

RELATIONSHIPS BETWEEN THE DUNNAGE–GANDER ZONES IN THE VICTORIA LAKE–PETER STRIDES POND AREA

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ABSTRACT

Preliminary results of fieldwork in the Victoria Lake–Peter Strides Pond area indicate that a high-strain zone, the Victoria Lake shear zone, separates low-grade tectonites of the Exploits Subzone from medium- to high-grade tectonites (staurolite to sillimanite + K-feldspar zone). These metamorphic tectonites include a band having rocks typical of the Exploits Subzone, i.e., the Howley Waters belt. Amalgamation of the Howley Waters belt with the Meelapaeg Subzone took place before peak regional metamorphism. The development of the Victoria Lake shear zone took place during the D2 deformation and coincides with peak metamorphism in the staurolite zone. The shear zone shows progressive change in trend, dip and motion from a reverse southeast-dipping fault in the southwest to a north-dipping normal fault in the central sector and back to a south-east-dipping reverse fault in the east.

INTRODUCTION

The Exploits Subzone (Dunnage Zone)–Meelapaeg Subzone (Gander Zone) lithotectonic boundary is marked by the Noel Paul's Line in central Newfoundland (Figure 1; Williams *et al.*, 1988). This boundary has been traced from its type locality at Noel Paul's Brook across Victoria Lake to Wood Lake (southeast of Peter Strides Pond, Figure 2; e.g., Colman-Sadd *et al.*, 1990; Piasecki, 1995) where it joins with the Red Indian Line. In addition to defining a lithotectonic boundary (Williams *et al.*, 1988), the Noel Paul's Line is also supposed to separate medium- to high-grade metamorphic rocks from low-grade rocks (Brown and Colman-Sadd, 1976). Near Noel Paul's Brook, a shear zone separates amphibolite-facies quartzitic tectonites of the Gander Zone from greenschist-facies volcanosedimentary tectonites of the Exploits Subzone. However, this summer's fieldwork (2000) near Victoria Lake indicates that the relationships between the Exploits and Meelapaeg subzones are more complicated than at Noel Paul's Brook. A high-strain zone, the Victoria Lake shear zone, separates the low-grade tectonites of the Exploits Subzone from medium- to high-grade metamorphic tectonites to the south (Figure 2), although this shear zone does not represent the Exploits–Meelapaeg lithotectonic boundary as defined by Williams *et al.* (1988). A narrow band of medium- to high-grade metamorphic tectonites that has compositions typical of the Exploits Sub-

zone, the Howley Waters belt, occurs immediately south of the Victoria Lake shear zone (Figure 2). The Exploits Subzone rocks of the Howley Waters belt thus were amalgamated with the quartzitic rocks of the Meelapaeg Subzone before peak regional metamorphism and tectonic juxtaposition with the low-grade rocks of the Exploits subzone north of the Victoria Lake shear zone.

GEOGRAPHICAL LOCATION

The study area encompasses parts of the following map areas: King George IV Lake (NTS map area 12 A/4), Puddle Pond (NTS map area 12 A/5) and Victoria Lake (NTS map area 12 A/6). Fieldwork during the summer of 2000 was mainly confined to the area between Wood Lake and Victoria Lake, and the southwestern and eastern arms of Victoria Lake, but also includes the area between Victoria River and Peter Strides Pond (Figure 2). The geology of this area was mapped previously by Kean (1982, 1983). Most of the work in Victoria Lake was done along the south shore of the lake, including the mouth of the Howley Waters.

GEOLOGICAL SETTING AND LITHOLOGY

The Victoria Lake–Peter Strides Pond area is located near a triple point between the Dashwoods, Exploits and

