

## GEOLOGY OF THE NORTH BROOK ANTICLINE, HARRYS RIVER MAP AREA (NTS 12B/09)

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### ABSTRACT

*The North Brook Anticline is host to lower Paleozoic shelf-carbonate and clastic rocks. It is fault bounded by a number of slate terranes. The succession in the anticline is comparable with that preserved in other neighbouring structures to the west and east. Precambrian crystalline basement that is unconformably overlain by basal formations of the Labrador Group is exposed in the southwest. The upper part of the Labrador Group, which occupies much of the core of the anticline to the northeast, preserves the depositional transition from dominantly massive quartz arenites of the Hawke Bay Formation in the west to thin-bedded, fine-grained sandstones, siltstones, shales and minor limestones of the Penguin Cove Formation in the centre and east of the structure.*

*The Middle to Late Cambrian Port au Port Group is a mixed succession of thick units, dominated by ribbon limestone alternating with equally thick intervals of peritidal carbonate including oolitic, intraclastic and skeletal grainstone, bioturbated and stromatolitic limestone and dolostone, thick-bedded dolostone and dololaminite and minor shale and chert. Again, the succession appears to be similar to the nearby Phillips Brook structure and reflects a more outboard shelf setting on the ancient margin.*

*Lower to Middle Ordovician carbonate rocks are divided between the St. George and Table Head groups. The succession of the St. George Group compares closely to its counterparts elsewhere in western Newfoundland. However, limestones of the Table Point Formation, Table Head Group, are dominated by rock types and fabrics that suggest a more distal shelf setting.*

*Limestone conglomerate (Daniels Harbour Member) associated closely with ribbon limestone (Table Cove Formation) and black shales (Black Cove Formation) outcrop in a number of small structural culminations in the slate terrane to the north of the carbonate terrane. One limestone conglomerate contains pebbles of mafic volcanic rock. Other lithostratigraphic units identified in this same terrane include allochthonous carbonate rocks of the Weasel group as well as broken formation of the Green Point Formation, Cow Head Group. East of the anticline, a separate slate terrane is dominated by broken formation of the Goose Tickle Group but also includes rocks of the Weasel group, and the Summerside and Irishtown formations.*

*The carbonate rocks in the anticline are host to a number of vein-hosted base-metal showings. Sphalerite–calcite–quartz veins cut sucrosic dolostones that replace oolitic carbonate rocks of the Middle Cambrian March Point Formation. Sphalerite–galena–pyrite–calcite veins cut the limestones of the Table Point Formation. The pink to red, purple and white-mottled limestone of the Devils Cove Member, Forteau Formation, near the base of the Labrador Group is a potential dimension-stone target in the southwest of the anticline.*

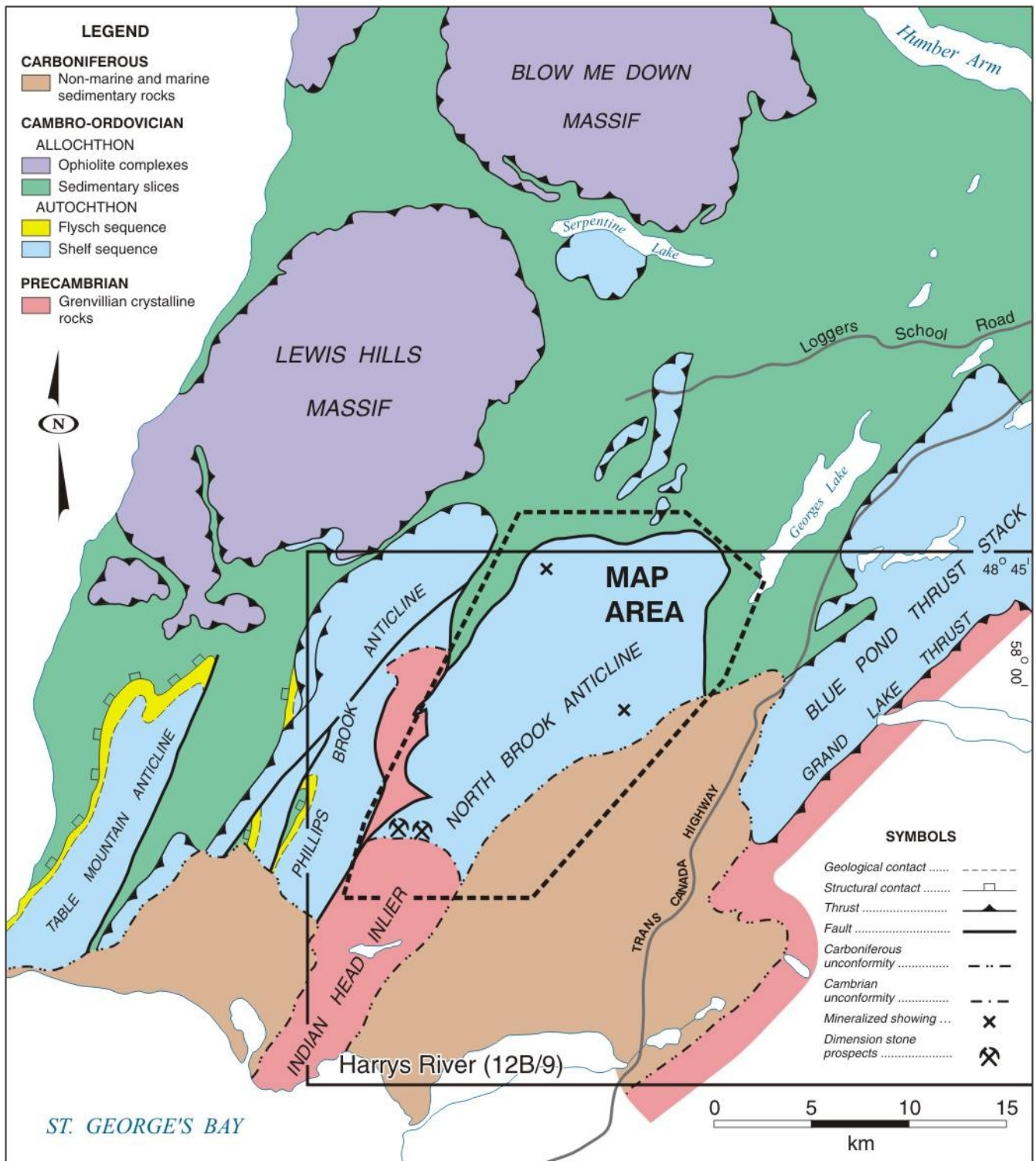
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### INTRODUCTION

The North Brook Anticline is the largest of three north-east-trending structures that deform lower Paleozoic shelf rocks of the outer domain of the tectonostratigraphic Humber Zone between Stephenville and Corner Brook, western Newfoundland (Figure 1). The structure is outlined on earlier maps of Walthier (1949), Williams (1985) and Williams and Cawood (1989). It was called the Robairs Brook anti-

cline by Walthier (1949) but renamed by Williams (1985). The present mapping is part of ongoing mapping of the shelf rocks in this general area (Knight, 1997; Knight and Boyce, 2000, 2002).

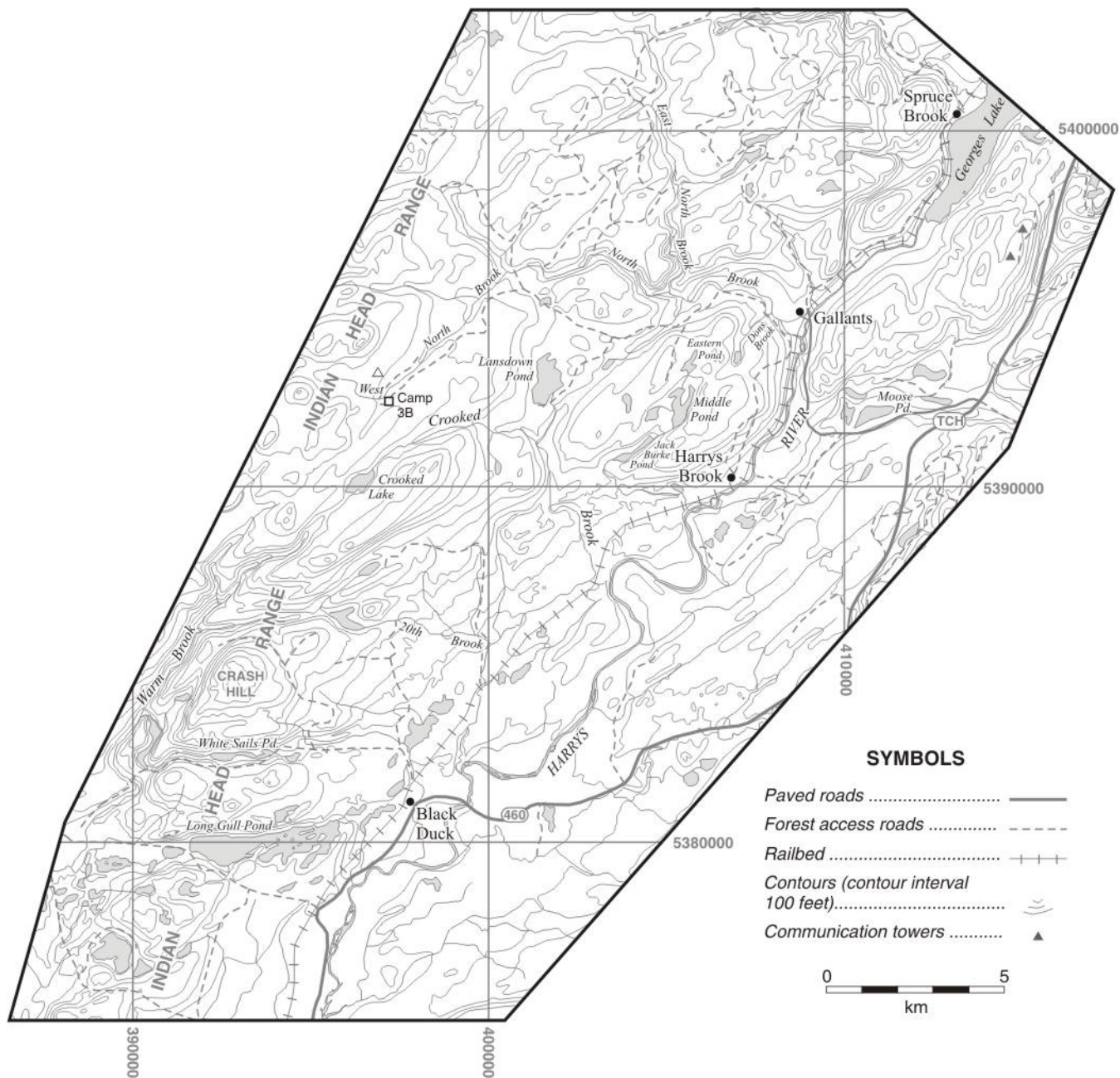
The map area is characterized by a broad, dissected plateau comprising steep ridges and rolling hills. Streams and rivers are deeply incised and valleys host many ponds. Foliage cover in the area divides between 40-year forest



**Figure 1.** Simplified geological map of the main geological terranes of the Harry's River map area showing the North Brook Anticline in its regional setting and the approximate location of the area (see Figures 2 and 3) described in this report (map modified after Williams and Cawood, 1989).

growth and large areas of bog, the latter often matched to underlying upper Cambrian dolostones. Bogs also surround the northern margin of the anticline where they lie domi-

nantly above a broad terrane of slates; patches of forest in these bogs are commonly underlain by carbonate. Access to the area is possible by ATV along a less than abundant sys-



**Figure 2.** Topographic map of study area showing places mentioned in the text.

tem of old woods-roads from the old rail bed that runs along the north bank of Harrys River (Figure 2). Locally, in the west and in the north, more recent road systems allow access by truck from Black Duck and Loggers School road respectively. Most of the old bridges that cross over brooks in the back country have rotted and collapsed.

