

GM 42825

RECONNAISSANCE GEOLOGY OF THE THETFORD MINES OPHIOLITE, HAM SUD, DISRAELI AND THETFORD AREAS

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RECONNAISSANCE
GEOLOGY
OF THE
THETFORD MINES OPHIOLITE
HAM SUD, DISRAELI AND THETFORD AREAS

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
REGIONAL GEOLOGICAL SETTING	1
STRATIGRAPHY	4
Cambrian	4
Unit 1 (Caldwell Group)	4
Unit 2, Amphibolite	6
Cambrian - Lower Ordovician	8
Ophiolite Sequence	8
Unit 3, Serpentinized Harzburgite	8
Unit 4a, Dunite and Wehrlite	9
Unit 4b, Pyroxenite	9
Unit 4c, Gabbro	10
Unit 4d, Differentiated Intrusions	11
Lower Volcanic Sequence	12
Unit 5a, Pillow Basalt and Pillow Breccia	12
Unit 5b (5bx, 5bif, 5bs, 5bxf)	14
Unit 5b	14
Unit 5bx	15
Unit 5bif	15
Unit 5bs	15
Unit 5bxf	16
Upper Volcanic Sequence	16
Unit 6a	16
Unit 6b	17
Unit 6bt	18
Unit 6c	18
Unit 6d	18
Unit 6dg	19
Lower Ordovician	19
Saint Daniel Formation (Units 7a, 7b, 7bx)	19
STRUCTURAL GEOLOGY	20
ECONOMIC GEOLOGY	21
RECOMMENDATIONS	22
REFERENCES	23

LIST OF FIGURES

		Page
FIGURE 1	The Baie Vert-Brompton Line and Major Rock Units of the Quebec Eastern Townships (after Williams and St. Julien, 1982)	2
FIGURE 2	Relationships between rock groups and structures at the Baie Vert-Brompton Line, Thetford Mines, Quebec (after Williams and St. Julien, 1982)	3
FIGURE 3	Geological compilation by Y. Hebert, 1979 (after Seguin, 1983).	5
FIGURE 4	Geologic Map of the Belmina Ridge area, Quebec (after Feninger, 1981)	7

**LIST OF MAPS
(bound in rear of report)**

		Scale
MAP 1	Ham-South-Geology	1:20,000
MAP 2	Disraeli-Geology	1:20,000
MAP 3	Thetford Mines-Geology	1:20,000

INTRODUCTION

Reconnaissance mapping was conducted from June to August, 1985 on the Thetford Mines Ophiolite to provide a working scale geological map for the Eastern Townships property as none are currently available from the mines branch. Mapping and prospecting were concentrated in areas known to be underlain by volcanic rocks in order to establish the stratigraphic sequence and evaluate the exploration potential for volcanic-hosted stratiform base metal sulfides. The results are presented on three sheets (Ham Sud, Disraeli, Thetford) at a scale of 1:20,000.

Previous geological mapping in the region was conducted largely by Cooke (1937), Riordon (1954) and Y. Hebert (1974, 1983). Working scale maps for the Ham Sud sheet were produced by R. Hebert (1979) and Beullac (1982) and were found to be of good quality. Areas not extensively mapped by BCL are reproduced from their work. A geological compilation of the Thetford Mines area was produced by Y. Hebert (1979) at a scale of 1:50,000 from the work of the aforementioned authors and also includes work by P. St. Julien, R. LaMarche, C. DeRosier, R. Laurent and M. Blackburn. Lithological subdivisions for the Disraeli and Thetford sheets are duplicated from this compilation in areas not covered by the reconnaissance mapping.

REGIONAL GEOLOGICAL SETTING (Figures 1 and 2)

Discussions of the geology and tectonics of the Thetford Mines Ophiolite and adjacent areas in southern Quebec abound in the published literature and the salient features have been summarized by Williams and St. Julien (1982).

The Baie Verte-Brompton Line (St. Julien and Hubert, 1975) describes the narrow zone of ophiolitic complexes which occur along the western margin of the Appalachian Orogen from Southern Quebec to Newfoundland. The Thetford Mines

