INTRODUCTION

This trip will introduce the participants to the principal lithologies present in the Fredericton area. These include: locally graptolite-bearing, complexly folded Silurian meta-wackes and slates of the Kingsclear Group; Mississippian McKinley Formation red beds; several Mississippian-Pennsylvanian basaltic flows with rubbly tops and their possible feeder dike, and; overlying Pennsylvanian Boss Point Formation quartz-conglomerates. Features of regional significance include an angular unconformity present at the Mactaquac Dam which represents the level of post-Acadian Orogeny erosion in the area, and the Fredericton Fault which is the shallower-level equivalent of the Norumbega Fault Zone that is present south-west of the U.S. border. Participants will be taken on a tour of the Mactaquac Dam, which has recently achieved infamy owing to deterioration of concrete in the water-intake and spillway areas as a result of alkali-aggregate reactions. This could potentially halve the expected life of the dam.

GEOLOGIC OVERVIEW

The simplified geology of New Brunswick comprises a series of belts, zones and subzones that are part of the NE-SW Appalachian trend (Figure 1). These include, from southeast to northwest, the Precambrian to Cambrian rocks of the Avalon Zone (a.k.a. the Avalon Terrane; Williams and Hatcher, 1982), the St. Croix Subzone of the Gander Zone, the Silurian wackes and slates of the Fredericton Trough, the Ordovician Sedimentary rocks and Late
Silurian to Devonian plutons of the Miramichi Subzone (also within the Gander Zone), and the Ordovician to Devonian Matapedia Basin (Fyffe, 1982). These were developed during several tectonic episodes, including the Ordovician to Silurian Taconian orogeny and the Devonian Acadian orogeny. Syn- and post-orogenic intrusions are abundant, particularly in the Miramichi Subzone and in the St. George area in the south-west of the province (Figure 1). Central and eastern New Brunswick are unconformably overlain by Carboniferous successor deposits that comprise part of the Maritimes Basin. These Carboniferous cover rocks are also preserved in P.E.I., Cape Breton and parts of northern Nova Scotia (Fyffe and Barr, 1986).

**METAMORPHIC AND SEDIMENTARY ROCKS**

Silurian rocks in the Fredericton region consist of the Burts Corner beds of the Kingsclear Group (Figures 1 and 2). They comprise thin- to thick-bedded, non-calcareous meta-wackes and interbedded slates (Wake, 1984). Graptolites from the *Cyrtograptus linarsoni* to *Monograptus nilsonni* Zones are present in the Burts Corner beds near Hayesville and near Woolastock (Stop 7), and constrain the beds to a Wenlockian to upper Ludlovian age (Fyffe, 1995).

Although these rocks were intensely folded during the Acadian Orogeny and weakly metamorphosed to a sub-greenschist grade, this event has not significantly destroyed their sedimentary features. These features are best preserved where folding-induced layer-parallel shear and penetrative slaty cleavage development are at a minimum.

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*Figure 2 - Detailed location map showing stops. Abbreviations: F’ton - Fredericton center; MSR - Mazerville Settlement Road; RRQ - Royal Road quarry; TCH - Trans-Canada Highway; UNB - University of New Brunswick; WB - Woolastock Bridge.*
Sedimentary features include: tool marks (Stop 3) and flute casts (Stops 4 and 8) whose orientations differ significantly between beds; graded units (Stop 4); small bed scours (Stop 13); and cross-bedded laminations.

The Silurian units are interpreted to have been deposited on the continental rise region of a middle Paleozoic ocean, which closed during the Acadian Orogeny (Berry and Osberg, 1989). Erosional horizons and the development of large scale flute casts are consistent with instabilities on the continental rise having generated these turbidite units.

