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STRUCTURES ASSOCIATED WITH THE RED INDIAN LINE IN SOUTHWESTERN NEWFOUNDLAND

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ABSTRACT

The Red Indian Line segment between Lloyds Lake and Mink Lake is marked by a narrow D_1 shear zone, which appears to have accommodated mainly sinistral oblique reverse movements, such that the Early Ordovician Annieopsquotch ophiolite belt was thrust to the south–southeast over the Victoria Lake Group. Time constraints imposed by the Boogie Lake intrusive complex and Silurian red beds indicate that initial amalgamation of the Notre Dame and Exploits subzones along the Red Indian Line took place, prior to 435 Ma (Early Silurian). However, D_1-related movements continued into the Silurian as indicated by the presence of D_1 structures in the Silurian red beds that formed during brittle–ductile southeast-directed thrusting of the Annieopsquotch ophiolite belt. Three ductile (D_2 to D_4) and one brittle–ductile deformation event have modified the original thrust geometry and appear to have reactivated the Red Indian Line after the Early Silurian.

INTRODUCTION

The Notre Dame Subzone–Exploits Subzone lithotectonic boundary in Newfoundland, designated as the Red Indian Line (RIL), was defined, based on contrasts in Ordovician–Early Silurian structure, stratigraphy and fauna (e.g., Williams *et al.*, 1988). To the northwest of the RIL, the Notre Dame Subzone, which has Laurentian faunal affinities is, in part, represented by the Annieopsquotch ophiolite belt (AOB) consisting of ophiolitic fragments including the Annieopsquotch and King George IV ophiolite complexes (Dunning, 1987a). The AOB is now in tectonic contact to the west with the Dashwoods Subzone (Lissenberg and van Staal, *this volume*), which probably represents a Laurentian microcontinent (Waldron and van Staal, 2001). The Exploits Subzone, which has Gondwanan faunal affinities, lies to the southeast of the RIL and consists of (sub)greenschist-facies volcanic and sedimentary rocks. Although the RIL may represent the principle suture (separating rocks with Laurentian faunal affinities from those with Gondwanan affinities), this structure has received little attention in the past. Field mapping has revealed that a variably exposed zone of mylonite and phyllonite marks the RIL. This zone and associated sheared rocks have been studied from Lloyds Lake to the junction between Notre Dame, Dashwoods, Exploits and Meelpaeg subzones, where the RIL and the Victoria Lake shear zone join (Valverde-Vaquero and van Staal, 2001; Figure 1, Loc. A).

GEOGRAPHICAL LOCATION

The study area partially covers King George IV Lake, Puddle Pond, and Victoria Lake map sheets (NTS map area 12 A/4, 12 A/5, and 12 A/6) and was mapped previously by Kean (1982, 1983) and Dunning (1984). The field area was reached by traverses from Victoria Lake, Mink Lake and Pats Pond access roads, Burgeo Highway (Route 480), and from minor logging roads.

REGIONAL GEOLOGY

The Notre Dame and Dashwoods subzones represent a Early to Middle Ordovician magmatic arc formed as a result of east-dipping subduction immediately outboard of the Laurentian margin (van Staal, 1994; Whalen *et al.*, 1997). Following collision of this magmatic arc with the Laurentian margin during the Middle Ordovician, a new, west-dipping subduction zone was established immediately east of the Notre Dame and Dashwoods subzones (van Staal *et al.*, 1998; Waldron and van Staal, 2001). The AOB may represent scraped off segments of oceanic crust that were incorporated into this subduction zone (Annieopsquotch accre-