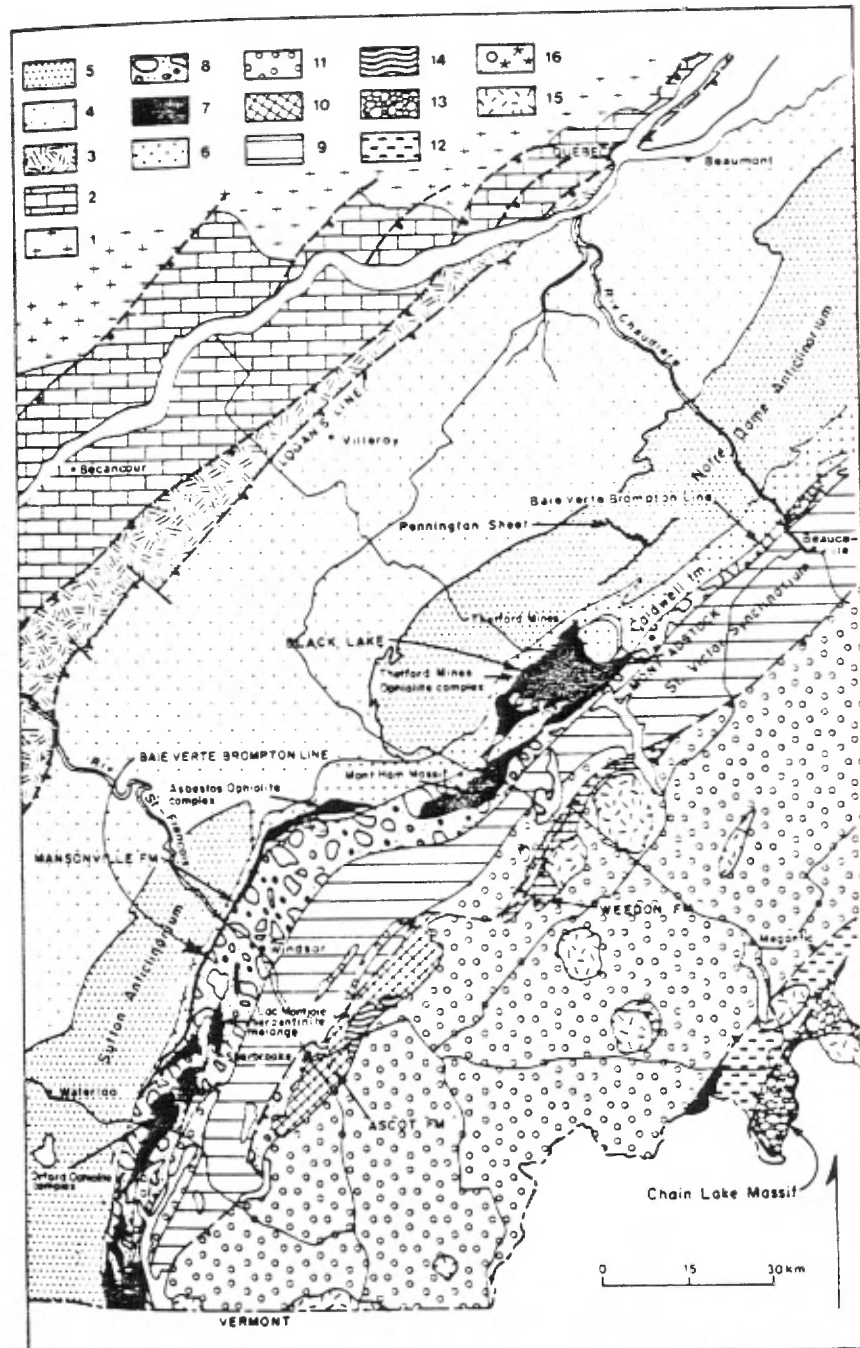


Figure 1. The Baie Verte-Brompton Line and major rock units of the Quebec Eastern Townships: 1) Grenville basement (Pe); 2) St. Lawrence platform ($\epsilon-0$); 3) Foreland thrust belt (0); 4) Allochthonous of the external domain ($\epsilon-0$); 5) Allochthonous of the internal domain (mainly Sutton-Bennett schists) ($\epsilon-0$); 6) Caldwell Gr. and Mansonville Fm. (ϵ); 7) ophiolites (ϵ); 8) St. Daniel and Brompton Fms. (Mélange) (L.0); 9) St. Victor synclinorium (Magog Gr.) (M.0); 10) Ascot-Weedon Fms (L.0-M.0); 11) Connecticut Valley-Gaspé synclinorium (S-D); 12) Frontenac Fm. (0?); 13) Chain Lakes Massif (Helikian); 14) Ordovician granites; 15) Devonian granites; 16) Mesozoic alkaline intrusive rocks.

(after Williams and St. Julien, 1982)

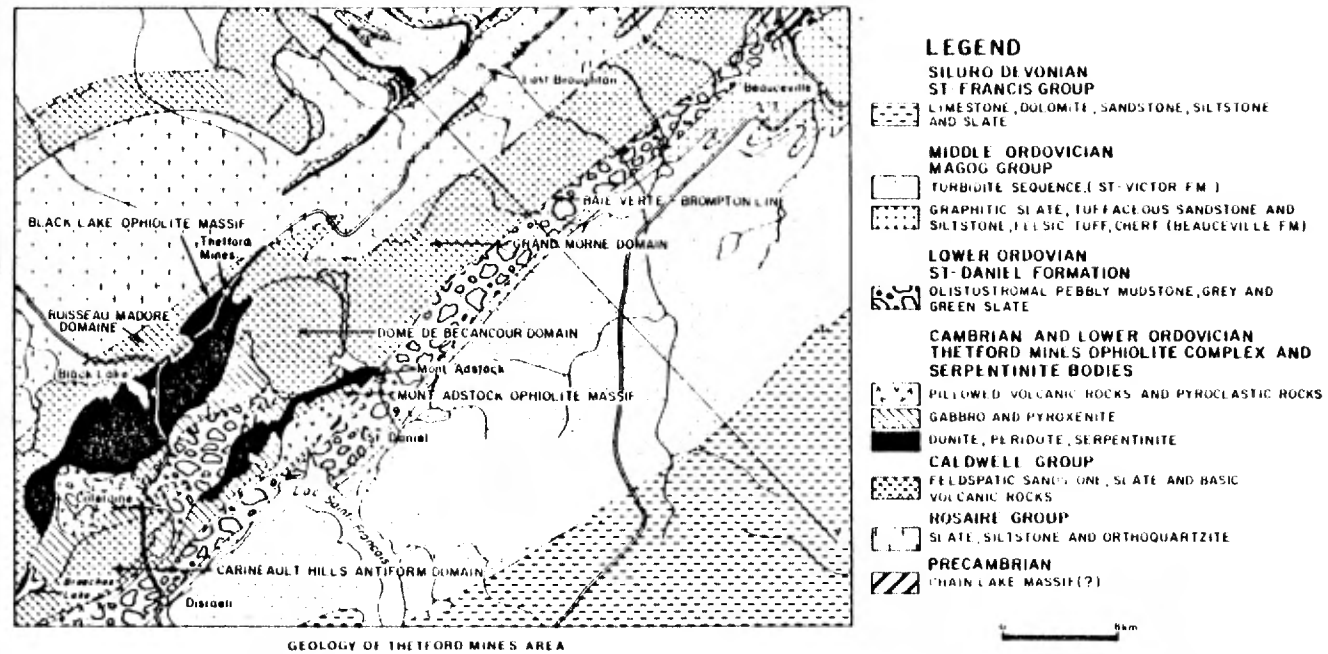


Figure . Relationships between rock groups and structures at the Baie Verte-Brompton Line, Thetford Mines, Quebec.