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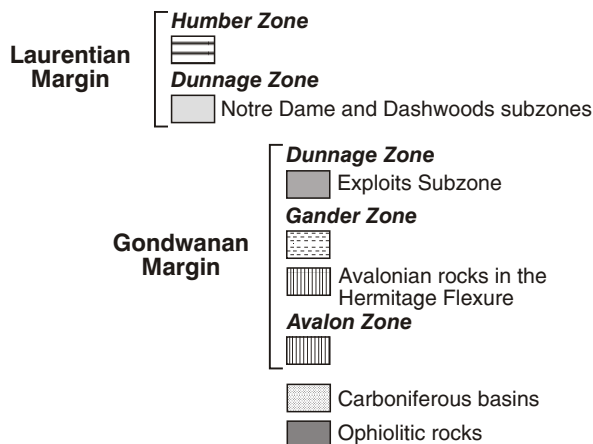
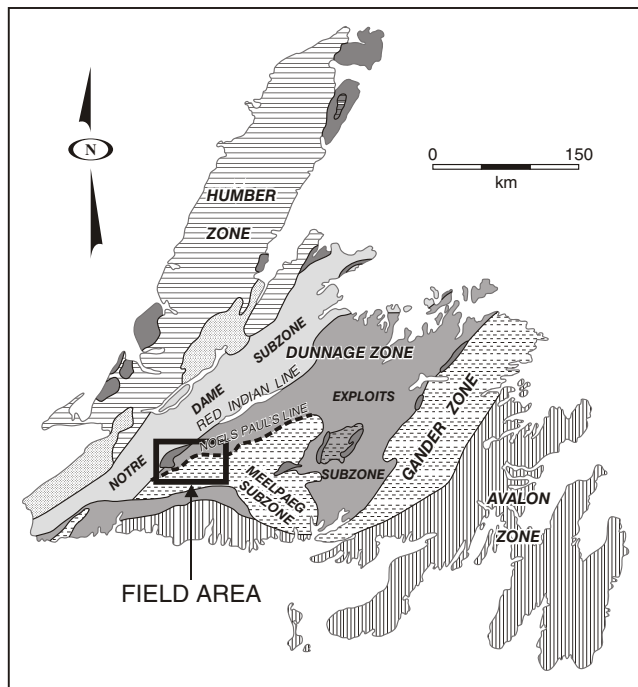


Figure 1. Lithotectonic zones of the Newfoundland Appalachians (modified after Williams *et al.*, 1988).

Meelapaeg subzones (Figure 1). The low-grade rocks of the Exploits Subzone are sandwiched between the Dashwoods and Meelapaeg subzones (Figure 1). The metamorphic tectonites of the Exploits and Meelapaeg subzones, south of the Victoria Lake shear zone, show an increase in metamorphic grade from the staurolite zone in the west to the sillimanite–K-feldspar (\pm cordierite) zone in the east (Owen, 1992).

THE LOW-GRADE ROCKS OF THE EXPLOITS SUBZONE

The low-grade metamorphic rocks of the Exploits Subzone that occur north of the Victoria Lake shear zone are

represented by the late Precambrian Valentine Lake quartz–monzonite (Avalonian basement inlier?; 563 ± 2 Ma; Evans *et al.*, 1990), the Cambrian to Middle Ordovician volcanic and sedimentary rocks of the Victoria Lake Group, the Rogerson Lake conglomerate (e.g., Kean, 1982, 1983; Williams, 1995), and the volcanic and associated sedimentary rocks of the fault-bounded Wood Lake and Victoria dam belts (Figure 2).

The Rogerson Lake conglomerate is a narrow unit that can be traced for a length of at least 160 km. It separates the Victoria Lake Group and Valentine Lake quartz monzonite from the Wood Lake and Victoria dam belts to the south and east (e.g., Evans *et al.*, 1990). The Rogerson Lake conglomerate is polymictic and contains clasts of the unconformably underlying Victoria Lake Group and the Valentine Lake quartz monzonite. The conglomerate is considered equivalent to the Botwood Belt, and therefore interpreted as Silurian (e.g., Kean, 1983; Williams, 1995).

The Wood Lake Belt

The Wood Lake belt extends from the southern shore of the southwestern arm of Victoria Lake, where it is in tectonic contact with a foliated mylonitic granite, south to Wood Lake following the trace of the Victoria River. This unit comprises deformed mafic volcanic rock, felsic fragmental volcanic rock, black shale, siltstone, psammite, chlorite schist, tuffaceous sandstone, and basaltic and gabbroic intrusions. The stratigraphic relationships between the various constituents of this belt are at this stage of the investigation largely unknown. The Wood Lake belt is separated by the Wood Brook fault (Figure 2) from the Victoria Lake Group and the Rogerson Lake conglomerate to the northwest and by the Victoria River fault from the staurolite zone metamorphic tectonites of the Howley Waters belt to the southeast. The Wood Brook and Victoria River faults are two discrete faults that form part of the Victoria Lake shear zone. The Wood Brook fault cuts the trace of the Rogerson Lake conglomerate near Wood Lake, juxtaposing highly deformed pillow basalt, siltstone, and mafic intrusions of the Wood Lake belt with the Victoria Lake Group. At the Victoria River fault, the Howley Waters belt is locally cut out and the Wood Lake belt is in direct tectonic contact with mylonitic granite (Figure 2). Rocks of the Wood Lake belt are equivalent to rocks of subunit 8a and partially to subunit 8b of the Bay du Nord Group of Kean (1983). All the rocks of the Wood Lake belt are strongly deformed and are metamorphosed to greenschist-facies conditions (biotite zone).

