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# SUMMARY OF THE GEOLOGY BETWEEN LA POILE BAY AND COUTEAU BAY (11O/9 AND 11O/16), SOUTHWESTERN NEWFOUNDLAND

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## ABSTRACT

*The geology of the La Poile Bay–Couteau Bay region is summarized by describing the evolution of the Bay d'Est, Cinq Cerf and Grand Bruit fault zones of the Hermitage Flexure system. Southeast-dipping listric thrusts or fold slides, important constituents of these fault zones, juxtapose Precambrian, Precambrian-Cambrian, Ordovician and Silurian rocks, which are separately disposed in four thrust sheets. Phyllite, schist and gneiss units of variable age, but of predominantly sedimentary and volcanic origin, were translated northwestward and dynamothermally metamorphosed in the greenschist facies during Silurian $D_1$ deformation. The thrusting of Precambrian schist–gneiss units over Precambrian–Cambrian phyllite units is thought, however, to have occurred during pre-Silurian movements in the Grand Bruit fault zone. An unconformity at the base of the Silurian La Poile Group is interpreted to be displaced by thrusting along an old fault structure in the Cinq Cerf fault zone.*

*The Siluro–Devonian $D_2$ deformation affected parts of each of the four thrust sheets after their assembly but prior to the cessation of regional metamorphism. $D_2$ deformation is best developed within the Silurian plutons and batholiths, and in country rocks marginal to these intrusions. Syn-$D_2$ extension of the thrust sheets facilitated the sheet-like emplacement of Silurian magmas of alternating felsic and mafic composition. It was also responsible for reorientating and then refolding $D_1$ or older structures and permitted, at least within the thrust sheet containing the La Poile Group, the infiltration of auriferous fluids along pre-existing foliations, folds and faults.*

## INTRODUCTION

The study area is located in the Central Mobile Belt of the Newfoundland Appalachians and forms part of the western Hermitage Flexure (Figure 1). It consists of several distinct structural and lithological assemblages, some of which may correlate with the Avalon and Dunnage zones. The region between La Poile Bay and Couteau Bay in southwestern Newfoundland comprises the Grand Bruit–Cinq Cerf map area surveyed in 1986 (O'Brien, 1987) and the La Poile Bay–Roti Bay map area surveyed in 1987 (O'Brien, 1988).

The purpose of this report is to present 1:100,000 scale compilation maps and 1:50,000 scale sections of the study area showing the regional disposition of lithological units and major structures. In addition, the geological history of the region is summarized from the perspective of local faults within the Hermitage Flexure system, and new correlations and age assignments of lithostratigraphic units and tectonic structures are suggested. In this paper, the names of informal map units are distinguished by the use of upper case to identify place and lower case to distinquish representative lithology.

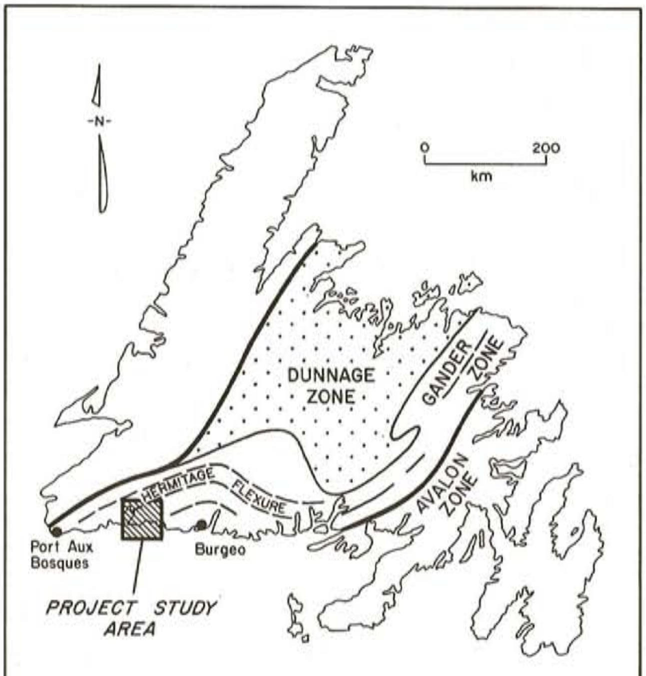


**Figure 1.** *Location map showing the study area in relation to the Hermitage Flexure and the Avalon, Gander and Dunnage Zones.*

## GENERAL STATEMENT

The region between La Poile Bay and Couteau Bay is underlain by stratified and intrusive rocks ranging from the Precambrian to the Devonian (Figure 2; Cooper, 1954; Chorlton and Dallmeyer, 1986; Dunning *et al.*, 1988; Dunning and O'Brien, *in press*). The regional distribution

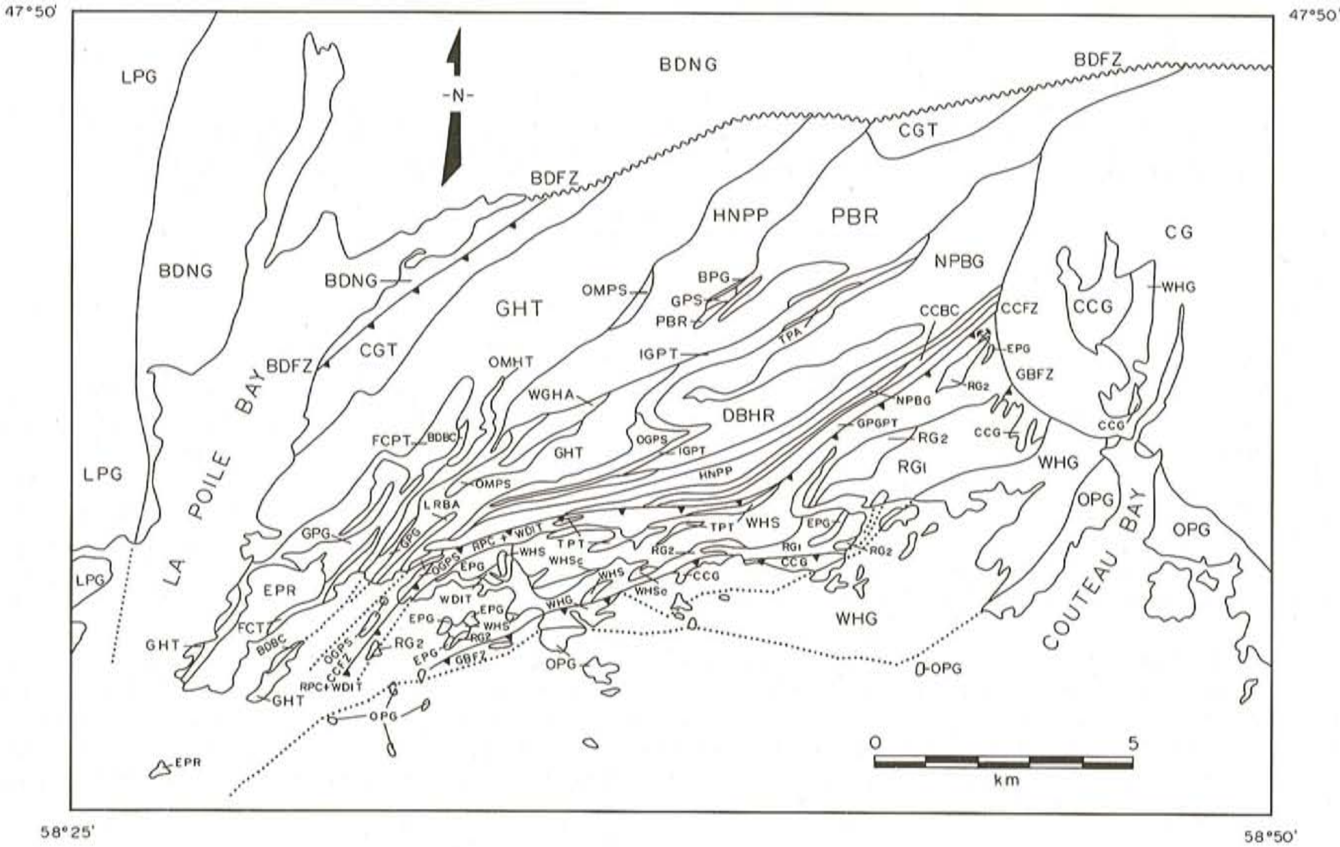


**Figure 2.** *Geological map of the region between La Poile Bay and Couteau Bay, southwestern Newfoundland (1:100,000 scale). Location of the Hope Brook Gold Mine is indicated.*

