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NEW INSIGHTS ON THE STRUCTURAL GEOLOGY OF THE PACQUET HARBOUR GROUP AND POINT ROUSSE COMPLEX, BAIE VERTE PENINSULA, NEWFOUNDLAND

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ABSTRACT

The Baie Verte Peninsula represents one of the classical areas to study the structural evolution of peri-Laurentian ophiolite and arc complexes, before and following, their tectonic juxtaposition to the early Paleozoic Laurentian margin. Regional structural data are presented that focus on the ophiolitic and cover rocks of the Pacquet Harbour Group (PHG) and Point Rousse complex (PRC) that have been affected by, at least, four phases of regional deformation. The D_1 fabrics are poorly preserved and strongly overprinted in the ophiolitic rocks, but are locally preserved in the Fleur de Lys Supergroup (Humber Zone). The D_1 phase is interpreted to be related to the obduction of ophiolites during the Ordovician Taconian Orogeny; D_2 represents the main tectonometamorphic phase. In the PRC, D_2 fabrics are mostly parallel to, and associated with, the west-trending south-directed reverse faults. Southward, these culminate with the Scrape fault, a ductile shear zone that juxtaposes serpentinized mantle of the PRC over amphibolitic gabbros and basalts of the PHG. The Scrape fault and D_2 south-directed shear zones separating the PRC from the PHG are affected by penecontemporaneous transverse high-strain zones (D_{2b}) interpreted as lateral ramps. The intensity of D_2 fabrics and metamorphism decreases southward from strong L>S fabric in the amphibolites north of the Rambler Mines area to a series of open folds in the low-grade mafic volcanic rocks of the southern PHG; D_2 is interpreted to be related to transpression and crustal thickening during the Silurian Salinic Orogeny. In the northern PHG, D_2 fabrics are progressively affected by recumbent F_3 folds, which appear to be cogenetic with extensional shear zones and inversion of reverse faults in an overall dextral, locally transtensional regime during the Early to Middle Devonian. Late northeast- to northwest-trending open F_4 crossfolds deform all of pre-existing fabrics but are generally not associated with any cleavage development.

The disposition of the base-metal deposits such as the Ming and Rambler deposits is strongly controlled by these deformational events; D_2 was the most significant, giving ore bodies an overall northeast plunge, subparallel to L_2 stretching lineations, and D_2 shear zones and folds may also have displaced or structurally thickened ore bodies. Post-D_2 deformation is locally significant and affects the orientation and geometry of prospective horizons and ore deposits. Ongoing structural analysis and geochronology will be critical in further refining the structural evolution of the Baie Verte Peninsula and will help establishing guidelines for mineral exploration.

INTRODUCTION

The Baie Verte Peninsula records the Paleozoic tectonic evolution of both the Cambro-Ordovician Laurentian margin and ophiolitic and arc complexes during, and after, their accretion to Laurentia along the Baie Verte Line (Hibbard, 1983, and references therein). It is also one of the most prospective areas for base metals and gold in Newfoundland (Evans, 2004). A better understanding of the structural and tectonometamorphic evolutions of the Baie Verte Peninsula is part of the objectives of a multidisciplinary Targeted Geoscience Initiative Program (TGI3) of the Geological Survey of Canada. The overall aim is to provide a predictive framework for targeting base-metal deposits and reduce economic risks for exploration. The purpose of this contribution is to provide new insights on the regional structural framework of the Pacquet Harbour Group (PHG) and neighbouring Point Rousse complex (PRC), two of the ophiolitic-arc complexes of the Baie Verte oceanic tract in the Baie Verte Peninsula.