The Victoria Dam Belt

The Victoria dam belt is principally exposed in the eastern arm of Victoria Lake, near the Victoria dam, from which

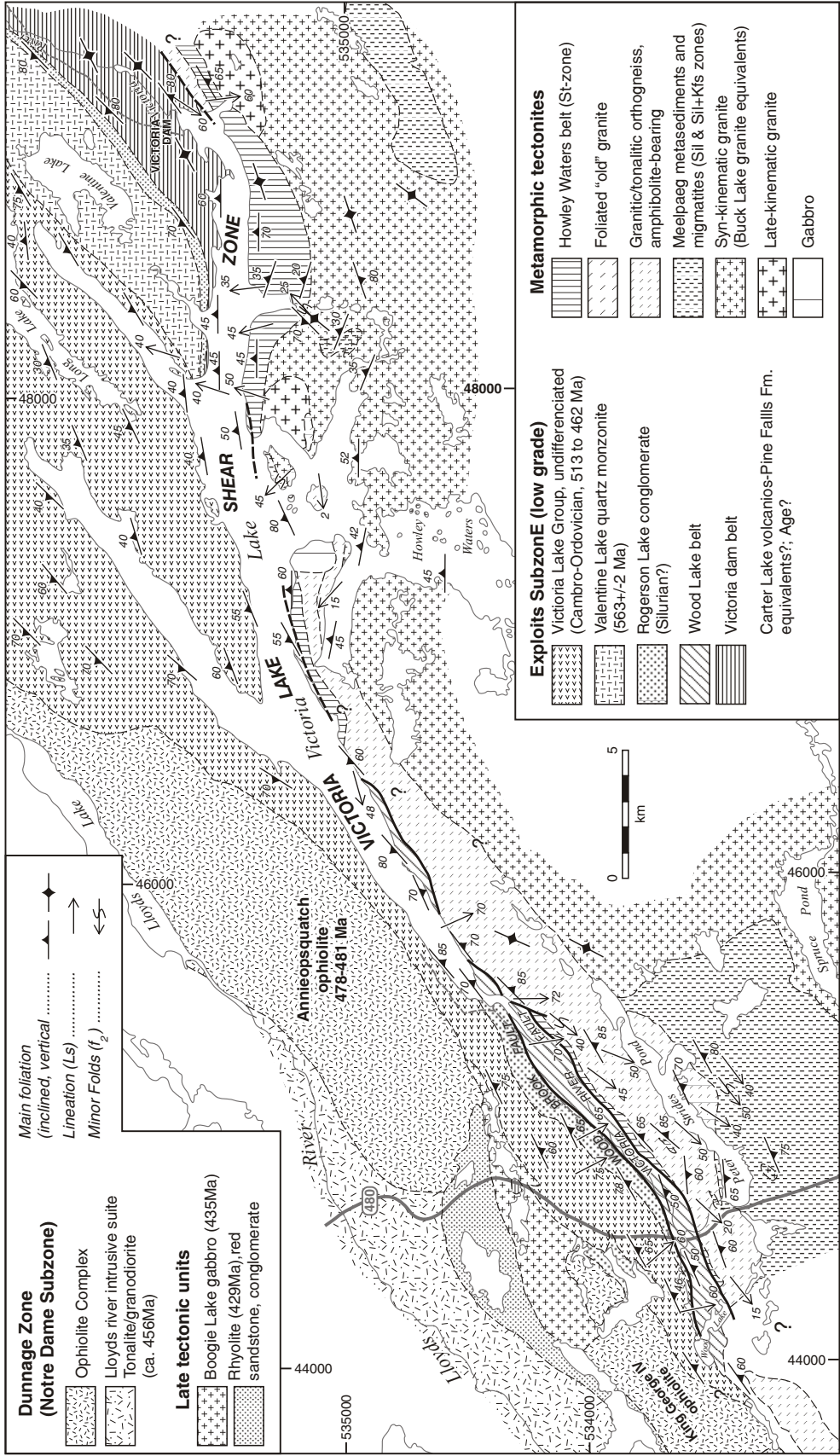


Figure 2. Geological map of the Victoria Lake-Peter Strides Pond area, partially compiled after Kearn (1982, 1983) and Durring (1987).

it extends north following the trace of the Rogerson Lake conglomerate (Kean, 1982). Rocks of this belt are sandwiched between the Rogerson Lake conglomerate to the west and the metamorphic tectonites of the Howley Waters belt to the east; hence it occupies the same tectonic position as the Wood Lake belt to the southwest. The Victoria dam belt includes black shale, tuffaceous sandstone/psammite and felsic volcanic rock, but basalt typical of the Wood Lake belt, is absent. The contact relationships with the adjacent Rogerson Lake conglomerate are unknown, but this contact is suspected to be a fault (continuation of the Wood Brook fault?). Rocks of the Victoria dam belt are equivalent to subunits 7c and 7d of the Victoria Lake Group of Kean (1982). Later these rocks were excluded from the Victoria Lake Group (Evans *et al.*, 1990).