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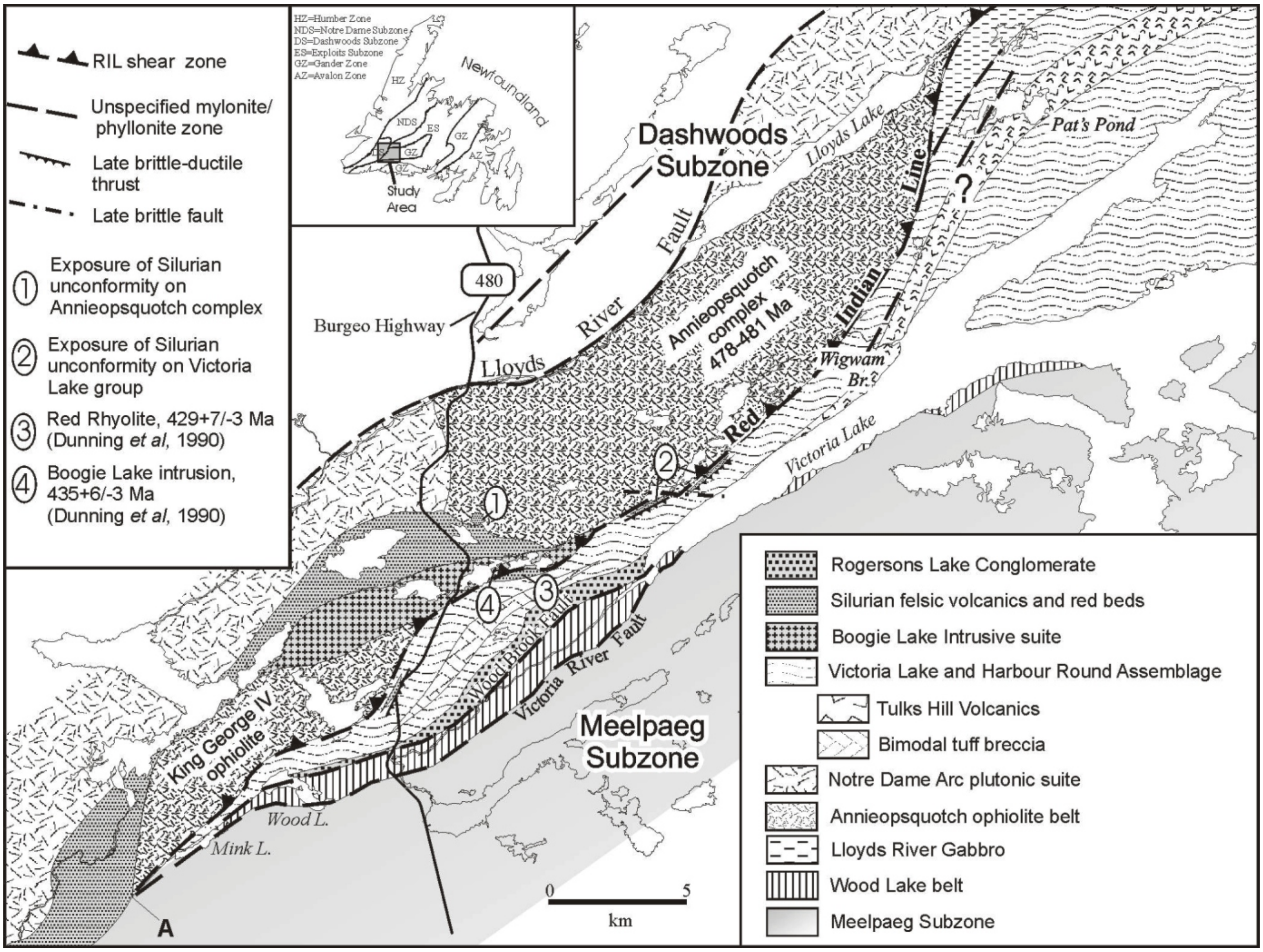

Figure 1. *Regional geology of the Mink Lake–Lloyds Lake area, partially modified from Kean (1982, 1983), Dunning (1984), Valverde-Vaquero and van Staal (2001), Lissenberg and van Staal (*this volume*).*

tionary tract) or remnants of oceanic crust that was attached to the Dashwoods Subzone (Lissenberg and van Staal, *this volume*). The rocks of the immediately adjacent Exploits Subzone represent the vestiges of Peri-Gondwanan island-arc–back-arc systems that were accreted to the Laurentian margin during the Late Ordovician and Silurian (van Staal *et al.,* 1998). The Red Indian Line (RIL) has experienced a protracted history of movements, and represents the principal suture zone separating rocks with Laurentian faunal affinities from those having Gondwanan affinities.

ANNIEOPSQUOTCH OPHIOLITE BELT

The AOB consists of Early Ordovician ophiolitic fragments exposed on the west side of the RIL, including the King George IV and Annieopsquotch ophiolite complexes (Dunning, 1987b). Previous mapping indicated that younger rocks separated these two ophiolite complexes. The present investigations suggest that they may still be structurally connected by a series of thin slivers caught up in the RIL.

The lithology of Annieopsquotch ophiolite complex has been studied in detail by Dunning (1984) and comprises layered ultramafic and mafic cumulate, gabbro, sheeted dyke and pillow basalt. The ophiolitic stratigraphy suggests an overall younging to the east. However, close to the RIL, the pillows of the Annieopsquotch ophiolite complex generally young toward the southwest (Figure 2a). Pillow basalt of the King George IV ophiolite also young toward the southwest, suggesting that the ophiolites may be internally folded, contrary to the interpretation by Dunning (1984). Penetrative tectonic structures are generally not developed in the ophiolitic rocks except in proximity to the RIL (Plate 1) and the Lloyds River fault.