(after Williams and St. Julien, 1982)

Ophiolite Complex is part of the Baie Verte-Brompton Line and comprises the Black Lake, Mont Adstock and Mont Ham Massifs (Figures 1 and 2). Polydeformed and metamorphosed quartzites and phyllites of the Cambrian Caldwell Group lie to the northwest of the ophiolite complex and pass into the Cambro-Ordovician higher grade equivalent, the Sutton-Bennett Schists (Allochtons of the Internal Domain) and thence into Cambro-Ordovician Allochtons of the External Domain separated by Logans Line¹ from the Ordovician Foreland thrust belt and the Cambro-Ordovician St. Lawrence platform which overlie Precambrian Grenville basement.

The Ophiolite Complex is bound to the southeast by Lower Ordovician olistostromes of the St. Daniel Formation which are succeeded by a Middle Ordovician turbidite sequence (Magog Group) occupying the St. Victor Synclinorium. The Siluro-Devonian Connecticut Valley-Gaspe Synclinorium lies to the southeast of the Magog Group and is in fault contact with the Weedon Formation of Lower to Middle Ordovician age which is thrust northwest over the Siluro-Devonian rocks.

STRATIGRAPHY

The stratigraphic succession is generally similar in all of the massifs of the Thetford Mines Ophiolite and the generalized geology is shown in Figure 3.

Cambrian

Unit 1 (Caldwell Group)

These rocks occupy four structural domains (Williams and St. Julien, 1982); the Becancour Dome, Grand Morne, Madore Brook and Carineault Hills (Figure 3). The rocks consist of polydeformed and metamorphosed psammitic to pelitic schists metamorphosed to upper greenschist facies which are interpreted to be part of a clastic wedge that was deposited on a rifted Grenvillian basement. Intercalated mafic volcanics

¹ Logans Line marks the western limit of the Taconian allochtons and is approximately the western limit of Taconian and Acadian deformation.

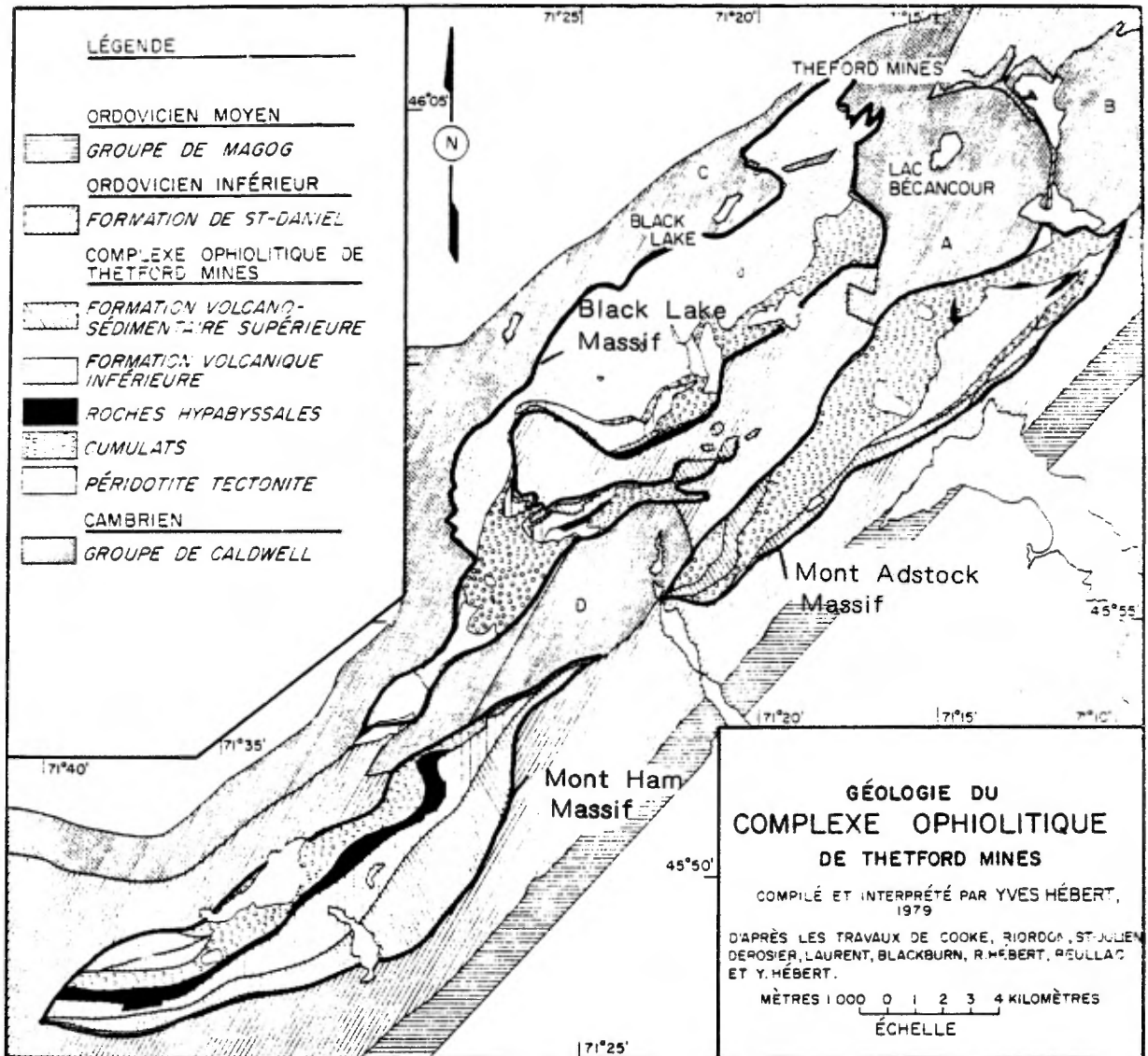


FIG. 1. Carte géologique simplifiée de la région étudiée et ses environs (compilation de Y. Hébert, 1979) avec la permission de l'auteur. Les principales unités structurales dans le groupe de Caldwell sont: (A) lac Bécancour, (B) Grand Morne, (C) ruisseau Madore et (D) collines Carineault.

