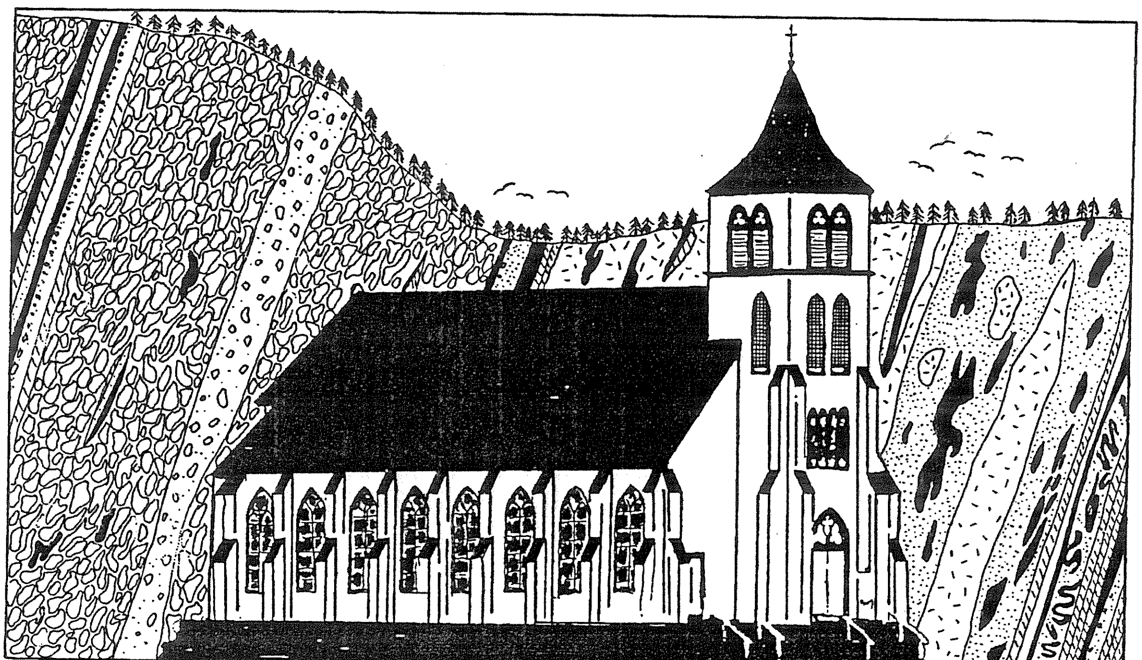
GEOLOGICAL ASSOCIATION OF CANADA
Newfoundland and Labrador Section

AUTUMN 1993 FIELD TRIP
October 1st - 3rd



T. Dec

St. Ann's Church in Fortune Harbour

FORTUNE HARBOUR PENINSULA (NOTRE DAME BAY)

Led by: Tomasz Dec, Brian O'Brien
Lawson Dickson and Dave Evans

FIELD TRIP GUIDE

GENERAL INTRODUCTION

The 1993 G.A.C. Newfoundland Section Fall field trip will focus on Ordovician and Silurian, volcano-sedimentary successions of the Notre Dame and Exploits subzones. On the day 1 some critical stratigraphic and structural relationships will be examined between Fortune Harbour and Charles Brook. The excursion will highlight recent mapping projects and related structural, sedimentological and provenance studies conducted by Brian O'Brien, Tomasz Dec, Steve Colman-Sadd, David Evans and Lawson Dickson of the Department of Mines and Energy. Day 1 of the trip will be led mainly by Tomasz Dec and Brian O'Brien. Lawson Dickson, Brian O'Brien, David Evans and Dean Sheppard of Gander River Minerals Ltd. will lead Day 2.

Acknowledgements The Department of Earth Sciences, Memorial University, and the Geological Survey Branch, Newfoundland Department of Mines and Energy are thanked for their logistical support. Noranda Exploration Ltd. and Gander River Minerals Inc. are kindly thanked for permission to visit the Appleton property.

DAY 1: FORTUNE HARBOUR PENINSULA

On leaving Lewisporte proceed directly toward Trans Canada Highway. Turn right onto the TCH and proceed toward Fortune Harbour via highways 350 and 352. At Fortune Harbour proceed through the village, pass the white St. Ann's Church on the right and stop at mussel processing plant of Atlantic Ocean Farms. This is Stop 1-1.

Km 0 - Stop 1-1: Fortune Harbour Formation (Cottrells Group)

Background for stops 1-1 to 1-5

The Dunnage Zone has been subdivided into the Notre Dame and Exploits Subzones, based on regional, geochemical and geophysical considerations (Williams et al., 1988). The two subzones cover a similar time span but their geological histories differ. They have been interpreted as representing arc - back-arc sequences formed in different parts of Iapetus Ocean (Swinden et al., 1988).

The Notre Dame Subzone contains distinct Late Cambrian and Early Ordovician ophiolitic and volcanic/volcaniclastic rocks which formed in a series of island arcs and back-arc basins. In the area between Fortune Harbour and Cottrells Cove to the south (which we passed through on the way up; Fig. 1) the Notre Dame Subzone is represented by the Cottrells Cove Group. It is broadly correlated with Buchans, Roberts Arm and Cutwell groups, that contain volcanic rocks exhibiting a clear volcanic-arc geochemical signature (Swinden 1990). Conodonts from the Buchans and Cutwell groups indicate ages ranging from late Arenig to late Llanvirn (Nowlan and Thurlow, 1984; O'Brien and Szybinski, 1989)., consistent with U/Pb dates from the Buchans, Roberts Arm, and Cutwell groups (Dunning et al., 1987; Dunning and Krogh, 1988).

The rocks of the Cottrells Cove Group are arranged in a very complex system of north-verging thrust slices. Younging directions within the fault-bound, volcano-sedimentary packages vary from north to south; although the north facing direction is most common.

The Fortune Harbour Formation forms the lower part of the Cottrells Cove Group and not the upper part as previously thought (Dean, 1978; Swinden et al., 1985). It consists of massive and pillow basalts, interbedded with red radiolarian cherts, greenish grey felsic tuffs and tuffaceous conglomerates, sandstones and mudstones. Pelagic mudstones, followed by turbiditic sandstones and minor conglomerates comprise the Moores Cove Formation.

Mélange of the Boones Point Complex constitutes the southern boundary of the Cottrells Cove Group. This boundary defines in part the Red Indian Line which separates rocks of Notre Dame and Exploits Subzone (Williams et al., 1988).

LEGEND

EXPLOITS SUBZONE

INTRUSIVE ROCKS (Units 13 and 14)

SILURIAN AND DEVONIAN

LONG ISLAND GRANODIORITE

| 14 | *hornblende, biotite granodiorite; biotite granite; felsite; quartz-feldspar porphyry*

SOUTH ARM GABBRO

| 13 | *dykes and sills of gabbro, diorite and associated diabase and mafic pegmatite*

BOONES POINT COMPLEX

| 12 | *melange assemblage of polymictic conglomerate, turbiditic sandstone, black shale, chert, limestone and basalt*

ORDOVICIAN AND SILURIAN

BOTWOOD GROUP

| 11 | *sandstone and mudstone*

RANDELS COVE CONGLOMERATE ("Goldson" Conglomerate, Upper Ashgil)

| 10 | *turbiditic, polymictic conglomerate; minor sandstone*

ORDOVICIAN

POINT LEAMINGTON FORMATION (Ashgil)

| 9 | *turbiditic sandstone and mudstone*

LAWRENCE HARBOUR SHALE (Caradoc)

| 8 | *black siliceous shale and grey chert*

STRONG ISLAND CHERT (Llanvirn-Llandeilo)

| 7 | *green and grey cherts, pillow and massive lava, volcaniclastic sandstone and mudstone; minor conglomerate and felsic tuff*

EXPLOITS GROUP

LAWRENCE HEAD VOLCANICS (Llanvirn-Llandeilo)

| 6 | *mafic pillow lava; rare green chert*

NEW BAY FORMATION

| 5 | *turbiditic conglomerate, sandstone and mudstone*

SAUNDERS COVE FORMATION

| 4 | *turbiditic conglomerate, sandstone and mudstone*

NOTRE DAME SUBZONE

ORDOVICIAN OR EARLIER

COTTRELLS COVE GROUP (Units 2 and 3)

MOORES COVE FORMATION

| 3 | *turbiditic sandstone and mudstone; minor conglomerate*

FORTUNE HARBOUR FORMATION

| 2 | *pillow and massive lava, red or green chert, volcaniclastic conglomerate, sandstone and mudstone; minor tuff*