HARBOUR ROUND ASSEMBLAGE

Purplish-stained pillow basalt containing interpillow jasper and red shale, as well as interbedded buff-weathering felsic tuff and jasper (Figure 2b) are discontinuously present from east of Lloyds Lake to the south of the Annieopsquotch ophiolite complex. These rocks are tentatively interpreted as the continuation of the lithologically similar Harbour Round assemblage (an informal name temporarily assigned to the Harbour Round Formation of Evans *et al*. (1990) until more data becomes available to test whether its rocks are related to those of the Notre Dame Subzone to the west as proposed by Thurlow *et al*. (1992) or to the adjacent rocks of the Victoria Lake Group of the Exploits Subzone to the east). Felsic pyroclastic rocks interbedded with jasper, red shale and locally basalt and basaltic breccia that occur to the southeast of King George IV ophiolite complex up to Mink Lake (Figure 1) may represent a further extension of the Harbour Round assemblage.

VICTORIA LAKE GROUP

The Victoria Lake Group is a part of the Exploits Subzone and consists mainly of low-grade Cambro-Ordovician (513 to 462 Ma) volcanic and sedimentary rocks of the Tally Pond volcanic assemblage (513 ± Ma) and Tulks Hill volcanic assemblage (498 +6/-4 Ma; Evans *et al.*, 1990). Locally, it also includes younger Middle Ordovician sedimentary rocks. The Victoria Lake Group is bounded by the Rogerson Lake Conglomerate to the south and east, and by the Middle Ordovician Harbour Round and Sutherlands Pond assemblages to the west (Rogers and van Staal, *this volume*). Volcanic rocks correlative with the Victoria Lake Group are probably present in the Wood Lake–Lloyds Lake area although precise correlation is not yet possible and awaits geochronological and geochemical investigations.

Bimodal Tuff Breccia

A belt of bimodal tuff breccia and pillow basalt is prominent in the purported Victoria Lake Group southeast of the RIL and Annieopsquotch ophiolite complex. The tuff breccia comprises large angular blocks of felsic volcanic and locally basalt, set in a lapilli- to ash-tuff matrix; bedding is poorly developed in this unit. The tuff breccia appears to be transitional with southeast-younging pillow basalt. The basalt has well-formed vesicular pillows, fragments of which appear in the overlying bimodal tuff breccia.

Tulks Hill Volcanic Assemblage

A narrow belt consisting of quartz- and feldspar-phyric felsic tuff and tuff breccia, commonly altered to emerald green chlorite and white mica-rich phyllite, is continuous from Wigwam Brook on the shore of Victoria Lake, where it is associated with pyritic black shale, to Pat's Pond (Figure 1). Near Pat's Pond, this unit is transitional having beige-weathered quartz- and feldspar-phyric tuff and tuff breccia, and associated with quartz-phyric granodiorite considered to form part of the Tulks Hill volcanic assemblage (e.g., Jambor and Barbour, 1987). Based on lithological similarities, it seems reasonable to extend the Tulks Hill volcanic assemblage at least to the shore of Victoria Lake near the mouth of Wigwam Brook.

SILURIAN RED BEDS

Red sandstone and minor conglomerate, mudstone and limestone unconformably overlie the rocks of the Annieopsquotch ophiolite complex (Dunning, 1987a) and the Victoria Lake Group. This unit has been deposited in a braided river setting in an arid environment, as evidenced by calcite cement in some areas (Chandler and Dunning, 1983). The red beds are variably folded and faulted and, as a result, are typically moderately to steeply dipping. They are locally interbedded with purplish red rhyolite dated at 429 +7/-3 Ma (Dunning *et al.*, 1990), constraining the red bed deposition mainly to the late Early Silurian.

An unconformity between the Annieopsquotch ophiolite and the Silurian red beds is exposed in several localities north of the Bear Pond (Dunning, 1987a; Figure 1, Loc. 1). At one locality, crudely stratified conglomerate, rich in gabbro and diabase cobbles overlie hematite-stained rocks of the Annieopsquotch ophiolite complex. Conglomerate is interbedded with thinly laminated trough crossbedded sandstones, which indicate transport to the northeast (Dunning, 1987a).

Silurian red beds unconformably overlie the rocks of the Harbour Round assemblage or the Victoria Lake Group. The unconformity is exposed in several locations in proximity to the RIL (Figure 1, Location 2). Brownish-weathering diabase and basalt below the unconformity gradually become more yellow-orange and appear transitional with red siltstone, sandstone and pebble conglomerate (Figure 2c). Locally, basalt and diabase are directly in contact with the unconformably overlying conglomerate. The polymictic conglomerate is clast-supported and is dominated by mafic clasts where diabase, basalt (locally epidotized) and gabbro comprise as much as 70 percent of the rock. There are also significant amounts of red shale, jasper, and felsic volcanic clasts. The unconformity is folded, forming a tight, well-cleaved syncline on the southeast side of the RIL.

