlies the Ayles or M'Clintock formations west or east of M'Clintock Inlet, respectively. West of the head of M'Clintock Inlet it lies on Succession 2 with a high-angle unformity (Fig. 120). Succession 4, which normally overlies this unconformity, probably was removed by uplift and erosion earlier during the Ashgill. The Zebra Cliffs Formation generally overlies the Taconite River Formation with a conformable contact but oversteps it east of the head of the inlet to lie unconformably on Succession 2 (Fig. 126).

Ashgill clastic and minor carbonate sediments: Taconite River Formation

The Taconite River Formation is composed mainly of interbedded sandstone and mudrock with minor amounts of limestone and pebble to boulder conglomerate. Exposures range in thickness from tens of metres to more than 600 m. The clastic sediments, which include many redbeds, represent nonmarine to predominantly shallow-marine environments. The limestones contain a benthonic fauna of Late Ordovician age.

Ashgill carbonate and minor clastic sediments: Zebra Cliffs Formation

The Zebra Cliffs Formation ranges in thickness from about 300 m to probably more than 1 km, and is divisible into four members, A to D (in order upward). It consists mainly (Members A and C) of limestone and minor dolostone that were deposited in subtidal shelf environments and contain an abundant and diverse benthonic fauna of Ashgill age. Red-weathering clastic sediments in the lower middle part (Member B) indicate a brief regression. Limestones in the uppermost part (Member D) are of outer shelf-upper slope origin.

Late Ordovician–Early Silurian facies belts and further disturbances: lower part of Succession 5B

Succession 5B comprises siliciclastic and carbonate sediments lying between the Zebra Cliffs Formation and the Sverdrup Basin that show complex facies relations (Fig. 118) and reflect continuing tectonism. Reconstructions, however, are difficult because of outcrop limitations, faulted contacts, and insufficient fossil control or biostratigraphic resolution. It has been impossible, for example, to distinguish the ages of four different generations of stratigraphic units (assigned variously to Successions 4, 5A, or 5B) all of which have yielded fossils of Ashgill age. Two different configurations appear to have existed in Late Ordovician time and from latest Ordovician to early Ludlow time, respectively.

Late Ordovician facies belts and tectonism

Two major facies are recognized from the later part of the Late Ordovician (Ashgill, Richmondian). They are represented by the shallow-marine Lorimer Ridge Formation and the deep-marine Ooblooyah Creek Formation, which overlie the Zebra Cliffs Formation in different areas (Fig. 133).

Ashgill shallow-marine clastic and carbonate sediments: Lorimer Ridge Formation

The Lorimer Ridge Formation lies between the Zebra Cliffs Formation and the Marvin or Cranstone formations. It is composed mainly of variegated sandstone and mudrock with small amounts of limestone and rare conglomerate, and is 813 m thick in the type section on Lorimer Ridge. The formation was deposited in intertidal to subtidal shelf environments, and an eastward increase in the proportion of clastic sediments and red strata indicates a shoreline in that direction. The limestones contain a benthonic fauna of Ashgill age.

Ashgill deep-marine carbonate and clastic sediments: Ooblooyah Creek Formation

The Ooblooyah Creek Formation probably overlies the Zebra Cliffs Formation stratigraphically, but the contacts are faulted or concealed. It contains roughly 400 m of dark grey mudrock and resedimented impure lime mudstone and calcarenite. The unit was deposited in slope or basinal environments and contains graptolites of Late Ordovician age.

Tectonism

The Lorimer Ridge Formation overlies the Zebra Cliffs Formation with a low-angle unconformity on Harley Ridge, east of the head of M'Clintock Inlet (Fig. 126); elsewhere the contact is concealed. The unconformity indicates a short-lived, weak uplift and minor tilting that may have been of local extent. The subsidence of the northwestern part of the area may be due to simultaneous normal faulting.

Latest Ordovician–early late Llandovery facies belts and tectonism

The northwestern deep-water belt probably persisted from Late Ordovician to early Ludlow time, but its stratigraphic record is limited to the Late Ordovician Ooblooyah Creek Formation discussed above, and fault slices of the Danish River and Lands Lokk formations considered later in this chapter (Mid-Early to Late Silurian depositional pattern). Two additional deep-water belts developed in the previously shallow-marine area represented by the Lorimer Ridge Formation. The record of these belts is limited to outcrops of the flyschoid Cranstone Formation. Two outcrop belts of shallow-marine carbonates, assigned to the Marvin Formation, lie between the three deep water belts (Fig. 137).

Middle Llandovery and(?) older deep-water clastic sediments: Cranstone Formation

The Cranstone Formation occurs in two main outcrop belts east and west of the lower reaches of Disraeli Glacier, and possibly also in a fault block east of Markham Fiord. The contact with the underlying Lorimer Ridge Formation is concealed and the top of the formation is not preserved. In the fault-bounded outcrop area west of Disraeli Glacier, which includes the type section, it comprises more than 1 km of sandstone, mudrock, and conglomerate. Primary structures indicate deposition by sediment gravity flows and tractive currents. The formation was derived mainly from sedimentary, metamorphic, and igneous sources that probably were located northeast of the present exposures of Succession 5B, but outsized carbonate clasts appear to have been derived from the adjacent Marvin Formation. Graptolites of middle Llandovery age have been obtained from the middle and upper parts of the formation.

Ashgill–Llandovery carbonate sediments: lower Marvin Formation

In the central shallow-marine belt, the Marvin Formation overlies the Lorimer Ridge Formation with a conformable contact. It consists of limestones and minor dolostones that represent a variety of shelf environments (Fig. 145). Conodonts and macrofossils indicate an overall age range from Late Ordovician to Late Silurian. The relatively thin development of the lower part of the formation, and the apparent absence of fossils of latest Ordovician to middle Llandovery age may indicate a hiatus, but sedimentological evidence for a disconformity has not been observed.

Tectonism

The two additional deep-water belts probably originated during latest Ordovician or earliest Silurian time by normal faulting that continued as growth faulting during the middle Llandovery. Very weak subsidence and/or mild uplift occurred in the adjacent shallow-marine belts during the latest Ordovician to middle Llandovery interval.

ACCRETION OF PEARYA

Regional relations of Pearya

Relations with the Franklinian mobile belt and evidence for allochthoneity of Pearya

Schuchert (1923) assumed that the Precambrian basement of Pearya was contiguous with the Canadian Shield beneath the Phanerozoic Franklinian Geosyncline (see Chapter 4, Introduction). The more recent concept (Churkin and Trexler, 1980; Trettin, 1987b), that Pearya represents an exotic terrane, implies that prior to accretion it was separated by a plate boundary from the continent Laurentia, which is underlain by the Canadian Shield. This hypothesis is based on: (1) the geology of the intervening region; (2) differences in basement ages and in Early to Middle Ordovician tectonic history that link Pearya with the Caledonides rather than the Franklinian mobile belt; and (3) differences in structural trends (Trettin, 1987b). Pearya's relations with the Caledonides are reviewed in more detail in the next section of this chapter.

Geological setting

Outcrops of Pearya are separated from the Canadian Shield by lower Paleozoic strata of the Franklinian Shelf and of the adjacent Deep Water Basin, which is represented by the sedimentary rocks of the Hazen Fold Belt and the sedimentary and volcanic rocks of the Clements Markham Fold Belt. The Franklinian Shelf is linked with the sedimentary cover of the Shield by various shallow-marine units, such as the Cambrian Ellesmere Group and the overlying Scoresby Bay Formation. The search for a possible plate boundary can therefore be limited the Hazen and Clements Markham fold belts. Moreover, it can be limited to formations older than latest Llandovery, the upper limit for the possible age of accretion, as explained later.

The Lower Cambrian to mid-Early Silurian units of the Hazen Fold Belt, i.e., the Nesmith beds and the Grant Land and Hazen formations, are linked with formations of the Franklinian Shelf by interlocking facies changes (Trettin, 1994). The basin was no less than 280 km wide in palinspastic reconstruction (see Palinspastic restoration, Fig. 165). Stratigraphic relations suggest a water depth of possibly 1.4 km for the southeasternmost part of the basin in Late Ordovician time (Trettin, 1994, chapter 4), which, in turn, implies an attenuated continental crust. Both stratigraphic relations and inferred water depth exclude a plate boundary in this region.

The sedimentary subprovince of the Deep Water Basin was bordered on the northwest by the Southeastern belt of Succession A of the Clements Markham Fold Belt. This belt is linked with the sedimentary subprovince, and thus indirectly with the North American craton, by the Grant Land and Hazen formations. In addition, it contains volcanics of Early Cambrian or older age, that are assigned to the Yelverton Formation. The volcanics are mafic and tholeiitic in composition, and broader regional relations suggest a rift or drift-related extensional origin. The presence of shelf-type carbonates, and the absence of typical members of the ophiolite suite, such as an underlying sheeted dyke complex or overlying radiolarian chert, argue for an intraplate setting and against a mid-ocean ridge origin; i.e., against a divergent plate margin.

The Southwestern belt of Succession A is linked with the Hazen Fold Belt only by Ordovician radiolarian chert assigned to the Hazen Formation. In the absence of exposures of the Grant Land Formation, these deep-marine sediments provide only a tenuous tie with North America. The volcanics of the Southwestern belt, included in Member B of the Fire Bay Formation, are too altered for a confident identification of their mode of origin, but more likely represent a bimodal, partly alkaline suite of extensional intraplate origin than a subduction-related arc suite.

The Ordovician to Lower Silurian volcanics in the remaining three belts, assigned to Member A of the Kulutingwak Formation, map unit OSv, and the Mount Rawlinson Complex, contain alkaline suites indicative of weakly extensional conditions, and subalkaline suites, including andesite and dacite, that may represent a volcanic arc. If so, a plate boundary is implied and three different settings are possible: (a) on the northwestern margin of the Laurentian plate, above a southeast-dipping subduction zone, (b) on the southeastern margin of Pearya, above a northwest-dipping subduction zone (Bjornerud and Bradley, 1994), or (c) on a third plate that was separated, at different times, by subduction zones from Laurentia and Pearya (Klaper, 1992a, Fig. 16).

Several stratigraphic links with Pearya are possible. (1) The Phillips Inlet Formation of the Northwestern Belt, tentatively placed into the Llandovery, may in fact be a deep-water equivalent of Member A of the Cape Discovery Formation. (2) The Mount Rawlinson Complex of the Northeastern belt, and Member A of the Kulutingwak Formation of the Northwestern belt may be equivalents of the M'Clintock Formation. (3) Member B of the Kulutingwak Formation may be a facies equivalent of the Ayles Formation. If correct, these correlations would seem to support hypothesis (b), as stated above.

In this context, calc-alkaline andesitic volcanics of the Caradoc–Ashgill M'Clintock Formation of Pearya also have to be considered. They would indicate a plate boundary between Pearya and the Clements Markham Fold Belt, provided that the subduction zone lay at the southeastern margin of Pearya and dipped northwest, but the location and dip of the subduction zone are unknown and other configurations are possible.

Basement ages and Early to Middle Ordovician tectonic events

The crystalline basement in the northernmost parts of the Canadian Shield is Paleoproterozoic and Archean in age (Frisch and Trettin, 1991). In contrast, the basement of Pearya is late Mesoproterozoic–early Neoproterozoic, as it is in parts of the Caledonides and in the southeastern Canadian Shield. This relation provides no proof for the allochthoneity of Pearya but supports other, more persuasive linkages with the Caledonides.

The Cambrian and Ordovician stratigraphy of Pearya is very different from that of the Hazen and Clements Markham fold belts, but these differences could be explained by facies changes and do not prove the allochthoneity of Pearya. More relevant is the Early to early Middle Ordovician M'Clintock Orogeny, which was accompanied by Barrovian metamorphism and granitoid plutonism and involved ultramafic-mafic complexes of Early Ordovician age. Comparable events took place in the Caledonian and Appalachian belts that had important effects on adjacent basins and miogeoclines (see below). In contrast, no such effects are apparent in the region between the Canadian Shield and Pearya. In the Hazen Fold Belt and in the Southeastern and Southwestern belts of the Clements Markham Fold Belt, this interval is represented by condensed deep-water sediments. Signs of uplift and deformation or a flyschoid clastic wedge are absent.

Structural trends

The Hazen Fold Belt and most of the Clements Markham Fold Belt show regular southwesterly to westerly trends that are slightly convex to the southeast. By contrast, the trends in Pearya are exceedingly complex (Fig. 1a). In some areas, for example at Clements Markham Inlet (*Clements Markham Inlet–Robeson Channel*), the trends of Pearya seem to be truncated by those of the Clements Markham Fold Belt.

Relations with the Caledonian and Appalachian mobile belts

The Caledonides are an early to middle Paleozoic orogenic system, exposed in Scandinavia, East Greenland, Svalbard, and Scotland, which is unconformably overlain by clastic sediments of latest Silurian–Early Devonian age, earlier referred to as the Old Red Sandstone. Three main stages in the development of this orogen are can be distinguished:

1. Disintegration of the early Neoproterozoic supercontinent Rodinia and development of the Iapetus Ocean in late Neoproterozoic–Cambrian time.

2. Plate convergence, resulting in volcanism and initial collisions in Late Cambrian and Ordovician time.

3. Collision of Laurentia (North America, Greenland, and part of the British Isles) with Baltica (Scandinavia, northwestern Russia and the Barents Shelf) during the Silurian–Early Devonian Scandian Orogeny. Part of the suture belt may be exposed in the Norwegian Caledonides (Stephens and Gee, 1989), and the beginning of the collision may be indicated by a shortlived phase of high-pressure metamorphism that occurred at 432 ± 6 Ma, i.e., in about mid-Llandovery time (Dallmeyer et al., 1992).

On the east side of Laurentia, the Caledonides are linked with the Appalachian orogenic system in the British Isles. In the southwestern British Isles and the northern Appalachians, an Ordovician collision of the Laurentian margin with volcanic arcs (Taconian and Grampian orogenies; see below) was followed by a Silurian collision with Avalonia, a Gondwana-related terrane (Soper et al., 1992 and references therein).

Crystalline basement

Parts of the Caledonides and Appalachians are underlain by a Grenville age (ca. 1.3-1.0 Ga) crystalline basement comparable in age and composition to the basement of Pearya. The Grenville Orogen of eastern Canada, and exposures in Scandinavia, East Greenland and Svalbard are important in this context (Fig. 159).

The Grenville Orogen proper is exposed mainly in the southeastern part of the Canadian Shield, but also underlies adjacent parts of the Appalachian Orogen in Newfoundland and in the continental shelf region northeast of Newfoundland. In the Canadian Shield the orogeny was characterized by northwest-directed thrusting of continental crust upon continental crust, and associated high-grade metamorphism (Moore et al., 1986; Hoffman, 1989, and references therein). Plutonic and metamorphic rocks that formed during earlier Mesoproterozoic and Paleoproterozoic events are common within the orogen, and granitoid plutons younger than 1.0 Ga also are present. In the southern part of the eastern Grenville Province the latest phase of granitoid plutonism occurred between 966 and 956 Ma (Gower, 1990).

In the Caledonides, Grenville-age orogenies are apparent in parts of Scandinavia, Greenland, and Svalbard. The event is best represented in southern Norway and Sweden where it is referred to as the Sveco-Norwegian Orogeny and dated at ca. 1270 to 800 Ma, with the main phase at ca. 1100–945 Ma (Wielens et al., 1981; Gorbatschev, 1985; Starmer, 1993).

Unequivocal evidence for Grenville-age plutonism has been obtained at several localities in central East Greenland (Fig. 159, locations marked G; Higgins, 1988 and references therein). Metamorphism may also have occurred, but this is difficult to establish by isotopic age determinations because some Grenville-age zircon in the Neoproterozoic metasediments of this region is of detrital origin (Peucat et al., 1985).

Grenville-age plutonism has also been demonstrated in two parts of the Svalbard Archipelago. (1) On Biskayerhalvøa of northwesternmost Spitsbergen (Fig. 159, loc. B), zircon from a metagranite gave a crystallization age of 965 ± 1 Ma, and a source age of

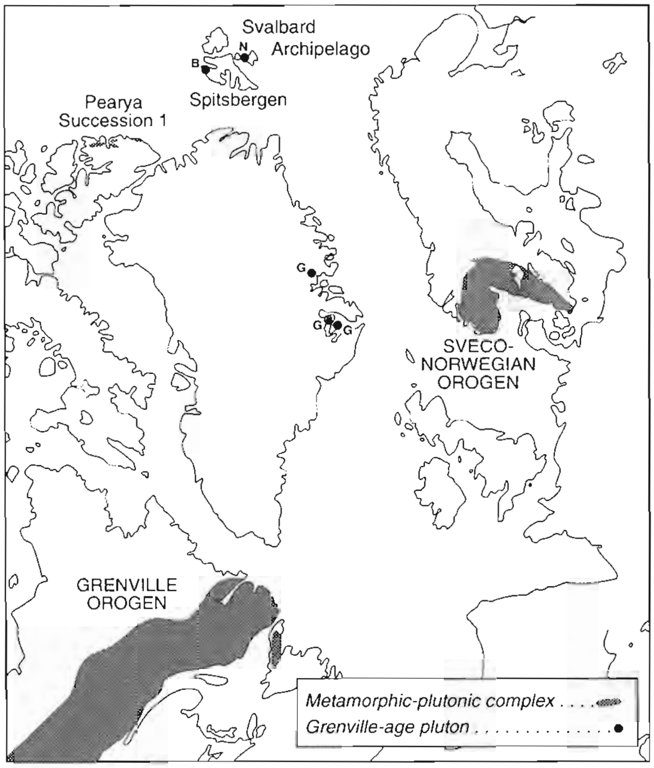


***Figure 159**. Grenville-age orogens of North Atlantic region. Pre-drift base from Le Pichon et al., 1977.* B*: Biskayerhalvøya of northwestern Spitsbergen;* N*: Nordaustetland;* G*: plutons in East Greenland.*

3234±43 Ma. A corona gabbro, associated with gneiss, had a crystallization age of 955±1 Ma (Peucat et al., 1989). (2) A major unconformity and granitoid intrusions with U-Pb (zircon) ages 939±8 Ma and 961±17 Ma have been reported from Nordaustlandet (Fig. 159, loc. N), a smaller island of the Svalbard Archipelago (Gee et al., 1994). In contrast, older U-Pb ages of ca. 1800 to 1700 Ga have been obtained in the Ny Friesland Orogen of northeastern Spitsbergen (Gee et al., 1992).

It is generally agreed that the world-wide Grenvillian Orogeny consisted of continental collisions that produced the early Neoproterozoic supercontinent Rodinia. Several different reconstructions of Rodinia have been published (Hoffman, 1991; Ross et al., 1992; Dalziel, 1992; Dalziel et al., 1994; Condie and Rosen, 1994), but none includes Succession 1 of Pearya.

Succession 2

The stratigraphy of Succession 2 is too poorly known to permit systematic comparisons. The late Neoproterozoic diamictites are comparable not only to glaciogenic deposits in the North Atlantic region, especially in Svalbard (Harland et al., 1993), but also to correlative deposits in the eastern Cordillera (Aitken, 1991).

Succession 3, Thores Suite, and M'Clintock Orogeny

As a result of plate convergence, arc volcanism was common at the Iapetus margins in Late Cambrian and Early Ordovician time, and some volcanics in this region may be co-eval with the poorly dated volcanics of the Maskell Inlet Complex.

The Thores Suite, as mentioned, is a predominantly ultramafic-mafic complex with minor granitoid differentiates, one of which has yielded a U-Pb (zircon) age of 481 +7/-6 Ma. The suite is comparable in overall composition and age to plutonic complexes in Newfoundland, Scotland, and Norway, which have been dated by the same method. The Thores Suite is here interpreted as an ensimatic sub-arc plutonic complex whereas the North Atlantic ophiolites are interpreted as basement of back-arc basins by some authors (e.g., Dunning and Pedersen, 1988). However, the two settings are closely related. The classical Troodos ophiolite of Cyprus, for example, is now widely considered to have formed above a subduction zone (Robertson and Xenophontos, 1993).

The generalized distribution and age ranges of the North Atlantic ophiolites are shown in Figure 160. The total age range of the Newfoundland occurrences, as determined by the U-Pb (zircon) method, is ca. 494 to 477 Ma (Dunning and Krogh, 1985). An age of 481.4 +4.0/-1.9 Ma on the Annieopsquotch Complex is close to the determination from the M'Clintock West body. A trondjhemite from the Ballantrae complex in Scotland has a U-Pb (zircon) age of 483±4Ma (Bluck et al., 1980).

Lower Paleozoic ophiolites and associated felsic intrusions are widespread in the Caledonian Orogen of Norway. Recent U-Pb age determinations from Norway (Furnes et al., 1985) fall into three age groups that are 497, 493 to 489, and 442 Ma old, respectively (Dunning and Pedersen, 1988). The dated granitoid rock in the M'Clintock West body, a quartz monzodiorite, is slightly younger than an arc-related trondjhemite that intrudes the second group. The latter has yielded a U-Pb age of 485±2 Ma.

The M'Clintock Orogeny is comparable in age and character to extensive Early-Middle Ordovician

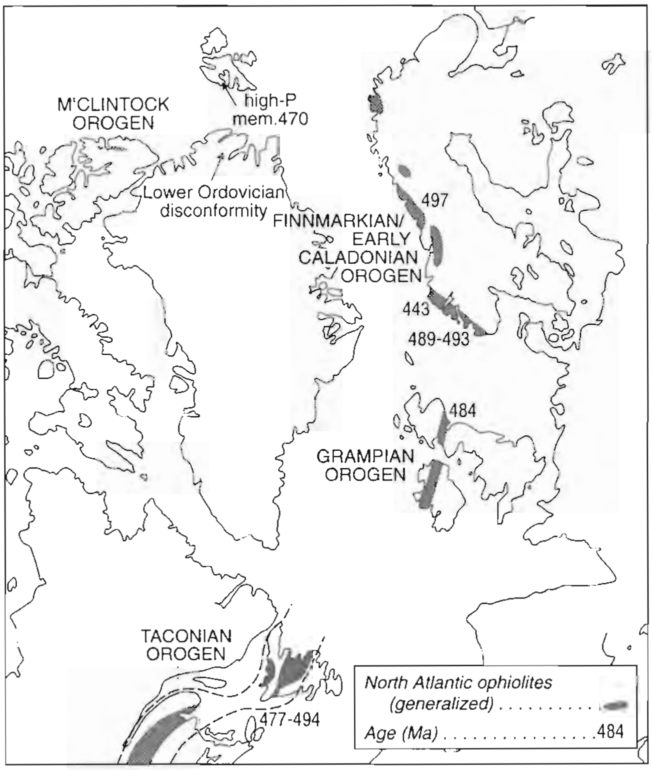


Figure 160. Lower-Middle Ordovician orogens, ophiolites, and U-Pb ages (partly after Williams, 1984, figs. 3, 7). The Thores Suite of the M'Clintock Orogen includes comparable rocks, but is interpreted as a sub-arc plutonic complex. (Base as in Fig. 159.)

orogenies in the Appalachian and Caledonian mobile belts that have been interpreted as collisions of volcanic arcs or back-arc basins and their ophiolitic basement with continental margins. These events include the Taconian Orogeny of eastern North America, best known from the Canadian Appalachians (Williams and Hatcher, 1983; van der Pluijm et al., 1990; Stockmal et al., 1990; Keppie, 1993), the Grampian Orogeny of the British Isles (Dewey and Shackleton, 1984; Dewey and Ryan, 1990; Ryan and Dewey, 1991; Harris, 1993), and events apparent within ophiolite-bearing thrust sheets of the Scandinavian Caledonides. The nature and palaeogeographic position of the continental block onto which the Scandinavian ophiolites were juxtaposed are not well known, and diverse opinions have been expressed about this subject (Nordgulen et al., 1993). The Late Cambrian–Early Ordovician Finnmarkian Orogeny may represent accretion to the margin of Baltica (Andréasson, 1994), whereas the Early Ordovician "Early Caledonian Orogeny" may represent accretion to a Iapetus terrane or Laurentia (Stephens and Gee, 1989).

In the Svalbard Archipelago the evidence for such events is restricted to a small area in west-central Spitsbergen where a phase of high-pressure metamorphism has been dated at ca. 475 Ma (late Arenig) by three different methods (Horsfield, 1972; Ohta et al., 1986; Dallmeyer et al., 1990; Bernard-Griffiths et al., 1993). The metamorphic terrain must have been uplifted and eroded during the Ordovician, because clasts of metamorphic rocks occur in unmetamorphosed Upper Ordovician sediments (Kanat and Morris, 1988).

Successions 4 and 5

As a result of the late Llandovery to Early Devonian Scandian Orogeny, strata of Middle Ordovician to Early Devonian age are poorly preserved in the Caledonides and no similarities are apparent with Pearya, where thick and stratigraphically complex successions are preserved.

Summary

Relations between Pearya and the Caledonian–Appalachian mobile belts can be summarized as follows:

1. Pearya is related to the Caledonian–Appalachian belts by the Grenville age of its crystalline basement and by Early–Middle Ordovician movements that involved continental crust, volcanic island arcs, and Early Ordovician ultramafic complexes.

2. Pearya was not involved in the late Llandovery to Ludlow phases of the Scandian Orogeny.

3. The stratigraphic relations of the two regions are difficult to establish because of poor knowledge of the pre-Caradoc stratigraphy of Pearya, and limited preservation of Caradoc and younger strata in the Caledonides. Apart from diamictites of probable late Neoproterozoic (Varanger) age that are not confined to the North Atlantic region, no specific stratigraphic similarities are apparent.

Relations with the Arctic Alaska Plate

It is also necessary to compare Pearya with the Arctic Alaska Plate, which comprises northern Alaska and adjacent parts of the Yukon and Siberia, because a widely favoured pre-drift reconstruction for the

Amerasian Basin of the Arctic Ocean juxtaposes this plate with the northwestern rim of the Arctic Islands (Lawver and Scotese, 1990, and references therein). An alternative reconstruction that restores it to the Barents Shelf continental margin (Condie and Rosen, 1994; Patrick and McClelland, 1995) ignores upper Paleozoic stratigraphic continuities between Alaska and the northwestern Yukon (cf. Bamber et al., 1992; Richards et al., 1993; Moore et al., 1994). Relations between Pearya and northern Alaska may be summarized as follows:

1. Neoproterozoic orthogneisses, Neoproterozoic to Cambrian metasedimentary rocks, and Devonian granitic orthogneisses in northern Alaska have Nd and Sr isotope compositions consistent with at least partial derivation from a Mesoproterozoic to Paleoproterozoic crust (Nelson et al., 1993) that is older than Succession 1 of Pearya.

2. The oldest known granitoid plutons in different areas have U-Pb (zircon) ages of 820 ± 30 Ma (Dillon et al., 1980), 750 ± 6 Ma, 705 ± 35 Ma (Karl and Aleinikoff, 1990), and 681 ± 3 Ma (Patrick and McClelland, 1995). Intrusions of this age are unknown in Pearya.

3. Stratigraphic or isotopic evidence for an Early–Middle Ordovician event comparable to the M'Clintock Orogeny is lacking in Alaska (cf. Moore et al., 1994, and references therein; Dumoulin and Harris, 1992).

4. Devonian granitoid intrusions in the Brooks Range of northern Alaska with U-Pb (zircon) ages of 390 ± 20 Ma (Dillon et al., 1987) are approximately co-eval with the Cape Woods Pluton of Pearya, but these rocks postdate the accretion of Pearya (see below).

On Wrangel Island (Kos'ko et al., 1993), a basement complex of volcanic and clastic sedimentary rocks with small mafic and granitoid intrusions of Neoproterozoic age (ca. 0.63 to 0.70 Ga) is unconformably overlain by Upper Silurian–Lower Devonian siliciclastic and carbonate sediments. No similarities with Pearya are apparent.

Time and mode of accretion

The evidence reviewed above suggests, but does not prove conclusively, that Pearya is an exotic terrane. The following discussion of the time and mode of accretion is based on the hypothetical assumption that this is the case.

Time limits

The accretion of Pearya probably postdates the compressional phase of the M'Clintock Orogeny in late Arenig–Llanvirn time and predates overlap by the Danish River Formation in the early late Landovery. As mentioned above, a major phase of andesitic and alkaline volcanism occurred in Caradoc–Ashgill time, both in Pearya and in the Northwestern and Northeastern belts of the Clements Markham Fold Belt. If the andesitic volcanism was caused by subduction between Pearya and a part of the Clements Markham Fold Belt, then the accretion postdates it and its possible age is limited to an interval extending from Ashgill to about early late Llandovery.

Present contacts between Pearya and Succession A of Clements Markham Fold Belt

If Pearya is exotic and accretion occurred prior to the deposition of the Danish River Formation, this event should have resulted in fault contacts between Pearya and Succession A of the Clements Markham Fold Belt. Such contacts are exposed in two areas of northwestern Ellesmere Island (*Yelverton Inlet*) but have yielded no conclusive information because the present contacts may be younger than the accretion event. On the northern flank of the Kulutingwak Anticlinorium, Succession 2 of Pearya has been thrust upon the Kulutingwak Formation in a southerly direction. Because other thrust faults in the area involve the Danish River Formation, it is uncertain whether this fault dates back to the accretion event. Farther north, the Petersen Bay Fault thrusts the crystalline basement of Pearya upon the Kulutingwak Formation. The associated amphibolite-grade metamorphism, which must be post-Llandovery in age because it affects the Danish River Formation, would have eliminated any structural evidence of possible earlier movements (see Klaper and Ohta, 1993).

Structural history during the critical time interval

In the absence of reliable information from present contacts, conclusions about the specific time and the mode of accretion can be based only on the structural record of Pearya and the Clements Markham Fold Belt during the critical interval. The underlying assumption is that the docking of Pearya caused a deformation that is represented by an unconformity. A high-angle unconformity and evidence for widespread folding and thrust faulting would support a hypothesis of head-on collision or strongly transpressive strike-slip. Conversely, the absence of such features would lend support to mildly transpressive or neutral strike-slip, but, in this case, must be supported by other types of evidence.

Pearya

The relevant information from Pearya can be summarized as follows:

1. The unconformity at the base of Succession 5A (Taconite River or Zebra Cliffs formations) indicates differential vertical movements in Ashgill time. The movements were strongest near the head of M'Clintock Inlet where Succession 5A lies on Succession 2 (Figs. 120, 126), and moderate farther north where it lies on the M'Clintock or Ayles formations. The structural style of this deformation is uncertain, but the fact that the unconformity is both overlain and underlain by Ashgill strata over large areas militates against significant folding or thrust faulting, i.e., against strong compression.

2. A low-angle unconformity is apparent between Succession 5A and shallow-marine strata of Succession 5B on Harley Ridge, east of the head of M'Clintock Inlet (Fig. 126). At the same time the adjacent northwestern and southeastern belts subsided below shelf level, probably as a result of extensional normal faulting.

3. A possible disconformity within the Marvin Formation may indicate further weak uplifts in the Central shallow-marine belt between latest Ordovician and early late Llandovery time.

4. Growth faulting probably occurred in the central deep-marine belt during the middle Llandovery when several hundreds of metres of coarse clastic sediments were deposited (Cranstone Formation).

Clements Markham Fold Belt

The record of the Clements Markham Fold Belt during the critical interval is poorly known, but Late Ordovician–Early Silurian tectonic activity is indicated by the following features:

1. A possible high-angle unconformity between the Danish River Formation and the Mount Rawlinson Complex (Caradoc and younger) in the Northeastern belt, that has yet to be confirmed by ground investigation.

2. A probable unconformity between the Danish River and Kulutingwak formations in the Northwestern belt, inferred from an age gap that may extend from latest Ordovician through early late Llandovery time.

3. Indirect information about contemporaneous tectonism provided by the Fire Bay Formation, which is early late Llandovery in age. An uplift of volcanic rocks to the northwest is apparent from the composition and clast-size variations of the sedimentary rocks. The presence of Middle Ordovician carbonate olistostromes indicates gravitational faulting at the basin margin and uplift of relatively old rocks farther northwest. Weak extension within the depositional basin is demonstrated by the alkaline composition and probably bimodal composition of the volcanic rocks.

4. Detrital serpentinite in Member A of the Phillips Inlet Formation, derived either from oceanic crust or from a subarc plutonic complex. The preservation of serpentinite detritus requires rapid uplift and redeposition and therefore this unit indicates contemporaneous tectonism, but its age is uncertain. If, as suggested, it is correlative with clastic sediments in the lower part of the Fire Bay Formation that contain trace amounts of chromite and serpentinite, then the uplift of the ultramafic rocks occurred in early late Llandovery time. However, ultramafic detritus also occurs in Ordovician strata of Northeast Pearya (Cape Discovery Formation, Member A and Taconite River Formation), and a Caradoc or Ashgill age cannot be ruled out.

5. An abrupt contact between the deep-water chert of the Hazen Formation and the shallow-marine Yelverton Pass beds (early late Llandovery) that may represent an unconformity developed upon an intrabasinal structural high. Alternatively, this contact could be interpreted as a listric normal fault, and the Yelverton Pass beds as olistromes. If so, they were emplaced at about the same time as the olistromes in the Fire Bay Formation and carbonate conglomerates at the top of the Hazen Formation at Caledonian and Ella bays (Trettin, 1994).

Conclusions

In view of the limited information, only tentative inferences about the time and mode of accretion are possible. The first published hypothesis (Trettin, 1987b) proposed sinistral transpression associated with the Late Silurian–Early Devonian orogenic events discussed in the next section of this chapter. Additional fieldwork, and a re-evaluation of the available information has led to major modifications of this hypothesis. It is evident now that the accretion predates overlap of Pearya by the Danish River Formation in the latest early Llandovery, and therefore occurred during a different tectonic regime. The arcuate shape of the fold belt in the Southwestern domain of Northeast Pearya, previously explained by bending due to transpression, is now considered to have been inherited from an older rift margin. The Caradoc–Ashgill andesitic volcanism in the northwestern and northeastern parts of the Clements Markham Fold Belt may indicate a subduction regime that immediately preceded accretion (Klaper, 1992a, b; Bjornerud and Bradley, 1994).

Conclusions concerning the specific time of accretion will have to be based on the stratigraphic-structural record of Pearya, which is better known than that of the Clements Markham Fold Belt. In Pearya, the most important event during the critical interval clearly coincides with the unconformity at the base of Succession 5A and occurred in Ashgill (Richmondian) time. The movements indicated by the unconformity at the base of Succession 5B also fall into the Ashgill. Probable unconformities at the base of the Danish River Formation in the Northwestern and Northeastern belts of the Clements Markham Fold Belt may indicate co-eval events but cannot be dated more precisely than being younger than Caradoc and older than latest Llandovery.

Concerning the mode of deformation, possible evidence for strongly compressive deformation is limited to an inferred angular unconformity between the Mount Rawlinson Complex and the Danish River Formation in the northeastern part of the Clements Markham Fold Belt that has yet to be confirmed by groundwork. The first disturbance of Ashgill age in Pearya may also have been caused by compression, but the movements were essentially vertical. The apparent absence of widespread thrust faulting or folding in northern Ellesmere Island during Ashgill (or possibly early to middle Llandovery) time argues against head-on collision or strongly transpressive strike-slip.

On the other hand, the tectonic relations with the Caledonides still suggest a sinistral component of movement, as pointed out previously. If strike-slip has taken place, it probably occurred on predecessors of extensive, linear, strike-parallel faults such as the Emma Fiord Fault Zone and the M'Clintock Glacier, Mount Rawlinson and Inlet Head faults (Fig. 1a). If these faults indeed originated before the latest Llandovery, then they must have been overlapped by the Danish River Formation and re-activated during later orogenies under entirely different stress conditions.

These seemingly conflicting observations can perhaps be reconciled by a hypothesis of oblique, sinistral convergence and strain partitioning, with limited compression confined to northern parts of the region and strike-slip occurring farther southeast.

The postulated sinistral movement of Pearya may be related to motions within the Caledonides. Extensive sinistral movements in the Caledonides were first proposed by Harland (Harland, 1969; Harland and Wright, 1979; Harland et al., 1992) to explain the geology of Svalbard. Some aspects of Harland's hypothesis have been challenged on the basis of more detailed studies in Spitsbergen (Lamar et al., 1986; Bjornerud et al., 1991). Other aspects have been supported, with modifications, by paleomagnetic and structural studies in Greenland, Scandinavia, the British Isles, and Spitsbergen (e.g., Torsvik et al., 1990; Strachan et al., 1992; Soper et al., 1992; Gee and Page, 1994; Ohta, 1994). Pre-accretionary positions for Pearya are indicated in speculative paleogeographic reconstructions by Harland and co-authors (1992, fig. 8), and Soper and co-authors (1992, fig. 6). The reconstruction by Harland and co-authors is compatible with the Caledonian affinities of Pearya but differs from the conclusions presented here with respect to the timing of the movements.

MID-EARLY TO LATE SILURIAN DEPOSITIONAL PATTERN

Introduction

This section reviews the depositional pattern that existed after the accretion of Pearya and before the onset of a predominantly orogenic interval that resulted in extensive erosion. In the Northern Heiberg Fold Belt the pre-orogenic stratigraphic record terminates in the late Wenlock, and in Ellesmere Island in the late Ludlow or possibly Pridoli. Three major lithofacies are distinguished:

1. In the Northern Heiberg Fold Belt a volcanic arc and forearc basin (Svartevaeg Formation) existed in Llandovery and Wenlock time.

2. A flysch basin occupied large parts of northern Ellesmere Island and North Greenland from latest Llandovery to latest Silurian time (Danish River and Lands Lokk formations and correlative units in North Greenland). It received sediments from orogenic sources located to the northeast and north.

3. The flysch basin was bordered on the north by a shelf that received carbonate and lesser amounts of clastic sediments. During latest Llandovery to early Ludlow time this shallow-marine facies was limited to two narrow belts in Northeast Pearya (Marvin Formation; Fig. 137). During the middle to late Ludlow and possibly Pridoli, it appears to have covered much of Northeast Pearya (upper part of Marvin Formation and Crash Point beds) and of the northeastern Clements Markham Fold Belt (Markham River and Piper Pass formations) but only relatively small remnants of these shelf deposits are preserved.

Volcanic arc and forearc facies: Svartevaeg Formation

The Svartevaeg Formation of the Northern Heiberg Fold Belt (*Cape Stallworthy–Bukken Fiord*) is a volcanic-sedimentary assemblage with a minimum thickness of about 1.6 km. The base of the formation is a thrust fault and the top an angular unconformity overlain by Early Devonian or older strata of the Stallworthy Formation. The formation is divisible into two members.

Member A is exposed only in the Svartevaeg Cliffs where it consists of about 1 km of volcanic flows and tuffs with small amounts of volcanogenic clastic sediments and carbonate olistostromes and olistoliths. The composition of the volcanics, mainly calc-alkaline andesite and basaltic andesite, indicates an arc origin.

Member B overlies Member A in the Svartevaeg Cliffs. There it is more than 600 m thick and consists mainly of clastic sediments with lesser amounts of tuff and small amounts of volcanic flows. The clastic sediments range in grade from mudrock to boulder conglomerate and their primary structures indicate deposition by subaqueous debris flows and turbidity currents in deep-water channel and overbank settings. They are chiefly composed of arc-derived andesitic detritus, but also include minor amounts of quartz, quartzite, and chert, and carbonate rocks. Member B also occurs in two areas southwest of the Svartevaeg Cliffs where Member A is absent at the surface, and, judging from the structural style, perhaps also in the subsurface. Variations in clast size and composition suggest derivation of the volcanic material from easterly sources, and if this is so, the member probably represents a forearc deposit. The chert, quartz and quartzite, on the other hand, are more common in the western outcrop belts and appear to have been derived from a western source, possibly a forearc ridge (see concluding section of this chapter and Fig. 166b).

Member A has not been dated. Graptolites of probable latest Llandovery age have been obtained from the middle part of Member B, and graptolites of probable late Wenlock age from the uppermost part.

Flysch facies

The mid-Early to Late Silurian flysch facies as a whole is composed of sandstone and mudrock with minor amounts of conglomerate and uncommon carbonate olistostromes and olistoliths. Derived from orogenic sources, the detrital sediments were deposited in submarine fan, channel, and basin floor environments, mainly by turbidity currents and subaqueous debris flows. The sediments are assigned to two formations, the Danish River, and Lands Lokk, that differ in age, detrital composition, and in the relative proportions of sandstone, mudrock and conglomerate. Both units are widely distributed, in contrast to flyschoid units of middle and early late Llandovery age, such as the Cranstone Formation and Member A of the Fire Bay Formation, which have been discussd earlier in this chapter.

Upper Llandovery flysch: Danish River Formation

Flysch of latest Llandovery age is widespread and uniform in composition and primary structures. It is assigned to the Danish River Formation in Ellesmere Island, and to the Merqujoq Formation in North Greenland Fold Belt (Hurst and Surlyk, 1982). The Danish River Formation overlaps all of the Hazen and Clements Markham fold belts and parts of Pearya, and directly overlies, or seems to overlap stratigraphically, a total of seven different units.

The base of this flysch is probably slightly diachronous, occurring within the earlier part of the late Llandovery in North Greenland (*turriculatus* or *spiralis* zones; Higgins and Soper, 1985; Escher and Larsen, 1987, fig. 3) and in the latest Llandovery

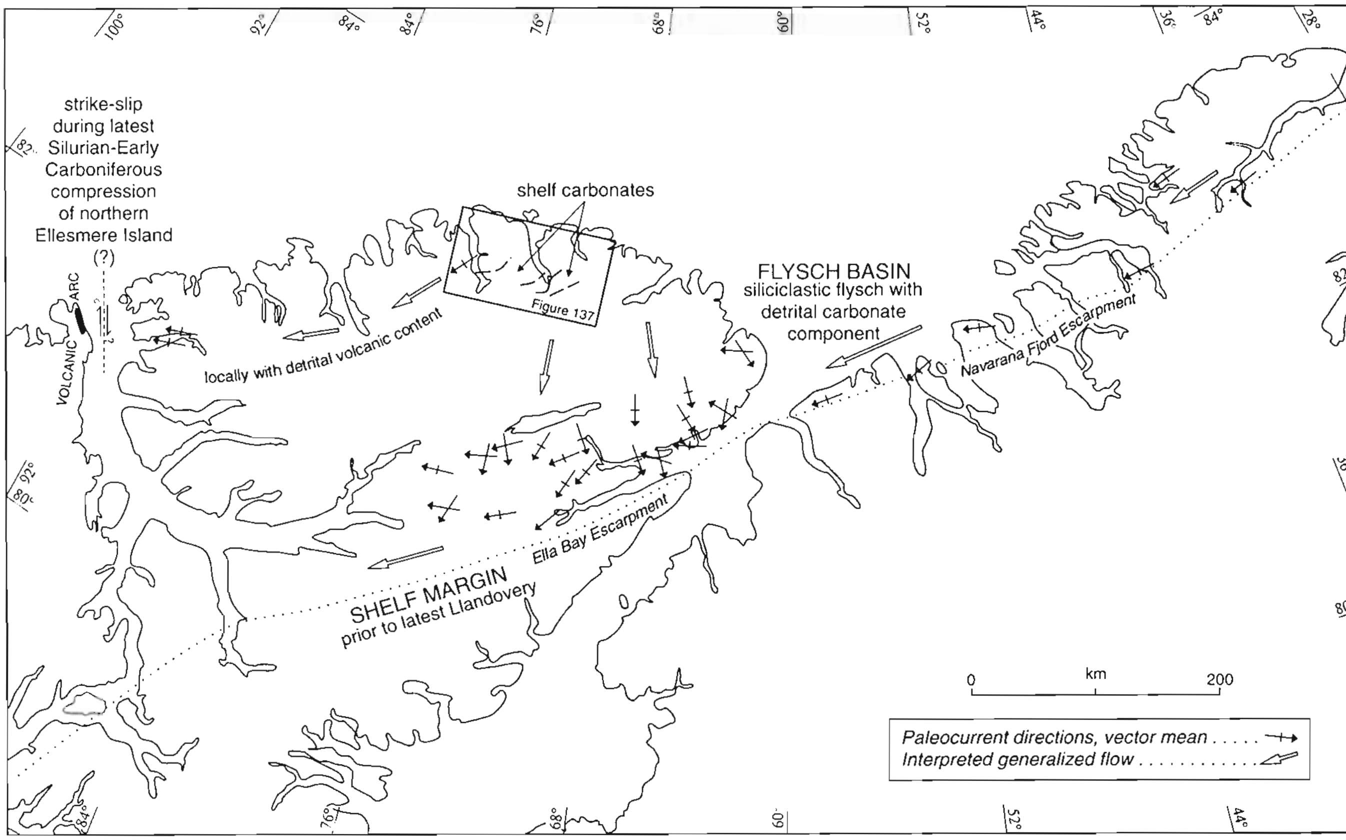


***Figure 161**. Late Early Silurian (late Llandovery, late Telychian) depositional framework. Age control for paleocurrent directions is limited; presentation may include data from younger strata. Dashed areas indicate insufficient structural control. Rose diagrams of paleocurrent measurements are given in Figure 59; Trettin (1994, fig. 118); Hurst and Surlyk (1982, fig. 124).*

(*sakmarius* Zone, previously referred to as the *Stomatograptus grandis* Zone) at Caledonian Bay (Trettin, 1994, p. 129–131). The top of the Danish River Formation lies within the latest Llandovery (late Telychian).

The formation is composed mainly of sandstone and interbedded mudrock with minor amounts of granule conglomerate and fine pebble conglomerate and a few carbonate olistoliths. Combined XRD, carbon, and thin section analyses indicate a uniform composition throughout northern Ellesmere Island. The clastic sediments contain substantial proportions (>20% on average) of carbonate grains, which are uniformly mixed with minerals and rock fragments of low-grade metamorphic provenance. Significant proportions of volcanic rock fragments have been observed only at M'Clintock Inlet and Fire Bay, Emma Fiord. An olistolith at Fire Bay has yielded conodonts of unspecified Middle to Late Ordovician age.

A total of 2020 paleocurrent determinations from 22 stations on the Hazen Plateau revealed two main directions: parallel with local strike in a southwesterly direction (68% of data), and perpendicular to strike in a southeasterly direction (30% of data; Trettin, 1979, 1994, p. 126). The age of the beds on the plateau is poorly constrained; available evidence suggests that they are limited to the late Llandovery and Wenlock. The means of 97 paleocurrent indicators at two stations near Emma Fiord are strike-parallel to the southwest.

The generalized paleocurrent directions shown in Figure 161 demonstrate that the unit was derived from the Caledonides east of Greenland (Hurst and Surlyk, 1982; Surlyk and Hurst, 1984) and but probably also from a more northerly source, located northeast of Ellesmere Island.

Uppermost Llandovery–lower Ludlow flysch: Lands Lokk Formation and correlative units

The Uppermost Llandovery-lower Ludlow flysch in the report area is assigned to the Lands Lokk Formation, which is composed mainly of mudrock and sandstone with smaller amounts of conglomerate and volcanogenic deposits. The formation is exposed mainly in the central part of the Clements Markham Fold Belt, but a small outcrop area occurs at M'Clintock Inlet (Figs. 1a, 162; *M'Clintock Inlet*). The Lands Lokk Formation is correlative with middle parts of the Danish River Formation in the type section at Caledonian Bay, Cañon Fiord (*Greeley Fiord, East-Greeley Fiord West,* and *Cañon Fiord*). It is similar to the Danish River Formation with respect to primary structures, but differs in detrital composition: quartz and chert are more abundant and detrital carbonate is subordinate. Volcanogenic material is also more common, although it is confined to the vicinity of Emma Fiord (*Otto Fiord*). Moreover, the Lands Lokk Formation contains larger proportions of mudrock and slightly larger proportions of conglomerate. Most of the Lands Lokk Formation was deposited in the same kind of deep-water settings as was the Danish River Formation, but uppermost parts, exposed northwest of Markham River (*Clements Markham Inlet-Robeson Channel*) and at Crash Point, M'Clintock Inlet (*M'Clintock Inlet*), are of shelf origin.

Near the head of Emma Fiord (*Otto Fiord*), the Lands Lokk Formation is divisible into two facies composed of mudrock and volcanogenic strata, and of quartzose sandstone and mudrock, respectively (Figs. 60–62). Both facies have yielded graptolites of undifferentiated late Llandovery–early Ludlow ages and are essentially co-eval, but paleocurrent determinations combined with stratigraphic observations indicate that in the vicinity of the Hvitland Peninsula 1 section the sandstone-mudrock facies prograded over the mudrock-volcanogenic facies in a northwestward direction. The sandstone-mudrock facies, which probably has a minimum thickness of 1 km, is composed of interstratified quartzose sandstone and mudrock with small amounts of chert pebble conglomerate and volcanogenic conglomerate. Exposures with larger proportions of pebble conglomerate, observed near Phillips and Yelverton inlets (Fig. 65; *Otto Fiord*, and *Yelverton Inlet*), probably occur in the upper part of this facies. A total of 128 paleocurrent determinations from three stations show northwestward and northeastward flow directions (Figs. 59, 162).

The sandy and conglomeratic parts of the Lands Lokk Formation are similar in lithology and close in age to Member B of the Danish River Formation at Caledonian Bay (Trettin, 1979, 1994, p. 129) and also to the Nordkronen Formation of North Greenland (Hurst and Surlyk, 1982; Larsen and Escher, 1985, 1987). Paleocurrent directions and the westward decrease in clast size indicate that the Nordkronen Formation was derived from Caledonian sources east of North Greenland (op. cit.). The volcanogenic material, on the other hand, may have been derived from the Svartevaeg arc, which may have persisted to early Ludlow time, although strata of Ludlow age are not preserved.

Figure 162 gives an interpretation of the depositional framework that accounts for these relations and for the divergent paleocurrent directions. It is assumed that the conglomerates were transported in channels that extended from Greenland along the Hazen Plateau to northwestern Ellesmere Island and Cañon Fiord. Conglomerates have not been observed on the Hazen Plateau but, in the absence of graptolites younger than Wenlock, it is reasonable to assume that strata of Ludlow age have been eroded in this region. The implied distance of transport, more than 900 km, appears to be extraordinary for terrigenous conglomerate with clast sizes up to 10 cm at Caledonian Bay (Trettin, 1979, appendix 1, supplementary stratigraphic section 1-2-2, unit 3; p. 11 on microfiche in pocket), although submarine channels more than 1000 km long are not uncommon in present oceans (Hesse et al., 1987, Table 1).

Shallow-marine carbonate and clastic facies

Carbonates of late Llandovery to early Ludlow age: middle Marvin Formation

Carbonates of late Llandovery to early Ludlow age that are correlative with the combined Danish River and Lands Lokk formations are confined to two belts in Northeast Pearya (Figs. 137, 161, 162) where they occur in the lower middle part of the Marvin Formation (Fig. 145). These strata have yielded conodonts of late Llandovery age and macrofossils of undifferentiated Wenlock to Pridoli age and cannot be separated from the strata of post-early Ludlow age discussed below. Like the younger strata, they consist of a variety of shelf-type limestones and minor dolostone.

Carbonate and clastic sediments of Late Silurian age: upper Marvin Formation, Crash Point beds, and Markham River and Piper Pass formations

Shallow-marine carbonate and clastic sediments younger than the Lands Lokk Formation are preserved in four different areas. The lithology of these strata

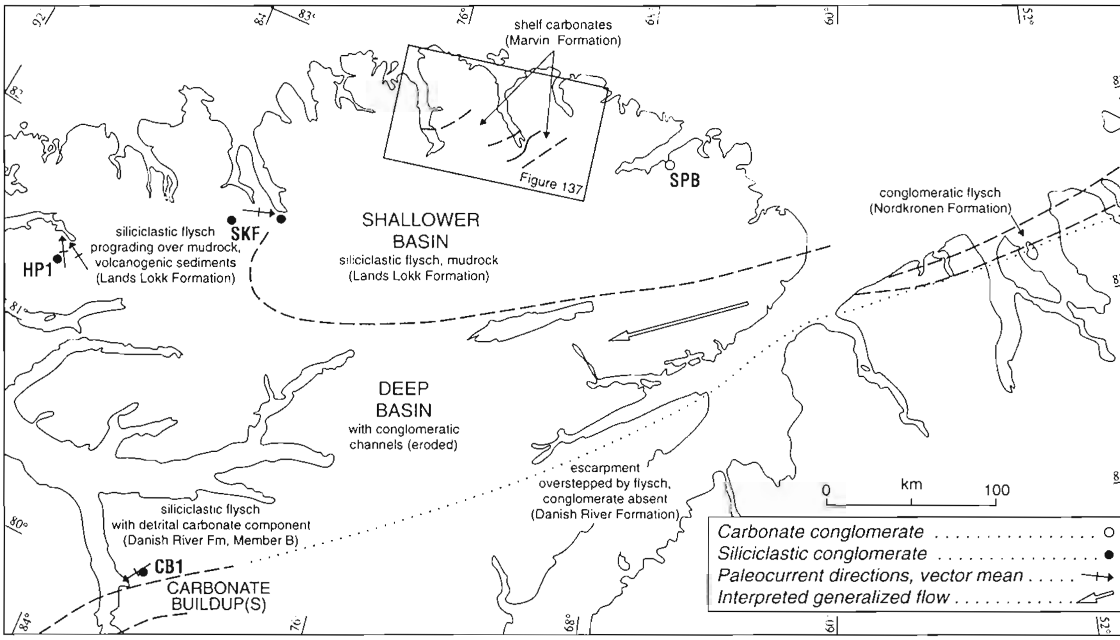


***Figure 162**. Late Early–early Late Silurian (latest Llandovery–early Ludlow) depositional framework. The volcanic arc in Axel Heiberg Island, shown in Figure 161, persisted to late Wenlock or later time. Rose diagrams of paleocurrent directions are given in Figure 59, and in Trettin (1979, fig. 67). For information on Nordkronen Formation, see Larsen and Escher (1985, 1987).* CB1: *Caledonian Bay 1 section;* HP1: *Hvitland Peninsula 1 section;* SKF: *section south of Kulutingwak Fiord;* SPB: *section south of Parker Bay.*

varies over short distances, and depositional environments range from outer shelf to peritidal. They are probably approximately correlative with each other and range in age from middle to late Ludlow or possibly Pridoli. The different occurrences may be summarized as follows:

1. An outcrop belt in Northeast Pearya located at Crash Point, M'Clintock Inlet, comprises about 150 m of limestone and minor sandstone assigned to a tongue of the upper Marvin Formation and more than 100 m of sandstone, limestone and siltstone, assigned to the Crash Point beds (Figs. 118, 137; *M'Clintock Inlet*). The Marvin Formation overlies the Lands Lokk with an abrupt contact. Both the Marvin Formation and Crash Point beds have yielded conodonts of unspecified Late Silurian age and represent quiet to turbulent shelf environments.

2. An outcrop belt farther southeast in Northeast Pearya (Figs. 118, 137, 145) comprises the upper part of the Marvin Formation, which is probably more than 500 m thick, and lies on a relatively thin lower part of the same formation that ranges in age from Late Ordovician to early Ludlow. These strata represent a variety of predominantly subtidal shelf environments and have yielded conodonts of Late Silurian age, along with brachiopods of unspecified late Wenlock to Pridoli age.

3. In a northeastern part of the Clements Markham Fold Belt located northwest of Markham River (*Clements Markham Inlet-Robeson Channel*), the Markham River Formation overlies the Lands Lokk Formation with a disconformable contact. It consists of about 170 m of dolostone, cherty and dolomitic spiculite, pebble conglomerate, sandstone, and minor siltstone that were deposited in a variety of nearshore to deep subtidal settings. Ostracodes from the Markham River Formation, combined with palynomorphs from the underlying Lands Lokk Formation, indicate a Ludlow age.

4. Farther southeast in the Clements Markham Fold Belt, lime wackestone and minor calcareous mudrock of the Piper Pass Formation are in fault contact with the Lands Lokk Formation. The Piper Pass Formation was deposited in a subtidal shelf or shelf margin environment and has yielded conodonts of middle to late Ludlow age.

LATE SILURIAN TO EARLY CARBONIFEROUS OROGENIC PHASES AND RELATED SEDIMENTATION, VOLCANISM, AND PLUTONISM

Introduction

The latest Silurian to Early Carboniferous interval was characterized by deformation, uplift, erosion, granitoid intrusion, and limited regional metamorphism of greenschist to lower amphibolite grade. A review of the poorly preserved stratigraphic record will be followed by summaries of granitoid plutonism, deformation, and metamorphism.

Stratigraphic record

The stratigraphic record is limited to three units restricted to small areas in northern Axel Heiberg Island and northwestern Ellesmere Island and not in contact with each other.

Early Devonian and (?)older clastic sediments: Stallworthy Formation

In the Northern Heiberg Fold Belt, the Stallworthy Formation overlies the Svartevaeg Formation with a high-angle unconformity. It is Early Devonian and possibly Late Silurian in age and consists of roughly 4 km of sandstone, siltstone, and conglomerate, including many redbeds. The lower part (Members A and B), which consists of sandstone, conglomerate, and mudrock, was deposited in alluvial settings, the upper part (Member C), which consists mainly of mudrock with minor sandstone, conglomerate, and limestone, in brackish to shallow-marine deltaic settings. The detrital composition and setting suggest derivation from uplifted strata of the Grant Land and Hazen formations to the southwest. This is the youngest pre-Carboniferous formation of Axel Heiberg Island, and correlative strata are not preserved on Ellesmere Island.

Middle Devonian or older volcanic and sedimentary rocks: Bourne Complex

The Bourne Complex of Kleybolte Peninsula, northwesternmost Ellesmere Island (*Cape Stallworthy–Bukken Fiord*) consists of andesitic flows, tuffaceous phyllite, phyllite, and minor sandstone with abundant dykes of different ages. The volcanics are of arc origin and have yielded a Givetian (380±10 Ma) ^{40}Ar–^{39}Ar age (Henry, 1991). This apparent age requires confirmation by a different method because of possible argon loss caused by the intrusion of dykes that may be substantially younger.

Middle and/or Upper Devonian clastic sediments: Okse Bay Formation

The Okse Bay Formation is exposed at Yelverton Pass and de Vries Glacier (*Tanquary Fiord*) within a large area covered by strata of the Sverdrup Basin. The formation is unconformably overlain by different units of the Sverdrup Basin and its base is concealed (Mayr, 1992). It is composed of up to 1360 m of interbedded chert pebble conglomerate, quartzose sandstone, and mudrock, including common redbeds, with minor amounts of calcareous beds and coal. The sediments were deposited by northwest-flowing meandering and braided rivers, and were derived either from the Grant Land and Hazen formations in the Grantland Uplift on the southeast (Trettin, 1994, chapter 2, fig. 5) or from the equivalent Polkorridoren and Amundsen Land groups of North Greenland. Palynomorphs from the Okse Bay Formation are of Devonian, probably late Givetian and/or Frasnian, age (McGregor, *in* Mayr, 1992). Ages of detrital zircon range from 1141 to 3003 Ma (McNicoll et al., 1995).

Granitoid plutons and related hypabyssal intrusions

The only dated granitoid intrusion of Middle Devonian age is the large Cape Woods Pluton in Southwest Pearya. Small granitoid intrusions of Late Devonian age are present both in the Northern Heiberg Fold Belt and in the western part of the Clements Markham Fold Belt. A felsic dyke swarm in the Northern Heiberg Fold Belt has yielded a similar Late Devonian age.

Middle Devonian Cape Woods Pluton

The large (166 km^2) Cape Woods Pluton intrudes Succession 2 of Pearya on northwestern Wootton Peninsula, Ellesmere Island (Fig. 154; *Yelverton Inlet*). It consists of peraluminous to metaluminous biotite quartz monzonite and granodiorite and has a U-Pb (sphene) age of 390±10 Ma (Eifelian with confidence limits in the Pragian and Givetian).

Late Devonian intrusions

In the Northern Heiberg Fold Belt, four small granitoid plutons in the compositional fields of granodiorite, tonalite, and quartz diorite intrude the Grant Land Formation and older rocks in an area north of Rens Fiord. One has a Late Devonian U-Pb (zircon) crystallization age of 370 to 360 Ma. Inherited zircon has a mean upper intercept age of about 2 Ga, considerably older than the basement of Pearya, but comparable to zircon ages from the Boothia Uplift (Frisch and Hunt, 1993).

A northwesterly trending swarm of felsic dykes and plugs south of Rens Fiord is composed of rhyolite-dacite or silicified trachyandesite. One dyke has yielded a Frasnian-Famennian U-Pb (zircon) age of 368 ± 3 Ma and an early Paleoproterozoic inheritance age of 2436 Ma. This swarm was emplaced during a phase of northeast-southwest extension, perpendicular to the structural trend.

In Ellesmere Island, a small plug of metaluminous tonalite intrudes Silurian flysch in an area about 19 km south-southeast of the head of Phillips Inlet (*Otto Fiord*) in the Clements Markham Fold Belt. The presence of clinopyroxene indicates at least partial derivation from mantle sources. A ^{40}Ar-^{39}Ar (hornblende) determination gave an early Famennian plateau age of 364.1 ± 2.0 Ma.

Orogenic phases

Two main phases of deformation are distinguished in the Northern Heiberg Fold Belt and in those parts of the Clements Markham Fold Belt and Pearya located in northwestern Ellesmere Island. The first is dated to the Late Silurian-earliest Devonian on Axel Heiberg Island, but poorly constrained in Ellesmere Island. It coincided approximately with more precisely dated movements of the Boothia Uplift (Thorsteinsson, 1980; de Freitas and Mayr, 1992b). The second phase is probably Late Devonian-Early Carboniferous in age and slightly older than or co-eval with the Ellesmerian Orogeny in more southerly parts of the Arctic Islands (Thorsteinsson and Tozer, 1970; Harrison, 1995).

Northern Heiberg Fold Belt

Ages of deformation

In northern Axel Heiberg Island a deformation of unspecified Late Silurian-Early Devonian age is apparent from an angular unconformity between the Svartevaeg and Stallworthy formations. The age of this event is constrained by graptolites of late Wenlock age from strata 15 m below the unconformity and by fossil fish of late Lochkovian or early Pragian age from strata about 1.3 to 1.5 km above it.

A second phase is demonstrated by a high-angle unconformity that separates the Stallworthy Formation from the base of the Sverdrup Basin fill. The age of this event is bracketted by fossils of Early Devonian (Lochkovian or Pragian) and late Early Carboniferous (Viséan) ages. Other evidence, discussed below, suggests that it postdates the Late Devonian felsic dykes.

Structural features

The structural trends of both deformations are southeasterly, in contrast to the southwesterly or westerly trends prevalent in the Clements Markham, Hazen, Central Ellesmere, and Parry Islands fold belts.

The tight and complex minor folds characteristic of the Grant Land and Hazen formations and of the western exposures of Member B of the Svartevaeg Formation probably formed during the first event because they are absent from the Stallworthy Formation, which has a monoclinal structure. This is apparent from a diagrammatic cross section perpendicular to the structural trend (*Cape Stallworthy-Bukken Fiord*, cross section A-A′), but not from a photograph taken parallel to the structural trend (Fig. 19). Farther northeast, in the Svartevaeg Cliffs, Member B of the Svartevaeg Formation is less deformed because its structure there is controlled by the thick, massive, and mechanically competent volcanics of Member A. The complex structure of Member B in the southwestern area suggests either absence of Member A in the subsurface as a result of a facies change (Fig. 18), or a structural detachment at the top of that member.

Major thrust faults are common at the base of mechanically competent units, such as the Jaeger Lake and Svartevaeg volcanics and the Aurland Fiord carbonates. The age of most of these faults is uncertain, but the Svartevaeg and Aurland Fiord thrusts can probably be assigned to the second phase. The Svartevaeg Thrust places the Svartevaeg Formation upon the Stallworthy, and appears to be overlain by undisturbed strata of the Borup Fiord Formation, although the Svartevaeg-Borup Fiord contact is concealed. These relations indicate that the fault is younger than mid-Early Devonian and older than late Early Carboniferous. The Aurland Fiord Thrust places an extensive subhorizonatal sheet of the Aurland Fiord Formation upon the Grant Land and

Hazen formations. The fault is cut by unaltered mafic dykes of probable Cretaceous age that extend from the Aurland Fiord sheet into the adjacent Grant Land Formation. This indicates that the fault is probably no younger than Early Carboniferous because no thrust faulting occurred between Early Carboniferous and Cretaceous times. The Aurland Fiord Thrust sheet seems to overlie Late Devonian intrusions within the Grant Land Formation, but the contacts are not exposed or preserved (*Cape Stallworthy-Bukken Fiord*, inset E and cross section B-B′). If so, then a Late Devonian-Early Carboniferous age would be indicated for the thrust.

The Svartevaeg and Aurland Fiord thrust sheets were probably transported in opposite directions, the Svartevaeg sheet to the southwest and the Aurland Fiord sheet probably to the northeast. Opposing directions of transport may also be represented in the central part of the fold belt (Domain 4 of Figure 20), where the Greenstone Lake and Jaeger Lake thrusts verge southwest and the Eetookashoo Bay Thrust verges northeast, but the vergence at depth and age of these faults is uncertain. It is interesting to note that thrust faults with opposing directions of transport are also present in Carboniferous to Cretaceous strata of the Bunde Fiord-Bukken Fiord region of northwestern Axel Heiberg Island (Fischer, 1984, 1985, 1991). These thrusts, however, probably terminate above or within the Upper Carboniferous Otto Fiord evaporite.

Clements Markham Fold Belt and Pearya

Ages of deformation

A major deformation of the Clements Markham Fold Belt and Pearya is apparent from a high-angle unconformity at the base of the Sverdrup Basin fill. In the north coast region, the age of this deformation is bracketed by fossils of late Ludlow (or possibly Pridoli) and late Early Carboniferous (Viséan) ages.

The following isotopic evidence suggests that in Pearya and in the northwestern part of the Clements Markham Fold Belt the main phase of deformation occurred relatively early within this broad interval:

1. Muscovite from a metamorphic rock of the Kulutingwak Formation in the footwall of the Petersen Bay Fault Zone has been analyzed by the ^{40}Ar-^{39}Ar method. The sample has been affected by argon gain, but the emission spectrum suggests a cooling age no younger than 424 Ma, late Ludlow (Roddick *in* Trettin et al., 1992).
2. The Cape Woods Pluton, as mentioned, has yielded a sphene crystallization age of 390 ± 10 Ma. It lacks any kind of feature suggestive of a syntectonic origin, and its large size, massive internal structure, and roughly circular shape in plan, along with the low metamorphic grade of the host terrane strongly suggest a post-tectonic origin. If so, the tectonism that produced it probably was older than Eifelian. Inherited zircon has given an upper intercept age of 1360 ± 200 Ma, which indicates derivation from Succession 1 of Pearya. If the partial melting of this basement were caused by crustal thickening due to compression, then a certain delay between the thickening and the melting has to be taken into account. An "incubation period" of 10 to 40 million years (Patino Douce et al., 1990) would place the compressional deformation into the early Devonian or latest Silurian.

Farther southeast in the Clements Markham Fold Belt, the Silurian and older formations show tight and complex chevron folds (Klaper, 1992a, b) and underlie Sverdrup Basin strata with a high-angle unconformity, whereas the Okse Bay Formation is gently tilted and underlies the Sverdrup Basin fill with a low-angle unconformity (Fig. 163). Unfortunately, the base of the Okse Bay Formation and strata of latest Silurian to early Givetian age are not exposed. The contrast in structural style permits two different interpretations.

According to the first interpretation (Maurel, 1989; Mayr, 1992; Trettin 1991c), two deformations have taken place. The first occurred between Late Silurian and Givetian or Frasnian time and caused the tight folding of the Silurian and older units. It changed the mechanical properties of these strata in such a manner that, in the absence of advanced metamorphism, only faulting or broad and open folding were possible during later compressive events. A similar stabilization is apparent in those parts of the Hazen Fold Belt where Silurian and older strata are unconformably overlain by upper Paleozoic or Tertiary strata (Trettin, 1994, chapter 2). This deformation was followed by uplift, erosion, and deposition of another succession, incompletely represented by the Okse Bay Formation, that may range in age anywhere from latest Silurian to Late Devonian. The second deformation occurred between Late Devonian and late Early Carboniferous time and was approximately co-eval with the Ellesmerian Orogeny in the Central Ellesmere and Parry Islands fold belts. In the southeasternmost part of the Clements Markham Fold Belt it was characterized mainly by faulting, which caused the tilting of the Okse Bay Formation.

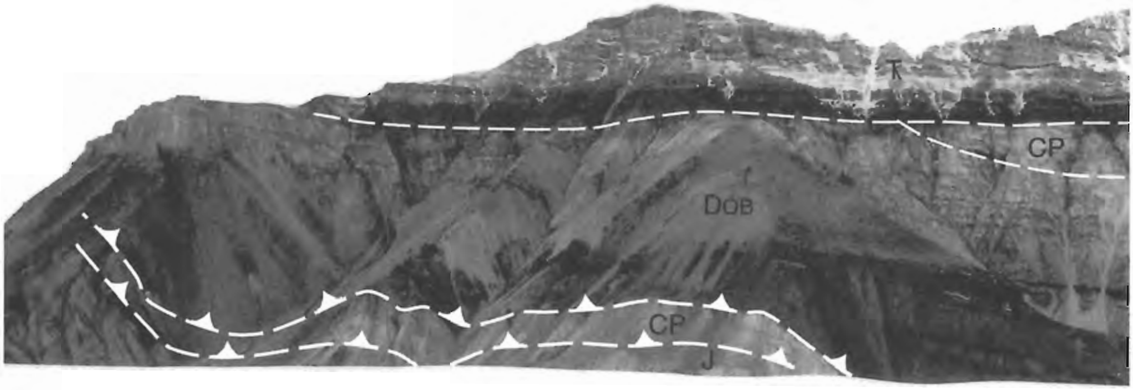


***Figure 163**. Low-angle unconformity between Devonian Okse Bay Formation* (DOB) *and upper Paleozoic* (CP) *and Triassic* (T) *units of the Sverdrup Basin in Yelverton Pass, about 38 km northwest of head of Tanquary Fiord, looking northwest. The Okse Bay Formation has been thrust over upper Paleozoic strata* (CP), *which in turn have been thrust over Jurassic strata* (J). *Based on work by U. Mayr (1992). ISPG photo 1505-7.*

On the other hand, it cannot be ruled out that only one event, the Ellesmerian Orogeny, which caused both the chevron folding of the Silurian and older formations and the tilting of the Okse Bay Formation has occurred. In this case, the contrast in structural style would reflect a structural detachment rather than an angular unconformity.

Structural features

In Northeast Pearya the Late Silurian-Early Carboniferous deformations resulted mainly in a reactivation of the diverse structural trends that were produced during Cambrian(?) rifting, the M'Clintock Orogeny, and later minor events. Deformation was relatively gentle in units of Successions 4 or 5 that directly overlie intensely deformed strata of the M'Clintock Orogen (Successions 2 and 3) in northwestern parts of the *M'Clintock Inlet* map area and near the head of M'Clintock Inlet (Figs. 111, 120, 126, 156, 157). Elsewhere units of Successions 4 and 5 are involved in complex folds and faults.

A complex structural history is apparent in the vicinity of the Petersen Bay Fault, which separates the Clements Markham Fold Belt from gneiss of Succession 1 of the Mitchell Point Belt. Three successive events are apparent there:

1. Folding of the Danish River Formation about west-northwest-striking axes.
2. A clockwise rotation of these trends on the southeastern side of the Petersen Bay Fault, probably caused by dextral motion of Central Pearya.
3. Southeastward thrusting of the heated crystalline basement of Pearya over the Clements Markham Fold Belt, which resulted in a southeastward diminishing Barrovian metamorphism of lower amphibolite to lower greenschist grade in the Kulutingwak and Danish River formations (Klaper and Ohta, 1992).

Possible evidence for dextral strike-slip has also been observed by Ohta (Ohta and Klaper, 1992; Ohta, 1994) in a fault block of schist that borders the Mitchell Point Belt in an area northeast of Phillips Inlet. There, measurements of schistosity and compositional layering indicate a major synform that postdates the schistosity. The axis of the fold plunges about 20° due south and, in plan, forms an intermediate angle with the southwest-striking Mitchell Point Fault Zone.

In the Kulutingwak Anticlinorium and vicinity two phases of folding along westerly trending axes and one phase of south-directed thrust faulting can be distinguished (Fig. 79; *Yelverton Inlet*, inset and cross section A-A'; Klaper, 1992a, figs. 5b, 7).

Farther southeast in the Clements Markham Fold Belt, a single event of chevron folding (Klaper, 1992a, b) occurred along axes that show a uniform, slightly arcuate, south-southwest trend, parallel to the trend of the adjacent Hazen Fold Belt.

MID-EARLY SILURIAN TO EARLY DEVONIAN HISTORY OF THE NORTHERN HEIBERG FOLD BELT: PRELIMINARY DISCUSSION OF PLATE-TECTONIC ASPECTS

Introduction

The preceding review indicates that the history of the Franklinian mobile belt terminated with an orogenic interval that extended from Late Silurian to Early Carboniferous and included two major phases of deformation and two phases of granitoid plutonism. Studies of other orogenic systems that are better known, such as the Caledonides, the North American Cordillera, or the Alps, have revealed a complex series of events that commonly involved more than two plates, and transcurrent as well as convergent motions. Events of comparable complexity probably occurred at the Franklinian continental margin, but are difficult to resolve there because of the poor preservation of the stratigraphic record during this interval, and the reconnaissance state of the present investigations. In view of these problems, a comprehensive plate-tectonic interpretation of the Late Silurian–Early Carboniferous events in the project area is not attempted here.

On the other hand, the available information is sufficient to interpret at least some aspects of the Late Silurian–Early Devonian deformation in the Northern Heiberg Fold Belt and the preceding late Early Silurian volcanism. Previous interpretations of the deformation were based mainly on analogies with the Boothia Uplift, discussed later. The present re-interpretation is based on new information about the Svartevaeg Formation, a re-evaluation of the Svartevaeg–Stallworthy unconformity, and well-known plate tectonic principles. Before discussing these aspects, it is necessary to consider the position of the Northern Heiberg Fold within a palispastically restored depositional framework of the Arctic Islands.

Palinspastic restoration: preliminary considerations

The Northern Heiberg Fold Belt now is at about the same latitude as the Clements Markham Fold Belt (Fig. 1a, b). The original relation of these two belts, however, must have been different because of the difference in structural trend (Figs. 1a, 164). The trends are southwest in the Clements Markham Fold Belt, but southeast in the Northern Heiberg Fold. Any reconstruction, therefore, must shift the Clements Markham Fold Belt to the northwest and must expand the Northern Heiberg Fold Belt in a southwestward direction, away from Nansen Sound, which separates the two sets of trends.

Unfortunately, a reliable palinspastic restoration is not feasible for two reasons: uncertainty about the precise amount of shortening in the various fold belts, and uncertainty about the structural significance of Nansen Sound. The marked differences in structural trend on either side of this deeply eroded seaway suggest that it may be underlain by a zone of crustal weakness. If so, dextral motion may have occurred there during regimes of southerly or southeasterly compression. The speculative reconstruction in Figure 165 is based on the following, more or less arbitrary assumptions:

1. An average shortening of 1.2:1 is assumed for the Central Ellesmere Fold Belt, based on a 1.37:1 shortening near the northern limit of the belt (line-length measurements along a contact within the Ninnis Glacier Syncline; *Lady Franklin Bay*, cross section A–A′) and no shortening at the southeastern limit of the fold belt.

2. An average shortening of 2:1 is assumed for the Hazen Fold Belt, based on line length measurements by Klaper (1990). This is a conservative estimate that does not take into account possible layer-parallel shortening and concealed thrust faulting.

3. Possible strike-slip under Nansen Sound is ignored.

As pointed out below, the Northern Heiberg Fold Belt and the Southeastern belt of the Clements Markham Fold Belt are similar in Early Cambrian or older to mid-Early Silurian stratigraphy and probably represent outermost parts of a continental margin. If these two belts together are used as a marker, then the Northern Heiberg Fold Belt is seen to lie on a segment of the continental margin that had a more southerly trend than the segment in northern Ellesmere Island. On a regional scale, this segment is sub-parallel to an important re-entrant in the central part of the Central Ellesmere Fold Belt that has a more southerly trend than adjacent segments on the east and west.

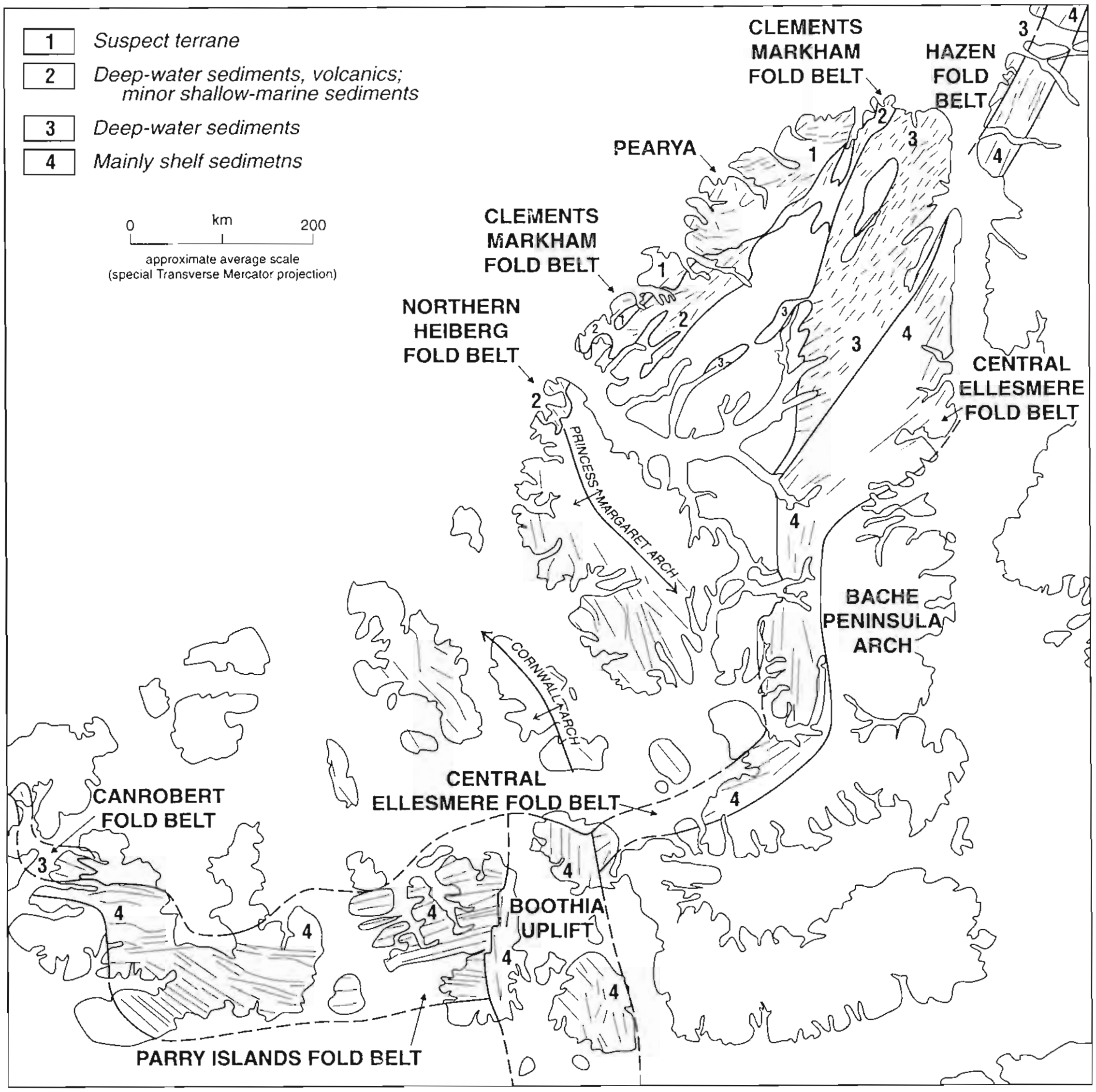


Figure 164. *Late Silurian–Early Carboniferous fold belts of the Arctic Islands and Pearya and their structural trends. Also shown are northwesterly structural trends and arches in the Sverdrup Basin that are aligned with Northern Heiberg Fold Belt and Boothia Uplift.*

Late Early Silurian volcanism

Member A of the Svartevaeg Formation is interpreted as a volcanic arc, developed on the northwestern margin of the North Amerian (Laurentian) plate (Fig. 166). The underlying succession probably includes not only the Hazen, Grant Land, Aurland Fiord, and Jaeger Lake formations, but also a concealed Proterozoic supracrustal succession and an extended and thinned Proterozoic or older crystalline basement (cf. Sobczak et al., 1991). At still greater depth, the continental margin was probably underlain by a subduction zone that dipped towards the continental interior. Member B of the Svartevaeg Formation is interpreted as a forearc deposit, laid down on the west side of the arc. The volcanic materials clearly were derived from the arc itself, but the chert and quartzite seem to have come from a westerly source, possibly a forearc ridge.