## LEGEND

**DEVONIAN**

**Plutonic Rocks**

| CG | *Chetwynd Granite: pink, equigranular biotite, granite; microspherulitic dykes* |
|---|---|

**SILURIAN**

**La Poile Group**

Cross Gulch tuff

| CGT | *lithic tuff composed of a variety of volcanic fragments, minor argillite and sandstone* |
|---|---|

Gallyboy Harbour tuff

| GHT | *pink, medium and coarse, locally layered and stratified, quartz–feldspar crystal tuff; rare blocks of volcanic and sedimentary rocks* |
|---|---|

Flint Cliff Pond tuff

| FCPT | *buff-weathered lithic tuff; coarse agglomerate composed of massive, pink rhyolite blocks; minor siliciclastic beds and rare lava flows* |
|---|---|

Eastern Point rhyolite

| EPR | *massive, pink, aphanitic lava; locally welded* |
|---|---|

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**LEGEND**
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French Cove tuff

| FCT | *well-stratified, lithic tuff and breccia containing sedimentary and volcanic fragments; minor lithic–crystal tuff* |
|---|---|

Guiders Pond grit

| GPG | *poorly sorted, grey-brown, locally stratified, quartz–feldspar grit and tuffaceous wacke; minor boulder conglomerate and olistostrome; rare slate* |
|---|---|

Black Duck Brook conglomerate

| BDBC | *polymictic, cobble and boulder conglomerate; siliciclastic sandstone interbedded with laminated argillite; minor grey slate* |
|---|---|

Old Man Hill tuff

| OMHT | *buff-weathered, fine grained, lithic tuff composed of pink rhyolite fragments* |
|---|---|

Withy Gulch Hill agglomerate

| WGHA | *agglomerate and breccia composed of massive, flow-banded and flow-folded rhyolite; minor pink and cream rhyolite* |
|---|---|

Old Man Pond slate

| OMPS | *grey slate and laminated argillite; minor thin-bedded sandstone and lithic tuff* |
|---|---|

Little Roti Bay agglomerate

| LRBA | *crudely stratified, coarse agglomerate and breccia containing polymictic volcanic blocks; purple lithic tuff* |
|---|---|

Outside Gull Pond slate

| OGPS | *grey slate and laminated argillite; rare thin-bedded sandstone* |
|---|---|

Georges Pond slate

| GPS | *grey slate and laminated argillite* |
|---|---|

Butterfly Pond grit

| BPG | *poorly sorted, grey-brown, quartz–feldspar grit and tuffaceous wacke; grey slate* |
|---|---|

Phillips Brook rhyolite

| PBR | *massive and finely laminated, cream and pink lava; breccia composed of flow-banded rhyolite* |
|---|---|

Twin Pond argillite

| TPA | *laminated argillite; minor cobble and boulder, polymictic conglomerate; rare sandstone and wacke* |
|---|---|

Inside Gull Pond tuff

| IGPT | *fine grained, buff-weathered, lithic tuff; local breccia composed of pink rhyolite fragments; welded lithic–crystal tuff* |
|---|---|

Dinner Box Hill rhyolite

| DBHR | *flow-banded and massive, pink, locally phenocrystic lava; rare rhyolite breccia* |
|---|---|

| HNPP | Hawks Nest Pond porphyry: biotite, quartz–feldspar porphyry |
|---|---|
| OPG | Otter Point granite: biotite, potassium feldspar-megacrystic granite |
| LPG | La Poile granite: biotite, potassium feldspar-megacrystic granite |

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**LEGEND**
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Northwest Pond Brook grit

| NPBG | *poorly sorted, grey-brown, massive and stratified, locally graded and cross-bedded, quartz–feldspar grit and tuffaceous wacke; rip-up clasts and large blocks of laminated argillite; clasts of metamorphic and plutonic rocks* |
|---|---|

Cinq Cerf Brook conglomerate

| CCBC | *thick-bedded, polymictic, boulder and cobble conglomerate interstratified with tuffaceous sandstone; local and exotic clasts of volcanic, sedimentary, plutonic and metamorphic rocks* |
|---|---|

Grand Bruit Gull Pond tuff

| GBGPT | *fine grained, light green, lithic tuff; red and purple lithic tuff and slate; quartz-pebble conglomerate* |
|---|---|

**ORDOVICIAN**

**Bay du Nord Group**

| BDNG | unseparated metavolcanic and metasedimentary schist |
|---|---|

**CAMBRIAN**

| EPG | Ernie Pond gabbro: hornblende-bearing gabbro and diorite; minor pyroxenite |
|---|---|
| $RG_2$ | Roti Granite: medium grained, blue-quartz-bearing tonalite and porphyry |
| WHG | Western Head granite: biotite–hornblende granodiorite |
| $RG_1$ | Roti Granite: coarse grained, blue-quartz-bearing granodiorite |

**PRECAMBRIAN–CAMBRIAN**

*phyllite units*

Roti Point conglomerate

| RPC | *red-coloured, polymictic, boulder and cobble conglomerate interstratified with thin-bedded tuff; clasts of vein quartz, jasper, tuff and foliated granitoids* |
|---|---|

Woody Duck Island tuff

| WDIT | *fine grained, light green, lithic tuff; red slate and tuffaceous sandstone* |
|---|---|

Round Pond tuff

| RPT | *pink, quartz (± feldspar) crystal tuff* |
|---|---|

Third Pond tuff

| TPT | *green lithic tuff; minor green agglomerate; rare beds of laminated argillite* |
|---|---|

Whittle Hill sandstone

| WHS | *well-bedded, buff-weathered, quartz-rich sandstone; green and grey, laminated argillite; grey slate* |
|---|---|
| $WHS_C$ | *conglomerate subfacies of the Whittle Hill sandstone; quartz-cobble conglomerate; polymictic cobble conglomerate containing clasts of foliated granitoids* |