A high-strain zone within the Victoria Lake shear zone separates rocks of the Victoria dam belt from the metamorphic tectonites of the Howley Waters belt. The contact between the contrasting rocks of the two belts is masked by a strongly foliated granite. There is no well defined metamorphic contrast across the shear zone because rocks of the Victoria dam belt show an increase in metamorphic grade to garnet zone toward the contact with the Howley Waters belt.

The Victoria dam and Wood Lake belts lie in equivalent tectonic position, within the Victoria Lake shear zone, and may form part of one continuous belt of Exploits Subzone rocks. It also includes the Carter Lake volcanics and the Pine Falls Formation farther to the north, and possibly the Lake Douglas pillow lavas? (e.g., Evans *et al.*, 1990).

METAMORPHIC TECTONITES

Most of the metamorphic tectonites consist of quartzites and pelitic schist typical of the Meelpaeg Subzone. The Howley Waters belt forms a narrow, 2- to 3-km-wide belt of Exploits Subzone rocks that occur immediately south of the Victoria Lake shear zone. It is uncertain whether the Howley Waters belt widens and includes the Bay du Nord unit of Kean (1983) south of Peter Strides Pond. It is also uncertain if some of the migmatite and gneiss that occur south of the Victoria dam are high-grade Exploits equivalents (Figure 2).

The Howley Waters Belt

This belt of metamorphic tectonites comprises pelite, semipelite, psammite, amphibole-bearing psammite, amphibolite, felsic porphyritic rocks (metavolcanic?), minor calc-silicate and marble. The Howley Waters belt is mainly exposed between the Howley Waters and the Victoria dam along the south shore of Victoria Lake, but thin, isolated slivers of similar tectonites extend along the Victoria River fault to the Burgeo road north of Peter Strides Pond (Figure

2). A large mass of foliated and undeformed granite separates the Howley Waters belt from the migmatites of the Meelpaeg Subzone. High-grade gneissic rocks of the Howley Waters belt are exposed on the islands that occur at the mouth of the Howley Waters; the gneisses are intruded by late-kinematic granite and undeformed gabbro.

The tectonites of the Howley Waters belt are equivalent to the amphibolite-facies rocks of the Victoria Lake Group of Kean (1982) and subunit 8b of the Bay du Nord Group of Kean (1983); correlation with subunit 8c of the Bay du Nord Group of Kean (1983) is pending further investigation south of Wood Lake. The close spatial association within Gander Zone rocks and the presence of calc-silicate rock and marble suggest that the tectonites of the Howley Waters belt are correlative of the rocks of the Lower to Middle Ordovician Davidsville and Baie d'Espoir groups (Colman-Sadd, 1980; Colman-Sadd *et al.*, 1992).

Meelpaeg Subzone Tectonites

Tectonites that conform to the definition of the rocks of the Meelpaeg Subzone are exposed in the vicinity of Peter Strides Pond (Figure 2). They include quartz-rich psammite, quartzite, biotite-rich, locally sillimanite-bearing schist, migmatite, and minor amphibolite dykes. Tonalitic and granitic orthogneiss is locally closely associated with the metasedimentary tectonites. The orthogneiss hosts amphibolite dykes and enclaves; amphibolite dykes are also present with the metasediments as a minor component.

A large pink/grey mylonitic granite has intruded the tectonites of the Howley Waters belt and the Meelpaeg Subzone near Peter Strides Pond. This granite, which is herein referred to as the "old" granite can be traced from Wood Lake to Victoria Lake and intruded before the D2 deformation. D2 also overprinted the migmatites, which were presumably formed by anatexis of the sillimanite-zone metasedimentary rocks. Enclaves of staurolite-bearing mica schist found within the "old" granite having syn-D2 staurolite porphyroblasts, suggest that this granite intruded before peak-temperature metamorphism in the staurolite zone. Large bodies of the younger, syn- to post-D2 Buck Lake granite (Kean, 1983) occupy most of the Meelpaeg Subzone south and east of Peter Strides Pond. The Buck Lake granite includes foliated megacrystic granite, foliated to non-foliated garnetiferous granite, and schlieren-rich foliated granite. Granodiorite and tonalite, locally hornblende-bearing, are associated with the Buck Lake granite, and where intensively deformed have been transformed into migmatitic gneiss. The oldest component of a migmatitic gneiss near Peter Strides Pond yielded a U-Pb zircon age of 418 ± 4 Ma (Currie *et al.*, 1991). This age broadly coincides with an unpublished Mid-Silurian U-Pb monazite age from Peter Strides

Pond (Dunning in Owen, 1992). Weakly deformed to undeformed two-mica garnetiferous granite has intruded the metamorphic tectonites during the late stages of the regional deformation, further masking the relationships between the tectonites of the Meelpaeg Subzone and the Howley Waters belt.

