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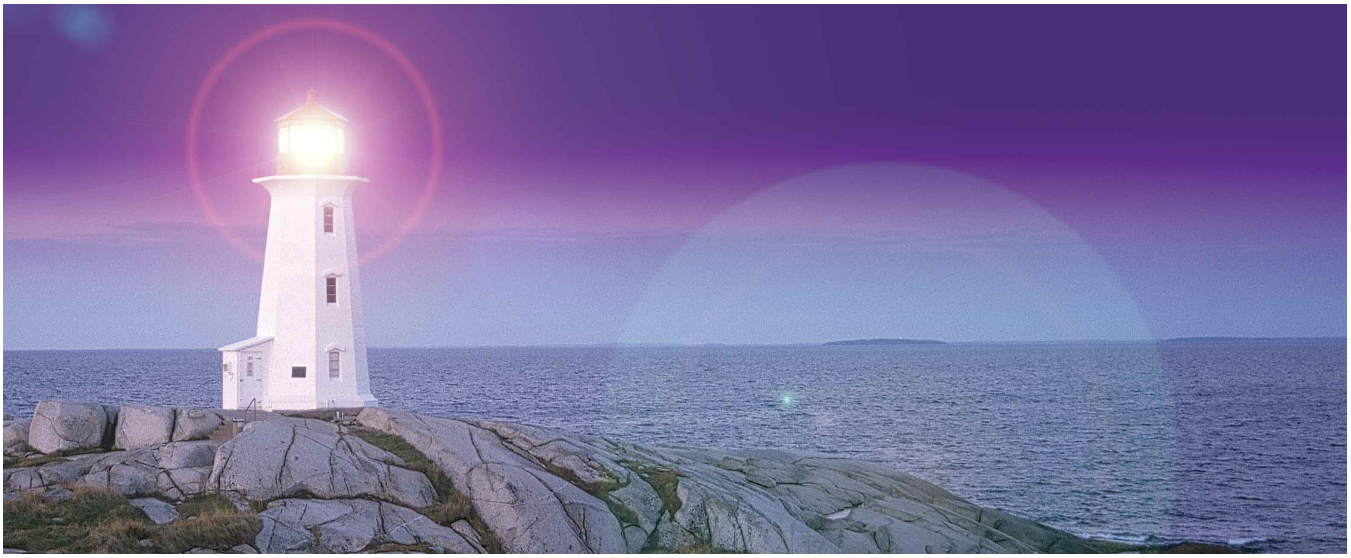

Field Trip A6

Geological setting of intrusion-related gold mineralization in southwestern New Brunswick

Kathleen Thorne, Malcolm McLeod,
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Joint Meeting - Halifax, May 2005

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Geological setting of intrusion-related gold mineralization in southwestern New Brunswick

Kathleen Thorne[1], Malcolm McLeod[2], Les Fyffe[1], and David Lentz[3]

[1]New Brunswick Department of Natural Resources
P.O. Box 6000, Fredericton, New Brunswick, Canada E3B 5H1
[2]New Brunswick Department of Natural Resources
P.O. Box 5040, Sussex, New Brunswick, Canada E4E 5L2
[3]Department of Geology, University of New Brunswick
Fredericton, New Brunswick, Canada E3B 5A3

Department of Earth Sciences
Dalhousie University
Halifax, Nova Scotia, Canada B3H 3J5

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SAFETY

For the sake of personal and group safety, all field trip participants are required to read and abide by the safety related guidelines given below. Although many of them are common sense, we ask for your cooperation to ensure a safe and enjoyable trip for everyone.

1. **First Aid/Medical Conditions**: First Aid providers will be identified to the participants at the beginning of the trip. Any participants that are certified First Aiders will be encouraged to identify themselves to the trip leaders. There will be several first aid kits available in the field trip vehicles. As a precautionary measure, field trip participants with medical conditions are encouraged to advise the trip leaders in advance of the trip. This personal medical information will be treated with the strictest confidence.

2. **Suitable Footwear and Clothing**: Participants are required to have sturdy footwear with good traction to avoid injury in the trenches and during hiking. Also, because of unpredictable spring weather, participants are to bring proper clothing to protect themselves from the cold (possibly wet) weather (i.e., hat, gloves, rain gear).

3. **Rock Hammers**: Please use extreme caution when hammering and be aware of those around you. It is strongly recommended that you wear proper eye protection (i.e., safety glasses or goggles) while hammering and while others are hammering around you. The use of hammers and chisels that are not made for breaking rocks is strictly prohibited because of their potential to splinter and/or break.

4. **Hard Hats**: A supply of hard hats will be available for the participants to use at any time. Participants will be encouraged to wear a hard hat when examining cliff exposures where falling rocks are a potential hazard.

5. **Slippery Surfaces**: Much of the trip will involve examining trenched exposures and glaciated, sometimes steeply sloped outcrops. Please be aware that these surfaces can be extremely slippery, particularly when wet. At Stop 1, extreme caution should be exercised on the smooth, steep outcrop along the river's edge.

6. **Falling rocks**: Several of the stops involve examining exposures along a cliff face that may be unstable. Be sure to look over head for any loose rocks that may be potentially dangerous before getting too close to the outcrop. Climbing the cliff exposures is prohibited as it may be hazardous to you and those around you. If examining the top of a cliff exposure, stay well back from the edge and avoid any activity that may be hazardous to those people that may be at the base of the exposure.

7. **Hiking Hazards**: A few of the trails that we will be using to access the trenched exposures consist of cut lines through the woods. Please watch your step to avoid tripping on the small pointy stumps. Also, please don't wander off from the rest of the

group, particularly during traverses. If it is absolutely necessary to stray from the group at any time, for the sake of safety, please advise one of the trip leaders before doing so.

8. **Transportation**: While the vehicle is in motion, please remain seated and ensure that all of your belongings (especially rock hammers, chisels, and samples) are safely stowed at the back of the van or beneath your seat.

9. **Roadside Stops**: The majority of the field trip stops will take place along roads where traffic is minimal. However, depending on time constraints, there may be some impromptu stops along the highway and secondary roads where traffic may be a concern. In the event that this occurs, please listen for directions from the tip leaders before crossing the road. Also, be aware of traffic at all times and always stay well off to the side of the road.

10. **IN THE UNLIKELY EVENT OF AN EMERGENCY, CALL 911.** All field trip leaders will be equipped with cellular and/or satellite phones. The location of these phones will be made known to all the participants in case of an accident or injury. It may be necessary to use a pay/private phone in the more remote areas where cellular phone coverage is poor.

ITINERARY

Day 1 – Thursday, May 12, 2005
Geology of southwestern New Brunswick
Meet 8 AM at the City Motel (Fredericton)
Head toward St. Stephen area to view parts of the stratigraphy of the Fredericton Trough and the Mascarene Cover Sequence
Magaguadavic Granite contact with Digdeguash Formation
Return to Fredericton

Day 2 – Friday, May 13, 2005
Clarence Stream Gold Deposit
Meet 8 AM at the City Motel (Fredericton)
Head to Clarence Stream area to view trenches at the Main Zone and Anomaly A
View core from the Clarence Stream deposits at the Mount Pleasant Mine site
Return to Fredericton

Day 3 – Saturday, May 14, 2005
Mount Pleasant Sn-W-Mo-Bi Mine
Meet at 8:30 AM at the City Motel
McDougall Brook showing in the Mount Pleasant Caldera
Kedron occurrence core
Travel to Mount Pleasant to examine outcrops peripheral to the mine and the tailings pile
Travel to Halifax in the afternoon for the GAC-MAC Annual General Meeting

INTRODUCTION

The discovery of significant gold mineralization in southwestern New Brunswick has generated much collaborative research by the University of New Brunswick, federal and provincial government organizations, and Freewest Resources Canada Incorporated. Since 1999, Freewest has conducted extensive exploration programs in the vicinity of Clarence Stream, east of St. Stephen, and has delineated two principal areas of mineralization referred to as the Clarence Stream "Main Zone" and "Anomaly A" deposits. These two mineralized zones are situated to the south and north of the major, northeast-trending Sawyer Brook Fault within Silurian and Ordovician rocks, respectively.

Results of the research and exploration have shown that gold at the Main Zone deposits is hosted primarily by steeply dipping to shallowly dipping, mylonitic shear zones with quartz veins and stockworks, whereas the Anomaly A deposits occur in quartz veined and stockwork zones characterized by intense alteration and locally developed mineralized cataclasites within a high-level thrust zone(s) that is openly folded. Several lines of evidence strongly suggest that gold mineralization at the Main Zone deposits, and probably that at Anomaly A as well, are genetically related to specific older phases of the Siluro-Devonian Saint George Batholith, whereas Sn-W-Mo-polymetallic deposits in the region were generated by younger phases. Other studies around Poplar Mountain and Lake George, west of Fredericton, conducted in conjunction with those in the Clarence Stream area, demonstrate that similar, intrusion-related gold mineralizing events persist across the New Brunswick segment of the Northern Appalachian orogen, as recognized early on by McLeod and McCutcheon (2000), and are associated with roughly coeval plutonic rocks (e.g., felsic intrusions of the Pokiok Batholith). The discovery of these types of systems has significant implications with respect to future exploration throughout New Brunswick, and elsewhere in the Atlantic Provinces and Maine.

The purpose of this trip is to introduce you to the geological setting of an assortment of intrusion-related deposits, with an emphasis on gold in southwestern New Brunswick, to the various styles of mineralization associated with these systems, and to review evidence supporting proposed models. The stop locations for this 2.5 day field trip are shown in Figure 1. Day one will involve travel to the southwestern part of the province near St. Stephen to see several outcrop exposures that outline the structural and stratigraphic setting of the deposits. Selected units that host the gold deposits in the Fredericton, St. Croix, and Mascarene belts, along with intrusive phases of the Saint George Batholith responsible for generating the gold deposits will be examined. The second day will consist of visits to various trenched exposures at the Clarence Stream gold deposits in the same area, and will end with core examination at the Mount Pleasant Mine site south of Fredericton. Stops on the final day will include visits to the Mount Pleasant Mine to examine outcrop exposures near the W-Mo-Bi deposit of the Fire Tower Zone and to a gold showing (McDougall Brook) related to a Mount Pleasant-type system in the Mount Pleasant Caldera Complex. Core will be available from a similar system outside the caldera that has associated gold mineralization (Kedron occurrence).

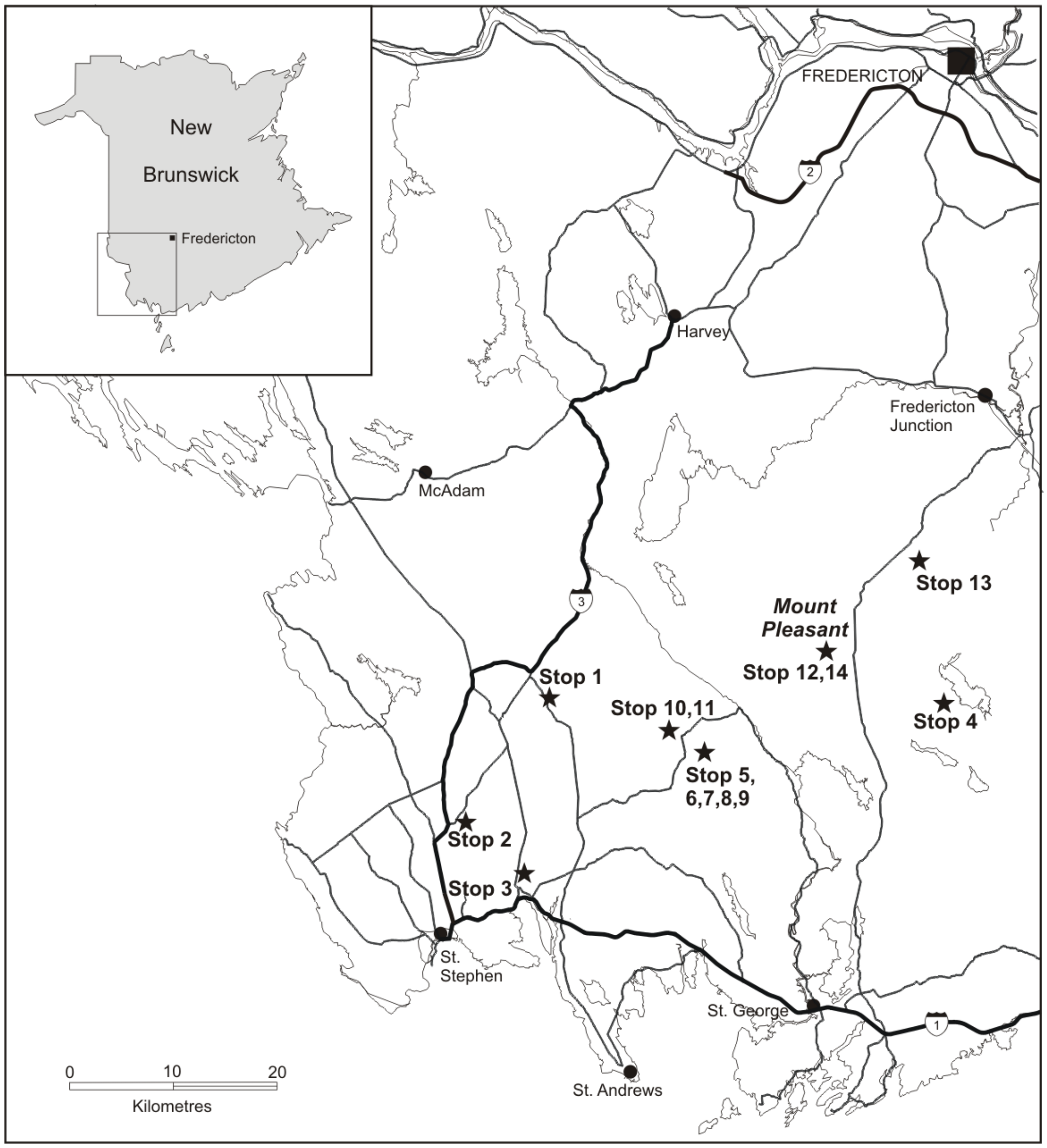

Figure 1. Locations of the various field trip stops in southwestern New Brunswick.

GEOLOGICAL SETTING

Regional Geology of New Brunswick

The basic geological framework of the Northern Appalachians of eastern Canada can be defined in terms of broad zones that reveal a complex history of extensional and accretionary tectonic processes, and continental collision events during Late Neoproterozoic to Paleozoic time (Williams, 1995). From northwest to southeast, these are the Grenville, Humber, Gander-Dunnage, Avalon, and Meguma zones (Figure 2). The Grenville Zone represents the ancestral North American craton, whereas the Humber Zone contains remnants of the craton's margin formed along the northwestern boundary of the Early Paleozoic Iapetus Ocean. The Avalon Zone consists of several amalgamated, peri-Gondwanan belts of Neoproterozoic to Cambrian in age that represents a linear microcontinent bordering Iapetus to the southeast. The Gander-Dunnage Zone represents the central mobile belt of the orogen that contains relics of the Avalonian continental margin, and of Cambro-Ordovician arcs and related back-arc basins generated during closure of the ocean. The Meguma Zone was emplaced in it's present position during continental assembly in Late Paleozoic time, and is thought to originally be either a segment of the Gondwanan continental margin that was left behind after the opening of the modern Atlantic Ocean, or a remnant of a sedimentary basin floored by Avalonian-type basement (Murphy et al., 1992).

Superimposed on this basic framework are vestiges of Late Ordovician to Early Devonian sequences formed within and adjacent to the central mobile belt in foredeep depocentres, in extensional basins, and in arc- to back-arc environments as the Avalonia microcontinent collided with the North American landmass (e.g., van Staal and Fyffe, 1991). This collisional event was accompanied by syn- to post-orogenic, Late Silurian to Late Devonian plutonic suites emplaced across the orogen (Figure 3). In the wake of the collision, large parts of the orogen were concealed by extensive successor basins formed during Late Devonian through Permian time, and by sedimentary deposits formed in extensional basins in Triassic to Jurassic time in response to opening of the present day Atlantic Ocean (e.g., Pe-Piper et al., 1992; St. Peter, 1993).

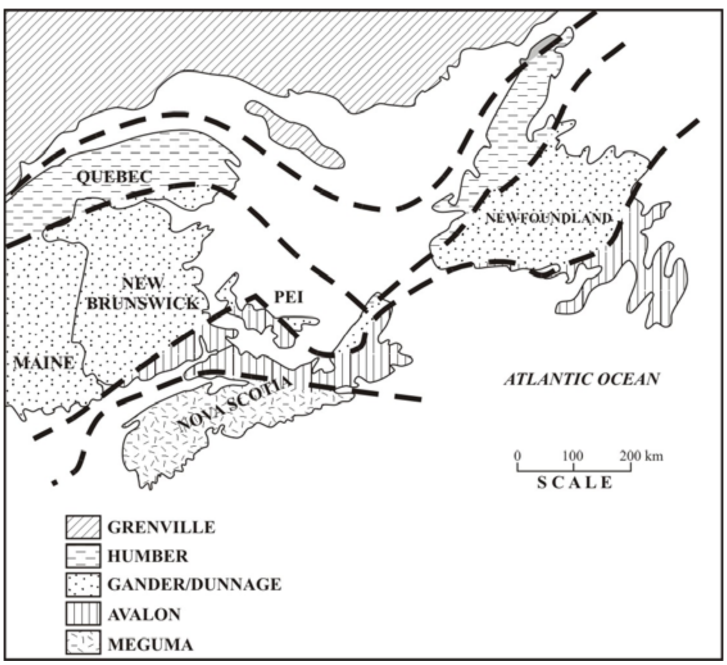

Figure 2. Tectonic divisions of the Atlantic Provinces (modified after Williams, 1995; Barr and White, 1996; from McLeod, 2003).

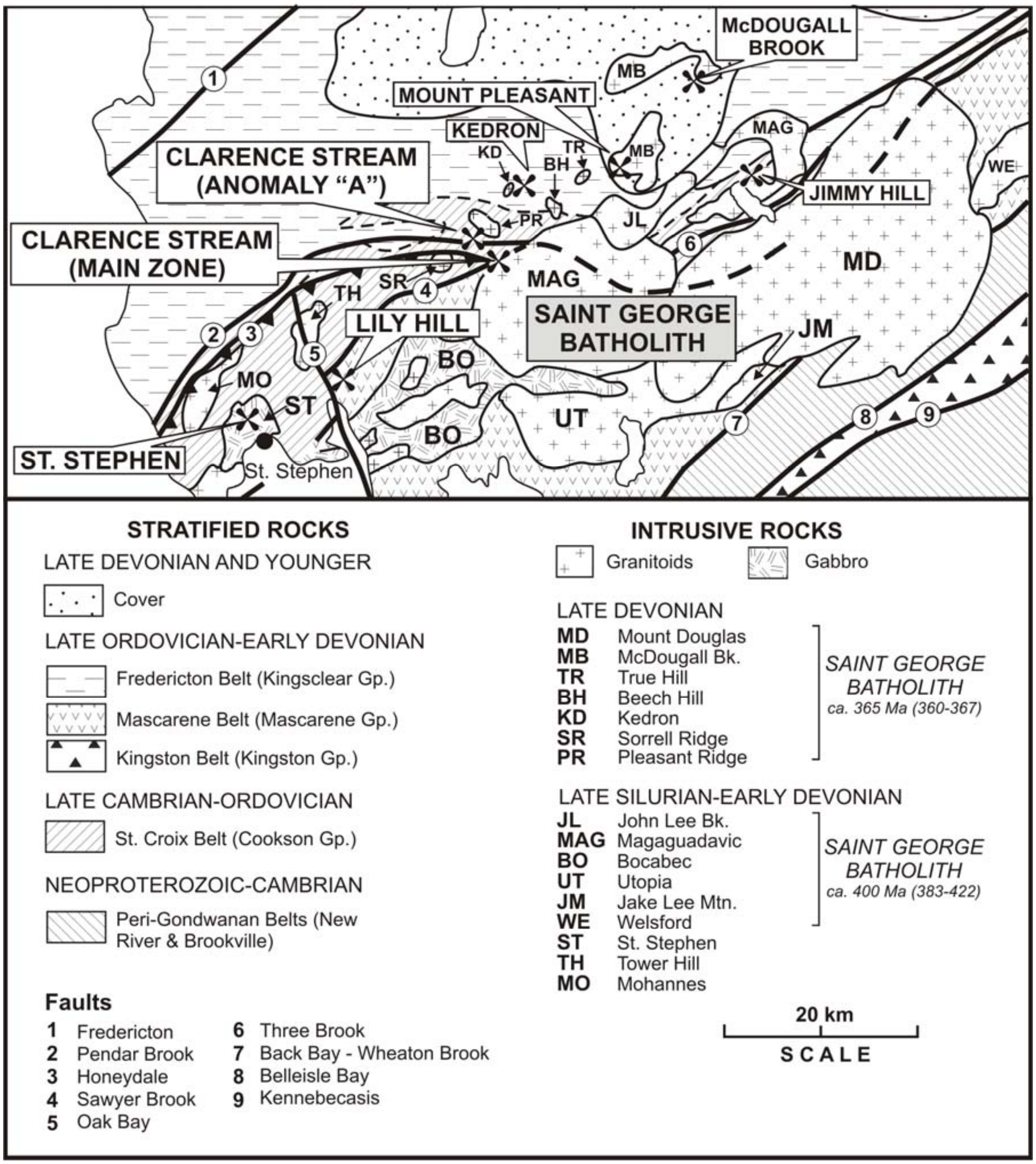

Figure 3. Geology of southwestern New Brunswick (modified from Thorne and McLeod, 2003a).

Neoproterozoic to Middle Paleozoic sequences in southwestern New Brunswick comprise several northeast-trending and mainly fault-bounded tracts, each of which exhibit some unique structural, stratigraphic, plutonic and/or geochemical features. Previously, these have been variously referred to as tectonostratigraphic zones or belts, terranes, and/or cover sequences depending on their intended significance in research documents. To avoid regional tectonic connotations, they are herein simply termed belts and include the Neoproterozoic to Cambrian New River, Brookville, and Caledonia belts, the Early to Middle Ordovician St. Croix Belt, the Late Ordovician to Silurian Mascarene Belt, and the Silurian Kingston and Fredericton belts (Figure 3). Terminology and general distribution of these belts, or terranes and cover sequences, were documented by Fyffe and Fricker (1987), Barr and White (1989), and Johnson and McLeod (1996). Other regional-scale geological units relevant to this discussion include plutonic suites associated with the Siluro-Devonian Saint George Batholith (McLeod, 1990) and extrusive and intrusive rocks constituting the Late Devonian Mount Pleasant Caldera Complex (McCutcheon et al., 1997).

General Geology of the Clarence Stream Area

The Clarence Stream area encompasses stratified units in the eastern part of the St. Croix Belt (Cookson Group), the southernmost margin of the Fredericton Belt (Kingsclear Group), and the northern part of the Mascarene Belt (Mascarene Group). The stratigraphy and approximate ages of the lithological units that comprise these belts/groups are shown in Figure 4. The Cookson Group consists of polydeformed formations ranging from Tremadocian through Caradocian in age (Ludman, 1987; Fyffe and Riva, 1990) and includes the Calais, Woodland, and Kendall Mountain formations. These units predominantly consist of black shale and minor basalt, a feldspathic wacke sequence, and quartz arenite interbedded with shale, respectively. The overlying Silurian Kingsclear Group comprises lithic and feldspathic wacke and shale of the Digdeguash Formation overlain by feldspathic wacke and slightly calcareous shale of the Sand Brook Formation, and calcareous wacke and shale of the Flume Ridge Formation (Ruitenberg, 1967; Ruitenberg and Ludman, 1978; Fyffe and Riva, 2001). The early Llandoverian Digdeguash Formation appears to lie conformably on the Kendall Mountain Formation at some localities, but is generally faulted against various units of the Cookson Group (Fyffe and Riva, 2001).

