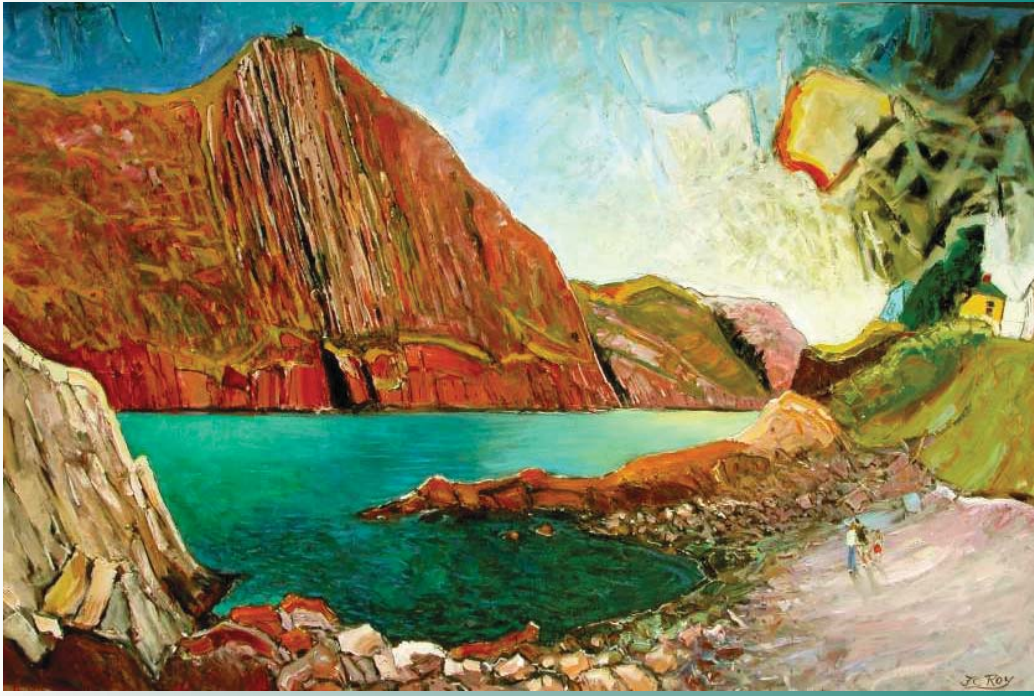




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VOLCANOGENIC MASSIVE SULPHIDE (VMS) DEPOSITS OF THE CENTRAL MOBILE BELT, NEWFOUNDLAND

Leaders: Stephen J. Piercey and John Hinchey

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FIELD TRIP GUIDEBOOK – B4

**VOLCANOGENIC MASSIVE SULPHIDE (VMS) DEPOSITS
OF THE CENTRAL MOBILE BELT, NEWFOUNDLAND**

FIELD TRIP LEADERS

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SAFETY INFORMATION

General Information

The Geological Association of Canada (GAC) recognizes that its field trips may involve hazards to the leaders and participants. It is the policy of the Geological Association of Canada to provide for the safety of participants during field trips, and to take every precaution, reasonable in the circumstances, to ensure that field trips are run with due regard for the safety of leaders and participants. GAC recommends steel-toed safety boots when working around road cuts, cliffs, or other locations where there is a potential hazard from falling objects. GAC will not supply safety boots to participants. Some field trip stops require sturdy hiking boots for safety. Field trip leaders are responsible for identifying any such stops, making participants aware well in advance that such footwear is required for the stop, and ensuring that participants do not go into areas for which their footwear is inadequate for safety. Field trip leaders should notify participants if some stops will require waterproof footwear.

The weather in Newfoundland in May is unpredictable, and participants should be prepared for a wide range of temperatures and conditions. Always take suitable clothing. A rain suit, sweater, and sturdy footwear are essential at almost any time of the year. Gloves and a warm hat could prove invaluable if it is cold and wet, and a sunhat and sunscreen might be just as essential. It is not impossible for all such clothing items to be needed on the same day.

Above all, field trip participants are responsible for acting in a manner that is safe for themselves and their co-participants. This responsibility includes using personal protective equipment (PPE) when necessary (when recommended by the field trip leader or upon personal identification of a hazard requiring PPE use). It also includes informing the field trip leaders of any matters of which they have knowledge that may affect their health and safety or that of co-participants. Field trip participants should pay close attention to instructions from the trip leaders and GAC representatives at all field trip stops. Specific dangers and precautions will be reiterated at individual localities.

Specific Hazards

Some of the stops on this field trip are in coastal localities. Access to the coastal sections may require short hikes, in some cases over rough, stony or wet terrain. Participants should be in good physical condition and accustomed to exercise. The coastal sections contain saltwater pools, seaweed, mud and other wet areas; in some cases it may be necessary to cross brooks or rivers. There is a strong possibility that participants will get their feet wet, and we recommend waterproof footwear. We also recommend footwear that provides sturdy ankle support, as localities may also involve traversing across beach

boulders or uneven rock surfaces. On some of the coastal sections that have boulders or weed-covered sections, participants may find a hiking stick a useful aid in walking safely.

Coastal localities present some specific hazards, and participants **MUST** behave appropriately for the safety of all. High sea cliffs are extremely dangerous, and falls at such localities would almost certainly be fatal. Participants must stay clear of the cliff edges at all times, stay with the field trip group, and follow instructions from leaders. Coastal sections elsewhere may lie below cliff faces, and participants must be aware of the constant danger from falling debris. Please stay away from any overhanging cliffs or steep faces, and do not hammer any locations immediately beneath the cliffs. In all coastal localities, participants must keep a safe distance from the ocean, and be aware of the magnitude and reach of ocean waves. Participants should be aware that unusually large “freak” waves present a very real hazard in some areas. If you are swept off the rocks into the ocean, your chances of survival are negligible. If possible, stay on dry sections of outcrops that lack any seaweed or algal deposits, and stay well back from the open water. Remember that wave-washed surfaces may be slippery and treacherous, and avoid any area where there is even a slight possibility of falling into the water. If it is necessary to ascend from the shoreline, avoid unconsolidated material, and be aware that other participants may be below you. Take care descending to the shoreline from above.

Other field trip stops are located on or adjacent to roads. At these stops, participants should make sure that they stay off the roads, and pay careful attention to traffic, which may be distracted by the field trip group. Participants should be extremely cautious in crossing roads, and ensure that they are visible to any drivers. Roadcut outcrops present hazards from loose material, and they should be treated with the same caution as coastal cliffs; be extremely careful and avoid hammering beneath any overhanging surfaces.

The hammering of rock outcrops, which is in most cases completely unnecessary, represents a significant “flying debris” hazard to the perpetrator and other participants. For this reason, we ask that outcrops not be assaulted in this way; if you have a genuine reason to collect a sample, inform the leaders, and then make sure that you do so safely and with concern for others. Many locations on trips contain outcrops that have unusual features, and these should be preserved for future visitors. Frankly, our preference is that you leave hammers at home or in the field trip vans.

Subsequent sections of this guidebook contain the stop descriptions and outcrop information for the field trip. In addition to the general precautions and hazards noted above, the introductions for specific localities make note of specific safety concerns such as traffic, water, cliffs or loose ground. Field trip participants must read these cautions carefully and take appropriate precautions for their own safety and the safety of others.

OVERVIEW OF FIELD TRIP

The Central Mobile Belt (CMB) of the Newfoundland Appalachians is host to numerous past and present producing regions, and is an area that has remained an active exploration environment, for volcanogenic massive sulphide (VMS) deposits from pre-confederation times to the present day. The CMB is an ideal location to view a wide variety of VMS deposit styles and types, representing a geological and metallogenic cross-section of the Cambrian to Ordovician Iapetus Ocean's geological components. The goal of this field trip is to provide participants with a feel for the regional geological environment of the CMB and its contained mineral deposits, with the hopes of providing information on the nature and styles of deposit types, and their variation as a function of host rock assemblage, age, and tectonic environment. The trip will involve stops to classic past-producing regions (*e.g.*, Buchans), active mines (*e.g.*, Duck Pond and Ming), and new and exciting prospects (*e.g.*, Lemarchant, Little Deer). In addition, it will provide regional field trip stops to place these deposits in regional context and illustrate their framework within an evolving orogen. We hope that you enjoy the trip and please feel free to ask questions at any time.

GEOLOGY AND VOLCANOGENIC MASSIVE SULPHIDE (VMS) DEPOSITS OF CENTRAL NEWFOUNDLAND

INTRODUCTION

The Dunnage Zone of central Newfoundland is host to numerous styles of volcanogenic massive sulphide (VMS) mineralization that have been important contributors to the provincial economy since pre-confederation times (Swinden and Kean, 1988). The "Central Mobile Belt" VMS district has had important past production (*e.g.*, Buchans), ongoing production (*e.g.*, Duck Pond, Ming), and numerous new discoveries (*e.g.*, Lemarchant, Boomerang), and will continue to be an important exploration target in the province for the foreseeable future. Volcanogenic massive sulphide within the Central Mobile Belt occur in a variety of settings, including arc, back-arc, and arc rift environments (*e.g.*, Swinden *et al.*, 1988; Swinden, 1991, 1996; van Staal, 2007). The goals of this guidebook and field trip are to provide an overview of the range of styles of deposits that occur in central Newfoundland, their host sequences, emplacement mechanisms, and their variations in time and space. The field trip stops will include regional stops to place the deposits in regional context, and specific VMS-related stops, including old mines, showings, and alteration types. In addition, given that many deposits do not outcrop on surface, or are in areas that are dif-

difficult to reach with a large group, drill core will be utilized to illustrate host sequences and mineralization styles. Two active mines will be visited to provide some participants with the opportunity to view deposits in an active mining framework.

REGIONAL GEOLOGICAL AND TECTONIC SETTING OF VMS DEPOSITS IN CENTRAL NEWFOUNDLAND

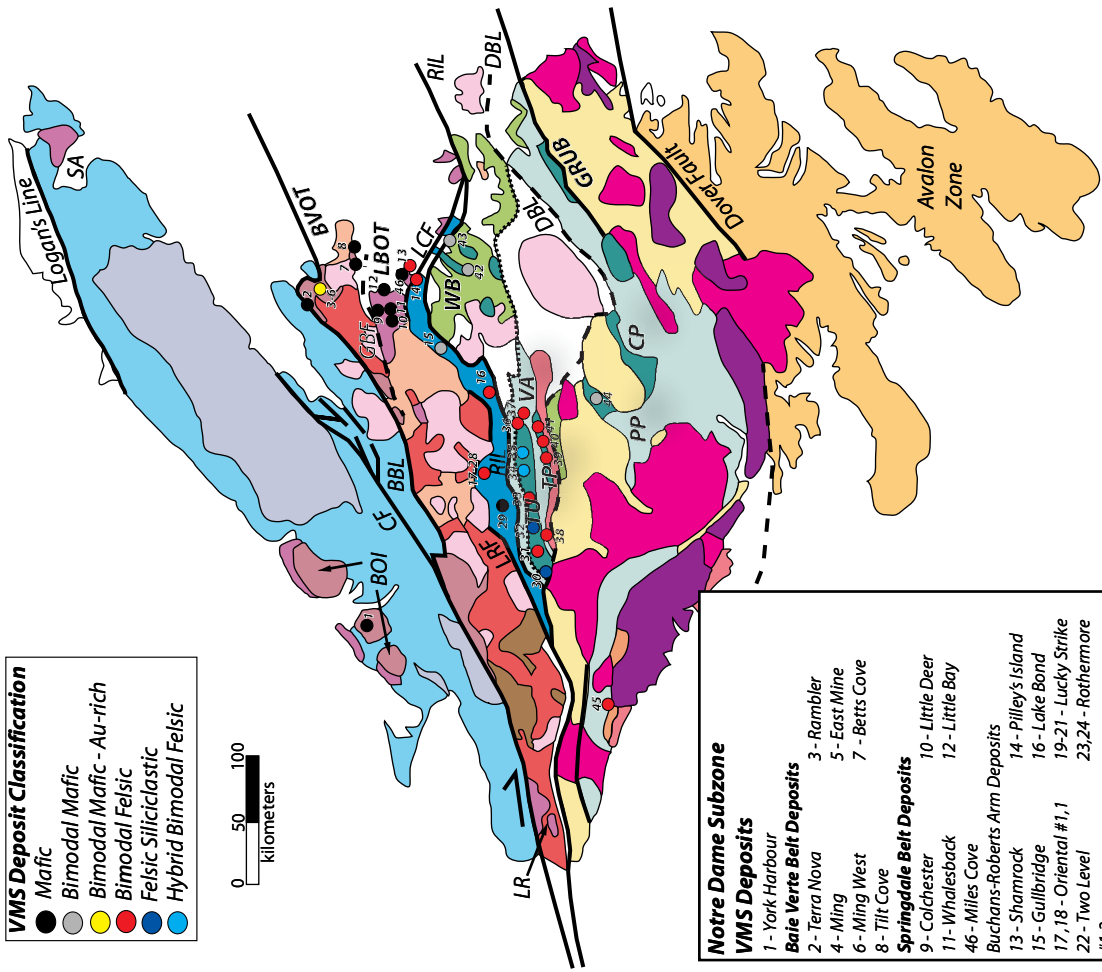
The Newfoundland Appalachians is divided into four tectonostratigraphic zones from west to east (*e.g.*, Williams, 1979): 1) Humber Zone; 2) Dunnage Zone; 3) Gander Zone; and 4) Avalon Zone (Figure 1). The Humber Zone represents predominantly Cambrian and Ordovician ancient passive margin rocks that were deposited upon the Laurentian craton (Williams and Hiscott, 1987; Lavoie *et al.*, 2003) (Figure 1). The Avalon and Gander zones represent Gondwana-derived microcontinental blocks with Neoproterozoic to Ordovician geological histories (O'Brien *et al.*, 1991; van Staal, 1994, 2007; van Staal and Barr, *in press*) (Figure 1). The Dunnage Zone, which is the focus of this trip, is the main host to VMS mineralization in Newfoundland and throughout the Appalachians in other parts of Canada and the United States (Swinden and Kean, 1988; Goodfellow *et al.*, 2003; Goodfellow, 2007). The Dunnage Zone is subdivided into two subzones: the Notre Dame and Exploits subzones (Williams *et al.*, 1988) (Figure 1). The Notre Dame subzone consists of Cambrian to Ordovician arc and back-arc rocks that formed along the margin of Laurentia (peri-Laurentian), whereas the Exploits subzone contains arc and back-arc rocks that formed along the margin of Gondwana (peri-Gondwana) (O'Brien *et al.*, 1997; Swinden *et al.*, 1997; Zagorevski *et al.*, 2006; van Staal, 2007; Zagorevski *et al.*, 2007; Zagorevski *et al.*, 2010; van Staal and Barr, *in press*) (Figure 1).

The two subzones are associated with distinctive rock assemblages and associations. The Notre Dame subzone contains rocks that range from Cambrian to Ordovician. The Lushs Bight Group of the Lushs Bight Ocean Tract (LBOT) consists of Cambrian ophiolitic

Figure 1 (opposite). *Geological map of the Newfoundland Appalachians with tectonostratigraphic zones, accretionary tracts, VMS deposits, their classifications and associated belts. Map tectonostratigraphy modified from van Staal (2007) and van Staal and Barr (in press). Volcanogenic massive sulphide (VMS) deposit classification from Piercey (2007c) and Hinchey (2011). Abbreviations: BBL=Baie Verte Brompton Line; BOI=Bay of Islands; BVOT=Baie Verte Oceanic Tract; CF=Cabot Fault; CP=Coy Pond Complex; DBL=Dog Bay Line; GBF=Green Bay Fault; GRUB=Gander River Ultramafic Belt; LBOT=Lushs Bight Oceanic Tract; LCF=Lobster Cove Fault; LR=Long Range; LRF=Lloyds River Fault; PP=Pipestone Pond Complex; RIL=Red Indian Line; SA=St. Anthony; TP=Tally Pond Belt; TU=Tulks Volcanic Belt; VA=Victoria Arc; WB=Wild Bight Group.*

VMS Deposit Classification

- Mafic
- Bimodal Mafic
- Bimodal Mafic - Au-rich
- Felsic
- Felsic Siliciclastic
- Hybrid Bimodal Felsic



Notre Dame Subzone

VMS Deposits

Baie Verte Belt Deposits

- 1 - York Harbour
- 2 - Terra Nova
- 3 - Rambler
- 4 - Ming
- 5 - East Mine
- 6 - Ming West
- 7 - Betts Cove
- 8 - Tilt Cove

Springdale Belt Deposits

- 9 - Colchester
- 10 - Little Deer
- 11 - Whalesback
- 12 - Little Bay
- 46 - Miles Cove

Buchans-Roberts Arm Deposits

- 13 - Shamrock
- 14 - Pilley's Island
- 15 - Gullbridge
- 16 - Lake Bond
- 17, 18 - Oriental #1,1
- 19-21 - Lucky Strike
- 22, 24 - Rothermore #1,2
- 25 - Maclean
- 26 - Maclean Extension
- 27 - Clementine
- 28 - Engine House

Devonian and younger Plutonic Rocks

- Silurian Syn-Salinic Plutonic/Volcanic Rocks
- Silurian successor basins

Laurentia

- Humber Margin
- Sediments/Volcanics
- Mesoproterozoic Inlier

Peri-Laurentia

- AAT (481-460 Ma)
- Notre Dame Arc (488-435)
- BVOT (489-477 Ma)
- LBOT (510-501 Ma)
- Dashwoods Sediments

Ganderia

- Popelogan Victoria Arc & Tetagouche-Exploits Backarc
- Ensialic/Ensismatic rocks (475-455 Ma)
- Penobscot Arc/Backarc (513-486 Ma)
- Mainly Neoproterozoic Rocks
- Coastal Arc & Maascarene Backarc (445-422 Ma)
- Ganderian Sedimentary Rocks

Exploits Subzone

VMS Deposits

Tulks Belt Deposits

- 30 - Boomerang
- 31 - Tulks Hill
- 32 - Tulks East
- 33 - Jacks Pond
- 34 - Daniels Pond
- 35 - Bobbys Pond
- 36 - Victoria Mine
- 37 - Hungry Hill

Long Lake Belt

- 38 - Long Lake

Tally Pond Belt

- 39 - Lemarchant
- 40 - Duck Pond
- 41 - Boundary

Point Leamington Belt

- 42 - Point Leamington
- 43 - Lockport

Other Deposits

- 44 - Great Burnt Lake
- 45 - Strickland

rocks that host Cu-rich VMS deposits in the Springdale area and are interpreted to have formed within a primitive arc environment (Kean *et al.*, 1995; Swinden *et al.*, 1997; van Staal, 2007; van Staal and Barr, *in press*) (Figure 1). The Lushs Bight Group rocks were obducted onto the Dashwoods Block, a rifted continental fragment from the Laurentian margin (Waldron and van Staal, 2001), in the early Ordovician (~500–490 Ma) (Szybinski, 1995; Swinden *et al.*, 1997; van Staal, 2007; van Staal and Barr, *in press*). Obduction of the LBOT was coincident with the closure of the Humber Seaway, the oceanic tract that formed between the Dashwoods Block and the Laurentian margin (Waldron and van Staal, 2001), and the closure of this ocean resulted in the formation of the rocks of the Baie Verte belt: the Baie Verte Oceanic Tract (BVOT) (Hibbard, 1983; Bedard *et al.*, 1999; van Staal, 2007; Skulski *et al.*, 2009; Skulski *et al.*, 2010; van Staal and Barr, *in press*). The BVOT contains ophiolitic rocks (*e.g.*, Pacquet Harbour Group) that are ~490–488 Ma (Dunning and Krogh, 1985; Skulski *et al.*, 2009; Skulski *et al.*, 2010), and have primitive arc affinities, including rhyolitic rocks (Piercey *et al.*, 1997; Bedard *et al.*, 1999; Bailey, 2002) (Figure 1). The ophiolitic rocks are host to both Cu-rich VMS deposits (*e.g.*, Tilt Cove) and Au-rich bimodal mafic deposits (*e.g.*, Rambler-Ming; *see below*) (Figure 1). These ophiolitic rocks formed the basement to younger ~487–470 Ma arc-back-arc rocks of the Snooks Arm Group and equivalents (Skulski *et al.*, 2009; Skulski *et al.*, 2010). Obduction of the BVOT in the Ordovician, coupled with extension, resulted in ophiolite emplacement onto the Humber Zone (van Staal, 2007; van Staal and Barr, *in press*), some of which host ophiolite-hosted Cu-rich VMS deposits (*e.g.*, York Harbour) (Duke and Hutchinson, 1974) (Figure 1). The Notre Dame subzone also contains later Ordovician rocks of the Anniepsquotch Accretionary Tract (AAT) that includes ~480–473 Ma ophiolitic rocks (*e.g.*, Anniepsquotch Ophiolite), and ~473–462 Ma arc and back-arc rocks of the Buchans–Roberts Arm belt that host the deposits of the Buchans and Pilley’s Island districts (Dunning and Krogh, 1985; Dunning *et al.*, 1987; Lissenberg, 2005; Zagorevski *et al.*, 2006) (Figure 1).