MORETONS HARBOUR GROUP

| 1 | *unseparated pillow lava, diabase, gabbro, trondhjemite and minor sedimentary rocks*

thrust fault

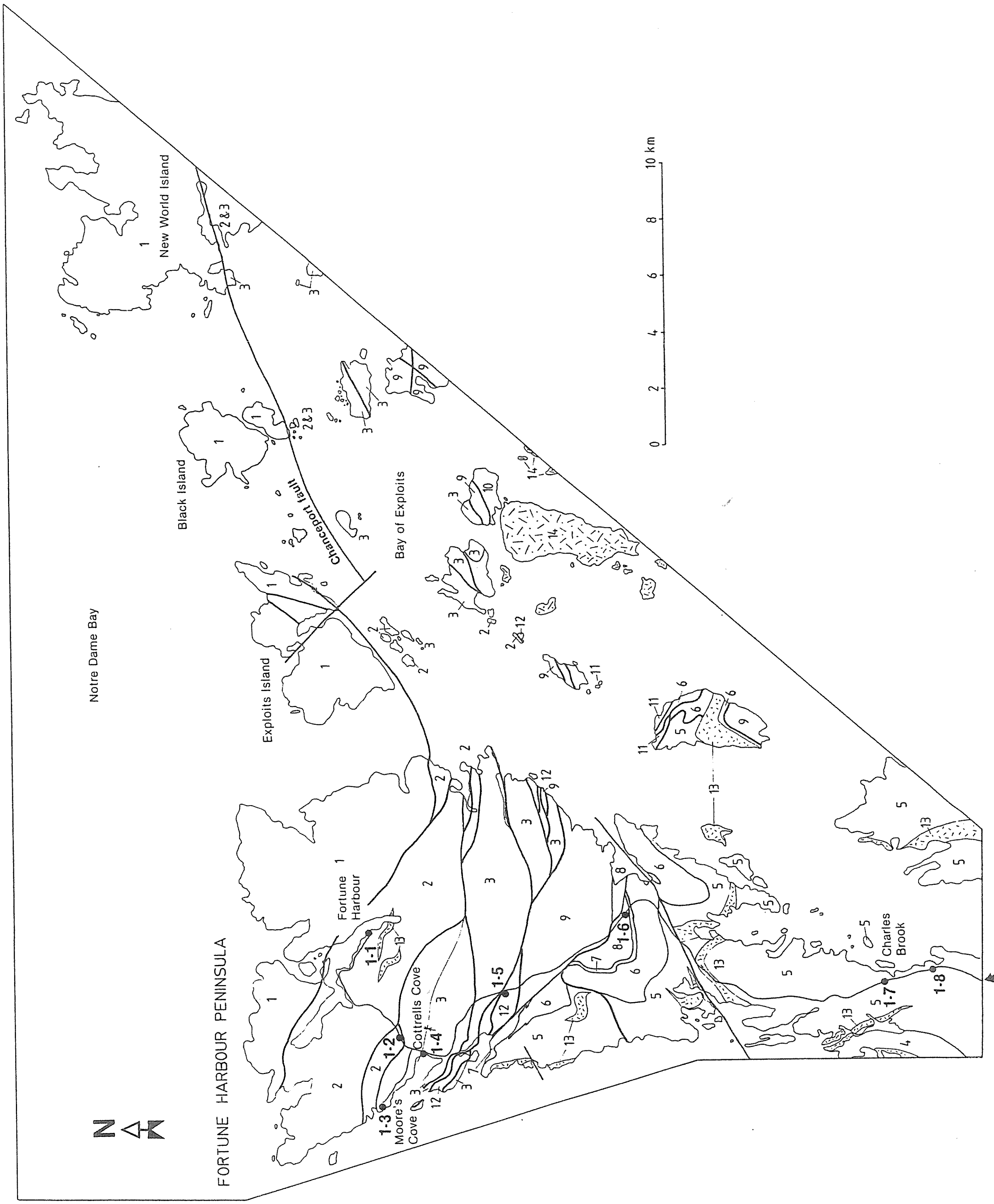


Figure 1: General geology of central Notre Dame Bay. Field trip stops are indicated by solid circles.

Chanceport Fault

The north-eastern and northern boundary of the Cottrells Cove Group is either represented by a fault, commonly referred to as the Chanceport Fault, or by a gradational contact with older pillow lavas and intrusive mafic rocks of the Moretons Harbour Group (Fig. 2). However, field relationships and preliminary geochemical data from mafic lavas of the Fortune Harbour Formation are incompatible with the existing status of the Chanceport Fault as a prominent structural boundary (e.g. Strong and Payne, 1973; Dean and Strong, 1977), separating the Moretons Harbour and Cottrells Cove groups, or the Twillingate and the Chanceport terranes (of Lafrance and Williams, 1992). At a number of localities on Fortune Harbour Peninsula, Exploits Island, Little Black Island and New World Island, the "Chanceport Fault" outcrops as a minor structure that is restricted to the rocks of the Cottrells Cove Group.

Description of Stop 1-1

By the plant and along the shore we can observe typical sedimentary rocks of the Fortune Harbour Formation such as volcaniclastic, mass-flow sandstones with rafts of red radiolarian chert (locally with burrows), *in situ* red chert, felsic tuff with interesting pillow features, and tuffaceous, siliceous mudstones.

An extensive olistostrome unit, similar to the raft-bearing sandstones, is mappable on Duck Islands (Fig. 1). It forms the base of the main sedimentary package of the Fortune Harbour Formation (Fig. 2). It contains basalt blocks of island-arc affinity and it is underlain by basalt flows with very similar geochemistry.

Geochemical constraints

Pillow and massive basalts of the Fortune Harbour Formation seem to fall into three, well defined groups. Two different groups of non-arc lavas (Type A and B) form the lowest and the highest horizons of the Fortune Harbour Formation (Fig. 2). On the western shore of the Fortune Harbour Peninsula the lower, type A non-arc lavas occur on both sides of the site of the Chanceport Fault. The third group - island-arc pillow and massive basalts underlies the thickest sedimentary package of the Fortune Harbour Formation. Blocks with similar island-arc chemistry occur in the overlying olistostrome.

Km 4 - Stop 1-2: Fortune Harbour Formation

Follow the road back towards Cottrells Cove. Stop by the road cut, past the school on the left.

Description

The main rocks seen in this road cut are amygdaloidal basalts, red radiolarian cherts, mudstones and tuffaceous sediments, of the Fortune Harbour Formation. The basalts represent some of the youngest flows in the formation; in places they are pillowed and locally interstratified with pillow breccia and hyaloclastite.

To the northwest, the basalt - red chert - tuffaceous sediment succession is observed to be stratigraphically overlain by mudstones and sandstone of the Moores Cove Formation. There, the transitional beds outcrop in the core of a southwesterly overturned syncline, exposed at Rowsell Cove (NE of Moores Cove). At stop 1-2, the primary boundary of the Fortune Harbour and the Moores Cove formations is tectonically modified. The local contact of these units is a fault which lies approximately parallel to the regional stratification in the tectonically adjacent mudstones and sandstones of the Moores Cove Formation. In the road cut, the Fortune Harbour succession is largely inverted in the hanging wall of a northwest-dipping reverse fault (Fig. 3), and extensive veining and alteration is found in the hinge zones of asymmetrical, southeasterly overturned folds. Note that the tectonic transport direction is opposite to that of many of the structures in the Cottrells Cove Group and that the reverse fault could be interpreted as a backthrust.

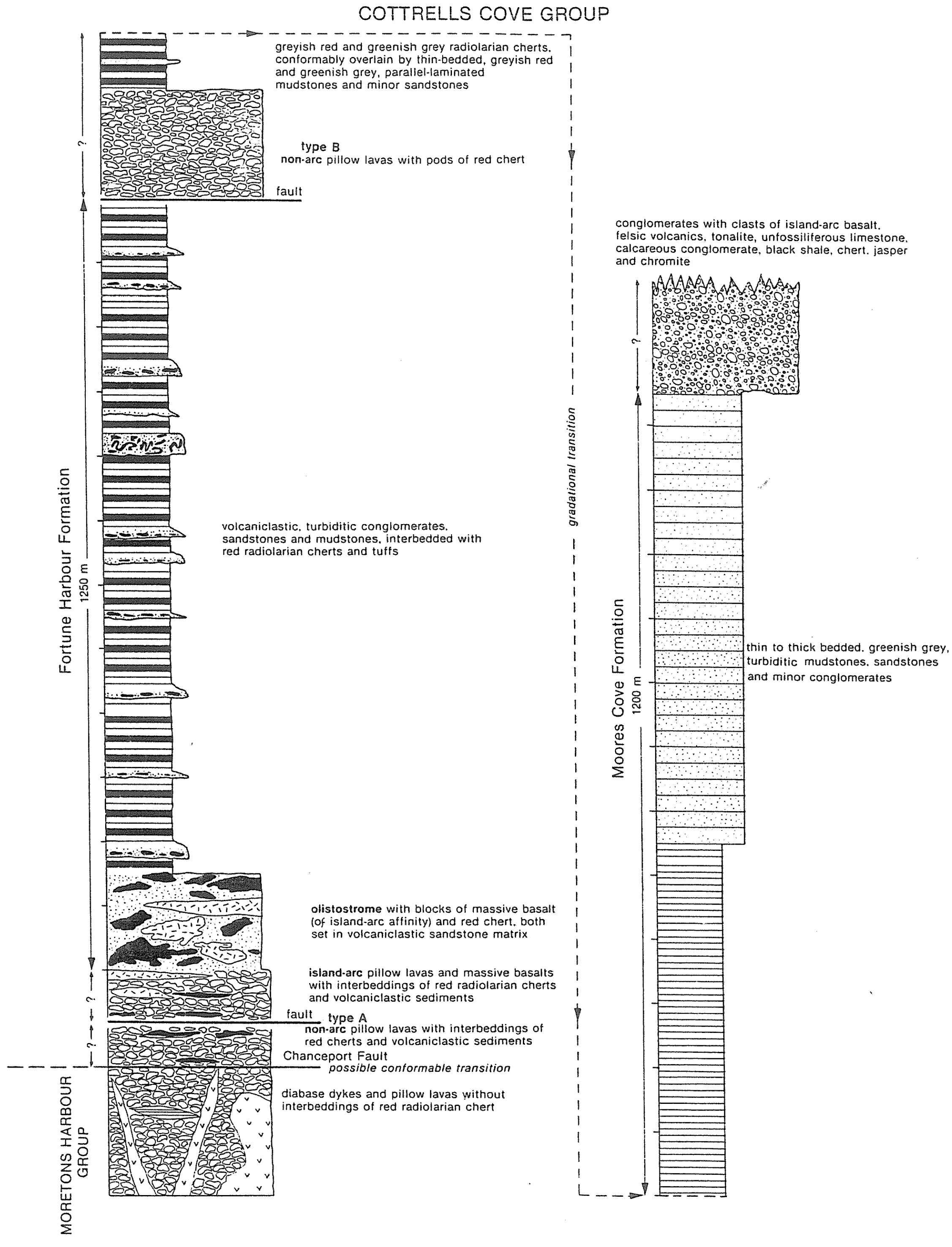


Figure 2: Provisional stratigraphic chart of the Cottrells Cove Group.