Carboniferous sedimentary units present in the Fredericton area belong to the Mabou, Cumberland, and Pictou groups (van de Poll, 1995; van de Poll and others, 1995) and were principally deposited during Namurian to Westphalian times (during a period that brackets the Mississippian-Pennsylvanian boundary) (Figure 3). Red conglomerates, breccio-conglomerates, sandstones and siltstones of the McKinley Formation (Mabou Group) locally rest unconformably on the Lower Paleozoic Silurian turbidites at the Mactaquac Dam (Stop 4) and along the new Trans-Canada Highway (Stop 11). At the basal conglomerate, angular clasts of the Silurian Kingsclear Group are common. Rapid changes in water velocity are demonstrated by a wide variation in grain sizes and erosional bases to the coarsest-grained beds. The Mabou Group has been compared to that of contemporary alluvial fan deposits deposited in areas of low relief (van de Poll, 1995).

Overlying the basalt flows in the Carlisle Road quarry on the north side of the Saint John River at Fredericton (Stop 1) are highly mature, buff-colored quartz conglomerates that belong to the Boss Point Formation (Cumberland Group). Veining of jasper is present at this location. The uppermost flow(s) in the Carlisle Road quarry is discontinuous, which may reflect its original lateral extent, or may indicate some erosion of the uppermost flow(s) prior to the deposition of the Boss Point Formation. The Boss Point Formation is not exposed in the Royal Road quarry, though is present 400 m (360 yds) to the NE of the quarry along a hydro line cut.

The bulk of the Carboniferous sedimentary rocks in the Fredericton area are buff-colored sandstones, conglomerates with minor red siltstones of the Westphalian Pictou Group. These mature sandstones are dominated by moderate- to well-rounded quartz clasts, though granitoid clasts, presumably derived from the erosion of Devonian plutons, and slate clasts also occur locally. The sandstones commonly contain plant leaves, Calamites stems and fossilized trees which are indicative of an increasingly humid climate. This contrasts with the Lower Carboniferous arid climate during which extensive evaporite deposits formed in the south of New Brunswick and in Nova Scotia. Paleomagnetic studies of Namurian Mabou Group basalt flows (see below) indicate a paleolatitude of

![Figure 3 - Stratigraphy of selected locations in the Fredericton area. Stratigraphic units after van de Poll and others (1995) and Keighley (1996). Abbreviations: Fm. - Formation; Mnt - Mountain; RB - red bed units, as in Figure 4; Rd - Road; Sil - Silurian, and; Stn - Station.](image)
Thick units of interbedded red siltstones have been used to subdivide the Pictou Group into up to eight cyclic sandstone-siltstone units (van de Poll, 1995). Such a marker siltstone unit can be seen on the north-bound lane of the new Trans-Canada Highway, 16 km southwest of Fredericton (see road log, 82.1 km, 51.3 miles). If this red siltstone is a laterally extensive marker, it divides cyclic sequence I to the southwest, from cyclic sequence II underlying the city of Fredericton, or subdivides sequence I into upper (1b) and lower (1a) sub-units.

**IGNEOUS ROCKS**

Igneous rocks in the vicinity of Fredericton are restricted to several Carboniferous alkaline basalt flows and its possible feeder dike on the north side of the Saint John River. Exposures within the eastern-most outcrop of the Late Silurian-Early Devonian Pokiok granitoid batholith are present ~27 km (16.9 miles) to the west of the city (Figure 1).

The basalts comprise sparse plagioclase phenocrysts (up to 2mm in diameter) with a groundmass comprising sub-millimeter-sized andesine to labradorite which is enclosed subophytically in clinopyroxene (Wo46, En36, Fs18), iddingsite-chlorite replacements of olivine (Fo47-48). Minor constituents include interstitial analcime, calcite, apatite and Fe-Ti oxides (Fyffe and Barr, 1986).

Their major- and trace-element chemistries are consistent with a continental intraplate origin (Fyffe and Barr, 1986). Although they have not been dated by radiometric dating techniques, upper-Mississippian spores have been identified from a core sample of the underlying McKinley Formation red beds (Barss, 1983) (Figure 3). The flows are therefore upper Mississippian to lower Pennsylvanian (Namurian) in age.

