GEOLOGICAL SURVEY OF CANADA

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# GEOLOGY OF PRECAMBRIAN TO DEVONIAN ROCKS, M'CLINTOCK INLET AREA, DISTRICT OF FRANKLIN (NTS 340E, H) - PRELIMINARY GEOLOGICAL MAP AND NOTES

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# INTRODUCTION

The M'Clintock Inlet area, underlain mainly by Precambrian to Devonian rocks and to a lesser extent by Carboniferous, Permian and (?) Tertiary strata, is geologically one of the most complicated regions in the Arctic Islands.

The first geological reconnaissance in parts of the area was done by R.L. Christie with dogs and sledges in 1954 (1957), and 1957-58 (1964). More specialized studies were made in 1965-67 by T.O. Frisch (1974) and H.P. Trettin (1969b). A program to complete the geological reconnaissance of parts of nine map-areas in northern Ellesmere Island was begun by the Geological Survey in 1975 and probably will continue until 1982. In the M'Clintock Inlet area, U. Mayr is responsible for the geology of the Carboniferous and younger strata and the writer for that of the older rocks and intrusions. In the course of this program he spent a total of about seven weeks of field work in the area during 1977, 1979 and 1980. The work consisted of foot traverses out of nine fly camps and of helicopter traverses, using Bell 206B machines out of base camps at Clements Markham Inlet and Tanquary Fiord.

In 1980 the writer found a small copper deposit near Thores River (see below) and the purpose of this Open File release is to aid prospecting by industry in 1981 although many of the structural and stratigraphic interpretations on the map and in the accompanying notes still are tentative. The upper Paleozoic geology of the area has not yet been compiled so that the upper Paleozoic (and locally Tertiary) formations had to be shown as a single, undifferentiated map-unit.

Petrographic and chemical studies of lower Paleozoic and older rocks, isotopic age determinations, compilations of stratigraphic sections, and interpretations of the depositional and structural history are in various

stages of progress. Some results are mentioned but systematic accounts will be published later. The main purpose of these notes is to explain stratigraphic nomenclature and age assignments on the map legend.

## PROTEROZOIC

Rocks designated as Proterozic underlie three separate belts, in the northeastern, northwestern and southeastern parts of the map area. The northeastern belt includes a metasyenite on Ward Hunt Island (Pnsy) that intrudes a schist (Ps), and a gneiss complex (Pn) that extends from Cape Albert Edward eastward into the Clements Markham Inlet map area to Cape Aldrich. The latter has yielded a Rb/Sr isochron age of 1083 ± 18 Ma and discordant zircon ages of 926 and 980 Ma (Sinha and Frisch, 1976; Rb/Sr age not corrected for present decay constants).

The northwestern belt consists of gneiss (Pn), and of metasediments with associated gneiss (Pcsn). It extends to north of Phillips Inlet and has an (uncorrected) Rb/Sr isochron age of 742 ± 12 Ma, interpreted as a minimum age (Sinha and Frisch, 1975); zircon determinations are in progress.

The southwestern belt is underlain by metamorphosed granitic intrusions and hybrid rocks (Png, Pns) that are petrographically similar to those in the other belts. Zircon studies of intrusive rocks are under way.

## PROTEROZOIC AND/OR LOWER PALEOZOIC

Units of unspecified Proterozoic and/or early Paleozoic age underlie a large, crescent-shaped belt in the western part of the M'Clintock Inlet map area and a small area in the northeasternmost part. Collectively, they constitute a thick and varied assemblage of predominantly metasedimentary strata with lesser amounts of metavolcanic rocks. The Commonwealth Mountain Uplift (term of Trettin and Balkwill, 1979, Fig. 2) is metamorphosed in

upper greenschist to amphibolite facies (map-units sc, cs), the other terrain mainly in the lower greenschist facies. The structure is so complex that the internal stratigraphy could not be established except for a small area east of Milne Fiord, located mainly in the Yelverton Inlet map area but extending into the central western part of the present map area. Fossils and trace fossils seem to be absent and radiometric age determinations have not yet been made. For these reasons the various map-units are denoted by lower case letters only without the customary upper case letters indicating age. The italicized (i.e. underlined) letters indicate lithology and comprise unique units, present in one area only, as well as recurrent lithologies.

Three stratigraphic units of formational rank are recognized in the area east of Milne Fiord. They are informally referred to as units 1, 2 and 3 of the Milne Fiord assemblage and marked by numbers that follow the lithological letter symbols.

Unit 1 (map-unit c1) consists of more than 150 m of microcrystalline limestone or marble with lesser amounts of dolomitic limestone or marble and dolostone. The rocks are faintly to distinctly laminated.

Unit 2 (map-unit p2) comprises about 640 m of pelitic slate or phyllite with lesser proportions of tuffaceous phyllite and recrystallized silty and sandy limestone or dolostone.

Unit 3 (map-unit q3) has a minimum thickness of about 560 m and consists almost entirely of very fine to medium grained orthoquartzite, locally with pelitic slate in the lower few metres.

In the westernmost part of the M'Clintock Inlet map area only units 1 and 2 are exposed. Unit 3 may be represented by quartzite in two fault slices east of M'Clintock Glacier but has not been designated as such because of uncertainty about the stratigraphic position of the rocks.

At Ayles Fiord, unit 1 is underlain by metamorphosed mudrocks, carbonates and volcanics that are similar to the Milne Fiord assemblages but older. North of upper Ayles Fiord, these strata are overlain with high angular unconformity by the upper Middle Ordovician Cape Discovery Formation, which is different in lithology from all units discussed here. This imples that all these units are pre-late Middle Ordovician in age. Most also are different from units of known or suspected Cambrian to early Middle Ordovician age, such as the Grant Land Formation, lower parts of the Hazen Formation and the Oakley River and Bromley Island assemblages, which suggests that they are Proterozoic in age if they originated on the North American Plate. If they were deposited on another plate that collided with North America in the middle Ordovician they could range in age from Precambrian to early Middle Ordovician.