**PRECAMBRIAN**

*schist-gneiss units*

**Cinq Cerf gneiss**

| CCG | paragneiss and schist; amphibolite gneiss |
|---|---|

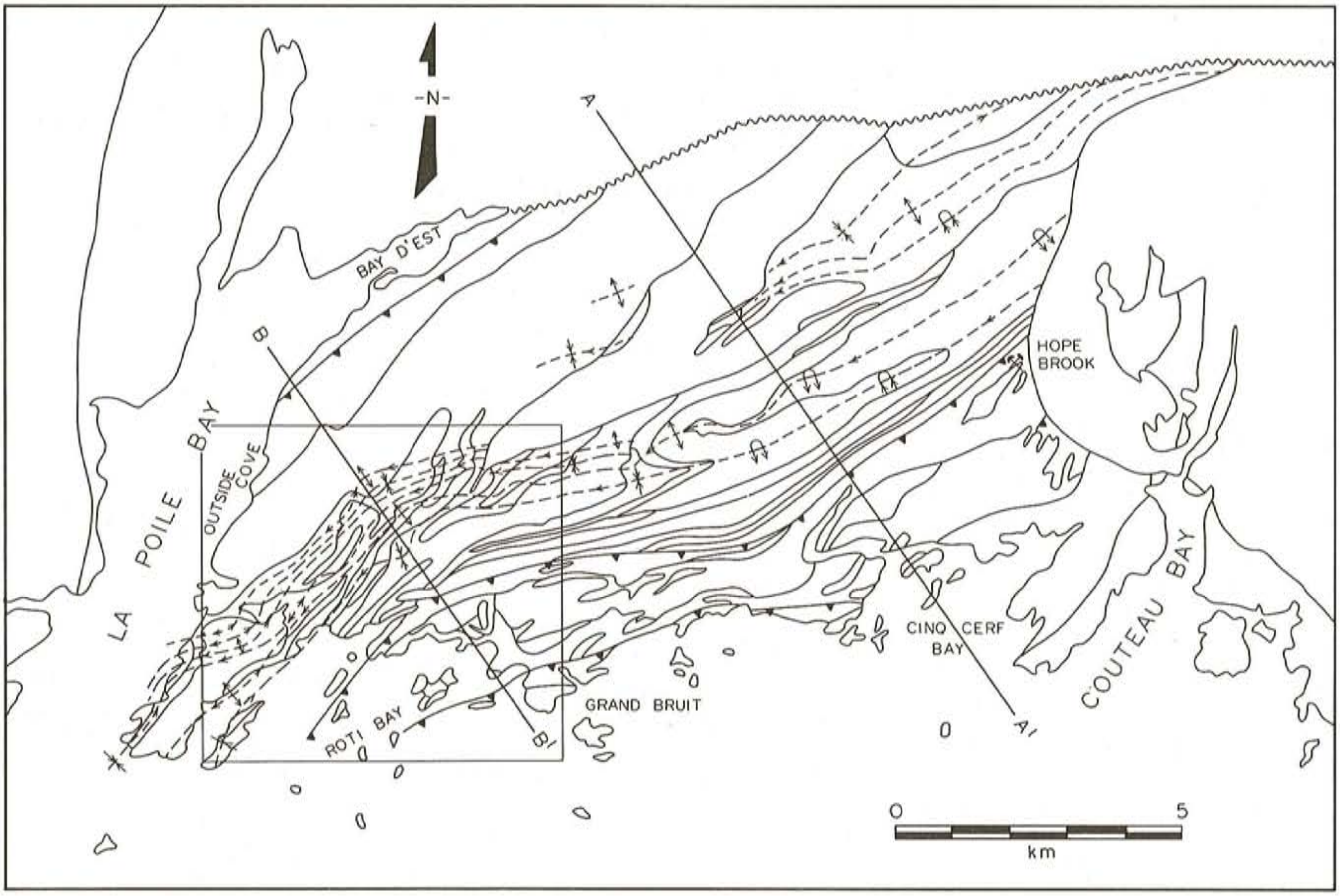


**Figure 3.** *Map showing the major structures of the La Poile Bay–Couteau Bay region on 1:100,000 scale. Traces of major folds and major faults are illustrated with dashed lines and solid barbed lines, respectively. Solid lines represent traces of lithological unit boundaries. See Figure 2 for legend and Figure 4 for key to symbols. Note areas where major folds are overturned and the location of the Hope Brook Gold Mine.*

of recently recognized Precambrian, Ordovician and Silurian metasedimentary and metavolcanic rocks (Dunning *et al.*, 1988) is controlled by three major faults; namely, the Grand Bruit (GBFZ), Bay d'Est (BDFZ) and Cinq Cerf (CCFZ) fault zones (O'Brien, 1987, 1988). The Bay d'Est and Cinq Cerf mylonite zones formed during Silurian $D_1$ shortening as synfolding thrusts (fold slides), defining the bottom and top, respectively, of a 5-km-thick thrust sheet (Figures 2 and 3). Greenschist facies rocks within the thrust sheet represent all of what is locally preserved of the recently dated Silurian La Poile Group. Lower–Middle Ordovician rocks regionally metamorphosed to the amphibolite facies between the Early Ordovician and Late Silurian (O'Brien *et al.*, 1986), occur beneath the Bay d'Est thrust and, in contrast to this writer's previous correlations, do not recur southeast of the Cinq Cerf or Grand Bruit fault zones. The Grand Bruit fault zone separates greenschist facies and upper amphibolite facies metamorphic rocks (Chorlton, 1978; O'Brien, 1988). The earliest displacements in the Grand Bruit fault zone were probably related to pre-Silurian folding and thrusting (see below), although the extent and nature of syn- to post-Silurian movements in the fault zone are unknown.

## REVISION OF STRATIGRAPHICAL SUCCESSION AND STRATIGRAPHICAL NOMENCLATURE

Recent geological and geochronological studies have produced significant information about the La Poile Bay–Couteau Bay region (Stewart, 1988a,b; Yule, 1987; Stewart and Stewart, 1988; Vaskovic and Wilton, 1988; Dunning *et al.*, 1988; Dunning *et al.*, *in preparation;* Dunning and O'Brien, *in press;* G. Dunning, personal communication, 1988). Refinements to the preliminary map of O'Brien (1987) and the legend (O'Brien, 1988) reflect the expanded data base and these changes have been incorporated into the 1:100,000 scale compilation map and legend presented here (Figure 2).

The most important revisions of the stratigraphical succession and nomenclature of the La Poile Bay–Couteau Bay region are listed below. The reader should consult a Table of Formations (O'Brien, 1987, Table 1, page 313) for a review of previous age and nomenclatural assignments and for the description of numbered units referred to in the following paragraphs.

1) Amphibolitic gneiss and schist (Unit 1 of O'Brien, 1987), subsequently referred to as the Cinq Cerf gneiss (CCG of O'Brien, 1988), already possessed gneissose and schistose foliation prior to intrusion of the latest Precambrian–earliest Cambrian (Dunning *et al.*, 1988, Dunning and O'Brien, *in press)* phase of $RG_1$ Roti Granite. CCG is now considered a Precambrian metamorphic unit.

2) Metasedimentary schist (Unit 2 of O'Brien, 1987) was correlated with the Bay du Nord Group (O'Brien, 1988) on the basis of lithological similarity, structural style and metamorphic grade, relative to the Silurian La Poile Group. However, it contained amphibolitic interlayers and possessed schistosity prior to the intrusion of granodiorite grouped with the $RG_1$ phase of the Roti Granite. It is, therefore, reassigned to the Precambrian Cinq Cerf gneiss.

3) Unseparated metasedimentary and metavolcanic formations of the Bay du Nord Group (Unit 3 of O'Brien, 1987; BDNG of O'Brien, 1988) only occur northwest of the Bay d'Est fault zone. Peak metamorphism of the Lower–Middle Ordovician (Chorlton and Dallmeyer, 1986) Bay du Nord Group probably occurred prior to the earliest deformation and metamorphism of the La Poile Group (O'Brien, 1988), although both groups constitute Lower Paleozoic metamorphic units. This may corroborate suggestions that the early metamorphism of the Bay du Nord Group was synchronous with eruption of La Poile Group volcanic rocks (Dunning *et al.*, *in preparation).*

4) Siliciclastic sedimentary rocks (Unit 6 of O'Brien, 1987) have been separated into three lithostratigraphical units (O'Brien, 1988). The Outside Gull Pond Slate (OGPS) and the Georges Pond Slate (GPS) comprise part of the Georges Brook Formation of the Silurian La Poile Group. The Whittle Hill sandstone (WHS) has been reassigned to an older, unnamed group of metasedimentary and metavolcanic rocks (see following sections on the Grand Bruit fault zone and the Cinq Cerf hanging wall). The $RG_1$ Roti Granite provides the minimum depositional age of the Precambrian Whittle Hill sandstone, whereas the $RG_2$ Roti Granite delimits its pre-Ordovician metamorphic age.

5) In the Grand Bruit–Cinq Cerf area, felsic tuff and quartz pebble conglomerate, formerly included with Unit 6 of (O'Brien, 1987), are now separated from it and grouped together to form the Grand Bruit Gull Pond tuff of (O'Brien, 1988). GBGPT is now considered to be the oldest member of the La Poile Group and is thought to stratigraphically underlie Unit 7 polymictic boulder conglomerate (O'Brien, 1987), which is herein renamed the Cinq Cerf Brook Conglomerate (CCBC). Units 8, 9, 11 and 12 of O'Brien (1987) have been called the Dinner Box Hill rhyolite (DBHR), Northwest Pond Brook grit (NPBG), Cross Gulch tuff (CGT) and Phillips Brook rhyolite (PBR), respectively (O'Brien, 1988). Unit 10 is now separated into the Twin Pond argillite (TPA), Inside Gull Pond tuff (IGPT) and Gallyboy Harbour tuff (GHT). The revised outcrop pattern of DBHR (Unit 8) shows it to be stratigraphically pinched out between NBPG and IGPT but also to be regionally infolded with these units (Figure 2).

6) In the La Poile Bay–Roti Bay area, felsic lithic tuff and overlying polymictic boulder conglomerate, originally correlated with GBGPT and CCBC (O'Brien, 1988), are herein renamed the Woody Duck Island tuff (WDIT) and the Roti Point conglomerate (RPC), respectively. Intruded by the Ernie Pond gabbro (EPG) and the $RG_2$ Roti Granite, the WDIT and RPC units have been separated from the Silurian La Poile Group. The Woody Duck Island tuff appears to be in conformable contact with the Round Pond tuff (RPT) and the presumably Precambrian Whittle Hill sandstone. In the La Poile Bay–Couteau Bay region, mafic tuff and agglomerate are restricted to Unit 5 of O'Brien (1987), later named the Third Pond tuff (TPT) by O'Brien (1988). These mafic volcanic rocks are interstratified with cross-bedded quartz wacke and argillite of the Whittle Hill sandstone and quartz–feldspar crystal tuff belonging to the Round Pond tuff. Rare felsic volcanic layers in WHS wacke and local bombs of felsic volcanic material in TPT agglomerate indicate that mafic and felsic volcanism occurred together with sedimentation during deposition of this unnamed group of Precambrian–Cambrian metasedimentary and metavolcanic rocks.