Late Silurian–Early Devonian deformation

Arc activity is commonly terminated by a collision that occurs when an element enters the trench that is difficult to subduct because it has a lower density and

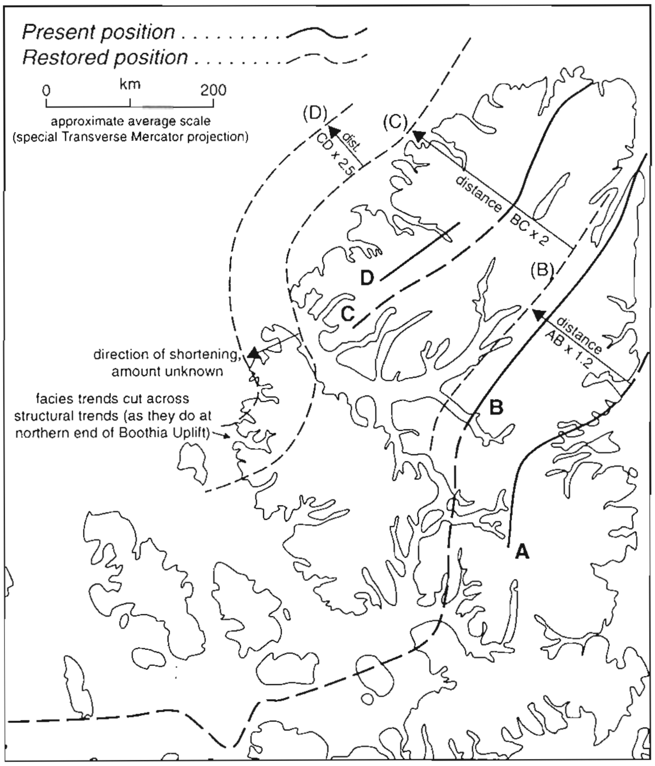


Figure 165. *Speculative palinspastic reconstruction, linking southeastern Clements Markham Fold Belt with Northern Heiberg Fold Belt.* ***A.*** *southeastern limit of Central Ellesmere Fold Belt;* ***B.*** *approximate position of shelf margin from late Early Cambrian to Middle Ordovician time;* ***C.*** *northwestern limit of Hazen Fold Belt;* ***D.*** *northwestern limit of Southeastern belt of Succession A of Clements Markham Fold Belt.*

greater thickness than normal oceanic crust (Cloos, 1993). The deformation caused by the collision may result in a high-angle unconformity at the top of the volcanic-sedimentary arc assemblage that is overlain by syntectonic clastic sediments. The unconformity between the Svartevaeg and Stallworthy formations probably originated in this manner.

In this type of collision, the orientation of the suture is normally controlled by that of the preceding subduction zone, so that the arc and its basement override the subducted plate (Dewey, 1977 and numerous other references). Thrust faulting along the subduction zone, or parallel to it, may be accompanied or followed by backthrusting in the distal part of the orogen. The model implies that in the present case the Northern Heiberg Fold Belt was thrust over the colliding plate. The initial collision occurs at the trench, which in modern settings generally lies within 100 to 300 km seaward of the arc (Hyndman and Hamilton, 1993). The exposures in northern Axel Heiberg Island probably represent a distal part of the inferred collisional orogen because the arc is exposed here. The overthrusting normally is accompanied by compressional uplift and followed by intermittent isostatic uplift of the thickened crust. The sediments produced by these movements are deposited in foredeeps or foreland basins on both sides of the orogen. The Stallworthy Formation probably represents part of the filling of a rapidly subsiding foreland basin developed on the northeast side of the orogen, and the quartz and chert of this formation were probably derived from uplifted strata of the Grant Land and Hazen formations closer to the collision site. The Svartevaeg-Stallworthy unconformity exposed northeast of Rens Fiord (Fig. 19; *Cape Stallworthy-Bukken Fiord*, cross section A-A′) represents the encroachment of the foreland basin onto the eroded orogen. Only a fraction of the syn- and post-tectonic sediments is preserved and exposed. Other parts have probably been eroded or are concealed under the Sverdrup Basin.

The following major problems remain unresolved by this very generalized interpretation:

1. The location and orientation of the trench associated with the postulated subduction zone.

2. The direction of approach of the overridden plate. The reconstructed setting of the Northern Heiberg Fold Belt, suggests an approach from a westerly or northwesterly direction. A northwest-southeast-directed compression could also explain the dextral slip of Central Pearya along the Petersen Bay Fault mentioned earlier.

3. The nature of the overidden plate. Was it an inactive arc, an oceanic plateau, a microcontinent or a larger continental fragment?

Relations with the Boothia Uplift

The Late Silurian–Early Devonian deformation of the Northern Heiberg Fold Belt seems to be related to movements of the Boothia Uplift with respect to age and structural trend, as follows.

Two phases of movements are recognized in the Boothia Uplift (Thorsteinsson, 1980; de Freitas and Mayr, 1992a, b). The first, limited to the southern part, occurred in latest Ludlow–early Pridoli time; the second, which affected the entire uplift, in late Lochkovian–early Pragian time. The movements of the

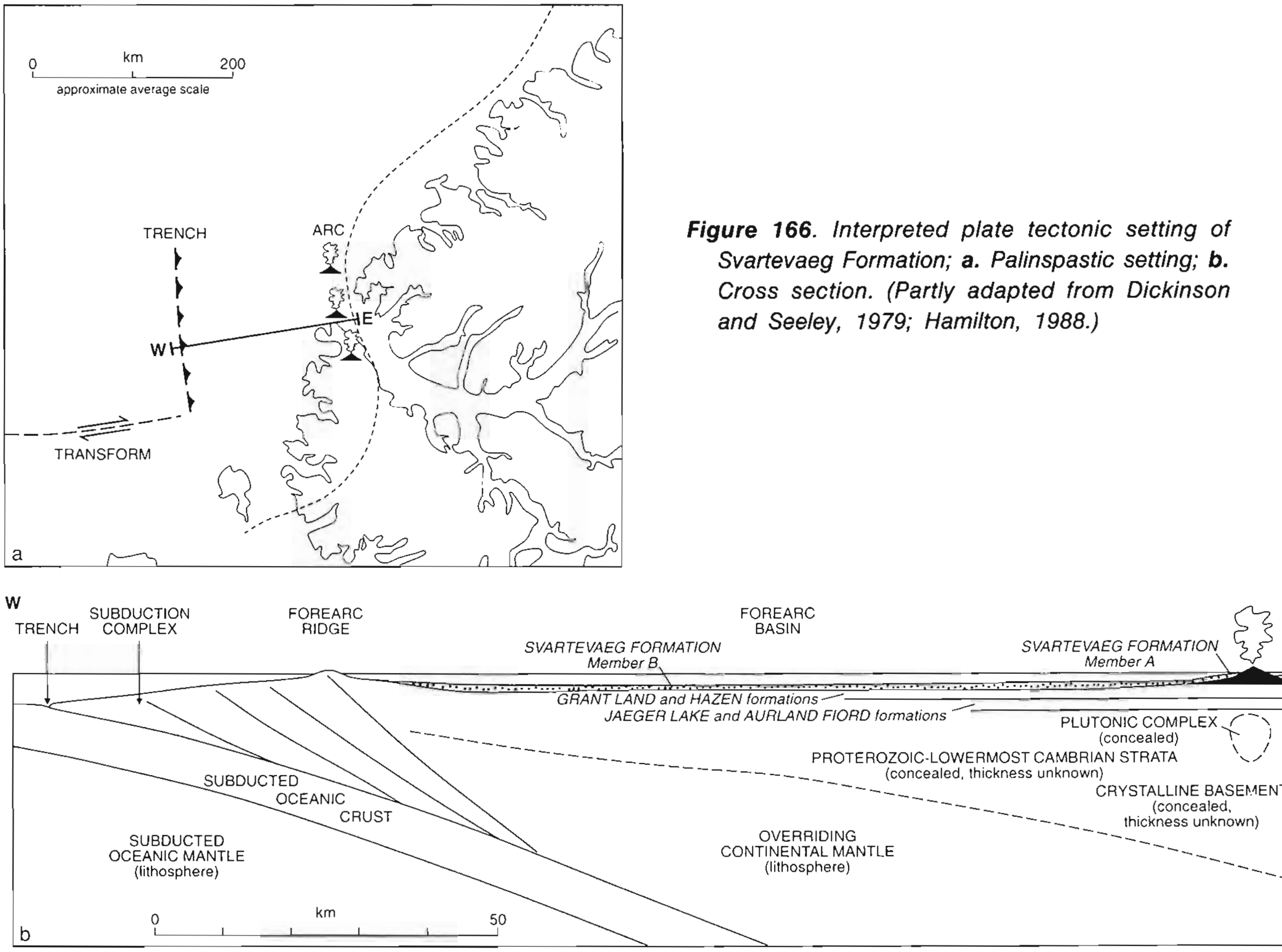


***Figure 166.** Interpreted plate tectonic setting of Svartevaeg Formation; **a.** Palinspastic setting; **b.** Cross section. (Partly adapted from Dickinson and Seeley, 1979; Hamilton, 1988.)*

Northern Heiberg Fold Belt took place between the latest Wenlock and the late Lochkovian or early Pragian, but have not been dated precisely.

Both areas form part of a large domain in the central part of the Arctic Islands characterized by southerly to southeasterly trends. Most of the domain is covered by strata of the Sverdrup Basin, but older rocks are exposed in the Northern Heiberg Fold Belt and in the Boothia Uplift (Fig. 164). In the Boothia Uplift, these trends are controlled by the foliation of the Precambrian crystalline basement, which strikes north and is perpendicular to the westerly trend of the Ordovician shelf margin. The southerly to southeasterly trends in the central parts of the Sverdrup Basin and in the Northern Heiberg Fold Belt may also reflect Precambrian basement structures that have been re-activated during the Late Silurian-Early Devonian deformation and later events, including the Eurekan Orogeny. Seismic refraction and gravity surveys support the concept that this part of the Arctic continental margin is underlain by a Precambrian crystalline basement contiguous with the basement of the Boothia Uplift (Sobczak et al., 1991). Moreoever, inherited zircon in Upper Devonian intrusions has yielded Paleoproterozoic upper intercept ages comparable to ages from the Boothia Uplift (Frisch and Hunt, 1993). However, the structural trends within this basement are unknown and it may be argued that the parallelism or alignment of structures is accidental.

The deep structure of the Boothia Uplift and the mechanism of deformation are uncertain. Two different hypotheses have been proposed that also have implications for the Northern Heiberg Fold Belt. An earlier hypothesis of mantle-controlled vertical movements suggested that the Boothia Uplift is bounded by faults that are vertical at depth but become outward-directed reverse faults at shallower crustal levels (Kerr and Christie, 1965; Kerr, 1977). The same concept was previously applied to the oldest part of the Northern Heiberg Fold Belt (Domains 4 and 5 of Chapter 2 and Fig. 20), which was referred to as the Rens Fiord Uplift (Trettin, 1973).

An alternative hypothesis of horizontal compression suggested east-dipping thrust faults that flatten at depth. This concept was first applied to the Boothia Uplift by Berkhout (1970, 1973) on the basis of gravity studies. It was revived by Miall (1983, 1986) on sedimentological grounds, and further developed by Okulitch and co-authors (1986). A more complex structure, which included transverse faults and a west-dipping thrust fault, has recently been inferred for the northernmost part of the uplift by de Freitas and Mayr (1992b). Their cross section is based on new sedimentological and structural information and on published gravity data.

The compressional interpretation raises the problem of the origin of the stresses. A possible relation with compression in the Caledonides has been considered by several authors (Trettin, 1963; Miall, 1986; Okulitch et al., 1986; de Freitas and Mayr, 1992b). Okulitch and co-authors (op. cit.) suggested that in the Arctic Islands this Caledonian compression affected areas with meridional Precambrian basement trends.

Deformations of such a large extent require a tectonic framework of almost global scale for an adequate understanding. For example, Mesozoic-Cenozoic orogenic events on the west side of North America cannot be understood without taking into consideration seafloor spreading in the Atlantic. Previous interpretations of the Late Silurian–Early Devonian deformations in the Arctic Islands have focussed exclusively on the Caledonides because this mountain belt was relatively well known and nothing was known about events on the northwest side of the Arctic Islands. The new information on the Silurian–Lower Devonian geology of northern Axel Heiberg Island permits a first glimpse in that direction. It suggests that the deformation of the Northern Heiberg Fold Belt was caused by the collision of an unknown plate with a segment of the Arctic continental margin that had a more meridional orientation than the segments on the east and west.

CHAPTER 6

ECONOMIC GEOLOGY

Geological considerations indicate the project area has the potential for a variety of mineral deposits. Features attractive for mineral exploration include: ultramafic, mafic, and granitoid intrusions of different compositions and ages; felsic to mafic volcanics of different origins and ages; a great variety of sedimentary rocks; innumerable faults; and a complex tectonic history. However, the area has been of little interest to industry because it is accessible only by aircraft or icebreaker, and because a National Park Reserve was established in its northeastern part in 1988 (Fig. 167). Apart from brief forays by a Petro-Canada field party in 1981, no mineral exploration has been carried out.

In the course of the present project, two small showings of metallic copper minerals and two malachite showings were discovered by the author, both inside and outside of the Park Reserve, in volcanic and carbonate strata of the Clements Markham Fold Belt and Pearya. The strata range in age from Early Cambrian or older to Late Silurian.

One metallic copper showing occurs in Member A of the Kulutingwak Formation in the fault-bounded structural high south of the Kulutingwak Anticlinorium (Fig. 167, loc. 1; *Yelverton Inlet*, inset, loc. Cu). The host rock is Caradoc in age and forms part of the Northwestern belt of Succession A of the Clements Markham Fold Belt (Chapter 3). A boulder of volcanic rock, which is nearly *in situ,* contains a veinlet, more than 15 cm long and 1.5 to 3.5 cm wide, composed mainly of chalcocite with minor bornite, malachite, and quartz. In addition to Cu, X-ray fluorescence analysis indicated trace amounts of Mn and Cr. Silver, if present at all, was below the detection limit.

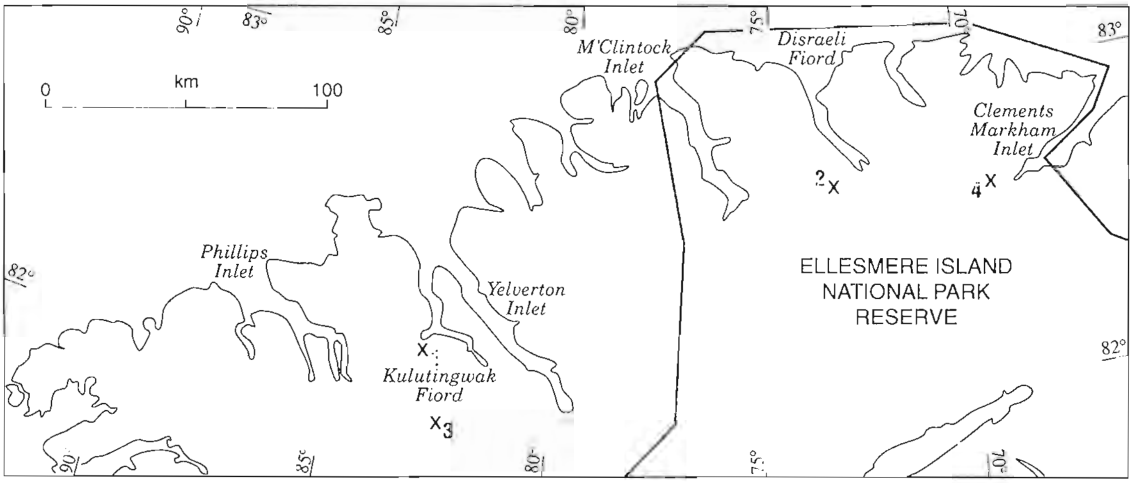


Figure 167. Economic mineral showings in the project area. 1: chalcocite in Kulutingwak Formation; 2: tennantite in Zebra Cliffs Formation; 3: malachite in Yelverton Formation; 4: malachite in Markham River Formation.

The other metallic showing occurs on the southern, fault-bounded flank of an anticline that exposes the Zebra Cliffs Formation in a small area north of Thores River (Fig. 167, loc. 2; *M'Clintock Inlet*, inset D). The host rock is Ashgill in age and belongs to Succession 5A of Pearya (Chapter 4). The surrounding area is covered mainly by the Lorimer Ridge Formation. When discovered (Trettin, 1981), the surface of the deposit, no more than few tens of metres in diameter, was strewn with rubble of dolostone weathered *in situ* that contained scattered crystals, or lumps or crystals, of tennantite, surrounded by haloes of malachite and minor azurite. Most of this material has since been removed, but representative samples are curated at the Geological Survey of Canada, Calgary. The samples collected contain trace amounts to an estimated 5 to 10 per cent by volume of tennantite. The crystals are euhedral, mostly tetrahedral (Fig. 168), and vary in edge length from 0.7 mm to about 3 cm. Semiquantitative X-ray fluorescence analysis indicates that, in addition to Cu, Fe, As, Sb and S contents characteristic of this mineral, it includes trace amounts (<0.1%) of Ag and Cd. Dolomitization of the host limestone and introduction of quartz preceded the crystallization of the tennantite, which contains inclusions of these two minerals.

Malachite is common in volcanics of the Yelverton Formation in the vicinity of the section southeast of Yelverton Inlet (Fig. 167, loc. 3; *Otto Fiord* section SEYI). The Yelverton Formation is Early Cambrian or older in age and forms the oldest unit of the Southwestern belt of Succession A of the Clements Markham Fold Belt (Chapter 3). Chemical analyses of volcanic rocks from this area show up to 1000 ppm Cu (Appendix 4A, Table 2-5).

Malachite is also common in dolostone of the Markham River Formation northeast of the section north of Markham River (Fig. 167, loc. 4; *Clements Markham Inlet–Robeson Channel*, NMR). The host rock is Ludlow in age and belongs to Succession B of the Clements Markham Fold Belt (Chapter 3).

Because of the intense deformation and generally high degree of organic metamorphism, the petroleum potential of study area is negligible.

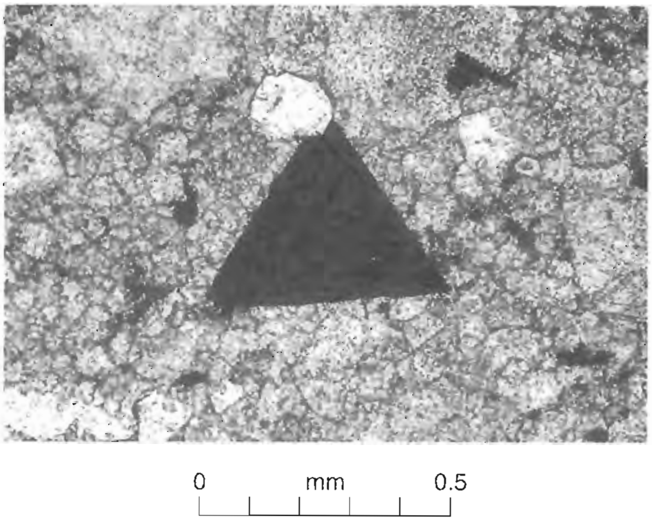


Figure 168. Photomicrograph (ordinary light) of tennantite from Zebra Cliffs Formation, displaying characteristic tetrahedral habit, in matrix of quartz (Q) and dolomite. ISPG photo 1506-6.

REFERENCES

Aitken, J.D.
1991: The Ice Brook Formation and post-Rapitan, Late Proterozoic glaciation, Mackenzie Mountains, Northwest Territories. Geological Survey of Canada, Bulletin 404, 43 p.

Aldridge, R.J.
1972: Llandovery conodonts from the Welsh Borderland. Bulletin of the British Museum (Natural History) Geology, v. 22, p. 125-231.

1975: The stratigraphic distribution of conodonts in the British Silurian. Journal of the Geological Society [London], v. 131, p. 607-618.

Andréasson, P.G.
1994: The Baltoscandian margin in Neoproterozoic-early Palaeozoic times. Some constraints on terrane derivation and accretion in the Arctic Scandinavian Caledonides. Tectonophysics, v. 231, p. 1-32.

Assereto, R.L.A.M. and Kendall, C.G.St.C.
1977: Nature, origin and classification of peritidal tepee structures and related breccias. Sedimentology, v. 24, p. 153-210.

Baker, P.E.
1982: Evolution and classification of orogenic volcanic rocks. *In* Andesites, R.S. Thorpe (ed.). John Wiley and Sons, p. 11-23.

Bally, A.W., Scotese, C.R., and Ross, M.I.
1989: North America; plate-tectonic setting and tectonic elements. *In* The Geology of North America; an Overview, A.W. Bally and A.R. Palmer (eds.). Geological Society of America, The Geology of North America, v. A, p. 1-15.

Bamber, E.W., Henderson, C.M., Richards, B.C., and McGugan, A.
1992: Carboniferous and Permian stratigraphy of the Foreland Belt. *In* Geology of the Cordilleran Orogen in Canada, H. Gabrielse, and C.J. Yorath (ed.). Geological Survey of Canada, The Geology of Canada, no. 4 (also Geological Society of America, The Geology of North America, v. G-2), p. 242-265.

Barbarin, B.
1990: Granitoids: main petrogenetic classifications in relation to origin and tectonic setting. Geological Journal, v. 25, p. 227-238.

Barnes, C.R.
1977: Ordovician conodonts from the Ship Point and Bad Cache Rapids formations, Melville Peninsula, southeastern District of Franklin. *In* Geology of Ordovician rocks, Melville Peninsula and region, southeastern District of Franklin, Geological Survey of Canada, Bulletin 269, p. 99-119.

Beard, J.S.
1986: Characteristic mineralogy of arc-related cumulate gabbros: implications for the tectonic setting of gabbroic plutons and for andesite genesis. Geology, v. 14, p. 848-851.

Beauchamp, B., Harrison, J.C., and Henderson, C.M.
1989: Upper Paleozoic stratigraphy and basin analysis of the Sverdrup Basin, Canadian Arctic Archipelago: Part 1, time frame and tectonic evolution. *In* Current Research, Part G. Geological Survey of Canada, Paper 89-1G, p. 105-113.

Berkhout, A.W.J.
1970: The gravity anomaly field of Prince of Wales, Somerset and northern Baffin islands, District of Franklin, Northwest Territories. Publications of the Dominion Observatory, v. 39, no. 7, p. 179-209.

1973: Gravity in the Prince of Wales, Somerset and northern Baffin islands region. *In* Proceedings of the Symposium on the Geology of the Canadian Arctic, J.D. Aitken and D.J. Glass (eds.). Geological Association of Canada and Canadian Society of Petroleum Geologists, p. 63-80.

Bernard-Griffiths, J., Peucat, J.J., and Ohta, Y.
1993: Age and nature of protoliths in the Caledonian blueschist-eclogite complex of western Spitsbergen: a combined approach using U-Pb, Sm-Nd, and REE whole-rock systems. Lithos, p. 81-90.

Bernoulli, D. and Weissert, H.
1985: Sedimentary fabrics in Alpine ophicalcites, South Pennine Arosa zone, Switzerland. Geology, v. 13, p. 755-758.

Bjornerud, M.
1989: Structural transects in northwestern Ellesmere Island. *In* Current Research, Part G. Geological Survey of Canada, Paper 89-1G, p. 125-131.

1991: Structural evolution of the Kulutingwak zone, northwestern Ellesmere Island, Northwest Territories: the northern edge of Paleozoic North America? *In* Current Research, Part E. Geological Survey of Canada, Paper 91-1E, p. 187-195.

Bjornerud, M.G. and Bradley, D.C.
1994: Silurian foredeep and accretionary prism in northern Ellesmere Island: implications for the nature of the Ellesmerian orogeny. *In* Proceedings International Conference on Arctic Margins 1992, D.K. Thurston and K. Fujita (eds.). U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, Alaska, p. 129-133.

Bjornerud, M., Decker, P.L., and Craddock, C.
1991: Reconsidering Caledonian deformation in southwest Spitsbergen. Tectonics, v. 10, p. 171-190.

Blackadar, R.G.
1954: Geological reconnaissance of the north coast of Ellesmere Island, Arctic Archipelago, Northwest Territories. Geological Survey of Canada, Paper 53-10, 22 p.

1960: The age of the metamorphic complex of northernmost Ellesmere Island. Arctic, v. 13, p. 51-52.

Bluck, B.J., Halliday, A.N., Aftalion, M., and Macintyre, R.M.
1980: Age and origin of Ballantrae ophiolite and its significance to the Caledonian Orogeny and Ordovician time scale. Geology, v. 8, p. 492-495.

Bolton, T.E. and Nowlan, G.S.
1979: A Late Ordovician fossil assemblage from an outlier north of Aberdeen Lake, District of Keewatin. *In* Contributions to Canadian Paleontology, Geological Survey of Canada Bulletin 321, p. 1-6, 137 p.

Boucot, A.J. and Johnson, J.G.
1979: Pentamerinae (Silurian Brachiopoda). Palaeontographica, Abt. A, v. 163, no. 4-6, p. 87-129.

Bourque, P.A., Mamet, B., and Roux, A.
1981: Algues siluriennes du synclinorium de La Baie de Chaleurs, Québec, Canada. Revue de Micropaléontologie, v. 24, p. 83-126.

Bowring, S.A., Grotzinger, J.P., Isachsen, C.E., Knoll, A.H., Pelechaty, S.M., and Kolosov, P.
1993: Calibrating rates of Early Cambrian evolution. Science, v. 261, p. 1293-1298.

Brewer, T.S. and Atkin, B.P.
1989: Elemental mobilities produced by low-grade metamorphic events. A case study from the Proterozoic subcrustals of Norway. Precambrian Research, v. 45, p. 143-158.

Brooke, C. and Riding, R.
1987: A new look at the Solenoporaceae. Fourth International Symposium on Fossil Algae, Cardiff, July, 1987, Abstracts, p. 7.

Burns, L.E.
1985: The Border Ranges ultramafic and mafic complex, south-central Alaska: cumulate fractionates of island-arc volcanics. Canadian Journal of Earth Sciences, v. 22, p. 1020-1038.

Caby, R., Dupuy, C., and Dostal, J.
1987: The very beginning of the Ligurian Tethys: petrological and geochemical evidence from the oldest ultramafit-derived sediments in Queyras, Western Alps. Eclogae Geologicae Helveticae, v. 80, p. 223-240.

Chafetz, H.S. and Folk, R.L.
1984: Travertines: depositional morphology and the bacterially constructed constituents. Journal of Sedimentary Petrology, v. 54, p. 289-316.

Churkin, M.J., Jr. and Trexler, J.H., Jr.
1980: Circum-Arctic plate accretion - isolating part of a Pacific Plate to form the nucleus of the Arctic Basin. Earth and Planetary Science Letters, v. 48, p. 356-362.

Christie, R.L.
1957: Geological reconnaissance of the north coast of Ellesmere Island, District of Franklin, Northwest Territories. Geological Survey of Canada, Paper 56-9, 40 p.

1964: Geological reconnaissance of northeastern Ellesmere Island, District of Franklin (120, 340, parts of). Geological Survey of Canada, Memoir 331, 79 p.

Claoué-Long, J.C., Jones, P.J., Roberts, J., and Maxell, S.
1992: The numerical age of the Devonian-Carboniferous boundary. Geological Magazine, v. 129, p. 281-291.

Cloos, M.
1993: Lithospheric buoyancy and collisional orogenesis: Subduction of oceanic plateaus, continental margins, island arcs, spreading ridges, and seamounts. Geological Society of America, Bulletin, v. 105, p. 715-737.

Cocks, L.R.M., Holland, C.H., Richards, R.B., and Strachan, I.
1971a: A correlation of Silurian rocks in the British Isles. Journal of the Geological Society [London], v. 127, p. 103-136.

Cocks, L.R.M., Toghill, P., and Ziegler, A.M.
1971b: Stage names within the Llandovery Series. Geological Magazine, v. 107, p. 79-87.

Coleman, R.G.
1977: Ophiolites - ancient oceanic lithosphere? Springer Verlag, Berlin, Federal Republic Germany, 229 p.

Compston, W. and Williams, I.S.
1992: Ion probe ages for the British Ordovician and Silurian stratotypes. *In* Global Perspectives on Ordovician Geology, B.D. Webby and J.R. Laurie (eds.). Balkema, Rotterdam, p. 59-67.

Compston, W., Williams, I.S., Kirschvink, J.L., Zhang Zichao, and Mao Guogan
1992: Zircon U-Pb ages for the Early Cambrian time-scale. Journal of the Geological Society [London], v. 149, p. 171-184.

Condie, K.C. and Rosen, O.M.
1994: Laurentia-Siberia connection revisited. Geology, v. 22, p. 168-170.

Coney, P.J., Jones, D.L., and Monger, J.W.H.
1980: Cordilleran suspect terranes. Nature, v. 288, p. 329-333.

Cooper, G.A.
1956: Chazyan and related brachiopods. Smithsonian Miscellaneous Collection, v. 127, two parts, 1245 p.

Cooper, R.A.
1992: A relative time scale for the early Ordovician derived from depositional rates of graptolitic shales. *In* Global Perspectives on Ordovician Geology, B.D. Webby and J.R. Laurie (eds.). Balkema, Rotterdam, p. 3-20.

Dallmeyer, R.D., Johansson, L., and Möller, C.
1992: Chronology of Caledonian high-pressure granulite-facies metamorphism, uplift, and deformation within northern parts of the Western Gneiss Region, Norway. Geological Society of America, Bulletin, v. 104, p. 444-455.

Dallmeyer, R.D., Peucat, J.-J., Hirajama, T., and Ohta, Y.
1990: Tectonothermal chronology within a blueschist-eclogite complex, west-central Spitsbergen, Svalbard: evidence from $^{40}Ar/^{39}Ar$ and Rb-Sr mineral ages. Lithos, v. 24, p. 291-304.

Dalziel, I.W.D.
1992: On the organization of American plates in the Neoproterozoic and the breakout of Laurentia. GSA Today, v. 2, p. 237, 240-241.

Dalziel, I.W.D., Dalla Salda, L.H., and Gahagan, L.M.
1994: Paleozoic Laurentia-Gondwana interaction and the origin of the Appalachian-Andean mountain system. Geological Society of America, Bulletin, v. 106, p. 243-252.

Davies, G.R. and Nassichuk, W.W.
1991: Carboniferous and Permian history of the Sverdrup Basin, Arctic Islands. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, Geology of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 13 (1992).

Davis, J.M., Elston, W.E., and Hawkesworth, C.J.
1993: Basic and intermediate volcanism of the Mogollon-Datil volcanic field: implications for mid-Tertiary tectonic transitions in southwestern New Mexico, USA. *In* Magmatic Processes and Plate Tectonics, H.M. Prichard, T. Alabaster, N.B.W. Harris, and C.R. Neary (eds.). Geological Society [London] Special Publication no. 76, p. 469-488.

de Freitas, T.A.
1991a: Stratigraphy, mud buildups, and carbonate platform development of the Upper Ordovician to Lower Devonian sequence, Ellesmere, Hans, and Devon islands, Arctic Canada. Unpublished Ph.D. thesis, Ottawa-Carlton Geoscience Centre and University of Ottawa, Ottawa, Ontario, 431 p.

1991b: Ludlow (Silurian) lithistid and hexactinellid sponges, Cape Phillips Formation, Canadian Arctic. Canadian Journal of Earth Sciences, v. 28, p. 2042-2061.

de Freitas, T. and Mayr, U.
1992a: The middle Paleozoic sequence of northern Devon Island, Northwest Territories. *In* Current Research, Part B. Geological Survey of Canada, Paper 92-1B, p. 53-63.

1992b: Middle Paleozoic tear faulting, basin development, and basement uplift, central Canadian Arctic. Canadian Journal of Earth Sciences, v. 30, p. 603-620.

Dewey, J.F.
1977: Suture zone complexities: a review. Tectonophysics, v. 40, p. 53-67.

Dewey, J.F. and Ryan, P.D.
1990: The Ordovician evolution of the South Mayo Trough, western Ireland. Tectonics, v. 9, p. 887-901

Dewey, J.F. and Shackleton, M.
1984: A model for the evolution of the Grampian tract in the early Caledonides and Appalachians. Nature, v. 312, p. 115-121.

Dickinson, W.R. and Seely, D.R.
1979: Structure and stratigraphy of forearc regions. American Association of Petroleum Geologists, Bulletin, v. 63, p. 2-31.

Dillon, J.T., Pessel, G.H., Chen, J.H., and Veach, N.C.
1980: Middle Paleozoic magmatism and orogenesis in the Brooks Range, Alaska. Geology, v. 8, p. 338-343.

Dillon, J.T., Tilton, G.R., Decker, J., and Kelly, M.J.
1987: Resource implications of magmatic and metamorphic ages for Devonian igneous rocks in the Brooks Range. *In* Alaskan North Slope Geology, I. Taileur, and P. Weimer (eds.). The Pacific Section, Society of Economic Paleontologists and Mineralogists, Bakersfield California and The Alaska Geological Society, Anchorage, Alaska, v. 1, p. 713-723.

Drummond, J.M.
1963: Carbonates and grade size. Bulletin of Canadian Petroleum Geology, v. 11, p. 33-53.

Dumoulin, J.A. and Harris, A.G.
1992: Pre-Carboniferous carbonate sequences of the Seward Peninsula and western and central Brooks Range, northern Alaska. International Conference on Arctic Margins, Anchorage, Alaska, September 2-4, 1992, ICAM Abstracts, p. 15.

Dunning, G.R. and Krogh, T.E.
1985: Geochronology of ophiolites of the Newfoundland Appalachians. Canadian Journal of Earth Sciences, v. 22, p. 1659-1670.

Dunning, G.R. and Pedersen, R.B.
1988: U/Pb ages of ophiolites and arc-related plutons of the Norwegian Caledonides: implications for the development of Iapetus. Contributions to Mineralogy and Petrology, v. 98, p. 13-23.

Embry, A.F.
1991: Mesozoic history of the Arctic Islands. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, Geology of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 14.

Embry, A.F. and Osadetz, K.G.
1988: Stratigraphy and tectonic significance of Cretaceous volcanism in the Queen Elizabeth Islands, Canadian Arctic Archipelago. Canadian Journal of Earth Sciences, v. 25, p. 1209-1219.

Epstein, A.G., Epstein, J.B., and Harris, L.D.
1977: Conodont color alteration - an index to organic metamorphism. U.S. Geological Survey, Professional Paper 995, 27 p.

Erzinger, J.
1989: Chemical alteration of the oceanic crust. Geologische Rundschau, v. 78, p. 731-740.

Escher, J.C. and Larsen, P.-H.
1987: The buried western extension of the Navarana Fjord escarpment in central and western North Greenland. *In* Grønlands Geologiske Undersøgelse, Rapport nr. 133, p. 81-89.

Fairchild, I.J., Hambrey, M.J., Spiro, B., and Jefferson, T.H.
1989: Late Proterozoic glacial carbonates in northeast Spitsbergen: new insights into the carbonate-tillite association. Geological Magazine, v. 126, p. 469-490.

Feilden, H.E. and De Rance, C.E.
1878: Geology of the coasts of the Arctic lands visited by the late British expedition under Captain Sir George Nares, R.N., K.C.B., F.R.S. The Quarterly Journal of the Geological Society [London], v. 34, p. 556-567.

Fischer, B.F.G.
1984: Stratigraphy and structural geology of the region surrounding Bunde and Bukken fiords, Axel Heiberg Island, Canadian Arctic. *In* Current Research, Part B. Geological Survey of Canada, Paper 84-1B, p. 309-314.

1985: The geology of the area surrounding Bunde and Bukken fiords, northwestern Axel Heiberg Island, Canadian Arctic Archipelago. Unpub. M.Sc. thesis, The University of Calgary, Department of Geology and Geophysics, 114 p.

1991: Structural cross-sections, northwestern Axel Heiberg Island. Figure 3E *In* H.P. Trettin (ed.). Geological Survey of Canada, Geology of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E) [portfolio].

Folk, R.L.
1959: Practical petrographic classification of limestones. Bulletin of the American Association of Petroleum Geologists, v. 43, p. 1-38.

Folk, R.L. and McBride, E.F.
1978: Radiolarites and their relation to subjacent oceanic crust in Liguria, Italy. Journal of Sedimentary Petrology, v. 48, p. 1069-1102.

Fordham, B.G.
1992: Chronometric calibration of mid-Ordovician to Tournaisian conodont zones: a compilation from recent graphic-correlation and isotope studies. Geological Magazine, v. 129, p. 709-721.

Fricker, P.E. and Trettin, H.P.
1962: Pre-Mississippian succession of northernmost Axel Heiberg Island, District of Franklin. Geological Survey of Canada, Paper 62-18, 24 p.

Frisch, T.
1974: Metamorphic and plutonic rocks of northernmost Ellesmere Island, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 229, 87 p.

1976: Igneous and metamorphic rocks, northern Ellesmere Island. *In* Report of Activities, Part A. Geological Survey of Canada, Paper 76-1A, p. 429-430.

Frisch, T. and Hunt, P.
1993: Reconnaissance U-Pb geochronology of the crystalline core of the Boothia Uplift, District of Franklin, Northwest Territories. *In* Radiogenic Age and Isotopic Studies,Report 7. Geological Survey of Canada, Paper 93-2, p. 3-22.

Frisch, T. and Trettin, H.P.
1991: Precambrian successions in the northernmost part of the Canadian Shield. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 6 (1992).

Fryer, P. and Fryer, G.J.
1987: Origins of nonvolcanic seamounts in a forearc environment. *In* Seamounts, Islands, and Atolls, B.H. Keating, P. Fryer, R. Batiza, and G.W. Boehlert (eds.). American Geophysical Union, Geophysical Monograph Series, v. 63, p. 61-72.

Fryer, P. Pearce, J.A., Stokking, L.A. et al.
1990a: 15. Summary of results from Leg 125. Proceedings of the Ocean Drilling Program, Initial Reports, v. 125, p. 367-380

Fryer, P., Saboda, K.L., Johnson, L.E., Mackay, M.E., Moore, G.F., and Stoffers, P.
1990b: 4. Conical Seamount: SeaMARC II, *Alvin* submersible, and seismic-reflection studies.. *In* Proceedings of the Ocean Drilling Program, P. Fryer, J.A. Pearce, L.B. Stokking et al. Initial Reports, v. 125, p. 69-80.

Furnes, H., Ryan, P.D., Grenne, T., Roberts, D., Sturt, B.A., and Prestvik, T.
1985: Geological and geochemical classification of the ophiolitic fragments in the Scandinavian Caledonides. *In* The Caledonide Orogen - Scandinavia and related areas, D. Gee and B.A. Sturt (eds.). John Wiley and Sons, Chichester, England, p. 657-669.

Gabrielse, H. and Campbell, R.B.
1992: Upper Proterozoic assemblages. *In* Geology of the Cordilleran Orogen in Canada, H. Gabrielse and C.J. Yorath (eds.), Geological Survey of Canada, The Geology of Canada, no. 4 (also Geological Society of America, The Geology of North America, v. G-2), Chapter 6, p. 127-150.

Gee, D.G., Johansson, A., Ohta, Y., Tebenkov, A.M., Krasil'schiikov, A.A., Balashov, Y.A., Larionov, A.N., Gamnibal, L.F., Ryungenen, G.
1994: Grenvillian basement and a major unconformity within the Caledonides of Nordaustlandet, Svalbard. Precambrian Research, v. 70, p. 215-234.

Gee, D.G. and Page, L.M.
1994: Caledonian terrane assembly on Svalbard: new evidence from ^{40}Ar-^{39}Ar dating in Ny Friesland. American Journal of Science, v. 294, p. 1166-1186.

Gee, D.G., Schouenborg, B., Peucat, J.-J., Abakumov, S.A., Krasil'scikov, A., and Tebenkov, A.
1992: New evidence of basement in the Svalbard Caledonides: Early Proterozoic zircon ages from Ny Friesland granites. Norsk Geologisk Tidsskrift, v. 72, p. 181-190.

Glaessner, M.F.
1979: Precambrian. A. Introduction. *In* Treatise on Invertebrate Paleontology, R.A. Robison and C. Teichert (eds.). Geological Society of America and University of Kansas Press, Lawrence, Kansas, p. A79-A118.

Goddard, E.N., Trask, P.D., De Ford, R.K., Rove, O.N., Singewald, J.T. Jr., and Overbeck, R.M.
1963: Rock-color chart. Geological Society of America.

Gorbatschev, R.
1985: Precambrian basement of the Scandinavian Caledonides. *In* The Caledonide Orogen - Scandinavia and Related Areas, D.G. Gee and B.A. Sturt (eds.). John Wiley and Sons, Chichester, U.K., p. 197-212.

Gower, C.F.
1990: Mid-Proterozoic evolution of the eastern Grenville Province, Canada. Geologiska Föreningens i Stockholm Förhandlingar, v. 112, Pt. 2, p. 127-139.

Gradstein, F.M, Agterberg, F.P., Ogg, J.G., Hardenbol, J., van Veen, P., Thierry, J., and Huang, Z.
1994: A Mesozoic time scale. Journal of Geophysical Research, v. 99, p. 24,051-24,074.

Greenough, J.D. and Papezik, V.S.
1986: Acado-Baltic volcanism in eastern North America and western Europe: implications for Cambrian tectonism. Maritime Sediments and Atlantic Geology, v. 22, p. 240-251.

Guilbault, J.P. and Mamet, B.L.
1976: Codiacées (Algues) ordoviciennes des Basses-Terres du Saint-Laurent. Canadian Journal of Earth Sciences, v. 13, p. 636-660.

Hajcak, C.A.
1992: Pre-and post-lithification sructures in a Silurian accretionary prism, northern Ellesmere Island, Arctic Canada. Unpublished M.Sc. thesis, Department of Geology, Miami University, Oxford, Ohio, 75 p.

Hambrey, M.J. and Spencer, A.M.
1987: Late Precambrian glaciation of central East Greenland. Meddelelser om Grønland, Geoscience 19-1987, 50 p.

Hamilton, W.B.
1988: Plate tectonics and island arcs. Geological Society of America, Bulletin, v. 100, p. 1503-1527.

Harland, W.B.
1969: Contribution of Spitsbergen to understanding of tectonic evolution of North Atlantic region. *In* North Atlantic-geology and continental drift, a symposium, M. Kay (ed.). American Association of Petroleum Geologists, Memoir 12, p. 817-851.

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G.
1990: A geologic time scale 1989. Cambridge University Press, 263 p.

Harland, W.B., Cox, A.V., Llewellyn, P.G., Pickton, C.A.G., Smith, A.G., and Walters, A.R.
1982: A geologic time scale. Cambridge University Press, Cambridge, United Kingdom, 131 p.

Harland, W.B., Hambrey, M.J., and Waddams, P.
1993: Vendian Geology of Svalbard. Norsk Polarinstitutt Skrifter no. 193, 150 p.

Harland, W.B., Scott, R.A., Auckland, K.A., and Snape, I.
1992: The Ny Friesland Orogen, Spitsbergen. Geological Magazine, v. 129, p. 679-708.

Harland, W.B. and Wright, N.J.R.
1979: Alternative hypothesis for the pre-Carboniferous evolution of Svalbard. Saertrykk av Polarinstitutt, Skrifter no. 167, p. 90-117.

Harris, D.H.M.
1993: The Caledonian evolution of the Laurentian margin in western Ireland. Journal of the Geological Society [London], v. 150, p. 669-672.

Harrison, J.C.
1995: Melville Island's salt-based fold belt, Arctic Canada. Geological Survey of Canada, Bulletin 472, 331 p.

Harrison, J.C., Fox, F.G., and Okulitch, A.V.
1991: Late Devonian-Early Carboniferous deformation of the Parry Islands and Canrobert Hills fold belts, Bathurst and Melville islands. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, Geology of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 12G (1992).

Harrison, T.M., Duncan, I., and McDougall, I.
1985: Diffusion of ^{40}Ar in biotite: temperature, pressure, and compositional effects. Geochimica et Cosmochimica Acta, v. 49, p. 2461-2468.

Hartman, W.D., Wendt, J.W., and Wiedenmayer, F.
1980: Living and fossil sponges. Sedimenta, v. 8, 274 p.

Heaman, L.M., LeCheminant, A.N., and Rainbird, R.H.
1992: Nature and timing of Franklin igneous events, Canada: implications for a Late Proterozoic mantle plume and the break-up of Laurentia. Earth and Planetary Science Letters, v. 109, p. 117-131.

Henry, A.S.
1991: The petrochemistry and origin of the Bourne Complex, northwestern Ellesmere Island, Canada. Unpublished B.Sc., Honours, thesis, Department of Geology, Dalhousie University, Halifax, Nova Scotia, 120 p.

Héroux, Y., Hubert, C., Mamet, B., and Roux, A.
1977: Algues siluriennes de la Formation de Sayabec (Lac Matapédia, Québec). Canadian Journal of Earth Sciences, v. 14, p. 2865-2908.

Hesse, R., Chough, S.K., and Rakofsky, A.
1987: Northwest Atlantic Mid-Ocean Channel of the Labrador Sea. V. Sedimentology of a giant deep-sea channel. Canadian Journal of Earth Sciences, v. 24, p. 1595-1624.

Higgins, A.K.
1988: The Krummedal supracrustal sequence in East Greenland. *In* Later Proterozoic Stratigraphy of the Northern Atlantic Regions, J.A. Winchester (ed.). Blackie, Glasgow and London, U.K. and Chapman and Hall, New York, U.S.A., p. 86-96.

Higgins, A.K., Ineson, J.R., Peel, J.S., Surlyk, F., and Sonderholm, M.
1991a: Cambrian to Silurian basin development and sedimentation, North Greenland. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and

Greenland, H.P. Trettin (ed.). Geological Survey of Canada, Geology of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 7.

Higgins, A.K., Ineson, J.R., Peel, J.S., Surlyk, F., and Sonderholm, M.
1991b: Lower Palaeozoic Franklinian Basin of North Greenland. *In* Sedimentary Basins of North Greenland, J.S. Peel and M. Sonderholm (eds.). Grønland Geologiske Undersøgelse, Bulletin 160, p. 71-139.

Higgins, A.K. and Soper, N.J.
1983: The Lake Hazen fault zone: a transpressional upthrust? *In* Current Research, Part B. Geological Survey of Canada, Paper 83-1B, p. 215-221.

1985: Cambrian-Lower Silurian slope and basin stratigraphy between northern Nyboe Land and western Amundsen Land, North Greenland. Grønlands Geologiske Undersøgelse, Rapport no. 126, p. 79-86.

Hoffman, P.F.
1989: Precambrian geology and tectonic history of North America. *In* The Geology of North America - an Overview, A.W. Bally and A.R. Palmer (eds.). Geological Society of America, The Geology of North America, v. A, p. 447-512.

1991: Did the breakout of Laurentia turn Gondwanaland inside-out? Science, v. 252, p. 1409-1412.

Hofmann, H.J., Cecile, M.P., and Lane, L.S.
1994: New occurrences of *Oldhamia* and other trace fossils in the Cambrian of the Yukon and Ellesmere Island, Arctic Canada. Canadian Journal of Earth Sciences, v. 31, p. 767-782.

Horsfield, W.T.
1972: Glaucophane schists of Caledonian age from Spitsbergen. Geological Magazine, v. 109, p. 29-36.

Hurst, J.M.
1980: Silurian stratigraphy and facies distribution in Washington Land and western Hall Land, North Greenland. Grønlands Geologiske Undersøgelse, Bulletin no. 138, 95 p.

Hurst, J.M. and Surlyk, F.
1982: Stratigraphy of the Silurian turbidite sequence of North Greenland. Grønlands Geologiske Undersøgelse, Bulletin no. 145, 121 p.

Hyndman, R.D. and Hamilton, T.S.
1993: Queen Charlotte area Cenozoic tectonics and volcanism and their association with relative plate motions along northeastern Pacific margin. Journal of Geophysical Research, v. 98, p. 14,257-14,277.

Irvine, T.N.
1974: Petrology of the Duke Island ultramafic complex, southeastern Alaska. Geological Society of America, Memoir 138, 240 p.

Irvine, T.N. and Baragar, W.R.A.
1971: A guide to the chemical classification of the common volcanic rocks. Canadian Journal of Earth Sciences, v. 8, p. 523-548.

Kal'o, D.L.
1970: Silur Estonii. Izdatel'stvo "Valgus", Tallin.

Kanat, L. and Morris, A.
1988: A working stratigraphy for central western Oscar II Land, Spitsbergen. Norsk Polarinstitutt Skrifter no. 190, 23 p.

Karl, S.M. and Aleinikoff, J.N.
1990: Proterozoic U-Pb zircon age of granite in the Kallarichuk Hills, western Brooks Range, Alaska: evidence for Precambrian basement in the schist belt. *In* Geological Studies in Alaska by the U.S. Geological Survey, 1989. U.S. Geological Survey Bulletin 1946, p. 95-100.

Kay, M.
1951: North American Geosynclines. Geological Society of America, Memoir 48, 143 p.

Keppie, J.D.
1993: Synthesis of Palaeozoic deformational events and terrane accretion in the Canadian Appalachians. Geologische Rundschau, v. 82, p. 381-431.

Kerr, J.W.
1975: Cape Storm Formation - a new Silurian unit in the Canadian Arctic. Bulletin of Canadian Petroleum Geology, v. 23, p. 67-83.

1977: Cornwallis Fold Belt and the mechanism of basement uplift. Canadian Journal of Earth Sciences, v. 14, p. 1374-1401.

Kerr, J.W. and Christie, R.L.
1965: Tectonic history of Boothia Uplift and Cornwallis Fold Belt, Arctic Canada. Bulletin of the American Association of Petroleum Geologists, v. 49, p. 905-926.

Klaper, E.M.
1990: The mid-Paleozoic deformation in the Hazen fold belt, Arctic Canada. Canadian Journal of Earth Sciences, v. 27, p. 1359-1370.

1992a: The Paleozoic tectonic evolution of the northern edge of North America - a structural study of northern Ellesmere Island, Canadian Arctic. Tectonics, v. 11, p. 854-870.

1992b: The Paleozoic tectonic evolution of northern Ellesmere Island, Canadian Arctic Archipelago - a structural study. Habilitationsschrift vorgelegt der Philosophisch- naturwissenschaftlichen Fakultät der Universität Bern, 135 p.

Klaper, E.M. and Ohta, Y.
1993: Paleozoic metamorphism across the boundary between the Clements Markham fold belt and the Pearya terrane in northern Ellesmere Island, Canadian Arctic Archipelago. Canadian Journal of Earth Sciences, v. 30, p. 867-880.

Klapper, G. and Murphy, M.A.
1975: Silurian – Lower Devonian conodont sequence in the Roberts Mountains Formation of central Nevada. University of California Publications in Geological Sciences, v. 3 (1974), 62 p.

Kleffner, M.A.
1989: A conodont-based Silurian chronostratigraphy. Geological Society of America, Bulletin, v. 101, p. 904–912.

Kos'ko, M.K., Cecile, M.P., Harrison, J.C., Ganelin, V.G., Khandoshko, N.V., and Lopatin, B.G.
1993: Geology of Wrangel Island, between Chukchi and East Siberian Seas, northeastern Russia. Geological Survey of Canada, Bulletin 461, 101 p.

Krogh, T.E.
1973: A low-contamination method for hydrothermal decompositon of zircon and extraction of U and Pb for isotopic age determinations. Geochimica et Cosmochimica Acta, v. 37, p. 485–494.

1982: Improved accuracy of U-Pb zircon ages by the creation of more concordant systems using an air abrasion technique. Geochimca et Cosmochimica Acta, v. 46, p. 637-649.

Kuschel, E. and Smith, I.E.M.
1992: Rare earth mobility in young arc-type volcanic rocks from northern New Zealand. Geochimica et Cosmochimica Acta, v. 56, p. 3951-3955.

La Gabrielle, Y. and Auzende, J.-M.
1982: Active in situ disaggregation of oceanic crust and mantle on Gorringe Bank: analogy with ophiolite massives. Nature, v. 297, p. 490–493.

Lamar, D.L., Reed, W.E., and Douglass, D.N.
1986: Billefjorden fault zone, Spitsbergen. Geological Society of America, Bulletin, v. 97, p. 1083-1088.

Landing, E.
1994: Precambrian-Cambrian boundary global stratotype ratified and a new perspective of Cambrian time. Geology, v. 22, p. 179–182.

Larsen, P.-H. and Escher, J.C.
1985: The Silurian turbidite sequence of the Peary Land Group between Newman Bugt and Victoria Fjord, western North Greenland. Grønlands Geologiske Undersøgelse, Rapport no. 126, p. 47–67.

1987: Additions to the lithostratigraphy of the Peary Land Group (Silurian) in western and central North Greenland. Grønlands Geologiske Undersøgelse, Rapport no. 133, p. 65–80.

Laub, R.S.
1975: The ancestry, geographical extent, and fate of the Brassfield coral fauna (Middle Llandovery, North America). Bulletin of American Paleontology, v. 67, no. 287, p. 273-286.

Lawver, L.A. and Scotese, C.R.
1990: A review of tectonic models for the evolution of the Canada Basin. *In* The Arctic Ocean Region, A. Grantz, L. Johnson, and J.L. Sweeney (eds.). The Geology of North America, v. L, Chapter 31.

Leighton, W.M. and Pendexter, C.
1962: Carbonate rock types. *In* Classification of Carbonate Rocks, W.E. Ham (ed.). The American Association of Petroleum Geologists, Memoir 1, p. 33–61.

Lenz, A.C. and Melchin, M.J.
1990: Wenlock (Silurian) graptolite biostratigraphy of the Cape Phillips Formation, Canadian Arctic Islands. Canadian Journal of Earth Sciences, v. 27, p. 1–13.

Le Pichon, X., Sibuet, J.C., and Francheteau, J.
1977: The fit of the continents around the North Atlantic Ocean. Tectonophysics, v. 38, p. 169–209.

Lockwood, J.P.
1971: Sedimentary and gravity-slide emplacement of serpentinite. Geological Society of America, Bulletin, v. 82, p. 919–936.

Long, D.G.F.
1989a: Kennedy Channel Formation: key to the early history of the Franklinian continental margin, central eastern Ellesmere Island, Arctic Canada. Canadian Journal of Earth Sciences, v. 26, p. 1147–1159.

1989b: Ella Bay Formation: Early Cambrian shelf differentiation in the Franklinian basin, central eastern Ellesmere Island, Arctic Canada. Canadian Journal of Earth Sciences, v. 26, p. 2621-2635.

Lopatin, B.G., Tchuchonin, A.P., and Kos'ko, M.K.
1993: About the development of the basement of the Innuitian mobile belt on Ellesmere Island (Canadian Arctic Archipelago). Doklady Akademia NAUK, v. 328, no. 2, p. 217–220 (Title translated from Russian).

Lowden, J.A., Stockwell, C.H., Tipper, H.W., and Wanless, R.K.
1963: Age determinations and geological studies (including isotopic ages – Report 3). Geological Survey of Canada, Paper 62–17, 140 p.

Ludwig, K.R.
1980: Calculation of uncertainties of U-Pb isotope data. Earth and Planetary Science Letters, v. 46, p. 212–220.

Lumsden, D.N.
1979: Discrepancy between thin-section and X-ray estimates of dolomite in limestone. Journal of Sedimentary Petrology, v. 49, p. 429–436.

Maurel, L.E.
1989: Geometry and evolution of the Tanquary Structural High and its effects on the paleogeography of the Sverdrup Basin, northern Ellesmere Island, Canadian Arctic. *In* Current Research, Part G. Geological Survey of Canada, Paper 89–1G, p. 177–189.

Mayr, U.
1976: Upper Paleozoic succession in the Yelverton area, northern Ellesmere Island, District of Franklin. *In* Report of Activities, Part A. Geological Survey of Canada, Paper 76-1A, p. 445-448.

1992: Reconnaissance and interpretation of Upper Devonian to Permian stratigraphy of northeastern Ellesmere Island, Canadian Arctic Archipelago. Geological Survey of Canada, Paper 91-08, 117 p.

Mayr, U. and Trettin, H.P.
1990: Revised geological maps, Clements Markham Inlet and Robeson Channel, District of Franklin (NTS 120 E, F, G), scale 1:125 000. Geological Survey of Canada, Open File 2138.

1995a: Geology, Clements Markham Inlet and part of Robeson Channel, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1883A, scale 1:250 000 (1997).

1995b: Geology, Tanquary Fiord, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1886A, scale 1:250 000 (1997).

Mayr, U., Trettin, H.P., and Embry, A.F.
1982: Preliminary geological map and notes, part of Tanquary Fiord map-area, District of Franklin (NTS 340D). Geological Survey of Canada, Open File 835, 32 p.

McCracken, A.D. and Barnes, C.R.
1981: Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Quebec, with special reference to Late Ordovician - Early Silurian chronostratigraphy and the systematic boundary. Geological Survey of Canada, Bulletin 329, Part 2, p. 51-134.

McGregor, D.C. and Narbonne, G.M.
1968: Upper Silurian trilete spores and other microfossils from the Read Bay Formation, Cornwallis Island, Canadian Arctic. Canadian Journal of Earth Sciences, v. 15, p. 1292-1303.

McIlreath, I.A. and James, N.P.
1978: Facies models 13. Carbonate slopes. Geoscience Canada, v. 5, p. 189-199.

McLean, R.A.
1977: Early Silurian (Late Llandovery) rugose corals from western North Greenland. Grønlands Geologiske Undersogelse, Bulletin 121.

McNicoll, V.J., Harrison, J.C., Trettin, H.P., and Thorsteinsson, R.
1995: Provenance of the Devonian clastic wedge of Arctic Canada: evidence provided by detrital zircon ages. *In* Stratigraphic Evolution of Foreland Basins, S.L. Dorobek and G.M. Ross (eds.). SEPM (Society for Sedimentary Geology), Special Publication no. 52, p. 77-93.

Meschede, M.
1986: A method of discriminating between different types of mid-ocean ridge basalts and continental tholeiites with the Nb-Zr-Y diagram. Chemical Geology, v. 56, p. 207-218.

Melchin, M.J.
1989: Llandovery graptolite biostratigraphy and paleobiography, Cape Phillips Formation, Canadian Arctic Islands. Canadian Journal of Earth Sciences, v. 26, p. 1726-1746.

Miall, A.D.
1979: Tertiary fluvial sediments in the Lake Hazen intermontane basin. Geological Survey of Canada, Paper 79-9, 25 p.

1980: Tertiary sedimentation and tectonics in the Judge Daly Basin, northeast Ellesmere Island, Arctic Canada. Geological Survey of Canada, Paper 80-30, p. 17.

1983: The Nares Strait problem: a re-evaluation of the geological evidence in terms of a diffuse oblique-slip plate boundary between Greenland and the Canadian Arctic Islands. Tectonophysics, v. 100, p. 227-239.

1986: Effects of Caledonian tectonism in Arctic Canada. Geology, v. 14, p. 904-907.

Mirza, K.
1976: Late Ordovician to Late Silurian stratigraphy and conodont biostratigraphy of the eastern Canadian Arctic Islands. Unpub. M.Sc. thesis, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, 302 p.

Moore, J.M., Davidson, A., and Baer, A.J. (eds.)
1986: The Grenville Province. Geological Association of Canada, Special Paper 31, 358 p.

Moore, T.E., Wallace, W.K., Bird, K.J., Karl, S.M., Mull, C.G., and Dillon, J.T.
1994: Geology of northern Alaska. *In* The Geology of Alaska, Boulder Colorado, G. Plafker and H.C. Berg (eds.). Geological Society of America, The Geology of North America, v. G-1., Chapter 3, p. 49-140.

Moore, T.E.
1987: Geochemistry and tectonic setting of some volcanic rocks of the Franklinian assemblage, central eastern Brooks Range, Alaska. *In* Alaskan North Slope Geology, I. Tailleur and P. Weimer (eds.). Society of Economic Paleontologists and Mineralogists, Pacific Section, Bakersfield, California, v. 2, p. 691-710.

Muir, M.D., Lock, D., and von der Borch, C.
1982: The Coorong model for penecontemporaneous dolomite formation in the middle Proterozoic McArthur Group, Northern Territory, Australia. *In* Concepts and Models of Dolomitization, D.H. Zenger, J.B. Dunham, and R.L. Ethington (eds.). Society of Economic Paleontologists and Mineralogists, Special Publication no. 28, p. 51-67.

Mullins, H.T., Neumann, A.C., Wilber, R.J., and Boardman, M.R.
1980: Nodular carbonate sediment on Bahamian slopes: possible precursors to nodular limestones. Journal of Sedimentary Petrology, v. 50, p. 117-131.

Murphy, J.B. and Hynes, A.J.
1986: Contrasting secondary mobility of Ti, P, Zr, Nb, and Y in two metabasaltic suites in the Appalachians. Canadian Journal of Earth Sciences, v. 23, p. 1138-1144.

Myrow, P.M. and Hiscott, R.N.
1993: Depositional history and sequence stratigraphy of the Precambrian-Cambrian boundary stratotype section, Chapel Island Formation, southeast Newfoundland. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 104, p. 13-35.

Narbonne, G.M. and Dixon, O.A.
1984: Upper Silurian lithistid sponge reefs on Somerset Island, Arctic Canada. Sedimentology, v. 31, p. 25-50.

Nassichuk, W.W. and Christie, R.L.
1969: Upper Paleozoic and Mesozoic stratigraphy in the Yelverton Pass region, Ellesmere Island, District of Franklin. Geological Survey of Canada, Paper 68-31, 31 p.

Nelson, B.K., Nelson, S.W., and Till, A.B.
1993: Nd- and Sr-isotope evidence for Proterozoic and Paleozoic crustal evolution in the Brooks Range, Northern Alaska. The Journal of Geology, v. 101, p. 435-450.

Nicoll, R.S. and Rexroad, C.B.
1969: Stratigraphy and conodont paleontology of the Salamonie Dolomite and Lee Creek Member of the Brassfield Limestone (Silurian) in southeastern Indiana and adjacent Kentucky. State of Indiana, Department of Natural Resources, Geological Survey Bulletin 51.

Nordgulen, O., Bickford, M.E., Nissen, A.L., and Wortman, G.L.
1993: U-Pb ages from the Bindal Batholith, and the tectonic history of the Helgeland Nappe Complex, Scandinavian Caledonides. Journal of the Geological Society [London], v. 150, p. 771-783.

Norford, B.S.
1966: Ordovician stratigraphic section at Daly River, northeast Ellesmere Island. Geological Survey of Canada, Paper 66-55, 37 p.

1971: Silurian stratigraphy of northern Manitoba. *In* Geoscience Studies in Manitoba, A.C. Turnock (ed.). The Geological Association of Canada, Special Paper no. 9, p. 199-206.

Nunes, P.D.
1980: The Ontario Geological Survey geochronology research program - an overview. Ontario Geological Survey, Miscellaneous Paper 92, p. 4-6.

Ohta, Y.
1994: Caledonian and Precambrian history in Svalbard: a review, and an implication of escape tectonics. Tectonophysics, v. 231, p. 183-194.

Ohta, Y., Hirajima, T., and Hiroi, Y.
1986: Caledonian high-pressure metamorphism in central western Spitsbergen. *In* Blueschists and eclogites, B.W. Evans and E.H. Brown (eds.). Geological Society of America, Memoir 164, p. 205-216.

Ohta, Y. and Klaper, E.
1992: The Mitchell Point Fault Zone at Phillips Inlet, northern Ellesmere Island, Northwest Territories. *In* Current Research, Part E. Geological Survey of Canada, Paper 92-1E, p. 149-156.

Okulitch, A.V.
1995: Geological time scale, 1995. Geological Survey of Canada, Open File 3040 (National Earth Science Series, Geological Atlas).

Okulitch, A.V., Packard, J.J., and Zolnai, A.I.
1986: Evolution of the Boothia Uplift, Arctic Canada. Canadian Journal of Earth Sciences, v. 23, p. 350-358.

Okulitch, A.V. and Trettin, H.P.
1991: Late Cretaceous - Early Tertiary deformation, Arctic Islands. *In* Innuitian Orogen and Arctic Platform: Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, Geology of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 18 (1992).

Parrish, R.R.
1987: An improved micro-capsule for zircon dissolution in U-Pb geochronology. Chemical Geology, Isotope Geoscience Section, v. 66, p. 99-102.

Parrish R.R. and Krogh, T.E.
1987: Synthesis and purification of 205Pb for U-Pb geochronology. Chemical Geology, Isotope Geoscience Section, v. 66, p. 103-110.

Patino Douce, A.E., Humphreys, E.D., and Johnston, A.D.
1990: Anatexis and metamorphism in tectonically thickened continental crust exemplified by the Sevier hinterland, western North America. Earth and Planetary Science Letters, v. 97, p. 290-315.

Patrick, B.E. and McClelland, W.C.
1995: Late Proterozoic granitic magmatism on Seward Peninsula and a Barentian origin for Arctic Alaska-Chuchotka. Geology, v. 23, p. 81-84.

Pearce, J.A.
1976: Statistical analysis of major element patterns in basalt. Journal of Petrology, v. 17, p. 15-43.

Pearce, J.A. and Cann, J.R.
1973: Tectonic setting of basic volcanic rocks determined using trace element analyses. Earth and Planetary Science Letters, v. 19, p. 290-300.

Pearce, J.A., Harris, N.B.W., and Tindle, A.G.
1984: Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. Journal of Petrology, v. 25, Part 4, p. 956-983.

Peary, R.E.
1907: Nearest the Pole: a narative of the polar expedition of the Peary Arctic Club in the SS. Roosevelt, 1905-1906. Hutchinson, London, United Kingdom, 411 p.

Peryt, T.M.
1983: Vadoids. *In* Coated Grains, T.M. Peryt (ed.). Springer Verlag, Berlin, Heidelberg, New York, Tokyo, p. 438-449.

Peucat, J.J., Ohta, Y., Gee, D.G., and Bernard-Griffiths, J.
1989: U-Pb, Sr and Nd evidence for Grenvillian and latest Proterozoic tectonothermal activity in Spitsbergen Caledonides, Arctic Ocean. Lithos, v. 22, p. 275-285.

Peucat, J.J., Tisserant, D., and Clauer, N.
1985: Resistance of zircons to U-Pb resetting in a prograde metamorphic sequence of Caledonian age in East Greenland. Canadian Journal of Earth Sciences, v. 22, p. 330–338.

Phipps, S.P.
1984: Ophiolitic olistostromes in the basal Great Valley sequence, Napa County, northern California Coast Ranges. *In* Melanges: Their Nature, Origin, and Significance, L.R. Raymond (ed.). Geological Society of America, Special Paper 198, p. 103–125.

Pickett, J.W.
1983: An annotated bibliography and review of Australasian fossil sponges. Association of Australasian Palaeontologists, Memoir 1, p. 93–120.

Plumb, K.A.
1991: New Precambrian time scale. Episodes, v. 14, p. 139–140.

Poulsen, C.
1941: The Silurian faunas of North Greenland. II. The fauna of the Offley Island Formation, Part I. Coelenterata. Meddelelser om Grønland, Band 72, no. 2.

Ramsay, J.G. and Huber, M.I.
1987: The techniques of modern structural geology, Volume 2, Fractures and folds. Academic Press, London, United Kingdom, 462 p.

Rejebian, V.A., Harris, A.G., and Huebner, J.S.
1987: Conodont color and textural alteration: an index to regional metamorphism, contact metamorphism, and hydrothermal alteration. Geological Society of America, Bulletin, v. 99, p. 471–479.

Richards, B.C., Bamber, E.W., Higgins, A.C., and Utting, J.
1993: Carboniferous. Subchapter 4E. *In* Sedimentary Cover of the Craton in Canada, D.F. Stott and J.D. Aitken (ed.). Geological Survey of Canada, Geology of Canada, no. 5, p. 202–271 (also Geological Society of America, The Geology of North America, v. D-1).

Riding, R.
1991: Calcified cyanobacteria. *In* Calcareous Algae and Stromatolites, R. Riding (ed.). Springer Verlag, London, p. 55–87.

Rigby, J.K.
1986: Sponges of the Burgess shale (Middle Cambrian), British Columbia. Palaeontographica Canadiana, no. 2, 105 p.

Roberts, M.P. and Clements, J.D.
1993: Origin of high-potassium, calc-alkaline, I-type granitoids. Geology, v. 21, p. 825–828.

Robertson, A. and Xenophontos, C.
1993: Development of concepts concerning the Troodos ophiolite and adjacent units in Cyprus. *In* Magmatic Processes and Plate Tectonics, H.M. Prichard, T. Alabaster, N.B.W. Harris, and C.R. Neary (eds.). Geological Society [London], Special Publication no. 76, p. 85–119.

Roddick, J.C., Loveridge, W.D., and Parrish, R.R.
1987: Precise U/Pb dating of zircon at the sub-nanogram Pb level. Chemical Geology, Isotope Geoscience Section, v. 66, p. 111–121.

Roden, M.K., Parrish, R.R., and Miller, D.S.
1990: The absolute age of the Eifelian Tioga ash bed, Pennsylvania. Journal of Geology, v. 98, p. 282–285.

Roots, E.F.
1963: Volcanic rocks east of Cape Stallworthy. *In* Geology of the North-central Part of the Arctic Archipelago, Northwest Territories (Operation Franklin), Y.O. Fortier et. al. (eds.). Geological Survey of Canada, Memoir 320, p. 515–517.

Ross, G.M., Parrish, R.R., and Winston, D.
1992: Provenance und U-Pb geochronology of the Mesoproterozoic Belt Supergroup (northwestern United States): implications for age of deposition and pre-Panthalassa plate reconstructions. Earth and Planetary Science Letters, v. 113, p. 57–76.

Ross, R.J. Jr. et al. [**27 co-authors**]
1982: The Ordovician System in the United States, correlation chart and explanatory notes. International Union of Geological Sciences, Publication no. 12, 73 p.

Roux, A.
1991: Ordovician to Devonian marine calcareous algae. *In* Calcareous algae and stromatolites, R. Riding (ed.). Springer Verlag, London, p. 349–369.

Royse, C.F. Jr., Waddell, J.S., and Peterson, L.E.
1971: X-ray determination of calcite-dolomite: an evaluation. Journal of Sedimentary Petrology, v. 41, p. 483–488.

Rubin, J.N., Henry, C.D., and Price, J.G.
1993: The mobility of zirconium and other "immobile" elements during hydrothermal alteration. Chemical Geology, v. 110, p. 29–47.

Ryan, P.D. and Dewey, J.F.
1991: Geological and tectonic cross-section of the Caledonides of western Ireland. Journal of the Geological Society [London], v. 148, p. 173–180.

Samson, S.D., Patchett, P.J., Roddick, J.C., and Parrish, R.R.
1989: Origin and tectonic setting of Ordovician bentonites in North America: isotopic and age constraints. Geological Society of America, Bulletin, v. 101, p. 1175–1181.

Schönlaub, H.P.
1971: Zur Problematik der Conodonten-Chronologie an der Wende Ordoviz/Silur mit besonderer Berücksichtigung der Verhältnisse im Llandovery. Geologica et Palaeontologica, v. 5, p. 35–57.

Schuchert, C.
1923: Sites and nature of the North American geosynclines. Bulletin of the Geological Society of America, v. 34, p. 151–229.

Scrutton, C.T.
1975: Corals and stromatoporoids from the Ordovician and Silurian of Kronprins Christian Land, northeast Greenland. Meddelelser om Grønland, Bd. 171, no. 4.

Seilacher, A.
1992: Vendobiota and Pasammocorallia: lost constrictions of Precambrian evolution. Journal of the Geological Society [London], v. 149, p. 607-613.

Sevigny, J.H., Parrish, R.R., and Ghent, E.D.
1989: Petrogenesis of peraluminous granites, Monashee Mountains, southeastern British Columbia. Journal of Petrology, v. 30, p. 557-581.

Shand, S.J.
1943: Eruptive rocks, their genesis, composition, classification, and their relations to ore-deposits. John Wiley, New York, revised second edition, 444 p.

Sinha, A.K. and Frisch, T.
1975: Whole-rock Rb/Sr ages of metamorphic rocks from northern Ellesmere Island, Canadian Arctic Archipelago. I. The gneiss terrain between Ayles Fiord and Yelverton Inlet. Canadian Journal of Earth Sciences, v. 12, p. 90-94.

1976: Whole-rock Rb/Sr and zircon U/Pb ages of metamorphic rocks from northern Ellesmere Island, Canadian Arctic Archipelago. II. The Cape Columbia Complex. Canadian Journal of Earth Sciences, v. 13, p. 774-780.

Smith, J.V.
1974: Feldspar Minerals, v. 2, Chemical and textural properties. Springer Verlag, New York, Heidelberg, Berlin, 690 p.

Snoke, A.W., Sharp, W.D., Wright, J.E., and Saleeby, J.B.
1982: Significance of mid-Mesozoic peridotitic to dioritic intrusive complexes, Klamath Mountains - western Sierra Nevada, California. Geology, v. 10, p. 160-166.

Sobczak, L.W., Forsyth, D.A., Overton, A., and Asudeh, I.
1991: B. Crustal structure from seismic and gravity studies. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 5, p. 71-78 (1992).

Soper, N.J., Strachan, R.A., Holdsworth, R.E., Gayer, R.A., and Greiling, R.O.
1992: Sinistral transpression and the Silurian closure of Iapetus. Journal of the Geological Society [London], v. 149, p. 871-880.

Souther, J.G.
1992: Volcanic regimes. *In* Geology of the Cordilleran Orogen in Canada, H. Gabrielse and C.J. Yorath (ed.). Geological Survey of Canada, The Geology of Canada, no. 4 (also Geological Society of America, The Geology of North America, v. G-2), Chapter 14, p. 457-490.

Stacey, J.S. and Kramers, J.D.
1975: Approximation of terrestrial lead isotope evolution by a two-stage model. Earth and Planetary Science Letters, v. 26, p. 207-221.

Starmer, I.C.
1993: The Sveconorwegian Orogeny in southern Norway, relative to deep crustal structures and events in the North Atlantic Proterozoic Supercontinent. Norsk Geologisk Tidsskrift, v. 73, p. 109-132.

Steiger, R.H. and Jager, E.
1977: Subcommission on Geochronology; convention on the use of decay constants in geo- and cosmochronology. Earth and Planetary Science Letters, v. 36, p. 359-362.

Stephens, M.B. and Gee, D.G.
1989: Terranes and polyphase accretionary history in the Scandinavian Caledonides. *In* Terranes in the Circum-Atlantic Paleozoic Orogens, R.D. Dallmeyer (ed.). Geological Society of America, Special Paper 230, p. 17-30.

Stevens, R.D., Delabio, R.N., and Lachance, G.R.
1982: Age determinations and geological studies, K-Ar isotopic ages, Report 15. Geological Survey of Canada, Paper 81-2, 56 p.

Stigh, J.B.
1980: Detrital serpentinites of the Caledonian Allochthon in Scandinavia. *In* Proceedings of "The Caledonides in the USA", D.R. Wones (ed.). Virginia Polytechnical Institute, Department of Geological Sciences, Memoir 2, p. 149-156.

Stockmal, G.S., Colman-Sadd, S.P., Keen, C.E., Marillier, F., O'Brien, S.J., and Quinlan, G.M.
1990: Deep seismic structure and plate tectonic evolution of the Canadian Appalachians. Tectonics, v. 9, p. 45-62.

Strachan, R.A., Holdsworth, R.E., Friderichsen, J.D., and Jepsen, H.F.
1992: Regional Caledonian structure within an oblique convergence zone, Dronning Louise Land, NE Greenland. Journal of the Geological Society [London], v. 149, p. 359-371.

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

Stroup, J.B. and Fox, P.J.
1981: Geologic investigations in the Cayman Trough: evidence for thin oceanic crust along the Mid-Cayman Rise. The Journal of Geology, v. 89, p. 395-420.

Sturt, B.A., Ramsay, D.M., and Neuman, R.B.
1991: The Otta Conglomerate, the Vogamo Ophiolite — further indications of early Ordovician orogenesis in the Scandinavian Caledonides. Norsk Geologisk Tidsskrift, v. 71, p. 107-115.

Surlyk, F. and Hurst, J.M.
1984: The evolution of the early Paleozoic deep-water basin of North Greenland. Geological Society of North America Bulletin, v. 95, p. 131-154.

Sverdrup, O.
1904: New land. London and Bombay, Longmans, Green and Co., 2 vols.

Sweet, W.C.
1979: Late Ordovician conodonts and biostratigraphy of the Western Midcontinent Province. Brigham Young University, Geology Studies, v. 26, Pt. 3, p. 45-74, Figs. 5-10.

Sweet, W.C. and Bergström, S.M.
1986: Conodonts and biostratigraphic correlation. Annual Review of Earth and Planetary Sciences. v. 14, p. 85-112.

Sweet, W.C., Ethington, R.L., and Barnes, C.R.
1971: North American Middle and Upper Ordovician conodont faunas. *In* Symposium on Conodont Biostratigraphy, W.C. Sweet and S.M. Bergstrom (eds.). Geological Society of America, Memoir 127, p. 163-193.

Sweet, W.C., Thompson, T.L., and Satterfield, I.R.
1975: Conodont biostratigraphy of the Cape Limestone (Maysvillian) of eastern Missouri. *In* Missouri Geological Survey, Studies in Stratigraphy, Report of Investigations no. 57, Part 1, p. 1-60.

Thorsteinsson, R.
1974: Carboniferous and Permian stratigraphy of Axel Heiberg Island and western Ellesmere Island, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 224, 115 p.

1980: Part I. Contributions to stratigraphy (with contributions by T.T. Uyeno). *In* Stratigraphy and Conodonts of Upper Silurian and Lower Devonian Rocks in the Environs of the Boothia Uplift, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 282, p. 1-38.

Thorsteinsson, R. and Mayr, U.
1987: The sedimentary rocks of Devon Island, Canadian Arctic Archipelago. Geological Survey of Canada, Memoir 411, 182 p.

Thorsteinsson, R. and Tozer, E.T.
1960: Summary account of structural history of the Canadian Arctic Archipelago since Precambrian time. Geological Survey of Canada, Paper 60-7, 23 p.

1962: Banks, Victoria, and Stefansson islands, Arctic Archipelago. Geological Survey of Canada, Memoir 330, 85 p.

1970: Geology of the Arctic Archipelago. *In* Geology and Economic Minerals of Canada, R.J.W. Douglas (ed.). Geological Survey of Canada, Economic Geology Report, no. 1, p. 547-590.

Thorsteinsson, R. and Trettin, H.P.
1972a: Geology, Cape Stallworthy, scale 1:250,000. Geological Survey of Canada, Map 1305A.

1972b: Geology, Bukken Fiord, District of Franklin, scale 1:250,000. Geological Survey of Canada, Map 1310A.

Torsvik, T.H., Olesen, O., Ryan, P.D., and Trench, A.
1990: On the palaeography of Baltica during the Paleozoic: new palaeomagnetic data from the Scandinavian Caledonides. Geophysical Journal International, v. 103, p. 261-279.

Trettin, H.P.
1963: Caledonian movements in the Canadian Arctic Archipelago. Bulletin of Canadian Petroleum Geology, v. 11, p. 107-115.

1964: Pre-Mississippian rocks of Nansen Sound area, District of Franklin. Geological Survey of Canada, Paper 64-26.

1969a: Pre-Mississippian geology of northern Axel Heiberg and northwestern Ellesmere islands, Arctic Archipelago. Geological Survey of Canada, Bulletin 171, 82 p.

1969b: Geology of Ordovician to Pennsylvanian rocks, M'Clintock Inlet, north coast of Ellesmere Island, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 183, 93 p.

1971a: Geology of lower Paleozoic formations, Hazen Plateau and southern Grant Land Mountains, Ellesmere Island, Arctic Archipelago. Geological Survey of Canada, Bulletin 203, 134 p.

1971b: Reconnaissance of lower Paleozoic geology, Phillips Inlet region, north coast of Ellesmere Island, District of Franklin. Geological Survey of Canada, Paper 71-12, 29 p.

1973: Early Paleozoic evolution of northern parts of the Canadian Arctic Archipelago. *In* Arctic Geology, M.G. Pitcher (ed.). American Association of Petroleum Geologists, Memoir 19, p. 57-75.

1976: Reconnaissance of lower Paleozoic geology, Agassiz Ice Cap to Yelverton Bay, northern Ellesmere Island. *In* Report of Activities, Part A. Geological Survey of Canada, Paper 76-1A, p. 431-444

1978: Devonian stratigraphy, west-central Ellesmere Island. Geological Survey of Canada, Bulletin 302, 119 p.

1979: Middle Ordovician to Lower Devonian deep-water succession at southeastern margin of Hazen Trough, Cañon Fiord, Ellesmere Island. Geological Survey of Canada, Bulletin 272, 84 p.

1981: A tennantite deposit in the M'Clintock Inlet area, northern Ellesmere Island, District of Franklin. *In* Current Research, Part A. Geological Survey of Canada, Paper 81-1A, p. 103-106.

1987a: Investigations of Paleozoic geology, northern Axel Heiberg and northwestern Ellesmere islands. *In* Current Research, Part A. Geological Survey of Canada, Paper 87-1A, p. 357-367.

1987b: Pearya: a composite terrane with Caledonian affinities in northern Ellesmere Island. Canadian Journal of Earth Sciences, v. 24, p. 224-245.

1987c: Pre-Carboniferous geology, M'Clintock Inlet map-area, northern Ellesmere Island, interim report and map (340E, H). Geological Survey of Canada, Open File 1652, 210 p.

1991a: Tectonic framework. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 4 (1992).

1991b: The Proterozoic to Late Silurian record of Pearya. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 9 (1992).

1991c: Middle Devonian to Early Carboniferous deformations, northern Ellesmere and Axel Heiberg islands. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 12, p. 309–317 (1992).

1994: Pre-Carboniferous geology of the northern part of the Arctic Islands. Hazen Fold Belt and adjacent parts of Central Ellesmere Fold Belt, Ellesmere Island. Paleontological appendices by G.S. Nowlan, B.S. Norford, W.H. Fritz and others. Geological Survey of Canada, Bulletin 430, 248 p.

1995a: Geology, parts of Greely Fiord East, Greely Fiord West, and Cañon Fiord, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1888A, scale 1:250 000 (1997).

1995b: Geology, parts of Cape Stallworthy and Bukken Fiord, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1884A, scale 1:250 000 (1997).

Trettin, H.P. and Frisch, T.O.
1981: Preliminary geological map and notes, Yelverton Inlet map-area, District of Franklin (NTS 340F, 540G). Geological Survey of Canada, Open File 758, 9 p.

1987: Bedrock geology, Yelverton Inlet map-area, northern Ellesmere Island, interim report and map (340F, 560D). Geological Survey of Canada, Open File 1651, 98 p.

1995: Geology, Yelverton Inlet, District of Franklin. Geological Survey of Canada, Map 1881A, scale 1:250 000 (1997).

Trettin, H.P., Loveridge, W.D., and Sullivan, R.W.
1982: U-Pb ages on zircon from the M'Clintock West massif and the Markham Fiord pluton, northernmost Ellesmere Island. Geological Survey of Canada, Paper 82-1C, p. 161–166.

Trettin, H.P. and Mayr, U.
1981: Preliminary geological map and notes, parts of Otto Fiord and Cape Stallworthy map-areas, District of Franklin (NTS 340C, 560D). Geological Survey of Canada, Open File 757, 10 p.

1995a: Geology, part of Lady Franklin Bay, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1887A, scale 1:250 000 (1997).