The Oak Bay Formation and conformably overlying Waweig Formation (Ruitenberg, 1967; Fyffe et al., 1999) comprise the Mascarene Group to the south of the St. Croix Belt in the Clarence Stream area and constitute a homocline exhibiting affects of a single deformational event. The Oak Bay Formation constitutes the base of the group in the region and contains polymictic conglomerate, coarse-grained sandstone and tuffaceous rocks lying unconformably on top of the Cookson Group. The Waweig Formation is a volcano-sedimentary succession dominated by assorted volcanogenic sedimentary rocks, medium-to fine-grained clastics interbedded with mafic to felsic volcanic rocks that are locally intruded by abundant mafic dykes (Fyffe et al., 1999). This formation has recently been assigned an Early to Late Silurian (Llandoverian to Ludlovian) age by Miller and Fyffe (2002).

The main mass of the Saint George Batholith, which consists of several multiphase intrusive suites, crops out over the southern part of the Clarence Stream area, and based on geophysical information, underlies the entire area at shallow depths (Thomas and Willis, 1989; King and Barr, 2004a, 2004b). At the present day surface in the vicinity of Anomaly A, apophyses of the batholith referred to as satellite plutons are prevalent. The

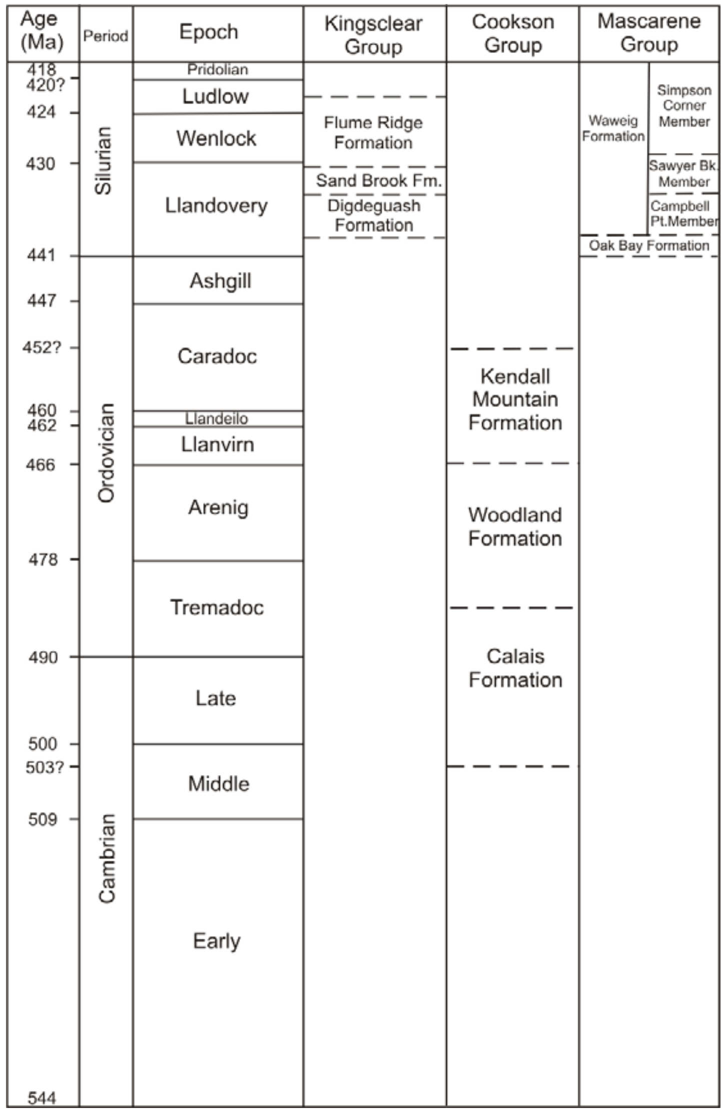

Figure 4. Stratigraphic column for the Kingsclear, St. Croix, and Mascarene Group rocks. Mascarene Group from Fyffe et al. (1999); Cookson Group after Fyffe and Fricker (1987), Ludman (1987), and Fyffe and Riva (1990); Kingsclear Group from Ruitenberg (1967), Ruitenberg and Ludman (1978), and Fyffe (1991). Time scale after Okulitch (1999).

suites and constituent intrusions of main interest here are the Early Devonian Magaguadavic Granite of the South Oromocto Lake Suite, and Late Devonian Kedron (formerly the Bonny River Granite), McDougall Brook, and Mount Pleasant granites of the Pomeroy Suite (e.g., McLeod, 1990; Taylor et al., 1985; Sinclair, 1994; McCutcheon et al., 1997) (Figure 3). The Magaguadavic Granite was emplaced at moderate crustal depths and consists of subequal proportions of granite and granodiorite, is xenolith-rich, and exhibits chemical and mineralogical features of oxidized “I”- type granites. This intrusion and its later fractionated components are considered the source of gold in the

Clarence Stream deposits (Thorne et al., 2002a). In contrast, intrusions of the Pomeroy Suite were emplaced at very shallow crustal levels and are mostly, high-silica and/or topaz granites that are highly evolved and exhibit mostly “A”- type characteristics. Volcanism in the Mount Pleasant Caldera Complex is associated with this suite of intrusions, as is the mineralization at the Mount Pleasant Sn-W-Mo-Bi-polymetallic deposit and numerous other similar mineral occurrences throughout the area (e.g., Sinclair, 1994). Minor gold mineralization is also related to the Pomeroy Suite, especially with relatively unevolved granites such as the McDougall Brook Granite (Thorne and McLeod, 2003a; Yang et al., 2003). The potential for significant gold deposits to be associated with this suite has yet to be fully evaluated.

Tectonic Considerations

The belts containing Neoproterozoic units and the St. Croix Belt have been the subject of much discussion in relation to plate tectonic interpretations (e.g., Fyffe and Fricker, 1987; Fyffe et al., 1999; Johnson, 2001; Barr et al., 2002b). These authors present information to model these units as separate terranes or as amalgamated terranes (all or in part) during Late Neoproterozoic to Early Paleozoic time. Most agree that those belts/terranes containing Neoproterozoic units are peri-Gondwanan, but not all would characterize them as Avalonian in the sense of Williams (1995). The mostly Silurian units of the Kingston, Mascarene, and Fredericton belts, are generally thought to represent cover sequences on the New River and St. Croix belts, but the zonal affiliation of the latter belts (Ganderian or Avalonia?) remains equivocal.

Particularly relevant to this field trip is to understand the relationship between the St. Croix and New River belts and their associated cover sequences up until juxtaposition of the Mascarene Belt with the St. Croix Belt along the Sawyer Brook Fault. This aspect is significant since gold mineralization is intimately linked to intrusions and structures generated during this period. In a synoptic tectonic analysis of southern New Brunswick, Fyffe et al. (1999) suggested that the sedimentary sequences of the St. Croix Belt were deposited on a passive Ganderian continental margin underlain by Miramichi basement. Southeasterly subduction of an oceanic tract beneath the peri-Gondwanan New River terrane generated arc- and back-arc volcanism during Cambrian time. Cambrian rocks associated with this subduction event occur in the Mosquito Lake area of New Brunswick and in the Ellsworth area of adjacent Maine (Stewart et al., 1995; Johnson, 2001). Closure of the ocean basin resulted in accretion of the Miramichi and New River terranes in Ordovician time (Figure 5). In this model, the St. Croix Belt represents a foreland basin that developed on the Miramichi continental margin as it was overridden by New River basement. Generation of early and rare northwesterly verging isoclinal folds in the St. Croix Belt are attributed to emplacement of the New River terrane along a major detachment zone in the mid-Ordovician. The St. Croix/New River boundary in southern New Brunswick would thus mark the thrust front between terranes with Ganderian and Avalonian aspects. This boundary is hidden beneath the Saint George Batholith in New Brunswick but is exposed along the Turtle Head Fault in adjacent Maine (Stewart et al., 1995).

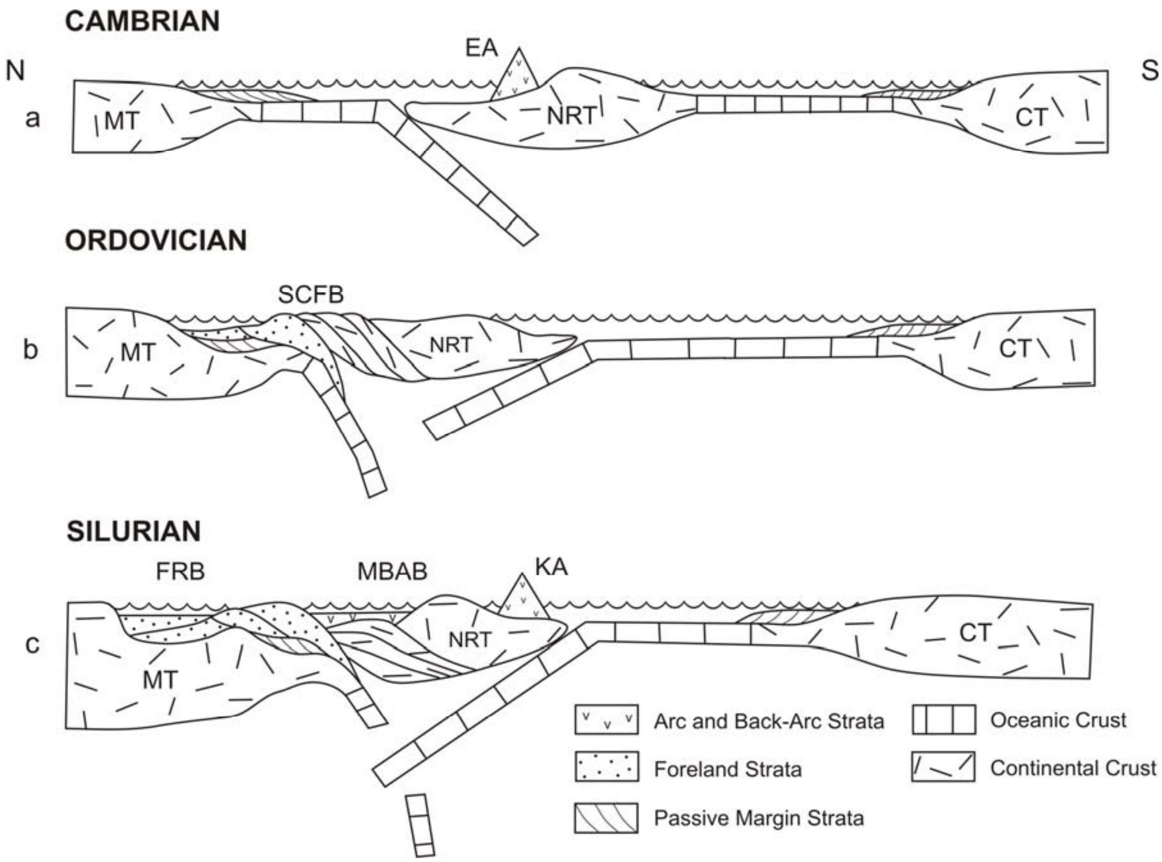

Figure 5. Cartoon depicting the early Paleozoic tectonic evolution of the Appalachian Orogen in southwestern New Brunswick. CT=Caledonia terrane; NRT=New River terrane; MT=Miramichi terrane; SCFB=St. Croix foreland basin; EA=Ellsworth/Mosquito Lake arc; KA=Kingston arc; MBAB=Mascarene back-arc basin; FRB=Fredericton retroforeland basin (modified after Fyffe et al., 1999).

Furthermore, Fyffe et al. (1999) suggest that a later northwesterly dipping subduction zone developed along the northern margin of an oceanic tract separating the New River terrane from the Caledonia terrane farther to the south. This subduction zone generated a Late Ordovician to Silurian arc (the Kingston Belt) and back-arc (Mascarene Belt) complex (Fyffe et al., 1999; Barr et al., 2002a). In this interpretation, the Neoproterozoic limestone and gneiss of the Brookville Belt represent exhumed basement to the New River terrane. Late southeasterly verging folds in the St. Croix Belt and associated thrusts may be related to closure of the ocean basin. Major northeast-trending strike-slip fault zones near the northwestern margin of the arc and back-arc complex, which are one of the main controls on gold mineralization at the Clarence Stream Main Zone deposits, and high-angle reverse faults further south within the complex are attributed to oblique convergence of the Caledonia terrane against the arc during Late Silurian to Early Devonian time.

Recent information and ongoing research has resulted in refinement to the above model, which is critical to unravelling processes involved in gold generation in the Clarence Stream area. Five main points and speculation surrounding these are discussed below.

(1) Recent geochronological studies have indicated the presence of abundant Late Neoproterozoic detrital zircons (~550 Ma) in the Early Ordovician Calais Formation of the Cookson Group (unpublished results). These new data support the suggestion by Fyffe et al. (1999) that the shales of the Calais Formation were derived from erosion of New River basement. In this interpretation (Figures 4 and 5), the black shales of the Calais Formation represent the early, starved phase of foreland basin development; the overlying feldspar-rich wackes of the Woodland Formation are derived from the volcanic arc in the rising New River hinterland; and the quartz-arenites of the Kendall Mountain Formation are derived from the uplifted passive Miramichi continental margin.

(2) Fyffe and Fricker (1987) have noted that quartzite and black shale clasts in the Oak Bay conglomerate were clearly derived from the Ordovician Cookson Group and therefore link the Mascarene and St. Croix belts in the Silurian. Recent geochronological studies also indicate that volcanic clasts in the conglomerate were multi-sourced, with the most abundant likely derived from the New River Belt (Fyffe et al. 2001). However, the older dates reported for some clasts could indicate derivation from the more distal Brookville and Caledonia belts.

(3) New exposures in the Oak Bay area reveal, for the first time in the region, an indisputably unsheared, unconformable contact between the Oak Bay Formation and the Ordovician Cookson Group of the St. Croix Belt. Previously, all such contacts were considered sheared and bounded by regional faults such as the Sawyer Brook Fault (e.g., Gates, 1989; Fyffe et al., 1999). The fact that the Cookson-Oak Bay contact is preserved as an unconformity indicates that the Sawyer Brook Fault does not mark a terrane boundary separating the St. Croix and Mascarene belts. Thus the black shales of the Cookson Group likely continue to the south stratigraphically beneath the Silurian Mascarene Group. Recent geophysical modelling by King and Barr (2004b) support this southern provenance for the Cookson Group. It can be concluded that the arc and back-arc rocks of the Mascarene Group lie stratigraphically on both the St. Croix and New River belts and thus oversteps the Ordovician suture zone.

(4) Mesoscopic, upright, isoclinal folds in black shale of the Calais Formation beneath the newly exposed Oak Bay unconformity locality plunge shallowly to the southwest and are accompanied by a well-developed, steeply dipping axial-planar cleavage not present in the overlying Silurian strata. The observation that the folded beds are truncated by the unconformity confirms the previous conclusion by Fyffe et al. (1999) that a major deformational event occurred in southern New Brunswick in the mid-Ordovician. Fyffe et al. (1999) associated this deformation with the accretion of a Cambrian arc, floored by New River basement, to the Miramichi continental margin.

(5) The presence of a few clasts derived from rocks older than those known to exist in the New River Belt combined with those derived from the St. Croix Belt in the Oak Bay conglomerate (Fyffe et al., 2001), could be interpreted to indicate that the St. Croix, New River, Brookville, and Caledonia belts were all linked to the Mascarene Belt by the Silurian. Results from other geochronological studies (Barr et al., 2003) may indicate that the Brookville and Caledonia belts developed near the same continental landmass. Considering these possibilities, it seems possible that the peri-Gondwanan belts in this region and the St. Croix belt, if they represent separate terranes, were amalgamated before deposition of the Early Silurian Oak Bay Formation, and perhaps much earlier as suggested by Johnson (2001). Further, workers in Maine along strike suggest that belts containing sequences correlated in total or part with the Brookville, New River, and St. Croix belts, although partly disrupted by later faulting, are related stratigraphically, and therefore do not represent separated terranes at their inception (Robinson et al., 1998; Tucker et al., 2001). In the above scenario, no subduction zone could have existed south of the New River Belt in contradistinction to the model proposed by Fyffe et al. (1999).

(6) Robinson et al. (1998) and Tucker et al. (2001) have presented a tectonic model for coastal Maine suggesting that a cryptic suture would lie buried beneath the Fredericton Belt. Recent evaluation of temporal and stratigraphic relationships in New Brunswick, coupled with new geochemical and geochronological data, supports this interpretation (McLeod et al., 2005). The new data suggest that Late Ordovician to Late Silurian volcano-sedimentary sequences of the Kingston and Mascarene groups could have evolved in response to a northwestward migrating continental arc-type complex above a southeasterly dipping subduction zone that plunged beneath the St. Croix and peri-Gondwanan belts further south.

(7) Recent regional and detailed structural studies (Thorne and Lentz, 2001b, 2003; Park, 2001, 2003; Park et al., in press; Castonguay et al., 2003; Watters et al., 2003, in press) have determined that the distribution of gold zones in the Clarence Stream area are primarily controlled by closely timed, late D_2 thrusts and shear zones at Anomaly A, and by D_3 mylonitic zones at the Main Zone, and that the gold mineralizing event was coeval with these structures. The gold zones, which occur in the Kendall Mountain Formation of the Cookson Group at Anomaly A, are hosted by structures defining sheared limbs of mesoscopic to megascopic, isoclinal F_2 folds that developed near high strain zones. Mineralized areas at the Main Zone, which occur just to the south of the main St. Croix-Mascarene boundary, were emplaced along splays of the Sawyer Brook Fault that formed in response to shearing along the southern limb of a megascopic, open F_3 fold that refolds the D_2 structures to the north of the boundary. Based on these studies, and dating programs that constrain timing of gold mineralization and related intrusions in the Clarence Stream area (Bevier, 1989, 1990; McLeod, 1990; Thorne et al., 2002a; Davis et al., 2004), the structures hosting most of the gold deposits found to date developed late in Early Devonian time.

The recent information referred to above indicates that late thrusting, major strike-slip faulting, and deformation associated with these structures in the Clarence Stream area took place in the Early Devonian. In the models proposed by Tucker et al. (2001) and McLeod et al. (2005), the causative tectonic process for developing the thrusts is the northwestward stacking of a Late Ordovician - Silurian arc and back-arc complex (Mascarene and Kingston belts) above a southeasterly dipping subduction zone located north of the St. Croix Belt. In the contrasting model of Fyffe et al. (1999), the thrusting is associated with shortening in a retroforeland basin (Fredericton Belt) above a subduction zone dipping northwesterly beneath a Silurian arc (Kingston Belt) and back-arc basin (Mascarene Belt).

Regardless of the specific details of the plate tectonic processes assumed to have been operative in southern New Brunswick, accretionary complexes related to at least two major tectonic events likely lie concealed beneath the younger plutonic rocks of the Saint George Batholith. These deep crustal structures may well have served as primary conduits for mineralizing magmas in the Clarence stream area during emplacement of the Saint George Batholith (Thomas and Willis, 1989; McLeod, 1990).

DAY 1- GEOLOGY OF SOUTHWESTERN NEW BRUNSWICK

GEOLOGICAL SETTING

The Clarence Stream gold deposits are situated above a complex accretionary zone largely concealed in the near surface by volcanic and sedimentary rocks of the Mascarene Group and intrusions of the Saint George Batholith (Figure 3). Major transcurrent movement (transpressional to transtensional) along such “terrane” boundaries were reactivated periodically during the development of the Appalachian Orogen (Williams and Hatcher, 1982). Ponded mafic magma, possibly fed by mantle-derived basalt that facilitated crustal melting at depth, led to the eventual emplacement of the composite Saint George Batholith. This composite intrusion, possibly along with other plutonic bodies in the region (i.e., Pokiok Batholith), is thought to have utilized deep crustal structures as it travelled to higher crustal levels (Thomas and Willis, 1989; McLeod, 1990; Whalen et al., 1994). One likely structural manifestation of this accretionary boundary at the present day surface is the Sawyer Brook Fault zone (Figure 6), which locally separates Ordovician rocks in the Cookson Group (St. Croix Belt) and Silurian Kingsclear Group (Fredericton Belt) to the northwest, from Silurian rocks of the Mascarene Group (Mascarene Belt) to the southeast.

The stratigraphy, lithology, and structure of units relevant to this field trip are summarized in the following sections. These include stratified units in parts of the Fredericton, St. Croix, and Mascarene belts (from northwest to southeast in southwestern New Brunswick), some of the intrusions related to the Saint George Batholith, and dykes in the Mascarene Belt.

STRATIGRAPHY

Fredericton Belt

Rocks of the Silurian Kingsclear Group constitute the Fredericton Belt. It forms a thick, clastic turbiditic sequence deposited during Early Silurian time within a ~80 km wide, southwestward-trending trough north of the St. Croix Belt (e.g., Fyffe and Fricker, 1987). In the Clarence Stream area, the belt is divided into the Digdeguash, Sand Brook, and Flume Ridge formations, as established by Ruitenberg (1967), Ruitenberg and Ludman (1978), Fyffe (1991), McLeod et al. (1994), and Fyffe and Riva (2001).

Early Silurian (upper Rhuddanian Stage of the early Llandoverian) rocks of the Digdeguash Formation at the base of the sequence define the southern boundary of the Fredericton Belt and consist of medium to dark grey, medium- to coarse-grained, lithic to feldspathic wacke, light grey quartz wacke and polymictic, granule conglomerate, and dark grey to black shale (Ruitenberg and Ludman, 1978; Fyffe, 1991; Fyffe and Riva, 2001). The contact between the Digdeguash Formation and the Ordovician Kendall Mountain Formation of the Cookson Group is generally faulted, but based on fossil evidence and detailed bedrock mapping, is thought to be an unconformity as discussed by Fyffe and Riva (2001).