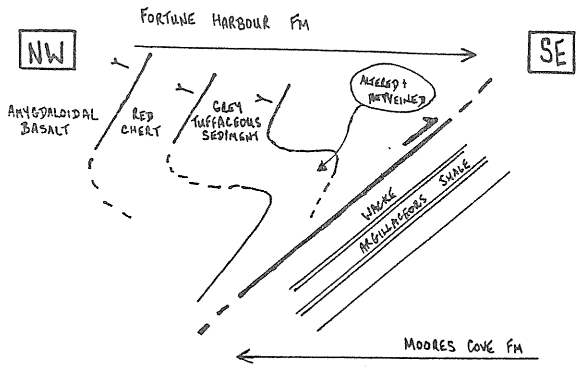


Figure 3: Structural modification of boundary between older Fortune Harbour formation and younger Moores Cove Formation (Cottrells Cove Group).

Km 6.8 - Stop 1-3: Moores Cove Formation (lower part)

Follow the road to Cottrell's Cove and turn right and follow the road to Moore's Cove. Stop at the end of the road and walk 150 m across a meadow towards a gravel beach and a cliff section nearby. Examine the rocks on the south side of the beach, walking along the base of the cliff.

Description

Pelagic, greyish red and greenish grey, mainly parallel-laminated mudstones dominate an overturned and north-facing section of the lowest portion of the Moore's Cove Formation (Fig. 2). These basin-plain, pelagic mudstones are interbedded with minor thin-bedded turbidites (T_C-T_D) and slumped mudstones and sandstones. The mudstones are in a conformable, gradational relationship with the underlying radiolarian cherts of the Fortune Harbour Formation and pass upward into thin to medium-bedded turbiditic sandstones and mudstones that are best exposed in Cottrells Cove (next stop).

Km 9.3 - Stop 1-4: Moores Cove Formation (upper part)

Return to Cottrell's Cove but turn right, before getting to the junction with highway 352. Follow the road down towards the waterfront and turn left. Pass a small graveyard on the left and stop close to the gravel beach at the end of the road. A NE facing section of turbiditic sandstones and mudstones is well exposed along an easily accessible cliff.

Description

The upper part of the Moores Cove Formation is made up of thin to thick bedded, turbiditic sandstone, mudstones and minor conglomerates. Here in Cottrell's Cove the section is composed mainly of thin to medium bedded T_C-T_D, T_B-T_D turbidites that represent an outer to middle submarine-fan environment (Fig. 4). Interesting trace fossils - flattened horizontal burrows - are commonly found in the section.

Many turbidites are mud-rich, structureless and contain mudstone, rip-up clasts. The rip-ups must have been fairly soft during incorporation and show either an imbrication or folding with consistent vergence. Although it seems fair to categorise many of these deposits as slumps or some other kind of high-density, mass-flow deposits, sedimentary features in a number of beds suggest that their "slumped" or "slurried" appearance may actually be mainly a result of *in situ* liquefaction and/or mixing during collapse and inversion of sediment layers of different densities.

Km 13 - Stop 1-5: Boones Point Complex

Leave Cottrell's Cove and follow highway 352 south for about 3.7 km. Pass a long pond on the left. Ahead there is a large road cut on the right turn. Stop beyond the turn.

Hard hats recommended !

The mélange of the Bonnes Point Complex separates the Notre Dame and the Exploits subzones. It is a fault-zone of the Red Indian Line. In the road cut the mélange consists of wide range of rocks. Polymictic boulder

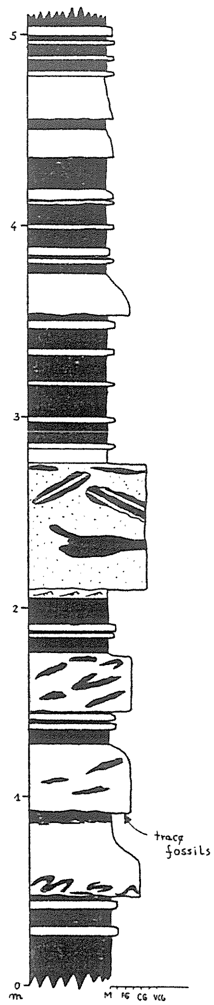


Figure 4: Selected log of the turbiditic deposits of the Cottrells Cove Group, measured at site 1-4. Note characteristic turbidites with rip-up mudstone clasts. M - mudstone; FG - fine-grained sandstone; CG - coarse-grained sandstone; VCG - very coarse-grained sandstone.

conglomerate is most conspicuous, with rounded boulders of tonalite and smaller clasts of chert and volcanic rocks. Dismembered fragments of sandstone, black shale and chert are also present in the mélange. In other localities the Bonnes Point Complex also contains blocks of limestone, with Llanvirn-Llandeilo conodonts, and pillow lava.

Some components of the mélange superficially resemble Llanvirn - Upper Ashgill sedimentary rocks of the Exploits Subzone (Strong Island Chert, Caradocian black shale, turbidites of Point Leamington Formation and Randels Cove Conglomerate). There is also evidence that rocks of the Notre Dame Subzone (e.g., Cottrells Cove Group) have been incorporated into the mélange.

EXPLOITS SUBZONE

Km 18.3 - Stop 1-6: Lawrence Head Volcanics - Strong Island Chert - Lawrence Harbour Formation

Continue along highway 350 for 5.3 km. Stop by the large aggregate quarry.

Background to stops 1-6 - 1-8

In the Notre Dame Bay area, the Exploits Subzone contains thick volcano-sedimentary units that formed in island arcs and in arc-related basins. They are represented by Wild Bight, Exploits and parts of the Summerford groups. The volcanic rocks of the Summerford Group range from Tremadoc to Llanvirn and recently discovered graptolites place the upper part of the Exploits Group in the Llanvirn (O'Brien, 1991). The stratigraphically equivalent lower parts of the Wild Bight and Exploits groups record a primitive ensimatic arc environment dominated by arc tholeiites (Swinden et al., 1990; Dec et al., 1992). The uppermost parts of these groups are dominated by ocean-floor tholeiites, oceanic-island tholeiites and mildly alkaline basalts (Wasowski and Jocobi, 1984; Swinden et al., 1990; Dec et al., 1992). Swinden et al. (1990) attributed the Wild Bight sequence to rifting of an island arc and the formation of a back-arc basin.

The cessation of submarine volcanism was followed by the widespread deposition of black shale, beginning in the Llandeilo and extending into the Caradoc or Ashgill. The start of black shale deposition appears to have been synchronous across the Exploits Subzone. The black shale interval shows a consistent lithologic sequence wherever its internal stratigraphy has been determined. The basal parts are dominated by chert and siliceous argillite and have been interpreted to be in conformable and gradational contact with underlying volcanic and volcaniclastic rocks. The chert is manganiferous, locally rich in radiolaria, commonly bioturbated and contains volcaniclastic interbeds. The Strong Island Chert is a perfect example of these siliceous deposits.

Stop 1-6 Strong Island Chert

The road cut exposes a section through the Lawrence Head Volcanics, Strong Island Chert and Lawrence Harbour Formation. The Strong Island Chert is composed mainly of brown-red and grey to green and turquoise-green radiolarian cherts, siliceous brown-red, grey, green and black shales ("ribbon radiolarites"). The cherts that occur directly above and close to the pillow lavas of the Lawrence Head Volcanics have a distinctive turquoise colour, due to abundant celadonite.

The grey and green cherts are commonly bioturbated. The burrows are seen in sections normal to the bedding as Fe-enriched, wispy mottles. The non-bioturbated cherts and shales show erosional bases, normal grading, parallel- and small-scale cross laminations that indicate deposition from low-density turbidity currents and from pelagic fallout. Felsic tuffs, volcaniclastic debrites and turbidites are a minor constituent of the Strong Island Chert. Some isolated turbidites also contain rock fragments of continental affinity (quartzite and quartz arenite) and accessory chromite.

The pillow lavas of the Lawrence Head Volcanics show non-arc geochemical signatures which are similar to those observed in the inferred back-arc section of the Wild Bight and in the type section of Strong Island Chert at Strong Island (Dec et al., 1992; Swinden et al., 1990).