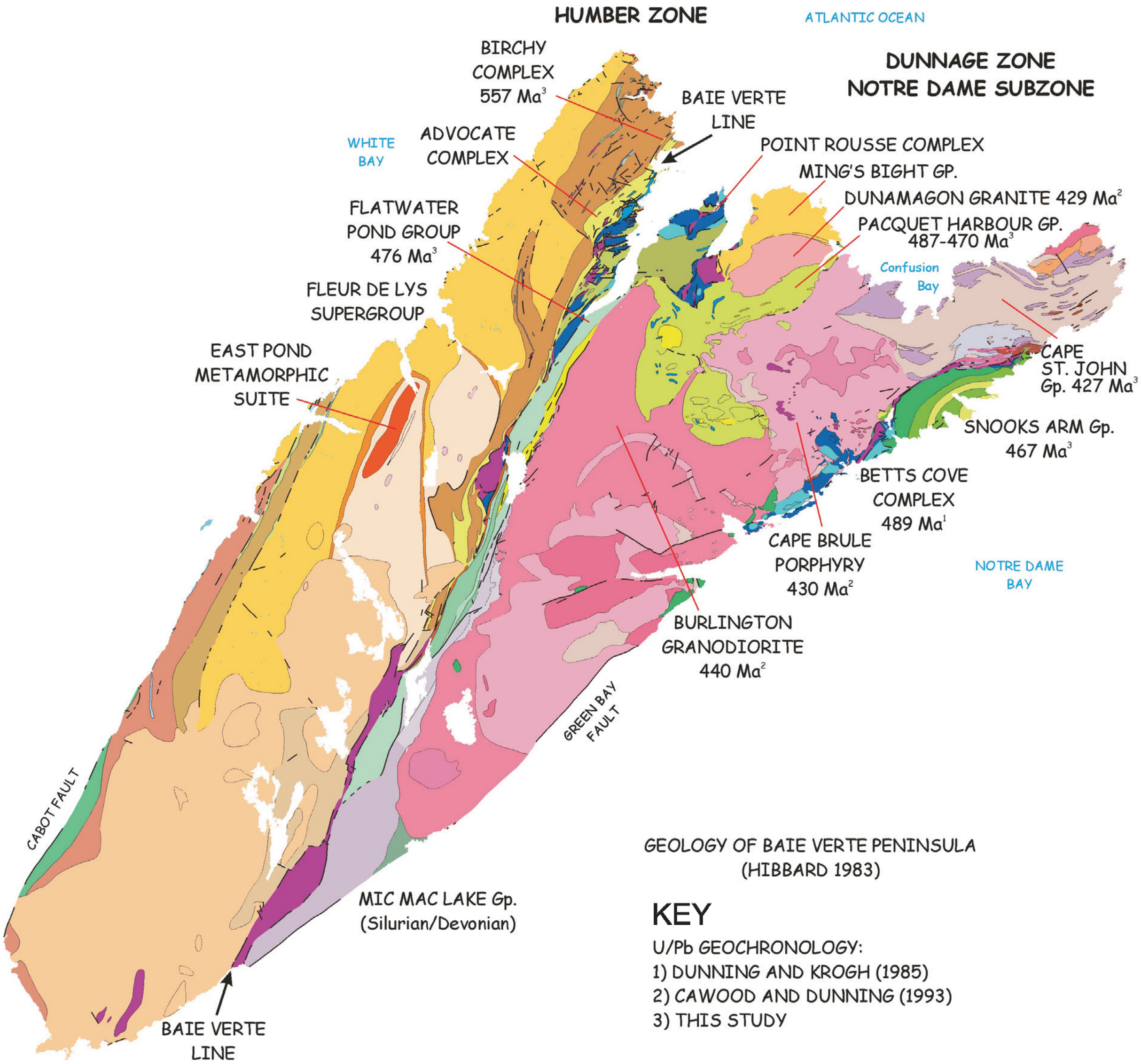

Figure 1. *Simplified geological map of the Baie Verte Peninsula (modified from Hibbard, 1983).*

GEOLOGICAL SETTING

The Baie Verte Peninsula is underlain by the Humber and Dunnage zones of the Canadian Appalachians (Figure 1; Williams, 1995, and references therein): The Humber Zone, to the northwest, represents the Cambro-Ordovician continental margin of Laurentia that has been tectonically thickened and metamorphosed as a result of the Taconic accretion of the Lower Ordovician ophiolitic and arc complexes, of the Baie Verte oceanic tract, following the closure of the Humber Seaway (Waldron and van Staal, 2001; van Staal *et al.,* 2007). The Dunnage Zone is represented by the aforementioned Ordovician ophiolitic and arc complexes that formed outboard of the Laurentian Margin. The boundary between the Humber and Dunnage zones is known as the Baie Verte Line (BVL, Hibbard, 1983), which represents a long-lived and composite fault zone.

Following the Taconic collision, the Baie Verte oceanic tract was intruded by granitic intrusions and unconformably overlain by Silurian volcanic and sedimentary sequences (Cawood *et al.,* 1993). The area was variously affected by deformation and metamorphism associated with the Silurian Salinic Orogeny (Dunning *et al.,* 1990), which is attributed to the accretion of a peri-Gondwanan terrane to the composite Laurentia (van Staal and de Roo, 1995). Major mid-Paleozoic oblique transcurrent deformation during the Salinic and Acadian orogenies has affected both the Humber and Dunnage zones and led to protracted polyphase transpressional and transtensional faulting along the Baie Verte