The Exploits subzone also contains abundant VMS deposits of Cambrian to Ordovician age (Figure 1). The deposits of the Victoria Lake supergroup are some of the oldest deposits within the Exploits subzone and formed within arc and arc-rift complexes associated with the Penobscot and Popelogan–Victoria arc systems (Dunning *et al.*, 1991; Evans and Kean, 2002; Rogers *et al.*, 2006; van Staal, 2007; Zagorevski *et al.*, 2007; van Staal and Barr, *in press*) (Figure 1). The Tally Pond group (~514–509Ma) hosts some of the oldest VMS systems, including Duck Pond, Boundary, and Lemarchant, and consists of a bimodal assemblage of calc-alkalic to transitional rhyolitic and basaltic rocks with lesser carbonaceous sedimentary rocks (Evans and Kean, 2002; Rogers and van Staal, 2002; Rogers *et al.*, 2006)

(Figure 1). The Tally Pond group contains inherited zircon of Neoproterozoic age, and is underlain by Neoproterozoic (~563Ma) arc rocks of roughly similar age (*e.g.*, Sandy Brook Group; Figure 1) and are interpreted to have formed a peri-continental/continental arc that developed upon a Neoproterozoic basement (Rogers *et al.*, 2006; McNicoll *et al.*, 2010). The Tally Pond group is in thrust contact with the Long Lake group, which consists of bimodal volcanic rocks that are late Cambrian (~505 Ma) and host the Long Lake deposit and other showings (Evans and Kean, 2002; Rogers and van Staal, 2002; Rogers *et al.*, 2006) (Figure 1). The younger belts in the Victoria Lake supergroup include the Tulks group (~498 Ma), the Pats Pond group (~488 Ma) (Rogers and van Staal, 2002; Rogers *et al.*, 2006), the Sutherlands Pond group (*ca.* 462 – 457 Ma; Zagorevski *et al.*, 2008; Dunning *et al.*, 1987), and the Wigwam Brook group (~453 Ma; van Staal *et al.*, 2005; Zagorevski *et al.*, 2007), which are parts of the classically described Tulks Volcanic Belt (TVB), a terminology we use herein (McKenzie *et al.*, 1993; Evans and Kean, 2002; Hinchey, 2011). The TVB lies in fault contact with the Long Lake group (Figure 1). The TVB has varying styles of mineralization ranging from shale- and rhyolitic volcanoclastic-rich deposits (*i.e.*, Bathurst-like) in the south of the belt (*e.g.*, Tulks East, Boomerang), ranging to hybrid VMS-epithermal-type deposits in the north of the belt (*e.g.*, Bobby's Pond, Daniel's Pond) (Hinchey, 2011) (Figure 1). The northeastern portion of the Exploits Subzone also hosts VMS mineralization within primitive arc rocks of the lowermost portion of the Wild Bight Group (Swinden *et al.*, 1990; MacLachlan and Dunning, 1998; MacLachlan *et al.*, 2001) (Figure 1). The Glovers Harbour Formation of the Wild Bight Group is the host to the VMS mineralization in the group, and consists of a ~486 Ma mafic dominated, bimodal assemblage of boninite and low-Ti arc tholeiites (Swinden *et al.*, 1990; MacLachlan and Dunning, 1998; MacLachlan *et al.*, 2001). The Glovers Harbour Formation is host to the Point Leamington and Lockport deposits (Walker and Collins, 1988) (Figure 1).

VOLCANOGENIC MASSIVE SULPHIDE (VMS) DEPOSIT CLASSIFICATION AND SETTING

Volcanogenic massive sulphide (VMS) deposits form as a result of the syngenetic exhalation of metalliferous hydrothermal fluids upon or near the sea floor. These deposits are classified in numerous manners (*e.g.*, metal content, type locality), but the most robust and widely accepted classification involves the utilization of host lithostratigraphy and geodynamic setting (Barrie and Hannington, 1999; Franklin *et al.*, 2005; Galley *et al.*, 2007). Under the lithostratigraphic classification deposits are classified into six groups, including (Figure 2): 1) mafic; 2) mafic–siliciclastic (or pelitic–mafic); 3) bimodal–mafic; 4) bimodal

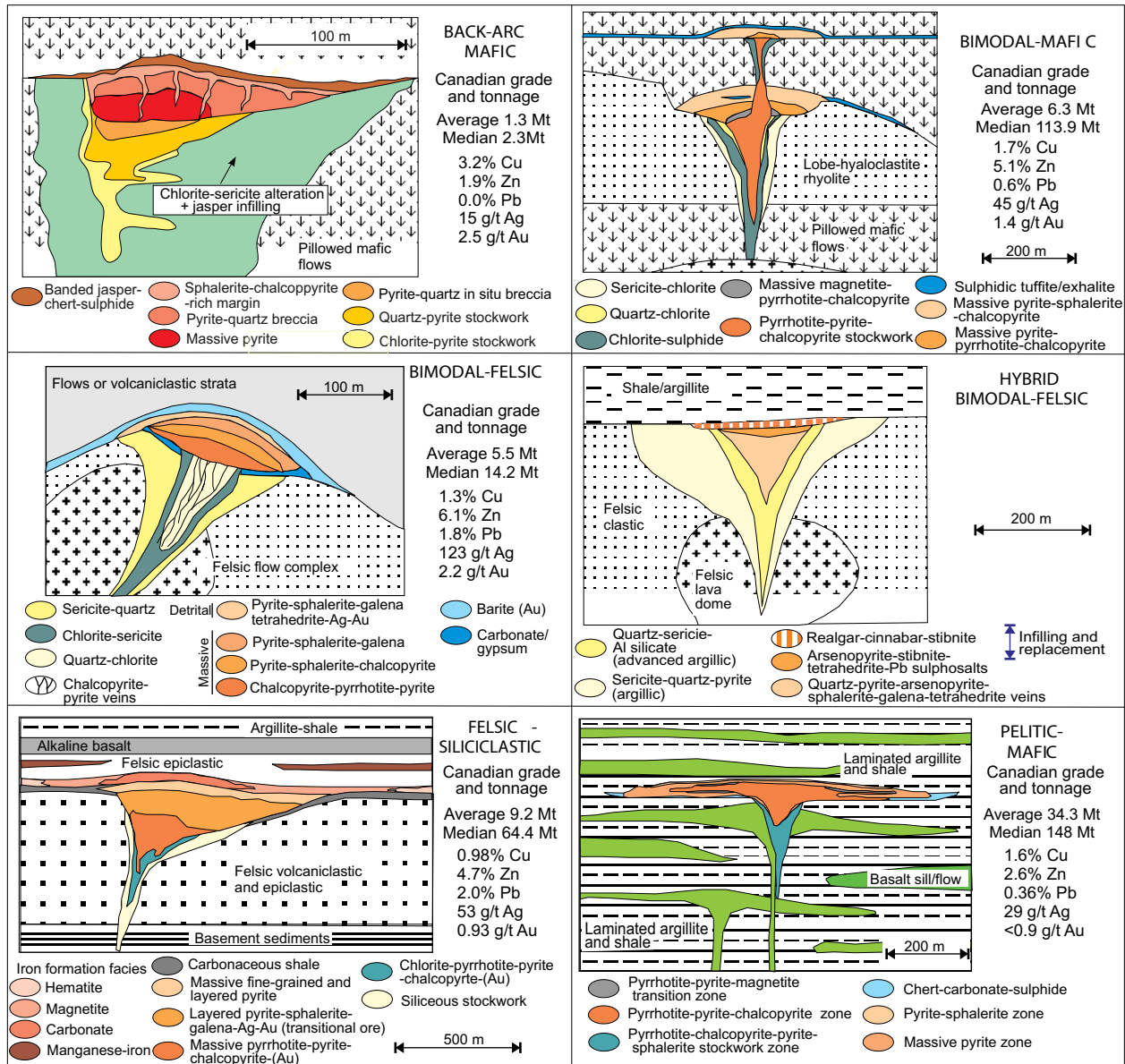


Figure 2. Lithostratigraphic classification of volcanogenic massive sulphide (VMS) deposits, with emphasis on Canadian deposits. Classification based on Barrie and Hannington (1999), Franklin et al. (2005), and Galley et al. (2007). Diagram modified from Galley et al. (2007).

felsic; 5) felsic siliciclastic; and 6) hybrid bimodal felsic. With minor exception, all of these various sub-types of the VMS clan are found in Newfoundland. The details of each of these deposit classifications are as follows (*op. cit.*):

- 1) **Mafic** – these are VMS deposits hosted by mafic/ophiolitic rocks where the deposits are typically Cu–(Zn)-rich and hosted within basaltic flows or sheeted dykes. These are the Cyprus-type deposits and the deposits of the Springdale Peninsula, Betts

- Cove Complex, and the ophiolitic rocks of the Bay of Islands are Newfoundland examples (Figures 1 and 2).
- 2) **Mafic Siliciclastic** – these are VMS deposits hosted in sequences rich in sedimentary rocks, often carbonaceous or turbiditic in nature, and interlayered with abundant basaltic intrusive and extrusive rocks, with or without ultramafic rocks. These deposits are the Besshi-type deposits, are typically Cu–Co–Au-enriched, and there are no bona fide examples of this deposit type in the Newfoundland Appalachians (Figure 2).
 - 3) **Bimodal Mafic** – these are VMS deposits hosted in belts that are mafic dominated, but where the deposits are often hosted by felsic rocks. Often these environments are primitive arc terranes, they are often polymetallic, but with abundant Zn and Cu. These are the VMS deposits that are common to the Noranda and Flin Flon districts, and Newfoundland Appalachian examples include deposits such as Ming, Rambler, and Point Leamington (Figures 1 and 2).
 - 4) **Bimodal Felsic** – these are VMS deposits hosted in belts that are bimodal, but felsic dominated, and in which the deposits are typically hosted by felsic volcanic and volcanoclastic rocks. They are the polymetallic (Zn–Pb–Cu–Au–Ag–Ba) Kuroko-type deposits. The Buchans, Duck Pond, and Lemarchant deposits are examples of this type of deposit in the Newfoundland Appalachians (Figures 1 and 2).
 - 5) **Felsic Siliciclastic** – these are VMS deposits that are hosted within volcanic and sediment-rich belts, where there are abundant siliciclastic sedimentary rocks, often graphitic, iron formation, and the volcanic rocks are often volcanoclastic. This deposit type is typical of the Brunswick-type deposits in the Bathurst Mining Camp, they are polymetallic, and the Tulks East and Boomerang deposits of the Newfoundland Appalachians are examples of this sub-group (Figures 1 and 2).
 - 6) **Hybrid Bimodal Felsic** – these deposits are those that are like bimodal felsic deposits, but they contain additional features, including aluminous alteration attributes, precious metal enrichments, and enrichments in epithermal suite elements (*e.g.*, Bi–Te–Hg–Sb–As). They are interpreted to be shallow water VMS systems with features hybrid between epithermal and VMS deposits. They are similar to the deposits at Eskay Creek and in the Bousquet-LaRonde camp; the Daniel’s Pond deposit represents an example of this sub-type (Figure 2).

The various deposits types above are found in different VMS belts within Newfoundland. In the Exploits subzone, the belts include (Figure 1):

- 1) **Tally Pond Belt** – this belt is hosted by the ~514–509 Ma Tally Pond group, and contains the bimodal felsic Duck Pond, Lemarchant, and Boundary deposits;
- 2) **Long Lake Belt** – this belt is hosted by the bimodal, yet felsic dominated ~505 Ma Long Lake group, and it contains the bimodal felsic Long Lake deposit;
- 3) **Tulks Belt** – this belt hosted by the bimodal, yet felsic volcanoclastic-dominated ~498–453 Ma Tulks Volcanic Belt. The belt has highly variable deposits, ranging from felsic siliciclastic deposits (Boomerang, Tulks East), bimodal felsic deposits (Tulks Hill, Victoria Mine), and hybrid bimodal felsic deposits (Bobby’s Pond, Daniel’s Pond).
- 4) **Point Leamington Belt** – this belt is hosted by the ~486 Ma primitive arc rocks of the Glovers Harbour Formation of the Wild Bight Group in the northeastern Notre Dame Bay area. The belt contains bimodal mafic deposits, including Point Leamington and Lockport.

In the Notre Dame subzone the belts include (Figure 2):

- 1) **Springdale Belt** – this belt is hosted by the ~505 Ma ophiolitic rocks of the Lushs Bight group and consists of mafic-type deposits, including Little Deer, Whalesback, Little Bay, and Colchester.
- 2) **Baie Verte Belt** – this belt consists of deposits hosted by ~489 Ma ophiolitic rocks of the Betts Cove ophiolite complex and ~487 Ma rocks of the Pacquet Harbour Group. In both sequences the deposits are hosted by primitive arc rocks, with mafic-type deposits hosted within boninitic and tholeiitic pillow lavas in the Betts Cove complex, whereas precious metal-rich bimodal mafic deposits are hosted by rhyolitic rocks within the Rambler Camp, including the Ming, Rambler Main, East, and Big Rambler Pond mines.
- 3) **Buchans–Roberts Arm Belt** – this belt is hosted by ~471–465 Ma calc-alkalic to much lesser tholeiitic rocks of the Anniopsquotch Accretionary Tract. Deposits of the Buchans area are bimodal felsic deposits hosted by the Buchans Group. Deposits in the Roberts Arm/Pilley’s Island area are bimodal felsic deposits hosted by the Roberts Arm Group. The Skidder Formation of the Red Indian Lake Group hosts the mafic dominated Skidder deposit.

FIELD TRIP STOP DESCRIPTIONS

Where available, all stops are given in universal transverse mercator (UTM) coordinates using North American Datum 1927 (NAD27). All are in UTM zone 21.

DAY 1 – MAY 30th

The first part of May 30th will involve departure from St. John's and travel to central Newfoundland. Participants will be staying at the Mount Peyton Hotel in Grand Falls-Windsor (214 Lincoln Road, Grand Falls-Windsor, NL, A2A 1P8, Ph. - 1-800-563-4894 or 709-489-2251). There will be a few stops to outline regional geology and we will visit the historic Buchans district. The number of stops on this day will be limited to ensure that people can check in to their hotel at a reasonable hour.

STOP 1.1: Caradoc Shale and Chert – Red Cliff Section (Easting: 588850, Northing: 5421900)

(Modified from Thurlow et al., 1988)

This stop is located just past the Red Cliff overpass heading west from Grand Falls on the Trans-Canada Highway. Vehicles should be parked on the north side of the Trans-Canada Highway. Care must be taken to ensure that people are safe as this area is often very busy with abundant traffic. Participants must also be careful of falling rocks from the road cuts.

The outcrop consists of highly folded and faulted sections of mid-Ordovician (Caradoc) chert and shale along two road cuts. The outcrop contains Caradoc shales and cherts that are conformably overlain by Sansom Greywacke. The rocks are laminated to bedded with thin shale and chert beds that contain variable amounts of phosphatic materials and pyrite of both fracture-filling and framboidal varieties; the latter is often weathered leading to sulphide staining on many exposures. The shales are often graptolite bearing. They are interpreted to have been deposited in the Caradoc upon rocks of the Victoria Lake supergroup after arc-arc collision between peri-Gondwanan and peri-Laurentian terranes along the Red Indian Line.

Participants will drive from Stop 1.1 to the core storage facility in the town of Buchans. First drive to Badger along the Trans-Canada Highway, turn left at Badger, and then drive along the Buchans Highway to the town of Buchans to the Buchans core storage facility.

STOP 1.2: Ski Hill Buchans (Easting: ~509824, Northing: ~5048260)

This stop is located behind the core storage facility and the vehicles should be parked either at this facility or along the Sandy Lake Road (location GB-5 on Figure 3). Participants should follow field trip leaders and walk to the top of Ski Hill. Please be careful walking on the trail up the ski hill and the general area and terrane around the core storage facility.

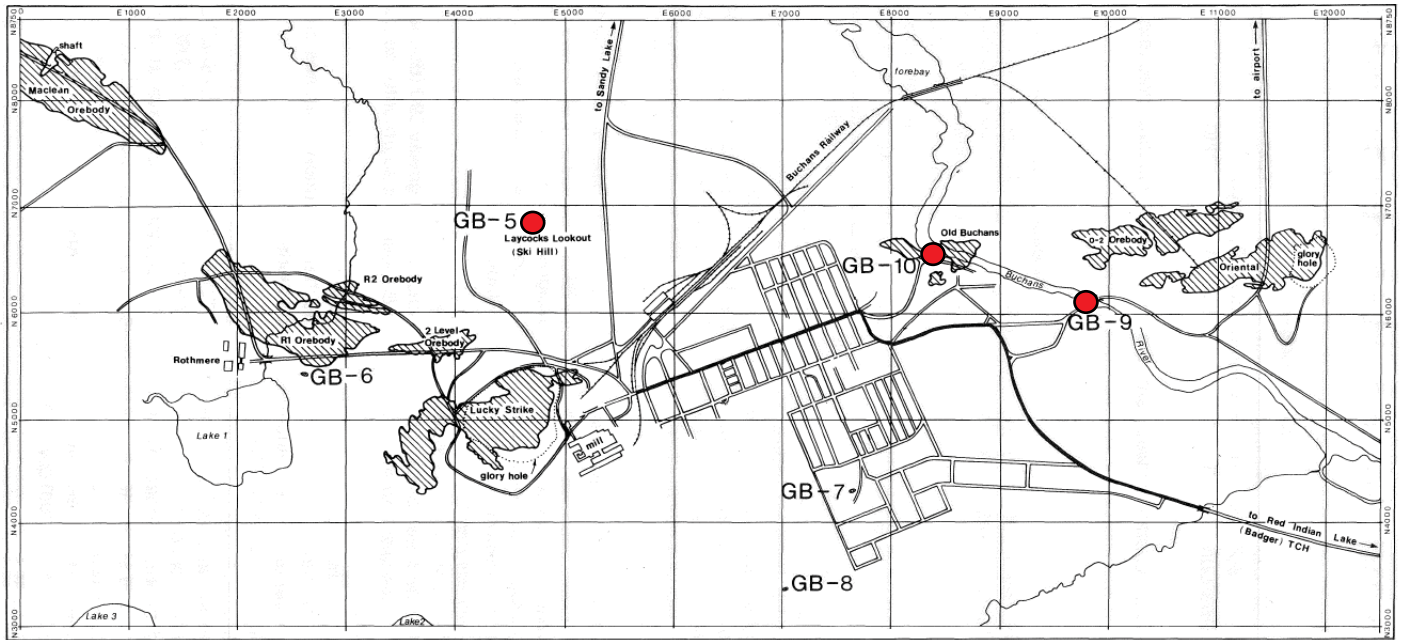


Figure 3. Field trip stops for the Buchans region. Diagram from Thurlow et al. (1988).