Lawrence Harbour Formation

The Strong Island Chert passes gradationally into highly fossiliferous carbonaceous shale and minor chert. The quality of preservation of the graptolites is remarkable and many are pyritized. These beds belong to the *Nemograptus Gracilis and Climacograptus bicornis* zones.

Km 26.3 - Stop 1-7: New Bay Formation

Follow highway 352 for about 8 km. Stop in Charles Brook by the small boat harbour.

Background for stops 1-7 and 1-8

New Bay Formation is an extensive (1500 m thick), volcaniclastic unit of the Exploits Group. It is composed of deep-sea epiclastic turbidites and subordinate marine pyroclastic deposits. The lower, 1000 m-thick part of the New Bay Formation consists of outer-fan, thick-bedded conglomerate and sandstone turbidites, separated by thick packages of basin-plain turbiditic mudstones and numerous $T_{c\text{-}d}$ thin turbidites (Fig. 5). Abundant flutes, tool marks and cross beds, measured from the main, outer-fan section of the formation, indicate a general dispersal of the resedimented, pyroclastic and epiclastic sediments, and construction of a submarine fan, to the east and northeast.

Provenance of New Bay Formation

Volcanogenic clinopyroxene grains that are locally preserved in the tuffaceous sandstones and conglomerates have average compositions $Wo_{42,40}$ $En_{36,38}$ $Fs_{22,22}$ and their "orogenic" major-element signatures (Leterrier et al., 1982) suggest derivation of a significant quantity of the volcanogenic detritus from island-arc eruptions. This source volcanism may be represented today by island-arc rocks of the Exploits and the Wild

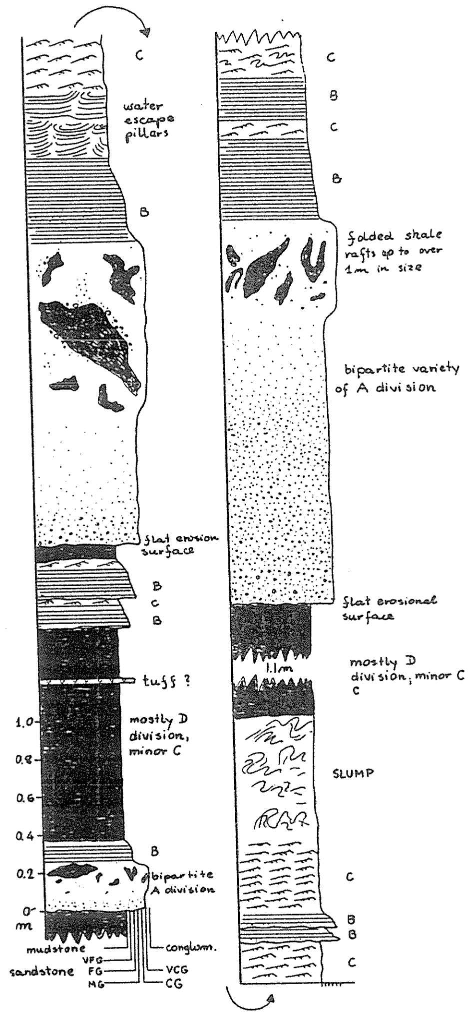


Figure 5: Selected log from the outer-fan section of the New Bay Formation, measured on the eastern coast of the Fortune Harbour Peninsula.

Bight groups (Swinden et al., 1990; Dec et al., 1992).

Description of Stop 1-7

The road section in Charles Brook exposes two thick T_{A-D} turbidites separated by dark grey mudstones. They are cut by a diabase sill. The conglomeratic parts of the turbiditic beds contain tuffaceous, fine-grained matrix and are rich in vesicular, mafic detritus. Note dark wispy volcanic fragments, commonly with reaction rims. The upper turbidite contains larger proportion of coarser felsic volcanic fragments.

Km 28.3 - Stop 1-8: New Bay Formation

Follow the road south for about 2 km, pass a deep road cut and stop by the road in a safe place. *HARD HATS RECOMMENDED !*

Description

Spectacular flutes and tool marks are exposed in the eastern face of the road cut. Their orientation is consistent with the general paleodispersal direction in the outer-fan section of the New Bay Formation to the E and NE. An interesting slump bed occurs in the middle of the section with axial planes of the slump folds oriented approximately parallel to the bedding. Other sedimentary structures associated with turbiditic sedimentation can be found in this outcrop. These include Bouma sequences, parallel stratification (T_B division); trough cross-stratification (T_B); ripple cross-lamination (T_C), convolute lamination and load casts. The turbidites are cut by a lamprophyre dyke. This is the final stop for the day 1.

DAY 2: SILURIAN ROCKS OF THE EXPLOITS SUBZONE

Depart from Lewisporte and take Route 340 southwards to its junction with the Trans-Canada Highway. Between Lewisporte Harbour and the Department of Forestry depot you will pass spectacular exposures of a regionally southwest-facing Late Ordovician marine turbidite succession. The poorly exposed ground south of the depot is underlain by the terrestrial Laurenceton and Wigwam formations of the Silurian Botwood Group.

Proceed westbound along the Trans-Canada Highway to the south bank of the Exploits River near Bishop Falls and turn right onto Route 351 prior to crossing the Sir Robert Bond Bridge. Park vehicles safely off Route 351 and proceed to the river section immediately northeast of the bridge abutments. The geology of the area and location of Stops 2-1 to 2-5 is shown in Figure 6.

Km 0.0 - Stop 2-1: Sandstone of Lower Wigwam Formation

Description

These riverside exposures are representative of the lithology, structure and stratigraphy of the lower part of the younger Wigwam Formation of the Botwood Group. In the Bishop Falls area, this succession regionally youngs to the west and northwest, stratigraphically overlying the scoriaceous basalts of the Laurenceton Formation that outcrop downstream. It originally underlay the typical red micaceous sandstones that crop out upstream in the western part of the town of Bishop Falls and in the type area of the formation in northern Peterview.

The lower Wigwam Formation comprises, in ascending order, buff-weathering, quartz-rich grey sandstone, grey-green sandstone with minor red shale partings or rip-ups, and interbedded green and red sandstone with common red argillite beds. These strata display a variety of primary sedimentary features, some of which are well illustrated in the exposures at Stop 2-1. The green and red cross-stratified, ripple-marked beds are probably of fluvial origin, although certain other horizons may have formed in a lacustrine environment. These distinctive strata are commonly found out of stratigraphic position with respect to younger and older rocks, or they are completely tectonically excised in other localities in the region.

Regional relationships

The Wigwam Formation is the youngest pretectonic stratified unit in central Notre Dame Bay and, like all older rocks, it is regionally deformed. Trains of mesoscopic, gently southwest-plunging folds are well displayed in the river section. Some are open and symmetric (parallel); others are strikingly asymmetric with west-striking short limbs. Northeast-striking slaty cleavage fans steeply southeast and northwest of the vertical. Axial planar to the parallel folds, this foliation is best developed in fold hinges or crestal regions. In certain beds in this folded sequence, sedimentary ripple crests are seen to be aligned parallel to the bedding-cleavage intersection lineation. However, ripple crests that pitch variably but generally steeper than the lineation occur on other bedding planes within the same succession, and thus attest to a low bulk regional strain in unfaulted tracts of the Wigwam Formation. The river section also contains numerous, northwest-trending, brittle cross faults. Associated with quartz vein arrays, these late stage structures dextrally offset the fold axial traces.

Km 8.5 - Stop 2-2: Fossiliferous Greywacke of the Point Leamington Formation

Proceed 7.7 km east of on Route 351 (old TCH); turn right 50 m west of small concrete bridge; proceed through old gravel pit on dirt road than turn left after approx. 200 m and proceed south approx. 250 m where hill should be in sight. Park about 50 m north of hill. Walk to hill.