Crustal extension during the Early Carboniferous generated mantle melts, whose erupted equivalents decreased in quantity through the rest of the Carboniferous as the extension waned. Increasing fractionation of the mantle melts coupled with decreasing amounts of source melting controlled their geochemical evolution from initially basic alkalic basalts in the late Visean and Namurian to peralkaline rhyolites in the late Westphalian (Fyffe and Barr, 1986).

Two discrete, 30°NE-dipping flows are separated by a red argillaceous to arenaceous unit from 3 to 4 m (10-13') thick in the old city quarry on Royal Road. A second, larger quarry on the Carlisle Road (Stop 1) is curiously unreported in the literature (Figure 4). This location exposes three stratigraphic levels of flows, the lower two of which are separated by a unit of interbedded hematitic argillite and arenite 1 to 4 m thick. The lower two laterally-extensive flows extend with uniform thicknesses across the 150 m width of the quarry. The uppermost volcanic unit appears to have divided into at least two, possibly three flows, separated by clastic basaltic rubble (aa). Although the duration of the volcanism is unknown, it is clear that periods of active effusion were interspersed with volcanic-quiescent periods in which clasts from the rubbly tops of the flows were incorporated into overlying red beds. The lateral continuity of the red beds in the Carlisle Road quarry and the presence of basaltic intraclasts within this unit clearly indicate that the red beds are not merely a local raft of red sedimentary rock entrained by the flow (cf., Laughlin, 1960).
The tops of the flows are rubbly and more highly vesiculated than lower parts. The flows are typically massive, though flow-parallel jointing and margin-orthogonal columnar jointing are heterogeneously developed. Near the entrance to the uppermost Royal Road quarry and in the northwest wall of the Carlisle Road quarry, curvature of the flow-parallel jointing mimics the pattern expected in the toe of a lava flow. The closure direction of the curvature provides a crude indication of the provenance direction of the lava flow (Figure 5). On this basis, the flow (lava unit 2; Figure 4) in the Carlisle Road quarry came from the south, and the Royal Road lava flowed from the west.

A 30°east-dipping, columnar jointed basalt dike occurs at Currie Mountain (formerly Clarke’s Hill) (Stop 2). It intrudes and bakes horizontally-bedded McKinley Formation (Mabou Group) red siltstones and sandstones. Rounded void spaces in the siltstone suggest that the sediment was not lithified during intrusion of the dike and that heat conducted from the dike caused pore water to boil. This, coupled with the geochemical similarities between the dike and flows, and the presence of McKinley-type red-bedded layers in both quarries indicates that the dike and flows are broadly contemporaneous.

It has been suggested that the Currie Mountain dike feeds the flows 5 km to the northeast in the Royal Road quarry (Bailey, 1910). The new exposures in the Carlisle Road quarry, located less than one kilometer (0.5 mile) to the north of Currie Mountain, provides a closer tie between the flows and the potential feeder dike than existed between the dike and the lavas in the Royal Road quarry. The flow directions in both quarries, based on the curved jointing patterns seen in the basalts, are also consistent with having been derived from the Currie Mountain area.

**STRUCTURE**

Several episodes of deformation can be distinguished in the Silurian rocks. The principal folds in the region are upright, generally high amplitude folds that plunge shallowly to the NE or SW. They typically possess tight hinge zones with straight limbs (approaching a chevron fold morphology; Stop 9) though locally, lower amplitude open folds are present (Stop 10). Modification of these folds by limb faulting as the interlimb angle decreases is common, especially where the psammite beds are of non-uniform thickness. Steeply plunging slickensides along the bedding surfaces suggest folding by flexural slip. The pelites possess a well-developed axial planar slaty cleavage, with little or no cleavage in the wacke beds. The cleavage developed during the Late Silurian, concomitant with the earliest phases of the intrusion of the Pokiok batholith (Caron, 1996).