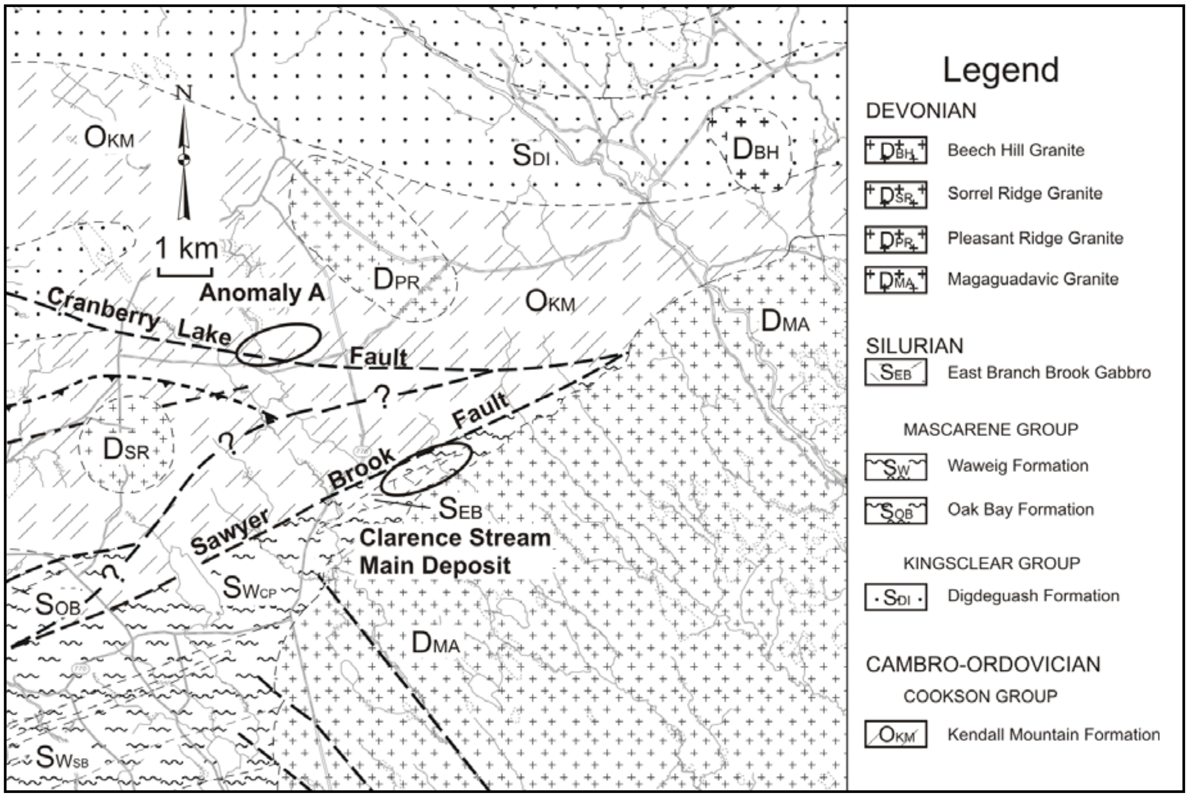

Figure 6. Regional geological setting of the Clarence Stream gold deposits. Geology after Fyffe (1998), McLeod et al. (1998), and Fyffe and Thorne (2002).

The Digdeguash Formation is conformably overlain by Silurian rocks of either the Sand Brook Formation, which interfingers with the top of the formation to the east, or the Flume Ridge Formation to the west (Ruitenberg, 1967; Ruitenberg and Ludman, 1978; Fyffe, 1991). The Sand Brook Formation is characterized by graded, light green feldspathic wacke beds of variable thickness interbedded with distinctive, green to maroon, laminated siltstone and shale (Fyffe, 1991). The distinctive colour is attributed to the abundance of epidote and actinolite attesting to the formation's overall calc-silicate composition. Units are commonly highly micaceous and locally calcareous. Rocks of the Flume Ridge Formation include light grey to greyish green, calcareous, wacke with characteristic large detrital muscovite flakes and shale as thin partings in the coarser grained clastics that are interstratified with light to medium grey, non-calcareous slate (Ruitenberg and Ludman, 1978; Fyffe, 1991).

St. Croix Belt

The St. Croix Belt lies in between the Fredericton and Mascarene belts and comprises Ordovician clastic sedimentary rocks of the Cookson Group, that in the Clarence Stream area, includes (from oldest to youngest) the Tremadocian Calais Formation, the Woodland Formation, and the Caradocian Kendall Mountain Formation (Ruitenberg, 1967; Ludman, 1987; Fyffe and Riva, 1990; Fyffe et al., 1992) (Figure 4). The southern margin of the belt, against the Oak Bay or Waweig formations of the Mascarene Group, is delineated by the Sawyer Brook Fault throughout most of the area. The relationship between the stratigraphic equivalents to the Oak Bay and Cookson formations in Maine, are interpreted by Gates (1989) to be a faulted unconformity. A similar relationship was suggested for the Oak Bay-Cookson relationship as well, but the contact has recently been observed as an unsheared, angular unconformity at a newly exposed location immediately south of the fault in the Clarence Stream area.

The stratigraphy described here is from the summary presented by Fyffe et al. (1992). Readers are referred to this document for numerous other relevant references. The Early Ordovician Calais Formation comprises black carbonaceous shale interstratified with minor, thin-bedded siltstone with a ~100 m thick pillowed basalt member near the top. They also review the results of a re-examination of graptolites from the formation that indicate an Early Tremodocian age. The Woodland Formation includes quartzofeldspathic wacke and lesser siltstone and shale that occur in thin- to medium-bedded, rhythmically interbedded units that commonly exhibit convolute laminations. Slightly calcareous wacke beds and calcareous concretions are present locally within the section. A unit of light grey, medium- to thick-bedded quartz arenite with thin beds of black shale and thick beds of volcaniclastic conglomerate near its base is assigned to the Kendall Mountain Formation. Graptolites discovered in slatey units of the Kendall Mountain Formation indicate an age of Early Caradocian for the formation (Fyffe and Riva, 1990).

Mascarene Belt

Oak Bay and Waweig Formations

The southernmost stratified units in the Clarence Stream area comprise the Silurian Oak Bay Formation and overlying Waweig Formation (Ruitenberg, 1967) that constitute the Mascarene Group (Mascarene Belt) immediately south of the Sawyer Brook Fault. The southern margin of this package is delineated by the main mass of the Saint George Batholith throughout most of southwestern New Brunswick.

The detailed stratigraphy of these units and a description of newly assigned members of the Waweig Formation are documented by Fyffe et al. (1999) and are summarized and expanded upon below. The Oak Bay Formation consists of massive to thick-bedded, polymictic, pebble- to cobble-conglomerate containing moderately to well-rounded clasts of various volcanic rock types, granitoids, rare limestone, and black shale. The black shale clast content, and locally the size of the clasts, increases towards the base of the formation and are clearly derived from the underlying Cookson Group, while other lithologies could well be sourced from peri-Gondwanan belts and/or older Mascarene Group units to the southeast (Fyffe and Fricker, 1987; Fyffe et al., 2001). The thickness of the conglomerate section, which is a minimum of 600 m in the southwest, decreases to 200 m towards the northwest where it is composed of thin-bedded feldspathic sandstone interbedded with turbidites. As discussed previously, an unsheared unconformable contact between the Oak Bay conglomerate and underlying Cookson Group is preserved in the Clarence Stream area. A regional evaluation of the sedimentological characteristics of the Oak Bay conglomerate indicates deposition was contemporaneous with faulting along basin-bounding scarps like the Sawyer Brook Fault (Gates, 1989).

The conformably overlying Waweig Formation consists of a mainly turbiditic sequence interstratified with a variety of mafic tuffaceous and minor felsic volcanic rocks. The formation is subdivided into three units by Fyffe et al. (1999) that include the Campbell Point, Sawyer Brook, and Simpson Corner members (Figure 4). The Campbell Point Member is described as containing interstratified greyish pink to dark grey volcaniclastic and siliciclastic sedimentary rocks and medium grey felsic volcanics. In detail, it consists of the following lithofacies from the base upwards: a tuffaceous sandstone facies that contains medium- to very thick-bedded pebbly and medium- to fine-grained sandstones, a chaotic tuffaceous sandstone facies with slump fold horizons interstratified with thin-bedded sandstone, a waterlain pyroclastic facies consisting of crystal and crystal-lithic lapilli tuff, a medium- to thick-bedded sandstone facies with fine-grained sandstone, and a thin-bedded mudstone facies. The Sawyer Brook Member is characterized by pyrite-bearing, medium grey to black shales interbedded with dark greyish green mafic tuff and hyaloclastite, and minor calcareous sandstone. The Simpson Corner Member is predominated by light grey and fine-grained sandstone grading into dark grey laminated silty mudstone. Minor amounts of volcanic rocks occur throughout the unit and include a variety of felsic, crystal to crystal-lithic tuffs and an amygdaloidal flow.

Similarity of fossil assemblages in the Mascarene Group to those in established Silurian sections in Maine has previously been used to suggest that the Oak Bay and overlying Waweig formations are Ludlovian to Pridolian in age (see review in Fyffe et al., 1999). More recently however, a U-Pb zircon date of 438 ± 4 Ma on a felsic volcanic rock from the Campbell Point Member of the Waweig Formation (Miller and Fyffe, 2002) indicate a Llandoverian age for the onset of deposition in this segment of the Mascarene Belt.

East Branch Brook Metagabbro

The East Branch Brook Metagabbro occurs as a number of linear, dyke-like bodies that trend northeast, parallel to the regional fabric. The gabbro intrudes volcanic and volcaniclastic units of the Early Silurian Waweig Formation immediately adjacent to the Magaguadavic Granite. There are three phases of dykes ranging from Fe-rich to Mg-rich, all of which are mantle-derived and have subalkaline to alkaline continental tholeiitic compositions (Thorne and Lentz, 2001a). A maximum age for the metagabbro is constrained by its intrusive relationship with Early Silurian (437 ± 7 Ma) rocks of the Waweig Formation (Miller and Fyffe, 2002), and a 390 ± 8 Ma U-Pb monazite electron microprobe age obtained from auriferous granite and aplite dykes that cross-cut the gabbro (Thorne et al., 2002a). Similar U-Pb (monazite) ages for cross-cutting granitoid dykes were reported to be 396 ± 0.5 Ma by Davis et al. (2004). The East Branch Brook gabbroic dykes are interpreted to have been emplaced along splays of the Sawyer Brook

Fault Zone during transpressional movement of the suture zone during Late Silurian-Early Devonian time (Thorne and Lentz, 2001a).

Magaguadavic Granite

The Magaguadavic Granite comprises much of the northwestern margin of the Saint George Batholith in the Clarence Stream area (main body) and to the northeast (north body) (McLeod, 1990). In general, it consists of an undeformed, heterogeneous unit of pink to grey, medium- to coarse-grained, commonly megacrystic monzogranite, monzonite, and granodiorite with minor microgranite dykes, all of which commonly exhibit well-developed rapakivi textures. Mappable units primarily composed of pink porphyritic to equigranular, fine- to medium-grained syenogranite and monzogranite also occur in the north body. Xenoliths of partially to near totally assimilated metasedimentary and mafic igneous material are common throughout the intrusion. Irregular areas containing anomalously high mafic mineral contents (up to about 25% biotite and/or amphibole) attest to the large volume of incorporated foreign material in the intrusion. Chemically, the intrusion is an oxidized magnetite-bearing pluton with overall I-type geochemical signatures (McLeod, 1990). Megacrystic, coarse-grained granite from the main body near McDougall Lake yielded a U-Pb zircon age of 396 ± 1 Ma (Bevier, 1990) and a ^{40}Ar-^{39}Ar biotite age of 400 ± 4 Ma (McLeod, 1990). Seriate rapakivi granite from the north body in the Jimmy Hill area yielded a U-Pb zircon age of 403 ± 2 Ma (Davis et al., 2004), thus confirming its Early Devonian age.

STRUCTURE

Ruitenberg (1967) in his regional structural synthesis covering the Clarence Stream area, recognized the heterogeneous nature of polydeformation in sequences of the St. Croix and Fredericton belts. He documented four phases of deformation, recognizing that an earlier, bedding-parallel fabric was developed at some localities prior to first phase folds. In his interpretation, first and second phase folds plunge gently northeast and/or southwest, are accompanied by steeply dipping and shallowly dipping planar fabrics respectively, and formed in response to northwesterly-southeasterly directed stress. The main regional northeast-trending structure that affects overall map patterns in the area was termed the St. David Dome (Ruitenberg, 1967). It was thought to be essentially controlled by composite, first phase folds followed by upwarping in response to the emplacement of the granitic intrusions. Third phase folds attributed to northeasterly-southwesterly shortening, which resulted in kinking of previous fabrics, were seen to plunge steeply northeast and northwest, and were accompanied by locally developed, steeply dipping axial-planar fabrics. Local folding and shearing associated with the last deformational event were attributed to late, northwest-trending faults formed in a tensional stress regime.

Ruitenberg (1972) and numerous other workers have conducted further structural studies of the area (e.g., Stringer and Burke, 1985; Ruitenberg and Ludman, 1978; Fyffe, 1990; Fyffe et al., 1992; Fyffe et al., 1999), with the most recent work (Castonguay et al., 2003; Watters et al. in press) involving integrated structural studies on the regional and local scales in the St. Croix Belt and along the southern margin of the Fredericton Belt, north of the Sawyer Brook Fault. As a result, Ruitenberg's (1967) interpretations have been modified in part, and summarized below, drawing mostly on the work of Fyffe (1990), Castonguay et al. (2002, 2003), and Watters et al. (2003, in press). These authors observed rare isoclinal or intrafolial early folds (F_1) with associated bedding-parallel cleavage (pre-first phase and first phase deformation of Ruitenberg (1967)) that are refolded by gently and mostly northeasterly plunging isoclinal F_2 folds accompanied by a locally well-developed and shallowly dipping, axial-planar cleavage (second phase folds of Ruitenberg, 1967). It was concluded that these early folding episodes could be composite and represent a continuum in deformation likely directly related to thrusting events. Shallowly-dipping, high strain zones (thrust faults) were recognized as late components of the D_2 deformation as exemplified by low-angle dismemberment of F_2 fold limbs. Further, they attribute the formation of the St. David Dome or Anticlinorium, thought by Ruitenberg (1967) to be an early structural feature, to a later D_3 event. Deformation associated with D_3, which openly to tightly folds pre-existing structural elements and is only locally accompanied by a steeply-dipping cleavage, is mostly coaxial with F_2 folds and has a profound impact on regional map patterns. Strike-slip movement along the sheared southern limb of the regional domal structure is suggested as a mechanism to produce northeast-trending mylonitic zones like those found associated with the Sawyer Brook Fault. Kinematic evidence supports late dextral movement along this structure. A late D_4 event, roughly analogous to Ruitenberg's (1967) late event, broadly deforms the St. David Anticlinorium, producing northwest-trending F_4 kink and chevron folds suggested to be associated with late transverse, northwest-trending structures (e.g., Oak Bay Fault).

In contrast to the Silurian (Fredericton Belt) and Ordovician (St. Croix Belt) sequences north of the Sawyer Brook Fault, those in the Silurian Mascarene Belt immediately to the south are not polyphase deformed. As documented by Fyffe et al. (1999), the Oak Bay and Waweig formations exhibit a single, generally pervasive, moderately to steeply northwest- to southeast-dipping fabric, and form a regionally extensive, moderately, mostly southeasterly dipping homocline that is essentially devoid of folds associated with fabric development. These authors further suggest that the deformational episodes affecting Ordovician and Silurian rocks in the region can be attributed to distinct accretionary events related to a complex history of terrane interaction in southern New Brunswick.

STOP DESCRIPTIONS

<u>STOP 1:</u>

Digdeguash Formation of the Kingsclear Group (Fredericton Belt)

Location: *From Fredericton, head west on Hwy 8 (~3 km); take the first exit (Exit 3 to Hanwell Road) just after the first overpass. Turn right onto Hwy 2 and then right again onto Hwy 640. Head south on Hwy 640 for ~32 km. Head west (bear left) at the junction with Hwy 3 at Acton and proceed toward Harvey. Follow Hwy 3 through Harvey and* *proceed to the turnoff for Hwy 127 on the left (~42 km from Harvey). Head south on Hwy 127 until reaching the Wyman Mills Road on the left (~3 km). Follow this road and stop just before the bridge that crosses the Digdeguash River; park along the side of the road and proceed to the picnic area via the trail along the old railway bed on the right hand side of the road.*

Hazards: Please exercise <u>extreme caution</u> at this location! The outcrop at this stop is very steep and smooth, with the potential to be very slippery when it is wet. Please stay back from the river and don't stray too far from the main group.

Light to medium grey, medium- to thick-bedded feldspathic, micaceous wackes interbedded with dark grey shales of the Digdeguash Formation at this location are highly folded and cleaved. Fold noses and long, gently dipping limbs of the large-scale F_2 folds can be seen on the banks of the river, and graded beds indicate younging to the north (toward the bridge). The S_2 cleavage dips about 40 degrees to the north. The graded characteristics of the beds indicate deposition in deep-water conditions. An Early Silurian age is assigned to this sequence on the basis of correlation with graptolite-bearing shales farther to the east. The Digdeguash Formation, which overlies the northern margin of the St. Croix Belt, is therefore roughly coeval with relatively shallow-water deposits of the Oak Bay and Waweig formations of the Mascarene Belt, which overlies the southern margin of the St. Croix Belt.

<u>STOP 2:</u>

Moores Mills Quarry – Kendall Mountain Formation of the Cookson Group (St. Croix Belt)
(From Castonguay and Ravenelle, 2002)

Location: *From Stop 1 on the Wyman Mills Road, return to Hwy 127 and turn right; proceed until the junction with Hwy 3 (~3 km). Turn left and head west and then south on Hwy 3 to Moores Mills (~22 km). Turn left onto the secondary road and proceed east for ~250 m. At the junction with Hwy 750, bear left until reaching the Tower Hill Road on the right (~1.5 km). Proceed to the quarry on the right hand side of the road (~800 m) and park in the cleared area.*

Hazards: The bank of the quarry is unstable. Please exercise caution when examining the quarry face.

This stop shows three of the four generations of deformation that affect the host rocks to the gold mineralization at Clarence Stream and in part control the mineralization. At this location, rocks of the Kendall Mountain Formation exhibit F_1, F_2, and F_4 folds (see Figure 7). The thick-bedded quartz arenite and interbedded black carbonaceous (graptolite-bearing) slate are deformed in a series of moderately inclined isoclinal F_2 folds, which have the lower inverted limb cut by a fault along an arenite-slate contact.

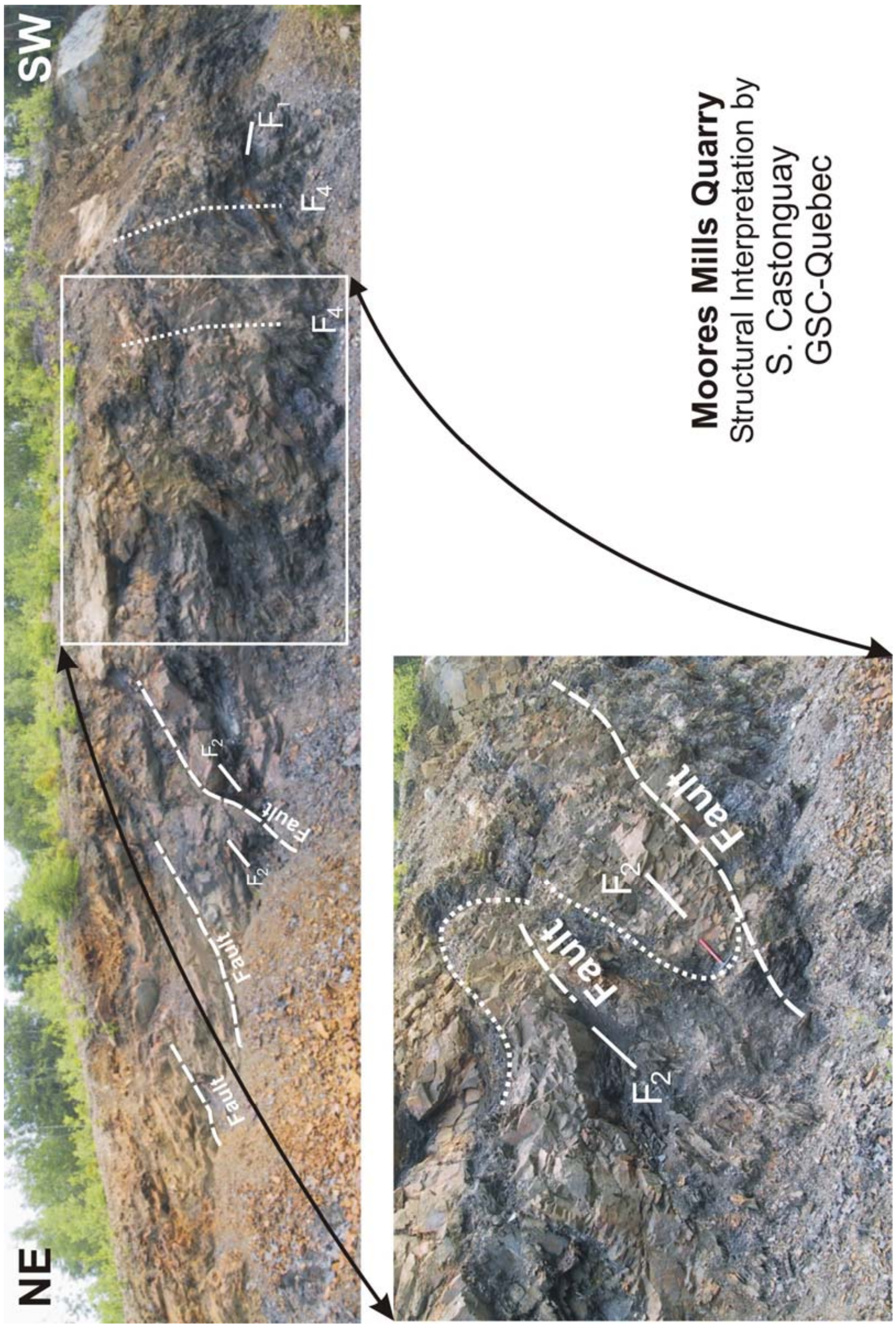

Figure 7. The quarry face at the Moores Mills pit showing the F_1, F_2, and F_4 folds as well as the location of the faults related to the late D_2 deformation (from Castonguay and Ravenelle, 2002).

These faults are marked by the presence of 2 to 5 cm wide cataclastic breccia and gouge. The second generation is strongly visible along the quarry face, whereas sheath folds can be seen at the southwestern end of the quarry face. At the regional scale, documented late D_2 high strain zones are often nearly coincident with a change in asymmetry of mesoscopic F_2 folds, thus reinforcing the genetic link between F_2 folds and the locus of faults. The overall structural control of the gold mineralized zones at the Anomaly A portion of the Clarence Stream deposit is interpreted to be compatible with D_2 thrust-related deformation documented regionally and observed here at the mesoscopic scale.

<u>STOP 3a:</u>

Lily Hill – Contact between the Calais Formation of the Cookson Group (St. Croix Belt) and the Oak Bay Formation of the Mascarene Group (Mascarene Belt)

Location: *From Stop 2 at the quarry, retrace the route back to Hwy 3. Turn left and head south on Hwy 3 toward St. Stephen (~10 km). At the junction with Hwy 1, turn left and head east until reaching the junction with Hwy 760 on the left (~8 km). Proceed north along Hwy 760 and turn right immediately after crossing the overpass that crosses the new highway construction. Head west on the new highway until reaching the last of the outcrop exposure on the right hand side of the road.*

Hazards: Please be careful along the edge of the road cut. The banks are very steep and unstable. Be sure to look over head for any loose rocks that may be potentially dangerous before getting close to the outcrop. Also, the smooth surfaces of the outcrop may be slippery when wet so please exercise caution.