1995b: Geology, Otto Fiord, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1885A, scale 1:250 000 (1997).

1995c: Geology, M'Clintock Inlet, District of Franklin, Northwest Territories. Geological Survey of Canada, Map 1882A, scale 1:250 000 (1997).

Trettin, H.P., Mayr, U., Long, G.D.F., and Packard, J.J.
1991: Cambrian to Early Devonian basin development, sedimentation, and volcanism, Arctic Islands. *In* Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland, H.P. Trettin (ed.). Geological Survey of Canada, no. 3 (also Geological Society of America, The Geology of North America, v. E), Chapter 8 (1992).

Trettin, H.P. and Parrish, R.
1987: Late Cretaceous bimodal plutonism and volcanism, northern Ellesmere Island: isotopic age and origin. Canadian Journal of Earth Sciences, v. 24, p. 257–265.

Trettin, H.P., Parrish, R., and Loveridge, W.D.
1987: U-Pb age determinations of Proterozoic to Devonian rocks from northern Ellesmere Island, Arctic Canada. Canadian Journal of Earth Sciences, v. 24, p. 246–256.

Trettin, H.P. Parrish, R.R., and Roddick, J.C.
1992: New U-Pb and ^{40}Ar-^{39}Ar age determinations from northern Ellesmere and Axel Heiberg islands and their tectonic significance. *In* Radiogenic Age and Isotopic Studies: Report 6. Geological Survey of Canada, Paper 92-2, p. 3–30 (1993).

Trettin, H.P. and Nowlan, G.S.
1990: Middle Ordovician sedimentary and volcanic rocks at Fire Bay, Emma Fiord, northwestern Ellesmere Island. Geological Survey of Canada, Paper 90-1D, p. 147–151.

Tucker, R.D., Krogh, T.E., Ross, R.J. Jr., and Williams, S.H.
1990: Time-scale calibration by high-precision U-Pb zircon dating of interstratified volcanic ashes in the Ordovician and Lower Silurian stratotypes of Britain. Earth and Planetary Science Letters, v. 100, p. 51–58.

Tucker, R.D. and McKerrow, W.S.
1995: Early Paleozoic chronology: a review in light of new U-Pb zircon ages from Newfoundland and Britain. Canadian Journal of Earth Sciences, v. 32, p. 368–379.

Utting, J., Jachowicz, M., and Jachowicz, A.
1989: Palynology of the Lower Carboniferous Emma Fiord Formation of Devon, Axel Heiberg, and Ellesmere islands, Canadian Arctic Archipelago. *In* Contributions to Canadian Paleontology, Geological Survey of Canada, Bulletin 396, p. 145–171.

Uyeno, T.T.
1980: Part II. Systematic study of conodonts. *In* Stratigraphy and Conodonts of Upper Silurian and Lower Devonian Rocks in the Environs of the Boothia Uplift, Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 292, p. 39–75.

Uyeno, T.T. and Barnes, C.R.
1983: Conodonts of the Jupiter and Chicotte formations (Lower Silurian), Anticosti Island, Québec. Geological Survey of Canada, Bulletin 355, 49 p.

van der Pluijm, B.A., Johnson, R.J.E., and Van der Voo, R.
1990: Early Paleozoic paleogegraphy and accretionary history of the Newfoundland Appalachians. Geology, v. 18, p. 898-901.

Vieth, J.
1980: Thelodontier-, Acanthodier- und Elasmobranchier-Schuppen aus dem Unter-Devon der Kanadischen Arktis (Agnatha, Pisces). Im Selbstverlag des Geologisch-Paläontologischen Instituts der Georg-August Universitt Göttingen, Germany, no. 23, 69 p.

Viyra, V.Ya.
1977: Sostav i rasprostranenie konodontov v silure Pribaltiki (skv. Okhesaare, Kunkoyay, Ukmerge i dr.). Fatsii i fauna

silura Pribaltiki, D.L. Kal'o (ed.). Inst. Geol. Akad. Nauk Eston. SSR, Tallin, p. 179-192.

Walliser, O.H.
1964: Conodonten des Silurs. Abhandlungen des Hessischen Landesamtes für Bodenforschung, v. 41.

1971: Conodont biostratigraphy of the Silurian of Europe. Geological Society of America, Memoir 127, p. 195-206.

Wang, P. and Glover, L. III.
1992: A tectonics test of the most commonly used geochemical discriminant diagrams and patterns. Earth Science Reviews, v. 33, p. 111-131.

Wanless, R.K., Stevens, R.D., Lachance, G.R., and Rimsaite, R.Y.H.
1965: Age determinations and geological studies. Part 1 - Isotopic ages, Report 5. Geological Survey of Canada, Paper 64-17 (Part 1), 126 p.

Wanless, R.K., Stevens, R.D., Lachance, G.R., and Edmonds, C.M.
1968: Age determinations and geological studies, K-Ar isotopic ages, Report 8. Geological Survey of Canada, Paper 67-2, Part A, 141 p.

Wanless, R.K., Stevens, R.D., Lachance, G.R., and Delabio, R.N.D.
1970: Age determinations and geological studies, K-Ar isotopic ages, Report 9. Geological Survey of Canada, Paper 74-2, 78 p.

1974: Age determinations and geological studies, K-Ar isotopic ages, Report 12. Geological Survey of Canada, Paper 74-2, 72 p.

1978: Age determinations and geological studies. K-Ar isotopic ages, Report 13. Geological Survey of Canada, Paper 77-2, 60 p.

Wielens, J.B.W., Andriessen, P.A.M., Boelrijk, N.A.I.M., Hebeda, E.H., Priem, H.N.A., Verdurmen, E.A.T., and Verschure, R.H.
1981: Isotope geochronology in the high-grade metamorphic Precambrian of southwestern Norway: new data and reinterpretations. Norges geologiske undersøkelse, v. 359, p. 1-30.

Williams, H.
1984: Miogeoclines and suspect terranes of the Caledonian-Appalachian Orogen: tectonic patterns in the North Atlantic region. Canadian Journal of Earth Sciences, v. 21, p. 887-901.

Williams, H., Gillespie, R.T., and van Breemen, O.
1985: A late Precambrian rift-related igneous suite in western Newfoundland. Canadian Journal of Earth Sciences, v. 22, p. 1727-1735.

Williams, H. and Hatcher, R.D., Jr.
1983: Appalachian suspect terranes. *In* Contributions to the Tectonics and Geophysics of Mountain Chains, R.D. Hatcher, Jr., H. Williams, and I. Zietz (eds.). Geological Society of America, Memoir 158, p. 33-53.

Wilson, D.G.
1976: Eureka Sound and Beaufort formations, Yelverton Bay, Ellesmere Island, District of Franklin. *In* Report of Activities, Part A. Geological Survey of Canada, Paper 76-1A, p. 453-456.

Wilson, M.
1988: Igneous petrogenesis. Unwyn Hyman, London, 466 p.

Winn, R.D. and Dott, R.H., Jr.
1977: Large-scale traction-produced structures in deep-water fan-channel conglomerates in southern Chile. Geology, v. 5, p. 41-44.

Winchester, J.A. and Floyd, P.A.
1977: Geochemical discrimination of different magma series and their products using immobile elements. Chemical Geology, v. 20, p. 325-343.

Wood, D.A.
1980: The application of a Th-Hf-Ta diagram to problems of tectonomagmatic classification and to establishing the nature of crustal contamination of basaltic lavas of the British Tertiary Volcanic Province. Earth and Planetary Science Letters, v. 50, p. 11-30.

Young, G.M.
1982: The late Proterozoic Tindir Group, east-central Alaska: evolution of a continental margin. Geological Society of America, Bulletin, v. 93, p. 759-783.

APPENDIX 1

STRATIGRAPHIC SECTIONS
(Fig. 169)

CONTENTS

NORTHERN HEIBERG FOLD BELT

SECTION NORTHEAST OF GREENSTONE LAKE
(Partial type section of Jaeger Lake Formation)

Location: *Cape Stallworthy-Bukken Fiord*, inset D, section GL; west-facing slope on northeast side of Greenstone Lake; NTS 560 D; UTM[1] Zone 15X, 494200E, 9020300N.

Dips are to the northeast (mainly 63–73° but up to 90°) but tops face southwest; i.e., section is overturned. The section was measured from top down, but the following description reads from base up. Field number 61TM-C; from Trettin, 1969a, p. 9, with minor modifications.

Base of section: talus of dolostone and volcanic rocks; level within Jaeger Lake Formation.

[1]The UTM coordinates were obtained from manual plots on topographic base maps at the 1:250,000 scale, using a graduated transparent overlay. They are stated in metres (6 numbers for eastings, 7 numbers for northings) and their accuracy is generally within ±300 m.

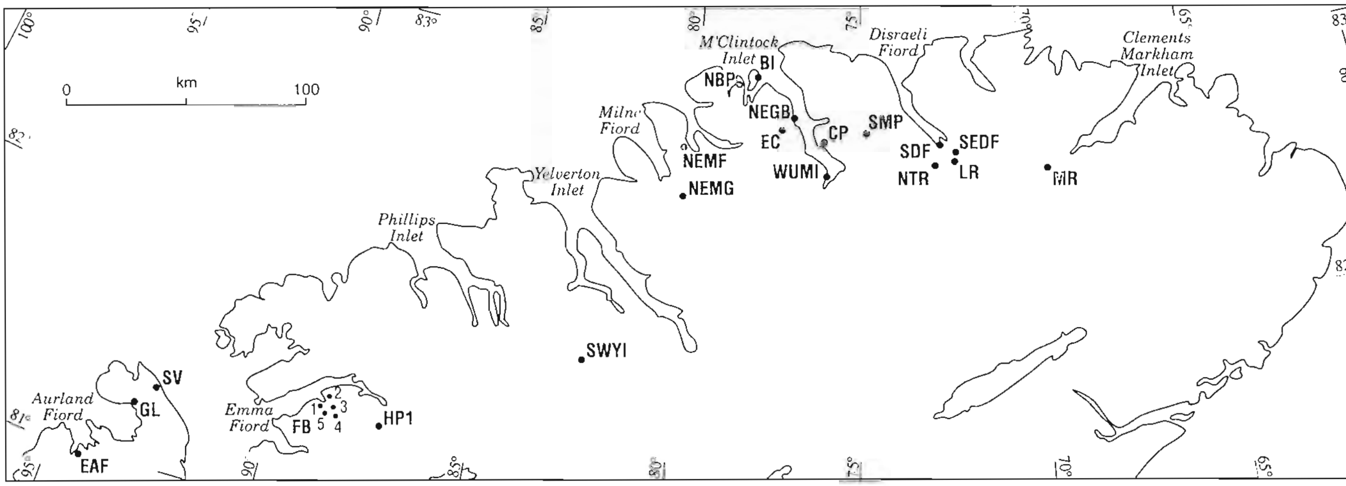


Figure 169. Location of stratigraphic sections described in Appendix 1. BI: *Bromley Island;* CP: *Crash Point;* EAF: *southeast of Aurland Fiord;* EC: *Egingwah Creek;* FB: *Fire Bay;* GL: *Greenstone Lake;* HP1: *Hvitland Peninsula 1;* LR: *Lorimer Ridge;* MR: *Markham River;* NBP: *north of Bethel peak;* NEGB: *north of Egingwah Bay;* NEMF: *northeast of Milne Fiord;* NEMG: *northeast of Milne Glacier;* NTR: *north of Thores River;* SDF: *south of Disraeli Fiord;* SEDF: *southeast of Disraeli Fiord;* SMP: *southern Marvin Peninsula;* SWYI: *southwest of Yelverton Inlet;* WUMI: *west of upper reaches of M'Clintock Inlet.*

Jaeger Lake Formation

Unit 1, 0–79 m (79 m)
Dolostone: light to medium grey, microcrystalline to fine crystalline, massive; many quartz veins.

Unit 2, 79–200 m (121 m)
Metabasalt: as in unit 4; upper 10 m showing pillow structure (stratigraphic tops facing southwest).

Unit 3, 200–265 m (65 m)
Dolostone: light grey, microcrystalline, massive to medium bedded; upper 10 m with stringers of chert/quartz, dark grey; dolostone grades laterally to **calcareous marble**: light grey, microcrystalline, laminated to thin bedded.

Unit 4, 265–285 m (20 m)
Metabasalt: green; flows about 30–60 cm thick with highly vesicular/amygdaloidal layers at top and bottom; minor tuffaceous greenschist as in units 5 and 7.

Unit 5, 285–328 m (43 m)
Tuffaceous(?) greenschist and **volcanic breccia**: as in unit 7.

Unit 6, 328–333 m (5 m)
Dolostone: light to medium grey, microcrystalline to very fine crystalline, medium bedded; contact relations with underlying tuffaceous beds (intraformational breccia) indicate that tops are facing southwest.

Unit 7, 333–425 m (92 m)
Tuffaceous(?) greenschist and **volcanic breccia**: dark green, poorly stratified; fragments up to 30 cm long; poorly developed schistosity subparallel or at low angles with bedding.

Top of section: top of exposures; level within Jaeger Lake Formation; talus of volcanic rocks continues.

SECTION SOUTHEAST OF AURLAND FIORD

Location: Cape Stallworthy-Bukken Fiord, inset E, section EAF; 3.5 km southeast of Aurland Fiord; NTS 560 A; UTM Zone 15X, 481000E, 8989700N.

Measured from base up; field number 86TM2.

Base of section: top of covered interval, 11.5 m thick, underlain by quartzite of Grant Land Formation.

Hazen Formation

Carbonate member

Unit 1, 0-11.0 m (11.0 m)
Dolostone: medium grey, calcareous; coarse microcrystalline to very fine crystalline dolomite and minor interstitial micritic calcite; thin flat lamination; minor **flat-pebble conglomerate**: medium grey; composed of laminated dolostone, microcrystalline and phanerocrystalline; lamination flat or contorted; stylolites; vugs contain quartz, chalcedony, opaques.

Unit 2, 11.0-14.0 m (3.0 m)
Covered.

Unit 3, 14.0-18.3 (4.3 m)
Intermittent outcrop of **lime mudstone**: medium dark grey, dolomitic, slightly argillaceous, pyritic; thin flat lamination.

Unit 4, 18.3-19.5 m (1.2 m)
Sill (or flow?): medium grey; felsic in composition; microphenocrysts of feldspar in groundmass of feldspar and quartz; some carbonate alteration.

Unit 5, 19.5-25.5m (6.0 m)
Covered interval, recessive.

Unit 6, 25.5-32.5 m (7.0 m)
Lime mudstone: medium dark grey, argillaceous and variably dolomitic; some recrystallized radiolarian tests; flat lamination; minor **calcarenite-lime mudstone**: medium dark grey, very coarse to very fine grained; flat lamination and some convolute lamination; normal and reverse graded bedding; unidentified trace fossils (carbon films) on bedding planes.

Unit 7, 32.5-38.5 (6.0 m)
Lime mudstone: medium dark grey, argillaceous, variably dolomitic, and related **dolostone**; some **flat-pebble (and cobble) conglomerate**: clasts of lime mudstone, up to 10 cm long, in dolomitic matrix; rare skeletal(?) fragments of microscopic size (trilobite appendages?).

Unit 8, 38.5-56.0 m (17.5 m)
Covered interval, recessive.

Unit 9, 56.0-59.0 m (3.0 m)
Limestone: medium grey, fine crystalline (de-dolomite?), laminated; parting thickness 1-20 cm and related **flat-pebble conglomerate**; chalcedony lenses.

Top of section: top of exposures; level within, or at top of, carbonate member of Hazen Formation.

SVARTEVAEG SECTION

(partial type section of Svartevaeg Formation)

Location: Cape Stallworthy-Bukken Fiord, inset C, section SV; northeast-facing slope, about 13 km southeast of Cape Stallworthy; NTS 560 D; UTM Zone 15X, 501900E, 9028700N.

Measured from base up; field number 92TM2.

Base of section: base of exposures; level within upper part of member B of Svartevaeg Formation.

Svartevaeg Formation

Member B

This section is composed of sandstone, siltstone, volcanic rocks and minor conglomerate. Sandstone, volcanic rocks and conglomerate are all greenish grey; siltstone is medium dark grey. All sedimentary rocks are largely of volcanic derivation. The sandstone can be classified as volcanic arenite.

Unit 1, 0–10.5 m (10.5 m)
Conglomerate: volcanic clasts up to 15 cm, limestone clasts up to 20 cm in lower 1 m; fines upward to fine pebble conglomerate; large rip-up clast of siltstone in upper 2 m or so; outcrop is intermittent.

Unit 2, 10.5–13.5 m (3 m)
Sandstone: massive, medium bedded.

Unit 3, 13.5–18.0 m (4.5 m)
Covered, recessive; probably mainly **siltstone**.

Unit 4, 18.0–18.5 (0.5 m)
Sandstone: coarse grained, massive; rip-up clasts of mudrock and some carbonate pebbles.

Unit 5, 18.5–19.9 m (1.4 m)
Covered, probably siltstone.

Unit 6, 19.9–21.7 m (1.8 m)
Sandstone: medium and coarse grained, massive; rip-up clasts of mudrock to 20 cm long.

Unit 7, 21.7–23.2 m (1.5 m)
Mainly covered; probably mainly siltstone with 30 cm outcrop of **siltstone** and very fine grained **sandstone** in upper part.

Unit 8, 23.2–25.2 m (2.0 m)
Sandstone: medium and coarse grained, massive; large rip-up clasts of mudrock 90–110 cm above base.

Unit 9, 25.2–35.7 m (10.5 m)
Thinly interstratified **sandstone** and **siltstone**; sandy beds 0.5–20 cm thick are turbidites; flat lamination common.

Unit 10, 35.7–40.9 m (5.2 m)
Covered, recessive, mainly **siltstone**; 20 cm of interbedded fine grained **sandstone** and **siltstone** at top.

Unit 11, 40.9–53.1 m (12.2 m)
At base 75 cm of **sandstone**: fine to medium grained, with rip-up clasts of mudrock up to 25 cm long; above this interbedded **sandstone** and **siltstone**; **sandstone** beds 0.5–30 cm thick.

Unit 12, 53.1–56.0 m (2.9 m)
Covered, recessive.

Unit 13, 56.0–57.6 m (1.6 m)
Interbedded **sandstone** and **siltstone**; flat lamination common.

Unit 14, 57.6–65.1 m (7.5 m)
Talus and scattered outcrop of thinly interstratified **sandstone** and less abundant **siltstone**.

Unit 15, 65.1–75.6 m (10.5 m)
As unit 14 but **siltstone** more abundant.

Unit 16, 75.6–89.3 (13.7 m)
Sandstone: very fine or fine grained, and **siltstone**; interstratified at mm to cm scale; flat lamination, some convolute lamination, some climbing ripples; turbidites of $T_{b\text{-}d}$ and T_{cd} type.

Unit 17, 89.3–90.25 m (0.95 m)

0–85 cm – **sandstone**: very coarse grained at base, fining upwards to very fine grained; flat lamination.

85–90 cm – **sandstone**: very fine grained and **siltstone**: convolute lamination.

90–95 cm – **siltstone**: flat lamination.

This $T_{b\text{-}d}$ turbidite forms a lens estimated to be 20–30 m long.

Unit 18, 90.25–112.0 m (21.75 m)
Thinly interstratified and interlaminated **sandstone** and **siltstone** as in unit 17.

Unit 19, 112.0–125.0 m (13.0 m)
Sandstone, **siltstone**, and a little **pebble conglomerate**: massive, highly resistant unit.

Unit 20, 125.0–141.0 m (16.0 m)
Thinly interstratified **sandstone** and **siltstone**; **sandstone** bed thickness increases to 30 cm in upper 3 m or so, and **sandstone** becomes more abundant.

Unit 21, 141.0–142.7 m (1.7 m)
Sandstone; mudrock rip-up clasts at top.

Unit 22, 142.7–155.2 m (12.5 m)
Interstratified **sandstone** (probably >60%) and **siltstone**: sandstone beds 0.5–30 cm.

Unit 23, 155.2–182.5 m (27.3 m)
Several ledges of **sandstone**, 50–100 cm thick, alternating with thinner **sandstone** units, 0.5–50 cm thick; apparent dip of climbing ripple marks is to the south.

Unit 24, 182.5–194.5 m (12.0 m)
Tuff: crystal-lithic, andesitic (Appendix 4, 92TM1-2-6A-1, 2, 3); beds mostly 1 m thick or massive; also some flat lamination.

Unit 25, 194.5–198.0 m (3.5 m)
Tuff (or tuffaceous sandstone?) as in unit 24, interbedded with **siltstone**: laminated or thin bedded.

Unit 26, 198.0–205.0 m (7.5 m)
Volcanic conglomerate: clasts range from pebble to boulder grade (40 cm); massive.

Unit 27, 205.5–214.5 m (9.0 m)
Tuff: crystal-lithic and crystal, and **volcanic flow(s)**: amygdaloidal, all andesitic (Appendix 4, 92TM1-2-8-1, 2, 3).

Unit 28, 214.5–218.0 m (3.5 m)
Tuff: crystal, andesitic (Appendix 4, 92TM1-2-9), thin bedded and laminated.

Unit 29, 218.0–225.0 m (7.0)
Tuff: crystal-lithic, andesitic (Appendix 4, 92TM1-2-10), massive.

Unit 30, 225.0–234.0 m (9.0 m)
Tuff: crystal, crystal-lithic, lithic-crystal; analyzed sample (Appendix 4, 92TM1-2-11-4) is andesite; XRD analysis indicates that rhyolite also is present; laminated to thin bedded; minor **siltstone** in lower 3 m.

Unit 31, 234.0–252.5 m (18.5 m)
Covered.

Unit 32, 252.5–254.5 m (2.0 m)
Tuff: crystal-lithic, andesitic (Appendix 4, 92TM1-2-13); bedrock, broken in situ; some covered intervals.

Unit 33, 254.5–258.7 m (4.2 m)
Covered.

Unit 34, 258.7–263.5 m (4.2 m)
Volcanic conglomerate: clast diameter up to 3.5 cm; present as felsenmeer and broken outcrop.

Unit 35, 263.5–266.0 m (2.5 m)
Tuff: crystal-lithic, andesitic (Appendix 4, 92TM1-2-16); broken outcrop.

Top of section: top of exposures; level within member B of Svartevaeg Formation.

CLEMENTS MARKHAM FOLD BELT

SECTION SOUTHWEST OF YELVERTON INLET

(partial type section of Yelverton Formation)

Location: *Otto Fiord*, section SWYI; hills on southwest side of unnamed river flowing northwestward to Phillips Inlet; section SWYI-1 lies on the southern slope and section SWYI-2 on the crest of a south-southeast-trending ridge.

Section SWYI-1: NTS 340 C; UTM Zone 17X, 476450E, 9081500N. Section SWYI-2: NTS 340 C; UTM Zone 17X, 476300E, 9082000N.

Section SWYI-1 includes the lower part, and section SWYI-2 an upper part of a major thrust sheet of the Yelverton Formation emplaced upon the Grant Land Formation. The two are separated by a cliff-forming volcanic unit.

Measured from base up in 1982, field numbers 88TM1 and 88TM3.

Base of section: thrust fault underlain by Grant Land Formation.

Yelverton Formation

Section SWY-1

Unit 1, 0–4.5 m (4.5 m)
At base, **basaltic tuff and flow**: dark grey, schistose, less than 0.5 m thick; overlain by **phyllite**: medium dark grey, siliceous (cherty?), carbonaceous.

Unit 2, 4.5–15.0 m (10.5 m)
Rubble, more or less in place, of **phyllite**: medium dark grey, siliceous (cherty?), carbonaceous.

Unit 3, 15.0–19.0 m (4 m)
Chert: medium dark grey, with thinly interlaminated **lime mudstone**: light grey.

Unit 4, 19.0–27.0 m (8.0 m)
Phyllite: medium dark grey, chloritic and carbonaceous.

Unit 5, 27.0–37.0 m (10.0 m)
Basaltic flows and tuffs: medium dark grey and greenish grey.

Unit 6, 37.0–38.0 m (1.0 m)
Lime mudstone: brownish weathering, laminated, with chert lenses; **phyllite**: medium dark grey and greenish grey.

Unit 7, 38.0–39.6 m (1.6 m)
Basaltic tuffs and flows: as in units 5 and 1; covered from 38.6–39.4 m.

Unit 8, 39.6–50.6 m (11.0 m)
Lime mudstone: medium to medium dark grey, laminated; crystals mainly 10–20 μm but up to 60 μm long; **chert** laminae and lenses; lamination due to vertical variations in submicroscopic carbonaceous matter and chert content.

Unit 9, 50.6–72.5 m (21.9 m)
Mainly **phyllite**: medium dark grey; minor **chert** and **limestone** as in underlying units; talus from volcanics higher in the section contains some malachite and pyrite.

Unit 10, 72.5–81.0 m (8.5 m)
Volcanics: as in units 7, 5, and 1; massive.

Unit 11, 81.0–81.7 m (0.7 m)
Phyllite: medium dark grey, siliceous.

Unit 12, 81.7–184.0 m (102.3 m)
Basaltic flows and tuffs: greenish grey, massive; **diabase sills**; sill at 137 m contains malachite.

Unit 13, 184.0–186.3 m (2.3 m)
Phyllite: medium dark grey, indistinctly laminated, siliceous, calcareous, with chert lenses; carbonaceous matter shows undulating schistosity.

Unit 14, 186.3–287.0 m (100.7 m)
Basaltic flows and tuffs: greenish grey, massive, with **diabase sills**.

Section SW-YI-2

Base of section: top of cliff-forming volcanic unit; probably several hundred metres above top of section SW-YI-1.

Unit 1, 0–3.0 m (3.0 m)
Basaltic flow: greenish grey.

Unit 2, 3.0–4.0 m (1.0 m)
Phyllite: medium dark grey.

Unit 3, 4.0–9.0 m (5.0 m)
Lime mudstone: medium light grey, massive, dolomitic; dolomite crystals microcrystalline to very fine crystalline, scattered; **phyllite**: light greenish grey, highly calcareous, slightly argillaceous.

Unit 4, 9.0–15.0 m (6.0 m)
Phyllite: medium dark grey, recessive weathering, partly covered.

Unit 5, 15.0–17.0 m (2.0 m)
Limestone: medium dark grey, pyritic, schistose.

Unit 6, 17.0–20.0 (3.0 m)
Limestone: as in unit 5 with lenses of **phyllite**: greenish grey

Unit 7, 20.0–22.0 m (2.0 m)
Phyllite: greenish grey

Unit 8, 22.0–32.5 m (10.5 m)
Basaltic flows and tuff: greenish grey, massive, resistant; unit may include sill(s).

Unit 9, 32.5–34.2 m (1.7 m)
Limestone: as in unit 6.

Unit 10, 34.2–38.7 m (4.5 m)
Basaltic flows and tuff: as in underlying units.

Unit 11, 38.7–42.0 m (3.3 m)
Limestone: as in unit 6.

Unit 12, 42.0–52.0 m (10.0 m)
Phyllite: medium dark grey; some flat lamination.

Unit 13, 52.0–53.5 m (1.5 m)
Phyllite: greenish grey.

Unit 14, 53.5–57.5 m (4.0 m)
Limestone: as in unit 6.

Unit 15, 57.5–72.5 m (15.0 m)
Recessive, partly covered interval; some outcrop of **limestone** and **phyllite**.

Unit 16, 72.5–78.5 m (6.0 m)
Limestone: phyllitic, partly silicified; quartz veins common.

Unit 17, 78.5–93.5 m (15.0 m)
Limestone: as in underlying units, variably argillaceous, phyllitic.

Unit 18, 93.5–100.5 m (7.0 m)
Phyllite: greenish grey and medium dark grey, partly cherty.

Unit 19, 100.5–105.5 m (5.0 m)
Limestone: phyllitic, mostly silicified, resistant.

Unit 20, 105.5–107.5 m (2.0 m)
Phyllite: greenish grey, calcareous.

Unit 21, 107.5–110.0 m (2.5 m)
Limestone: as in unit 19, largely silicified.

Unit 22, 110.0–111.6 m (1.6 m)
Dolostone: yellowish grey, microcrystalline to fine crystalline, **chert**: medium dark grey, and **limestone**: as in unit 19.

Unit 23, 111.6–114.5 m (2.9 m)
Limestone: as in unit 19, largely silicified.

Unit 24, 114.5–121.5 m (7.0 m)
Limestone: as in unit 19.

Unit 25, 121.5–124.2 m (2.7 m)
Phyllite: medium dark grey, calcareous and **limestone**: medium dark grey, phyllitic.

Unit 26, 124.2–125.5 m (1.3 m)
Limestone: medium dark grey, largely silicified.

Unit 27, 125.5–128.0 m (2.5 m)
Phyllite: calcareous and **limestone**: phyllitic, as in underlying units.

Unit 28, 128.0–134.0 m (6.0 m)
Limestone: as in underlying units, largely silicified, resistant.

Unit 29, 134.0–138.0 m (4.0 m)
Limestone: as in underlying units, phyllitic, grading upwards to **phyllite**.

Unit 30, 138.0–140.5 m (2.5 m)
Phyllite: greenish grey; minor **limestone**: as in underlying units.

Unit 31, 140.5–155.5 m (15.0 m)
Limestone: medium dark grey, phyllitic; base and upper 7.5 m partly silicified.

Unit 32, 155.5–156.7 m (1.2 m)
Phyllite: greenish grey.

Unit 33, 156.7–158.0 m (1.3 m)
Limestone: medium dark grey, phyllitic, partly silicified.

Unit 34, 158.0–162.0 m (4.0 m)
Mainly **phyllite**: grey, calcareous; minor interbedded **limestone**: medium dark grey, phyllitic, and **dolostone**: coarse crystalline; lenses of **chert**.

Unit 35, 162.0–166.5 m (4.5 m)
Limestone: medium dark grey, phyllitic.

Unit 36, 166.5–177.0 m (10.5 m)
Limestone: medium dark grey, phyllitic, partly silicified with minor interbedded **phyllite**: medium dark grey; units 0.1–0.3 m thick.

Top of section: top of good exposures; level within Yelverton Formation.

FIRE BAY 1 SECTION

(part of composite type section of Fire Bay Formation)

Location: *Cape Stallworthy-Bukken Fiord*, inset B, section FB1; 0.8 km south of Fire Bay; NTS 560 D; UTM Zone 16X; 470250E, 9042800N.

Measured from base up; field number 92TM3.

Base of section: faulted contact with Hazen Formation.

Fire Bay Formation

Member A, northwestern facies

Unit A1

Unit 1, 0-60± m (60± m)
Mostly covered; intermittent outcrop of **sandstone**, **mudrock,** and minor **pebble conglomerate**; thickness uncertain because of poor attitude control due to frost heaving; **sandstone**: medium grey; fine to coarse grained, in part pebbly; calcite replacement common; beds 10 cm to 2.8 m thick.

Unit A2

Unit 2, 60-65.8 m (5.8 m)
Pebble conglomerate: medium grey; composed mainly of quartz (including vein quartz), chert (in part metamorphosed), and volcanic rocks; mainly pebble grade but quartzose clasts up to 9 cm, volcanic clasts up to 23 cm long; indistinct horizontal stratification, beds about 0.1-1 m thick; some lenses of **mudrock**.

Unit A3

Unit 3, 65.8-71.1 m (5.3 m)
Mostly covered, recessive; some outcrop of **mudrock**.

Unit 4, 71.1-72.8 m (1.7 m)
Sandstone: medium grey, medium to very coarse grained with some granule-bearing strata; rip-up clasts of mudrock at base; massive; some reverse graded bedding.

Unit 5, 72.8-80.7 m (1.7 m)
Covered.

Unit 6, 80.7-81.2 m (0.5 m)
Sandstone: medium grey, fine to medium grained with some granule-bearing strata.

Unit 7, 81.2-97.5 m (16.3 m)
Covered.

Unit A4

Unit 8, 97.5-102.0 m (4.5 m)
Interbedded **mudrock** and **sandstone**: very fine to coarse grained; beds 5-30 cm thick; some flat lamination; concretions; beds broken by frost-heaving.

Unit 9, 102.0-103.0 (1.0 m)
Sandstone: massive.

Unit 10, 103.0-105.4 m (2.4 m)
Lower part of unit is **sandy conglomerate**, upper part is **pebbly sandstone**; volcanic and carbonate clasts up to 11 cm in diameter, mudrock rip-up clasts up to 30 cm.

Unit 11, 105.4-118.9 m (13.5 m)
Lithic-crystal tuff (or resedimented tuff): greenish grey, coarse sand grade.

Unit 12, 118.9-120.6 m (1.7 m)
118.9-119.5 m: **sandy conglomerate**: volcanic clasts up to 15 cm in diameter, carbonate clasts up to 35 cm; 119.5-120.6: **conglomeratic sandstone** with carbonate cobbles.

Unit 13, 120.6-140± m (19.4± m)
Mainly **sandstone**, minor fine **pebble conglomerate**; frost-heaved; bedding attitude and thickness uncertain.

Top of section: top of exposures in centre of syncline; level within unit A4 of northwestern facies of Member A of Fire Bay Formation.

FIRE BAY 2 SECTION (FB2)

(part of composite type section of Fire Bay Formation)

Location: Cape Stallworthy–Bukken Fiord, inset B, section FB2; southeast-facing slope, 1.6 km east-northeast of head of Fire Bay; NTS 560 D; UTM Zone 16X, 472600E, 9045000N.

Measured from base up; field number 92TM6.

Base of section: base of exposures; level within Fire Bay Formation, Member A, northwestern facies, unit A4.

Fire Bay Formation

Member A, northwestern facies

Unit A4

Unit 1, 0–48.0 m (48.0 m)
Sandstone, minor **pebble conglomerate**, a little **siltstone**; beds mostly 1 m thick, rarely 0.1–10 cm.

- gravitational(?) fault -

Carbonate olistolith (probably early Middle Ordovician)

Unit 2, 48.0–67.0 m (19.0 m)
Dolostone: massive.

- gravitational(?) fault -

Hazen Formation

Unit 3, 67.0–71.0 m (4.0 m)
Chert: dark grey, contorted.

- gravitational(?) fault -

Member B

Unit B1

Unit 4, 71.0–89.0 m (18.0) m
Tuff: sample is crystal tuff, medium grey-greenish grey, silt and coarse sand-grade, laminated; rich in K-feldspar, albite, quartz, and chlorite with ankerite replacement and veinlets.

Unit 5, 89.0–96.0 m (7.0 m)
Covered.

Unit 6, 96.0–159 (63 ± m)
Tuff: medium grey-greenish grey, massive; thickness uncertain because of lack of attitude control; sample is crystal tuff composed mainly of albite, chlorite, and clinopyroxene; probably andesite/basalt (Appendix 4A, 92TM6–97 m); carbonate clasts in upper 4.5 m.

Unit 8, 159–173 ± (14 ± m)
Volcanic flows and tuffs: contorted; thickness uncertain; samples represent mafic tuffs (andesite/basalt) and a felsic flow (rhyodacite/dacite; Appendix 4A, 92TM6–159m, -163m, -166.5 m).

Top of section: base of highly disturbed and poorly exposed interval; level within, or at top of, Unit B1 of Member B of Fire Bay Formation.

FIRE BAY 3 SECTION

(part of composite type section of Fire Bay Formation)

Location: Cape Stallworthy–Bukken Fiord, inset B, section FB3; south-facing slope, about 3 km east-southeast of Fire Bay; NTS 560 D; UTM Zone 16X, 473800E, 9042800N.

Measured from base up; field number 92TM5.

Base of section: base of exposures; level within Fire Bay Formation, Member A, southeastern facies.

Fire Bay Formation

Member A, southeastern facies

Unit A3

Unit 1, 0–45.0 m (45.0 m)
Mostly covered with intermittent outcrop of **mudrock**: flat and undulating lamination.

Unit A4

Unit 2, 45.0–51.45 m (6.45 m)
Mainly **sandstone**: medium grained at base, very fine grained at top; massive; rip-up clasts to 5 cm long in lower 40 cm, small rip-up clasts at 48.0 m; overlain by about 25 cm of **mudrock**: flat-laminated.

Unit 3, 51.45–58.2 m (6.75 m)
At base 25 cm of **mudrock**, flat-laminated; remainder of unit mainly covered with some outcrop of **mudrock**.

Unit 4, 58.2–63.85 m (5.65 m)
Mainly **sandstone**: as in unit 2, minor **intraformational conglomerate**; overlain by about 50 cm of **mudrock**: sandy, flat-laminated.

Unit 5, 63.85–70.80 m (6.95 m)
At base 50 cm of **mudrock**: sandy, flat-laminated; remainder is undifferentiated **mudrock**.

Unit 6, 70.80–75.3 m (4.5 m)
T_{a-d} turbidite, composed mainly of **sandstone**: medium to coarse grained at base with rip-up clasts of mudrock up to 1.1 cm long; very fine grained at top (T_{a-c}); overlain by 50 cm of **siltstone**: sandy; flat and undulating lamination (T_d).

Unit 7, 75.3–94.9 m (19.6 m)
Mudrock.

Unit 8, 94.9–100.7 m (5.8 m)
Partly covered; some outcrop of **sandstone**: coarse grained with abundant rip-up clasts of mudrock.

Unit 9, 100.7–102.7 m (2.0 m)
Covered.

Unit 10, 102.7–106.5 m (3.8 m)
Frost-heaved interval; **sandstone** with intraformational conglomerate in lower part.

Unit 11, 106.5–110.2 m (3.7 m)
Mostly covered; probably structurally disturbed interval.

Unit 12, 110.2–114.9 m (4.7 m)
T_{a-b} turbidite.

110.2–113.7 m (3.5 m): **sandstone**: coarse grained at base, fining upward; rip-up clasts in lower 0.9 m.

113.7–114.9 m (1.2 m): **sandstone**: fining upward, laminated.

Unit 13, 114.9–116.9 m (2.0 m)
Partly covered; some outcrop of **mudrock** in lower part, showing phyllitic texture; probably structurally disturbed.

Unit 14, 116.9–127.6 m (10.7 m)
Outcrop and talus of **mudrock**: in part sandy and **sandstone**: very fine grained, silty.

Unit 15, 127.6–135.6 m (8.0 m)
T_{a-c} turbidite.

127.6–131.7 m (4.1 m): **sandstone**: medium grained at base, fining upward; massive; rip-up clasts of mudrock up to 5 cm long.

131.7–135.1 m (3.4 m): **sandstone**: fining upward, very fine grained, silty at top; flat-laminated.

135.1–135.6 m (0.5 m): **siltstone**: sandy, frost-heaved; indistinct convolute lamination.

Unit 16, 135.6–140.0 m (1.4 m)
Mudrock.

Top of section: top of exposures on ridge; level within unit A4 of southeastern facies of Member A of Fire Bay Formation.

FIRE BAY 4 SECTION

Location: Cape Stallworthy-Bukken Fiord, inset B, section FB4; 4.1 km southeast of Fire Bay; north side of unnamed creek; NTS 560 D; UTM Zone 16X, 474400E, 9041300N.

Measured from base up; field number 92TM4.

Base of section: base of exposures by creek; level within Fire Bay Formation, Member A, southeastern facies, unit A4.

Fire Bay Formation

Member A, southeastern facies

Unit A4

Sandstones are mainly medium dark grey but also medium grey; mudrocks are medium dark grey.

Unit 1, 0–0.82 m (0.82 m)
Mudrock: sandy; flat lamination; partly replaced by ankerite (concretions).

Unit 2, 0.82–1.14 m (0.32 m)
Mudrock: in part sandy; mainly flat lamination; convolute lamination at 0.88–92.5 cm.

Unit 3, 1.14–1.75 m (0.61 cm)
T_{a-c} turbidite.

1.14–1.57 m (0.43 m): **sandstone**: fine to medium grained, massive; top sheared. 1.57–1.71 m (0.14 m): **sandstone**: very fine to fine grained, flat-laminated.

1.71–1.75 m (0.04 m): **sandstone**: very fine grained, silty and **siltstone**: sandy; convolute lamination.

Unit 4, 1.75–3.45 (1.7 m)
Mudrock: flat-lamination and some convolute lamination; subtle graded bedding; partly replaced by ankerite.

Unit 5, 3.45–5.55 m (2.1 m)
Mainly **sandstone**: very fine grained, silty; minor **mudrock**: flat lamination and some convolute lamination.

Unit 6, 5.55–5.79 m (0.24 m)
Sandstone: fine grained at base, very fine grained at top, massive.

Unit 7, 5.79–6.05 m (0.26 m)
Mudrock: medium dark grey, fine grained.

Unit 8, 6.05–6.70 m (0.65 m)
Sandstone: medium dark grey, coarse grained; mostly massive but upper 10 cm has indistinct convolute lamination; some rip-up clasts.

Unit 9, 6.70–6.89 m (0.19 m)

6.70–6.73 (0.03 m): **mudrock**: as in underlying units overlain by T_{b-d} turbidite.

6.73–6.82 m (0.09 m): **sandstone**: medium dark grey, very fine grained and **siltstone**: medium dark grey; flat lamination.

6.82–6.88 m (0.06 m): **siltstone**: convolute lamination.

6.88–6.89 m (0.01 m): **siltstone**: flat lamination.

Unit 10, 6.89–8.54 m (1.65 m)
Mudrock: medium dark grey, fine, partly covered.

Unit 11, 8.54–8.76 m (0.22 m)
Sandstone: medium to medium dark grey, medium to coarse grained; mostly massive with indistinct convolute lamination structure in upper 6 cm.

Unit 12, 8.76–10.06 m (1.3 m)
Mudrock: medium dark grey.

Unit 13, 10.06–11.36 m (1.3 m)
Mainly **mudrock**: medium dark grey; in lower part minor **sandstone**: beds 5–10 cm thick.

Unit 14, 11.36–13.21 m (1.85 m)
Sandstone: medium to coarse grained at base, medium grained at top; massive; rip-up(?) clasts (including radiolarian chert) in lower 40 cm and at top.

Unit 15, 13.21–19.21 m (6.0 m)
Lower part covered; upper part has scattered outcrop of **mudrock**: medium dark grey.

Unit 16, 19.21–20.01 m (0.8 m)
Sandstone: medium dark grey, very fine grained, silty and **siltstone**: medium dark grey, coarse grained, sandy; some flat and convolute lamination (frost-heaved).

Unit 17, 20.01–22.31 m (2.3 m)
Sandstone: medium grey; medium to coarse grained at base, medium grained at top; structure obscured by frost-heaving, probably massive; some mudrock rip-up clasts.

Top of section: top of exposures; level within unit A4 of southeastern facies of Member A of Fire Bay Formation.

FIRE BAY 5 SECTION

Location: *Cape Stallworthy-Bukken Fiord*, inset B, section FB5; 1.9 km southeast of Fire Bay; cliffs on southwest side of unnamed river; NTS 560 D; UTM Zone 16X, 472200E, 9042100N.

Measured from base up; field number 92TM2.

Base of section: base of nearly continuous exposures; level within Fire Bay Formation, Member A, southeastern facies, unit A4.

Fire Bay Formation

Southeastern facies

Unit A4

Unit 1, 0–1.7 m (1.7 m)
Interbedded (about 50% each) **mudrock**: medium dark grey, and **sandstone**: medium dark grey; flat lamination and cross-lamination; mainly very fine or fine grained; also coarse grained with mudrock rip-up clasts.

Unit 2, 1.7–2.05 m (0.35 m)
Sandstone: medium dark grey; coarse grained at base fining upward to very fine grained, silty; massive; overlain by 1.5 cm of **mudrock**: medium dark grey, flat-laminated.

Unit 3, 2.05–5.25 m (3.2 m)
Mainly **mudrock** as before; minor **sandstone**: medium dark grey, very fine and fine grained; some flat lamination; concretions and partial replacement by microcrystalline dolomite or ankerite.

Unit 4, 5.25–13.25 m (8.0 m)
Sandstone and **mudrock** as before; T_{b-d} sequences common; **sandstone**: medium dark grey, mostly very fine and fine grained; beds 1–20 cm, commonly 5–10 cm thick; flute marks would indicate transport parallel with strike, roughly from southwest to northeast, if structural plunge (not determined) is subhorizontal.

Unit 5, 13.25–15.75 m (2.5 m)
Sandstone and **mudrock** as before (about 50% each); **sandstone**: medium dark grey; very fine and fine grained; beds 1–10 cm thick.

Unit 6, 15.75–39.5 m (23.75 m)
Sandstone and **mudrock** as before; T_{a-d} and T_{b-d} sequences common; **sandstone**: medium dark grey, mainly very fine and fine grained; sandy beds a few mm to 11 cm, commonly <6 cm thick.

Unit 7, 39.5–40.0 m (0.5 m)
T_{a-d} turbidite; mainly **sandstone**: fine grained at base, very fine grained at top, poorly sorted; with **siltstone** in upper 2 cm.

Unit 8, 40.0–46.2 (6.2 m)
Sandstone and **mudrock** as before; mainly T_{a-d} and T_{b-d} turbidites; **sandstone**: medium dark grey, very fine grained; beds 2–12 cm thick.

Unit 9, 46.2–48.4 m (2.2 m)
T_{a-d} turbidite.

46.2–47.0 m (0.8 m): **sandstone**: medium grey, coarse grained, massive.

47.0–48.1 m (1.1 m): **sandstone**: medium grey, fine and very fine grained; flat lamination.

48.1–48.3 m (0.2 m): **sandstone**: medium and medium dark grey, very fine grained, cross-laminated.

48.3–48.4 m (0.1 m): **siltstone**: medium dark grey, sandy, flat-laminated.

Unit 10, 48.4–48.9 m (0.5 m)
Siltstone: medium dark grey, variably sandy; flat lamination and crosslamination.

Unit 11, 48.9–51.1 m (2.2 m)
Mudrock: medium dark grey (folded).

Top of section: top of accessible exposures; level within unit A4 of southeastern facies of Member A of Fire Bay Formation.

HVITLAND PENINSULA 1 SECTION

(partial type section of Lands Lokk Formation)

Location: *Otto Fiord*, section HP1; Hvitland Peninsula, 8 km south of head of Emma Fiord; NTS 340 C; UTM Zone 16X, 495200E, 9039200N.

Originally measured in 1962 (Trettin, 1969), remeasured in 1986 from base up; field number 86TM5.

Base of section: mudrock present as rubble; top of mudrock-volcanogenic facies (map unit SLpv).

Lands Lokk Formation

Sandstone-mudrock facies (map unit SLq)

Unit 1, 0–65.2 m (65.2 m)
Mudrock, minor **sandstone** (for description, *see* unit 2).

Unit 2, 65.2–68.5 m (3.3) m
Sandstone (81%), minor **mudrock** (19%). **Sandstone**: medium to medium dark grey, coarse to very fine grained; massive bedding, flat lamination, convolute lamination; some slaty cleavage; composed mainly of quartz and chert with minor feldspar, mica, chlorite, carbonates, etc. **Mudrock**: medium dark grey; fine to coarse grained, in part sandy; flat lamination common; slaty cleavage.

Detailed interval (a) at 65.2 m (327.7 cm):

M (massive sandstone): 2 units, 16–69 cm thick; fine and medium grained **sandstone**; rip-up clasts of mudrock in one unit.

T_a (single A-divisions of Bouma model): 5 units, 3–21 cm thick; graded, no lamination; bases fine to coarse grained, tops very fine to medium grained **sandstone**.

T_b (single B-divisions): 1 unit, 5 cm thick; flat lamination; fine and very fine grained **sandstone**.

T_c (single C-divisions): 2 units 3 cm thick; convolute lamination; very fine grained, silty **sandstone** and coarse grained, sandy **siltstone**.

T_{ab} (A and B-divisions): 5 units, 3–60.5 cm thick; bases fine and coarse grained **sandstone**, tops fine or very fine grained **sandstone**.

P (undifferentiated **mudrock**; includes D-divisions): 12 units, 0.2–28.5 cm thick.

Unit 3, 68.5–239.5 m (171 m)
Mudrock and **sandstone**.

Detailed interval (b) at 74.0 m (47 cm):

T_b: 4 units, 1–18 cm thick; bases very fine or fine grained **sandstone**, tops very fine to fine grained or very fine grained **sandstone**.

T_c: 1 unit, 1 cm thick; very fine grained, silty **sandstone**.

P: 5 units, 1–9 cm thick; **mudrock**.

Detailed interval (c) at 79.0 m (47.6 cm):

M: 1 unit, 20 cm thick, fine to medium grained **sandstone**.

T_b: 1 unit, 1.6 cm thick; very fine and fine grained **sandstone**.

T_{a-c}: 2 units, 8.3–9.9 cm thick; medium grained **sandstone** at base, very fine grained, silty **sandstone** at top.

P: 2 units, 0.2–8 cm thick; **mudrock**.

Detailed interval (d) at 178.9 m (64.8 cm):

T_b: 2 units, 1–2.3 cm thick; flat-laminated, very fine grained **sandstone** at base; very fine grained silty **sandstone** or sandy **siltstone** at top.

T_{ab}: 1 unit, 34 cm thick; medium to coarse grained **sandstone** at base, very fine grained **sandstone** at top.

T_{bc}: 1 unit, 4 cm thick; very fine grained **sandstone** at base, **siltstone** at top.

P: 5 units, 1–10 cm thick; **mudrock**.

Detailed interval (e) at 182.0 m (23.9 cm):

T_b: 2 units, 1–1.4 cm thick; very fine grained **sandstone**.

T_{ab}: 2 units, 5.5–7 cm thick; fine or medium grained **sandstone** at base, very fine grained **sandstone** or coarse grained **siltstone** at top.

P: 3 units, 1.5–4 cm thick; **mudrock**.

Detailed interval (f) at 186.0 m (15.0 cm):

T_b: 2 units, 2.5–3 cm thick; very fine grained **sandstone** at base, coarse grained **siltstone** at top.

T_{bc}: 2 units, 1.5–2 cm thick; very fine to fine grained or very fine grained **sandstone** at base, very fine grained **sandstone** at top.

P: 3 units, 1–3 cm thick; **mudrock**.

Detailed interval (g) at 192.5 m (14.4 cm):

T_{ab}: 1 unit, 6 cm thick, very fine to fine grained **sandstone** at base, very fine grained sandstone at top.

P: 2 units, 3–5.5 cm thick; **mudrock**.

Detailed interval (h) at 214.5 m (18.8 cm):

T_{ab}: 1 unit, 14.5 cm thick; very fine to fine grained **sandstone** at base, very fine grained **sandstone** at top.

P: 2 units, 0.3–3 cm thick; **mudrock**.

Graptolite collections:

C-94397 from talus 50–200 m above base of section; Early Silurian, late Llandovery (Telychian).

C-94398 from talus 180–240 m above base; Early Silurian to Early Devonian (undifferentiated).

Unit 4, 239.5–240.9 m (1.4 m)
Sandstone.

Detailed interval (i) at 239.5 m (137.5 cm); T_{ac}:

Division A: 95 cm; coarse grained **sandstone** at base.
Division B: 39.2 cm; fine grained **sandstone** at base.
Division C: 1 cm; very fine grained **sandstone**.
Division D: 2.3 cm; very fine grained **sandstone**.
Overlain by **mudrock** of unit 5, below.

Unit 5, 240.9–257.5 m (16.6 m)
Mudrock and **sandstone**.

Unit 6, 257.5–268.6 m (11.1 m)
Sandstone, minor mudrock.

Detailed interval (j) at 257.5 m (401.5 cm):

T_{ab}: 2 units, 50–346 cm thick; medium to coarse or coarse grained **sandstone** at base, very fine or fine grained **sandstone** at top.

P: 2 units, 0.6–6 cm thick, **mudrock**.

Detailed interval (k) at 263.6 m (58 cm):

T_{ab}: 2 units, 20.5-29 cm; medium or medium to coarse grained **sandstone** at base, fine or fine to medium grained **sandstone** at top.

P: 1 unit, 8.5 cm thick; **mudrock**.

Unit 7, 268.6-330.6 m (62.0 m)
Mudrock and **sandstone**.

Graptolite collection C-94399; Early Silurian to Early Devonian (undifferentiated).

Unit 8, 330.6-344.1 m (13.5 m)
Sandstone (about 95%): in units 30-70 cm thick; minor **mudrock**.

Unit 9, 344.1-362.4 m (18.3 m)
Mudrock and **sandstone** (roughly 30%): beds commonly 5-10 cm thick.

Unit 10, 362.4-363.5 m (1.1 m)
Sandstone.

Unit 11, 363.5-367.5 m (4.0 m)
Mudrock and **sandstone**.

Unit 12, 367.5-369.0 m (1.5 m)
Sandstone.

Unit 13, 369.0-371.0 m (2.0 m)
Mudrock and **sandstone**.

Unit 14, 371-380 m (9.0 m)
Sandstone (about 95%): beds 10-50 cm, becoming thinner upward; minor **mudrock:** mudrock content increases upward.

Unit 15, 380-394 m (14.0 m)
Sandstone (about 50-60%:): beds up to 50 cm thick; **mudrock** (about 40-50%).

Unit 16, 394-396 m (2.0 m)
Sandstone: locally **chert pebble conglomerate** in upper part.

Unit 17, 396-442 m (46.0 m)
Mudrock and **sandstone**: relatively thin bedded, recessive unit.

Graptolite collection C-94400; from talus 396-450 m; Silurian, probably Ludlow.

Unit 18, 442-442.85 m (0.85 m)
Sandstone: massive.

Unit 19, 442.85-472.9 m (30.05 m)
Sandstone: units up to 30 cm thick, and **mudrock**.

Graptolite collection C-94401; from talus 460-472.9 m; Silurian, probably Ludlow.

Unit 20, 472.9-474.1 m (1.2 m)
Sandstone.

Unit 21, 474.1-488.9 m (14.8 m)
Mudrock and **sandstone**.

Unit 22, 488.9-498.4 m (9.5 m)
Sandstone (about 90%) and **mudrock** (about 10%).

Unit 23, 498.4-533.4 m (35.0 m)
Mudrock.

Unit 24, 533.4-534.5 m (1.1 m)
Sandstone.

Unit 25, 534.5-540.7 m (6.2 m)
Mudrock and **sandstone**.

Unit 26, 540.7-541.5 m (0.8 m)
Sandstone.

Unit 27, 541.5-554.5 m (13.0 m)
Mudrock and **sandstone**.

Unit 28, 554.5-556.3 m (1.8 m)
Sandstone.

Unit 29, 556.3-571.8 m (15.5 m)
Mudrock and **sandstone**.

Unit 30, 571.8-572.8 m (1 m)
Mainly **sandstone**: 3 beds; minor **mudrock**: 2 very thin beds.

Unit 31, 572.8-580.3 m (7.5 m)
Mainly **sandstone**, minor **mudrock**.

Unit 32, 580.3-581.5 m (1.2 m)
Mainly **sandstone**, minor **mudrock**; T_{a-c} in lower 80 cm, base medium grained.

Unit 33, 581.5-583.0 m (1.5 m)
Mudrock and **sandstone**.

Unit 34, 583.0-585.5 m (2.5 m)
Sandstone.

Unit 35, 585.5-614.0 m (28.5 m)
Mudrock and **sandstone**.

Unit 36, 614.0–618.5 m (4.5 m)
Sandstone with minor **pebble conglomerate** at base; massive, graded unit (T_a); volcanogenic in lower and(?) middle part; nonvolcanogenic in upper part;

Detailed interval (l) at 614 m (448 cm):

0–1.5 cm (1.5 cm): **volcanogenic fine pebble conglomerate** (maximum clast size 6 mm) in matrix of volcanogenic sand.

1.5–5 cm (4.5 cm): **volcanogenic sandstone**; fine grained at base, very coarse grained at top; massive.

5–190 cm (185 cm): **volcanogenic sandstone**, massive, graded; very coarse grained with granules to 19.5 cm (or higher); medium to coarse grained with granules at 55 cm; medium grained (maximum grain size very coarse) at 190 cm.

at 430 cm: **quartz-chert sandstone**, fine grained (maximum grain size very coarse to granule grade), massive.

at 448 cm: **quartz-chert sandstone**, very fine grained (maximum size medium grained), massive.

Unit 37, 618.5–673.5 m (55.0 m)
Mudrock and **sandstone**.

Unit 38, 673.5–678.5 m (5.0 m)
Sandstone.

Unit 39, 678.5–699.0 m (20.5 m)
Mudrock and **sandstone**.

Unit 40, 699.0–700.3 m (1.3 m)
Sandstone.

Unit 41, 700.3–727.8 m (27.5 m)
Sandstone and **mudrock**.

Unit 42, 727.8–729.2 m (1.4 m)
Mainly **sandstone** with 2 units of **mudrock**, about 20 cm thick each.

Unit 43, 729.2–733.5 m (4.3 m)
Sandstone and **mudrock**.

Unit 44, 733.5–735.5 m (2.0 m)
Mainly **sandstone** with minor **mudrock** in lower part.

Unit 45, 735.5–743.0 m (7.5 m)
Sandstone and **mudrock**.

Unit 46, 743.0–744.8 m (1.8 m)
Sandstone with minor interbedded **mudrock** in upper part.

Unit 47, 744.8–777.8 m (33.0 m)
Sandstone and **mudrock**.

Unit 48, 777.8–779.9 m (2.1 m)
Sandstone: 2 units, 0.8 m below and 1.1 m above; with 1 unit of interbedded **mudrock**: 0.2 m thick.

Unit 49, 779.9–784.4 m (4.5 m)
Mudrock.

Unit 50, 784.4–792.6 m (8.2 m)
Sandstone and less abundant **mudrock**.

Top of section: top of exposures in axis of syncline; level within sandstone-mudrock facies of Lands Lokk Formation.

MARKHAM RIVER SECTION

(type section of Markham River Formation)

Location: *Clements Markham Inlet-Robeson Channel*, section MR; southeast-facing slopes, about 2.4 km northwest of Markham River; NTS 120 F; UTM 19X, 493400E, 9168300N.

Measured from base up in 1982, with some additional work in 1979 and 1990; field numbers 79TM237A, 82TM11, 82TM149A, and 90TM127C.

Underlying strata: mudrock, medium to dark grey, intensely bioturbated and carbonated, assigned to Lands Lokk Formation. Palynomorphs of Late Siluriuan to possibly Devonian (Lochkovian or younger) age occur in upper 100 m or so of mudrock unit (McGregor, Appendix 4D, C-54943, C-54946).

Lands Lokk Formation

Unit 1, 0–34.5 m (34.5 m)
Mainly **sandstone** (est. 75%): composed mainly of quartz with minor muscovite, feldspar (in part extremely sericitized), and chert, and secondary dolomite and calcite; very fine to very coarse grained; flat lamination, some small-scale crosslamination, some bioturbation; minor **siltstone**, and very small amounts of **conglomerate**: granule and fine pebble grade, occurring in thin lenses.

Unit 2, 34.5–36.5 m (2.0 m)
Rubble of **mudrock**: grey, fissile.

– abrupt, probably disconformable contact –

Markham River Formation

Unit 1, 0–6.1 m (6.1 m)
Nodular dolostone, pebble conglomerate, and minor sandstone (stratigraphy of unit varies considerably over short distances).

0–1.5 m (1.5 m): **Nodular dolostone:** medium dark grey, microcrystalline to fine crystalline, quartz silty and sandy with some cherty and dolomitic spicules and abundant, finely disseminated pyrite; probably bioturbated; nodules, up to 10 cm in diameter, have irregular, but rounded outlines; unit is conglomeratic in appearance.

1.5–3.0 m (1.5 m): Covered, recessive.

3.0–3.5 m (0.5 m): **Nodular dolostone:** as in underlying units; nodules are of pebble grade and commonly bounded by solution surfaces.

– abrupt contact, possibly disconformable –

3.5–5.5 m (2.0 m): **Pebble conglomerate:** medium light grey, massive, sandy, poorly sorted and rounded; pebbles of quartzite, chert (including spicules), dolostone, and quartz; medium light grey.

5.5–6.1 m (0.6 m): **Sandstone:** light grey, quartzose, cherty, dolomitic; bimodal, fine grained with granules of chert; flat-laminated; trough, 10 cm deep, at base.

Unit 2, 6.1–38.0 m (31.9 m)
Steep talus slope.

Unit 3, 38.0–70.5 m (32.5 m)
Partly covered; outcrop and talus of **spiculite**: cherty and dolomitic, bioturbated.

Unit 4, 70.5–106.5 m (36.0 m)
Mainly interbedded **dolostone**, **spiculite**, and **sandstone**, with minor amounts of **dolomitic oncolite** and **pebble conglomerate**.

Dolostone: medium light grey, microcrystalline.

Spiculite: medium light grey, cherty, dolomitic.

Sandstone: medium light grey, quartzose, cherty, highly dolomitic; partly fine grained, but up to very coarse grained with granules; beds 2–10 cm thick at 70.5–71 m; crosslaminated at 72.7–73.0 m.

Oncolite: oncoids up to 1.8 cm in diameter; composed of microcrystalline dolomite with clotted structure; vague concentric layering, commonly accentuated by selective chert replacement; at 103.5 m two layers, 0.3 and 0.7 m thick, separated by 0.3 m of dolostone.

Pebble conglomerate: granules and pebbles, up to 7 mm in diameter, composed of chert, quartz, dolostone, etc. at 72.5 m.

Unit 5, 106.5–138.8 m (28.0 m)
Pebble conglomerate, **mudrock**, **dolomitic oncolite**, **dolomitic ostracode grainstone**, and **dolostone**.

106.5–110.5 m (4.0 m): **Pebble conglomerate**: pebbles of dolostone, chert, quartzite etc.; vague flat bedding; beds 0.3–1.0 m thick; ledge-forming unit.

110.5–112.5 m (2.0 m): **Dolomitic ostracode grainstone**: quartz-silty and sandy, includes unidentified skeletal grains, generally coated.

112.5–113.2 (0.7 m): **Oncolite:** dolomitic oncoids as in underlying units with some dolostone intraclasts, and ostracodes in matrix of silt and very fine grained sand of dolomite and quartz.

113.2–115.0 (1.8 m): Partly covered; some outcrop of **mudrock**: medium light grey near base, coarse grained, dolomitic; and of **dolomitic ostracode grainstone**: quartz-silty and sandy.

115.0–120.0 (5.0 m): **Pebble conglomerate:** cobbly, as in underlying units; clasts up to 10 cm long; vaguely bedded (0.5 m), massive.

120.0–121.6 m (1.6 m): **Mudrock:** medium grey, dolomitic; partings spaced 1–10 cm.

121.6–121.85 m (0.25 m): **Dolomitic ostracode grainstone**: as in underlying units.

121.85–122.05 m (0.2 m): **Dolomitic oncolite:** as in underlying units.

122.05–122.75 m (0.7 m): **Mudrock:** medium light grey, coarse grained, dolomitic.

122.75–123.05 m (0.3 m): **Pebble conglomerate:** as in underlying units; pebbles up to 2 cm long; massive.

123.05–123.35 m (0.3 m): **Mudrock**: as in underlying units.

123.35–123.6 m (0.25 m): **Pebble conglomerate**: as in underlying units.

123.6–126.8 m (3.2 m): **Dolomitic ostracode grainstone**: as in underlying units; beds 5–10 cm thick; interbedded with **dolomitic oncolite**: as in underlying units; beds 5–20 cm thick.

126.8–127.0 m (0.2 m): **Pebble conglomerate:** as in underlying units; clasts up to 2 cm long.

127.0–134.5 m (7.5 m): **Dolostone:** microcrystalline, argillaceous; beds 1–5 cm thick; some beds contain ostracodes, others oncoids.

Ostracode collection C-94377 at 127.3–128.5 m: Silurian, late Llandovery to late Ludlow.

134.5–138.8 m (4.3 m): Poorly exposed, recessive interval; mainly **mudrock**: light grey to light brownish grey; partings at 1–3 mm; with a few layers of **pebble conglomerate**: fine (clasts up to 8 mm in sample); thickest pebble conglomerate 20 cm thick (in middle of unit).

Unit 6, 138.8–166.0 m (27.2 m)
Mainly **dolostone**: microcrystalline; containing some quartz mainly of silt and very fine sand grade; minor **pebble conglomerate**: fine (at 152.4–152.6 m), **dolomitic ostracode grainstone**: sandy (at 146.8–147.3 m), and **dolomitic oncolite** (at 140 m).

Top of section: top of exposures; level within, or at top of, Markham River Formation.

PEARYA

SECTION NORTHEAST OF MILNE GLACIER

Location: ***Yelverton Inlet***, section NEMG; directly northeast of lower reaches of Milne Glacier; NTS 340 F; UTM Zone 17X, 510275E, 9156800N.

Based on brief traverse by author and photogrammetric thickness determinations by Geophoto Ltd.; field numbers 80TM211C, 80TM214E, 80TM215A.

Base of section: core of anticline; level within Succession 2, map unit M3.

Succession 2

Map unit M3

150 M ±
Marble: calcareous and dolomitic.

–abrupt contact –

Map unit M4

900 m ±
Phyllite: dark grey with two or more beds of **tuffaceous schist** in lower and middle part, and **rhyolitic flow** or **welded tuff** in uppermost part; U–Pb zircon age 503.2 +7.8/-1.7 Ma.

– gradational contact –

Map unit M5

550 m ± *
Mainly massive **quartzite**, with thinly interstratified **argillaceous phyllite** in lower few metres.

Top of section: top of exposures at margin of Milne Glacier; level within, or at top of, map unit M5.

SECTION NORTHEAST OF MILNE FIORD

Location: *Yelverton Inlet*, section NEMF; 9.3 km northeast of middle part of Milne Fiord; NTS 340 F; UTM Zone 17X, 510600E, 9179500N.

Measured from base up in 1977; field number 77TM4.

Base of section: talus slope covered with phyllite, etc.; level within Succession 2, map unit M4.

Succession 2

Map unit M4

Unit 1, 0–345 m (345 m)
Phyllite: medium grey, medium dark grey, and greenish grey; includes argillaceous phyllite, in part calcareous-dolomitic and tuffaceous phyllite (relatively rich in chlorite and/or albite).

Unit 2, 345–413 m (68 m)
Mainly **dolostone** and **lime mudstone**, minor interlaminated **argillaceous phyllite**; lenses of **tuffaceous phyllite** at 392.5–393.5 m; flat lamination and small-scale crosslamination are common in this unit; **dolostone**: microcrystalline, variably argillaceous and sandy; **lime mudstone**: dolomitic and argillaceous.

Unit 3, 413–518 m (105 m)
Phyllite: as in unit 1; **felsic tuff**: phyllitic, at 462.0–462.5 m.

Unit 4, 518–540 m (22 m)
Phyllite: medium dark grey, quartzose, argillaceous.

– abrupt contact –

Map unit M5

Unit 5, 540–660 m (120 m)
Quartzite: very fine to medium grained; massive; parting thickness 5–30 cm, commonly about 20 cm; joints normal to bedding.

Top of section: top of exposures, beginning of dip slope; level within map unit M5.

SECTION NORTH OF BETHEL PEAK
(part of composite type section of Cape Discovery Formation)

Location: *M'Clintock Inlet*, section NBP; northwest side of unnamed cape north of Bethel Peak, west of Bromley Island; NTS 340 E; UTM Zone 17X, 531000E, 9209800N.

Measured from base up in 1966; field number 66TM213B.

Base of section: angular unconformity, underlain by calcareous greenish phyllite of Succession 2, map unit pwqc.

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*Thickness seems to be excessive but structural evidence for repetition by folding or faulting has not been seen.

Cape Discovery Formation

Member A

Unit 1, 0–43.6 m (43.6 m)
Conglomerate: massive, grading up to pebbly **sandstone**; lower 10 m or so are boulders of phyllite, highly altered volcanic rocks, vein quartz, etc.; also present one boulder of serpentinized and carbonated gabbro or ultramafic rock.

Unit 2, 43.6–61.9 m (18.3 m)
Mainly **mudrock**, lesser amounts of **sandstone** and **pebble conglomerate**: all medium light grey to medium grey, variably dolomitic; some flat lamination, graded bedding, and medium-scale crossbedding; concave foresets dip 15–20°; pebbles consist mainly of chert, partly replaced by carbonates; sand fraction of quartz, chert, phyllite, carbonates, etc.

Unit 3, 61.9–132.0 m (70.1 m)
Mudrock: medium to medium dark grey and **sandstone**: medium grey, in part pebbly; all variably calcareous and slightly dolomitic; poorly bedded, fossiliferous unit containing trilobites, colonial corals, straight cephalopods, bryozoans, ostracodes, etc.

Fossil collection GSC 75418: Middle Ordovician to Middle Devonian; probably also source of GSC 24720: Blackriveran–Rocklandian (Christie, 1964, p. 21).

Unit 4, 132.0–143.6 m (11.6 m)
Tuff (or tuffaceous sandstone): felsic, laminated to medium bedded; some medium-scale cross-stratification.

Member B

(Part of composite type section)

Unit 5, 143.6–195.4 m (51.8 m)
Lime wackestone: argillaceous, dolomitic; trilobites, gastropods, colonial corals, brachiopods, oncoids with envelopes of *Girvanella.*

Top of section: fault; level within member B of Cape Discovery Formation.

BROMLEY ISLAND SECTION

Location: *M'Clintock Inlet*, section BI; northeastern Bromley Island; NTS 340 E; UTM Zone 17X, 539100E, 9209700N.

Measured from base up in 1966; field number 66TM305a.

Base of section: angular unconformity, underlain by volcanics, chert, and marble of Maskell Inlet Formation.

Cape Discovery Formation

Member A

Unit 1, 0–9.1 m (9.1 m)
Covered.

Unit 2, 9.1–10.4 m (1.3 m)
Breccia-conglomerate: subrounded to angular pebbles and cobbles, up to 9 cm long, in sandy matrix; beds 30–80 cm thick; pebbles and cobbles mainly of chert, massive or schistose, rarely with indistinct ghosts of radiolarians(?); less commonly of felsic volcanics; sandy matrix composed of grains of chert and lesser proportions of quartz, feldspar, chlorite, and chalcedony; carbonate alteration common.

Unit 3, 10.4–42.4 m (32.0 m)
Covered.

Unit 4, 42.4–44.0 m (1.6 m)
Breccia-conglomerate: pebbles mainly of chert (with rare radiolarian ghosts) in abundant matrix of sand- and silt-grade quartz, fossil fragments (trilobites, brachiopods, algae), lime mud, and microcrystalline dolomite.

Fossil collection GSC 75417: Middle Ordovician (probably Blackriveran) to Late Silurian (Ludlow).

Top of section: top of exposures; level within, or at top of, Member A of Cape Discovery Formation; contact with Member B is covered.

SECTION NORTH OF EGINGWAH BAY

(part of composite type section of Cape Discovery Formation)

Location: M'Clintock Inlet, section NEGB; west side of M'Clintock Inlet, 3.5 km north of Egingwah Bay; NTS 340 E; UTM Zone 18X, 472100N, 9195250N.

Measured from base up in 1965; field number 65TM–F.

Base of section: base of outcrop near sea level; level within Member B of Cape Discovery Formation.

Cape Discovery Formation

Member B

Unit 1, 0–18 m (18 m)
Dolostone: fractured and contorted; beds up to about 15 cm thick; some lamination.

Unit 2, 18-107 m (89.0 m)
Lower part: **dolostone**: fine microcrystalline, silty, slightly calcareous; beds about 1–15 cm thick with thin flat lamination and argillaceous partings; some brecciation.

Upper part: **lime mudstone**: quartz silty, partly laminated, and **mudrock**: calcareous, graded, interlaminated with **peloidal limestone**.

Member C

Unit 3, 107–414 m (307.0 m)
Limestone, minor **mudrock** and **flat-pebble conglomerate**.

Limestone: pale red to greyish red, variably argillaceous, commonly laminated.

Mudrock: pale red to greyish red; calcareous; thinly interlaminated with limestone.

Flat-pebble conglomerate: composed of limestone and minor mudrock as described; pebbles are bedding-parallel to steeply inclined; commonly in solution contact with each other.

Member D

Unit 4, 414–423 m (9.0 m)
Dolostone: medium light grey, fine crystalline; beds 1–8 cm thick; stringers of chert; ledge-forming, vuggy weathering unit.

Unit 5, 423–882 m (459.0 m)
Mainly **sandstone**, minor **mudrock** and fine **pebble conglomerate** with a few beds of **dolostone** in lower part.

Sandstone: mostly pale to greyish red, rarely medium grey; very fine to very coarse, predominantly fine grained; derived from felsic volcanics; flat lamination common.

Mudrock and conglomerate: similar to sandstone in colour and composition.

Dolostone: microcrystalline, variably silty and very fine grained sandy.

Thickness of member D: 468 m.

Top of section: conformable contact with M'Clintock Formation.

EGINGWAH CREEK SECTION

(partial type section of M'Clintock Formation and type sections of Ayles and Taconite River formations)

Location: M'Clintock Inlet, inset A, sections EC1 to EC3; NTS 340 E; EC1: UTM Zone 18X, 467700E, 9191000N; EC2-1: UTM Zone 18X, 466900E, 9190100N; EC2-2: UTM Zone 18X, 466400E, 9190300N; EC3: UTM Zone 18X, 465800E, 9190350N.

Sections EC-1 and EC-3 measured from base up in 1965, field numbers 65TM5 and 65TM-A. Section EC2-1 measured from base up in 1988, field number 88TM125D. Section EC2-2 traversed in 1988; field numbers 88TM126B, C, D; thickness determined by photogrammetry.

Base of section: level within uppermost M'Clintock Formation.

M'Clintock Formation (Section EC-1)

Unit 1, 0–6.1 m (6.1 m)
Calcarenite: medium grey, light olive grey weathering, very fine to very coarse grained, laminated, well sorted; composed of cryptocrystalline to microcrystalline lime mudstone with some skeletal fragments and a lesser proportion of chloritized shards.

Unit 2, 6.1–83.2 m (77.1 m)
Volcanic flows: green-brown weathering, probably mainly andesite–basalt.

Unit 3, 83.2–88.1 m (4.9 m)
Lime mudstone: medium light grey, microcrystalline to cryptocrystalline; slightly silty and sandy; generally poorly bedded but showing some wavy laminations (possibly stromatolitic); rare chain corals.

Fossil collection GSC 69207: Upper Ordovician, Richmondian, or Silurian.

– conformable contact –

Ayles Formation (Sections EC-2-1, EC-2-2)

Unit 1, 0–586 m (586.0 m)
Dolostone: light grey to medium grey; mainly microcrystalline to fine crystalline, but up to coarse crystalline; slightly calcareous with minor chalcedony replacements in upper half; relics of bioturbation(?) common; tectonic brecciation, solution zones and stylolites fairly common; vuggy weathering in places; generally massive with rare lamination; parting thickness 5 m or greater; resistant unit.

Fossil collection C-97394 from upper part: Late Ordovician, Ashgill (Richmondian or later).

Unit 2, 586–1111 m (525.0 m)
Mainly **dolostone**, minor **silty dolostone** and **dolomitic siltstone**: all medium to medium dark grey, generally massive with parting thicknesses of a few m to 10 cm; fossils abundant in lower few m; less resistant and slightly darker than unit 1.

Dolostone: microcrystalline to fine crystalline; replacement by chalcedony common; fossils rare; relics of bioturbation(?) and stylolites fairly common.

Siltstone: highly dolomitic and quartzose with minor muscovite, chlorite, albite, and calcite.

Fossil collections: C-97377 from lowermost part: Late Ordovician, Ashgill (Richmondian or later); C-97402: late Middle Ordovician to Silurian; GSC 69204 from upper part: Middle Ordovician, Trentonian to Late Ordovician (Richmondian or younger).

– disconformity –

Taconite River Formation (Section EC-3)

Unit 1, 0-183 m (183.0 m)
Mudrock: medium to medium dark grey, fine to predominantly coarse grained, calcareous and dolomitic, in part pyritic, and **sandstone**: medium dark grey, very fine grained, silty to fine grained, calcareous and dolomitic, in part pyritic; flat and undulating lamination; unit includes minor covered intervals.

Unit 2, 183-286.5 m (103.5 m)
Covered.

Unit 3, 286.5-308.5 m (22.0 m)
Limestone, medium dark grey, present as rubble.

Unit 4, 308.5-354.8 m (46.3 m)
Covered.

Unit 5, 354.8-429.2 m (74.4 m)
Mudrock and **sandstone**: medium grained, quartzose and cherty at 360 m.

Unit 6, 429.2-429.8 m (0.6 m)
Dolostone: microcrystalline, calcareous, silty and sandy; stylolites common.

Unit 7, 429.8-437.1 m (7.3 m)
Mudrock and **sandstone**, minor **pebbly sandstone** and **sandy pebble conglomerate**: at 432 m; pebbles mainly of chert, up to 1.5 cm in diameter.

Top of section: conformable contact with Zebra Cliffs Formation.

SECTION WEST OF UPPER REACHES OF M'CLINTOCK INLET

Location: M'Clintock Inlet, section WUMI; cliffs west of upper reaches of M'Clintock Inlet; NTS 340 E; UTM Zone 18X, 485300E, 9168300N.

Measured from base up in 1979 (field number 79TM6).

Base of section: angular unconformity at top of marble of Succession 2, map unit sc.

Taconite River Formation

Unit 1, 0-3.0 m (3.0 m)
Boulder conglomerate: massive; boulders of marble up to 50 cm in diameter, tightly packed.

Unit 2, 3.0-3.3 m (0.3 m)
Sandstone: greenish grey, pebbly; flat lamination.

Unit 3, 3.3-11.0 m (7.7 m)
Boulder conglomerate: poorly sorted, with slumped blocks of sandstone, up to 4 m long; maximum diameter of boulders about 80 cm in lower part, 40 cm in upper part.

Unit 4, 11.0-39.4 m (28.4 m)
Pebble and cobble conglomerate: clasts mainly 5-20 cm.

Unit 5, 39.4-45.4 m (6.0 m)
Pebble and cobble conglomerate: clasts mainly 5-10 cm with some coarser clasts.

Unit 6
Inaccessible; appears to be fining upward succession of **pebble conglomerate** and **sandstone**.

Top of section: conformable contact with Zebra Cliffs Formation.

SECTION ON SOUTHERN MARVIN PENINSULA

(partial reference section of Taconite River Formation)

Location: M'Clintock Inlet, section SMP; Marvin Peninsula, northern flank of syncline; NTS 340 E; UTM Zone 18X, 501300E, 9189000N.

Measured from base up in 1979; field number 79TM7.

Base of section: disconformable contact with M'Clintock Formation; rubble of volcanic rocks. Note that conglomerate is present at base of Taconite River Formation on southern flank of same syncline.

Taconite River Formation

Unit 1, 0–5.7 m (5.7 m)
Covered with talus from unit 2.

Unit 2, 5.7–53.5 m (47.8 m)
Mainly **sandstone**, minor interlaminated **mudrock**; **sandstone**: light brownish grey or pale red; fine and very fine grained; flat or undulating, partly indistinct lamination; some rip-up clasts of mudrock; **mudrock**: light brownish grey, fine and coarse grained, partly sandy; flat lamination.

Unit 3, 53.5–66.3 m (12.8 m)
Sandstone: light brownish grey; very fine and fine grained; flat lamination and small-scale cross-lamination; in lower 2 m rubble of **mudrock**: light olive grey, coarse grained, highly calcareous.

Unit 4, 66.3–68.2 m (1.9 m)
Mainly **sandstone** with minor interlaminated **mudrock**; at base **intraformational conglomerate**: sandstone clasts up to 2 cm long in sandy matrix; **sandstone**: light brownish grey; fine to medium grained; flat lamination and crosslamination; sets of crosslaminae 10–30 cm thick.

Unit 5, 68.2–70.5 m (2.3 m)
Sandstone, **mudrock**, and minor **intraformational conglomerate**; **sandstone**: light brownish grey; very fine and fine grained; flat and undulating lamination; some indistinct, bedding-parallel trace fossils; **mudrock**: pale red; fine and coarse grained, flat and undulating lamination.

Unit 6, 70.5–71.4 m (0.9 m)
Sandstone: medium light grey; very fine to fine grained; flat lamination, minor small-scale cross-lamination.

Unit 7, 71.4–75.4 m (4.0 m)
Rubble and some outcrop of **lime mudstone**: light grey to yellowish grey, variably silty and sandy (grading to calcareous mudrock); vague flat lamination; trace fossils (cf. *Chondrites*).

Unit 8, 75.4–77.9 m (2.5 m)
Mudrock: medium light grey, calcareous, sandy, in part pebbly, poorly exposed.

Unit 9, 77.9–85.6 m (7.7 m)
Rubble of **mudrock** and **wackestone**; **mudrock**: medium light grey, highly dolomitic and calcareous, sandy; **wackestone**: medium light grey, highly fossiliferous rudstone, argillaceous and sandy.

Unit 10, 85.6–88.6 m (3.0 m)
Sandstone with minor interlaminated **mudrock**; **sandstone**: light brownish grey, very fine and fine grained; flat lamination and crosslamination; sets of crosslaminae about 10 cm thick, beds up to 30 cm thick; **mudrock**: light brownish grey; coarse grained, sandy; flat and undulating lamination.

Unit 11, 88.6–90.3 m (1.7 m)
Mudrock: light grey, coarse grained, highly calcareous; flat and undulating lamination; small trace fossils on bedding planes.

Unit 12, 90.3–93.2 m (2.9 m)
Sandstone: medium light grey, very fine to fine grained, flat-laminated, ledge-forming.

Unit 13, 93.2–94.7m (1.5 m)
Mudrock: light olive grey, highly calcareous, sandy; flat lamination.

Unit 14, 94.7–95.9 m (1.2 m)
Mudrock: light brownish grey, coarse grained, sandy, highly calcareous; flat lamination and some undulating and small-scale crosslamination.

Unit 15, 95.9–103.6 m (7.7 m)
Sandstone: medium light grey, fine to medium grained, highly calcareous; flat lamination and small-scale crosslamination.

Unit 16, 103.6–104.7 m (1.1 m)
Sandstone with interlaminated **mudrock** and small amounts of flat-**pebble conglomerate**; **sandstone**: pale red to greyish red, very fine to fine grained, silty; **mudrock**: light brown, coarse grained, sandy, highly calcareous.

Unit 17, 104.7–107.0 m (2.3 m)
Sandstone: medium light grey, very fine grained, silty, dolomitic and calcareous, flat-laminated.

Unit 18, 107.0–107.7 m (0.7 m)
Mudrock: light olive grey to medium light grey, coarse grained, sandy, highly calcareous; flat and undulating lamination.