A later set of small-scale chevron folds with near-horizontal axial surfaces are locally present. These probably correlate with the second generation folds identified by Fyffe (1995) in the Flume Ridge Formation south of the Fredericton Fault. Conjugate sets of kink folds are also present in the Burrits Corner beds, and probably post-date the recumbent chevron folds if the folding age relationship deduced south of the Fredericton Fault (Fyffe, 1995) can be extrapolated to this area.

The Fredericton Fault is the northern, shallow-level equivalent of the mid- to upper-crustal Norumbega Shear Zone exposed south of the U.S.-Canada border (Hubbard and others, 1995). Seismic reflection surveys in Maine indicate the fault penetrates the Moho (Doll and others, 1996).

Although it has been assigned the distinction of a major terrane boundary (Keppie, 1985), the similarities of the Silurian Burrits Corner beds and the Flume Ridge Formation to the north and south of the fault in New Brunswick suggest continuity, though the fault may still have accommodated significant transcurrent motion (Fyffe, 1995). Rotation of slaty cleavage in the Kingsclear Group near the Fredericton Fault indicates a dextral-transcurrent motion (Fyffe, 1988). Although post-Devonian movement is not extensive (Wones, 1980), post-Carboniferous motion is indicated by the truncation of Carboniferous beds in the Fredericton area (Figures 1 and 2). Extensive specularite-
calcite slickenfibres along joints in the vicinity of the fault in the Royal Road quarry possess shallow plunges and may indicate continued post-Carboniferous strike-slip motion. Along the new Trans-Canada Highway at Stop 14, normally near-horizontal Pictou Group sandstones and conglomerates are increasingly tilted with proximity to the Fredericton Fault until they are locally overturned. The Fredericton Fault is now here exposed, though is located to within 10 m (30') along road-cuts along the new Trans-Canada Highway (Whitehead and Park, 2001) (Stop 13).

Although four post-Famennian (Late Devonian) periods of deformation are discernible in the Canadian Appalachians, the first is thought to have been restricted to Nova Scotia and southern New Brunswick (van de Poll and others, 1995), while the second, although regional, cannot be clearly discerned in the Fredericton area. Subsidence following the second period of deformation allowed onlap of the Carboniferous sediments to its greatest extent on the underlying bedrock. Deformation inducing the gentle tilting of the Carboniferous strata in the Fredericton area is believed to have occurred between Early Permian and Late Triassic times because Early Triassic red beds on P.E.I. are tilted, and an angular unconformity exists between mid-Carboniferous and Triassic strata in the Bay of Fundy region (van de Poll, 1983). This period also generated the regional synclines such as the Marysville basin (Figure 1) and the Moncton Basin (van de Poll and others, 1995). The fourth, post-Triassic period of deformation cannot be distinguished in the Fredericton area owing to a lack of preserved Triassic sedimentary rocks.

MACTAQUAC DAM

The Mactaquac Dam is located at the confluence of the Saint John and Mactaquac rivers. Mactaquac in the local indigenous Maliseet language, translates as ‘big branch’ alluding to this meeting of the waterways. Since its construction in 1968, the dam has been the largest hydroelectric plant in the Maritimes, with a generating capacity of 600 megawatts of power.

The structure is of composite design: the water intakes and spillways were constructed of massive concrete while the main section of the dam comprises a core of various grades of sieved tills and crushed Silurian metagreywackes and slates, derived almost entirely from the excavated region where the intake channels and spillways are now located (Watson, 1970). This main section, known as a rockfill dam, was chosen over a wholly concrete dam owing to the ease with which the rockfill could be placed on top of surficial deposits present in the river valley without requiring their complete removal, thereby expediting the construction time by approximately one year over that anticipated for a wholly concrete structure. Additional bedrock widening of the channel would also have been necessary for a concrete dam should additional faults have been discovered during excavation (Watson, 1970).