STRUCTURE

The Victoria Lake shear zone is divided into three sectors: a) a greenschist-facies fault system along the southwestern contact with the metamorphic tectonites (southwestern sector); b) a north-dipping central sector; and c) a steep southeast-dipping shear zone near the Victoria dam (eastern sector; Figure 2). The shear zone is only well exposed in the eastern and southwestern sectors.

The Southwestern Sector, a Greenschist-Facies Fault System

In the southwestern part of the field area, the Victoria Lake shear zone is mainly represented by the highly strained rocks of the Wood Lake belt and bounded by two relatively discrete faults: the Wood Brook and the Victoria River faults (Figure 2). The rocks affected by the shear zone have a well developed L-S fabric. The Wood Brook fault truncates the Rogerson Lake conglomerate, whereas the Victoria River fault marks a metamorphic jump between the relatively low-temperature biotite zone rocks of the Wood Lake belt and the high-temperature amphibolite-facies tectonites of the Howley Waters belt and Meelpaeg Subzone. Greenschist-facies mylonitic fabrics are well developed along the trace of the Victoria River fault, particularly in the mylonitic granite exposed along the southwestern arm of Victoria Lake. The lineation (Ls) and the main foliation in rocks of the Rogerson Lake conglomerate, the Wood Lake belt and the Victoria River fault are subparallel (Figures 2 and 3), suggesting that the strain accumulated in the rocks and the translations accommodated by both faults are linked to the same deformational event. The main foliation in the Wood Lake belt is a transposition foliation (S2), and locally preserved intrafolial folds suggest the presence of an earlier phase of deformation (D1). A stretching lineation (Ls) defined by the long dimension of the widespread boudins is associated with the S2 fabric and plunges generally 60° to 75° to the southeast. In the Rogerson Lake conglomerate, the main foliation is a composite S-C fabric (Plate 1a; Lister and Snoke, 1984) with a steep foliation (p-plane) cut at 20° by a second foliation (c-plane), this c-plane contains the stretching lineation (Ls; Figure 3) and shears the p-plane. Asymmetric boudins (Plate 1b), winged and rotated clasts in the conglomerate and S-C fabrics in areas of high strain indicate a reverse motion of top to the north-northwest, if the transport vector is assumed to be parallel to the direction of finite extension (Ls).

Deformation associated with the Victoria Lake shear zone in the metamorphic tectonites, at least, in part postdates peak-temperature metamorphism. The main foliation (S2) of the metamorphic tectonites contains locally aligned sillimanite (fibrolite) that wraps around the older staurolite porphyroblasts. This foliation is also the main fabric in the "old" mylonitic granite situated along the Victoria River fault and the migmatites, and is axial planar to isoclinal F2 folds (Plate 1c) that plunge moderately to the southwest, parallel to a strong lineation (Lm). The F2 structures fold the S0-S1 fabric in the staurolite-micaschist quartz veins and a S1 fabric in the granite and orthogneisses, and re-fold leucosome patches in migmatitic metapelite. In the area near Peter Strides Pond, the main foliation (S2) in the metamorphic tectonites dips south-southeast and is subparallel to the main foliation (S1) in the low-grade rocks of the Exploits Subzone (Figure 3). In contrast to the greenschist-facies rocks of the Wood Lake belt, the lineation (Lm) in the amphibolite-facies tectonites is more oblique and plunges 15 to 50° to the southwest, subparallel to the F2 folds (Figure 3), suggesting that the deformation accommodated by the Victoria Lake shear zone in this sector is sinistral transpressive. However, wherever mesoscopic kinematic indicators have been observed in these rocks, the strike-slip component is dextral rather than sinistral (Plate 1d). Possibly, the Victoria Lake shear zone accommodated a complex, polyphase movement history. The D2 deformation was penetrative throughout the area underlain by the metamorphic tectonites. Injections of granite associated with the Buck Lake phase, into the tectonites, locally cut S2, but are also folded by F2 and/or show extensive boudinage, suggesting that they intruded during D2. The absence of any fabrics in the youngest members of the Buck Lake granite phase suggests that intrusion locally outlasted D2 deformation. The absence of clear marker units and the widespread injection of granite coupled with lack of continuous outcrop have so far prevented mapping the large-scale geometry of the metamorphic tectonites.