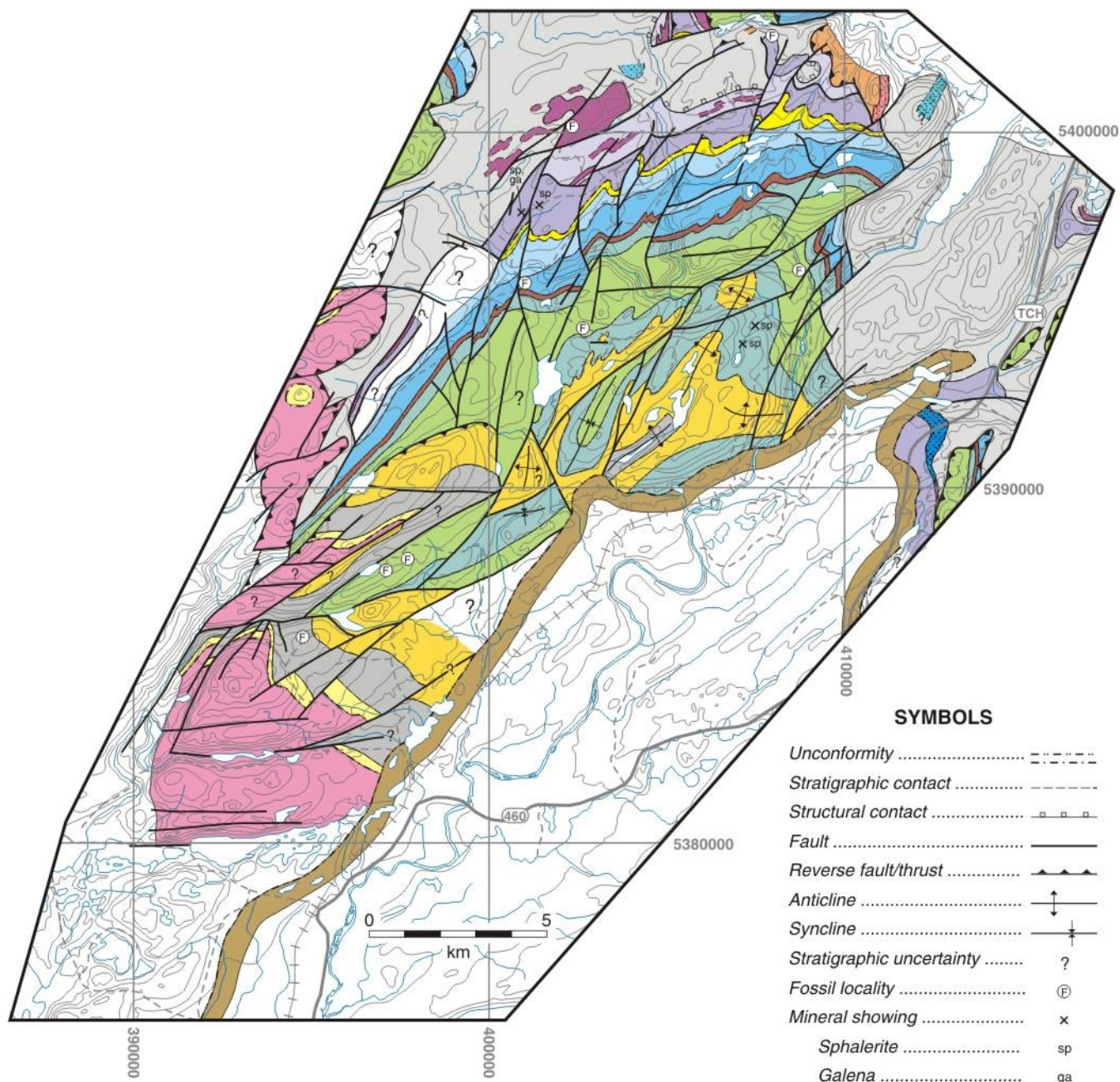
The present mapping is at best patchy and there are still large areas unmapped. This precludes an exhaustive and definitive treatment of the geology of this structure in this article. Nonetheless, information from previous maps is

integrated into the present survey program. Trends, lineaments, fold closures and potential faults are defined and extended beyond the field mapping by stereoscopic examination of aerial photography.

### GEOLOGICAL SETTING

The North Brook Anticline is a complexly folded and faulted structure that hosts lower Paleozoic shelf rocks (Figure 3). It predominantly trends and plunges northeast. It is fault bounded in the west and north against a terrane of Pale-























**Figure 3.** Simplified preliminary geological map of the North Brook Anticline. The map is based on incomplete ground control augmented by data from Williams (1985) and airphoto interpretation.

ozoic slates and Precambrian basement rocks. Similarly, it is fault bounded in the east mostly against probable parautochthonous broken formation of the Taconian foreland basin as well as some slate of probable allochthonous origin. In the southwest, the structure is cored by Precambrian crystalline rocks of the Indian Head Range that are unconformably overlain by the base of the cover sequence. Although the stratigraphy in the structure generally youngs northward and eastward, the structural simplicity is broken by populations of both northeast- and east-trending faults.

The southeastern edge of the structure is marked by a topographic descent into the valley of Harrys River, a lowland plain of bogs and glacial and outwash gravels. This termination is generally believed to correspond to the margin of the Carboniferous Bay St. George Subbasin (Knight, 1983; Williams and Cawood, 1989) although no Carboniferous strata are recognized in the map area unconformably resting upon the lower Paleozoic or Precambrian rocks. The nearest Carboniferous sediment, which outcrop 8 km into the basin on Route 460, are essentially flat-lying and belong

## LEGEND

	Quaternary gravels and peats overlying Pennsylvanian sedimentary rocks
	Undivided slate terranes including mostly broken Goose Tickle Group and elements of mélangé, Green Point Formation, Irishtown Formation, and Weasel Group
	Weasel Group?
<b>HUMBER ARM ALLOCHTHON</b>	
	Irishtown Formation
	Summerside Formation
<b>AUTOCHTHON</b>	
<b>GOOSE TICKLE GROUP</b>	
	American Tickle Formation
	Daniels Harbour Member plus or minus Table Cove and Black Cove formations
<b>TABLE HEAD GROUP</b>	
	Table Cove Formation
	Table Point Formation
<b>ST. GEORGE GROUP</b>	
	Aguathuna Formation
	Catoche Formation
	Boat Harbour Formation
	Watts Bight Formation
<b>PORT AU PORT GROUP</b>	
	Berry Head Formation
	Petit Jardin Formation
	March Point Formation
<b>LABRADOR GROUP</b>	
	Hawke Bay/Penguin Cove Formation
	Forteau Formation
	Bradore Formation
<b>GRENVIILLIAN BASEMENT</b>	
	Granite and gneiss

to the Pennsylvanian Barachois Group. Pleistocene gravels and sands overlain by thick peats fill the regional depression excavated by erosion of the relatively soft Carboniferous strata. Some spectacular eskers occur from Harrys Brook to Black Duck.

## STRATIGRAPHY OF THE NORTH BROOK ANTI-CLINE AND ADJOINING TERRANES

## Grenvillian Crystalline Rocks

Granitic rocks of the Indian Head Range outcrop in a series of horsts in the southwest of the area. At Crash Hill, the basement appears to be mostly a foliated to mylonitic megacrystic pink granite. At this locality, the granite is characterized by a strong banding to foliation containing augened pink feldspar crystals. The banding generally trends west and dips at moderate angles to the north but it is also locally folded. The augen give a northwest sense of vergence that appears to correspond to a stretching lineation, trending  $325^\circ$ , carried on the folia. The granite is sausseritized and chloritized, and epidote is common along joints and fractures. It is cut by white quartz veins.

## Paleozoic Shelf Rocks

The Grenvillian basement is unconformably overlain by clastic rocks of the Labrador Group. The basement beneath the sediments locally displays a green (reduction) colouration. There is no definite evidence that this is paleo-weathering beneath the unconformity as similar reduction of red Labrador Group rocks occurs close to faults that are common in this area.

The anticline hosts the four rock groups mapped throughout the shelf sequence of western Newfoundland (Figure 4). A mix of coarse-grained to fine-grained clastic and lesser carbonate rocks characterize the Early to Middle Cambrian Labrador Group below the overlying Middle Cambrian to Middle Ordovician carbonate shelf sequence of the Port au Port, St. George and Table Head groups. Younger foreland basin siliciclastic and minor carbonate rocks of the Goose Tickle Group are mapped generally in the bounding terranes outside the anticline.

*Labrador Group*

Formations of the Labrador Group underlie substantial parts of the southern part of the anticline between North Brook and Harrys River. The oldest rocks belonging to the Bradore and Forteau formations underlie the north slopes of Crash Hill where the Devils Cove Member limestone, at the base of the Forteau Formation, is also well exposed. These two formations, which were called the Kippens Formation by Williams (1985), are postulated to underlie narrow ridges southwest of Crooked Lake. The Forteau Formation may also be hidden in the deep valleys near Jack Burke Pond and Middle Pond.