At this location, the contact between the Ordovician Calais Formation and the Silurian Oak Bay Formation can be seen in the outcrop along the north side of the new highway cut (Figure 8). The contact is undulatory but not sheared, and a laminated/folded bed within the Calais Formation appears to be cut off by the Oak Bay conglomerate, indicating that the contact between the two formations represents an unconformity. The thin- to medium-bedded, slightly calcareous rhythmically bedded sequence of hornfelsed, biotitized cordierite-bearing wackes (light) with siltstones (dark) of the Calais Formation youngs and dips steeply towards the east, and are deformed by upright and gently southwest-plunging, isoclinal folds. A well-developed axial-planar cleavage to these early (F_1?) folds and subparallel to local bedding is evident within the outcrop exposure. The overall younging direction of these beds is to the east.

The overlying Oak Bay conglomerate contains polymictic pebbles and cobbles of volcanic rocks, granite, quartzite, slate, and rare limestone. As noted earlier, these clasts were sourced from older rocks in Ganderian and peri-Gondwanan belts to the northwest and southeast respectively, thus indicating belt (or “terrane” depending on the preferred terminology) amalgamation occurred prior to deposition.

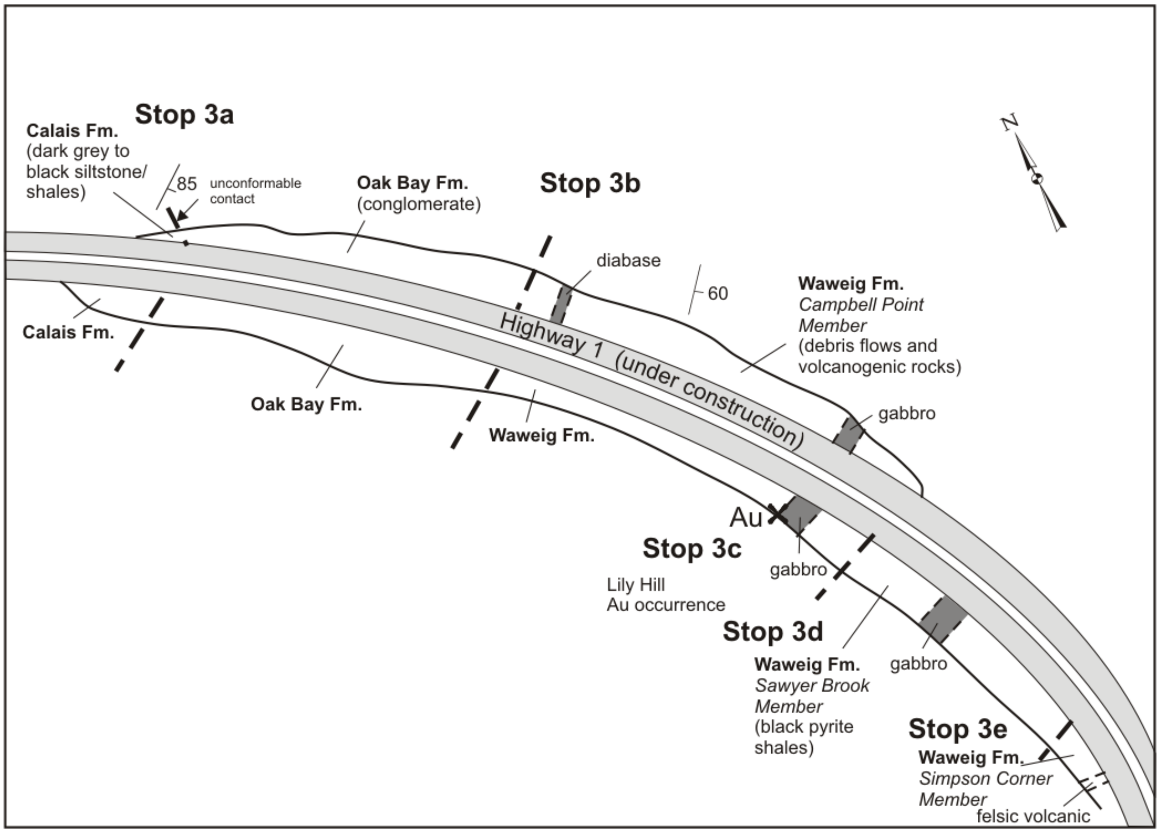

Figure 8. Schematic diagram of the outcrop exposure along the new highway cut across the St.Croix-Mascarene Group contact.

STOP 3b:

Lily Hill – Contact between Oak Bay and Waweig formations of the Mascarene Group (Mascarene Belt)

Location: *Proceed east along the outcrop exposure for ~250 m from Stop 3b.*

Hazards: The banks of the road cut are very steep and unstable. Please be sure to look over head for any loose rocks that may be potentially dangerous before getting close to the outcrop.

The gradational contact between the underlying Oak Bay Formation and the overlying Waweig Formation can be seen at this location (Figure 8). The light grey, quartzose-feldspathic medium- to thick-bedded volcanogenic rocks (crystal tuffs) belonging to the Campbell Point Member of the Waweig Formation (Fyffe et al., 1999), young to the east in this area and are also calc-silicate banded locally. These are overlain by dirtier beds with interbeds of intraformational conglomerate (debris flows) containing purple cherty clasts derived from the underlying Calais Formation that are indicative of an active volcano-tectonic environment overall. Two cycles, consisting of basal debris fining upwards toward the east, are recognizable in the Waweig Formation in this outcrop exposure. The depositional nature of these reworked volcanic rocks is ambiguous and could be explained in terms of two scenarios. One possibility is that they were deposited directly into the basin during volcanic activity and the other is that they could have been deposited on the margin of the basin and subsequently slumped into the basin during seismic/tectonic activity. Note that these rocks have also been intruded by two mafic (diabase to gabbro) dykes/intrusions of unknown affinity. These particular rocks and their geological setting are strikingly similar to those that host the gold mineralization at the Main Zone of the Clarence Stream deposit.

STOP 3c:

Lily Hill – Gabbro Intrusion at the Lily Hill Au Occurrence (Mascarene Belt)

Location: *Cross the four lane highway at the end of the outcrop exposure on the north side of the road and head toward the outcrop on the south side of the road (see Figure 8).*

Hazards: The banks of the road cut are very steep and unstable. Be sure to look over head for any loose rocks that may be potentially dangerous before getting close to the outcrop.

At this location, a massive northeasterly trending gabbroic intrusion of unknown affinity intrudes the Waweig Formation (Figure 8). The dyke may be related to the Saint George Batholith, based on its close proximity to the Late Silurian Bocabec Gabbro, which comprises an aerially extensive phase in the southwestern part of the batholith (McLeod, 1990). Alternatively, it could be one of the numerous, northeasterly-trending Silurian mafic intrusions prevalent in most sequences of the Mascarene Belt (e.g., Fyffe et al. 1999) or represent substantially younger period of mafic magmatism (mid-Carboniferous?) recently recognized in the region, which generated a texturally diverse suite of northwesterly trending mafic dykes.

Minor gold mineralization is associated with the intrusion as well, particularly where the sulphide content is more abundant (i.e., increased presence of striated arsenopyrite crystals). Sampling of the overlying soils showed that they contained up to 568 ppb Au, whereas grab samples from the outcrop exposure contain up to 0.53 g/t Au (Gardiner, 2003). The exact origin of the gold mineralizing fluids and the controlling parameters at this occurrence has not yet been fully investigated. It is notable that high-grade gold zones appear to be associated with similar mafic intrusions near northwesterly trending faults at the head of Oak Bay, 2 km to the west.

STOP 3d:

Lily Hill – Sawyer Brook Member of the Waweig Formation (Mascarene Belt)

Location: *Proceed east along the road cut from Stop 3c (see Figure 8).*

Hazards: The banks of the road cut are very steep and unstable. Be sure to look over head for any loose rocks that may be potentially dangerous before getting close to the outcrop.

The Sawyer Brook Member of the Waweig Formation typically consists of grey to black shale interbedded with several thick horizons (10 m) of greyish-green mafic tuffs (Fyffe et al., 1999). At this location (see Figure 8), the black shales of the Sawyer Book Member contain abundant cubic pyrite (up to 0.5 cm in diameter) as disseminations throughout the beds, associated with quartz along fracture fillings, as well as along bedding planes. Fyffe et al. (1999) infer the thickness of this unit to be within the range of 300 m (along the eastern shore of Oak Bay) to 600 m (along Sawyer Brook). This sequence is interpreted to represent the deepest part of the basin, with the overlying strata indicating deposition within a shallowing environment. Note that although the finer grained lithologies in the Waweig Formation commonly exhibit a well-developed cleavage, no folds like those found in the underlying Cookson Group (Stop 3a) have been observed in the Waweig Formation.

STOP 3e:

Felsic unit within the Simpson Corner Member of the Waweig Formation (Mascarene Belt)

Location: *Proceed east along the road cut (see Figure 8).*

Hazards: The banks of the road cut are very steep and unstable. Be sure to look over head for any loose rocks that may be potentially dangerous before getting close to the outcrop.

The medium purple to white felsic tuff unit (with minor lapilli horizons) exposed at this locality is typical of the felsic units that occur in the upper part of the Waweig Formation in the Simpson Corner Member (Fyffe et al., 1999). Note the flow-banded texture within this particular bed. These felsic volcanic rocks are very similar to those uncovered by trenching at the Main Zone deposits. However, those at the latter locality are intensely sheared and recrystallized.

STOP 4:

Granitic dykes crosscutting the Digdeguash Formation (Fredericton Belt)

Location: *Return to Hwy 1 from Stop 3 and head east toward St. George (~31 km). Take Exit 56 east of St. George and turn left onto Hwy 780 and head toward Utopia. Turn right at the next intersection. At the cross road (~2.5 km), turn left and head north along Hwy 785 for ~20 km. Turn right onto the logging road and proceed ~4.7 km and turn left onto the next logging road. This stop is located ~4.1 km down this road, on the right hand side of the road.*

Hazards: The smooth surfaces of the outcrop may be slippery when wet. Please exercise caution.

At this location, fractured and deformed metasedimentary rocks of the Silurian Digdeguash Formation (Kingsclear Group) are cross-cut by a series of relatively massive granitic dykes interpreted to have emanated from the nearby Magaguadavic Granite phase of the Saint George Batholith. The overall general trend of the dykes is roughly 060/90, whereas select few are subparallel to bedding (080/85S). Aplitic dykes (from less than a cm to 60 cm in width) are locally cross-cut by later quartz veins that trend in various orientations. Early veins and dykes are boudinaged parallel to bedding suggesting that they were emplaced syn-tectonically. At the south end of the trench, there is a quartz-rich pod (with epidote crystals) within the aplite dyke. At one location, an early quartz vein is cut by a dyke that is offset by later quartz veins, thus providing supporting evidence for multiple generations of veining and dyke emplacement, and the likely genetic connection.

Approximately ~200 m further down the road, the youngest phase of the Magaguadavic Granite is exposed. This unit consists of grey to pink, medium- to coarse-grained (locally megacrystic) granodiorite and quartz diorite that is transitional to granite. Rapakivi texture is distinguishable in the megacrystic phases.

Return to the vehicles and head back along the logging road toward Hwy 785. Turn right and head north toward Central Blissville (~37 km). At the stop sign, turn left and left again onto Hwy 101. Follow Hwy 101 through Fredericton Junction and New Maryland, to Fredericton (~42 km).

DAY 2 – CLARENCE STREAM GOLD DEPOSIT

INTRODUCTION

The Clarence Stream gold deposit, situated east of St. Stephen in southwestern New Brunswick, was initially discovered by prospector Reginald Cox Jr. who located several significantly mineralized boulders in the area during the fall of 1999. Since then, Freewest Resources Canada Incorporated optioned the property, and conducted a comprehensive exploration program consisting of soil and till geochemical sampling, IP and magnetometer surveys, trenching, geological mapping, as well as several drilling programs that have encompassed an extensive area. As a result, several significant mineralized areas along the northwestern margin of the Saint George Batholith have been identified that comprise two broad zones with contrasting styles of gold mineralization (Figure 6). The two zones are interpreted to represent the proximal (Main Zone) and distal (Anomaly A) components of an intrusion-related gold mineralized system that is spatially and temporally related to the Magaguadavic granitic phase of the adjacent batholith (Thorne et al., 2002a; Lutes et al., 2003; Watters et al., 2003). The characteristics of these zones and their settings will be discussed in more detail in the sections below.

GEOLOGICAL SETTING

At the Main Zone of the Clarence Stream gold deposit, located on the southeastern margin of the Sawyer Brook Fault, mineralization is hosted within a secondary splay of this fault that transects the Silurian metasedimentary and metavolcanic rocks in the Waweig Formation of the Mascarene Group (Figure 6). The stratigraphic sequence has been intruded and contact metamorphosed by several injections of mantle-derived gabbroic dykes of the East Branch Brook Gabbro (Thorne and Lentz, 2001a) followed by the emplacement of the Early Devonian Magaguadavic Granite (McLeod, 1990).

Approximately 3 km to the northwest of the Main Zone, on the northwestern side of the Sawyer Brook Fault, the Anomaly A zone of the Clarence Stream gold deposit is hosted by polydeformed argillites and quartz arenites of the Ordovician Kendall Mountain Formation (Cookson Group) within shallowly dipping thrusts (Figure 6). The Pleasant Ridge and Sorrell Ridge granites, which represent apophyses emanating from the Pomeroy Intrusive Suite of the Saint George Batholith, intrude the sequence to the east and west of the mineralized area, respectively. Although trenching and drilling have not yet exposed granitic lithologies spatially associated with the mineralization at this location, geophysical data suggests that a granitic mass of unknown age and affinity underlies the area at relatively shallow depths (Thomas and Willis, 1989; King and Barr, 2004b). Northwest-trending faults are interpreted to transect the area; however, their role in localizing mineralizing fluids is unknown at present.

MAIN ZONE DEPOSITS

Gold mineralization at the Main Zone of the Clarence Stream deposits is structurally bound within a brittle-ductile shear zone associated with the Sawyer Brook Fault (Thorne and Lentz, 2001b, 2002, 2003). The splay intersects local metasedimentary and metavolcanic units, and parallels the intrusive contact with the Early Devonian, I-type Magaguadavic Granite to the south (Figures 9 and 10). The stratified units are dominated by a well-developed fabric near the fault that Castonguay et al. (2003) attribute to heterogeneous deformation produced by a D_3 deformational event. They interpret the fault as a late-D_3 dextral strike-slip fault that cuts the southeastern limb of the regional-scale, northeast-trending St. David Antiform, which itself is a manifestation of the regional D_3 event.

Several subzones of mineralization at the Main Zone have been identified that include (from West to East) the Cox, N, West, Central, and East zones (Figures 9 and 10). For the most part, free gold occurs within a series of parallel northeast-trending, steeply dipping quartz veins hosted by cordierite-biotite-muscovite-bearing schistose metasedimentary rocks of the Early Silurian Campbell Point Member (Waweig Formation), and the Silurian metagabbroic dykes of the East Branch Brook Gabbro. Gold also occurs as disseminations within the metagabbroic wall rocks and in mineralized pegmatite/aplite dykes that are late fractionates of the Magaguadavic Granite (Thorne et al., 2002a).

The metal association at the Main Zone consists mainly of arsenopyrite, pyrrhotite, pyrite, berthierite, minor chalcopyrite and sphalerite, as well as a variety of Sb-bearing minerals and is thus broadly representative of a Au-As-Sb metal association. Gold was found to have a positive correlation with Ag, Bi, Cd, Te, S, and Cu, which resembles the geochemical signature of intrusion-related gold deposits as described by Thompson et al. (1999), Lang et al. (2000), Thompson and Newberry (2000), and Lang and Baker (2001). Alteration associated with the gold mineralization persists as K-metasomatism within the mafic rocks and Na-metasomatism in the metasedimentary/metavolcanic rocks (Thorne and Lentz, 2002).

A detailed structural investigation of the Main Zone by Park (2001, 2003) and Park et al. (in press) indicates that dextral movement along the brittle-ductile shear zone occurred both syn- and post-deformation, thus boudinaging and rotating the mineralized quartz veins. He stated that the quartz veins experienced at least two episodes of deformation subsequent to their precipitation, which involved initial dextral strike-slip movement (regional D_3) followed by later dip-slip movement. The latter movement is possibly related to isostatic readjustment related to cooling of the Magaguadavic Granite. The saccharoidal texture, lack of primary depositional features, and brecciated nature of select veins provides supporting evidence for reworking of the vein material subsequent to deposition of the quartz and associated mineralization. Slight folding and offsetting of these veins is obvious in small (post-mineralization) north-northwest-trending shear zones.

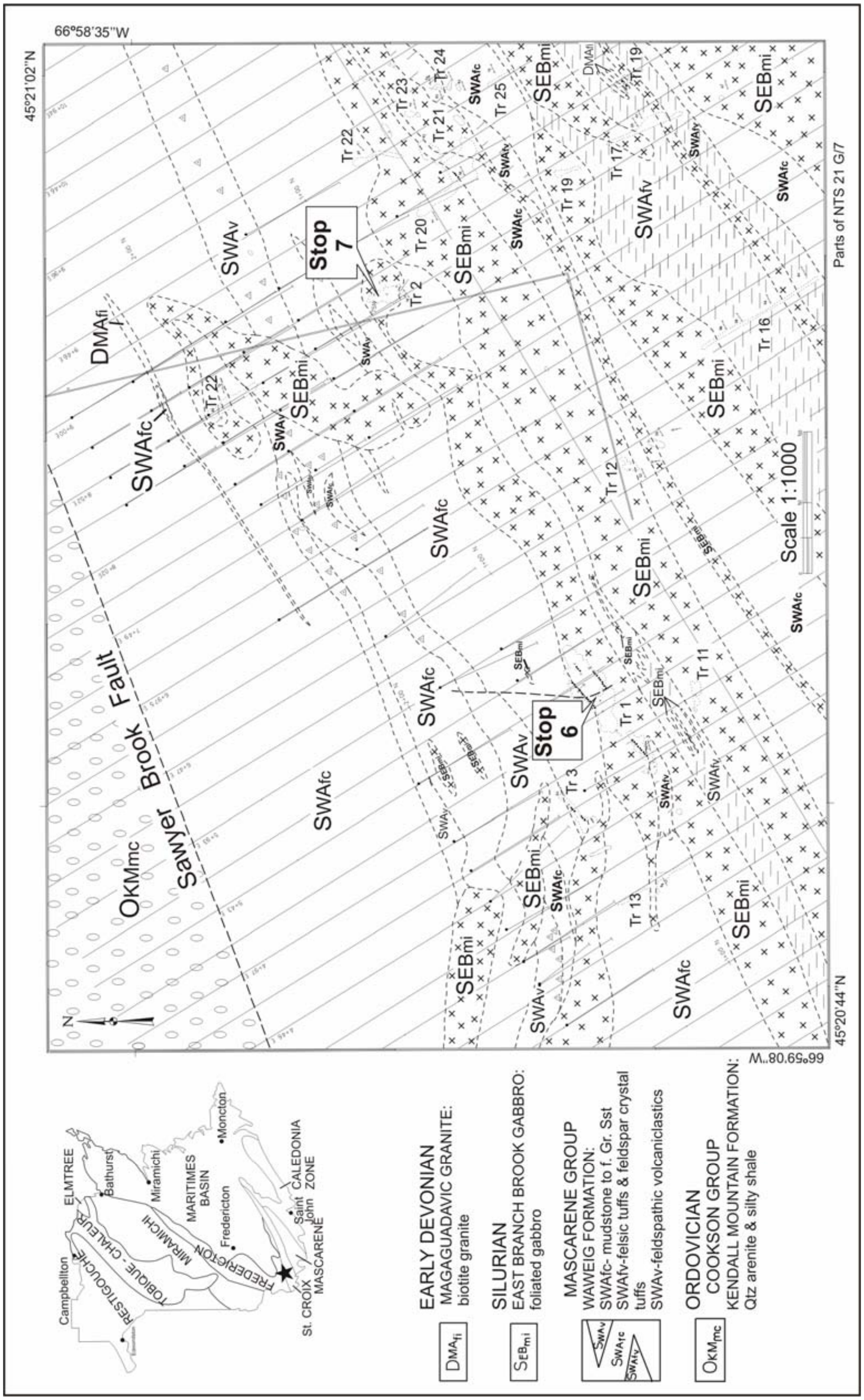

Figure 9. Geology of the West Zone and the locations for stops 6 and 7. Modified after Thorne et al. (2004c).

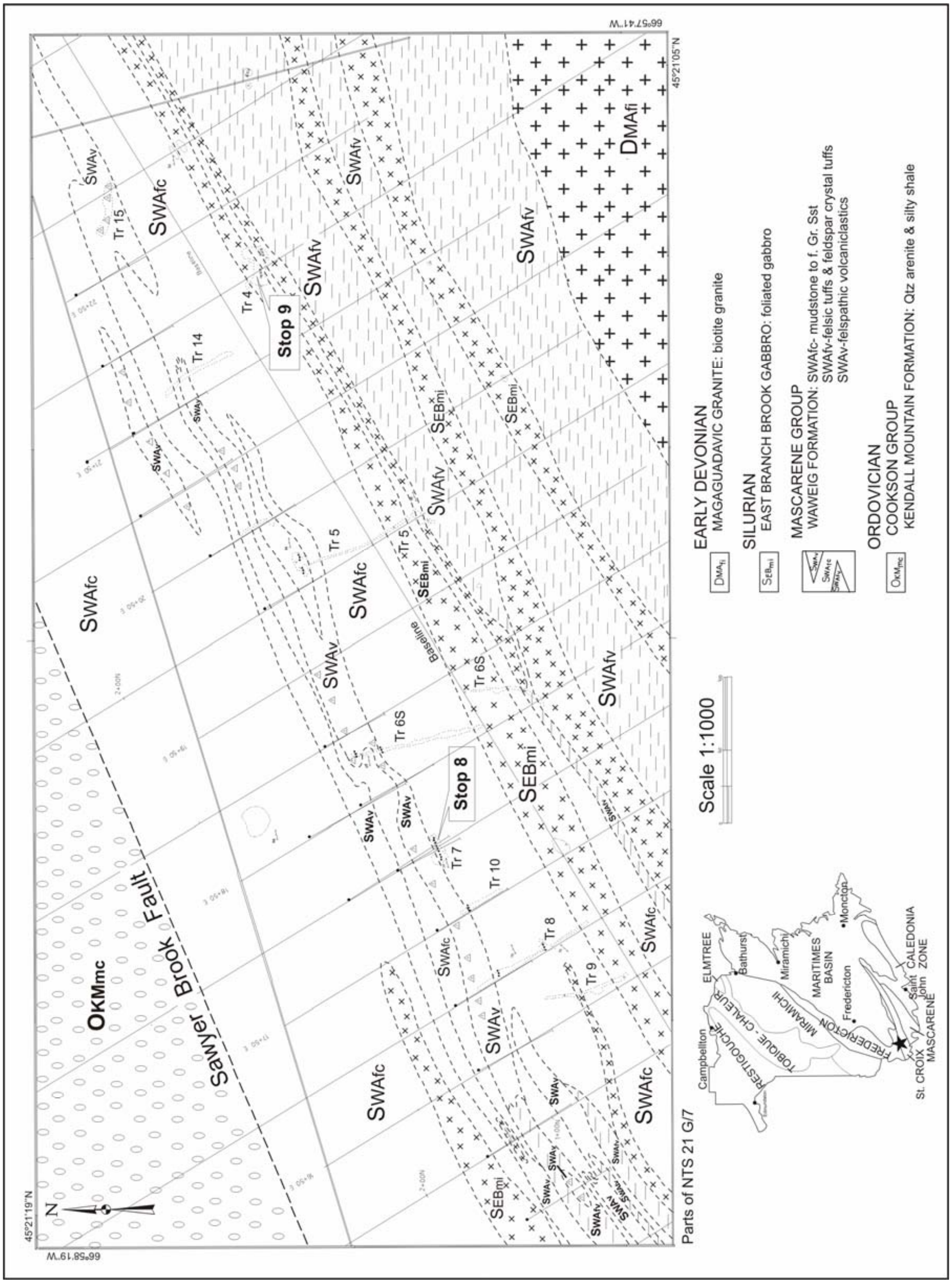

Figure 10. Geology of the East Zone and locations of stops 8 and 9. Modified after Thorne et al. (2004b).