ROGERSON LAKE CONGLOMERATE

The Rogerson Lake Conglomerate has been mapped from the Burgeo Highway to Victoria Lake. It is a continuous unit of strongly deformed polymictic conglomerate interbedded with sandstones and rare limestone beds. Clast population is predominantly felsic volcanic, with lesser amounts of jasper, red shale, mafic volcanic, black shale, red sandstone, vein quartz and granite. Felsic clast dominance

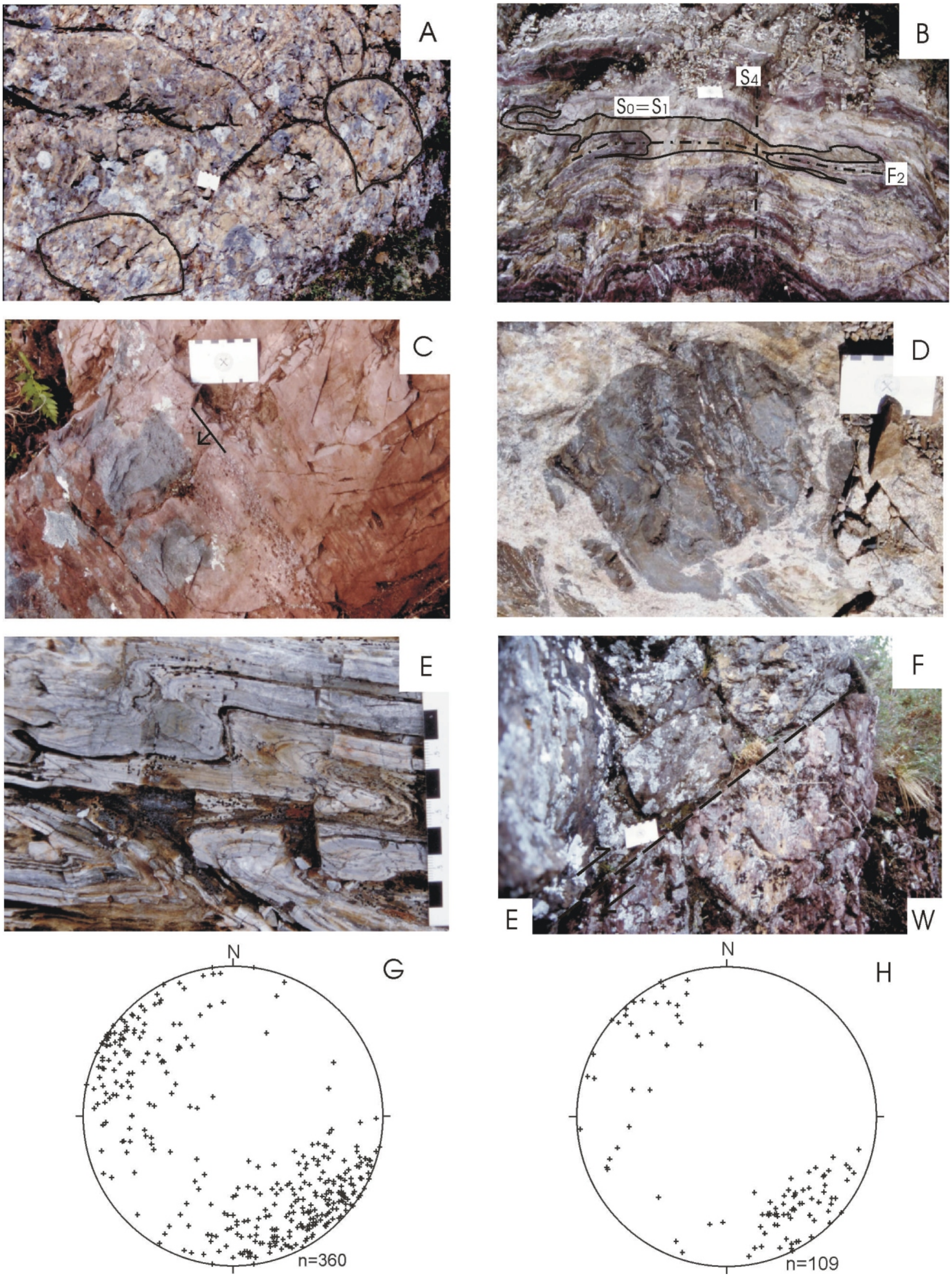

Figure 2. Caption on facing page.