This area contains an outstanding regional view of the Buchans and surrounding area. Ski Hill itself contains basaltic to andesitic volcanic and volcanoclastic rocks of the Ski Hill Formation, the deeper footwall basaltic rocks to the Buchans deposits. Towards the southeast and in the distance south of Red Indian Lake, one can see Harpoon Hill and Hungry Hill which are intrusions into the rocks of the Victoria Lake supergroup. Red Indian Lake and rocks in the foreground represent the Red Indian Line and peri-Laurentian rocks. Also present in the immediate Buchans area one can see the relict pits from old mine operations, including the glory hole from the Lucky Strike pit. Towards the north, west, and east are the rocks of the younger Silurian Topsails Igneous Suite.

STOP 1.3: Discovery Outcrop from the Buchans Orebodies (Easting: 510886, Northing: 5408118)

No hammering please!

This stop is located near the Buchans River and easily accessible just off the main street of Buchans (location B-10 on Figure 3). Park vehicles near the building just off of Main Street and walk towards the Buchans River. Be careful of slippery rocks and ensure your footing.

This is the location of the original prospector's discovery and what became the Old Buchans Orebodies (Thurlow *et al.*, 1988). The outcrops consist of barite breccias with sulphide clasts, and grey to white rhyolitic clasts that are angular with interstitial pyrite. The outcrop contains a fault, Buchans River Thrust of Thurlow *et al.* (1988), with some of the rhyolitic fragmental rocks being potentially rounded by the fault. At the west end of the outcrop are granitic cobbles potentially representing the Feeder Graniodiorite with basalt, rhyolite/dacite, and sulphides.

STOP 1.4 (optional): Arkose of the Sandy Lake Formation (Easting: 511399, Northing: 5407944)

(Modified from Thurlow et al., 1988)

This stop is within walking distance from the previous stop and consists of thick sections of arkose that are typical of the Buchans Group (location GP-9 on Figure 3). The rocks contain varying amounts of quartz, plagioclase, and rhyolitic clasts, and under the bridge there are matrix-supported conglomerates with rhyolitic clasts and large quartz phenocrysts. These likely represent the weathering products of rhyolitic rocks of the Buchans Group and the hosts to mineralization.

Participants will drive from STOP 1.4 and return to Grand Falls-Windsor to accommodations at the Mount Peyton Hotel.

DAY 2 – MAY 31st

TALLY POND BELT DEPOSITS

Participants will drive from Grand Falls-Windsor to the Duck Pond minesite. Drive west from Grand Falls-Windsor to Badger, take a left onto the Buchans Highway, drive to Buchans Junction and take a left at the turn off to Millertown. Drive from through Millertown onto a dirt road at the end of Millertown. This dirt road is the road to the Duck Pond mine. Drive ~27 km to the Duck Pond minesite, follow all signage and obey speed limits along this road. During Day 2 we will visit the Duck Pond and Lemarchant VMS deposits in the Tally Pond Belt (Figure 4).

STOP 2.1: Duck Pond Mine Site

This stop will include an underground visit of the Duck Pond deposit for some visitors and examination of drill core from the Duck Pond and Boundary deposits. Participants must adhere to all safety regulations of Teck Duck Pond Operations, including wearing proper personal protective equipment, where appropriate.

The Duck Pond deposit is one of Newfoundland's producing VMS deposits and combined with the Boundary deposit has a geological tonnage of 4.078 Mt @3.29% Cu, 5.68% Zn, 0.9% Pb, 59.3g/t Ag and 0.9g/t Au (Aur Resources Ltd., 2007, Company Brochure). The Duck Pond deposit contains two blocks: a Mineralized Block, which hosts the deposit, and an Upper Block, which is weakly mineralized, and these are offset along the Duck Pond Thrust (Figures 5 to 7) (Squires *et al.*, 1991, 2001; Piercey, 2007a). Uranium–Pb zircon ages from the Mineralized Block are ~509 Ma, whereas the ages from the Upper Block are ~513–512 Ma (McNicoll *et al.*, 2010). The Mineralized Block consists of polygonally jointed, block rhyolite flows and tuff breccias that host the mineralization at Duck Pond (Figures 5 to 7). The mineralization occurs as multiple lenses which occur in permeable zones within the volcanic and volcanoclastic rocks, often occurring within polygonal joints in the rhyolite flows or replacing volcanoclastic rocks; these textural associations have been interpreted to represent replacement-style mineralization (Squires *et al.*, 1991, 2001). The mineralization occurs in numerous “lenses”, with the bulk of the mineralization hosted within the Upper Duck Lens and the Sleeper Lens. Additional resources occur deeper in the stratigraphy within the Lower Duck Lens, likely representing a faulted offset of the upper lenses in the mine (Squires *et al.*, 1991, 2001) (Figures 5 to 7). The mineralization in the Upper Duck and Sleeper lenses are often zoned with an outer zone of pyritic massive sulphide that is partially recrystallized and grades inwards towards more Zn-rich mineralization, and ultimately to more Cu-rich mineralization in the centre of the lenses (Squires *et al.*, 1991, 2001; Piercey, 2007a). Footwall alteration within the deposit ranges from distal

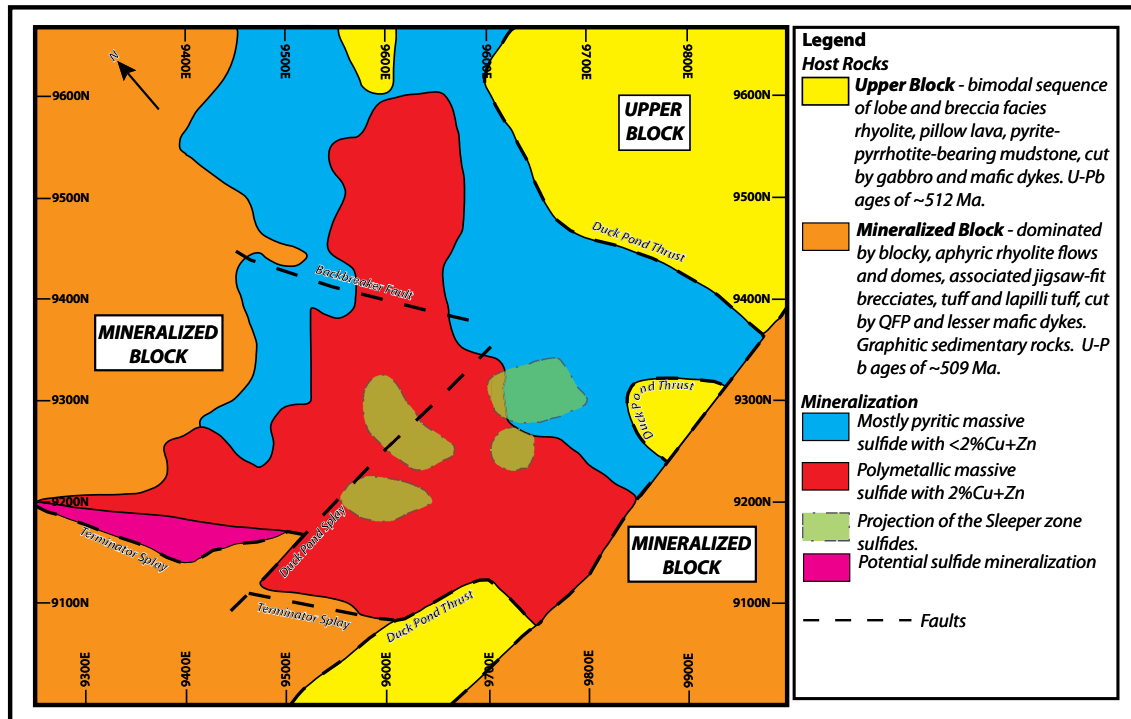
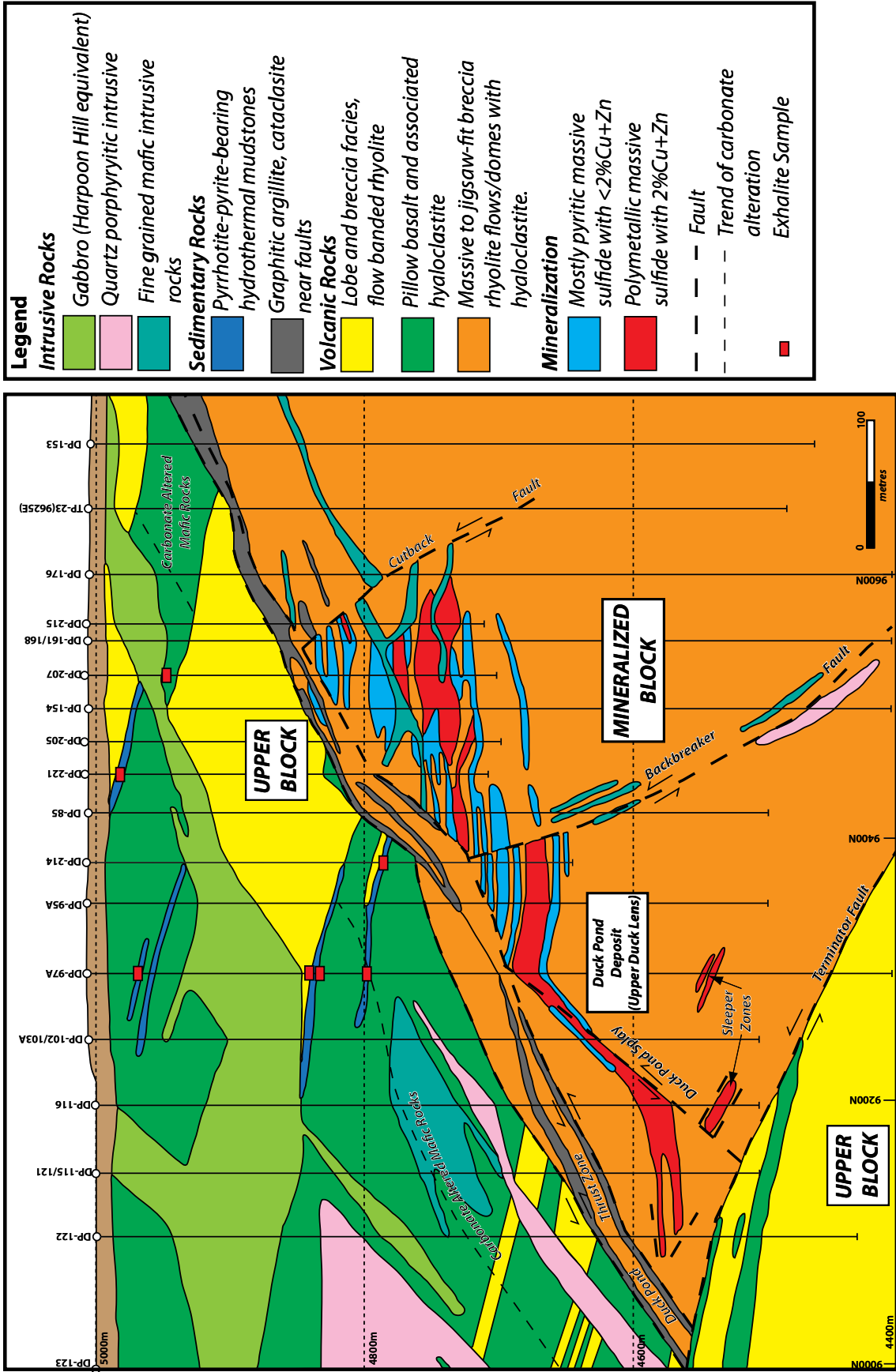


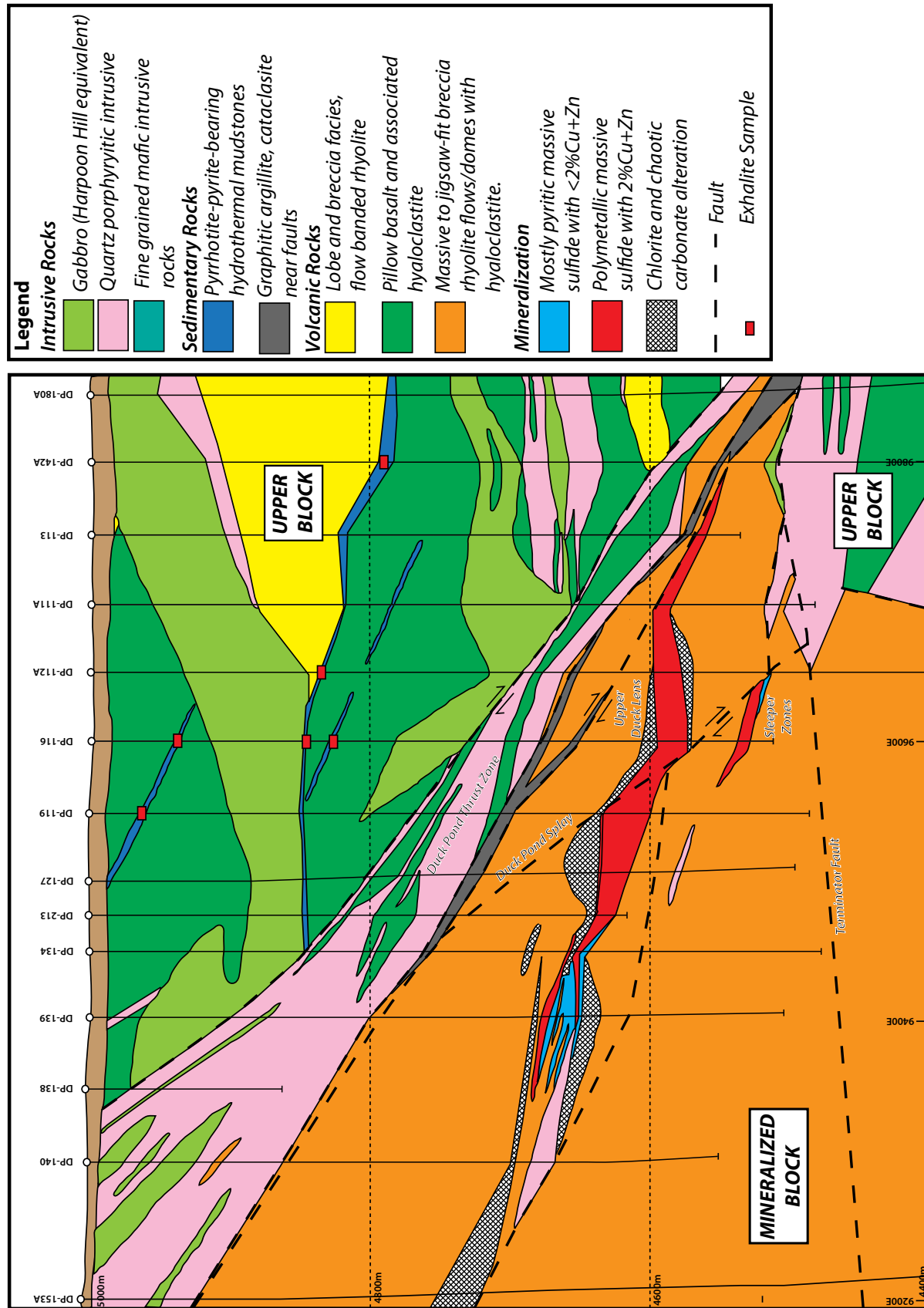
Figure 5. Shadow plot of the Duck Pond massive sulphide lenses and the associated geological host units. The diagram projects the geology from ~200-450 m depth onto a horizontal surface. Diagram from Squires *et al.* (2001).

sericite and quartz alteration, to strong chlorite–quartz and locally “chaotic carbonate” alteration that consists of dendrites and balls of dolomite proximal to Cu-rich mineralization (Squires *et al.*, 1991, 2001; Piercey, 2007a).

The Upper Block has contrasting lithofacies with the Mineralized Block and contains a bimodal assemblage of interlayered basaltic and rhyolitic rocks (Figures 5 to 7). The basaltic rocks are predominantly pillow lavas and massive flows with lesser hyaloclastite and volcanoclastic rocks (Squires *et al.*, 1991, 2001; Piercey, 2007a). These rocks are interlayered with rhyolitic rocks distinctive from the Mineralized Block, consisting of flow banded, locally glassy, lobe and breccia facies rhyolites (Squires *et al.*, 1991, 2001; Piercey, 2007a). Locally the rhyolitic rocks form distinctive breccias that are matrix supported and consist of variably altered rhyolite clasts in a “marker unit” (Squires *et al.*, 1991, 2001; Piercey, 2007a). Both the mafic lavas and rhyolitic rocks are interlayered with pyrrhotite- to pyrite-bearing hydrothermal mudstone units (Piercey *et al.*, 2012). These units are interpreted to be distal hydrothermal sedimentary rocks (Piercey *et al.*, 2012).