Mineralization is better preserved in quartz veins that were shielded by the more competent metagabbroic bodies at the West Zone (Figure 9), whereas quartz veins hosted within fissile metasedimentary units at the East Zone (Figure 10) are boudinaged, and therefore less continuous. The latter, which exhibit textures ranging from mylonitic to brecciated, formed during episodic deformation, with late development of an annealed saccharoidal resulting from thermally induced recrystallization of strained quartz.

Geochemical, geochronological, and isotopic investigations suggest that fluids that evolved from the Magaguadavic Granite during the cooling stages were the source of the gold mineralization (Thorne et al., 2002a; Thorne and Lentz, 2003). The best evidence to support this is the presence of granitic dykes that grade laterally into gold- and sulphide-bearing quartz veins in one of the trenched exposures. The geochemistry of these dykes indicate that they are similar in composition to late phases (fractionates) of the Magaguadavic Granite (Thorne and Lentz, 2002). Gold-As-Sb-Bi mineralization was deposited within dilatant areas of the shear zone from high temperature (>300, <375˚C), chlorine-bearing fluids, whose characteristics are consistent with a mesothermal system (Thorne and Lentz, 2003). Pressure fluctuations are likely the predominant control on mineralization (i.e., fault-valve action), although changes in redox state of the fluids, temperature, pH, and fluid-wallrock interaction were likely influential in the precipitation of gold as well.

ANOMALY A DEPOSITS

Several zones of mineralization have been identified within the area of Anomaly A, including (from east to west), the Murphy, 93, AD, and MW zones (Figure 11). Styles of mineralization at the Anomaly A portion of the Clarence Stream gold deposit differ markedly from those at the Main Zone. The mineralization at the Murphy, AD, and MW zones is characterized by stockwork and auriferous quartz veins hosted by shallowly northward-dipping, brittle-ductile high strain zones within polydeformed, sericitized argillites (Lutes et al., 2003). These zones of mineralization bear similarities to those described for distal deposits of intrusion-related gold systems.

Castonguay et al. (2003) and Watters et al. (2003, in press) present detailed descriptions of the structure and mineralization at the Anomaly A deposits. They document several generations of quartz veining related to various episodes of deformation as summarized below. Mineralization at Anomaly A is broadly contained within tabular-shaped deformation zones, that are usually several metres thick and that strike generally east-northeast. Gold mineralization appears to be associated with shearing that occurred along limbs of F_2 folds late in the D_2 event, and is later deformed/overprinted by D_3 and D_4 open folding events. The mineralized intervals at the MW and AD zones dip in opposite directions, hence are interpreted to occupy opposing limbs of a broad fold (i.e, synform) associated with D3. Very recent drilling by Freewest Resources Canada Incorporated indicates that the 93 zone may also be a direct

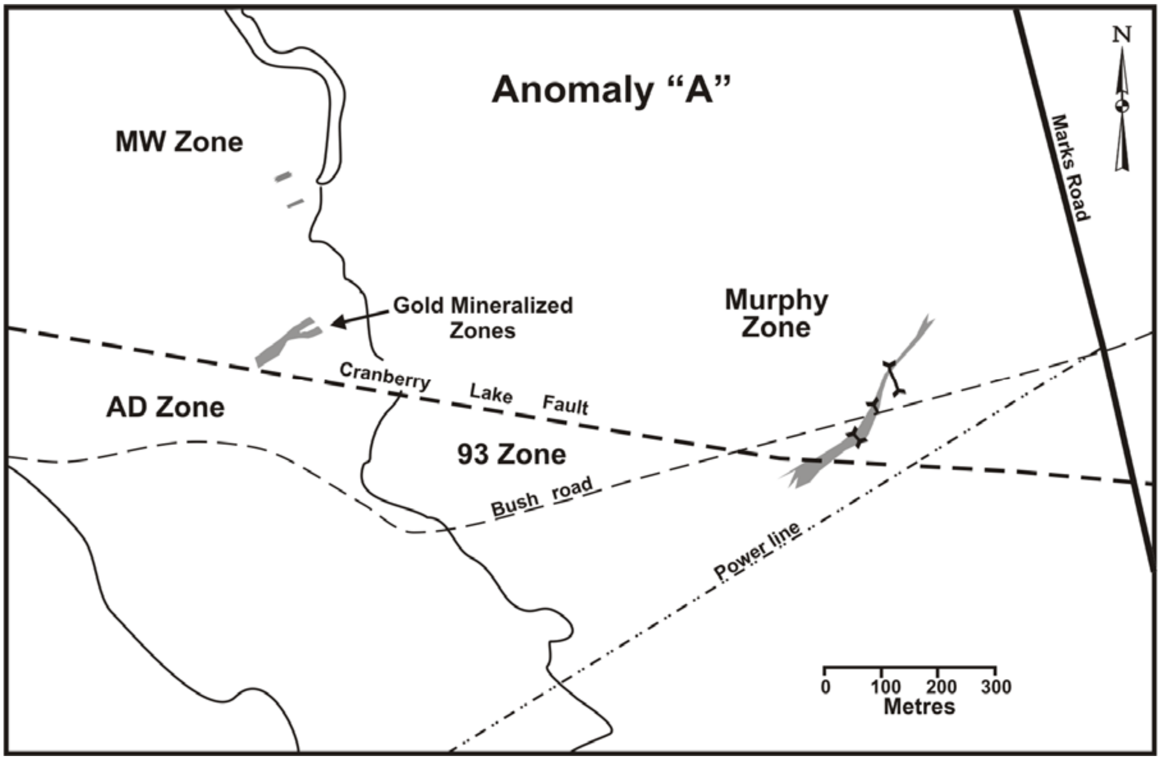

Figure 11. Plan map showing the locations of the AD, MW, 93, and Murphy zones at Anomaly A (modified after Watters et al., 2003).

continuation of this structure. Further, Watters et al. (in press) describe auriferous veins that are overprinted by greisen veins interpreted to be related to the young, Late Devonian Sn-bearing intrusions (i.e., Pleasant Ridge Granite). This helps constrain the timing of mineralization, which at the Main Zone is inferred to be associated with the Early Devonian Magaguadavic Granite (Thorne et al., 2002a; Thorne and Lentz, 2003).

At least three main stages of quartz veining are evident throughout the Anomaly A deposits (Castonguay et al., 2003; Watters et al., 2003, in press). Gold predominantly occurs in the middle quartz-sulphide vein stage in association with pyrrhotite, arsenopyrite, pyrite and stibnite, with minor amounts of gold (1-2 g/t Au) contained within the altered metasediments. The metal signature of the deposits is similar to that of the Main Zone with the exception that there is a lack of Bi minerals and an abundance of Sb, which can be explained in terms of geochemical zonation and proximity of the deposits to the gold-generating granites. Gold mineralization at Anomaly A is thought by these authors to be contemporaneous with that at the Main Zone, and is therefore consistent with the proposed proximal–distal relationship between the two mineralized areas.

STOP DESCRIPTIONS

STOP 5:
Magaguadavic Granite (Saint George Batholith)

Location: *From Fredericton, head west on Hwy 8 (~3 km); take the first exit after the first overpass. Turn right onto Hwy 2 and then right again onto Hwy 640. Head south on Hwy 640 for ~32 km. Head west (bear left) at the junction with Hwy 3 at Acton and proceed toward Harvey. Follow Hwy 3 through Harvey and proceed to the Flume Ridge Road (~32 km) just past Brockway. Follow this road to Pleasant Ridge (~14 km) and then turn left onto Hwy 770. Follow this road for ~3.5 km and turn onto the logging road on the left at the bottom of the hill. This outcrop is accessed via a small trail ~2 km down the main logging road.*

Hazards: The traverse to the outcrop on the brook involves walking on a rough, boulder-littered road and a small hike through the woods. Please watch your step along the road. Please stick with the group while traversing through the wooded area. Once on the brook, please be aware that the smooth surfaces of the outcrop exposure are very slippery when wet.

Lying in the stream bed at this location, are large flat-lying outcroppings of the megacrystic Magaguadavic Granite. It ranges in colour from light grey to light pink on the weathered surface, whereas the fresh surface can vary drastically depending on the abundance of mafic minerals. The mafic content of this unit is typically 8-10%, but locally ranges up to 23%, depending on the amount of wall rock assimilation (McLeod, 1990). The predominant mineral assemblage consists of K-feldspar, quartz, biotite, muscovite, and hornblende. Rapakivi textures can be seen where the pink-orange coloured K-feldspar is mantled by white feldspar (albite). Small aplitic dykes, representing later stage fractionates, are seen to cut the coarser grained to megacrystic phases. McLeod (1990) suggests that late fluids evolved from the Magaguadavic Granite are enriched in metals (particularly gold), in part as a result of the incorporation of voluminous, sulphide-bearing metasedimentary rocks from the St. Croix Belt and Mascarene Belt country rocks.

STOP 6:
Clarence Stream Trench 1 (Main Zone)

Location: *Return to vehicles and drive back along the logging road until reaching the first road on the left. Follow this road to the end (~1.5 to 2 km) and park the vehicles in the cleared area. Follow the trail at the end of the road to the far west end of the trench.*

Hazards: The smooth surfaces of the outcrop exposure may be slippery when wet.

At the far west end of the trench (Figure 12), a sheared felsic tuffaceous unit of the Waweig Formation exhibits a strongly penetrative foliation (regional D_3) and a well-developed C-S fabric that indicates a dextral sense of movement along the shear zone. The geochemistry of this unit is compatible with felsic volcanic rocks that are found throughout the Waweig Formation (Thorne et al., 2004a; in preparation). It is cross-cut by a hydrothermal breccia that contains angular fragments of the felsic volcanic unit suspended within an epidote-rich matrix. To the north of the felsic volcanic unit (in the top part of the trench) is one of several phases of the East Branch Brook gabbroic dykes. This metagabbro is highly strained in places and is cross-cut by numerous generations of randomly oriented and contorted, amphibole-rimmed prehnite veins. An auriferous quartz vein (up to 3 m wide) occupies the contact between the gabbro and the felsic volcanic unit. The vein contains visible gold in addition to sphalerite, arsenopyrite, berthierite/stibnite, and minor amounts of pyrite and chalcopyrite. A 0.5 m channel sample taken from the central portion of the vein yielded 68.1 g/t Au, and another 0.5 m channel sample from the same vein ran 72.1 g/t Au. A small 10 cm wide granitic dyke (likely an offshoot of the Magaguadavic Granite) on the north side of the larger quartz vein can be seen in the central portion of the trench.

The east end of this trench (Figure 13) exposes a number of quartz veins of various generations that cut across the local strata, generally parallel to the northeast-trending regional structural fabric. The fabric is variably developed throughout the lithological units. A down-dip lineation is distinguishable within the altered phase of the gabbro and is defined by the parallel alignment of amphibole, whereas within the metasedimentary unit, it is defined by the long axes of retrograded cordierite porphyroblasts. An undulatory chilled margin between altered and relatively unaltered phases of gabbro is present at the

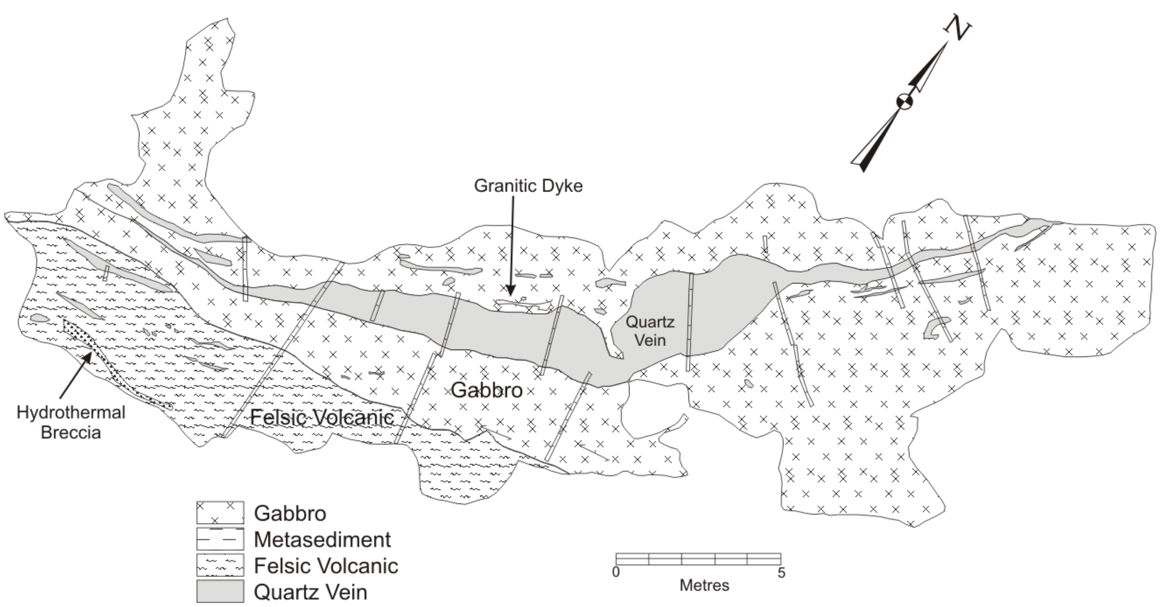

Figure 12. Plan view of the western portion of Trench 1.

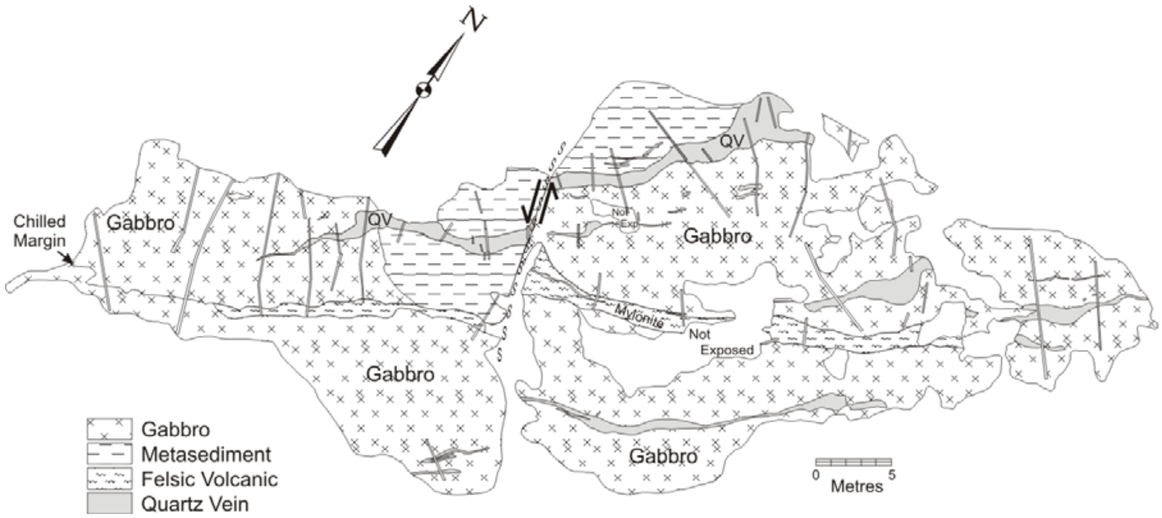

Figure 13. Plan view of the eastern portion of Trench 1.

junction between the two portions of the trench. The south end of the trench consists of a relatively fresh looking (but older) phase of gabbro that is cut by a barren-looking white quartz vein; however, grab samples from this vein yielded up to 7 g/t Au. This gabbro is truncated/deformed by a felsic unit of unknown origin that has been variously interpreted as a volcanic rock, a dyke, or a mylonite. Curiously, this unit appears to locally mark the boundary between the fresh and altered gabbro bodies. The rusty altered gabbro contains gold and abundant pyrrhotite, as well as Au-bearing quartz veins.

To the north of the altered gabbro are the hornfelsed, moderately northwest dipping cordierite-biotite-muscovite-bearing metasediments of the Waweig Formation. Younging of the graded bedding to the south indicates that these beds are overturned. The largest quartz vein in this trench occupies the boundary between the metasedimentary and metagabbroic units, and it consistently carries high grade gold values along its strike length, reaching grades of up to 23.7 g/t over 1 m. Other metallic minerals seen in the quartz vein include sphalerite, arsenopyrite, stibnite, pyrite, and pyrrhotite. The trench is cut by a later post-mineralization, northwest-trending fault zone that displaces the units approximately 4.5 m in a sinistral fashion.

<u>STOP 7:</u>

Clarence Stream, Trench 2 (Main Zone)

Location: *Head back out the logging road and stop at the trench exposed on the right side of the road, just around the corner from where the vehicles were parked.*

Hazards: The smooth surfaces of the outcrop exposure may be slippery when wet.

The relationship between the gabbroic intrusions and the metasedimentary units is more clearly defined in this trench exposure than at the previous stop (Figure 14). The

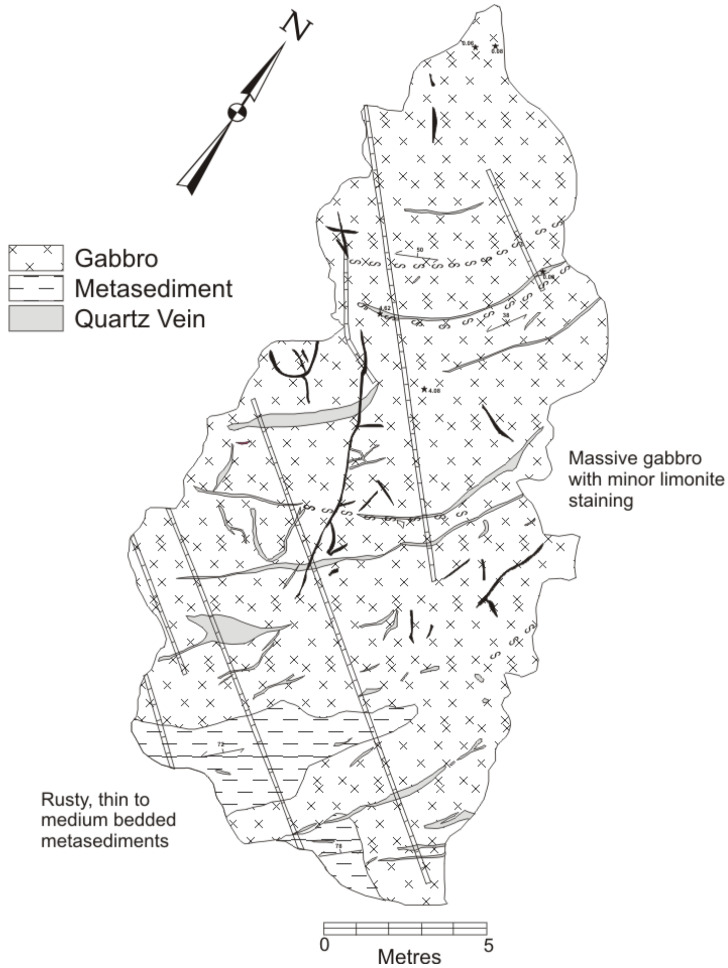

Figure 14. Plan view of Trench 2.

southern portion of this trench shows the metasedimentary units being cut off by the gabbroic intrusion. The heterogeneity of the deformation is reflected in the variability of fabric development within the metagabbro. Generally, the intensity of the strain increases toward the south end of the trench. In the central portion of the trench, a chilled margin between the two gabbroic units is visible with small sinistral offsets along the margin. A grab sample from the white quartz vein within the small shear zone contained 4.6 g/t Au, while a grab sample of altered gabbro from the edge of the trench near the road yielded 45.6 g/t Au.

STOP 8:

Clarence Stream Trench 7 (Main Zone)

Location: *Proceed further along the logging road until reaching the small pond on the right. Park in the cleared area and follow the trail through the woods to Trench 7, which is located south-southwest of the pond.*

Hazards: The trail to the trench has low pointy stumps from the cut lines. Please watch your step. Also be aware that there are a number of open trenches in the wooded areas along the trail that may pose a hazard to those that wander away from the rest of the group.

Sheared, fissile metasedimentary and volcanic units of the Waweig Formation host the gold-bearing veins, pods, and boudins in this trenched exposure (see Figure 15). A steep lineation is associated with the bedding-parallel fabric and subtle, dismembered fold hinges plunging moderately eastward can be observed. Abundant stibnite, kermesite, and arsenopyrite are the prominent minerals found in association with the gold and comprise the typical assemblage that defines the East Zone. In the northern portion of this trench, a wide shear zone with boudinaged quartz veins scattered throughout the fissile material is evident. This shear zone seems to mark the boundary between the finer units with the coarser lithologies to the north. It appears to be a prominent feature in this area and can be traced along strike for at least 400 m. From east to west, three grab samples along the strike length of the widest quartz vein ran 574.5 g/t Au, 71.75 g/t Au, and 114.15 g/t Au.

STOP 9:
Clarence Stream, Trench 4 (Main Zone)

Location: *Drive a bit further down the road (~300 m) and follow the trail to Trench 4 on the right side of the road.*

Hazards: There are wet areas and low pointy stumps on the trail to the trench. Please watch your step and stay with the group. At the trench site, the smooth steep surfaces of the outcrop exposure may be slippery when wet. Please exercise caution, particularly near the steep slope.

Thin, interbedded fine-grained metasediments and medium- to coarse-grained metagabbros are intensely sheared, then crosscut by pegmatitic-aplitic dykes at this location (Figure 16). The texture of the granitic dykes ranges from aplitic to granophyric to pegmatitic in places. Anomalous gold values (up to 9.11 g/t Au) are obtained within these dikes and are thus far the best indication of an intrusion-related origin for gold mineralization. The presence of these dikes in this trench is most likely a function of the close proximity of the Magaguadavic Granite to the south. Smaller scale pegmatite dykelets are present in the eastern part of the trench and appear to be transposed and boudinaged parallel to the main foliation. The geochemical signature of these dykes indicate that they are late fractionates of the Magaguadavic Granite (Thorne et al., 2002a). Note the extreme attenuation with rotated boudins (i.e., “fish”) of the coarser grained units in the metasedimentary sequence, thus signifying the high degree of deformation that these beds have endured.