(after Seguin, 1983)

occur within the Caldwell Group and west of the Baie Verte-Brompton Line locally contain sodic amphiboles, magnesium riebeckite and crossite, suggesting a blueschist facies metamorphism presumably related to ophiolite emplacement (Laurent, 1977). The Becancour Dome and the Carineault Hills antiform are surrounded by normal faults marked by zones of tectonic breccia and appear to have been emplaced as horsts uplifted from beneath the ophiolite complex late in the tectonic history of the area (Post-Saint Daniel Formation).

Unit 2, Amphibolite

This unit is distinguished as a narrow, discontinuous layer of amphibolite at the tectonic contact between Caldwell Group feldspathic sandstones and harzburgite of the Black Lake Ophiolite Massif. It has been suggested by Feninger (1981) that this amphibolite was derived from ocean floor basalt which was attached to the sole of the ophiolite at the decollement and transported to its present position. Our observations along the section exposed along Highway 263 as directed by R. LaMarche suggests that the amphibolite (at least at this locality) has more probably been produced by metasomatism of the Caldwell Group metasediments adjacent to the base of the thrust, apparently involving substantial mass transfer of magnesium and iron. The rock is noted by Feninger (1981) to contain "varying proportions of only four major minerals: amphibole, garnet, epidote and quartz". Relict bedding is locally discernable however, and the metasomatic effects decrease gradationally away from the thrust. It should be noted from Figure 4 that the type section espoused by Feninger is north of the section examined by us and that Feninger's amphibolite is not apparently represented on Highway 263. It is possible that LaMarche's amphibolite is not the same as that of Feninger.

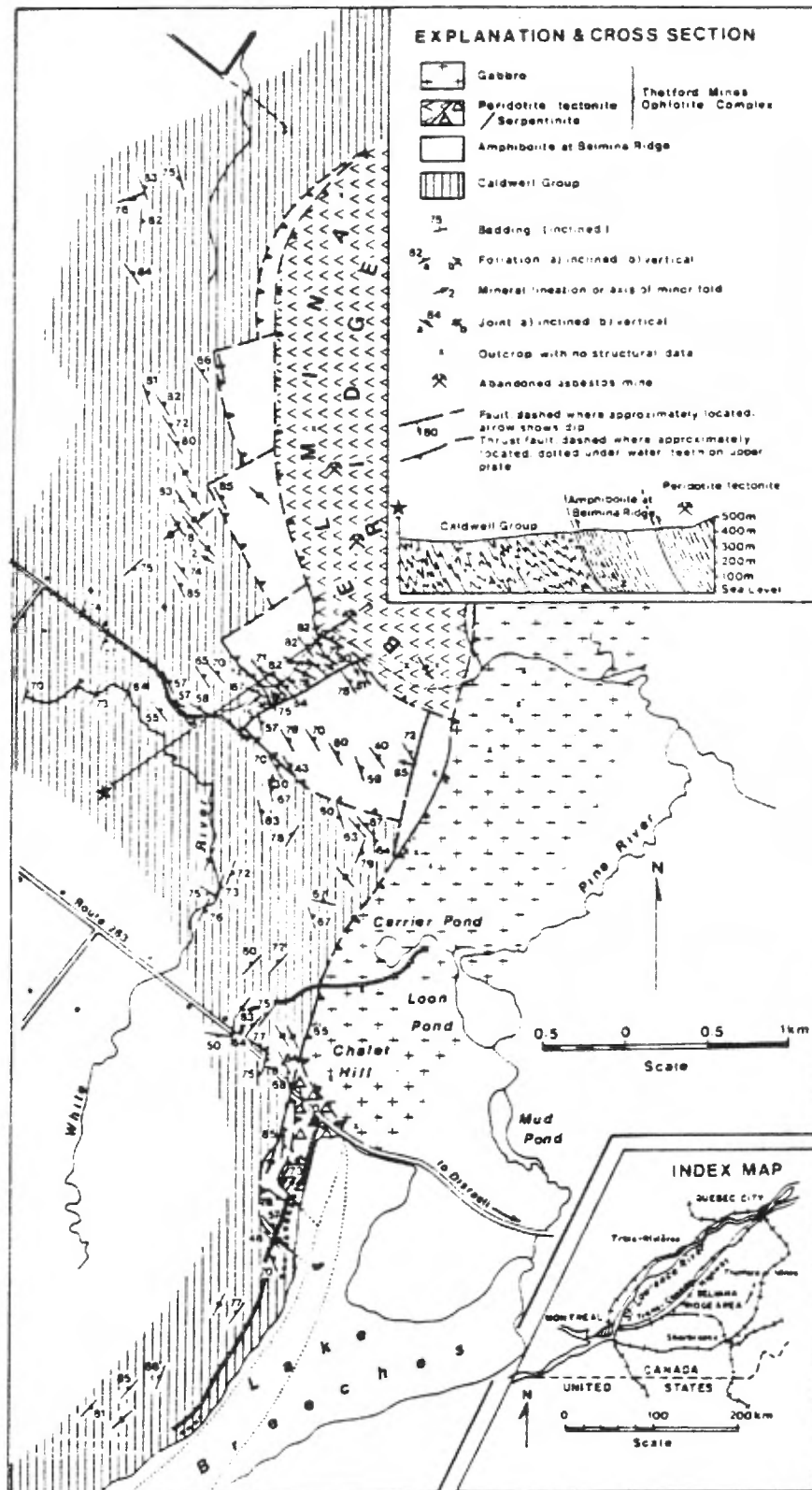


FIG. 4. Geologic map of the Belmina Ridge area, Quebec.
(after Feninger, 1981)

Cambrian - Lower Ordovician

Ophiolite Sequence

The Black Lake Ophiolite Massif extends 25 kilometers in a northeasterly direction from Breeches Lake, southwest of Coleraine, to Thetford Mines. The Mont Adstock Ophiolite Massif extends twenty kilometers in a northeasterly direction from Disraeli to Mont Adstock and the Mont Ham Massif can be traced in a northeasterly direction for 25 kilometers from Mont Ham (Figure 3).