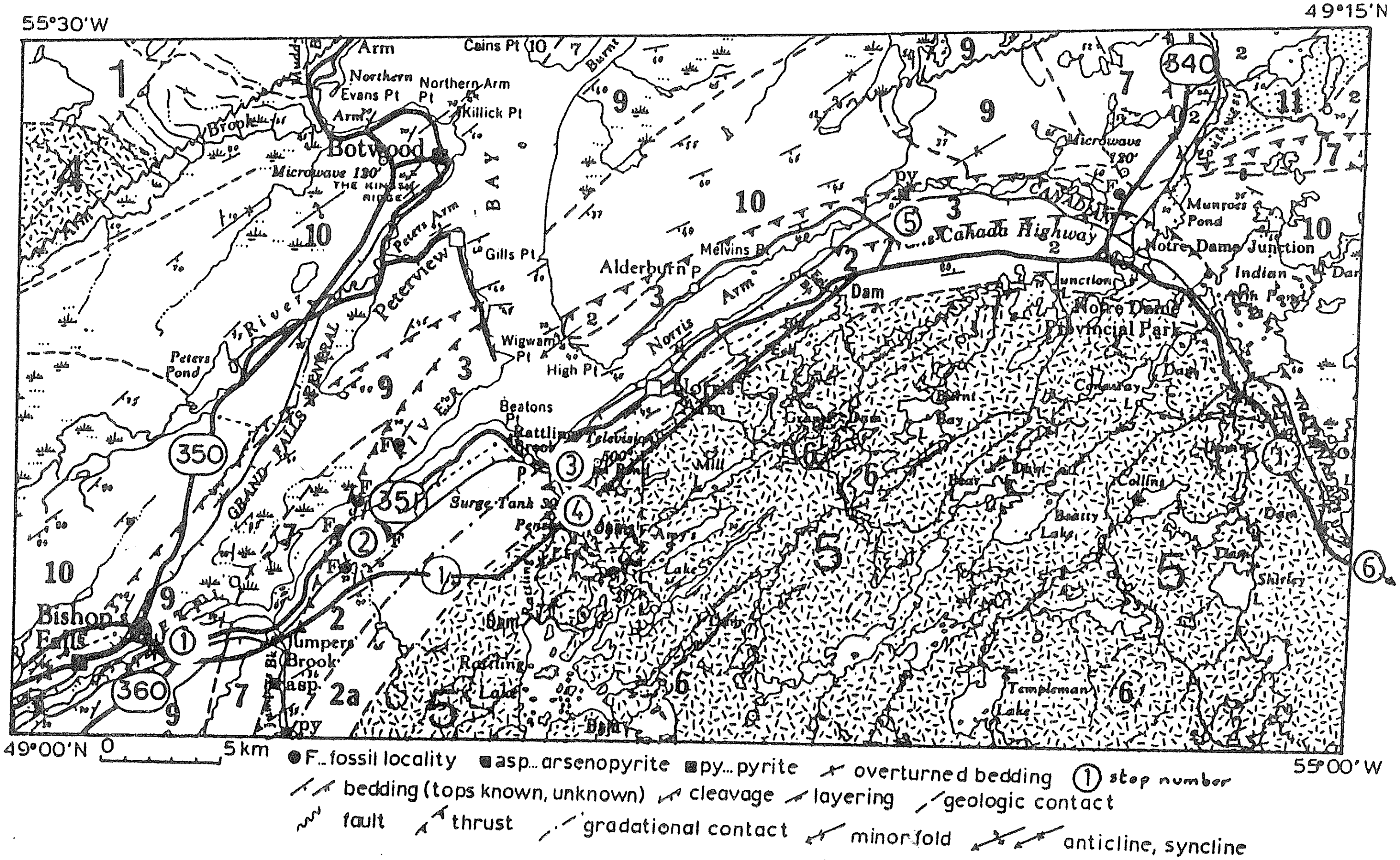


Figure 6. Geology of the Norris Arm area.

Legend for Figure 6

SILURIAN OR YOUNGER

11 Massive, biotite granite and minor granodiorite

SILURIAN

LUDLOW OR OLDER

BOTWOOD GROUP (Units 7 to 10)

Wigwam Formation (Units 9 and 10)

10 Red, thick-bedded, variably cleaved sandstone

9 Green-grey, medium-bedded, cleaved sandstone and minor felsic volcanic-clast conglomerate

Laurenceton Formation (Units 7 and 8)

8 Red, laharic breccia of felsic volcanic rocks, felsic-clast conglomerate and felsic tuff

7 Grey basalt, including plagioclase-porphyritic, amygdaloidal and massive flows and felsic tuff; minor red sandstone lenses

LLANDOVERY OR YOUNGER

MOUNT PEYTON INTRUSIVE SUITE (Units 5 and 6)

6 Pink and cream, massive, medium- and fine-grained, equigranular, biotite ± hornblende granite

5 Grey, massive, dominantly fine-grained, equigranular, pyroxene ± biotite ± hornblende gabbro

HODGES HILL INTRUSIVE SUITE

4 Grey and buff, massive, medium-grained, equigranular, biotite ± hornblende granodiorite and gabbro

LATE ORDOVICIAN AND EARLY SILURIAN

LLANDOVERY

GOLDSON GROUP AND EQUIVALENTS

3 Green, grey and minor red, very thick-bedded to medium bedded, cleaved, pebble conglomerate containing abundant chert and volcanic clasts and locally fossiliferous limestone clasts and interbedded with coarse-grained sandstone and minor siltstone

ASHGILL TO LLANDOVERY

Point Leamington Formation

2 Grey and green, medium- and thin-bedded, cleaved, locally fossiliferous greywacke, siltstone and conglomerate; 2a, black hornfels and contact migmatite

MIDDLE ORDOVICIAN

WILD BIGHT GROUP

1 Grey, fine-grained, basalt breccia and pillow breccia; minor felsic tuff

BEWARE OF VERY SLIPPY MOSS-COVERED ROCK

Description

This isolated hill is a southwest-dipping anticline in the Point Leamington Formation (Sansom Greywacke). Steeply south-dipping greywacke forms the south side of the hill and the main curved ridge is the fold axis. Rocks on the north side dip gently to the north. A strong cleavage/bedding intersection lineation indicates the plunge of the fold. Numerous fossil collecting sites will be apparent. The dominant fossil is the brachiopod *Leptaena* recognised by the abundant fine ribs and "wings". Other fossils collected by Doug Boyce, Steve Ash, Lawson Dickson and Barry Wheaton include trilobites, articulated and inarticulate brachiopods, crinoids and gastropods. These indicate a Late Llandovery (approx. 430 Ma) age for this unit.

Regional Relationships

1 km northeast of this stop a similar but underlying greywacke has produced a greater variety of fossils, including bivalves, ostracodes and corals, and a greater number of genera. To the west of stop 2.2 the greywacke is overlain by several fossiliferous conglomerates and sandstones which form the upper portion of the Point Leamington Formation and the lower portion Goldson Group (Conglomerate).

Km 14.5 - Stop 2.3: Contact Aureole of the Mount Peyton Intrusive Suite

Return to Route 351; turn right (east) and drive to junction with the western Norris Arm access road; turn left and proceed 200 m towards Norris Arm; turn right onto hydro road and park. Proceed to tail-race below hydro station.

Description

Along the east side of the tail race, convoluted, medium-bedded greywacke of the Point Leamington Formation display the effects of contact metamorphism. The greywacke still contains graded beds, cross- and parallel laminations, and slump structures. The greywacke is dark grey on fresh surfaces and appears recrystallized. Fine- grained biotite and locally coarse-grained amphibole porphyroblasts can be observed. Thin granite veins are scattered throughout the outcrop. Adjacent to the road, a small plug of gabbro has intruded the greywacke. The gabbro is fine-grained, massive, dark grey, pyroxene ± hornblende ± biotite gabbro of the Mount Peyton Intrusive Suite and will be seen in its full glory at the next stop.

Regional Relationships

The greywacke hornfels seen at this stop is correlated with the greywacke of the previous stop. This hornfels can be traced from the Notre Dame Junction area around the northern and western sides of the Mount Peyton Intrusive Suite as far as Miguels Lake. Closer to the intrusion, the greywacke beds are disrupted, boudinaged, veined by granite and gabbro dykes and pegmatite veins and are also extensively migmatized.

Km 16.5 - Stop 2.4: Gabbroic phase of the Mount Peyton Intrusive Suite

Turn left out of the parking lot and proceed southwards for 2 km along the access road towards the TCH. The rock cuts are the continuation of the aureole. Stop along the access road near the TCH. **WEAR HARD-HATS!**

Description

On both sides of the access road to Norris Arm, several rock cuts expose typical fine-grained, massive, dark grey, pyroxene ± hornblende ± biotite gabbro of the Mount Peyton Intrusive Suite. The gabbro is locally cut by light grey, fine-grained biotite ± hornblende granodiorite dykes that dip gently across the rock face. These dykes are better exposed along the TCH, for 3 km east of the access road.

Regional Relationships

The gabbro exposed here is at the northern end of the 1400 km^2 composite, calc-alkaline Mount Peyton Intrusive Suite. To the south of the TCH, the gabbro is cut by very thick, medium-grained, biotite granite dykes that generally trend northeastwards. Well to the southeast, the gabbro is intruded by plutons of medium-grained, granophyric biotite ± hornblende granite. The gabbro has intruded and contact metamorphosed folded and cleaved Early Silurian (Upper Llandovery), locally fossiliferous greywacke that is correlated with the Point Leamington Formation (Sansom Greywacke). The penetrative fabrics in the greywacke are largely obliterated in the aureole and small folds are cut by dykes indicating that the deformation predates intrusion of the gabbro.

The various units of the Botwood Group are not affected by the intrusion, i.e., there is no contact metamorphism or granitic or gabbroic dykes in the Botwood Group that can be related to the Mount Peyton Intrusive Suite, and inclusions of Botwood Group strata have not been found in the suite.

Published radiometric ages for the Mount Peyton Intrusive Suite give Rb-Sr whole rock age of 390 ± 15 Ma (recalculated Rb-Sr whole rock isochron; Bell and Blenkinsop, *in* Reynolds et al., 1981). The gabbro in the area of the stop has been dated at 423 ± 5 Ma (Ar-Ar hornblende; Reynolds et al., 1981). Samples of coarse-grained gabbro have been collected for U-Pb dating.

Km 29.7 - Stop 2-5: Greywacke - Wigwam Formation relations

BEWARE OF RCMP RADAR PATROLS ALONG THE TCH

Proceed south to the TCH (approx 150 m). Turn left (east) and proceed eastward (12.5 km) to the Norris Arm North turn-off. Turn left towards Norris Arm North; turn right after approx. 1.2 km onto a dirt road; drive approx. 200 m and park in quarry area. Wear hard-hats and be careful!