Unit 19, 107.0-108.7 m (1.0 m)
Sandstone: pale red, medium to coarse grained; flat-laminated, resistant.

Unit 20, 108.7–110.4 m (1.7 m)
Sandstone: medium light grey, fine grained; beds up to 30 cm thick; interbedded with **mudrock**: light olive grey to medium light grey, sandy, highly calcareous (transitional to lime mudstone); flat and undulating lamination.

Unit 21, 110.4–112.0 m (1.6 m)
Deeply weathered rubble of **pebble conglomerate**: pebbles include fossiliferous limestone, lime mudstone, and metaquartzite; matrix of calcareous sand with small amounts of muscovite and shell fragments (mainly corals and stromatoporoids, minor ostracodes).

Fossil collection C–54938 at 11.5 m (transported): Middle or Late Ordovician.

Unit 22, 112.0–112.6 m (0.6 m)
Lime mudstone and **sandstone**; some flat and undulating lamination and sedimentary brecciation; **lime mudstone**: medium light grey, highly silty and very fine grained sandy; **sandstone**: medium light grey, highly silty, calcareous.

Unit 23, 112.6–114.4 m (1.8 m)
Mainly **wackestone**, minor **lime mudstone**; **wackestone**: medium light grey, silty, slightly sandy, richly fossiliferous: corals, echinoderms, dasycladacean algae, gastropods, etc.; **lime mudstone**: medium light grey, silty, sandy.

Fossil collection C–54939 at 114 m: probably Late Ordovician to Middle Devonian.

Unit 24, 114.4–117.1 m (2.7 m)
Mainly **mudrock** with two units of **sandstone**, 10–20 cm thick, in lower part; **mudrock**: light grey, calcareous (lime mud), sandy; some brachiopod fragments; mainly flat-laminated with some cross-lamination, set 10 cm thick; bioturbation and sedimentary brecciation; **sandstone**: medium light grey, highly silty, flat-laminated.

Unit 25, 117.1–126.8 m (9.7 m)
Wackestone: medium light grey, silty, slightly sandy; richly fossiliferous: echinoderms, brachiopods, corals, trilobites, dasycladacean algae(?).

Fossil collection C–54940 at 117.5 m: Late Ordovician.

Unit 26, 126.8–141.8 m (15.0 m)
Mainly **mudrock** with 6 units of **wackestone** and some **limestone breccia** in argillaceous matrix; **mudrock**: light olive grey to medium light grey, highly calcareous (lime mud); some indistinct flat lamination; **wackestone**: medium grey to greenish grey; highly silty; richly fossiliferous: dasycladacean algae, brachiopods, trilobites, cephalopods, corals.

Unit 27, 141.8–144.8 m (3.0 m)
Wackestone: grey, silty, richly fossiliferous: brachiopods, cephalopods, corals, etc.

Fossil collection C–54941 at 141.8–144.8 m: late Middle Ordovician to Silurian.

Unit 28, 144.8–202.6 m (57.8 m)
Sandstone, minor **mudrock**; **sandstone**: medium light grey to greenish grey, very fine grained, silty; beds 2–20 cm thick; some flat lamination; some rip-up clasts of mudrock; **mudrock**: greenish grey.

Unit 29, 202.6–203.6 m (1.0 m)
Limestone: fractured and contorted.

Top of section: top of exposures in centre of syncline; level within Taconite River Formation.

SECTION SOUTH OF DISRAELI FIORD (SDF)

(reference section of Zebra Cliffs Formation and type section of Cranstone Formation)

Location: M'Clintock Inlet, section SDF; south of head of Disreali Fiord, west of lowermost reaches of Disraeli Glacier; NTS 340 E; UTM Zone 18X, 533250E, 9182800N to 533750E, 9180000N.

Section consists of three parts (SDF1, SDF2, and SDF3) separated by concealed strata and faults.

Measured from base up in 1981 and 1982; field numbers 81TM3, 82TM4.

Base of section: level within uppermost part of Taconite River Formation.

Taconite River Formation (Section SDF-1)

0–9.0 m (9.0 m)
Interbedded **mudrock** and **sandstone**: both medium light grey and greenish grey with faint reddish hue in lower 0.7 m, calcareous and dolomitic, laminated or bioturbated; **mudrock**: commonly coarse grained and sandy; **sandstone**: very fine grained, argillaceous.

– conformable contact –

Zebra Cliffs Formation

Member A

Unit 1, 0–47.0 m (47.0 m)
Limestone: skeletal wackestone, medium to medium dark grey; well stratified, beds 5–20 cm thick; bedding surfaces wavy (amplitudes 1–2 cm, half-wavelengths about 5 cm); colonial and solitary corals, bryozoans, gastropods, cephalopods.

Fossil collection C–54957, Late Ordovician, Ashgill.

Member B

Unit 2, 47.0–56.0 m (9.0 m)
Limestone as in unit 1 with interbedded less abundant **mudrock** and **sandstone**, both medium grey or greenish grey, bioturbated; **mudrock**: coarse grained; parting thickness 1–2 cm; trace fossils, including *Chondrites*; **sandstone**: very fine grained, argillaceous.

Unit 3, 56.0–95.0 m (39.0 m)
Interbedded **mudrock** and **sandstone**: both mainly pale red or greyish red with some medium grey strata; calcareous and dolomitic; beds 0.5–1 m thick, commonly bioturbated, with some flat and undulating lamination preserved; **mudrock**:, coarse grained, partly sandy; **sandstone**: very fine and fine grained, partly argillaceous.

Member C

Unit 4, 95.0–143.0 m (48.0 m)
Roughly 2/3 **limestone** and 1/3 **mudrock** and minor **sandstone**; unit occurs mainly as rubble in place; **limestone**: skeletal wackestone and lime mudstone, medium to medium dark grey, commonly bioturbated; corals and fragments of gastropods, ostracodes, trilobites, etc.; **mudrock**: medium grey, coarse grained, partly sandy; **sandstone**: medium light grey, very fine grained, argillaceous, calcareous, dolomitic, bioturbated.

Fossil collection C–54958 at 137 m: probably Late Ordovician, Ashgill, possibly Silurian.

Top of section: SDF1: top of exposures; level within member C of Zebra Cliffs Formation; exposures are overlain by rubble that represents a thick succession of predominantly limestone.

Base of section: level within uppermost part of Zebra Cliffs Formation.

Zebra Cliffs Formation (Section SDF-2)

Member C

Unit 5, 0–23.0 m (23.0 m)
Limestone: lime mudstone and skeletal wackestone, medium to medium dark grey; indistinct, undulating parting surfaces spaced 5–20 cm; ledges 2–10 m thick; chain corals in talus; fragments of sponges, dasycladacean algae, trilobites, echinoderms, pelecypods, etc. in thin sections.

Member D

Unit 6, 0–34.0 m (34.0 m)
Limestone: medium dark grey, medium grey weathering; beds of moderately argillaceous and sandy wackestone, rich in calcareous sponge spicules with lesser amounts of trilobite debris; 2–10 cm, commonly 5 cm thick, with internal flat lamination, separated by laminae of highly argillaceous limestone and/or calcareous mudrock, also rich in calcareous spicules.

Unit 7, 34.0–39.5 m (5.5 m)
Packstone: medium grey, recrystallized; composed mainly of lime mudstone clasts with lesser amounts of skeletal material (dasycladacean algae, trilobites); massive; parting thickness 10–50 cm.

Conodont collection C-96701 at 35.5–36.5 m: mainly Late Ordovician with one Middle Ordovician element; C-96700 at 38.0 m: Late Ordovician; C-96699 at 39.0 m: late Middle to latest Ordovician.

Unit 8, 39.5–41.8 m (2.3 m)
As unit 1.

Unit 9, 41.8–44.6 m (2.8 m)
As unit 1 but beds 5–20 cm thick.

Unit 10, 44.6–50.8 m (6.2 m)
As unit 1; beds 2–20 cm thick.

Unit 11, 50.8–51.6 m (0.8 m)
Wackestone: medium dark grey, cherty, laminated; rich in predominantly calcareous (calcified?) sponge spicules.

Unit 12, 51.6–55.1 m (3.5 m)
Covered.

- concealed fault -

(Lorimer Ridge Formation and lowermost part of Cranstone Formation are absent).

Base of section: level within Member A of Cranstone Formation.

Cranstone Formation (Section SDF-3)

Member A

Major unit A1

Unit 1, 0–40.5 m (40.5 m)
Interbedded **sandstone**, **mudrock**, and **pebble conglomerate**.

0–2.0 m (2.0 m): **Sandstone**: medium and medium dark grey, olive grey weathering; very fine grained, argillaceous, with pebbles and minor cobbles of quartzite etc. up to 10 cm in diameter; mostly structureless but with some discontinuous, irregular lamination.

2.0–18.5 m (16.5 m): **Mudrock:** partly sandy, and minor **sandstone:** medium dark grey, olive grey weathering, very fine grained, argillaceous, massive; at 6.5–7.0 m: dispersed **pebbles,** up to about 5 cm in diameter.

18.5–23.0 m (4.5 m): **Mudrock:** medium dark grey, olive grey weathering, highly calcareous, more resistant than underlying strata.

23.0–23.5 m (0.5 m): **Pebble conglomerate:** sandy matrix; flat upper and lower contacts.

23.5–23.8 m (0.3 m): **Sandstone**.

23.8–25.3 m (1.5 m): **Pebble conglomerate:** cobbly, clasts up to 9 cm in diameter; fining upward to **sandstone:** pebbly.

25.3–28.0 m (2.7 m): **Sandstone:** coarse grained, with dispersed pebbles up to 5 cm in diameter.

28.0–31.0 m (3.0 m): **Mudrock:** massive; scattered pebbles of chert etc. in upper 1 m.

31.0–32.2 m (1.2 m): **Pebble conglomerate:** cobbly, with sandy matrix; clasts up to 15 cm in diameter.

32.2–33.7 m (1.5 m): **Mudrock:** sandy, with dispersed granules and pebbles up to 5 cm in diameter.

33.7–35.2 m (1.5 m): **Sandstone**: medium grained, quartzose, dolomitic; beds 20–30 cm thick.

35.2–38.0 m (2.8 m): **Pebble conglomerate**: cobbly; clasts up to 12 cm in diameter; in upper part lenses of **sandstone:** pebbly, about 10 cm thick, 1–2 m long.

38.0–38.4 m (0.4 m): **Sandstone:** with interlaminated mudrock; flat lamination.

38.4–39.4 m (1.0 m): **Sandstone:** with dispersed pebbles up to a few cm in diameter.

39.4–40.4 m (1.0 m): **Sandstone**.

40.4–40.5 m (0.1 m): **Mudrock:** sandy.

Unit 2, 40.5–61.5 m (21.0 m)
Intermittent outcrop of **sandstone, mudrock**, and **conglomerate**; complex structure.

Unit 3, 61.5–179.5 m (118.0 m)
Mainly **sandstone** and **mudrock**, minor **pebble conglomerate**. Bouma sequences composed of divisions A and B, or of Division A alone, common.

Detailed description of interval 61.5–63.17 m:

0–8.0 cm (8.0 cm): **Mudrock:** coarse grained.

8.0–38.0 cm (30.0 cm): **Sandstone:** fining upward from medium-grained (max. coarse-very coarse) to fine grained (max. medium); mostly structureless with flat lamination at 29.0–38.0 cm.

38.0–49.0 cm (11.0 cm): **Sandstone:** very fine grained, argillaceous; slight upward decrease in grain size; flat lamination.

49.0–58.3 cm (9.3 cm): Abrupt lower contact with poorly developed small flute casts, overlain by **sandstone**: medium grained at base (max. very coarse), fining upward to very fine grained; 3 mm of **mudrock** at top, forming small diapir.

58.3–60.0 cm (1.7 cm): **Sandstone:** very fine grained; 2 layers, separated and overlain by two layers of mudrock; flat lamination.

60.0–62.3 cm (2.3 cm): **Sandstone,** fining upward to mudrock: forming small diapir.

62.3–64.5 (2.2 cm): **Sandstone,** fining upward to mudrock.

64.5–72.0 cm (7.5 cm): Interlaminated **sandstone** and **mudrock**; flat lamination.

72.0–73.5 cm (1.5 cm): **Sandstone,** fining upward to mudrock: sandy in lower part; flat lamination.

73.5–79.5 cm (6.0 cm): Arupt lower contact with small grooves and ridges; **sandstone**: relatively calcareous; fine grained at base, very fine grained at top.

79.5–119.0 cm (39.5 cm): **Mudrock** with minor interlaminated sandstone; flat lamination.

119.0–167.0 (48.0 cm): Abrupt lower contact with load casts; **sandstone**: coarse grained, poorly sorted; granules and pebbles at 119.0–136.0 cm; contorted mudrock clasts at 124.0–126.0 cm; vague flat lamination at 154.0–160.0 cm; distinct flat lamination at 160.0–167.0 cm; fine and medium grained in upper few cm.

At 112.5 m: upward from this level a few conglomerate beds, 30–50 cm thick.

At 151.5–154.0 m: ledge of **pebble conglomerate**: with cobbles up to 15 cm in diameter.

At 154.0–173.0 m: interbedded **sandstone** and **mudrock** with a few percent or less of **pebble conglomerate**.

At 173.0–179.5 m: **pebble conglomerate**: ledge-forming, cobbly, with mudrock matrix.

Unit 4, 179.5–218.5 m (39.0 m)
Mudrock and **sandstone** as in underlying units with very minor amounts of **pebbly mudrock**; proportion of **sandstone** decreases upward.

Unit A2

Unit 5, 218.5–298.0± (79.5± m)
Mainly **mudrock** with small amounts of **sandstone** and very small amounts of **pebble conglomerate** and **pebbly mudrock**; thickness uncertain because of complex structure and incomplete exposure; (note that unit was measured in rain and fog).

At 218.5–219.0 m: **sandstone**, filling channel.

At 223.5 m: **sandstone** bed.

At 235.0–240.0 m: **sandstone**.

At 258.0–261.0 m: **sandstone**: beds up to 50 cm thick, interbedded with **mudrock**.

At 261.0–263.5 m: **sandstone** and **pebble conglomerate**: pebbles up to 5 cm in diameter.

At 263.5–264.0 m: **pebbly mudrock**.

Unit 6, 298.0–377.0 m (79.0 m)
Mainly **mudrock**: medium dark grey, olive grey weathering; flat lamination partly destroyed by bioturbation.

At 361.0–362.0 m: **sandstone**: very fine grained, argillaceous; beds 5–10 cm thick; with minor interlaminated **mudrock**.

Unit 7, 377.0–395.0 m (18.0 m)
Covered, recessive.

Unit 8, 395.0–402.0 m (7.0 m)
Mudrock and **argillaceous limestone**: wackestone rich in calcareous sponge spicules; flat lamination; laminae, 0.12–3 mm thick, differ in grain size and concentration of argillaceous and carbonaceous impurities; rare graptolites.

Graptolite collections C-94373 and C-94374: middle or earliest late Llandovery.

Unit 9, 402.0–416.0 m (14.0 m)
Mudrock: medium and medium dark grey, olive grey weathering; flat lamination; partings at 1–5 cm.

– abrupt contact, probably conformable –

Member B

Unit B1

Unit 10, 416.0–434.0 m (18.0 m)
Conglomerate with minor amounts of **sandstone**; bluff-forming unit.

416.0–419.0 m (3.0 m): **Pebble conglomerate** and **sandstone**; **pebble conglomerate** (est. 60%): cobbly; clasts mainly 1–2 cm, but up to 10 cm in diameter; closely packed, but with sandy matrix; beds 10–50 cm thick, structureless; flat lower and upper surfaces at outcrop scale; **sandstone** (est. 40%): lenticular units, a few m long, with some concave foresets; conglomeratic clast imbrication and dip of foresets suggests transport to southwest.

419.0–431.0 m (12.0 m): Mainly **pebble conglomerate**: cobbly; clasts mainly 1–5 cm but up to 10 cm long; flat bed of **sandstone** at 426.8–426.9 m.

431.0–434.0 m (3.0 m): Pebble conglomerate: cobbly, with beds and lenses of **sandstone**: 10–70 cm thick.

Unit 11, 434.0–449.5 m (15.5 m)
Partly covered, recessive; some outcrop of **sandstone** and **mudrock**.

434.0–439.0 m (5.0 m): Covered, recessive.

439.0–441.0 m (2.0 m): Partly covered; some outcrop of **sandstone**: medium grey, olive grey and brown weathering, very fine grained, argillaceous; some flat lamination (outcrop disturbed by frost action).

441.0–447.5 m (6.5 m): Partly covered; some outcrop of interbedded **sandstone** and **mudrock**.

447.5–448.2 m (0.7 m): **Sandstone:** very fine grained, argillaceous, interlaminated with **mudrock.**

448.2–448.7 m (0.5 m): **Sandstone**: medium grained at top.

448.7–449.5 m (0.8 m): **Sandstone** and **mudrock**: abrupt basal contact.

Unit 12, 449.5–549.0 m (99.5 m)
Conglomerate: mainly pebbles but with rare carbonate cobbles up to 17.5 cm in diameter; cobbles, 8–17 cm in diameter common at 525.0–526.0 m; minor **sandstone** (est. 10%): in part pebbly; flat beds 1–15 cm thick, with some low-angle, concave foresets.

Unit 13, 549.0–565.5 m (16.5 m)
Recessive, partly covered; some outcrop of **mudrock** and **sandstone**.

549.0–550.0 m (1.0 m): Mainly **mudrock**: medium grey, olive grey weathering, variably sandy, flat-laminated; less **sandstone**: medium grey, olive grey weathering, in part flat-laminated.

550.0–555.5 m (5.5 m): Mostly covered; some rubble and outcrop of frost-heaved **mudrock**.

555.5–565.5 m (10.0 m): Covered, recessive.

Unit 14, 565.5–566.8 m (1.3 m)
Mainly **pebble conglomerate**: clasts 1–5 cm; 10 cm of **sandstone** at top.

Unit 15, 566.8–578.5 m (11.7 m)
Covered, recessive.

Unit 16, 578.5–593.5 m (15.0 m)
Mainly **pebble conglomerate**: cobbly, with sandy matrix; clasts mainly 2–5 cm, but up tc 10 cm in diameter; some conglomerates fine upward to sandstone; e.g., at 587.5–588.4 m:

0–10 cm (10 cm): **Sandstone:** pebbly and cobbly, clasts up to 10 cm in diameter.

10–30 cm (20 cm): **Sandstone:** pebbly.

30–90 cm (60 cm): **Sandstone.**

Unit 17, 593.5–598.0 m (4.5 m)
Covered, recessive (creek).

Unit 18, 598.0–607.2 m (9.2 m)
Pebble conglomerate: with cobbles and boulders; massive, matrix-supported; terrigenous clasts up to 10 cm; formation-derived clasts of sandstone up to 40 cm in diameter.

Unit 19, 607.2–636.5 m (29.3 m)
Mainly **sandstone** (est. 60%): very fine to medium grained or coarser; less **mudrock**; both medium grey, olive grey-brownish grey weathering; pyrite common; flat to slightly undulating lamination; fining upward sandstone–mudrock bed at base; some lenses of **pebble conglomerate**: 5 cm thick.

Unit 20, 636.5–663.0 m (26.5 m)
Mudrock: medium grey, olive grey and brownish weathering; in part sandy; some flat lamination.

Unit 21, 663.0–701.0 m (38.0 m)
Mainly **pebble conglomerate**: sandy, massive; cobbles up to 17 cm in diameter at 669.0–670.0 m, boulders up 30 cm at 695.5 696.0 m; large cobbles and boulders are limestone and dolostone; lenses of **mudrock**: medium grey, olive grey weathering, perhaps a few tens of m in strike length.

Unit 22, 701.0–705.5 m (4.5 m)
Covered, recessive, with rubble of **mudrock** in upper 1 m; facies change to **pebble conglomerate** 30 m to the south.

Unit 23, 705.5–735.5 m (30.0 m)
Pebble conglomerate: with cobbles up to 10 cm in diameter; **sandstone**: medium to coarse grained, flat-bedded, massive, at 705.9–706.0 m.

Unit 24, 735.5–772.5 m (37.0 m)
Pebble conglomerate (51%): cobbly; **mudrock** (23%), **sandstone** (11%), and covered intervals (15%).

735.5–737.0 m (1.5 m): **Mudrock:** medium grey, olive grey weathering.

737.0–739.0 m (2.0 m): **Pebble conglomerate**: with cobbles up to 19 cm in diameter; carbonate cobble contains favositid coral.

739.0–740.5 m ((1.5 m): Mostly covered with 30 cm of **mudrock**: medium grey, olive grey weathering, at top.

740.5–742.0 m (1.5 m): **Pebble conglomerate:** with cobbles up to 15 cm in diameter; sandy matrix.

742.0–745.0 (3.0 m): Covered.

745.0–746.5 m (1.5 m): **Pebble conglomerate** with cobbles up to 10 cm in diameter.

746.5–751.5 m (5.0 m): Mostly covered, recessive; some rubble of **mudrock**: as in underlying units, and of **sandstone**: medium grey, pebbly.

751.5–753.5 m (2.0 m): **Pebble conglomerate** with 0.5 m of sandstone in middle.

753.5–759.0 m (5.5 m): Covered, recessive.

759.0–768.0 m (9.0 m): **Pebble conglomerate:** cobbly, poorly exposed.

768.0–772.5 m (4.5 m): **Pebble conglomerate** and **sandstone** (about 30%): pebbly, mainly in upper part.

Unit 25, 772.5–796.0 m (23.5 m)
Mainly **pebble conglomerate**: cobbly, mostly flat-bedded; units commonly 1–2 cm thick; minor **sandstone** (est. 10%) and **mudrock** at 789.0–789.3 m.

Unit 26, 796.0–800.0 m (4.0 m)
Recessive, partly covered; some outcrops of **sandstone** and **mudrock**.

796.0–797.0 m (1.0 m): Covered, recessive.

797.0–800.0 m (3.0 m): Interbedded **mudrock** and **sandstone**, with 50 cm of **pebble conglomerate**; upper part is **mudrock**.

Unit 27, 800.0–819.5 m (19.5 m)
Pebble conglomerate with cobbles up to 25 cm in diameter.

Unit B2

Unit 28, 819.5–856.5 m (37.0 m)
Rubble and intermittent outcrop of **mudrock**: medium dark grey, olive grey weathering; some flat lamination; rare graptolites.

Graptolite collection C-75496: middle Llandovery.

Unit B3

Unit 29, 856.5–899.6 m (43.1 m)
Mostly **pebble conglomerate**: cobbly, with a few lenses of **sandstone** and **mudrock**.

856.5–861.0 m (4.5 m): **Pebble conglomerate:** cobbly, with argillaceous and sandy matrix; clasts up to 8 cm in diameter.

861.0–861.3 m (0.3 m): **Mudrock** lens, a few metres in strike length.

861.3–897.3 m (36.0 m): Mainly **pebble conglomerate**: cobbly; indistinct beds about 0.5–2 m thick; clasts up to 22 cm (e.g., at 864.5 m); some small lenses of **sandstone**: in part pebbly.

897.3–898.6 m (1.3 m): **Mudrock**.

898.6–899.6 m (1.0 m): **Pebble conglomerate**.

Unit B4

Unit 30, 899.6–920.1 m (20.5 m)
Mudrock: medium dark grey, olive grey weathering; 899.6–905.6 m outcrop, 905.6–920.1 m rubble.

Unit 31, 920.1–936.1 m (16.0 m)
Mudrock and **sandstone** interbedded.

920.1–921.1 m (1.0 m): **Sandstone:** partly medium grained; mostly present as rubble.

921.1–936.1 m (15.0 m): Mainly **mudrock** as in underlying units; mostly present as rubble with some outcrop.

Top of section: limit of exposures; level within Cranstone Formation; rubble continues to a stratigraphic height of possibly 1050 m; top of formation is not preserved.

SECTION NORTH OF THORES RIVER

Location: *M'Clintock Inlet*, sections NTR1, NTR2; west of lower reaches of Disraeli Glacier; Thores River 1 section (NTR1) is 1.2 km north of mouth of Thores River; NTS 340 E; NTS 340 E; UTM Zone 18X, 533000E, 9173600N; Thores River 2 section (NTR2) is about 2 km north of Thores River; NTS 340 E; UTM Zone 18X, 532700E, 9174400N.

The Thores River 1 section represents a relatively well exposed, 48 m thick interval in the middle part of the Lorimer Ridge Formation; the Thores River 2 section describes the lower part of a fault slice of the Marvin Formation.

Measured from base up in 1981; field numbers 81TM4 and 81TM117C.

Base of section: level within Lorimer Ridge Formation.

Lorimer Ridge Formation (Section TR-1)

Unit 1, 0–1.5 m (1.5 m)
Mudrock: greenish grey, slightly sandy, highly calcareous, bioturbated.

Unit 2, 1.5–6.0 m (4.5 m)
Covered, recessive.

Unit 3, 6.0–6.4 m (0.4 m)
Mudrock: coarse grained, sandy, and **sandstone**: very fine grained, silty; both greenish grey, calcareous; some flat and undulating lamination.

Unit 4, 6.4–8.0 (1.6 m)
Mudrock: coarse grained, sandy, and **sandstone**: very fine grained, silty; both greyish red, calcareous, bioturbated.

Unit 5, 8.0–10.5 m (2.5 m)
Sandstone: very fine grained, with intraclasts of lime mudstone, and **mudrock**; both medium light grey, calcareous, bioturbated.

Unit 6, 10.5–10.9 m (0.4 m)
Mudrock: coarse grained, sandy, and **sandstone**: very fine grained, silty; both medium light grey, calcareous, bioturbated.

Unit 7, 10.9–13.0 m (2.1 m)
Mudrock: coarse grained, sandy, and **sandstone**: very fine grained, silty; both greenish grey, calcareous, bioturbated.

Unit 8, 13.0–14.5 m (1.5 m)
Lime mudstone: medium light grey, highly silty; some skeletal material (trilobites, molluscs), bioturbated; beds 2–10 cm thick.

Unit 9, 14.5–15.0 m (0.5 m)
Mudrock: greenish grey, slightly sandy, calcareous, bioturbated; some parting surfaces.

Unit 10, 15.0–20.5 m (5.5 m)
Mudrock: coarse grained and minor **sandstone**: very fine grained; both greyish red, calcareous, bioturbated, poorly exposed.

Unit 11, 20.5–26.5 m (6.0 m)
Mudrock: greenish grey, coarse grained, sandy, bioturbated; beds 1–5 cm thick in lower part, 1–2 m in upper part.

Unit 12, 26.5–28.5 m (2.0 m)
Covered, recessive.

Unit 13, 28.5–30.5 m (2.0 m)
Lime mudstone: light grey, **mudrock**: greenish grey, and very small amounts of **sandstone**: very fine grained, silty; intraclasts of limestone in lower 30 cm.

Unit 14, 30.5–32.8 m (1.3 m)
Mudrock: coarse grained, and **sandstone**: very fine grained, silty; both greyish red, calcareous, bioturbated; also **sandstone**: brownish grey, very fine and fine grained, flat-laminated.

Unit 15, 32.8–35.0 m (2.2 m)
Partly covered; some outcrop of **mudrock**: greenish grey, as below.

Unit 16, 35.0–36.0 m (1.0 m)
Lime mudstone: medium to medium dark grey, silty; macrofossils include favositid corals and gastropods; skeletal fragments of trilobites, ostracodes, etc.

Coral collection C-54959: Late Ordovician (Ashgill) to Silurian.

Unit 17, 36.0–38.0 m (2.0 m)
Covered.

Unit 18, 38.0–40.0 m (2.0 m)
Mudrock: medium grey and greenish grey, in part coarse grained, sandy; calcareous, bioturbated; some indistinct undulating and flat lamination.

Unit 19, 40.0–42.0 m (2.0 m)
Mudrock: coarse grained, sandy and **sandstone**: very fine grained, silty; both greyish red, calcareous, bioturbated; some flat lamination.

Unit 20, 42.0–44.4 m (2.4 m)
Mudrock: greenish grey, in part sandy, calcareous, bioturbated.

Unit 21, 44.4–45.7 m (1.3 m)
Wackestone: medium grey, argillaceous and very fine grained sandy; fragments of trilobites, bryozoans, corals, etc.; indistinct bedding surfaces spaced 5-20 cm.

Unit 22, 45.7–48.0 m (2.3 m)
Mudrock: coarse grained, sandy, and **sandstone**: very fine grained, silty; both greenish grey, calcareous; flat and undulating lamination and some lenticular lamination.

Top of section: level within Lorimer Ridge Formation.

Base of section: covered contact with Lorimer Ridge Formation.

Marvin Formation (Section TR-2)

Unit 1, 0-8 m (8.0 m)
Rubble of **limestone**: medium to medium dark grey, variably dolomitic; samples represent lime mudstone with skeletal content and skeletal wackestone (gastropods, brachiopods, trilobites), both slightly silty, with variable proportions of microcrystalline dolomite.

Conodont collection C-54985 at 1.5-2.0 m: mid-Ordovician to Late Silurian; C-54986 at 3.0-5.0 m: Late Ordovician.

Unit 2, 8-90 m (82.0 m)
Outcrop and rubble of **limestone**: medium to medium dark grey; beds 10-50 cm thick; some burrow-controlled dolomitic mottling in lower part; large brachiopods common at 33-53 m; samples represent peloidal packstone/wackestone with skeletal content and skeletal wackestone (mainly brachiopods; minor echinoderms, ostracodes, trilobites(?)).

Conodont collection C-54 at 30-33 m: Late Ordovician.

Top of section: upper limit of exposures of Marvin Formation; concealed contact with Cranstone Formation is probably faulted.

LORIMER RIDGE SECTION
(type section of Lorimer Ridge Formation)

Location: M'Clintock Inlet, section LR; east side of Lorimer Ridge; NTS 340 E; UTM Zone 18X, 539800E, 9175700N.

Measured from base up by R. Gardner and D. Jones in 1977 (loc. 77MSARG33) and by H.P. Trettin in 1988; field number 88TM4.

Fossil collections by Gardner and Jones (unpublished field notes), lithological decription based on work by Trettin.

Base of section: flat covered with talus and till, probably close to base of Lorimer Ridge Formation.

Lorimer Ridge Formation

Unit 1, 0-60.0 m (60.0 m)
Slope covered with talus.

Unit 2, 60.0-72.0 m (12.0 m)
Mostly covered; rubble, more or less in place, of **mudrock**: medium grey, highly calcareous, slightly dolomitic; brachiopod fragments common.

Fossil collection C-70082 at approximately 71-72 m: brachiopods, Ordovician or Silurian.

Unit 3, 72.0-127.5 m (55.5 m)
Mudrock interbedded with **sandstone**; unit is mainly medium grey with some greyish red beds in upper 7 m; **mudrock**: beds about 0.1-1 m thick; fine to coarse grained and sandy, moderately to highly calcareous; bioturbated; **sandstone**: beds 0.5-3 cm thick; very fine to medium grained, siliceous, feldspathic, lithic, variably calcareous; some rip-up clasts of mudrock; intrabasinal pebbles of mudrock up to 8 mm in diameter at 90 m; some flat lamination and rare, small-scale crosslamination; structureless beds more common.

Unit 4, 127.5-152.5 m (25.0 m)
Sandstone with interbedded **mudrock**; unit is greyish red; **sandstone**: predominantly sandy units up to 4 m thick; lamination rare; sample is fine grained; **mudrock**: bioturbated, moderately calcareous.

Unit 5, 152.5-157.0 m (4.5 m)
Sandstone and **pebble conglomerate**: light grey to medium grey, crossbedded.

152.5-154.5 (2.0 m): **Pebbly sandstone**, minor **pebble conglomerate** (at 153 m): trough-crossbedding; sets of crossbeds 25 cm thick; pebbles composed of chert, in part red weathering, and limestone (lime mudstone, in part peloidal).

154.5–157.0 (2.5 m): **Sandstone:** sample is fine grained, quartzose, feldspathic, lithic and slightly calcareous, crosslaminated.

Unit 6, 157.0–222.5 m (65.5 m)
Sandstone: greyish red, fine grained, quartzose, feldspathic; beds up to 3 m thick, commonly massive; some vague flat lamination and vague crosslamination; minor **mudrock**: greyish red; occurs mostly as thin interbeds, but 1.5 m thick bioturbated mudrock unit occurs at 200.5 m; **pebble conglomerate** (at 160.0–160.3 m): grey, crossbedded; pebbles to 1 cm in diameter.

Unit 7, 222.5–314.0 m (91.5 m)
Sandstone: interbedded with **mudrock**; both mostly greyish red and massive; units 0.3–3 m thick, mostly massive; **sandstone**: samples are very fine to fine grained, moderately calcareous; **mudrock**: samples are moderateley calcareous, bioturbated.

Unit 8, 314.0–332.0 m (18.0 m)
Sandstone and **mudrock** as in unit 7; mostly massive with some flat lamination; mainly greyish red with roughly 20% of medium light grey strata; **sandstone**: sample is very fine grained, silty; moderately calcareous; **mudrock**: samples are moderately to highly calcareous.

Unit 9, 332.0–347.0 m (15.0 m)
Sandstone and **mudrock** as in unit 7; mainly greyish red with minor amounts of grey beds; unit underlies dip slope.

Unit 10, 347.0–513.5 m (166.5 m)
Sandstone: greyish red, very fine to fine grained, quartzose, feldspathic, moderately calcareous with some mudrock rip-up clasts; massive; some flat lamination; crossbedding (planar foresets) at 487–488 m; minor **mudrock**.

Unit 11, 513.5–520.0 (6.5 m)
Mudrock: medium light grey, in part coarse grained, sandy and **sandstone**: very fine grained, silty; beds 10–20 cm thick with some indistinct flat lamination and crosslamination.

Unit 12, 520.0–527.0 m (7.0 m)
Lime mudstone: medium grey to medium dark grey; silty and very fine grained sandy; skeletal fragments (ostracodes, bryozoans, chain corals, brachiopods, stromatoporoids).

Fossil collection C-70091: Ordovician to Permian.

Unit 13, 527.0–532.5 m (5.5 m)
Mudrock: medium light grey, coarse grained, sandy, calcareous; and **sandstone**: medium light grey, very fine grained, silty, calcareous; beds 10–30 cm with partings at 10–20 cm and some flat lamination.

Unit 14, 532.5–549.5 m (17.0 m)
Sandstone: very fine grained and **mudrock**; both mainly greyish red, minor medium light grey; some flat lamination and small-scale crosslamination, some bioturbation; sandy units up to 30 cm thick; some mudrock rip-up clasts.

Unit 15, 549.5–551.0 m (1.5 m)
Sandstone: medium light grey, fine grained, ledge-forming (1 m); minor mudrock.

Unit 16, 551.0–750.5 m (199.5 m)
Mudrock and lesser amounts of **sandstone**, both greyish red; **mudrock**: calcareous, in part sandy, generally bioturbated with some flat lamination preserved; **sandstone**: very fine, fine and fine to medium grained, feldspathic, calcareous; present as talus in lower part of unit; present as ledges up to 30 cm thick from 638 m to top of unit.

Unit 17, 750.5–764.0 m (13.5 m)
Covered.

Unit 18, 764.0–782.0 m (18.0 m)
Mudrock: light grey, dolomitic and calcareous with interlaminated **lime mudstone**, argillaceous; bioturbated with some flat or undulating lamination preserved.

Fossil collection C-70106 (probably from this unit); corals and conodonts of Middle or Late Ordovician age.

Unit 19, 782.0–813.0 m (31.0 m)
Mudrock: greyish red, variably sandy, dolomitic and calcareous; bioturbated with some flat lamination preserved; and **sandstone**: greyish red, very fine and fine grained, dolomitic and calcareous; bioturbated with some flat lamination preserved; **limestone**, highly argillaceous with colonial corals in upper 1 m; upper 0.5 m covered.

Coral collection C-70093 at 812–813 m: Ordovician, Middle or Late Ordovician.

Top of section: conformable contact with Marvin Formation.

SECTION SOUTHEAST OF DISRAELI FIORD

(reference section)

Location: M'Clintock Inlet, section SEDF; about 6.5 km southeast of head of Disraeli Fiord; NTS 340 E; UTM Zone 18X, 540100E, 9179600N.

Measured from base up in 1981; field number 81TM5.

Base of section: base of outcrop near glacier; level within uppermost part of Lorimer Ridge Formation.

Lorimer Ridge Formation

Unit 1, 0–0.6 m (0.6 m)
Interbedded **mudrock** and **sandstone**; **mudrock**: pale red to moderate red, coarse grained, calcareous and dolomitic, bioturbated; units 2–15 cm thick; **sandstone**: pale red, fine grained, calcareous; flat lamination.

Unit 2, 0.6–0.8 m (0.2 m)
Sandstone: greenish grey, very fine grained, highly silty, calcareous, bioturbated.

Unit 3, 0.8–1.5 m (0.7 m)
Mudrock: brownish, partly sandy, massive, rubbly weathering, probably bioturbated.

Unit 4, 1.5–37.0 m (35.5 m)
Mudrock with lesser amounts of **limestone** and **sandstone**; **mudrock**: mainly medium grey; mostly coarse grained, sandy, calcareous; bioturbated with some flat lamination preserved; **limestone**: medium dark grey; skeletal wackestone (mainly gastropods, minor ostracodes, trilobites, echinoderms); microcrystalline dolomite common in burrows; parting surfaces at 5–30 cm; occurrences at 16 m, 18 m, and 27 m; **sandstone**: medium grey, very fine grained, silty, calcareous; flat and wavy lamination; parting thickness 5–10 cm; occurence mainly at 31.2–36.0 m.

Coral collection C-54961 at 28 m: Late Ordovician (Ashgill) to Middle Devonian.

Unit 5, 37.0–41.3 m (4.3 m)
Limestone: medium grey; corals common; undulating parting surfaces at 5–10 cm in lower 1 m; massive at 1–1.5 m; above this, parting surfaces at 5–10 cm.

Coral collection C-54962 at 38 m: Late Ordovician (Ashgill) to Late Silurian.

Unit 6, 41.3–46.0 m (4.7 m)
Sandstone: light grey, very fine grained, silty, calcareous; minor **mudrock**: flat and undulating lamination, rare crosslamination; parting thickness 5–8 cm; some trace fossils on bedding planes.

Unit 7, 46.0–47.5 m (1.5 m)
Sandstone: medium light grey, very fine and fine grained, variably calcareous; some flat lamination and brecciation.

Unit 8, 47.5–48.0 m (0.5 m)
Covered, recessive.

– contact probably conformable –

Marvin Formation

Unit 1, 0–36.0 m (36.0 m)
Limestone: mainly medium grey, massive, resistant; mainly peloidal-skeletal packstone (trilobites, ostracodes, gastropods, echinoderms, corals); matrix variably recrystallized; some peloidal grainstone in upper part (e.g., at 30 m); irregular stringers of microcrystalline dolomite in upper part (occurs in samples from 14–30 m).

Conodont collection C-54977 at 2 m: probably Ordovician; C-54978 at 4–5 m: Middle Ordovician to Devonian.

Unit 2, 36.0–44.0 m (8.0 m)
Dolostone: light grey, weathering in hues of yellow, brown, and orange; microcrystalline to very coarse crystalline; some lamination preserved; parting thickness 20–50 cm; vuggy weathering.

Unit 3, 44.0–55.0 m (11.0 m)
Limestone: medium dark grey, dolomitic; brachiopods very common.

Unit 4, 55.0–58.5 m (3.5 m)
Dolostone: medium to medium dark grey; groundmass microcrystalline; blobs of light grey, very fine to very coarse crystalline dolomite probably are ghosts of shells.

Unit 5, 58.5–73.0 m (14.5 m)
Limestone: medium to medium dark grey; brachiopods fairly common; parting thickness about 1 m; sample is peloidal packstone/wackestone transitional to skeletal grainstone (ostracodes, molluscs, etc.).

Unit 6, 73.0–80.5 m (7.5 m)
Rubble and some outcrop of **dolostone**: medium grey, microcrystalline to coarse crystalline, with ghosts of brachiopods(?).

Unit 7, 80.5–122.0 m (41.5 m)
Limestone: medium grey to medium dark grey, massive with parting surfaces spaced 50 cm; some dolomite replacement, commonly in stringers.

80.5–83.0 m (2.5 m): Brachiopods very common; sample is peloidal packstone/wackestone transitional to skeletal grainstone (brachiopods, ostracodes, gastropods).

Brachiopod collection C-54964 at 82.0 m: late Wenlock-early Pridoli.

83.0–84.5 m (1.5 m): Brachiopods less abundant; favositid corals present.

Coral collection C-54965 at 84.5 m: Ordovician (Ashgill) to Silurian (Ludlow).

84.5–89.0 m (4.5 m): Brachiopods very common, some are large; sample is peloidal packstone/wackestone transitional to skeletal grainstone (brachiopods, gastropods, ostracodes); stringers of microcrystalline dolomite.

89.0–103.0 m (14.0 m): Fossils less common than in underlying part of unit; sample is peloidal packstone/wackestone with scarce brachiopod fragments; stringers of microcrystalline dolomite.

103.0–122.0 m (19.0 m): Large brachiopods common in places (e.g., at 107 m and at 113–116 m); large favositid coral at 110 m; samples are peloidal-skeletal packstones (brachiopods, ostracodes, trilobites); some stringers of microcrystalline dolomite.

Brachiopod collections C-54966 at 107 m and C-54968 at 113–116 m: late Wenlock to early Pridoli.

Coral collection C-54967 at 110 m: Upper Ordovician to Upper Silurian (Ludlow).

Unit 8, 122.0–145.0 m (23.0 m)
Limestone: medium dark grey; parting surfaces spaced 5–20 cm; more recessive than underlying units, upper 10 m represented by rubble; some brachiopods and corals; samples are lime mudstones with sparse skeletal fragments (brachiopods, ostracodes at 126.5 m) and richly fossiliferous peloidal packstone/wackestones transitional to skeletal grainstones (mainly brachiopods, minor ostracodes, gastropods, echinoderms at 144 m).

Coral collection C-54969 at 128 m: Silurian.

Unit 9, 145.0–147.0 m (2.0 m)
Rubble of **limestone**: medium dark grey, recessive; sample is skeletal wackestone (mainly calcareous sponge spicules, minor trilobites, ostracodes, gastropods); abundant stringers of microcrystalline dolomite.

Unit 10, 147.0–155.0 m (8.0 m)
Intermittent outcrop and rubble of **dolostone**: medium light grey, microcrystalline to medium crystalline; beds about 10 cm thick.

Unit 11, 155.0–211.5 m (56.5 m)
Mainly **limestone**: medium dark grey; small amounts of **dolostone**; rare **chert lenses**; **limestone** samples: skeletal lime wackestone (mainly calcareous sponge spicules; minor siliceous spicules, ostracodes, brachiopods, gastropods, echinoderms, trilobites) and peloidal packstone/wackestone; stringers of microcrystalline dolomite common.

155.0–156.5 m (1.5 m): **Limestone:** parting thickness 5 cm, overlain by **dolostone**: parting thickness 30 cm; both recessive.

156.5–172.0 m (15.5 m): Mainly **limestone**: parting thickness 5–20 cm, with dolomitic stringers; minor **dolostone**: medium dark grey, microcrystalline to medium crystalline; parting thickness 10–20 cm; bluff-forming unit.

172.0–174.0 m (2.0 m): **Limestone:** as in underlying strata, bluff-forming, with chert lenses.

174.0–187.0 m (13.0 m): **Limestone:** as in underlying strata but more recessive; parting thickness 5–30 cm.

187.0-211.5 m (24.5 m): **Limestone:** as in underlying strata; parting thickness 5-10 cm; some small **chert lenses**; cephalopods, gastropods, brachiopods, etc.; chain corals from 193 m to top.

Fossil collection C-54970 at 193 m: Middle Ordovician to Late Silurian.

Coral collection C-54971 at 209 m: Silurian, probably Ludlow; C-54972 at 211 m: Upper Ordovician to Upper Silurian.

Unit 12, 211.5-230.0 m (18.5 m)
Mainly **dolostone**: medium grey, microcrystalline to coarse crystalline with ghosts of fossils (ostracodes etc.); parting thickness 5-30 cm; minor amounts of dolomitic **limestone** and **chert lenses** in lower 2 m (211.5-213.5 m); silicified corals common in lower 10 m; relatively recessive unit.

Unit 13, 230.0-239.0 m (9.0 m)
Limestone: medium dark grey; parting thickness 5-20 cm; relatively recessive; sample is peloidal-skeletal packstone (calcareous sponges, ostracodes, echinoderms, corals, etc.).

Unit 14, 239.0-246.0 m (7.0 m)
Limestone: dolomitic and **dolostone**: in part calcareous; parting thickness 5-20 cm; silicified corals.

Coral collection C-54973 at 241 m: Upper Ordovician to Upper Silurian.

Unit 15, 246.0-289.0 m (43.0 m)
Limestone: medium light grey to medium dark grey; massive or with parting surfaces spaced 10-20 cm; bluff-forming unit; large, broken brachiopods common at 259.5 and 288-289 m; favositid corals at 254.5 and 287 m; samples are transitional between peloidal packstone/wackestone and skeletal-peloidal grainstone (brachiopods, echinoderms, corals); stringers of microcrystalline dolomite common.

Coral collection C-54974 at 254.5 m: Upper Ordovician (Ashgill) to Middle Devonian; C-54975 at 287 m: Upper Ordovician (Ashgill) to Middle Devonian (Givetian).

Unit 16, 289.0-292.0 m (3.0 m)
Dolostone: light grey, weathering in hues of orange, yellow, and brown; microcrystalline to very coarse crystalline; vuggy weathering; ghosts of brachiopods.

Unit 17, 292.0-294.5 m (2.5 m)
Limestone: medium grey, thick bedded; some large brachiopods; sample is peloidal packstone/wackestone transitional to skeletal grainstone (brachiopods, echinoderms).

Unit 18, 294.5-316.0 m (21.5 m)
Dolostone: light grey, microcrystalline to coarse crystalline, vuggy weathering.

Unit 19, 316.0-325.0 m (9.0 m)
Limestone: medium grey, massive; present as rubble and outcrop; sample is peloidal-skeletal (mainly brachiopods, ostracodes, molluscs) packstone.

Unit 20, 325.0-334.0 m (9.0 m)
Limestone: as in unit 19, partly replaced by **dolostone**: light grey, microcrystalline to very coarse crystalline; unit forms steep bluff.

Unit 21, 334.0-365.0 m (31.0 m)
Mainly **limestone**: medium dark grey; large brachiopods common; samples are peloidal-skeletal (mainly brachiopods) packstone; stringers of microcrystalline dolomite.

Unit 22, 365.0-368.0 m (3.0 m)
Dolostone: medium grey with irregular but rounded light grey blobs; microcrystalline to very coarse crystalline; some relic lamination.

Unit 23, 368.0-372.0 m (4.0 m)
Rubble of **limestone**: probably thin bedded; parting thickness about 10 cm; sample is wackestone and peloidal-skeletal packstone (mainly brachiopods); stringers of microcrystalline dolomite.

Unit 24, 372.0-390.0 m (18.0 m)
Dolostone: medium grey, microcrystalline to coarse crystalline; ghosts of brachiopods; blotchy texture in lower part; parting thickness 10-50 cm; cliff-forming unit.

Unit 25, 390.0-402.0 m (12.0 m)
Recessive, partly covered unit with rubble of **limestone**: medium grey, with brachiopods; sample is peloidal-skeletal (brachiopods) packstone; stringers of microcrystalline dolomite.

Unit 26, 402.0-434.5 m (32.5 m)
Limestone: medium to medium dark grey; massive and bluff-forming to 421.5 m, then more recessive; parting thickness 5-10 cm at 426.5-434.5 m; samples are lime mudstone (at 403 m) and recrystallized peloidal-skeletal packstone(?) (at 426 m).

Unit 27, 434.5–439.5 m (5.0 m)
Dolostone: medium grey, microcrystalline to very coarse crystalline; blotchy texture; parting thickness 10–20 cm; grades to limestone laterally.

Unit 28, 439.5–442.5 m (3.0 m)
Limestone: medium grey to medium dark grey; parting thickness 10–20 cm; sample is peloidal grainstone with rare ostracodes.

Unit 29, 442.5–451.5 m (9.0 m)
Dolostone: as in unit 27; parting thickness 10–20 cm.

Unit 30, 451.5–460.5 m (9.0 m)
Rubble of **limestone**: thin bedded.

Unit 31, 460.5–461.5 m (1.0 m)
Limestone: medium to medium dark grey; parting thickness 2–10 cm; sample is peloidal packstone/wackestone with rare trilobite fragments; faint lamination; fenestrae; stringers of microcrystalline dolomite.

Unit 32, 461.5–464.5 m (3.0 m)
Dolostone: light grey and medium grey; microcrystalline to very coarse crystalline; swirly texture; parting thickness 2–10 cm and 1–1.5 m; vuggy weathering.

Unit 33, 464.5–468.0 m (3.5 m)
Rubble of **limestone**.

Unit 34, 468.0–487.0 m (19.0 m)
Limestone: medium grey; parting thickness 5–15 cm; some thin, flat lamination in lower 1.5 m; specimens are peloidal packstone/wackestone with or without sparse trilobite fragments; fenestral structures, in part laminar; stringers of microcrystalline dolomite in lower 1 m or so.

Unit 35, 487.0–491.0 m (4.0 m)
Covered.

Unit 36, 491.0–493.0 m (2.0 m)
Limestone: medium dark grey; some dolomitic mottling; sample is peloidal packstone/wackestone with a few fragments of gastropods and ostracodes(?).

Unit 37, 493.0–499.4 m (6.4 m)
Covered.

Unit 38, 499.4–501.1 m (1.7 m)
Limestone: medium dark grey; parting thickness 0.5–1 m; sample is peloidal-skeletal (brachiopods, corals, ostracodes, trilobites) packstone.

Unit 39, 501.1–504.0 m (2.9 m)
Limestone: medium dark grey; parting thickness 2–5 cm; partly present as rubble.

Unit 40, 504.0–516.0 m (12.0 m)
Limestone: medium grey, partly dolomitic; some brachiopods; parting thickness 5–15 cm; bluff-forming unit; sample is peloidal grainstone with rare trilobite fragments.

Unit 41, 516.0–517.0 m (1.0 m)
Limestone: medium dark grey; parting thickness 3–5 cm; recessive; sample is recrystallized peloidal-skeletal (ostracodes etc.) packstone.

Unit 42, 517.0–576.0 m (59.0 m)
Limestone: medium to medium dark grey; resistant, thick bedded units alternate with recessive, thin bedded units; specimens are peloidal packstone/wackestone with scarce skeletal material (mainly trolobites); rare flat lamination; laminar and irregular fenestrae present in all samples.

Conodont collections C-54981, C-54982, and C-54983 at 573–574 m: Ludlow or Pridoli.

Top of section: top of exposures. (R. Gardner and D. Jones (unpublished field notes) obtained a thickness of 741 m along a different line in the same general area.)

CRASH POINT SECTION (CRP)
(type section of Marvin Formation)

Location: *M'Clintock Inlet*, inset C, section CRP; east of central M'Clintock Inlet, northeast of Crash Point; NTS 340 E; NTS 340 E; UTM Zone 18X, 483700E, 9183600N.

Measured in 1966 and 1981; field numbers 66TM2, 66TM302a to 66TM304c; 81TM6, 81TM129C.

Base of section: abrupt contact with Lands Lokk Formation (difficult to access where exposed).

Marvin Formation

Unit 1, 0–39 m (39 m)
Limestone: medium light grey; samples are peloidal limestones, some transitional to grainstone or wackestone with scarce to abundant skeletal material (brachiopods, echinoderms, trilobites, ostracodes, corals, gastropods, pelecypods, bryozoans(?)); skeletal grains commonly have single or multiple micritic coatings (coated grains, oncoids).

0–31.0 m (31.0 m): Parting thickness 1–2 m; resistant unit.

31.0–39.0 m (8.0 m): Parting thickness 0.5–1 cm and 5–10 cm; recessive.

Fossil collection GSC loc. 75421 from basal strata: late Wenlock–early Pridoli (brachiopod), probably Ludlow (conodont).

Unit 2, 39–104± m (65± m)
Limestone: as in unit 1; some beds rich in fossils (brachiopods, large cephalopods, corals, bryozoans, stromatoporoids, algae etc.); massive or thick-bedded, resistant units alternate with recessive units that have more closely spaced parting surfaces.

Pelecypod C-54976 at 45 m: probably Silurian.

Algae at 60 m C-94307.

Brachiopod GSC loc. 75422 (position not determined): late Wenlock–early Pridoli.

Unit 3, 104±–154± m (50 m)
Limestone (about two thirds), interbedded with **sandstone** (one third); **limestone**: samples are skeletal wackestone and oncolite with silty and sandy matrix; ledge-forming units 3–6 m, beds 2–15 cm thick; some beds rich in fossils (corals, brachiopods, echinoderms, gastropods, stromatoporoids, bryozoans); **sandstone**: fine grained, quartzose, variably calcareous, micaceous, flat-laminated.

Brachiopod GSC loc. 69208 (position not determined): late Wenlock–early Pridoli.

Top of section: conformable contact with Crash Point beds.

APPENDIX 2

CONTENTS

PEARYA, SUCCESSION 2, SUMMARY DESCRIPTION OF MAP UNITS

PRELIMINARY LITHOSTRATIGRAPHIC UNITS

ARTHUR LAING AND CRANSTONE PENINSULAS (MAP UNITS L1 TO L6, *CLEMENTS MARKHAM INLET–ROBESON CHANNEL* AND *M'CLINTOCK INLET*)

Map unit L1

Distribution: southeast of Markham Fiord and 7 to 9 km northwest of the mouth of Gypsum River (*Clements Markham Inlet–Robeson Channel*).

Contacts: concealed.

Thickness: probably >200 m.

Lithology: Southeast of the head of Markham Fiord three units are exposed on the northern limb of a west-northwest-plunging anticline; in order upward:

Unit A: **Volcanogenic pebble conglomerate**: cobbly, medium grey, composed mostly of felsic volcanic rock fragments with small amounts of sand-sized quartz and feldspar.

Unit B: **Volcanogenic pebble conglomerate, pebbly sandstone**, and **sandstone**: all medium grey, composed of felsic volcanic rock fragments and chert(?) with a larger proportion of clastic quartz and feldspar than in unit 1; also present are small amounts of **felsic tuff** and **porphyritic flow(?) rocks**: medium dark grey to medium light grey, composed of quartz, albite, and chlorite with minor K-feldspar and white mica; an analyzed sample is classified as rhyolite or andesite(?) on major and trace elements, respectively (Appendix 4A, Tables 1, 2–10, 3–10, no. 1); pervasive carbonate and quartz(?) alteration.

Unit C: **Lime mudstone**: medium grey, dolomitic, with authigenic quartz and feldspar; sheared and largely recrystallized to **marble**, but micritic texture is preserved in patches; **slate**: medium grey, quartzose or highly calcareous and dolomitic; chlorite flakes about 10 μm long.

The southeastern part of this outcrop belt, known only from brief helicopter visits, includes: **sandstone**: medium grey, quartzose, containing volcanic quartz and some felsic volcanic fragments; **quartzite**: medium grey, fine grained, sheared, phyllitic; **phyllite**: light greenish grey (Appendix 3, Table 42); **siltstone**: medium grey, quartzose and dolomitic, phyllitic (Appendix 3, Table 42); and **interlaminated slate** and **microcrystalline dolostone:** medium grey to olive grey.

Northwest of the mouth of Gypsum River the following rock types are exposed: **crystal-lithic tuff** and/or **tuffaceous siltstone** and **sandstone**: medium and medium dark grey; moderately well sorted; average grade mainly silt to fine grained sand, maximum grain size medium or coarse; fine grained rocks are slaty or phyllitic; composed of volcanic quartz, feldspar, felsic volcanic rock fragments, white mica, chlorite, rare biotite (relatively large flakes); some carbonate alteration; **quartzite**: light grey, very fine to medium grained; well sorted; rounded or well rounded; composed largely of quartz with minor feldspar; some carbonate alteration; **dolostone, dolomitic limestone, marble**: medium grey to medium light grey; units no more than a few tens of metres thick; **dolostone**: microcrystalline to very coarse crystalline; criss-crossed by shear bands; **limestone**: cryptocrystalline to fine microcrystalline with scattered, microcrystalline to medium crystalline dolomite; partly recrystallized to **marble** with intensely twinned calcite; **slate**: medium dark grey, laminated.

Tentative age and correlation: Neoproterozoic, pre-Varanger on the basis of stratigraphic position beneath map unit L2 (*see* below); correlative units are present within map units Y2 (felsic tuff) and D1 (volcanics, quartzite).

Map unit L1?

Distribution: southeast of Markham Fiord, on southeast side of Markham Fiord Pluton (*Clements Markham Inlet–Robeson Channel*).

Contacts: faulted.

Thickness: unknown.

Lithology: calcareous **schist**; **amphibolite**; **marble**: sandy.

Tentative age and correlation: Neoproterozoic, pre-Varanger(?); assignment to L1 is questionable.

Map unit L1?b

Distribution: west of Markham Fiord (*Clements Markham Inlet–Robeson Channel* and *M'Clintock Inlet*).

Contacts: faulted.

Thickness: unknown.

Lithology: **carbonate rocks**; calcareous **phyllite**; impure **quartzite**: composed mainly of quartz with some plagioclase, siliceous volcanic rock fragments, chert, chlorite and white mica; abundant and thick sills of unaltered Cretaceous(?) **gabbro/diabase**.

Tentative age and correlation: Neoproterozoic, pre-Varanger(?); assignment to L1 is questionable.

Map unit L2 (Gypsum River diamictite)

Distribution: Arthur Laing Peninsula: southeast of the head of Markham Fiord, northeast and southwest of lower Gypsum River, and vicinity of Mount Disraeli (*Clements Markham Inlet–Robeson Channel*).

Contacts: concealed.

Thickness: ±200 m(?) (approximate topographic relief of nearly horizontal strata southeast of Mount Disraeli).

Lithology: **diamictite**, minor interlaminated **phyllite**; **diamictite (conglomeratic greywacke)**: generally light grey to medium grey but brownish grey where altered by limonite (e.g., southeast of head of Markham Fiord); massive, cliff-forming; poorly sorted; sparse cobbles and/or pebbles, commonly carbonate rocks, supported by abundant sandy and argillaceous matrix (for lithological description *see* Chapter 4; for XRD analyses, Appendix 3, Table 43).

Tentative age and correlation: Neoproterozoic, Varanger; the unit is similar in lithology to deposits of the late Neoproterozoic Varangian glaciation in Svalbard and East Greenland (*see* Chapter 4); equivalents occur within map units Y2 and W2.

Map units L3 and L3?

Distribution: Arthur Laing Peninsula; mapped mainly from air photographs; L3 occurs in anticlinal structures north of lower Gypsum River, L3(?) west and southwest of Mount Disraeli (Clements Markham Inlet–Robeson Channel).

Contacts: concealed.

Thickness: probably >100 m.

Lithology: Map unit L3: recessive, poorly known unit; uppermost part consists of **sandstone**: very fine grained, silty (quartz; minor feldspar, white mica, chlorite, rare biotite); **mudrock**: slaty or phyllitic; both coloured in hues of grey, red, brown.

Map unit L3(?): sampled at one locality only but appears to be uniform (Appendix 3, Table 45); interlaminated **sandstone**: medium grey, very fine grained, silty, calcareous, slaty, and **siltstone**: medium grey, calcareous, slaty; subtle graded bedding, flame structure.

Tentative age and correlation: latest Neoproterozoic and/or Cambrian on the basis of stratigraphic position between map units L2 and L4 (*see* below); equivalents probably are present within map units Y2 and W2.

Map unit L1–3 (undifferentiated)

Distribution: Arthur Laing and Cranstone peninsulas (*Clements Markham Inlet–Robeson Channel* and *M'Clintock Inlet*), but rocks equivalent to map unit L2 are absent from Cranstone Peninsula.

Contacts: concealed or faulted.

Thickness: unknown.

Lithology: metamorphosed **mudrock**: in part calcareous and dolomitic; **fine grained tuff or tuffaceous sediments**: characterized by relatively high proportions of plagioclase; **quartzite**: very fine to medium grained; **calcareous sandstone**, and **sandy calcarenite**; **greywacke**: in part pebbly, poorly sorted; commonly carbonate-rich and similar in composition to the Gypsum River diamictite (Appendix 2, Table 44), but carbonate-poor greywacke also is present (Appendix 2, Table 46); thin units of **limestone** and **dolostone**: in part sandy, silty or cherty; metamorphism generally increases in a northerly direction; fine grained sediments and tuffs are metamorphosed to **schist, phyllite or slate**; the more highly metamorphosed rocks contain biotite and white mica, the rest white mica and chlorite; chloritoid occurs in one sample, together with white mica; biotite, chloritoid, and graphite occur as late porphyroblasts, unrelated in orientation to earlier foliations defined by the white mica.

Tentative age and correlation: Neoproterozoic, pre-Varanger to latest Neoproterozoic or Cambrian on the basis of stratigraphic position; includes equivalents of map units L1 to L3 and may include strata older than map unit L1.

Map unit L4 (Mount Hornby carbonates)

Distribution: Arthur Laing and Cranstone peninsulas (*Clements Markham Inlet–Robeson Channel* and *M'Clintock Inlet*).

Contacts: concealed; appear to be abrupt on air photographs.

Thickness: 300 m or greater (topographic relief of nearly horizontal strata on central Arthur Laing Peninsula).

Lithology: mainly carbonate rocks (*see* Chapter 4), partly metamorphosed and/or silicified, including: **lime mudstone**; **packstone**: peloidal and oolitic; **oncolite**: sandy and dolomitic; **flat-pebble conglomerate**: oncolitic; **dolostone**: microcrystalline to very fine crystalline, partly silty and sandy, laminated and crosslaminated; interbeds of **quartzite** : medium to medium dark grey, fine to coarse grained, well rounded (present at Gypsum River).

Tentative age and correlation: probably Early Cambrian; a sample from an outcrop 4.9 km northeast of the upper reaches of Gypsum River has yielded sponge spicules of probable Phanerozoic age (de Freitas, Appendix 5D, C–194741); the age of the unit is inferred from: (1) the spicules and (2) its stratigraphic position, no more than a few hundred metres above the Gypsum River diamictite; it is probably correlative with map units D2, Y3, and W3.

Map unit L5

Distribution: Arthur Laing Peninsula; overlies map unit L4 in synclines (*Clements Markham Inlet–Robeson Channel*).

Contacts: lower contact is abrupt on air photographs, but has not been observed on the ground; the top is not preserved; not in contact with map unit L6.

Thickness: unknown.

Lithology: distinguished on air photographs from map unit L4 by a relatively dark tone and recessive profile; examined on the ground only on the unnamed peninsula west of Doidge Bay where it consists of interlaminated **quartzite**: light grey, very fine grained, and **phyllitic siltstone**: dark grey; composed of quartz with minor white mica, chlorite, feldspar, and carbonaceous matter; photogeological interpretation suggests that minor amounts of carbonate rocks may be present in an area north of Gypsum River.

Tentative age and correlation: Cambrian, possibly Early Cambrian on the basis of stratigraphic position above map unit L4; probably correlative with map units D3 and L4.

Map unit L6

Distribution: graben west of lower Gypsum River (*Clements Markham Inlet–Robeson Channel*).

Contacts: faulted contacts with map unit L4; lower contact concealed, upper contact not preserved.

Thickness: unknown.

Lithology: **quartzite**: medium light grey, weathering greenish and purplish grey; in part thinly laminated; very fine and fine grained; consists mainly of quartz but also includes albite, chlorite, and white mica (Appendix 3, Table 47); in some specimens, chlorite and white mica appear to be pseudomorphous after morphological glauconite; minor **phyllite**.

Tentative age and correlation: Cambrian; structural relations suggest that this unit is younger than map unit L4; it must also be younger than L5, because L5 overlies L4; chlorite and white mica pseudomorphous after glauconite are common in clastic formations of the Central Ellesmere and Hazen fold belts that are late Early Cambrian in age (Kane Basin Formation and upper part of Grant Land Formation).

DISREALI GLACIER (MAP UNITS D1 TO D3, *M'CLINTOCK INLET* AND *CLEMENTS MARKHAM INLET–ROBESON CHANNEL*)

Map unit D1

Distribution: east and west of of Disraeli Glacier (*M'Clintock Inlet* and *Clements Markham Inlet–Robeson Channel*).

Contacts: faulted.

Lithology: **quartzite**: mainly medium grey; partly laminated; rounded, poorly sorted quartz of sand to fine pebble grade (observed maximum grain size 7 mm) in matrix of quartz silt and metamorphic chlorite and mica (mainly white mica with minor biotite) (Appendix 3, Table 48); **meta-siltstone**: medium and medium dark grey; commonly laminated; phyllitic; quartzose (Appendix 3, Table 49); **argillaceous phyllite:** hues of grey and/or green; composed of quartz, white mica, chlorite, minor feldspar, ±chloritoid (Appendix 3, Table 50); **chlorite**-rich **phyllite**: light green, probably tuffaceous (Appendix 3, Table 51); **albite**-rich **phyllite**: medium grey and greenish grey, probably tuffaceous (Appendix 3, Table 52); **tuff**: two specimens of crystal tuff are classified as **trachyandesite** on the basis of trace elements (Appendix 4A, Tables 1, 2-10, 3-10, nos. 2, 3); **calcareous-dolomitic phyllite**: medium grey (Appendix 3, Table 53); **marble**: medium grey, schistose, calcareous and dolomitic, in part silty and sandy (Appendix 3, Table 54).

Thickness: unknown.

Tentative age and correlation: probably Neoproterozoic, pre-Varanger; the quartzite resembles quartzite of map unit W1 northeast of Yelverton Inlet but is coarser grained; it also resembles quartzite of map unit Y1 northeast of Ayles Fiord but contains less feldspar; the volcanics may be related to those in map unit L1.

Map unit D2

Distribution: east and west of Disraeli Glacier, south of map unit D1 (*M'Clintock Inlet* and *Clements Markham Inlet–Robeson Channel*).

Contacts: fault contact with map unit D1; overlain by map unit D3, with an abrupt stratigraphic(?) contact.

Thickness: >300 m (estimate based on topographic relief).

Lithology: **dolostone**: medium to dark grey, microcrystalline to phanerocrystalline; some relic breccia texture; partly replaced by quartz and minor chert.

Tentative age and correlation: possibly Early Cambrian; possibly correlative with map units L4, Y3, and W3 but differs from these units by its entirely dolomitic composition; equivalents of map unit D2 may be present in map unit pcq at M'Clintock Glacier; several large samples, dissolved in acetic acid, yielded no organic remains.

Map unit D3

Distribution: east and west of Disraeli Glacier (*M'Clintock Inlet*).

Contacts: overlies map unit D2 with an abrupt stratigraphic(?) contact; top not preserved; fault contact with Danish River Formation.

Thickness: 60–100 m (estimate on west side of Disraeli Glacier); top not preserved.

Lithology: mainly **mudrock**: medium to dark grey, variably calcareous and dolomitic (Appendix 3, Table 55); minor **greywacke**: sand to pebble grade clasts of chert, felsic volcanics, carbonate rocks, and mudrock in argillaceous matrix.

Tentative age and correlation: Cambrian, possibly Early Cambrian, on the basis of position above D2; possibly correlative with map units L5 and Y4; the greywacke is similar to the Gypsum River diamictite (map unit L2) in texture and composition, but not in thickness and stratigraphic setting; equivalents of map unit D3 may be present in map unit pcq at M'Clintock Glacier.

NORTHEAST OF LOWER REACHES OF AYLES FIORD (MAP UNIT A, *M'CLINTOCK INLET* AND *YELVERTON INLET*)

Map unit A

Distribution: northeast of lower reaches of Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: overlies succession 1 in an anticline (Figs. 4-4, 4-5); contact is interpreted as sheared nonconformity (*see* Chapter 4).

Thickness: unknown.

Lithology: lowest strata are **schist**, followed by interbedded **quartzite** and **schist**; **marble** reported by Frisch (1974, p. 29) must occur higher in the succession; includes small fault slices of granitoid **gneiss** of succession 1 (larger slices have been mapped separately); **schist**: cataclastically deformed; composed of quartz, plagioclase (albite or oligoclase), ±K-feldspar, white mica, ±biotite, ±chlorite, ±epidote, ±garnet; schist near Cape Fanshawe Martin Intrusion contains sillimanite and hornblende (Frisch, 1974, p. 30); **quartzite**: samples are very fine to medium grained and contain small amounts of feldspar, mica, and chlorite.

Tentative age and correlation: Neoproterozoic, pre-Varanger on the basis of stratigraphic position above Succession 1; represents the oldest known unit of Succession 2; correlative units are unknown.

NORTHEAST OF MILNE GLACIER AND MILNE FIORD (MAP UNITS M1 TO M5, *M'CLINTOCK INLET* AND *YELVERTON INLET*)

Map units M1, M1a, M1b, M1?

Distribution: north of Ooblooyah Creek on the west side of M'Clintock Inlet and south of upper reaches of Ayles Fiord (*M'Clintock Inlet*); M1? occurs northeast of Ayles Fiord.

Contacts: concealed.

Thickness: probably several hundred metres.

Lithology: Map unit M1 (undifferentiated): mainly **carbonate rocks** (**dolostone**, **calcareous marble**), minor **phyllite**, **phyllitic tuff**.

Map unit M1a: lower resistant unit, rich in **carbonates**.

Map unit M1b: upper, recessive unit, relatively rich in **phyllite** (recognized only in an area south of upper reaches of Ayles Fiord).

Map unit M1?: (assignment to M1 uncertain; may be related to M2): mainly calcareous marble.

Samples from the eastern anticlinorium, south of the upper reaches of Ayles Fiord represent: **dolostone**: medium light grey to medium dark grey; fine microcrystalline to phanerocrystalline; variably calcareous; in part silty and very fine grained sandy (Appendix 3, Table 64), partly laminated; **calcareous marble**: light grey; **phyllite**: medium dark grey, quartzose, carbonaceous (Appendix 3, Table 65); **phyllitic tuff**: light grey–light brownish grey, albite-rich (Appendix 3, Table 65).

Samples from north of the upper reaches of Ayles Fiord (map unit M1?) are **marble**: medium grey, calcareous, slightly dolomitic, in part sandy, variably recrystallized (some micritic textures preserved).

Tentative age and correlation: Cambrian and/or Early Ordovician on the basis of stratigraphic position beneath the dated unit M4 (a Cambrian age appears more likely than an Ordovician age); correlative units are unknown.

Map units M2, M2c, M2pc, M2v

Distribution: northeast of the upper reaches of Milne Glacier to north of the upper reaches of Ayles Fiord (*M'Clintock Inlet*).

Contacts: overlies map unit M1 in anticlinal structures but contact has not been seen.

Thickness: unknown.

Lithology: Map unit M2 (undifferentiated): **phyllite, schist, metavolcanics, quartzite, carbonate rocks**.

The following units are listed in alphabetic order (stratigraphic order is uncertain):

Map unit M2c: **carbonate rocks** (mappable from air photographs).

Map unit M2pc: **phyllite** and **carbonates**.

Map unit M2v: **metavolcanics** (mapped separately only north of the upper reaches of Ayles Fiord).

Phyllite and **schist**: medium grey, medium dark grey, greenish grey; some lamination preserved; composed of quartz, minor chlorite, mica (mainly white mica; schists have biotite) ±chloritoid, ±staurolite, ±garnet, ±calcite, ±dolomite (Appendix 3, Table 66); **metavolcanics**: greenish grey, commonly phyllitic; probably mainly tuffs with lesser flow rocks; one chemically analyzed flow rock is a subalkaline basalt (Appendix 4A, Tables 1, 2-10, 3-10, no. 4); composed of quartz, chlorite, albite, ±K-feldspar, epidote, ±actinolite, ±mica, ±K-feldspar, ±calcite (Appendix 3, Table 67); **quartzite**: medium light grey and medium grey; very fine and fine grained; contains minor albite, white mica, calcite; **carbonate rocks**: medium or medium dark grey; variably calcareous, dolomitic, silty, and/or sandy; variably recrystallized to marble.

Tentative age and correlation: Cambrian and/or Early Ordovician on the basis of stratigraphic position beneath the dated unit M4 (a Cambrian age appears more likely than an Ordovician age); correlative units are unknown.

Map unit M3

Distribution: northeast of lower reaches of Milne Glacier to north of Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: abrupt.

Thickness: >150 m at incomplete section northeast of Milne Glacier; about 202 m were measured at a section northeast of Ayles Fiord (NEAF; not in Appendix 1), but there the basal contact may be faulted and the upper 40 m or so may be repeated by folding and faulting.

Lithology: **carbonate rocks**; samples from section northeast of Ayles Fiord are mainly **calcareous marble**, medium light grey, rather pure (Appendix 2, Table 68) with lime mudstone texture and some flat lamination preserved in some samples; minor **dolostone**: light red, predominantly phanerocrystalline, partly laminated, rather pure (Appendix 2, Table 69); sample from northeast of Milne Fiord is **calcareous marble**: pale red, silty, laminated, possibly stromatolitic.

Tentative age and correlation: Cambrian and/or Early Ordovician on the basis of stratigraphic position beneath the dated unit M4; correlative units are unknown.

Map unit M4

Distribution: northeast of lower reaches of Milne Glacier to northwest of Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: abrupt.

Thickness: 900 m± at section northeast of Milne Glacier (photogrammetric determination).

Lithology: (*see* stratigraphic sections northeast of Milne Glacier and northeast of Milne Fiord) mainly **phyllite**: medium grey, medium dark grey, and greenish grey, argillaceous and partly calcareous-dolomitic (Appendix 3, Tables 70, 71); minor **dolostone** (Appendix 3, Table 72) and **lime mudstone**: both medium light grey, silty and sandy, laminated and crosslaminated; minor **metavolcanics**: phyllitic **tuff**, rich in albite and/or chlorite (Appendix 2, Table 73); rare **rhyolite** (welded tuff(?); Appendix 4A, Tables, 1, 2-10, 3-10, no. 5).

Age: Early Ordovician, Tremadoc;[1] rhyolite in the uppermost part of the unit has yielded a U-Pb (zircon) age of 503.2 +7.8/-1.7 Ma (Trettin et al., 1987).

Map unit M5

Distribution: northeast of lower reaches of Milne Glacier to north of Ayles Fiord (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: abrupt or gradational (*see* above).

Thickness: 120 m at incomplete section northeast of Milne Fiord; 550± m at photogrammetric section northeast of Milne Fiord; this thickness appears to be excessive but evidence for repetition by folding or faulting has not been seen.

Lithology: mainly **quartzite**: light grey, very fine to medium grained, generally well sorted and rounded; nearly pure with trace amounts to a few per cent of plagioclase, white mica, biotite and/or chlorite (Appendix 3, Table 74); **argillaceous phyllite** is interbedded with quartzite in the lower few metres of the section northeast of Milne Glacier.

Tentative age and correlation: Early Ordovician on the basis of stratigraphic position above M4; it is possible, however, that this unit represents a thrust sheet of Cambrian or Neoproterozoic strata; correlative units are unknown.[2]

NORTHEAST OF YELVERTON INLET (MAP UNITS Y1 TO Y4, *YELVERTON INLET* AND *M'CLINTOCK INLET*)

Map units Y1 and Y1?

Distribution: map unit Y1 occurs south of Petersen Bay; map unit Y1? (tentatively correlated with Y1 on the basis of petrography) in a fault block northeast of Yelverton Inlet (*Yelverton Inlet*).

Contacts: map unit Y1 has been thrust over part of map unit Y2; its base is concealed and its top is not preserved; map unit Y1? is in fault contact with map unit Y3 and Danish River Formation.

Lithology: quartzite with lesser amounts of interbedded **phyllite** or **schist**; **quartzite**: light grey, poorly sorted; fine to very coarse grained sand and granules supported by matrix of very fine grained sand, silt, and metamorphic white mica and minor chlorite; some carbonate alteration; feldspar (chessboard-twinned albite common, minor K-feldspar) averages 4.7% in XRD analyses (Appendix 3, Table 79; corrected F/F+Q is about 8%) but some laminae are rich in relatively coarse grained feldspar; **phyllite/schist**: medium grey or medium dark grey; represents metamorphic equivalent of micaceous quartz sandstone and mudrock.

Tentative age and correlation: Neoproterozoic, pre-Varanger on the basis of stratigraphic position beneath map unit Y2 (*see* below); possibly correlative with Map unit W1 (*see* below).

Map units Y2, Y2c, Y2ss, Y2x

Distribution: northeast of Yelverton Inlet (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: faulted contacts with Succession 1 (Deuchars Glacier belt) and map unit Y1; contact with Y3 appears to be stratigraphic but has not been studied.

Thickness: unknown.

Lithology: map unit Y2 (undifferentiated): original mudrock, metamorphosed to **phyllite**, and locally to **schist** or **hornfels**; **sandy phyllite**, **diamictite**, **quartzite**, **calcareous marble**; minor **dolostone**, **tuff**, **metachert**.

The following units are listed in alphabetic order; the stratigraphic order is uncertain:

Map unit Y2c: **carbonate units** (mappable from air photographs).

Map unit Y2ss: **schist**: staurolite-bearing.

Map unit Y2x: **diamictite** and **phyllite.**

Map unit Y2xq: **diamictite**, **quartzite**, and **phyllite**.

Phyllite: medium or medium dark grey; composed of quartz with lesser chlorite, feldspar, white mica ±biotite (Appendix 3, Table 80); in part highly dolomitic-calcareous (Appendix 3, Table 81); siltstone-grade phyllite shows flat lamination and graded bedding; **sandy phyllite**: medium light grey

[1]The age is Late Cambrian according to Tucker and McKerrow (1995).
[2]A Late Cambrian age is acceptable.

to medium dark grey, partly laminated; phyllite approaching greywacke is characterized by poorly sorted sand in metamorphosed argillaceous matrix; sand fraction consists mainly of well rounded quartz but includes carbonates, siltstone, and chert in some samples (Appendix 3, Table 82); **diamictite**: medium grey, poorly sorted, massive; pebbles of carbonate rocks (including dolostone), mudrock, minor tuff, and sand grains mainly of quartz with minor lithic clasts (dolomitic quartz siltstone) and feldspar are supported by matrix composed of quartz, carbonate, mica (white mica and biotite) and chlorite (Appendix 3, Table 83); **quartzite**: light grey or medium grey; very fine to coarse grained; partly interlaminated with phyllite; **marble**: light grey to medium grey, calcareous, partly sandy, micaceous; **tuff**: dark grey, phyllitic; felsic and intermediate in composition (quartz, albite, variable proportions of chlorite, minor mica; Appendix 3, Table 84); **metachert**: dark grey; composed largely of quartz with minor plagioclase, white mica, and chlorite (Appendix 3, Table 84); quartz has schistose, stretched texture, but crystals are up to 40 μm in diameter; **schist**: quartz, feldspar (albite to andesine), biotite, ±white mica, ±chlorite, ±staurolite

Tentative age and correlation: Neoproterozoic, pre-Varanger to late Neoproterozoic or Cambrian; includes equivalents of map units L1 (tuff and probably some quartzite), L2 (diamictite), and L3 (probably some quartzite and phyllite); probably is partly correlative with map unit W2.

Map units Y3, Y3?b

Distribution: southeast of Milne Glacier and northeast of Yelverton Inlet; carbonates east and southeast of Petersen Bay and northeast of Milne Fiord are tentatively included (map units Y3?, Y3b) (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: contacts with map units Y2 and Y4 appear to be stratigraphic but have not been studied.

Thickness: several hundred metres (estimate from air photographs).

Lithology: **dolostone**: microcrystalline and phanerocrystalline; **limestone**: variably recrystallized (microsparite and marble); both light grey to medium grey, partly silty and/or sandy with some quartz or chert replacement.

Map unit Y3?b: includes abundant mafic intrusions.

Tentative age and correlation: probably Early Cambrian; probably correlative with map units L4, D2, and W3.

Map unit Y3?b: correlation with Y3 is questionable.

Map units Y4, Y4?p

Distribution: southwest of Milne Fiord and Milne Glacier (*Yelverton Inlet* and *M'Clintock Inlet*).

Contacts: contact with Y3 appears to be stratigraphic but has not been studied; top not preserved.

Thickness: unknown.

Lithology: **phyllite**: light grey to medium dark grey, greenish grey; predominantly argillaceous (Appendix 3, Table 85); **metavolcanics**: phyllitic tuff (Appendix 3, Table 86), also flow rocks and/or sills (Appendix 3, Table 86); **carbonate** beds, a few metres thick.

Map unit Y4?p: includes **mudrock**: greyish red and greenish grey, highly dolomitic and calcareous, possibly bioturbated (Appendix 3, Table 87); (sampled at one locality only).

Tentative age and correlation: Cambrian, possibly Early Cambrian on the basis of stratigraphic position above Y3; possibly correlative with map units L5 and D3.

Map unit Y4?p: assignment to Map unit Y4 is questionable.

WOOTTON PENINSULA (MAP UNITS W1 TO W3, *YELVERTON INLET*)

Map unit W1

Distribution: northeastern Wootton Peninsula (*Yelverton Inlet*); occurs as thrust sheets emplaced upon W2.

Contacts: faulted or concealed (thrust over map unit W2).

Thickness: unknown.

Lithology: mainly **quartzite** with lesser amounts of interstratified quartzite and **phyllite** or **slate**; unit occurs mainly as felsenmeer but medium-scale planar crossbedding is locally preserved; **quartzite**: medium light grey; very fine to very coarse grained; maximum grain size very fine sand to granule grade; moderately or poorly sorted; quartz sand embedded in a (secondary?) matrix of white mica, chlorite and quartz; sand grains were probably rounded originally but rounding has been largely destroyed by pressure solution and marginal replacement; some calcite and dolomite alteration (Appendix 3, Table 88); **phyllite**: medium dark grey and dusky green; argillaceous and sandy (Appendix 3, Table 89).

Tentative age and correlation: Neoproterozoic, pre-Varanger on the basis of structural relation with map unit W2; possibly correlative with map unit Y1.

Map unit W2

Distribution: northeastern Wootton Peninsula (*Yelverton Inlet*).