The lithological succession in the ophiolites consists of a basal cumulate sequence comprising dunite, pyroxenite and gabbro which in the Black Lake Massif overlies a serpentized harzburgite (peridotite tectonite) which is host to the asbestos deposits of the Thetford Mines area. The top of the gabbroic unit is often occupied by erratically distributed trondhjemite bodies. A sheeted dyke swarm of variable thickness overlies the gabbroic rocks and passes into a sequence of pillowed basalts (Lower Sequence). The top of these pillowed basalts appears to be marked locally by one of pillow breccia, red argillite and chert, oxide iron formation, subaerial oxidation, or local felsic volcanics. These lithological markers appear to be discontinuous horizons of limited stratigraphic extent, but are usually succeeded by pillowed mafic volcanics of more andesitic appearance which generally contain smaller pillows (more viscous flows?) and contain greater proportions of pillow breccia and related fragmentals (Upper Volcanic Sequence). The Upper Volcanic Sequence is also characterized by local siliceous volcaniclastic, pyroclastic and volcanic units which are commonly associated with red and green argillites and cherts. Extensive multiple horizons of grey-black graphitic slate and siltstone occur in the top of the Upper Volcanic Sequence in the Mont Ham Massif and appear to underlie the Lac Coulombe Mineralized Zone.

Unit 3, Serpentinized Harzburgite

This unit extends along the west side of the Black Lake Ophiolite from Belmina Ridge to Thetford Mines and contains all of the asbestos deposits in the area. It is

essentially homogeneous and consists of serpentized harzburgite (olivine, orthopyroxene, chromium spinel) which is often layered, containing variable proportions of orthopyroxene across layers (Riordon, 1954) and is up to 5,000 meters thick (Laurent, 1975).

Unit 4a, Dunite and Wehrlite

These rocks form the base of the cumulate sequence and occur in all three massifs. They are greenish black and typically massive olivine cumulates which are variably serpentized. Pyroxene occurs locally (wehrlite), generally at the dunite-pyroxenite contacts.

In the Mont Ham Massif, these rocks occur around Lac Nicolet in a fault bound thrust slice adjacent to slates of the Saint Daniels Formation to the northwest and gabbros to the southeast. Two narrow fault slivers occur west of Petit lac a la Truite.

In the Black Lake Massif, these rocks occur southwest of Breeches Lake, south of East Lake and northeast of Coleraine. The latter two sections of cumulate appear to be more or less complete and pass into the pyroxenite unit without the typically severe structural complications noted elsewhere.

Extensive dunite occurs along the base of the Mont Adstock Massif and is in most areas succeeded by the pyroxenite. Structural complications are most severe along the southeast margin and fault slices of dunite along this contact do not appear to have profound stratigraphic implications, particularly in the Mont Adstock area and at Disraeli.

Unit 4b, Pyroxenite

These rocks sit stratigraphically above the dunite-wehrlite unit and consist of coarsely crystalline clinopyroxene with subsidiary amounts of olivine. They are rusty weathering, medium to dark green and massive. Only a narrow fault sliver occurs in the Mont Ham Massif west of Petit lac a la Truite, the remainder apparently structurally removed from the Lac Nicolet section.

Relatively continuous sections of pyroxenite occur at the expected stratigraphic position in the Black Lake Massif and the Mont Adstock Massif.

Unit 4c, Gabbro

The gabbro unit lies stratigraphically above the pyroxenites in the cumulate sequence and consists largely of coarse clinopyroxene and plagioclase. This unit is continuous along the length of the Mont Ham Massif and is in fault contact with various rock types along its northwestern contact. The southeast contact passes into a finer grained and locally glassy, dark greenish black hypabyssal rock (diabase) which can be observed southeast of Lac Nicolet to possess "dyke-in-dyke" morphology (Unit 4cds). These rocks are therefore distinguished as "sheeted dyke complex" and mark the uppermost extent of the cumulate sequence.

In the Black Lake Massif, gabbro is most extensively preserved northeast of Breeches Lake (Map 2). Here it occupies the core of the broad, steep northeast facing synclinorium bound to the northwest by the major thrust fault at the base of the massif. Some dunite and pyroxenite is preserved in a narrow, continuous apparently conformable band along its southeast margin. This gabbro is overlain by a narrow, poorly exposed and apparently poorly developed sheeted dyke complex in the axial zone of the synclinorium which passes into a variety of overlying volcanic and sedimentary lithotypes in the East Lake area which are described in some detail by Hebert (1983).

A section of gabbros is also preserved north of the Grid 15 area (Map 2) which is apparently southward facing and passes into the Lower Volcanic Sequence without the usual accompanying sheeted dyke complex. This area was not extensively examined and these relationships cannot be confirmed. Airphoto interpretation suggests that the area is poorly exposed.

A narrow (50 to 100 meter thick) band of gabbro strikes northeast across the Lac Noir-Lac Caribou area (Maps 2 and 3) in contact with pyroxenite to the northwest and in fault contact with the Saint Daniel Formation slates to the southeast. It would

appear that a decollement in this section developed within or at the upper contact of the gabbro unit.

Numerous short and discontinuous sections of gabbro occur within the Adstock Massif, many within thrust slices preempting stratigraphic interpretation. The most continuous section extends for about six kilometers through the Lac Bisby - Grid 17-M area (Map 2). Both contacts of this unit appear stratiform, and there is no evidence of a sheeted dyke complex at its upper contact with mafic volcanics. Only a narrow section of mafic volcanics is preserved, however and these are adjacent to, and probably in fault contact with slates of the Saint Daniel Formation.

Sections of gabbro with preserved sheeted dyke complex are relatively well preserved near Lac Rond and on the golf club access road near Mont Adstock (Map 3). The latter appears to be stratigraphically intact but is terminated by multiple thrust faults to the southeast. Several small localized sections of gabbro can be recognized in exposures around the golf course but tectonic contacts can easily be envisioned for all.