The Central Sector

In the central part of Victoria Lake, near the mouth of the Howley Waters on the southern shore of the lake, the metamorphic tectonites are characterized by a consistently north-dipping S2 transposition foliation having a nearly down-dip lineation (Ls). These structures are parallel to the main L-S fabric in the Victoria Lake Group and the Rogerson Lake conglomerate on the northern shore of the lake and suggest that the low-grade rocks of the Exploits Subzone structurally overlie the amphibolite-facies tectonites in this sector. Kinematic indicators in the Rogerson Lake conglomerate and the staurolite-zone rocks of the Howley Waters belt indicate a normal shear sense of top to the north.

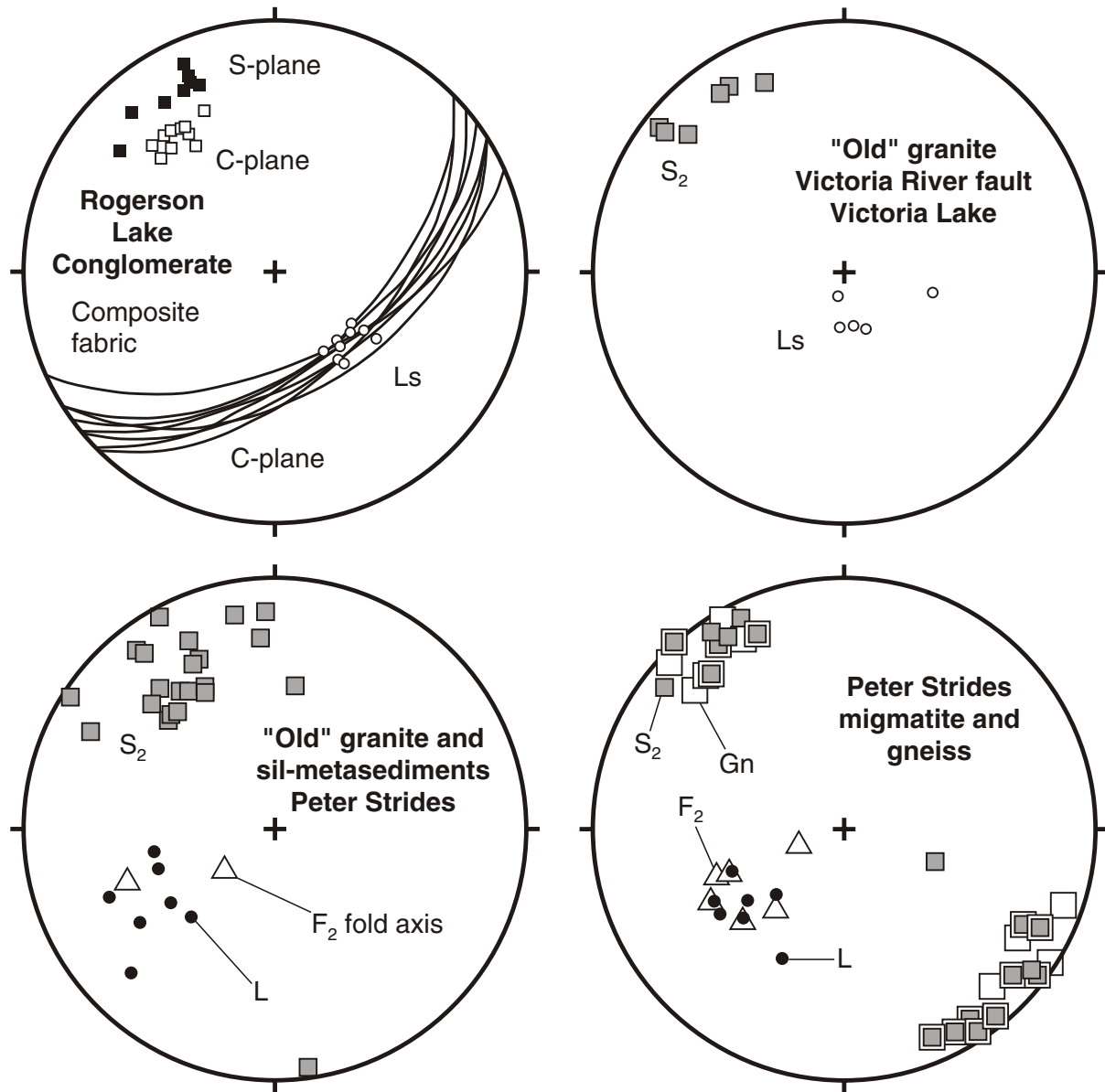


Figure 3. Lower hemisphere, equal area stereonets: S_2 , main fabric; L_s , stretching lineation (greenschist facies); L , lineation (metamorphic tectonites); F_2 , F_2 fold axis; Gn , gneissosity. Location of the data from the Rogerson Lake conglomerate: Burgeo road (UTM 444700-5335450).