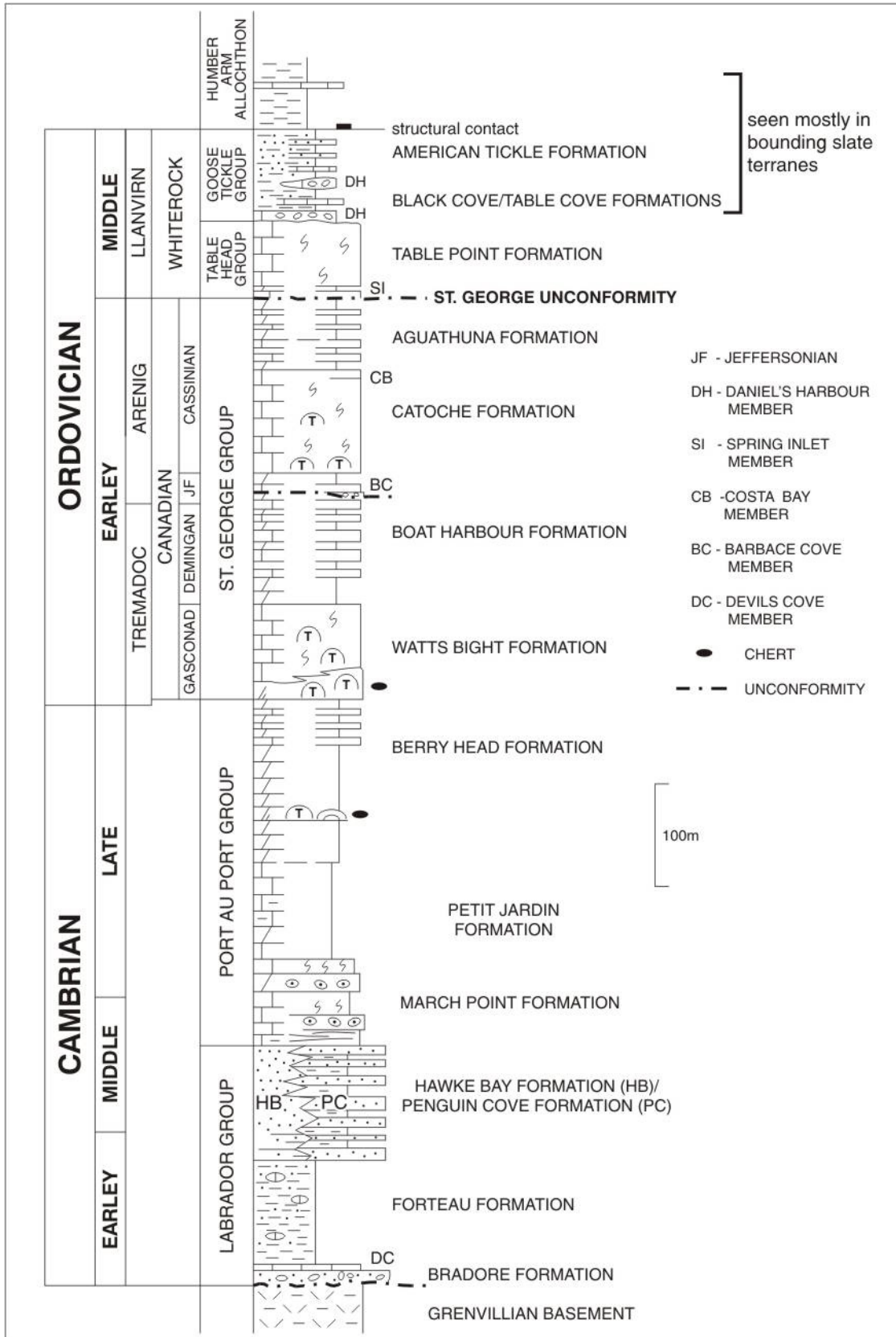


Figure 4. Stratigraphy of the Cambro-Ordovician shelf rocks of the North Brook Anticline.



The upper stratigraphy of the Labrador Group in the anticline consists of rocks of both the Hawke Bay and the Penguin Cove formations. They were mapped as the De Gras Formation by Williams (1985). Massive quartz arenites that dominate the Hawke Bay Formation in much of the rest of western Newfoundland only underlie a prominent ridge, south and east of Crooked Lake, and a domal hill just west of Crooked Brook (Walthier, 1949; Williams, 1985; and air-photo interpretation). Rocks of the Penguin Cove Formation, which are equivalent to the Hawke Bay Formation, form the top of the group in the Landowns Pond (called Langdon Pond by Walthier, 1949) and Eastern Pond areas. The formation also outcrops along the trail south of North Brook and occurs in one outcrop along Harrys River. This suggests that the facies transition between these two formations occurs within the anticline. The Hawke Bay Formation is found westward into the Phillips Brook Anticline (Knight and Boyce, 2001) and onto the Port au Port Peninsula (I. Knight, unpublished data) whereas the Penguin Cove Formation has been mapped to the east in the Blue Pond Thrust Stack (Knight, 1997) and far to the northeast in the Goose Arm Thrust Stack (Knight and Boyce, 1991; Knight, 1994).

#### *Bradore Formation*

The Bradore Formation, in the Crash Hill area, is a sequence, about 20 to 30 m thick, of coarse- to fine-grained, red, pink, purple, white and green arkosic sandstones and lesser quartz arenite. The sandstones are locally granular and pebbly and are generally well cemented and indurated.

Arkose rocks, which are coarse grained to granular and commonly trough crossbedded, dominate the lower part of the formation. A basal conglomerate locally rests on the unconformity and the crossbedded arkoses locally enclose small pebble conglomerate lenses. Pebbles are strictly confined to white and red quartz, pink K-feldspar and some granite.

In the upper 10 m, however, the succession is more variable, and includes fine- to medium-grained sandstones including quartz arenites as well as coarse-grained sandstones. The sandstones display trough and some convex-upward crossbeds, well-rounded coarse-grained sandstones, apparent reversal of crossbed directions, and sandstone beds of planar stratified, grain-size-sorted layers. Rare bioturbation resembling *Monocrateria* was noted at one outcrop. Beds, 2 to 25 cm thick, of poorly sorted, small-pebble conglomerate occur at the top of the formation where they are intercalated with crossbedded and laminated, coarse-grained arkose containing fine-grained, heavy-mineral laminations. The purple sandstones are magnetic and, just below the top of the formation, the sandstone and conglomerate enclose concretions of kidney haematite suggesting that the colour is

mostly diagenetic in origin. White calcite cement invades the conglomerate immediately below the upper contact of the formation.

The Bradore Formation in the Crash Hill area compares closely to the same unit along the east side of the Phillips Brook Anticline, 10 km to the north (Knight and Boyce, 2000), although it appears to be at least twice as thick. The basal arkoses are probably braided stream in origin, when compared to the upper part, which contains features that support a marginal marine depositional setting, implying the initiation of marine transgression of the Bradore floodplain.

#### *Forteau Formation*

The Forteau Formation in the Crash Hill area comprises three distinct intervals, a basal limestone, the Devils Cove Member, a middle shale interval and an upper interval of intercalated shale, siltstone, sandstone and limestone. The formation is of unknown thickness.

The Devils Cove Member rests apparently conformably upon the Bradore Formation, locally infiltrating into the matrix pore space of the underlying capping conglomerate. The limestone is a distinctive member, approximately 15 to 25 m thick, of argillaceous, nodular-bedded limestone and grainstone ranging in colour from grey to purple to red and white. Nodular, argillaceous, fine-grained limestone containing dark-grey to green shale partings and thin beds and lenses of coarse-grained, recrystallized grainstone characterize the lower half of the section. White to pink and red grainstone, again containing argillaceous partings and lesser intercalations of fine-grained limestone, dominates the upper half of the formation. Fossil fragments are still discernible in the recrystallized grainy facies and include trilobites (especially *Wanneria* with its net-like ornamentation), the mollusc *Salterella*, unidentified articulate brachiopods and possible small cup-shaped archeocyathids.

The middle shale member is dominated by cleaved, silvery-grey to dark-grey shales (locally phyllite), silty shales having some limestone nodules, and rare beds of nodular, grey, fine-grained to grainy limestone. The limestone nodules are rich in comminuted fossil fragments and also host pyrite nodules. The nodular limestone beds consist of burrowed, skeletal wackestone–packstone containing abundant *Salterella* and other thin shelled fossils as well as nodular pyrite. Cleavage faces indicate that the shales are generally thinly planar stratified, although some units, tens of centimetres thick, are intraformational pebbly mudstone of deformed centimetre-size shale clasts and ripups set in a slurry-like matrix. Dark-grey, mud-filled, curved burrows are common in some shales. Quartz–carbonate veins cut the shale locally.

The shale member rapidly gives way upward into the upper member of grey shales interbedded with bioturbated, thin- to thick-bedded, white- to rusty-weathering, siltstone and very fine sandstone, and some black limestone. The succession ranges through a number of facies associations and small-scale parasequences. Shales attaining a metre or so in thickness are intercalated with metre-thick intervals of thin-bedded, sharp-based, laminated to crosslaminated siltstones, 5 to 20 cm thick, or thick-bedded (2 m) massive siltstone. Load casts, convolution and complete bed disintegration are common. Burrows range from mudlined to sand-and-mud-lined tubes, including *Rosselia*–*Asterosoma*, *Teichichnites*, *Paleophycus*, *Chondrites*, and other burrows. Skeletal wackestone–packstone–grainstone limestone lenses and concretions are common in the siltstone facies, as are also laminae of *Salterella* molds after the dissolution of the shell.

Upward, parasequences of shale to thin-bedded siltstones are capped by thick units of well-bedded, very fine sandstone and by some limestone. The thick sandstones are dominated by 15- to 25-cm-thick beds of lamination and crosslamination. The tops of most beds are intensely burrowed. Burrows include *Skolithus*, *Arenicolites*, *Rhizocorallium*, and *Rosselia* as well as others. Long, straight to slightly sinuous ripple marks are seen on blocks in this part of the section. Skeletal hash layers also occur within and at the top of some beds. Like the hash layers elsewhere in the formation, the shell debris is reduced to open intraskeletal porosity.

Limestones that cap parasequences include bioturbated and stylonodular, shaly and dolomitic, fine-grained limestone and oolitic grainstone. The finer limestones that are 1 to 2 m thick, are generally burrowed, skeletal mudstones and wackestones. Units of oolitic grainstone reach 5 m in thickness; they are stylobedded, and consist of very coarse-grained concentric ooids and fine-grained ooids. Imbricated limestone intraclasts in the grainstone suggest crossbedding and the finer grainstones display crosslamination. Trilobites occur in the tops of the grainstones.