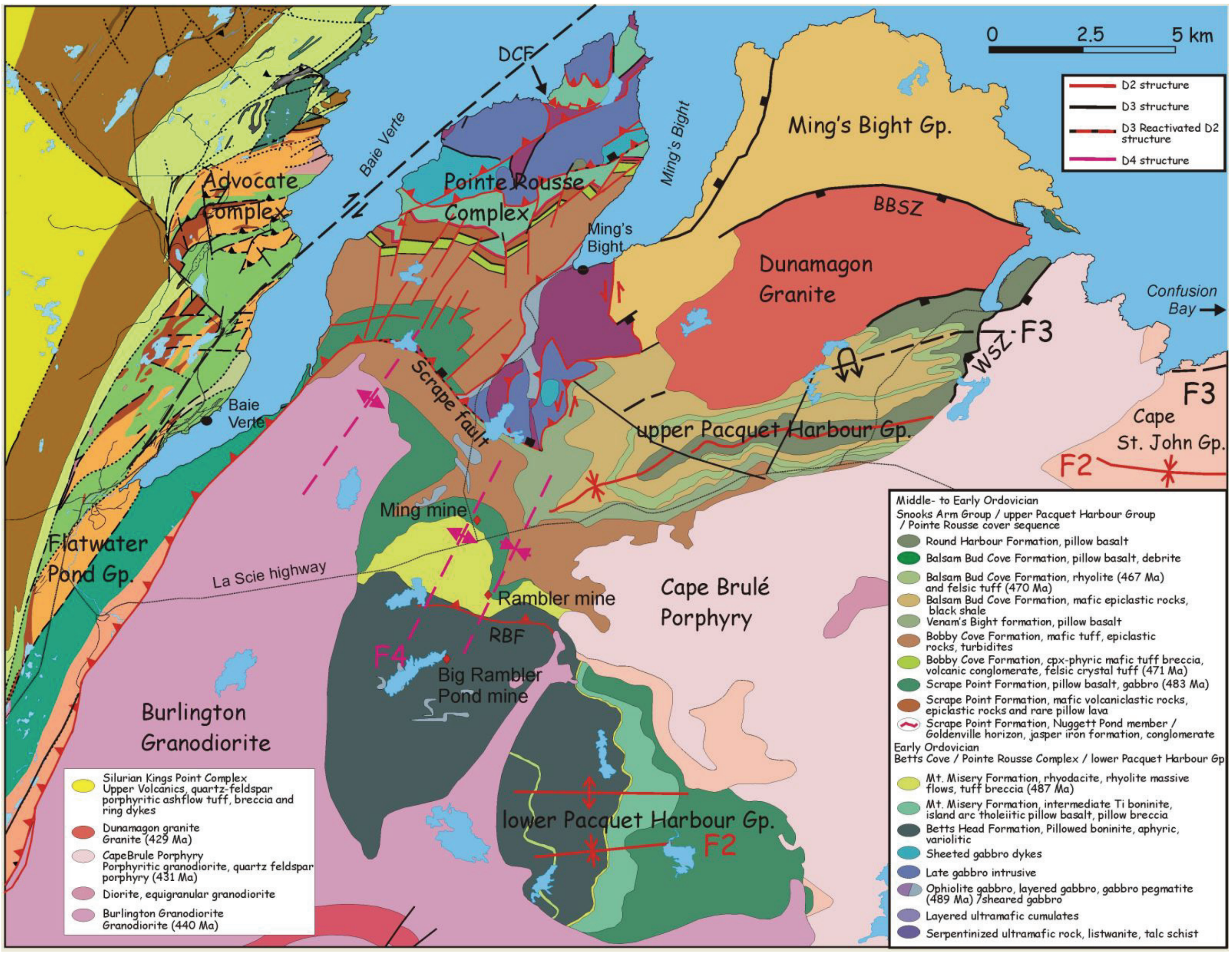

Figure 2. *Preliminary geological map of the Pacquet Harbour Group and Point Rousse complex, compiled from this study and modified from Hibbard (1983) and Anderson (1998). Note that the geology of the Fleur de Lys Supergroup, Advocate Complex and Flatwater Pond Group is not addressed in this contribution and should be considered as unseparated. BBSZ, Big Brook shear zone; DCF, Deer Cove fault; RBF, Rambler Brook fault; WSZ, Woodstock shear zone.*

Line and its subsidiary structures (Waldron *et al.,* 1998; Anderson *et al.,* 2001).

The PHG and PRC occupy the central portion of the Baie Verte Peninsula (Figure 2) and host several base-metal and gold deposits, such as the Ming, Rambler and the Stog'er Tight mines and the Deer Cove and Pine Cove gold deposits (Evans, 2004). The PHG and PRC structurally overly the Ming's Bight Group and are intruded and overlain by Silurian rocks. A brief description of the lithostratigraphy of these entities is given below. More details on the tectonostratigraphy of the study area can be found in Skulski *et al.* (*In press*).

The PHG is made of variably deformed and metamorphosed mafic and felsic volcanic and volcanoclastic units, mafic dykes and sills (Tuach and Kennedy, 1978; Hibbard, 1983). Although deformed and folded, the PHG is mainly north-younging. The southern PHG is characterized by a boninitic lower volcanic sequence characterized by pillowed, variolitic and aphyric basalts overlain by felsic volcanic and volcanoclastic rocks in the footwall of the Rambler and Ming mines. North of the Rambler–Ming mines, the northern PHG comprise tholeiitic and e-MORB basalts intercalated with mafic volcanogenic turbidites and calc-alkaline tuffs, which may correlate to the Snooks Arm Group.

The PRC is composed of fault-bounded blocks that define a nearly complete section of ophiolite crust including mantle harzburgite, ultramafic and mafic cumulate rocks, gabbro intrusives and sheeted dykes and pillow lava (Norman and Strong, 1975; Kidd *et al.,* 1978). The volcanic cover sequence comprises a jasper chert and red magnetite–siltstone iron formation that hosts epigenetic gold mineralization at the Goldenville Mine (Evans, 2004), green volcanogenic turbidites, tuff breccia and volcanic conglomerate. Overlying these are turbiditic and tuffaceous epiclastic sedimentary rocks interlayered with pillowed to massive tholeiite basalts with compositions typical of e-MORB.

The Ming's Bight Group (Figures 1 and 2) is a correlative of the Fleur de Lys Supergroup of the Humber Zone (Hibbard, 1983) and is exposed in a tectonic window through ophiolitic and arc rocks of the Baie Verte oceanic tract on the eastern side of the BVL. Recent work by Anderson (1998) and Anderson *et al.* (2001) indicated that the Ming's Bight Group has a different tectonometamorphic evolution than the Humber Zone units on the western side of the BVL and suggested that it represents a symmetric metamorphic core complex, bordered by Devonian extensional shear zones.

Several Silurian granitic intrusions have intruded the ophiolitic complexes and their cover rocks (Figures 1 and 2): the Burlington granodiorite (440±2 and 432±2 Ma; Cawood and Dunning, 1993), the Dunamagon granite (429±4 Ma; Cawood and Dunning, 1993) and the Cape Brulé porphyry (*ca.* 430 Ma; Cawood and Dunning, 1993). The latter is interpreted to be cogenetic with the Silurian volcanic and sedimentary sequences of the Cape St. John Group, which occupies the northeastern part of the Baie Verte Peninsula. The Silurian plutonic, volcanic and sedimentary rocks were all affected by the main tectonometamorphic phase (D_2, *see* below) observed in the Ordovician ophiolitic complexes (Hibbard, 1983); these rocks thus form an important time marker in the deformation history.

REGIONAL STRUCTURAL GEOLOGY

The PHG and PRC have been the focus of numerous local to subregional studies and theses that included components of bedrock mapping and description of the structural geology (*see* Hibbard, 1983 and Anderson, 1998 for a review). The structural investigations of Gale (1971), Norman and Strong (1975), Tuach and Kennedy (1978), Kidd *et al.* (1978), the compilation of Hibbard (1983) and more recent work by Kirkwood and Dubé (1992), Dubé *et al.* (1993), Anderson (1998), and Anderson *et al.* (2001) provide a framework which is the starting point of this study. Construction of a consistent regional structural correlation scheme (Table 1) has been hindered because some of these studies only cover small areas either characterized by additional local complexity or simplicity. In addition, the small number of new isotopic age constraints on the absolute age of deformation is also critical. Regional correlations using new geochronological constraints will constitute an important output of the overall project. This contribution represents the first stage and focuses on the PHG and PRC.