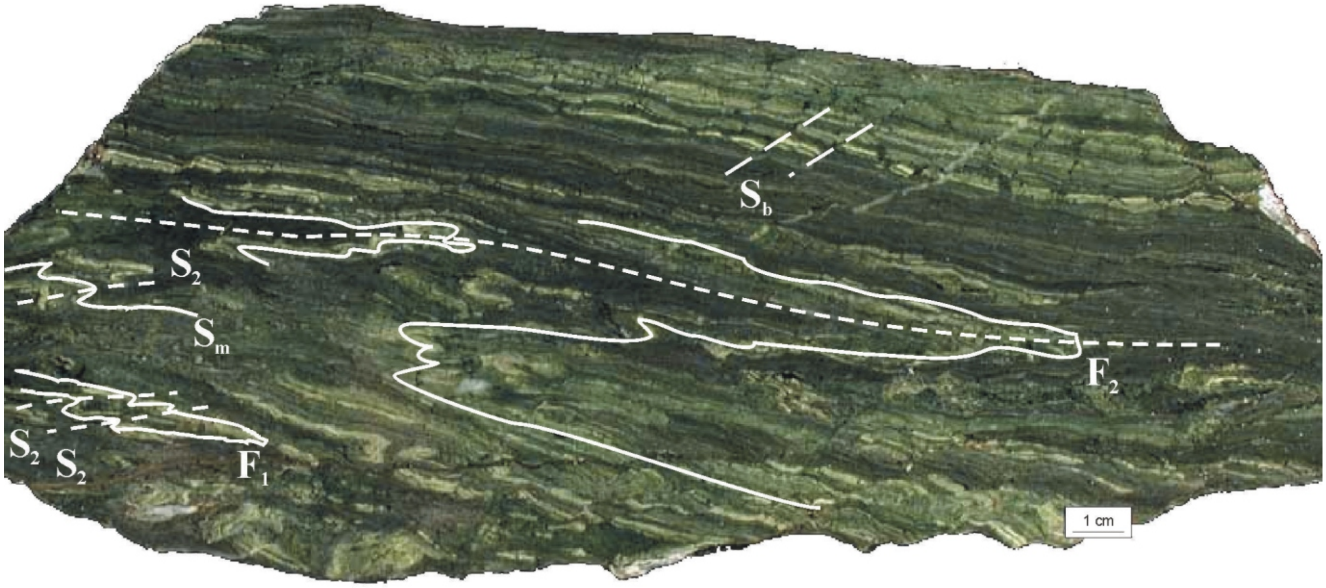

Plate 1. *Vertical slab cut parallel to stretching lineation of mafic phyllonite from the Red Indian Line. The phyllonite comprises a composite transposition foliation with dismembered F_1 folds of S_m (solid lines) overprinted by tight, z-shaped F_2 folds (axial plane traces marked by short dashed lines) and shallow west-dipping shear fractures (S_b, long dashed lines).*

suggests that this unit may unconformably overlie the Victoria Lake Group, while the presence of red sandstone clasts suggests that Early Silurian red beds contributed detritus to this unit.

The contact between Victoria Lake Group and Rogerson Lake Conglomerate is exposed in two locations. On the Burgeo Highway, highly strained conglomerate is in tectonic contact with the Victoria Lake Group (Valverde-Vaquero and van Staal, 2001). Ten kilometres to the northeast a weakly strained, probably depositional contact between the conglomerate and felsic volcanic rocks of the Victoria Lake Group is exposed. At this locality, felsic tuff grades into felsic-dominated conglomerate and into the typical polymictic facies characteristic of Rogerson Lake Conglomerate.

BOOGIE LAKE INTRUSIVE COMPLEX

The Boogie Lake intrusive complex is an elongate body comprising gabbro, hornblende diorite and monzonite–monzogranite that intrudes the AOB and mylonitic rocks of the RIL. The monzonite–monzogranite is intrusive into the mafic phases and has yielded an Early Silurian U–Pb zircon age of 435 +6/-3 Ma (Dunning *et al.*, 1990). Generally, the rocks of the intrusive complex are weakly foliated and/or appear macroscopically unstrained. The intrusive complex cuts the mylonitic rocks of the RIL south of Bear Pond, immediately on the west side of the Burgeo Highway. Mylonitic mafic xenoliths of the Annieopsquotch ophiolite complex within monzogranite (Figure 2d) confirm that most ductile movements along the RIL predate the ca. 435 Ma phase of the Boogie Lake intrusive complex.