Fossils collected in both siliciclastics and limestones are dominated by *Olenellus thompsoni*, *Salterella*, inarticulate brachiopods and unidentified hyolithids.

The succession described from the Crash Hill area indicates that the sedimentary facies package of the Forteau Formation was formed by marine flooding of the Lower Cambrian Laurentian margin. Transgression of the Bradore coastal plain isolated clastic input which allowed the deposition of the fossil-rich grainy to muddy limestone in the clean shallow sea. Shale partings probably reflect episodic, climatic-driven fluvial input of mud onto the shelf.

Maximum flooding of the margin drowned the carbonates and lead to widespread deposition of deeper water shelf muds. The upward coarsening of the succession, with its renewed input of clastic silts and sands associated with a good marine fauna and elements of the *Cruziana* and *Skolithus* ichnofaunas, implies the repeated progradation of nearshore clastic environments across the muddy shelf. Limestones deposited in low-energy, subtidal to high-energy, oolitic shoal settings developed whenever the clastic input was suppressed by flooding of the margin, cutoff behind in-basin barrier complexes, redirected in the basin, or reduced by climatic variations.

#### *Hawke Bay–Penguin Cove Formations*

The Hawke Bay Formation has yet to be examined in the western areas cited above. However, it is likely that it will comprise a two-part division of lower thin-bedded sandstone and shale overlain by an upper sequence of thick-bedded to massive-bedded quartz arenite, similar to the formation in the Phillips Brook Anticline (Knight and Boyce, 2000).

The Penguin Cove Formation mapped in the eastern half of the North Brook Anticline is principally thin bedded. It is characterized by yellow-, brown- to rusty-weathering, fine-grained, flaggy, grey sandstone to siltstone, thin-bedded white quartz arenite, thin beds of grey shale, thick units of purplish grey mudstone and metre-thick beds of white-, pink- to pale-yellow-weathering quartz arenite. Exposures are mostly small, patchy and unexceptional. However, some outcrops near Eastern Pond suggest that the succession consists of coarsening-upward sequences of shale–mudstone, thin-bedded sandstone and shale, and thick beds of quartz arenite. Cleaved, grey shale–mudstone beds, tens of centimetres thick, are distinguished by colour variations, thin partings of sandstone and siltstone, and some crosscutting, narrow, compacted, sandstone dykes. The latter also cut the thin-bedded sandstone–shale facies. This facies consists of metre-thick packages of thin-bedded, grey quartz sandstone, quartz arenite and siltstone intercalated with shale partings and thin beds. Although the flaggy sands may appear structureless, many beds show lamination and crosslamination. The tops of some flagstones display small, straight ripple marks and common bioturbation such as bedding-parallel tubes (*Planolites?*) and less commonly *Skolithus*, *Teichichnites* and *Arenicolites*. The grain-size rarely exceeds fine grained. A single outcrop on Harrys River, includes slumped, bedded shales and calcareous siltstones truncated by a scour-based siltstone displaying swaley internal bedding. The thick quartz arenite facies consists of white quartz arenites, which are trough crossbedded, or pink quartz arenites, which are typified by thin stratification marked by shale



partings and extensive burrowing. The arenites, which range from fine to medium grained, may have hummocky sharp tops.

No fauna has been recovered in the area from either the Hawke Bay or Penguin Cove formations.

The characteristics of the Hawke Bay–Penguin Cove formations suggest that the succession preserves a shifting collage of low-energy offshore shelf to high-energy foreshore settings formed as shorelines, repeatedly prograded. The map area appears to preserve a relatively rapid paleogeographic transition from the nearshore sand complexes of the Hawke Bay Formation in the west, to the more outboard shelf to foreshore settings of the Penguin Cove Formation in the east.

### *Port au Port Group*

The Port au Port Group comprises three units, the March Point, Petit Jardin and Berry Head formations. They are shown undivided on the map of Williams (1985). The March Point and Petit Jardin formations include a substantial percentage of dolomitic ribbon limestone, a facies linked to the Reluctant Head Formation of the Goose Arm and Blue Pond thrust stacks (Knight and Boyce, 1991; Knight, 1994, 1997). The ribbon facies appears to predominate in the hills that lie east of Harrys River near Moose Pond. Here, it has been assigned to the March Point Formation. However, no fossils have been recovered from this ribbon-dominated eastern section and there remains doubt that it is truly part of this formation, rather than the younger Petit Jardin Formation. Furthermore, until more mapping is completed in this area there is also a possibility that the facies might correlate with the Pinchgut Formation that structurally overlies the shelf carbonates and underlies the Humber Arm Allochthon proper (Knight, 1997) or even the Table Cove Formation, Table Head Group.

### *March Point Formation*

In the central part of the anticline, the March Point Formation consists of a succession of oolitic grainstone, bioturbated dolomitic limestone and dolomitic ribbon limestone. Dark-brown-weathering, dark-grey to grey, finely crystalline dolostone replaces substantial parts of the formation in this area. The top of the succession, as exposed along the banks of Harrys River, is illustrated in the crudely measured section of Figure 5.

Mapping suggests that the lower part of the formation is dominated by bioturbated dolomitic limestone, ribbon limestone and nodular dolomitic limestone. *Skolithus* and *Planolites* dominate the burrowed sections. Oolitic grainstones are intercalated with the other rock types in the upper half of the

formation, where they are dolomitized in sections along Dons Brook and near Lansdown Pond. The grainstones are trough and planar crossbedded and have common herringbone structure. Straight to branching to truncated symmetrical ripple marks are also present. Crossbeds give bipolar southeast and northwest paleoflow in the Harrys River section. Oncolites are common in the grainstones at Lansdown Pond but not Harrys River or Dons Brook. *Chondrites*, in fine-grained interbeds, and rare *Arenicolites*, occur in this facies.

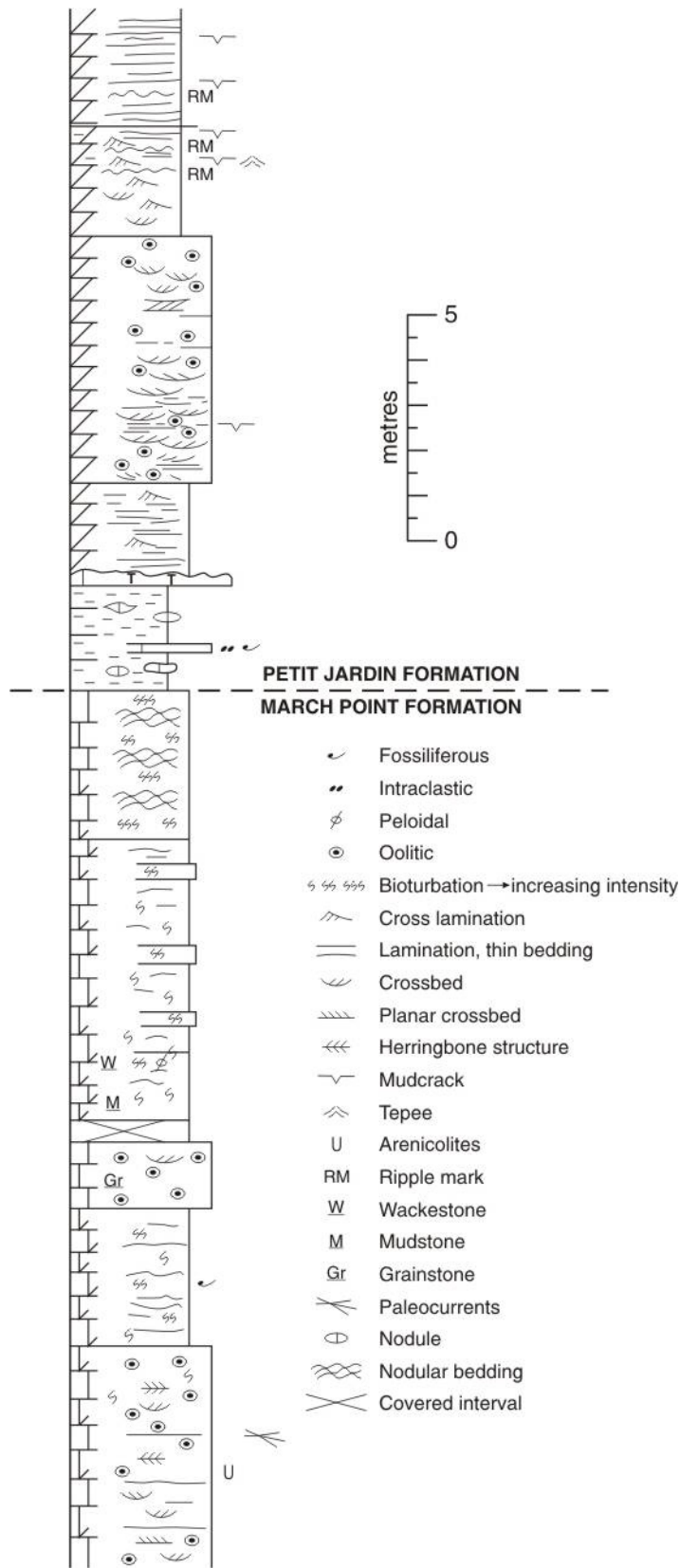
East of Harrys River, the ribbon-bedded rocks assigned to the March Point Formation are dominated by grey-weathering, dark-grey to grey, stylo-thin-bedded, nodular-bedded, and flaggy-bedded, dolomitic limestones having lenses of crosslaminated limestone and some beds, 5 to 15 cm thick, of massive limestone. There are also thin beds of edgewise intraformational rudstone as well as beds of clean, fine-grained grainstone displaying crosslamination, and wavy and convoluted lamination also occur. Interbeds, tens of centimetres thick, of grey shale having lenses of undulose laminated limestone with loaded bases occur at the base of the section.

No fauna has so far been retrieved from the formation in the map area.

The March Point Formation in the map area north of Harrys River compares fairly closely to its counterpart at Goose Arm and Canada Bay (Knight, 1987; Knight and Boyce, 1987, 1991; Knight and Cawood, 1991; Knight and Saltman, 1980). In all these areas, high-energy, oolitic lime sand shoals are associated with intensely burrowed shelf limestones and more outboard shelf ribbon carbonate. The possible transition to a succession dominated by ribbon limestone just east of Harrys River suggests that the oolitic sands of the anticline mark the break to the outer shelf.