Contacts: concealed; thrust over map unit W3.

Thickness: unknown.

Lithology: phyllite, diamictite, thin units of **calcareous marble** and **dolostone**, minor **quartzite**; recessive unit, exposed mainly as felsenmeer, cut by numerous ridge-forming dykes; **phyllite**: light to medium dark grey, greenish grey; flat lamination and some small-scale crosslamination; argillaceous, variably calcareous-dolomitic, in part sandy (Appendix 3, Table 90); **diamictite**: hues of grey and green; massive; poorly sorted sand grains, ±granules, ±pebbles supported by recrystallized matrix (Appendix 3, Table 91); pebbles: ovoid or discoid; analyzed examples are calcareous and dolomitic quartz sandstone and highly dolomitic mudrock (Appendix 3, Table 92); sand grains: mainly quartz (rounded), minor carbonate and siliciclastic rock fragments, feldspar, and recrystallized chert; matrix is similar to phyllite; **calcareous marble**: medium to medium dark grey; microcrystalline; original lime mud texture recognizable in places; variably dolomitic; **dolostone**: medium to medium dark grey; microcrystalline and phanerocrystalline; variably calcareous; some relic coated grains; some quartz and chert replacement.

Tentative age and correlation: Neoproterozoic, pre-Varanger to late Neoproterozoic or Cambrian; probably includes equivalents of map units L1, L2 (diamictite), L3, and Y2.

Map unit W2*

(Summary adapted from detailed acccount by Ohta and Klaper, 1992).

Distribution: southwestern Wootton Peninsula; fault block, bordered by two branches of Mitchell Point Fault Zone (*Yelverton Inlet*).

Contacts: lower contact concealed; faulted contacts with volcanics and plant-bearing sediments probably of Late Cretaceous age (Hansen Point volcanics) (Ohta and Klaper, 1992, map units 2, 4 and 6).

Lithology: a thick unit of **dolostone** (map unit 1, Ohta and Klaper, 1992) includes a brecciated subunit, 30–40 m thick, which has chert concretions and silicified stromatolites(?) and a non-brecciated subunit of argillaceous dolostone, more than 35 m thick, which contains little chert; **phyllitic pebble conglomerate** and **minor quartzite** (map unit 3, *ibid.*): flattened pebbles of shale, sandstone, and rhyolite supported by a sandy and argillaceous matrix; **black slate, phyllitic siliceous tuff** and **tuff breccia** and **green phyllite** (map unit 5, *ibid.*); **diamictite** (map unit 7, *ibid.*): scattered, unsorted pebbles of carbonate and clastic sediments, mainly dolomitic, in coarse grained sandy matrix with carbonate cement; **brecciated siliceous carbonates** (map unit 8).

Tentative age and correlation: Neoproterozoic, pre-Varanger to Cambrian, possibly Early Cambrian; the diamictite (map unit 7 of Ohta and Klaper, 1992) is probably Varanger in age and correlative with map unit L2; the thick dolostone unit is probably Early Cambrian in age and correlative with map units W3, L4, Y3 and D2.

Map unit W3

Distribution: northern Wootton Peninsula (*Yelverton Inlet*).

Contacts: concealed.

Thickness: unknown.

Lithology: dolostone: light grey, medium light grey or medium grey, microcrystalline to very fine crystalline, in part silty and very fine to fine grained sandy; **lime mudstone**: medium to medium dark grey, also pale red, partly recrystallized and schistose; common solution zones.

Tentative age and correlation: probably Early Cambrian; probably correlative with map units L4, D2, and Y3; analyses for insoluble microfossils were unsuccessful.

CLEMENTS MARKHAM INLET-ROBESON CHANNEL (MAP UNIT Ps)

Map unit Ps

Distribution: northern Arthur Laing Peninsula (*Clements Markham Inlet-Robeson Channel*).

Contacts: faulted contacts with map units Pn and L1-3.

Lithology: schist: composed mainly of muscovite, quartz, albite and garnet with minor chlorite, epidote, biotite, amphibole, and carbonates (Frisch, 1974).

Comments: the schist is comparable to some metamorphic rocks in map unit L1-3 but may represent retrograde rocks of Succession 1 (Frisch, 1974).

M'CLINTOCK INLET (MAP UNITS Ps, sy, pwqc, s, sc, pc, pcq, qpcv, p)

Map units Ps and sy

Distribution: Ward Hunt Island.

Contacts: map unit Ps is in fault contact with upper Paleozoic strata; map unit sy intrudes Ps.

Lithology: Map unit Ps: **schist and phyllite**: composed of biotite, muscovite, chlorite, sodic plagioclase (An_{5-13}), and quartz; some rocks have a cataclastic texture (Frisch, 1974).

Map unit sy: mainly **syenite**: composed of microcline perthite, quartz and mafic minerals altered to green biotite and oxides; crushed and gneissic texture is common (Frisch, 1974); minor **monzodiorite**: metaluminous, composed mainly of hornblende and albite with lesser epidote, chlorite, quartz and corundum (sample from Walker Hill, Appendix 4B, Table 1, no. 3-1).

Comments: the syenite resembles rocks in Succession 1, but the phyllite resembles strata of Succession 2; if it indeed is part of Succession 2, the syenite must be younger than Succession 1.

Map unit pwqc

Distribution: northwesternmost part of map area, north of Ayles Fiord to Cape Richards.

Contacts: faulted contacts with map units A and M2 to M5; intruded by Cape Richards Complex; unconformably overlain by Cape Discovery Formation.

Lithology: phyllite: medium dark grey or greenish grey; partly laminated; composed mainly of quartz, with lesser chlorite, white mica, feldspar (albite and minor K-feldspar), ±chloritoid, ±calcite, ±dolomite (Appendix 3, Table 75); **sandy phyllite** (greywacke): medium grey; poorly sorted quartz sand (up to coarse grained) in finer grained matrix of quartz, feldspar (mainly albite), white mica, and chlorite (Appendix 3, Table 76); **quartzite**: medium dark grey or light greenish grey; composed mainly of quartz with minor feldspar and chlorite, ±white mica (Appendix 3, Table 77); **lime mudstone**: dolomitic, silty and very fine grained sandy, partly dolomitic; variably sheared and recrystallized to marble (Appendix 3, Table 78); **dolostone**: light grey, microcrystalline, calcareous, silty.

Comments: the sandy phyllites are similar to some rocks in map units L1-3 and Y2 that probably are Neoproterozoic, Varanger in age.

Map unit s

Distribution: west of M'Clintock Inlet, north of Ooblooyah Creek.

Contacts: faulted contacts with map unit M1 and with the M'Clintock-West body of the Thores Suite; unit is unconformably overlain by upper Paleozoic strata.

Lithology: **schist**: composed of quartz, K-feldspar, plagioclase, white mica, chlorite, chloritoid (Appendix 3, Table 56).

Map unit sc

Distribution: widely distributed east and west of lower reaches of M'Clintock Glacier; outcrop area is 66 km wide (east-west) and 36 km long in a north-south direction (*M'Clintock Inlet*).

Contacts: faulted contacts with map units M1 and s on the northwest; unconformably overlain by Zebra Cliffs and Taconite River formations and upper Paleozoic formations.

Lithology: **schist**: composed of quartz, plagioclase, ±K-feldspar, mica (white mica and/or biotite),

±chlorite, ±epidote, ±calcite, ±hornblende, ±garnet, ±staurolite, ±graphite; **marble**: calcareous and/or dolomitic; may contain quartz, mica, sillimanite (rare); minor **amphibolite**: composed of hornblende, plagioclase, ±biotite, ±chlorite.

Comments: the unit probably includes rocks of different ages; south of Ayles Fiord it proably includes equivalents of map unit M2 and possibly of Cambrian strata underlying map unit M1; older rocks may be present in the vicinity of M'Clintock Glacier where the metamorphism is commonly of amphibolite grade.

Map unit pc

Distribution: northeast and southwest of the lower reaches of M'Clintock Glacier.

Contacts: faulted contacts with Danish River Formation and upper Paleozoic formations.

Lithology: **phyllite**: medium grey, laminated, argillaceous, calcareous, and dolomitic (Appendix 3, Table 57); photogeological interpretation suggests a high proportion of carbonate minerals (resistance to weathering and light grey tone).

Map unit pcq

Distribution: east of the upper reaches of M'Clintock Glacier.

Contacts: faulted contacts with Taconite River, Danish River, Lands Lokk, and Borup Fiord formations.

Lithology: (known only from overflight and one brief helicopter visit) **phyllite, carbonate rocks**, including **dolostone**: medium grey, massive; **quartzite**: medium grey, massive, medium grained, well sorted, and well rounded although affected by pressure solution.

Comments: may include equivalents of map units D2 and D3 at Disraeli Glacier.

Map unit qpcv

Distribution: southwest of the upper reaches of M'Clintock Glacier (*M'Clintock Inlet*).

Contacts: faulted contacts with map unit p, Danish River Formation, and upper Paleozoic strata.

Lithology: **quartzite**: medium grey and greenish grey, fine and medium grained, well sorted, rounded; some indistinct flat lamination (Appendix 3, Table 58); **sandstone, quartzose, dolomitic**: medium light grey to medium grey, locally greyish red purple weathering, very fine to medium grained, moderately and well sorted, rounded; some flat lamination (Appendix 3, Table 59); **siltstone**: medium grey, yellowish grey or light greenish grey; partly slaty or phyllitic; quartzose, partly calcareous-dolomitic (Appendix 3, Table 60); **dolostone**: medium grey, microcrystalline, quartz sandy (some quartz grains have micritic coatings) (Appendix 3, Table 61); **felsic tuff or tuffaceous sandstone**: medium grey, fine grained, altered (Appendix 3, Table 62).

Map unit p

Distribution: southwest of the upper reaches of M'Clintock Glacier.

Contacts: faulted contacts with map unit qpcv and Danish River Formation.

Lithology: slate, medium dark grey, dolomitic and calcareous (Appendix 3, Table 64).

YELVERTON INLET (MAP UNITS cpv, sq, sqc, scq, c, s)

Map unit cpv

Distribution: northeast of Milne Fiord.

Contacts: faulted contacts with map unit Y3? and M3.

Lithology: **carbonate rocks**: including **calcareous marble**: medium grey, pure and argillaceous, variably schistose; **phyllite**: medium grey, argillaceous; **metavolcanics**: including phyllite, greenish grey, tuffaceous; minor **quartzite**.

Comments: may include equivalents of map units Y3, M3, and/or Kulutingwak Formation.

Map unit sq

Distribution: southeast side of Yelverton Bay (*Yelverton Inlet*).

Contacts: thrust over succession 1 (Mitchell Point belt).

Lithology: **schist, quartzite**, minor **marble**; **schist**: hues of grey, green, and brown; composed of quartz, white mica, biotite, feldspar, garnet, ±chlorite,

±hornblende, ±carbonate, ±pyrite (retrograde metamorphism common in some areas; Frisch, 1974, p. 39); **quartzite**: hues of grey and brown; very fine to fine grained, micaceous, feldspathic, in part pyritic; **marble**: occurs in 1-m-wide beds (Frisch, op. cit.).

Map unit sqc

Distribution: west of the upper reaches of Kulutingwak Inlet; forms thrust sheet on northern flank of Kulutingwak Anticlinorium.

Contacts: fault contacts with the Kulutingwak and Danish River formations.

Lithology: **schist** and **phyllite**: medium grey or greenish grey; some lamination and rare graded bedding; composed of quartz, feldspar (mainly albite), white mica, chlorite, dolomite, calcite (Appendix 3, Table 99); **quartzite:** light grey and orange; mainly very fine or fine grained(?) (grain size affected by tectonic abrasion and recrystallization); composed largely of quartz with small amounts of dolomite, albite, white mica, and chlorite (Appendix 3, Table 100); **marble**: light grey and medium grey; calcareous; in part sandy, silty, dolomitic (Appendix 3, Table 101).

Map unit scq

Distribution: southwestern Wootton Peninsula (*Yelverton Inlet*).

Contacts: separated from other exposures of Succession 2 by glaciers; intruded by Cape Woods pluton (Devonian) and small granitoid bodies with gneissic texture.

Lithology: mainly **schist**, minor impure **dolostone** (Appendix 3, Table 94), calcareous **marble**, and **quartzite**; **schist**: light grey and medium grey; composed mainly of quartz and calcite or dolomite with lesser chlorite, white mica and/or biotite, and minor feldspar, ±actinolite, ±garnet (Appendix 2, Tables 93, 94); **quartzite**: light grey, very fine and fine grained, impure (Appendix 3, Table 94).

Comments: calcareous-dolomitic schist includes some poorly sorted sediments comparable in texture to sandy phyllite (or greywacke) in map unit W2.

Map unit c

Distribution: southwestern Wootton Peninsula; occurs within map unit sqc but is mappable from air photographs (in contrast to minor units of carbonate rocks included in map unit sqc).

Contacts: probably has stratigraphic contacts with components of map unit sqc; partly in fault contact with Wootton Intrusive Complex (Late Cretaceous).

Lithology: *carbonate rock*: probably marble (known only from air observation and airphoto interpretation).

Map unit s

Distribution: north of Phillips Inlet.

Contacts: faulted contacts with Succession 1 and map unit W2*.

Lithology: "mainly **felsic garnet two mica schists** with intercalated thin, **pelitic, garnet two-mica schists** and **amphibolites**"; **felsic schist**: mainly plagioclase and quartz with lesser amounts of biotite, muscovite, chlorite, hornblende, garnet and staurolite; **amphibolite**: mainly hornblende and plagioclase with small amounts of actinolite (Ohta and Klaper, 1992, "southeastern subzone of Mitchell Point Fault Zone"; for microprobe analyses *see* Table 2 of that paper).

YELVERTON INLET AND *OTTO FIORD* (MAP UNIT c)

Map unit c

Distribution: southwest of Phillips Inlet.

Contacts: faulted contacts with Succession 1, map unit s, Danish River Formation, and Upper Cretaceous Henson Point volcanics.

Lithology: **marble**: medium grey to medium dark grey; relatively pure with only small amounts of quartz ±feldspar ±white mica and carbonaceous matter; variably calcareous and dolomitic (Appendix 2, Table 95); original micritic texture preserved in patches; schistose texture; abundant carbonate veinlets.

Comments: possibly correlative with map unit W3; analyses for insoluble microfossils were unsuccessful.

OTTO FIORD (MAP UNIT s)

Map unit s

Distribution: southwest of Phillips Inlet.

Contacts: faulted contacts with map unit c and Danish River Formation (here metamorphosed to biotite schist).

Lithology: **biotite schist**: garnetiferous.

OTTO FIORD AND *CAPE STALLWORTHY-BUKKEN FIORD* (MAP UNIT cqps)

Map unit cqps

Distribution: between Phillips and Imina inlets.

Contacts: faulted contacts with Danish River Formation.

Lithology: **carbonate rocks**, **quartzite**, **phyllite**, **schist**; minor **diamictite carbonate rocks**: light and medium grey, variably silty and sandy; includes **calcareous marble**, variably dolomitic, and minor calcareous **dolostone**; **quartzite**: light grey, medium grey, brownish grey; very fine to medium grained; impure (Appendix 3, Table 96); **phyllite**, **schist**: medium grey, medium dark grey, brownish grey; composed of quartz, mica (white mica ±biotite), feldspar (mainly plagioclase), chlorite, ±garnet (trace amounts), ±epidote, ±hornblende (rare) (Appendix 3, Table 97); **diamictite**: medium grey; pebbles of mudrock and carbonates, and sand of quartz and minor feldspar in argillaceous matrix; all metamorphosed to phyllite (white mica and biotite) (Appendix 3, Table 98).

Comments: diamictite was observed at only one locality; it is texturally comparable to map unit L2 but has a smaller carbonate content.

CAPE STALLWORTHY-BUKKEN FIORD (MAP UNITS c, v, pqc)

Map unit c

Distribution: east and southeast of Imina Inlet.

Contacts: faulted contacts with map unit cqps and Danish River Formation.

Lithology: **marble**.

Map unit v

Distribution: north of Audhild Bay, east of Kleybolte Peninsula.

Contacts: intruded by granitoid bodies; in fault contact with Carboniferous and Triassic formations.

Lithology: metavolcanics of greenschist grade (Trettin, 1969, p. 44).

Map unit pqc

Distribution: southeastern Kleybolte Peninsula.

Contacts: faulted contacts with Danish River Formation and Carboniferous formations; intruded by numerous small granitoid bodies.

Lithology: **hornfels**: (metamorphosed mudrock) dark grey, commonly laminated; composed of quartz, white mica, biotite, carbonate, etc.; **quartzite**: fine grained; minor **carbonate rocks** (Trettin, 1969, p. 44).

APPENDIX 3

CONTENTS

X-RAY DIFFRACTION AND POINT COUNT ANALYSES

INTRODUCTION

This appendix presents the results of a total of 719 XRD analyses and 26 point count analyses; additional analyses are given in the text. The methods and abbreviations used, as well as corrections for the values F/F+Q and P/P+Kf are explained in Trettin (1994, p. 213, 214). Note that P/P+Kf is recorded only if F is ≥5%. Standard deviations are recorded only if N is ≥10.

A total of 22 samples from the Danish River Formation were analyzed for mineralic and organic carbon. Assuming that all mineralic carbon occurs in the calcite and dolomite, and that the ratio of these two minerals is given by the XRD peak height ratio C/C+D with a correction of +2.3% (Royse et al., 1971; but note objections by Lumsden, 1979), corrected values for calcite and dolomite have been calculated.

The two sets of values compare as follows:

calcite by XRD: 9.5%
calcite by XRD and carbon analysis: 11.4%
correction factor for XRD values: x1.2
dolomite by XRD: 11.7
dolomite by XRD and carbon analysis: 14.4
correction factor for XRD values: x1.2

NORTHERN HEIBERG FOLD BELT

Table 1
Unit: Svartevaeg Formation, Member B
Location: Svartevaeg sea cliffs
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz*	7	39–68	54.4
Albite	7	24–39	28.4
Mica**	7	1–2	1.1
Chlorite	7	4–13	6.4
Calcite	7	0–22	9.3
F/F+Q	7	28–49	34.4

*alteration and veinlets; original quartz grains are rare
**largely sericite (feldspar alteration)

CLEMENTS MARKHAM FOLD BELT

Table 2
Unit: Yelverton Formation
Location: entire outcrop area
Rock type: limestone/marble
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	25	2–35	15.2	11.4
K-feldspar	25	0–1	0.2	0.4
Plagioclase	25	0–6	1.3	1.7
Mica	25	0–5	1.5	0.8
Chlorite	25	0–9	0.6	1.9
Calcite	25	37–98	78.0	16.6
Dolomite	25	0–22	3.8	5.9
D/D+C	25	0–38	5.4	9.1

Table 3
Unit: Yelverton Formation
Location: entire outcrop area
Rock type: dolostone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	5–32	16.7
Calcite	3	0–8	2.7
Dolomite	3	68–93	80.0
D/D+C	3	91–100	97.0

Table 4
Unit: Yelverton Formation
Location: section and localities southwest of Yelverton Inlet
Rock type: phyllite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	9	51–89	70.9
K-feldspar	9	90–3	1.1
Albite	9	1–11	5.7
Mica	9	0–14	5.3
Chlorite	9	0–15	6.4
Calcite	9	0–11	3.1
Dolomite	9	0–41	7.2
F/F+Q	8	3–17	9.4
P/P+Kf	6	78–100	86.3

Table 5
Unit: Yelverton Formation
Location: section and localities southwest of Yelverton Inlet
Rock type: phyllite, tuffaceous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	51–58	56.0
K-feldspar	4	0–1	0.3
Albite	4	1–24	12.0
Mica	4	3–8	5.5
Chlorite	4	15–29	22.5
Calcite	4	0–7	3.0
F/F+Q	3	10–30	22.3
P/P+Kf	3	86–100	95.3

Table 6
Unit: Grant Land Formation
Location: base of section southwest of Yelverton Inlet
Rock type: sandstone, silty
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	77–85	81.0
Albite	5	9–14	12.6
Mica	5	1–6	2.2
Chlorite	5	2–8	3.4
Calcite	5	0–4	0.8
F/F+Q	5	10–15	13.2

Table 7
Unit: Grant Land Formation
Location: base of section southwest of Yelverton Inlet
Rock type: mudrock, slaty, in part sandy
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	50–77	67.0
K-feldspar	4	0–3	1.8
Albite	4	5–14	10.0
Mica	4	4–23	9.3
Chlorite	4	6–16	10.0
Calcite	4	0–7	1.8
F/F+Q	4	9–17	15.0
P/P+Kf	4	67–100	82.0

Table 8
Unit: Grant Land Formation
Location: southwest of upper reaches of Yelverton Inlet
Rock type: sandstone, fine and coarse grained
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	98–100	99.2
Albite	5	0–1	0.2
Mica	5	tr–2	0.8
F/F+Q	5	0–1	0.2

Table 9
Unit: Grant Land Formation
Location: southwest of upper reaches of Yelverton Inlet
Rock type: sandstone, very fine grained
Method: X-ray diffraction

	%
Quartz	79
K-feldspar	tr
Albite	6
Mica	8
Chlorite	5
Dolomite	2
F/F+Q	7
P/P+Kf	98

Table 10
Unit: Grant Land Formation
Location: southeast of Phillips Inlet
Rock type: sandstone, very coarse grained, containing granules and fine pebbles
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	95–97	96.0
Albite	2	(2–2)	2.0
Mica	2	0–1	0.5
Chlorite	2	(1–1)	1.0
Calcite	2	0–1	0.5
F/F+Q	2	(2–2)	2.0

Table 11
Unit: Hazen Formation
Location: southwest of Yelverton Pass
Rock type: lime mudstone and minor calcarenite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	(11–11)	11.0
Plagioclase	2	0–3	1.5
Calcite	2	86–89	87.5

Table 12
Unit: Hazen Formation
Location: southwest of Yelverton Pass
Rock type: siltstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	47–60	53.5
K-feldspar	2	2–3	2.5
Plagioclase	2	2–3	2.5
Mica	2	0–tr	tr
Calcite	2	30–43	36.5
Dolomite	2	5–5	5.5
F/F+Q	2	8–11	9.5

Table 13
Unit: Fire Bay Formation, Member A, unit A1, northwestern facies
Location: Fire Bay 1 section
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	69–83	75.0
Albite	4	0–8	2.0
Mica	4	0–1	0.3
Chlor./serpent.	4	2–4	2.8
Calcite	4	0–26	18.3
Dolomite	4	0–6	2.0
F/F+Q	4	0–9	2.3

Table 14
Unit: Fire Bay Formation, Member A, unit A2, southeastern facies
Location: *Cape Stallworthy*, inset B, loc. L1 and vicinity of loc. F12
Rock type: sandstone, in part pebbly
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	61–75	67.8
Albite	4	19–28	23.0
Mica	4	tr–1	0.8
Chlorite	4	1–3	2.5
Dol./ankerite	4	4–11	6.3
F/F+Q	4	20–30	25.0

Table 15
Unit: Fire Bay Formation, Member A, unit A3, southeastern facies
Location and lithology:
1: mudrock. *Cape Stallworthy*, inset B, loc. F12
2: mudrock. Fire Bay 3 section, 0.2 m
3: mudrock. Fire Bay 3 section, 24.3 m
4: mudrock. *Cape Stallworthy*, inset B, loc. L2
5: mudrock. *Cape Stallworthy*, inset B, loc. L3
6: interlaminated sandstone, very fine grained, silty, and siltstone. *Cape Stallworthy*, inset B, loc. L3
7: mudrock. *Cape Stallworthy*, inset B, loc. L4
Method: X-ray diffraction analysis

	1	2	3	4	5	6	7	$\bar{X}$
Quartz	96	91	78	74	86	92	93	87.1
Albite	(?)1	5	15	(?)1	0	tr	3	3.6
Mica	1	1	1	2	1	3	2	1.6
Chlorite	1	3	4	2	1	1	2	2.0
Calcite	1	0	3	0	0	0	0	0.6
Dolomite	0	0	0	22	12	4	0	5.4
F/F+Q	(?)1	5	16	1	0	tr	4	3.9

Table 16
Unit: Fire Bay Formation, Member A, unit A4, northwestern facies
Location: east of head of Fire Bay
Rock type: pebbly sandstone and sandy pebble conglomerate
Method: X-ray diffraction

	%	%
Quartz	13	24
K-feldspar	0	?2
Albite	66	29
Mica	0	29
Chlorite	17	12
Calcite	4	32
Dolomite	0	1
F/F+Q	84	56

Table 17
Unit: Fire Bay Formation, Member A, unit A4
Rock type: facies
Location:
1: pebbly sandstone or tuff, northwestern facies, east of head of Emma Fiord; 61TMH3 (from Trettin, 1969a, p. 68, Table XII)
2: sandstone, southeastern facies, Fire Bay section 3, base of unit A4; 92TM4-45.0 m
Method: point count

	1	2
Volcanics	76	61
Feldspar	12	28
Chlorite	3	4
Carbonates	3	3
Quartz		2
Chert		1
Matrix	5	
Opaque	1	
Rip-up clasts		1

Table 18
Unit: Fire Bay Formation, Member A, unit A4, northwestern facies
Location: Fire Bay 1 section
Rock type: tuff
Method: X-ray diffraction

	%	%	%
Quartz	4	16	16
Albite	77	67	59
Chlorite	9	7	6
Calcite	11	20	19
F/F+Q	96	92	78

Table 19
Unit: Fire Bay Formation, Member A, unit A4, southeastern facies
Location: Fire Bay 3 section
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	46–63	56.8
Albite	6	26–44	33.8
Mica*	6	1–2	1.2
Chlorite	6	3–6	4.7
Calcite	6	0–7	2.5
Dolomite	6	0–4	1.0
F/F+Q	6	29–49	37.5

*white mica, trace of biotite

Table 20
Unit: Fire Bay Formation, Member A, unit A4, southeastern facies
Location: Fire Bay 4 section
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	9	46–79	65.0
Albite	9	17–40	26.2
Mica*	9	1–2	1.1
Chlorite	9	1–6	3.6
Calcite	9	0–3	0.5
Dol./ankerite	9	2–7	3.6
F/F+Q	9	17–47	29.1

*white mica

Table 21
Unit: Fire Bay Formation, Member A, unit A4, southeastern facies
Location: Fire Bay 5 section and vicinity
Rock type: sandstone
Method: X-ray diffraction

	%	%	%
Quartz	46	80	81
Albite	33	11	10
Mica	1	2	1
Chlorite	7	0	4
Calcite	11	0	0
Dol./ankerite	2	6	4
F/F+Q	42	12	11

Table 22
Unit: Fire Bay Formation, Member A, unit A4, southeastern facies
Location: Fire Bay 3 section
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	61–73	68.6
Albite	4	23–32	25.8
Mica*	4	(1–1)	1.0
Chlorite	4	2–4	2.6
Calcite	4	1–3	2.2
F/F+Q	4	24–34	27.2

*white mica

Table 23
Unit: Fire Bay Formation, Member A, unit A4, southeastern facies
Location: Fire Bay 4 section
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	57–88	71.8
Albite	4	8–28	20.5
Mica*	4	(1–1)	1.0
Chlorite	4	2–3	2.5
Dol./ankerite	4	1–11	4.3
F/F+Q	4	9–33	22.8

*white mica

Table 24
Unit: Fire Bay Formation, Member A, unit A4, southeastern facies
Location: Fire Bay 5 section and vicinity
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	79–91	86.8
Albite	6	4–16	7.3
Mica	6	1–4	2.0
Chlorite	6	1–3	1.8
Dol./ankerite	6	0–4	2.3
F/F+Q	6	5–21	10.3

Table 25
Unit: Kulutingwak Formation, Member A
Location: Kulutingwak Anticlinorium
Rock type: tuff, plagioclase-rich
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	9	4–33	18.3
Albite	9	47–77	60.2
Mica	9	1–17	11.0
Chlorite	9	0–10	6.3
Calcite	9	0–11	3.4
Dolomite	9	0–4	0.4
F/F+Q	9	63–99	76.4

Table 26
Unit: Kulutingwak Formation, Member A
Location: Kulutingwak Anticlinorium
Rock type: quartzose tuff or tuffaceous siltstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	51–82	60.0
Albite	5	12–38	21.6
Mica	5	2–8	3.8
Chlorite	5	0–4	1.8
Calcite	5	0–32	6.8
Dolomite	5	0–13	6.4
F/F+Q	5	13–42	26.4

Table 27
Unit: Kulutingwak Formation, Member A
Location: Kulutingwak Anticlinorium
Rock type: tuffaceous sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	42–87	68.3
Albite	6	8–31	18.7
Mica	6	1–5	2.0
Chlorite	6	0–4	1.7
Calcite	6	0–20	4.2
Dolomite	6	0–13	5.5
F/F+Q	6	8–48	28.8

Table 28
Unit: metamorphic equivalent of Kulutingwak Formation(?), map unit O_{Ks}?
Location: southwest of Petersen Bay
Rock type: schist
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	66–87	74.5
Albite	4	6–24	13.0
Mica*	4	4–16	9.3
Chlorite	4	0–4	1.3
Garnet	4	0–6	2.8
F/F+Q	4	7–26	14.8

*biotite and white mica

Table 29
Unit: Danish River Formation
Location: Clements Markham Fold Belt
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	57	39–84	63.1	11.7
K-feldspar	57	0–3	0.8	0.5
Albite	57	1–16	6.0	2.8
Mica	57	tr–18	5.8	4.0
Chlorite	57	0–21	6.4	5.3
Calcite	57	0–23	8.8	6.4
Dolomite	57	0–34	9.6	6.2
F/F+Q	57	0–28	9.7	5.2
P/P+Kf	44	77–100	89.8	6.6
D/D+C	57	0–100	52.1	28.7

Table 30
Unit: Danish River Formation
Location: Clements Markham Fold Belt
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	14	43–74	59.1	10.0
K-feldspar	14	0–2	0.9	0.4
Albite	14	3–11	6.2	2.2
Mica	14	3–20	6.9	4.4
Chlorite	14	2–18	6.9	4.5
Calcite	14	0–20	10.2	6.4
Dolomite	14	3–16	9.4	3.2
F/F+Q	14	5–19	10.6	3.7
P/P+Kf	13	64–100	85.2	8.3
D/D+C	14	14–98	48.7	19.7

Table 31
Unit: Danish River Formation
Location: Clements Markham Fold Belt
Rock type: granule conglomerate, sandy, moderate carbonate content
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	72–79	74.7
K-feldspar	3	(1–1)	1.0
Albite	3	2–4	3.3
Mica	3	2–3	2.7
Chlorite	3	0–3	1.3
Calcite	3	0–8	2.7
Dolomite	3	9–20	14.7
F/F+Q	3	3–6	5.0
P/P+Kf	2	85–87	86.0
D/D+C	3	51–100	83.7

Table 32
Unit: Lands Lokk Formation
Location: Clements Markham Fold Belt
Rock type: sandstone, quartzose
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	59	66–97	86.6	8.7
K-feldspar	59	0–2	0.2	0.5
Plagioclase	59	0–9	2.4	2.0
Mica	59	0–11	2.6	2.3
Chlorite	59	0–19	5.1	4.4
Calcite	59	0–16	1.3	3.1
Dolomite	59	0–13	1.8	2.4
F/F+Q	19	5–13	6.3	2.3
P/P+Kf	19	10–100	85.3	26.9

Table 33
Unit: Lands Lokk Formation, mudrock-volcanogenic facies
Location: northeast of upper reaches of Emma Fiord
Rock type: sandstone, volcanogenic
Method: point count (from Trettin, 1969, Table XI)

	N	Range %	$\bar{X}$ %
Quartz	3	11–21	15.7
Chert	3	3–6	4.7
Feldspar	3	32–37	35
White mica	3	1–4	2.0
Biotite	3	0–tr	
Chlorite	3	5–18	10.0
Carbonates	3	5–19	10.0
Volcanics	3	16–28	20.3
Schist/phyllite	3	0–tr	
Argill. sediments	3	tr–2	
Opaque minerals	3	tr–1	

Table 34
Unit: Lands Lokk Formation
Location: Clements Markham Fold Belt
Rock type: sandstone, volcanogenic or mixed
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	52–75	66.5
K-feldspar	4	0–1	0.5
Albite	4	15–21	17.5
Mica	4	1–10	3.8
Chlorite	4	6–10	8.3
Calcite	4	1–7	3.5
Dolomite	4	0–1	tr
F/F+Q	4	17–29	20.8
P/P+Kf	4	94–100	97.0

Table 35
Unit: Lands Lokk Formation
Location: Clements Markham Fold Belt
Rock type: sandstone, calcareous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	50–75	65.3
K-feldspar	3	0–1	tr
Albite	3	1–5	2.3
Mica	3	0–1	tr
Chlorite	3	4–10	6.3
Calcite	3	16–36	24.0
Dolomite	3	0–4	2.0

Table 36
Unit: Lands Lokk Formation
Location: Clements Markham Fold Belt
Rock type: mudrock, coarse grained
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	14	66–94	78.9	8.9
K-feldspar	14	0–2	1.0	0.5
Albite	14	tr–11	4.7	3.3
Mica	14	1–13	6.0	3.7
Chlorite	14	2–14	7.9	4.0
Calcite	14	0–7	0.5	1.8
Dolomite	14	0–7	1.1	2.3
F/F+Q	9	5–15	9.4	
P/P+Kf	9	67–92	82.7	

Table 37
Unit: Lands Lokk Formation
Location: Clements Markham Fold Belt
Rock type: mudrock, fine grained
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	7	34–59	51.1
K-feldspar	7	1–4	2.1
Albite	7	2–4	3.0
Mica	7	18–40	26.7
Chlorite	7	3–25	16.6
Dolomite	7	0–2	0.6
F/F+Q	5	8–13	9.8
P/P+Kf	5	33–76	47.6

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Succession 1

Table 38
Unit/Location: Deuchars Glacier belt
Rock type: granite
Method: point count

	N	Range %	$\bar{X}$ %
Quartz	5	37–50	43.8
Microcline	5	11–28	20.5
Albite	5	11–30	24.3
Biotite	5	1–11	4.4
White mica	5	1–20	6.6
Chlorite	5	0–1	0.7

Table 39
Unit/Location: Deuchars Glacier belt
Rock type: granodiorite
Method: point count

	N	Range %	$\bar{X}$ %
Quartz	3	17–40	29.0
Microcline	3	12–14	13.0
Albite	3	38–60	45.7
Biotite	3	5–18	9.7
White mica	3	0–2	1.3
Chlorite	3	0–2	1.0

Table 40
Unit/Location: Deuchars Glacier belt
Rock type: schist
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	59–69	64.3
K-feldspar	4	0–13	4.0
Albite	4	8–17	13.3
Mica*	4	4–32	18.8
F/F+Q	4	12–29	20.5
P/P+Kf	4	54–100	85.3

*biotite and/or white mica

Table 41
Unit/Location: Mitchell Point belt
Rock type: gneiss
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	57–69	62.2
K-feldspar	6	3–19	9.3
Plagioclase	6	13–28	20.3
Mica*	6	0–8	2.8
Chlorite	6	1–12	5.7
F/F+Q	6	26–35	32.3
P/P+Kf	6	43–89	69.2

*biotite and/or white mica

Succession 2

Table 42
Unit: map unit L1
Location: southeast of head of Markham Fiord
Rock type: siltstone, phyllitic
Method: X-ray diffraction

	%	%
Quartz	55	65
K-feldspar	3	2
Albite	3	11
Mica*	0	8
Chlorite	0	14
Dolomite	39	0
F/F+Q	10	16
P/P+Kf		85

*white mica

Table 43
Unit: Gypsum River diamictite (map unit L2)
Location: Arthur Laing Peninsula
Rock type: greywacke, in part pebbly
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	11	46–84	68.5	11.2
K-feldspar	11	0–4	1.4	1.2
Albite	11	0–11	4.7	3.2
Mica*	11	0–10	4.6	3.0
Chlorite	11	1–9	4.2	2.7
Calcite	11	0–26	7.3	9.0
Dolomite	11	1–21	9.5	6.4
F/F+Q	11	1–15	9.3	5.9
P/P+Kf	6	60–93	80.0	10.9
D/D+C	11	4–100	65.6	34.2

*white mica ± biotite

Table 44
Unit: map unit L1-3
Location: Arthur Laing Peninsula
Rock type: greywacke, carbonate-rich, nonconglomeratic
Method: X-ray diffraction

	%	%
Quartz	55	55
K-feldspar	3	2
Albite	7	7
Mica*	4	10
Chlorite	4	9
Calcite	23	10
Dolomite	4	7
F/F+Q	15	14
P/P+Kf	73	82

*white mica

Table 45
Unit: map unit L3?
Location: Southwest of Mount Disraeli
Rock type: sandstone, very fine grained, silty and siltstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	65–73	68.3
K-feldspar	3	(1–1)	1.0
Albite	3	8–10	8.7
Mica*	3	1–3	2.3
Chlorite	3	4–7	5.3
Calcite	3	8–20	12.7
Dolomite	3	(2–2)	2.0
F/F+Q	3	11–15	12.7
P/P+Kf	3	83–91	87.3
D/D+C	3	8–19	13.7

*white mica, trace of biotite

Table 46
Unit: map unit L1-3
Location: Arthur Laing Peninsula
Rock type: greywacke, carbonate-poor, nonconglomeratic
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	68–76	73.3
K-feldspar	3	1–2	1.3
Albite	3	6–15	10.7
Mica*	3	2–10	5.0
Chlorite	3	5–9	6.7
Calcite	3	0–2	0.7
Dolomite	3	0–6	2.0
F/F+Q	3	9–18	14.0
P/P+Kf	3	83–93	87.3

*white mica, minor biotite

Table 47
Unit: map unit L6
Location: west of lower Gypsum River
Rock type: impure quartzite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	82–88	84.0
K-feldspar	4	0–1	0.5
Albite	4	6–11	8.0
Mica*	4	1–2	1.5
Chlorite	4	4–7	5.3
F/F+Q	4	6–12	8.8
P/P+Kf	4	92–100	95.5

*white mica

Table 48
Unit: map unit D1
Location: Disraeli Glacier
Rock type: quartzite, poorly sorted, silty
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	16	83–98	92.9	4.1
K-feldspar	16	0–1	0.3	0.5
Plagioclase	16	0–6	1.1	1.7
Mica*	16	0–3	1.7	1.0
Chlorite	16	1–9	3.4	2.2
Calcite	16	0–4	0.3	1.0
F/F+Q	15	0–7	1.7	2.0
P/P+Kf	2	(100–100)	100	

*white mica ± biotite

Table 49
Unit: map unit D1
Location: Disraeli Glacier
Rock type: siltstone, quartzose, phyllitic
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	7	65–94	82.1
K-feldspar	7	0–2	1.0
Albite	7	1–20	8.7
Mica*	7	1–8	3.7
Chlorite	7	2–8	4.6
Calcite	7	0–1	0.1
F/F+Q	7	1–25	11.7
P/P+Kf	5	41–100	81.2

*white mica

Table 50
Unit: map unit D1
Location: Disraeli Glacier
Rock type: phyllite, chloritoid-bearing
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	56–87	76.8
K-feldspar	4	1–3	1.8
Albite	4	1–3	1.5
Mica*	4	2–7	3.5
Chlorite	4	3–12	7.0
Chloritoid	4	4–19	9.3
F/F+Q	4	3–10	5.0
P/P+Kf	1	46	

*white mica

Table 51
Unit: map unit D1
Location: Disraeli Glacier
Rock type: phyllite, chlorite-rich
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	64–71	68.0
K-feldspar	3	1–3	2.0
Albite	3	1–6	3.3
Mica*	3	3–6	5.0
Chlorite	3	18–24	20.3
Calcite	3	0–2	0.7
F/F+Q	3	3–10	7.0
P/P+Kf	2	53–78	65.5

*white mica ± biotite

Table 52
Unit: map unit D1
Location: Disraeli Glacier
Rock type: phyllite, albite-rich, tuffaceous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	9	25–55	36.6
K-feldspar	9	0–3	0.8
Albite	9	19–58	33.6
Mica*	9	0–40	14.0
Chlorite	9	4–24	11.6
Calcite	9	0–7	1.5
Dolomite	9	0–15	1.9
F/F+Q	9	30–69	47.9
P/P+Kf	9	86–100	96.5

*white mica ± biotite

Table 53
Unit: map unit D1
Location: Disraeli Glacier
Rock type: phyllite, calcareous-dolomitic
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	38–56	49.3
K-feldspar	3	0–1	0.7
Albite	3	2–7	5.0
Mica*	3	3–6	4.7
Chlorite	3	1–3	1.7
Calcite	3	17–22	19.7
Dolomite	3	10–31	18.7
F/F+Q	3	8–11	9.7
P/P+Kf	2	89–100	94.5
D/D+C	3	32–60	46.0

*white mica

Table 54
Unit: map unit D1
Location: Disraeli Glacier
Rock type: marble, silty sandy
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	35–47	41.0
K-feldspar	2	0–1	0.5
Albite	2	2–10	6.0
Chlorite	2	0–3	1.5
Calcite	2	33–45	39.0
Dolomite	2	6–19	12.5
D/D+C	2	11–35	23.0

F/F+Q	18		
P/P+Kf	82		
D/D+C	44		

*white mica

Table 55
Unit: map unit D3
Location: west of Disraeli Glacier
Rock type: mudrock, dolomitic, slaty
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	2	54–55	54.5
K-feldspar	2	(2–2)	2.0
Albite	2	5–6	5.5
Mica*	2	10–11	10.5
Chlorite	2	16–18	17.0
Dolomite	2	10–11	10.5
F/F+Q	2	10–12	11.0
D/D+C	2	100–100	100.0

*white mica

Table 56
Unit: map unit s
Location: west of M'Clintock Inlet, north of Ooblooyah Creek
Rock type: schist
Method: X-ray diffraction

	%	%
Quartz	54	44
K-feldspar	2	2
Plagioclase	5	2
Mica*	11	7
Chlorite	24	2
Chloritoid	4	43
F/F+Q	11	9
P/P+Kf	72	

*white mica

Table 57
Unit: map unit pc
Location: northeast of M'Clintock Glacier
Rock type: mudrock, calcareous and dolomitic, phyllitic
Method: X-ray diffraction

	%
Quartz	37
K-feldspar	1
Albite	7
Mica*	9
Chlorite	13
Calcite	19
Dolomite	15

Table 58
Unit: map unit qpcv
Location: southwest of M'Clintock Glacier
Rock type: quartzite
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	4	95–99	96.3
K-feldspar	4	0–tr	tr
Albite	4	0–3	1.5
Mica*	4	0–3	1.8
Chlorite	4	0–1	0.3
Dolomite	4	0–tr	tr
F/F+Q	4	0–tr	tr

*white mica

Table 59
Unit: map unit qpcv
Location: southwest of M'Clintock Glacier
Rock type: sandstone, dolomitic
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	76–82	78.7
K-feldspar	3	0–1	0.7
Albite	3	0–1	0.3
Mica*	3	0–5	2.3
Chlorite	3	0–6	3.7
Calcite	3	0–1	0.3
Dolomite	3	10–23	14.7
F/F+Q	3	tr–2	1.0

*white mica

Table 60
Unit: map unit qpcv
Location: southwest of M'Clintock Glacier
Rock type: siltstone, slaty or phyllitic
Method: X-ray diffraction

	%	%
Quartz	55	71
Albite	10	11
Mica*	5	6
Chlorite	8	13
Calcite	18	0
Dolomite	5	0

F/F+Q	15	13
P/P+Kf	100	100

*white mica ± trace of biotite

Table 61
Unit: map unit qpcv
Location: southwest of M'Clintock Glacier
Rock type: dolostone, sandy
Method: X-ray diffraction

	%
Quartz	47
K-feldspar	tr
Plagioclase	1
Mica	1
Calcite	1
Dolomite	51
F/F+Q	2
D/D+C	98

Table 62
Unit: map unit qpcv
Location: southwest of M'Clintock Glacier
Rock type: felsic tuff or tuffaceous sandstone
Method: X-ray diffraction

	%
Quartz	69
K-feldspar	1
Albite	17
Mica*	2
Chlorite	4
Calcite	tr
Dolomite	8
F/F+Q	20
P/P+Kf	97

*white mica

Table 63
Unit: map unit p
Location: southwest of M'Clintock Glacier
Rock type: slate
Method: X-ray diffraction

	%
Quartz	60
K-feldspar	1
Plagioclase	4
Mica*	7
Chlorite	16
Calcite	3
Dolomite	10
F/F+Q	69
P/P+Kf	80

*white mica

Table 64
Unit: map units M1, M1?, and M1a
Location: south of Ayles Fiord
Rock type: dolostone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	3–17	10.3
K-feldspar	4	0–2	0.5
Mica*	4	0–2	0.5
Calcite	4	0–32	15.3
Dolomite	4	49–92	73.5
D/D+C	4	60–100	82.3

*white mica

Table 65
Unit: map unit M1a
Location: south of Ayles Fiord
Rock type: phyllite and phyllite, albite-rich, tuffaceous
Method: X-ray diffraction

	%	%
Quartz	87	68
Albite	2	24
Mica*	6	4
Chlorite	5	4
F/F+Q	3	26
P/P+Kf		100

*white mica

Table 66
Unit: map unit M2
Location: north and south of Ayles Fiord
Rock type: phyllite, schist
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	56–78	66.3
K-feldspar	4	0–3	1.3
Albite	4	4–9	6.3
Mica*	4	3–16	10.5
Chlorite	4	3–14	7.8
Chloritoid	4	0–20	5.0
Staurolite	4	0–6	1.5
Dolomite	4	0–5	1.3
F/F+Q	4	7–12	10.3
P/P+Kf	4	62–100	81.0

*white mica and/or biotite (biotite rare)

Table 67
Unit: map unit M2
Location: north of Ayles Fiord
Rock type: volcanics
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	4–63	36.2
K–feldspar	5	0–13	5.0
Albite	5	3–26	14.8
Mica*	5	0–8	2.0
Chlorite	5	20–32	25.0
Actinolite	5	0–33	11.0
Epidote	5	0–12	5.0
Calcite	5	0–4	1.4
F/F+Q	5	11–89	42.2
P/P+Kf	5	68–100	83.4

*white mica

Table 68
Unit: map unit M3
Location: section northeast of Ayles Fiord
Rock type: marble, calcareous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	0–1	0.8
K–feldspar	6	0–1	0.2
Mica*	6	0–2	0.3
Calcite	6	96–99	97.7
Dolomite	6	0–2	1.0
D/D+C	6	0–2	0.9

*white mica (mostly concealed by carbonate)

Table 69
Unit: map unit M3
Location: section northeast of Ayles Fiord
Rock type: dolostone
Method: X-ray diffraction

	%	%
Calcite	0	1
Dolomite	100	99

Table 70
Unit: map unit M4
Location: section northeast of Milne Fiord
Rock type: phyllite, argillaceous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	7	65–79	71.9
K–feldspar	7	0–1	0.3
Albite	7	4–16	10.3
Mica*	7	2–20	7.9
Chlorite	7	5–16	9.1
Calcite	7	0–1	0.3
Dolomite	7	0–3	0.4
F/F+Q	7	7–17	12.6
P/P+Kf	7	76–100	95.4

*white mica

Table 71
Unit: map unit M4
Location: section northeast of Milne Fiord
Rock type: phyllite, argillaceous and calcareous–dolomitic
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	62–77	60.0
K–feldspar	6	0–2	1.0
Albite	6	3–10	6.5
Mica*	6	2–10	6.2
Chlorite	6	2–16	7.0
Calcite	6	0–19	6.5
Dolomite	6	0–25	12.7
F/F+Q	6	7–18	11.0
P/P+Kf	6	9–100	72.7
D/D+C	6	0–100	63.5

*white mica

Table 72
Unit: map unit M4
Location: section northeast of Milne Fiord
Rock type: dolostone, silty (with chert replacement in one sample)
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	25–28	26.5
K–feldspar	2	1–3	2.0
Albite	2	(1–1)	1.0
Mica*	2	(1–1)	1.0
Calcite	2	0–1	0.5
Dolomite	2	68–69	68.5
F/F+Q	2	5–15	10.0
D/D+C	2	99–100	99.5

*white mica

Table 73
Unit: map unit M4
Location: section northeast of Milne Fiord
Rock type: metavolcanics, mainly tuffaceous phyllite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	22–45	30.0
K-feldspar	5	3–5	3.8
Albite	5	1–38	15.8
Mica*	5	0–14	6.8
Chlorite	5	1–43	25.0
Actinolite	5	0–6	1.2
Epidote	5	0–2	0.4
Calcite	5	0–26	13.8
Dolomite	5	0–14	3.0
F/F+Q	5	11–59	37.8
P/P+Kf	5	11–93	68.6

*white mica

Table 74
Unit: map unit M5
Location: northeast of Milne Glacier to northeast of Milne Fiord, mainly section northeast of Milne Fiord
Rock type: quartzite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	97–100	99.0
Plagioclase	5	0–2	0.6
Mica*	5	0–1	0.2
Chlorite	5	0–1	0.2

*white mica ± biotite (trace)

Table 75
Unit: map unit pwqc
Location: south of Cape Richards
Rock type: phyllite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	51–72	63.5
K-feldspar	4	1–4	2.0
Albite	4	3–11	5.8
Mica*	4	7–12	9.5
Chlorite	4	7–16	10.5
Calcite	4	0–1	0.3
Dolomite	4	0–10	6.0
Chloritoid	4	0–24	6.0
F/F+Q	4	5–16	11.0
P/P+Kf	3	54–89	68.7

*white mica

Table 76
Unit: map unit pwqc
Location: south of Cape Richards
Rock type: phyllite, sandy (greywacke)
Method: X-ray diffraction

	%	%
Quartz	86	93
K-feldspar	1	0
Albite	8	1
Mica*	2	4
Chlorite	2	2
F/F+Q	10	4
P/P+Kf	89	

*white mica and biotite (trace)

Table 77
Unit: map unit pwqc
Location: south of Cape Richards
Rock type: quartzite
Method: X-ray diffraction

	%	%
Quartz	89	92
K-feldspar	1	0
Albite	0	7
Chlorite	10	2
F/F+Q	1	7
P/P+Kf		100

Table 78
Unit: map unit pwqc
Location: south of Cape Richards
Rock type: lime mudstone
Method: X-ray diffraction

	%	%
Quartz	22	23
K-feldspar	0	1
Plagioclase	7	2
Mica*	4	0
Chlorite	3	0
Calcite	64	37
Dolomite	0	36
F/F+Q	23	11
P/P+Kf	100	

*white mica

Table 79
Unit: map unit Y1
Location: northeast of Yelverton Inlet
Rock type: quartzite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	12	78–94	87.3	5.7
K-feldspar	12	0–3	0.9	1.3
Plagioclase	12	0–7	3.8	2.3
Mica*	12	1–10	3.3	2.5
Chlorite	12	0–1	0.3	0.4
Calcite	12	0–15	4.3	4.7
Dolomite	12	0–2	0.2	0.6
F/F+Q	12	0–11	5.4	3.7
P/P+Kf	6	60–100	77.7	16.1

*white mica ± biotite (trace)

Table 80
Unit: map unit Y2
Location: northeast of Yelverton Inlet
Rock type: phyllite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	57–73	63.8
K-feldspar	5	0–3	0.8
Albite	5	4–15	8.6
Mica*	5	5–12	9.0
Chlorite	5	7–24	17.0
Calcite	5	0–1	0.2
Dolomite	5	0–1	0.2
F/F+Q	4	6–21	13.0
P/P+Kf	3	61–100	87.5

*white mica ± biotite (rare)

Table 81
Unit: map unit Y2
Location: northeast of Yelverton Inlet
Rock type: dolomitic-calcareous phyllite
Method: X-ray diffraction

	%
Quartz	61
K-feldspar	1
Plagioclase	4
Mica*	3
Chlorite	1
Calcite	7
Dolomite	24
F/F+Q	6

*white mica, trace of biotite

Table 82
Unit: map unit Y2
Location: northeast of Yelverton Inlet
Rock type: sandy phyllite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	51–80	70.3
K-feldspar	4	0–5	1.8
Albite	4	0–8	2.3
Mica*	4	2–13	6.8
Chlorite	4	1–10	4.0
Calcite	4	4–28	15.3
F/F+Q	4	0–15	6.0
P/P+Kf	1		92

*white mica ± biotite

Table 83
Unit: map unit Y2
Location: northeast of Yelverton Inlet
Rock type: conglomeratic greywacke
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	49–80	60.8
K-feldspar	4	1–2	1.3
Albite	4	1–10	6.3
Mica*	4	6–10	8.0
Chlorite	4	0–25	9.0
Calcite	4	0–13	8.3
Dolomite	4	0–12	6.5
F/F+Q	4	3–19	11.8
P/P+Kf	3	79–92	85.7

*white mica ± biotite

Table 84
Unit: map unit Y2
Location: northeast of Yelverton Inlet
Rock type: 1) tuff, 2) felsic tuff or tuffaceous quartzite, 3) metachert
Method: X-ray diffraction

	1	2	3
Quartz	60	81	97
K-feldspar	0	0	tr
Plagioclase	24	15	1
Mica*	0	1	1
Chlorite	16	3	tr
F/F+Q	29	16	2
P/P+Kf	100	100	

*white mica

Table 85
Unit: map unit Y4
Location: southwest of Milne Glacier
Rock type: phyllite, argillaceous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	54–77	63.7
K-feldspar	3	1–4	2.7
Albite	3	2–7	4.7
Mica*	3	3–12	7.7
Chlorite	3	14–20	17.0
Dolomite	3	0–13	4.3
F/F+Q	3	4–17	11.0
P/P+Kf	2	62–66	64.0

*white mica

Table 86
Unit: map unit Y4
Location: southwest of Milne Fiord/Milne Glacier
Rock type: 1) phyllitic tuff, 2) flow or sill
Method: X-ray diffraction

	%	%
Quartz	4	41
K-feldspar	12	2
Plagioclase	37	22
Mica*	0	1*
Chlorite	38	13
Actinolite	6	0
Epidote	4	0
Calcite	0	22
F/F+Q	93	37
P/P+Kf	76	92

*not identifiable in thin section

Table 87
Unit: map unit Y4?p*
Location: northeast of Yelverton Inlet
Rock type: phyllite, red and green
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	48–52	50.0
K-feldspar	2	(1–1)	1.0
Albite	2	3–4	3.5
Mica*	2	6–7	6.5
Chlorite	2	4–7	5.5
Calcite	2	(12–12)	12.0
Dolomite	2	17–25	21.0
F/F+Q	2	7–8	7.5
D/D+C	2	58–67	62.5

*white mica ± biotite

Table 88
Unit: map unit W1
Location: northeastern Wootton Peninsula
Rock type: quartzite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	12	86–99	94.8	3.7
K-feldspar	12	0–2	0.1	0.3
Plagioclase	12	0–4	1.4	1.6
Mica*	12	0–7	2.4	1.9
Chlorite	12	0–2	0.6	0.9
Calcite	12	0–1	0.1	0.3
Dolomite	12	0–3	0.7	1.2
F/F+Q	12	0–5	1.5	1.8
P/P+Kf	1		88	

*white mica ± biotite (rare)

Table 89
Unit: map unit W1
Location: northeastern Wootton Peninsula
Rock type: phyllite
Method: X-ray diffraction

	%	%
Quartz	84	68
K-feldspar	1	2
Plagioclase	3	14
Mica*	9	8
Chlorite	3	8
F/F+Q	4	18
P/P+Kf	67	89

*white mica

Table 90
Unit: map unit W2
Location: northeastern Wootton Peninsula
Rock type: phyllite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	9	41–69	56.2
K-feldspar	9	0–2	0.8
Albite	9	2–12	6.1
Mica*	9	2–14	6.9
Chlorite	9	0–12	4.0
Calcite	9	3–31	14.0
Dolomite	9	0–28	12.3

F/F+Q	9	6–16	10.8
P/P+Kf	7	74–100	90.6

*white mica ± biotite (trace)

Table 91
Unit: map unit W2
Location: northeastern Wootton Peninsula
Rock type: conglomeratic greywacke (diamictite)
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	60–77	70.0
K-feldspar	5	0–1	0.6
Albite	5	1–9	5.2
Mica*	5	0–7	4.4
Chlorite	5	0–8	4.4
Calcite	5	0–13	3.6
Dolomite	5	0–29	12.0
F/F+Q	4	4–10	7.2
P/P+Kf	3	91–100	97.0

*white mica

Table 92
Unit: map unit W2
Location: northeastern Wootton Peninsula
Rock type: pebbles in greywacke
Method: X-ray diffraction

	%	%
Quartz	63	55
K-feldspar	1	0
Plagioclase	8	2
Mica*	3	3
Chlorite	5	0
Calcite	14	2
Dolomite	7	37
F/F+Q	12	4
P/P+Kf	91	

*white mica

Table 93
Unit: map unit scq
Location: southwestern Wootton Peninsula
Rock type: schist, calcareous-dolomitic
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	24–60	49.8
K-feldspar	5	0–1	0.4
Albite	5	2–8	3.2
Mica*	5	6–13	9.8
Chlorite	5	0–14	3.6
Calcite	5	4–24	17.6
Dolomite	5	9–26	15.2
F/F+Q	5	3–26	8.4
P/P+Kf	1		91

*white mica and/or biotite

Table 94
Unit: map unit scq
Location: southwestern Wootton Peninsula
Rock type: 1) schist, 2) quartzite, 3) dolostone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	32	88	3
K-feldspar	12	0	3
Plagioclase	0	5	0
Mica*	0	2	0
Chlorite	3	5	0
Calcite	16	0	7
Dolomite	11	0	81
Actinolite	22	0	0
Tremolite	0	0	7
Garnet	3	0	0
F/F+Q	28	5	
P/P+Kf	0	100	
D/D+C	40		92

*white mica

Table 95
Unit: map unit c
Location: western peninsula in Phillips Inlet
Rock type: marble
Method: X-ray diffraction

	%	%	%
Quartz	3	3	1
Plagioclase	0	0	2
Mica*	0	2	0
Calcite	97	84	0
Dolomite	0	11	97
D/D+C	0	12	100

*white mica

Table 96
Unit: map unit cqps
Location: between Imina and Phillips inlets
Rock type: quartzite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	82–97	89.0
K-feldspar	3	0–1	0.3
Albite	3	1–8	5.3
Mica*	3	2–6	4.3
Chlorite	3	0–4	1.7
F/F+Q	2	8–9	9.5
P/P+Kf	2	90–100	95.0

*white mica ± biotite

Table 97
Unit: map unit cqps
Location: between Imina and Phillips inlets
Rock type: phyllite and schist
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	42–82	67.4
K-feldspar	5	0–2	0.6
Albite	5	4–14	7.6
Mica*	5	11–40	19.8
Chlorite	5	2–9	5.0
F/F+Q	5	6–20	11.8
P/P+Kf	5	76–100	92.2

*white mica ± biotite; one sample contains trace amount of garnet

Table 98
Unit: map unit cqps
Location: between Imina and Phillips inlets
Rock type: conglomeratic greywacke
Method: X-ray diffraction

	%
Quartz	82
K-feldspar	tr
Plagioclase	3
Mica*	8
Chlorite	3
Calcite	4
F/F+Q	4

*white mica

Table 99
Unit: map unit scq
Location: Kulutingwak Anticlinorium
Rock type: schist
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	6	55–90	74.0
K-feldspar	6	0–2	0.7
Albite	6	2–11	5.8
Mica*	6	1–17	6.5
Chlorite	6	1–9	5.3
Calcite	6	0–8	2.3
Dolomite	6	0–20	5.2
F/F+Q	6	4–13	8.3
P/P+Kf	6	72–100	87.3

*white mica

Table 100
Unit: map unit scq
Location: west of upper reaches of Kulutingwak Fiord
Rock type: quartzite
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	89–99	93.4
Albite	3	0–2	1.3
Mica*	3	0–3	1.7
Chlorite	3	0–2	1.2
Calcite	3	0–1	0.3
Dolomite	3	0–5	2.3
F/F+Q	3	0–2	1.3

*white mica

Table 101
Unit: map unit scq
Location: west of upper reaches of Kulutingwak Fiord
Rock type: marble
Method: X-ray diffraction

	%	%	%
Quartz	2	39	42
K-feldspar	0	tr	tr
Plagioclase	0	1	tr
Mica*	0	7	0
Calcite	98	37	58
Dolomite	0	16	0
D/D+C	0	30	0

*white mica

Succession 3

Table 102
Unit: Maskell Inlet Complex
Location: main outcrop belt (west of M'Clintock Inlet)
Rock type: impure limestone
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	8	9–29	19.0
K-feldspar	8	0–3	0.5
Albite	8	1–20	8.6
Mica	8	0–2	0.8
Chlorite	8	0–14	2.9
Calcite	8	52–80	63.9
Dolomite	8	0–5	4.5
F/F+Q	8	9–62	29.9
P/P+Kf	6	74–100	94.5
D/D+C	8	0–7	6.1

Table 103
Unit: Maskell Inlet Complex
Location: main outcrop area
Rock type: impure dolostone
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	12–33	22.0
K-feldspar	3	0–1	0.7
Albite	3	1–5	3.3
Mica	3	1–3	1.7
Chlorite	3	0–1	tr
Calcite	3	0–35	19.3
Dolomite	3	35–87	53.3
F/F+Q	3	5–18	12.0
P/P+Kf	1		89
D/D+C	3	52–100	71.0

Succession 4

Table 104
Unit: Cape Discovery Formation, Member A
Location: entire outcrop area
Rock type: pebble conglomerate
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	6	52–86	72.5
K-feldspar	6	0–1	0.2
Albite	6	1–11	5.2
Mica	6	0–3	1.2
Chlorite	6	0–10	4.0
Calcite	6	0–39	14.2
Dolomite	6	0–12	3.2
F/F+Q	6	1–12	6.3
P/P+Kf	6	80–100	93.3

Table 105
Unit: Cape Discovery Formation, Member A
Location: section north of Bethel Peak
Rock type: pebbly sandstone
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	68–73	70.0
K-feldspar	3	0–1	0.3
Albite	3	6–10	8.3
Mica	3	(2–2)	2.0
Chlorite	3	7–15	9.7
Calcite	3	0–5	3.0
Dolomite	3	3–10	7.0
F/F+Q	3	8–13	11.0
P/P+Kf	3	89–100	96.3

Table 106
Unit: Cape Discovery Formation, Member A
Location: section north of Bethel Peak
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	57–62	59.0
K-feldspar	3	0–1	0.7
Albite	3	2–10	5.3
Mica	3	2–3	2.3
Chlorite	3	6–11	8.0
Calcite	3	0–17	5.7
Dolomite	3	2–32	19.3
F/F+Q	3	3–16	9.0
P/P+Kf	2	81–94	87.5

Table 107
Unit: Cape Discovery Formation, Member C
Location: entire outcrop area
Rock type: impure limestone and flat-pebble conglomerate
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	6	16–36	23.3
K-feldspar	6	0–1	0.3
Albite	6	0–5	3.0
Mica	6	0–1	0.2
Chlorite	6	0–1	0.3
Calcite	6	64–81	72.7
Dolomite	6	0–1	0.2

F/F+Q	6	0–19	13.3
D/D+C	6	0–1	0.2

Table 108
Unit: Cape Discovery Formation, Member D
Location: section north of Egingwah Bay
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	7	65–76	71.6
K-feldspar	7	0–4	1.0
Albite	7	19–29	23.3
Mica	7	0–4	1.3
Chlorite	7	1–3	2.1
Calcite	7	0–2	0.3
Dolomite	7	0–2	0.3
F/F+Q	7	20–34	25.4
P/P+Kf	7	88–100	95.9

Table 109
Unit: Cape Discovery Formation, Member D
Location: section north of Egingwah Bay
Rock type: sandstone (from Trettin, 1969b, p. 87)
Method: point count

	N	Range %	X̄ %
Volcanics	3	33–46	39.7
Microfelsite/chert	3	tr–1	0.7
Quartz	3	3–22	12.0
Feldspar	3	18–36	29.7
Mica*/chlorite	3	tr–1	0.3
Carbonates	3	0–8	3.0
Opaques	3	tr–31	14.7

*white mica

Succession 5A

Table 110
Unit: Taconite River Formation
Location: entire outcrop area
Rock type: sandstone
Method: point count (total less than 100% because trace amounts not included in tally)

	N	Range %	X̄ %
Quartz	3	34–58	43.0
Quartzite	3	0–2	1.0
Chert	3	7	7.0
Feldspar	3	4–11	7.3
White mica	3	1	1.0
Biotite	3	0–1	0.7
Chlorite	3	0–1	0.3
Carbonates	3	18–47	35.3
Phyllite/schist	3	1–3	3.0
Igneous rocks	3	0–1	0.3
Opaques	3	1–2	1.3

Table 111
Unit: Taconite River Formation
Location: entire outcrop area
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	X̄ %	σ %
Quartz	20	52–88	72.3	10.2
K-feldspar	20	0–4	1.3	1.3
Albite	20	0–14	5.1	3.5
Mica	20	0–4	1.5	1.2
Chlorite	20	0–9	2.5	2.0
Calcite	20	0–29	11.0	8.5
Dolomite	20	0–18	6.5	5.5
F/F+Q	19	1–79	11.7	16.2
P/P+Kf	15	52–100	82.3	15.3
D/D+C	17	0–100	36.2	30.1

Table 112
Unit: Taconite River Formation
Location: entire outcrop area
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	X̄ %	σ %
Quartz	15	43–81	62.6	10.5
K-feldspar	15	0–3	0.9	1.0
Albite	15	1–14	6.4	4.0
Mica	15	0–15	4.0	3.4
Chlorite	15	2–12	5.5	2.9
Calcite	15	0–28	9.8	7.4
Dolomite	15	0–25	11.1	7.7
F/F+Q	15	3–19	9.9	5.0
P/P+Kf	11	57–100	91.0	13.2
D/D+C	14	27–100	57.4	23.9

Table 113
Unit: Zebra Cliffs Formation
Location: entire outcrop area
Rock type: limestone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	8	3–15	9.4
K-feldspar	8	0–1	0.1
Plagioclase	8	0–4	1.4
Mica	8	0–2	0.9
Chlorite	8	0–4	0.5
Calcite	8	76–92	83.4
Dolomite	8	1–11	4.3
D/D+C	8	1–12	4.6

Table 114
Unit: Zebra Cliffs Formation
Location: entire outcrop area
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	60–67	63.2
K-feldspar	5	0–3	1.2
Albite	5	4–12	8.2
Mica	5	0–4	2.2
Chlorite	5	1–6	3.4
Calcite	5	0–24	12.2
Dolomite	5	4–14	9.2
F/F+Q	5	8–16	12.4
P/P+Kf	5	65–100	84.2
D/D+C	5	28–100	48.0

Table 115
Unit: Zebra Cliffs Formation
Location: entire outcrop area
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	3	49–67	60.7
K-feldspar	3	tr–4	2.0
Albite	3	3–10	6.0
Mica	3	2–7	3.7
Chlorite	3	4–9	6.0
Calcite	3	0–21	7.0
Dolomite	3	11–19	14.0
F/F+Q	3	6–16	11.0
P/P+Kf	2	56–81	68.5
D/D+C	3	35–100	78.3

Succession 5B

Table 116
Unit: Cranstone Formation
Location: west of Disraeli Glacier
Rock type: sandstone
Method: point count

	N	Range %	$\bar{X}$ %
Quartz	5	35–46	40.4
Quartzite	5	2–12	7.6
Chert	5	4–16	9.6
Feldspar	5	4–23	12.6
White mica	5	tr–1	0.8
Biotite	5	tr–1	0.4
Chlorite	5	1–2	1.2
Carbonates*	5	7–17	12.4
Phyllite, schist	5	3–19	10.2
Volcanics	5	1–9	3.8
Granite/gneiss	5	0–2	0.6
Mudrock	5	tr–1	0.2

*from XRD analyses (carbonates leached before point count)

Table 117
Unit: Cranstone Formation
Location: west of Disraeli Glacier
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	13	60–85	74.8	6.9
K-feldspar	13	0–4	0.7	1.2
Albite	13	4–10	6.3	1.9
Mica	13	0–4	1.4	1.4
Chlorite	13	2–12	5.4	2.7
Calcite	13	3–22	9.7	4.8
Dolomite	13	0–5	1.5	1.5
F/F+Q	13	5–23	9.5	4.6
P/P+Kf	12	64–100	90.6	13.1
D/D+C	13	0–58	14.1	15.1

Table 118
Unit: Cranstone Formation
Location: west of Disraeli Glacier
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	8	59–70	65.5
K-feldspar	8	0–2	0.6
Albite	8	4–6	5.4
Mica	8	4–9	5.9
Chlorite	8	7–14	10.0
Calcite	8	3–10	7.3
Dolomite	8	3–7	4.9

F/F+Q	8	6–11	8.6
P/P+Kf	8	76–100	90.3
D/D+C	8	28–51	41.5

Table 119
Unit: Ooblooyah Creek Formation
Location: vicinity of Zebra Cliffs, M'Clintock Inlet
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	38–54	44.0
K-feldspar	3	1–1	1.0
Albite	3	6–14	9.0
Mica	3	2–7	4.7
Chlorite	3	4–7	5.3
Calcite	3	23–31	26.0
Dolomite	3	4–17	9.7
F/F+Q	3	13–27	18.7
P/P+Kf	3	84–92	87.7
D/D+C	3	14–42	25.3

Table 120
Unit: Ooblooyah Creek Formation
Location: vicinity of Zebra Cliffs, M'Clintock Inlet
Rock type: lime mudstone
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	7–21	11.7
K-feldspar	3	0–1	0.7
Albite	3	1–2	1.7
Mica	3	tr–1	0.7
Chlorite	3	tr–2	1.0
Calcite	3	72–87	82.0
Dolomite	3	1–3	2.0
D/D+C	3	2–3	2.3

Table 121
Unit: Danish River Formation
Location: vicinity of Zebra Cliffs
Rock type: sandstone
Method: point count analysis (from Trettin, 1969b)

	N	Range %	X̄ %
Quartz, quartzite	7	9–52	36.5
Chert	7	0–4	3.2
Chert/volcanics*	7	0–6	2.8
Feldspar	7	1–3	8.2
Chlorite	7	0–4	1.3
Biotite	7	0–tr	tr
White mica/phyllite	7	0–3	0.8
Volcanics	7	2–21	5.3
Carbonates**	7	30–87	41.5

*includes felsic volcanic material
**includes masked argillaceous matter, etc.

Table 122
Unit: Danish River Formation
Location: west of central M'Clintock Inlet
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	2	60–69	64.5
K-feldspar	2	5–7	6.0
Albite	2	5–12	8.5
Mica	2	1–3	2.0
Chlorite	2	1–4	2.5
Calcite	2	0–26	13.0
Dolomite	2	2–6	4.0
F/F+Q	2	14–21	17.5
P/P+Kf	2	45–64	54.5
D/D+C	2	6–100	53.0

Table 123
Unit: Lands Lokk Formation
Location: vicinity of Crash Point
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	X̄ %
Quartz	3	65–73	68.0
K-feldspar	3	0–3	1.3
Albite	3	6–8	7.0
Mica	3	5–9	6.7
Chlorite	3	6–9	7.7
Calcite	3	2–3	2.7
Dolomite	3	6–8	7.3
F/F+Q	3	8–13	10.7
P/P+Kf	3	74–100	88.7
D/D+C	3	69–77	73.3

Table 124
Unit: Lorimer Ridge Formation
Location: Lorimer Ridge section
Rock type: sandstone
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	22	66–88	74.5	6.6
K–feldspar	22	0–5	0.3	1.1
Albite	22	4–14	9.3	2.7
Mica	22	tr–4	1.3	0.8
Chlorite	22	1–4	2.1	1.0
Calcite	22	0–25	10.9	5.2
Dolomite	22	0–9	2.1	2.1
F/F+Q	22	5–16	11.4	3.1
P/P+Kf	20	66–100	97.1	8.8
D/D+C	22	0–51	13.0	12.8

Table 125
Unit: Lorimer Ridge Formation
Location: Lorimer Ridge section
Rock type: mudrock
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %	σ %
Quartz	18	47–75	65.4	7.1
Albite	18	4–14	7.8	2.5
Mica	18	1–3	2.2	0.8
Chlorite	18	1–7	3.2	1.6
Calcite	18	9–40	15.6	7.4
Dolomite	18	1–15	6.1	3.9
F/F+Q	18	6–16	10.5	2.6
D/D+C	18	0–62	26.8	15.2

Table 126
Unit: Crash Point beds
Location: Crash Point
Rock type: sandstone, fine grained
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	4	81–87	83.0
K–feldspar	4	2–4	2.5
Albite	4	3–6	4.5
Mica	4	1–3	2.0
Chlorite	4	2–5	2.8
Calcite	4	2–7	4.5
Dolomite	4	1–2	1.3
F/F+Q	4	5–10	7.5
P/P+Kf	4	58–78	66.6
D/D+C	4	13–42	26.0

Table 127
Unit: Crash Point beds
Location: Crash Point
Rock type: siltstone, coarse grained, sandy and sandstone, very fine grained, argillaceous
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	5	66–75	68.6
K–feldspar	5	0–2	0.8
Albite	5	4–10	6.6
Mica	5	5–10	7.8
Chlorite	5	6–8	6.8
Calcite	5	3–7	4.8
Dolomite	5	3–7	4.6
F/F+Q	5	7–14	10.2
P/P+Kf	5	75–100	87.4
D/D+C	5	34–62	49.0

Table 128
Unit: Crash Point beds
Location: Crash Point
Rock type: limestone, silty, sandy
Method: X-ray diffraction

	N	Range %	$\bar{X}$ %
Quartz	2	20–29	24.5
K–feldspar	2	(1–1)	1.0
Albite	2	1–3	2.0
Mica	2	2–3	2.5
Chlorite	2	(3–3)	3.0
Calcite	2	58–70	64.0
Dolomite	2	3–4	3.5
F/F+Q	2	10–11	10.5
D/D+C	2	4–7	5.5

APPENDIX 4

CHEMICAL AND ISOTOPIC ANALYSES

CONTENTS

A. CHEMICAL ANALYSES OF VOLCANIC ROCKS

INTRODUCTION

This appendix presents chemical analyses of 156 samples from 11 major units. Table 1 summarizes petrographic information obtained from thin section inspection and whole-rock XRD analysis, along with classifications based on major elements (Irvine and Baragar, 1971) and trace elements (Winchester and Floyd, 1977, Fig. 6). The third row, Analysis report no., refers to the original analytical reports received from three different laboratories.

1. Analyses made by the laboratories of the Geological Survey of Canada at Ottawa are listed as follows (e.g., Table 2-1, Current no. 2): 57-82-3, referring to Report 57-82, made in 1982.

2. Analyses by the Geological Survey of Canada at Calgary are listed as follows (e.g., Table 2-6, no. 5): ISPG-92- 01.XLS, referring to a report prepared in 1992.

3. Analyses by Elemental Research Inc., Vancouver are listed as follows (e.g., Table 2-2, Current no. 1): ERI-4157-29, referring to Report 4157. Their analyses were made in 1991 and 1992.

Table 2 lists routine analyses of 152 samples (20 in duplicate) done by wavelenth dispersive X-ray fluorescence on fused discs, in combination with rapid analytical techniques for FeO, H_2O, and CO_2, and with optical emission spectography for low values of MnO, MgO, and CaO. Totals are reproduced as received, but were calculated by two different methods. In the totals received from the GSC laboratories, data listed with two decimals were rounded off to one decimal before addition. In the total received from Elemental Research Inc. all data were added as listed.

Table 3 summarizes special analyses of Nb, Y, Zr and Ti on 134 samples (54 in duplicate) done mainly by energy-dispersive X-ray fluorescence or by induced coupled plasma mass spectrometry (ICP-MS). The exceptions are Ti analyses in report 86-3 by the GSC laboratory at Ottawa. In this case a variety of methods (wavelength dispersive X-ray fluorescence, spectometric analysis, and colorimetric spectography) were used and a value was selected by G.R. Lachance that appeared most approriate in view of the observed scatter and the reliability of given methods for certain concentrations.