Surficial deposits in the area comprise: up to 30 m (100') of permeable silts, sands and gravels that comprise an artesian layer; an overlying 20 m (65') of impermeable tills, including a lower, stiff brown till and an upper gray till with considerably lower yield strength; a discontinuous unit of estuarine clay up to 16 m (53') thick deposited during flooding of the river valley at the end of the last glaciation, prior to significant isostatic readjustment and; a discontinuous layer of alluvium up to 7 m (23') thick. Assessments of the yield strengths of these layers indicated that the alluvium, estuarine clays and weak gray till were incapable of bearing the load of the rockfill dam, and were consequently removed. The removal of these overlying units temporarily released the pressure within the basal artesian layer, whose pore water pressures had to be reduced via piping in order to prevent rupture of the overlying brown till until the main mass of the rockfill was introduced.

The elevated waters behind the dam extend some 97 km (60 miles) upstream and flooded numerous settlements. Historically significant buildings were relocated to the Kings Landing Historic Settlement which is the province’s #2 tourist attraction, located 14 km (9 miles) upstream of the dam. The additional crustal load provided by the headpond waters may have resulted in local subsidence, though absolute ground elevations were not established during the local surveying prior to dam construction to allow for a present day comparison. Glacial striae that are offset vertically along joints may have been generated by loading-related subsidence or by isostatic rebound following the last glaciation.

The concrete sections of the dam are suffering from alkali-aggregate reaction damage (AAR). AAR decay involves a reaction between the cement and aggregate clasts that contain fine-grained quartz (Demerchant and others, 2000) and results in volume expansion and cracking, which can affect the operation of equipment in the structure. Despite an original expected lifespan of one hundred years, a NB Power Commission engineering report contracted in 1999 estimated the remaining lifespan to be 15-30 years, should the AAR-related decay continue at the current rate (Seguin, 2000). Remedial action is currently underway to reduce the effects of the AAR damage.
ACKNOWLEDGEMENTS

Thanks are extended to Adrian Park for providing companionship and expertise during transects along the new Trans-Canada Highway, and to Les Fyffe and Ron Pickerill for providing useful feedback on an earlier version on the manuscript. Logistical support provided by the DNRE Minerals and Mines Branch for one of the preliminary excursions is gratefully acknowledged.

ROAD LOG

The assembly point is in the parking lot of the Holiday Inn at Mactaquac, 9.00 am, 22nd September, 2001. Participants will be asked to consolidate into as few vehicles as possible as parking is severely limited at a number of the stops. Bring lunch with you, as we will have no opportunity to stop for supplies.