Description

Within the rock quarry, strata strike northwest, dip moderately northeastward and are unaffected by agmatization and contact metamorphism. This conspicuously red-weathered, right-way-up succession is composed of finely laminated, green and grey-green siliceous argillite and thin-bedded, graded, sandy wacke. The wacke beds have sharp (locally erosive) bases, pass gradationally upwards from sandy into finer, greener, cherty material and display Bouma divisions characteristic of turbidite deposits. In the northwest corner of the quarry face, a northwest-trending diorite dyke intrudes vertically across the moderately inclined beds. A margin-parallel flow foliation is observable in its chilled margin, whereas vesicles and amygdules are present in the coarser grained, central part of the intrusion. Its relationship to the diorite phase of the Mount Peyton Intrusive Suite is unknown, although similar dioritic intrusions are altered and locally sheared in Upper Ordovician greywackes near Indian Arm Brook, and in presumed Silurian greywackes north of Wigwam Point and High Point (Norris Arm).

Leave the quarry and take the road around the top of its northern face. Where the overburden has been extensively stripped adjacent to the road, there are excellent exposures of the Wigwam Formation of the Botwood Group. The local Wigwam sequence dips vertically and strikes westward. It is composed of well stratified, buff to pink coloured, fine- and medium-grained sandstones interbedded with red micaceous sandstones that contain minor red shale rip-up clasts.

Regional relationships

Although the mutual boundary of the marine turbidite and terrestrial units is unexposed, their contact must be abrupt and located near the roadway. The local strike and dip discordance, together with the regional evidence for excision of the entire Laurenceton Formation and the lower part of the Wigwam Formation, lead to the interpretation of the local contact as a west- to northwest-trending fault. The relationship of this structure to the regionally flexured fault (Figures 6 and 7) which trends eastward north of this locality is not precisely known; however, the faults are probably linked in some fashion.

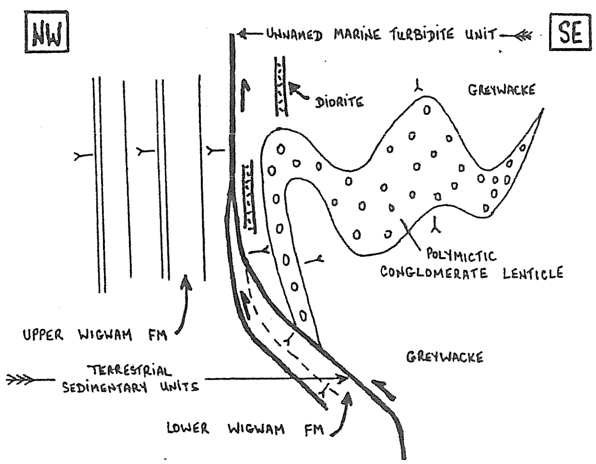


Figure 7. Schematic cross-section of regional fault zone north of Stop 2.5.

Km 71.7 - Stop 2-6: APPLETON GOLD PROSPECT

Return to TCH turn left (east) and drive through Glenwood and Appleton. 0.7 km east of the Appleton railway overpass, at bend in road, turn right onto the dirt road; drive for 300 m. The workings of the Bullet showing should be apparent on your left (east side of the road).

Introduction

In 1978 auriferous quartz veins were discovered in gabbroic rocks of the ophiolitic Gander River Complex (Blackwood, 1978). Subsequent exploration resulted in the discovery of approximately 40 occurrences (Figure 8). In the northeastern Dunnage Zone, gold mineralization occurs in mesothermal (i.e., quartz veins, quartz vein/altered wall rock, and disseminated gold) and epithermal deposits (i.e., hydrothermal breccias and argillic alteration).

Glenwood-Appleton Area

Nine gold occurrences are located in a 10 km radius of Glenwood and Appleton (Figure 8). Two of the more significant prospects are "The Knob" and "The Bullet". Exploration work including trenching, mapping, diamond drilling and assays have carried out by Noranda Exploration Ltd., Noront Resources Ltd., and Gander River Minerals Ltd.

Regional Setting

The turbiditic shales and greywackes that host The Knob and nearby Bullet prospects are part of the Middle Ordovician Davidsville Group (Blackwood 1982). These rocks contain a strong, steep cleavage and later conjugate kink bands and minor folds. Metamorphism is in the lower greenschist facies.

Stop 2-6-1: The Bullet

The Bullet prospect comprises a narrow, quartz-carbonate vein set (Figure 9) developed within a northeast-trending, steeply south-dipping, dextral shear zone. The veins are generally less than 15 cm thick and are composed of milky-white quartz with disseminated pyrite, arsenopyrite and minor base metals. The gold occurs as specks and patches of free gold. Assay values include 2.67 oz/ton Au over a 1.1 m channel sample (Noront Resources Ltd., 1990).

The shear zone, which has a maximum width of 50 cm and an exposed strike length of 24 m, cuts highly cleaved, slightly graphitic shales and siltstone of the Davidsville Group (Figure 10). The shear dies out quickly towards the northeast. To the southwest the shear and quartz veining is offset approximately 1 m by a sinistral shear zone. Late movement along the shear zone has broken and disrupted these veins (Figure 10).

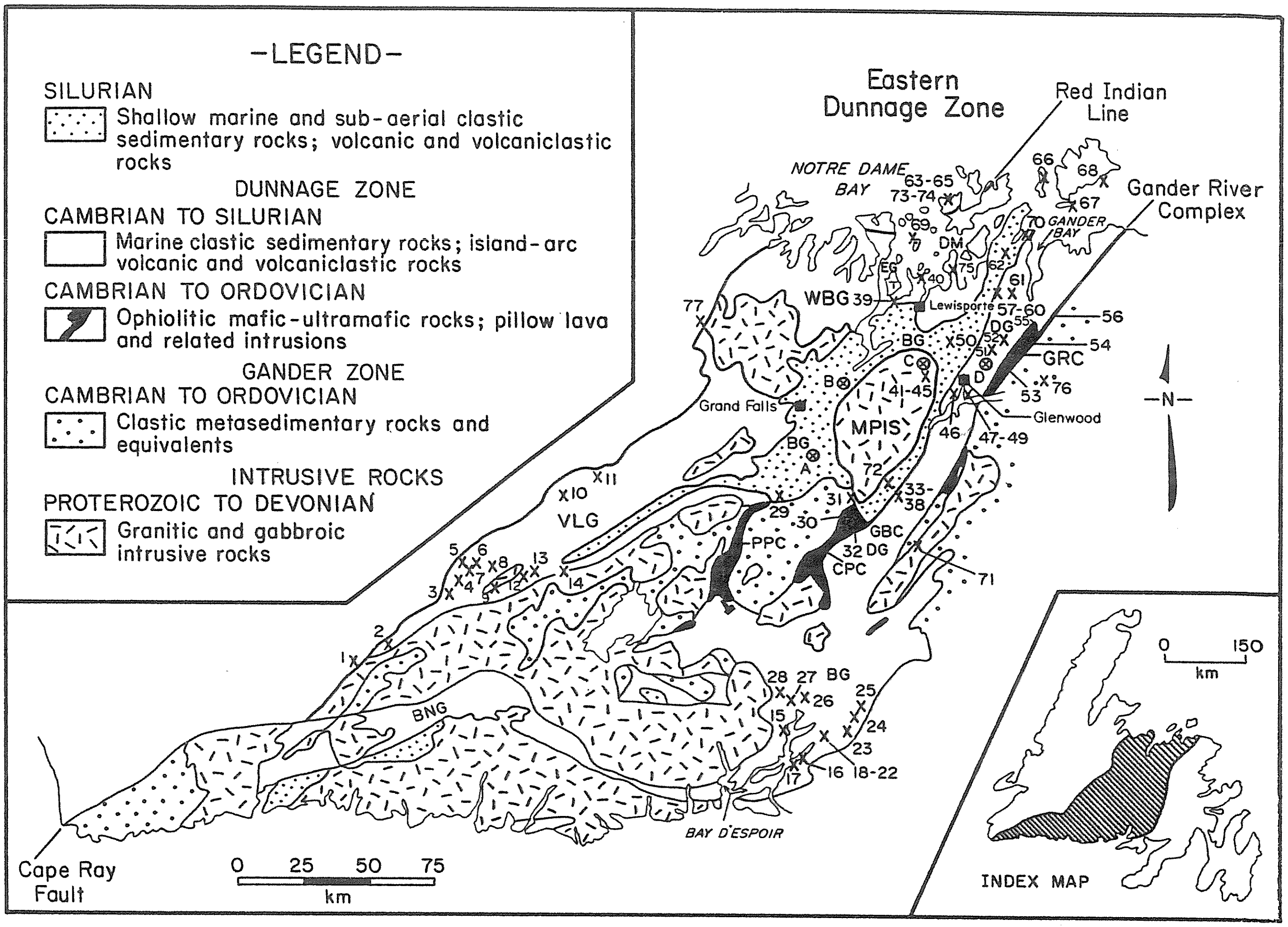


Figure 8: Simplified regional geology of the eastern Dunnage Zone, central Newfoundland, showing the locations of the significant gold occurrences (numbers are keyed to Table 1; geology modified after Tuach et al., 1988). DG-Davidsville Group; BG-Botwood Group; DM-Dunnage Mélange; EG-Exploits Group; WB-Wild Bight Group; VLG-Victoria Lake Group; BDG-Baie d'Espoir Group; PPC-Pipestone Pond Complex; CPC-Coy Pond Complex; GBC-Great Bend Complex; GRC-Gander River Complex; MPIS-Mount Peyton intrusive suite; T-Thwart Island.