At least four phases of regional deformation have affected the rocks of the Baie Verte Peninsula (Hibbard, 1983). Most deformation phases are domainal, as structures vary in style and in intensity, geographically. The rocks show an increase in strain and metamorphic grade from east to west and from south to north across the peninsula. However, the PRC exhibits a significantly lower grade of metamorphism than the neighbouring Pacquet Harbour and Ming's Bight groups. Structural domains and polyphase deformation styles of the PHG and neighbouring rock units are shown schematically in Figure 3. Mesoscopic and regional-scale structural features of each phase are described below.

Structures related to D_1 (D_e of Hibbard, 1983) have been strongly overprinted by subsequent deformation. The D_1 fabrics have been observed in the Fleur de Lys Supergroup where an S_1 micaceous schistosity is preserved in areas of low post-D_1 strain and/or in the hinges of F_2 folds. The latter were refolded locally into fold interference patterns during D_3 (Hibbard, 1983). In the PHG and PRC, the D_1 structures are poorly preserved. A relict S_1 fabric is deduced in some localities of less intense S_2 transposition and where F_2 folds have folded an earlier bedding/layering parallel foliation (Plate 1A). In areas of isoclinal F_2 folding, S_2 is probably composite $S_{1/2}$ foliation (*see* below). The contacts between the rocks of the Humber Zone and the ophiolitic complexes (*e.g.,* Big Brook shear zone at the southern contact of the Ming's Bight and most fault zones along the BVL; Hibbard, 1983) have been interpreted as D_1 structures, although they have been strongly modified and overprinted during subsequent deformation.

The D_2 represents the main tectonometamorphic phase of most parts of the Baie Verte Peninsula (D_m of Hibbard (1983), D_1 of Gale (1971) and Anderson *et al.* (2001), and D_2 of Tuach and Kennedy (1978)). The intensity of D_2 fabrics and accompanying metamorphism mineral assemblages varies regionally and overall increases from south to north in the PHG (Figure 2). S_2 is a north- to northeast-dipping spaced cleavage south of the Rambler Brook fault, where it is best developed in sedimentary and volcanoclastic rocks. Mesoscopic F_2 folds (Plate 1A) were rarely observed, but reversal of pillow tops and map-scale distribution of marker felsic horizons suggest that F_2 folds are present in the southern part of the PHG. In the northwestern PHG, D_2 is characterized by a strong L-S fabric (Figure 3). A L>S fabric is commonly observed around, and north of, the Rambler Mine, where it is manifested as a northeast-plunging mineral or a stretching lineation defined by extended clasts and

Table 1. Tentative structural correlation chart of previous studies in and around the Pacquet Harbour Group; see Regional Structural Geology section for more detailed descriptions

Gale (1971) Rambler Mines area	**Tuach and Kennedy (1978)** Rambler Mines area	**Hibbard (1982)** Eastern BVP	**Anderson (1998)** Ming's Bight area	**Anderson (1998)** Pacquet Harbour area	**This study** Pacquet Harbour Group
	D4 NE-trending crenulation; NE-plunging upright F4	DL+1 steep NE fabric; upright folds	D5 mylonitic foliation associated with N-dipping shear zone	D3 semi-penetrative localized foliation S-dipping	D4 NNE-trending open to close upright crossfolds
D3 crenulation; recumbent minor F3	D3 cleavage shallowly NE-dipping; open NE-plunging overturned F3	DL spaced crenulation (s) to sub-penetrative (N) foliation shallowly N-dipping	D4 spaced crenulation to mylonitic fabric shallowly W-dipping; reclined W-plunging F4	D2 mylonitic fabric shallowly SE-dipping; SE-plunging F2 // to L2	D3 spaced (S) to crenulation (N) foliation shallowly SE-dipping; SE-plunging recumbent F3
			D3 spaced crenulation dipping shallowly SW to S3		
D2 local sub-vertical crenulation; minor F2	D2 strong L-S fabric dipping N to NE; close to isoclinal NE-plunging F2	DM strong L-S fabric; upright; NE-plunging, close to isoclinal FM; Lm sub-// to FM axes	D2 steep W-dipping crenulation to mylonitic foliation; sub-horizontal L2; upright S-plunging F2	D1 weak to locally mylonitic fabric, local L1; tight to isoclinal fold in D1 shear zone	D2b steep W-dipping crenulation; S-plunging F2 sinistral transpression during thrusting
D1 L>S penetrative fabric			D1 penetrative to mylonitic L-S fabric NE to NW-dipping; close to isoclinal F1 fold		D2 main fabric N to NE dipping; NE-plunging close to isoclinal upright F2 S-directed faults locally strong NE-plunging L2>S2
	D1 Relic fabric	DE Relic fabric			D1 Relic fabric

pillows (Plate 1B). The long-axes of the Rambler and Ming ore bodies are parallel to the L_2 lineation (Tuach and Kennedy, 1978). The S_2 fabric varies from weak to a penetrative schistosity; S_2 is axial planar to close to isoclinal northeast-plunging F_2 folds. The trace of a major east-northeast-trending F_2 syncline is recognized roughly 500 m north and parallel to the La Scie Highway (Figure 2); its southern limb is generally steep, whereas dips are progressively shallower along the northern limb, most probably due to the influence of F_3 recumbent folding (*see* below). Based on comparable style and geometry, this fold correlates to similar large-scale folds to the northeast affecting much of the Silurian Cape St. John Group (Figures 2 and 3).