Figure 2. (opposite page) *(a) Southwest-younging pillow basalts in the Annieopsquotch complex. Two well-formed pillows outlined in black with younging indicated in the top right corner. (b) Doubly plunging F_2 folds (outline of bedding) in interbedded felsic tuff and jasper of the presumed Harbour Round assemblage. Composite S_0/S_1 and a possible F_1 hinge are folded by F_2 folds with steep axial surfaces. All structures are crenulated by steep S_4. D_3 structures are not visible in this outcrop but are present in the surrounding area. (c) Overturned redbed sandstone and granule to pebble conglomerate less than a metre away from the unconformity with the Victoria Lake Group or the Harbour Round assemblage. (d) Amphibolite xenolith with intense fabric (S_1, solid line) in unfoliated Boogie Lake intrusion. (e) Asymmetric, s-shaped folds in mylonitic (S_1, solid line) tectonites that mark the Red Indian Line. The interlimb angle changes from open to isoclinal along the axial surfaces of the folds. The relative anticlockwise rotation of the axial planes (dashed line) when the fold becomes tighter indicates sinistral shear. (f) West-verging brittle - ductile thrust emplacing Victoria Lake Group or the Harbour Round assemblage above the Silurian redbeds. Lower hemisphere equal-area projection of (g) S_1 measurements, and (h) S_2 measurements.*

STRUCTURE

The RIL defines the tectonic boundary between the Exploits and Notre Dame subzones, however the exact location, character and nature of this tectonic boundary was not well known (e.g., Williams *et al.,* 1988; Dunning, 1987b). This preliminary investigation show that the RIL is marked by a mylonitic or phyllonitic shear zone wherever it is exposed. The shear zone separates rocks with distinctly different structural histories. Some of the mylonites are developed in felsic volcanic rocks and transformed into very fine-grained rock that resemble cherts. The chert unit mapped by Dunning (1981) is largely composed of mylonitic rocks that are associated with the RIL.

MYLONITES AND PHYLLONITES OF THE RED INDIAN LINE

The Annieopsquotch and King George IV ophiolite complexes appear to mostly represent well-preserved fragments of oceanic crust with little or no imprint of regional deformation (Dunning 1984, 1987a, b). Although Dunning (1984) proposed that the whole ophiolite complex acted as a relatively rigid body throughout Ordovician orogenesis, and attributed all of the structures and metamorphism internal to the ophiolite to seafloor deformation and associated alteration, the present observations only partially support this. Deformation structures such as shear zones, multiple generations of foliations and mesoscopic folds as well as indications of large-scale folding have been observed in the field (*see above*).

Mapping of the Annieopsquotch ophiolite complex this summer (2001) was mainly restricted to the areas immediately to the northwest of the RIL. Here, a penetrative north–northwest-trending foliation is locally developed, but abruptly disappears to the southeast where it is replaced by northeast-trending mylonites and/or phyllonites that are associated with the RIL shear zone (Plate 1).

The RIL shear zone can be internally separated into two parallel, narrow belts. The southeastern belt is mainly represented by low temperature (chlorite-zone), generally steeply dipping tectonites of the Harbour Round assemblage and/or Victoria Lake Group that have a strong phyllonitic foliation (S_1), which is commonly crenulated and kinked by subsequent deformation events (D_2 to D_4 recognized by overprinting relationships). The northwestern belt is represented by steeply dipping mafic mylonites with marked grain-size reduction. The main protolith appears to be ophiolitic gabbro because virtually undeformed pods of coarse-grained gabbro of the AOB are locally present. These tectonites commonly contain hornblende (macroscopically identified) suggesting they formed at upper greenschist- to lower amphibolite-facies conditions. The lineations are weakly developed but are generally steeply plunging to the north.

Reliable macroscopic shear-sense indicators are rare but include rotated porphyroclasts, shearbands and drag folds. These preliminary shear-sense indicators suggest that the AOB has been obliquely thrust over the Harbour Round assemblage and/or Victoria Lake Group with a sinistral strike–slip component (Figure 2e).

The RIL shear zone is cut by the Boogie Lake intrusive complex and the Annieopsquotch diorite (Dunning, 1987a), which indicate that most movements on the RIL took place before 435 Ma (Dunning *et al.,* 1990). However, presence of synclinal lenses containing Lower to Upper Silurian red beds in the immediate footwall of the RIL, but not in the immediate hanging wall suggests that the shear zone may have been reactivated as a ductile–brittle fault during the Silurian. This faulting probably caused uplift of the AOB, such that it breached sea level and was unconformably overlain by terrestrial conglomerates and red beds. Truncation of the synclinal lenses by the RIL suggests partial excision of the Silurian red beds by continuous movements. In several places (e.g., near Lloyds Lake), the RIL shows ample evidence for a multi-stage history where ductile structures are overprinted by brittle–ductile structures (Plate 1). This faulting is attributed to Silurian convergence between the western and eastern parts of the Exploits Subzone. Silurian deformation and Late Silurian marine sedimentation in the Exploits Subzone, east of the Dog Bay Line (Williams *et al.,* 1993) combined with the absence of a Gondwanan provenance in the detrital zircon population of the upper Llandovery sandstones of the Badger group (McNicoll *et al.,* 2001) suggest the existence of an incompletely closed marine seaway between the eastern and western parts of the Exploits Subzone, at least until the Late Silurian.