Appendix 4A

Table 1

Summary of petrography and classification

NORTHERN HEIBERG FOLD BELT

Jaeger Lake Formation (Tables 2-1, 3-1)

Current no.: 1
Field no.: 61TMC4
Analytical report no.: 57-82-1, 86-83-53
Petrography: flow; phenocrysts of albite in groundmass of albite, chlorite, etc.; calcite and quartz alteration; lenses and veinlets of quartz
Major element classification: calc-alkaline dacite, average series
Trace element classification: subalkaline basalt

Current no.: 2
Field number: 61TM13F6
Analytical report no.: 57-82-3, 86-83-55
Petrography: amygdaloidal flow, aphyric; albite, chlorite, muscovite; chlorite also occurs in amygdules; calcite and quartz alteration and veinlets
Major element classification: calc-alkaline (high alumina) basalt, K-rich series
Trace element classification: subalkaline basalt

Current no.: 3
Field no.: 61TM13F1
Analytical report no.: 57-82-2, 86-83-54
Petrography: breccia of aphanitic flow; albite, chlorite, minor mica; calcite alteration and veinlets; quartz veinlets and cavity linings
Major element classification: calc-alkaline (high-alumina) andesite, K-poor series
Trace element classification: subalkaline basalt

Current no.: 4a, 4b
Field no.: 86TM102G2
Analytical report no.: 118-86-4, 118-86-13
Petrography: flow or intrusion; albite, chlorite, pyroxene; minor calcite
Major element classification: tholeiitic picrite basalt, average series
Trace element classification: andesite/basalt, close to boundary with subalkaline basalt

Current no.: 5a, 5b
Field no.: 86TM102G4
Analytical report no.: 118-86-5, 118-86-14
Petrography: breccia of amygdaloidal flow; albite, chlorite, minor calcite, quartz
Major element classification: 1) hawaiite, sodic alkali basalt series, 2) calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 6a, 6b
Field no.: 86TM124H7
Analytical report no.: 118-86-6, 118-86-15
Petrography: amygdaloidal flow; plagioclase, chlorite, quartz, carbonate veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 7a, 7b
Field no.: 86TM124H11
Analytical report no.: 118-86-7, 118-86-16
Petrography: amygdaloidal flow; plagioclase, chlorite, quartz, carbonate veinlets
Major element classification: tholeiitic picrite basalt, K-poor series
Trace element classification: andesite/basalt

Svartevaeg Formation

Member A (Tables 2-2, 3-2)

Current no.: 1
Field no.: 92TM113A1
Analytical report no.: ERI-4157-29
Petrography: brecciated flow(?); phenocrysts of albite; chlorite, epidote, sericite; calcite and quartz veinlets and replacements
Major element classification: hawaiite, sodic alkali basalt series
Trace element classification: andesite

Current no.: 2
Field no.: 92TM113A4
Analytical report no.: ERI-4157-30
Petrography: flow; phenocrysts of albite; chlorite, epidote (common in veinlets), sericite; calcite and quartz veinlets and replacements
Major element classification: tholeiitic dacite, K-poor series
Trace element classification: andesite/basalt

Current no.: 3
Field no.: 92TM113C1
Analytical report no.: ERI-4157-31
Petrography: flow; phenocrysts of albite, clinopyroxene, minor orthopyroxene(?) and olivine(?); chlorite, epidote, sericite; calcite and quartz veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: andesite/basalt

Current no.: 4
Field no.: 92TM113C2
Analytical report no.: ERI-4157-32
Petrography: brecciated amygdaloidal flow; phenocrysts of albite, clinopyroxene; chlorite, epidote, sericite; amygdules contain chlorite and calcite; calcite and quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) basalt, average series
Trace element classification: andesite/basalt

Current no.: 5
Field no.: 92TM113C3
Analytical report no.: ERI-4157-33
Petrography: amygdaloidal flow; phenocrysts of albite and clinopyroxene; chlorite, sericite, epidote; amygdules contain chlorite, calcite, chalcedony; calcite and quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: andesite

Current no.: 6
Field no.: 92TM113D1
Analytical report no.: ERI-4157-34
Petrography: breccia including fragments of flows and crystal tuff; phenocrysts of albite, clinopyroxene and rare hornblende and quartz; chlorite, epidote, sericite, quartz, calcite
Major element classification: calc-alkaline (high alumina) andesite, K-rich series
Trace element classification: andesite

Current no.: 7
Field no.: 92TM113E1
Analytical report no.: ERI-4157-35
Petrography: flow; phenocrysts of albite and clinopyroxene; chlorite, sericite, epidote, quartz; calcite veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: on boundary between andesite and andesite/basalt

Current no.: 8, 8a
Field no.: 92TM113B1
Analytical report no.: ERI-4263-1
Petrography: flow breccia; phenocrysts of albite; chlorite, sericite, epidote (common in veinlets); calcite and quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: andesite

Current no.: 9
Field no.: 92TM113E2
Analytical report no.: ERI-4263-2
Petrography: amygdaloidal flow; phenocrysts of albite and clinopyroxene; chlorite, sericite, epidote (common in veinlets); amygdules contain chlorite, calcite, quartz, epidote
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: andesite

Current no.: 10
Field no.: 92TM113F1
Analytical report no.: ERI-4263-3
Petrography: crystal-lithic tuff; phenocrysts of albite, clinopyroxene, hornblende(?); chlorite, sericite, epidote (partly in veinlets); quartz and calcite veinlets and replacements
Major element classification: calc-alkaline (high-alumina) basalt, average series
Trace element classification: andesite/basalt

Current no.: 11
Field no.: 92TM113F2
Analytical report no.: ERI-4263-4
Petrography: flow breccia (or lithic tuff?); phenocrysts of albite, clinopyroxene; chlorite, sericite, epidote (common in veinlets); calcite and quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-rich series
Trace element classification: andesite

Current no.: 12
Field no.: 92TM113G1
Analytical report no.: ERI-4263-5
Petrography: lithic-crystal tuff; phenocrysts of labradorite, clinopyroxene; chlorite, sericite, epidote, quartz, calcite
Major element classification: tholeiitic basalt, K-rich series
Trace element classification: andesite/basalt

Current no.: 13
Field no.: 92TM113G2
Analytical report no.: ERI-4263-6
Petrography: flow; phenocrysts of labradorite and clinopyroxene; chlorite, sericite, epidote (common in veinlets); calcite and quartz replacements
Major element classification: calc-alkaline (high alumina) basalt, K-rich series
Trace element classification: andesite/basalt

Current no.: 14
Field no.: 92TM113H1
Analytical report no.: ERI-4263-7
Petrography: flow; phenocrysts of albite; chlorite, sericite, epidote (common in veinlets); quartz alteration and veinlets
Major element classification: calc-alkaline (high alumina) basalt, K-poor series
Trace element classification: andesite

Current no.: 15
Field no.: 92TM113H2
Analytical report no.: ERI-4263-8
Petrography: flow; phenocrysts of albite, clinopyroxene; chlorite, sericite, epidote (pervasive); quartz and calcite alteration and veinlets
Major element classification: calc-alkaline (high alumina) basalt, average series
Trace element classification: andesite

Current no.: 16
Field no.: 92TM113H3
Analytical report no.: ERI-4263-9
Petrography: amygdaloidal flow; phenocrysts of labradorite and pyroxene; chlorite, sericite; amygdules filled with calcite and minor chlorite
Major element classification: trachybasalt, potassic alkali series
Trace element classification: andesite/basalt

Current no.: 17
Field no.: 92TM113J4
Analytical report no.: ERI-4263-10
Petrography: crystal-lithic tuff; phenocrysts of albite, K-feldspar, clinopyroxene, and minor hornblende; chlorite, sericite, epidote; quartz and calcite alteration and veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 18, 18a
Field no.: 92TM113J5
Analytical report no.: ERI-4263-11
Petrography: flow; phenocrysts of albite; chlorite, sericite, epidote; quartz and calcite veinlets and alteration
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: andesite

Current no.: 19
Field no.: 92TM113J8
Analytical report no.: ERI-4263-12
Petrography: flow; phenocrysts of albite; chlorite, sericite; calcite alteration and veinlets common
Major element classification: sodic trachyte, sodic alkali basalt series
Trace element classification: andesite

Current no.: 20 (collected by P.E. Fricker, 1960; from Fricker and Trettin, 1962, p. 11; analysis by M. Weibel, Federal Technial Institute, Zurich, Switzerland; also Trettin, 1969a, p. 62)
Petrography: tuff; albite (approx. An_5), chlorite, carbonate
Major element classification: calc-alkaline (high alumina) andesite, K-poor series

Member B, conglomerate clasts (Tables 2-3, 3-3)

Current no.: 1
Field no.: 92TM104B-7
Analytical report no.: ERI-4157-17
Petrography: flow; phenocrysts of albite and clinopyroxene; albite, sericite; calcite and quartz veinlets and replacements
Major element classification: calc-alkaline (high-alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 2
Field no.: 92TM104B8
Analytical report no.: ERI-4157-18
Petrography: amygdaloidal flow; phenocrysts of labradorite and clinopyroxene (rare); chlorite; amygdules contain chlorite, chalcedony, quartz, and calcite; calcite and quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 3
Field no.: 92TM104B9
Analytical report no.: ERI-4157-19
Petrography: crystal-lithic-vitric (glass recrystallized) tuff; phenocrysts of albite, clinopyroxene, minor quartz; chlorite, sericite; replacements of calcite and quartz; calcite veinlets common
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: andesite/basalt

Current no.: 4
Field no.: 92TM104B10
Analytical report no.: ERI-4157-20
Petrography: mainly amygdaloidal flow rock; phenocrysts of albite; chlorite, sericite; amygdules contain chlorite, calcite, chalcedony; calcite replacements common; also includes crystal tuff (albite), largely replaced by calcite
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: andesite

Current no.: 5
Field no.: 92TM104B11
Analytical report no.: ERI-4157-21
Petrography: volcanic conglomerate, sandy; rounded pebbles of porphyritic volcanics (plagioclase phenocrysts) in matrix of plagioclase crystals and sand-grade volcanic rock fragments; XRD analysis suggests plagioclase is mainly labradorite; also includes limestone pebble with echinoderm columnals and aggregate of vein quartz
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 6
Field no.: 92TM104B12
Analytical report no.: ERI-4157-22
Petrography: lithic tuff or conglomerate; phenocrysts of albite, minor pyroxene; chlorite, sericite; calcite and quartz veinlets and alteration
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 7
Field no.: 92TM104B13
Analytical report no.: ERI-4157-23
Petrography: flow; phenocrysts of albite, clinopyroxene; chlorite, sericite, prehnite, epidote; quartz and carbonate replacements
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 8
Field no.: 92TM104B14
Analytical report no.: ERI-4157-24
Petrography: volcanic conglomerate, sandy; porphyritic volcanic rock fragments with feldspar phenocrysts; grains of feldspar; feldspar (of rock fragments and grains) is mainly albite with minor K-feldspar; limestone fragments; carbonate, quartz, chalcedony replacements
Major element classification: tholeiitic basalt, K-poor series
Trace element classification: andesite/basalt

Current no.: 9
Field no.: 92TM104B15
Analytical report no.: ERI-4157-25
Petrography: flow; phenocrysts of albite; chlorite, sericite; calcite, quartz, chalcedony replacements and veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 10
Field no.: 92TM104B16
Analytical report no.: ERI-4157-26
Petrography: amygdaloidal flow; phenocrysts of albite, clinopyroxene; chlorite, sericite, epidote; amygdules contain quartz, chlorite; quartz and calcite replacements; calcite veinlets
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: andesite/basalt

Current no.: 11
Field no.: 92TM104B17
Analytical report no.: ERI-4157-27
Petrography: flow; phenocrysts of albite; chlorite, sericite; extensive calcite replacement
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 12
Field no.: 92TM104B18
Analytical report no.: ERI-4157-28
Petrography: porphyritic flow; phenocrysts of albite; chlorite, sericite; calcite and quartz replacements; calcite veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Member B, strata (Tables 2-4, 3-4)

Current no.: 1
Field no.: 92TM1-2-6A1
Analytical report no.: ERI-4157-2
Petrography: crystal-lithic tuff; albite, clinopyroxene; quartz, chlorite, epidote, calcite, sericite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 2
Field no.: 92TM1-2-6A2
Analytical report no.: ERI-4157-3
Petrography: crystal-lithic tuff; albite, clinopyroxene; quartz, chlorite, epidote, calcite, sericite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 3
Field no.: 92TM1-2-6A3
Analytical report no.: ERI-4157-4
Petrography: crystal-lithic tuff; albite, chlorite, epidote; veinlets and alteration of quartz and minor calcite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 4
Field no.: 92TM1-2-8-1
Analytical report no.: ERI-4157-5
Petrography: predominantly crystal tuff; albite; quartz, chlorite, sericite; calcite alteration and veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 5
Field no.: 92TM1-2-8-2
Analytical report no.: ERI-4157-6
Petrography: crystal-lithic tuff; albite; chlorite, sericite; quartz and calcite alteration and veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 6
Field no.: 92TM1-2-8-3
Analytical report no.: ERI-4157-7
Petrography: porphyritic flow, amygdaloidal; phenocrysts of labradorite; groundmass of plagioclase, chlorite, minor quartz and ore; amygdules contain chlorite and quartz
Major element classification: calc-alkaline (high alumina) andesite, K-rich series
Trace element classification: andesite

Current no.: 7
Field no.: 92TM1-2-9
Analytical report no.: ERI-4157-8
Petrography: predominantly crystal tuff; albite; chlorite, sericite, calcite; quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: andesite

Current no.: 8
Field no.: 92TM1-2-10
Analytical report no.: ERI-4157-9
Petrography: crystal-lithic tuff; albite, clinopyroxene; chlorite, epidote, sericite; quartz and calcite veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 9
Field no.: 92TM1-2-8-11-4
Analytical report no.: ERI-4157-10
Petrography: lithic-crystal tuff; albite, clinopyroxene, trace of hornblende; chlorite, epidote, sericite, quartz, calcite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 10, 10a
Field no.: 92TM1-2-13
Analytical report no.: ERI-4157-11
Petrography: crystal-lithic tuff; albite, minor clinopyroxene, hornblende; chlorite, sericite, quartz
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 11
Field no.: 92TM1-2-16
Analytical report no.: ERI-4157-12
Petrography: crystal-lithic tuff; albite, clinopyroxene; chlorite, quartz, calcite
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: andesite

Current no.: 12
Field no.: 61TM4A (from approximately upper 60 m of member)
Analytical report no.: 68-13-3502
Petrography: lithic-crystal tuff; volcanic rock fragments and crystals of plagioclase and pyroxene cemented by chlorite; XRD indicates plagioclase is mainly andesine
Major element classification: calc-alkaline (high alumina) basalt, K-poor series

CLEMENTS MARKHAM FOLD BELT

Yelverton Formation (Tables 2-5, 3-5)

Current no.: 1
Field no.: 82TM3-0M
Analytical report no.: 110-82-14, 86-83-49
Petrography: aphyric, altered
Major element classification: tholeiitic picrite basalt, K-poor series
Trace element classification: andesite/basalt, close to border with subalkaline basalt

Current no.: 2
Field no.: 82TM1-3-51M
Analytical report no.: 110-82-7, 86-83-47
Petrography: aphyric; actinolite, albite, chlorite, clinopyroxene, quartz, calcite
Major element classification: tholeiitic basalt, K-poor series
Trace element classification: on boundary between andesite/basalt and subalkaline basalt

Current no.: 3
Field no.: 75TM136-0M
Analytical report no.: 2-82-1, 86-83-44
Petrography: phenocrysts of clinopyroxene and albite; groundmass of clinopyroxene, albite, chlorite, actinolite, mica
Major element classification: tholeiitic basalt, average series
Trace element classification: subalkaline basalt, close to border with andesite/basalt

Current no.: 4
Field no.: 75M136-176M
Analytical report no.: 2-82-3, 86-83-46
Petrography: phenocrysts of albite; phenocrysts of plagioclase and clinopyroxene; groundmass of albite, minor clinopyroxene
Major element classification: tholeiitic basalt, average series
Trace element classification: andesite/basalt, close to border with subalkaline basalt

Current no.: 5
Field no.: 82TM1-3-214M
Analytical report no.: 110-82-13, 86-83-48
Petrography: aphyric; actinolite, albite, chlorite, clinopyroxene, epidote, quartz, calcite
Major element classification: tholeiitic basalt, K-poor series
Trace element classification: andesite/basalt, close to border with subalkaline basalt

Current no.: 6
Field no.: 75TM-136-170M
Analytical report no.: 2-82-2, 86-83-45
Petrography: aphyric, amygdaloidal; albite, clinopyroxene, chlorite, actinolite, quartz
Major element classification: tholeiitic basalt, average series
Trace element classification: andesite/basalt, close to border with subalkaline basalt

Current no.: 7
Field no.: 75TM114-5
Analytical report no.: 57-79-1, 86-83-43
Petrography: aphyric; albite, chlorite, quartz, calcite
Major element classification: tholeiitic picrite basalt, K-poor series
Trace element classification: subalkaline basalt, near border with alkali basalt

Current no.: 8
Field no.: 75TM117-1
Analytical report no.: 57-79-2
Petrography: phenocrysts of clinopyroxene, minor albite; groundmass of clinopyroxene, albite, chlorite; carbonate alteration; veinlets of quartz
Major element classification: alkalic picrite basalt, sodic series

Current no.: 9
Field no.: 82TM1-3-150M
Analytical report no.: 110-82-12
Petrography: laths of albite, partly enclosed by clinopyroxene, the latter largely replaced by actinolite; chlorite, epidote, quartz; ophitic texture; flow or very fine grained sill
Major element classification: tholeiitic basalt, K-poor series

Current no.: 10
Field no.: 75TM120
Analytical report no.: 57-79-4
Petrography: phenocrysts of actinolite; groundmass of actinolite, epidote, chlorite, quartz, calcite
Major element classification: tholeiitic basalt, K-rich series

Current no.: 11
Field no.: 77TM330A1
Analytical report no.: 2-82-4
Petrography: aphyric; albite, chlorite, actinolite, K-feldspar(?); veinlets with calcite and quartz
Major element classification: tholeiitic andesite, K-poor series

Current no.: 12
Field no.: 75TM119-3
Analytical report no.: 57-79-3
Petrography: phenocrysts of actinolite; groundmass of albite, actinolite, epidote, chlorite, quartz, calcite
Major element classification: hawaiite, sodic alkali basalt series

Current no.: 13
Field no.: 75TM123-2
Analytical report no.: 57-79-5
Petrography: phenocrysts of clinopyroxene; groundmass of quartz, albite, epidote, actinolite, calcite
Major element classification: tholeiitic basalt, average series

Current no.: 14
Field no.: 82TM1-3-54M
Analytical report no.: 110-82-8
Petrography: aphyric; actinolite, albite, clinopyroxene, chlorite, epidote, quartz, calcite
Major element classification: tholeiitic basalt, average series

Current no.: 15
Field no.: 82TM1-3-144M
Analytical report no.: 110-82-11
Petrography: aphyric; actinolite, albite, chlorite, epidote, clinopyroxene, quartz
Major element classification: tholeiitic basalt, K-poor series

Current no.: 16
Field no.: 82TM1-3-64.5M
Analytical report no.: 110-82-9
Petrography: aphyric; actinolite, albite, chlorite, clinopyroxene, epidote, quartz
Major element classification: tholeiitic basalt, average series

Current no.: 17
Field no.: 82TM1-3-132M
Analytical report no.: 110-82-10
Petrography: aphyric; albite, actinolite, chlorite, clinopyroxene
Major element classification: tholeiitic basalt, K-poor series

Current no.: 18
Field no.: 75TM119-1
Analytical report no.: 10-79-14
Petrography: phenocrysts of actinolite; groundmass of albite, actinolite, chlorite, quartz, epidote; lenses of quartz; undulating schistosity
Major element classification: tholeiitic basalt, average series

Fire Bay Formation, Member B (Tables 2-6, 3-6)

Unit B1

Current no.: 1
Field no.: 92TM6-97m
Analytical report no.: ERI-4157-13
Petrography: crystal tuff; mainly albite, minor clinopyroxene; chlorite; minor quartz, carbonate
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: probably andesite/basalt (Nb below measurement limit)

Current no.: 2
Field no.: 92TM6-159m
Analytical report no.: ERI-4157-14
Petrography: crystal-lithic tuff; albite, chlorite, quartz, dolomite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series (insufficient silica)
Trace element classification: probably andesite/basalt (Nb below measurement limit)

Current no.: 3
Field no.: 92TM6-163m
Analytical report no.: ERI-4157-15
Petrography: porphyritic flow; phenocrysts of albite; groundmass of quartz, albite, minor chlorite; dolomite alteration and veinlets
Major element classification: rhyolite, K-poor series
Trace element classification: rhyodacite/dacite

Current no.: 4
Field no.: 92TM6-166.5m
Analytical report no.: ERI-4157-16
Petrography: lithic-crystal tuff; phenocrysts of albite; quartz, chlorite; dolomite veinlets and replacements common
Major element classification: rhyolite, K-poor series
Trace element classification: andesite

Current no.: 5
Field no.: 61TMH2
Analytical report no.: ISPG-92-01.XLS, ERI-2227
Petrography: flow; phenocrysts of albite and minor quartz; microfelsitic groundmass of quartz and albite with minor chlorite
Major element classification: tholeiitic rhyolite, K-poor series
Trace element classification: rhyodacite-dacite

Current no.: 6a, 6b
Field no.: 88TM204F3
Analytical report no.: 67-89-49, 67-89-50
Petrography: flow breccia or lithic-crystal tuff; quartz, albite, minor chlorite, calcite
Major element classification: rhyolite, K-poor series
Trace element classification: trachyandesite

Current no.: 7
Field no.: 88TM204F4
Analytical report no.: 67-89-51
Petrography: vitric tuff, weakly recrystallized to microfelsite; XRD indicates quartz, albite, minor chlorite
Major element classification: rhyolite, average series
Trace element classification: trachyandesite

Unit B2

Current no.: 8
Field no.: 92TM137A3
Analytical report no.: ERI-4263-19
Petrography: flow; phenocrysts of quartz and minor feldspar in groundmass of quartz and feldspar; feldspar is largely or entirely albite according to XRD; rock appears to have been replaced by chert or microfelsite along fractures
Major element classification: rhyolite, K-poor series
Trace element classification: andesite (petrography indicates more felsic composition)

Current no.: 9
Field no.: 92TM137A4
Analytical report no.: ERI-4263-20
Petrography: phenocrysts of quartz and feldspar; groundmass of quartz, feldspar and minor chlorite and white mica; feldspar is largely or entirely albite according to XRD; rock appears to have been replaced by chert or microfelsite along fractures; carbonate veinlets and replacements; quartz veinlets
Major element classification: rhyolite, K-poor series
Trace element classification: andesite (petrography indicates more felsic composition)

Current no.: 10, 10a
Field no.: 92TM137A5
Analytical report no.: ERI-4263-21
Petrography: laminated tuff; quartz, albite, chlorite, muscovite, calcite veinlets and replacements
Major element classification: rhyolite, K-poor series
Trace element classification: andesite/basalt (petrography indicates more felsic composition)

Current no.: 11
Field no.: 92TM140A1
Analytical report no.: ERI-4263-22
Petrography: flow or sill; albite, chlorite; calcite veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: alkali basalt

Current no.: 12
Field no.: 92TM140A2
Analytical report no.: ERI-4263-23
Petrography: brecciated amygdaloidal flow; albite, chlorite; amygdules contain calcite and chlorite; calcite veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: subalkaline basalt

Current no.: 13
Field no.: 92TM140A3
Analytical report no.: ERI-4263-24
Petrography: brecciated flow; albite, chlorite; calcite veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: alkali basalt

Current no.: 14
Field no.: 92TM140B
Analytical report no.: ERI-4263-25
Petrography: brecciated flow; albite, chlorite; calcite replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: rhyolite (petrography indicates mafic composition)

Current no.: 15
Field no.: 92TM140C1
Analytical report no.: ERI-4263-26
Petrography: brecciated amygdaloidal flow; albite, chlorite; amygdules contain chlorite, calcite; calcite veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: subalkaline basalt

Current no.: 16
Field no.: 92TM140C2
Analytical report no.: ERI-4263-27
Petrography: amygdaloidal flow; albite, chlorite; amygdules contain calcite, chlorite; calcite and chlorite veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: subalkaline basalt

Current no.: 17
Field no.: 92TM140C3
Analytical report no.: ERI-4263-28
Petrography: amygdaloidal flow; albite, chlorite; amygdules contain calcite, chlorite; calcite veinlets and replacements
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: subalkaline basalt

Current no.: 18
Field no.: 90TM124E1
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: amygdaloidal flow, altered by carbonate
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: alkali basalt

Current no.: 19
Field no.: 90TM121F
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: volcanic flow or tuff; albite, quartz, chlorite, calcite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 20
Field no.: 90TM124G1
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: brecciated flow(?); albite, calcite, quartz, minor chlorite
Major element classification: rhyolite, K-poor series
Trace element classification: trachyandesite

Map unit OSv (Tables 2-7, 3-7)

Current no.: 1
Field no.: 75TM181-2
Analytical report no.: 57-79-7, 86-83-31
Petrography: lithic and crystal tuff; albite, K-feldspar(?), actinolite, chlorite, epidote, apatite, quartz, calcite
Major element classification: calcalkaline (high alumina) andesite, average series
Trace element classification: andesite

Current no.: 2
Field no.: 75TM181-1
Analytical report no.: 57-79-6, 86-83-30
Petrography: porphyritic flow; phenocrysts of albite and actinolite (less common); groundmass of albite, K-feldspar(?), actinolite, chlorite, epidote, apatite, quartz, calcite
Major element classification: tristanite, potassic alkali basalt series
Trace element classification: trachyandesite

Current no.: 3
Field no.: 90TM130A1
Analytical report no.: ISPG 92-01.XLS, ERI-2277
Petrography: brecciated flow; albite, microcline(?), quartz, chlorite, epidote; calcite veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-rich series
Trace element classification: trachyandesite

Current no.: 4
Field no.: 90TM130A2
Analytical report no.: ISPG 92-01.XLS, ERI-2277
Petrography: flow; albite, microcline, quartz, chlorite, calcite
Major element classification: calc-alkaline (high alumina) andesite, average series
Trace element classification: trachyandesite

Kulutingwak Formation (Tables 2-8, 3-8)

Member A

Current no.: 1a, 1b
Field no.: 88TM205B2 (Kulutingwak Anticlinorium)
Analytical report no.: 67-89-53, 67-89-54
Petrography: flow; phenocrysts of albite and actinolite-chlorite; groundmass of albite, chlorite, actinolite
Major element classification: hawaiite, sodic alkali basalt series
Trace element classification: alkali basalt

Current no.: 2a, 2b
Field no.: 88TM205B4 (Kulutingwak Anticlinorium)
Analytical report no.: 67-89-55, 67-89-56
Petrography: flow; phenocrysts of albite, actinolite-chlorite, minor biotite; groundmass of albite, chlorite, actinolite; epidote and calcite replacement
Major element classification: hawaiite, sodic alkali basalt series
Trace element classification: alkali basalt

Current no.: 3
Field no.: 88TMBJ23A (Kulutingwak Anticlinorium)
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: flow; phenocrysts of albite, rotated, partly broken; microfelsitic groundmass of albite, quartz, muscovite, biotite, and chlorite; dolomite alteration
Major element classification: rhyolite, K-poor series
Trace element classification: rhyodacite-dacite, nearly on border with andesite

Current no.: 4
Field no.: 90TMBJ705A (south of Kulutingwak Anticlinorium; radiometrically dated sample)
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: flow; phenocrysts of albite; groundmass of feldspar, chlorite, quartz; minor calcite alteration
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: andesite, close to border with rhyodacite-dacite

Current no.: 5
Field no.: 90TMBJ712C (Kulutingwak Anticlinorium)
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: flow; phenocrysts of albite in matrix, mainly of chlorite and albite; calcite alteration
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: alkali basalt, nearly on border with subalkaline basalt

Current no.: 6
Field no.: 90TM101A4 (south of Kulutingwak Anticlinorium)
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: flow; phenocrysts of albite; microfelsitic matrix of plagioclase, quartz, minor chlorite; minor carbonate alteration (dolomite or ankerite)
Major element classification: sodic trachyte, sodic alkali basalt series
Trace element classification: andesite, close to border with rhyodacite-dacite

Current no.: 7
Field no.: 90TM101A6 (south of Kulutingwak Anticlinorium)
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: flow; phenocrysts of albite; microfelsitic groundmass of albite, quartz, minor chlorite
Major element classification: sodic trachyte, sodic alkali basalt series
Trace element classification: rhyodacite-dacite, close to border with andesite

Current no.: 8
Field no.: 90TM105A (south of Kulutingwak Anticlinorium)
Analytical report no.: ISPG-92-01.XLS, ERI-2130
Petrography: sheared crystal-lithic tuff or flow breccia; albite, chlorite; quartz and calcite replacement
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: subalkaline basalt

Current no.: 9
Field no.: 90TM129B1 (Kulutingwak Anticlinorium)
Analytical report no.: ERI-2839-9
Petrography: tuff, laminated, phyllitic; albite, quartz, biotite, muscovite, chlorite, minor calcite
Trace element classification: trachyandesite

Current no.: 10
Field no.: 90TM129B2 (Kulutingwak Anticlinorium)
Analytical report no.: ERI-2839-10
Petrography: tuff, laminated, phyllitic; albite, quartz, biotite, muscovite, chlorite, calcite
Trace element classification: trachyandesite

Current no.: 11
Field no.: 90TM129B4 (Kulutingwak Anticlinorium)
Analytical report no.: ERI-2839-11
Petrography: tuff, laminated, phyllitic; mainly albite; minor biotite, muscovite, chlorite, quartz
Trace element classification: trachyte, nearly on border with trachyandesite

Current no.: 12
Field no.: 90TM129B5 (Kulutingwak Anticlinorium)
Analytical report no.: ERI-2839-12
Petrography: tuffaceous sandstone or tuff; albite, fragments of microfelsite, quartz, biotite, muscovite, chlorite
Trace element classification: trachyandesite

Mount Rawlinson Complex (Tables 2-9, 3-9)

Current no.: 1
Field no.: 82TM149B
Analytical report no.: 110-82-1, 86-83-29
Petrography: flow; phenocrysts of albite; microfelsitic matrix of quartz, albite, minor chlorite, muscovite; dolomite alteration
Major element classification: rhyolite, K-poor series
Trace element classification: andesite

Current no.: 2
Field no.: 77TM310E1
Analytical report no.: 57-79-10, 86-83-26
Petrography: tuff with undulating schistosity; crystals of albite and K-feldspar with lesser amounts of quartz and biotite-chlorite in microfelsitic groundmass; veinlets of calcite and quartz
Major element classification: rhyolite, average series
Trace element classification: trachyandesite, close to border with rhyodacite-dacite

Current no.: 3
Field no.: 77TM310E10
Analytical report no.: 57-79-19, 86-83-28
Petrography: tuff or tuffaceous sandstone; crystals of quartz, albite, minor K-feldspar and quartz-feldspar intergrowths; felsic rock fragments; minor chlorite, calcite
Major element classification: rhyolite, K-poor series
Trace element classification: border rhyodacite-dacite/andesite

PEARYA

Succession 2 (Tables 2-10, 3-10)

Map Unit L1

Current no.: 1
Field no.: 82TM134F
Analysis no.: ERI-4157-1
Petrography: flow; phenocrysts and groundmass of albite and quartz; dolomite alteration; if this rock indeed is an andesite, considerable quartz replacement must have occurred
Major element classification: rhyolite, K-poor series
Trace element classification: andesite(?)

Map Unit D1

Current no.: 2a, 2b
Field no.: 88TM124B4
Analysis no.: 67-89-23, 67-89-24
Petrography: crystal-vitric tuff, sheared; albite, chlorite, quartz; calcite veinlets
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: alkali basalt

Current no.: 3a, 3b
Field no.: 88TM124C6
Analysis no.: 67-89-25, 67-89-26
Petrography: sheared crystal vitric tuff (or tuffaceous sediment); albite, quartz, chlorite, minor muscovite
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: alkali basalt

Map Unit M2v

Current no.: 4
Field no.: 77TM218A3
Analysis no.: 56-80-8, 86-83-51
Petrography: flow; phenocrysts and phenocrysts of albite; groundmass of chlorite, feldspar, quartz, epidote; calcite alteration; indistinct schistosity
Major element classification: tholeiitic basalt, K-poor series
Trace element classification: subalkaline basalt

Map unit M4

Current no.: 5
Field no.: 82TM211C
Analysis no.: 110-83-82, 86-83-52
Petrography: metamorphosed flow or welded tuff; microphenocrysts of quartz, albite, and K-feldspar; groundmass of quartz, feldspar and white mica; undulating lamination curves around eye-shaped microphenocrysts
Major element classification: rhyolite, K-rich series
Trace element classification: rhyolite, close to boundary with rhyodacite-dacite

Maskell Inlet Complex (Tables 2-11, 3-11)

Main (western) outcrop belt

Current no.: 1
Field no.: 77TM302C2 (main outcrop area)
Analysis no.: 57-79-14, 86-83-6
Petrography: crystal-lithic tuff; albite, clinopyroxene, chlorite, quartz, prehnite; calcite veinlets
Major element classification: hawaiite, sodic alkali basalt series
Trace element classification: andesite/basalt, nearly on boundary with andesite

Current no.: 2
Field no.: 77TM301C1
Analysis no.: 57-79-13, 86-83-3
Petrography: flow; albite, chlorite, actinolite, epidote, minor calcite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt, nearly on boundary with subalkaline basalt

Current no.: 3
Field no.: 77TM301C2
Analysis no.: 2-82-5, 86-83-4
Petrography: crystal-lithic tuff; albite, chlorite, quartz, epidote, actinolite
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite, nearly on boundary with andesite/basalt

Current no.: 4
Field no.: 77TM302C1
Analysis no.: 10-79-11, 86-83-5
Petrography: crystal-lithic tuff; albite, clinopyroxene, chlorite, quartz
Major element classification: calc-alkaline (high alumina) andesite, K-rich series
Trace element classification: andesite

Current no.: 5
Field no.: 77TM301B1
Analysis no.: 57-79-12, 86-83-1
Petrography: crystal-vitric tuff; albite, chlorite; veinlets of quartz and calcite
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: andesite/basalt

Current no.: 6
Field no.: 77TM233C1
Analysis no.: 10-79-12, 86-83-2
Petrography: crystal-lithic tuff; albite, chlorite, epidote, quartz, K-feldspar(?)
Major element classification: tholeiitic basalt, K-poor series
Trace element classification: andesite/basalt

Current no.: 7
Field no.: 80TM207A1
Analysis no.: 92-80-3, 86-83-7
Petrography: crystal-vitric tuff, laminated; albite, K-feldspar, quartz, chlorite, trace amounts of muscovite; veinlets of quartz and calcite
Major element classification: rhyolite, average series
Trace element classification: andesite

Current no.: 8a, 8b
Field no.: 88TM128E1
Analysis no.: 67-89-45, 67-89-46
Petrography: crystal-vitric tuff; albite, clinopyroxene, chlorite, epidote(?)
Major element classification: hawaiite, sodic alkali basalt series
Trace element classification: andesite/basalt

Current no.: 9a, 9b
Field no.: 88TM128E2
Analysis no.: 67-89-47, 67-89-48
Petrography: crystal-vitric tuff, microcrystalline; albite, clinopyroxene, chlorite, epidote(?)
Major element classification: mugearite, sodic alkali basalt series
Trace element classification: subalkaline basalt

Current no.: 10
Field no.: 88TM118B
Analysis no.: 225-88-3
Petrography: crystal tuff; quartz, albite, chlorite, epidote
Major element classification: calc-alkaline (high alumina) basalt, K-poor series
Trace element classification: subalkaline basalt, near boundary with andesite/basalt. Note: plots outside all fields outlined by Meschede (1986, Fig. 1) and Pearce and Cann (1973, Fig. 3)

Current no.: 11
Field no.: 88TM118C
Analysis no.: 225-88-4
Petrography: crystal tuff, schistose; albite, quartz, chlorite, actinolite, quartz, K-feldspar, epidote
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 12
Field no.: 80TM207D
Analysis no.: 96-83-4
Petrography: amphibolite; andesine, hornblende, quartz, chlorite, mica
Trace element classification: andesite

Current no.: 13
Field no.: 80TM227H1
Analysis no.: 96-83-5
Petrography: flow; phenocrysts of albite; groundmass of albite, actinolite, chlorite; lenses of epidote
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Nunatak east of M'Clintock Inlet

Current no.: 14
Field no.: 77TM237A1
Analysis no.: 10-79-9, 86-83-8
Nunatak east of M'Clintock Inlet, close to M'Clintock East body
Petrography: flow; phenocrysts of clinopyroxene, phenocrysts of albite; groundmass of albite, K-feldspar(?), chlorite, epidote, clinopyroxene, actinolite

Major element classification: calc-alkaline (high alumina) basalt, K-rich series
Trace element classification: andesite/basalt, close to boundary with subalkaline basalt

Current no.: 15
Field no.: 77TM237A2
Analysis no.: 10-79-10, 86-83-9
Petrography: flow; phenocrysts of albite; groundmass of albite, chlorite, epidote
Major element classification: calc-alkaline (high alumina) andesite, K-rich series
Trace element classification: subalkaline basalt, close to boundary with andesite/basalt

Cape Discovery Formation (Tables 2-12, 3-12)

Member A

Current no.: 1
Field no.: 77TM233B4
Analysis no.: 57-79-16, 86-83-12
Petrography: flow or sill; phenocrysts and phenocrysts of albite in groundmass of albite, chlorite, and muscovite; dolomite and quartz alteration
Major element classification: sodic trachyte, sodic alkali basalt series
Trace element classification: alkali basalt, nearly on boundary with trachyandesite

Current no.: 2
Field no.: 66TMB5-1
Analysis no.: 57-79-22, 86-83-10
Petrography: crystal-lithic tuff; quartz, albite, minor muscovite, chlorite
Major element classification: rhyolite, K-rich series
Trace element classification: andesite

Current no.: 3
Field no.: 77TM233B5
Analysis no.: 10-79-13, 86-83-13
Petrography: flow breccia or tuff; fragments consist of microfelsite, with or without phenocrysts of feldspar; some replacement by quartz and carbonates
Major element classification: rhyolite, K-poor series
Trace element classification: trachyte

Current no.: 4
Field no.: 66TMB5-3
Analysis no.: 57-29-23, 86-83-11
Petrography: fragmental volcanic rock, probably tuff; phenocrysts of albite, microfelsitic groundmass; quartz, albite, minor muscovite, chlorite
Major element classification: rhyolite, K-poor series
Trace element classification: rhyolite, nearly on boundary with comendite-pantellerite

Member D

Current no.: 5
Field no.: 65TMF40
Analysis no.: 10-84-10
Petrography: flow; phenocrysts of albite; groundmass of albite, quartz, K-feldspar, minor mica, chlorite
Major element classification: rhyolite, K-poor series
Trace element classification: rhyodacite-dacite

M'Clintock Formation (Tables 2-13, 3-13)

Current no.: 1
Field no.: 65TM3A1
Analysis no.: 56-80-4, 86-83-16
Petrography: flow, aphyric; mainly albite, chlorite; quartz, calcite, sericite alteration
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: alkali basalt

Current no.: 2
Field no.: 80TM225C4
Analysis no.: 92-80-7, 86-83-21
Petrography: lithic-crystal tuff; albite, chlorite, clinopyroxene; some quartz replacement; amygdules in lithic fragments contain quartz, chlorite, calcite
Major element classification: tholeiitic basalt, K-rich series
Trace element classification: subalkaline basalt

Current no.: 3
Field no.: 65TM2D2
Analysis no.: 56-80-3, 86-83-15
Petrography: vitric-lithic tuff; albite, chlorite, epidote, K-feldspar(?); quartz, sericite, minor calcite alteration; amygdules contain chlorite and quartz
Major element classification: tholeiitic basalt, K-rich series
Trace element classification: andesite/basalt

Current no.: 4
Field no.: 65TM2D1
Analysis no.: 56-80-2, 86-83-14
Petrography: vitric-crystal tuff, laminated; albite, chlorite, epidote, K-feldspar(?); quartz, minor calcite alteration
Major element classification: calc-alkaline (high-alumina) basalt, K-rich series
Trace element classification: andesite/basalt

Current no.: 5
Field no.: 79TM218C2
Analysis no.: 100-79-6, 86-83-19
Petrography: flow, albite, chlorite, minor clinopyroxene, K-feldspar(?), epidote; veinlets of quartz and calcite; amygdules contain quartz, albite, calcite

Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 6
Field no.: 79TM218C4
Analysis no.: 100-79-7, 86-83-20
Petrography: flow or sill, amygdaloidal; albite, chlorite, clinopyroxene; veinlets and amygdales contain chlorite and calcite; minor quartz alteration
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 7
Field no.: 77TM315E1
Analysis no.: 10-79-8, 86-83-17
Petrography: fragmental, lithic tuff or flow breccia; albite, chlorite, minor clinopyroxene; quartz and calcite veinlets and replacements
Major element classification: calc-alkaline (high alumina) basalt, K-rich series
Trace element classification: andesite/basalt

Current no.: 8
Field no.: 79TM211D1
Analysis no.: 100-79-1, 86-83-18
Petrography: amygdaloidal flow; albite, chlorite; veinlets and amygdales filled with calcite, chlorite, quartz
Major element classification: tholeiitic picrite basalt, K-poor series
Trace element classification: andesite/basalt

Current no.: 9
Field no.: 80TM228A2
Analysis no.: 92-80-9, 86-83-22
Petrography: flow; phenocrysts of albite and clinopyroxene, groundmass of albite and chlorite, minor epidote, trace amounts of prehnite; veinlets of chlorite, quartz, albite
Major element classification: hawaiite, sodic alkali basalt series
Trace element classification: andesite/basalt

Current no.: 10
Field no.: 80TM228B1
Analysis no.: 92-80-10, 86-83-23
Petrography: crystal-lithic tuff; lithic fragments are felsic; albite, quartz, chlorite; veinlets of calcite and quartz
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: andesite

Current no.: 11a, 11b
Field no.: 88TM127C1
Analysis no.: 67-89-27, 67-89-28
Petrography: flow; phenocrysts of feldspar in groundmass of microfelsite; quartz, albite, minor K-feldspar; veinlets of dolomite
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: rhyodacite/dacite

Current no.: 12a, 12b
Field no.: 88TM127C2
Analysis no.: 67-89-29, 67-89-30
Petrography: flow, tectonically fragmented; phenocrysts of feldspar in groundmass of microfelsite; quartz, albite, minor K-feldspar, chlorite; minor calcite, epidote alteration
Major element classification: rhyolite, K-poor series
Trace element classification: trachyandesite

Current no.: 13a, 13b
Field no.: 88TM127C3
Analysis no.: 67-89-31, 67-89-32
Petrography: flow(?), tectonically fragmented; phenocrysts of albite; groundmass mainly albite and chlorite; chlorite and epidote veinlets and replacements; sericite common
Major element classification: not possible, high MgO K-rich series
Trace element classification: trachyandesite

Current no.: 14a, 14b
Field no.: 88TM127C4
Analysis no.: 67-89-33, 67-89-34
Petrography: flow; phenocrysts of feldspar; groundmass of albite, chlorite, K-feldspar (?); epidote veinlets and replacements, sericite and some quartz alteration
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite

Current no.: 15a, 15b
Field no.: 88TM127C5
Analysis no.: 67-89-35, 67-89-36
Petrography: crystal tuff, sheared; albite, chlorite, epidote; quartz veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: subalkaline basalt, nearly on border with andesite/basalt

Current no.: 16a, 16b
Field no.: 88TM127C6
Analysis no.: 67-89-37, 67-89-38
Petrography: flow, tectonically fragmented; albite, chlorite; veinlets and replacements by quartz and epidote; sericite common
Major element classification: calc-alkaline dacite, K-poor series
Trace element classification: trachyandesite

Current no.: 17a, 17b
Field no.: 88TM127C7
Analysis no.: 67-89-39, 67-89-40
Petrography: flow; phenocrysts of feldspar; albite, minor K-feldspar, chlorite; quartz veinlets and replacements common
Major element classification: rhyolite, K-poor series
Trace element classification: trachyandesite

Current no.: 18a, 18b
Field no.: 88TM127D1
Analysis no.: 67-89-41, 67-89-42
Petrography: crystal-vitric tuff; albite, chlorite, minor K-feldspar, epidote; quartz and calcite veinlets and replacements common
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: andesite/basalt

Current no.: 19a, 19b
Field no.: 88TM127D2
Analysis no.: 67-89-43, 67-89-44
Petrography: crystal-lihic tuff; mainly albite, chlorite, minor epidote, actinolite(?); quartz, chlorite, calcite veinlets and replacements
Major element classification: calc-alkaline (high alumina) andesite, K-poor series
Trace element classification: subalkaline basalt

Current no.: 20
Field no.: 79TM213A3
Analysis no.: 100-79-4
Petrography: crystal-lithic tuff; mainly albite, minor chlorite, epidote, hematite
Major element classification: mugearite, sodic alkali basalt series

Current no.: 21
Field no.: 80TM205D1
Analysis no.: 92-80-5
Petrography: flow; albite, K-feldspar, chlorite, minor mica (mainly biotite); veinlets and replacments of quartz, calcite, chlorite
Major element classification: calc-alkaline (high alumina) andesite, average series

Current no.: 22
Field no.: 80TM225C3
Analysis no.: 92-80-6
Petrography: flow; phenocrysts of albite, quartz and biotite in microfelsitic groundmass with spherulitic texture; albite shows chessboard twinning (albitized K-feldspar); veinlets with quartz and mica
Major element classification: rhyolite, K-poor series

Current no.: 23
Field no.: 65TM2C1
Analysis no.: from Trettin, 1969b, p. 83
Petrography: tuff, mainly lithic; lithic fragments have phenocrysts of albite, K-feldspar and chlorite
Major element classification: calc-alkaline dacite, average series

Appendix 4A

Table 2

Standard chemical analyses

Table 2-1. Jaeger Lake Formation

No.	1	2	3	4a	4b	5a	5b	6a	6b	7a	7b
SiO_2	43.5	46.0	48.6	46.8	46.8	51.2	51.0	52.5	53.1	48.6	48.7
Al_2O_3	15.1	15.9	17.3	14.1	14.1	14.4	14.4	13.0	13.0	13.8	13.8
TiO_2	3.5	1.05	0.74	2.02	2.03	1.65	1.65	2.26	2.27	2.53	2.56
Fe_2O_3	5.5	10.0	5.3	5.4	5.3	5.9	6.0	6.2	6.2	5.2	5.1
FeO	4.0	3.0	4.5	12.0	12.0	8.5	8.4	5.8	5.8	9.7	9.9
MnO	0.16	0.09	0.07	0.28	0.27	0.02	0.22	0.14	0.14	0.23	0.23
MgO	6.55	7.97	8.65	8.16	8.25	7.69	7.73	6.32	6.31	6.61	6.59
CaO	5.78	6.41	1.67	6.80	6.80	4.73	4.74	6.51	6.52	6.85	6.84
Na_2O	2.0	2.3	4.9	3.18	3.11	5.48	5.34	3.79	3.75	4.70	4.66
K_2O	3.11	1.06	0.90	1.02	1.02	0.24	0.25	1.01	0.99	0.16	0.16
P_2O_5	1.18	0.03	0.09	0.24	0.24	0.20	0.21	0.41	0.34	0.28	0.29
CO_2	5.0	1.0	1.3	0.0	0.1	0.1	0.1	1.6	1.6	1.4	1.3
H_2O	5.0	5.4	5.5								
Total	100.4	100.2	99.5	100.0	100.0	100.1	100.0	99.5	100.0	100.1	100.1
As ppm	9.5	8.5	5.5	0	0	0	15	0	5	0	0
B	33	28	21								
Ba	890	120	170	970	190	250	360	290	270	140	30
Be											
Br	3.5	2.5	2.0	0	0	0	0	0	0	0	1
Co	30	59	56								
Cr	230	800	270								
Cu	10	150	29								
La	58	45	<30								
Mo	0	1	2	1	3	3	2	3	2	4	4
Nb	59	4.5	3.5	7	8	9	8	11	10	10	13
Ni	80	240	160								
Pb	12	15.5	9.5								
Rb	48	12.5	15	8	7	0	2	10	10	0	0
Sr	139.5	235	93.5	32	34	25	27	65	70	57	56
Th	4.5	4.5	1.5	0	0	0	0	0	0	0	0
U	2.5	0	0	0	0	0	1	0	0	0	0
V	190	140	190								
Y	18.5	12.5	12.5	53	55	45	46	75	81		
Yb	3.2	<2	<2							70	74
Zn	70	120	93								
Zr	259	53.5	42.5	98	97	95	94	130	140	130	140

Table 2-2. Svartevaeg Formation, Member A (no trace element analyses)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SiO_2	42.56	55.53	52.73	49.58	32.32	53.87	51.86	55.94	57.18	51.36	54.90	50.53	46.20	52.35	53.75	41.31	51.34	56.16	54.02	57.6
Al_2O_3	19.19	16.34	19.43	17.63	17.69	16.87	17.22	16.58	16.78	16.52	17.39	15.92	18.01	17.83	17.50	19.34	16.39	17.49	16.54	17.3
TiO_2	0.83	0.68	0.75	0.82	0.87	0.73	0.68	0.67	0.97	1.28	0.63	0.88	1.12	1.08	1.03	0.63	0.92	0.65	0.70	0.71
Fe_2O_3	5.05	4.86	3.42	3.60	2.88	3.51	3.45	3.01	2.12	5.43	3.43	5.13	3.20	1.88	1.82	2.80	3.24	3.53	6.50	1.4
FeO	6.2	2.7	2.3	6.1	5.1	5.0	5.0	4.7	4.5	5.6	4.4	6.4	8.0	4.5	4.9	4.8	6.5	3.9	1.2	5.9
MnO	0.21	0.10	0.10	0.16	0.13	0.16	0.16	0.16	0.16	0.15	0.15	0.16	0.13	0.12	0.16	0.23	0.23	0.13	0.10	0.16
MgO	4.42	1.57	1.65	4.20	2.63	3.34	2.60	3.85	2.48	3.02	2.69	3.99	5.03	1.55	2.00	2.99	4.47	3.31	1.14	4.2
CaO	8.99	5.71	7.43	6.80	7.05	6.19	7.24	6.23	5.28	7.39	6.00	8.66	8.58	12.33	9.28	12.07	5.89	2.76	5.77	2.1
Na_2O	3.45	6.27	5.49	3.78	3.92	3.05	5.11	3.35	4.44	3.52	3.77	2.16	2.51	2.80	3.17	3.18	4.23	7.46	8.89	4.5
K_2O	0.79	1.07	2.12	1.13	2.55	2.61	1.14	0.81	2.36	0.77	2.57	0.69	0.94	0.03	1.29	2.66	0.88	0.29	0.10	2.6
P_2O_5	0.15	0.16	0.21	0.18	0.29	0.22	0.22	0.19	0.38	0.22	0.19	0.18	0.14	0.40	0.35	0.26	0.23	0.16	0.21	0.18
CO_2	1.95	2.22	2.1	1.04	1.04	0.77	3.66	0.64	0.86	0.67	0.84	1.08	0.96	0.43	0.87	5.69	1.37	1.44	3.94	
H_2O																				3.6
l.o.i.	4.54	1.8	2.23	3.5	2.82	3.17	0.18	2.78	2.25	2.67	2.37	2.39	3.36	3.74	2.59	3.27	3.49	2.39	1.01	
Total	98.33	99.01	99.96	98.52	99.29	99.49	98.52	98.91	99.76	98.60	99.33	98.17	98.18	99.04	93.71	99.23	99.18	99.67	100.12	100.2

Table 2-3. Svartevaeg Formation, Member B, conglomerate clasts

No.	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	52.73	56.10	52.44	55.77	56.12	56.02	56.68	48.43	59.17	67.29	54.85	57.76
Al_2O_3	17.93	14.98	16.38	16.79	14.82	16.10	16.87	15.31	15.93	11.94	15.68	16.57
TiO_2	0.50	0.37	0.72	0.63	0.45	0.90	0.50	1.35	0.68	0.60	0.47	0.67
Fe_2O_3	1.92	1.38	2.35	1.66		1.70	1.56	3.29	1.51	0.90	1.60	1.61
FeO	6.2	6.5	5.8	5.2	8.6	5.1	4.8	4.6	4.6	3.6	5.4	4.7
MnO	0.13	0.12	0.13	0.11	0.11	0.13	0.10	0.08	0.11	0.07	0.12	0.11
MgO	3.75	5.10	4.59	4.24	4.73	3.64	4.04	3.15	4.07	2.46	4.90	4.13
CaO	4.27	4.22	6.11	2.71	5.33	4.58	4.98	13.72	3.58	3.92	4.37	3.78
Na_2O	5.72	3.31	3.81	6.86	2.75	5.64	4.07	1.98	4.19	4.14	4.72	4.36
K_2O	0.99	1.11	1.11	0.22	0.66	0.28	1.10	0.06	0.80	0.16	0.47	0.78
P_2O_5	0.25	0.08	0.19	0.20	0.08	0.23	0.10	0.32	0.16	0.22	0.10	0.15
CO_2	1.21	2.15	0.98	1.46	2.49	1.47	0.93	2.08	1.22	0.92	2.11	1.45
H_2O												
l.o.i	2.61	2.44	3.49	2.58	1.76	2.80	2.78	3.85	2.61	2.13	3.32	2.76
Total	98.21	97.86	98.10	98.43	97.90	98.59	98.51	98.22	98.63	98.35	98.11	98.83

Table 2-4. Svartevaeg Formation, Member B, strata

No.	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	54.81	49.83	63.14	52.23	54.59	45.70	53.74	56.03	49.41	53.73	52.33	52.1
Al_2O_3	11.54	19.51	15.77	19.06	17.40	15.57	18.79	16.71	18.47	17.71	16.20	19.0
TiO_2	0.45	0.43	0.25	0.50	0.48	0.50	0.52	0.40	0.58	0.43	0.57	1.01
Fe_2O_3	2.46	2.91	2.54	2.47	2.29	2.06	2.29	2.46	3.06	2.28	3.59	2.8
FeO	4.4	5.5	2.4	6.4	5.9	4.4	4.9	4.0	6.1	5.4	5.3	3.4
MnO	0.13	0.15	0.09	0.14	0.14	0.20	0.14	0.15	0.21	0.18	0.20	0.09
MgO	3.20	4.36	1.68	3.93	5.31	2.75	4.60	3.65	4.21	3.65	4.21	2.1
CaO	8.71	4.20	5.86	4.29	2.19	10.61	2.53	4.98	5.62	5.11	7.08	11.8
Na_2O	4.57	5.40	4.92	3.64	4.38	1.98	3.79	5.12	3.99	4.53	3.86	3.8
K_2O	0.39	0.86	0.15	1.14	0.79	3.53	2.45	0.77	1.29	1.20	0.83	0.3
P_2O_5	0.14	0.14	0.11	0.16	0.15	0.22	0.24	0.10	0.19	0.12	0.14	0.39
CO_2	0.86	1.10	0.48	0.99	0.66	7.21	0.60	1.54	1.37	1.45	0.97	0.3
H_2O												3.7
l.o.i	2.73	2.94	1.33	2.94	3.56	3.00	3.59	2.51	3.11	2.68	2.72	
Total	100.39	97.33	98.72	97.84	97.84	97.73	98.18	98.42	97.61	98.47	98.00	100.8

Table 2-5. Yelverton Formation

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SiO_2	43.3	46.2	46.9	48.2	48.4	48.7	51.5	35.4	45.8	46.4	46.7	46.9	47.1	47.3	48.2	48.3	48.7	50.9
Al_2O_3	12.8	16.1	15.0	14.8	13.4	12.5	14.6	10.6	14.5	13.2	13.4	14.7	13.9	15.0	14.3	13.9	14.5	13.3
TiO_2	2.11	1.67	1.43	1.40	1.65	2.57	3.84	3.69	1.59	1.89	4.43	2.28	2.25	1.65	1.62	1.60	1.68	2.22
Fe_2O_3	2.7	2.7	0.0	5.0	2.9	2.4	3.5	11.9	3.9	3.1	3.4	3.1	7.0	3.1	2.2	3.2	2.2	4.8
FeO	10.1	8.9	10.4	6.2	9.2	12.0	9.1	13.3	9.0	7.1	12.0	7.0	4.6	8.9	10.0	8.6	9.8	5.9
MnO	0.31	0.21	0.16	0.19	0.22	0.22	0.13	0.25	0.20	0.14	0.38	0.13	0.19	0.20	0.20	0.21	0.23	0.18
MgO	6.21	6.34	8.72	7.37	8.28	6.46	3.44	7.73	6.40	7.17	5.06	5.38	7.03	6.73	7.47	7.13	6.67	5.81
CaO	8.84	12.6	8.40	9.38	8.47	8.62	2.22	7.60	11.9	12.26	3.89	10.72	9.63	12.7	7.97	11.5	7.70	12.07
Na_2O	2.6	2.2	2.7	2.8	2.6	2.5	5.2	1.90	2.0	0.8	3.2	4.0	2.6	1.8	3.6	1.9	3.6	2.3
K_2O	0.12	0.13	0.69	0.49	0.29	0.37	0.1	0.57	0.10	0.95	0.44	0.79	0.43	0.12	0.23	0.13	0.34	0.35
P_2O_5	0.19	0.14	0.10	0.09	0.13	0.23	0.43	0.47	0.14	0.12	0.90	0.27	0.20	0.15	0.14	0.13	0.13	0.26
CO_2	6.4	0.4	0.9	0.1	0.3	0.1	1.3	0.1	0.3	2.4	1.1	1.6	0.5	0.1	0.7	0.2	0.1	0.4
H_2O	4.8	2.7	4.2	4.0	3.7	3.9	4.2	4.8	3.4	4.7	4.6	3.4	4.5	2.7	3.9	3.2	3.4	2.4
Total	100.4	100.2	99.6	100.1	99.6	100.6	99.4	98.4	99.2	100.3	99.5	100.3	99.9	100.5	100.5	99.9	99.0	101.0

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
As	ppm	7.5	22.5	5.5	16.5	14	7	12	<2000	<1500	<2000	<2000	<2000	<2000	<1500	<1500	<1500	<1500	<2000
B		<15	22	<50	<50	15	<50			<15	<15	<50			16	<15	17	27	<50
Ba		27	28	540	130	31	99	54	74	14	280	120	290	57	22	29	27	54	80
Be																			
Br		0.5	2	6.5	11	0.5	6	12											
Co		40	50	52	43	48	41	43	60	35	52	53	45	55	49	49	52	60	43
Cr		92	250	240	160	220	41	62	61	200	460	30	250	270	220	310	330	220	350
Cu		140	190	150	180	1000	250	7	26	130	130	20	86	40	180	160	120	280	86
La		35	33	<100	<100	<30	<100	31	40	<30	<30	<100	38	<30	31	37	32	44	<100
Mo		0	0	2.5	1.5	0	0	1.5	<50	<30	<50	<50	50	<50	<30	<30	<30	<30	<50
Nb		1.5	1.5	4	3.5	1.5	4.5	24.5											
Ni		63	100	98	94	100	58	78	46	81	150	59	110	160	96	120	120	110	140
Pb		11	18.5	16.5	17.5	13	13	15	<700	<300	<700	<700	<700	<700	<300	<300	<300	<300	<700
Rb		0	0.5	9	7	4.5	3.5	3	<20	10	<20	<20	<20	<20	<20	30	<20	20	<20
Sr		147.5	309	260.5	454.5	95	315	105	69	100	310	310	270	520	380	220	230	78	280
Th		0	8	4	8	1.5	2.5	4											
U		0	0	0	0	0.5	0	3.5											
V		280	390	330	320	380	440	280	310	330	140	330	220	210	370	330	350	450	250
Y		31	25.5	22	26.5	29.5	41	39.5	43	26	15	46	31	21	27	28	27	34	<40
Yb		<2	<2	5.9	5.9	<2	7.3	5.5	<3	<2	2.2	13	3.5	3.5	<2	<2	<2	<2	<4
Zn		120	90	90	80	60	50	100	200	100	100	130	100	100	100	90	150	100	70
Zr		104.5	83.5	70	76.5	73.5	138.5	273	280	60	110	480	190	130	70	60	80	70	140

Table 2-6. Fire Bay Formation (no trace element analyses)

No.	1	2	3	4	5	6a	6b	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SiO_2	47.64	47.60	70.47	48.68	80.89	69.3	69.5	81.2	84.45	79.60	72.54	50.73	41.84	18.17	44.85	43.96	47.11	42.78	35.26	56.79	59.55
Al_2O_3	17.88	16.91	13.88	13.37	11.14	14.5	14.4	7.0	8.51	10.62	10.53	16.99	15.09	16.55	16.57	15.62	16.49	15.70	12.48	16.94	17.54
TiO_2	0.65	0.42	0.18	0.48	0.29	0.37	0.36	0.24	0.25	0.25	0.33	1.12	1.83	1.13	0.16	1.83	2.17	1.65	1.10	0.37	0.57
Fe_2O_3	2.21	2.53	0.63	1.46	0.10	0.8	0.8	3.4	0.31			1.38	2.21	1.49	2.02	2.19	1.63	1.70	1.00	1.33	0.19
FeO	7.3	5.8	2.7	4.5	1.82	2.4	2.4		1.4	1.9	5.0	5.0	7.0	4.1	7.7	7.0	6.6	8.2	5.33	3.58	1.22
MnO	0.13	0.16	0.03	0.12	0.03	0.04	0.04	0.03	<0.01	0.02	0.09	0.10	0.14	0.08	0.16	0.13	0.13	0.15	0.12	0.08	0.12
MgO	7.17	7.53	1.69	6.12	0.20	2.06	2.07	1.50	0.54	0.59	2.79	1.95	3.14	1.31	3.79	3.47	3.07	3.69	2.28	3.82	0.89
CaO	2.65	3.33	0.64	6.14	1.10	0.75	0.75	0.38	0.23	0.50	0.89	8.27	11.52	12.11	8.73	9.86	8.16	9.38	20.44	6.72	6.78
Na_2O	4.71	3.90	6.44	4.91	2.64	5.2	5.2	1.4	4.68	5.67	2.18	7.23	5.12	6.78	5.37	5.66	6.25	5.38	4.16	4.18	6.55
K_2O	1.29	2.87	0.82	1.19	0.04	2.21	2.23	1.45	0.05	0.12	1.44	0.35	0.55	0.09	0.57	0.74	0.74	0.50	0.31	0.43	0.64
P_2O_5	0.28	0.10	0.05	0.16	0.04	0.08	0.08	0.05	0.10	0.13	0.10	0.52	0.32	0.50	0.37	0.37	0.40	0.36	0.36	0.05	0.38
CO_2	0.77	2.03	0.96	8.14	0.60	0.4	0.4	0.5	0.86	1.87	0.96	3.36	5.97	5.16	3.49	5.59	4.24	5.25	15.06	2.16	6.02
H_2O						2.2	2.2	2.3													
l.o.i.	4.09	4.61	0.88	2.95	0.30				0.21		2.48	2.35	3.23	2.14	3.18	2.84	2.58	3.40	1.29	2.74	
Total	96.77	97.79	99.37	98.22	99.19	100.4	100.5	99.5	101.59	101.27	99.33	99.35	97.96	99.61	96.96	99.26	99.57	98.14	99.19	99.19	100.45

Table 2-7. Map unit OSv

No.	1	2	3	4
SiO_2	52.4	57.4	54.08	54.39
Al_2O_3	14.7	16.5	14.60	16.53
TiO_2	0.74	0.55	0.61	0.68
Fe_2O_3	2.5	3.4	1.78	4.30
FeO	4.5	2.0	4.18	2.31
MnO	0.17	0.10	0.14	0.11
MgO	3.76	1.87	3.53	3.83
CaO	8.60	4.68	8.36	4.57
Na_2O	4.4	5.5	2.93	4.47
K_2O	2.81	4.47	2.95	4.07
P_2O_5	0.28	0.25	0.55	0.72
CO_2	3.5	1.3	3.59	1.47
H_2O	1.9	1.5		
l.o.i.			1.81	1.63
Total	100.3	99.7	99.11	99.08
As ppm	9	8.5		
B		30		
Ba	1500	2600	1200	1700
Be				
Br	1.5	2		
Co	18	11		
Cr	26	49		
Cu	30	31		
La	66	55		
Mo	0	0		
Nb	9	13.5		
Ni	12	25		
Pb	20.5	19		
Rb	67	102.5		
Sr	358	445		
Th	19	39		
U	1.5	8		
V	140	100		
Y	23	16.5		
Yb	2.4	1.5		
Zn	100	<200		
Zr	137	184.5		

Table 2-8. Kulutingwak Formation, Member A

No.	1a	1b	2a	2b	3	4	5	6	7	8
SiO_2	47.7	47.7	51.5	51.9	58.41	58.04	47.01	59.09	60.46	46.73
Al_2O_3	18.11	18.2	17.5	17.4	16.63	16.69	15.28	17.45	17.64	16.88
TiO_2	0.59	0.59	0.56	0.55	0.39	0.35	0.38	0.33	0.32	0.45
Fe_2O_3	4.8	4.7	2.8	2.8	0.79	1.42	0.66	1.50	1.26	5.63
FeO	6.7	6.7	5.9	5.9	3.25	2.98	7.91	5.52	5.80	5.76
MnO	0.19	0.19	0.16	0.16	0.19	0.11	0.23	0.03	0.01	0.11
MgO	6.32	6.25	5.01	4.97	2.06	1.68	5.18	1.76	1.10	4.90
CaO	7.04	6.98	7.79	7.73	4.01	7.00	8.80	1.46	0.46	6.49
Na_2O	4.6	4.5	5.0	4.9	5.04	5.36	4.07	9.39	10.36	3.52
K_2O	0.53	0.54	0.75	0.75	2.73	1.49	0.25	0.38	0.25	0.76
P_2O_5	0.12	0.12	0.11	0.11	0.44	0.22	0.11	0.16	0.16	0.07
CO_2	0.0	0.0	0.5	0.5	4.22	2.63	5.19	0.99	0.18	4.22
H_2O	4.0	4.0	2.6	2.6						
l.o.i.					0.88	1.17	2.81	1.11	1.32	3.18
Total	100.6	100.5	100.3	100.4	99.04	99.14	97.88	99.17	99.32	98.70
As ppm										
B										
Ba	573	540	512	531	1900	540	180	130	180	270
Be	1.5	1.5	1.6	1.6						
Br										
Co	36	36	30	31						
Cr	36	32	36	33						
Cu	73	76	72	73						
La	21	22	22	21						
Mo										
Nb	20	8	13	16						
Ni	31	34	32	32						
Pb										
Rb	29	53	54	60						
Sr	537	541	657	669						
Th										
U										
V	260	260	250	250						
Y	14	13	13	13						
Yb	0.6	0.6	0.7	0.7						
Zn	87	86	67	78						
Zr	90	90	95	100						

Table 2-9. Mount Rawlinson Complex

No.	1	2	3
SiO_2	60.7	61.7	75.6
Al_2O_3	15.6	16.1	10.25
TiO_2	0.39	0.48	0.42
Fe_2O_3	0.25	3.6	1.1
FeO	3.7	0.9	2.4
MnO	0.08	0.53	0.05
MgO	3.40	0.91	1.53
CaO	2.85	2.19	0.91
Na_2O	3.2	4.8	4.3
K_2O	2.09	5.79	0.23
P_2O_5	0.14	0.24	0.05
CO_2	4.9	1.5	0.8
H_2O	2.9	1.1	2.2
l.o.i.			
Total	100.3	99.8	99.9
As ppm	15	11.5	12.5
B	58	30	30
Ba	470	1700	95
Be			
Br	2	1	4
Co	11	10	9
Cr	93	19	13
Cu	8	18	8
La	51	86	<30
Mo	0	0	2
Nb	1.5	15	4.5
Ni	14	<10	<10
Pb	<300	17	5.5
Rb	35	103	8
Sr	141	230	107
Th	8	20	11
U	3.5	5	7
V	74	98	79
Y	19	20	7
Yb	<2	1.5	27.5
Zn	70	<200	<200
Zr	125.5	233	138.5

Table 2-10. Pearya, Succession 2

No.	1	2a	2b	3a	3b	4	5
SiO_2	63.93	49.4	49.5	56.4	56.3	45.4	74.6
Al_2O_3	9.66	15.6	15.5	18.4	18.5	14.5	12.3
TiO_2	0.22	2.66	2.64	0.77	0.79	2.82	0.18
Fe_2O_3	1.27	2.4	2.5	1.9	1.8	4.6	1.1
FeO	3.00	9.7	9.7	5.4	5.4	8.5	<0.03
MnO	0.08	0.15	0.16	0.06	0.06	0.14	0.03
MgO	2.04	5.91	5.84	4.64	4.61	5.33	0.31
CaO	4.49	3.69	3.68	0.80	0.80	6.82	1.54
Na_2O	4.19	4.5	4.5	5.6	5.5	2.5	3.2
K_2O	0.55	0.03	0.03	1.76	1.74	0.05	4.48
P_2O_5	0.08	0.28	0.28	0.21	0.21	0.69	0.04
CO_2	7.83	1.2	1.2	0.6	0.6	3.0	2.0
H_2O		4.8	4.8	3.9	3.9	4.6	0.8
l.o.i.	0.1						
Total	97.44	100.4	100.3	100.5	100.2	99.0	100.6
As ppm						14.5	5
B						<50	21
Ba		114	85	347	301	21	290
Be		1.0	0.9	1.2	1.2		
Br						4	1.5
Co		36	36	17	16	24	<7
Cr		89	110	66	71	96	290
Cu		51	43	22	14	58	8
La		13	13	19	18	<100	53
Mo						2.5	1
Nb		43	38	26	25	23	25
Ni		61	60	42	40	48	<10
Pb						20.5	8.5
Rb		19	0	55	59	0.5	118
Sr		480	488	68	75	273	82
Th						7.5	42.5
U						0	7.5
V		300	290	200	190	210	<10
Y		25	24	28	28	50.5	34
Yb		1.2	1.1	2.6	2.5	9.1	3.9
Zn		120	110	84	73	100	<20
Zr		171	169	110	106	232.5	155.5

Table 2-11. Maskell Inlet Complex

	1	2	3	4	5	6	7	8a	8b	9a	9b	10	11	12	13	14	15
SiO_2	48.6	50.1	51.8	54.2	54.9	55.6	60.1	45.8	45.8	51.3	51.3	44.9	53.9	56.2	50.6	49.9	47.5
Al_2C_3	16.9	16.5	17.0	17.4	16.3	14.9	15.4	16.5	16.5	16.6	16.5	16.8	14.8	17.5	16.1	15.1	18.9
TiO_2	1.02	0.96	0.99	0.90	0.71	1.24	0.89	0.99	1.01	0.70	0.70	1.06	1.30	1.09	1.30	0.79	0.90
Fe_2O_3	6.0	3.9	6.3	1.0	0.8	3.6	3.4	4.7	4.5	2.9	2.9	9.5	4.0	1.4	3.1	7.4	9.1
FeO	3.0	6.6	4.6	6.5	5.6	6.4	3.7	6.6	6.6	5.1	5.1	2.5	8.0	5.4	6.3	3.9	2.5
MnO	0.17	0.19	0.21	0.16	0.18	0.27	0.30	0.16	0.16	0.16	0.16	1.21	0.21	0.17	0.26	0.36	0.26
MgO	3.66	5.73	4.44	4.27	3.48	4.29	2.73	7.12	7.05	4.47	4.44	7.82	4.75	4.70	8.95	8.13	6.19
CaO	9.54	6.35	4.15	4.60	4.66	5.32	1.57	6.51	6.46	6.66	6.65	8.53	3.83	5.80	3.48	3.11	1.42
Na_2O	4.0	4.2	4.7	3.5	6.8	3.0	3.5	4.0	4.0	6.1	6.0	1.7	5.6	4.4	4.5	2.4	2.1
K_2O	1.59	1.02	0.77	3.28	0.31	0.42	3.5	0.94	0.93	0.47	0.48	0.02	0.09	0.80	0.73	4.72	5.72
P_2O_5	0.29	0.12	0.10	0.32	0.13	0.17	0.16	0.20	0.20	0.14	0.15	0.20	0.18	0.19	0.14	0.23	0.28
CO_2	0.3	0.4	0.2	0.3	3.5	0.2	1.2	0.1	0.1	0.9	0.9	1.5	0.7	0.0	0.1	0.1	0.1
H_2O	4.4	4.7	4.2	3.5	3.3	4.6	3.5	6.8	6.8	4.8	4.8	4.6	3.1	1.6	3.6	3.9	5.4
Total	99.5	100.8	99.5	100.0	100.7	100.0	100.1	100.4	100.2	100.4	100.2	100.3	100.5	99.3	99.2	100.0	100.4
As ppm	21	14	9	0.5	4.5	6.5	2							8	7	32	26
B			<50	<50		<50	<50									<50	58
Ba	800	230	87	1430	80	300	620	1136	1123	334	320	74	105			2000	3100
Be								1.2	1.2	1.1	1.1	0.9	0.7				
Br	3	4.5	7	7.5	3	6.5	4							4	8	10	5
Co	23	24	27	38.3	17	42	13	44	45	37	38	51	32			58	37
Cr	25	55	7	47	58	22	15	41	49	41	45	100	20			30	27
Cu	110	220	57	110	67	80	28	110	110	130	140	35	120			26	16
La	58	<30	<100	110	<30	<100	<100	7	8	6	6	27	7			<100	<100
Mo	1.5	3	1.5	1	0.5	1	0							0	2	3.5	3
Nb	4.5	2	3.5	10	2	5	6	0	1	9	3	21	8	5	3	1	3
Ni	19	22	<10	40	31	25	12	39	41	37	40	76	14			37	29
Pb	20	19	10	45	4	13.5	16.5							5	0	18	21.5
Rb	33.5	7.5	9	77	2.5	6	63.5	48	50	34	41	13	27	26	20	75.5	215.5
Sr	274.5	119.5	93	976	229	157	265	964	969	861	865	274	66	200	170	193.5	410
Th	16.5	4.5	3.5	30.5	4.5	6	15.5							14	8	6.5	4
U	3.5	1.5	1	0	0	3.5	3.5							8	7	1.5	1
V	330	340	250	220	190	300	110	190	190	260	260	570	310			180	350
Y	27.5	21.5	40.5	22	24.5	37.5	44	15	15	11	12	68	32	27	26	16.5	18
Yb	4	4.3	6.2	<4	2.9	<4	5.4	0.9	1.0	0.6	0.6	2.3	3.1			<4	<4
Zn	100	100	70	80	<200	110	90	86	7.6	59	63	88	110			180	140
Zr	118	49.5	115.5	180.5	73	103.5	223	83	87	69	68	94	141	180	78	43	42.5

Appendix 4A

Table 2-12. Cape Discovery Formation

No.	1	2	3	4	5
SiO_2	55.6	74.2	79.5	80.9	64.9
Al_2O_3	19.0	13.2	11.4	9.8	15.2
TiO_2	1.72	0.23	0.16	0.12	0.86
Fe_2O_3	3.3	0.6	1.5	0.0	5.5
FeO	2.4	2.1	0.3	1.6	1.0
MnO	0.07	0.01	0.02	0.01	0.08
MgO	0.88	1.23	0.22	0.78	0.99
CaO	1.93	0.03	0.42	0.14	0.87
Na_2O	8.8	1.0	4.1	3.1	5.0
K_2O	0.76	3.16	1.52	1.23	3.11
P_2O_5	0.65	0.01	0.01	0.00	0.26
CO_2	1.4	0.0	0.7	0.0	0.4
H_2O	2.8	3.3	1.1	1.3	1.1
Total	99.4	99.0	100.9	98.9	99.4
As ppm	10.5	6	9.5	11	0
B		30	<50	<50	
Ba	70	190	77.5	80	730
Be					
Br	4	0.5	3	3.5	4
Co	8	<7	<10	<7	
Cr	10	9	<5	14	
Cu	6	10	<7	13	
La	87	60	<100	37	
Mo	0	0	0	0	0
Nb	59.5	54	121	36.5	6
Ni	<10	<10	<10	<10	<3000
Pb	8.5	9.5	7	10.5	0
Rb	33	145	65.5	59.5	49
Sr	136.5	59.5	77.5	242.5	68
Th	10	31	33	30	14
U	4	11.5	13.5	5.5	8
V	140	12	20	<10	
Y	48	163.5	65	63.5	71
Yb	4.2	9	7.4	3.2	
Zn	<200	100	20	<200.0	<200
Zr	377	524.5	777	338	470

Table 2-13. M'Clintock Formation

	1	2	3	4	5	6	7	8	9	10	11a	11b	12a	12b	13a	13b
SiO_2	44.3	48.3	48.7	49.0	49.1	49.9	50.5	50.8	50.8	55.4	59.3	59.3	72.0	72.3	13.71	13.71
Al_2O_3	13.9	14.1	15.7	16.6	14.1	15.6	15.4	15.4	14.9	16.2	15.7	15.7	14.7	14.8	0.2	0.2
TiO_2	2.21	0.73	1.02	1.04	2.24	2.63	0.75	2.66	2.13	0.75	0.79	0.78	0.43	0.44	0.01	0.01
Fe_2O_3	6.5	9.6	8.5	4.0	7.1	5.6	7.4	6.9	7.5	5.1	2.8	2.7	0.7	0.7	0.0	0.0
FeO	5.3	4.4	0.8	4.6	5.1	5.8	3.4	6.9	5.5	2.7	3.1	3.1	0.6	0.6	0.61	0.6
MnO	0.13	0.16	0.11	0.12	0.17	0.18	0.34	0.14	0.25	0.1	0.11	0.11	0.02	0.02	0.07	0.07
MgO	8.37	8.82	9.16	7.9	4.31	3.99	7.8	4.67	4.65	3.35	5.29	5.37	0.84	0.83	18.17	18.20
CaO	5.27	3.50	7.39	8.01	5.72	4.85	3.04	1.60	5.93	3.25	1.43	1.45	0.88	0.88	26.93	26.95
Na_2O	4.5	2.1	1.7	2.3	4.9	5.5	2.3	4.3	5.6	6.8	5.2	5.1	7.2	7.1	0.0	0.0
K_2O	0.35	1.39	1.04	1.29	0.30	0.23	5.06	0.33	0.29	0.13	1.91	1.92	1.33	1.32	0.03	0.03
P_2O_5	0.53	0.10	0.19	0.22	0.43	0.55	0.25	0.52	0.32	0.20	0.18	0.18	0.08	0.08	0.01	0.01
CO_2	3.7	1.3	0.4	0.3	1.5	1.0	0.2	0.6	0.2	1.8	0.6	0.6	0.1	0.1	41.6	41.6
H_2O	5.1	5.1	5.3	5.0	3.2	3.2	3.9	3.8	2.4	2.6	3.8	3.8	1.1	1.1	0.6	0.6
Total	100.2	99.6	100.0	100.0	98.1	99.1	100.3	98.6	100.5	98.5	100.2	100.2	99.9	100.2	101.9	102.0
As ppm	3	31	9	12	24.5	8.5	31	15	6	12						
B	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50						
Ba	150	510	320	480	110	92	2070	4300	150	83	439	446	262	252	0	7
Be											1.6	1.6	1.2	1.1	0.4	0.4
Br	0	4.5	2	5	8.5	8	8.5	7.5	9	1						
Co	37	56	17	18	30	29	45	39	28	11	21	21	4	5	7	7
Cr	300	1100	380	250	11	13	24	22	19	27	29	30	6	16	3	6
Cu	24	18	48	77	13	75	24	23	180	13	4	3	4	12	5	1
La	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	23	23	18	18	1	2
Mo	0	1.5	3	0	0.5	0.5	6.5	0	0	0.5						
Nb	26.5	0.5	1	0.5	2	2.5	3	2.5	1.5	11	9	15	19	22	0	7
Ni	200	250	210	100	10	19	25	21	29	13	53	48	11	12	19	17
Pb	13.5	25	8	6.5	16.5	17	17.5	16.5	20	18.5						
Rb	1.5	54	11.5	10.5	5.5	5.5	82	3.5	3	2	89	32	73	66	15	0
Sr	392.5	324.5	244	307.5	327	260	207	223.5	314	219	189	187	154	150	29	83
Th	7.5	7	2.5	3	5.5	5	5.5	8	10	7.5						
U	0	0	1	0	0	0	1	1.5	1	0.5						
V	160	310	160	240	330	360	150	410	370	150	64	63	11	11	3	3
Y	18.5	14.5	20	26	48	60.5	20	43	40	26.5	28	29	26	26	2	2
Yb	5.9	<4	<4	4.5	<4	5.7	<4	<4	4.3	<4	2.8	3.1	3.0	3.6	0.3	0.3
Zn	110	90	80	80	120	130	180	110	<200	90	100	89	18	24	13	1
Zr	256	31	69	68	147.5	170.5	42.5	161.5	124	124.5	238	232	216	220	4	5

Table 2-13 (cont'd.). M'Clintock Formation

	14a	14b	15a	15b	16a	16b	17a	17b	18a	18b	19a	19b	20	21	22	23
SiO_2	59.1		57.5	57.5	66.7	66.7	70.8	71.8	46.3	46.4	50.6	50.7	55.1	49.1	78.1	56.4
Al_2O_3	16.5		117.4	17.8	15.5	15.4	14.0	14.2	15.6	15.7	15.5	15.5	16.4	15.9	10.8	17.6
TiO_2	0.97		0.72	0.69	0.63	0.61	0.45	0.44	1.43	1.42	1.13	1.11	0.78	1.55	0.14	0.72
Fe_2O_3	3.7		3.7	3.6	3.0	3.2	0.8	0.8	3.1	3.0	2.2	2.1	6.8	8.4	1.1	3.8
FeO	2.2		2.5	2.5	0.7	0.7	1.0	1.0	6.9	6.9	6.5	6.5	0.8	0.3	1.1	3.4
MnO	0.12		0.11	0.11	0.06	0.05	0.04	0.04	0.18	0.18	0.16	0.15	0.09	0.05	0.01	0.09
MgO	4.04		3.97	3.98	1.34	1.34	0.84	0.86	7.02	6.96	7.25	7.23	1.47	10.4	1.81	4.4
CaO	4.42		5.62	5.61	2.37	2.39	0.34	0.34	7.27	7.23	4.58	4.55	8.97	1.92	0.11	0.8
Na_2O	5.2		4.5	4.6	5.8	5.8	5.2	5.4	4.5	4.4	5.3	5.2	6.0	2.4	4.8	3.2
K_2O	0.58		1.08	1.07	2.15	2.16	3.88	4.00	0.40	0.40	0.50	0.50	0.87	3.58	0.21	5.1
P_2O_5	0.29		0.29	0.19	0.19	0.18	0.10	0.10	0.23	0.23	0.19	0.19	0.17	0.83	0.03	0.23
CO_2	0.1		0.1	0.1	0.1	0.1	0.3	0.3	3.0	3.0	2.1	2.1	0.3	0.8	0.2	0.1
H_2O	3.2		3.0	3.0	1.6	1.6	0.9	0.9	4.8	4.8	4.6	4.6	1.9	4.5	1.5	3.5
Total	100.3		100.4	100.3	100.2	100.3	98.6	100.1	100.7	100.6	100.7	100.5	99.7	99.8	99.9	99.3
As ppm													<2000	<2000	<2000	
B													<50	<50	<50	
Ba	123		226	194	420	445	859	840	375	398	207	206	100	820	40	
Be	1.2	1.2	1.4	1.4		1.6	1.1	1.1	0.9	0.9	0.8	0.8				
Br																
Co	23	23	23	24		8	4	4	45	45	41	41	<10	18	10	
Cr	41	42	58	70		12	9	10	170	170	150	160	130	250	<5	
Cu	25	8	4	6		16	9	3	70	62	110	110	32	19	48	
La	36	35	15	15		28	17	16	8	8	6	6	<100	<100	<100	
Mo													<50	<50	<50	
Nb	15		7	6	21	24	15	17	0	8	7	18				
Ni	44	32	39	41		20	9	8	93	91	94	92	62	160	<10	
Pb													<700	<700	<700	
Rb	38		53	57	48	44	71	69	16	33	27	29	40	50	10	
Sr	428		53.0	523	309	303	93	87	210	206	87	90	180	230	50	
Th																
U																
V	130	130	120	130		42	6	5	220	210	200	200	140	150	<20	
Y	29	30	15	15		30	22	22	20	20	20	20	<40	<40	58	
Yb	2.5	2.6	1.1	1.0		30	3.0	2.9	1.3	1.3	1.5	1.4	<4	4.4	11	
Zn	110	120	71	65		39	26	19	120	100	110	93	60	80	70	
Zr	178		93	96	207	208	223	209	87	85	80	81	110	190	550	

Appendix 4A

Table 3

TiO_2, Nb, Y, and Z analyses used for classification

NORTHERN HEIBERG FOLD BELT

Table 3-1. Jaeger Lake Formation

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	3.55	9.0	18.5	259.0
2*	1.05	4.5	12.5	53.5
3*	0.74	3.5	12.5	42.5
4*	1.925	7.5	54.0	97.5
5*	1.585	8.5	45.5	94.5
6*	2.155	10.5	78.0	135.0
7*	2.40	11.5	72.0	135.0

Table 3-2. Svartevaeg Formation, Member A

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1	0.83	8.4	27	110
2	0.68	2.7	18	66
3	0.75	3.3	22	64
4	0.82	3.7	70	76
5	0.87	6.7	34	140
6	0.73	6.3	32	130
7	0.68	3.2	23	81
8	0.70	8.4	27	150
8a	0.63	8.4	31	140
9	0.97	11	47	220
10	1.28	7.2	28	130
11	0.63	7.2	29	140
12	0.88	5.4	27	94
13	1.12	5.1	26	70
14	1.08	12	43	180
15	1.03	9.4	48	150
16	0.63	4.3	20	71
17	0.92	6.7	27	81
18	0.72	6.3	30	93
18a	0.58	6.1	24	83
19	0.70	6.2	22	97

Table 3-3. Svartevaeg Formation, Member B, conglomerate clasts

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1	0.50	4.1	22	94
2	0.37	2.2	13	36
3	0.72	4.3	20	76
4	0.63	3.1	20	82
5	0.45	3.1	15	53
6	0.90	7.0	31	150
7	0.50	5.2	15	64
8	1.35	6.8	39	160
9	0.68	4.2	17	63
10	0.60	2.8	16	63
11	0.47	2.5	15	50
12	0.67	4.4	18	64

Table 3-4. Svartevaeg Formation, Member B, strata

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1	0.45	2.5	18	56
2	0.43	2.5	18	63
3	0.25	2.7	18	74
4	0.50	3.6	20	85
5	0.48	3.5	21	70
6	0.50	4.8	25	97
7	0.52	4.2	32	84
8	0.40	2.8	13	57
9	0.58	3.5	25	76
10	0.43	2.8	17	60
10a	0.43	2.9	19	64
11	0.57	3.1	21	69

CLEMENTS MARKHAM FOLD BELT

Table 3-5. Yelverton Formation

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	2.10	1.5	31.0	104.5
2*	1.67	1.5	25.5	83.5
3*	1.43	4.0	22.0	70.0
4*	1.40	3.5	26.5	76.5
5	1.65	1.5	29.5	73.5
6	2.57	4.5	41.0	138.0
7	3.84	24.5	39.5	273.0

Table 3-6. Fire Bay Formation, Member B

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
Unit B1				
1	0.65	<1.0	18	43
2	0.42	<1.0	12	32
3	0.18	9.5	47	150
4	0.48	2.8	34	78
5	0.29	6.6	22	140
6	0.365	37.0	47.5	218.0
7	0.24	18.0	24.0	121.0
Unit B2				
8	0.25	1.5	15	41
9	0.25	1.7	25	55
10	0.37	3.7	23	42
10a	0.30	3.0	17	42
11	11.18	22	29	170
12	18.35	18	30	140
13	11.34	26	32	180
14	1.57	39	130	260
15	18.35	18	34	130
16	21.69	19	34	150
17	16.51	16	29	120
18	1.10	26	15	120
19	0.37	1.4	11	21
20	0.57	20	19	210

Table 3-7. Map unit OSv

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	0.74	9.0	23.0	137.0
2*	0.55	13.5	16.5	184.5
3	0.61	23	20	153
4	0.68	31	22	190

Table 3-8. Kulutingwak Formation, Member A

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	0.590	14.0	13.5	90.0
2*	0.555	14.5	13.0	97.5
3	0.39	17	18	150
4	0.35	5.6	12	81
5	0.38	5.9	8.7	47
6	0.33	5.0	16	81
7	0.32	4.6	11	84
8	0.45	0.76	8.2	14
9	0.62	46	22	190
10	0.53	38	20	170
11	0.48	76	33	320
12	0.55	44	22	180

Table 3-9. Mount Rawlinson Complex

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	0.39	1.5	19.0	126.5
2*	0.48	15.0	20.0	233.0
3*	0.42	4.5	27.5	138.5

PEARYA

Table 3-10. Pearya, Succession 2

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
Map unit L1				
1	0.22	<1.0	16	27
Map unit D				
2*	2.65	40.5	24.5	170.0
3*	0.78	25.5	28.0	108.0
Map unit M2v				
4*	2.82	23.0	50.5	232.5
Map unit M4				
5*	0.18	25.0	39.0	155.5

Table 3-11. Maskell Inlet Complex

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	1.02	4.5	27.5	118.0
2*	0.96	2.0	21.5	49.5
3*	0.99	3.5	40.5	115.5
4*	0.90	10.0	22	180.5
5*	0.71	2.0	24.5	73.0
6*	1.24	5.0	37.5	103.5
7*	0.89	6.0	44.0	223.0
8*	1.00	0.5	15.0	85.0
9*	0.70	6.0	11.5	68.5
10	1.06	21	68	94
11	1.30	8	32	141
12	1.09	5	27	180
13	1.30	3	26	78
14	0.79	1.0	16.5	43.0
15	0.90	3.0	18.0	42.5

Table 3-12. Cape Discovery Formation

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1	1.72	59.5	48.0	377.0
2	0.23	54.0	163.5	524.5
3	0.16	121.0	65.0	777.0
4	0.12	36.5	63.5	338.0
5	0.86	6	71	470

Table 3-13. M'Clintock Formation

No.	TiO_2 (%)	Nb (ppm)	Y (ppm)	Zr (ppm)
1*	2.21	26.5	18.5	256.0
2*	0.73	0.5	14.5	31.0
3*	1.02	1.0	20.0	69.0
4*	1.04	0.5	26.0	68.0
5*	2.24	2.0	48.0	147.5
6*	2.63	2.5	60.5	170.5
7*	0.75	3.0	20.0	42.5
8*	2.66	2.5	43.0	161.5
9*	2.13	1.5	40.0	124.0
10*	0.75	11	26.5	124.5
11*	0.785	12.0	28.5	235.0
12*	0.435	20.5	26.0	218.0
13*	0.01	3.5	2.0	4.5
14**	0.97	15	29.5	178
15*	0.705	6.5	15.0	94.5
16*	0.62	22.5	30.0	207.5
17*	0.445	16.0	22.0	216.0
18*	1.425	4.0	20.0	86.0
19*	1.120	12.5	20.0	80.5

*Arithmetic mean of duplicate analyses (or weighted mean of 2 to 3 analyses done with different methods on TiO_2 in the case of the 86-83 series); one more significant number shown than justified by analytical precision.
**Duplicate analyses for Y only.
Note: Ti values by Elemental Research Inc. were stated in ppm with two significant figures but have been recalculated to per cent TiO_2 with two decimals to conform with the GSC analyses.