The Boundary deposit is located 4 km to the northeast of the Duck Pond deposit (Figure 4). The deposit bears some similarities to the Duck Pond deposit, with deeper footwall rocks





having very similar features to the blocky rhyolite flows in the mineralized block at Duck Pond (Squires *et al.*, 1991; Wagner, 1993; Piercey, 2007b; Piercey *et al.*, *in prep.*). The immediate hosts to mineralization, however, are fundamentally different than Duck Pond and consists of a flat lying assemblage of rhyolite lapillistone with abundant, clast-supported lapillistone with rounded rhyolitic clasts and interstitial variably altered rhyolite shards and ash (Figures 8 to 11). The mineralization is overlain and occurs at the contact between these lapillistones and an overlying variably altered lobe and breccia facies, quartz-bearing, flow banded rhyolite (Figures 8 to 11). The mineralization is dominated by pyrite, chalcopyrite,

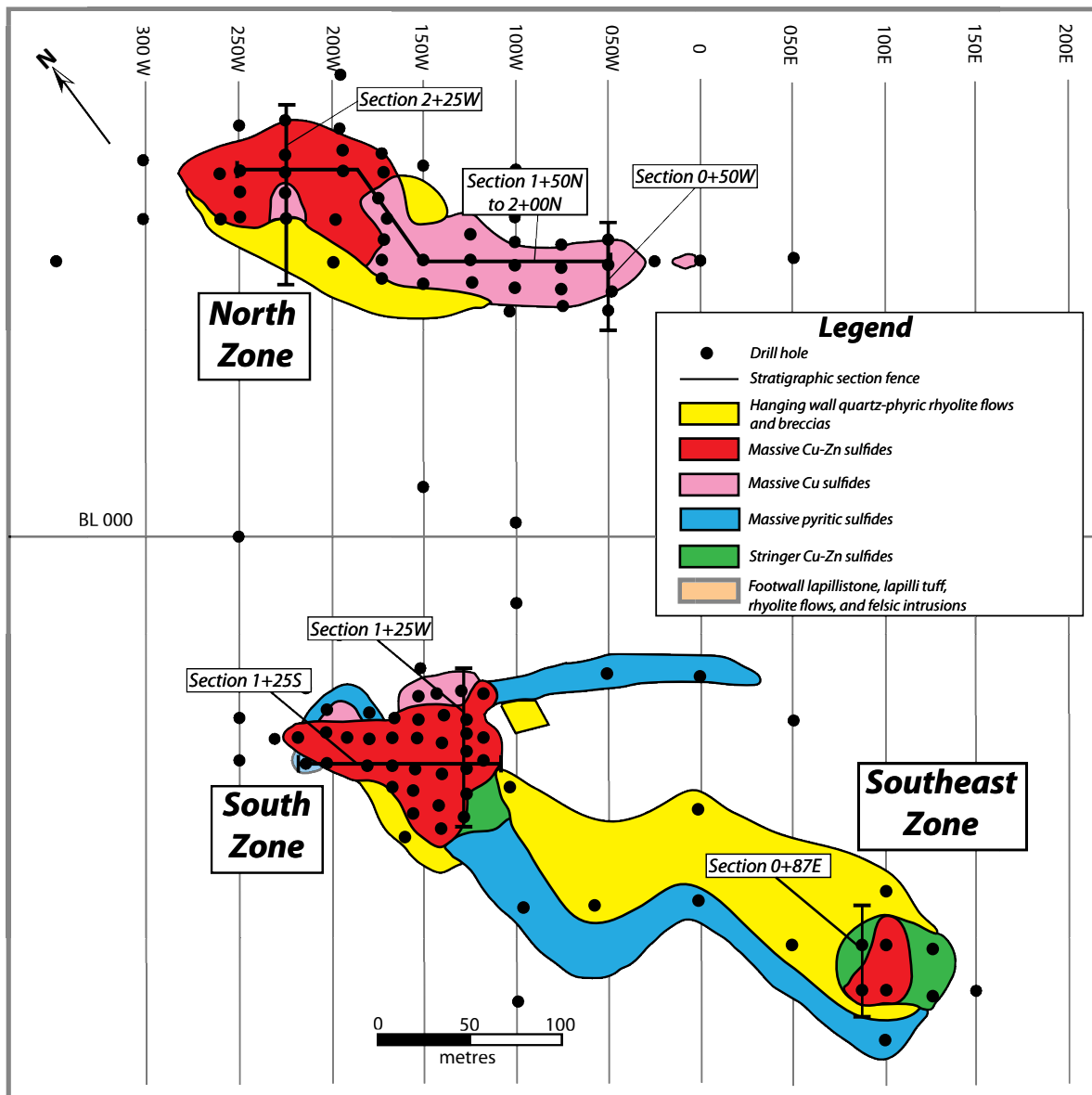


Figure 8. Boundary deposit surface geology plan map with distribution of sulphide mineralization types, and locations of sections in Figures 9-11. Diagram modified from Squires *et al.* (2001).

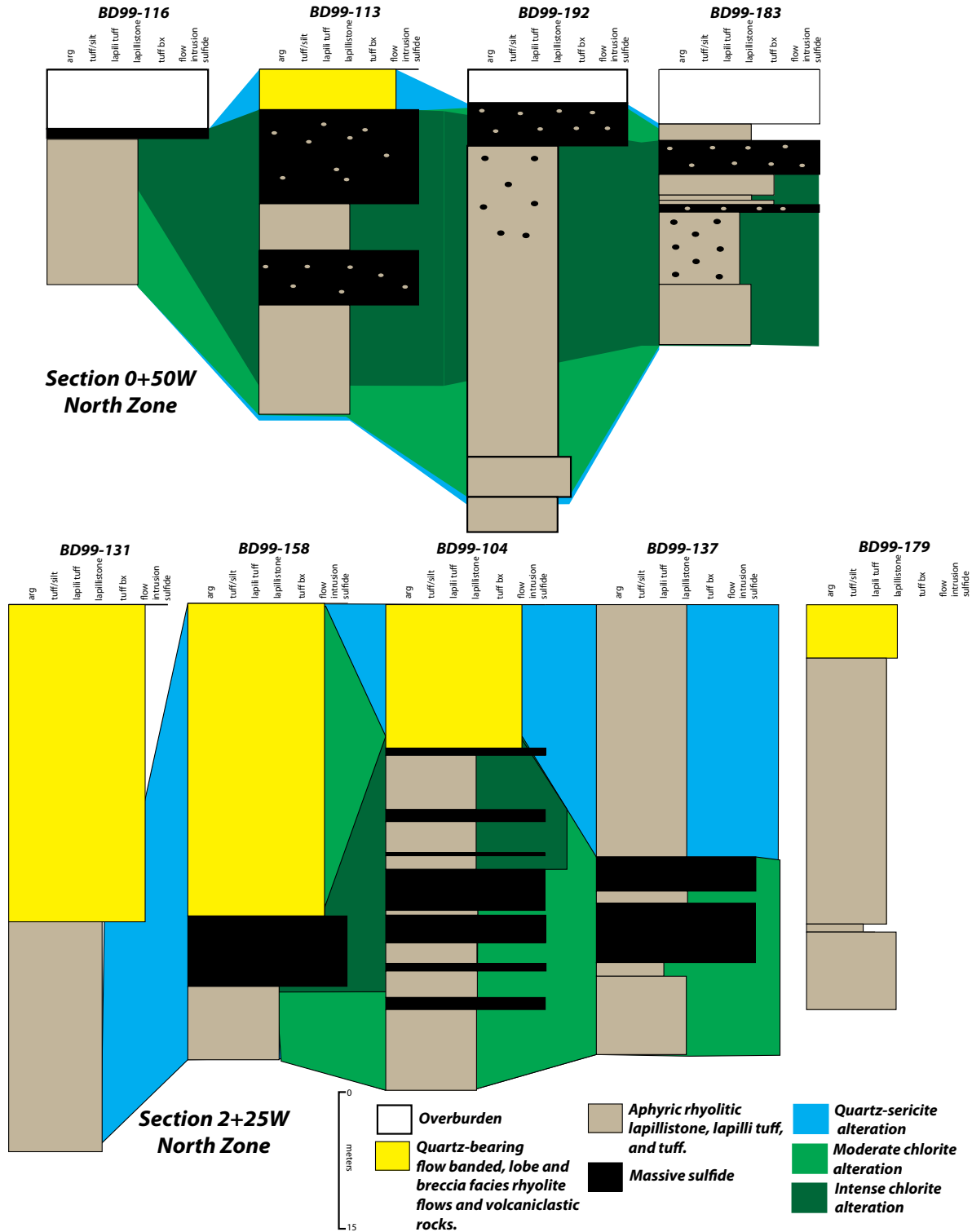


Figure 9. Stratigraphic fence diagrams/cross sections from the North Zone of the Boundary deposit. Locations of sections shown on Figure 8. Diagrams from Piercey et al. (in prep.).

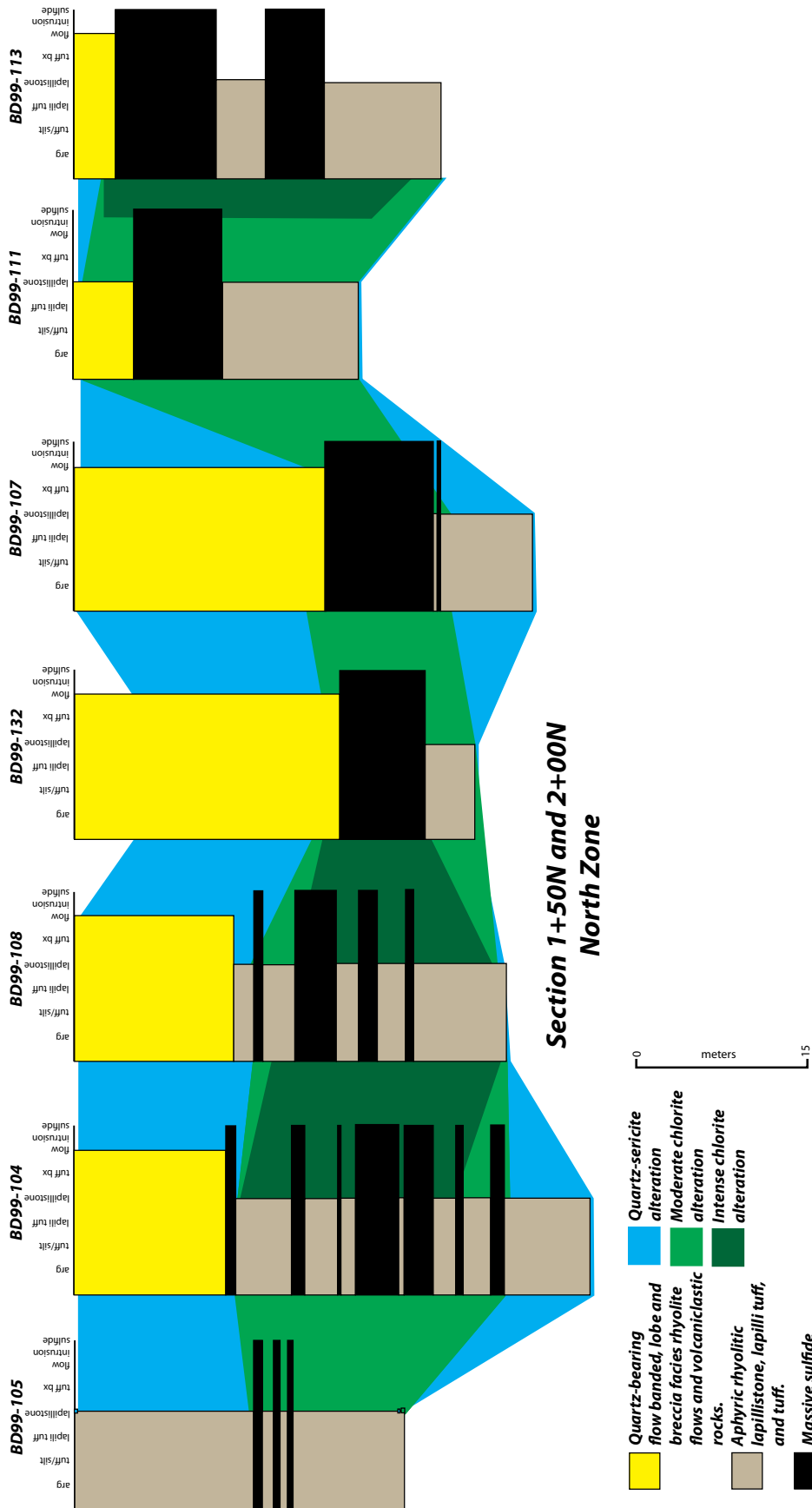


Figure 10. Stratigraphic fence diagram/long section from the North Zone of the Boundary deposit. Locations of Figure 8. Diagrams from Piercey et al. (in prep.).

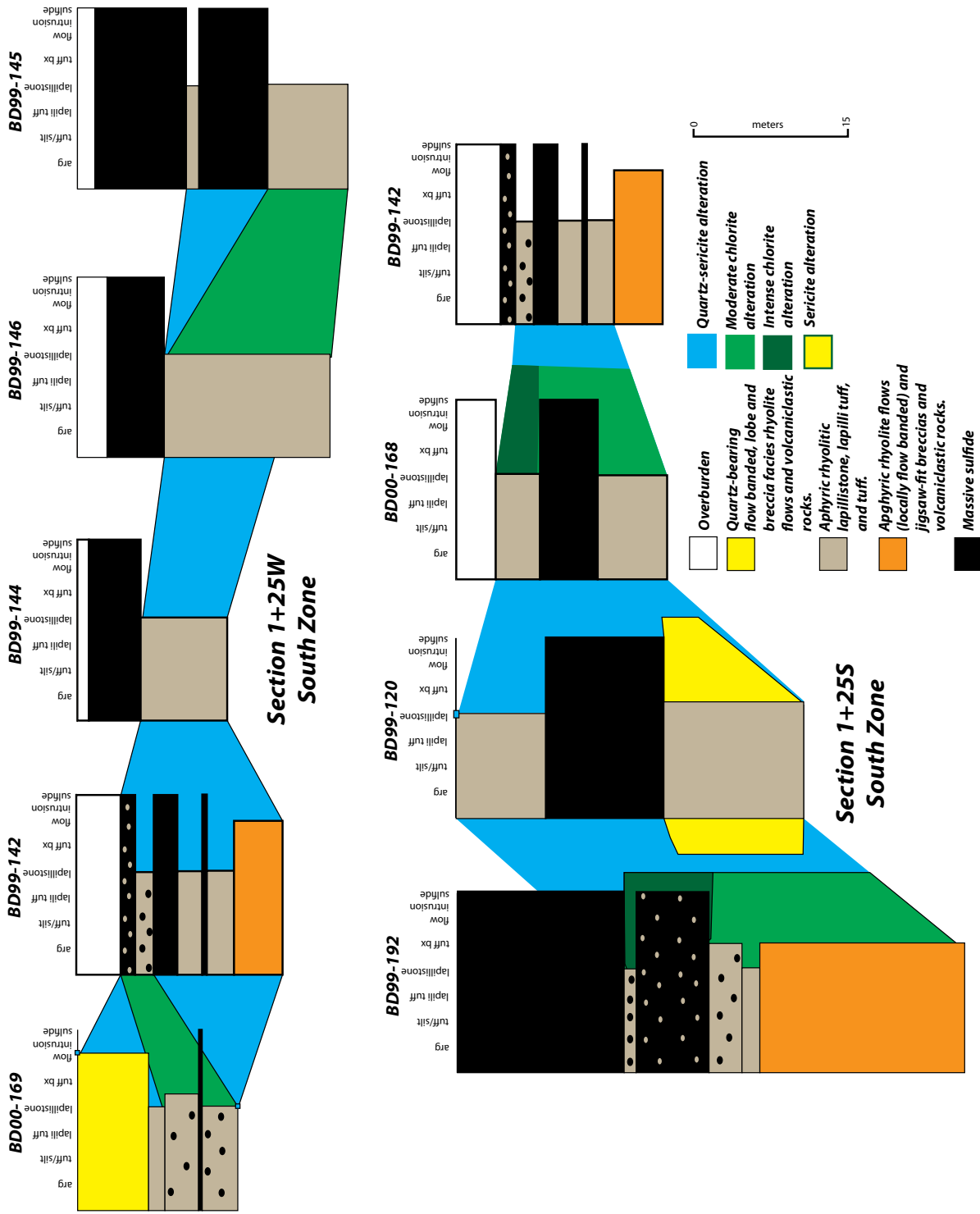


Figure 11. Stratigraphic fence diagrams/cross sections from the South Zone of the Boundary deposit. Locations of sections shown on Figure 8. Diagrams from Piercey et al. (in prep.).

and lesser sphalerite that occurs in three zones: the south, southeast, and north zones that have similar stratigraphic, alteration, and mineralization associations (Squires *et al.*, 1991; Wagner, 1993; Piercey, 2007b; Piercey *et al.*, *in prep.*); Wagner (1993) proposed that the north zone was fault offset from the south and southeast zones, and recent stratigraphic and geophysical data are in support of this interpretation (Squires, pers. comm., 2012) (Figure 8). The mineralization occurs as roughly bedding parallel lenses that consist of pyrite and chalcopyrite, with lesser sphalerite and pyrrhotite (Figures 8 to 11). The sulphides also contain abundant clasts of host rhyolite that is variably altered to quartz, sericite, and chlorite. The footwall alteration consists of chlorite proximal to mineralization that grades into sericite and quartz distal from mineralization; alteration also parallels the stratigraphy and sulphide lenses in a horizontal manner (Figures 8 to 11). The alteration also continues into the hanging wall rhyolitic rocks, where present, and consists of quartz and sericite alteration (Figures 8 to 11). The collective relationships above, and sulphide textures, are consistent with the Boundary deposit having formed via seafloor replacement mechanisms (Squires *et al.*, 1991; Wagner, 1993; Piercey, 2007b; Piercey *et al.*, *in prep.*).

STOP 2.2: Paragon Minerals Core Shack

This stop will examine drill core from the Lemarchant deposit (Figures 4 and 12). The drill core facility is located at Buchans Junction and all participants must adhere to all safety regulations of Paragon Minerals, including wearing proper personal protective equipment, where appropriate.