### *Petit Jardin Formation*

The Petit Jardin Formation is a thick succession of unknown but substantial thickness comprising intercalated ribbon limestones and peritidal limestones, dolostones, argillaceous dolostones and minor red and green shales. The base of the formation, which is exposed on Harrys River, is placed at the base of a 3-m-thick bed of brown-weathering, cleaved grey mudstone enclosing irregular lumpy beds of skeletal–intraclastic wackestone–packstone. This bed occurs below the first thick yellow-weathering, light-grey dolostone. The latter commences with thin-bedded argillaceous dolostone that passes upward into crossbedded, crosslaminated and laminated, oolitic dolostone and grainstone, which is intercalated toward the top with mudcracked and teeped, green and red shale and fine-grained dolostone.



**Figure 5.** A short section measured across the contact of the March Point and Petit Jardin formations. The section is located on the west bank of Harrys River, southwest of Gallants.

The formation above this distinctive basal interval is a mix of thick intervals of cyclic shallow-water limestones intercalated with dololaminites and argillaceous dolostones, thick intervals of massive dolostone and intervals dominated by dolomitic ribbon limestone. In this aspect, the succession compares to that mapped and described in the Phillips Brook Anticline to the west (Knight and Boyce, 2000).

The ribbon-limestone facies is possibly the dominant facies association. It comprises parasequences of ribbon rock intercalated with lenses of intraclastic edgewise conglomerate and caps of oncolitic-intraclastic oolitic grainstone as well as skeletal packstone–wackestone. Single beds of stromatolitic limestone may cap some sequences. Beds of grey shale having thin limestone ribbons may occupy the base of some parasequences. Fossils include trilobites and inarticulate brachiopods.

Intervals consisting of parasequences of peritidal limestone and dolostone include decametre to metre-thick beds that begin with a bed of nodular to planar, dolomitic ribbon limestone overlain by oolitic limestone and/or stromatolitic limestone and are capped by dololaminite and argillaceous dolostone. The latter display shallow scour and fill structures, mudcracks and tepees as well as *in situ* brecciation. Trilobites and inarticulate brachiopods also occur with this association.

The dolostone association is marked by well-bedded but massive dolostone. Some beds exhibit lamination and other features of dololaminites and there are also beds of domal stromatolites with ferruginous shale partings outlining mounds and microbial growth layers. One such unit was mapped immediately below cherty dolostones assigned to the base of the overlying Berry Head Formation, a feature in common with the succession in the Phillips Brook Anticline to the west. Rounded, coarse-grained quartz sand is scattered in this uppermost dolostone.

Inarticulate brachiopods and indeterminate ptychopariid trilobite fragments occur in limestone lenses and pebbly grainstones at the base of the formation. However, collections of well-preserved trilobites, some associated with inarticulate brachiopods, from higher in the formation have yielded two Dresbachian faunas (D. Boyce, personal communication, 2002). The older fauna collected from two geographically separate localities contains the trilobites, *Blountia*, *Kingstonia* and *Arapahoa*. These faunas compare to faunas found in similar rocks in the lower part of the undivided March Point–Petit Jardin formations of the Phillips Brook Anticline (Knight and Boyce, 2000). They support a correlation with the upper part of the Campbells Member and the overlying Big Cove Member of the Petit Jardin Formation type section on the Port au Port Peninsula (Chow and James, 1987; Westrop, 1992; Cowan and James, 1993).

The younger Dresbachian fauna includes the trilobites *Terranovella* and *Komaspidella* collected from two sites, one near North Brook and the other from the Twentieth Brook area respectively. Both are hosted by oolitic grainstones and restricted to single species at their respective localities. The younger Dresbachian rocks correlate with rocks of the Felix Member of the Port au Port Peninsula type section. Both faunas belong to the *Crepicephalus Zone* of the Dresbachian stage and can be correlated with the Marjumen stage of Ludvigsen and Westrop (1985).

The succession in the Petit Jardin Formation in the North Brook Anticline appears to compare closely to that in the Phillips Brook Anticline to the west (Knight and Boyce, 2000). In both these structures, the succession is dominated by the ribbon limestone facies with intervening intervals of cyclic peritidal carbonates and oolitic grainstone. A dolostone unit caps the formation in both areas. The importance of ribbon limestone, a lithofacies of importance in the Reluctant Head Formation (Knight and Boyce, 1991), suggests that this succession, in this general area, was laid down more outboard on the Upper Cambrian shelf. The fine-grained ribbon facies association is probably a deeper ramp subtidal limestone deposited below wave base. It was influenced by storms that ripped up the seabed and redeposited debris as rudstones. Sequences of oolitic grainstone and peritidal lithofacies indicate that shallowing of the shelf allowed the formation of high-energy, lime sand complexes and tidal flats.

#### *Berry Head Formation*

Like the other formations in the Port au Port Group, the Berry Head Formation is exposed as a scattering of small outcrops and no continuous sections through the formation are known in the area; hence, it is of unknown thickness. The formation consists of a basal cherty dark-grey dolostone member, a middle thick-bedded dolostone member, and an upper member of limestone and dolostone.

The base of the formation is placed immediately below a regional marker of dark-grey to black, cherty, finely crystalline dolostone that has been mapped throughout the Cambro-Ordovician carbonate terrain in western Newfoundland. The marker is best exposed just north of Gallants. The marker comprises burrow-mottled dolostone, thrombolitic and stromatolitic dolostone, shaly parted dolostone, crossbedded oolitic dolostone and dololaminite. Mounds commonly are very chert rich, have areas of brecciation, and host vugs lined or closed by white sparry calcite, white quartz and clear prismatic quartz.

The marker is succeeded by a succession of thick-bedded, grey dolostones that generally have few distinguishing features. However, outcrops along the old woods-road from

Gallants north to Spruce Ponds show units of granular and pebbly intraclastic dolrudstone, burrow-mottled dolostone, dolostone containing cryptalgal mounds, thin-bedded dolostone and mudcracked dololaminite.

The upper member of intercalated limestone and dolostone is well exposed along the Gallants to Spruce Ponds woods-road, as well as the roads hugging the valley of North Brook. It consists of metre-scale parasequences of grey to dark-grey, parted to bioturbated, dolomitic limestone, oolitic and intraclastic grainstone, stromatolitic and thrombolitic limestone and interbeds of dolostone and dololaminite.

No fauna has been recovered from the formation although cross sections of open whorl gastropods were noted in several limestones in the upper member.

### ***St. George Group***

The mostly Lower Ordovician St. George Group is divided in the North Brook Anticline, as elsewhere in western Newfoundland, into the Watts Bight, Boat Harbour, Catoche and Aguathuna formations. There is no information about the thickness of each unit and the succession is described here in a general and abbreviated manner.

#### *Watts Bight Formation*

The Watts Bight Formation is a succession of black to dark-grey, bioturbated and thrombolitic dolomitic limestones, locally intercalated with 20- to 60-cm-thick dololaminite beds; black chert is common throughout. Some beds or parts of beds, particularly close to the base of the formation, are replaced by tan-grey-weathering, dark-grey, sucrosic, finely crystalline dolostone. Ghosts of gastropods and short straight cephalopods are not uncommon and may be locally silicified.

#### *Boat Harbour Formation*

The formation consists of a basal unit of thickly bedded, massive dolostone overlain by a succession of metre-scale parasequences of peritidal limestone and dolostone. The metre-scale sequences are predominantly of bioturbated dolomitic limestone capped by laminated limestone and/or dololaminite. Beds of thrombolitic and stromatolitic limestone occur locally. A number of prominent laminated shaly and dolomitic, mudcracked limestones mark the top of the formation as elsewhere in western Newfoundland. This implies the presence of the upper Barbace Cove Member (Knight and James, 1987) throughout the area, although it has been impossible to separate it from the lower unnamed member of the formation. So far, the Boat Harbour Disconformity, which marks the base of the upper member, has not

been seen, although it is described in the formation in the Phillips Brook Anticline (Knight and Boyce, 2000). The most obvious fossils are dolomitized gastropods.

#### *Catoche Formation*

Limestones of the overlying Catoche Formation are mostly dark grey, medium to thick bedded, dolomite-mottled and bioturbated. Scour-based lenses of crossbedded, skeletal-intraclastic grainstone, laminated, very fine-grained grainstone, and crudely graded, intraclastic rudstone occur in the lower part of the formation. Interbeds of stylonodular and locally ribbon-bedded, dolomitic lime mudstone also occur. A bed of brown-weathering, argillaceous dolostone containing scattered lime mudstone nodules and the trace fossil *Chondrites* occurs low in the formation, at the collapsed wooden trellis bridge across North Brook. The dolostone underlies a nodular to thin-bedded limestone hosting graptolites, brachiopods and trilobites, below chert-rich burrowed limestone containing abundant silicified gastropods, opercula and straight cephalopods. Several horizons of nodular, ropy and continuous chert are also common in this part of the section near the North Brook trellis bridge. A few small thrombolite mounds have been noted in the formation in the anticline.

Macluritid and murchisonid gastropods are the most obvious fossils. However, straight and curved cephalopods (*Protocycloceras* and *Cassinoceras*), silicified opercula (*Ceratopea*, “Billings second opercula” and *Maclurites* operculum type 1, see Rohr *et al.*, 2001), the rostroconch, *Euchasma blumenbachia*, crinoid ossicles, unidentified ostracods, the brachiopod *Diaphelasma*, and the trilobites, *Benthamaspis* and *Ischyrotoma*, as well as unidentified graptolite fragments, have been recovered from the formation at the wooden trellis bridge over North Brook.

The Costa Bay Member, a clean, light-grey to off-white limestone, 10 m thick, occurs at the top of the Catoche Formation. It comprises intraclastic grainstone and skeletal mudstones that host ostracods and gastropods. The member is best exposed east of East North Brook and appears to be thinly developed or intercalated with dolostone west of this stream making it difficult to distinguish from the overlying Aguathuna Formation.

#### *Aguathuna Formation*

The Aguathuna Formation appears to be unevenly developed through the North Brook Anticline. It is readily mapped east of East North Brook but appears to be relatively thin west of this brook. The base of the formation is consistently marked by a stromatolitic limestone bed, which is also a basal marker in the adjacent Phillips Brook Anticline.



East of East North Brook, the Aguathuna Formation consists of metre-scale parasequences of interbedded burrowed and stromatolitic limestone, lime grainstone, lime mudstone or bioturbated dolostone interbedded with dololaminite, argillaceous dolostone–dololaminite and laminated limestone. Many of the limestones are clean, commonly light grey and range from mudstones through peloidal wackestones to packstones and grainstones; a few skeletal grains are also visible. There are also rare beds of oolitic grainstone; dark-grey, bioturbated dolomitic limestones also occur. Silicified opercula are characteristic of the formation but straight cephalopods and gastropods are also present. Based on the outcrop width, the formation appears to range up to about 85 m in thickness in the anticline east of East North Brook but is approximately 10 m thick west of the brook.