Rocks in the northeasternmost part of the M'Clintock Inlet area and in the adjacent Clement Markham Inlet area are assigned to the Mount Disraeli assemblage (Mount Disraeli Group of Blackadar, 1954), a structurally very complex succession of variably metamorphosed carbonate and mudrocks, quartzites and diamictites of unknown internal stratigraphy. The diamictites are similar to conglomeratic mudrocks in the Yelverton Inlet area and superficially comparable to upper Proterozoic tillites or tilloids in many other regions. The specimens studied to date, however, seem to represent subaqueous debris flow deposits (with carbonate intraclasts derived from an adjacent shelf) rather than ice-rafted dropstone conglomerates or tillites. Nevertheless, they could have been produced by sea level changes, in turn caused by a late Proterozoic glaciation.

## LOWER PALEOZOIC SEDIMENTARY AND VOLCANIC UNITS

### Cambrian to lower Upper Ordovician

#### Grant Land Formation

The Grant Land Formation (Trettin, 1972) is a more than 1.5 km thick succession of variably feldspathic quartzite and purple, green and grey slate and phyllite with minor amounts of granule and pebble conglomerate in the lower part. Both average and maximum grain size decrease stratigraphiclly upwards so that the uppermost part consists mainly of slate or phyllite. The formation has neither yielded fossils nor diagnostic trace fossils. Stratigraphic relationships with the overlying Hazen Formation suggest that it is mainly Cambrian in age although it may extend into the Early Ordovician. The formation is exposed only in the southeasternmost part of the M'Clintock Inlet map-area. Its absence in the northwestern parts could be explained by erosion at the mid-Ordovician unconformity.

#### Oakley River assemblage

The informal name, Oakley River assemblage is here given to a structurally complex succession of sedimentary and less abundant volcanic rocks, north south, and southeast of the head of Ayles Foird. It is named for a river on the northwest side of the northern outcrop belt. The sedimentary rocks consist of:

- dolostone and limestone, slaty, variably pelitic or sandy
- mudrock, slaty to phyllitic, commonly reddish
- radiolarian (?) chert, dark grey

The volcanic rocks include both flow rocks and pyroclastic deposits. Five analyzed specimens are classified as follows (on the basis of Irvine and Baragar, 1971):

- hawaiite, sodic alkali basalt series (2)

- basalt, tholeiitic, K-poor series (1)
- andesite, calc-alkaline (high alumina), K-rich series (1)
- dacite, calc-alkaline, K-poor series (1)

However, the K-content may not be original but the result of alteration. The rocks are partly metamorphosed: the plagioclase has been albitized but some clinopyroxene is preserved. North of Ayles Fiord the volcanics appear in the core of some anticlines. South of the fiord they form a flat sheet, possibly a thrust plate, that overlies the sedimentary rocks.

Airphoto interpretation suggests that the Oakley River assemblage locally has been thrust over the Bromley Island assemblage and therefore possibly is older than the latter; its base is not exposed. The contact with the Cape Discovery Formation is faulted, but the assemblage undoubtedly forms part of the pre-late Middle Ordocian complex unconformably overlain by that formation. The presence of radiolarian (?) chert suggests that it is no older than Cambrian and possibly correlative with lower parts of the Hazen Formation.

Bromley Island assemblage

The Bromley Island assemblage, an informal stratigraphic unit introduced here, is a structurally complex succession of volcanic and sedimentary rocks. It is exposed mainly in a belt that extends from the north tip of Bromley Island to southwest of Ayles Fiord and may also be represented by volcanic rocks immediately south and east of the M'Clintock East ultramafic massif.

The volcanic rocks, comprising both flows and pyroclastics, are mainly siliceous to intermediate in composition and partly metamorphosed, like the Oakley River assemblage. The sediments comprise radiolarian (?) chert, limestone, dolostone and slaty to phyllitic mudrocks. Some carbonate units are mappable (Obrc) and reveal a complex pattern of both eastward and northward thrust faulting. Southwest of the head of Ayles Fiord a lower unit with

common red mudrock (Obr1) is distinguished from an upper unit composed of cliff-forming volcanic (Obr2).

Cape Discovery Formation

The Cape Discovery Formation (Trettin, 1969b) is an about 1 km thick unit of clastic and carbonate sediments with small amounts of volcanic rocks, divisible into four members.

Member A consists of 70 m + of compositionally immature sandstone and granule to boulder conglomerate with minor amounts of slaty mudrock, limestone and dolostone. It now is known to be exposed in two major belts; one extending from west of Bromley Island to north of Ayles Fiord, and the other (previously assigned to the Taconite River Formation) from southeast of Bromley Island to west of Egingwah Bay. Minor outcrops also occur west of the M'Clintock West massif.

Member B, 134 m + thick, is composed of limestone and dolostone locally with minor amounts of volcanic flow rocks and pyroclastics, including rhyolite, andesite and trachyte.

Member C contains 320 m + of interlaminated calcareous red mudrock and silty limestone.

Member D comprises about 450 m of red clastic sediments, mainly sandstone with smaller proportions of mudrock and granule to pebble conglomerate, and minor amounts of dolostone, limestone and volcanic rocks of siliceous to intermediate composition.

The Cape Discovery Formation lies with high angular unconformity on map-units c and pp and on the Bromley Island assemblage. It is conformably overlain by the M'Clintock Formation. Member A and B are assigned to the Wildernessian stage (late but not latest Middle Ordovician) on the basis of

diagnostic fossils. Members C and D probably also are Middle Ordovician in age because of the great thickness of overlying units that all are Late Ordovician in age (and the relatively short duration of that age).

M'Clintock Formation

This unit was introduced by Christie (1957) as a (reconnaissance) group and redefined as a formation by Trettin (1969b). It consists of mainly of pyroclastics and volcanic flow rocks with small amounts of volcanogenic conglomerate, sandstone and mudrock and local carbonates, mainly limestone. A tuffaceous calcarenite in the uppermost part of the formation was originally designated as member B but does not deserve member status because of its very small areal extent.