The Lemarchant VMS deposit is located approximately 10km to the southwest of the Duck Pond deposit and is also hosted by the Tally Pond group (Figures 4 and 12). A recent NI-43-101 resource was completed and yielded an indicated resource of 1.24 million tonnes @ 5.38% Zn, 0.58% Cu, 1.19% Pb, 1.01 g/t Au and 59.17 g/t Ag and an inferred resource of 1.34 million tonnes @ 3.70% Zn, 0.41% Cu, 0.86% Pb, 1.00 g/t Au and 50.41 g/t Ag (Paragon Minerals Corp., press release, March 8, 2012 and Fraser *et al.*, 2012). The deposit is hosted within a bimodal assemblage of basalts and rhyolitic rocks that have been variably dissected by thrust faults (Copeland *et al.*, 2008; Copeland *et al.*, 2009; Fraser *et al.*, 2012) (Figures 11 to 13). The deposit's hanging wall is dominated by pillowed and massive basalt flows with lesser interflow chert and hydrothermal sedimentary rocks (Figures 12 and 13). The footwall and the host rocks to the mineralization contain blocky rhyolitic flows and associated volcanoclastic rocks very similar to those present in the Mineralized Block at Duck Pond. However, mineralization at the Lemarchant deposit is dominated by massive sulphide

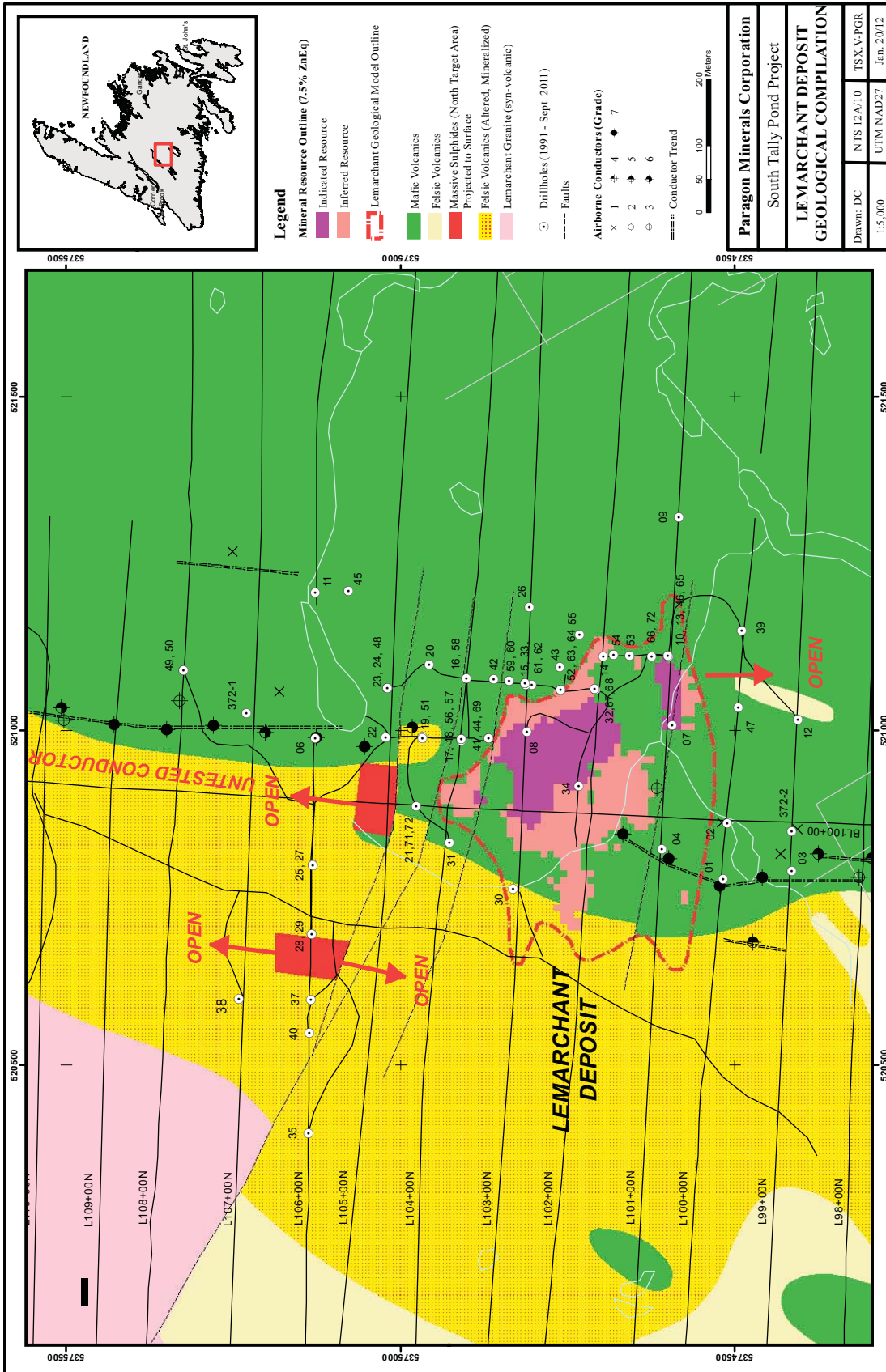


Figure 12. Surface geology, drill hole locations, and resource classifications for the Lemarchant VMS deposit. From www.paragonminerals.com.

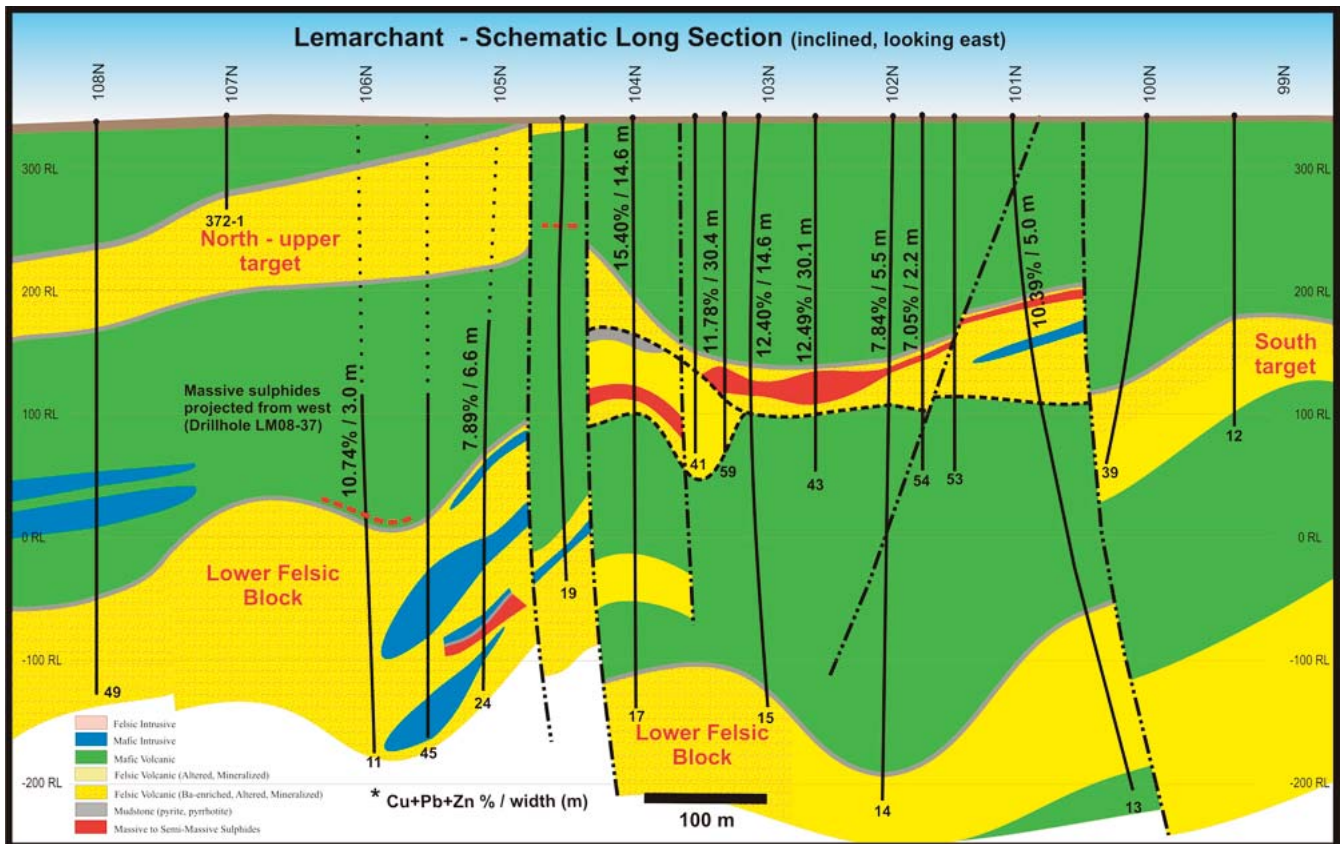
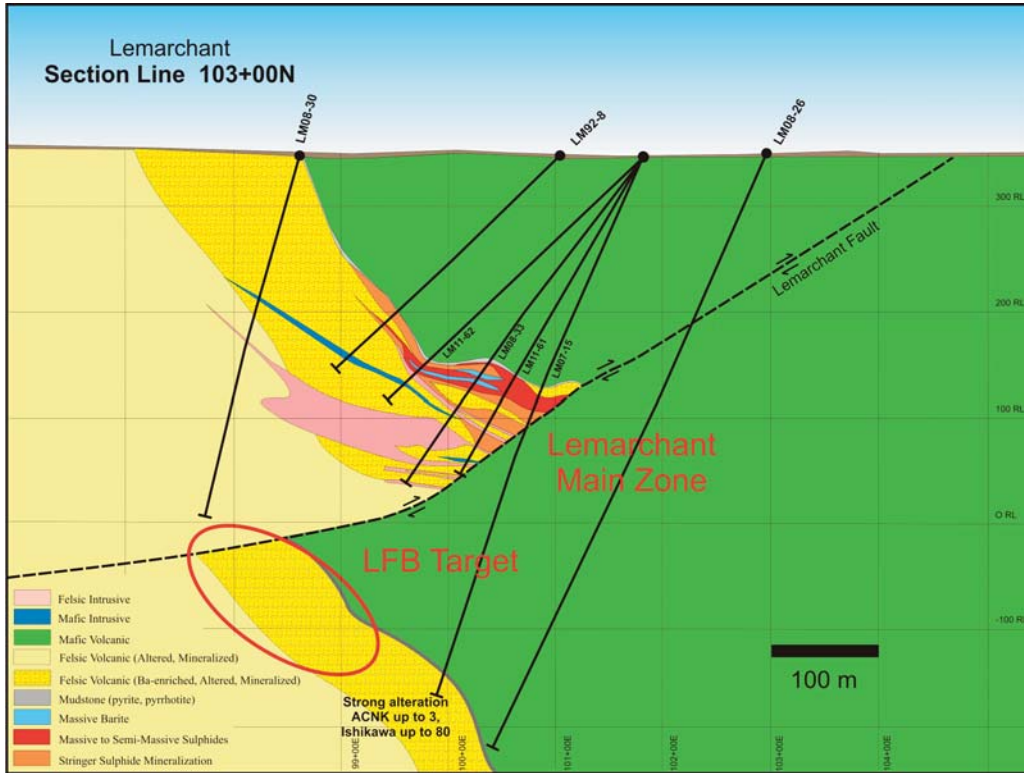


Figure 13. Schematic cross section and long section through the Lemarchant VMS deposit. From www.paragonminerals.com.

intergrown with barite, interpreted to have formed on the seafloor rather than by subseafloor replacement (Copeland *et al.*, 2008, 2009; Fraser *et al.*, 2012) (Figures 12 and 13). The mineralization is dominated by Zn–Pb rich sulphides with abundant galena, sphalerite, tetrahedrite and much lesser pyrite, chalcopyrite, bornite, covellite, digneite, cubanite, and trace amounts gold and stromeryite; all of which is associated with barite (Copeland *et al.*, 2009). The deposit is been interpreted to represent a classic Kuroko-type VMS system that formed from low temperature fluids.

Participants will drive from Stop 2.2 and return to Grand Falls-Windsor to accommodations at the Mount Peyton Hotel.

DAY 3 – JUNE 1st

SPRINGDALE PENINSULA

Participants will drive from the Mount Peyton Hotel on the Trans-Canada Highway to the turnoff for Springdale and Kings Point. Upon reaching the turnoff drive ~8-9 km towards the town of Springdale until you reach the Timbr Mart.

STOP 3.1: Pillow Lavas, of the Lushs Bight Group (Easting: 565022, Northing: 548043)

Park vehicles in the parking lot of the Timbr Mart. This outcrop is proximal to a busy street so participants should be aware of traffic. This is also a road/parking lot cut so be aware of other participants and potentially falling rocks. The outcrops are comprised of typical sheared and chloritized pillow lavas of the Lushs Bight Group (Figure 14). The pillow lavas are broken, veined, and variably deformed with some pyrite and Fe-carbonate stringers. This stop is just to illustrate the typical pillow lavas present in the Lushs Bight Group.

STOP 3.2: Little Bay Mine Area, Shaft Area – Overview (Easting: 576456, Northing: 549103)

Participants should leave the Timbr Mart, take a right, and drive towards the turnoff for Little Bay Mine Road. Take a right on the Little Bay Mine Road and drive towards the town of Little Bay for approximately 15 km towards the Little Bay Mine Road Junction. Turn right here and proceed about 600 m towards the mine. Park vehicles at the bottom of the hill and walk to the top. This area contains numerous covered trenches, capped adits and shafts, and there is fencing around the former mine pits. Please stay clear of all these things. Also, despite being reclaimed, there is debris in places, so be aware of this while traversing the area.

The vantage point from the top of this hill provides an overview of the Little Bay area (Figure 14). The immediate area consists of variably deformed pillow lavas and breccias. In the distance to the north one can see the rusty hills of sheeted dykes. Towards the south, near Little Bay, one can see the reclaimed tailings, the past shipping port, and in the distance rocks of the Roberts Arm Group.

STOP 3.3: Little Bay Mine Area, “Glory Hole” – (Easting: 576394, Northing: 5484240)

Walk down to the base of the hill with the capped shaft and towards the left one will see a small road. The road is passable by 4x4 vehicle, but we will walk in. Walk approximately 200-300 m towards the “glory hole.” This area is littered with debris and the glory

hole has fencing surrounding it to prevent access: beware of the debris and do not go near the fence.

The hills immediately north of the glory hole contain spectacularly preserved pillow lavas that are variolitic and contain amygdules filled with quartz and interpillow chert.

The glory hole illustrates the host and style of mineralization associated with the Little Bay Mine. The mine produced ~3 Mt of ore with grades of 0.8-2% Cu and produced 195 kg of Au during two periods (1878-1894 and 1961-1969) (Kean, 1988; Kean *et al.*, 1995). The mineralization in the glory hole consists of a northeast trending chlorite schist zone that occurs as a vertical surface with gossanous rocks towards the northwest (footwall?) and well-developed variolitic pillow lavas towards the north. The mineralization within the Little Bay Mine occurred as massive lenses, pods, veins, and veinlets of sulphide and sulphide-bearing quartz veins. This site is visited as it gives insight into the nature of mineralization that will be seen in drill core at the Little Deer deposit (Stop 3.6).

STOP 3.4: Catchers Pond Group Rhyolite

(Modified from Kean, 1988)

From the previous stop drive back to the Little Bay Mine road and head back towards the Springdale Highway. When the turnoff is reached, turn right and head towards the Kings Point Road. Turn right and drive approximately 2.9 km. The outcrop is located on the right side of the Kings Point Road. Given that this is a highway road cut be careful for traffic and for falling rocks from the rock faces.

This outcrop consists of pink to purple columnar jointed rhyolite from the Catchers Pond Group (Figure 14). The unit is variably pyrite altered and locally clastic with lapilli. In places it is potentially welded. The Catchers Pond Group is early Ordovician (Dunning and O'Brien, pers. comm.) and was deposited on top of the Lushs Bight Group (Kean, 1988). This outcrop is mostly shown to illustrate the textures associated with younger columnar jointed rhyolites of the Springdale Peninsula.

STOP 3.5: Springdale Group Conglomerate – (Easting: 559664, Northing: 5484923)

Turn around at an appropriate location and drive towards the Springdale Highway. There is a large road cut approximately 1.5 km back from the turnoff to the Springdale Highway. As in Stop 3.4 this is a road cut so be aware of oncoming traffic and falling rocks.

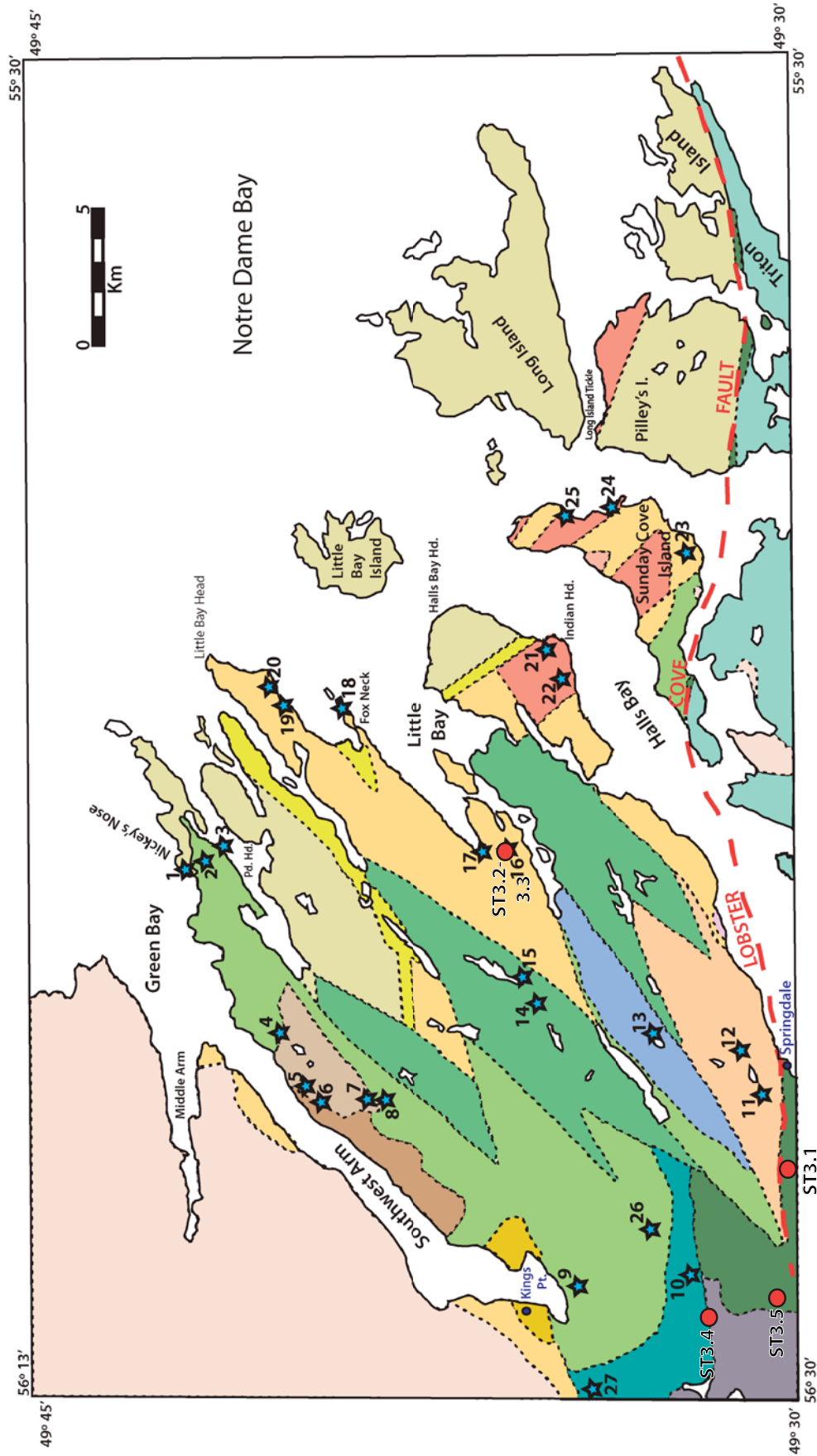
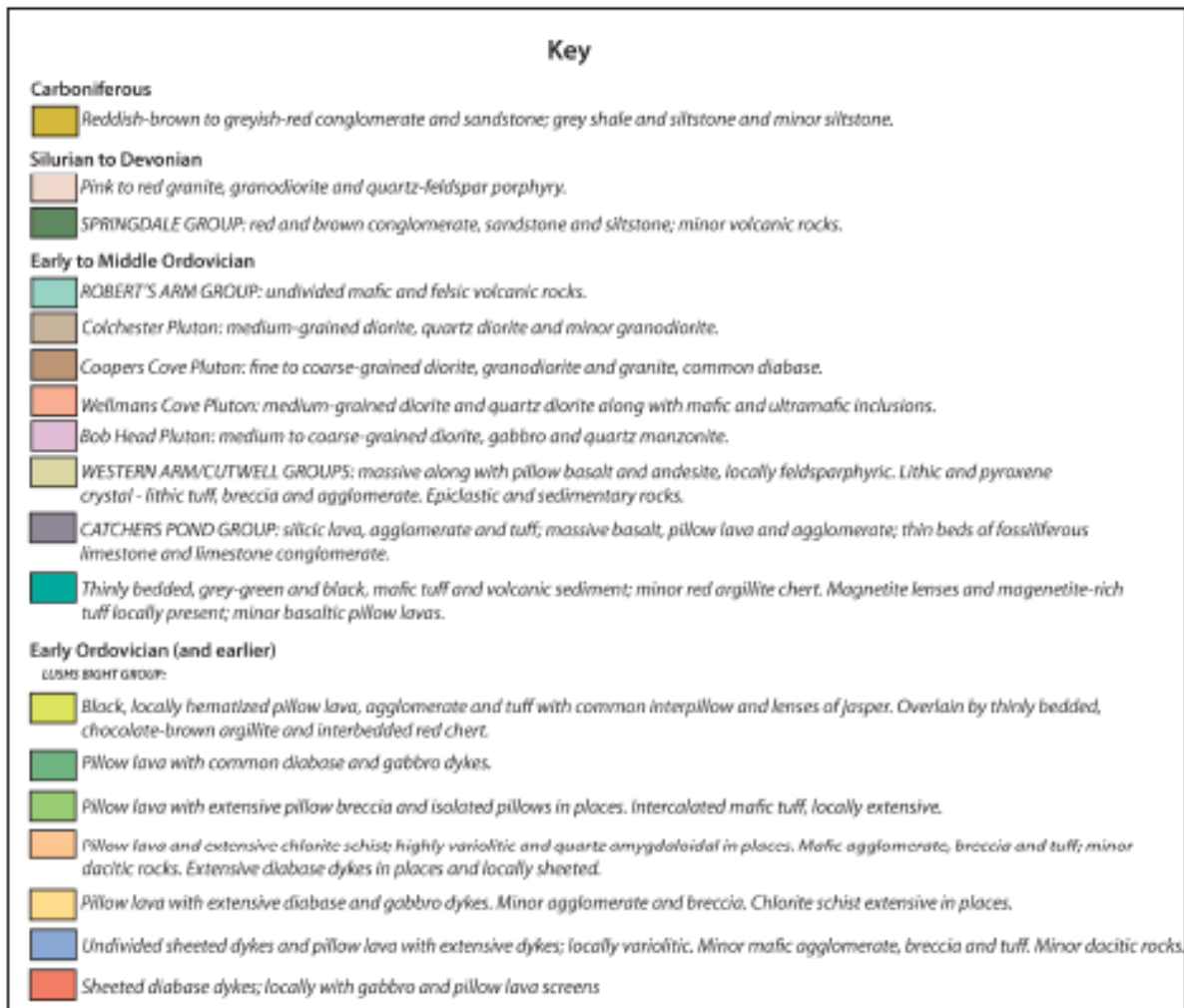


Figure 14. Geological map of the Springdale Peninsula and surrounding area with various mineral showings and deposits. Diagram from Kean et al. (1995). Diagram redrafted and provided by Helena Toman (2012). Field trip stops denoted in red dots with annotation.