A problematic section along the northwest edge of the anticline hosts a sequence of argillaceous and dolomitic ribbon limestone, intraclastic edgewise conglomerate, oolitic grainstone and stromatolitic moundstone intercalated with dolostone beds. The rock types, which also host inarticulate brachiopods, resemble those seen in the upper Cambrian Petit Jardin Formation. The succession is exposed in a stream gorge at the headwaters of West North Brook and one of its tributaries near Camp 38 (the site of an abandoned logging camp). The unit is faulted against steeply dipping Catoche Formation in the southeast. To the northwest, it is stratigraphically overlain by thick-bedded cherty limestone and dolostone that is also of problematic origin. This succession is in fault contact with limestones of the Table Point Formation, which are locally overlain by a carbonate conglomerate, that was mapped as the Cape Cormorant Formation by Williams (1985).

The problematic succession has been mapped as Ordovician carbonates beneath the Table Point Formation by Williams (1985), implying a simple, although faulted succession along the northwest limb of the fold. However, the succession, if interpreted as Aguathuna Formation, is quite anomalous compared to any other section in western Newfoundland. The faults appear to be zones of intense vertical displacement and this plus the similarity to the Petit Jardin Formation suggests that the succession is exotic for the area and may be footwall to a complex faulted margin in this part of the anticline.

#### ***Table Head and Goose Tickle Groups***

The limestones of the Table Head Group and the slaty flysch of the Goose Tickle Group are two parts of a carbonate to clastic succession laid down in an evolving Middle to Late Ordovician foreland basin during the early stages of Taconian orogenesis. Limestones of the Table Head Forma-

tion occur both in the anticline and in surrounding rock terranes. Only the Table Point Formation however, is definitively mapped within the anticline proper, the formation also including the basal Spring Inlet Member. The upper formation of the group, the Table Cove Formation, occurs in the surrounding slate terrane to the north of the anticline where it is intimately associated with limestone conglomerate of the Daniels Harbour Member of the American Tickle Formation and with black shales of the Black Cove Formation, both belonging to the Goose Tickle Group.

A carbonate conglomerate already mentioned in the description of the Aguathuna Formation lies along the northwest margin of the carbonate terrane near Camp 38. Although it was assigned to the Cape Cormorant Formation by Williams (1985), its age, stratigraphic designation and origin are considered to be uncertain (*see below*).

The St. George Unconformity (Knight *et al.*, 1991) defines the base of the Table Head Group. East of East North Brook, it is marked by erosion, surface karst structures such as small karren, and a basal conglomerate (Knight and Boyce, 2002). West of the same brook, the unconformity is not exposed but the generally thin expression of the Aguathuna Formation in this area suggests significant erosion of the top of the St. George Group beneath the unconformity.

#### ***Table Point Formation (Table Head Group)***

The Table Point Formation is divided into two units, the basal Spring Inlet Member and an upper unnamed limestone member.

The Spring Inlet Member, which locally includes a basal conglomerate east of East North Brook, is characterized by metre-scale sequences of various limestones capped by dolostones. The member in this area is approximately 10 to 14 m thick and consists predominantly of clean, cross-bedded, intraclastic, skeletal and peloidal grainstone with minor dolostone interbeds and some fenestral laminites and grainstone. The crossbeds range from planar tabular to trough cross sets up to 25 cm thick. A few paleocurrents suggest dominant flow was west to northwest. The crossbedded grainstone persists 4 km to the east and abuts against the Shoal Brook Fault. There, it consists of 10 to 11 m of skeletal, intraclastic and oolitic beds that overlie interbedded planar thin-bedded and laminated limestone and dolostone, stylonodular dolomitic lime mudstone and some grainstone. The grainstone unit is overlain sharply by stylonodular to lumpy, dolomitic lime mudstone, above which is a higher interval of grainstone comprising 40 cm beds of skeletal grainstone intercalated with bioturbated dolomitic limestone and lumpy limestone. Gastropods, brachiopods, crinoids,

bryozoa, trilobites and ostracods as well as some large straight cephalopods occur in the grainstones at several localities. A bed of stromatolitic limestone mounds, 0.6 to 1.5 m thick, associated with grainstone and capped by microbial-laminite occurs midway through the member.

Traced west of East North Brook, the member is not well exposed but does include both the metre-scale sequences of limestone and dolostone and the crossbedded grainstone facies.

The upper unnamed limestone member is dominated by well-bedded, dark-grey, dolomitic limestone composed of beds of bioturbated to nodular and lumpy, skeletal lime mudstone to muddy wackestone. The lime mudstone is interspersed with scour-based lenses as well as thin wedges and sheets of intraclastic and skeletal, small pebble rudstone to grainstone and thin beds of crosslaminated, very-fine-grained grainstone. Within the stylo-nodular to lumpy limestones, the carbonates are locally brecciated to conglomeratic, a fine-grained, argillaceous dolostone matrix supporting the pseudo-clasts. Remnants of ribbon thin bedding are also preserved in the lime mudstone beds. Small (less than 1 m in scale) scoop-shaped, and inclined planar scours reminiscent of slump scars occur locally and it is not unusual to trace nodular and thin stratification into local *in situ* breccias. Each of these features implies instability of partly lithified sediment, induced by gravity, the depositional slope and possibly seismicity associated with the foreland basin. High-spired and Macluritid gastropods, cephalopods, ostracods, trilobites, and crinoids are common in the limestone.

Toward the top, the brecciated and conglomeratic facies becomes more common, although it is still interbedded with bioturbated and stylonodular limestone. It forms beds up to 1 m thick. A few 15 cm interbeds of thin-bedded dolomitic ribbon limestone similar to facies of the Table Cove Formation (Stenzel *et al.*, 1990) also occur. The conglomeratic facies is reminiscent of the Daniels Harbour Member conglomerates but because it is intercalated with normal Table Point lithofacies, it is not considered as part of that member.

#### *Daniels Harbour Member (Goose Tickle Group)*

Aside from the conglomeratic Daniels Harbour facies that occurs in the Table Point Formation, there are a number of units of this conglomeratic facies intercalated in the slate terrane, stratigraphically above the Table Point Formation. In one fault block along the northern edge of the anticline, the conglomerates are intercalated with shales lying stratigraphically above the top beds of the Table Point limestone. In some outliers in the slate terrane north of this particular section, it erosively overlies Table Cove Formation and, in turn, is succeeded by black shale of the Black Cove Formation.

Conglomerates that appear to be either overlapped or overlain by ribbon limestone typical of the Table Cove Formation were noted by Knight and Boyce (2002) at a number of localities at the top of the formation north of Spruce Ponds. At least one locality was mapped with similar stratigraphic relationships in the slate terrane west of East North Brook. Therefore, it is reasonable to conclude that there are two or more units of limestone conglomerate lying above the Table Point Formation and intercalated with the Goose Tickle Group, as well as a significant conglomeratic presence in the Table Point Formation itself. This suggests that the transition from the Table Point Formation to Goose Tickle flysch is complex throughout this region of western Newfoundland. The intercalation of a number of conglomeratic units with thin-bedded limestone of Table Cove affinity and grey and black shales of Black Cove affinity, suggests that the transition combines a succession of facies associations in the same manner as the Cape Cormorant Formation on the Port au Port Peninsula (Stenzel *et al.*, 1990; Stenzel, 1992). The significant difference is that the North Brook succession derived clasts from only the Table Head and Goose Tickle groups compared to the back stripping of much of the Cambro-Ordovician carbonate succession to provide detritus for the Cape Cormorant Formation.

The limestone conglomerate units are roughly estimated to range up to about 10 m in thickness. They are generally poorly sorted and matrix-supported, although one unit is clast- to matrix-supported. The conglomerates consist mostly of clasts, a few centimetre in size, of nodular to lumpy lime mudstone, but also host angular flagstone clasts of ribbon limestone, laminated and crosslaminated limestone and rare large clasts, 30 by 20 cm in size, of crinoidal-intraclastic grainstone. Small clasts of fenestral limestone, burrowed limestone and laminated shaly siltstone and grey shale are also present. The matrix consists of fine-grained calcareous dolostone and locally carries scattered coarse-grained quartz sand. A delicate and small fossil fauna was also noted locally in the matrix in the area mapped in 2002. It is similar to the fauna of bryozoa, ostracods, brachiopods, crinoids (including intact stems), trilobites, small gastropods and graptolites that was described near Spruce Ponds by Knight and Boyce (2002).

#### *Table Cove Formation (Table Head Group)*

The Table Cove Formation consists of flaggy thin beds of grey, structureless to faintly laminated lime mudstone (2 to 5 cm) and dolostone (1 to 2 cm) separated by thin grey shales. Some flaggy limestones display long tubular burrows locally. Beds, 15 to 20 cm thick, of graded, very coarse-grained calcarenite to laminated calcisiltite are intercalated with the flaggy limestone at one locality. Beds, 2 to 3 m thick, of grey to black shale are also intercalated with the flaggy limestone. The formation is seen in a number of

outcrops just north of the anticline and appears to be no more than about 10 m thick. The importance of this facies as clasts in the Daniels Harbour Member and the erosive base of the conglomerate into the formation at one location suggests that the thin unit is more widespread than observed during mapping and that it was significantly reworked during the generation and emplacement of the conglomerate.

#### *Black Cove Formation*

The Black Cove Formation is a succession of black shale and bilge-green-weathering, sulphurous, pyritic shale that appears to overlie the Daniels Harbour conglomerates at a number of localities within the slate terrane.

#### *Carbonate Conglomerate of Uncertain Designation*

This conglomerate, which was assigned to the Cape Cormorant Formation by Williams (1985), was mapped in two small tributary streams of the West North Brook near Camp 38. Williams (*op. cit.*) shows it to continue to the northeast.

The conglomerate occurs intermittently at the westernmost edge of the carbonate terrane where it sits apparently stratigraphically above dark-grey dolomitic limestone, which may belong to the Table Point Formation, and is faulted against grey slate of the slate terrane. The conglomerate is strongly sheared in the tributary nearest Camp 38 and appears to cut out just a few hundred metres to the northeast before reappearing as essentially undeformed conglomerate 2 km to the northeast in the other tributary.