7) A previously unseparated and unnamed unit of felsic tuff and less common sandstone comprising the uppermost part of the La Poile Group in the La Poile Bay–Roti Bay area (O'Brien, 1988) is here correlated with the Cross Gulch tuff (CGT), which outcrops in the Grand Bruit–Cinq Cerf area (O'Brien, 1987).

## CINQ CERF FAULT ZONE (CCFZ)

Fault rocks of the Cinq Cerf zone everywhere separate the Silurian La Poile Group from an unnamed group of Precambrian–Cambrian phyllite units (Figure 2; Dunning and O'Brien, *in press).* In the Grand Bruit–Cinq Cerf area, the fault zone is marked by moderately southeast-dipping mylonite or by platy or straightened rocks showing large total strains. In the La Poile Bay–Roti Bay area, a steeply inclined zone of cataclasite is developed along part of the southeasternmost body of Silurian Hawks Nest Pond porphyry and is host rock to a northeast-trending, microspherulitic dyke of the Chetwynd Granite. Near the head of Little Roti Bay, the east-northeast-trending cataclasite zone transects a northeast-trending, subvertical, Silurian $D_1$ platey zone at the base of the Outside Gull Pond Slate (lower-middle La Poile Group).

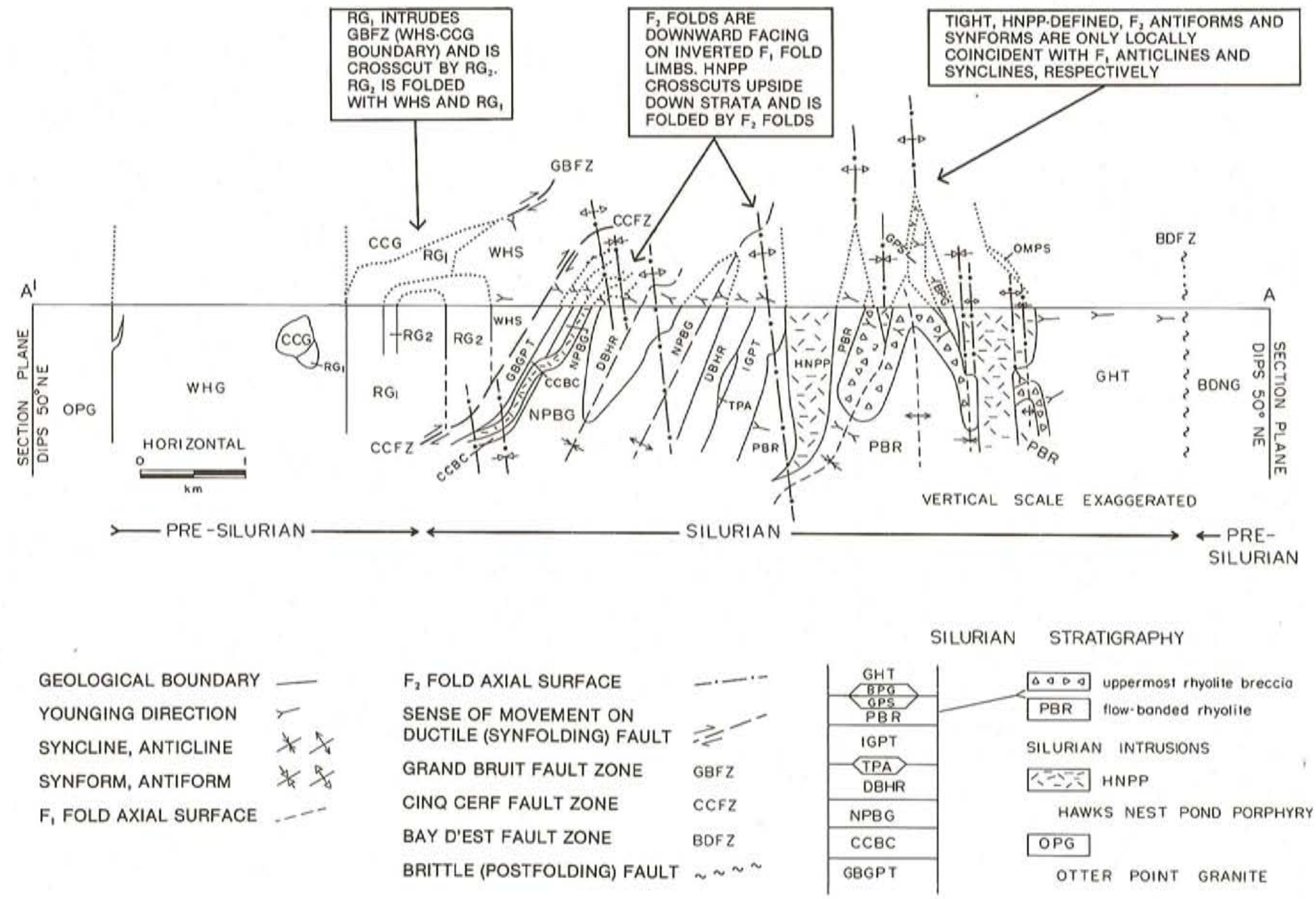


**Figure 4.** *Representative geological section of the Grand Bruit–Cinq Cerf area. Horizontal scale is 1:50,000, vertical scale is exaggerated and section plane dips 50° NE. Insets summarize and identify important geological relationships. Folds are not necessarily seen in profile. See Figure 3 for line of section.*

## CCFZ Footwall

In section AA' (Figures 3 and 4), the Cinq Cerf fault zone is a Silurian $D_1$ thrust zone, across which a hanging wall sequence of Precambrian–Cambrian stratified rocks and pre-Silurian intrusive rocks are translated northwestwards, over a footwall sequence of Silurian stratified and intrusive rocks. Beneath the synfolding thrust or fold slide, the La Poile Group is isoclinally folded by southeasterly inclined, overturned, major $F_1$ folds that display consistent S-shapes and sinistral vergence (Figures 3 and 4). In the Grand Bruit–Cinq Cerf area, for at least 3 km beneath the $D_1$ thrust, inverted members of the La Poile Group predominate over right-way-up members. This is consistent with common observations of upward-facing, $S_1$ slaty cleavage, lying more gently than bedding in upside-down Silurian phyllites (O'Brien, 1987).

The gentle to moderate plunge of the S-shaped, $F_1$ major folds in the Grand Bruit–Cinq Cerf area means that the stratigraphical order of La Poile Group members can be discerned from a map by looking southwest down-the-plunge of fold hinge zones (Figure 3) or from a section by looking northwest on the long limbs of regional folds (Figure 4). By doing so, it is evident that the Cinq Cerf fault zone is regionally transgressive relative to La Poile Group stratigraphy, the amount of stratigraphical separation apparently increasing southwestward. Therefore, as the thrust zone is traced northeastward, progressively older parts of the La Poile Group are presumably brought from subcrop to outcrop. The oldest part of the Grand Bruit Gull Pond tuff (lowermost La Poile Group) occurs near the Hope Brook Gold Mine where, regionally inverted and unaltered, it is intruded by the Silurian Hawks Nest Pond porphyry and is terminated by the Devonian Chetwynd Granite (see also Stewart and Stewart, 1988; Stewart, 1988a).