	OCCURRENCE	CLASS	GRADES	MINERALOGY	HOST ROCK	ALTERATION
1	SECOND EXPLOITS	Dilational Veins	7.5 g/t Au	Au,Gn,Sp,Hem,Pyr	Granite	Sil, Epi
2	WOODS LAKE	Dilational Veins	11.93 g/t	(Au),Asp	Metasediments	Seri
3	PATS POND	Dilational Veins	1.9 g/t Au	(Au,Ag),Cp,Gn,Sp	Felsic Volc	Sil
4	ROAD (CAMP)	Dilational Veins	5.5 g/t Au	(Au),Gn,Sp,Pyr	Felsic Volc	Seri, Pyr
5	WEST TULKS	Dilational Veins	N/A	(Au),Gn,Pyr	Felsic Volc	Seri, Sil
		Disseminated	N/A	(Au),Hem		Sil, Hem
6	MIDAS POND	Shear-Controlled	7.3 g/t Au	(Au),Pyr,Tour	Mafic Volc	Fe-carb, Pyr, Intense Argillic
7	GLITTER POND	Dilational Veins	2.55 g/t Au	(Au),Ba,Pyr	Felsic Volc	Seri
8	LONG LAKE	Dilational Veins	N/A	(Au),Pyr	Granite	Sil
9	VALENTINE LAKE	Dilational Veins	24 g/t Au	Au,Pyr,W,Tour	Trondhjemite, Conglomerate	Seri, Alb, Sil Pyr
10	BOBBYS POND	Epithermal		Pyr,S,Pph,Ser,	Felsic Volc	Intense Argillic
11	VICTORIA MINE WEST/INCO	Veins	2.2 g/t	(Au),Asp	Felsic-Volc	Sil
12	VICTORIA BRIDGE	Dilational Veins	32.5 g/t	(Au),Pyr	Trondhjemite	?
13	GUANO PIT	Dilational Veins	20.0 g/t	(Au),Pyr	Trondhjemite	?
14	SOUTH QUINN LAKE	Dilational Veins	N/A	(Au),Asp,Pyr,Po	Metasediments	Sil
15	RATTLING BROOK	Dilational Veins	6.5 g/t Au	(Au),Bi,Mo	Schist	
16	BOWERS TICKLE	Dilational Veins	13.7 g/t Au	(Au),Sb,Ag	Schist	Sil
17	LONG JACKS BIGHT	Disseminated	12.34 g/t Au	(Au,Ag),Pyr,Po,Ar,Gn	Schist	Sil
	LITTLE RIVER (18-22)				Felsic Volc	
18	WOLF POND	Dilational Veins	6.51 g/t	(Au),Asp,Pyr,Po,Sb	Felsic Volc	Sil
19	22 WEST/LITTLE RIVER	Disseminated	4.11 g/t	(Au),Asp,Pyr,Po,Sb	Felsic Volc	?
20	22 WEST/TILLICUM	Disseminated	4.9 g/t	(Au),Asp,Po,Pyr,Sb	Felsic Volc	Carb, Seri
21	38 WEST/42 WEST	Disseminated	3.09 g/t	(Au),Asp,Po,Pyr,Sb	Felsic Volc	?
22	89 TO 97 WEST/ESSO	Disseminated	3.8 g/t	(Au),Po,Pyr,Asp,Sb	Felsic Volc	Carb, Seri
23	LE POUVOIR	?	1.9 g/t	(Au),Asp,Sb	Schist	?
24	KIM LAKE #1	Veins	20.52 g/t	(Au),Gn,Sp,Cp	Felsic Volc	?
25	KIM LAKE #3	Veins	9.7 g/t	(Au),Sb,Asp	Felsic Volc	Carb, Seri
26	TRUE GRIT	Veins	30.2 g/t	(Au),Asp	Siltstone	?
27	GOLDEN GRIT TRENCH 4	Dilational Veins	16.9 g/t	(Au),Pyr	Pelite	Seri
28	GOLDEN GRIT TRENCH 5	Dilational Veins		Sb,Pyr	Pelite	Seri
29	GREAT RATTLING Bk	Shear-Controlled	2.3 g/t Au	(Au),Pyr	Ultramafic, Metasediments	Sil, Seri
30	LIZARD POND	Shear-Controlled	12.6 g/t Au	(Au),Pyr,Asp	Ultramafic	Sil
31	CHIOUK BROOK	Disseminated	1.9 g/t Au	(Au),Pyr,Asp	Altered Seds	Sil
32	BRECCIA POND	Shear-Controlled	< 2 g/t Au	(Au)	Ultramafic	Sil, Hem
33	AZTEC	Epithermal	<1 g/t Au	(Au),Pyr	Altered Seds	Pyr, Argillic
34	HORNET	Dilational Veins	9.7 g/t Au	(Au),Pyr,Asp	Granite	Sil
35	A-ZONE EXTENSION	Dilational Veins	2.6 g/t Au	(Au),Pyr,Asp	Siltstone	Chlor, Potassic
36	ROAD GABBRO	Dilational Veins	7.9 g/t Au	(Au),Pyr,Asp	Gabbro	Sil, Fe-Carb
37	GOOSE	Dilational Veins	1.3 g/t Au	Au,Pyr,Asp	Greywacke	Seri, Sil
38	LBNL	Dilational Veins	1.8 g/t Au	(Au),Pyr,Asp	Porphyry	Sil
39	PORTERVILLE	Shear-Controlled	2.12 g/t Au	(Au),Pyr,Asp	Gabbro	Fe-Carb, Leucoxene
40	POWDERHOUSE COVE	Dilational Veins	78.2 g/t Au	(Au),Pyr,Asp	Felsic Dike	Sil
	MOUNT PEYTON (41-45)					
41	HURRICANE	Shear-Controlled	4.6 g/t Au	(Au),Pyr,Asp	Diorite	Seri
42	CORSAIR	Shear-Controlled	3.2 g/t Au	(Au),Pyr,Asp	Diorite	Seri
43	COMANCHE	Shear-Controlled	1.3 g/t Au	(Au),Pyr,Asp	Diorite	Seri
44	SABRE	Disseminated	2.1 g/t Au	(Au),Pyr,Asp	Aplite Dike	Sil
45	APACHE	Shear-Controlled	1.3 g/t Au	(Au),Pyr,Asp	Diorite	
46	THE OUTFLOW	Epithermal	12.23 g/t Au	(Au),Pyr,Sb	Greywacke	Sil
47	BULLET	Shear-Controlled	83 g/t Au	Au,Pyr,Asp,Gn,Cp	Shale	Fe-Carb
48	THE KNOB	Shear-Controlled	155 g/t Au	Au,Pyr,Asp,Cp,Bou	Greywacke	Fe-Carb
49	BOWATER	Dilational Veins	<3 g/t Au	(Au),Pyr	Greywacke	Sil
50	BIG POND	Dilational Veins	440 g/t Au	Au,Pyr,Asp	Gabbro	Fe-Carb
51	THIRD POND	Dilational Veins	4.6 g/t Au	(Au),Pyr	Greywacke	Sil
52	KNOB HILL	Dilational Veins	2.7 g/t Au	(Au),Pyr	Greywacke	Chlor,Pyr
53	JONATHANS POND	Shear-Controlled	6 g/t Au	(Au),Pyr,Asp		
54	BURSEY'S HILL	Disseminated	3.5 g/t Au	(Au),Cr	Ultramafic	Talc-Carb
55	CRIPPLE CREEK	Epithermal	9.6 q/t Au	(Au),Pyr,Asp	Trondhjemite	Sil
56	WEIRS POND	Dilational Veins	2.5 g/t Au	(Au),Asp,Pyr	Gabbro	Fe-Carb
	DUDER LAKE (57-60)					
57	FLIRT	Dilational Veins	N/A	(Au),Pyr,Asp	Gabbro	Fe-Carb, Chlor
58	GOLDSTASH	Disseminated	12.5 g/t Au	(Au),Pyr,Asp	Gabbro	Sil,Seri,Fe-Carb, Leucoxene
59	CORVETTE	Disseminated	N/A	(Au),Pyr,Asp	Gabbro	Sil,Seri,Fe-Carb, Leucoxene
60	STINGER	Shear-Controlled	N/A	(Au),Pyr,Asp	Siltstone	Seri,Fe-Carb
61	BURNT LAKE	Dilational Veins	N/A	(Au),Pyr	Greywacke	Sil
62	CLUTHA	Shear-Controlled	N/A	Au,Pyr,Asp	Gabbro	Fe-Carb, Sil
	MORETON'S HARBOUR (63-65)					
63	STUCKLESS COVE	Dilational Veins	20.2 g/t Au	(Au),Sb,Asp	Felsic Dike	Sil
64	TAYLERS ROOM	Dilational Veins	13.3 g/t Au	(Au),Sb,Asp	Felsic Dike	Sil
65	STEWARTS MINE	Dilational Veins	10.9 g/t Au	(Au),Asp,Pyr,Sp	Felsic Dike	Sil
66	CHANGE ISLANDS	Dilational Veins	164.1 g/t Au	(Au),Pyr,Po,Cp	Felsic Dike	Sil
67	INDIAN ISLANDS	Dilational Veins	8 g/t Au	(Au),Pyr,Asp	Felsic Dike	Sil
68	CANN ISLAND	Shear-Controlled	3.1 g/t Au	(Au),Pyr,Cp,Sp	Mafic Volc	Chlor
69	POND ISLAND	Dilational Veins	<1 g/t Au	(Au),Cp,Sp,Sb,Bi,Ag, Asp,Tet	Granodiorite	Sil, Seri
70	CHARLES COVE	Dilational Veins	6.2 g/t Au	(Au),Pyr,Asp,W,Cp,Mo	Granodiorite	Sil
71	MIDDLE RIDGE	Shear-Controlled	1 g/t Au	(Au),Pyr,W	Granite	Seri, Sil
72	HUNAN	Dilational Veins			Greywacke	Seri, Carb
73	MORETONS HR. HEAD	Veins	9.11 g/t	(Au),Pyr,Asp,Sb	Mafic volc	?
74	PIERCE HR. EAST	Veins	4.79 g/t	(Au),Pyr,Asp,Sb	Mafic volc	?
75	SHOAL POINT	Shear-Controlled	4.67 g/t	(Au),Asp,Pyr,Cp	Gabbro	?
76	GANDER AIRPORT	Epithermal (?)		Pyr	Slate	Sil
77	HAND CAMP	Disseminated	10.6 g/t Au	(Au,Ag),Pyr,Gn,Sp	Sericite schist	Seri
	FLOAT					
A	PARADISE LAKE	Epithermal			Sandstone(?)	Sil
B	MOOSEHEAD	Dilational Veins	N/A	Au,Pyr,Asp	Sandstone(?)	Sil
C	SALMON RIVER	Dilational Veins	N/A	(Au),Asp,(Ag),Sp,Gn,Cp, Pyr,Po	Diorite	Sil
D	PANHANDLER	Dilational Veins	161 g/t Au	Au	Greywacke(?)	