ROCKS EAST OF THE AOB

To the southeast of the RIL shear zone, the Harbour Round assemblage and the Victoria Lake Group are generally more intensely deformed than the ophiolitic rocks of the AOB. Four generations of ductile structures (Figure 2b) and at least one generation of brittle–ductile structures have been identified on basis of overprinting relationships; the most penetrative structures formed during D_1 and D_2. D_1 is mainly represented by a well-developed bedding-parallel foliation and a differentiated layering (S_1) in meta-igneous rocks. Structures formed during these deformation events have a dominantly northeast trend. In outcrop, S_1 generally has a steeper, near vertical dip and is better developed than the generally northwest-dipping S_2 (Figure 2g, h).

D_2 produced tight to isoclinal, upright to steeply inclined F_2 folds of S_1 and/or bedding. Moderately plunging F_2 folds are locally downward-facing. Examples occur in the Rogerson Lake Conglomerate, where it unconformably overlies the Victoria Lake Group, suggesting that D_1 at least locally produced markedly overturned folds and started or continued after deposition of the Rogerson Lake Conglomerate (Silurian?).

D_3 produced a shallow-dipping foliation, crenulation/intersection lineation, and small-scale box folds that deformed the D_1/D_2 structures. The L_3 crenulation/intersection lineations can be used effectively to differentiate S_1/S_2 from steep S_4, because the L_3 is folded by F_4.

D_4 structures are only locally developed southwest of Wigwam Brook and are predominantly present as upright crenulations of existing foliations including S_3. In Wigwam Brook (Figure 1), steep, north-striking S_4 accompanies open steeply plunging F_4 folds and crenulations. Southeast of Pat's Pond, S_4 locally becomes the dominant foliation and overprints D_1 and D_2 structures (Figure 2b).

Narrow brittle–ductile (1 to 5 cm wide) west-verging thrust faults occur near the RIL. These thrust faults overprint S_1 and S_2, but their relationships with respect to D_3 and D_4 structures are not well constrained. The thrusts were identified in several places where rocks of the Ordovician and older Victoria Lake Group are structurally overlying Silurian red beds, which are preserved as isolated wedges beneath the thrusts (Figure 2f), and/or show opposite facing directions. Local lack of exposure of the RIL shear zone may be attributed to the thrusting of the low-grade tectonites along these faults over the RIL. These brittle–ductile thrust faults may be related to the Early Devonian west-verging thrust movements accommodated by the Victoria Lake shear zone (Valverde-Vaquero and van Staal, 2001).

DISCUSSION

The Red Indian Line shear zone separates the Notre Dame and Exploits Subzones. The pre-Silurian movement history of the RIL is not well constrained because macroscopic shear-sense indicators are poorly developed. Preliminary data suggest that the RIL mainly accommodated sinistral oblique–reverse movements, which emplaced the AOB above the Harbour Round assemblage and/or Victoria Lake Group. Intrusive relationships and the presence of Silurian red beds on both sides of the RIL indicates that the Victoria Lake Group had been accreted to the Notre Dame Subzone by at least the Early Silurian (ca. 435 Ma).

D_1 deformation event must have continued at least into the Early Silurian as it affects the Silurian red beds, which have a penetrative axial-plane foliation in the footwall syncline beneath the RIL. Timing of D_2 to D_4 deformation events cannot be constrained accurately at present. However, because the Devonian 'grey-bed' sequence of Chandler and Dunning (1983) is deformed, deformation must have lasted into the Devonian. This is consistent with a previous interpretation for a final, Early Devonian deformation event associated with the juxtaposition of Gander and Dunnage zones in this area (Valverde-Vaquero and van Staal, 2001).

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REFERENCES

Chandler, F.W. and Dunning, G.R.
1983: Fourfold significance of an early Silurian U-Pb age from rhyolites in redbeds, southwest Newfoundland. *In* Current Research, Part B. Geological Survey of Canada, Paper 83-1B, pages 419-421.

Dunning, G.R.
1981: The Annieopsquotch ophiolite belt, southwest Newfoundland. *In* Current Research, Part B. Geological Survey of Canada, Paper 81-1B, pages 11-15.
1984: The geology, geochemistry, geochronology and regional setting of the Annieopsquotch Complex and related rocks of Southwest Newfoundland. Ph.D. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, 403 pages.