A $D_1$ transition from near upright to subrecumbent structures occurs on various scales and is a characteristic feature of the La Poile Group near the $D_1$ mylonite belts that form its boundaries. The overturned, southeasterly inclined, major $F_1$ folds present in the La Poile Group beneath the southeast-dipping $D_1$ thrust, are paired with upright, major $F_1$ folds that plunge gently in the central part of the thrust

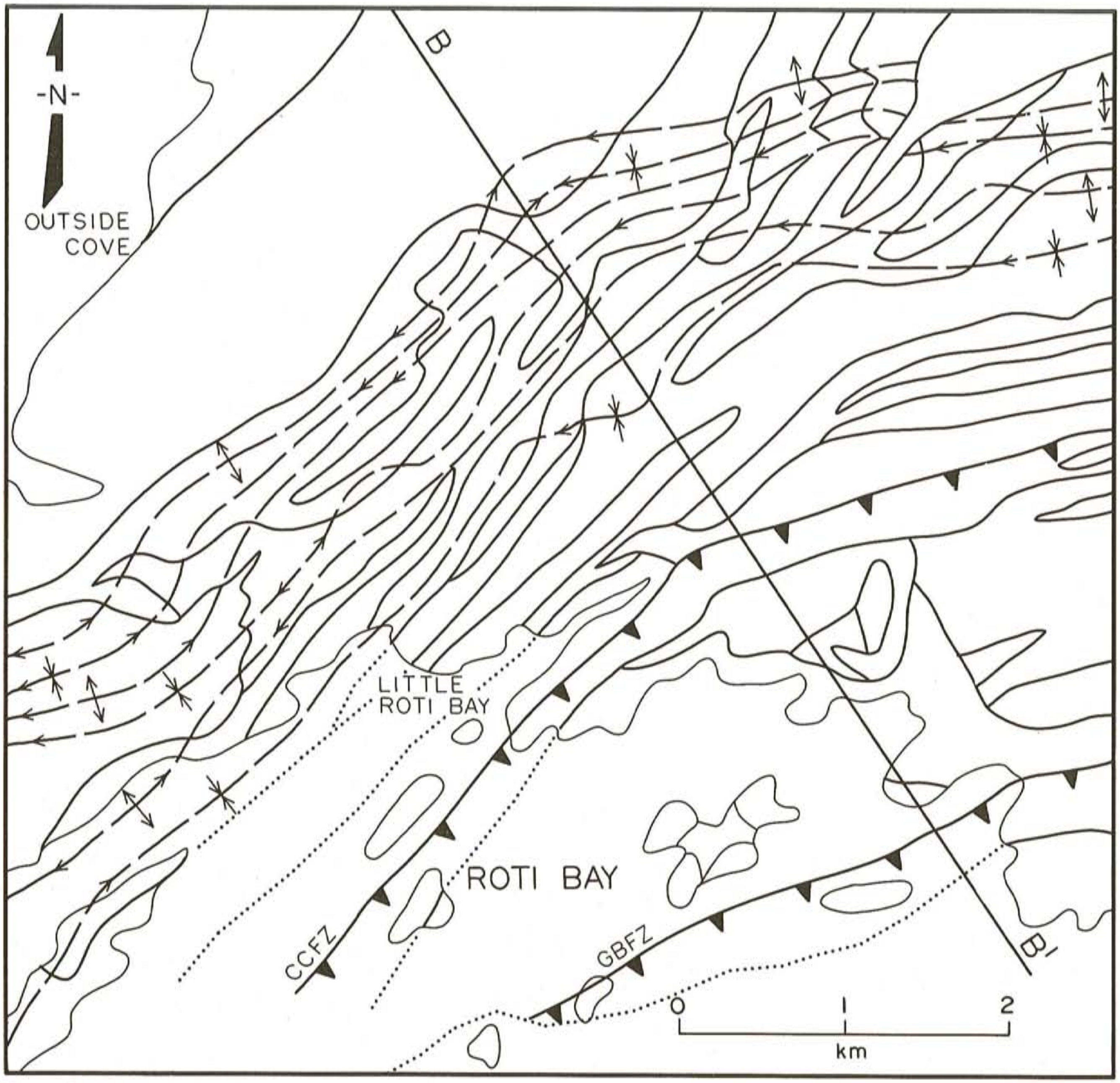


**Figure 5.** *Detailed map of the Roti Bay–Outside Cove area illustrating, in particular, the nature of the periclinal folds affecting members of the Georges Brook Formation of the La Poile Group northwest of the Cinq Cerf fault zone. See inset in Figure 3 for regional setting.*

sheet (e.g., the PBR-cored anticlines in section AA', Figure 4). Likewise, moderately plunging, overturned $F_1$ folds are traceable southwestward down-the-plunge into upright periclinal folds (Figures 2, 3 and 5). Steeply plunging anticlines–synclines, and neutral $F_1$ folds of thin, wedge-shaped members of the La Poile Group occur immediately northwest of the narrow 'straightened' zone at the base of OGPS in the Cinq Cerf fault zone (Figure 6). Platey OGPS rocks displaying steeply dipping $S_1$ foliation and vertically plunging $L_1$ lineation parallel to $F_1$ fold hinges, indicate vertical extension (translation) of the La Poile Group near an upright, $D_1$ fold slide. Some La Poile Group members comprising the sidewall sequence northwest of the upright fold slide, can be traced continuously into the footwall sequence beneath the gently inclined fold slide in the Grand Bruit–Cinq Cerf area. Therefore, the major $D_1$ structure is assumed to be a ductile listric thrust composed of vertical- and southeast-dipping segments. Regardless of the attitude of ductile fault rocks, Silurian strata moved downward relative to pre-Silurian strata everywhere along the CCFZ during $D_1$ deformation (Figures 4 and 6). The listric thrust forms both vertical and southeast-dipping footwall ramps in the La Poile Group; fold-related contraction faulting did not produce thrust flats.

Within the Silurian thrust plate, sheet intrusion of dykes and sills of Silurian diabase and Silurian quartz–feldspar porphyry was controlled by pre-existing $F_1$ folds and $D_1$ faults

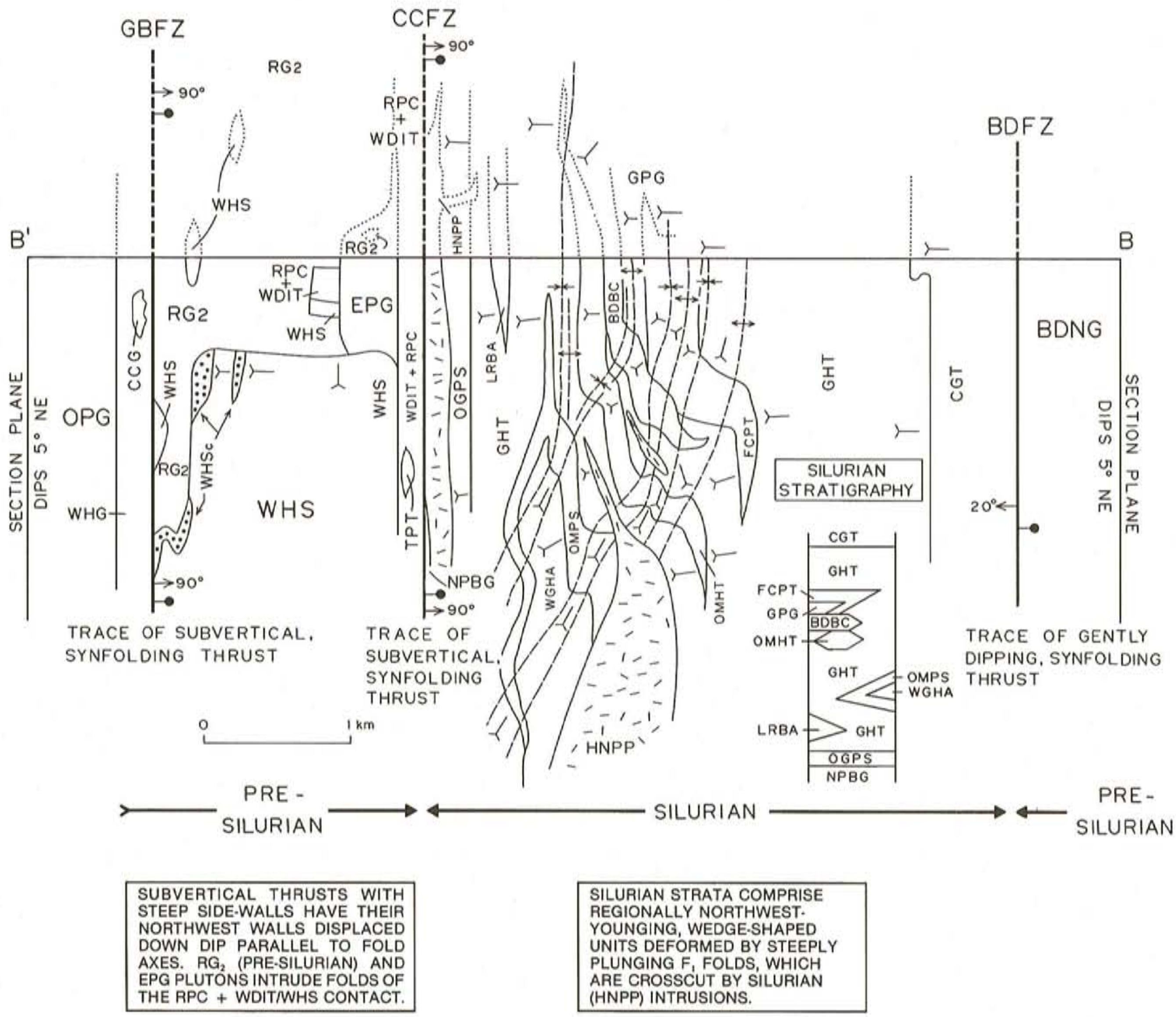


**Figure 6.** *Representative geological section of the La Poile Bay–Roti Bay area. Horizontal scale is 1:50,000, vertical scale is slightly exaggerated and section plane dips 5° NE. Insets summarize relationships of pre-Silurian rocks between the Grand Bruit fault zone (GBFZ) and the Cinq Cerf fault zone (CCFZ) and relationships of Silurian rocks northwest of CCFZ. Folds are not necessarily seen in profile. See Figure 3 for line of section and Figure 4 for key to symbols.*