The main fabrics in the PRC are also attributed to D_2 (D_m of Hibbard, 1983; D_1 of Kirkwood and Dubé, 1992; Norman and Strong, 1975; Kidd *et al.,* 1978). In the basalts and volcanoclastic rocks, S_2 varies from a spaced cleavage to a well-developed moderately north-dipping schistosity that often contains a down-dip stretching lineation. Mesoscopic F_2 folds are generally tight; hence S_2 is subparallel to bedding. Previous workers have described a major tight syncline overturned to the southeast affecting most of the PRC (Norman and Strong, 1975; Kidd *et al.,* 1978; Hibbard, 1983). The fold has been depicted as a faulted and telescoped D_m (D_2 herein) structure based on opposing younging directions of the ophiolitic cover sequence between the overturned northern and upright southern portions of the complex. Mapping has documented opposing younging directions in the central portions of the complex (Figure 2), which may corroborate the presence of a faulted megascopic fold. However, the regional extent of this plausible fold or the precise location of its axial trace remains uncertain.

The D_2 fabrics are interpreted to be associated with ductile to brittle-ductile moderately north-dipping south-directed shear zones, such as the Rambler Brook fault and the Scrape fault in the PHG (Figure 2; Hibbard, 1983). In the hanging wall of the Scrape fault, D_2 second-order thrust and high-angle faults divide the PRC into several fault-bounded panels or 'thrust sheets' (Figures 2 and 3; *e.g.,* Deer Cove Sole fault, Plate 1C; Hibbard, 1983; Gower *et al.,* 1990; Kirkwood and Dubé, 1992; Dubé *et al.,* 1993). The Scrape fault juxtaposes the greenschist-grade mafic and ultramafic rocks of the PRC to the northeast, against amphibolitic gabbros and mafic volcanic rocks of the PHG to the southwest (Plate 1D). The footwall of the shear zones comprises a *ca.* 200-m-wide mylonite zone with consistent south-directed reverse shear-sense indicators (Plate 1E). However, the contrasting and sharp upward decrease of metamorphic grade across the Scrape fault (low grade over higher grade) and the southward decrease of M_2 metamorphic grade across structurally deeper levels (apparent inverted metamorphic gradient) of the PHG indicate post-D_2 structural juxtaposition (*see* below).