<table>
<thead>
<tr>
<th>km (mile)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 (0.0)</td>
<td>Turn left at the exit to Holiday Inn Mactaquac and cross the dam. Take the first right, Route 105 east, towards Fredericton.</td>
</tr>
<tr>
<td>8.1 (5.0)</td>
<td>Route 104 will join from the left. Continue east on Route 105.</td>
</tr>
<tr>
<td>15.0 (9.4)</td>
<td>Turn left at Carlisle Cross Road. At the T-junction with Carlisle Road, turn left.</td>
</tr>
<tr>
<td>15.5 (9.7)</td>
<td>The entrance to the Carlisle Road quarry is immediately opposite civic address 139. Take the right hand (lower) track into the quarry.</td>
</tr>
<tr>
<td>15.7 (9.8)</td>
<td>STOP 1: Drive into the quarry. There are three layers of lava exposed. The lower two are present in the lowest excavated bench and are separated by a hematitic siltstone-sandstone bed 1 to 4 m (3 to 13') thick. The flow tops are rubbly and rip-up clasts of basalt are incorporated into the lower parts of the overlying beds. The base of the volcanic unit 2 (Figure 4) has baked &lt;10 cm (4&quot;) of the underlying red beds. The upper part of volcanic unit 2 is extremely rubbly, resembling aa lava. Internal shearing of the lavas are defined by attenuated vesicles and shrinkage joints parallel to the cooling surface. These joints are curved at two localities (Figure 4) and define the toe of two flows, that advanced from the south. Fracturing of the basalt as it advanced over wet red siltstones, has resulted in injections of silt veins into the flow at the northern end of the quarry. A third flow(s) overlies the lava and lava rubble of volcanic unit 2 in the northern end of the quarry. The uppermost flow(s) was partially eroded prior to the deposition of the overlying Boss Point Formation mature quartz conglomerates. Jasper veining is present in the Boss Point Formation.</td>
</tr>
<tr>
<td>15.9 (9.9)</td>
<td>Exiting the quarry, turn left on Carlisle Rd. Take the first right, onto Carlisle Cross Road again. Turn right at the bottom. Drive 1.2 km to Currie Mountain.</td>
</tr>
<tr>
<td>17.6 (11.0)</td>
<td>STOP 2: The exposure adjacent to civic address 1122 is the largest exposure on Currie Mountain. Take care when cutting across the oncoming traffic into the parking lane adjacent to the river. The contact between a basaltic dike and the adjacent McKinley Formation is present at the western end of the exposure. The dike dips 30° towards 114° (east) and the intruded hematitic siltstones and sandstones are horizontal. Columnar jointing orthogonal to the cooling surface is well developed within ~10 m (30') of the contact. Exposures along the base of Currie Mountain indicate that this dike is greater than 200 m (650') wide. A fissile iron-reduced contact zone is developed in the McKinley Formation within 10 cm (4&quot;) of the dike contact. Voids in the sediment may be related to boiling of pore water during intrusion. On leaving, the exposure, continue back to the Mactaquac head pond, turn left towards Edmundston and re-cross the dam. Immediately after crossing, turn into the parking lot that overlooks the dam.</td>
</tr>
<tr>
<td>30.9 (19.3)</td>
<td>STOP 3: View of the dam. On foot, take the path at the rear of the parking lot into a small quarry</td>
</tr>
</tbody>
</table>
on the right. Weakly metamorphosed, steeply dipping Silurian beds belong to the Burtts Corner beds of the Kingsclear Group. The exposure is predominantly psammite with minor pelitic intercalations. Tool marks and small current-eddy pits 1 to 10 cm wide indicate that the beds are inverted. The anastomosing fissility of the pelites, generated by layer-parallel slip during their folding, masks any cleavage. Both limbs of a tight, upright anticlinal synform can be seen, though the core is disrupted (a common feature, owing to competence contrasts between the pelite and psammite layers).

Continue along the track. Winsconsinan basal till is present and comprises a poorly sorted, matrix supported surficial unit up to 2 m (7') thick. The clasts, which range from sub-angular to unusually rounded for a till, comprise locally derived psammite and pelite, granodiorite and alkali granites derived from the Pokiok Batholith to the southwest, buff-colored sandstones which are probably derived from erosion of the Carboniferous Pictou Group, as well as minor rhyolite and basalt. Striated, glacially polished Silurian bedrock exhibits striae sets oriented 108° and 142°. The 142° set overprints the earlier 108° set, though likely has no regional significance. Down-flow plucking indicates an ice-flow direction up-slope, towards E-SE.