in the La Poile Group. As a result, the intrusive rocks also reflect the upright-recumbent structural transition. For example, subvertical, discordant, diabase intrusions occupy the hinge zones of EPR–GPG–FCPT-cored, upright $F_1$ periclines (Figures 3 and 5) in the centre of the thrust sheet; whereas, subhorizontal, concordant, diabase intrusions are emplaced into thrust-generated $D_1$ mylonite at the structural base of the La Poile Group.

The southeasternmost body of Hawks Nest Pond porphyry (Figures 2 and 3) intrudes several members of the lower part of the La Poile Group as the intrusion follows the course of the Cinq Cerf fault zone. In the Grand Bruit–Cinq Cerf area, the southeast-dipping, slightly transgressive, porphyry sill intrudes upside down, highly deformed strata on the inverted limb of an overturned, DBHR-cored syncline (Figure 4). Traced continuously southwestward into the La Poile Bay–Roti Bay area, the HNPP sill becomes vertical where the $F_1$ syncline becomes upright. Here, the porphyry is hosted by right-way-up, northwest-dipping or vertical, northwest-younging strata on the upright limb of the fold (section BB', Figure 6). In both areas, the porphyry intrusion is emplaced parallel to axial planar $S_1$ slaty cleavage and contains xenoliths of this foliation (O'Brien, 1988). Extensive, northeast-trending bodies of HNPP cut across the limbs and hinges of gently and steeply plunging, $F_1$ major folds and, thereby, transgress most members of the La Poile Group (Figures 3, 4 and 6).

A major effect on the geometry of the thrust plate caused by the emplacement of Silurian sheet intrusions is the distortion and local reorientation of $F_1$ folds and $S_1$ cleavage in the La Poile Group (O'Brien, 1987). A map showing the regional traces of $F_1$ axial surfaces illustrates that the $F_1$ folds near the northeastern and southeastern borders of the main body of the Hawks Nest Pond porphyry were either sharply transected by the sheet intrusion or displaced and locally reoriented near its intrusive margins (Figure 3). The $D_1$ structures affected by the Hawks Nest Pond porphyry were distorted from the regional $D_1$ trend prior to being overprinted by $F_2$ upright folds and $F_3$ cross folds. Bauer (1986) describes a similar example of pluton emplacement and multiple folding in the Archean of Minnesota. Patterns of $F_1$ axial traces in the southwesternmost part of the La Poile Group may indicate the presence of HNPP porphyry bodies at shallow depth.

The Silurian $D_1$ and Siluro–Devonian $D_2$ deformations are regionally coaxial, both producing northeast-trending structures in the La Poile Group. Interference of $F_1$ and $F_2$ folds and overprinting of $S_1$ and $S_2$ foliation are, however, restricted to areas where $D_1$ structures were suitably oriented to be affected by $D_2$ deformation. This configuration only existed where steep $D_1$ structures were reoriented or bent to lie flatter near intrusion margins or, near southeast-dipping thrusts, where $D_1$ structures originally formed with gentle inclinations. $F_2$ folds deform $D_1$ mylonites in the Cinq Cerf (Figure 4) and Bay d'Est (O'Brien, 1988) fault zones.

Quartz–feldspar porphyry and diabase intrusions of Silurian age are locally foliated by vertical $S_2$ cleavage and folded by steeply to gently plunging $F_2$ folds. In the central part of the Silurian thrust sheet, where all structures are generally steeply dipping, country-rock defined, open $F_1$ anticlines and synclines are locally coincident with intrusion-defined, tight $F_2$ antiforms and synforms, respectively (section AA', Figure 4). However, periclinal $F_2$ folds of the country rocks are more commonly developed on $F_1$ fold limbs, where they are variably upward or downward facing (e.g., NPBG-cored refolded fold in Figure 3 and in section AA' in Figure 4). Typically open and upright to asymmetrical, $F_2$ folds consistently form Z-shaped fold pairs that display dextral vergence. In La Poile Group phyllite, $F_2$ folds have axial planar $S_2$ crenulation cleavage.

Gold and copper mineralization is found in the central part of the Silurian thrust sheet. Pyrite and chalcopyrite occur in zones of sericitic and silicic alteration developed in the main and satellite bodies of the Hawks Nest Pond porphyry and in the PBR, NPBG, GHT, WGHA, OMHT and FCPT members of the La Poile Group peripheral to the intrusion. This period of Silurian gold mineralization is post-$F_1$ –pre-$F_2$ in age.

**CCFZ Hanging Wall**

Pre-Silurian rocks in the hanging wall and side wall of the $D_1$ listric thrust in the Cinq Cerf fault zone have a similar lithological composition, degree of metamorphism, intrusive history, structural association and alteration style as the Silurian rocks in the footwall of the structure. As a result, with the exception of the original surveyor (Cooper, 1954), all previous workers in the La Poile Bay–Couteau Bay region (Chorlton, 1978,1980; Swinden, 1981,1984; McKenzie, 1986; O'Brien, 1987,1988) assigned stratified rocks outcropping between the Cinq Cerf and Grand Bruit fault zones to the La Poile Group. In previous reports, this writer implied that the Cinq Cerf fault zone was an intra-La Poile Group splay off the Grand Bruit fault zone, which contained the $D_1$ thrust separating Silurian phyllite from pre-Silurian schist and gneiss (O'Brien, 1988). Furthermore, because the Whittle Hill sandstone (Figure 2) was taken to be the stratigraphically lowest member of the La Poile Group, the Hope Brook Gold Mine was considered to be hosted, at least in part, by Silurian deposits.

The common premise of all previous workers was that the intrusive rocks in the CCFZ hanging-wall sequence either formed part of the La Poile Group or were younger than it. Dunning and O'Brien *(in press)* report, however, a latest Cambrian–earliest Ordovician crystallization age for the $RG_2$ phase (Figure 2) of the Roti Granite. This suggests that the postulated correlations and age assignments of previous workers are in doubt. In the La Poile Bay–Roti Bay area, as illustrated in section BB' in Figure 6, the tonalite and porphyry ($RG_2$) phase of the Roti Granite intrudes the Whittle Hill sandstone (WHS) and the Woody Duck Island Tuff (WDIT). Because the conglomeratic subfacies of the Whittle Hill sandstone (WHSc), the Third Pond tuff (TPT), the Round Pond tuff (RPT) and the Roti Point conglomerate (RPC) are interstratified with one or both of WHS and WDIT (Figure 2), the depositional age of all the above units is presumed older than the $RG_2$ phase of the Roti Granite, dated as 499 $^{+3}_{-2}$ Ma (Dunning and O'Brien, *in press).*

In the Grand Bruit–Cinq Cerf area, the $RG_1$ phase of the Roti Granite intrudes the Whittle Hill sandstone and is reported to have yielded a latest Precambrian–earliest Cambrian (563 ± 4 Ma) crystallization age (Dunning *et al.*, 1988; Dunning and O'Brien, *in press).* This gives the minimum depositional age of the Whittle Hill sandstone as pre-earliest Cambrian. In this area, the $RG_2$ phase of the Roti Granite is emplaced as sheets along steeply dipping beds of the Whittle Hill sandstone. $RG_2$ screens cross-cut the $RG_1$–WHS intrusive contact (Figure 4) and are folded along with bedding-parallel phyllitic foliation in the Whittle Hill sandstone (O'Brien, 1987). This writer is uncertain if the primary foliation in the Whittle Hill sandstone is Precambrian or Cambrian in age.