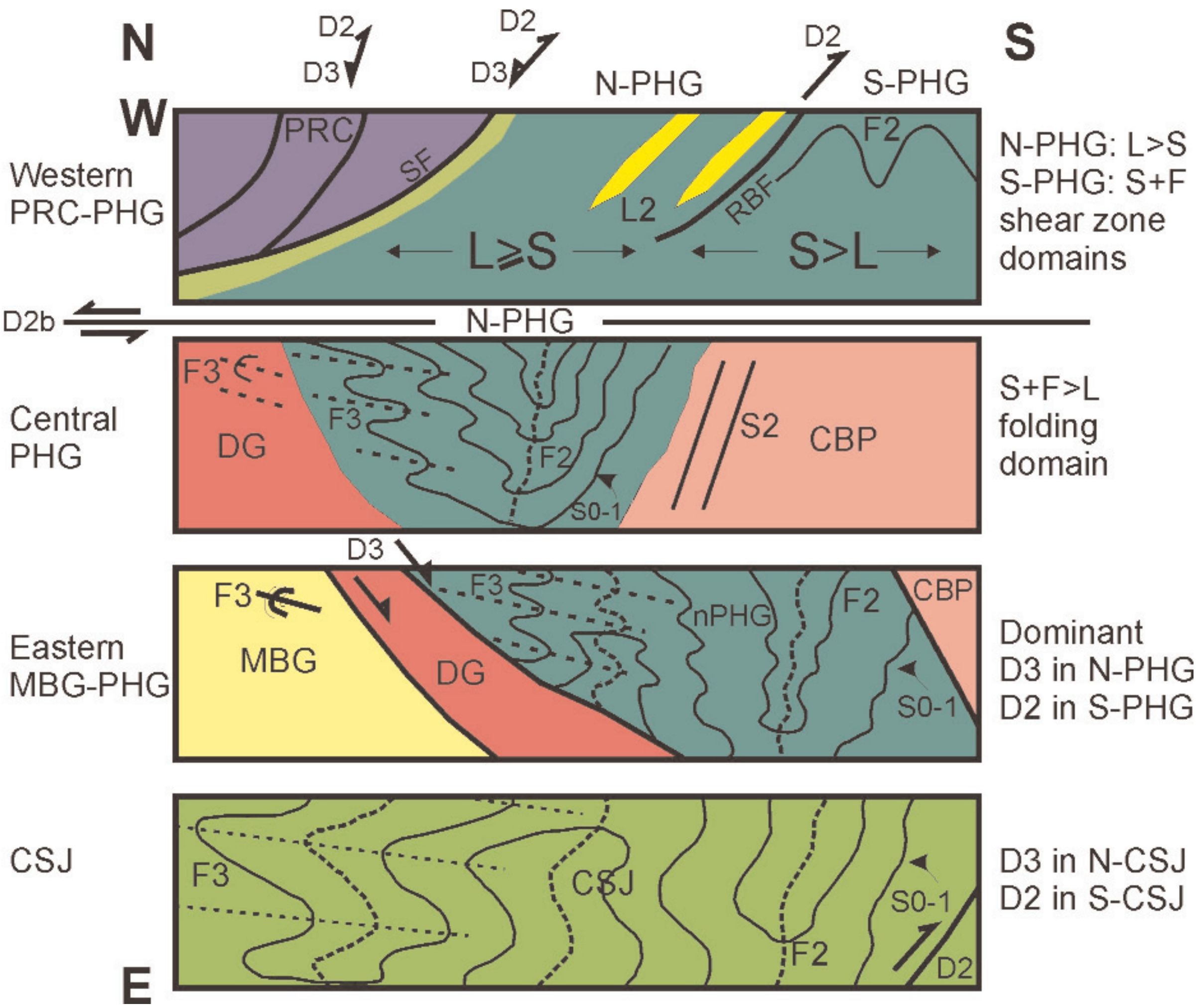

Figure 3. *Schematic cross section across eastern Baie Verte Peninsula showing the various structural domains with their dominant deformation phases and styles. Overprinting effects of F_4 folds, which axial planes are mostly parallel to these sections, are not illustrated. The western Point Rousse complex/Pacquet Harbour section shows D_2 south-directed thrust and reverse faults in the PRC. In the footwall of the Scrape fault, the northern PHG is dominated by a strong lineated L_2 domain, the long axis of the Ming and Rambler deposits (in yellow) is subparallel to L_2. In the southern PHG, the style is dominated by open F_2 fold. Eastward, across a probable lateral ramp causing sinistral transpression, the central PHG section represents a F_2 dominated domain with increasing D_3 overprinting to the north. The eastern Ming's Bight Group/Pacquet Harbour Group section show a stronger overprint of D_3 structures (recumbent folds and extensional faults) on D_2 fabrics. The easternmost section in the Cape St John Group depicts a similar north–south variation, with a southern F_2 dominated domain and a F_3 domain to the north. CBP, Cape Brulé Porphyry; CSJ, Cape St John Group; DG, Dunamagon granite; MBG, Ming's Bight Group; PHG, Pacquet Harbour Group (N- Northern; S-Southern); PRC, Point Rousse complex; RBF, Rambler Brook fault; SF, Scrape fault. L, Lineation; S, foliation; F, fold.*

South and west of Ming's Bight, D_2 fabrics associated with these shear zones and reverse faults are locally affected by oblique high-strain zones (Kidd *et al.,* 1978; Hibbard, 1983; Anderson, 1998), herein tentatively ascribed to D_{2b} (D_2 of Gale (1971) and Ming's Bight area D_2 of Anderson (1998)). The D_{2b} fabrics are characterized by a strong north-northwest- to north-northeast-trending, moderately to steeply west-dipping fabric, subhorizontal to slightly oblique lineation and collinear open to isoclinal shallowly south-plunging mesoscopic folds. Microstructural and field relationships indicate that D_2 and D_{2b} fabrics apparently evolved synchronously and that both are folded by the F_3 crenulation (Anderson, 1998). The D_{2b} high-strain zones occur at the north-northeast-trending contact between ultramafic rocks of the PRC with the PHG south of Ming's Bight, and at the contact with the Ming's Bight Group east of Ming's Bight (Anderson, 1998). These zones are characterized by a strong crenulation fabric associated with sinistral east-directed transpressional shear. These fabrics and shear zones extend southward where they coincide with the apparent southeastern termination of the south-directed D_2 Scrape fault. Interestingly, this transverse zone is in strike southward with the area of strongly developed L_2 tectonites in the vicinity of the Ming and Ramblers mines. Eastward in the PHG, S_{2b} is not observed, L_2 is much less conspicuous and, as described above, the structural style is apparently dominated by large-scale F_2 folds (Figures 2 and 3).

In the PRC, south-southeast to south-trending transverse faults dissecting the west-trending thrust and reverse faults have been mapped (Kidd *et al.,* 1978; Gower *et al.* 1990). These are similar in style and orientation as to the D_{2b} structures described above and may represent lateral ramps (Dubé *et al.,* 1993) or tear faults genetically associated with the south-directed D_2 reverse faults.

Structures formed during the third phase of deformation (D_3) are inhomogeneously developed and mainly present north of the La Scie Highway. They are particularly well-developed in the northeastern part of the Baie Verte Peninsula where they become the dominant structure in the Pacquet Harbour, Ming's Bight and the Silurian Cape St. John groups (Figures 2 and 3). These structures also corresponds to the third phase (D_3) of most previous studies (*i.e.,* Gale, 1971; Tuach and Kennedy, 1978; Pacquet Harbour area D_2 of Anderson, 1998, and part of D_L of Hibbard, 1983). In the PHG, D_3 structures comprise shallowly inclined to recumbent, open to tight southeast-plunging F_3 folds (Plate 1F). An axial-planar S_3 fabric is locally observed. It dips shallowly to the southeast or south and ranges from a weakly developed spaced or crenulation cleavage, to a well-defined composite foliation mainly formed by transposition of S_2, northward, near the contact with the Dunamagon granite. In the northeastern PHG, Anderson (1998) and Anderson et al. (2001) have interpreted the contacts with the Dunamagon granite and Cape Brulé porphyry as D_3 shallowly south-dipping brittle-ductile extensional shear zones, such as the Woodstock shear zone. The third phase of deformation, D_3, is well-developed and locally the dominant structure in the Ming's Bight Group, where it is associated with an amphibolite-facies assemblage overprinting D_2 fabrics (Anderson, 1998). Similar shallow-dipping to flat-lying structures are present eastward in the northernmost part of the Cape St. John Group, where the dominant S_2 fabric is progressively affected by F_3 recumbent folding. A large-scale recumbent isoclinal F_3 fold is well-exposed on the eastern side of Confusion Bay (Plate 1G; Hibbard, 1983).