The undeformed conglomerate is approximately 10 to 15 m thick. It overlies well-bedded, bioturbated and stylonodular limestone although the contact is not exposed. The conglomerate exhibits a crude succession that begins with densely packed small pebble conglomerates hosting scattered larger floating clasts and a low volume of matrix passing upward into poorly sorted and vaguely stratified, more sparsely pebbly, matrix-supported conglomerate (MS) intercalated with clast-supported, small pebble conglomerate layers. The densely packed, small pebble conglomerates are dominated by nut- to golf-ball sized, black lime mudstone pebbles. Clasts, which are randomly oriented in the MS conglomerate, consist of large, angular fragments of dolostone and laminated dolostone, and tabular pieces of thin-bedded limestone (of Table Cove affinity) and bioturbated limestone. They are set in a matrix of limestone and small pebbles. The clasts range from 10 by 10 cm in size near the base, increasing to 70 by 15 by 6 cm in size upward. Lenses of thin-bedded, fine-grained limestone appear to be

interbedded locally in the conglomerate but the outcrop in the stream bed is not good enough to confirm this.

This conglomerate is probably part of the Daniels Harbour Member, resting erosively upon Table Point Formation limestone. Clasts appear to be derived from reworking of the lower and upper parts of the Table Point Formation and the ribbon limestone of the Table Cove Formation. Nonetheless, the conglomerate is distinctively different from the conglomerates seen a few kilometres to the northeast in the slate terrane (*see above*) and it does not appear to have a counterpart elsewhere along the northern margin of the carbonate terrane of the North Brook Anticline. Palmer *et al.* (2002), however, report a conglomerate resting with karsted unconformity upon limestones of the Catoche Formation at the north end of the Phillips Brook Anticline and this could possibly be a correlative. They assign the conglomerate to the Cape Cormorant Formation.

#### **Clastic Terranes Bounding the North Brook Anticline**

##### ***Lithostratigraphic Elements of the Slate Terrane, North of the North Brook Anticline***

##### *Grey Slates with Broken Thin Sandstone*

This is the predominant lithology of the slate terrane. The sandstones are mostly dark-brown-weathering and frequently well rotted. Generally, the thin sandstones are disarticulated into ribbons but several outcrops have thick beds (up to 50 cm) of grey, fine- to medium-grained sandstones of Goose Tickle type. The slaty cleavage is not always penetrative and planar. Rather it may show a hackly character, possibly reflecting a less homogenous protolith.

##### *Multicoloured Shales with Lithic Augen*

This is uncommon but was mapped in a few outcrops close to the northern edge of the map sheet. The shales are blue-black and green-grey in colour, and are intermixed in a semi-plastic soupy fashion suggestive of deformation of unlithified sediment. Clots of rusty-weathering grey shale also occur. Lithic augen of laminated and crosslaminated calcareous sandstone having rounded edges are scattered throughout the mix. The shale mixture is then overprinted by a phacoidal cleavage having shiny polished surfaces.

This lithic unit, in spite of being broken formation, is similar to distal shale sequences of the Cow Head Group (cf. Green Point Formation; James and Stevens, 1986) and is perhaps best considered as a *mélange*-like rock body. It is fairly widespread east of East North Brook (Knight and Boyce, 2002).

*Ribbon Limestones and Intraformational Mixtite (Pebbly Mudstone)*

These rock types are found in a cluster of outcrops and broken outcrops along the woods-road just west of East North Brook. The limestones, which retain their lithological competence and lack a penetrative cleavage, occupy the core of a syncline and structurally overlie grey slates. Dolomitic ribbon limestones displaying 1-cm planar stratification are associated with intraformational mixtites and graded beds of sandstone and limestone. The intraformational mixtite consists of widely spaced platy clasts of laminated and crosslaminated sandy limestone, up to 25 cm by 3 cm in size, floating in a calcareous medium- to very coarse-grained granular matrix. Quartz sand also floats in the matrix. The graded dark-grey sandstone to sandy limestone beds, 50 cm thick, dominate intervals a few metres thick. They display crosslamination overlain by planar lamination and may enclose shale pebbles.

This facies resembles rock types of the Reluctant Head Formation-Pinchgut Formation-Weasel group. Ribbon limestones suggest outer ramp deposition and are intercalated with mixtites produced by slumping and re-sedimentation, as well as graded sands to limestones (Knight and Boyce, 1991; Boyce *et al.*, 1992; Knight, 1997; I. Knight and W.D. Boyce, unpublished data, 2003).

*Limestone Conglomerate associated with Shale Pebble and Volcanic Pebble Conglomerate*

A single broken exposure of limestone conglomerate surrounded by grey slate outcrops in the slate terrane in the boggy ground northwest of the North Brook Anticline. It lies at least structurally close to, if not above, nearby outcrops of Daniels Harbour conglomerate. The conglomerate is matrix-supported with mostly centimetre-sized limestone clasts in an argillaceous dolomitic matrix. The conglomerate is associated with a well-rotted, grainy conglomerate hosting small shale clasts in a shale matrix as well as vesicular, amygdaloidal, and microcrystalline basalt and some sandstone clasts.

A similar conglomerate, which contains mafic volcanic pebbles, was mapped in the slate terrane in the footwall to the Spruce Pond Klippe (Knight and Boyce, 2002). As pointed out in that paper, the affiliation of this conglomerate unit is uncertain. Here, the close proximity to the Daniels Harbour conglomerate may imply that this is affiliated with the Howe Harbour Member of Quinn (1995) and is therefore part of the Goose Tickle flysch sequence.

**Clastic Terranes lying East of the North Brook Anticline**

This area lies east of the complex of faults, including the Spruce Brook Fault of Williams (1985), which form the eastern boundary of the anticline. The area stretches from the Trans Canada Highway (TCH) to Gallants and northeast through the hills that lie either side of Harrys River, downstream of Georges Lake, and overlook the valley of Spruce Brook. This is an area of generally poor outcrop and thick gravel and forest cover. Like the other slate terranes surrounding the carbonate-cored anticline, the geology of the eastern terrane is frustrating and it is unsettling to lump all slates into a single unit.

*Grey Slates hosting Broken Ribbons of Sandstone, Siltstone and Limestone and patches of Green and Black Shale*

This slate occurs in the hills between the bounding fault and Georges Lake, and the hills that lie east of Harrys River and north of the Gallants road. The broken strata then continue bordering the TCH from the Gallants turnoff to the east shore of Georges Lake. They lie above the Table Point Formation and/or Table Cove Formation, which forms the cores of anticlines and at a few localities includes some outcrops of the Daniels Harbour Member.

Throughout this area, there are outcrops of grey and black slates having a strong penetrative cleavage as well as outcrops of polydeformed shale-dominated strata. Just east of Gallants, grey slates host thin, dismembered and deformed, brown-weathering siltstone-sandstone ribbons, which are cut by the main cleavage, implying that the dismembering deformation occurred when the sediment was soft. Bordering the TCH from Georges Lake to the Gallants turnoff, there are numerous outcrops of polydeformed, grey to black, pyritic slates enclosing dismembered thin-bedded siltstone and sandstone as well as thin, laminated and cross-laminated limestones, limestone nodules and pyrobitumen. Some thicker beds of green-grey, coarser grained sandstone also occur, as do isolated limestone conglomerate outcrops of the Daniels Harbour Member. Close to the communication tower that overlooks the TCH to the east, a succession of black pyritic shales and grey slates with thin quartz sandstones are associated with a thick unit of cleaved grey calcisiltite. The latter is similar to a limestone associated with the Daniels Harbour conglomerate in the Pistolet Bay area (Knight, 1986).

Parts of this broken formation include areas of black and green shale (now slate), in which black shales plastically inject the green. Ragged fragments of brown-weathering siltstone are suspended in the shale.



The abundance of soft-sediment features, associated with the dismembered lithofacies, implies that the dismemberment of this clastic package as a whole predated the main cleavage and later crenulation cleavage that imprints these strata. This succession is interpreted by Knight (1997) to be broken Goose Tickle Group, which also forms the footwall to the Blue Pond Thrust Stack. The black and green shales are similar to the Green Point Formation but, because there is no defined belt of these rocks mappable through the area, they may be no more than small patches enclosed within the broken formation.

#### *Limestone Conglomerate of Pinchgut Formation - Weasel Group Affinity*

A large outcrop of steeply dipping limestone conglomerate, possibly a succession tens of metres thick, occurs at the eastern edge of a scarp overlooking Spruce Brook. The conglomerate erosively overlies a grey phyllite, which shows green and black banding and is interbedded with a very fine-grained, dark-grey limestone. The conglomerate is clast-supported with tightly packed, centimetre-sized plates (up to 15 by 2 cm in size) and chips of grey, fine-grained limestone set in a dolomitic matrix. Limestone pebbles and rounded, very coarse-grained quartz sand also occur in the conglomerate. The conglomerate is mostly amalgamated, but when traced to the north it is clearly interbedded with beds up to 50 cm thick of pebbly sandy limestone. The pebbles, which float in the sandy limestone, are a few centimetre in size. Rounded quartz sand is coarse to very coarse grained. Mapping, north of the conglomerate, indicates that the hills are underlain by grey slates and phyllitic slates that include some brecciated limestone.

The conglomerate is assigned to the Cooks Brook Formation by Williams (1985), who shows it as a block in Ordovician shale/mélange. However, the relatively thick succession of limestone conglomerate and its associated lithofacies is similar to Late Cambrian conglomerates of the Pinchgut Formation and Weasel groups (Knight, 1997; Boyce *et al.*, 1992). The presence of a significant succession of limestone conglomerate interbedded with associated facies implies that this is more than a large block within a shale mélange. Confirmation that it is part of a mappable unit that can be traced into the hillside will require further mapping of the hills between Spruce Brook and the Spruce Brook Fault.

#### *Curling Group*

North of the limestone conglomerate and the slates just discussed and at higher elevations above Spruce Brook are a number of outcrops belonging to the Curling Group. The outcrops occur in close proximity to the Spruce Brook Fault and the edge of the North Brook Anticline.

The Summerside Formation, seen in two outcrops, consists of green slate with some dark blue-grey slate interleaved locally. No bedding is discernable. The outcrops are structurally interspersed with outcrops of the Irishtown Formation. The latter consists of grey slates and intercalated thin beds of white-weathering metasandstone and thick beds (50 cm or greater) of quartz arenite. Bedding in the slates is just discernable because of faint colour banding. Lamination and crosslamination in some of the thin sandstone beds indicate that the succession here is largely inverted and younging to the west.