VMS Occurrences

1 = Nickey's Nose	11 = Sterling	21 = Indian Beach
2 = Rushy Pond	12 = Sullivan Pond	22 = Indian Head
3 = Rushy Pond Head	13 = Lady Pond	23 = Miles Cove
4 = Swatridge and Swatridge East	14 = Little Deer	24 = Jerry Harbour
5 = Old English	15 = Whalesback	25 = Paddock Bight
6 = South Naked Man	16 = Little Bay and Sleepy Hollow	26 = Timber Pond
7 = Colchester and Southwest Colchester	17 = Hearn	27 = Hammer Down
8 = McNeily	18 = Fox Neck	
9 = Rendell-Jackman	19 = Shoal Arm	
10 = Yogi Pond and Nolan	20 = Little Bay Head	

Figure 14 (continued). Legend for geological map of the Springdale Peninsula and surrounding area with various mineral showings and deposits. Diagram from Kean et al. (1995). Diagram redrafted and provided by Helena Toman (2012).

This outcrop consists of a beautiful conglomerate of the Springdale Group that contains cobble- to pebble-sized clasts within a sandy matrix (Figure 14). The conglomerate beds are interbedded with sandstone that is locally cross-bedded. The clasts include granitic clasts, purple and red rhyolite, andesite, amygdaloidal basalt, and chert. These rocks are interpreted to have been deposited unconformably atop the Lushs Bight Group and are interpreted to have formed in extensional, alluvial basins, associated with Silurian caldera development (Coyle, 1987; Kean, 1988) following arc-arc collision and closure of the Iapetus Ocean along the Red Indian Line; marking the terminal phase of the Taconic Orogeny in the late Ordovician (van Staal, 2007).

STOP 3.6: Drill Core from the Little Deer VMS Deposit – Core Storage Area of Cornerstone Resources and Thundermin Resources

Drive to the Springdale Highway, turn left and head towards the town of Springdale. Follow the field trip leaders to the core storage facility of Cornerstone Resources and Thundermin Resources. Representative drill cores of the mineralization found in the Little Deer deposit will be shown.

The deposit was found in 1952 by Falconbridge Nickel Mines Ltd and was further explored by Brinex in 1955 (West, 1972; Kean, 1988; Kean *et al.*, 1995). From 1962-1969 Brinex undertook extensive drilling and a shaft was sunk on the deposit. From 1962-1972 reserves were delineated and Green Bay Mining Company produced 75 000 tonnes of ore in 1974 (West, 1972; Kean, 1988; Kean *et al.*, 1995). Since 2007 Cornerstone and Thundermin Resources have undertaken exploration and development. The deposit has currently had revised resources and a preliminary economic update and contains indicated resources of 1.911 Mt @ 2.32% Cu, and inferred resources of 3.748 Mt @ 2.13% Cu (Putrich *et al.*, 2011).

Mineralization at Little Deer is hosted within a sequence of pillow lavas and massive flows of the Lushs Bight Group that are variably strained and deformed and crosscut by pyroxene-bearing mafic dykes (Figure 15) (Papezik and Fleming, 1967; Fleming, 1970; West, 1972; Kean, 1988; Kean *et al.*, 1995). The mineralization is typically stringer, clot, to semi-massive in nature and is hosted within the lavas or within chlorite-schist zones, interpreted to be deformed basaltic rocks (West, 1972; Kean *et al.*, 1995; Pressacco, 2009; Putrich *et al.*, 2011) (Figures 15 to 17). The mineralization is dominated by chalcopyrite and pyrrhotite, with lesser pyrite, sphalerite, cobaltite, rare galena, and microscopic grains

Geological Map of the Little Deer - Whalesback Area

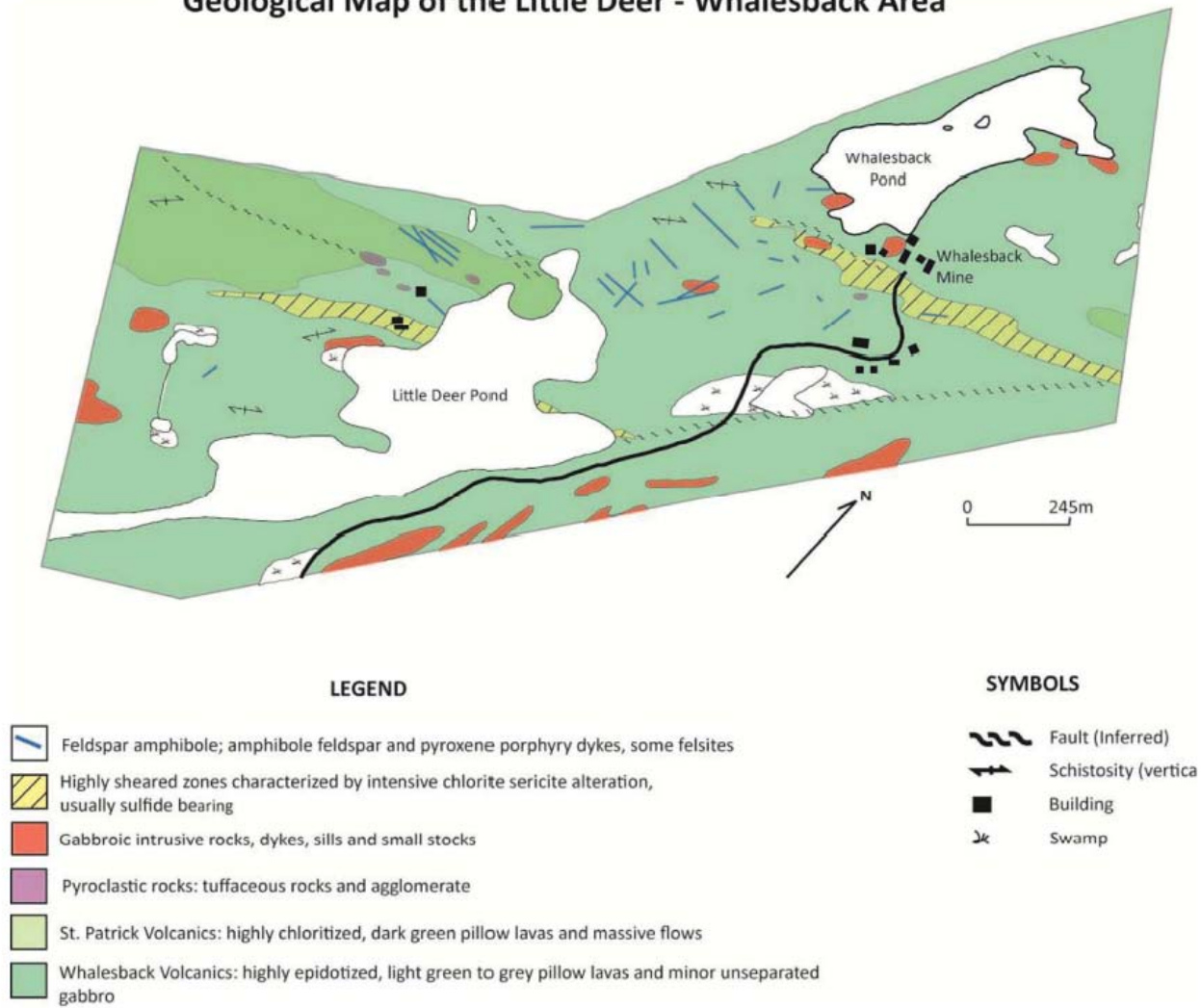


Figure 15. Geological map of the Little Deer-Whalesback area. Map from Papezik and Fleming (1967), Fleming (1970), and Kean et al. (1995). Diagram redrafted and provided by Helena Toman (2012).

of Bi and Ag tellurides and electrum (Helena Toman, unpublished data). The mineralization represents the type locality for stringer-type Cyprus-style mineralization in the Newfoundland Appalachians (e.g., Figure 17).

Participants will drive from Stop 3.6 and drive towards the town centre of Springdale to the Pelly Inn (located on the Springdale Highway, Phone (709)673-3931 or 1-877-9SAFARI; E-Mail: cog@islandsafaris.com).

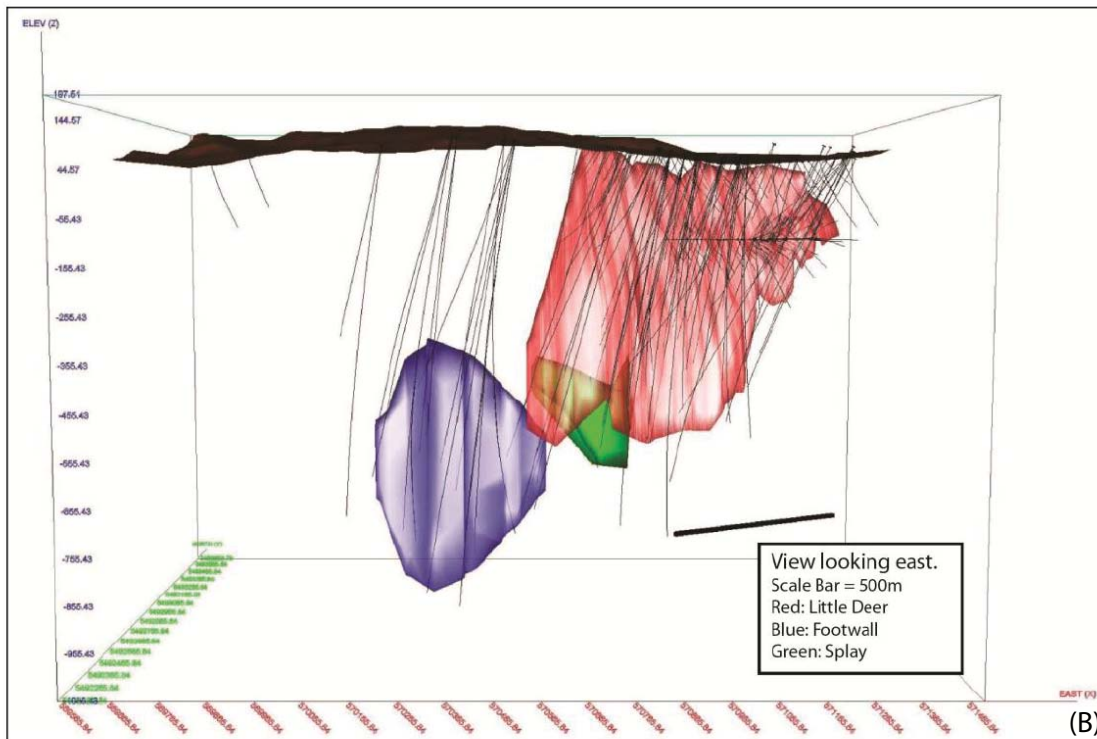
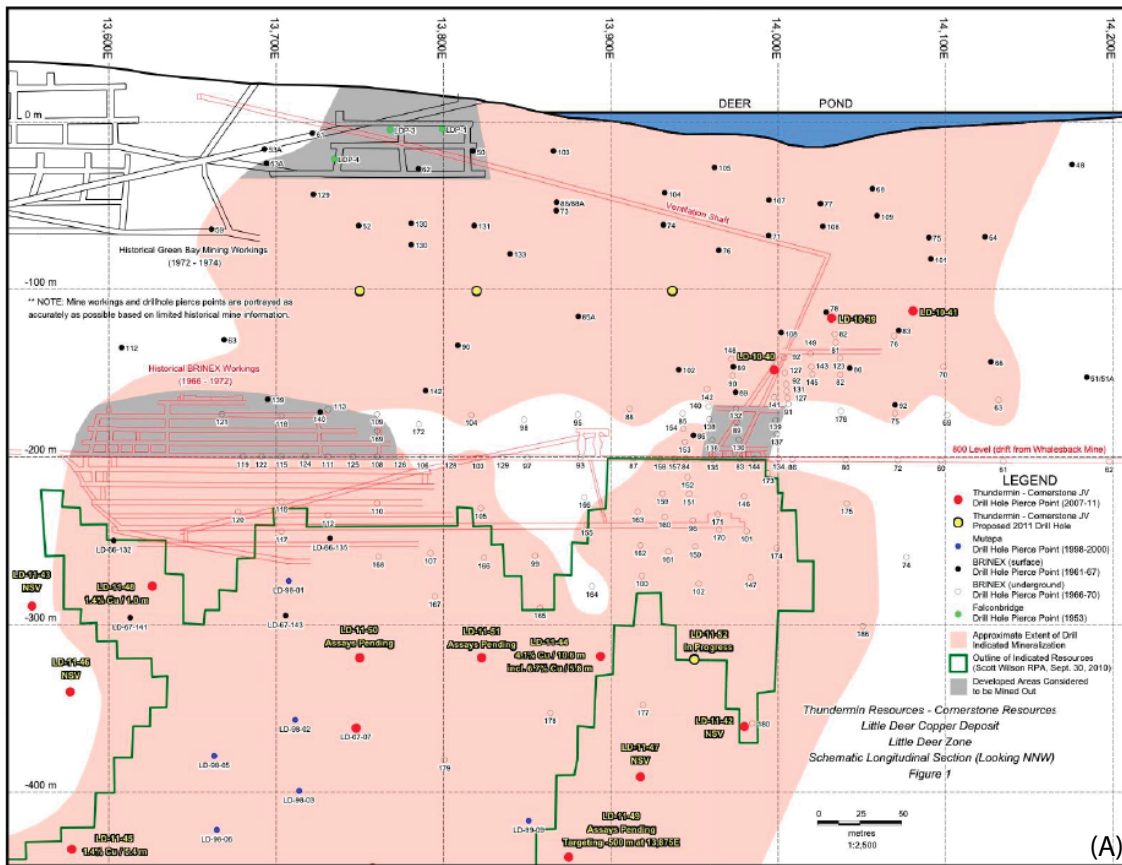


Figure 16. A) Long section through the Little Deer deposit with locations of drill hole intersections, previous workings, and grades. B) Isometric projections of the mineral resource domains from the Little Deer deposit. The different colours represent different resource blocks. The shells give an idea of the geometry of mineralization. From Putrich et al. (2011).

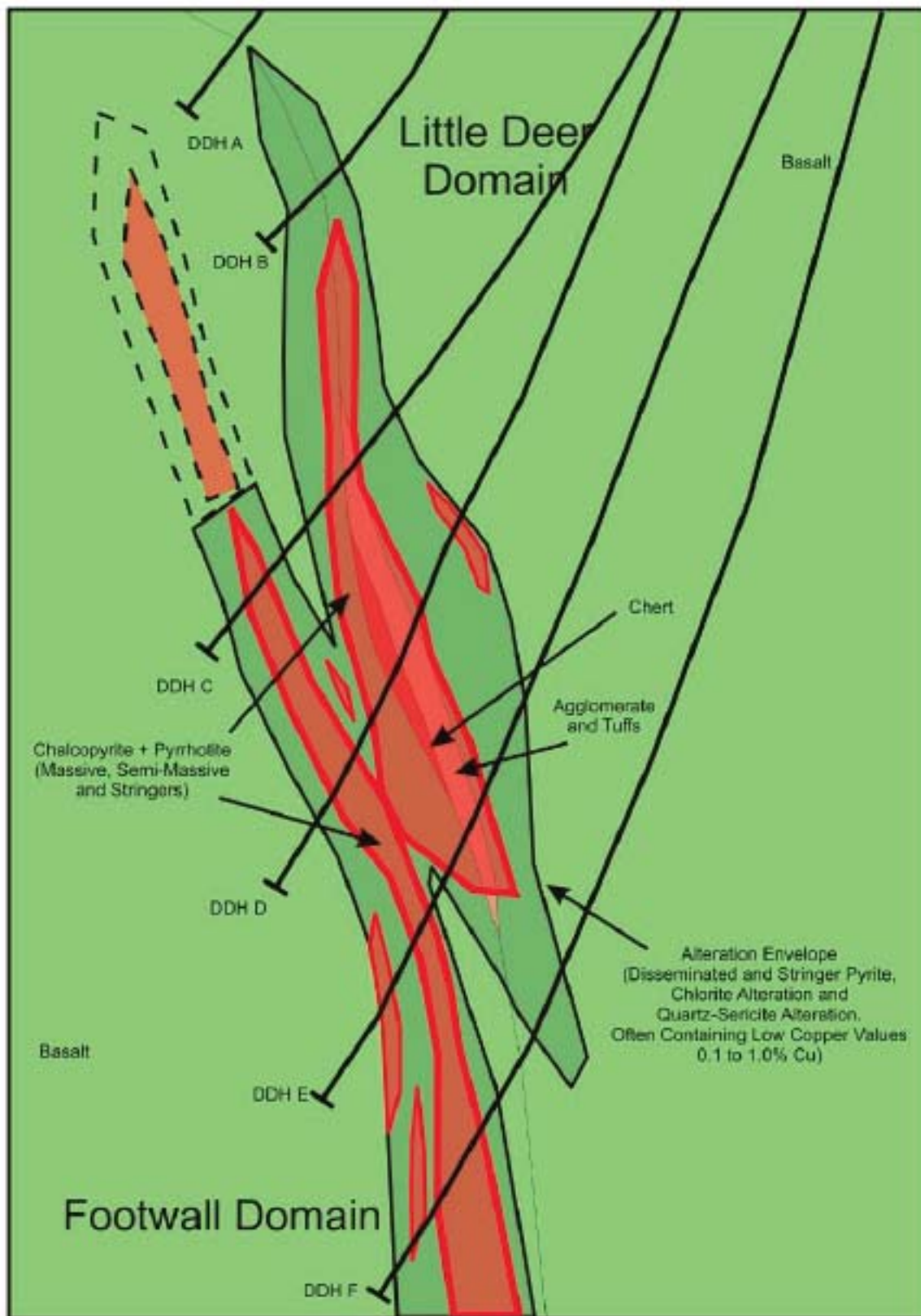


Figure 17. Schematic section through the Little Deer deposit outlining the nature of mineralization as stringers within basaltic host rocks with a tight envelope of chlorite alteration. Their association with shear zones is interpreted to be due to remobilization of original chlorite alteration pipes (e.g., Kean et al., 1995). Diagram from Pressacco (2009) and Putrich et al. (2011).