In the PRC, the main fabric (S_2) is locally cut by a younger subparallel but steeper crenulation cleavage. This moderately to steeply north-dipping S_3 crenulation is associated with asymmetric folds and kink-bands. However, recumbent folds and low-angle structures are absent. In D_3 high-strain zones, foliations become subparallel making a composite $S_{2\text{-}3}$ fabric. Kinematic indicators and D_3 kinks suggest north-side-down motion. In the PRC, several of these D_3 high-strain zones appear to reactivate D_2 thrusts and reverse faults as extensional faults, as tentatively suggested by Kidd *et al.* (1978). Post D_2, probably D_3 extensional shear bands (Plate 1H) in the immediate footwall of the Scrape fault suggest that it was affected by normal sense reactivation, as previously postulated by Jamieson *et al.* (1993). This reactivation of the thrusts as extensional faults may have contributed to the apparent low over high-grade relationship across the Scrape fault.

An important shear zone has been recognized along the eastern shore of Baie Verte Peninsula (Figure 2), affecting the Point Rousse gabbros just north of Lower Green Cove (Plate 1I). Most of the shear zone extends offshore underneath Baie Verte, but is clearly delineated on aeromagnetic maps, as tentatively shown by Kidd *et al.* (1978). The mylonitic fabric associated with the shear zone is striking to the south-southwest and dips moderately to the west-northwest. The mineral or stretching lineation along the fabric is plunging moderate to steeply to the northwest (Plate 1J), suggesting slightly oblique dip-slip motion. Shear bands affecting the mylonitic fabric suggest dextral kinematics (Plate 1K). The relationships between this shear zone and the regional fabrics are uncertain, however, preliminary $^{40}Ar/^{39}Ar$ data from amphibolitic mylonite indicate Silurian Salinic ages.

The D_4 deformation (D_4 of Tuach and Kennedy, 1978, and part of D_L of Hibbard, 1983) is characterized by undulating to open, upright F_4 crossfolds, although styles and plunges of these folds vary depending on the orientation of earlier fabrics. These folds are locally associated with a subvertical fracture or weakly developed crenulation axial-planar cleavage. The F_4 folds trend to the north-northeast in the PHG, especially in the Rambler Mines area (Plate 1L), and to the north to north-northwest in the Cape Brulé Porphyry and Cape St. John Group, where they are conspicuous at map scale affecting both regional F_2 and F_3 axial planes. These folds have not been recognized in the PRC.

DISCUSSION AND CONCLUSION

The structural evolution of the Baie Verte Peninsula is largely dictated by polyphase long-lived deformation events, with localization and partitioning of strain along the Baie Verte Line and its subsidiary fault structures occurring on both sides of the line (Hibbard, 1983; Waldron *et al.,* 1998; Anderson *et al.,* 2001). The PHG and Point Rousse complex were mainly affected by a complex non-coaxial deformation following their Taconic obduction. This deformation is possibly related to formation of a regional-scale transfer zone between the Baie Verte Line and fault systems

Plate 1. *Field photographs of representative structural features. A) Tight moderately north-plunging F_2 folds in mafic volcanic rocks of the PHG at the Big Rambler Pond deposit. B) Epiclastic conglomeratic wacke showing a moderate to strong L_2 stretching lineation, PHG on the La Scie Highway. C) Section view of the Deer Cove Sole 'thrust' at the Deer Cove deposit. The fault is interpreted as a D_2 ductile-brittle reverse fault juxtaposing altered basalts in the hanging wall against gabbros and serpentinized ultramafic rocks. Asymmetric kink bands affecting the shear fabric in the immediate hanging wall suggest some down-to-the north reactivation. D) Section view of the Scrape fault zone along the Ming's Bight road. The Scrape fault juxtaposes greenschists and serpentinized ultramafic rocks of the PRC against amphibolitic and mylonitic gabbros and basalt of the PHG. E) Boudinaged and sheared sigmoidal quartz vein, coupled with the down-dip lineation, suggesting south-directed thrust motion on the S_2 shear fabric. F) shallow-inclined southeast-plunging F_3 fold in the*