<table>
<thead>
<tr>
<th>Mileage</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>40.0 (25.0)</td>
<td>Leaving the parking lot, turn right and cross the dam.</td>
</tr>
<tr>
<td>41.5 (25.9)</td>
<td>Turn right (east) onto Route 105 again.</td>
</tr>
<tr>
<td>41.7 (26.1)</td>
<td>Turn right onto Powerhouse Road and keep left at the fork in the road at the bend.</td>
</tr>
<tr>
<td>42.4 (26.4)</td>
<td><strong>STOP 4:</strong> Park opposite the first red exposure. Please pull completely off the road, as large trucks frequent this route. This exposure comprises McKinley Formation red beds. These include a basal unit of hematitic fissile siltstone that contains buff-colored calcareous concretions that extend downwards from the upper limit of the bed for tens of centimeters (&gt;6”). These may represent concretions nucleated around roots in a caliche-type environment. The upper layers of the possible paleosol were eroded during the deposition of the overlying 2 m (7’) thick breccio-conglomerate. The breccio-conglomerate bed sharply grades upwards into a coarse sandstone unit. Several laterally discontinuous sandstone-conglomerate layers are present.</td>
</tr>
<tr>
<td>42.9 (26.8)</td>
<td>The Burtts Corner beds opposite the Mactaquac Fish Culture Station sign include at least four identifiable packets of fine-grained, well-sorted psammite grading upwards to fissile pelite, with large flute casts defining the base of each packet. The beds dip steeply (76°) to the west, though are not inverted as seen at STOP 3.</td>
</tr>
<tr>
<td>42.926.8)</td>
<td><strong>STOP 5:</strong> Tour of the Mactaquac Dam, provided by staff of the facility.</td>
</tr>
<tr>
<td>44.3 (27.7)</td>
<td><strong>STOP 6:</strong> After 300 m (330 yds), pull off the road to the picnic area by the waters edge for LUNCH. Re-cross the dam and pass the Holiday Inn.</td>
</tr>
<tr>
<td>46.5 (29.1)</td>
<td>Take Route 102 (inaccurately signposted Route 2 at the time of writing) towards Edmundston.</td>
</tr>
<tr>
<td>56.9 (35.6)</td>
<td>Note the folds in the Burtts Corner beds on the left (east) side of the road. These were generated during the Acadian Orogeny, as a result of the collision of the Meguma Terrane with the Laurentian margin in the Devonian.</td>
</tr>
</tbody>
</table>
STOP 7: Pull completely off the road. Take care crossing to the oxidized iron-stained area of the exposure. The staining belies the presence of pyrite which is spatially associated with the graptolite-bearing organic-rich horizon. Graptolite localities are rare, owing to the pervasive Acadian cleavage in many exposures and destruction by layer-parallel slip during folding. Consequently, please DO NOT HAMMER THE EXPOSURE. Collecting can be done from the copious samples in the scree. Monoserial- and biserial-stiped graptolites are common, as are curved *Cyrtograptus* sp.

Continue south and slow at the picnic sign. Park before the sign.

STOP 8: Classic overturned flute casts are present in this exposure (Figure 6). The timing of en-echelon quartz veining seen at the southern end of the flute cast occurrence is moot. They may be the consequence of Acadian or later Carboniferous earth movements.

Continue south along Route 102. After crossing the first inlet of the Mactaquac headpond, pull to the side of the road by the first large exposure encountered.

STOP 9: Splendid Acadian fold closures can be observed on the eastern rock face (Burts Corner beds). Three synforms and three antiforms can be clearly identified. These are steep-upright folds with straight limbs and tight closures. They verge to the south. The northern limbs are slightly overturned, as indicated by flute casts in the northern-central part of the exposure. Pelite comprises a larger fraction of the exposure than hitherto encountered (20-30%), which may account for the development of these similar folds without excessive accommodation structures (e.g., faults).

Continue south. Cross the Woolastock Bridge.

Follow the signs for Route 3, take the left hand fork in the road on the bend, and follow the signs for St. Stephen and Edmundston.

At the first opportunity, follow the sign for Route 2 towards Fredericton.

Turn left onto Route 2 towards Fredericton (east).

STOP 10: 2.3 km (1.4 miles) along Route 2 pull off the road, as far away from the moving lanes as possible. TAKE CARE, this is a dangerously busy road and stopping here is not strictly allowed. A classic open antiform is present here, in contrast to the tight folds observed elsewhere in the Burts Corner beds. A synform with a pinched hinge is present at the eastern end of the exposure. Way-up structures include: truncated foresets in cross-beds, small scour hollows and larger flute casts. Layer-parallel shear has opened en-echelon shear veins oriented perpendicular to bedding in the psammite on the eastern limb of the largest antiform. Pyrite is common along fractures and in asymmetric sheared lenses parallel to S_o. Unconformable McKinley Formation red beds can be seen in the adjacent exposure (STOP 11).