DAY 4 – JUNE 2nd

BAIE VERTE PENINSULA

Participants will leave the Pelley Inn, drive from Springdale to the Trans-Canada Highway, take a right, and drive towards Baie Verte junction. At Baie Verte junction take a right and drive towards Baie Verte until they meet the LaScie Highway where one takes a right and drives to the Mings Bight Road turnoff. Take a left at this junction and proceed approximately 200 m and the Ming Mine will be on the left hand side.

STOP 4.1: Ming Mine Site

This stop will include a visit to the mine site and to view drill core of the stratigraphy, alteration, and mineralization from the Ming Mine. Staff at Rambler Metals and Mining Ltd. and Stefanie Brueckner will lead a significant portion of this part of the tour. Participants must adhere to all safety regulations of Rambler Metals and Mining Ltd., including wearing proper personal protective equipment, where appropriate.

The Ming Mine is a past producer and is currently producing. It currently has a total NI-43-101 compliant geological resource of 3.65 Mt @2.26% Cu, 1.13 g/t Au, 6.78 g/t Ag, and 0.32% Zn occurring in numerous different zones. One of the zones, the 1806 zone, is very precious metal-rich and contains 487 000 tonnes of 3.4 g/t Au and 22.31 g/t Ag (Pilgrim, 2009); it has recently gone into production following a feasibility study (Darling *et al.*, 2010). The deposit is hosted by rocks of the Pacquet Harbour Group within the Baie Verte VMS belt, and is generally considered as a regional correlative to rocks of the Betts Cove complex (Hibbard, 1983; Castonguay *et al.*, 2009; Skulski *et al.*, 2009, 2010) (Figures 18 to 20). The general stratigraphy of the deposit consists of a footwall of strongly deformed rhyolitic flows and volcanoclastic rocks, regionally referred to as the “Rambler Rhyolite”, that are boninite-like and part of Skulski *et al.*’s (2009; 2010) Lower Pacquet Harbour Group (*see also* Tuach and Kennedy, 1978; Pilgrim, 2009; Brueckner *et al.*, 2011) (Figures 18 to 22). The hanging wall rocks consist of relatively fresh, but deformed, turbiditic rocks of mixed provenance (Tuach and Kennedy, 1978; Pilgrim, 2009; Brueckner *et al.*, 2011) (Figure 21). This package is overlain regionally by a distinctive chert and iron formation that is correlated with the Nugget Pond horizon, host to orogenic Au mineralization elsewhere on the Baie Verte Peninsula (Skulski *et al.*, 2009, 2010) (Figures 20 and 22). The entire stratigraphic package is crosscut by two generations of post-mineralization mafic dykes (Tuach and Kennedy, 1978; Pilgrim, 2009; Brueckner *et al.*, 2011) (Figures 21 and 22). The mineralization occurs in numerous zones and includes pyritic massive sulphide that is variably precious metal enriched (*i.e.*, Ming South upplunge and downplunge extensions), polymetallic and precious metal-rich sulphides (*i.e.*, 1806 and 1807 zones), and Cu-rich, footwall

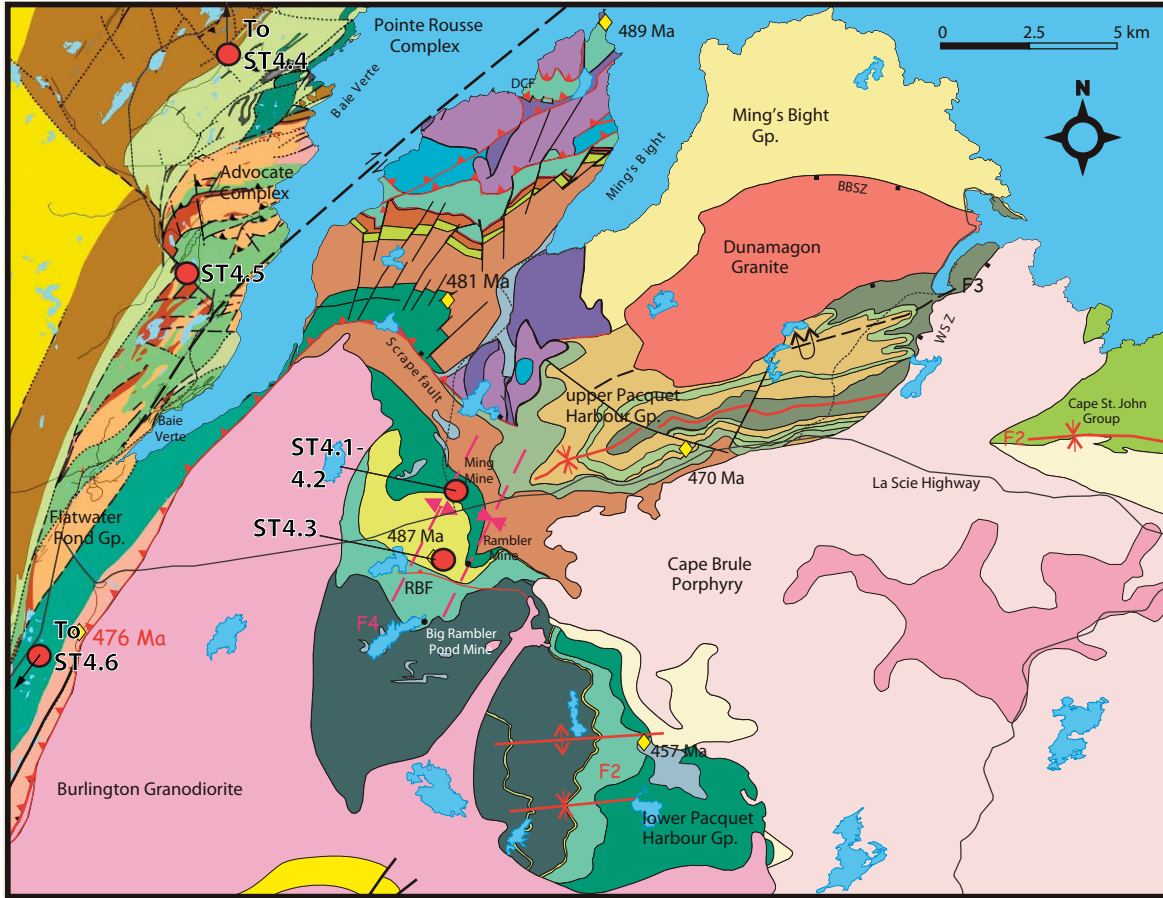


Figure 18. Geological compilation map of the Pacquet Harbour Group and associated rocks near the Ming Mine, Baie Verte Peninsula. Compilation from Skulski et al. (2009, 2010) and Castonguay et al. (2009) based on original mapping by Hibbard (1983). Field trip stops denoted by red dots with annotation. Other stops are off this map. Legend for lithostratigraphic units in Figure 19.

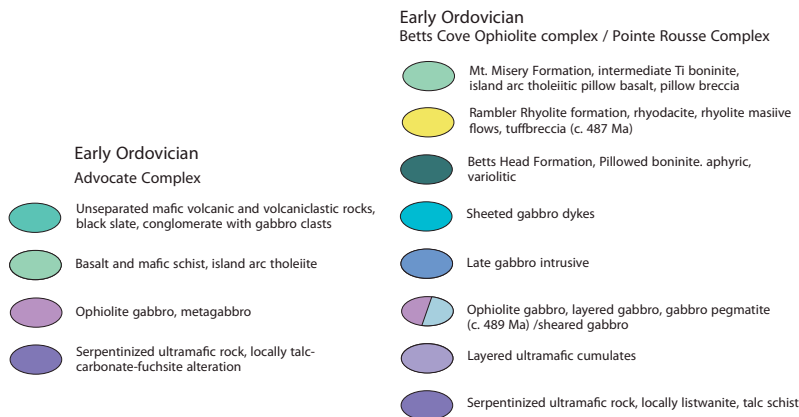
stringer-type mineralization (Ming Footwall zone) that is precious metal poor (Tuach and Kennedy, 1978; Pilgrim, 2009; Brueckner *et al.*, 2011) (Figures 21 to 23). Alteration associated with the massive sulphide mineralization is predominantly quartz and sericite alteration, with or without green mica (Tuach and Kennedy, 1978; Pilgrim, 2009; Brueckner *et al.*, 2011). The precious metal-rich 1806 zone also contains intensely silicified zones that are often associated with green mica immediately at the hanging wall-footwall contact to mineralization (Brueckner *et al.*, 2011). The Ming Footwall zone contains intensely chlorite altered rhyolitic rocks, often with blue quartz eyes still preserved within a sea of green-black chlorite, representative of typical, chlorite pipe-like alteration (*e.g.*, Franklin *et al.*, 2005).

DUNNAGE ZONE

Ophiolite Cover Sequence



Baie Verte Oceanic Tract



HUMBER ZONE

Laurentian Continental Margin

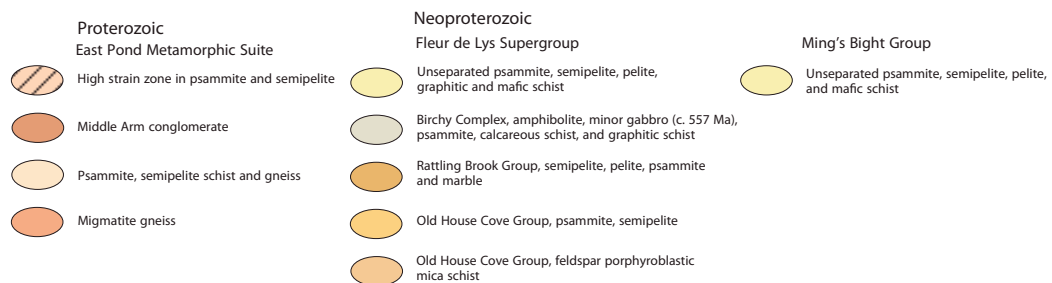


Figure 19a. Provisional lithostratigraphic units for Ordovician and older units of the Baie Verte Peninsula. From Skulski et al. (2009, 2010).

Continental Cover Sequence

Silurian



Figure 19b. Provisional lithostratigraphic units for Silurian units of the Baie Verte Peninsula. From Skulski et al. (2009, 2010).

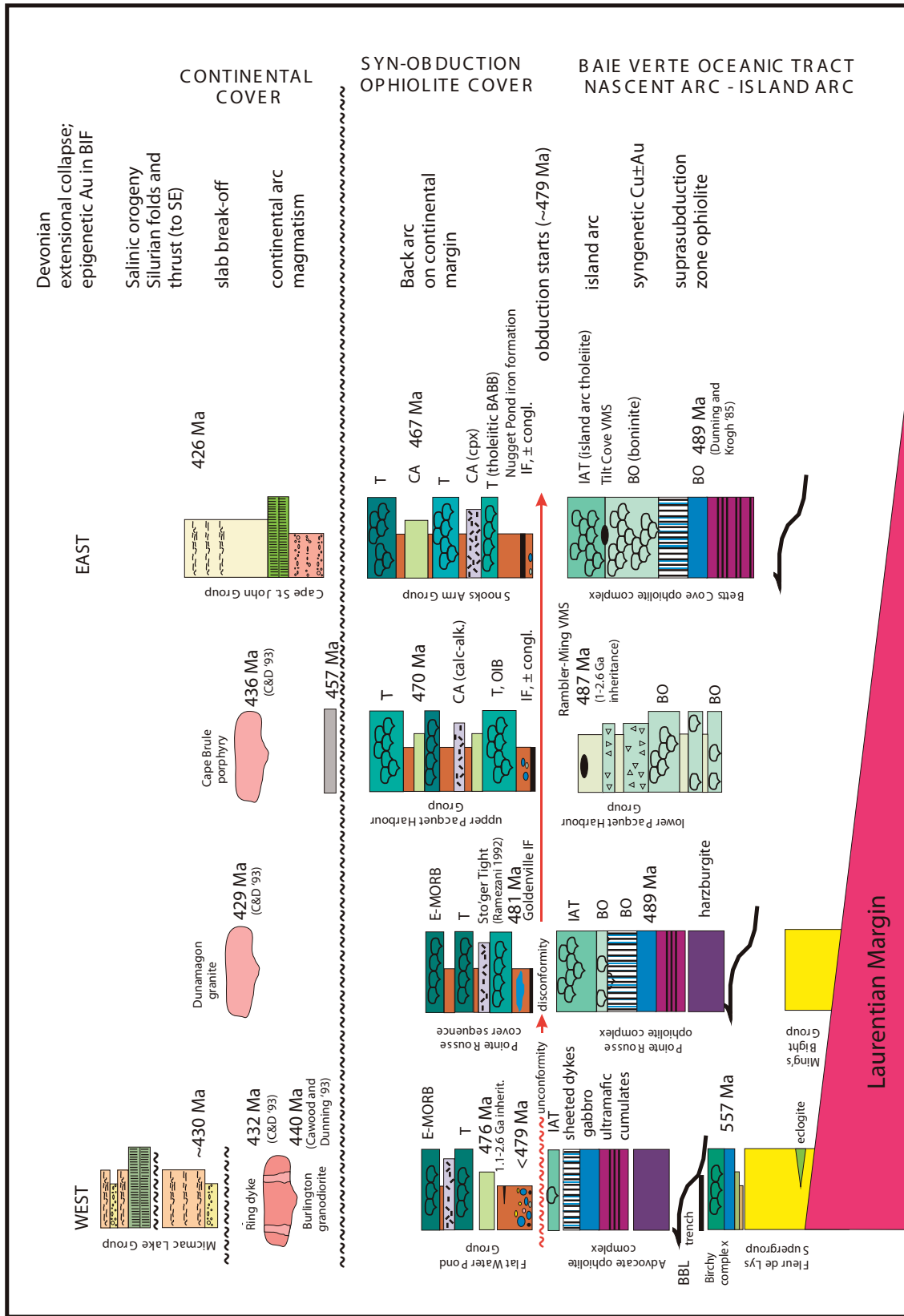


Figure 20. Tectonostratigraphy of the Baie Verte Peninsula with regional correlations. Diagram from Skulski et al. (2009, 2010).

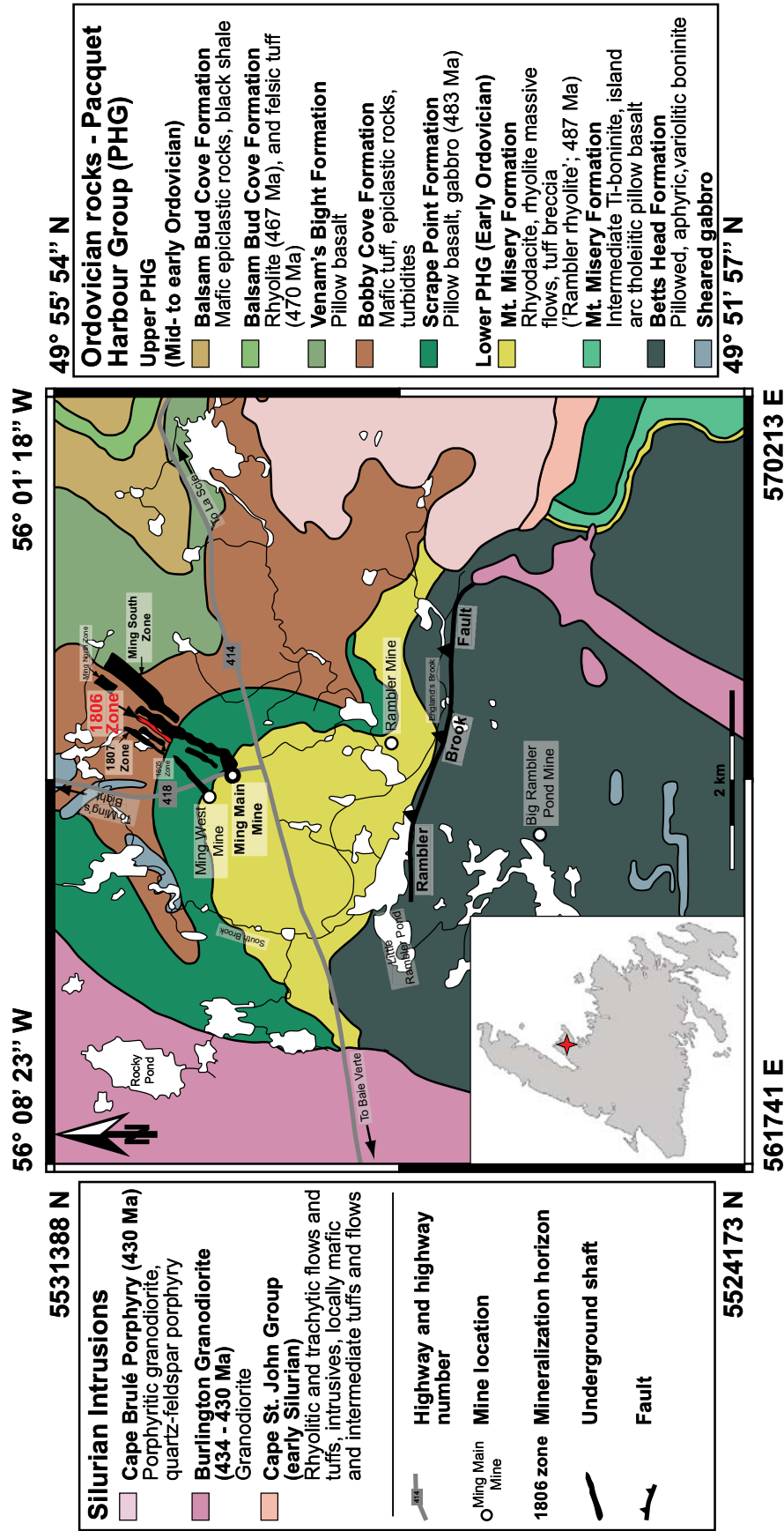


Figure 21. Geological setting of the Rambler VMS deposits with emphasis on the Ming Mine and associated zones of the Ming deposit. Diagram is modified from Brueckner et al. (2011) based on original mapping by Hibbard (1983), Skulski et al. (2009, 2010), and Cas-tonguay et al. (2009).