1987a: The Annieopsquotch Complex, southwest Newfoundland; An early Ordovician ophiolite and its unconformable Silurian cover. Geological Society of America, Centennial Field Guide - Northeastern Section, pages 441-444.

1987b: Geology of the Annieopsquotch Complex, southwest Newfoundland. Canadian Journal of Earth Sciences, Volume 24, 1162-1174.

Dunning, G.R., O'Brien, S.J., Colman-Sadd, S.P., Blackwood, R. F., Dickson, W. L., O'Neill, P.P., and Krogh, T.E.
1990: Silurian orogeny in the Newfoundland

Appalachians. Journal of Geology, Volume 98, pages 895-913.

Evans, D.T.W., Kean, B.F. and Dunning, G.R.
1990: Geological studies, Victoria Lake Group, central Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 131-144.

Jambor, J.J. and Barbour, D.M.
1987: Report 12: Geology and mineralogy of the Tulks pyritic massive sulphide deposit. *In* Buchans Geology, Newfoundland. *Edited by* R.V. Kirkham. Geological Survey of Canada, Paper 86-24, pages 219-226.

Kean, B.F.
1982: Geology of the Victoria Lake map area, southwestern Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, 1:50 000.

1983: Geology of King George IV Lake map area (12 A/4). Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-4, 67 pages.

Lissenberg, C.J. and van Staal, C.R.
This volume: The relationships between the Annieopsquotch ophiolite belt, the Dashwoods block and the Notre Dame arc in southwestern Newfoundland.

McNicoll, V.J., van Staal, C.R. and Waldron, J.W.F.
2001: Accretionary history of the northern Appalachians: SHRIMP study of Ordovician-Silurian syntectonic sediments in the Canadian Appalachians. *In* Geological Association of Canada – Mineralogical Association of Canada Joint Annual Meeting, St. John's, Newfoundland, Abstracts Volume 26, pages 100-101

Rogers, D. and van Staal, C.R.
This volume: Toward a Victoria Lake Supergroup: A provisional stratigraphic revision of the Red Indian to Victoria lakes area, central Newfoundland.

Thurlow, J.G., Spence, C.P., Boerner, D.E., Reed, L.E. and Wright, J.A.
1992: Geological interpretation of a high resolution reflection seismic survey at the Buchans Mine, Newfoundland. Canadian Journal of Earth Sciences, Volume 29, pages 2022-2037.

van Staal, C.R.
1994: Brunswick subduction complex in the Canadian Appalachians; record of the late Ordovician to Late Silurian collision between Laurentia and the Gander margin of Avalon. Tectonics, Volume 13, Number 4, pages 946-962.

van Staal, C.R., Dewey, J.F., Mac Niocaill, C. and McKerrow, W.S.
1998: The Cambrian-Silurian tectonic evolution of the northern Appalachians and British Caledonides: history of complex, west and southwest Pacific-type segment of Iapetus. *In* Lyell: the Past is the Key to the Present. *Edited by* D.J. Blundell and A.C. Scott. Geological Society, London, Special Publication, Volume 143, pages 199-242.

Valverde-Vaquero, P. and van Staal, C.
2001: Relationships between the Dunnage–Gander zones in the Victoria Lake–Peter Strides Pond area. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 01-1, pages 159-167.

Waldron, J.W.F. and van Staal, C.R.
2001: Taconian orogeny and the accretion of the Dashwoods block: a peri-Laurentian microcontinent in the Iapetus Ocean. Geology, Volume 29, pages 811-814.

Whalen, J.B., Jenner, G.A., Longstaffe, F.J., Gariepy, C. and Fryer, B.J.
1997: Implications of granitoid geochemical isotopic (Nd, O, Pb) data from the Cambrian-Ordovician Notre Dame Arc for the evolution of the Central Mobile Belt, Newfoundland Appalachians. *In* The Nature of Magmatism in the Appalachian Orogen. *Edited by* A.K. Sinha, J.B. Whalen and J.P. Hogan. Geological Society of America, Memoir 191, pages 367-395.

Williams, H., Colman-Sadd, S.P. and Swinden, H.S.
1988: Tectonic-stratigraphic subdivisions of central Newfoundland. *In* Current Research, Part B. Geological Survey of Canada, Paper 88-1B, pages 91-98.

Williams, H., Currie, K.L. and Piasecki, M.A.J.
1993: The Dog Bay Line: a major Silurian tectonic boundary in northeast Newfoundland. Canadian Journal of Earth Sciences, Volume 30, pages 2481-2494.