Unit 4d, Differentiated Intrusions

A variety of differentiated intrusions occur generally at the top of the cumulate sequence and have previously been mapped as one of: quartz diorite, trondjemite, plagiogranite, or simply as ultramafic. Many of these have been remapped and have proven to be trondjemite (subequal amounts of quartz and oligoclase feldspar with minor clinopyroxene). Detailed mapping on the Lac au Canard Grid (Map 1) has outlined two stocks of trondjemite which occur at a high level in the volcanic sequence proving that these are not restricted to the cumulate series. The most extensive body of trondjemite occurs in the Adstock Massif north of Disraeli (Map 2). Only one of these contacts appears to be intact, and that is against gabbro to the west. All other contacts appear to be tectonic.

Poddy quartz-rich differentiates (tonolite) occur on the south slope of Mont Adstock within the gabbro unit (Map 3) and trondhjemitic differentiates have been mapped on Grid 17-M. Buff-colored ultramafic dykes have been mapped on Grid 17-J and have proven to be olivine-rich rocks.

Lower Volcanic Sequence

A Lower Volcanic Sequence is distinguished in all of the massifs consisting of pillowed basalts with local pillow breccia, overlain by and intercalated with localized felsic volcanics and pyroclastics, rare volcanoclastic sediments, red argillite and chert and in one locality - iron formation.

Unit 5a, Pillow Basalt and Pillow Breccia

The volcanic sequence in the Mont Ham Massif is exposed in two belts - the Petit lac a la Truite thrust, and the massif proper. The former is about four kilometers long, up to one kilometer wide and is bound by arcuate thrust faults at both its northern and southern contacts which give this belt a lozenge-shape. Extremely sheared slices of cumulate rocks can be found in either fault zone. No way-up indications were found within these volcanics and in the absence of adjacent stratigraphically significant indicators, no tops for this belt can be determined. A thick section of red cherts and argillites occurs in the center of the belt and includes some felsic pyroclastic rocks.

The massif proper contains a well preserved volcanic assemblage along its entire strike length. Pillow basalts of the Lower Volcanic Sequence are mapped from the southwest extremity of the massif to the Lac Coulombe area - a strike length of 16 kilometers and vary from about 0.5 to 1.5 kilometers in thickness. Top determinations from pillow morphology are often possible in well exposed areas and have generally been found to be reliable. The lower contact of this unit passes into the sheeted dyke complex and gabbro along its entire length with no structural dismemberment. The upper contact is fault-bound against the Saint Daniel Formation in the southwest

and is overlain by rocks of the Upper Volcanic Sequence to the northeast. The position of the contact between the Lower Volcanic Sequence and the Upper Volcanic Sequence appears to be gradational from dark greenish black basalt to light green andesite and from generally large, well-formed pillows to generally small poorly formed pillows. As none of the 1984-1985 grids covered the lower volcanics or this contact, these relationships have not been examined in detail and the contact is only approximately known. In the Lac au Canard-Lac Coulombe area broad gossanous zones or heavily oxidized hematite-rich basalt horizons are taken as markers of this transition. These would seem to indicate a periodic subaerial weathering prior to the onset of renewed volcanism, this having a notably more felsic component.

Sections of pillow basalt are locally preserved in the Black Lake Massif (Map 2). The best preserved of these is in the East Lake area where Hebert (1983) has recognized a transition from basalt of the lower sequence directly into basalt of the Upper Sequence and thence into felsic derivatives and red chert and sediments. In the Grid 15 area the lower basalt passes directly into a peculiar mixed mafic-felsic agglomerate and drilling on this grid has shown that it is overlain without tectonic disruption by the adjacent Saint Daniel slatey olistostrome. As the East Lake section and the Grid 15 section have been interpreted to be on opposite sides of the synclorium and are therefore stratigraphically continuous, it would therefore seem apparent that rapid facies transitions are the rule rather than the exception and the type section so heavily promoted for the Thetford Ophiolites from the East Lake area cannot be used for the assignment of lithotypes elsewhere.

In the Mont Adstock Massif a narrow (up to 400 meters) section of Lower Volcanics is exposed in the Bisby Lake area (Map 2) which is overlying gabbro and is in fault contact with the Saint Daniel Formation graphitic olistostrome to the southeast. The volcanics are faulted out south of Petit Lac Saint Francois but reappears east of the Ashberham River and broaden to the northeast (Maps 2 and 3). This

section is well exposed along roads and streams in the northeastern part of the Mont Adstock Massif and varies up to about two kilometers in thickness across strike. The extreme tectonic dismemberment in this area precludes an estimate of true thickness. Facing directions of pillows measured from the main road north of the Gosselin Quarry outline broad folds near the faulted northwest contact of this section. Stratigraphic sense is only observable south of Mont Adstock where a section of gabbro-sheeted dyke complex-basalt can be mapped. Several dismembered sections of basalt also occur in the fault complex east of Mont Adstock at the massif boundary.

Unit 5b (5bx, 5bif, 5bs, 5bxf)

This rock unit includes a variety of lithotypes intercalated with the pillowed basalts mapped as part of the Lower Volcanic Sequence. These occur generally in the upper parts of the volcanic unit 5a and may in some areas mark the transition to the Upper Volcanic Sequence.

Unit 5b

Unit 5b consists of red hematitic argillite and chert with local intercalated felsic volcanics or pyroclastics. A thick section of these mixed lithologies occurs in the Petit Lac a la Truite volcanic section of the Mont Ham Massif (Map 1). As these volcanics will be gridded and subjected to detailed mapping in 1986, it may be possible to further subdivide these rock types. In the absence of stratigraphic control on the position of this unit it may be part of either the Lower or Upper Volcanic Sequence.

In the Black Lake Massif a reconnaissance of the East Lake area did not indicate any red argillite and chert distinctly associated with other than "upper" sequence basalts mapped by Hebert (1983).

In the Mont Adstock Massif a narrow section of cherty hematitic slate is exposed along the main road east of Petit Lac Saint Francois (Map 2). This slate appears to be relatively high in the succession and may mark the top of the Lower Volcanic Sequence in this area. The slate is bound to the southeast by a major tectonic break and several

slices of dunite-pyroxenite can be mapped in the fault zone adjacent to slaty rocks of the Saint Daniel Formation.