Plate 1. (opposite page) Field and petrographic relationships. a) Composite fabric in the Rogerson Lake conglomerate, Burgeo road (see text for description; UTM 444700-5335450); b) Asymmetric boudinage of a quartz vein, Howley Waters belt, Victoria River fault (location UTM 453000-5341250). The pen marks the orientation of the lineation; c) F_2 isoclinal fold, metaquartzite, Meelpaeg Subzone, Peter Strides Pond (UTM 452950-5335700); d) Dextral shear bands (D_2), Howley Waters belt, west of the Burgeo road (UTM 444450-5335250); e) Syn-kinematic staurolite porphyroblast (5mm diameter), the external foliation (S_2) contains fibrolitic sillimanite, Howley Waters belt, Victoria Lake (UTM 484000-5351150); f) F_3 folding of the main S_2 - SO fabric in the Howley Waters belt (same location as 4e); g) F_2 fold of the S_1 - SO fabric and axial planar S_2 fabric, Victoria dam belt, Victoria Lake (UTM 491450-5355000).

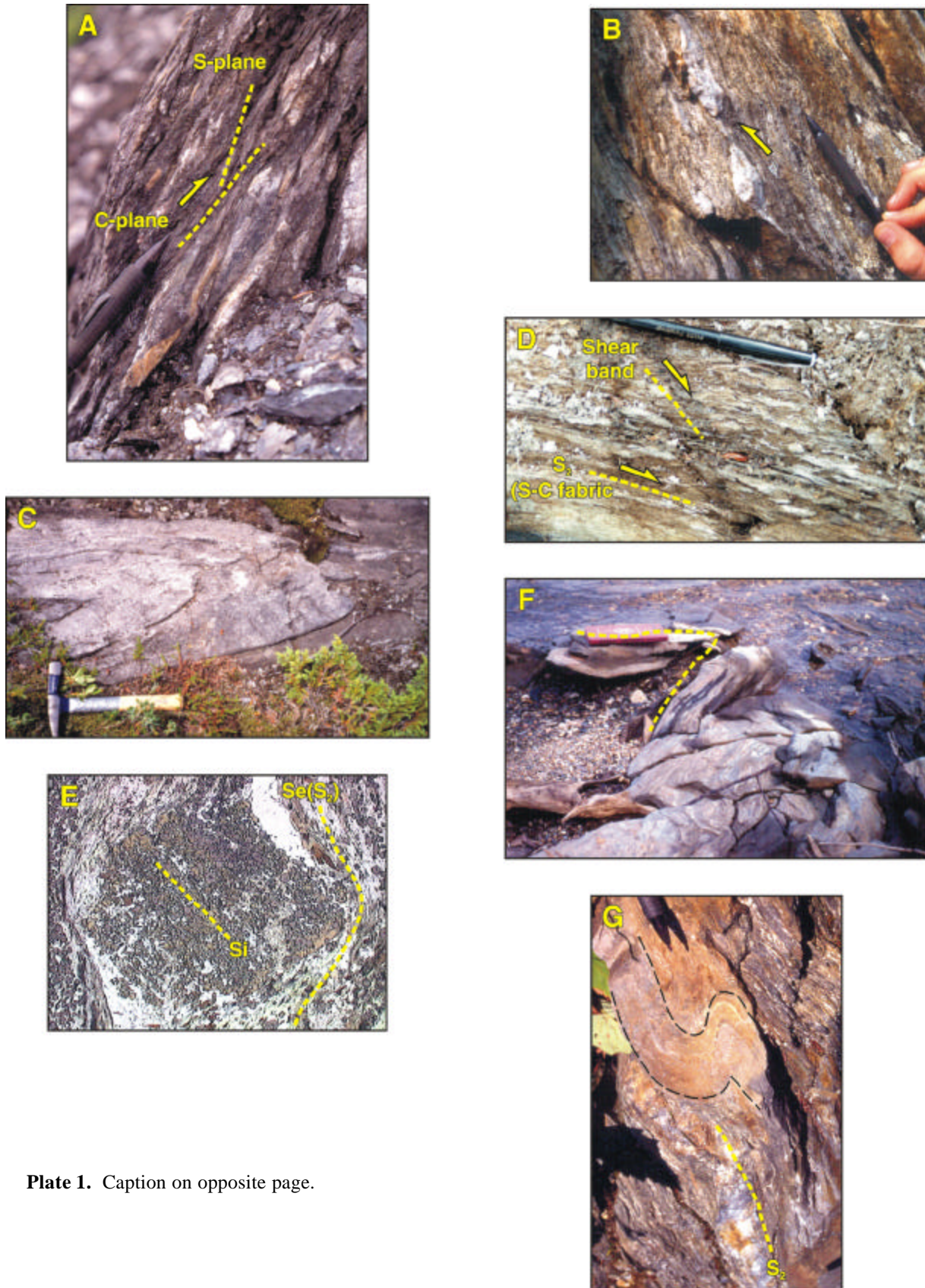


Plate 1. Caption on opposite page.