B. CHEMICAL ANALYSES OF INTRUSIONS

INTRODUCTION

Appendix 4B lists chemical analyses on a total of 47 samples (44 in duplicate) of granitoid intrusions and one sample (in duplicate) of a hypabyssal porphyritic felsic intrusion. Table 1 lists the petrographic classification and alumina indices. Table 2 lists standard analyses done with the same methods as those for the volcanic rocks. Table 3 lists special analyses for Y, Nb, Rb, Yb, and Ta made by the ICP-MS (induced coupled plasma mass spectrometry) to determine the setting of the plutons.

DISCUSSION OF TECTONIC DISCRIMINATION DIAGRAMS

Plots of Rb versus Nb + Y and versus Ta + Yb indicating the tectonic setting according to discrimination diagrams by Pearce et al. (1984, Figs. 4a, b) are presented for four different age groups in Figures 170 to 178. The plots distinguish four tectonic settings: volcanic arc, within plate, ocean ridge, and syncollisional, but do not identify the very common post-tectonic intrusions, which can fall into any of these fields.

In some cases the tectonic setting is known from geological evidence, and these permit testing the validity of the present plots. Best known are the settings of the Carboniferous Petersen Bay Pluton and the Cretaceous Wootton Intrusive Complex and Marvin Intrusion, which all originated in within-plate extensional settings. On the Rb versus Nb + Y diagram (Fig. 176), seven out of eight samples indeed plot in the within-plate field. The eighth sample, however, from the Petersen Bay Pluton, which is highly altered, plots in the field of volcanic arc granites. On the Rb versus Ta + Yb diagram (Fig. 177), seven samples are in the volcanic arc field and one is in the field of syncollisional granite. This may be due to an analytical problem as slightly higher values for Ta + Yb would shift the same samples into the within-plate field.

The tectonic setting of the Ayles Fiord Intrusion also is reasonably well known. This is clearly a syntectonic intrusion, emplaced into the crest of an anticline and containing bent feldspar crystals (Fig. 152). Inheritance in zircon crystals and the peraluminous chemical composition of the rocks both suggest a crustal origin, and one would expect the two analyzed samples to plot in the field of syncollisional granite, but this is not the case: they straddle the boundary between syncollisional and volcanic arc granite on the Rb versus Ta + Yb diagram (Fig. 173) and lie in the field of volcanic arc granite on the Rb versus Nb + Y diagram (Fig. 172).

Considering all these results and stated limitations, the tectonic discrimination diagrams should be disregarded in the following cases:

1. Highly altered or metamorphosed rocks:

   Deuchars Glacier Belt (note wide spread of analyses)
   Phillips Inlet Pluton
   Ward Hunt Pluton
   Disraeli Glacier Pluton (note wide spread of analyses)

2. Rocks of known or suspected post-tectonic origin:

   Markham Fiord Pluton (possibly of arc origin)
   Cape Richards Plutonic Complex

Even where these limitations do not apply, the plots should be used with caution (cf. Roberts and Clements, 1993). Note that there seems to be bias in favour of the volcanic arc field.

This leaves only one case where the trace elements plots may be of value: the granitoid intrusion within the M'Clintock West body. The available geological information suggests either an ophiolite or, more likely, a subarc volcanic complex, and the second alternative is supported by Figures 172 and 173.

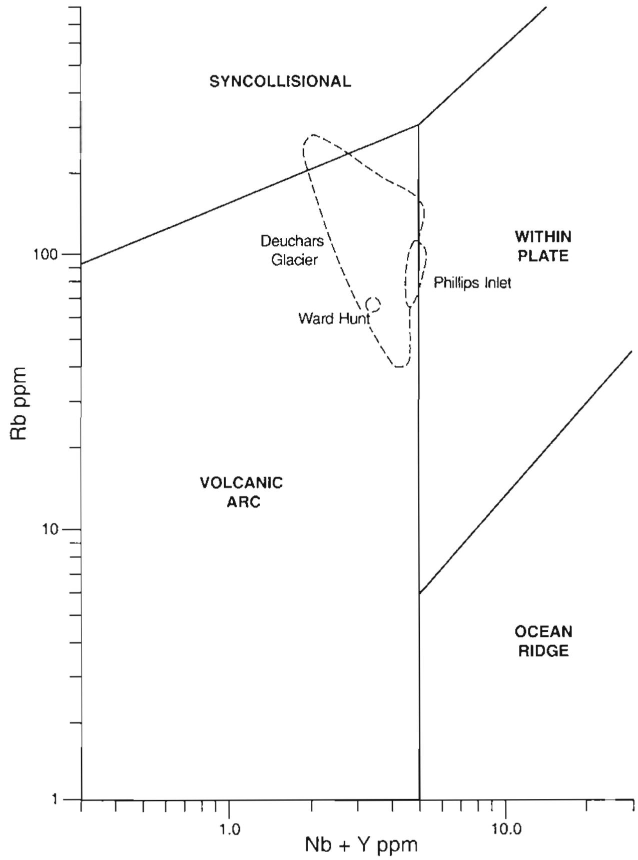

Figure 170. *Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4a) for Deuchars Glacier Belt, Phillips Inlet Pluton, and Ward Hunt Pluton.*

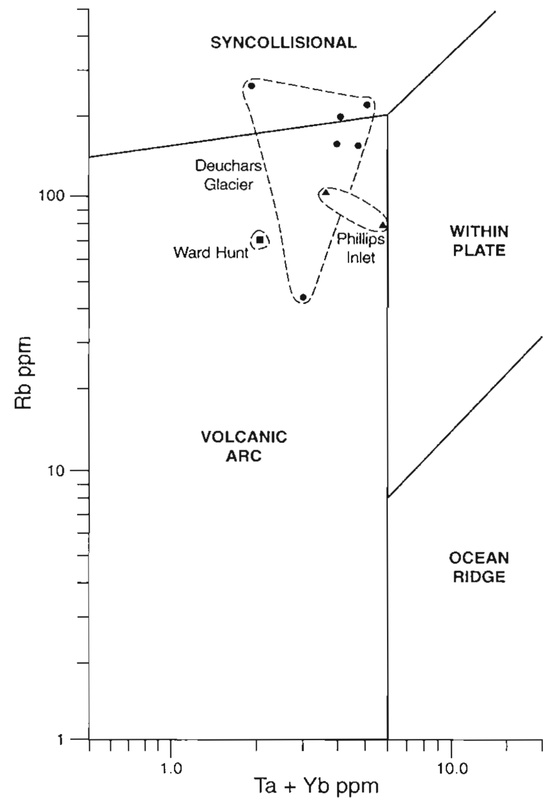

Figure 171. *Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4b) for Deuchars Glacier Belt, Phillips Inlet Pluton, and Ward Hunt Pluton.*

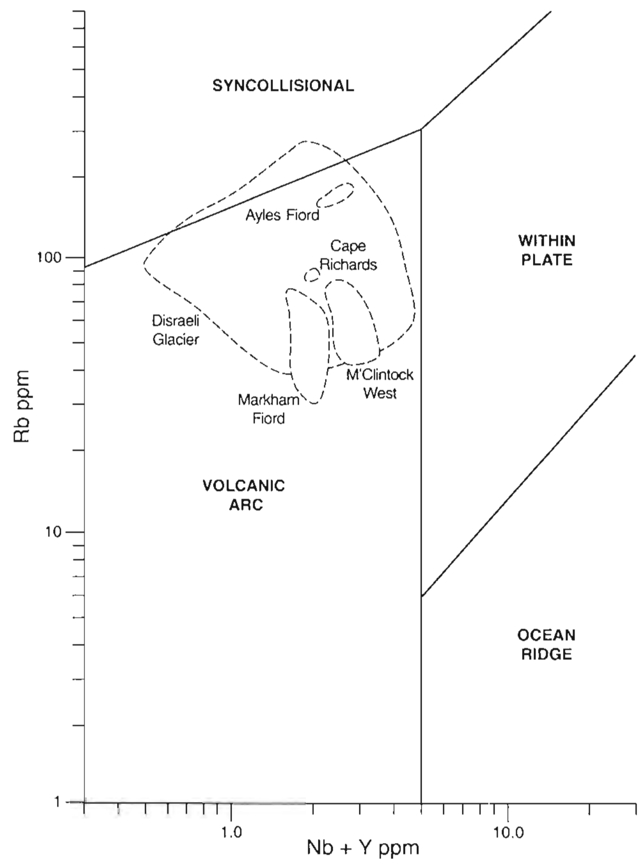

***Figure 172**. Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4a) for Ordovician granitoid intrusions.*

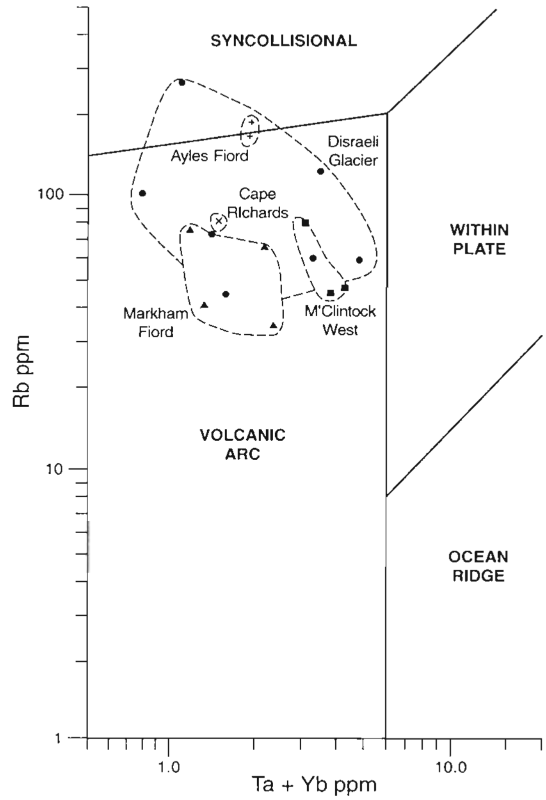

Figure 173. *Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4b) for Ordovician granitoid intrusions.*

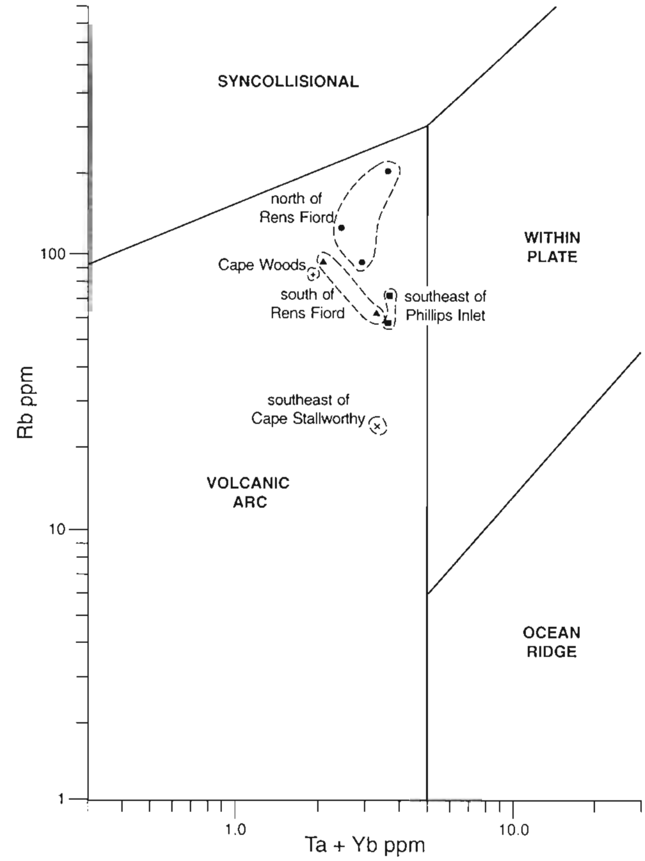

Figure 174. *Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4a) for Devonian granitoid intrusions.*

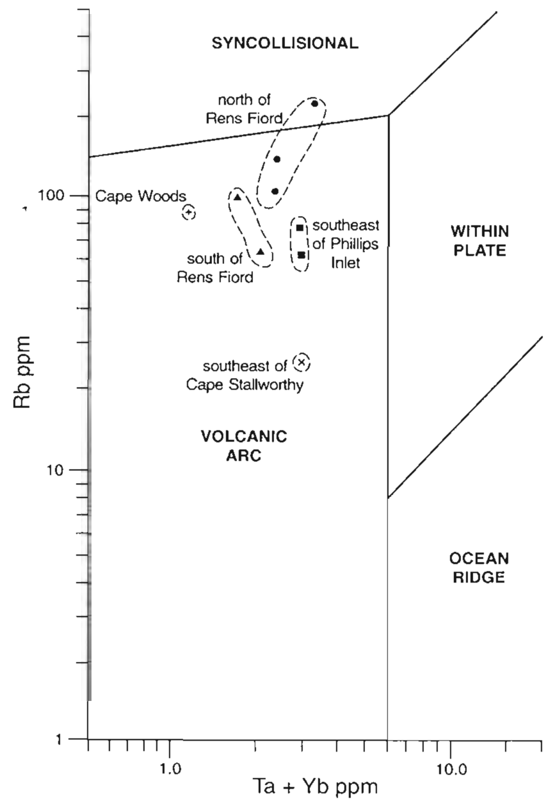

Figure 175. *Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4b) for Devonian granitoid intrusions.*

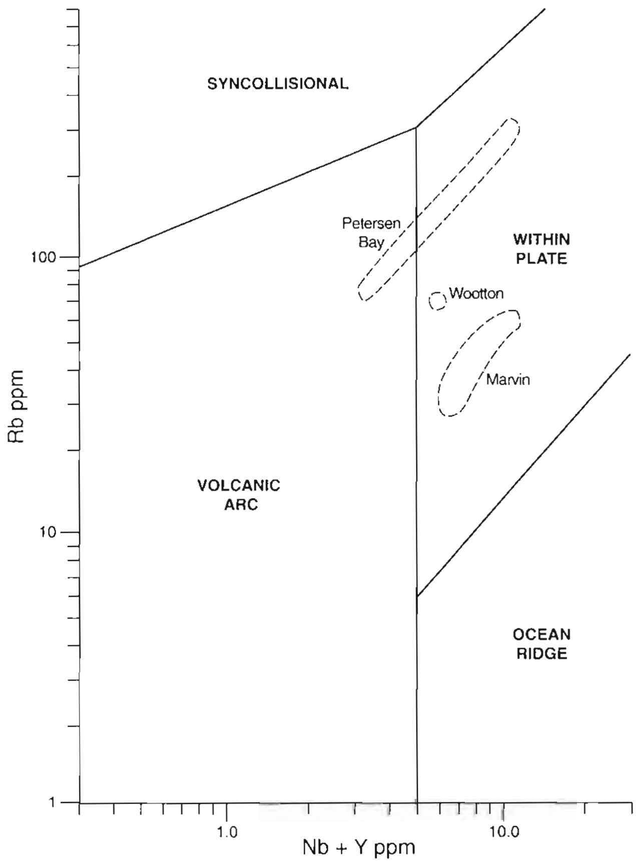

Figure 176*. Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4a) for Carboniferous and Cretaceous granitoid intrusions.*

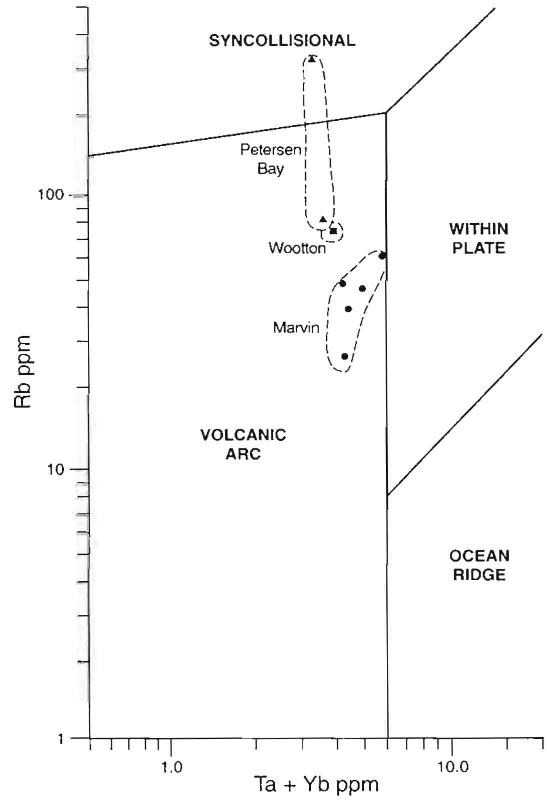

Figure 177*. Tectonic discrimination diagram (after Pearce et al., 1984, fig. 4b) for Carboniferous and Cretaceous granitoid intrusions.*

Appendix 4B

Table 1

Summary of petrography and classification

The following abbreviations and definitions are used (in accord with general practice) for the chemical parameters and characteristics:

A = Al_2O_3 (molecular)
C = CaO (molecular)
N = Na_2O (molecular)
K = K_2O (molecular)
CN = C + N
CNK = C + N + K
Peraluminous: A/CNK > 1
Metaluminous: A/CNK < 1, A/NK > 1
Peralkaline: A/NK < 1

Pearya, Deuchars Glacier Belt (Late Mesoproterozoic)

Current no.: 1-1
Field no.: 80TM213E1
Analysis no.: 215-89-35, 215-89-78 (duplicate analyses on same powder)
Granodiorite, peraluminous
A/CNK = 1.13, 1.13
A/NK = 1.18, 1.19

Current no.: 1-2
Field no.: 77TM322E
Analysis no.: 215-89-36, 215-89-79 (duplicate analyses on same powder)
Granite, peraluminous
A/CNK = 1.18, 1.18
A/NK = 1.29, 1.29

Current no.: 1-3
Field no.: 77TM322E4
Analysis no.: 215-89-37, 215-89-80 (duplicate analyses on same powder)
Tonalite, peraluminous (albite shows chessboard twinning; rock probably contained K-feldspar originally)
A/CNK = 1.24, 1.25
A/NK = 1.37, 1.38

Current no.: 1-4
Field no.: 77TM322G1
Analysis no.: 215-89-38, 215-89-81 (duplicate analyses on same powder)
Granodiorite, peraluminous
A/CNK = 1.24, 1.24
A/NK = 1.27, 1.27

Current no.: 1-5
Field no.: 77TM331E2
Analysis no.: 215-89-40, 215-89-83 (duplicate analyses on same powder)
Granite, peraluminous
A/CNK = 1.18, 1.18
A/NK = 1.33, 1.33

Current no.: 1-6
Field no.: 77TM331F1
Analysis no.: 215-89-39, 215-89-82 (duplicate analyses on same powder)
Granite, peraluminous
A/CNK = 1.21, 1.22
A/NK = 1.39, 1.41

Current no.: 1-7
Field no.: 77TM331G1
Analysis no.: 10-84-8
Granodiorite, peraluminous
A/CNK = 1.30
A/NK = 1.46

Phillips Inlet Pluton (earliest Neoproterozoic)

Current no.: 2-1
Field no.: 88TM208B
Analysis no.: 215-89-5, 215-89-48 (duplicate analyses on same powder)
Granodiorite, peraluminous
A/CNK = 1.41, 1.42
A/NK = 2.13, 2.14

Current no.: 2-2
Field no.: 62TM52D3
Analysis no.: 215-89-6, 215-89-49 (duplicate analyses on same powder)
Granite, garnetiferous, peraluminous
A/CNK = 1.22, 1.21
A/NK = 2.00, 1.96

Ward Hunt Pluton (Proterozoic or younger)

Current no.: 3-1
Field no.: 88TM118D
Analysis no.: 215-89-12, 215-89-55 (duplicate analyses on same powder)
Monzodiorite, metaluminous
A/CNK = 0.64, 0.61
A/NK = 2.87, 2.95

Granitoid intrusion in M'Clintock West body (Early Ordovician)

Current no.: 4-1
Field no.: 65TM227G
Analysis no.: 215-89-30, 215-89-73 (duplicate analyses on same powder)
Granite, metaluminous
A/CNK = 0.96, 0.96
A/NK = 1.09, 1.09

Current no.: 4-2
Field no.: 65TM206A1
Analysis no.: 215-89-31, 215-89-74 (analyses on same powder; sample was insufficient for complete duplicate analysis and determination of Fe)
Monzodiorite, leucocratic, metaluminous
A/CNK = 0.92, 0.92
A/NK = 1.59, 1.54

Current no.: 4-3
Field no.: 65TM206A2
Analysis no.: 215-89-32, 215-89-75 (duplicate analyses on same powder)
Quartz monzodiorite, leucocratic, metaluminous
A/CNK = 0.91, 0.90
A/NK = 1.43, 1.42

Ayles Fiord Intrusion (Early Ordovician)

Current no.: 5-1
Field no.: 88TMN136C
Analysis no.: 215-89-10, 215-89-53 (duplicate analyses on same powder)
Granite, peraluminous
A/CNK = 1.12, 1.13
A/NK = 1.59, 1.59

Current no.: 5-2
Field no.: 77TM219E2
Analysis no.: 215-89-11, 215-89-54 (duplicate analyses on same powder)
Granodiorite transitional to granite, peraluminous
A/CNK = 1.10, 1.10
A/NK = 1.74, 1.73

Markham Fiord Pluton (Middle Ordovician)

Current no.: 6-1
Field no.: 80TM224H2
Analysis no.: 1a, 1b: 215-89-28, 215-89-71 (duplicate analyses on same powder); 1c: different part of same specimen; Fe_2O_3t, Fe_2O_3, FeO from 113-92-2; CO_2: mean of duplicate LECO analysis (ISPG); other major elements from ISPG-92-01.XLS; Nb to Yb from ERI-2131
Tonalite, metaluminous
A/CNK = 0.98, 0.98, 0.94
A/NK = 2.42, 2.42, 2.64

Current no.: 6-2
Field no.: 80TM225B1
Analysis no.: 1a, 1b: 215-89-29, 215-89-72 (duplicate analyses on same powder); 1c: different part of same specimen; Fe_2O_3t, Fe_2O_3, FeO from 113-92-3; CO_2: mean of duplicate LECO analysis (ISPG); other major elements from ISPG-92-01.XLS; Nb to Yb from ERI-2131
Granodiorite, peraluminous
A/CNK = 1.06, 1.07, 1.09
A/NK = 2.00, 2.01, 2.25

Current no.: 6-3
Field no.: 80TM231A
Analysis no.: 1a, 1b: 215-89-41, 215-89-84 (duplicate analyses on same powder); 1c: different part of same specimen; Fe_2O_3t, Fe_2O_3, FeO from 113-92-6; CO_2: mean of duplicate LECO analysis (ISPG); other major elements from ISPG-92-01.XLS; Nb to Yb from ERI-2131
Quartz monzodiorite, metaluminous
A/CNK = 0.96, 0.96, 1.00
A/NK = 1.35, 1.36, 1.50

Current no.: 6-4
Field no.: 80TM225I
Analysis no.: 1a: 57-82-5; 1b different part of same specimen; Fe_2O_3t, Fe_2O_3, FeO from 113-92-4; CO_2: mean of duplicate LECO analysis (ISPG); other major elements from ISPG-92-01.XLS; Nb to Yb from ERI-2131
Quartz monzodiorite, metaluminous and peraluminous
A/CNK = 0.94, 1.24
A/NK = 1.26, 1.55

Current no.: 6-5
Field no.: 80TM225E1
Analysis no.: 57-82-4
Granodiorite, peraluminous
A/CNK = 1.03
A/NK = 1.37

Cape Richards Intrusive Complex (Middle Ordovician)

Current no.: 7-1
Field no.: 80TM227F1
Analysis no.: 215-89-22, 215-89-65 (duplicate analyses of same powder)
Granodiorite, peraluminous
A/CNK = 1.04, 1.05
A/NK = 1.45, 1.46

Disraeli Glacier Pluton (Middle Ordovician?)

Current no.: 8-1
Field no.: 88TM123B1
Analysis no.: 215-89-15, 215-89-58 (duplicate anlyses of same powder)
Tonalite, peraluminous
A/CNK = 1.25, 1.24
A/NK = 1.60, 1.59

Current no.: 8-2
Field no.: 88TM123B3
Analysis no.: 215-89-16, 215-89-59 (duplicate analyses of same powder)
Tonalite, peraluminous
A/CNK = 1.05, 1.08
A/NK = 1.71, 1.76

Current no.: 8-3
Field no.: 88TM123B4
Analysis no.: 215-89-17, 215-89-60 (duplicate analyses of same powder)
Granite, peraluminous
A/CNK = 1.08, 1.08
A/NK = 1.17, 1.17

Current no.: 8-4
Field no.: 88TM120D1
Analysis no.: 215-89-18, 215-89-61 (duplicate analyses of same powder)
Tonalite, metaluminous
A/CNK = 0.95, 0.95
A/NK = 1.45, 1.44

Current no.: 8-5
Field no.: 88TM120D3
Analysis no.: 215-89-19, 215-89-62 (duplicate analyses of same powder)
Granodiorite, metaluminous
A/CNK = 0.96, 0.98
A/NK = 1.22, 1.25

Current no.: 8-6
Field no.: 77TM 307B5
Analysis no.: 215-89-20, 215-89-63 (duplicate analyses of same powder)
Monzodiorite, metaluminous
A/CNK = 0.98, 1.00
A/NK = 1.73, 1.76

Current no.: 8-7
Field no.: 77TM307B6
Analysis no.: 215-89-21, 215-89-64 (duplicate analyses of same powder)
Granite, metaluminous
A/CNK = 0.80, 0.80
A/NK = 1.25, 1.24

Cape Woods Pluton (Middle Devonian)

Current no.: 9-1
Field no.: 80TM228K
Analysis no.: Fe_2O_3t, Fe_2O_3, FeO from 113-92-5; CO_2: mean of duplicate LECO analysis (ISPG); other major elements from ISPG-92-01.XLS; Nb to Yb from ERI-2131
Granodiorite, metaluminous
A/CNK = 0.91
A/NK = 1.40

Intrusions north of Rens Fiord (Late Devonian)

Current no.: 10-1
Field no.: 88TM103C
Analysis no.: 215-89-1, 215-89-44 (duplicate analyses of same powder)
Tonalite, peraluminous
A/CNK = 1.23, 1.23
A/NK = 1.99, 1.98

Current no.: 10-2
Field no.: 61TM47A
Analysis no.: 215-89-2, 215-89-45 (duplicate analyses of same powder)
Tonalite, peraluminous
A/CNK = 1.12, 1.12
A/NK = 2.01, 2.04

Current no.: 10-3
Field no.: 61TM45A
Analysis no.: 215-89-3, 215-89-46 (duplicate analyses of same powder)
Granodiorite, metaluminous
A/CNK = 0.90, 0.92
A/NK = 1.94, 1.97

Intrusion southeast of Cape Stallworthy (Late Devonian?)

Current no.: 11-1
Field no.: 61TM38H
Analysis no.: 215-89-4, 215-89-47 (duplicate analyses of same powder)
Quartz diorite, metaluminous
A/CNK = 0.97, 0.98
A/NK = 1.76, 1.77

Intrusions south of Rens Fiord (Late Devonian)

Current no.: 12-1
Field no.: 86TM107A
Analysis no.: 10-1a, 10-1b: 215-89-33, 215-89-76 (duplicate analyses of same powder); 10-1c, 10-1d: 118-86-8, 116-86-17 (duplicate analyses on different part of same sample)
Porphyritic felsite (dacite according to major elements, trachyandesite according to stable trace elements), peraluminous
A/CNK = 1.08, 1.09, 1.10, 1.12
A/NK = 1.50, 1.52, 1.44, 1.49

Current no.: 12-2
Field no.: 62TM8B
Analysis no.: 215-89-34, 215-89-77 (duplicate analyses of same powder); 10-2c, d: 118-86-9, 18 (duplicate analyses on different part of same sample)
Porphyritic felsite (dacite according to major elements, trachyandesite according to stable trace elements), peraluminous and metaluminous
A/CNK = 1.00, 1.00, 0.96, 0.97
A/NK = 1.57, 1.56, 1.48, 1.49

Pluton southeast of Phillips Inlet (Late Devonian)

Current no.: 13-1
Field no.: 88TM208C
Analysis no.: 215-89-7, 215-89-50 (duplicate analyses of same powder)
Tonalite, metaluminous
A/CNK = 0.81, 0.81
A/NK = 2.04, 2.04

Current no.: 13-2
Field no.: 62TM51I
Analysis no.: 215-89-8, 215-89-51 (duplicate analyses of same powder)
Tonalite, metaluminous
A/CNK = 0.82, 0.83
A/NK = 2.36, 2.38

Petersen Bay Pluton (late Early Carboniferous)

Current no.: 14-1
Field no.: 88TM117D
Analysis no.: 215-89-13, 215-89-56 (duplicate analyses of same powder)
Monzodiorite, metaluminous
A/CNK = 0.93, 0.94
A/NK = 1.19, 1.21

Current no.: 14-2
Field no.: 88TM116B1
Analysis no.: 215-89-14, 215-89-57 (duplicate analyses of same powder)
Tonalite, peraluminous
A/CNK = 1.17, 1.17
A/NK = 1.73, 1.73

Wootton Intrusive Complex (early Late Cretaceous)

Current no.: 15-1
Field no.: 82TM212C6
Analysis no.: 215-89-9, 215-89-52 (duplicate analyses of same powder)
Quartz monzonite, metaluminous
A/CNK = 0.93, 0.94
A/NK = 1.50, 1.51

Marvin Pluton (early Late Cretaceous)

Current no.: 16-1
Field no.: 77TM316F3
Analysis no.: 215-89-23, 215-89-66 (duplicate analyses of same powder)
Granodiorite, metaluminous
A/CNK = 0.80, 0.81
A/NK = 1.49, 1.51

Current no.: 16-2
Field no.: 77TM317B2
Analysis no.: 215-89-24, 215-89-67 (duplicate analyses of same powder)
Granodiorite, metaluminous
A/CNK = 0.64, 0.64
A/NK = 2.25, 2.27

Current no.: 16-3
Field no.: 77TM317C2
Analysis no.: 215-89-25, 215-89-68 (duplicate analyses of same powder)
Quartz monzodiorite, metaluminous
A/CNK = 0.72, 0.73
A/NK = 2.11, 2.14

Current no.: 16-4
Field no.: 77TM320A1
Analysis no.: 215-89-26, 215-89-69 (duplicate analyses of same powder)
Quartz diorite, metaluminous
A/CNK = 0.73, 0.74
A/NK = 1.80, 1.85

Current no.: 16-5
Field no.: 77TM317A1
Analysis no.: 215-89-27, 215-89-70 (duplicate analyses of same powder)
Quartz monzodiorite, metaluminous
A/CNK = 0.70, 0.71
A/NK = 2.08, 2.14

Appendix 4B

Table 2

Standard analyses

Unit	Deuchars Glacier belt 1-1a	Deuchars Glacier belt 1-1b	Deuchars Glacier belt 1-2a	Deuchars Glacier belt 1-2b	Deuchars Glacier belt 1-3a	Deuchars Glacier belt 1-3b	Deuchars Glacier belt 1-4a	Deuchars Glacier belt 1-4b
Field No.	**80TM-213E1**	**80TM-213E1**	**77TM-322E1**	**77TM-322E1**	**77TM-322E4**	**77TM-322E4**	**77TM-322G1**	**77TM-322G1**
SiO_2%	73.0	73.0	72.8	72.9	73.4	73.0	75.1	75.0
Al_2O_3	14.6	14.6	14.1	14.1	15.6	15.5	13.6	13.6
TiO_2	0.09	0.09	0.28	0.28	0.27	0.26	0.08	0.08
Fe_2O_3t	0.80	0.80	1.70	1.80	2.10	2.10	0.90	0.80
Fe_2O_3	0.0	0.0	0.3	0.4	0.4	0.4	0.6	0.5
FeO	0.7	0.7	1.3	1.3	1.5	1.5	0.3	0.3
MnO	0.00	0.00	0.02	0.01	0.01	0.01	0.01	0.01
MgO	0.27	0.27	0.55	0.56	0.88	0.86	0.31	0.32
CaO	0.34	0.34	0.55	0.56	0.62	0.61	0.14	0.14
Na_2O	3.5	3.50	3.50	3.50	6.40	6.30	3.20	3.20
K_2O	6.08	6.05	4.79	4.82	0.83	0.82	5.04	5.02
P_2O_5	0.17	0.16	0.16	0.17	0.16	0.16	0.10	0.10
CO_2	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1
H_2O	0.6	0.6	0.7	0.7	0.6	0.6	1.1	1.1
l.o.i.								
Total	100.2	99.4	99.3	99.5	100.7	100.1	99.6	99.4
Nb ppm	6	10	9	17	8	11	7	8
Rb	240	250	150	150	40	44	210	210
Ta		0.6		0.3		0.2		1.9
Y	13	13	29	30	33	34	21	21
Yb	1.4	1.2	3.2	3.8	2.4	2.9	3.1	2.7
Ba	690	660	520	550	90	90	290	250
Be	1.3	1.3	2.4	2.5	3.1	3.2	2.0	2.0
Co	2	8	7	6	6	6	2	1
Cr	3	9	8	10	8	9	10	10
Cu	0	4	1	3	2	1	5	3
La	4	4	14	21	22	21	7	6
Ni	0	6	1	7	3	7	1	3
Sr	130	140	170	170	150	150	31	36
V	0	3	9	11	10	9	0	0
Zn	0	0	0	3	0	0	0	6
Zr	69	68	160	160	140	140	66	70

Appendix 4B

Table 2 (cont'd.)

Unit	Deuchars Glacier belt 1-5a	Deuchars Glacier belt 1-5b	Deuchars Glacier belt 1-6a	Deuchars Glacier belt 1-6b	Deuchars Glacier belt 1-7	Phillips Inlet Pluton 2-1a	Phillips Inlet Pluton 2-1b	Phillips Inlet Pluton 2-2a
Field No.	**77TM-331E2**	**77TM-322E2**	**77TM-331F1**	**77TM-331F1**	**77TM-331G1**	**88TM-208B**	**88TM-208B**	**62TM-52D3**
SiO_2%	73.5	73.4	70.4	70.5	72.3	59.6	59.1	64.0
Al_2O_3	14.4	14.4	14.8	14.9	14.0	20.4	20.4	18.3
TiO_2	0.08	0.08	0.32	0.32	0.49	0.79	0.79	0.50
Fe_2O_3t	0.90	0.90	3.00	3.00		5.30	5.20	4.10
Fe_2O_3	0.3	0.3	0.7	0.7	0.9	1.1	1.0	1.0
FeO	0.5	0.5	2.1	2.1	2.3	3.8	3.8	2.8
MnO	0.03	0.03	0.05	0.05	0.05	0.08	0.08	0.07
MgO	0.31	0.30	1.20	1.23	0.87	1.41	1.39	1.08
CaO	0.75	0.75	0.91	0.91	0.66	2.72	2.67	3.21
Na_2O	3.6	3.60	3.50	3.50	4.4	3.20	3.20	3.60
K_2O	4.51	4.51	4.49	4.48	2.17	3.97	3.96	3.00
P_2O_5	0.06	0.06	0.10	0.1	0.15	0.12	0.12	0.13
CO_2	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.3
H_2O	1.0	1.0	2.0	2.0	1.3	2.3	2.3	1.7
l.o.i.								
Total	99.0	99.0	100.6	100.8	99.8	99.4	99.7	99.7
Nb ppm	7	7	14	17		23	25	16
Rb	190	190	150	150		100	100	75
Ta		0.9		1.2			0.3	
Y	25	27	31	32		32	27	31
Yb	0.9	3.1	3.4	3.1		3.1	3.2	4.6
Ba	230	210	430	430	590	1000	1100	870
Be	5.1	5.2	3.6	3.7		4.2	4.1	4.1
Co	4	5	7	4		19	4	10
Cr	5	7	9	11		27	20	19
Cu	99	97	2	1		8	3	43
La	14	17	30	28		95	79	58
Ni	0	5	3	6		18	5	5
Sr	65	67	92	83	91	250	250	300
V	0	0	20	20		54	42	31
Zn	62	73	12	24		6	47	11
Zr	84	79	180	170	240	510	500	270

Appendix 4B

Table 2 (cont'd.)

Unit	Phillips Inlet Pluton 2-2b	Ward Hunt Pluton 3-1a	Ward Hunt Pluton 3-1b	M'Clintock West body 4-1a	M'Clintock West body 4-1b	M'Clintock West body 4-2a	M'Clintock West body 4-2b	M'Clintock West body 4-3a
Field No.	**62TM-52D3**	**88TM-118D**	**88TM-118D**	**65TM-227G**	**65TM-227G**	**65TM-206A1**	**65TM-206A1**	**65TM-206A2**
SiO_2%	64.3	43.2	43.1	70.5	70.8	60.2	60.0	61.7
Al_2O_3	18.3	15.7	14.9	15.9	16.0	18.4	18.5	17.2
TiO_2	0.49	3.53	3.88	0.17	0.17	0.32	0.30	0.29
Fe_2O_3t	4.10	12.2	12.9	0.90	1.10	3.50	3.50	3.40
Fe_2O_3	1.0	4.5	5.2	0.3	0.5			0.8
FeO	2.8	6.9	6.9	0.5	0.5			2.3
MnO	0.06	0.15	0.16	0.05	0.05	0.17	0.20	0.16
MgO	1.07	5.57	5.99	0.50	0.50	2.57	2.50	2.74
CaO	3.17	10.4	10.7	1.05	1.05	4.60	4.50	3.81
Na_2O	3.70	1.70	1.60	7.00	7.00	5.90	6.00	5.50
K_2O	3.01	2.48	2.23	2.89	2.93	1.76	2.00	2.77
P_2O_5	0.13	0.18	0.21	0.05	0.05	0.15	0.20	0.14
CO_2	0.3	2.1	2.1	0.2	0.2	0.3	0.3	0.1
H_2O	1.7	3.1	3.1	0.5	0.5		3.1	1.4
l.o.i.								
Total	100.1	99.6	100.1	99.8	100.4	98.0	98.0	98.9
Nb ppm	21	22	19	8	6	7		6
Rb	81	67	66	42	45	45		81
Ta	0.5		0.7		0.4	1.4		
Y	31	13	16	26	27	20		18
Yb	5.3	1.4	1.2	3.1	3.4	2.6		2.2
Ba	840	310	260	1000	990	1800		2200
Be	3.9	1.0	1.2	1.4	1.4	2.0		1.6
Co	4	50	59	2	0	9		10
Cr	14	34	41	5	4	5		11
Cu	39	150	150	5	3	7		10
La	57	0	4	18	22	40		31
Ni	2	120	110	0	0	0		0
Sr	300	690	650	280	280	820		800
V	27	360	380	27	24	30		31
Zn	30	54	81	0	12	32		24
Zr	260	50	60	190	190	180		170

Appendix 4B

Table 2 (cont'd.)

Unit	M'Clintock West body 4-3b	N of middle Ayles Fiord 5-1a	N of middle Ayles Fiord 5-1b	N of middle Ayles Fiord 5-2a	N of middle Ayles Fiord 5-2b	Markham Fiord Pluton 6-1a	Markham Fiord Pluton 6-1b	Markham Fiord Pluton 6-1c
Field No.	65TM-206A2	88TM-136C	88TM-136C	77TM-219E2	77TM-219E2	80TM-224H2	80TM-224H2	80TM-224H2
SiO_2%	62.1	68.9	68.5	64.7	64.7	59.1	59.1	58.82
Al_2O_3	17.3	15.4	15.4	15.9	15.9	15.4	15.4	15.43
TiO_2	0.29	0.34	0.33	0.54	0.55	0.44	0.43	0.42
Fe_2O_3t	3.60	2.20	2.20	3.50	3.50	8.60	8.70	8.98
Fe_2O_3	1.0	0.2	0.2	0.9	0.9	3.8	3.9	2.38
FeO	2.3	1.8	1.8	2.3	2.3	4.3	4.3	5.94
MnO	0.16	0.08	0.08	0.10	0.10	0.16	0.16	0.17
MgO	2.75	1.99	1.97	3.24	3.24	4.19	4.22	4.20
CaO	3.83	2.20	2.17	2.88	2.87	5.17	5.17	5.86
Na_2O	5.60	3.00	3.00	3.00	3.00	3.10	3.10	2.77
K_2O	2.76	4.42	4.38	3.91	3.95	1.16	1.16	1.19
P_2O_5	0.14	0.18	0.18	0.29	0.29	0.11	0.11	0.10
CO_2	0.1	0.0	0.0	0.2	0.2	0.2	0.2	0.23
H_2O	1.0	1.0	1.0	1.5	1.5			
l.o.i.								1.67
Total	99.8	99.5	99.1	99.4	99.6	97.2	97.3	99.18
Nb ppm	8	14	16	16	16	4	5	5.1
Rb	73	160	160	170	180	30	31	34
Ta	0.6		0.7		0.5		0.2	0.24
Y	19	5	10	10	13	17	17	15
Yb	2.4	0.6	0.8	0.9	1.0	2.3	2.1	1.9
Ba	2200	730	700	580	590	190	240	
Be	1.6	3.8	4.1	4.1	4.2	0.7	0.8	
Co	5	4	16	10	26	26	20	
Cr	14	69	86	130	140	27	31	
Cu	11	2	11	11	19	46	46	
La	35	0	18	42	55	12	13	
Ni	0	37	52	72	86	14	9	
Sr	810	350	360	380	380	370	370	
V	32	8	28	28	46	190	190	
Zn	35	4	26	43	66	38	58	
Zr	170	150	150	200	200	45	44	

Appendix 4B

Table 2 (cont'd.)

Unit	Markham Fiord Pluton 6-2a	Markham Fiord Pluton 6-2b	Markham Fiord Pluton 6-2c	Markham Fiord Pluton 6-3a	Markham Fiord Pluton 6-3b	Markham Fiord Pluton 6-3c	Markham Fiord Pluton 6-4a	Markham Fiord Pluton 6-4b
Field No.	**80TM-225B1**	**80TM-225B1**	**80TM-225B1**	**80TM-231A**	**80TM-231A**	**80TM-231A**	**80TM-225I**	**80TM-225I**
SiO_2%	60.0	60.0	60.29	63.8	63.9	62.76	64.4	68.33
Al_2O_3	17.4	17.5	16.81	17.0	17.1	16.54	15.7	16.07
TiO_2	0.52	0.52	0.54	0.47	0.46	0.46	0.46	0.45
Fe_2O_3t	6.00	6.00	6.27	3.50	3.60	3.04		2.80
Fe_2O_3	2.4	2.4	2.13	1.6	1.7	1.55	1.4	0.89
FeO	3.2	3.2	3.73	1.7	1.7	1.49	1.4	1.72
MnO	0.10	0.10	0.11	0.05	0.05	0.05	0.06	0.06
MgO	2.47	2.50	2.39	1.74	1.74	1.58	1.71	1.72
CaO	4.21	4.19	4.37	2.82	2.83	2.99	2.32	1.41
Na_2O	4.00	4.00	2.97	5.50	5.50	4.36	5.9	4.64
K_2O	1.97	1.97	2.39	3.32	3.30	3.57	2.58	2.56
P_2O_5	0.18	0.18	0.18	0.20	0.20	0.23	0.22	0.27
CO_2	1.1	1.1	1.80	0.1	0.1	0.10	1.5	0.59
H_2O	2.3	2.3		1.1	1.1		1.5	
l.o.i.			1.50			3.90		0.66
Total	99.18	100.0	99.21	99.4	99.7	99.58	99.2	99.37
Nb ppm	6	7	7.7	10	9	8.7		12
Rb	60	62	58	74	71	71		37
Ta		0.2	<0.18		0.6	0.22		0.32
Y	16	15	13	9	8	6.4		6.3
Yb	2.1	1.9	1.7	0.9	0.9	0.69		1.0
Ba	450	460		1300	1400		1800	
Be	1.4	1.4		1.6	1.6		2.2	
Co	18	13		14	8		15	
Cr	2	2		31	23		28	
Cu	21	19		27	24		12	
La	5	5		24	23		66	
Ni	6	3		10	5		19	
Sr	580	580		1300	1300		1000	
V	120	110		71	65		91	
Zn	33	50		15	23		90	
Zr	120	130		200	190		100	

Appendix 4B

Table 2 (cont'd.)

Unit	Markham Fiord Pluton 6-5	Cape Richards Complex 7-1a	Cape Richards Complex 7-1b	E of Disraeli Glacier 8-1a	E of Disraeli Glacier 8-1b	E of Disraeli Glacier 8-2a	E of Disraeli Glacier 8-2b	E of Disraeli Glacier 8-3a
Field No.	**80TM-225E1**	**80TM-227F1**	**80TM-227F1**	**88TM-123B1**	**88TM-123B1**	**88TM-123B3**	**88TM-123B3**	**88TM-123B4**
SiO_2%	67.1	67.8	68.0	71.3	71.0	57.9	57.8	75.4
Al_2O_3	16.1	16.8	17.0	14.0	13.9	17.8	18.0	12.9
TiO_2	0.37	0.32	0.32	0.60	0.60	0.57	0.56	0.09
Fe_2O_3t		2.10	2.10	3.00	3.00	6.70	6.70	0.5
Fe_2O_3	1.2	1.4	1.4	0.6	0.6	3.1	3.1	0.2
FeO	1.3	0.6	0.6	2.2	2.2	3.2	3.2	0.3
MnO	0.05	0.04	0.04	0.05	0.05	0.12	0.13	0.01
MgO	1.21	0.71	0.71	1.67	1.66	2.93	2.94	0.27
CaO	2.11	2.50	2.49	1.37	1.36	3.57	3.55	0.49
Na_2O	5.2	5.00	5.00	3.90	3.90	5.10	5.00	2.50
K_2O	2.95	3.14	3.17	2.14	2.14	1.86	1.86	6.41
P_2O_5	0.16	0.12	0.12	0.06	0.06	0.31	0.30	0.02
CO_2	0.1	0.1	0.1	0.0	0.0	0.4	0.4	0.1
H_2O	0.1	0.9	1.9	1.7	1.7	2.9	2.9	0.9
l.o.i.								
Total	99.1	99.3	99.8	99.7	99.3	99.7	99.8	99.6
Nb ppm		12	12	8	9	7	7	3
Rb		83	74	68	69	58	57	98
Ta			0.3		0.6		0.4	
Y		10	8	6	7	22	25	1
Yb		1.1	1.3	0.7	0.9	2.6	3.0	0.3
Ba	1200	1500	1400	570	570	480	490	1700
Be	2.4	2.6	2.7	1.0	1.0	0.8	0.8	0.3
Co	11	9	0	3	3	9	8	1
Cr	22	15	5	2	7	5	4	4
Cu	11	6	0	30	31	20	18	40
La	57	27	21	6	7	19	22	2
Ni	11	10	0	0	0	8	4	0
Sr	1100	1700	1700	310	310	440	430	200
V	64	28	14	83	85	120	120	8
Zn	98	14	31	0	18	46	63	0
Zr	60	190	120	200	210	41	36	75

Appendix 4B

Table 2 (cont'd.)

Unit	E of Disraeli Glacier 8-3b	E of Disraeli Glacier 8-4a	E of Disraeli Glacier 8-4b	E of Disraeli Glacier 8-5a	E of Disraeli Glacier 8-5b	E of Disraeli Glacier 8-6a	E of Disraeli Glacier 8-6b	E of Disraeli Glacier 8-7a
Field No.	**88TM-123B4**	**88TM-120D1**	**88TM-120D1**	**88TM-120D3**	**88TM-120D3**	**77TM-307B5**	**77TM-307B5**	**77TM-307B6**
SiO_2%	75.4	61.0	61.0	70.1	70.6	53.3	54.1	70.0
Al_2O_3	12.9	15.3	15.2	14.8	15.0	20.8	21.2	13.8
TiO_2	0.09	0.52	0.51	0.22	0.22	0.73	0.73	0.06
Fe_2O_3t	0.60	5.40	5.40	1.00	1.00	6.20	6.30	0.20
Fe_2O_3	0.3	1.8	1.8	0.3	0.3	3.0	3.1	0.1
FeO	0.3	3.2	3.2	0.6	0.6	2.9	2.9	0.1
MnO	0.01	0.10	0.10	0.02	0.02	0.09	0.09	0.01
MgO	0.28	3.11	3.09	0.48	0.50	2.10	2.15	0.28
CaO	0.48	3.03	3.01	1.82	1.83	5.02	5.08	3.45
Na_2O	2.50	5.10	5.10	5.30	5.20	6.00	6.00	3.80
K_2O	6.41	2.01	2.02	3.14	3.15	2.00	2.04	4.44
P_2O_5	0.02	0.17	0.17	0.07	0.08	0.25	0.25	0.05
CO_2	0.1	1.6	1.6	1.2	1.2	0.6	0.6	2.6
H_2O	0.9	2.6	2.6	1.0	1.0	2.5	2.5	0.6
l.o.i.								
Total	99.4	99.5	99.4	99.0	99.7	99.3	100.8	99.4
Nb ppm	4	6	7	27	24	7	9	5
Rb	100	39	45	120	120	58	59	240
Ta	0.4		0.3		1.8		0.6	
Y	3	10	10	14	16	33	36	14
Yb	0.5	1.1	1.4	1.4	2.0	4.1	4.4	0.8
Ba	1700	590	600	760	770	350	310	180
Be	0.3	0.8	0.8	2.9	2.9	1.0	1.0	7.8
Co	0	12	12	2	1	3	6	5
Cr	0	17	15	3	5	2	1	8
Cu	36	150	150	2	2	22	19	6
La	4	2	4	22	27	2	6	7
Ni	0	10	5	0	0	2	0	10
Sr	200	240	240	300	290	810	910	210
V	1	100	94	14	16	77	71	5
Zn	0	33	49	0	1	24	40	0
Zr	73	180	190	190	190	260	240	23

Appendix 4B

Table 2 (cont'd.)

Unit	E of Disraeli Glacier 8-7b	Cape Woods Pluton 9-1	N of Rens Fiord 10-1a	N of Rens Fiord 10-1b	N of Rens Fiord 10-2a	N of Rens Fiord 10-2b	N of Rens Fiord 10-3a	N of Rens Fiord 10-3b
Field No.	**77TM-307B6**	**80TM-228K**	**88TM-103C**	**88TM-103C**	**61TM-47A**	**61TM-47A**	**61TM-45A**	**61TM-45A**
SiO_2%	69.6	68.91	65.3	64.6	68.3	67.9	62.2	62.3
Al_2O_3	13.7	15.65	15.2	15.2	16.3	16.1	16.0	16.3
TiO_2	0.07	0.35	0.72	0.72	0.37	0.37	0.59	0.59
Fe_2O_3t	0.20	1.99	6.20	6.20	3.20	3.30	4.90	4.90
Fe_2O_3	0.1	1.19	0.9	0.9	0.5	0.6	1.5	1.5
FeO	0.1	0.72	4.8	4.8	2.4	2.4	3.1	3.1
MnO	0.01	0.05	0.07	0.07	0.04	0.04	0.08	0.08
MgO	0.28	0.41	3.21	3.17	1.96	1.94	3.21	3.20
CaO	3.39	3.28	2.61	2.59	3.55	3.55	5.20	5.19
Na_2O	3.80	3.87	2.50	2.50	3.30	3.20	3.30	3.30
K_2O	4.45	4.47	3.26	3.28	2.47	2.45	2.62	2.63
P_2O_5	0.05	0.19	0.19	0.19	0.14	0.14	0.19	0.19
CO_2	2.6	0.07	0.2	0.2	0.1	0.1	0.2	0.2
H_2O	0.6		1.4	1.4	1.0	1.0	1.3	1.3
l.o.i.		0.23						
Total	98.9	99.39	100.4	99.7	100.5	99.8	99.5	99.9
Nb ppm	6	13	26	20	16	12	14	19
Rb	250	87	210	210	130	130	100	96
Ta	0.2	0.33		1.5		1.2		0.4
Y	14	7.0	16	15	12	12	16	12
Yb	1.0	0.80	1.6	1.7	1.2	1.1	1.5	2.2
Ba	180		880	870	840	820	1400	1400
Be	7.7		1.7	1.7	2.0	2.0	2.1	2.1
Co	2		22	20	14	16	25	7
Cr	0		56	57	28	32	62	55
Cu	0		4	4	1	3	15	7
La	11		27	25	26	25	39	24
Ni	0		26	21	17	15	30	12
Sr	200		560	570	710	720	940	860
V	0		100	100	53	52	100	91
Zn	6		32	71	0	25	0	33
Zr	24		210	220	89	94	190	200

Appendix 4B

Table 2 (cont'd.)

Unit	SE of Cape Stallworthy 11-1a	SE of Cape Stallworthy 11-1b	S of Rens Fiord 12-1a	S of Rens Fiord 12-1b	S of Rens Fiord 12-1c	S of Rens Fiord 12-1d	S of Rens Fiord 12-2a	S of Rens Fiord 12-2b
Field No.	**61TM-38H**	**61TM-38H**	**86TM-107A**	**86TM-107A**	**86TM-107A**	**86TM-107A**	**62TM-8B**	**62TM-8B**
SiO_2%	60.5	60.8	62.1	62.2	63.6	62.4	61.9	62.5
Al_2O_3	16.8	16.9	16.5	16.7	16.3	16.0	16.3	16.5
TiO_2	0.63	0.62	0.45	0.45	0.47	0.47	0.43	0.43
Fe_2O_3t	5.20	5.20	4.10	4.20	4.39	4.33	4.00	4.00
Fe_2O_3	3.3	3.3	1.9	2.0	1.8	1.7	2.2	2.2
FeO	1.7	1.7	2.0	2.0	2.3	2.4	1.6	1.6
MnO	0.09	0.09	0.08	0.08	0.09	0.09	0.08	0.08
MgO	2.26	2.28	2.96	2.95	3.21	3.16	2.11	2.13
CaO	4.30	4.27	2.36	2.37	1.98	1.94	3.26	3.24
Na_2O	5.00	5.00	5.00	5.00	4.83	4.58	3.60	3.70
K_2O	1.22	1.21	2.59	2.59	3.09	2.98	4.14	4.16
P_2O_5	0.26	0.26	0.22	0.22	0.26	0.22	0.22	0.22
CO_2	1.6	1.6	1.3	1.3	0.9	1.0	1.5	1.5
H_2O	1.9	1.9	2.3	2.3			1.9	1.9
l.o.i.					2.3	2.1		
Total	99.6		99.9	100.3	101.2	99.1	99.2	100.1
Nb ppm	15	17	12	13			10	10
Rb	25	23	59	62			99	93
Ta		0.7		0.6				0.3
Y	21	17	12	11			12	12
Yb	2.2	2.3	1.5	1.5			1.4	1.5
Ba	1300	1400	1500	1600	3200	3000	1400	1400
Be	1.8	1.7	2.2	2.1			2.4	2.4
Co	21	5	12	9			11	13
Cr	8	3	20	23			20	23
Cu	3	0	2	4			18	21
La	45	30	33	28			30	32
Ni	10	0	0	3			2	6
Sr	1200	1200	820	830	900	890	740	740
V	78	69	54	57			54	58
Zn	0	11	37	50			36	47
Zr	200	210	170	170	160	160	160	160

Appendix 4B

Table 2 (cont'd.)

Unit	S of Rens Fiord 12-2c	S of Rens Fiord 12-2d	SE of Phillips Inlet 13-1a	SE of Phillips Inlet 13-1b	SE of Phillips Inlet 13-2a	SE of Phillips Inlet 13-2b	Petersen Bay Pluton 14-1a	Petersen Bay Pluton 14-1b
Field No.	62TM-8B	62TM-8B	88TM-208C	88TM-208C	62TM-51I	62TM-51I	88TM-117D	88TM-117D
SiO_2%	62.4	61.8	58.4	58.0	58.0	57.9	57.8	57.9
Al_2O_3	15.9	15.9	16.1	16.1	15.8	15.9	18.1	18.2
TiO_2	0.44	0.44	0.89	0.90	0.94	0.93	0.85	0.85
Fe_2O_3t	4.15	4.11	6.30	6.20	6.60	6.70	4.70	4.70
Fe_2O_3	1.8	1.8	1.3	1.2	1.4	1.5	1.9	1.9
FeO	2.1	2.1	4.5	4.5	4.7	4.7	2.5	2.5
MnO	0.09	0.09	0.12	0.12	0.13	0.13	0.24	0.25
MgO	2.28	2.27	3.43	3.44	3.66	3.65	2.99	2.98
CaO	3.21	3.19	6.60	6.55	6.91	6.90	2.33	2.35
Na_2O	3.74	3.70	3.00	3.00	2.80	2.80	6.40	6.30
K_2O	4.24	4.21	2.72	2.73	1.93	1.93	4.34	4.36
P_2O_5	0.25	0.23	0.50	0.50	0.57	0.57	0.13	0.14
CO_2	1.3	1.3	0.3	0.3	0.3	0.3	0.1	0.1
H_2O			1.8	1.8	2.3	2.3	1.2	1.2
l.o.i.	2.0	1.9						
Total	99.7	98.9	99.6	99.1	99.4	99.5	98.8	99.2
Nb ppm			20	16	17	12	205	180
Rb			73	74	61	56	300	300
Ta				0.2		0.2		0.6
Y			20	20	22	24	16	16
Yb			2.7	2.4	2.7	2.5	2.5	2.7
Ba	1600	1500	1100	1100	760	740	220	200
Be			2.4	2.3	2.6	2.5	5.0	5.2
Co			11	4	13	13	13	11
Cr			72	5	13	14	110	110
Cu			9	4	7	5	6	5
La			52	51	55	64	120	120
Ni			0	0	1	1	62	63
Sr	720	700	1600	1700	1200	1200	240	250
V			220	200	210	200	41	41
Zn			21	46	26	45	84	100
Zr	160	170	79	84	110	110	1100	1100

Appendix 4B

Table 2 (cont'd.)

Unit	Petersen Bay Pluton 14-2a	Petersen Bay Pluton 14-2b	Wootton Complex 15-1a	Wootton Complex 15-1b	Marvin Pluton 16-1a	Marvin Pluton 16-1b	Marvin Pluton 16-2a	Marvin Pluton 16-2b
Field No.	88TM-116B1	88TM-116B1	82TM-212C6	82TM-212C6	77TM-316F3	77TM-316F3	77TM-317B2	77TM-317B2
SiO_2%	71.6	71.6	59.4	59.2	55.4	55.6	49.8	49.8
Al_2O_3	14.9	14.9	18.3	18.5	14.3	14.5	13.5	13.6
TiO_2	0.31	0.31	0.89	0.89	1.59	1.59	3.80	3.80
Fe_2O_3t	2.70	2.70	5.80	5.80	12.3	12.3	15.4	15.5
Fe_2O_3	1.1	1.1	2.7	2.7	4.5	4.5	4.0	4.1
FeO	1.4	1.4	2.8	2.8	7.0	7.0	10.3	10.3
MnO	0.04	0.04	0.09	0.09	0.23	0.22	0.19	0.19
MgO	0.89	0.89	1.53	1.56	1.84	1.84	4.25	4.25
CaO	2.29	2.26	4.07	4.07	4.52	4.50	8.33	8.36
Na_2O	4.10	4.10	4.40	4.40	4.30	4.30	2.90	2.90
K_2O	1.71	1.72	4.58	4.60	2.34	2.37	1.15	1.14
P_2O_5	0.07	0.07	0.17	0.18	0.71	0.72	0.39	0.39
CO_2	0.0	0.0	0.1	0.1	0.6	0.6	0.1	0.1
H_2O	1.3	1.3	1.0	1.0	2.4	2.4	1.3	1.3
l.o.i.								
Total	99.7	99.7	100.1	100.2	99.6	100.1	100.1	100.3
Nb ppm	14	17	41	38	56	54	38	33
Rb	78	75	68	74	57	57	29	26
Ta		1.1		1.0		0.3		0.4
Y	19	20	21	24	59	55	35	33
Yb	2.3	2.7	2.7	2.7	5.6	5.0	3.3	4.0
Ba	560	570	1200	1200	900	860	320	330
Be	2.8	2.9	1.7	1.8	3.2	3.2	1.8	1.9
Co	0	0	7	14	14	11	40	37
Cr	6	9	7	14	9	2	10	4
Cu	0	0	0	4	15	12	80	77
La	32	33	23	34	47	43	22	16
Ni	0	1	0	4	7	2	31	27
Sr	280	290	300	300	370	370	560	560
V	12	15	42	52	28	22	320	320
Zn	0	15	17	38	210	240	65	85
Zr	190	180	740	750	480	490	300	300

Appendix 4B

Table 2 (cont'd.)

Unit	Marvin Pluton 16-3a	Marvin Pluton 16-3b	Marvin Pluton 16-4a	Marvin Pluton 16-4b	Marvin Pluton 16-5a	Marvin Pluton 16-5b
Field No.	**77TM-317C2**	**77TM-317C2**	**77TM-320A1**	**77TM-320A1**	**77TM-317A1**	**77TM-317A1**
SiO_2%	51.4	51.5	53.3	53.2	52.2	52.1
Al_2O_3	14.4	14.7	14.2	14.3	14.0	14.0
TiO_2	2.95	2.94	2.68	2.68	2.80	2.80
Fe_2O_3t	14.2	14.2	13.9	13.9	14.5	14.5
Fe_2O_3			3.6	3.6	4.7	4.7
FeO			9.3	9.3	8.8	8.8
MnO	0.20	0.20	0.21	0.21	0.23	0.22
MgO	3.28	3.26	2.79	2.78	2.96	2.97
CaO	7.33	7.36	6.42	6.39	7.23	7.18
Na_2O	3.30	3.30	3.60	3.50	3.10	3.00
K_2O	1.29	1.32	1.83	1.84	1.51	1.50
P_2O_5	0.52	0.52	0.49	0.49	0.53	0.53
CO_2			0.1	0.1	0.3	0.3
H_2O			1.5	1.5	1.7	1.7
l.o.i.						
Total	98.9	99.3	100.0	99.9	100.0	99.8
Nb ppm	36	33	46	47	39	33
Rb	31	41	43	46	40	45
Ta		0.3		0.2		0.3
Y	38	37	47	44	44	42
Yb	3.9	3.9	3.9	3.8	4.8	4.0
Ba	370	370	430	450	410	380
Be	2.1	2.1	2.4	2.4	2.3	2.3
Co	36	30	31	29	26	26
Cr	7	0	0	0	0	0
Cu	42	26	23	24	23	22
La	26	28	33	35	29	29
Ni	15	6	1	5	0	5
Sr	640	630	660	660	580	590
V	210	190	160	150	160	160
Zn	100	120	95	110	140	160
Zr	340	350	400	410	370	380

Appendix 4B

Table 3

Nb, Rb, Ta, Y, and Yb analyses (in ppm)

Deuchars Glacier Belt

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
1–1	6	10	240	250	0.6	13	13	1.4	1.2
1–2	9	17	150	150	0.3	29	30	3.2	3.8
1–3	8	11	40	44	0.2	33	34	2.4	2.9
1–4	7	8	210	210	1.9	21	21	3.1	2.7
1–5	14	17	150	150	1.2	31	32	3.4	3.1
1–6	7	7	190	190	0.9	25	27	2.9	3.1

Phillips Inlet Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
1–1	23	25	100	100	0.3	32	27	3.1	3.2
2–2	16	21	75	81	0.5	31	31	4.6	5.3

Ward Hunt Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
3–1	22	19	67	66	0.7	13	16	1.4	1.2

Granitoid intrusion in M'Clintock West body

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
4–1	8	6	42	45	0.4	26	27	3.1	3.4
4–2	7		45		1.4	20		2.6	
4–3	6	8	81	73	0.6	18	19	2.2	2.4

Ayles Fiord Intrusion

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
5–1	14	16	160	160	0.7	5	10	0.6	0.8
5–2	16	16	170	180	0.5	10	13	0.9	1.0

Markham Fiord Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
6–1	4	5	30	31	0.2	17	17	2.3	2.1
6–1	5.1		34		0.24	15		1.9	
6–2	6	7	60	62	0.2	16	15	2.1	2.9
6–2	7.7		58		<0.18	13		1.7	
6–3	10	9	74	71	0.6	9	8	0.9	0.9
6–3	8.7		71		0.22	6.4		0.69	
6–4	12		37		0.32	6.3		1.0	

Cape Richards Intrusive Complex

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
7–1	12	12	83	74	0.3	10	8	1.1	1.3

Disraeli Glacier Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
8–1	8	9	68	69	0.6	6	7	0.7	0.9
8–2	7	7	58	57	0.4	22	25	2.6	3.0
8–3	3	4	98	100	0.4	1	3	0.3	0.5
8–4	6	7	39	45	0.3	10	10	1.1	1.4
8–5	27	24	120	120	1.8	14	16	1.4	2.0
8–6	7	9	58	59	0.6	33	36	4.1	4.4
8–7	5	6	240	250	0.2	14	14	0.8	1.0

Cape Woods Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
9–1	13		87		0.33	7		0.8	

Intrusions north of Rens Fiord

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
10–1	26	20	210	210	1.5	16	15	1.6	1.7
10–2	16	12	130	130	1.2	12	12	1.2	1.1
10–3	14	19	100	96	0.4	16	12	1.5	2.2

Intrusion southeast of Cape Stallworthy

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
11–1	15	17	25	23	0.7	21	17	2.2	2.3

Intrusions south of Rens Fiord

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
12–1	12	13	59	62	0.6	12	11	1.5	1.5
12–2	10	10	99	93	0.3	12	12	1.4	1.5

Pluton southeast of Phillips Inlet

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
13–1	20	16	73	74	0.2	20	20	2.7	2.4
13–2	17	12	61	56	0.2	22	24	2.7	2.5

Petersen Bay Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
14–1	205	180	300	300	0.6	16	16	2.5	2.7
14–2	14	17	78	75	1.1	19	20	2.3	2.7

Wootton Intrusive Complex

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
15–1	41	38	68	74	1.0	21	24	2.7	2.7

Marvin Pluton

No.	Nb	Nb	Rb	Rb	Ta	Y	Y	Yb	Yb
16–1	56	54	57	57	0.3	59	55	5.6	5.0
16–2	38	33	29	26	0.4	35	33	3.3	4.0
16–3	36	33	31	41	0.3	38	37	3.9	3.9
16–4	46	47	43	46	0.2	47	44	3.9	3.8
16–5	39	33	40	45	0.3	44	42	4.8	4.0

APPENDIX 4

C. U–Pb (ZIRCON) AGE DETERMINATION ON A SAMPLE FROM THE KULUTINGWAK FORMATION (Fig. 178)

Janet E. Gabites
Department of Geological Sciences
University of British Columbia
6339 Stores Road, Vancouver, B.C. V6T 1Z4

SAMPLE NUMBER AND LOCATION
Sample: 90TM–BJO–705A (C–171512)
Location: Structural high south of Kulutingwak Anticlinorium (*Yelverton Inlet*, inset, circled A); NTS 340 F, UTM Zone 17X, 468000E, 9107100N

ANALYTICAL METHODS

Zircons are separated from finely crushed 10 to 40 kg rock samples using a wet shaking table, heavy liquids, and magnetic separator. The concentrates are split into magnetic (M) and nonmagnetic (NM) fractions, sized using new nylon mesh screens, and hand picked to 100% purity as required. Concordance is improved by air abrasion techniques (Krogh, 1982). Chemical dissolution and mass spectrometry follow the procedures of Krogh (1973). A mixed 205Pb–233U–235U spike is used (Parrish and Krogh, 1987; Roddick et al., 1987). The dissolution is in small-volume teflon capsules contained in a large Parr bomb (Parrish, 1987). Uranium and lead are eluted into the same beaker and loaded and run on the same rhenium filament with silica gel and phosphoric acid. Uranium is run at 1150°C, then lead at 1250°C. A Daly collector is used to improve the quality of measurement of low-intensity ^{204}Pb signals. U–Pb age errors are obtained by individually propagating all calibration and measurement uncertainties through the entire age calculation and summing the individual contributions to the total variance (Nunes, 1980). The laboratory blank has an isotopic composition: $Pb^{206:207:208:204} =$ 17.75:15.57:37.30:1.00. The isotopic composition of common Pb is based on the Stacey and Kramers (1975) common Pb growth curve. The decay constants are those recommended by the IUGS Subcommission on Geochronology (Steiger and Jäger, 1977). Concordia intercepts are based on a York (1969) regression and Ludwig (1980) error algorithm. Raw U–Pb ratios are calculated using weighted means of the mass spectrometer data. Errors reported for the U–Pb isotopic ratios are one sigma; those for final ages and shown on concordia plots are two sigma (95% confidence limits).

RESULTS AND INTERPRETATION

Three fractions were analysed from this rock. All were abraded to remove discordant outer material. The zircons extracted are euhedral to subhedral, doubly terminated prisms. They are pale pink, and clear crystals were chosen for each of the fractions. In the coarser fractions many of the crystals had been broken during crushing; the least damaged were chosen. None of the fractions are concordant. The fine magnetic fraction appears to have lost lead, while the coarse non-magnetic fraction contains a component of inherited old zircon, which pulls it to the right of concordia and away from the chord defined by the other two fractions.

The best estimate of the age of this rock is given by the weighted mean of the $^{207}Pb/^{206}Pb$ ages of fractions b and c, because of the inheritance in fraction a. All three fractions have the potential of containing an inherited old zircon component, since none of them lie on concordia, thus a conservative interpretation is appropriate. The rock is unlikely to be younger than the $^{206}Pb/^{238}U$ age of the most concordant fraction, b, at 440.6 ± 1.0 Ma, which gives a lower limit of 9 Ma on the age estimate. Thus the interpreted age of the sample is $449.7 + 3.5/- 9$ Ma (Fig. 178).

Appendix 4C
Table 1
U-Pb Zircon data

Fraction[1,2]		wt	U^3	$Pb^{3,4}$	^{208}Pb	Pb^5	^{206}Pb	Isotopic Ratios ($\pm$%1δ)			Isotopic Dates (Ma, $\pm 2\delta$)		
		mg	ppm	ppm	%	pg	$^{204}Pb^6$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$
705A													
A	N2, +a abr	0.70	1106	87.4	18.1	0.024	140600	0.07120 (.391)	0.5517 (.419)	0.05620 (.087)	443.4 ± 3.4	446.1 ± 3.0	460.3 ± 3.8
B	M2, -a+b abr	0.30	440	34.1	17.0	0.179	3175	0.07075 (.115)	0.5453 (.215)	0.05590 (.121)	440.6 ± 1.0	441.9 ± 1.5	448.4 ± 5.4
C	M1.5, -b abr	0.20	1872	150	21.6	0.312	5099	0.06894 (.124)	0.5319 (.210)	0.05596 (.106)	429.8 ± 1.0	433.2 ± 1.5	450.7 ± 4.7

Notes: Analyses by J.E. Gabites, 1990–91, in the Geochronology Laboratory, Department of Geological Sciences, U.B.C. IUGS decay constants (Steiger and Jäger, 1977) are: $^{238}U\lambda = 1.55125 \times 10^{-10} a^{-1}$, $^{235}U\lambda = 9.8485 \times 10^{-10} a^{-1}$, $^{238}U/^{235}U = 137.88$ atom ratio.

1. Column one gives the label used on the figure.
2. Zircon fractions are labelled according to magnetic susceptibility and size. N = nonmagnetic at given amperes on Frantz magnetic separator, M = magnetic. Side slope is given in degrees. The – indicates zircons are smaller than, + larger than the stated mesh (μm). Abr = air abraded. Magnetic fractions : N2 = N2a/1°, M2 = M2a/1°, M1.5 = M1.5a/3°. Size fractions: A 104 mm, B 74 mm, C 44 mm.
3. U and Pb concentrations in mineral are corrected for blank U and Pb. Isotopic composition of Pb blank is 206:207:208:204 = 17.835: 15.735:36.459:1.00, based on ongoing analyses of total procedural blanks of 20 ± 1 pg (Pb) and 6 ± 0.5 pg (U) during this study.
4. Radiogenic Pb.
5. Total common Pb in analysis based on blank isotopic composition.
6. Initial common Pb is assumed to be Stacey and Kramers (1975) model Pb at the $^{207}Pb/^{206}Pb$ age for each fraction.

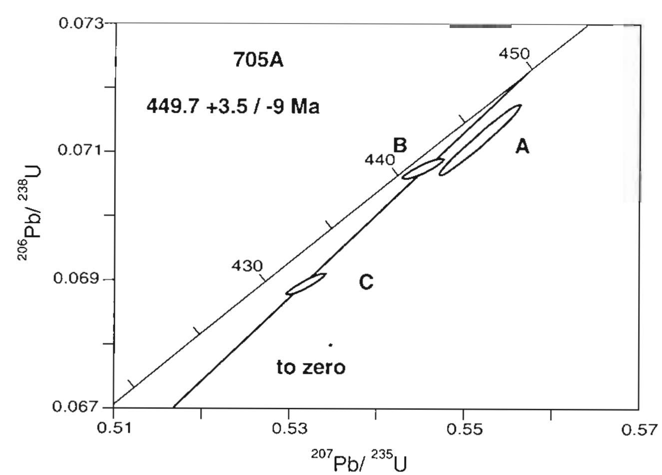

Figure 178. U-Pb concordia diagram for volcanic rock from Kulutingwak Formation.

APPENDIX 5

PALEONTOLOGY[1]

CONTENTS

A. IDENTIFICATIONS OF MACROFOSSILS

B.S. Norford, A.E.H. Pedder, J.W. Kerr, and R. Thorsteinsson

NORTHERN HEIBERG FOLD BELT

SVARTEVAEG FORMATION

Member B, Svartevaeg Cliffs

GSC locality 47511. 12.7 km southeast of Cape Stallworthy on east slope of ridge; *Cape Stallworthy-Bukken Fiord*, inset C, locality F1; NTS 560 D; UTM Zone 15X, 501400E, 9028000N; approximately 60 m above base of Member B; from limestone olistostrome, about 5 m long, enclosed in volcanic arenite; identification by B.S. Norford (from Trettin, 1969a, p. 25 and fig. 2, loc. 4; age revised).

Fauna
- echinoderm columnals
- fragments of solitary corals, 2 spp.
- bryozoa
- stromatoporoid(?)
- cf. *Favosites* sp.
- spire-bearing brachiopod, (?)*Howellela*
- *Encrinurus* sp.

Remarks. Silurian, probably late Llandovery to Pridoli.

GSC locality 47505. 11.3 km southeast of Cape Stallworthy; NTS 560 D; UTM Zone 15X, 500800E, 9029600N; from cobbles in limestone conglomerate; identification by B.S. Norford (from Trettin, 1969a, p. 26 and fig. 2, loc. 5).

Fauna
- coral fragments, including cystiphyllids
- stromatoporoid

Remarks. Silurian or Devonian.

GSC locality 47506. 14.5 km southeast of Cape Stallworthy; NTS 560D; UTM Zone 15X, 503250E, 9027900N; from limestone cobbles in conglomerate

[1]Concerning the method of determination and accuracy of the UTM coordinates see Appendix 1, footnote 1.

that may be correlative with GSC locality 47505; identification by B.S. Norford (from Trettin, 1969a, p. 26 and fig. 2, loc. 6); *see* Nowlan, Appendix 5B, C-194943 and de Freitas, Appendix 5C, C-194934-2.

Fauna

favositid and columnarid corals
?*Syringopora* sp.
stromatoporoid

Remarks. Silurian to Middle Devonian.

GSC locality C-194828. 13.3 km southeast of Cape Stallworthy; *Cape Stallworthy-Bukken Fiord*, inset C, locality F3; NTS 560 D; UTM Zone 15X, 502400E, 9028500N; upper part of member but below unit 24 of Svartevaeg section; identification by B.S. Norford.

Fauna

Monograptus aff. *M. parapriodon* Boucek

Remarks. Silurian, probably *turriculatus* Zone (Telychian) to *rigidus* Zone (Sheinwoodian).

GSC locality C-194929. Location as for C-194828 but from different strata; identification by B.S. Norford.

Fauna

Monograptus aff. *M. speciosus* Tullberg

Remarks. Early Silurian, probably late Telychian.

Member B, east of Eetookashoo Bay and Rens Fiord

GSC locality 47510. 5.6 km south-southeast of Cape Stallworthy; NTS 560 D; UTM Zone 15X, 493200E, 9030400N; from pebbles and cobbles in limestone conglomerate; identification by B.S. Norford (from Trettin, 1969a, p. 17 f. and fig. 2, loc. 1).

Fauna

echinoderm columnals
bryozoa
gastropods
brachiopod and foraminiferal fragments
cystiphyllid coral
Favosites sp.
Halysites sp.

Remarks. Silurian, probably Llandovery or Wenlock. The *Halysites* is similar to one described as *H. catenularius* by Poulsen from the Offley Island Formation of Greenland of Llandovery age.

GSC locality 52319. 2.6 km northeast of central Rens Fiord; *Cape Stallworthy-Bukken Fiord*, section ERF; NTS 560 D; UTM Zone 15X, 502400E, 9012400N; about 15 m below unconformable contact with Stallworthy Formation; identification by J.W. Kerr and R. Thorsteinsson (from Trettin, 1969a, p. 18 and fig. 2, loc. 2).

Fauna

Cyrtograptus sp.
(?)*Cyrtograptus* sp. (cladia)
Monograptus sp.
Monograptus cf. *M. flemingi*

Remarks. Middle Silurian, probably late Middle Silurian (late Wenlock).

STALLWORTHY FORMATION

Member C

GSC locality 47521. 7.1 km southeast of Cape Stallworthy; NTS 560 D; UTM Zone 15X, 496100E, 9030200N; identification by R. Thorsteinsson (from Trettin, 1969a, p. 22 and fig. 2, loc. 3); remarks by R. Thorsteinsson and H.P. Schultze (pers. comm., 1985); about 1.3-1.5 km above base of formation.

Fauna

Heterostraci: represented by *Traquairaspis* sp. and a member of Pteraspidida
Arthrodira: a member of Arctolepidida
Crossopterygii: probably a representative of Porolepididae or Osteolepdidae

Remarks. Early Devonian, late Lochkovian or early Pragian.

CLEMENTS MARKHAM FOLD BELT

HAZEN FORMATION

GSC locality C-194930. Northeast-facing slope, about 650 m south of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F1; NTS 560 D; UTM Zone 16X, 470700E, 9042700N; talus close to source; 0-15 m below faulted contact with Fire Bay Formation; identification by B.S. Norford.

Fauna

Cryptograptus cf. *C. schaeferi* (Lapworth)
C. cf. *C. tricornis* (Carruthers)
Eoglyptograptus? sp.
Glossograptus sp.

Pterograptus sp.
Undulograptus? sp.
dichograptid(?) stipes
indeterminate conodont

Remarks. Early Middle Ordovician (Llanvirn or Llandeilo). In western Canada and Newfoundland, this faunal assemblage first appears in the upper part of the *Paraglossograptus tentaculatus* Zone and ranges through the *Pseudoclimacograptus decoratus* and the ''*Glyptograptus*'' *euglyphus* Zone into the *Nemagraptus gracilis* Zone.