A total of 20 chemical analyses have been made. Computer classification, based on the scheme of Irvine and Baragar (1971) reveals the following spectrum of compositions:

rhyolite, calcalkaline, K-poor series (5)

dacite, calcalkaline, "average" series (1)
dacite, tholeiitic, K-poor series (1)

andesite, calc-alkaline (high alumina), K-rich series (1)
andesite, calc-alkaline (high alumina), K-poor series (2)
andesite, tholeiitic, K-poor series (2)

basalt, calc-alkaline (high alumina), K-rich series (3)
basalt, tholeiitic, K-rich series (1)

alkali basalt, potassic series (2)

mugearite, sodic alkali basalt series (1)

hawaiite, sodic alkali basalt series (1)

The M'Clintock Formation shows the same partial metamorphism as Oakley River and Bromley Island assemblages: the plagioclase has been albititized but clinopyroxene commonly is preserved.

The M'Clintock Formation lies conformably on the Cape Discovery Formation. West of M'Clintock Inlet it is overlain, apparently conformably, by the Ayles Formation and east of the inlet, probably disconformably, by the Upper Ordovician sandstones and limestones of map-unit uO that probably are correlative with the Taconite River Formation.

The coral ?Paleofavosites from the original member B indicates that the uppermost part of the formation is Late Ordovician in age (also considering the Late Ordovician age of the overlying units). The underlying parts may well extend into the late Middle Ordovician.

## Ayles Formation

The Ayles Formation, named for exposures on Mount Ayles (Trettin, 1969b), consists of 300 m+ of dolostone lying stratigraphically between M'Clintock and Taconite River formations. The lower contact is interpreted as comformable and the upper as disconformable. Outcrops are limited to an arcuate belt west of M'Clintock Inlet and to a small graben east of the inlet, south of Ootah Bay. The absence of the formation on northern Marvin Peninsula and east of Disraeli Fiord is attributed to erosion at the base of map-unit uO (= Taconite River Formation ?). The formation contains a sparse fauna of Late Ordovician age.

## Taconite River Formation and map-unit uO

### Type area of Taconite River Formation

The Taconite River Formation was established for roughly 300 m+ of mudrock and compositionally immature sandstone with minor amounts of conglomerate and limestone west of M'Clintock Inlet, lying between Ayles and Zebra Cliffs Formations (Trettin, 1969b). Both lower and upper contact were interpreted as comformable. Sparse fossils collections were of unspecified

late Middle to Late Ordovician age but the stratigraphic position of the unit indicated a Late Ordovician age. The environment of deposition was interpreted as shallow marine and nonmarine.

Studies since 1977 have shown that the lower contact is unconformable, at least in parts of the M'Clintock Inlet area and that thickness, lithology and depositional environments of the formation are very variable. A belt of relatively coarse clastic sediments east of Taconite River, originally mapped as Taconite River Formation, now is re-assigned to member A of the Cape Discovery Formation on the basis of lithology and association with other members of that formation in the area southeast of Bromley Island.

Southwest of head of M'Clintock Inlet

In this area the formation lies unconformably on schist and marble of presumed Proterozoic age and is conformably overlain by limestone of the Zebra Cliffs Formation. Its thickness varies from a few metres to a maximum of about 180 m just west of the unnamed small island near the head of the inlet. There it consists of a basal boulder conglomerate, derived from underlying Proterozoic marble, and an upward fining succession of cobble to pebble conglomerate, sandstone and mudrock. At least the lower parts of the formation are nonmarine in origin and probably represent alluvial fan and braided-river deposits.

The Taconite River Formation apparently is absent on the cliffs east of the head of M'Clintock Inlet, where the Zebra Cliffs Formation seems to lie directly on the Proterozoic basement. The covered contact was earlier interpreted as a low-angle fault (Trettin in Trettin and Balkwill, 1979) but now is regarded as an unconformity. This area probably formed a topographic high during Taconite River time.

Disraeli Glacier

An about 15 km wide belt east and west of Disraeli Glacier is underlain by folded and faulted sediments of the Taconite River Formation, flanked on the north and south by different facies of the Zebra Cliffs Formation. The thickness of the unit here cannot be established because of the complex structure but may well be in the order of kilometres. The unit is composed mainly of compositionally immature sandstone and mudrocks with local limestone comglomerate up to boulder grade (map-unit Otrcg) and minor amounts of argillaceous limestone (or calcareous mudrock). The metamorphic grade here is somewhat higher than in other parts - the mudrocks are slaty to phyllitic - and at least one small granitic intrusion is present.

Southern Marvin Peninsula

On southern Marvin Peninsula the Taconite River Formation is represented by red and green sandstones and mudrocks that underlie the Zebra Cliffs Formation. The lower contact of the formation is not exposed here and the contact with the adjacent M'Clintock Formation is faulted.

Northern Marvin Peninsula and area east of Disraeli Fiord
(map-unit u0)

Map-unit u0 comprises clastic and carbonate sediments overlying the M'Clintock Formation. The contact has not been seen exposed but is interpreted as an unconformity; the top of the unit is not preserved. It is divisible into a lower subunit, 203 m thick at section 79T7, which is composed mainly of compositionally immature, red and green sandstone and lesser amounts of mudrock and limestone, and an upper unit of limestone with an as yet undetermined thickness. Limestones at localities 79T7 and 80T205D contain fossils of unspecified late Middle to Late and of probable Late Ordovician ages respectively (identification by B.S. Norford); their strati-

graphic position implies a Late Ordovician age. The precise correlation of map-unit uO is uncertain. The simplest explanation would be that it is a facies of the Taconite River Formation with limestones more prominently developed than elsewhere. Alternative interpretations are (1) that it includes equivalents of Taconite River and lower Zebra Cliffs Formation, or (2) that it is a facies equivalent of the Lorimer Ridge beds.