The Silurian La Poile Group contains granodiorite clasts with a pre-incorporation foliation as well as clasts of porphyry injected by mafic intrusions. These fragments are lithologically similar to pre-Silurian intrusions hosted by the unnamed group of Precambrian–Cambrian sedimentary and volcanic rocks. This observation is in agreement with recently determined ages of the $RG_1$ and $RG_2$ phases of the Roti Granite (Dunning and O'Brien, *in press*). Furthermore, it indicates that deposition, intrusion, low-grade metamorphism and initial deformation of the CCFZ hanging-wall sequence took place prior to the time period in which the La Poile Group was deposited. Cooper (1954) originally alluded to an unconformity at the base of the La Poile Group, as he defined it, although he did not mention an exposed surface of unconformity. In the Grand Bruit–Cinq Cerf area, he drew the lower boundary of the group near CCBC and GBGPT; whereas, in the La Poile Bay–Roti Bay area, it was drawn near RPC and WDIT. As first suggested by Marten (1984) and re-emphasized by Stewart (1986), the Cinq Cerf shear belt or mylonite zone has probably displaced a sub-La Poile Group unconformity, which originally lay in the La Poile Bay–Couteau Bay region near what is now the site of the Cinq Cerf fault zone.

## BAY D'EST FAULT ZONE (BDFZ)

Fault rocks of the Bay d'Est zone everywhere separate the Ordovician Bay du Nord Group from the Silurian La Poile Group (Figure 2; O'Brien *et al.*, 1986; Dunning *et al.*, 1988). A zone of greenschist facies mylonite, presumably derived from both groups, occurs along the southeast coast of Bay d'Est. There, the mylonite zone dips gently beneath a Silurian hanging-wall sequence of subrecumbent $F_1$ folded phyllites that belong to a locally inverted part of the Cross Gulch tuff (uppermost La Poile Group). It is unknown if the Ordovician footwall sequence of southeast-dipping Bay du Nord schist is inverted or right-way-up beneath the Bay d'Est mylonite zone. However, in contrast to the Cinq Cerf fault zone, younger rocks overthrusted older rocks during Silurian $D_1$ movements in the Bay d'Est fault zone.

Where BDFZ mylonites dip subvertically in the fault zone, Bay du Nord Group rocks in the sidewall display an upright, bedding-parallel, $S_2$ crenulation cleavage that is associated with transposition and grain-size reduction of $S_1$ schistosity and retrogression of amphibolite facies schist (O'Brien, 1987,1988). This crenulation cleavage is also regionally expressed in the southeast-dipping footwall sequence well below the thrust. Here, it occurs as a sporadically developed, locally downward facing, spaced foliation that is axial planar to gently plunging, upright folds. These secondary folds refold southeasterly inclined, peak-metamorphic, intrastratal folds in the Bay du Nord Group. A similarly oriented, commonly downward facing, crenulation cleavage in hanging wall phyllite, developed during Siluro–Devonian $D_2$ deformation (O'Brien, 1987, 1988). Strong, inhomogeneous $D_2$ deformation of footwall ramps is a common feature of the Bay d'Est fault zone that is not observed in the Cinq Cerf structure.

The mylonite zone outcropping along the Bay d'Est coast is transected, near the head of the bay, by a fault zone of incohesive, random-fabric breccia and gouge (Figure 3). A steeply dipping structure within the Bay D'Est fault zone, it is marked by a distinct topographical depression throughout the La Poile Bay–Couteau Bay region. Unlike the $D_1$- and $D_2$-activated ductile fault, the brittle fault cross-cuts many of the major folds in the La Poile Group as well as the Devonian Chetwynd Granite (Figure 3). The matrix texture of the fault rocks, together with the presence of schist, phyllite and mylonite fragments, probably indicate that brittle faulting occurred after regional metamorphism of the Bay du Nord and La Poile groups. Quartz–chlorite–potassium feldspar veins invade gouge and breccia, and are associated with patchy silicification, sericitization, pyritization and gold mineralization.

## GRAND BRUIT FAULT ZONE (GBFZ)

At some time prior to Cambro–Ordovician intrusion and Silurian deposition, the Grand Bruit fault zone probably formed the northwestern boundary of exposed Cinq Cerf gneiss. On the scale of the La Poile Bay–Couteau Bay region, the Grand Bruit fault zone separates a hanging-wall sequence of Precambrian Cinq Cerf gneiss from a footwall sequence of unnamed Precambrian–Cambrian metasedimentary and metavolcanic rocks (Figure 2). However, on more detailed scales, intrusions within the fault zone intervene between gneiss and phyllite, and are commonly mylonitized along with gneiss or phyllite. Along the coast, GBFZ mylonite dips vertically or steeply southeast. However, in the northeastern part of the region near the Hope Brook Gold Mine, subhorizontal platey zones occur near the base of the Cinq Cerf gneiss (and the GBFZ ?).

The Cinq Cerf gneiss is narrowest near Roti Bay and widest north of Couteau Bay (Figures 2 and 3). On the Roti Bay islands, it is intruded by the Otter Point granite, which is assumed to terminate the CCG outcrop belt southwestward (Figure 2). In the northeastern part of the region, the Cinq Cerf gneiss is intruded by the posttectonic Chetwynd Granite, although a large roof pendant within the intrusion contains the on-strike extension of the CCG outcrop belt. Therefore, in the area surveyed, the Grand Bruit fault zone is transected by the Silurian Otter Point Granite and Devonian Chetwynd Granite (Figure 2).

In the La Poile Bay–Couteau Bay region, intrusions of known and presumed pre-Silurian age are restricted to the Grand Bruit fault zone, the GBFZ footwall and the GBFZ hanging wall. The $563 \pm 4$ Ma phase of the Roti Granite ($RG_1$) is interpreted to be emplaced along the Grand Bruit fault zone (Figure 4). Along its northwestern boundary, $RG_1$ Roti Granite intrudes the Whittle Hill sandstone; along its southeastern boundary, $RG_1$ Roti Granite contains xenoliths of Cinq Cerf gneiss. In places, only 250 m of this lenticular granite separate the Whittle Hill sandstone and the Cinq Cerf gneiss. $RG_1$ Roti Granite is considered a stitching pluton linking GBFZ hanging wall and GBFZ footwall because, at the time of latest Precambrian–earliest Cambrian intrusion, the CCG unit was already gneissic and yet lay very close to the WHS unit, which was never regionally metamorphosed above chlorite-grade. The overall distinction between WHS and CCG units, makes it unlikely that the pre-$RG_1$regional metamorphic gradient was notably steep and that the Whittle Hill sandstone comprised part of a succession that was the protolith of the Cinq Cerf gneiss (Cooper, 1954; Chorlton, 1978,1980). Rather, their pre-$RG_1$ relationship was probably faulted or unconformable; this writer favours the former interpretation because of the emplacement mode of $RG_1$ Roti Granite (O'Brien, 1988).

The GBFZ footwall is host to a variety of pre-Silurian intrusions, which extend along the strike of the footwall for considerable distances but do not occur in the GBFZ hanging wall. The same relationship applies to presumed pre-Silurian intrusions that occur exclusively in the hanging wall. Most of these variably deformed intrusive units are younger than the $RG_1$ pluton and, therefore, were emplaced after the presumed earliest displacements in the Grand Bruit fault zone. Nevertheless, continued movements along the structure apparently partitioned the intrusions so that they presently comprise either footwall or hanging-wall intrusive suites.

The GBFZ footwall is host to the $RG_2$ Roti Granite, the Ernie Pond gabbro and intrusive felsite bodies; the latter is not shown on the legend of Figure 2. The Western Head granite is spatially associated with the Cinq Cerf gneiss in the GBFZ hanging wall. Mafic dyke swarms and sheets of quartz-feldspar porphyry are present throughout the footwall and the hanging wall; however, they are most intensely deformed in the Grand Bruit mylonite zone.