Unit 5bx

Unit 5bx is distinguished in the Lower Volcanic Sequence as distinct mappable units of pillow breccia. A long continuous section was mapped by Hebert (1977) in the southwest part of the Mont Ham Massif but has not been substantiated by our reconnaissance. As Hebert's work was much more detailed than our own, this unit is retained as mapped by Hebert.

Extensive agglomerate and pillow breccia occurs in the northeast part of the Mont Adstock Massif (Map 3). As these are fault slices in an extremely dismembered part of the massif no stratigraphic significance can be assigned and it is suspected that these may be tectonic breccias rather than agglomerates or pillow breccias.

Unit 5bif

Unit 5bif consists of layered hematitic oxide iron formation which outcrops near the main road one kilometer south of Petit Lac a la Truite in the Mont Ham Massif (Map 1). It appears to have a strike length of about 500 meters and where exposed is about one to two meters in thickness. A breccia exposed at the southwestern extent of its strike-length includes fragments of both the iron formation and heavily oxidized hematitic pillow fragments (pillow breccia) suggesting a period of subaerial weathering.

Unit 5bs

Unit 5bs occurs only on Grid 17-M (Map 2). Green volcanoclastic sandstone and siltstone are recognized over a small area near the southeast boundary of the Mont Adstock Massif. Contact relationships are not exposed but the unit is probably in fault contact with pyroxenite to the north and is overlain by a felsic agglomerate to the south. No stratigraphic position can be assigned with confidence but as the sandstones and siltstones are associated with Unit 5bxf, they are presumed to lie near the top of the Lower Volcanic Sequence or perhaps are an erosional feature at the unconformity with the nearby Saint Daniel Formation.

Unit 5bxf

Unit 5bxf comprises a felsic fragmental rock (agglomerate and/or tuff-breccia) which occurs in the Black Lake Massif on Grid 15 and in the Grid 17-M area of the Mont Adstock Massif (Map 2). It consists of a mixed mafic-felsic fragmental at the former locality and is extremely hyaline containing both dark greenish black basaltic glasses and buff-colored rhyolitic fragments. These contain locally well developed spherulitic devitrification spots. In the Grid 17-M locality the unit is dominantly felsic and hyaline but also contains a basaltic component. It is exposed in several sections which, if continuous, indicate a strike length of about four kilometers and appears to be only 100 to 200 meters thick at most. The northeasternmost exposure appears to lie within Unit 5a (Lower Volcanics) and stratigraphically below Unit 5b.

Upper Volcanic Sequence

An Upper Volcanic Sequence is distinguished in all of the massifs and is distinguished by pillowed basalt and andesite with relatively abundant pillow breccia and intercalated felsic pyroclastic and volcanoclastic rocks. Red and green argillites and cherts and black graphitic slates form mappable units. In the Mont Ham Massif, several of these intercalated rock units can be traced semi-continuously along strike and are significant stratigraphic markers. Reports on the detailed mapping of the Lac au Canard and Lac Coulombe grids describe the geology of the Upper Volcanic Sequence in the Mont Ham Massif in detail.

Unit 6a

Unit 6a comprises pillowed basalt and andesite which is most extensively developed in the Mont Ham Massif over a strike length of about 13 kilometers and is about 2.5 kilometers thick at its broadest section. The lower contact of the rock unit is gradual into pillowed basalts of the Lower Sequence and the upper boundary is faulted against olistostromic slates of the Saint Daniel Formation. Stratigraphically higher parts of this unit are often more andesitic and fragmental than sections near the base

and may indicate progressive differentiation of a parental magma with time.

In the Black Lake Massif, the "upper sequence basalts" are only recognized in the East Lake area (Hebert, 1983) where they appear to overlie "lower sequence" basalts and are in turn overlain by felsic volcanics and sediments. Several large inliers of volcanics also occur in the Saint Daniel Formation olistostrome in the Coleraine area (Map 2).

In the Mont Adstock Massif this unit is mapped only in the Disraeli-Grid 21-A area. It is dominantly andesitic agglomerate in exposure along the highway and mixed volcanic-agglomerate on Grid 21-A. All contacts of this unit are faulted and its stratigraphic position is therefore unknown.

Unit 6b

Unit 6b consists of andesitic agglomerate and pillow breccia which is a common associate of Unit 6a. Unit status is conferred in those areas where it is most extensively developed and forms a mappable body. These occur in the East Lake section of the Black Lake Massif and in an inlier in the Saint Daniel Formation at Coleraine (Coleraine Breccia). The Coleraine Breccia consists of fragments of a variety of rock types from both ophiolitic rocks and gneissic basement rocks. These clasts are of various shapes and sizes and have a matrix of mudstone. The rock is more probably related to the olistostromic sediments of the Saint Daniel Formation (Unit 7bx) than the Upper Volcanic Sequence, but has been mapped by previous workers as part of the volcanic stratigraphy and as such, will be retained in that position.

Agglomerate and pillow breccia are also present in the Mont Adstock Massif at Disraeli and in the Mont Ham Massif locally throughout the Lac au Canard-Lac Coulombe area (see detailed geological reports for those areas). These rocks have no particular stratigraphic significance.

Unit 6bt

Unit 6bt comprises basaltic tuff and hyaloclastite which has only been recognized in the Mont Ham Massif. These have been recognized mostly in drill core from the Lac au Canard-Lac Coulombe areas and represent quenched hyaline mafic volcanics in close spatial association with graphitic slate bands (Unit 6dg) interbedded with Unit 6a throughout this area.

Unit 6c

Unit 6c comprises felsic pyroclastic and volcanoclastic tuffs which in the Mont Ham Massif have been recognized in the Lac au Canard and Lac Coulombe areas and seem to occur discontinuously across this area stratigraphically above the graphitic slates (Unit 6dg). In the Lac Coulombe area these are associated with stratiform massive sulfide mineralization and are described in the 1985 drill report for that area. In the Lac au Canard area the felsic unit comprises bedded coarse felsic pyroclastics in the same approximate stratigraphic position as the Lac Coulombe felsics and in addition seem to partly underlie and are partly intercalated with red argillite and cherts of Unit 6d. Unit 6d cherts would appear to be the stratigraphic equivalent to those which host the sulfide mineralization at Lac Coulombe. Felsic rocks have also been recognized at the southwesternmost extremity of Unit 6a but are severely deformed adjacent to slates of the Saint Daniel Formation and their exact stratigraphic position is uncertain.