Zebra Cliffs Formation

The name Zebra Cliffs Formation was given by Trettin (1969b) to about 970 m of carbonate and associated less abundant clastic sediments west of M'Clintock Inlet lying between Taconite River and Imina formations. The formation was divided into three members. Member A consisted of 22-23 m of cliff-forming limestone or dolostone; member B of about 550 m of limestone with minor amounts of sandstone and mudrock; and member C, in fault contact with member B, of about 400 m of interbedded dark grey, graptolitic, argillaceous lime mudstone and calcareous and dolomitic mudrock. Member B had an abundant and diverse benthonic fauna of Late Ordovician age (discovered by Christie in 1954) and also contained a few graptolites, and member C contained graptolites of the uppermost Ordovician graptolite zone. Member C now is considered as a tongue of the upper Hazen Formation, a unit that was introduced at a later time (Trettin, 1972). The redefined Zebra Cliffs Formation in its type area therefore comprises a total of about 572 m of limestone with minor amounts of mudrock and sandstone, and probably is conformably overlain by the Hazen Formation, although the contact is faulted at this locality.

It now is known that the Zebra Cliffs Formation, like the Taconite River Formation is very variable in thickness and lithology.

The best exposures, although difficult in access, are on the steep cliffs southeast and south of the head of M'Clintock Inlet. There, nearly flat-lying beds of the Zebra Cliffs Formation seem to overlie the Proterozoic metamorphic basement with a covered contact that now is interpreted as an unconformity (see Taconite River Formation) and are overlain with disconformity or low angluar unconformity by the Lorimer Ridge beds. The thickness is about 430 m near the head of the inlet (photogrammetric determination) but seems to increase markedly to the south. The formation consists mostly or entirely of sparsely to richly fossiliferous lime mudstone or wackestone that is alternatingly light grey and resistant or dark grey and slightly recessive. Seen from the west side of the Inlet, beds commonly are lenticular in vertical section and some reef or bank development is apparent.

Farther to east, in the area west and southwest of Disraeli Fiord, the formation seems to be represented by a series of thrust sheets of very variable thickness. Dolostone is fairly common and clastic sediments, (including red beds) ranging in grade from mudrock to pebble conglomerate are interbedded with the carbonate strata. Here as at M'Clintock Inlet, benthonic fossils of Late Ordovician age are common in the formation (identifications by B.S. Norford). Facies development probably is similar southeast of the head of Disraeli Glacier but has not been studied there. In the entire area around upper Disraeli Fiord, the Zebra Cliffs Formation is overlain by the Lorimer Ridge beds.

A very different facies development is apparent 15 km to the south, in the vicinity of upper Disraeli Glacier where the unit consists of massive dolostone. Here it overlies the Taconite River Formation and is conformably overlain by a tongue of the upper Hazen Formation, in turn succeeded by the

Imina Formation. This facies may represent a reefal belt that fringed the Hazen Trough on the north in Late Ordovician time, but fossil control is lacking. Macrosfossils seem to be absent and analyses for conodonts were unsuccessful.

Upper Ordovician - lower Upper Silurian deeper-water facies

During the interval extending from latest Ordovician to about early Late Silurian time two major, contrasting facies belts are recognized in the M'Clintock Inlet area that locally interfinger: a deeper-water belt in the south and southwest and a shallow marine and possibly nonmarine belt in the north and northeast. The deeper-water facies is related to the Hazen Trough and comprises parts of Hazen, Imina and Lands Lokk Formations.

Hazen Formation

In its type region, on the Hazen Plateau, (Trettin, 1972) the Hazen Formation is a starved-basin deposit that overlies the Grant Formation in the north and the Kane Basin Formation in the south, and underlies the Imnia Formation. The base is highly diachronous, being late Early Cambrian in age at Ella Bay, and probably Early Ordovician east of the head of Tanquary Fiord. The top appears to be mainly Early Silurian in age but may range down into the Late Ordovician (Trettin et al., 1979). It is divisible into a lower carbonate member composed mainly of resedimented carbonate sediments (calcilutite, calcarenite, pebble and granule conglomerate) and mudrock with lesser amounts of chert; and an upper chert member, composed mainly of radiolarian chert with interlaminated mudrock. The boundary between these two members is markedly diachronous.

Two belts of medium dark grey, pelitic calcilutite and calcareous and dolomitic mudrock lying stratigraphically between Zebra Cliffs and Imina formations represent a tongue of the upper Hazen Formation. The first occurs on the west side of M'Clintock Inlet and was originally designated member C of the Zebra Cliffs Formation (see above). It is about 400 m thick and contains graptolites of Late Ordovician age. The second occurs east and west of upper Disraeli Glacier and is lithologically similar to the strata at M'Clintock Inlet. It is less than 100 m thick and has not yielded any fossils.

Dark grey chert and calcareous mudrock east of M'Clintock Glacier also are assigned to the Hazen Formation. The strata are in fault contact with Imina Formation and map-unit qpv.

Imina Formation

The Imina Formation (Christie, 1957; Trettin, 1969a, b, 1972) is a thick succession of compositionally immature sandstone and mudrock with minor amounts of conglomerate that shows flysch-like primary structures. It was deposited by sediment gravity flows of northerly provenance in submarine fan and bottom environments of the Hazen Trough. The full age range of the formations is latest Ordovician or Early Silurian to Early Devonian but on the north coast of Ellesmere Island it seems to be restricted to the Early and possibly Middle Silurian.

In the M'Clintock Inlet area it occurs as a relatively narrow, discontinous, southwesterly trending belt in the ice fields of the British Empire Range and as a small, isolated outcrop on the Zebra Cliffs west of M'Clintock Inlet. There it is about 230 m thick, overlies the Hazen Formation with conformable contact and is unconformably overlain by Pennsylvanian strata. Here, as at several other localities in northern Ellesmere Island, it contains the graptolite Monograptus sp. aff. M. priodon of unspecified late Llandoverian to Wenlockian age.