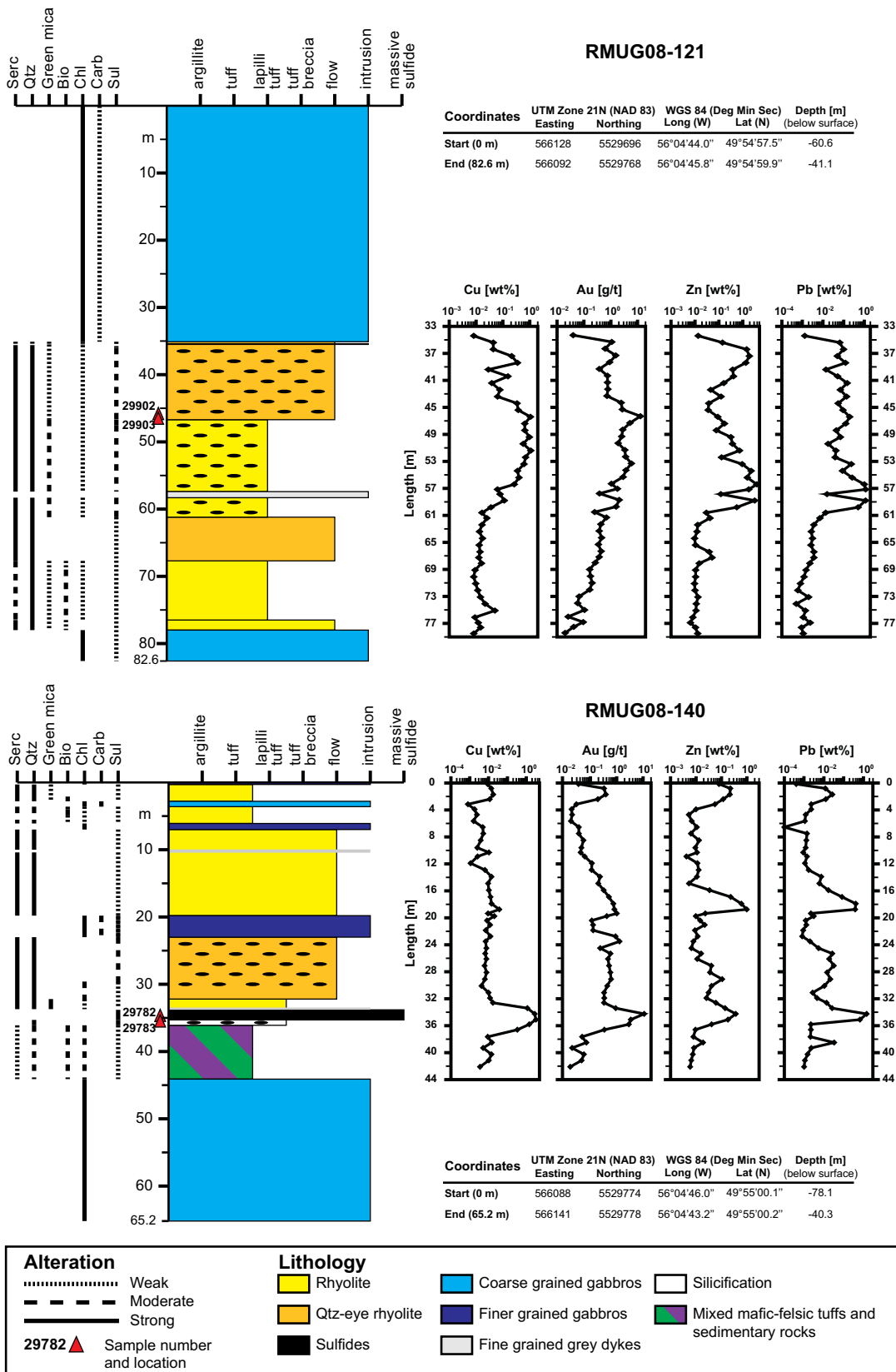


Figure 22. Stratigraphic sections of two drill holes from the 1806 zone, RMUG08-121 (top) and RMUG08-140 (bottom). Sections are overturned, assay data (right) from Rambler Metals & Mining Canada Limited. Mineral abbreviations: Serc–sericite, Qtz–quartz, Bio–biotite, Chl–chlorite, Carb–carbonate, Sul–sulphide. Diagram from Brueckner et al. (2011).

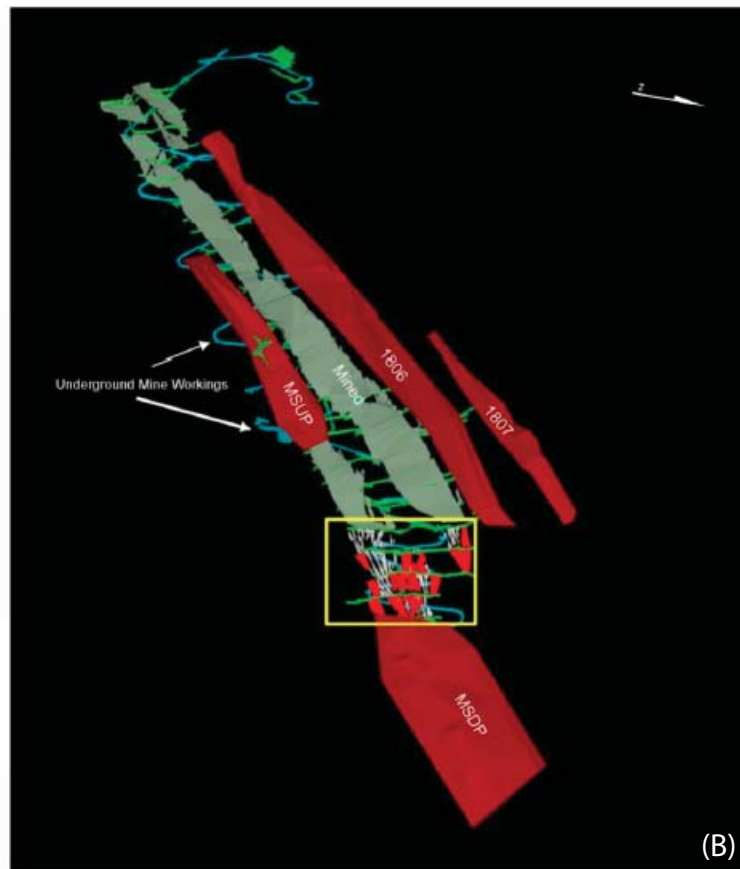
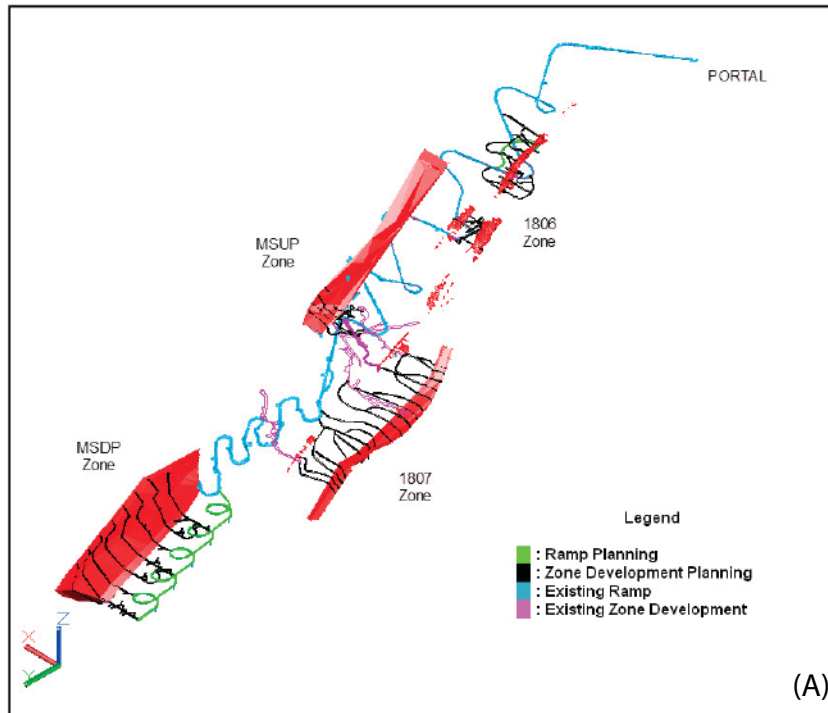


Figure 23. A) Isometric shells of the various ore zones and infrastructure from the Ming Mine. B) Unmined ore zones below the 2200 level and underground mine workings. Those shells represent the different sulphide zones and potential areas to be mined. Diagrams from Darling et al. (2010).

STOP 4.2: Iron Formation above the Rambler VMS Deposits (Nugget Pond Horizon Equivalent) (Easting: 565964, Northing: 5529370)

(Modified after Skulski et al., 2009)

This stop is located proximal across the Ming's Bight Highway across from the Ming Mine, located on the road immediately east of the turn off for the Ming Mine (Figure 18). Traverse this road towards an abandoned pit and the outcrops are located on the edge of the pit. This is a very dangerous location and participants should stay clear of overhanging faces, old workings and stopes, and obey all posted signage.

The footwall to this pit contains sericite altered, schistose Rambler Rhyolite with pyrite and minor massive sulphide mineralization. This is overlain by graded greywacke, siltstone, and thin 10-20 cm iron formation bands that are interpreted to be equivalent to the Nugget Pond horizon that hosted orogenic Au mineralization at the Nugget Pond mine near Betts Cove.

STOP 4.3: Rambler Rhyolite – Rambler Main Mine Area (Easting: 566323, Northing: 5527313)

(Modified after Skulski et al., 2009)

This site is located on the La Scie highway almost immediately across from the Ming's Bight Road turnoff. Head out the Ming's Bight road and take a left on the La Scie Highway and head east approximately 700 m to the Rambler Mine Road on the right hand side of the road. You will have to get out of the vehicles and walk about 500 m towards an outcrop of the Rambler Rhyolite (Figure 18). This area is an abandoned and partly reclaimed minesite, therefore, the road is not well maintained, the area has abundant debris, and it requires people to stay away from any sinkholes and potential hazards.

These outcrops consist of strongly deformed rhyolite with variably sericite, quartz, and pyrite alteration. There are locations in this immediate area that contain clasts and are likely tuff breccias. The rocks exhibit a very strong elongation lineation (L-fabric) that mirrors the regional plunge lineation and the geometry of the plunge of the various zones at the Ming Mine and the Rambler Main mine (Tuach, 1988; Castonguay *et al.*, 2009; Pilgrim, 2009). This L-fabric is related to the predominant regional D2 deformation and is associated with regional folding and thrusting.

This site is also the location where the only age constraint on the Pacquet Harbour Group exists. Despite numerous previous attempts to date the rhyolitic rocks of the Pacquet Harbour Group, their boninite-like affinities and low Zr contents (Piercey *et al.*, 1997; Bailey, 2002) result in them having very little zircon. McNicoll *in* Skulski *et al.* (2010), obtained a ~487 Ma age for the rhyolite at this site, which is slightly older but similar to ages obtained for regionally correlatable rocks of the Betts Cove Complex (Dunning and Krogh, 1985; Skulski *et al.*, 2009, 2010) (Figure 18).

STOP 4.4: The Dorset Eskimo Soapstone Quarry

(Modified after Skulski et al., 2009)

Drive from the previous site along the La Scie Highway towards Baie Verte. Drive through the town of Baie Verte and continue towards the community of Fleur-de-Lys and follow the signs for the “Dorset Soapstone Quarry Historic Site”, which is located on the north side of the harbour. Park the vehicles at the information centre. This centre is quite impressive and provides a lot of historical background to the area. The site itself is along the wooden boardwalk just behind the centre.

The rocks at the soapstone locality are altered ultramafic rocks that are structurally interleaved with metasedimentary rocks of the Fleur-de-Lys Supergroup. They were traditionally considered Paleozoic in age (Hibbard, 1983), but recent U–Pb work by McNicoll has obtained ages on correlative rocks that suggest they may be Precambrian (~558 Ma; McNicoll *in* Skulski *et al.*, 2009). The ultramafic rocks are interpreted to have been structurally interleaved with the metasedimentary rocks during obduction during the Taconic orogeny (Hibbard, 1983; Skulski *et al.*, 2009, 2010). This is a protected archaeological site therefore no sampling, hammering, or disturbance is permitted.

The ultramafic rocks at this historical site represent one of the oldest known mining excavations in North America and the material below is taken from Skulski *et al.* (2009) and O’Driscoll (1998). Excavations at this locality started in the 1980s and the archeological evidence suggests that it was used by the Maritime Archaic people ~4000 years ago and then subsequent by the Middle Dorset Paleoeskimo people ~1800-2000 years ago. The scars on the faces of these outcrops represent the remnants of stone vessels and unfinished vessels that are typical of the Middle Dorset period. Stone tools located at the site were made from chert and quartz.

The soapstone from the quarry was mostly used for functional purposes, such as cooking pots and lamp vessels, rather than for artistic carving. The site was interpreted to have been active for centuries based on the number of extraction scars present at the site. It is interpreted that the soapstone vessels were carved *in situ*, and the first round or ovoid soapstone “preform” created the inner surface for the next vessel, and the process continued. Some partially finished vessels have been left in the quarry after it was abandoned, and it is interpreted that the partially finished vessels were removed from this site and finished elsewhere.

STOP 4.5: Advocate Asbestos Historic Lookout Site

(Modified after Al et al., 1988)

Drive from the town of Fleur de Lys towards the town of Baie Verte. En route it will be obvious where the Advocate Mines site is (Figure 18). There is a lookout that we will stop at close to the mine location and reclamation of the old pits. This site is also an historic visit to a traditional mine in the area. The stop will be on the side of the highway so beware of traffic.

The Advocate Mines were in production from 1963-1981 and produced roughly 30 Mt of ore from which 967 590 tonnes of asbestos fiber was produced. The ore is hosted within serpentinitized ultramafic rocks of the Advocate Complex and mineralization consists of stockworks of chrysotile crossfiber veins, typical of ultramafic complexes within the Appalachians. Currently the site is being reclaimed.

STOP 4.6: Virginite Occurrences (Easting: 548917, Northing: 5516955)

(Modified after Skulski et al., 2009)

From the last stop drive through the town of Baie Verte towards the Trans-Canada Highway. The outcrops in question are located just past the turnoff for the Burlington Highway and they are located on the right side of the highway. The outcrops are bright green and contain abundant dun-coloured weathering. Be careful for traffic at this locality.

These outcrops are of “virginite”, a local term used for these metasomatized ultramafic rocks that are used in local crafts and jewelry. Meyer’s Minerals¹ currently own the mineral rights to this property and given this ownership please take only small samples. The rocks consist of quartz–magnesite–fuchsite-rich metasomatized ultramafic materials that are part

¹ <http://www.newfoundlandlabrador.com/planyourtrip/Detail/212112>

of a group of dismembered ophiolitic rocks that have been caught up in the Baie Verte Line, a fault that separates the Dunnage Zone from the Humber Zone. These rocks are often referred to as listwaenites, listvenites, or mariposites, but in Newfoundland they have been referred to as virginities by a local prospector and geologist Norman Peters. These rocks are often associated with orogenic gold elsewhere on the Baie Verte Peninsula.

Participants should drive from the last stop towards the Trans-Canada Highway. Take a left on this highway and drive towards Deer Lake and stop at the Deer Lake Motel, which will be on the left hand side of the highway (Deer Lake Motel: 5 Trans Canada Highway, Deer Lake, NL, A8A 2E5, Phone: (709) 635-2108, www.deerlakemotel.com).

DAY 5 – JUNE 3rd

DEER LAKE

Participants will either catch flights directly out of Deer Lake or will be returning to St. John's. The time of departure for the participants will be determined by the field trip leaders after consultation with the participants.

ACKNOWLEDGMENTS

This field trip would not have been possible without the support and contributions from numerous people and companies. Access to the various deposits, drill core, and mine sites was provided by Teck-Duck Pond Operations, Paragon Minerals Corp., Cornerstone Resources, Thundermin Resources, and Rambler Metals and Mining Canada Ltd.. Various individuals have contributed time and discussed many of the ideas and content provided within including (in alphabetical order): Terry Brace, Sebastien Castonguay, David Copeland, Christine Devine, Brad Dyke, Darren Hennessy, John Heslop, Andrew Hussey, Darrell Hyde, Baxter Kean, Stefanie Maloney, Sean McLenaghan, Peter Mercer, Larry Pilgrim, Neil Rogers, Hamish Sandeman, Tom Skulski, Barry Sparkes, Bryan Sparrow, Gerry Squires, Scott Swinden, Brent Thomas, Steve Tsang, Cees van Staal, Derek Wilton, and Alex Zagorevski. Students from Steve Piercey's research group at Memorial University have contributed significantly to the material presented within, including: Stefanie Brueckner, Stefanie Lode, Conor McKinley, and Helena Toman. Anyone that has not been noted above is not out of malice, and if we have forgotten anyone we apologize in advance.

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The following are field trips organized for the GAC – MAC Meeting, St. John's 2012.

PRE-MEETING TRIPS

- FT-A1 Accreted Terranes of the Appalachian Orogen in Newfoundland: In the Footsteps of Hank Williams**
Cees van Staal and Alexandre Zagorevski
- FT-A2 The Dawn of the Paleozoic on the Burin Peninsula**
Paul Myrow and Guy Narbonne
- FT-A4 Mistaken Point: A Potential World Heritage Site for the Ediacaran Biota**
Richard Thomas
- FT-A5 Neoproterozoic Epithermal Gold Mineralization of the Northeastern Avalon Peninsula, Newfoundland**
Sean J. O'Brien, Gregory W. Sparkes, Greg Dunning, Benoît Dubé and Barry Sparkes
- FT-A9 Cores from the Ben Nevis and Jeanne d'Arc Reservoirs: A Study in Contrasts**
Duncan McIlroy, Iain Sinclair, Jordan Stead and Alison Turpin

POST-MEETING TRIPS

- FT-B1 When Life Got Big: Ediacaran Glaciation, Oxidation, and the Mistaken Point Biota of Newfoundland**
Guy M. Narbonne, Marc Laflamme, Richard Thomas, Catherine Ward and Alex G. Liu
- FT-B2 Peri-Gondwanan Arc-Back Arc Complex and Badger Retroarc Foreland Basin: Development of the Exploits Orocline of Central Newfoundland**
Brian O'Brien
- FT-B3 Stratigraphy, Tectonics and Petroleum Potential of the Deformed Laurentian Margin and Foreland Basins in western Newfoundland**
John W.F. Waldron, Larry Hicks and Shawna E. White
- FT-B4 Volcanic Massive Sulphide Deposits of the Appalachian Central Mobile Belt**
Steve Piercey and John Hinchey
- FT-B5 Meguma Terrane Revisited: Stratigraphy, Metamorphism, Paleontology and Provenance**
Chris E. White and Sandra M. Barr
- FT-B6 The Grenville Province of Southeastern Labrador and Adjacent Quebec**
Charles F. Gower
- FT-B7 Geotourism and the Coastal Geologic Heritage of the Bonavista Peninsula: Current Challenges and Future Opportunities**
Amanda McCallum and Sean O'Brien