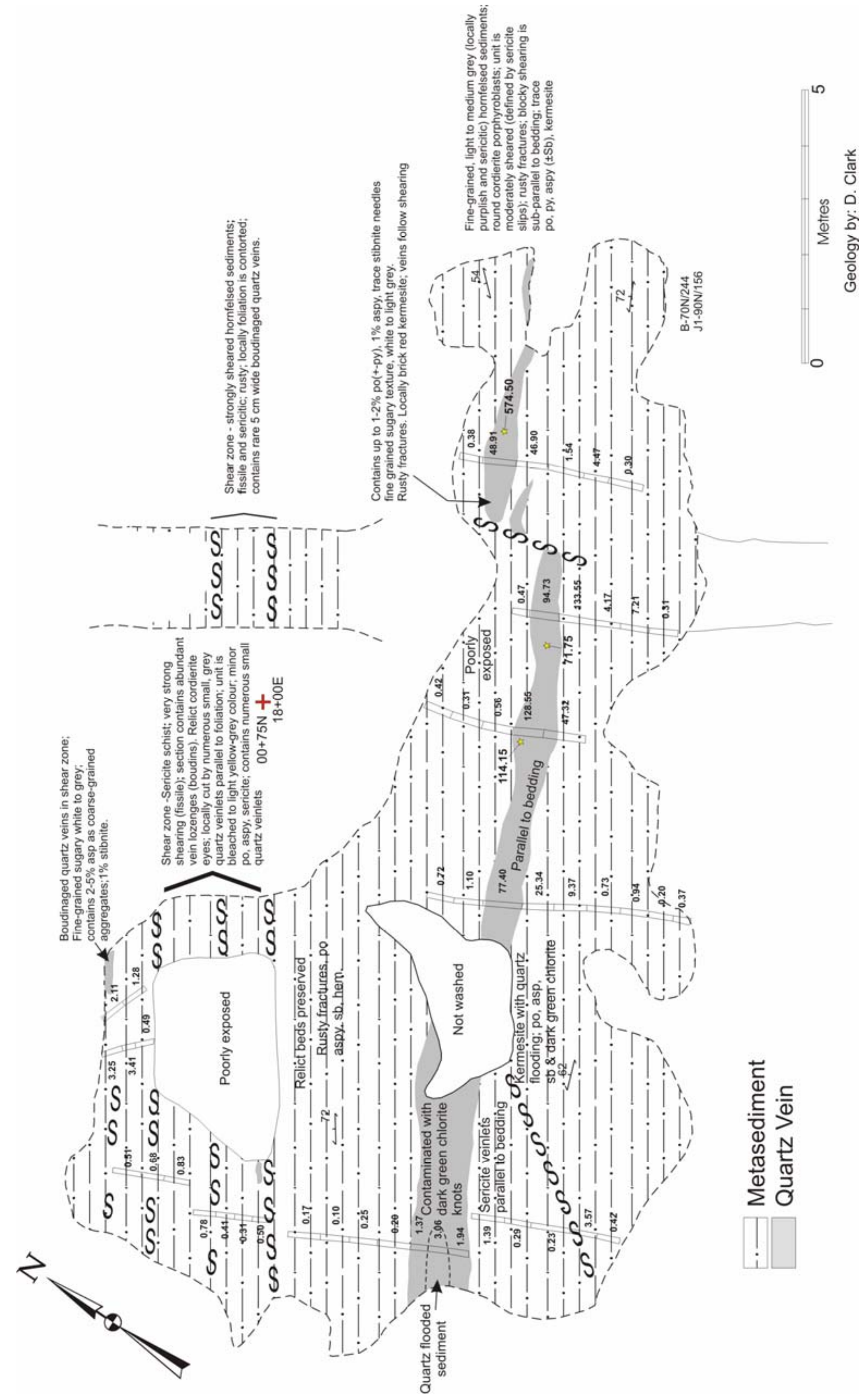

Figure 15. Plan view of Trench 7.

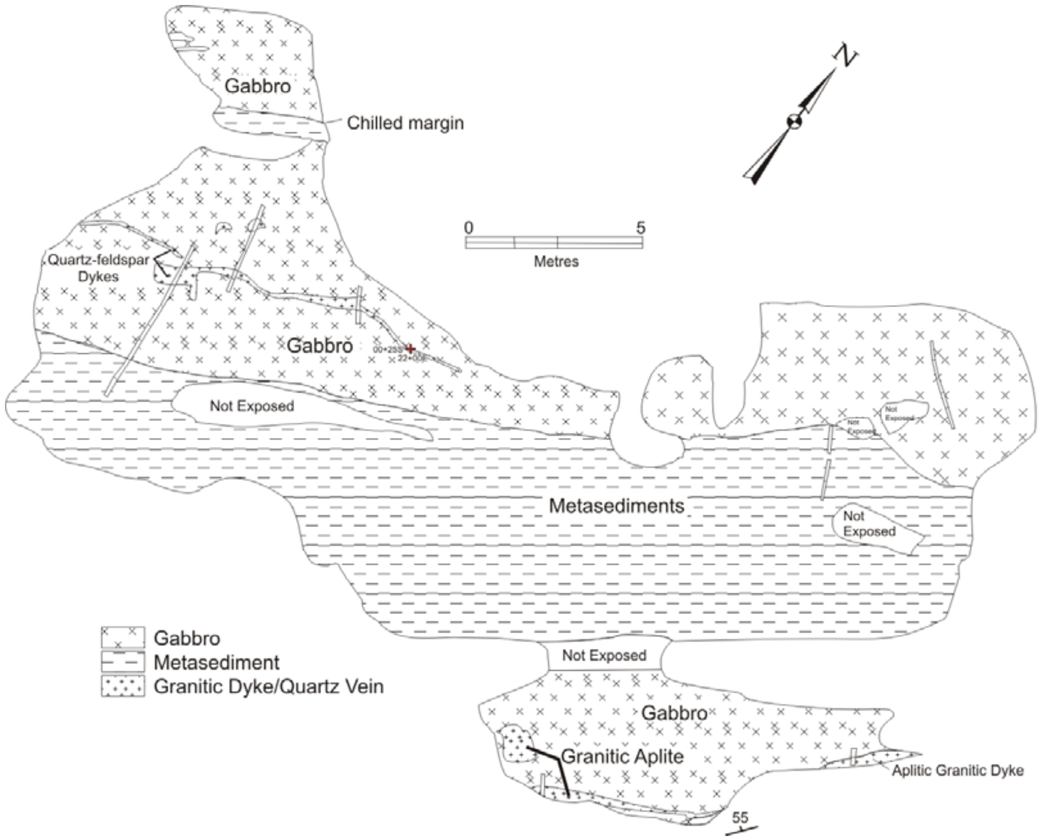

Figure 16. Plan view of Trench 4 at the East Zone (geology by D. Clark).

STOP 10:

Clarence Stream, Murphy Zone (Anomaly A)

Location: *Proceed to the "T" in the road and turn left and follow the logging road back to the main road (Hwy 770). Turn right and head up the hill. Turn left onto the dirt road near the top of the hill and proceed through the field. Park at the edge of the power line.*

Hazards: The banks of the trench are unstable - please be careful.

The distribution of the various zones that comprise Anomaly A are shown in Figure 11. The host rocks to the mineralization consist of grey, quartz-rich sandstones or greywackes interbedded with grey to black argillites with minor medium-grey siltstone. At the Murphy Zone, these rocks are sericitically altered and deformed, and exhibit a closely spaced cleavage. Stockwork veining containing low- to moderate- grade gold mineralization is the prominent style of mineralization throughout the trench at this location.

STOP 11:

Clarence Stream, AD Trench (Anomaly A)
(Modified from Lutes et al. 2003)

Location: *Drive a bit further down the logging road to the cleared area. Park the vehicles and walk down the road to the brook. Cross the brook and follow the trail to the AD Trench.*

Hazards: The hike to the AD Trench will involve crossing a fairly brisk brook and possibly getting a bit wet. For those of you that are not up for the long hike and not interested in getting wet, arrangements to stay behind with the van will be made. For the rest of the group who wish to proceed, please be sure to stick with the group and listen carefully for directions from the trip leaders before attempting to cross the brook.

The AD Trench exposes the AD Zone that is located on the west limb of a post-mineralization, major open fold formed during D_3, which is affected by N-S-trending post-mineralization folds (D_4) in the Kendall Mountain Formation of the Cookson Group. The main zone of mineralization is located along the southern side of the trench and has a general trend of 105˚ and dips shallowly to the north. It is hosted by a brittle-ductile fracture zone within coarser clastic units of wacke and interbedded siltstone suggesting some control by permeability and porosity in conjunction with structural development. Structural contour maps from drill hole data (Figure 17) show that the strike of the zone is ~070° with a dip of 25°N (Figure 18). The dip of the zone becomes both steeper and shallower down dip and along strike because of interference of E-W-trending folds with subhorizontal hinges (D_3). Alteration of the host rocks consists of pervasively weak to strong argillic to sericitic and arsenopyrite-pyrrhotite replacement. Mineralization mainly consists of pyrrhotite and pyrite with lesser arsenopyrite and stibnite within quartz veins and veinlets. Stibnite appears late in the paragenesis and occurs as undeformed semi-massive to massive veins and veinlets. Other sulphides that are present include berthierite ($FeSb_2S_4$) and gudmundite (FeSbS) with trace amounts of jamesonite ($Pb_4FeSb_6S_{14}$), ullmannite (NiSbS), tetrahedrite ($Cu_{12}SbS_{13}$), cobaltite (CoAsS), sphalerite, chalcopyrite, native antimony, nisbite ($NiSb_2$), native gold, and aurostibite ($AuSb_2$).

Argillite, which exhibits a single cleavage (S_2) and transposed bedding parallel to it, is the predominant lithology in the trench. This cleavage dips generally 50-60˚ to the north above the zone and has substantially shallower dips below the footwall as is evident in holes AD-2 and 4. Tops are generally right-way up through the sections drilled under the trench, however sharp reversals in tops elsewhere suggest isoclinal folding associated with D_2 or earlier deformation.

The exposed stockwork zone is closely associated with subhorizontal to shallow east-plunging asymmetric kink folds that have generally developed in the footwall to the zone (D_3). These folds have a long subhorizontal limb and a short steep limb with vergence to the south and fold both bedding and cleavage. Open to tight F_3 folds are common in drill

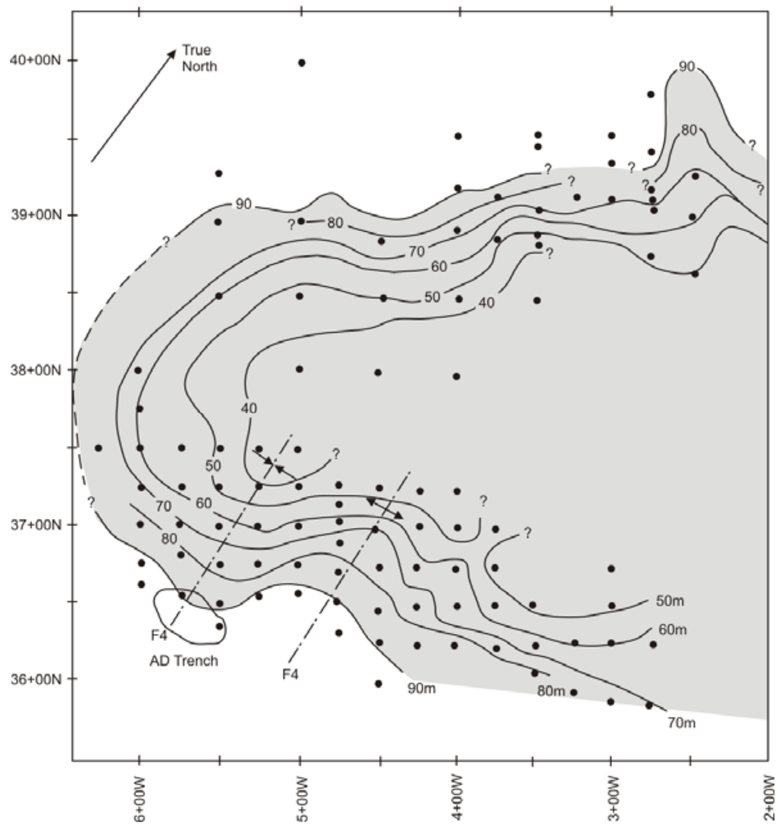

Figure 17. Plan view of the AD-MW zone, showing the depths (above sea level) to the basin-shaped zone of mineralization (modified from Lutes, 2004).

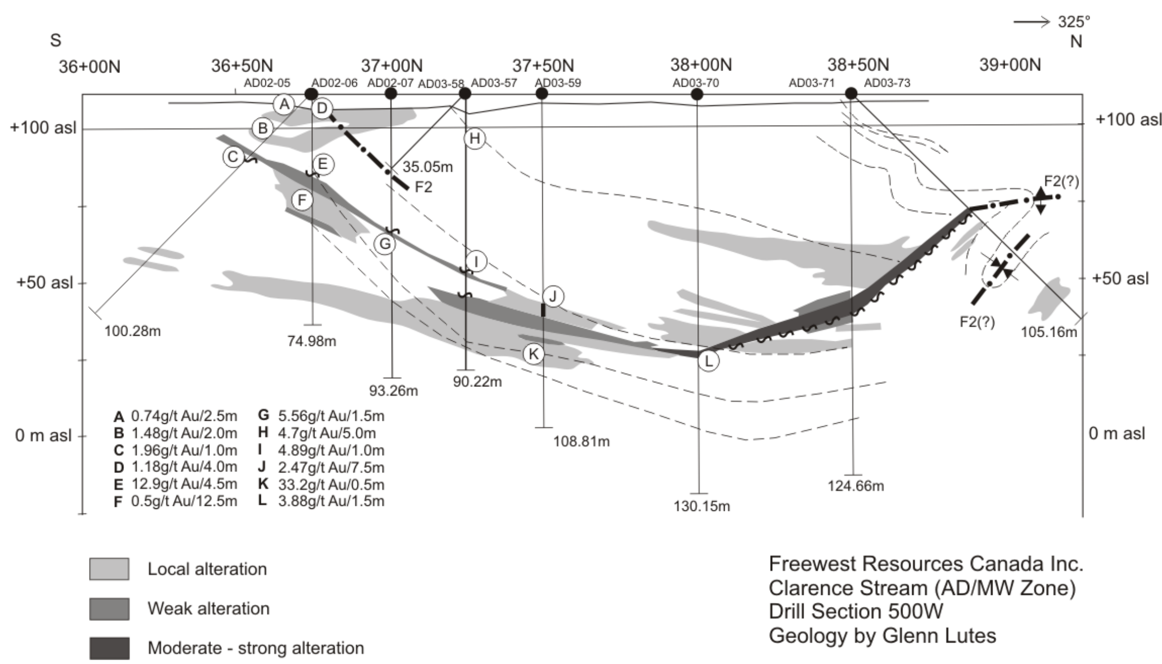

Figure 18. Drill section of the AD-MW zones (modified from Lutes, 2004).

core in the footwall to the AD Zone, and are likewise subhorizontal and asymmetric. These folds are associated with an irregularly developed S_3 crenulation cleavage with associated secondary mica growth. Interference between F_3 and F_4 folds in the trench generate an overall complex structural pattern. Early stages of quartz veining are more strongly deformed and are preserved locally as cataclasite. Replacement-style extensional quartz veins peripheral to the zone are developed at a high angle to S_2 cleavage/shearing, most commonly within greywacke units, and often have inherited the S_2 cleavage. The attitude of individual veins and zones of cataclasite may be at least partly controlled by locations of shallow and steep limbs of the D_3 kink folds.

A locally developed, subvertical fracture cleavage post-dates the asymmetric kinks and has a relatively consistent trend at 075-078˚ (D_4?). These are developed primarily in the more competent quartz veins and stockwork and are locally infilled by sheeted quartz-stibnite veinlets that are characteristic of the hanging wall style mineralization at the east end of the trench. This style of mineralization typically consists of coarse stibnite in vuggy, undeformed and generally sheeted quartz veins and veinlets at variable attitudes with only local associated alteration.

Hole AD02-1 was drilled under the west end of the trench and returned 2.34 g/t Au over 6.5 m, which included a higher grade interval of 12.7 g/t Au over 0.5 m. Hole AD02-3 was drilled under the east end of the trench and returned 11.60 g/t Au over 2.5 m. A broad zone of sheeted veins in the hanging wall to the main zone of mineralization returned 1.20 g/t Au over 7.5 m in AD02-3. High grade gold intercepts in drilling east of the trench are closely associated with late stibnite-rich sulphide veinlets.

STOP 12

Mount Pleasant Mine Site – Core viewing from the Clarence Stream Deposit

Location: *Return to the main road (Hwy 770) and head toward Pleasant Ridge. Follow Hwy 770 to Pomeroy (~4 km); cross the Magaguadavic River and follow the logging roads toward the Mount Pleasant Mine site on the right hand side of the road (~11 km).*

At the end of the day, head toward the junction with Hwy 785 (right at the entrance to the mine) and then proceed north (turn left) toward Central Blissville (~32 km). At the stop sign, turn left and left again onto Hwy 101. Follow Hwy 101 through Fredericton Junction and New Maryland, to Fredericton (~42 km).

DAY 3 - MOUNT PLEASANT Sn-W-Mo-Bi MINE AND RELATED MINERAL OCCURENCES

INTRODUCTION

The Mount Pleasant Sn-W-Mo-Bi deposit occurs within the Late Devonian Mount Pleasant Caldera Complex (McCutcheon, 1990) located northeast of the Clarence Stream area (Figure 3). The multi-phase intrusions of the Mount Pleasant Granites, responsible for the generation of the Mount Pleasant polymetallic deposit, and the McDougall Brook Granite are part of the Pomeroy Intrusive Suite of the Saint George Batholith (McLeod, 1990). Several other small satellite intrusions southwest of the caldera (Figure 3), including True Hill, Kedron, Beech Hill, and Sorrel Ride granites constitute the remainder of the Pomeroy Intrusive Suite.

The Mount Pleasant Caldera Complex crops out over a minimum area of 450 square kilometres and occurs as a cover sequence to the Fredericton Belt. It is bounded by younger, Late Carboniferous cover rocks and partly by the Saint George Batholith to the north and south, respectively. The caldera has been subdivided into several formations, members and intrusions assigned to major divisions termed Intracaldera, Exocaldera and Late Caldera-Fill sequences all comprising the Piskahegan Group (Figure 19). Comprehensive descriptions of the geology of the caldera complex, associated mineral deposits, and voluminous relevant references dealing with these and other aspects are presented by McCutcheon et al. (1997; 2001).

In general, these authors document that the Intracaldera Sequence is predominantly composed of a variety of rhyolitic volcanic units with subordinate amounts of andesite and marginal sedimentary breccias, whereas the coeval to younger Exocaldera Sequence contains greater amounts of andesite in addition to basalt and alluvial red beds. The Late Caldera-Fill Sequence, composed of rhyolitic volcanic rocks, and interbedded redbeds and basalt, covers both the above sequences, and is in turn, overlain by Namurian-aged red beds. The McDougall Brook Granite is considered part of the Intracaldera Sequence, while the granite and associated breccia systems at the Mount Pleasant deposits are slightly younger and are associated with the Caldera-Fill Sequence. As discussed by McCutcheon et al. (2001), the upper part of the Exocaldera Sequence was deposited in latest Devonian time based on U-Pb dating (363.4 ± 1.8 Ma, Tucker et al., 1998), thus constraining the age of the remainder of that sequence and the Intracaldera Sequence. The age of the Late Caldera-Fill is very poorly constrained, but based on the models presented below, is likely not substantially younger.

McCutcheon et al. (1997) describe the setting and eruptive history of the Mount Pleasant Caldera Complex as summarized below. It developed in an epi-continental setting, possibly in response to basaltic underplating and resulting lithospheric thinning, and evolved through a process of caldera collapse followed by several stages involving hiatuses in volcanic activity, repeated establishment of a high-level and zoned magma chamber, and resurgence. Each stage in the caldera’s development allowed tapping of

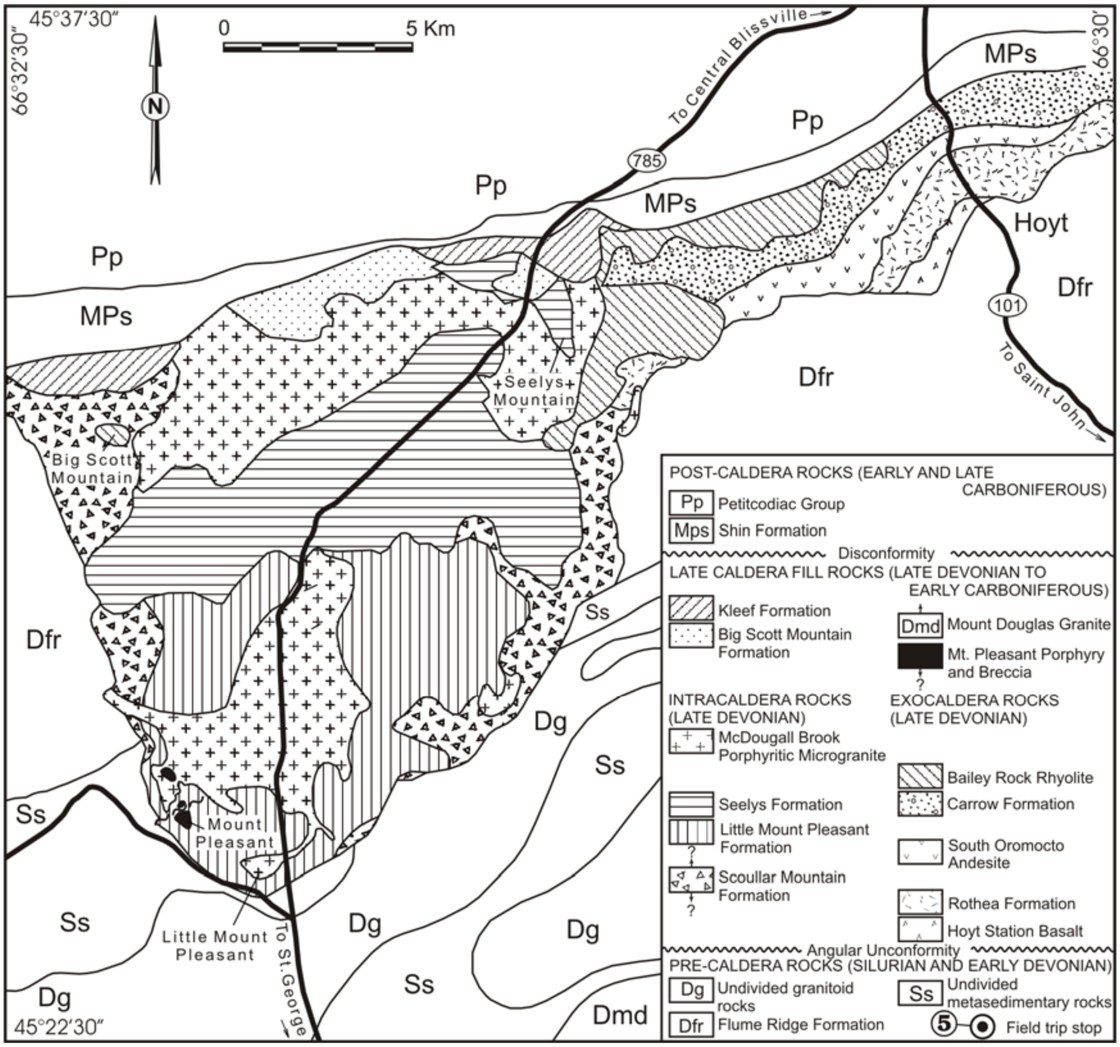

Figure 19. Simplified geological map of the Mount Pleasant Caldera Complex (modified after McCutcheon et al., 2001).

magmas from various levels in the system as evidenced by chemical and mineralogical features. The authors suggest that these features indicate that; (1) the basalt units were mantle-derived (i.e., from underplated material), (2) the andesitic volcanic rocks were likely a product of fractionally crystallizing basalt and crustal contaminants, and (3) the felsic units were derived from parts of the fractionating, high-level and zoned magma chamber.