Lands Lokk Formation

In the type area east of Emma Fiord, the Lands Lokk Formation conformably overlies the Imina Formation and is divisible into three members (Trettin, 1969a). Member A consists mainly of mudrock with minor amounts of tuff and tuffaceous sediments; member B of mudrock, tuff, volcanic flows and lenses of limestone; and member C of mudrock and sandstone with lesser amounts of granule and pebble conglomerate. This unit has flysch-like primary structures, comparable to those in the Imina Formation. Graptolite collections indicate that member A ranges in age from late Llandoverian to early Ludlovian and that members B and C both are early Ludlovian in age. Member C is represented only in the vicinity of Emma Fiord so that farther to the northeast member C directly overlies member A.

In northern Ellesmere Island, the Lands Lokk Formation underlies a narrow, elongate, generally fault-bounded belt that extends from the type area northeastwards to Porter Bay in the Robeson Channel map-area and passes through the southern part of the present map area. In this belt the Lands Lokk Formation commonly lies adjacent ot the Imina Formation, from which it is distinguished by a smaller carbonate content and darker colour. Members A and C have not been distinguished in the M'Clintock Inlet area and detailed partial sections have only been measured in the adjacent Yelverton Inlet and Clements Markham Inlet map-areas.

Upper Ordovician - Upper Silurian shallow marine and nonmarine facies

Lorimer Ridge beds

The informal, provisional name, Lorimer Ridge beds is here given to a predominantly clastic unit of formational rank that overlies the Zebra Cliffs Formation in parts of the M'Clintock and Clements Markham Inlet map-areas.

The contact between Zebra Cliffs Formation and Lorimer Ridge beds is a disconformity (or low-angle unconformity) southeast and south of the head of M'Clintock Inlet; elsewhere it remains to be studied. In most of the area around upper Disraeli Fiord the Lorimer Ridge beds are overlain by map-unit Sc and west of Disraeli Glacier by map-unit Ocg.

A section on Lorimer Ridge, overlain by map-unit Sc is about 770 m thick and consists of predominantly red weathering sandstone and mudrock with small amounts of limestone pebble conglomerate (R. Gardiner, field notes, 1977). The corals Paratetradium sp. and Calapoecia sp. of unspecified Middle to Late Ordovician age (identification by B.S. Norford) were found 732 m and 767 m respectively above the base of the formation. Combined with the stratigraphic position of the unit, these fossils implie a Late Ordovician age. The depositional environment appears to have been mainly shallow marine.

Map-unit Ocg

An as yet poorly known unit of formational rank, composed of conglomerate sandstone and mudrock, that overlies the Lorimer Ridge beds west of the end of Disraeli Glacier and at some localities in the Clement Markham Inlet map-area, is here provisionally referred to as map-unit Ocg. At locality 80T208D strata in the lower (but not lowermost) part consist of thick bedded to massive pebble conglomerate of nonmarine aspect. Airphoto interpretation suggests that the map-unit here is composed of three resistant subunits (conglomerate and sandstone ?) and two recessive, light grey weathering subunits (calcareous mudrock and sandstone ?) with a total thickness of perhaps more than 200 m. If the lower contact is conformable the unit must be latest Ordovician and (?) earliest Silurian age; if it is unconformable it could be Silurian, Devonian, or even Carboniferous in age although the strata are more deformed than Upper Carboniferous beds south of Thores River.

Map-unit Sc

This map-unit comprises carbonate rocks overlying the Lorimer Ridge beds in the vicinity of upper Disraeli Fiord. The contact is structurally conformable but abrupt and may represent a minor disconformity. The top of the unit is not preserved. At section 77MG46 the carbonate succession is about 740 m thick and consists mainly of limestone and dolomitic limestone with lesser amounts of dolostone (R. Gardiner, field notes, 1977). The limestones contain a sparse fauna mainly of crinoids with some brachiopods (pentamerids), ostracodes, corals, stromatoporoids and algae. Conodonts from the lower part are of Early Silurian, late Llandoverian age; poorly preserved conodonts from the upper part are of unspecified Late Silurian (early Ludlovian) to Early Devonian age (identifications by T.T. Uyeno), and corals from the upper part of unspecified Middle Silurian to Devonian age (identification by A.E.H. Pedder). Stratigraphic relationships with the Marvin Formation and map-unit Ocg remain to be clarified.

Map-unit Sp, Marvin Formation, and map-unit Sss

Three major units are exposed on the east side of M'Clintock Inlet, north of Crash Point, a lower and an upper predominantly clastic unit (map-units Sp and Sss) and a middle carbonate unit that includes the type section of the Marvin Formation (Trettin, 1969b).

Map-unit Sp, as yet poorly known, consists of mudrock in the lower part, overlain by interbedded mudrock, sandstone and limestone. Neither diagnostic macrofossils nor conodonts have been recovered from this unit. Its age is presumed to be Middle and/or early Late Silurian (Wenlockian and/or early Ludlovian).

The Marvin Formation is about 180 m thick and consists mainly of limestone with lesser amounts of sandy limestone and sandstone. Both lower and upper contact are interpreted as conformable. The type section has a benthonic fauna of brachiopods, corals, stromatoporoids, trilobites etc. originally assigned an unspecified late Middle to early Late Silurian (late Wenlockian to early Ludlovian) age by B.S. Norford (in Trettin, 1969b). Conodonts from outcrops at Piper Pass, Clements Markham Inlet map-area, are Late Silurian in age and younger than earliest Ludlovian (identification by T.T. Uyeno).

Map-unit Sss is about 83 m thick and consists mainly of sandstone with lesser amounts of limestone and mudrock.