## STRUCTURAL GEOLOGY

Mapping of the North Brook Anticline is still too preliminary to describe and interpret its structure with any certainty. Large parts are still unmapped in critical areas. Previous maps portrayed the folded carbonates as a very large, northeast-plunging anticline (Williams, 1985). The present mapping shows that the structure is complicated by numerous folds of various scales and by an array of faults of various orientations. In addition, there is still considerable doubt about the structural relationships along the margins of the structure. This is particularly true of the western margin of the anticline where both the configuration of faults and the stratigraphic designation of strata in fault blocks are presently uncertain. For these reasons, description of the structure is deferred until a later date when the area is completely mapped.

## ECONOMIC GEOLOGY

### BASE METALS

A number of base-metal showings located on the 1:100 000-scale map of Williams (1985) were revisited. All the showings are vein-hosted and contain galena, sphalerite and pyrite–marcassite mineralization. The veins cut rocks of the Middle Cambrian March Point Formation and the Middle Ordovician Table Point Formation.

A cluster of galena and sphalerite showings on or near Dons Brook is hosted by dolostones that replace oolitic carbonates of the March Point Formation. One of the reported showings in the forest north of the brook was not found. Disseminated sphalerite was also noted in the March Point Formation in some outcrops along Harrys River. Wide, but unmineralized, calcite veins cut the March Point Formation elsewhere in the anticline.

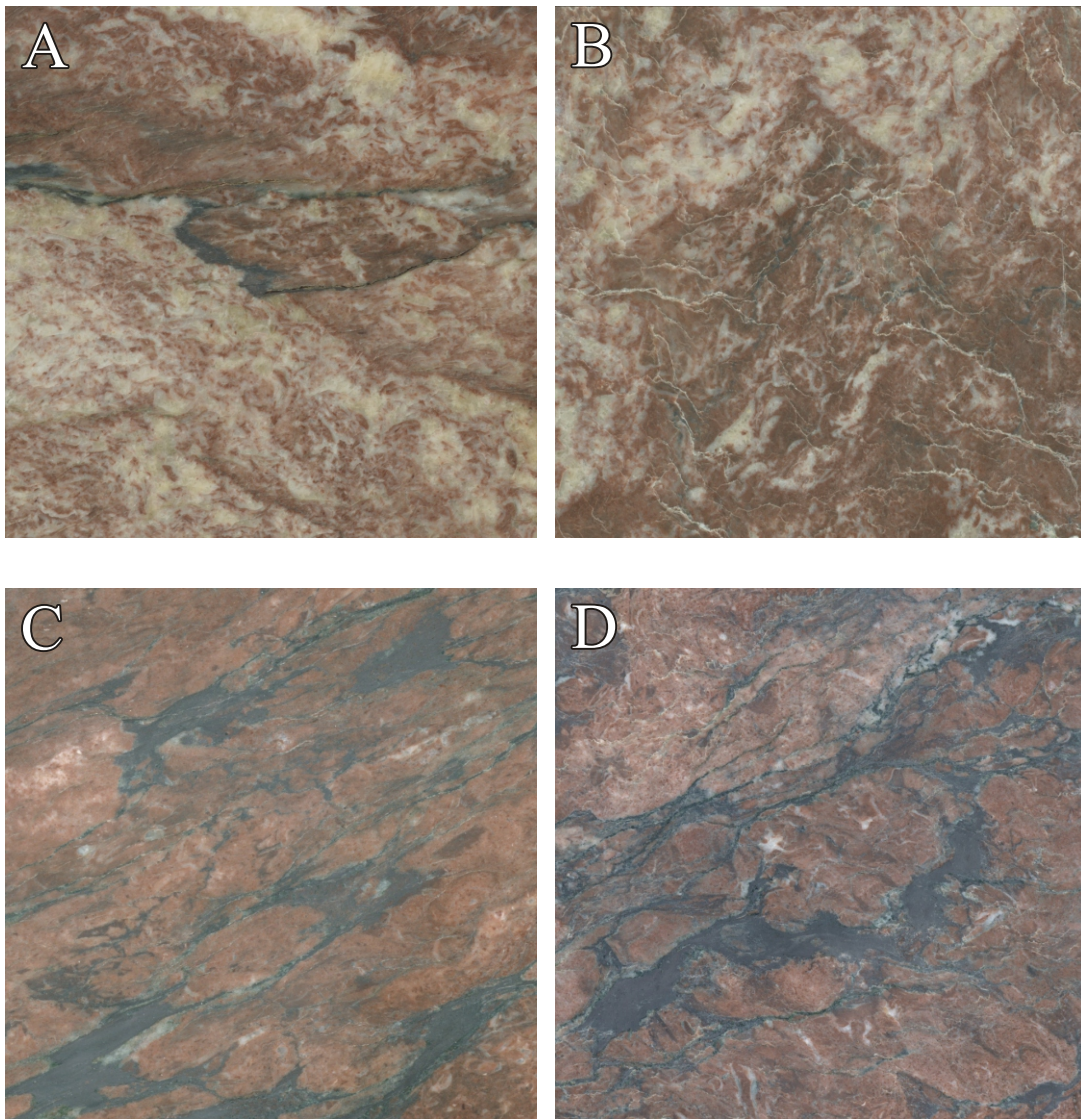
Two showings in the Table Point Formation occur close to the northern margin of the anticline. The showings occur spatially close to north- to northeast-trending faults that dissect the anticline in this area. Details of the various showings are summarized in Appendix 1.

## DIMENSION STONE

Dimension-stone prospects in the anticline are restricted to the Devils Cove Member limestone outcropping around the northern slopes of Crash Hill, north of the community of Black Duck. The member, which marks the base of the Forteau Formation, is exposed along the woods-road and in the hillside through several fault blocks as the stratigraphy is traced around the anticline. The beds generally dip gently north to northeastward. The limestone member is 15 to 20 m thick and consists of a section that includes nodular, argillaceous, maroon, pink and green, fine-grained limestone to pink, white and red, mottled, recrystallized grainy limestone (Plate 1). Recrystallized fossils, cement, grainstone fabrics and small veinlets, crossed by stylolites, all

give the marbles interesting textures. Nodular argillaceous marbles that are dominantly maroon in colour are regal and warm looking. The colour is possibly a secondary characteristic imparted to the limestone and the underlying Bradore Formation by the same iron-rich fluids that precipitated haematite concretions at the top of the Bradore Formation.

The limestone is quite massive and blocky weathering. It is well bedded and is cut by well-spaced steep joints (predominately trending  $310^\circ$  and dipping  $76^\circ$  to  $84^\circ$ NE) so that blocks up to at least 0.65 by 0.75 by 1.9 m in size are found beside the road. The limestones lie about 20 to 30 m above the Precambrian basement of salmon-pink, banded to mylonitic, granite gneiss. The granitic rock is locally over-



**Plate 1.** Grainy red, white and pink marble (A and B) and nodular maroon marble (C and D) of the Devils Cove Member limestone, Forteau Formation, Crash Hill, Indian Head Range. Samples 3A and C are cut across bedding; samples 3B and D are cut oblique to bedding.

printed by green, epidotic and chloritic alteration close to faults and the basal Cambrian unconformity, and may provide an additional dimension-stone target.

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## APPENDIX 1

## Summary of mineral showings in the March Point Formation and Table Point Formation - North Brook Anticline

Locality - Dons Brook

Field station number - K-02-31A

NTS coordinates - 407523E 5394554N, Harrys River Map Sheet, 12B/09, NAD 27, Zone 21

Minerals - Sphalerite

Assays of grab samples - Zn - 0.6 to 1.6%;Pb - <0.01%

Characteristics of Mineralization - Black Jack to dark ruby red, minor honey and rare green sphalerite in large masses, in scattered clots and disseminated in quartz.

Host type - Wide, white, coarsely crystalline, sparry calcite-white quartz vein associated with dolostone breccia; the vein appears to be zoned from hanging wall to footwall in the following manner: 1) non-mineralized calcite-quartz zone; dolostone breccia; middle sphalerite-calcite vein; quartz-sphalerite with brecciated zones; zone of en-échelon calcite veins cutting foot-wall

Vein trend - 155°/80°

Formation - March Point Formation

Age - Middle Cambrian

Host lithology - Dark-grey, finely crystalline, oolitic dolostone

Local structure - Strata dips almost due east at 15°; dolostone breccia suggests vein is parallel to fault; hanging wall is well jointed at 155°/80° and 290°/85°; en-échelon veins in footwall at 295°/85° and 120°/75°

Locality - Dons Brook

Field station number - K-02-31C2

NTS coordinates - 407098E 5394025N, Harrys River Map Sheet, 12B/09, NAD 27, Zone 21

Minerals - Sphalerite

Assays of grab samples - No data

Characteristics of Mineralization - Large centimetre crystals of sphalerite

Host type - Vein - white, coarse sparry calcite

Vein trend - No data, showing is rubble in stream bed

Formation - March Point Formation

Age - Middle Cambrian

Host lithology - Rubble nearby suggests dark-grey, dolomitic limestone

Local structure - No data, only boulders in stream and bank

Locality - Woods-road northwest edge of North Brook Anticline

Field station number - K-02-70G

NTS coordinates - 401216E 5397840N, Harrys River Map Sheet, 12B/09, NAD 27, Zone 21

Minerals - Sphalerite, galena, pyrite

Assays of grab samples - No data

Characteristics of Mineralization - large masses of dark-red sphalerite, disseminated sphalerite including some honey green crystals, veins of fine galena, rusty-weathering pyrite

Host type - Calcite vein, vuggy to coarse calcite spar with large spherical masses (15 cm diameter) of long radial prismatic crystals, vein at least 1 m wide

Vein trend - 270/57°N

Formation - Spring Inlet Member, Table Point Formation, Table Head Group

Age - Middle Ordovician

Host lithology - Interbedded grey, stylolitic and dark-grey, grainy and fossiliferous limestone and 30 to 60 cm dololaminite

Local structure - Occurs about 60 m west of grassy lineament that is locally associated with steepened bedding 000°/60° suggesting N-S fault here. At showing the beds strike 025° and dip 31°SE

Locality - Woods-road northwest edge of North Brook Anticline

Field station number - K-02-70F5

NTS coordinates - 401536E 5397940N, Harrys River Map Sheet, 12B/09, NAD 27, Zone 21

Minerals - Sphalerite

Assays of grab samples - no data

Characteristics of Mineralization - sparse disseminated sphalerite, some pyrite

Host type - Calcite vein, vuggy to coarse calcite spar, vein heavily weathered, may be 2 to 3 m wide

Vein trend - no data

Formation - Table Point Formation, Table Head Group

Age - Middle Ordovician

Host lithology - Dark-grey limestone, possibly grainy