Petrochemical studies and modelling of granitic systems in the caldera by Yang et al. (2003) suggest a direct link between the highly evolved Mount Pleasant granites and the less evolved McDougall Brook granite, which are the two main intrusive units in the caldera. They suggest that these intrusions could have been derived from the same parent magma through fractional crystallization with subsequent departures in composition likely controlled by crustal contamination for the McDougall Brook Granite, and by extensive liquid fractionation for the Mount Pleasant Granites. Further, they determined that gold behaves compatibly in this system, and therefore should be associated with less evolved suites, whereas tin behaves as a very incompatible element, and consequently should be associated with the more highly evolved suites. As gold exploration in the region proceeds, this recognition of potential gold-generating granite types in the younger intrusive suites could play a critical role in developing exploration programs.

The Fire Tower Zone Deposit

The mineral deposits at Mount Pleasant have been the subject of extensive research periodically since the early work of Ruitenberg (1963). Participants are referred to more recent publications that address various aspects of the geology and mineral deposits at Mount Pleasant (e.g., Taylor et. al, 1985; Kooiman et al., 1986; Sinclair et al., 1988; Sinclair, 1994) and a recent New England Intercollegiate Geological Conference field trip guide for the Mount Pleasant Deposit (McCutcheon et al., 2001).

The Fire Tower Zone W-Mo-Bi deposit is a complex porphyry-type system related to highly evolved, multi-phase, hypabyssal granite intrusions that were emplaced into the Intracaldera Sequence near the western margin of the Mount Pleasant Caldera Complex. McCutcheon et al. (2001) present a general review of several features at the deposit including unit descriptions, styles of mineralization, and associated alteration, which are summarized as follows.

Three main types of granite are recognized at depth in the Fire Tower Zone (Figure 20). These grade downward from an aplitic textured fine-grained granite, to similar aplitic textured granite porphyry characterized by quartz and K-feldspar phenocrysts, and eventually to an equigranular, fine- to medium-grained porphyritic microgranite. The phases are roughly analogous to successive phases of intrusions at the North Zone, which is located approximately 1 km north of the Fire Tower Zone and are renowned for their world-class Sn-In-base metal deposits. At higher levels in the Fire Tower Zone, the highly fractured and stockwork veined carapace of the fine-grained granite gradationally gives way to a variety of intensely altered and irregularly distributed hydrothermal breccias characterized by intense silica and topaz alteration. Apophyses of the granite porphyry intrude the fine-grained granite, the breccias, and surrounding intracaldera rocks at higher levels, and are in turn, cut by still younger hydrothermal breccias, that in this case, are typified by chlorite and biotite alteration.

Prior to mining in the early 1980’s, during which time about one million tonnes of ore was extracted and WO_3 concentrates produced, the resource of the Fire Tower Zone was estimated at 22.5 million tonnes grading 0.21% W, 0.10% Mo and 0.08% Bi (Parrish and Tulley, 1978). The ore body is hosted mostly by the silicified breccias but spans the fine-grained granite-breccia contact. The principal ore minerals are wolframite, molybdenite, and minor bismuth and bismithunite, which occur as fracture fillings, in quartz veinlets and as disseminations

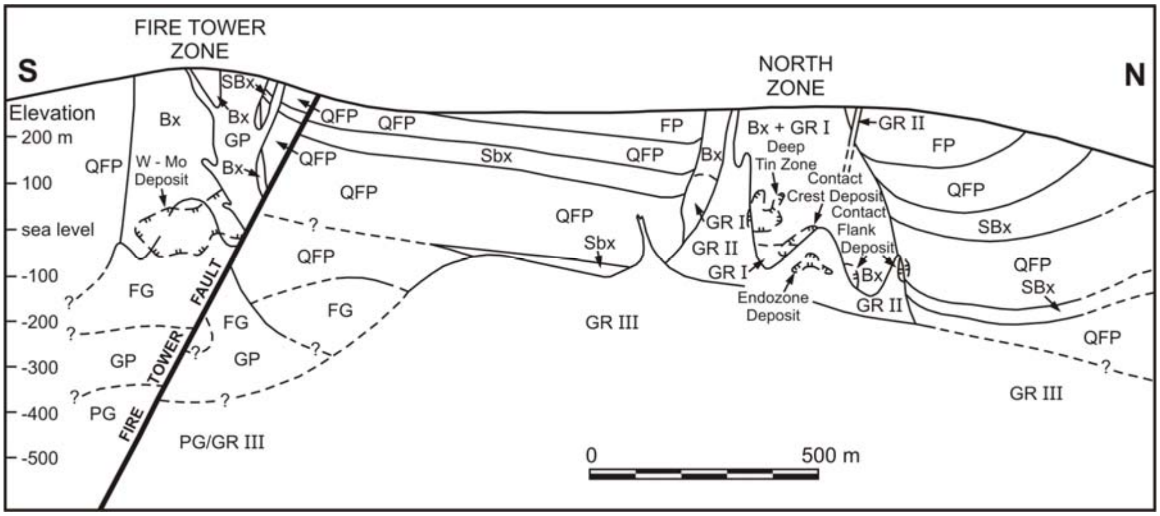

Figure 20. Cross-section through the Fire Tower and North zones at Mount Pleasant. GR III = granite III, GR II = granite II (Mount Pleasant porphyry), GR I = granite I, Bx = breccia, PG = porphyritic granite, GP = granite porphyry (Mount Pleasant porphyry), FG = fine-grained granite, FP = feldspar porphyry, QFP = quartz-feldspar porphyry, SBx = sedimentary breccia (modified after McCutcheon et al., 2001).

throughout the ore body. Quartz, topaz, fluorite, arsenopyrite and loellingite comprise the main gangue minerals. High-grade ore zones are characterized by an intense greisen-style (quartz-topaz-fluorite assemblage) and silicic alteration that grades outward over distances of up to 100 m away from the ore body through less intense silicification (quartz-biotite-chlorite-minor topaz assemblage). The less intense silicified zone is rimmed by an extensive (> 1000 m wide) propylitic-type alteration zone (chlorite-sericite assemblage). The granites in the lower part of the ore body and elsewhere in the system commonly exhibit pervasive chloritization that varies in intensity and is frequently irregularly distributed.

McDougall Brook Granite

The McDougall Brook Granite forms extensive, irregularly shaped intrusions in the northern and southwestern parts of the Mount Pleasant Caldera. Porphyritic monzogranite that locally grades to syenogranite (altered?) comprises the bulk of the intrusions with minor feldspar ± quartz porphyry and quartz monzonite (McCutcheon et al., 1997; 2001; Yang et al., 2003). Because this unit is not as highly evolved as most other granites in the Pomeroy Intrusive Suite, it is interpreted by Yang et al. (2003) to be the most likely source of gold-bearing fluids.

Kedron Granite

The Kedron Granite is a small cupola, about 100 m in diameter at surface (Taylor et al., 1985), which intrudes Silurian sedimentary sequences of the Fredericton Belt along the northwestern margin of the Saint George Batholith, to the west of the Mount Pleasant

Caldera. This felsic intrusion, referred to as the Bonny River Granite by Taylor et al. (1985) and Taylor (1992) is described as a lithian mica-topaz-bearing, fine- to medium-grained granite with an equigranular to seriate texture, similar to the Pleasant Ridge Granite near Anomaly A. The intrusion is weakly peraluminous, fluorine-rich, and contains tin-tungsten-bearing veins, lodes, and associated greisen alteration, features similar to those at Mount Pleasant. Taylor et al. (1985) describe the granite in the field as mostly aplitic, intensely silicified, and as containing significant quantities of topaz and fluorite. They determined through examination of drill holes that beneath the silicified zone, pegmatitic zones underlain by quartz-topaz-lithian mica-fluorite greisen are present, and that unaltered granite occurs beneath the greisen zone at a depth of approximately 100 m.

$^{40}Ar/^{39}Ar$ dating of the Kedron Granite yielded a preliminary age of ca. 362 Ma, which is similar to the ca. 361 Ma, $^{40}Ar/^{39}Ar$ age for the Pleasant Ridge Granite (Taylor, 1992). A recent attempt by Davis et al. (2004) to obtain a U-Pb date from monazite in this intrusion was unsuccessful at recovering grains suitable for determining a crystallization age. However, a series of poor quality, altered grains yielded an age of ca. 313 Ma, which likely reflects overprinting by a later hydrothermal event (Davis et al., 2004).

STOP DESCRIPTIONS

STOP 13a

McDougall Brook Au Occurrence (Mount Pleasant Caldera)
(Modified from Thorne and McLeod, 2003a)

Location: *From Fredericton, head west along Hwy 101 for approximately 42 km until reaching Central Blissville. Turn right onto Hwy 785 and head south for ~25 km and turn left onto the small logging road. Proceed up the hill and park the vehicles.*

Hazards: Before hammering the rocks, be aware of those around you.

Gold mineralization in this area was initially discovered by prospector Reg Cox Jr. in 1995. Mr. Cox discovered boulders of hydrothermal breccia up to 2 m wide along the margin of the Late Devonian McDougall Brook Granite that yielded consistent values of 200-500 ppb Au, with the highest being 1.05 g/t Au (Cox, 1997). At this location (see Figure 21), there are several large angular boulders of hematized hydrothermal breccia lying along side the logging road and at the edge of the woods that exhibit several styles of mineralization. They include hematite-rich veins within the hydrothermal breccia, sulphide-rich hydrothermal breccia that contains disseminated mineralization, and fluorite-rich veins as well as cockscomb-textured veins. The bulk of the mineralization is associated with topaz greisen with pyrite, arsenopyrite, and fluorite. The highest gold grades are contained within those boulders that are strongly hematized.

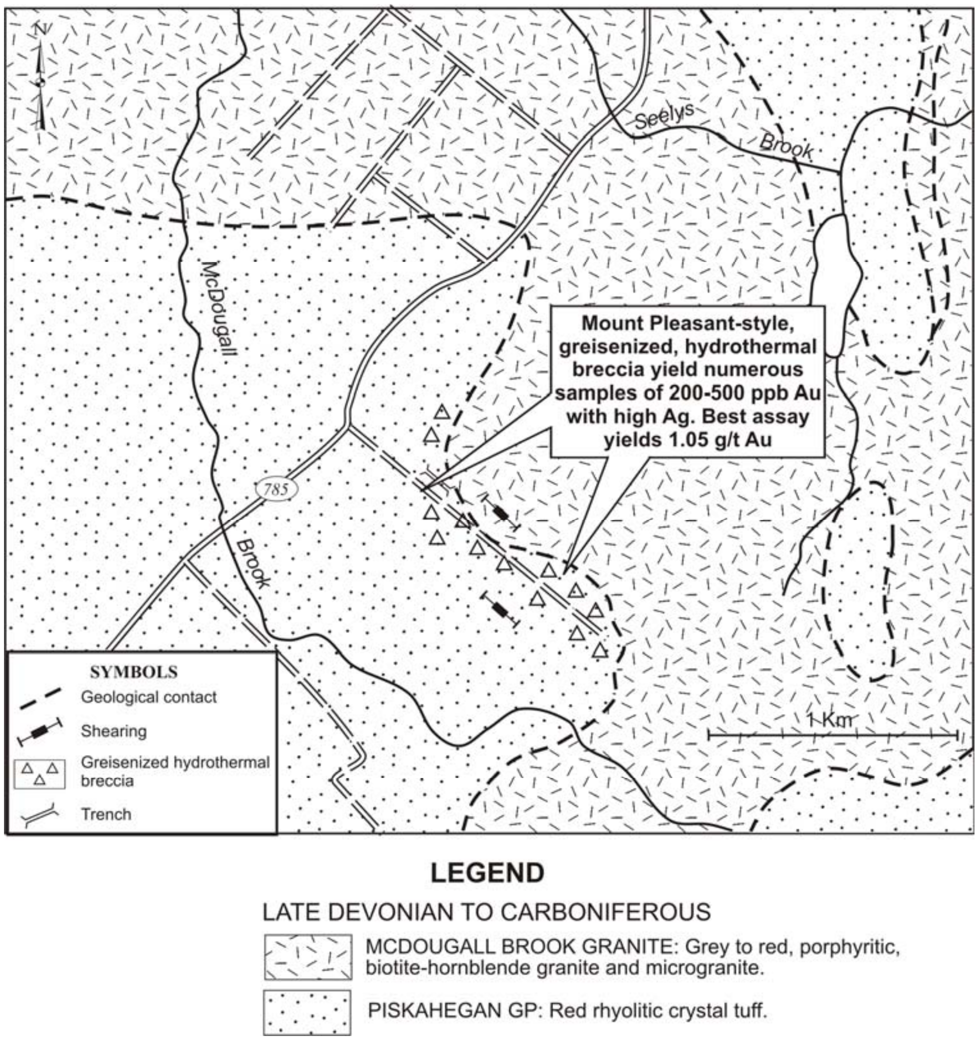

Figure 21. Local geology of the McDougall Brook gold showing (modified after McCutcheon, 1990; from Thorne and McLeod, 2003b).

The presence of fluorite- and arsenopyrite-rich greisenized hydrothermal breccias similar to those found at Mount Pleasant suggests a genetic connection with highly evolved granites. Also, the timing of the mineralization appears to be post-date the emplacement of the McDougall Brook Granite at this locality, since mineralized veins are locally seen to cross-cut the granite. However, it is still possible that less-evolved intrusions like the McDougall Brook Granite are capable of generating these types of greisenized hydrothermal breccias, and associated gold mineralization.

STOP 13b

Kedron Core, *auriferous lode mineralization in diamond drill core (Pomeroy Intrusive Suite)*
(Modified from Thorne and McLeod, 2003c)

Core from the Kedron pluton drilled by Billiton Canada Ltd. in the mid 1980’s will be available for examination at the McDougall Brook gold showing. Prior to the recent interest in intrusion-related gold deposits, the only commodity of significance in this particular endogranitic environment was tin. The tin mineralization in the Kedron Granite occurs within silica-rich, pegmatitic and greisenized zones that assay up to 2000 ppm (Taylor et al., 1985). One vein containing arsenopyrite, pyrite, chalcopyrite, molybdenite, and cassiterite, contained elevated gold and silver values as well (Taylor et al., 1985). These styles of alteration and accompanying mineral assemblages are typical of those at the Mount Pleasant deposit.

The chlorite- and arsenopyrite-rich tin lode exhibited in the drill core (BR-84-2) is typical of the tin mineralized zones at Mount Pleasant. The gold intersection considered here (see Figure 22) ran 0.4 g/t Au over 3 metres with 0.27% Sn, 0.55% Cu, and 1.75% Zn (Billiton, unpublished information). Although low grade, the presence of gold in this type of tin occurrence has significance regionally and perhaps at Mount Pleasant itself. The significance, if any, of the ca. 313 Ma hydrothermal alteration event (Davis et al., 2004), as it pertains to gold mineralization, is unknown.

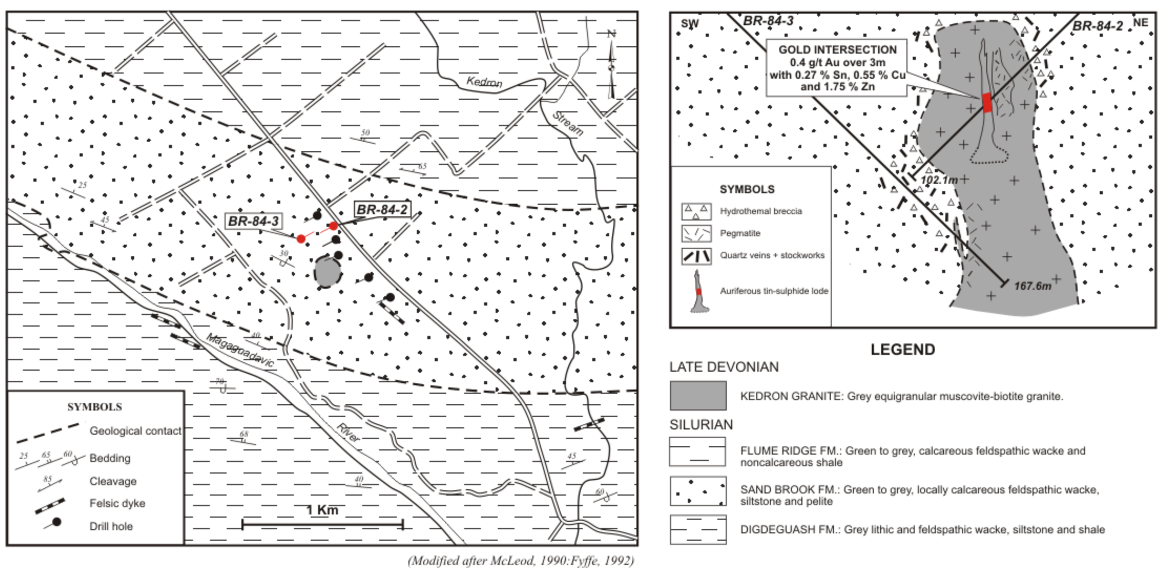

Figure 22. Geology of the Kedron gold occurrence (modified after McLeod, 1990; Fyffe, 1992; from Thorne and McLeod, 2003c).

STOP 14a

Fire Tower Breccia and Mount Pleasant Porphyry, Mount Pleasant deposit (Mount Pleasant Caldera)

(Modified from McCutcheon et al., 2001)

Location: *Return back to Hwy 785 and turn left toward the Mount Pleasant Mine site. At ~5 km down the road, turn right at the Y in the road and proceed towards the Mount*

Pleasant Mine. Drive about 6 km passing the mine site on your left and turn right up the road, then proceed about 2 km to the top of mountain.

Hazards: The smooth surfaces of the outcrop exposure may be slippery when wet.

Southeast of the communications tower is the silicified "Fire Tower Breccia", which was generated by early phases of granite at depth, intruded by banded porphyry dykes. The breccia consists of grey to white, greisen-altered fragments that are angular to subrounded and up to 10 cm in size. The protoliths of the fragments are nearly unrecognizable due to advanced argillic alteration, but from underground excavations, are known to be derived from autobrecciated early-phase granite and from surrounding, high-level quartz-feldspar porphyry intrusions. The dark green dyke rocks contain scattered quartz and feldspar phenocrysts, are banded near dyke margins and contain country rock xenoliths. Crosscutting relationships between dykes attest to multiple phases of intrusion.

<u>STOP 14b</u>

Mount Pleasant Porphyry and mineralized Mount Pleasant Breccia, Mount Pleasant deposit (Mount Pleasant Caldera)
(Modified after McCutcheon et al., 2001)

Location: *Walk southwest a few hundred metres to the large exposures on the mine side of the mountain*
Hazards: The smooth surfaces of the outcrop exposure may be slippery when wet.

On the mine side of the communications tower, is an expansive outcrop of greenish grey, pervasively chloritized, porphyritic microgranite (Mount Pleasant Porphyry) with quartz and feldspar phenocrysts and grey to white breccia (Fire Tower Breccia). The dyke in the previous stop and the Mount Pleasant Porphyry here are thought to be high-level products of the intermediate phase of granite at depth, which abruptly truncates W-Mo-Bi deposits in underground workings. In the North Zone 1 km to the north and likely in this area, similar intrusions are known to be the source of tin-related deposits at Mount Pleasant. At this locality, the porphyry is silicified along fractures and is cut by yet another generation of hydrothermal breccia dykes or pebble dykes that contain mostly microgranite fragments.

The Fire Tower breccia exposed here is similar to that hosting the W-Mo-Bi ore bodies exposed in underground workings and is characterized by intense quartz-topaz greisen-type alteration. Traces of fluorite, molybdenite, and wolframite can be found associated with the greisen-altered rock, in quartz veinlets and in fractures. It is notable that significant W-Mo-Bi deposits in a similar host occur at the North Zone and were also generated by an early phase of granite intrusion at depth.

At the end of the visit to Mount Pleasant, proceed back to Hwy 785 and head south toward St. George. At the junction with Hwy 1, turn left and head east toward NS.

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REFERENCES

Barr, S.M., & White, C.E. 1989. Re-interpretation of Precambrian stratigraphy, Kings and Saint John counties, New Brunswick. *In* Project Summaries for 1989, Fourteenth Annual Review of Activities. *Edited by* S.A. Abbott. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Information Circular 89-2, pp. 181-189.

Barr, S.M., & White, C.E. 1996. Contrasts in Late Precambrian-Early Paleozoic tectonothermal history between Avalon composite terrane senso stricto and other possible peri-Gondwanan terranes in southern New Brunswick and Cape Breton Island, Canada. *In* Avalonian and Related Peri-Gondwanan Terranes of the Circum North Atlantic. *Edited by* R.D. Nance and M.D. Thompson. Geological Society of America, Special Paper 304, pp. 95-108.

Barr, S.M., White, C.E., & Miller, B.V. 2002a. The Kingston terrane, southern New Brunswick, Canada: Evidence for an Early Silurian volcanic arc. Geological Society of America, Bulletin, 114, pp. 964-982.

Barr, S.M., White, C.E., Miller, B.V., & van Staal, C.R. 2002b. The myth of "Avalon": did it constitute a single terrane or several different terranes in the Early Paleozoic? Abstract presented at the Northeastern Section of the Geological Society of America - 37th Annual Meeting, Springfield, Massachusetts.

Barr, S.M., Davis, D.W., Kamo, S., & White, C.E. 2003. Significance of U-Pb zircon ages in quartzite from peri-Gondwanan terranes, New Brunswick and Nova Scotia, Canada. Precambrian Research, 126, pp. 123-145.

Bevier, M.L. 1989. U-Pb geochronologic studies of igneous rocks in N.B. *In* Thirteenth Annual Review of Activities, Project Résumés, 1988. *Edited by* S.A. Abbott. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Information Circular 88-2, (Second Edition), pp. 134-140.

Bevier, M.L. 1990. Preliminary U-Pb geochronologic results for igneous and metamorphic rocks, New Brunswick. *In* Project Summaries for 1989, Fourteenth Annual Review of Activities. *Edited by* S.A. Abbott. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Information Circular 89-2 (Second Edition), pp. 208-212.

Castonguay, S., & Ravenelle, J.-F. 2002. Stop description for Stop 1, Moores Mills quarry. *In* Gold mineralization in Ordovician rocks of the Rollingdam area in southwestern New Brunswick. *By* K. Thorne, M. Mcleod, L. Fyffe, J.-F. Ravenelle, G.

Lutes, D. Hoy, S. Castonguay and S. Watters. New Brunswick Department of Natural Resources and Energy; Minerals, Policy and Planning Division, Open File 2002-7, pp. 11-12.

Castonguay, S., Watters, S., & Ravenelle, J.-F. 2002. Regional structural geology of the Clarence Stream area, southwestern New Brunswick and implications for gold exploration. New Brunswick Department of Natural Resources and Energy, Abstracts 2002: 27th Annual Review of Activities, Information Circular 2002-1, pp. 15-16.

Castonguay, S., Watters, S., & Ravenelle, J.-F. 2003. Preliminary report on the structural geology of the Clarence Stream – Moores Mills area, southwestern New Brunswick: implications for gold exploration. Geological Survey of Canada, Current Research 2003-D2, 10 p.