The stratigraphic relationships of these three units with map-unit Sc can only be clarified when more specific biostratigraphic information has been obtained. Two alternative interpretations are possible: either the three units at M'Clintock Inlet all are younger than map-unit Sc or they are partly or wholly correlative with upper parts of the carbonate succession at Disraeli Fiord. If the latter interpretation is true, then the Marvin Formation represents a tongue of map-unit Sc extending into an area of predominantly clastic sedimentation.

Ordovician and (?) Lower Silurian volcanics and associated sedimentary and metasedimentary rocks in southern part of map area (map-units OSvs and OSvt

Map-unit OSvs, composed of volcanic rocks and greenschist-grade metasediments is contiguous with volcanics and associated sediments or metasediments in adjacent parts of the Tanquary Fiord and Otto Fiord map-areas (map-unit OSv of Otto Fiord map-area; see Open File by Trettin and Mayr). The unit, which has not yielded any fossils, probably is mainly Ordovician in age, although it extends into the earliest Silurian (early to middle Llandoverian) in an outcrop belt that straddles the boundary between the Otto Fiord and Yelverton Inlet map-areas (cf. Barnes in Trettin et al., 1979).

It probably belongs to a different facies belt from that represented in the central and northern parts of the M'Clintock Inlet area where sedimentary rocks are more abundant.

Map-unit OSvt, consisting of volcanic rocks, radiolarian (?) chert and carbonate rocks (at least partly of replacement origin), is in fault contact with the Imina Formation and unconformably overlain by Upper Carboniferous strata. It may represent parts of the Oakley River or Bromley assemblages or of the M'Clintock Formation but is separated from these units by expanses of older or younger rocks and ~~from~~ by southwestward-trending faults that may have had transcurrent motion. The unit is designated as of unspecified Ordovician to Lower Silurian age because it lies on strike with map-unit OSvt.

## PHANEROZOIC INTRUSIONS

### Ultramafic to granitic plutons of ophiolitic aspect

#### M'Clintock West massif

The M'Clintock west massif (Frisch, 1974; Trettin, 1969b) consists mainly of serpentinite and variably altered gabbro with minor amounts of wehrlite and small plugs and sheets of granitic rocks including diorite, monzodiorite, trondhjemite and granodiorite. This suite seems to represent middle parts of the standard ophiolite suite with the upper part, comprising the sheeted dyke complex, pillow basalt and chert, missing. The exposed part of the body is up to about 16 km long and 7 km wide. It is in fault contact with Proterozoic (?) schist and carbonates on the south (map-unit s, c), with the Oakley River and Bromley Island assemblages on the west, and with the M'Clintock and Ayles formations on the north. On the east it is unconformably overlain by clastic sediments of Late Carboniferous (Moscovian ?) age, and the absence of ocean floor basalt and chert can perhaps be attributed to

erosion at the sub-Carboniferous nonconformity. A granitic intrusion gave a K/Ar (biotite) age of 390 ± 20 Ma (Trettin, 1969b; corrected value 398 ± 20 Ma, cf. Dalrymple, 1979). A zircon determination on a sample from the same intrusion is in progress.

M'Clintock East massif

The M'Clintock East massif (Frisch, 1974) is composed of clinopyroxenite and lesser proportions of melagabbro and gabbro with sheets of leucocratic diorite and related rocks and local serpentinite and wehrlite. The ultamafic and gabbroic rocks commonly show cumulate texture. Its outcrop area is about 4 km long and 1 km wide. On the south the plutonic rocks are thrust over thinly interstratified siliceous tuff and marble, comparable to the Bromley Island assemblage, in turn thrust over the Taconite River Formation. Fault slices of the volcanic and carbonate rocks also occur within the plutonic complex. On the north it is in fault contact with upper Paleozoic strata. It is tentatively interpreted as a fault slice (or series of fault slices) derived from the cumulate portion of an ophiolite. The M'Clintock East massif probably is correlative with the M'Clintock West massif but differs from it by a considerably smaller content of serpentine.

Thores River complex

The Thores River complex is a stratified body of igenous rocks that forms an about 4.5 km long narrow, elongate outcrop belt, in fault contact with the Zebra Cliffs Formation to the north and upper Paleozoic carbonates to the south (cf. Trettin, 1981; Fig. 15.2). Three sets of samples collected during a brief traverse along its eastern extremity consist of : (1) slightly serpentinized clinopyroxenite (at the top); (2) hornblende-rich diorite with coarse phenocrysts of hornblende (in the middle); and (3) fine-grained,

leucocratic granitic rocks that are sheared, altered and partly metamorphosed in the greenschist facies (at the base). The compositional trend is opposite to that normally seen in layered intrusions, suggesting that the Thores River complex is overturned. It is comparable to the M'Clintock East complex in composition and setting and also interpreted as a thrust sheet derived from the cumulate part of an ophiolite.

### Small ultramafic body of uncertain affinity

An about 1 km long "dyke" of partly serpentinized clinopyroxenite and wehrlite west of Ootah Bay, Marvin Peninsula, occurs in a complex fault zone that involves Cape Discovery, M'Clintock and Taconite River formations. Origin and age of the ultramafic rocks are uncertain.

### Mafic-ultramafic intrusions not of ophiolitic aspect

#### Cape Fanshawe Martin instrusion

A partly layered body of mafic and ultramafic rocks at Cape Fanshawe Martin intrudes metamorphic rocks of probable Proterozoic age (Frisch, 1974). It is about 11 km long and 6 km wide and straddles the boundary between the M'Clintock Inlet and Yelverton Inlet map-areas. The body is divisible into an olivine-rich central zone composed of peridotite and gabbro, and a larger outer zone of gabbro. The inner zone also is characterized by more common igneous layering and cumulate texture, and by a more magnesian composition of the olivine and a more calcic composition of the plagioclase. The steep attitude of many flow layers suggests post-depositional tilting. A K/Ar determination on biotite has given an apparent age of 376 ± 16 Ma (Frisch, op. cit.; corrected value 383 ± 16 Ma).