Comparison of sections drawn through the GBFZ hanging wall and footwall gives an indication of the protracted history of intrusion and differential displacement that occurred near the Grand Bruit fault zone (Figures 4 and 6). In section BB', the contact of the Cambro–Ordovician $RG_2$ Roti Granite dips vertically and cross-cuts vertical, northwest-younging, WHSc conglomerate and southwest-younging, WHS sandstone on the limb and in the hinge zone, respectively, of northeast-trending, steeply southwest-plunging, major folds. The Woody Duck Island tuff (WDIT) and the Roti Point conglomerate (RPC) are also deformed by these folds, which have vertical, axial planar, slaty cleavage. Although only the Whittle Hill sandstone occurs as variably deformed, map-scale enclaves within $RG_2$ Roti Granite, the Woody Duck Island tuff, Roti Point conglomerate and Whittle Hill sandstone were regionally folded so that all units had a northwest strike prior to being intruded by the $RG_2$ pluton and the younger EPG pluton. Contact metamorphic porphyroblasts in hornfelses around bosses of Ernie Pond gabbro overgrow the regional slaty cleavage in several of the Precambrian–Cambrian phyllite units. Porphyroblasts are locally distorted, however, especially where the margins of the Ernie Pond gabbro are deformed. The intrusive contact between the $RG_2$ and WHS units is itself folded by map-scale vertical folds, which have highly variable apical angles dependent upon their position in the hanging wall relative to the main fault zone (Figures 2 and 6).

With increasing proximity to the Grand Bruit fault zone, stratified rocks in the footwall sequence display relatively more folds that display axial planar slaty cleavage, although on continuously decreasing orders of magnitude. In general, as the number of minor folds increases, so does the amount of minor sheet intrusions in the Whittle Hill sandstone. Regardless of size, all of these folds tighten and pass into upright, platey zones in which mafic sills are invariably foliated. Within the fault zone proper, the Whittle Hill sandstone and the $RG_2$ Roti Granite are strongly deformed and sheared together with mafic sills in upright zones of mylonite characterized by vertical extension lineations. Here, crenulation cleavage is locally developed in mafic sills that, along with previously mylonitized host rocks, define secondary, highly curvilinear, isoclinal folds.

Where the Grand Bruit fault zone forms the boundary of footwall units as young as the Cambro–Ordovician $RG_2$ Roti Granite (Figures 2 and 6), the hanging wall is locally composed of undated Western Head granite that contains a peripheral belt of mylonite and highly sheared mafic sills. In parts of the GBFZ hanging wall, away from the fault zone, undeformed Western Head granite intrudes foliated $RG_1$ Roti Granite and Cinq Cerf gneiss, and contains enclaves of both of these units. The intrusive contact between the Eocambrian $RG_1$ Roti Granite and the Precambrian Cinq Cerf gneiss is locally obliterated within the mylonite belt that juxtaposes the Western Head granite against several Ordovician and older footwall units. Fault movement along this particular structure in the Grand Bruit fault zone is likely to be either Ordovician or Silurian in age. Sheared mafic dykes in the deformed margin of the Otter Point granite attest to the Siluro–Devonian deformation near its intrusive contact with the Western Head granite and the GBFZ hanging wall.

In section AA' (Figure 4), an early GBFZ thrust defining the original WHS–CCG boundary is assumed to be occupied by the $RG_1$ pluton. The $RG_1$ Roti Granite and concealed Precambrian thrust are terminated by the Western Head intrusive body. The structurally lowest part of the Cinq Cerf gneiss is assumed to dip gently and to lie above $RG_1$ Roti Granite and present erosion level between Cinq Cerf Bay and the Hope Brook area, where it again comes to outcrop (Figures 2 and 3). The vertical northwestern margin of the Western Head granite transects steep CCG with concordant $RG_1$ on the coast and flat CCG with concordant $RG_1$ near the Hope Brook Gold Mine. Therefore, the presumed pre-$RG_1$ thrust had acquired its listric shape prior to intrusion of the Western Head granite. Despite being present throughout the GBFZ footwall, a major vertical swarm of $RG_2$ Roti Granite screens are emplaced along parts of the upright $RG_1$–WHS contact (Figures 2 and 4). This occurred after local *C–S* fabrics developed in the $RG_1$ Roti Granite and possibly, simultaneously, with some of the folding and shearing of the Whittle Hill sandstone. It appears, therefore, that there has been a longevity of Proterozoic and Phanerozoic ductile faulting in the Grand Bruit fault zone.

In the La Poile Bay–Couteau Bay region, extensive gold mineralization is predominantly located in the GBFZ footwall, although much rarer, less significant occurrences are found in the GBFZ hanging wall. In all locations, gold mineralization is associated with silicification, sericitization and pyritization of pre-Silurian intrusions or their country rocks. Altered rocks include lithologies typical of the $RG_1$, $RG_2$, WHS and CCG units. At the Hope Brook Gold Mine, cordierite-bearing mafic dykes forming one of the regional swarms in the GBFZ footwall are affected by high alumina alteration but contain xenoliths of completely silicified rocks (see also Stewart and Stewart, 1988; Stewart, 1988b).

## CONCLUSIONS

The conclusions to be drawn from this study are:

1) The region between La Poile Bay and Couteau Bay is underlain by variably deformed and metamorphosed, sedimentary and volcanic rocks that comprise four distinct belts of lithostratigraphical units separated by three major faults belonging to the Hermitage Flexure system. The Bay d'Est fault zone forms the southeastern limit of the Ordovician Bay du Nord Group, the Cinq Cerf fault zone marks the southeastern boundary of the Silurian La Poile Group, and the Grand Bruit fault zone separates an unnamed Precambrian–Cambrian group of phyllite units from the Precambrian Cinq Cerf gneiss.

2) The earliest formed structures in the Bay d'Est, Cinq Cerf and Grand Bruit fault zones are synfolding thrusts or fold slides, which were produced in association with an upright-recumbent structural transition. Precambrian, Precambrian–Cambrian, Ordovician and Silurian metasedimentary and metavolcanic rocks are separately disposed in four thrust sheets bounded by southeast dipping, listric thrusts. In the La Poile Bay–Couteau Bay region, northwestward translation of thrust sheets occurred during Silurian $D_1$ contraction faulting. With the exception of the Bay d'Est structure, all rocks in the hanging walls of these thrusts are older than the rocks comprising their footwalls. The earliest thrust-related structures in the Grand Bruit fault zone are, however, presumed to be older than those in the Cinq Cerf and Bay d'Est fault zones. Pre-Silurian movements in the Grand Bruit fault zone antedate the intrusion of the Western Head granite. Differential displacement preceded emplacement of Cambro–Ordovician $RG_2$ Roti Granite and mafic dyke swarms, and is probably related to the initial folding of the Precambrian–Cambrian metasedimentary and metavolcanic rocks.

3) Widespread deformation and low-grade regional metamorphism continued after the thrust sheets were assembled. Many of the metasedimentary and metavolcanic rocks in the La Poile Bay–Couteau Bay region were deformed to varying degrees after the intrusion of the Hawks Nest Pond porphyry, the La Poile granite and the Otter Point granite or, locally, by the emplacement of these plutons and batholiths. The Silurian–Devonian $D_2$ deformation was most intense near Silurian intrusions or major faults. However, it deformed most areas where Silurian $D_1$ or older structures were suitably oriented to be affected by $D_2$ deformation. A transition from upright to recumbent structures is seen in country rocks marginal to intrusions; however, in contrast to the earlier compression-related transition, this feature developed as the thrust sheets were extended to make space for resurgent Silurian magma. Subsequent 'hanging wall-down–footwall-up' movements in the Cinq Cerf and Bay d'Est fault zones may be responsible for producing the $F_2$ folds in the Silurian thrust sheet or, alternatively, their development may herald a return to a compressive regime.

4) In the La Poile Bay–Couteau Bay region, intrusions of Precambrian, Cambrian, Ordovician, Silurian and Devonian age, serve to bracket distinct intervals of deposition, deformation, metamorphism and alteration. Some events are unique to particular thrust sheets; others have affected most rocks in the region. Precambrian, Ordovician and Silurian geological events are significantly distinct. However, because the same types of processes were operative in the region from Precambrian to Devonian, rocks formed during this period are generally of similar aspect.

5) Gold mineralization occurs throughout the La Poile Bay–Couteau Bay region and is hosted, in order of increasing abundance, by rocks of the Precambrian Cinq Cerf gneiss, the Ordovician Bay du Nord Group, the Silurian La Poile Group and an unnamed group of Precambrian–Cambrian phyllite units. Sericitic, pyritic and silicious alteration is commonly associated with gold-bearing felsic intrusions within the thrust sheets or within the major fault zones. Gold was apparently introduced or remobilized at several times in different areas. Mineralization occurred sporadically as the fault zones evolved from early stage, synmetamorphic overthrusts affecting basement and cover to late stage, brittle faults. The latter structures are developed in the youngest unit in the region, the epizonal Chetwynd Granite (Dickson *et al., this volume)* and probably formed at shallow levels below a Devono–Carboniferous paleosurface similar to that described by Chorlton (1983).

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