In the East Lake section of the Black Lake Massif, the felsic rocks appear to be mixed with agglomeratic rocks of Unit 6b and overlie the mafic volcanic succession. They have also apparently been recognized in inliers near Coleraine by previous workers.

Unit 6d

Unit 6d comprises red and green argillite, siltstone and chert which outcrops in the Lac au Canard area of the Mont Ham Massif. The narrow section on the west side of the lake occurs stratigraphically below the graphitic units and may belong to

part of the Lower Volcanic Sequence. Detailed mapping is necessary in this area to determine this association.

Red argillite, siltstone and chert form the top of the succession in the East Lake area of the Black Lake Massif.

Unit 6dg

Unit 6dg comprises the olistostromic black graphitic slate bands which occur only in the Mont Ham Massif. These only outcrop in several areas but are easily located by their strong conductive response and have been drilled in several areas confirming them as frequent bedrock conductors. These slate bands do not appear to host any sulfide mineralization but do make good stratigraphic markers. These are a typical lithotype which comprises the Saint Daniel Formation and presumably represent similar depositional environments, partially developed within the upper part of the volcanic pile.

Lower Ordovician

Saint Daniel Formation (Units 7a, 7b, 7bx)

Where examined this unit consists generally of olistostromic black slate and siltstone which is locally graphitic and often calcareous. Soft sediment deformation is common and clasts of authogenous siltstone are generally present. Exogenous clasts are not uncommon and a section of sedimentary breccia/conglomerate (Unit 7bx) occurs adjacent to the Mont Adstock Massif (Map 2). Most areas extensively underlain by this formation were excluded from regional mapping due to the generally low outcrop frequency and lack of economic significance. A Unit 7a is distinguished along the southern margin of the Mont Ham Massif by the relatively common occurrence of greywacke and quartzwacke beds in this area. The regional significance of this formation is discussed in Doolan et, al (1982).

STRUCTURAL GEOLOGY

Volcanic rocks throughout the ophiolite massifs contain a single generally poorly developed subvertical cleavage of Taconic Age. Intercalated slates in the Mont Ham Massif and slates of the surrounding Saint Daniel Formation carry a single subvertical cleavage of similar vintage but is usually well developed and bedding is usually transposed parallel to cleavage. In the absence of original S-surfaces in volcanic and cumulate plutonic rocks no mesoscopic indications of folding are observable. An exception are the broad folds interpreted for the pillowed volcanics near the Gosselin Quarry in the Mont Adstock Massif from facing directions of pillows.

A synclinorium is outlined by the distribution of rock units in the Black Lake Massif west of Coleraine. This appears to be an early recumbent fold associated with the obduction of the ophiolite. It is cored by olistostromic black slate of the Saint Daniel Formation which contain numerous large rafts of country rock. It would seem that these and the "Coleraine Breccia" are both products of gravity slides and are characteristic of unstable slopes probably generated by emplacement of the ophiolite.

A later generation of folds is apparent in the East Lake area west of Coleraine and mesoscopic folds with axial planar cleavage have been observed in Unit 6d north of the lake suggesting that these are of Taconic Age and post-date emplacement of the ophiolite.

Faulting is the most common structural feature in these rocks. Thrust faults associated with the emplacement of the ophiolite are assumed to be those which truncate stratigraphy at a small angle to strike and often form the boundary between adjacent rock units which are not stratigraphically continuous. The attitude of all major faults examined in the field is subvertical and this criteria can therefore not be used to discriminate between early low angle thrust faults associated with obduction and later generations of faults associated with Taconic deformation. It is apparent that early low angle thrust faults have been transposed by this deformation.

In the Petit Lac a la Truite fault slice of the Mont Ham Massif slivers of dunite, pyroxenite and gabbro have been found in the boundary faults and are extremely sheared and altered. These lithologies are also commonly encountered in the fault zones at the eastern boundary of the Mont Adstock Massif. The preservation of these particular lithologies in such environments suggests that slip surfaces preferentially form in them, probably because they are most easily deformed. Shearing deformation accompanies all of the major thrust faults.

Faults which cross strike at a large angle appear to be much less common, do not significantly disrupt stratigraphic continuity, and where observed, are accompanied by only minor deformation. In the Mont Ham Massif there appears to be little structural dismemberment by cross faults as graphitic slate bands can be traced relatively continuously across the area.

ECONOMIC GEOLOGY

The only significant base metal mineralization in the ophiolites appears at present to be the Lac Coulombe sulfide zone which has been drill tested and is described in other company reports. Of lesser significance is the Gosselin Quarry showing in the Mont Adstock Massif (Map 3). It comprises a broad area of pillow basalt and pillow breccia which is locally silicified and carbonated with local minor pyrite, pyrrhotite and chalcopyrite.

A small showing of pyrite with local traces of chalcopyrite was located east of Petit Lac Saint Francois but soil sampling in the area did not yield any anomalous results. Two other gossanous areas occur in the Lac au Canard area of the Mont Ham Massif (Map 1). Drilling near one located east of the lake showed negative results. One located west of the lake will be further examined on the extended grids in 1986 but appears to be related to a shear zone in basalts of the Lower Sequence.

RECOMMENDATIONS

The area with the greatest potential is the Lac Coulombe-Lac au Canard portion of the Mont Ham Massif where extensive portions of the volcanic sequences have been preserved. A large area along strike from the Lac Coulombe mineralized zone will be thoroughly explored for continuations of this zone. The Petit Lac a la Truite thrust will also be subjected to gridding and detailed groundwork. As the 1984 grid areas have been drill tested without favourable results, it is recommended that the exploration permits for these areas be allowed to lapse.

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