Mafic and ultramafic intrusions on Bromley Island

On Bromley Island, subhorizontal sheets of partly metamorphosed diabase and gabbro and an associated small body of serpentinite lie between members A or B of the Cape Discovery Formation and the Bromley Island assemblage. It was previously assumed that the intrusions are unconformably overlain by the Cape Discovery Formation (Trettin, 1969b), but re-evaluation of the earlier observations suggests a different interpretation: the sills probably were intruded into the unconformity and into strata below it, and the Cape Discovery Formation has slipped on the unconformity so that now parts of the Cape Discovery Formation are in nearly horizontal fault contact with the intrusions. This interpretation implies that the sills are younger than medial Ordovician.

## Granitic intrusions

### Cape Richards intrusive complex

A syenite-quartz monzonite complex with alkalic affinity at Cape Richards (Frisch, 1974) forms two main outcrop areas. It intrudes pelitic phyllites of Proterozoic or early Paleozoic age and is divisible into an outer zone of quartz monzonite and an inner zone chiefly of hornblende syenite, which becomes progressively more felsic outwards from the centre and contains riebeckite-bearing dykes. K/Ar determination on co-existing hornblende and biotite gave apparent ages of 390 ± 19 and 347 ± 15 Ma respectively (Frisch, op. cit.; corrected values are 398 ± 18 and 354 ± 15 Ma). A zircon determination is in progress.

### Quartz diorite on south-central Marvin Peninsula

An about 3 km long, 1 km wide pluton of quartz diorite on south-central Marvin Peninsula intrudes the Taconite River Formation adjacent to a major fault with the M'Clintock Formation. A large sample gave K/Ar (hornblende)

ages of 94 ± 10 Ma and 92 ± 10 Ma (unpublished determinations by R.D. Stevens et al., 1981). The determinations are tentatively accepted as close to the time of emplacement because of the unmetamorphosed state of the rock and relatively unaltered state of the hornblende.

Minor granitic intrusions

A small plug of granite has intruded the Taconite River Formation east of Disraeli Glacier.

Granitic intrusions too small to be shown on the map include sheets of relatively fresh granodiorite in Proterozoic (?) carbonates north of Ayles Fiord (loc. 77T219E), and a diorite dyke cutting members A and B of the Cape Discovery Formation on the peninsula west of Bromley Island.

## COPPER DEPOSIT

A small replacement deposit of zincian tennantite occurs in dolostone of the Zebra Cliffs Formation in the east-central part of the map-area north of Thores River (Trettin, 1981). The surface area of the deposit is strewn with fragments of dolostone weathered in place that contain scattered crystals or lumps of crystals of the mineral, surrounded by haloes of malachite and minor azurite. The tennantite content of the samples collected varies from trace amounts to an estimated 5-10 per cent by volume. The deposit is close to a major fault zone that also involves the Thores River igneous complex.

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QUATERNARY

Q — unconsolidated sediments obscuring bedrock geology

TERTIARY OR OLDER

Lower Tertiary or older

T — carbonate conglomerate

CRETACEOUS OR OLDER

Upper Cretaceous or older

K gd — quartz diorite

CARBONIFEROUS AND/OR PERMIAN

Upper Carboniferous and/or Permian

uP — undifferentiated upper Paleozoic formations

DEVONIAN AND/OR OLDER

Cape Fanshawe Martin intrusion

D mum — gabbro, peridotite and related rocks

Cape Richards intrusive complex

D gm — quartz monzonite, syenite and related rocks

um o — ultramafic, mafic and granitic rocks of ophiolitic aspect

M'Clintock West massif: serpentinite, gabbro; minor wehrlite, granitic intrusions

M'Clintock East massif: clinopyroxenite, melagabbro, gabbro; minor serpentinite, wehrlite, granitic intrusions

Thores River complex: clinopyroxenite, hornblende-rich diorite, granitic rocks

dqo , do — mappable quartz diorite, diorite and related rocks, associated with ultramafic and mafic rocks of ophiolitic aspect

um — clinopyroxenite, wehrlite of uncertain age and origin (east of Ootah Bay)

s — serpentinite (associated with mafic intrusions of Bromley Island)

m — gabbro, diabase, amphibolite (of different ages)

SILURIAN

Lower to Upper Silurian

Sc — limestone, dolostone

ORDOVICIAN AND/OR YOUNGER

Upper Ordovician and/or younger

Ocg — conglomerate, sandstone, mudrock (overlies Lorimer Ridge beds but not in contact with Sc)

ORDOVICIAN

Upper Ordovician

Lorimer Ridge beds

Oe — compositionally immature sandstone; mudrock; minor limestone, granule and pebble conglomerate

SILURIAN

Middle and/or Upper Silurian

Ss — sandstone; minor limestone, mudrock

Marvin Formation

Sm — limestone; minor sandstone

Sf — mudrock, sandstone; minor limestone

SILURIAN

Lower to Upper Silurian

Lands Lokk Formation

Sl — sandstone, quartzose, cherty, micaceous; mudrock, slaty; minor intraformational conglomerate

Imina Formation

Si — compositionally immature sandstone, calcareous, dolomitic mudrock, slaty; small amounts of granule and pebble conglomerate

ORDOVICIAN

Upper Ordovician

Hazen Formation
(tongue of upper Hazen Form.)