Cox, R., Jr. 1997. Report of work, McDougall Brook, Sunbury County. New Brunswick Department of Natural Resources and Energy, Assessment Report 474896.

Davis, W.J., Chi, G., Castonguay, S., & McLeod, M. 2004. Temporal relationships between plutonism, metamorphism, and gold mineralization, Clarence Stream area, southwestern New Brunswick, U-Pb and Ar-Ar geochronological constraints. Geological Survey of Canada, Current Research 2004-F2, 20 p.

Fyffe, L.R. 1990. Geology of the Potters Lake map area, Charlotte County, New Brunswick. *In* Project Summaries for 1990, Fifteenth Annual Review of Activities. *Edited by* S.A. Abbott. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Information Circular 90-2, pp. 19-31.

Fyffe, L.R. 1991. Geology of the Flume Ridge-Kedron Stream map areas, New Brunswick. *In* Project Summaries for 1991, Sixteenth Annual Review of Activities *Edited by* S.A. Abbott. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Information Circular 91-2, pp. 12-20.

Fyffe, L.R. 1992. Geology of the Beech Hill area (NTS 21 G/07e), Charlotte County, New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 92-32 (Revised 2002).

Fyffe, L.R. 1998. Geology of the Rollingdam area (NTS 21 G/06), Charlotte County, New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 97-31. Revised 2002.

Fyffe, L.R., & Fricker, A. 1987. Tectonostratigraphic terrane analysis of New Brunswick. Maritime Sediments and Atlantic Geology, 23, pp. 113–123.

Fyffe, L.R., & Riva, J. 1990. Revised stratigraphy of the Cookson Group of southwestern New Brunswick and adjacent Maine. Atlantic Geology, 26, pp. 271–275.

Fyffe, L.R., & Riva, J.F.V. 2001. Regional significance of graptolites from the Digdeguash Formation of southwestern New Brunswick. *In* Current Research 2000. *Edited by* B.M.W. Carroll. New Brunswick Department of Natural Resources, Minerals and Energy Division, Mineral Resource Report 2001-4, pp. 47-54.

Fyffe, L.R., & Thorne, K.G. 2002. Geology of the Clarence Stream area (NTS 21G/07d), Charlotte County, New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals, Policy and Planning Division, Plate 2002-52 (Scale 1:20 000).

Fyffe, L., McLeod, M.J., & Ruitenberg, A.A. 1992. A geotraverse across the St. Croix-Avalon terrane boundary, southern New Brunswick. Geological Association of

Canada, Mineralogical Association of Canada, Joint Annual Meeting, Wolfville ’92, Field Trip A1, Guidebook, 44 p.

Fyffe, L.R., Pickerill, R.K., & Stringer, P. 1999. Stratigraphy, sedimentology and structure of the Oak Bay and Waweig formations, Mascarene Basin: implications for the paleotectonic evolution of southwestern New Brunswick. Altantic Geology, 35, pp. 59–84.

Fyffe, L.R., McNicoll, V., & van Staal, C. 2001. Provenance of detrital zircons from the Oak Bay conglomerate of southwestern New Brunswick. Atlantic Geoscience Society Colloquium and Annual General Meeting. Program and Abstracts volume, pp. 15.

Gardiner, W. 2003. Lily Hill Claim Group. New Brunswick Department of Natural Resources, Assessment Report 475637.

Gates, O. 1989. Silurian roundstone conglomerates of coastal Maine and adjacent New Brunswick. *In* Studies in Maine Geology. *Edited by* R.D. Tucker and R.G. Marvinney. Maine Geological Survey, Volume 2: Structure and Stratigraphy, pp. 127-144.

Johnson, S.C. 2001. Contrasting geology in the Pocologan River and Long Reach areas; implications for the New River belt and correlations in southern New Brunswick and Maine. Atlantic Geology, 37, pp. 61-79.

Johnson, S.C., & McLeod, M.J. 1996. The New River Belt: unique segment along the western margin of the Avalon composite terrane, southern New Brunswick. Geological Society of America, Special Paper 304, pp. 149-164.

King, M.S., & Barr, S.M. 2004a. Magnetic and gravity models across terrane boundaries in southern New Brunswick, Canada. Canadian Journal of Earth Sciences, 41, pp. 1027-1047.

King, M.S., & Barr, S.M., 2004b. Southern New Brunswick potential fields project part III; gravity and magnetic methods applied to granite-related mineral exploration in Charlotte County. New Brunswick Department of Natural Resources, Minerals, Policy and Planning Division, Open File 2004-4, 76 p.

Kooiman, G.J.A., McLeod, M.J., & Sinclair, W.D. 1986. Porphyry tungsten-molybdenum orebodies, polymetallic veins and replacement bodies, and tin-bearing greisen zones in the Fire Tower zone, Mount Pleasant, New Brunswick. Economic Geology, 81, pp. 1356-1373.

Lang, J.R., & Baker, T. 2001. Intrusion-related gold systems: the present level of understanding. Mineralium Deposita, 36, pp. 447-489.

Lang, J.R., Baker, T., Hart, C.J.R., & Mortensen, J.K. 2000. An exploration model for intrusion-related gold systems. Society of Economic Geologists Newsletter, no. 4, p. 1, & 6-14.

Ludman, A. 1987. Pre-Silurian stratigraphy and tectonic significance of the St. Croix Belt, southeastern Maine. Canadian Journal of Earth Sciences, 24, pp. 2459–2469.

Lutes, G. 2004. Report on Diamond Drilling, Clarence Stream –AD/MW Zones. Unpublished internal report for Freewest Resources Canada Incorporated, 109 p.

Lutes, G., Ravenelle, J.-F., Thorne, K, Castonguay, S., & Watters, S. 2003. Mineralization at Anomaly A, Clarence Stream gold deposit, southwestern New Brunswick. *In* Gold Deposits Associated with Felsic Intrusions in Southwestern New Brunswick-Field Guidebook. *Edited by* K.G. Thorne and M. McLeod. New Brunswick Department of Natural Resources and Energy, Open File Report 2003-4, p. 45-57.

McCutcheon, S.R. 1990. The Late Devonian Mount Pleasant Caldera Complex: Stratigraphy, mineralogy, geochemistry and the geologic setting of a Sn-W deposit in southwestern New Brunswick. Unpublished Ph.D. thesis, Dalhousie University, Halifax, 609 p.

McCutcheon, S.R., Anderson, H.E., & Robinson, P.T. 1997. Stratigraphy and eruptive history of the Late Devonian Mount Pleasant caldera complex, Canadian Appalachians. Geological Magazine, 134, pp. 17 - 36.

McCutcheon, S.R., Sinclair, W.D., & Kooiman, G.J.A. 2001. The Late Devonian Mount Pleasant caldera: Geological Setting of a W-Mo-Sn-In deposit in southwestern New Brunswick. I*n* Guidebook to field trips in New Brunswick and Western Maine. *Edited by* R.K. Pickerill and D.R. Lentz. New England Intercollegiate Geological Conference, 93rd Annual Meeting, New Brunswick Trip B-5, pp. B5-1–B5-14.

McLeod, M.J. 1990. Geology, geochemistry, and related mineral deposits of the Saint George Batholith; Charlotte, Queens, and Kings Counties, New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resource Report 5, 169 p.

McLeod, M.J. 2003. Regional Geology of Southwestern New Brunswick. In Gold Deposits Associated with Felsic Intrusions in Southwestern New Brunswick – Field Guidebook. *Edited by* K. Thorne and M. McLeod. New Brunswick Department of Natural Resources, Open File Report 2003-4, pp. 9–12.

McLeod, M.J., & McCutcheon, S.R. 2000. Gold environments in New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 98-25.

McLeod, M.J., Johnson, S.C., & Ruitenberg, A.A., 1994. Geological map of southwestern New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Map NR-5.

McLeod, M.J., Johnson, S.C., & Fyffe, L.R. 1998. Bedrock geological compilation of the McDougall Lake area (NTS 21G/07), Charlotte County, New Brunswick. New Brunswick Department of Natural Resources and Energy, Mines and Energy Division, Plate 98-25. Revised 2002.

McLeod, M.J., Van Wagoner, N., & Dadd, K. 2005. Correlation and geochemistry of Late Ordovician to Silurian sequences in southwestern New Brunswick: evidence for a northwesterly facing arc complex. *In* Abstracts, 2005: The Atlantic Geoscience Society (AGS) 31st Colloquium & Annual General Meeting. *Edited by* D. Keighley. Program with abstracts, p. 33.

Miller, B.V., & Fyffe, L.R. 2002. Geochronology of the Letete and Waweig formations, Mascarene Group, southwestern New Brunswick. Atlantic Geology, 38, pp. 29–36.

Murphy, J.B., Barr, S.M., Currie, K.L., Keppie, J.D., Nance, R.D., & White, C.E. 1992. The Avalon Terrane in Maritime Canada. Geological Association of Canada, Mineralogical Association of Canada, Joint Annual Meeting, Wolfville ’92, Field Trip C – 12, Guidebook, pp. 56-61.

Okulitch, A.V. 1999. Geological Time Chart, 1999. Geological Survey of Canada, Open File Report 3040, 1 p.

Park, A. 2001. Clarence Stream Project, structural geology: results of a field and microstructural study. Internal report prepared for Freewest Resources Canada Inc., 34 p.

Park, A. 2003. Deformation and vein formation: heterogeneities related to transient permeability in the Clarence Stream gold mineralized ductile shear zone, southern New Brunswick. Canadian Institute of Mining and Metallurgy, 105th Annual General Meeting, Montreal, Quebec, abstract volume, p. 108.

Park, A.F., Lentz, D.R., & Thorne, K.G., in press. Deformation and structural controls on intrusion history and gold mineralization in the Clarence Stream shear zone, southwestern New Brunswick, Canada. Exploration and Mining Geology.

Parrish, I.S., & Tully, J.V. 1978. Porphyry tungsten zones at Mt. Pleasant, New Brunswick. Canadian Institute of Mining and Metallurgy Bulletin, 71, No. 794, pp. 93-100.

Pe-Piper, G., Jansa, L.F., & Lambert, R. St. J. 1992. Early Mesozoic magmatism on the eastern Canadian margin: Petrogenetic and tectonic significance. *In* Eastern North American Mesozoic Magmatism. *Edited by* J. H Puffer and P.C. Ragland. Geological Society of America, Special Paper 268, pp. 13-36.

Robinson, P., Tucker, R.D., Bradley, D., Berry IV, H.N., & Osberg, P.H. 1998. Paleozoic orogens in New England, USA. GFF, 120, pp. 119-148.

Ruitenberg, A.A. 1963. Tin mineralization and associated rock alteration at Mount Pleasant, Charlotte County, New Brunswick. Unpublished M.Sc. thesis, University of New Brunswick, Fredericton, 172 p.

Ruitenberg, A.A. 1967. Stratigraphy, structure and metallization, Piskahegan-Rolling Dam area (Northern Appalachians, New Brunswick, Canada). Leidse Geologische Mededelingen, 40, pp. 79–120.

Ruitenberg, A.A. 1972. Metallization episodes related to tectonic evolution, Rolling Dam and Mascarene–Nerepis belts, New Brunswick. Economic Geology, 67, pp. 434–444.

Ruitenberg, A.A., & Ludman, A., 1978. Stratigraphy and tectonic setting of Early Paleozoic sedimentary rocks of the Wirral–Big Lake area, southwestern New Brunswick and southeastern Maine. Canadian Journal of Earth Sciences, 15, pp. 22–32.

St. Peter, C. 1993. Maritimes Basin evolution: key geologic and seismic evidence from the Moncton Subbasin of New Brunswick. Atlantic Geology, 29, pp. 233-270.

Sinclair, W.D. 1994. Tungsten-molybdenum and tin deposits at Mount Pleasant, New Brunswick, Canada: products of ore-fluid evolution in a highly fractionated granite system. *In* Metallogeny of Collisional Orogens focussed on the Erzgebirge and Comparable Metallogenic Settings. *Edited by* R. Seltmann, H. Kampf, and P. Moller, pp. 410-417.

Sinclair, W.D., Kooiman, G.J.A., & Martin, D.A. 1988. Geological setting of granites and related tin deposits in the North Zone, Mount Pleasant, New Brunswick. *In* Current Research, Part B. Geological Survey of Canada, Paper 88-1B, p. 201-208.

Stewart, D.B., Unger, J.D., & Hutchinson, D.R. 1995. Silurian tectonic history of Penobscot Bay region, Maine. Atlantic Geology, 31, pp. 67-79.

Stringer, P., & Burke, K.B.S. 1985. Structures in the southwest New Brunswick. *In* Fredericton '85, Field Excursions. *Edited by* R.K. Pickerill, C.K. Mawer, and L.R. Fyffe. Geological Association of Canada, Mineralogical Association of Canada, University of New Brunswick, Fredericton, New Brunswick, Excursion 9, 34 p.

Taylor, R.P. 1992. Petrological and geochemical characteristics of the Pleasant Ridge zinnwaldite-topaz granite, southern New Brunswick, and comparisons with other topaz-bearing felsic rocks. Canadian Mineralogist, 30, pp. 895-921.

Taylor, R.P., Sinclair, W.D., & Lutes, G.G. 1985. Geochemical and isotopic characterization of granites related to W-Sn-Mo mineralization in the Mount Pleasant area, New Brunswick. *In* Recent Advances in the Geology of Granite-Related Mineral Deposits. *Edited by* R.P. Taylor and D.F. Strong. Canadian Institute of Mining and Metallurgy, September 15-17, 1985, Halifax, N.S., Proceedings, pp. 265-273.

Thomas, M.D., & Willis, C. 1989. Gravity modelling of the Saint George Batholith and adjacent terrane within the Appalachian Orogen, southern New Brunswick. Canadian Journal of Earth Sciences, 26, pp. 561-576.

Thompson, J.F.H., & Newberry, R.J. 2000. Gold deposits related to reduced granitic intrusions. *In* Gold in 2000. *Edited by* S. Hagemann and P. Brown. Reviews in Economic Geology, 13, pp. 377-400.

Thompson, J.F.H., Sillitoe, R.H., Baker, T., Lang, J.R., & Mortensen, J.K. 1999. Intrusion-related gold deposits associated with tungsten-tin provinces. Mineralium Deposita, 34, pp. 323-334.

Thorne, K.G., & Lentz, D.R. 2001a. Geochemistry and petrogenesis of the East Branch Brook metagabbroic dykes in the Sawyer Brook fault zone, Clarence Stream gold prospect, southwestern New Brunswick. Atlantic Geology, 37, pp. 175–190.

Thorne, K.G., & Lentz, D.R. 2001b. Geological setting of the Clarence Stream gold deposit, southwestern New Brunswick. *In* Guidebook to Field Trips in New Brunswick and Eastern Maine. *Edited by* R.K. Pickerill and D.R. Lentz. New England Intercollegiate Geological Conference 2001, 93rd Annual Meeting, pp. C5–1 to C5–16.

Thorne, K.G., & Lentz, D.R. 2002. Geology, mineralization and associated alteration of the Main Zone at the Clarence Stream gold deposit, southwestern New Brunswick. *In* Abstracts 2002: 27th Annual Review of Activities. *Edited by* B.M.W. Carroll. New Brunswick Department of Natural Resources and Energy, Information Circular 2002-1, pp. 67–68.

Thorne, K.G., & Lentz, D.R. 2003. Geology of the Main Zone of the Clarence Stream gold deposit, southwestern New Brunswick. *In* Gold Deposits Associated with Felsic Intrusions in Southwestern New Brunswick-Field Guidebook. *Edited by* K.G. Thorne and M. McLeod. New Brunswick Department of Natural Resources and Energy, Open File Report 2003-4, pp. 13–29.

Thorne, K., & McLeod, M. 2003a. Gold Deposits Associated with Felsic Intrusions in Southwestern New Brunswick – Field Guidebook. New Brunswick Department of Natural Resources and Energy, Open File Report 2003-4, 83 p.

Thorne, K., & McLeod, M. 2003b. McDougall Brook gold occurrence, Mount Pleasant Caldera, southwestern New Brunswick. *In* Gold Deposits Associated with Felsic Intrusions in Southwestern New Brunswick-Field Guidebook. *Edited by* K.G. Thorne and M. McLeod. New Brunswick Department of Natural Resources and Energy, Open File Report 2003-4, pp. 41-44.

Thorne, K., & McLeod, M. 2003c. Kedron gold occurrence, northern Saint George Batholith, southwestern New Brunswick. *In* Gold Deposits Associated with Felsic Intrusions in Southwestern New Brunswick-Field Guidebook. *Edited by* K.G. Thorne and M. McLeod. New Brunswick Department of Natural Resources and Energy, Open File Report 2003-4, pp. 41-44.

Thorne, K.G., Lentz, D.R., Hall, D.C., & Yang, X. 2002a. Petrology, geochemistry, and geochronology of the granitic pegmatite and aplite dykes associated with the Clarence Stream gold deposit, southwestern New Brunswick. Geological Survey of Canada, Current Research 2002-E12, 13 p.

Thorne, K.G., McLeod, M.J., Fyffe, L.R., Ravenelle, J.-F., Lutes, G., Hoy, D., Castonguay, S., & Watters, S., 2002b. Gold mineralization in Ordovician rocks of the Rollingdam area in southwestern New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals, Policy and Planning Division, Open File 2002-7, 21 p.

Thorne, K.G., Lentz, D.R., & Fyffe, L.R. 2004a. Petrochemical analysis of various granitic intrusions and felsitic mylonites associated with the Clarence Stream gold deposit, southwestern New Brunswick. Atlantic Geoscience Society, Annual General Meeting, Moncton, New Brunswick, pp. 29–30.

Thorne, K.G., Lutes, G.G., Lentz, D.R., & Fyffe, L.R. 2004b. Geology of east zone Clarence Stream gold deposit, Charlotte County, New Brunswick. New Brunswick Department of Natural Resources, Map Plate 2002-54A.

Thorne, K.G., Lutes, G.G., Lentz, D.R., & Fyffe, L.R. 2004c. Geology of west and central zones Clarence Stream gold deposit, Charlotte County. New Brunswick Department of Natural Resources, Map Plate 2002-54B.

Thorne, K., Lentz. D., & Fyffe, L.R. in preparation. Petrochemical and geochronological analysis of various granitic intrusions and felsitic mylonites associated with the Clarence Stream Gold Deposit, southwestern New Brunswick. To be submitted to Atlantic Geology.

Tucker, R.D., Bradley, D.C., ver Straeten C.A., Harris A.G., Ebert, J.R., & McCutcheon, S.R. 1998. New U—Pb zircon ages and the duration and division of Devonian time. Earth and Planetary Science Letters, 158, pp. 175-186.

Tucker, R.D., Osberg, P.H., & Berry, H.N. 2001. The geology of part of Acadia and the nature of the Acadian orogeny across central and eastern Maine. American Journal of Science, 301, pp. 205-260.

van Staal, C.R., & Fyffe, L.R. 1991. Dunnage and Gander zones, New Brunswick: Canadian Appalachian Region. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Geoscience Report 91-2, 39 p.

Watters, S., Castonguay, S., & McLeod, M.J. 2003. Preliminary report on new gold deposits in the Clarence Stream area of southwestern New Brunswick: Anomaly “A”–distal deposits of an intrusion-related system? Geological Survey of Canada, Open File Report 1779, 40 p.

Watters, S., Castonguay, S., Lutes, G., & McLeod, M. in press. Gold mineralization in the Clarence Stream area of southwestern New Brunswick: Anomaly "A" - Distal deposits of a syn-deformational intrusion-related-gold system? Exploration and Mining Geology.

Whalen, J.B., Jenner, G.A., Currie, K.L., Barr, S.M., Longstaffe, F.J., & Hegner, E. 1994. Geochemical and isotopic characteristics of granitoids of the Avalon Zone, southern New Brunswick: possible evidence for repeated delamination events. Journal of Geology, 102, pp. 269-282.

Williams, H. 1995. Introduction: Chapter 1. *In* Geology of the Appalachian-Caledonian Orogen in Canada and Greenland. *Edited by* H. Williams. Geological Survey of Canada, Geology of Canada, no. 6, pp. 1-19.

Williams, H., & Hatcher, R.D., Jr. 1982. Suspect terranes and accretionary history of the Appalachian Orogen. Geology, 10, pp. 530-536.

Yang, X.M., Lentz, D.R., & McCutcheon, S.R. 2003. Petrochemical evolution of subvolcanic granitoid intrusions within the Late Devonian Mount Pleasant Caldera, southwestern New Brunswick: comparison of Au versus Sn-W-Mo polymetallic mineralization systems. Atlantic Geology, 39, pp. 97-121.

Pre-conference Field Trips

A1 Contamination in the South Mountain Batholith and Port Mouton Pluton, southern Nova Scotia
D. Barrie Clarke and Saskia Erdmann

A2 Salt tectonics and sedimentation in western Cape Breton Island, Nova Scotia
Ian Davison and Chris Jauer

A3 Glaciation and landscapes of the Halifax region, Nova Scotia
Ralph Stea and John Gosse

A4 Structural geology and vein arrays of lode gold deposits, Meguma terrane, Nova Scotia
Rick Horne

A5 Facies heterogeneity in lacustrine basins: the transtensional Moncton Basin (Mississippian) and extensional Fundy Basin (Triassic-Jurassic), New Brunswick and Nova Scotia
David Keighley and David E. Brown

A6 Geological setting of intrusion-related gold mineralization in southwestern New Brunswick
Kathleen Thorne, Malcolm McLeod, Les Fyffe, and David Lentz

A7 The Triassic-Jurassic faunal and floral transition in the Fundy Basin, Nova Scotia
Paul Olsen, Jessica Whiteside, and Tim Fedak

Post-conference Field Trips

B1 Accretion of peri-Gondwanan terranes, northern mainland Nova Scotia and southern New Brunswick
Sandra Barr, Susan Johnson, Brendan Murphy, Georgia Pe-Piper, David Piper, and Chris White

B2 The Joggins Cliffs of Nova Scotia: Lyell & Co's "Coal Age Galapagos"
J.H. Calder, M.R. Gibling, and M.C. Rygel

B3 Geology and volcanology of the Jurassic North Mountain Basalt, southern Nova Scotia
Dan Kontak, Jarda Dostal, and John Greenough

B4 Stratigraphic setting of base-metal deposits in the Bathurst Mining Camp, New Brunswick
Steve McCutcheon, Jim Walker, Pierre Bernard, David Lentz, Warna Downey, and Sean McClenaghan

B5 Geology and environmental geochemistry of lode gold deposits in Nova Scotia
Paul Smith, Michael Parsons, and Terry Goodwin

B6 The macrotidal environment of the Minas Basin, Nova Scotia: sedimentology, morphology, and human impact
Ian Spooner, Andrew MacRae, and Danika van Proosdij

B7 Transpression and transtension along a continental transform fault: Minas Fault Zone, Nova Scotia
John W.F. Waldron, Joseph Clancy White, Elizabeth MacInnes, and Carlos G. Roselli

B8 New Brunswick Appalachian transect: Bedrock and Quaternary geology of the Mount Carleton – Restigouche River area
Reginald A. Wilson, Michael A. Parkhill, and Jeffrey I. Carroll

B9 Gold metallogeny in the Newfoundland Appalachians
Andrew Kerr, Richard J. Wardle, Sean J. O'Brien, David W. Evans, and Gerald C. Squires