The main S2 transposition foliation in the tectonites of the Howley Waters belt wraps around staurolite porphyroblasts, the inclusions of which preserve evidence of the S1 foliation (Plate 1e). S2 is folded by north-dipping F3 folds, the significance of which is uncertain (Plate 1f). Locally, small dextral strike-slip shear zones are present in the granitic orthogneiss near the mouth of the Howley Waters. The structural relationship between the dextral shear zones, the F3 folds, and the normal movement in the north-dipping Victoria Lake shear zone in this sector remain to be established.

The Eastern Sector, The Victoria Dam Area

The Victoria Lake shear zone in the northeastern part of the study area, is exposed at the contact between the greenschist-facies Victoria dam belt and the amphibolite-facies tectonites of the Howley Waters belt. These two belts are separated by a strongly foliated granite that resembles the "old" granite phase in the southwestern sector. Evidence for discrete fault zones, like the Victoria River fault in the southwestern sector however, has not been observed. The Victoria Lake shear zone is defined by a steeply southeast-dipping S2 transposition foliation that is axial planar to small-scale F2 folds of bedding (S0) and S1 in the phyllites of the Victoria dam belt (Plate 1g) and the tectonites of the Howley Waters belt. S2 contains a south-plunging stretching lineation (Ls), mainly defined by the long dimension of boudins. Contrary to the central sector, the amphibolite-facies tectonites of the Howley Waters belt thus overlie the low grade rocks of the Exploits Subzone. Rare shearbands indicate a reverse motion with top to the north. The S2 foliation in the Victoria dam belt is locally folded by small-scale, open recumbent folds and a subhorizontal crenulation cleavage. Similar structures are also present locally in the rocks of the central sector. They are probably younger than the F3 folds.

The phyllites of the Victoria dam belt near the contact with the granite contain metamorphic assemblages having garnet, biotite and albite and structurally underlie higher grade, staurolite-zone tectonites of the Howley Waters belt. The inverse metamorphism with amphibolite-facies tectonites overlying greenschist-facies rocks is similar to that observed in the southwestern sector of the area, although the metamorphic contrast is not as strong.

DISCUSSION

The Victoria Lake shear zone marks the boundary between the amphibolite-facies tectonites (Howley Waters belt + Meelpaeg Subzone) and the greenschist-facies rocks of the Exploits Subzone. This structure is equivalent to the

original definition of the Noel Paul's Line by Brown and Colman-Sadd (1976), but does not coincide with the trace of Exploits–Meelpaeg lithotectonic boundary in the Victoria Lake area, which is located at the contact between the tectonites of the Howley Waters belt and the granites of the Meelpaeg Subzone (Colman-Sadd *et al.*, 1990). Unfortunately, the trace and nature of the Exploits–Meelpaeg contact is masked by the large mass of syn- to late-kinematic granites, generally referred to as the Buck Lake phase in this part of Newfoundland. Field and petrographic relationships suggest that the juxtaposition of the Howley Waters belt (Exploits) and the tectonites of the Meelpaeg Subzone took place before peak-temperature regional metamorphism and before the intrusion of the "old" granite.

The parallelism of the main L-S fabric across the central and eastern parts of the Victoria Lake shear zone suggests that the final juxtaposition of the low-grade rocks of the Exploits Subzone with the amphibolite-facies tectonites was associated with development of the S2 transposition foliation. Juxtaposition thus probably took place late during D2 after peak-temperature metamorphism represented by the S2 fibrolite. Migmatitic gneiss (F2 folded tonalite) near Peter Strides Pond, yielded a U–Pb age of 417 ± 4 Ma, which probably dates peak metamorphism in the tectonites (Currie *et al.*, 1991). Hence, D2 deformation associated with the Victoria Lake shear zone started at least by 417 Ma, while the final juxtaposition between the low- and high-grade terranes took place later, probably during the Early Devonian.

Piasecki (1995) interpreted the Victoria Lake shear zone, which he correlated with the Noel Paul's Line, as a sinistral–oblique thrust fault. This study confirms the proposed reverse motion along the Victoria River and Wood Brook faults in association with the greenschist-facies deformation. However, evidence for a sinistral strike-slip component motion has not been found. The progressive change in dip and trend of the shear-zone related foliation and change from reverse to normal and back to reverse motion along the length of the Victoria Lake shear zone is poorly understood at present.

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