STOP 11: McKinley Formation red beds are exposed on the west side of the road. They comprise hematitic, clast supported conglomerates with intercalations of red sandstone. The sandstones are locally entrained as clasts up to 30 cm (1') long by successive conglomerate layers, suggesting that
they were partly indurated prior to reworking. The clast load is dominated by psammites derived by erosion of the underlying Silurian units, though limonitic buff-colored sandstones also occur. Locally, sandstone layers are discontinuous owing to truncation by successive conglomerate flows. This outcrop of Carboniferous strata to the west of the Fredericton Fault (Figure 1), was identified as early as 1936 by A.C. Freeze (Freeze, 1936), without the assistance of new road cut exposures!

75.0 (46.9) Continue north along Route 2. Note the change in lithology at kilometer 75 (mile 46.9).

78.2 (48.9) **STOP 12:** These gray shales, buff-colored sandstones and conglomerates belong to the Pictou Group, which is the dominant bedrock stratigraphic unit under the city of Fredericton. Here, a lower meter (3') of gray shale has been mobilized by loading owing to the weight of the overlying beds. These overlying units include quartz-chert-conglomerates with rip-up clasts of the underlying gray shale. Preservation of these soft clasts in the conglomerates indicates that they were incorporated as the velocity of the current decreased. Erosive scours into the gray shale are also present. Overlying cross-bedded sandstones locally exhibit full sets of cross-beds, while many top sets have been removed by the erosion that preceded the deposition of subsequent sets. In this outcrop, the paleocurrent indicated by cross-beds was to the north-east. Fossil plants include several logs, internal casts of stems from the arborescent horsetail *Calamites*, and other unidentifiable fragmented plant remains.

81.2 (50.8) A thick sequence of red siltstones are present here, further north along Route 2. Red bed units have been used as marker horizons that help subdivide the Pictou Group (van de Poll, 1995). Although the reliability of these units as regional stratigraphic markers is questionable and depends on the paleoenvironmental interpretation assigned to them (van de Poll, 1995), this red siltstone unit may subdivide the lower Pictou Group cyclic sequence I from the overlying cyclic sequence 2.

84.4 (52.8) Continue north and cross Mazerolle Settlement Road.

88.6 (55.4) The bedding in the sandstone steepens with proximity to the Fredericton Fault, and here dips at 80° or more.

89.8 (56.1) **STOP 13:** This stop is reached by continuing north until Deerwood Drive. Park before the overpass, well off the road. Features present include: a synformal fold closure; tool marks; unidentified depressions on bedding planes up to 4 cm (2") wide with raised central peaks; scours on bedding surfaces and cross-bedded laminated mudstones.

97.1 (60.7) From STOP 13 continue north until Exit 289, Hanwell Road. Take the exit. At the junction with Hanwell Road, turn right towards the traffic lights. Cross into the left hand lane prior to the lights, signposted Route 2 towards Edmundston. Follow the signs for Edmundston (i.e., turn left again after the signal lights).

104.6 (65.4) You cross the Fredericton Fault from the opposite direction, immediately before the Deerwood Drive overpass.

106.8 (66.8) **STOP 14:** Pull into the weighbridge siding along the Highway. 20 m (70') to the south of the southern end of the excavated area, Pictou Group sandstones and conglomerates are encountered. The Fredericton Fault has again been crossed. The Carboniferous beds dip at 85° towards the north, rather than near-horizontal farther from the fault, owing to fault-related deformation.

110.8 (69.3) To return to the Holiday Inn at Mactaquac or Fredericton continue to the Mazerolle Settlement Road exit, then follow the signs for Kingsclear along Route 640.

119.9 (74.9) At the junction with Route 102, turn right.

126.9 (79.3) Take exit 274 for the Holiday Inn at Mactaquac, and continue on Route 102 for Fredericton.
REFERENCES CITED