( ) parentheses indicate that the mineral/commodity is present in minor or trace amounts or indicated by an assay.

Table 1: To accompany Figure 8.

Stop 2-6-2: The Knob

Auriferous quartz veins at "The Knob" prospect are developed within a variably deformed northeast-trending, steeply northwest dipping, overturned greywacke-shale unit (Figure 9). In the mineralized area the unit is about 70 m thick. The greywacke is in fault contact with a largely unmineralized and unaltered sequence of shale. The shale dips steeply to the northwest and forms the structural footwall to the mineralized package. Both units and the mineralized quartz veins are offset by late brittle faults.

Mineralized vein systems are developed over a strike distance of approximately 500 m. Two types of shear-controlled quartz veins are present: 1) pyrite-arsenopyrite-rich veins that contain low values of gold, and 2) milky-white massive and smaller sheeted quartz veins that contain coarse free gold and relatively minor amounts of pyrite, chalcopyrite and a steel-grey mineral identified by Collins (1991) as boulangerite ($Pb_4Sb_4S_{11}$). Both vein types are hosted by northwest- and north-trending structures. The veins are typically less than 50 cm wide and exhibit pinch-and-swell structures. The relationship between the two vein types is unknown. Extensional veins are also developed within the greywacke outside of the main shear zones. Wallrock alteration around the milky-white veins comprises silicification with disseminated pyrite and arsenopyrite, and intensely deformed, rusty-weathering zones.

The gold occurs as fine disseminations and coarse, wiry clots within the milky-white quartz veins and as fine disseminations along vein margins. Assays from the prospect include values up to 62.13 oz/ton Au from grab samples, 18.41 oz/ton Au over 0.6 m from channel sampling and 1.124 oz/ton Au over 6.45 m from drill core (Springer Resources Ltd., 1991).

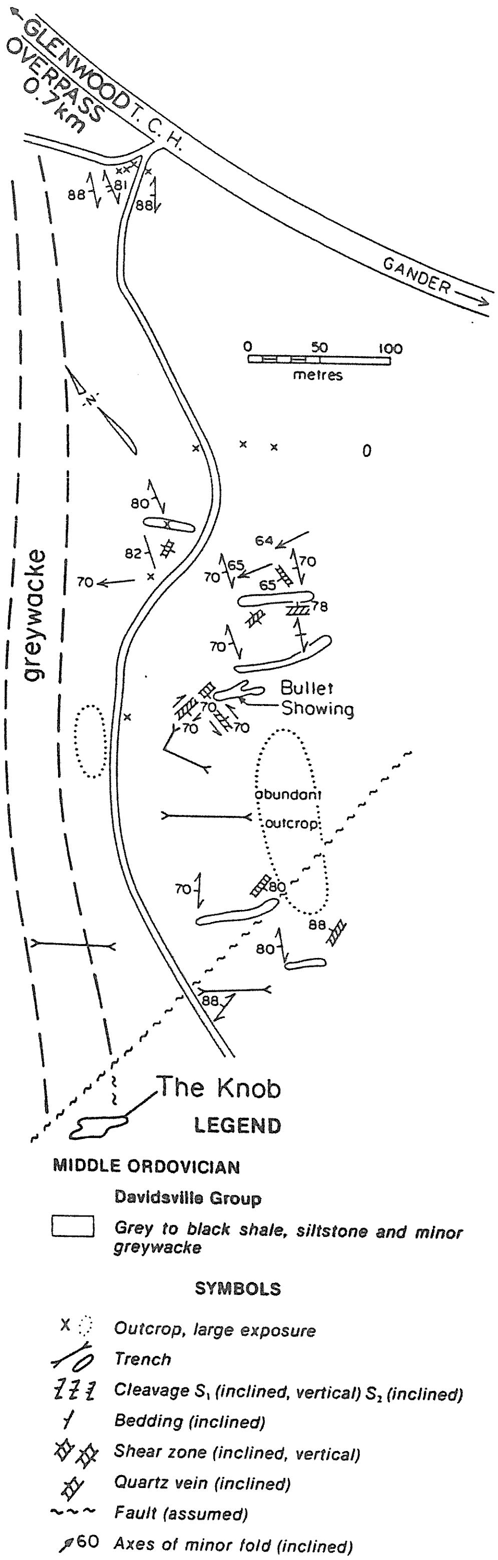


Figure 9: Geology of the Bullet prospect and location of the Knob prospect

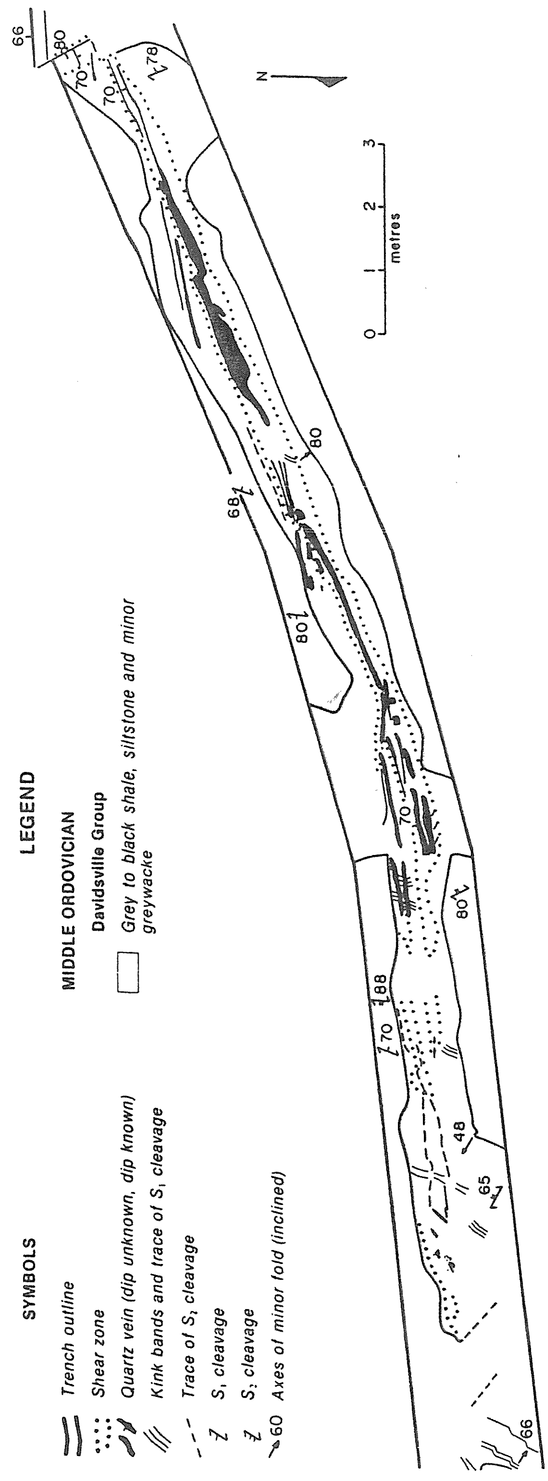


Figure 10: Trench map of the Bullet prospect showing the brecciation of the quartz veins, the shear zone that hosts the veins and the sinistral shear that offsets the mineralized shear.

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NOTE: Geological Survey Branch file numbers are included in the square brackets.