GSC locality C-194944. Top of southeast-trending ridge, about 625 m southwest of head of Fire Bay; *Cape Stallworthy–Bukken Fiord*, inset B, locality F2; NTS 560 D; UTM Zone 16X, 470300E, 9042700N; talus close to source; close to faulted contact with Fire Bay Formation; identification by B.S. Norford.

Fauna
Glossograptus sp.
Eoglyptograptus? sp.
Orthograptus? sp.
Pterograptus? sp.
Undulograptus? sp.

Remarks. Probably early Middle Ordovician.

GSC locality C-194945. Northeast-facing slope close to top of ridge, about 530 m southwest of head of Fire Bay; *Cape Stallworthy–Bukken Fiord*, inset B, locality F3; NTS 560 D; UTM Zone 16X, 470300E, 9042700N; talus close to source; identification by B.S. Norford.

Fauna
Eoglyptograptus? sp.
Undulograptus? sp.

Remarks. Probably latest Early Ordovician to Middle Ordovician.

GSC locality C-171532. 2.65 km south–southeast of head of Fire Bay; *Cape Stallworthy–Bukken Fiord*, inset B, locality F4; NTS 560 D; UTM Zone 16X, 471700E, 9040900N; identification by B.S. Norford.

Fauna
Climacograptus cf. *C. bicornis* (Hall)
C. sp.
?*Dicellograptus* sp.
Dicranograptus aff. *D. kirki* Ruedemann
Orthograptus sp.

Remarks. Middle Ordovician, Caradoc, *C. bicornis* Zone or *D. clingani* Zone. The *Climacograptus bicornis* Zone is the more likely correlation of both C-1171532 and C-171530, but the small *Dicranograptus* in C-171532 resembles *D. kirki*, which is present in the equivalent of the younger *Dicellograptus clingani* Zone in the western United States. Species of *Climacograptus* with pairs of very large basal spines similar to those of *C. bicornis* are present in the Upper Ordovician (Ashgill) but *Dicranograptus* is not known from such young horizons.

GSC locality C-171530. Drift near locality C-171532; identification by B.S. Norford.

Fauna
Climacograptus cf. *C. bicornis* (Hall)
?*Dicellograptus* sp.

Remarks. Middle Ordovician, Caradoc, *C. bicornis* Zone or *D. clingani* Zone.

GSC locality C-171533. NTS 560 D; UTM Zone 16X, 477400E, 9041400N; *Cape Stallworthy–Bukken Fiord*, inset B, locality F5; 9.4 km southeast of Fire Bay; identification by B.S. Norford.

Fauna
?*Orthograptus* sp.

Remarks. Probably Middle or Late Ordovician.

CARBONATE OLISTOLITHS AT FIRE BAY

GSC locality C-171528. 6.25 km west–southwest of head of Fire Bay; *Cape Stallworthy–Bukken Fiord*, inset B, locality F6; NTS 560 D; UTM zone 16X, 469700E, 9042900N; from limestone olistolith; identification by B.S. Norford; *see* Nowlan, Appendix 5C, C-171528.

Fauna
?*Palliseria* sp.

Remarks. Middle to Late Ordovician, probably early Middle Ordovician (Whiterockian).

YELVERTON PASS BEDS

GSC locality C-54807. Northeast side of Yelverton Pass, about 24 km northwest of Yelverton Lake; NTS 340 D; UTM Zone 17X, 532000E, 9086000N; from basal exposures; identification by A.E.H. Pedder; *see* Uyeno, Appendix 5C, C-54790.

Fauna

Ecclimadictyon pandum Nestor
Favosites gothlandicus Lamarck (*see* comments)
Paleofavosites multiporus (Sokolov)
Kiaerites(?) spec. nov.
Halysites sp. cf. *H. suessmilchi* Etheridge

Remarks. Llandovery Series, likely Raikküla "Stage" of Estonian stratotype (approximately middle Llandovery Series).

GSC locality 74813. Same locality as C-54807, talus at base of exposures; collected by W.W. Nassichuk, identification by A.E.H. Pedder.

Fauna

Favosites subfavosus Klaamann
gen. (cf. *Arachnophyllum*) and sp. nov.

GSC locality 741814. Same locality as C-74813 and C-54807; from lower part of exposures; collected by W.W. Nassichuk; identification by A.E.H. Pedder.

Fauna

Favosites gothlandicus Lamarck (*see* comments)
Favosites subfavosus Klaamann
Halysites sp. cf. *H. suessmilchi* Etheridge
Propora (s.l.) sp. nov
Pseudophaulactis sp. indet.
Pseudopilophyllum sp. nov.
Craterophyllum vatium McLean

Remarks. Llandovery Series, upper Raikküla or Adavere "Stage" of Estonian stratotype (= middle or late Llandovery).

The fauna shows obvious relationships to that of the Offley Island Formation of western North Greenland (Poulsen, 1941; McLean, 1977) and to the faunas of middle Llandovery strata in Estonia (Kal'o, 1970). It is not as closely related to the best-known middle Llandovery coral fauna of North America, the Brassfield fauna of the Cincinnati Arch area (Laub, 1975).

Favosites gothlandicus has been variously interpreted by numerous authors, and ranges in age from Late Ordovician to Late Silurian (Scrutton, 1975). Specimens in collections 74814 and C-54807 are small and have extremely fine septal apparatus; such forms have been described from the Raikküla "Stage" of Estonia (op. cit.).

The Llandovery Series of Estonia consists of three "stages", the Juuru (lowest), Raikküla (middle) and Adavere (highest), and the Yelverton Pass fauna is assigned to the Raikküla. Cocks and others (1971a, fig. 9) correlate the Raikküka "Stage" with the interval encompassing the *cyphus* to *convolutus* graptolite zones of Britain (early to middle Aeronian, middle Llandovery) and Viyra (1977) has established a correlation between the "bottom part" of the Adavere "Stage" and the European *celloni* conodont zone, which is approximately equivalent to the British late Llandovery (mid-Telychian) *inconstans* conodont zone (Aldridge, 1975).

FIRE BAY FORMATION

Member A

GSC locality C-171531. 2.4 km south-southeast of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F12; NTS 560 D; UTM Zone 16X, 471550E, 9041100N; Member A, southeastern facies, Unit A3; identification by B.S. Norford.

Fauna

Monograptus ex gr. *M. priodon* (Bronn)
Monograptus aff. *M. sedgwicki* (Portlock)
Pristiograptus aff. *P. regularis* (Törnquist)
inarticulate brachiopod

Remarks. Early Silurian, probably late Llandovery, possibly *Monograptus turriculatus* Zone.

Member C

GSC locality C-194931. 1.2 km northeast of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F13; NTS 560D; UTM Zone 16X; 471200E, 9045600N; talus close to source; identification by B.S. Norford.

Fauna

Pristiograptus aff. *P. nudus* (Lapworth)

Remarks. Early Silurian, probably late Aeronian or Telychian.

DANISH RIVER FORMATION

GSC locality 52313. 28.7 km east-northeast of head of Emma Fiord, close to top of formation; NTS 340 C; UTM Zone 16X, 523500E, 9057700N; identification by J.W. Kerr and R. Thorsteinsson (from Trettin, 1969a, p. 37 and fig. 8, loc. 1).

Fauna
Monograptus aff. *M. priodon*
Monograptus cf. *M. undulatus*

Remarks. Silurian, probably late Llandovery.

GSC locality C-194932. 2.2 km northeast of mouth of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F14; NTS 560D; UTM Zone 16X, 470750E, 9046500N; talus close to source; identification by B.S. Norford.

Fauna
Pristiograptus sp.
?*Monograptus* sp.
pelecypod
indeterminate fossil

Remarks. Silurian.

LANDS LOKK FORMATION

GSC locality 52315. 6.3 km north-northeast of upper Emma Fiord; NTS 340 C; UTM Zone 16X, 496200E, 9056100N; in mudrock of mudrock-volcanogenic facies; drift; identification by J.W. Kerr and R. Thorsteinsson (from Trettin, 1969a, p. 43 and fig. 8, loc. 2).

Fauna
Monograptus cf. *M. priodon*

Remarks. Silurian, late Llandovery or Wenlock.

GSC locality 52314. 8.1 km northeast of Emma Fiord; NTS 340 C; UTM Zone 16X, 500500E, 9056000N; in mudrock of mudrock-volcanogenic facies; talus, probably close to source, about 30 m above base of measured section (from Trettin, 1969a, p. 43, fig. 8, loc. 3, and fig. 9); identification by J.W. Kerr and R. Thorsteinsson (from Trettin, 1969a, p. 43, fig. 8, loc. 3, and fig. 9).

Fauna
Monograptus cf. *M. colonus*

Remarks. Silurian, probably early Ludlow.

GSC locality 52231. Same locality as 52314 in mudrock of mudrock-volcanogenic facies; talus, 78 m above base of measured section; identification by J.W. Kerr and R. Thorsteinsson (from Trettin, 1969a, p. 43, fig. 8, loc. 3 and fig. 9).

Fauna
Monograptus cf. *M. varians*

Remarks. Silurian, Ludlow, probably early Ludlow.

GSC locality 52312. 9.8 km south of head of Emma Fiord, east of Hvitland Peninsula 1 section; *Otto Fiord* section HP1; NTS 340 C; UTM Zone 16X, 497750E, 9037800N; in mudrock of sandstone-mudrock facies; identification by J.W. Kerr and R. Thorsteinsson (from Trettin, 1969a, p. 43 and fig. 8, loc. 5).

Fauna
Monograptus sp.
aff. *Monograptus nilssoni*
Monograptus cf. *M. bohemicus*

Remarks. Silurian, early Ludlow.

GSC locality C-94397. Hvitland Peninsula 1 section, about 8 km south of head of Emma Fiord; *Otto Fiord*, section HP1; NTS 340 C; UTM Zone 16X, 495200E, 9039200N; sandstone-mudrock facies; talus, 50–200 m above base of facies and section; identification by B.S. Norford.

Fauna
Monograptus marri (Perner)

Remarks. Early Silurian, Telychian.

GSC locality C-94398. Same locality as C-94397; sandstone-mudrock facies; talus, 180–240 m above base of facies and section; identification by B.S. Norford.

Fauna
Monograptus 2 spp.

Remarks. Early Silurian to Early Devonian.

GSC locality C-94399. Same locality as C-94397; sandstone-mudrock facies; talus, 270–330 m above base of facies and section; identification by B.S. Norford.

Fauna
Monograptus sp.

Remarks. Early Silurian to Early Devonian.

GSC locality C-94400. Same locality as C-94397; sandstone-mudrock facies; talus, 396–450 m above base of facies and section; identification by B.S. Norford.

Fauna

Bohemograptus cf. *B. bohemicus bohemicus* Barrande

Remarks. Silurian, probably Ludlow.

GSC locality C-94401. Same locality as C-94397; sandstone-mudrock facies; talus, 360–472.9 m above base of facies and section; identification by B.S. Norford.

Fauna

Bohemograptus cf. *B. bohemicus bohemicus* Barrande

Remarks. Silurian, probably Ludlow.

PIPER PASS FORMATION

GSC locality C-54926. Northeast side of Piper Pass, about 15 km south-southeast of head of Clements Markham Inlet; NTS 120 F; UTM Zone 19X, 512200E, 9160400N; identification by B.S. Norford; *see* Uyeno, Appendix 5C, C-54924.

Fauna

Encrinurus sp.
aff. *Sphaerexochus* sp.
Kirkidium sp.
Eospirifer? sp.
indeterminate trilobite
atrypid, rhynchonellid, and other brachiopods
ostracodes
algae?

Remarks. Silurian, late Wenlock to early Pridoli, *Kirkidium* is most common in the Ludlow.

GSC locality C-54932. Northeast side of Piper Pass, about 14.8 km south-southeast of head of Clements Markham Inlet; NTS 120 F; UTM Zone 19X, 512250E, 9160800N; identification by B.S. Norford; *see* Uyeno, Appendix 5C, C-54931.

Fauna

Favosites 2 spp.
Syringopora sp.

Remarks. Early Silurian to Middle Devonian.

GSC locality C-70. Southwest side of Piper Pass, about 17 km south-southeast of head of Clements Markham Inlet; NTS 120 F; UTM Zone 19X, 510150E, 9157600N; identification by B.S. Norford (from Trettin, 1971a, p. 87).

Fauna

echinoderm fragments
bryozoan
solitary coral
Favosites sp.
Syringopora sp.
Thamnopora sp.
stromatolitic structures
undetermined brachiopods
"*Camarotoechia*" sp.
?*Delthyris* sp.
Dicalosia sp.
Kirkidium sp.
undetermined trilobite
Sphaerexochus sp.

Remarks. earliest Ludlow or latest Wenlock.

GSC locality 36957. North side of Clements Markham Glacier; NTS 120 F; UTM Zone 19X, approximately 477500E, 9138300E (from Christie, 1964, p. 28 and GSC Map 1148A, loc. F8; shown as loc. F6 in fig. 2 of Trettin, 1971a); identification by T.E. Bolton.

Fauna

Atrypella phoca
coarse ribbed spirifer (*Delthyris*?)
rugose and phacelloid corals

Remarks. early Late Silurian (*Atrypella phoca* fauna).

PEARYA

CAPE DISCOVERY FORMATION

Member A

GSC locality 75417. Bromley Island section; *M'Clintock Inlet*, section BI; NTS 340 E; UTM Zone 17X, 539100E, 9209700N; 42–44 m above base of formation and member; identification by B.S. Norford (from Trettin, 1969b, p. 19 and fig. 15, loc. F9; age revised).

Fauna

trimerellid brachiopod

Remarks. Middle Ordovician (probably Blackriveran) to Late Silurian (Ludlow).

GSC locality 75416. About 4 km north of south tip of Bromley Island; NTS 340 E; UTM Zone 17X, 536600E, 9207700N; identification by B.S. Norford (from Trettin, 1969b, p. 19 and fig. 15, loc. F10).

Fauna

rhynchonellid brachiopod

Remarks. Probably Ordovician to Permian.

GSC locality 75418. Section north of Bethel Peak, northwest side of unnamed cape north of Bethel Peak, west of Bromley Island; *M'Clintock Inlet*, section NBP; NTS 340 E; UTM Zone 17X, 531000E, 9209800N; 62–132 m above base of formation and member; identification by B.S. Norford (from Trettin, 1969b, p. 19 and fig. 15, loc. F8).

Fauna

bifoliate bryozoan
straight cephalopod
colonial coral
undetermined trilobite

Remarks. Middle Ordovician to Middle Devonian.

GSC locality 24720. Same as GSC locality 75418; stratigraphic position not stated but probably same height; identification by G.W. Sinclair (from Christie, 1964, p. 21; remarks abbreviated).

Fauna

crinoid fragments
Anthozoa (coral), genus indeterminate
Sowerbyella sp.
Liospira sp.
Illaenus sp.
Gonioceras sp.
Richardsonoceras sp.
Lophospira sp.

Remarks. Middle Ordovician, Wildernessian Stage, equivalent to Black River and Rockland formations. (Blackriveran to Rocklandian; B.S. Norford, pers. comm., 1995).

Member B

GSC locality 75419. Same location as 75417; stratigraphic position within Member B not determined; identification by B.S. Norford (from Trettin, 1969b, p. 19 and fig. 15, loc. F9).

Fauna

echinoderm fragments
straight cephalopod
gastropod
undetermined corals

Remarks. Middle Ordovician to Permian.

GSC locality 69206. East side of unnamed peninsula west of Maskell Inlet; partly from outcrop and partly from a continuous stream of talus extenting for about 2 km to the north; NTS 340 E; UTM Zone 17X, 534600E, 9202600N; identification by B.S. Norford (from Trettin, 1969b, p. 20 and fig. 15, loc. F13; age revised).

Fauna

Maclurites sp.
Palaeophyllum sp.
bryozoan
stromatoporoids
straight cephalopods
echinoderm debris

Remarks. Ordovician, probably Blackriveran to Trentonian.

M'CLINTOCK FORMATION

GSC locality 69207. 5.4 km due west of Egingwah Bay, Egingwah Creek 1 section; *M'Clintock Inlet*, inset A, section EC1; NTS 340 E; UTM Zone 18X, 467700E, 9191000N; Egingwah Creek section EC-1; 0–4.9 m below top of formation; identification by B.S. Norford (from Trettin, 1969b, p. 23).

Fauna

Paleofavosites? sp.
stromatoporoids

Remarks. Richmondian to Silurian.

AYLES FORMATION

GSC locality C-97394. Egingwah Creek 2-1 section; *M'Clintock Inlet*, inset A, section EC2-1; NTS 340 E; UTM Zone 18X, 467000E, 9189800N; upper part of unit 1; identification by B.S. Norford.

Fauna

Catenipora cf. *C. rubra* Sinclair and Bolton
Palaeofavosites sp.
?*Streptelasma* sp.

Remarks. Late Ordovician, Ashgill (Richmondian or later).

GSC locality C-97377. Egingwah Creek 2-2 section; *M'Clintock Inlet*, inset A, section EC2-2; NTS 340 E; UTM Zone 18X, 466750E, 9190000N; lowermost part of unit 2; identification by B.S. Norford.

Fauna

?*Kionoceras* sp.
undetermined cephalopods
Maclurites sp.
indeterminate gastropods
Calapoecia cf. *C. coxi* Bassler
Calapoeia cf. *C. rubra* Sinclair and Bolton
Palaeophyllum cf. *P. halysitoides* (Wilson)
Paleofavosites sp.
Sarcinula sp.
Streptelasma sp.
aff. *Eodinobolus* sp.
pelecypod
?bryozoans
echinoderm fragments

Remarks. Late Ordovician, Ashgill (Richmondian or later). The collection has a diverse cephalopod fauna but the specimens are incomplete and probably transported. The trimerellid *Eodinobolus* (most probably a new genus) also is found as fragments, in contrast the corals are robust specimens.

GSC locality C-97402. Egingwah Creek section 2-2; NTS 340 E; UTM Zone 18X, 466200E, 9190300; unit 2; identification by B.S. Norford.

Fauna

Catenipora sp.

Remarks. Late Middle Ordovician to Late Silurian.

GSC locality 69204. About 6.6 km west of Egingwah Bay; NTS 340 E; UTM Zone 18X, 466400E, 9190300N; unit 2, upper part; identification by B.S. Norford (from Trettin, 1969b, p. 24 and fig. 15, loc. F20; age revised).

Fauna

Tollina sp.
bryozoan

Remarks. Middle Ordovician, Barneveldian (Trentonian) to Late Ordovician (Richmondian or younger).

TACONITE RIVER FORMATION

GSC locality 69205. Egingwah Creek 3 section; *M'Clintock Inlet*, inset A, section EC 3; NTS 340 E; UTM Zone 18X, 466000E, 9180300N; identification by B.S. Norford (from Trettin, 1969b, p. 29, fig. 15, loc. 24; age revised).

Fauna

Calapoecia sp.
Catenipora sp.
gastropod
cephalopod

Remarks. Middle Ordovician to Early Silurian, probably Trentonian to Richmondian.

GSC locality C-54938. Section on southern Marvin Peninsula; *M'Clintock Inlet*, section SMP; NTS 340 E; UTM Zone 18X, 501300E, 9189000N; 111.5 m above base of formation; fossils occur in (intraformational?) pebbles; identification by B.S. Norford.

Fauna

Palaeophyllum sp.
Protrochiscolithus? sp.
indeterminate brachiopods

Remarks. Late Middle or Late Ordovician.

GSC locality C-54939. Same locality as C-54938, 114 m above base of formation; identification by B.S. Norford.

Fauna

Favosites? sp.

Remarks. Probably Late Ordovician to Middle Devonian.

GSC locality C-54940. Same locality as C-54938, 117.5 m above base of formation; identification by B.S. Norford.

Fauna

Favosites? sp.
Palaeophyllum? sp.
Tollina sp.
streptelasmid coral
straight cephalopod

Remarks. Late Ordovician.

GSC locality C-54941. Same location as C-54938; 141.8–144.8 m above base of formation; identification by B.S. Norford.

Fauna

Paleofavosites sp.
straight cephalopod
undetermined brachiopod

Remarks. Late Middle Ordovician to Silurian.

GSC locality C-75459. Northernmost Marvin Peninsula, 20.8 km due east of Cape Discovery; NTS 340 E; UTM Zone 18X, 488000E, 9216800N; identification by B.S. Norford.

Fauna
Calapoecia sp.
favositid coral

Remarks. Late Middle or Late Ordovician, probably Ashgill.

ZEBRA CLIFFS FORMATION

Reference section south of Disraeli Fiord

Member A

GSC locality C-54957. Section south of Disraeli Fiord, *M'Clintock Inlet* section SDF1; NTS 340 E; UTM Zone 18X, 533250E, 9182800N; 0-47 m above base of formation; identification by B.S. Norford.

Fauna
Aulacera sp.
Calapoecia sp.
Catenipora sp.
Grewingkia sp.
Palaeophyllum raduguini Nelson, v. of Bolton, 1979
Armenoceras michaudae Bolton
bryozoans
ostracode
algae, several species
gastropod, brachiopod, and trilobite debris

Remarks. This faunule is remarkably similar to that described by Bolton (*in* Bolton and Nowlan, 1979) from an Ordovician outlier near Aberdeen Lake, southwest of Boothia Peninsula. Bolton correlated his fauna with the Upper Ordovician Churchill River Group, with a late Maysvillian to Richmondian age, corroborated by associated conodonts (Fauna 12) studied by Nowlan. Of palaeontological interest is the single large specimen of *Armenoceras michaudae* that reveals the external ornamentation of the species to consist of fine longitudinal ribs. Polished longitudinal sections show cameral deposits and long septal necks not normally characteristic of *Armenoceras*.

Member C

GSC locality C-54958. Same location as C-54957, 146 m above base of formation; identification by B.S. Norford.

Fauna
gastropod
Favosites 2 spp.
Grewingkia sp.
Sarcinula sp.

Remarks. Probably Late Ordovician, Ashgill or later.

GSC locality C-94164. Same location as C-54957, 3-113 m above base of formation; identification by B.S. Norford.

Fauna
Rhabdotetradium sp.

Remarks. Middle or Late Ordovician.

Vicinity of Zebra Cliffs

Member A

GSC locality 69203. 3.5 km south of Egingwah Bay, 2.9 km southwest of M'Clintock Inlet; NTS 340 E; UTM Zone 18X, 473500E, 9186500N; Member A, less than 22 m above base of formation; identification by B.S. Norford (from Trettin, 1969b, p. 32 and fig. 15, loc. 25).

Fauna
Troedssonites conspiratus (Troedsson)

Remarks. Ordovician, Richmondian.

Member C

GSC locality 69215. About 2 km southeast of Egingwah Bay; NTS 340 E; UTM Zone 18X, 474250E, 9188300N; identification by B.S. Norford (from Trettin, 1969b, p. 32 and fig. 15, loc. 31; age revised).

Fauna
Catenipora sp.
Receptaculites sp.

Remarks. Ordovician, Trentonian to Richmondian.

GSC locality 69217. Top of Zebra Cliffs, about 2.8 km south-southeast of Egingwah Bay; NTS 340 E; UTM Zone 18X; 475000E, 9188000N; original Member B; identification by B.S. Norford (from Trettin, 1969b, p. 32 and fig. 15, loc. 32).

Fauna

Favosites sp.
straight cephalopd
bryozoans

Remarks. Richmondian to Middle Devonian.

GSC locality 69210. 2.4 km south-southeast of Egingwah Bay; NTS 340 E; UTM zone 18X, 473800E, 9187750N; identification by B.S. Norford (from Trettin, 1969b, p. 32 and fig. 15, loc. 33; age revised).

Fauna

Calapoecia sp.
Catenipora sp.

Remarks. Middle Ordovician to Early Silurian, probably Trentonian to Richmondian.

GSC locality 69202. 1.9 km south-southeast of Egingwah Bay; NTS 340 E; UTM Zone 18X, 473400E, 9188200N (from Trettin, 1969b, p. 32 and fig. 15, loc. 34; also Norford, 1971).

Fauna

Sibiriolites sibiricus Sokolov
Rhynchotrema sp.

Remarks. Late Ordovician, Richmondian.

Undifferentiated, probably mainly Member C

GSC locality 24721. Zebra Cliffs; NTS 340 E; identification by G.W. Sinclair (from Christie, 1964, p. 22; loc. F7, Map 1148A; UTM co-ordinates not determinable).

Fauna

Plasmopora lambei Schuchert
Columnaria n. sp. aff. *C. halysitoides* Troedsson
Paleofavosites sp.
Calapoecia canadensis Billings
Halysites sp. aff. *H. feildeni* Etheridge
Syringopora n. sp.
Batostoma n. sp.
Rhinidictya sp.
Cyclospira cf. *C. vokesi* Roy
Hormotoma gracilis (Hall)
Lophospira spp.
Umbospira sp.
Holopea sp.
trilobite fragments
Leperditia sp.
Aparchites sp.
Krausella sp.
Conchoprimites sp.
scolecodonts

Remarks (abbreviated). Upper Ordovician, Richmondian.

Harley Ridge

GSC locality C-6. West side of Harley Ridge; NTS 340 E; UTM Zone 18X, 489400E, 9160800N; collected by W.W. Nassichuk, identification by B.S. Norford (from Trettin, 1969b, p. 33 and fig. 15, loc. 37, replotted).

Fauna

?*Liostrophia* sp.
Rafinesquina sp.
Calapoecia sp.
Catenipora 2 spp.
echinoderm fragments
undetermined trilobite
straight cephalopods
undetermined brachiopods

Remarks. Ordovician, Edenian to Richmondian.

GSC locality C-8. West side of Harley Ridge; NTS 340 E; UTM Zone 18X, 489500E, 9159400N; collected by W.W. Nassichuk, identification by B.S. Norford (from Trettin, 1969b, p. 33 and fig. 15, loc. 37, replotted; age revised).

Fauna

Rostricellula sp.
pelecypod
bryozoan
solitary coral
undetermined brachiopods 2 spp.

Remarks. Probably Ordovician, Blackriveran to Richmondian.

GSC locality C-9. Same locality as C-8 but about 50 m higher; collected by W.W. Nassichuk, identification by B.S. Norford (from Trettin, 1969b, p. 33 and fig. 15, loc. 37, replotted; age revised).

Fauna

Rostricellula sp.
pelecypod
bryozoan
?straight cephalopod

Remarks. Probably Ordovician, Blackriveran to Richmondian.

Other localities

Member A

GSC locality 69211. Marvin Peninsula, about 8.5 km east-northeast of Crash Point; NTS 340 E; UTM Zone 18X, 491600E, 9183750N; Member A, less than about 25 m above base of formation; identification by B.S. Norford (from Trettin, 1969b, p. 32 and fig. 15, loc. 29).

Fauna
Catenipora sp.
Calapoecia sp.
Palaeofavosites sp.

Remarks. Ordovician, Richmondian.

Undifferentiated

GSC locality C-75105. 3.8 km southwest of central part of Disraeli Fiord; NTS 340 E; UTM Zone 18X, 521200E, 9189500N; identification by B.S. Norford.

Fauna
Catenipora sp.
Favosites sp.
Palaeophyllum cf. *P. halysitoides* (Wilson)
gastropod
?stromatoporoid

Remarks. Late Ordovician, Ashgill or possibly Early Silurian.

GSC locality C-75393. 1.1 km southwest of Thores River; *M'Clintock Inlet*, inset D, locality F3; NTS 340 E; UTM Zone 18X, 520250E, 9174400N; identification by B.S. Norford.

Fauna
Catenipora sp.

Remarks. Middle Ordovician to Late Silurian.

GSC locality C-75394. 1.5 km northeast of Thores River; *M'Clintock Inlet*, inset D, locality F1; NTS 340 E; UTM Zone 18X, 524000E, 9175300N; identification by B.S. Norford.

Fauna
Catenipora sp.

Remarks. Middle Ordovician to Late Silurian.

GSC locality C-75395. 1.2 km northeast of Thores River; *M'Clintock Inlet*, inset D, south of locality F1; NTS 340 E; UTM Zone 18X, 524000E, 9175100N; identification by B.S. Norford.

Fauna
Palaeophyllum sp.
solitary coral
gastropods
bryozoan
pelecypods
Dicoelosia sp.
?*Austinella* sp.
?*Lepidocyclus* sp.
aff. *Rhynobolus* sp.
strophomenid, sowerbyellid, and orthid brachiopods
unidentified brachiopods
echinoderm debris

Remarks. Probably Late Ordovician.

GSC locality C-73596. 0.6 km northeast of Thores River; *M'Clintock Inlet*, inset D, locality F2; NTS 340 E; UTM Zone 18X, 523700E, 9174400N; identification by B.S. Norford.

Fauna
?*Maclurites* sp.

Remarks. Probably Middle or Late Ordovician.

GSC locality C-70043. Central Marvin Peninsula; NTS 340 E; UTM Zone 18X, 505900E, 9186700N; collected by U. Mayr, identification by B.S. Norford.

Fauna
Catenipora sp.
?*Parafavosites* sp.

Remarks. Late Ordovician (Ashgill) to Late Silurian.

GSC locality C-70045. Central Marvin Peninsula; NTS 340 E; UTM Zone 18X, 506600E, 9186300N; collected by U. Mayr, identification by B.S. Norford.

Fauna
Paleofavosites sp.
Palaeophyllum sp.
undetermined solitary coral

Remarks. Late Ordovician, Ashgill.

GSC locality C-70081. Northeast side of Lorimer Ridge; NTS 340 E; UTM Zone 18X, 540700E, 9175000N; talus, probably from uppermost Zebra Cliffs Formation, but possibly from lowermost Lorimer Ridge Formation; collected by R. Gardner and D. Jones (unpublished field notes), identification by B.S. Norford.

Fauna
Sibiriolites sibiricus Sokolov
Catenipora sp.
streptelasmid coral
stromatoporoid
indeterminate cephalopod

Remarks. Late Ordovician, Richmondian.

CRANSTONE FORMATION

Member A

GSC locality C-94374. Section south of Disraeli Fiord 2; NTS 340 E, UTM Zone 18X, 533800E, 9182100N; 395–402 m above base of formation and member; identification by B.S. Norford.

Fauna
Glyptograptus sp.
Monograptus sp.
sponge spicules
trilobite fragment

Remarks. Probably Early Silurian.

GSC locality C-94373. Same locality as C-94374; talus either from same beds or from strata 0–20 m below them; identification by B.S. Norford.

Fauna
Glyptograptus sp.
Monograptus sp.
Rastrites sp.
sponge spicules

Remarks. Silurian, Middle or earliest Late Llandovery.

GSC locality C-75497. 2.5 km north of Thores River; NTS 340 E, UTM Zone 18X, 532300E, 9174500N; stratigraphic position (within Member A) unknown; identification by B.S. Norford.

Fauna
Monograptus aff. *M. convolutus* (Hisinger)

Remarks. Silurian, Middle Llandovery.

GSC locality C-75498. Same locality as C-75497 but different strata; identification by B.S. Norford.

Fauna
Monograptus 2 spp., one with spiral curvature

Remarks. Silurian, probably Middle or Late Llandovery.

Member B

GSC locality C-75496. Near section south of Disraeli Fiord, NTS 340 E; UTM Zone 18X, 534200E, 9181500N; Unit B2, 820–856.5 m above base of formation; identification by B.S. Norford.

Fauna
Monograptus aff. *M. argenteus cygneus* Törnquist
M. aff. *M. convolutus* (Hisinger)

Remarks. Silurian, Middle Llandovery.

LORIMER RIDGE FORMATION

GSC locality C-75494. West side of Harley Ridge; NTS 340 E; UTM Zone 18X, 491400E, 9165800N; from lowermost part of formation; identification by B.S. Norford.

Fauna
Sibiriolites sibiricus Sokolov
bryozoan

Remarks. Late Ordovician, Richmondian.

GSC locality C-10. West side of Harley Ridge; NTS 340 E; UTM Zone 18X, 490400E, 9159700N; from lower part of formation; collected by W.W. Nassichuk; identification by B.S. Norford.

Fauna
Sibiriolites sibiricus Sokolov
ostracode
brachiopod fragment

Remarks. Late Ordovician, Richmondian.

GSC locality C-70082. Lorimer Ridge section, unit 2; *M'Clintock Inlet*, section LR; NTS 340 E; UTM Zone 18X, 539800E, 9175700N; collected by R. Gardner and D. Jones; identification by B.S. Norford.

Fauna
undetermined orthid brachiopod
pelecypod

Remarks. Probably Ordovician or Silurian.

GSC locality C-70091. Same locality as C-70082, 520–527 m above base; collected by R. Gardner and D. Jones; identification by B.S. Norford.

Fauna
indeterminate brachiopod
stromatoporoid
echinoderm fragments

Remarks. Ordovician to Permian.

GSC locality C-70106. Lorimer Ridge section; *M'Clintock Inlet*, section LR; NTS 340 E; UTM Zone 18X, 539800E, 9175700N; probably from 764–782 m above base; collected by R. Gardner and D. Jones; identification by B.S. Norford; *see* Tipnis, Appendix 5C, C-70106.

Fauna
Paratetradium sp.
stromatoporoid
bryozoan
gastropod

Remarks. Middle or Late Ordovician, Caradoc or Ashgill.

GSC locality C-70093. Lorimer Ridge section (*see* above, C-70082) from upper 1 m of formation; collected by R. Gardner and D. Jones (1977); identification by B.S. Norford.

Fauna
Calapoecia sp.
tabulate coral

Remarks. Probably Middle or Late Ordovician. *Calapoecia, Paratetradium*, and *Rhabdotetradium* occur together in the lower part of formation B on Judge Daly Promontory (Norford, 1966) (re-assigned to the Thumb Mountain Formation, in Trettin, 1994).

GSC locality C-54959. Thores River 1 section; *M'Clintock Inlet*, section TR1; NTS 340 E; UTM Zone 18X, 533000E, 9173600N; middle part of formation, 35–36 m above base of section; identification by B.S. Norford.

Fauna
Paleofavosites sp.
gastropods and other fossil fragments

Remarks. Late Ordovician (Ashgill) to Silurian.

GSC locality C-54960. Same locality as C-54960; 72.5 m above base of section; identification by B.S. Norford.

Fauna
Favosites? sp.
indeterminate bryozoan, gastropod, pelecypod(?)

Remarks. Late Ordovician (Ashgill) to Middle Devonian.

GSC locality C-54961. Section southeast of Disraeli Fiord; *M'Clintock Inlet*, section SDF1; NTS 340 E; UTM Zone 18X, 540100E, 9179600N; 20 m below top of formation; identification by B.S. Norford.

Fauna
Favosites sp.
indeterminate solitary coral
gastropod

Remarks. Late Ordovician (Ashgill) to Middle Devonian.

GSC locality C-54962. Same locality as C-54961; 10 m below top of formation; identification by B.S. Norford.

Fauna
Catenipora sp.
Favosites? sp.

Remarks. Late Ordovician (Ashgill) to Late Silurian.

MARVIN FORMATION

Central shallow-marine belt

Section southeast of Disraeli Fiord (collections by H.P. Trettin, keyed to description in Appendix 1)

M'Clintock Inlet, section SEDF; NTS 340 E; UTM Zone 18X, 540100E, 9179600N; GSC locality C-54964; section southeast of Disraeli Fiord; *M'Clintock Inlet*, section SEDF; NTS 340 E; UTM Zone 18X, 540100E, 9179600N; identification by B.S. Norford.

Fauna
Kirkidium sp.

Remarks. Late Wenlock to early Pridoli, most common in the Ludlow.

GSC locality C-54965. Same locality as C-54964; 84.5 m above base of formation; identification by A.E.H. Pedder.

Fauna
Mesofavosites sp.

Remarks. Ordovician (Ashgill) to Silurian (Ludlow).

GSC locality C-54966. Same locality as C-54964, 107 m above base of formation; identification by B.S. Norford.

Fauna
Kirkidium sp.

Remarks. Late Wenlock to early Pridoli, most common in the Ludlow.

GSC locality C-54967. Same locality as C-54964; 110 m above base of formation; identification by A.E.H. Pedder.

Fauna
Paleofavosites sp. indet.

Remarks. Upper Ordovician to Silurian (Ludlow).

GSC locality C-54968. Same locality as C-54964, 113 m above base of formation; identification by B.S. Norford.

Fauna
Kirkidium sp. c

Remarks. Late Wenlock to early Pridoli, most common in the Ludlow.

GSC locality C-54969. Same locality as C-54964; 128 m above base of formation; identification by A.E.H. Pedder.

Fauna
Paleofavosites sp. nov. cf. *P. maxima* Chernyshev
rugose coral, nov. genus cf. *Amplexoides* and *Thecacristatus*

Remarks. Silurian.

GSC locality C-54970. Same locality as C-54964, 193 m above base of formation; identification by B.S. Norford.

Fauna
Catenipora sp.
indeterminate straight cephalopods, gastropods, brachiopods, and chiton
algae

Remarks. Middle Ordovician to Late Silurian.

GSC locality C-54971. Same locality as C-54964; 209 m above base of formation; identification by A.E.H. Pedder.

Fauna
Paleofavosites sp.
Halysites sp.
Helioplasmolites sp.

Remarks. Silurian, likely Ludlow.

GSC locality C-54972. Same locality as C-54964; 211 m above base of formation; identification by A.E.H. Pedder.

Fauna
Catenipora sp.

Remarks. Upper Ordovician to Upper Silurian.

GSC locality C-54973. Same locality as C-54964; 241 m above base of formation; identification by A.E.H. Pedder.

Fauna
Catenipora sp.

Remarks. Upper Ordovician to Upper Silurian.

GSC locality C-54973. Same locality as C-54964; 241 m above base of formation; identification by A.E.H. Pedder.

Fauna
Catenipora sp.

Remarks. Upper Ordovician to Upper Silurian.

GSC locality C-54974. Same locality as C-54964; 254.5 m above base of formation; identification by A.E.H. Pedder.

Fauna
Favosites sp.

Remarks. Upper Ordovician (Ashgill) to Middle Devonian (Givetian, *varcus* Zone).

General remarks about C-54965, C-54967, C-54969, C-54971 to C-54975 by A.E.H. Pedder: very poorly preserved as a result of recrystallization, styolitization, and silification. It is a new fauna but certainly Silurian.

Section southeast of Disraeli Fiord (collections by R. Gardner and D. Jones) (unpublished field notes, 1977).

GSC locality C-70120. Approximately same locality as C-54964; collected by R. Gardner and D. Jones; 321 m above base of formation according to their measurement; identification by B.S. Norford.

Fauna
Favosites sp.

Remarks. Latest Ordovician to Middle Devonian.

GSC locality C-70133. Approximately same locality as C-54964; collected by R. Gardner and D. Jones; talus, 713.5 m above base of formation according to their measurement; identification by B.S. Norford.

Fauna
Zelophyllum? sp.
stromatoporoids

Remarks. Late Early Silurian to Devonian.

GSC locality C-70135. Approximately same locality as C-54964; collected by R. Gardner and D. Jones; 735 m above base of formation according to their measurement; identification by B.S. Norford.

Fauna
Zelophyllum? sp.
stromatoporoid

Remarks. Late Early Silurian to Devonian.

GSC locality C-70022. Approximately same locality as C-54964; collected by R. Gardner and D. Jones; talus in uppermost part of section; identification by A.E.H. Pedder.

Fauna
Spinolasma? sp. nov.
stromatoporoid

Remarks. Silurian.

Other localities

GSC locality C-54984. A short distance west of Thores River 2 section; NTS 340 E; UTM Zone 18X, 532400E, 9174200N; identification by B.S. Norford (cf. identification of conodonts from same locality by T.T. Uyeno).

Fauna
Kirkidium (*Kirkidium*) sp.

Remarks. Late Wenlock to early Pridoli, most common in the Ludlow.

GSC locality C-70049. central Marvin Peninsula; NTS 340 E; UTM Zone 18X, 507600E, 9184200N; collected by U. Mayr; identification by B.S. Norford.

Fauna
Catenipora sp.
Parafavosites sp.

Remarks. Late Ordovician (Ashgill) to Late Silurian.

OOBLOOYAH CREEK FORMATION

GSC locality C-59. Zebra Cliffs section; *M'Clintock Inlet*, section ZC-2; NTS 340 E; UTM Zone 18X, 476300E, 9185700N; stratigraphic position not determined; re-identification (from Norford and Thorsteinsson *in* Trettin, 1969b, p. 34 and fig. 15, loc. 28) by B.S. Norford.

Fauna
Climacograptus latus Elles and Wood
Glyptograptus cf. *G. tenuissimus* Ross and Berry
Orthograptus amplexicaulis abbreviatus Elles and Wood

Remarks. Late Ordovician, Ashgill, *ornatus* Zone or *pacificus* Zone.

GSC locality C-60. 3.1 km south-southwest of Egingwah Bay; NTS 340 E; UTM Zone 18X, 472800E, 9186700N; stratigraphic position not determined; re-identification by B.S. Norford (from Norford and Thorsteinsson *in* Trettin, 1969b, p. 34 and fig. 15, loc. 36).

Fauna
Climacograptus sp.
Orthograptus amplexicaulis abbreviatus Elles and Wood

Remarks. Late Ordovician, Ashgill.

GSC locality C-61. 3.6 km south of Egingwah Bay; NTS 340 E; UTM Zone 18 X; 473800E, 9186300N; probably from lower part of formation; identification by B.S. Norford and R. Thorsteinsson (from Trettin, 1969b, p. 34 and fig. 15, loc. 35).

Fauna
Climacograptus latus Elles and Wood
Orthograptus spp.

Remarks. Late Ordovician, Ashgill.

GSC locality C-75499. East side of M'Clintock Inlet, 3.2 km north of Crash Point; NTS 340 E; UTM Zone 18X, 483400E, 9184800N; identification by B.S. Norford.

Fauna
Climacograptus? sp.
Diplograptus? sp.

Remarks. Late Middle Ordovician to Early Silurian.

DANISH RIVER FORMATION

GSC locality C-68. Zebra Cliffs 3 section; NTS 340 E; UTM Zone 18X, 476000E, 9185200N; identification by B.S. Norford and R. Thorsteinsson (from Trettin, 1969b and fig. 15, loc. 38).

Fauna
Monograptus aff. *M. priodon* (Bronn)

Remarks. Silurian, late Llandovery to Wenlock.

MARVIN FORMATION

Northwestern deep- and shallow-marine belt

Crash Point section

GSC locality 75421. Crash Point section; *M'Clintock Inlet*, inset C, section CP; NTS 340 E; UTM Zone 18X, 483700E, 9183600N; basal strata of Marvin Formation; identification by B.S. Norford (from Trettin, 1969b, loc. p. 40; age assignment modified).

Fauna
?*Atrypella* sp.
?*Kirkidium* sp.
?*Howellella* sp.
rhynchonellid and undetermined brachiopods
undetermined trilobite
echinoderm fragments

Remarks. Silurian, late Wenlock to early Pridoli on the basis of *Kirkidium*; the latter is most common in the Ludlow.

GSC locality 75422. Same locality as 75421; 39–104 m above base of formation; identification by B.S. Norford.

Fauna
Kirkidium sp.

Remarks. Silurian, late Wenlock to early Pridoli; the genus is most common in the Ludlow.

GSC locality C-54976. Same locality as 75421; 45.5 m above base of formation; identification by B.S. Norford.

Fauna
megalamoid pelecypod

Remarks. Probably Silurian.

GSC locality 69208. Same locality as 75421; 104–154 m above base of formation; from Trettin, 1969b, p. 40; age assignment modified); identification by B.S. Norford.

Fauna
Kirkidium sp.
Cysthalysistes sp.
Halysites sp.

Fossopora sp.
Syringopora sp.
?*Tryplasma* sp.
solitary coral
fossil debris, including echinoderms, gastropods, and bryozoans

Remarks. Silurian, late Wenlock to early Pridoli on the basis of *Kirkidium*; the latter is most common in the Ludlow.

B. IDENTIFICATIONS OF CONODONTS

T.T. Uyeno, G.S. Nowlan, R.V. Tipnis, and C.R. Barnes

NORTHERN HEIBERG FOLD BELT

SVARTEVAEG FORMATION

Member B

GSC locality C-194943. Svartevaeg Cliffs, about 13.9 km southwest of Cape Stallworthy; *Cape Stallworthy-Bukken Fiord*, inset C, locality F2; NTS 560 D; UTM Zone 15X, 503250E, 9027900N; talus of carbonate conglomerate at base of northwest-facing cliffs; identification by G.S. Nowlan; *see* de Freitas, Appendix 5C, C-194934-2; conglomerate derived from same source as 47506; *see* Norford, Appendix 5A, 47506.

Sample weight. 1859 g (93% breakdown).

Fauna
The sample yielded a single fragmentary conodont element (CAI about 3-4) assignable as follows:
Panderodus sp.

Remarks. This single specimen is not age diagnostic and indicates a Middle Ordovician to Devonian age for the sample.

CLEMENTS MARKHAM FOLD BELT

CARBONATE OLISTOLITHS AT FIRE BAY

Within Hazen Formation

GSC locality C-97241. 1.25 km east-northeast of the head of Fire Bay, Emma Fiord; *Cape Stallworthy-Bukken Fiord*, inset B, locality F7; NTS 560 D; UTM Zone 16X, 472700E, 9044750N; from limestone olistolith, a few metres in diameter; identification by G.S. Nowlan.

Sample weight. 3285 g (97% breakdown).

Fauna
The sample yielded 10 conodont elements (CAI 2.5) identifiable as follows:
Erraticodon? sp. (1)
"*Microzarkodina*" *marathonensis* (Bradshaw) (4)
Parapanderodus striatus (Graves and Ellison) (1)
Proteropanderodus sp. (3)
"*Scolopodus*" *asymmetricus* Barnes and Poplawski (1)

Remarks. Middle Ordovician (Whiterockian). "*Microzarkodina*" *marathonensis* suggests an early to middle Whiterockian age. Whiterockian here is used as originally defined by Cooper (1956) and not as revised to Series level by Ross et al. (1982).

GSC locality C-97242. Same locality as C-97241 but from a different part of the olistolith; identification by G.S. Nowlan.

Sample weight. 2842 g (91% breakdown).

Fauna
The sample yielded 2 conodont elements (CAI indeterminate) identifiable as follows:
Histiodella holodentata Ethington and Clark (1)
Loxodus? *curvatus* Stouge (1)

Remarks. Middle Ordovician (Whiterockian) but the presence of *Histiodella holodentata* suggests a late Whiterockian age, implying that the olistolith includes strata of different ages.

GSC locality C-97247. 2.3 km east of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F10; NTS 560 D; UTM Zone 16X, 473100E, 9043400N; from limestone conglomerate/breccia, metres in diameter; identification by G.S. Nowlan.

Sample weight. 2109 g (81% breakdown).

Fauna

The sample yielded 3 conodont elements (CAI 3.5) identifiable as follows:

Protopanderodus sp. (2)
"*Scolepodus*" *gracilis* Ethington and Clark (1)

Remarks. Late Early Ordovician to Middle Ordovician in age.

GSC locality C-171528. 6.25 km west-southwest of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F6; NTS 560 D; UTM zone 16X, 469700E, 9042900N; from limestone olistolith; identification by G.S. Nowlan; *see* Norford, Appendix 5A, C-171528.

Sample weight. 2300 g (88% breakdown).

Fauna

The sample yielded 1 conodont element (CAI 3?) identifiable as follows:

simple cone indeterminate (1)

Remarks. Possibly Ordovician because this element is similar to an undescribed species known elsewhere in the Arctic from strata of Chazyan age — a speculative conclusion in the absence of sufficient material.

GSC locality C-97244. 3.2 km east of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F9; NTS 560 D; UTM Zone 16X, 474300E, 9044700N; from limestone olistolith, tens of metres long; identification by G.S. Nowlan.

Sample weight. 2270 g (91% breakdown).

Fauna

The sample yielded 7 conodont elements (CAI 4) identifiable as follows:

Erismodus? sp. (1)
Oistodus multicorrugatus Harris (4)
"*Scolopodus*" *gracilis* Ethington and Clark (2)

Remarks. Middle Ordovician (Whiterockian). The presence of *Oistodus multicorrugatus* suggests an early Whiterockian age.

GSC locality C-97245. Talus from same olistolith as C-97244; identification by G.S. Nowlan.

Sample weight. 1283 g (complete breakdown).

Fauna

The sample yielded 3 conodont elements (CAI 3) identifiable as follows:

Paraponderodus striatus (Graves and Ellison) (1)
"*Scolopodus*" *gracilis* Ethington and Clark (2)

Remarks. Late Early Ordovician to Middle Ordovician.

GSC locality C-97246. Talus from same olistolith as C-97244; identification by G.S. Nowlan.

Sample weight. 1458 g (77% breakdown).

Fauna

The sample yielded 6 conodont elements (CAI 3?) identifiable as follows:

Ansella sp. (5)
"*Scolopodus*" *gracilis* Ethington and Clark (1)

Remarks. Middle Ordovician.

Within Fire Bay Formation

GSC locality C-97243. About 2.1 km east-northeast of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F8; NTS 560 D; UTM Zone 16X, 473200E, 9048000N; from limestone olistolith, roughly 100 m long; identification by G.S. Nowlan.

Sample weight. 3237 g (95% breakdown).

Fauna

The sample yielded 9 conodont elements (CAI 3.5) identifiable as follows:

?*Drepanodus arcuatus* Pander (1)
Histiodella? sp. (1)
"*Scolopodus*" *gracilis* Ethington and Clark (6)
oistodontiform element indeterminate (1)

Remarks. Middle Ordovician (probably Whiterockian) in age.

GSC locality C-97248. 1.7 km northeast of head of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F11; NTS 560 D; UTM Zone 16X, 472800E, 9045000N; from limestone olistolith, metres in diameter; identification by G.S. Nowlan.

Sample weight. 2011 g (77% breakdown).

Fauna

The sample yielded 3 conodont elements (CAI 3.5?) identifiable as follows:

"*Scolepodus*" *gracilis* Ethington and Clark (3)

Remarks. Late Early Ordovician to Middle Ordovician in age.

In Danish River Formation

GSC locality C-194940. 0.8 km northeast of Fire Bay; *Cape Stallworthy-Bukken Fiord*, inset B, locality F15; UTM Zone 16X, 470400E, 9045300N; identification by G.S. Nowlan; *see* de Freitas, Appendix 5C, C-194940.

Sample weight. 1828 g (87% breakdown).

Fauna

The sample yielded seven small fragmentary conodont elements (CAI about 3) assignable to the following taxa:

Belodina sp. (2)
Panderodus sp. (5)

Remarks. The assemblage indicates a Middle Ordovician (Chazyan) to Upper Ordovician (Gamachian) age. Unfortunately, the specimens assigned to *Belodina* cannot be identified with confidence at the specific level and so a more precise age determination is not possible. However, it is likely that it is at least slightly younger than the samples reported above from the Hazen and Fire Bay formations.

YELVERTON PASS BEDS

GSC locality C-54790. Northeast side of Yelverton Pass, about 24 km northwest of Yelverton Lake; NTS 340 D; UTM Zone 17X, 532000E, 9086000N; identification by T.T. Uyeno; *see* Pedder, Appendix 5A, C-54807, C-74790, C-741814.

Fauna

Aulacognathus sp. (Pa-1)
Belodella? sp. (2)
Belodina? sp. (1)
"*Carniodus*"? (1)
Panderodus simplex (Branson and Mehl) (5)
unassigned elements: coronellan (1), Pb (1), Sb (1), Sc (1)

Remarks. The fauna is probably assignable to the *celloni* Zone or slightly older. The specimen identified as *Aulacognathus* sp. differs in some important features from *A. bullatus*, the type of which originates in the Brassfield Limestones of Indiana and Kentucky (Nicoll and Rexroad, 1969), and may, in fact, be slightly older. *Aulacognathus bullatus* Nicoll and Rexroad has been reported from the *Icriodella inconstans* Zone of Aldridge (1972), of C_5 subdivision of the Upper Llandovery Series (Telychian Stage of Cocks et al., 1971b). The *inconstans* Zone is identical with the *celloni* Zone of Walliser (1964). Among other interesting components of the collection are the specimens identified as *Belodella*? sp. and *Belodina*? sp. These appear to be new, and morphologically transitional between "typical" *Belodina* (which is restricted to the Ordovician) and *Belodella*. "*Carniodus*" has been reported from the *celloni* Zone and the underlying Bereich I of Walliser (1964, 1971). Bereich I is now considered to be mostly Late Ordovician, except for the uppermost part (Schönlaub, 1971).

KULUTINGWAK FORMATION

Member B

GSC locality C-97491. About 6.4 km southwest of southwestern arm of Kulutingwak Fiord, southwestern Kulutingwak Anticlinorium; *Yelverton Inlet*, inset, locality F1; NTS 340 F; UTM Zone 17X, 463300E, 9108500 N; identification by G.S. Nowlan.

Sample weight. 1832 g (87% breakdown).

Fauna

The sample yielded 5 conodont elements (CAI 5?) identifiable as follows:

Panderodus? sp. (2)
simple cone elements indeterminate (3)

Remarks. Middle Ordovician to Devonian.

GSC localities C-171526 and C-171527. 3.6 km south of Kulutingwak Fiord, northeastern Kulutingwak Anticlinorium; *Yelverton Inlet*, locality F2; NTS 340 F; UTM Zone 17X, 473400E, 9109800N; identification by G.S. Nowlan.

Sample weight. 4000 g (53% breakdown).

Fauna

The samples yielded 3 conodont element (CAI 1?) identifiable as follows:

Panderodus sp. (3)

Remarks. Middle Ordovician to Devonian.

Undifferentiated Kulutingwak Formation, probably Member B

GSC locality C-171516. 4 km south of southwestern arm of Kulutingwak Fiord, structural high south of Kulutingwak Anticlinorium; *Yelverton Inlet*, locality F3; NTS 340 F; UTM Zone 17X, 468200E, 9107100N; collected by M. Bjornerud; identification by G.S. Nowlan.

Sample weight. 6600 g (92% breakdown).

Fauna

The sample yielded 2 fragmentary conodont elements (CAI 5) identifiable as follows:

?*Periodon* sp. (1)
simple cone element indeterminate (1)

Remarks. Ordovician, Arenig to Ashgill.

GSC locality C-171515. 1.7 km due west of upper reaches of Kulutingwak Fiord, structural high southeast of Kulutingwak Anticlinorium; *Yelverton Inlet*, locality F4; NTS 340 F; UTM Zone 17X, 483200E, 9111250N; collected by M. Bjornerud; identification by G.S. Nowlan.

Sample weight. 4700 g (87% breakdown).

Fauna

The sample yielded 13 very poorly preserved conodont elements (CAI 5) identifiable as follows:

Panderodus sp. (4)
?*Protopanderodus* sp. (2)
belodiniform element indeterminate (2)
eobelodiniform element indeterminate (1)
denticulate fragments (4)

Remarks. Middle to Late Ordovician age, based on the presence of fragments of eobelodiniform and belodiniform elements that may represent part of a *Belodina* species. The elements referred to ?*Protopanderodus* have a long, posteriorly extended base similar to forms that occur in Caradoc and Ashgill strata.

GSC locality C-171514. Same locality as C-171514; collected by M. Bjornerud; identification by G.S. Nowlan.

Sample weight. 2900 g (85% breakdown).

Fauna

The sample yielded 11 very poorly preserved conodont elements (CAI 5) identifiable as follows:

Panderodus sp. (9)
drepanodontiform element indet. (1)
denticulate fragments (1)

Remarks. Probable Ordovician age, but none of the taxa present are biostratigraphically diagnostic.

MAP UNIT OSv

GSC localities C-54800 and C-54801. 3.4 km south of head of Kulutingwak Fiord, northeastern fault block of map unit OSv; NTS 340 F; UTM Zone 17X, 487000E, 9106000N; identification by C.R. Barnes.

Fauna

Astropentagnathus n. sp. (6)
cf. *Falcodus*? n. sp. sensu fructo (of Schönlaub, 1971) (1)
Ozarkodina cf. *O. gaertneri* sensu fructo Walliser (a form element of *Pterospathodus* cf. *P. amorphognathoides*) (1)
Panderodus sp. (2)
Belodina? sp. (2)

Remarks. The *Belodina*? sp. specimens are grey and poorly preserved; this genus is not known to occur in strata younger than Ordovician. The platform elements of *Astropentagnathus* n. sp. suggest that it is ancestral to *A. irregularis* Mostler, reported by Schönlaub (1971) from the lower part of the *celloni* Zone in the Carnic Alps and from the lower part of the Cape Storm Formation (transitional facies) by Mirza (1976). [The lower member of the Cape Storm Formation of Kerr (1975) has been re-assigned to the Allen Bay Formation by Thorsteinsson and Mayr (1987)]. *Falcodus* n. sp. also was reported by Schönlaub (op. cit.) from the *celloni* Zone. The specimen identified as *Ozarkodina* cf. *O. gaertneri* sensu fructo Walliser consists of a single fragmentary element only; it belongs within *Pterospathodus amorphognathoides*. The *P. amorphognathoides* Zone is of late Llandovery–early Wenlock age. Based on the *Astropentagnathus* n. sp., the sample is tentatively assigned to the early to middle Llandovery.

PIPER PASS FORMATION

GSC locality C-54924. Northeast side of Piper Pass, about 15 km south-southeast of head of Clements Markham Inlet; NTS 120 F; UTM Zone 19X, 512200E, 9160400N; 0-1.5 m above base of outcrop; identification by T.T. Uyeno; *see* Norford, Appendix 5A, C-54926.

Sample weight. 2000 g.

Fauna

The conodonts are fragmented, malformed, and black (CAI 5)

Kockelella variabilis Walliser
Ozarkodina confluens (Branson and Mehl) morphotype indet.
O. douroensis Uyeno
Panderodus sp.

Remarks. Late Silurian, Ludlow, older than latest Ludlow. This fauna is probably assignable to the lower part of the *siluricus* Zone (in broad sense), and may, in turn, be equivalent to the upper part of the *chimaera* Zone through the lower part of the *bohemicus tenuis* Zone.

GSC locality C-54925. Same locality as C-54924, 1.5-4.5 m above base of outcrop; identification by T.T. Uyeno.

Sample weight. 2000 g.

Fauna

The conodonts are fragmented, malformed, and black (CAI 5)

Dapsilodus? sp.
Oulodus sp.
Ozarkodina confluens? (Branson and Mehl)
Panderodus sp.

Remarks. Probably Late Silurian.

GSC locality C-54926. Same locality as C-54924, 4.5-11 m above base of outcrop; identification by T.T. Uyeno.

Sample weight. 2000 g.

Fauna

The conodonts are fragmented, malformed, and black (CAI 5)

Ozarkodina confluens? (Branson and Mehl), approaching gamma morphotype of Klapper and Murphy (1975)
Panderodus sp.

Remarks. Late Silurian.

GSC locality C-54930. Northeast side of Piper Pass, about 14.8 km south-southeast of head of Clements Markham Inlet; NTS 120 F; UTM Zone 19X, 512250E, 9160800N; identification by T.T. Uyeno; *see* Norford, Appendix 5A, C-54932.

Sample weight. 2000 g.

Fauna

The conodonts are fragmented, malformed, and black (CAI 5)

Ozarkodina confluens? (Branson and Mehl), approaching gamma morphotype of Klapper and Murphy (1975)
O. excavata excavata (Branson and Mehl)
Panderodus sp.

Remarks. Late Silurian.

GSC locality C-54931. Same locality as C-54930; identification by T.T. Uyeno.

Sample weight. 2000 g.

Fauna

The conodonts are fragmented, malformed, and black (CAI 5)

Ozarkodina confluens? (Branson and Mehl), gamma morphotype of Klapper and Murphy (1975)
O. cf. *O.* n. sp. A of Klapper and Murphy (1975)
Panderodus sp.

Remarks. Late Silurian, probably late Ludlow, probably *latialata* Zone. *Ozarkodina* n. sp. A was found previously associated with *Pedavias latialata* (Walliser) in the Barlow Inlet Formation (Uyeno, 1980).

PEARYA

CAPE DISCOVERY FORMATION

Member B

GSC locality C-74987. East side of unnamed peninsula west of Maskell Inlet; NTS 340 E; UTM Zone 17X, 534600E, 9202600N; identification by R.V. Tipnis; *see* Norford, Appendix 5A, C-69206.

Fauna

About 40 specimens were recovered. They are moderately well preserved and black (CAI 4 or 5)

Acodus mutatus (Branson and Mehl)
Drepanoistodus suberectus (Branson and Mehl)
Panderodus gracilis (Branson and Mehl)
Oistodus venustus Stauffer s.f.
Periodon aculeatus Hadding
aff. *Sagittodontus*? sp.
aff. *Coelocerondontus digonius* Sweet and Bergström, s.f.

Remarks. The most diagnostic taxon in this collection is *Periodon aculeatus* Hadding. Other taxa generally indicate a late Middle Ordovician to even Late Ordovician age. *P. aculeatus* extends from early Llanvirn to early Caradoc; higher in the stratigraphic column it is replaced by *P. grandis* (Ethington). Although these two multi-element species are somewhat difficult to separate, based on the features of the oistodiform element, the present taxon appears to be closer to *P. aculeatus*. With this in mind, I would suggest that the sample is probably Llandeilo to Caradoc.

Biographic affinity is clearly with the North Atlantic Province — not a single diagnostic Mid-continent taxon is present. From my experience with material from the southern and western District of Mackenzie, the fauna probably comes from a shelf margin or, more likely, from a slope area.

AYLES FORMATION

GSC locality C-97377. Egingwah Creek 2-2 section; *M'Clintock Inlet*, inset A, section EC2-2; NTS 340 E; UTM Zone 18X, 466750E, 9190000N; lowermost part of unit 2; identification by G.S. Nowlan; *see* Norford, Appendix 5A, C-97377.

Fauna

The sample yielded 2 conodont elements (CAI indeterminate) identifiable as follows:

Panderodus sp.
cusp fragment

Remarks. This material is not biostratigraphically diagnostic and indicates an age range from Middle Ordovician to Devonian.

ZEBRA CLIFFS FORMATION

Reference section south of Disraeli Fiord

Member D

GSC locality C-96701. Section south of Disraeli Fiord; *M'Clintock Inlet*, section SDF2; NTS 340 E; UTM Zone 18X, 532750E, 9182300N; 35.5-36.5 m above base of section and of Disraeli Glacier beds; identification by G.S. Nowlan; CAI 3.5.

Fauna

Belodina cf. *B. confluens* Sweet
Histiodella cf. *H. sinuosa* (Graves and Ellison)
Panderodus gracilis (Branson and Mehl)
Protopanderodus liripidus (Kennedy, Barnes, and Uyeno)
Pseudooneotodus mitratus (Moskalenko)

Remarks. Middle to Late Ordovician. The fauna is mixed however, because the genus *Histiodella* is not known to occur in strata younger than Whiterockian (early Middle Ordovician). It is assumed that the single specimen of *H.* cf. *H. sinuosa* is derived from underlying strata.

GSC locality C-96700. Same locality as as C-96701; 38.0 m; identification by G.S. Nowlan; CAI 3.5.

Fauna

Hamarodus europaeus (Serpagli)
Panderodus gracilis (Branson and Mehl)
oistodiform element indet.
panderodiform element indet.

Remarks. The presence of elements of *H. europaeus* suggests a Late Ordovician age for the sample. This is only the third report of *Hamarodus* from North America; it is of North Atlantic affinity.

GSC locality C-96699. Same locality as C-96701; 39.0 m; identification by G.S. Nowlan; CAI 3.5 m.

Fauna

Belodina sp.
Pseudobelodina? *dispansa* (Glenister)

Remarks. On the basis of *P.*? *dispansa*, this sample may range in age from late Middle Ordovician to latest Ordovician.

Harley Ridge

GSC locality C-74849. West side of Harley Ridge; NTS 340 E; UTM Zone 18X, 486700E, 9160700N; CAI 4.5 (B.J. Dougherty); identification by R.S. Tipnis.

Fauna

Phragmodus undatus Branson and Mehl
Belodina compressa (Branson and Mehl)
Panderodus gracilis (Branson and Mehl)
aff. *Pravognathus idiones* (Stauffer) s.f.
Acodus mutatus (Branson and Mehl)
Drepanoistodus suberectus (Branson and Mehl)

Remarks. The presence of *P. undatus* restricts the lower age limit of this sample to Rocklandian or Fauna 8 (Sweet et al., 1971). The upper limit extends to the top of the Ordovician. No other stratigraphically significant taxon being present, the only clue may be the recent comment by Barnes (1977) that, during Late Ordovician, elements of *Panderodus gracilis* are strongly recurved towards the tip. Based on this criterion (which is not very definitive), a Late Ordovician age is suggested.

LORIMER RIDGE FORMATION

GSC locality C-70106. Lorimer Ridge section; *M'Clintock Inlet*, section LR; NTS 340 E; UTM Zone 18X, 539800E, 9175700N; probably from 764-782 m above base; collected by R. Gardner and D. Jones; identification by R.S. Tipnis; *see* Norford, Appendix 5A, C-70106. CAI approximately 3.

Fauna

Panderodus gracilis (Branson and Mehl)
cf. *Panderodus panderi* sensu Sweet et al., 1975
Plectodina furcata tenuis Sweet et al., 1975
Oulodus? sp.
Eobelodina? sp. s.f.

Remarks. Latest Middle or Late Ordovician, Faunas 9-12 of Sweet et al., 1971. Both *P. furcata tenuis* and *P. panderi* range from Fauna 9 to Fauna 12. The elements of *Oulodus*? sp., though broken, show some similarity with the Late Ordovician oulodid *O. oregonia oregonia* (Branson, Mehl, and Branson). If this is true, then the sample would be of Late Ordovician age (Faunas 11 and 12 of Sweet et al., 1971). Biogeographic affinity lies with the Midcontinent Province. A shallow shelf environment is suggested.

MARVIN FORMATION

Central shallow-marine belt

Section southeast of Disraeli Fiord

GSC locality C-54977. Section southeast of Disraeli Fiord; *M'Clintock Inlet*, section SEDF; NTS 340 E; UTM Zone 18X, 540100E, 9179600N; 2-3 m above base of formation; CAI 3.5 (specimens are small and thin; B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Panderodus gracilis (Branson and Mehl)
Drepanoistodus? sp. (suberectiform, possibly of *D. suberectus* (Branson and Mehl)
Plegagnathus? sp. (proclined element)

Remarks. Age not precisely determinable but overall the faunule appears to be of probable Ordovician age.

GSC locality C-54978. Same locality as C-54977, 4-5 m above base of formation; CAI 4.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Panderodus gracilis (Branson and Mehl)

Remarks. Middle Ordovician to Late Silurian.

GSC locality C-54981. Same locality as C-54977, 573 m above base of formation; CAI 4.5 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Panderodus sp.
Ozarkodina cf. *O. excavata* (Branson and Mehl)

Remarks. Probably Late Silurian or Early Devonian.

GSC locality C-54982. Same locality as C-54977, 573-574 m above base of formation; CAI 4.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Ozarkodina cf. *O. confluens* (Branson and Mehl), possibly gamma morphotype of Klapper and Murphy, 1975
Ozarkodina cf. *O. excavata* (Branson and Mehl)
Panderodus sp.

Remarks. Silurian, probably Late Silurian.

GSC locality C-54983. Same locality as C-54977, 574 m above base of formation; CAI 4.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Ozarkodina cf. *O. confluens* (Branson and Mehl), form approaching epsilon morphotype of Klapper and Murphy, 1975
Ozarkodina cf. *O. excavata* (Branson and Mehl)
Panderodus sp.

Remarks. Late Silurian, Ludlow-Pridoli.

Other localities

GSC locality C-54985. Section north of Thores River 2; *M'Clintock Inlet*, section NTR2; NTS 340 E, UTM Zone 18X, 532700E, 9174400N; identifiction by T.T. Uyeno.

Fauna

Panderodus gracilis (Branson and Mehl) (graciliform element)

Remarks. Mid-Ordovician to Late Silurian.

GSC locality C-54986. Same locality as C-54985; 3-5 m above base of formation; CAI 4.5 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Belodina cf. *B. stonei* Sweet (belodiniform element)
Panderodus gracilis (Branson and Mehl)
P. sp. undet.

Remarks. Late Ordovician, probably Fauna 12 of Sweet et al., 1971.

GSC locality C-54987. Same locality as C-54985; 30-33 m above base of formation; CAI 4.0 (very poor preservation; B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Panderodus gracilis (Branson and Mehl)
Plegagnathus cf. *P. nelsoni* Ethington and Furnish (plegagnathiform element)

Remarks. Late Ordovician, Faunas 11 to 13 (of Sweet et al., 1971; Sweet, 1979; McCracken and Barnes, 1981).

GSC locality C-54984. West of Thores River 2 section; NTS 340 E; UTM Zone 18X, 532400E, 9174200N; CAI 4.5 (one specimen with poor preservation; B.J. Dougherty); identification by T.T. Uyeno (cf. identification of brachiopods from same locality by B.S. Norford).

Fauna

Panderodus gracilis (Branson and Mehl) (compressiform element)

Remarks. Mid-Ordovician to Late Silurian.

GSC locality C-75386. East-central Marvin Peninsula; NTS 340 E; UTM Zone 18X, 512600E, 9182000N; CAI 4.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Aulacognathus bullatus (Nicoll and Rexroad)
Oulodus? *fluegeli* n. subspec. A of Uyeno and Barnes (1983)
Panderodus sp.

Remarks. Silurian, late Llandovery, upper *staurognathoides* Zone to *inconstans* Zone.

GSC locality C-75387. Same locality as C-75386 but different strata; CAI 4.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Ozarkodina polinclanata (Nicoll and Rexroad)
Oulodus? *fluegeli* n. subspec. A of Uyeno and Barnes (1983)
Wallisserodus sancticlairi Cooper
Panderodus sp.

Remarks. Silurian, late Llandovery, *inconstans* Zone.

GSC locality C-75388. Same locality as C-75386 but different strata; CAI 3.0 (small, thin specimens; B.J. Dougherty); identification by T.T. Uyeno.

Fauna

Wallisserodus sancticlairi Cooper
Panderodus sp.

Remarks. Silurian, probably late Llandovery.

GSC locality C-75389. Same locality as C-75386 but different strata; CAI 4.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna
Oulodus? cf. *O.*? *fluegeli* Walliser
Panderodus sp.
Ozarkodina sp.
Walliserodus sp.

Remarks. Probably Early Silurian.

MARVIN FORMATION

Northwestern deep- and shallow-marine belt

GSC locality C-54988. Crash Point section; *M'Clintock Inlet*, inset C, section CP; NTS 340 E; UTM Zone 18X, 483700E, 9183600N; 0-1 m above base of section; CAI 1.5-2.0, mainly 1.5 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna
"*Neoprioniodus*" cf. "*N.*" *multiformis* Walliser
Panderodus sp.

Remarks. Probably Silurian (Ludlow?).

GSC locality C-74917. Same locality as C-54988, about 48 m above base of formation; identification by T.T. Uyeno.

Fauna
CAI 2.0-2.5
Ozarkodina excavata excavata (Branson and Mehl)
Panderodus sp.

Remarks. Late Silurian to Early Devonian, early Ludlow to Emsian; the lowest occurrences of *O. excavata excavata* is in the *crassa* Zone.

GSC locality C-74916. Same locality as C-54988, uppermost strata of formation; identification by T.T. Uyeno.

Fauna
CAI 2.0-2.5
Panderodus sp.

Remarks. Middle Ordovician to Middle Devonian.

CRASH POINT BEDS

GSC locality C-54996. East side of middle M'Clintock Inlet, northeast of Crash Point; NTS 340 E; UTM Zone 18X, 483600E, 9183200N; CAI 1.0-2.5, mostly 1.5 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna
Sa element (highly fragmented, possibly referable to *Ozarkodina excavata* (Branson and Mehl)

Remarks. Possibly Silurian-Devonian.

GSC locality C-54997. Same locality as C-54996 but different strata; CAI 2.0-2.5, mostly 2.0 (B.J. Dougherty); identification by T.T. Uyeno.

Fauna
Ozarkodina confluens (Branson and Mehl) (beta morphotype of Klapper and Murphy, 1975)
Oulodus sp.

Remarks. Silurian, Wenlock to Pridoli.

C. IDENTIFICATION OF OSTRACODES AND SPORES

M.J. Copeland and D.C. McGregor

CLEMENTS MARKHAM FOLD BELT

LANDS LOKK FORMATION

GSC locality C-54943. 1.9 km northwest of Markham River; NTS 120 F; UTM Zone 19X, 493800E, 9168200N; identification by D.C. McGregor.

Fauna
Spores are rather abundant in this sample, and certain other types of palynomorphs were also recovered. However, all are extremely highly carbonized. Most are completely black, and even those rare specimens that are somewhat translucent are difficult to identify

Retusotriletes sp.
?*Apiculatasporites* sp.
?*Calamospora* sp.

Remarks. Also present are rare apparently unsculptured specimens that may be zonate. All of the spores are small, the largest undoubted spores being only 52 μm in diameter. Some spore-sized fragments are reticulate, but they could equally well be acritarchs, or even fragments of the "cellular sheets" that are common in some Silurian and Early Devonian continental nearshore marine deposits. A few such "cellular sheets" are present.

A few specimens of spirally(?) or annularly thickened nemaphytalean(?) tubes were recovered. Similar structures have been found previously in several Llandovery to Emsian deposits (*see* McGregor and Narbonne, 1968, p. 1298).

Judging by the size and abundance of the spores, and their apparently simple structure and sculpture, their age is probably within the range Wenlock to Lochkovian, inclusive. If zonate and/or reticulate spores are in fact present (and this is not proven), the age would probably be Lochkovian.

GSC locality C-54946. Same location as C-54943, but different stratum; identification by D.C. McGregor.

Fauna

As in C-54943, the palynomorphs are highly carbonized, and most are completely opaque and unidentifiable. Spores are relatively abundant; all are less than 50 μm in diameter; and most lack sculpture or diagnostic structure
Tetraletes (1)

Remarks. Considering the presence of *Tetraletes*, and the small size and simple construction of the spores, the most reasonable assignment is late Silurian. However, on such meager evidence I cannot eliminate the possibility of Lochkovian, or even younger Early Devonian age.

MARKHAM RIVER FORMATION

GSC locality C-94377. Markham River section, 2.4 km northwest of Markham River; *Clements Markham Inlet–Robeson Channel*, section MR; NTS 120 F; UTM 19X, 493400E, 9168300N; 127–134.5 m above base of section; identification by M.J. Copeland.

Fauna

Ostracoda
cf. *Silenis mavii* (Jones)
cf. *Silenis symmetricus* Pranskevichius
immature gastropod or annelid worm

Remarks. The specimens are uniformly small, possibly indicting restricted marine conditions. Because of their size, identifications are necessarily tentative. *S. mavii* is reported from the Wenlock of the Baltic region, and *S. symmetricus* is from the early Ludlow of the same area. The genus *Silenis* ranges from late Llandovery to late Ludlow as presently known.

D. IDENTIFICATIONS OF CALCIMICROBES, ALGAE, AND SPONGE SPICULES

T.A. de Freitas

NORTHERN HEIBERG FOLD BELT

GSC locality C-194934-2. Svartevaeg Cliffs, about 13.9 km southwest of Cape Stallworthy; talus of carbonate conglomerate at base of northwest-facing cliffs; NTS 560 D; UTM Zone 15X, 503250E, 9027900N; identification by T.A. de Freitas; *see* Norford, Appendix 5A, 47506 and Nowlan, Appendix 5B, C-194934.

Fauna

Girvanella sp.
Whetheredella sp. cf. *W. silurica* Wood, 1948

Remarks. *Whetheredella* is very common in Paleozoic strata in many areas, but is best known from Ordovician strata of Scandinavia, Silurian strata of Gotland and eastern Canada, and Upper Devonian strata of Belgium. It also occurs in lesser numbers in upper Paleozoic strata, in the Viséan of Turkey, for example (Héroux et al., 1977). *Whetheredella* was mainly a reef dweller.

CLEMENTS MARKHAM FOLD BELT

CARBONATE OLISTOLITHS AT FIRE BAY

Within Danish River Formation

GSC locality C-194940. *Cape Stallworthy-Bukken Fiord*, inset B, locality F15; 0.8 km northeast of Fire Bay; UTM Zone 16X, 470400E, 9045300N; identification by T.A. de Freitas; *see* Nowlan, Appendix 5B, C-194940.

Fauna
cf. *Rhabdoporella* sp.

Remarks. This dasyclad genus is characterized by a circular cross section and by a faint radial structure in a thick wall. However, these specimens are recrystallized and genus characteristics are not well preserved. These algae are very common in lower Paleozoic strata, particularly in Ordovician and Silurian strata of Norway, Sweden, and Quebec (Héroux et al., 1977). They probably existed within, and adjacent to, many Paleozoic reefs.

PEARYA

SUCCESSION 2, MAP UNIT L4

GSC locality C-194741. Arthur Laing Peninsula, 4.9 km northeast of upper Gypsum River; NTS 120 F; UTM Zone 19X, 505700E, 9193200N; identification by T.A. de Freitas.

Fauna
fragmentary polyaxonous or monaxonous spicules, perhaps derived from a hexactinellid sponge

Remarks. Probably Cambrian to Recent. Prior to recent work by J.G. Gehling and J.K. Rigby (pers. comm., 1994), Precambrian spicules and other sponge body remains were unknown, despite numerous years of micropaleontological studies of Precambrian strata. One of the most controversial studies was by Glaessner (1979), who described monaxonous-like spicules from Precambrian strata, but they appear to be too small, as compared to extant and fossil hexactinellid-derived spicules, and Glaessner's spicules could simply be volcanic shards (Pickett, 1983; Rigby, 1986). The report of sponges from Neoproterozoic strata (Ediacaran of south Australia) by Gehling and Rigby (in press) potentially represents one of the most important finds concerning early sponge evolution. Although poorly preserved, these sponges possess a reticulate spicule net composed chiefly of stauracts. The spicules in this sample could be fragmentary stauracts, intact monaxons, or fragmentary polyaxonous spicules, and their range is Neoproterozoic to Recent, but I suspect that a Cambrian to Recent age range is probable, based on the following.

Neoproterozoic sponge occurrences are exceedingly rare and still controversial. Ediacaran fossil-bearing strata are widespread, occurring on five continents, and have been extensively studied on all scales; yet, only two poorly preserved sponges, and no isolated spicules have been reported. Spicules have been recovered for years from acid residues of Phanerozoic strata; I find it suspicious that none have been recovered from Precambrian strata. While it appears that we now have Precambrian sponge body fossils, we cannot be certain that they were constructed of monomineralic spicules, as are the Phanerozoic representatives. Perhaps the spicules were an organic variety that survived only because of the unique preservation of the Ediacaran strata. Ediacara fossils themselves are certainly unusual, a fact that prompted Seilacher (1992) to regard them as "Vendobiota" that did not survive the Phanerozoic transition.

CAPE DISCOVERY FORMATION

Member A

GSC locality C-194948, Bromley Island section; *M'Clintock Inlet*, section BI; NTS 340 E; UTM Zone 17X, 539100E, 9209700N; 42–44 m above base of formation and member; identification by T.A. de Freitas; *see* Norford, Appendix 5A, 75417.

Fauna
Hedstroemia halimedoida? Rothpletz, 1913

Remarks. The material consists of poorly preserved, recrystallized fragments. *Hedstroemia* is presently considered to be a calcified cyanobacteria or calcimicrobe (Riding, 1991). It is common in shallow-water deposits of Cambrian to Cretaceous age and also has some Recent analogues. In the Ordovician of Ontario and Quebec, it is found in bioturbated, fossiliferous wackestones of the Lowville Formation and Black River Group (Guilbault and Mamet, 1976). It also occurs in the Middle Ordovician of New York State and Quebec and is pandemic in the Silurian, typically associated with reef and back-reef deposits (Bourque et al., 1981; Roux, 1991).

ZEBRA CLIFFS FORMATION

Member D

GSC localities C-96302, C-96303, C-96305. Section south of Disraeli Fiord 2; *M'Clintock Inlet*, section SDF2; NTS 340 E; UTM Zone 18X, 532750E, 9182300N; 6.5, 16.5, 51.6 m above base of section and of Disraeli Glacier beds; identification by T.A. de Freitas; *see* Nowlan, Appendix 5B, C-96701.

Remarks. Spicule-rich lime mudstone and mudrock with relatively common monaxons and some polyaxon forms with well developed axial filaments. Where these filaments are well developed in cross section, clear differentiation between radiolarians and spicules might be difficult since all skeletal debris has been calcitized. Larger, polyaxonous spicule forms are probably hexactine derivatives; i.e., clathrops or stauracts (no three-dimensional view was available). Monaxonous forms included styles, oxeas, and a possible strongyle, but monaxon termini are typically lost in thin sectioning.

Little can be concluded about the paleoenvironment, except that hexactinellids in Ordovician time were exclusively deep-water inhabitants. The water was clearly not anoxic, nor was it stagnant, as most recent deep-water hexactinellids prefer currents of 1-3 km/h. Violent currents have adverse effects on their delicate construction, explaining their paucity in shallow-water sediments of all ages (Hartman et al., 1980). Monaxons range through the Phanerozoic.

MARVIN FORMATION

Northwestern deep- and shallow-marine belt

GSC locality C-94307. Crash Point section; *M'Clintock Inlet*, inset C, section CP; NTS 340 E; UTM Zone 18X, 483700E, 9183600N; identification by T.A. de Freitas.

Fauna

Hedstroemia sp. (fragment)
''*Solenopora*'' cf. ''*S.*'' *gotlandica* (fragment)

Remarks. Both fossils range through most of the Phanerozoic although they are best known from Ordovician and Silurian rocks of Québec, Gotland, Alaska, and the Michigan Basin. ''Solenopora'' is associated commonly with high-energy reef environments but not restricted to them.

Solenopora is used in quotation marks because of its controversial classification. Solenoporaceae is probably a heterogeneous group of metazoans, red algae, and cyanobacteria (Brooke and Riding, 1987). Fenestrae contain mostly equant, blocky calcite, although one cavity is lined with laterally discontinuous, inclusion-rich calcite that appears similar to microbial encrustations in many Paleozoic shallow- and deep-water reef cavities. However, it is poorly preserved and a name cannot be applied to it.