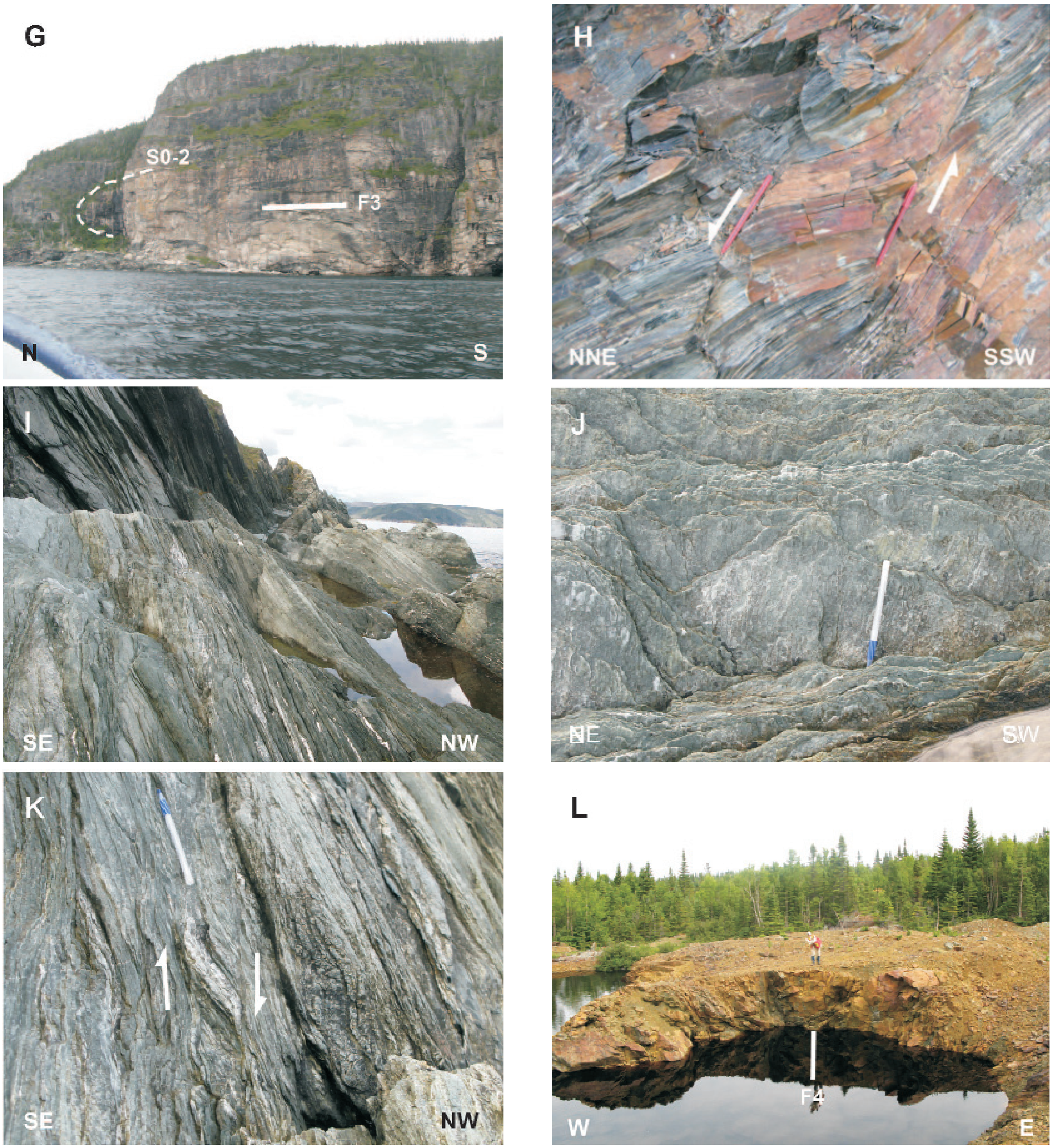

Plate 1. (continued) *northern PHG on the Woodstock road. Note the small blue pen for scale. G) Megascopic recumbent F_3 fold affecting the Cape St John Group along the eastern shore of Confusion Bay near Brent Cove Head. The cliff is approximately 100 m high. H) Steep-dipping extensional shear bands affecting the dominant S_2 fabric suggesting post-S_2 down-to-the-northeast motion. Photo taken at the same locality than photo D (Ming's Bight road), in the highly sheared amphibolitic gabbros of the Scrape fault shear zone. I) Southwest-trending mylonite zone affecting Point Rousse gabbros just north of Lower Green Cove, along the eastern shore of Baie Verte. J) Moderately to steeply northwest-plunging roding and stretching lineation along the mylonitic fabric suggesting slightly oblique dip-slip motion. Same locality as photo I. K) Shear bands affecting the mylonitic fabric suggest late- to post-dextral kinematics. L) North-trending close synform, interpreted as an F_4, in altered mafic volcanic rocks of the Pacquet Harbour group at the Big Rambler Pond deposit.*

to the east, such as the Green Bay fault (Figure 1). This complex fault-system was reactivated during subsequent phases of orogenesis, resulting in the observed polyphase deformation and metamorphism of the study area.

Our preliminary data indicate that polyphase orogenic history resulted in rapid changes in metamorphism grade and marked variations in style and in intensity of the structures in the PHG and PRC. The D_1 phase is interpreted to be related to obduction of the ophiolite complexes and arc collision during the main stages of the Ordovician Taconic Orogeny (Hibbard, 1983; Waldron *et al.,* 1998; van Staal *et al.,* 2007). The ophiolites of the Baie Verte Peninsula constituted the upper plate during the Taconic Orogeny and were less tectonized compared to the under-thrusted Laurentian margin units, which were rapidly buried and experienced high-pressure metamorphism (Jamieson, 1990). The D_2 regional deformation of the eastern part of the Baie Verte Peninsula is associated with an overall Silurian sinistral transpressive deformation regime localized along the BVL and subsidiary faults. Some of these structures were reactivated during subsequent dextral, locally transtensional D_3 and younger tectonic increments during the Devonian and Carboniferous. If correct, the structures in the northern part of the Baie Verte Peninsula may represent a large-scale long-lived transfer zone in between major orogen-parallel faults.

The relationships observed in this study between the various fabrics, regional structure, and the various mineral deposits of the study area have important implications for the base-metal and gold exploration on the Baie Verte Peninsula. The economically important sulphide deposits in the PHG have been strongly modified during D_2 as evidenced by the cigar-shape of the Rambler and Ming deposits that is co-linear with the strong northeast-plunging L_2 lineation. Hence, the sulphide deposits may have been dismembered and translated by thrusting related to D_2; and the sulphides may be structurally thickened in hinge zones of regional F_2 folds. Post-D_2 deformation is best developed in the northern PHG and may also have modified the orientation and geometry of prospective horizons and ore deposits at depth. For example, the recumbent F_3 folding north of the Ming deposits may have changed the shape of ore bodies down-plunge by refolding and reorientation. Hence, potential exists for structural thickening at depth.

Most mesothermal gold mineralization in the PRC is spatially and genetically associated with D_2 shear zones. Consequently, D_{2b} tear and transpressional faults may also be prospective themselves or may have caused lateral displacements of mineralized zones. Similar D_2 shear zones also occur in the southern PHG (*e.g.,* Rambler Brook fault) and may also be prospective for gold. The potential for presence or remobilization of mineralization during inversion of thrust faults and in late extensional shear zones may represent additional exploration targets. Ongoing multidisciplinary research including structural analysis and geochronology will be critical in further refining the tectonic evolution of Baie Verte Peninsula and for establishing targeted guidelines for mineral exploration.

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