Oh — limestone, mudrock; locally chert

ORDOVICIAN

Upper Ordovician

Zebra Cliffs Formation

Ozc — limestone, dolostone; minor compositionally immature sandstone, granule and pebble conglomerate, mudrock

Ozcd: pure dolostone

Taconite River Formation

Otr — compositionally immature sandstone; mudrock; minor limestone; granule to boulder conglomerate

Otrcg: carbonate conglomerate

Otrres: resistant marker unit

Ayles Formation

Oa — dolostone

upper Middle and Upper Ordovician

M'Clintock Formation

Omc — pyroclastic and volcanic flow rocks, rhyolitic to basaltic in composition; minor volcanogenic sandstone, conglomerate, mudrock; limestone

Omcc: limestone associated with M'Clintock Fm. (may include fault slices of Ocd2 or uO )

uO — sandstone, limestone; minor mudrock

ORDOVICIAN AND (?) SILURIAN

Lower Ordovician or younger to Lower Silurian or older

OSvt — predominantly pyroclastic volcanic rocks, siliceous; radiolarian (?) chert; carbonate rocks (carbonate replacement common)

OSvs — variably metamorphosed volcanic rocks and schist (greenschist facies)

ORDOVICIAN

upper Middle Ordovician

Cape Discovery Formation

Ocd — compositionally immature sandstone, slaty mudrock, limestone, dolostone, granule to boulder conglomerate; minor pyroclastic and volcanic flow rocks

Ocd1: member A -- compositionally immature sandstone, granule to boulder conglomerate; minor slaty mudrock, limestone, dolostone

Ocd2: member B --dolostone, limestone; minor pyroclastic and volcanic flow rocks, including rhyolite, andesite, trachyte

Ocd3: member C --silty limestone, calcareous mudrock

Ocd4: member D --volcanogenic sandstone; minor mudrock, granule to pebble conglomerate, dolostone, limestone, volcanic rocks of siliceous to intermediate composition

ORDOVICIAN AND/OR OLDER

Middle Ordovician and/or older

Bromley Island assemblage

Obr — pyroclastic and volcanic flow rocks, mainly siliceous to intermediate in composition (including dacite); less chert, metamorphosed limestone and dolostone, slaty to phyllitic mudrock

Obrc: mappable carbonate units

southwest of head of Ayles Fiord:
Obr1: sedimentary and volcanic unit
Obr2: cliff-forming volcanic unit

Oakley River assemblage

Oo — calcilutite, variably pelitic, sandy; dolostone, variably calcareous, pelitic, sandy; slate and phyllite, variably calcareous, dolomitic; radiolarian chert; pyroclastic rocks, commonly siliceous

Oov: pyroclastic and volcanic flow rocks, including andesite, dacite, basalt

CAMBRIAN AND/OR ORDOVICIAN

Cambrian and/or Lower Ordovician

Grant Land Formation

Cg — quartzite, variably feldspathic; mudrock, slaty to phyllitic; minor granule and pebble conglomerate

PROTEROZOIC AND/OR LOWER PALEOZOIC

stratigraphic order uncertain except where indicated

Mount Disraeli assemblage

md — variably metamorphosed dolostone, limestone; mudrock, in part sandy, conglomeratic (diamictite) metamorphosed to slate, phyllite or schist; less quartzite; small amounts of volcanic rocks, including andesite

c — variably metamorphosed carbonate rocks, mostly original limestone (recurrent lithology)

c1: Milne Fiord assemblage, unit 1 (stratigraphic unit)

cp — recrystallized limestone, slate

cpss m — carbonate rocks, slate, sandstone, quartzose, cherty; abundant basic sills

cs — marble, schist (greenschist or amphibolite facies); minor amphibolite

p — phyllite, mainly pelitic, also volcanic; minor carbonate rocks (recurrent lithology)

p2: Milne Fiord assemblage, unit 2 (stratigraphic unit)

pc — phyllite, carbonate rocks; minor quartzite

pp — phyllite, pelitic

pr — slate, variably calcareous, reddish, light grey and green

px — phyllite, pelitic, in part sandy, conglomeratic (diamictite); minor carbonate rocks, metachert

qpv — quartzite, slightly feldspathic, variably dolomitic; mudrock, slaty; small amounts of siliceous volcanic rocks

s — schist (greenschist facies)

sc — schist (greenschist or amphibolite facies), marble; minor amphibolite

PROTEROZOIC

$P_n$ — metamorphosed granitic intrusions (gneissic) and pegmatite, and associated amphibolite and greenschist-grade metasedimentary and meta-igneous rocks (schist, amphibolite; minor quartzite, marble

$P_{ng}$: (in southwestern part of map area) relatively massive, resistant; predominantly granitic intrusions

$P_{ns}$: (in southwestern part of map-area) relatively recessive, layered; includes high proportion of biotite-rich metasediments

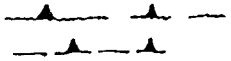
$P_{nsy}$: (Ward Hunt Island) metasyenite

$P_s$ — schist (greenschist grade; intruded by $P_{nsy}$)

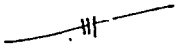
$P_{scn}$ — schist, metamorphosed carbonate rocks; minor gneiss

geological boundary (defined, approximate, assumed or projected through ice or overburden)

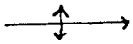
fault (defined, approximate, assumed or project through ice or overburden; solid circle indicates downthrow side, arrows indicate relative motion)



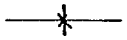
thrust fault (defined, approximate, assumed or projected through ice or overburden; teeth on hanging wall)



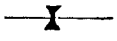
lineament (from air photographs)



anticline (arrow indicates plunge)



syncline

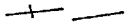


synform

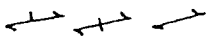
strike and dip of bedding, tops known

strike and dip of bedding, tops unknown;
dip estimate from air photographs:

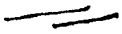
g: gentle (3°-10°)
m: medium (10°-25°)
s: steep (25°-45°)
vs: very steep (45°-89°)



vertical, dip unknown



gneissosity, schistosity (inclined, vertical, dip unknown)



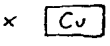
mafic dykes and sills of different ages (in part metamorphosed; from air photographs)



helicopter landing, outcrop observation during foot traverse or sample locality*

fossil locality*

radiometric age determination




copper deposit

Geology by H.P. Trettin 1977, 1979, 1980

(partly based on Trettin, 1969b and Frisch, 1974)

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* relevant locations of 1965-67 field work are shown in Trettin, 1969b, Fig. 15; locations of 1977-80 field work that are too crowded are not shown